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The Watermill at Bunbury

No mill could have been created without the millwright, and no historical background complete without his mention. Millwrighting was a craft which grew up with the invention of the water and windmills. It was a completely adaptable craft, for no two mills were ever the same. It had no previous technologies to guide it, except for the construction of the wheel itself and the construction of the building. Both of these crafts came together under the jurisdiction of the one man who had to adapt them to his needs. The wheel needed modifying to take the strains imposed upon it and, more importantly, for cogs or paddles to be fitted. The buildings, and here I include the ancillary constructions to direct the water onto the wheel, had to be custom made to suit the millwright, for this later became the task of the mason.

This idea helps to distinguish the character of the millwright. He was adaptable, for he had to be able to apply his craft to the variety of mills. Different needs, different requirements of power and different geographical conditions all determined the layout of the mill. He was the most technically minded of his trade, for he had to adapt new ideas and new technologies as they evolved. He was more intellectually alert for he had to communicate ideas, both with the miller and the mason. He also had to have a great understanding of the nature and properties of the materials he used.

Once a mill was complete he would move on, looking for more work, and as such he would probably work in an area both large enough to provide work, and small enough to be known by the millers. His work would be varied, from small repairs to the construction of new or badly damaged mills. The trade of the millwright, like that of the miller, was handed down from father to son, although apprenticeship might have been given. He would therefore be absent from his family for long periods of time.

With the decline of the wind and watermills in favour of the more convenient and advanced power sources, the craft of the millwright also came to an end. In mills which were working in the latter part of the 19th and early 20th centuries, the miller would have to do what repairs he could. If the repair was too large a job for the miller, then often the mill would fall into disuse, as the watermill at this time was not economically viable, and large repairs would have been too costly.

Bunbury Mill

At the turn of the century the mill was one of four in the immediate area, the others being situated below Beeston Castle, at Tilstone Fearnall and at Tarporley. The mill at Tarporley was powered by steam only, while the others derived their power from the River Gowey, being further downstream from Bunbury.

The mill prior to the one standing was probably a sandstone and timber framed building, built into the damside, and was probably burned down in the period 1839-1851. Charred remains were found during restoration work. The present building is all that now remains of the 1960 complex, which comprised the mill itself, stables and an engine shed. The miller still occupies the mill house which stands 100 m. away.

The present structure is a three storied brick building on a sandstone foundation which is built into the damside. It houses the water-wheel and all the gearing and machinery of the mill. The dam which creates the millpond has a sluice on one side of the mill and a culvert to direct the water onto the wheel in the mill at first floor level. It also affords access to the top floor for the off-loading and loading of the raw materials and the mill's produce. The building measures 12.3m. by 7.0m. with a wall thickness of 0.45m.

The ground floor is reached by a door opposite the damside of the building. It contains the wheel pit which is enclosed, the hursting with all the gearing to the millstones above, and the fire to the drying kiln. Access to the water-wheel is either gained from a store on the ground floor leading to the inner part of the wheel and axle spokes, or from the first floor to the paddles.

The first floor is reached by a narrow staircase, and containst the pentrough and sluice gate, three pairs of stones, of which only one has been restored to a working condition, the drive to the sack hoist and the drying room. Originally the wheel was covered with removable floorboards, but these have been removed, and a low partition substituted so that the wheel can easily be seen.

The second floor contains the sack hoist and partitions which separated the sacked grain. It was from this floor that the grain started its downward descent through trapdoors in the floor, through sacking into the hoppers and thence to the stones, finally being ground and collected in wooden troughs arranged round the hursting on the ground floor.

The Water-wheel

This is an overshot wheel containing 36 'J' section wooden buckets held by a cast iron rim. The axle is of cast iron, 370mm. in diameter, and ribbed to allow packing to be placed to secure the water-wheel and pit wheel. The central hubs of the water-wheel are of cast iron, but contain recesses for the six pairs of oak spokes of 120 x 100mm. cross section which are bolted to both the hubs and the rims. The rims themselves are in six pairs bolted together, with cast grooves on the inside to take the elm paddles. The outside board holds the lower one in position, and is itself secured with nails. The bottom boards, or 'sole plates', are fastened from the inside of the wheel and form a continuous drum. The whole assembly is therefore a composite structure of cast iron and elm measuring 1.45m. wide by 3.1m. diameter, weighing 10 tons, giving an estimated 16 horse-power.

Gearing

With reference to the schematic diagram showing the sequence of gearing, the transference of power from the water-wheel to the stones and sack hoist can be traced.

The pit wheel is located onto the same axle as the water-wheel, and transfers the drive from the horizontal plane to the vertical plane with the aid of the wallower. Both the wallower and the great spur wheel are mounted on an octagonal oak shaft, 400mm. A/F, and are held in position with wooden packing pieces. The teeth of the great spur wheel mesh with the stone nuts, yet they also continue over the upper surface of the gear. The reason for this was that the drive from the standby steam engine engaged onto this wheel, this shaft being horizontal and being directly driven from the flywheel via a two pronged dog clutch. This engine was rarely used and was dismantled and given to the War Effort in 1940.

Around the great spur wheel are three stone nuts and a spur gear of the same construction which is used to drive the hoist. These stone nuts and spur gear, unlike the others encountered so far which are completely of cast iron construction, are made of cast iron, but morticed to receive beech teeth. There are 28 teeth per gear, each clog being held in place by a matching taper on the inside of the gear, the ends of the teeth being dovetailed in the opposite direction.

These gears could be disengaged by raising them on their tapered square shaft, a composite part of the spindle, until they were clear of the great spur wheel. This was done by a jack ring, raised or lowered by a screwed rod located under the bridge tree, which supported the foot bearing for the stone spindle. The whole machinery had to be stopped if a stone nut was engaged or disengaged.

The drive from the stone nuts went through the floor above to engage the runner stone directly.

The only other gearing in the mill was to the sack hoist on the second floor. The drive for this was taken from the spur gear, which engaged onto the great spur wheel, to a cast iron bevelled gear on the first floor. This drove a horizontal metal shaft 56mm. square via a bevelled gear with 48 wooden teeth. This was of similar construction to the stone nuts. On the other end of this shaft are mounted two wooden pulley wheels. One of these pulleys is of clasp arm construction, 1.22m. in diameter and 383mm. yhick, and drove the ancillary machinery on this floor concerned with the production of feed for animals. The other pulley, mounted behind the first, is of solid construction, 430mm. in diameter, and around which fits a slack leather belt 100mm. wide. This belt also encompasses a wooden clasp arm pulley 800m. in diameter, in the eaves of the roof on the floor above. The axle of this last pulley serves as the sack hoist, being 230mm. square in section with chamfered corners and iron strips to reduce the wear of the sack hoist chains. The sack hoist is operated by a lever on the top floor to which is attached an idler pulley. The slack of the belt is taken up by the pulley moving into the belt and engaging the drive from the first to second floors. In order that the sack hoist can be operated on any floor, thin rope is attached to the lever to pull it in position, the rope descending to the other two floors.

The millstones

Of the three sets of millstones on the second floor, the one set which had been restored to working order was of French Burr. This is a quartz stone from the vicinity of La-Ferte-sous-Jouare and Epernon which, because of its nature, it is difficult to obtain a whole stone of uniform quality. These stones are therefore built up with selected pieces (often as many as 14) cemented together with plaster of Paris and bound with an iron casing. They were used for the harder cereals, in this case maize and wheat. The other two sets of stones were separated, one being Birmingham Burrstone, the other being a composite of a Birmingham Burrstone for the bed-stone and a Derbyshire Peak runner-stone. These two sets are natural stones hewn in one piece, and being of a soft nature, only used on the softer oats. The Birmingham Burrstone has a surface texture containing holes which cut the grain before grinding takes place. The diameter of the stones varied, the French Burrstone being 1.38m. in diameter, and the other two sets being 1.2m. in diameter.

The spindle stones were underdriven, the bed-stone resting on the floor with the spindle emerging through it. Around the spindle is the neck-box (a brass collar), which is held in place by 3 sets of shims and leather packing, so that it runs centrally in the bed-stone. This is then covered by a cover plate to exclude the grain. Onto the spindle which ends in a square taper fits the 'mace' which receives and supports the 'bar', a curved metal bar cemented in place in the runner-stone. Thus the whole weight of the runner-stone is supported by the spindle, which in turn is supported by the bridge tree of the hursting. If the stones were allowed to touch while operating, sparks would ensue, resulting in one of the miller's worst fears – a fire, the probable destiny of the previous structure. The stones are therefore kept about 0.3mm. apart by means of the 'tentering gear' which in this case involves adjusting the height of the bridge tree at one end by the tentering screw.

Enclosing the stones is a wooden octagonal cover, in this area called a 'case', but also known as a 'tun' or 'vat'. This supports the horse, a structure which holds the hopper and 'shoe' or 'slipper' in position. This shoe is free to move laterally, and the grain is shaken down its slightly inclined slopes by the 'damsel', an eccentric device which fits into the bar and revolves with the runner-stone. The shoe is normally held against this damsel by twine attached to the 'miller's willow', a springy piece of wood, but in this case the tension is controlled from below by a bobbin fixed to the hursting.

Dressing the stones is described in Schools Council Publications No. 11, and will not be repeated here except for a brief mention of points which are

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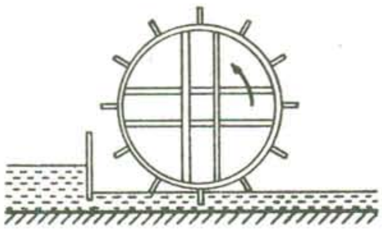
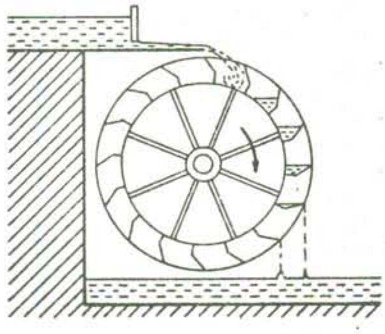
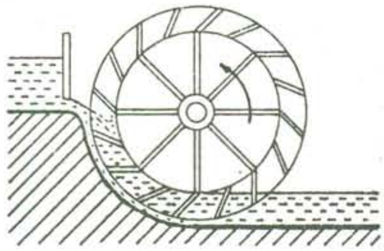
The Development of the Watermill



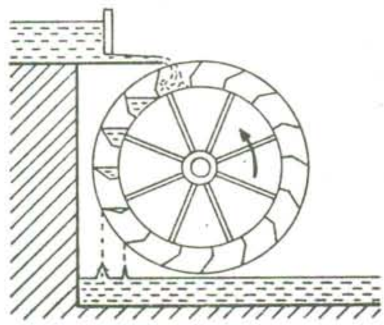
1. Undershot. A direct development from the Noira Wheel, the flowing water strikes the paddles and turns the wheel. The wheel has a low efficiency. Shown here with a clasp-arm construction.



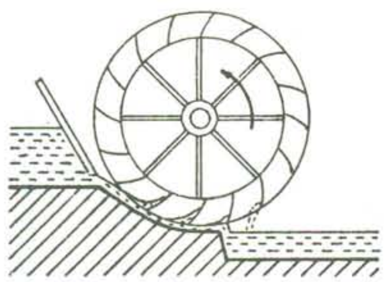
2. Overshot. 60-70% efficiency can be produced from this wheel if the lower part of the wheel is not allowed to enter the water. Otherwise backwash is produced where the wheel is moving in the opposite direction to the tailrace.



3. Breastshot. Both the weight and velocity of the water combines to turn this wheel, efficiencies ranging between 50-60%. The term 'high' or 'low' breastshot indicates water entering above or below the axle.



4. Pitch-back. An extreme example of a breastshot wheel introduced to overcome difficulties encountered with backwash in the overshot wheel. The wheel rlelies only on the weight of water to turn it and not its momentum.



5. Poncelot. An improved version of the undershot wheel introduced in the early 19th century by J.V. Poncelot. Water enters and leaves the calculated and especially shaped paddles with minimum shock thus improving the efficiency.

of interest. In order to turn the runner-stone over, a dovetailed slot had been made in the stone to receive a jig; this dismantled to fit into the stone, and when reassembled, permitted the stone to be lifted off the bed-stone rather than using wedges to separate the two stones. Secondly, no dish had been given to the runner-stone according to the miller. The runner-stone was finished level without the concave surface to improve feed and admit draught.

In order to ensure that the bed-stone dressing was horizontal, a quill was attached to a rod held parallel to the bed-stone, and held in position by fitting the rod over the taper of the spindle. By turning the spindle, it was possible to ascertain by the noise of the quill by how much the bed-stone was out of true.

Lastly, in order to make the runner-stone run parallel to the bed-stone, and because none of the stones used in the mill had balance weights, it was normal practice to adjust the angle of the spindle to compensate. This was done either by altering the packing around the neck-box, or by moving the adjusting screws in the bridging box.

Other noticeable features of the mill

As previously mentioned, there are some gears in this mill that use wooden cogs in a cast frame, and in only one instance is there a metal to metal contact between gears, i.e. the pit wheel and wallower.

According to the miller, cogs were made and inserted individually. The miller here cut the cogs and fitted them himself; the cogs at Bunbury were pre-shaped, presumably very little attention being paid to accuracy when running, the noise of the new cog produced an irregular sound each time it came into play.

The shaft bearings, being typical of the time, were solid soft metal bearings lubricated by 'Blackgrease', i.e. horsefat, which also served to lubricate the gears. The shafts were supported at the top by journals fixed to the side of a beam, and the whole weight of the main shaft and gears or stone nuts and runner-stone was taken by a thrust bearing. The thrust bearings were all of identical construction, the shaft running on a toe-brass block contained in a 'bridging box' which had four screws, one on each side to allow for lateral adjustment.

The other machinery in the mill was worked off the large drum on the sack hoist shaft on the second flooor. One of the machines was a hay cutter used only on Sundays, various parts of which are now missing. The other was a combined corn cutter and oat crusher producing chicken feed and horse feed respectively. This machine was fed from a chute above, the resultant produce being directed to bins in the ground floor below, neither of which has been replaced in the restoration work. A grain cleaner standing on the first floor was not part of this mill, but imported during restoration work. This is a simple belt driven reel separator using a mesh drum.

The drying kiln which occupies a large part of the building was not used by the last miller, the room on the second floor being used as a workshop. A fire was lit in the ground floor grate, the heat travelling upwards and percolating through the perforated tile floor of the room above. These tiles were 320mm. square and 41mm. thick, having 64 cavities with five 1mm. holes per cavity, the upper surface of the tile being flat. They were supported on iron T shaped girders to provide the floor and little remains of them now. The grain was spread onto this floor to dry, and periodically turned over before being discharged when dry enough through a chute to the floor below. The smoke from the fire was allowed to escape through the small window in the wall of the drying room.

The purpose of this kiln was to dry excessively wet grain, a need which was not required in the latter days of the mill. This wet grain could have been the result of a barge fire or similar misfortune and would have been sold cheaply, hence possibly the reason for the original construction.

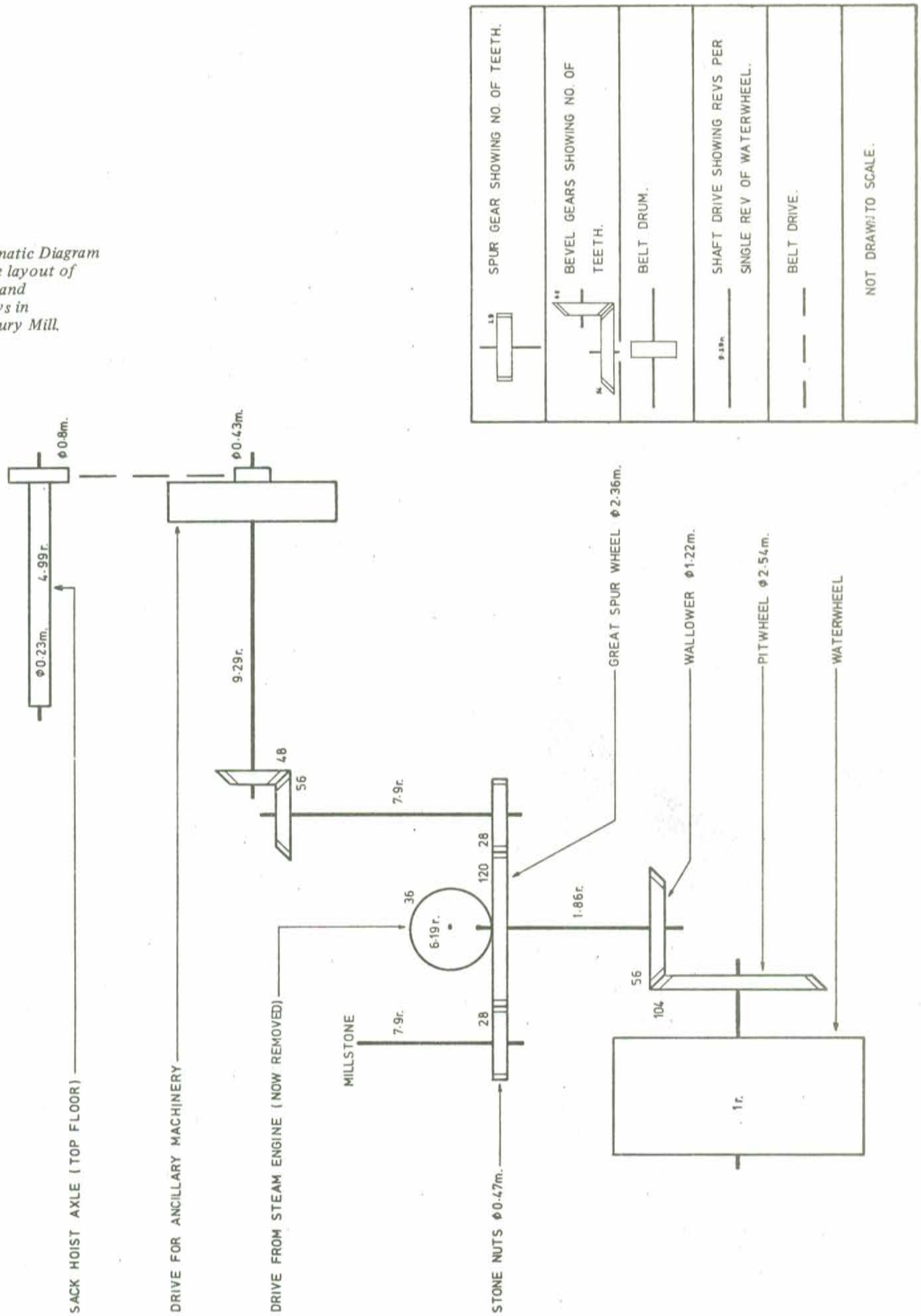
A feature of this mill common to most other mills is the trapdoor arrangement for the sack hoist. These trapdoors were arranged vertically above one another to provide a straight lift for the hoist, and automatically shut after the sack had passed through. This meant that the miller, after loading the sack on the hoist, could remain on that floor, and by operating the rope (see previous description) send the sack to any floor he wished, the sack sitting on the closed trapdoor of that floor. It also served as a safety feature, the sack could neither fall any great distance in the event of some mishap, nor could anybody or anything fall through an open hole in the floor. If the trapdoor hinges had been metal hinges, the doors would have swung open and not shut, so a rudimentary hinge was made out of leather nailed to the floor and door, thus providing the spring necessary to reclose the doors.

Lastly the steam engine that stood with the mill was scrapped for the second world war scrap appeal. It was only a standby engine and very rarely used. However the shaft which provided the drive from this engine is at the mill although not in position. The shaft is 3.2m. long and 100mm. diameter. At one end of this is a gear of 860mm. diameter containing 36 teeth, and at the other, a clutch with two V shaped teeth. This engaged directly onto the flywheel shaft and was disengaged by moving this shaft.

The mill in operation

This mill did not only serve the local farmers, it also transported the grain and produce as far afield as Chester (10 miles) by horse and cart, and Liverpool and Ellesmere Port via the canal which runs a mile away from the mill. Later motorised transport was used instead of the three horses kept on site. Flour was ground for the small local trade only.

The main jobs in the mill besides delivery included keeping the hoppers full (important); handling the grain; sacking the oats, wheat and maize; and making such minor repairs as were necessary – cogging, dressing the stones and general maintenance. To do



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Schematic Diagram of the layout of gears and pulleys in Bunbury Mill.

this, there were three people running the mill, of whom two were father and son. It was possible, to quote the miller, 'to grind a couple of tons in a morning'. Before it became outdated, it was presumably a small, thriving industry.

Unusual features

Although this section is entitled 'unusual features', it does not mean that the features mentioned here are peculiar to this mill; there may be several examples of mills with similar features. It does however mean that the points noted here either differ from the authoritative sources, or when examining the technology of the time they are peculiar to the mills, or even because upon examination they seem perfectly natural.

The first feature to note is the variety of materials used to produce the mill. The stone and masonry structure of the building itself is not uncommon, but the mixture of wood and metal used in the water-wheel and gearing is. The three woods used are oak, elm and beech; oak for the spokes of the water-wheel, elm for the buckets and beech for the cogs. It shows that these timbers have been used to their fullest purpose; the oak spokes transferring the strain to the axle, and the elm buckets being continuously immersed have to withstand the decay arising from their waterlogged condition.

The use of beech cogs however was an excellent idea. The metal/wood contact of two of the three pairs of gears ensured quiet running, and any damage caused to a gear wheel would fall onto the beech cogs (beech being used to asborb the impact of teeth hitting each other), which could readily be replaced. Why the remaining set of gears were not made to this pattern remains a mystery, but they do seem to have survived despite the fact that cast iron is a brittle substance. However the drive from the steam engine to the great spur wheel has suffered damage. Several teeth have been removed due to this form of gearing. It is interesting to note here that the whole shaft was moved when the clutch, consisting of two V shaped teeth diagonally opposite each other, was disengaged. This would have brought the gear connecting with the great spur wheel out of contact. None of the gear wheels contains a 'hunting cog' to ensure that the teeth mesh in a different place each time. This was probably due to the odd multiples of teeth used, the pit wheel turning seven times before repetition occurred.

There seems to be in this mill a complete disregard for stone speeds. The stones, being of different diameters should have operated at different speeds (cf. Project Technology Handbook 11, 1975, p.35) no provision being made for this in the stone nuts, a greater number of teeth being used on the smaller diameter stones to reduce their speeds. It is also interesting to note (cf. ibid. p.35) that the speeds for these stones should have been somewhat higher (150 r.p.m. for stones of 1.2m.). This probably ties in with the fact that none of the runner-stones carried balance weights, and the higher speeds would have thrown them dangerously out of balance.

There were not any storage bins in this mill. The sacks were up-ended over holes in the top floor, the grain falling down a sacking chute. This does seem to be rather a waste of manpower as the maximum grain which could be 'loaded' was governed by the hoppers on top of the 'cases', someone having to check and reload after every sackful. Neither was there a grain cleaner in the mill, a dangerous practice, for if a stone found itself with grain being fed into the stones, it could result in the runner-stone being thrown off and crashing through the floor of the mill. A wire mesh was inserted into the hoppers instead, but small particles would still go through with the grain and contaiminate the flour.

There are two holes in the wall of the water-wheel pit on the ground floor near the hursting. The only possible explanation that can be given to these is that they were part of one of the original mills, and could have been either for floor supports or fittings for a hursting.

In Conclusion

As stated in the introduction, the investigation of these mills is incomplete. More information is available to be assimilated. Similarly as with the other industrial artifacts which abound in our countryside, detailed surveys, or preliminary surveys of this type can be made by the experienced Industrial Archaeologist or by the enthusiastic amatuer. But hopefully it does not end there. The detailed notes, diagrams and photographs, while providing satisfaction for those collecting them, must be available to be enjoyed.

I certainly found this to be an interesting and enjoyable study. It has given me an insight into the history of a certain branch of technology, and a greater understanding of that technology compared to its contemporary derivative. It has also given me ideas as to how a school subject like craft can be, for pupils so motivated, allied to a previous technology. A dovetail, for example, is not just a feature of box construction, it can, and has been applied to perform another function, namely securing the wooden teeth in the stone nuts in Bunbury Mill. Castings take on another dimension when they are seen to be performing a function which they have served for many years.

There are other beneficial aspects when a survey is undertaken by a class. Metal and Woodwork become History; a building becomes an exercise in Technical Drawing and Geography; the use of gears promotes an understanding in Mathematics.
The survey therefore covers several subject areas, all of which can become realised in a workshop. Experimentation in the use of waterpower could be incorporated, the necessary materials being readily available. Renovation is another, although not on any scale so grand as a complete mill. The workshops can therefore induce pupils to act on, or react to,

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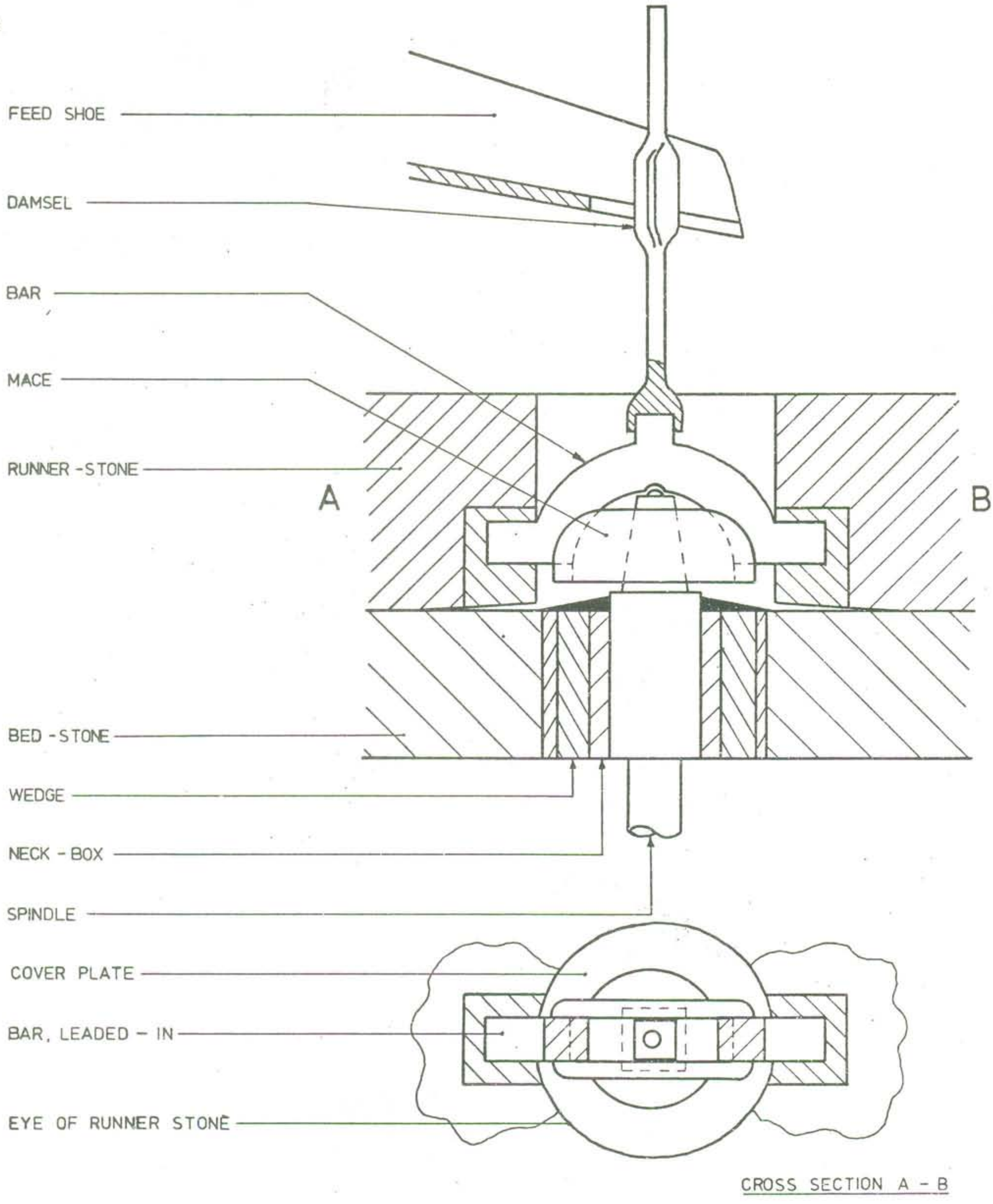
Sectioned view of a Millstone



their environment and thus help to fulfil one of the main aims of education.

One most noticeable aspect when comparing two mills, and this cannot be fully conveyed by photographs or diagrams, was the sense of frustration to see one mill working and the other falling further into decay. Rationally argued, this should be so; a mill which no longer fulfils its usefulness is either converted to perform another function, or else it is robbed of all useful machinery, allowed to fall into decay and finally demolished. Yet so many mills have taken this latter course, and now so few survive. Could not the destruction of those remaining be halted?

Bunbury Mill is fortunate; its future is assured and its water-wheel will once again provide power for a purpose. People will be able to visit, wonder at the craftsmanship and labour of a bygone era and enjoy the labours of those who researched and restored the building. The mill's produce will also be available for slae, thus offsetting the financial burden incurred in giving such a building a new lease of life.

Editor's Note: The above article is extracted from a student project, for the City of Liverpool College of Higher Education, on two Cheshire Mills and is included for its examples of the technical and analytical skills that can be developed through practical field-investigation.