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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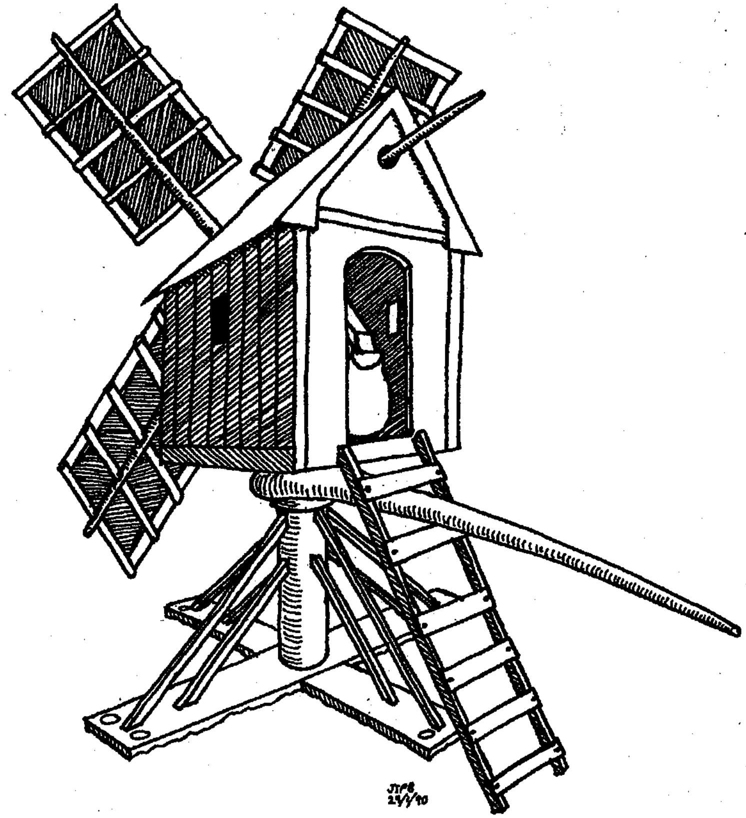
Wind and Water Mills

Number 20



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. A three dimensional modern representation of the Walsokne brass windmill (see pages 1 to 10).

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THE WALSOKNE BRASS AND ITS WINDMILL

By J. S. P. Buckland

The Brass and its Copies

One of the best medieval pictures of a post windmill is a minor part of the decoration of the magnificent Flemish brass, about 3 m x 1.7 m (9 ft. 10 in. x 5 ft. 8 in.), composed of over twenty-four closely butted pieces, dedicated to Adam de Walsokne (Walsoken), and his wife Margaret, in St. Margaret's Church, King's Lynn, Norfolk.

Lynn was one of the richest English ports, and undoubtedly Walsokne was one of the very wealthy wool merchants who ran the town. He is first mentioned in 1322, but then he is recorded as having made the king a personal loan of £100 in 1336. He had his own merchant's mark and was mayor several times between 1334 and 1343.[1] He died on 5th June 1349, his will being proved next day, leaving much of his property to his widow, and after her death to his son, however this proved to be his only descendent. Only his date of death is on the brass, which was prepared in his widow's lifetime, but possibly it was ordered by himself prior to his death.

Details of the brasses have been published at various times starting in 1738 but the first reasonably accurate reproduction of the windmill occurred in 1840.[2] A complete rubbing was made later in the 19th century and is now kept in the British Library.[3] Other rubbings were taken with one of them being used as an illustration in Bennett and Elton's book on corn milling published at the end of the 19th century.[4] This is probably the best published representation of the Walsokne brass windmill. Later versions had additions made to them such as a fourth sail[5] or were poor representations based on a crude rubbing.[6] In the photolithograph, published in 1891 (see Figure 1) the ladder is engraved a bit incorrect and an outline for the bottom sail has been added.

The brass's worn state was noticed with regret from 1840 onwards,[7] and the wear affects the windmill. The brass was removed from the choir during the restoration of the church in 1874 and placed beneath the southwest tower, then in 1934 it was set on a plinth in the south aisle.[8] The mill is in the left hand panel. In both panels, the generally sacred decoration of the main brass is replaced by profane scenes of daily temporal life, just as in several other brasses; but this remains the sole known portrayal of a windmill on a monumental brass either in Great Britain or abroad.

Figure 1. The Walsokne brass rubbing published in 1891 showing the 14th century post windmill.

Provenance

In 1907 it was argued persuasively, not to say forcibly, for a North German manufacture for the brass, specifically the great Baltic Hanseatic port of Lübeck,[9] so making it unique fourteenth-century evidence for a German post mill. But since then, it has been shown that it belongs to the class of large, very detailed rectangular brasses made by the Flemish School of monumental brass engravers at Tournai, which were widely distributed by the Hanseatic League in trade to England (for which Lynn was a major port) and elsewhere.[10]

The Windmill: Introduction

The earliest documentary evidence for the European vertical windmill dates from the middle of the 12th century in eastern England, with references to about 40 windmills before the end of the century. During the same period there are five references to windmills in Northern France and Flanders. Even allowing for the more conservative total of only 20 references to English windmills in the 1180s and 1190s, the preponderance of evidence available at the moment points to the windmill being an 12th century English invention.[11]

On the Continent, from its original nucleus, the windmill diffused along the Atlantic and North Sea coasts, and into the interior.[12] 'Within a generation', says Lynn White Jr., 'this power-machine had become a typical part of the landscape on the plains of north-western Europe.'[13] In England, Holt has shown that by 1200 it was known throughout eastern England from Newcastle upon Tyne to Sussex, though its large-scale introduction dates only from the 1230s; and it slowly extended westwards only in the second half of the century, and after 1300.[14]

We have a unique hint as to its early commercial form from the grants of two Sussex windmills, at Ecclesden between 1180 and 1197, and Bishopstone between 1218 and 1222, both of which included land 'outside the outer end of the beam by which the mill is turned round'.[15] So the first generation of windmill was winded (turned to face the wind); and, presumably, was a post mill not that greatly dissimilar from the established design shown by the first hard-dated illustrations a century after the windmill's first appearance (see Figure 2 below).

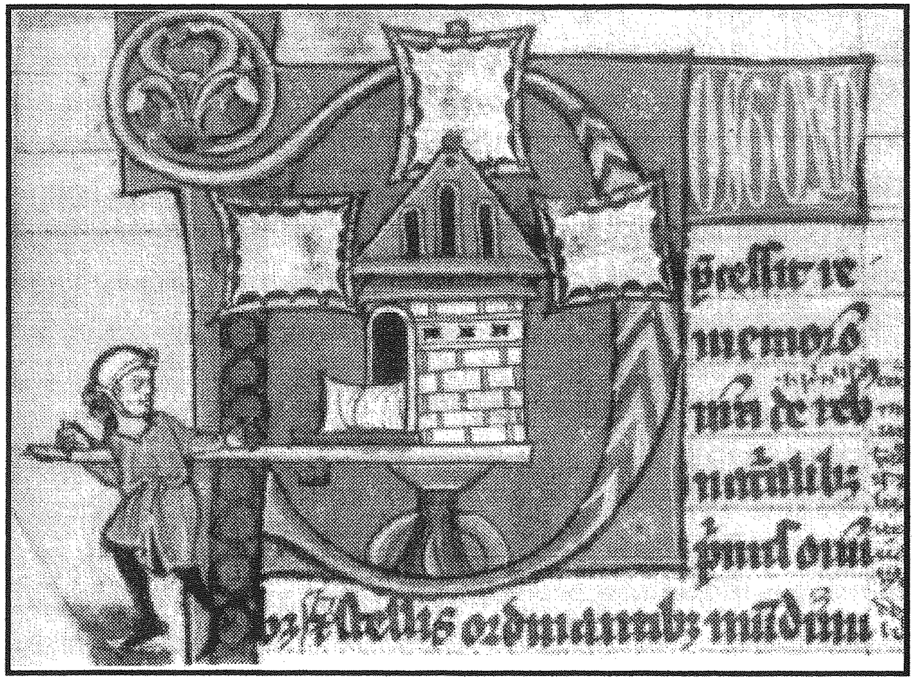

Figure 2. A 13th century illustration of a post mill.
(Cambridge University Library, Ms. Ea 2.31, fol. 130.)

The Walsokne mill is another 75 years on from this date, and therefore represents a thoroughly 'traditional' structure. And though, by the mid-fourteenth century, some of the Flanders post mills had already started to grow in size away from their thirteenth-century forerunners,[16] this mill, one of the very best and last fourteenth-century pictures of a post mill, is still small, like that in the British Library (see Figure 3) or that in the Bodleian Library completed by the Tournai miniaturist Jean de Grise (Gryse) in 1344 (see Figure 4) and would be perfectly at home in an English setting. Later fourteenth century French miniatures are of tower mills, and fifteenth century ones, all French, are mostly of tower mills with one or two post mills.

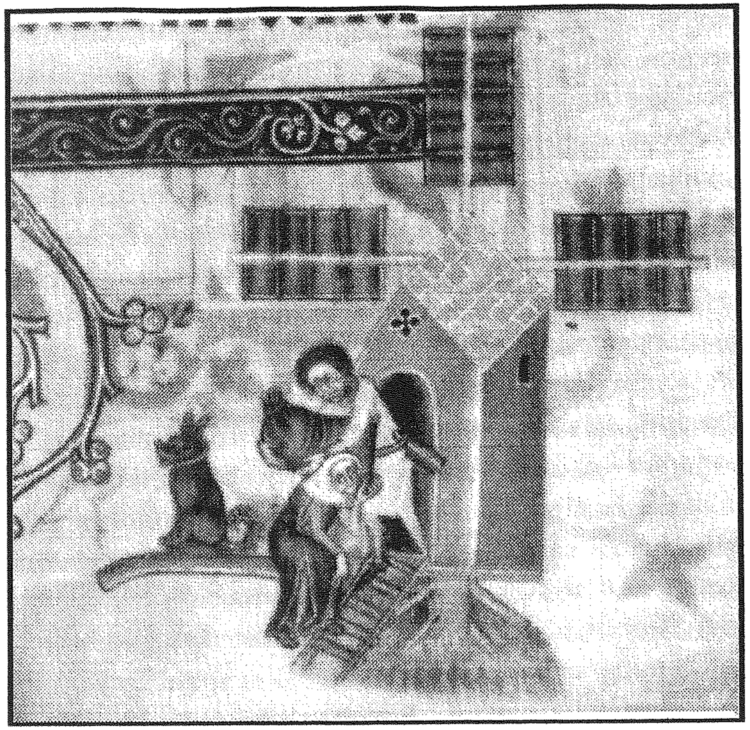

Figure 3. 14th century illustration of a post mill.
(British Library Add. Ms. 42130, fol.158.)

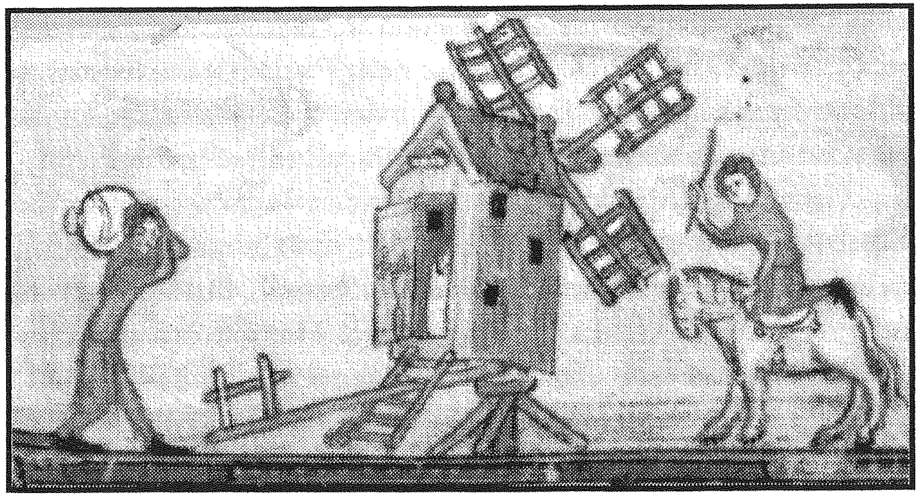

Figure 4. 14th Century illustration of a post mill by Jean de Grise
(Bodleian Library Ms. 264, fol.81.)

The Walsokne Mill: Description

The buck is a nearly square, pent-roofed, gable-ended box..The sails are typical examples of medieval cloth sails with broad, equal double-sided frameworks, similar to, though much smaller than, the sails of the tower mills today in the Lot region of southern France. The top left sail has the sail arm extending beyond the outer bar. The sail-bars can be seen on this sail, and perhaps on the top right sail too. The bottom sail is not very easy to see and sometimes appears as a ghostly outline. It is invisible on the rubbing in the British Library but it seems to have seen with enough clarity in 1838. It may be right to give the sails thick hemlaths. The separate panel view of 1891 (see Figure 1) has a largely invented bottom sail. It is almost certainly correct to stop the sail-bars at the margins of the sails instead of extending them further as in the panel view.

There is no roof finial, but the mill has a long manual hoist spindle. It has straight bargeboard on the rear gable-end, with a vertically boarded roof and side of the buck. What seems to be part of the outer buck framing is shown. There is a rectangular side window opening which is not a porthole. There is a rear arched doorway with the door open and the top of the door is visible. The interior is hinted at through the doorway, but not much sense can be made of it. The ladder has five rungs, although some illustrators have deceived themselves into seeing two more at the top. The tailpole curves down through the ladder, and clasps a deep steadying collar round the post below the buck. This is perfectly clear but several miniatures have a low, more-or-less horizontal tailpole whose end rings the post and is not joined to the buck. The buck is perched on the post, not framed round it as in latterday practice, for there would be no room for it.

In some medieval mills this last feature is more apparent, either by the collar being fixed to the apex of an inverted pyramid or cone below the buck or by its being part of a downward integral extension of the buck framing, the antecedent of the meal floor of later, larger mills.[17] The medieval buck has then become simply a very cramped stone floor, with the stones on a hurst table whose meal spout and meal sack are clearly glimpsed in Figure 4.

The trestle comprises a stout post, with light, doubled, bracing struts which do not appear to be loadbearing quarterbars as used in more modern post mill practice. These bracing struts spring from an apparent massive crosstree resting on the ground. Although there is just such a ground-set timber, drawn with impeccable clarity, to be seen on the illustration of a late thirteenth century French mill,[18] it is not clear whether the line at the bottom of the brass is not simply a scratch nearly parallel with the upper line. If it does represent a timber then the trestle is not a buried one, and must have been straked down to prevent the mill being blown over (though no such anchorage is hinted at on either mill). An apparent right hand end is clear in the rubbings, and the one rubbing has a light scratch or line which could indicate its left hand end. This may be a correct interpretation as the outer struts die into the post some four to five feet above the ground level, instead of just above it as on post mills with a buried mill trestle. This would imply that the weight of the mill was transferred to the ground down the central post unlike on modern post mills where it is transferred via the quarterbars.

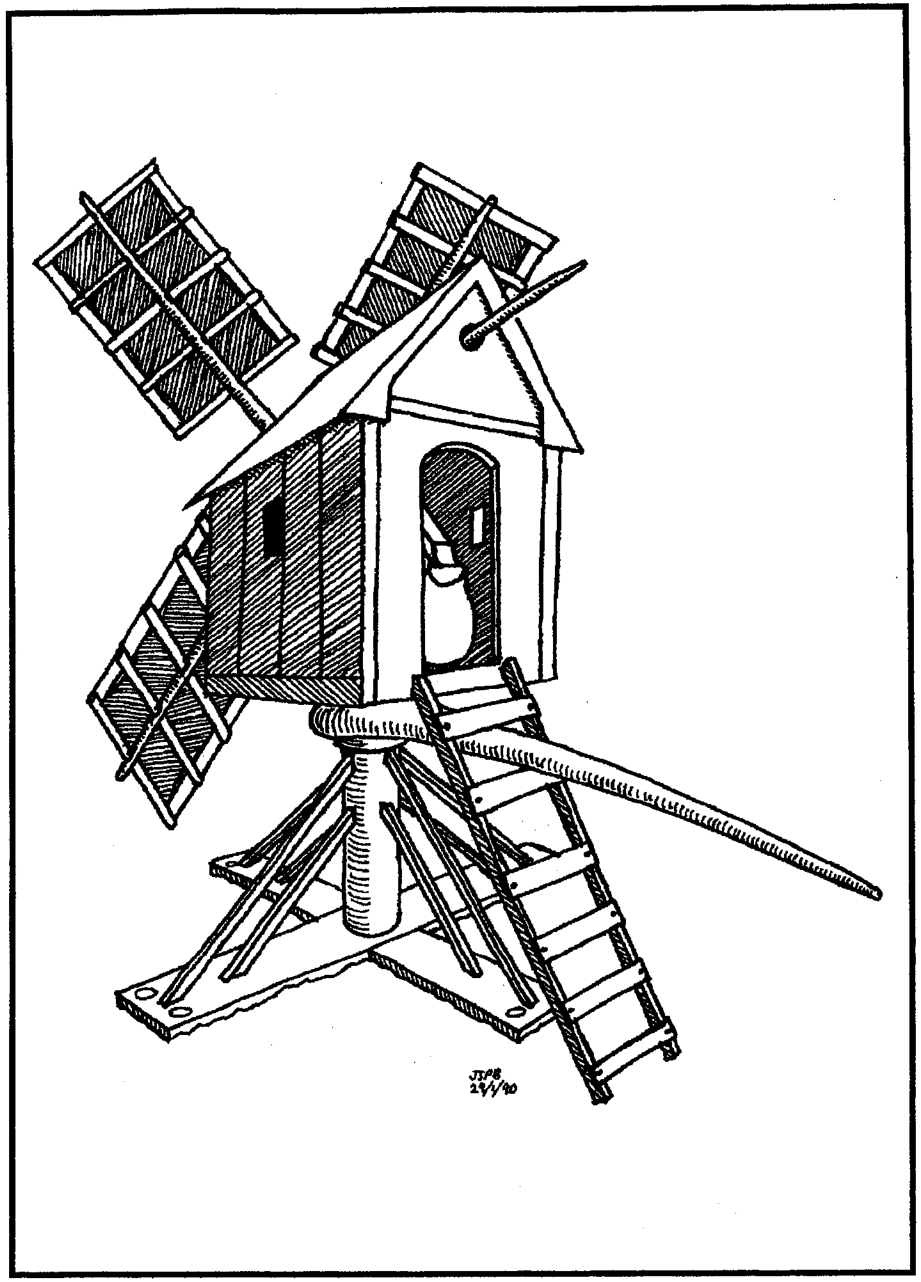

Figure 5. This drawing is loosely based on the Walsokne brass, but as a modern portrait of a medieval mill it is inevitably, more-or-less, a caricature.

The Walsokne Mill: Size

Dr. Richard A. Holt in his first-rate book entitled *The Mills of Medieval England*, dismisses medieval illustrations of windmills as a guide to their size because they are self-evidently drawn too small for the adjacent figures. From this he mistakenly supposes that these mills could have been as big as such smaller latterday survivors as Danzey Green, Warwickshire (c. 1830, about when English post mill building ceased), now in the Avoncroft Museum, Bromsgrove, and also the post mill at Bourn in Cambridgeshire (probably early 1740s, much altered).[19]

The Walsokne brass illustrates his point perfectly as the man on horseback carrying a sack of corn to the mill is almost the same height as the mill. However, from the Bayeux Tapestry onwards, the convention in medieval art is to draw people too large, often much too large, for the buildings they inhabit. This means that the mill must be scaled from the depiction of the mill alone, not from what lies next to it. Treating the picture as fieldwork it is then possible to make a reasonable estimate of the original mill's size.

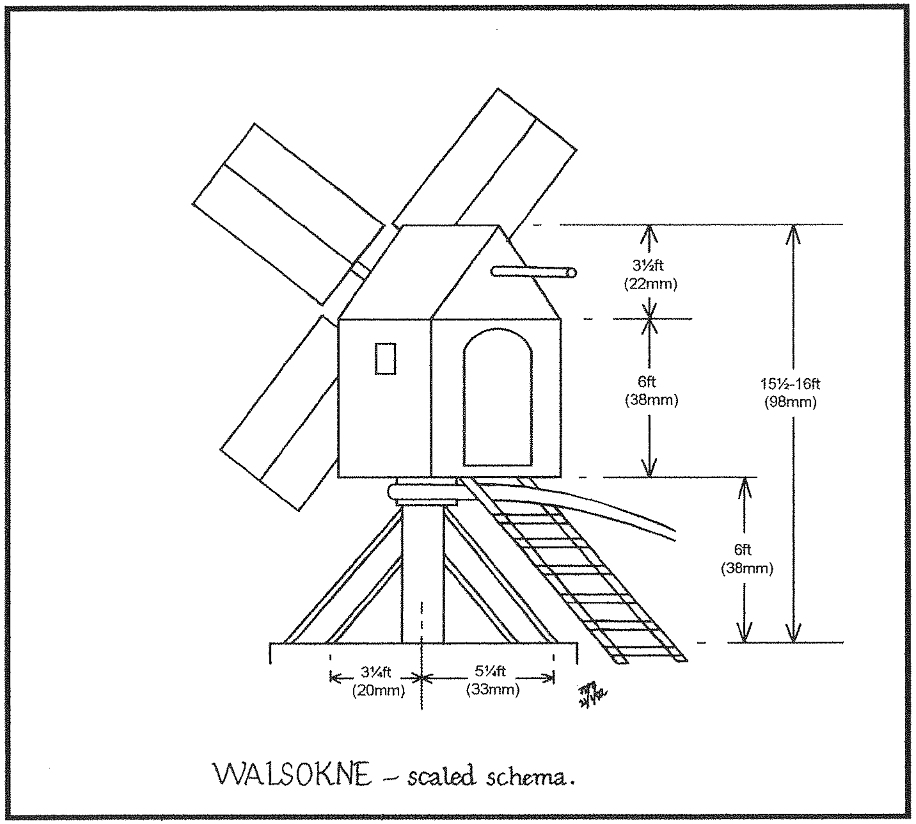

Figure 6. Schematic drawing of the Walsokne post mill (not to scale). Dimensions in brackets are from the British Library rubbing.

This has been attempted in Figure 6, which is measured off the British Library's rubbing, and assumes the buck is six feet high from floor to eaves' line, giving a scale of 6.25 mm: 1 foot, or nearly 1/50 full size. However while this makes the mill 16 feet high to the roof ridge, it is a figure which must be treated simply as an order-of-magnitude guide.

The Walsokne Mill: Performance

On this scaling, the sails only span 14 feet, but it is possible that several feet have been lopped off them to fit the picture frame, whereas if they nearly sweep the ground (the top of the presumed crosstree) they would span 22 feet. Either way, the power on the windshaft would be somewhere in the range of 150-600 watts (0.2-0.8 h.p.), much the same as that of a small, narrow undershot waterwheel powered corn mill wheel of the time, and at the lowest is equivalent to some half dozen women turning one quern stone. Such short sails, fairly lightly loaded, would easily do 20-40 r.p.m., and with a sails-to-stones gear ratio of 1:2 to 1:3, the small mill stones would turn at 40-80 to 60-120 r.p.m.

Modern parallels may help here. The little one-off mid-nineteenth century 'hobby' post mill at Bloxham Grove, near Banbury, Oxfordshire, (see Plate 1 below) stands 15 feet to the roof ridge, has a 22 foot sail span, and a c.27 inch diameter brakewheel geared 1:3.7 to the c.27 inch diameter stones.[20]

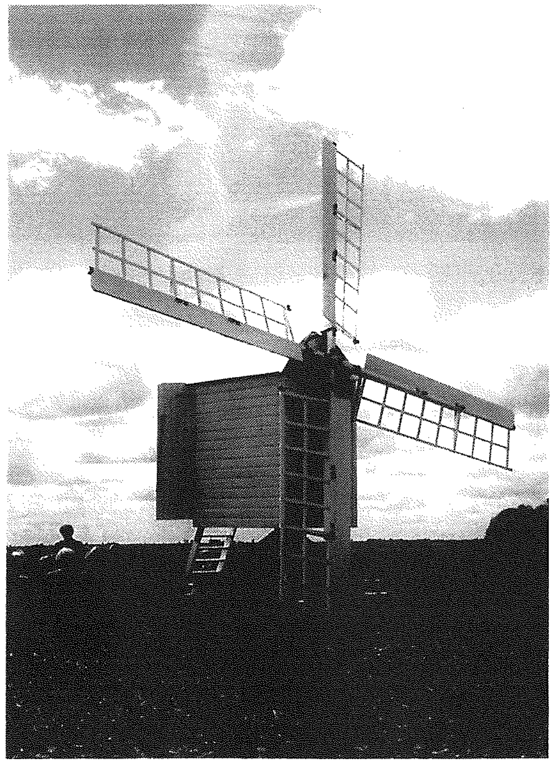

Plate 1. The small post mill at Bloxham Grove, Oxfordshire.

Plate 2. The small German post mill at Langerwisch near Berlin, 1999.

Another small post mill can be found at Langerwisch, just south-west of Berlin in Germany (see Plate 2 above). This little mill was used to produce animal feed in recent years. Another example is a post-1918 Hungarian farm pivot mill which has a 16 foot sail span and a brakewheel of about 21 inches diameter geared 1:1.5 to the 19 inch diameter stones; originally higher geared (at 1:2.5) off the same brakewheel, it was changed after 1945 so as to work in lighter winds. Although this design of Hungarian farm gristing mill is different from the standard post mill design (the post is to be found in front of the buck rather than centrally) it clearly did useful work even with with a mere 12 foot sail span.[21] However, only by building a plausible full-scale test-rig of a medieval post mill, could its likely real-life performance be ascertained.

Acknowledgement

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THE WATERPOWERED PUMP AT ELVASTON CASTLE DERBYSHIRE

By Tony Bonson, Tim Booth & Alan Gifford

Introduction

Elvaston Castle Country Park is about four miles south-east of Derby city centre, just off the A6. It was owned by the Stanhope family, who were the Earls of Harrington, until 1963 although not occupied by them since the late 1930s. Since 1969 it has been owned by Derbyshire County Council. During this time the 390 acres of surrounding grounds, which contain many unusual grottos, etc., have been well used by the public for leisure activities and for various fetes and functions. The importance of the grounds and gardens has been recognised by the award of a Grade II listing. However, the Castle itself, which is a Grade II* listed building, and its associated outbuildings, have continued to deteriorate over the years. This deterioration reached such a state that in 1998/9 Derbyshire County Council decided to offer the estate for sale. This action provoked a huge public outcry, the results of which at the time of writing, are still not resolved, but Derbyshire County Council have recently applied for a Lottery Grant to restore the gardens which possibly indicates that the whole estate may remain in the custodianship of the County Council in the future.

Within the grounds there is a large lake with a small brick building to the south side of its eastern end (SK 410330) which has the framing of an unusual low breastshot waterwheel in a walled pit alongside. Inside the building is a beautifully made, cast iron pumping machine whilst in a shallow pit alongside the waterwheel is a hydraulic ram pumping machine. The Midland Wind and Water Mills Group visited the park in 1999, during a tour of Derbyshire mills, when everyone was impressed with this machinery and the unusual water wheel alongside which caused considerable discussion. Concern was expressed that a change of ownership might render it inaccessible in the future and arrangements were therefore made with the Park management for a team of members to survey and record this unusual installation.

A History of the Park

The known history of Elvaston began in the ninth century when a Dane named Aelvold settled in country near the River Derwent. This hamlet became known as Aelvoldestune or as it is pronounced today, Elvaston. At the time of the Norman conquest extensive lands in the hamlet were owned by an Anglo-Saxon called Tochi, but by the time of the Domesday Book in 1086 these lands were in the possession of Sir Geoffrey Alselin, holding the land on behalf of the king.

The Alselins were lords of the manor for many years, being followed by the Bardolphs, and then, in 1420, Sir Walter Blount purchased the estate and surrounding villages from the Musards of Staveley. Later, in the mid-sixteenth century, Henry VIII granted the Manor of Elvaston to Michael Stanhope. During the civil war Elvaston was attacked by Parliamentary forces under Sir John Gell who ransacked the house and stormed the church. It is still possible to see the pit marks caused by volleys of musket balls on the outside walls of the church whilst inside the damage that was caused to the tomb of Sir John Stanhope is still visible. Various branches of the Stanhope family prospered becoming Earls of Chesterfield as well as Earl Stanhope, and finally in 1742 William Stanhope was created the first Earl of Harrington for services to the state.

Over the years, no doubt, some building and alterations took place on the manor house at Elvaston but by the early nineteenth century the third Earl of Harrington decided to rebuild the house and develop the gardens, engaging James Wyatt, a well known architect in the Gothic style. Unfortunately James Wyatt died in 1813 and it was only in 1815 that Robert Walker was appointed to implement James Wyatt's Gothic design for Elvaston Castle, a task he completed by 1819. As part of these plans the third Earl approached Capability Brown to provide a new landscaped garden but Brown turned down the commission saying 'the place is so flat and there is such a want of capability in it'. After the third earl's death in 1829 he was succeeded by his son, Viscount Petersham, who immediately married his great love, an actress called Maria Foote. As this marriage was frowned on in polite society the couple retired to Elvaston where the fourth earl decided to transform the grounds into a shrine to their undying passion. The man he engaged to make a garden 'second to none' was a young Scot, William Barron.

William Barron

William Barron was only twenty five when he came to Elvaston in 1830. Although he was academically gifted, excelling in mathematics and languages, his true love was gardening. After an apprenticeship at the Blackadder estate in Berwickshire, he spent five years at the Botanical Gardens in Edinburgh followed by three years at Syon House working for the Duke of Northumberland. On arrival at Elvaston he viewed the task with great misgiving, especially when the head gardener who was retiring told him that 'the land is waterlogged and nothing grows before June' and also claimed that the main drain through the grounds could not be lowered. Later William Barron was to record his solution to the problem as follows:-

> 'I had made up my mind that after proving his statement to be correct, I should relinquish my charge, but on going over the whole with my spirit level, I found, that commencing a mile from the garden, I could lower the stream four feet seven inches, this I did at once, and cut drains in the Kitchen Garden six feet deep, and for days the water ran through the pipes into the brook with a black and fetid smell. Thus the foundation was laid for successful operations all over the grounds.'

Plate 1. William Barron, 1805 - 1891.
(Reproduced by kind permission of Derbyshire County Council)

Barron set out to transform the parkland and to build themed gardens, such as the Italian garden, the bower garden and the Alhambra garden, to the south of the house. Many mature trees were moved or brought to the estate using Barron's patent method of transplanting large trees and long avenues of trees were created. To the north-east of the house he built a large ornamental lake complete with rock works, islands and exotic tree species. This lake is fed by a leat from the River Derwent.

In the mid 1830s a water supply system for the grounds was implemented. This consisted of a waterwheel driven pump, powered by water from the lake, which supplied a header tank mounted on top of a tower in the courtyard of the castle. This pump was manufactured by John Harrison of Derby. From the header tank water was distributed to the various gardens including a cistern in the Old English Garden, as well as providing fountains in the grounds and supplying the necessary hydraulic force to operate a lift in the main house.

Although details of the hydraulic lift at Elvaston are not known, a description of a similar installation at Osmaston Manor, some eight miles north-west of Derby, was published in the 1850s as follows:-

'A cylinder of cast iron, about 46 feet long, was made in convenient lengths, and truly bored to an internal diameter of 11 inches; into this a piston was fitted and made watertight by a leather collar, such as is used in the hydraulic press. The

cylinder was sunk in the ground, and set accurately upright in the basement of the house, and the stem of the piston carried a platform or landing, with suitable railing and other appliances.

A pipe leading down from the reservoir, conveys the water into the cylinder, below the piston, which forces it up with the platform and the person upon it, until the ascent is stopped by shutting off the water; then, by allowing the water to escape from the cylinder, the piston and platform descend by their own weight until the escape of the water is prevented, or until the piston reaches the bottom of the cylinder.'

Although the hydraulic lift at Elvaston was removed in the early 1970s it is quite probable that the large hydraulic cylinder buried underground will still be in situ as its removal would have been far to expensive and disruptive.

Plate 2. The tank on top of the tower and one of the fountains which were supplied from the pump mechanism, from a painting by George Maund.
(Reproduced by kind permission of Derbyshire County Council)

John Harrison

It is not known when John Harrison was born but he was the son of another John Harrison who possibly established an iron foundry in Derby. Iron founding was not an uncommon industry in the town going back until at least the 1780s. In March 1822 John Harrison (the younger) announced that he was 'commencing manufacture' at Bridge Gate Foundry in Derby. He was either taking over the foundry established earlier by his father or another foundry that was available. The business evidently prospered and John Harrison saw fit to marry Mary Crooks on 18th September 1825 and eventually had a family of two sons.

One of the products manufactured by John Harrison were neat cast iron mile posts that could be seen throughout the Derby area, all carrying the iron founders name 'Harrison - Derby'. Some of these mileposts are still to be found in the southern region of Derbyshire. He also took on quite significant contracts including in 1830 a wrought iron tank made for the Nottingham Gas Company which was 42 feet in diameter and 18½ feet deep - quite a structure at that time!

During the Reform riots of 1831 an irate mob 'took in Mr. Harrison's in Bridge Gate, smashing windows and other equipments' but no lasting damage appears to have been suffered by the business. A contemporary advertisement claimed that he 'manufactured steam engines, boilers for low and high pressures; gas and water tanks' and surprisingly, canal boats. John Harrison also could supply cast iron cooking ranges and offered 'apparatus for cutting chaff worked by horse power and thrashing machines to be worked by hand or by horse capable of processing up to 100 strikes a day'. Certainly he appears to have been quite capable of manufacturing the pumping equipment installed at Elvaston, although pumps and waterwheels do not appear in his advertisements.

Pigot's Directory of 1835 lists him as 'Engineer - Harrison, John - 47, Bridge Gate, Derby', and he continued to be so listed in the various directories until 1857 (although in 1842 he added boilermaker and sometimes also whitesmith to his skills). Unfortunately the business seems to have come to an end in 1855 when the Derby Mercury carried a notice to his creditors informing them that 'he is ceasing to trade'. Although he continued to be listed in the directories until 1857 this is probably an example of the time lag inherent in this type of publication. It is not known when John Harrison died or where he is buried.

Public Access

During the time of the fourth Earl of Harrington, William Barron supervised a staff of over eighty gardeners but when the earl died in 1851 the new incumbent reduced the workforce to only eleven gardeners and opened the grounds to the public with an entrance fee of 3s per head. In spite of these reduced circumstances Barron remained at Elvaston until 1865 when he resigned and went to live in Borrowash, just about a mile away from Elvaston, where he and his son set up their own nursery. This business prospered for many years and he finally retired in 1886 at the age of 81, an eminent figure in the horticultural world and leading authority on *coniferae*.

After the death of the fifth earl, the Stanhope family continued to live at Elvaston Castle until the late 1930s when William Stanhope the eleventh Earl of Harrington left Elvaston to live in County Limerick in Eire where the family still live. During the Second World War Elvaston Castle was used by a teacher training college evacuated from Derby city but this use came to an end in 1950. In 1963 the earl decided to sell the estate to the

Needlers Development Company in order to meet the cost of death duties. Derbyshire County Council and the old Derby Corporation purchased the estate in 1969 for the establishment of a Country Park. During the preparation of the Country Park the lift removed from the castle and the tower with its water tank were blown up by contractors for 'safety' reasons, however the cistern in the Old English Garden still remains.

An Early Attempt at Restoration

In the mid 1970s Leicestershire was setting up an industrial collection, to be designated the 'East Midlands Industrial Archaeology Museum' and as the pump was seen as a fine example of East Midlands engineering it was decided to dismantle the pump at Elvaston and reassemble it in Leicestershire, in the proposed new museum. However the embracing concept for the Museum was later abandoned in favour of a 'Leicester' only collection and the pump parts were returned to Elvaston. Derbyshire Archaeological Society and the Leicestershire Industrial History Society were approached with a view to assist in re-building the installation.

Members of the Derbyshire Archaeological Society cleaned and painted all the pump machinery. Dorothea Restorations were given the contract to completely refurbish the waterwheel and this was fitted with new floats, sole plates and some new float frames. The pumps were rebuilt and new leather pump washers were fitted. Unfortunately, although the waterwheel turned satisfactorily and the pump mechanism also appeared to operate, the water supply and delivery pipes were changed from the original configuration. Because the header tank and the fountains were no longer present the inlet to the pump mechanism was taken from the lake and the pumped water was led into the tailrace. From the evidence provided by the mechanism itself it would appear as though only one pump cylinder was connected to the waterwheel for the trial run of the system.

Plate 3. Members of the Derbyshire Archaeological Society painting parts of the pump mechanism during the restoration in the 1970s

Plate 4. Dorothea staff working on the waterwheel in the 1970s.

Inevitably this configuration caused problems with water in the tail race backing up and eventually stopping the waterwheel from working. Apparently considerable efforts were made to clear the tailrace tunnel, an action which could not lead to any improvement, and so before long work stopped and the project was abandoned. The site has subsequently been plagued by break-ins and damage and sadly three sets of pump push rods and the top half of a brass bearings are now missing (it is possible these parts were never assembled for the trial in the 1970s and are still in storage somewhere).

A Description of the Outside of the Building

The pump house at Elvaston Park is located just to the south of the lake at its eastern end (see Figure 1). The orientation of the building is very nearly due north-south with the entrance door in the southern gable end and the waterwheel mounted on its eastern side. The headrace runs southtward from the lake in an open leat whereas the tailrace runs underground away from the waterwheel initially also in a southward direction.

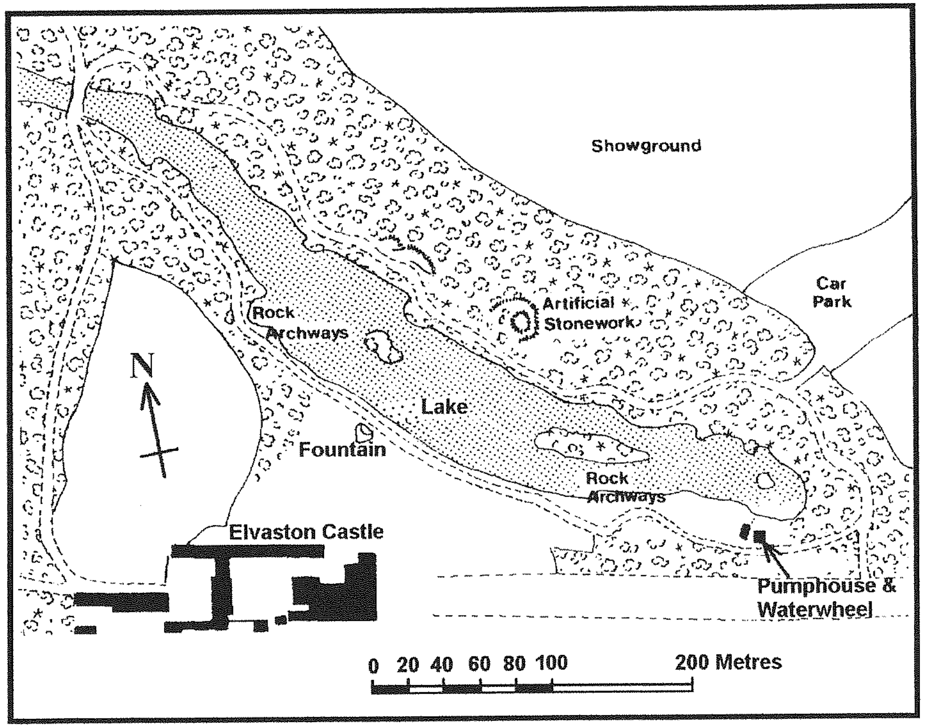

Figure 1. Map of Elvaston Castle grounds showing the position of the Pump House.

The pump house itself is rectangular in shape being about 16 feet long on its north-south axis and 13 feet wide. It is built of brick, laid in Flemish bond, on top of a ten inch high stone foundation plinth. The side walls have a curious batter to them, being vertical for the first seven feet from the ground; curving inward for the next two feet and then curving back to the vertical for the last two feet. These side walls have a parapet consisting of a single layer of engineering brick headers on top of a tile base, giving a total height to the side walls of about eleven feet (see Figure 2). The two gable end walls are built so that their edges follow the curve of the side walls, however the gables reach a total height of about fourteen feet. The top of the gables are flat in the middle with scalloped curves leading down to the sides of the gables about 18 inches above the height of the side walls. The entire top of the gables have a terminating parapet of engineering brick headers on a tile base (see Figure 3). The roof has a simple pitched shape with the ridge, which runs north to south, being surmounted with semi-circular ridge tiles. The roof itself is covered in roofing felt. There are two skylights in the roof, one on each side of the roof, set in a central position. These windows are about two foot six inches high by just over a foot wide. The lower end of the roof sides each terminate in a gully about six inches below the top of the side walls. These gullies are drained into internal downspouts mounted inside the southern gable end. The gullies are flat, possibly with a slight slope towards the downspouts, and are covered in roofing felt.

The door is located in the middle of the southern gable. The doorway is four and a half feet wide by about seven foot high in the centre, and has splayed brick reveals. The top of the doorway is surmounted by a stone lintel which is cut to give the doorway a chamfered, trefoil head which complements the splay of the reveal. The wooden door is made out of two vertical planks with a six inch wide edging that follows the curves of the aperture. Above the doorway there is a cinquefoil headed niche about four feet high by two feet wide and approximately six inches deep, centrally located (see Plate 5). Mounted within the niche is a Gothic lower case letter 'h' (for Harrington) which is painted gold. The central space within the curve of the 'h' is quartered, with opposing quarters painted red and white with a central boss in gold. The rest of the inside of the niche is plastered and is painted light blue (see Plate 7).

There are window apertures in the northern gable and western side walls. These windows are set in the middle of their respective walls, being about five feet high by two feet wide, with their sills about two feet from the ground. These window apertures have the same style as the doorway, having a chamfered stone sill, splayed brick reveals, but are surmounted by chamfered stone lintels with a cinquefoil cut out. The window apertures, which are not glazed, have nine horizontal circular iron bars across fixed into the brickwork of the reveals (see Figure 2 & Plate 5). The building characteristics, which are similar to others in Elvaston Castle grounds, and the nature of the brick and stone work are consistent with being contemporary with the re-designing of the gardens in the 1830s.

The waterwheel that is mounted on the eastern side of the building is surrounded by a four foot high brick wall surmounted by three foot high steel railings. Although the brick wall is topped by a row of engineering brick headers it is constructed in what can be best described as 'modern house bond' and is of recent erection (i.e. 20th century). Examination of the eastern side wall of the building shows the scars of an previous alternative arrangement. First of all there used to be an aperture roughly six feet high by about two feet three inches wide directly above the waterwheel axle where it enters the pump house. This aperture has been bricked up at some time in the past. There is also evidence of a roof line joining on to the eastern wall of the building. This has been left by what would have been a pitched roof shelter for the waterwheel. The ridge of this roof, some nine feet above ground level, ran west to east at right angles to the ridge of the pump house itself. The steeper pitch of this roof was at the southern side with the ridge being approximately four feet from the southern gable end and hence twelve feet from the northern gable end (see Figure 4). It is not known how this roof would have been supported, possibly just by pillars, or alternatively by solid walls. Its purpose would most likely have been to provide shelter from the weather for the waterwheel, especially from frost as the installation had to work throughout the year, but at the same time provide reasonable access for maintenance work.

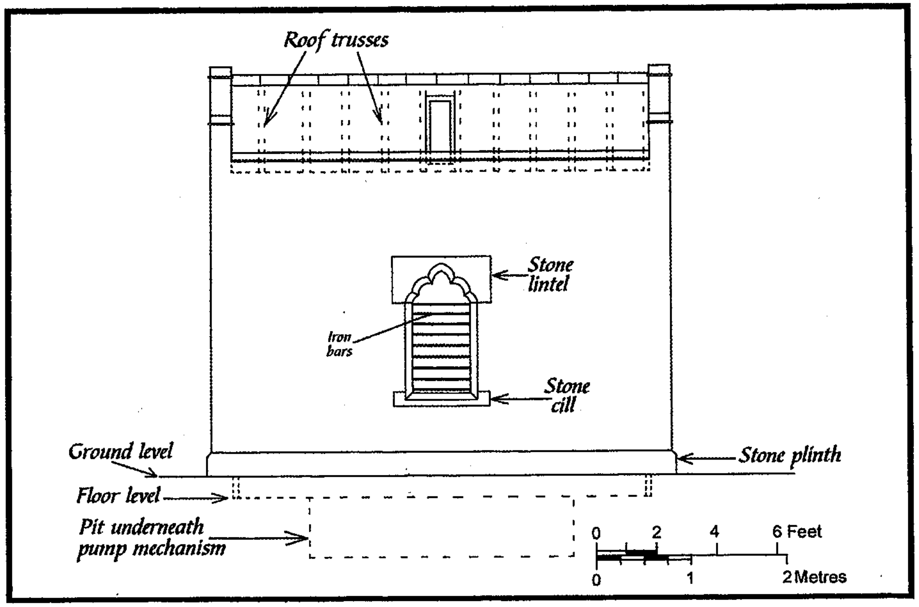

Figure 2. Western elevation of the Pump House.

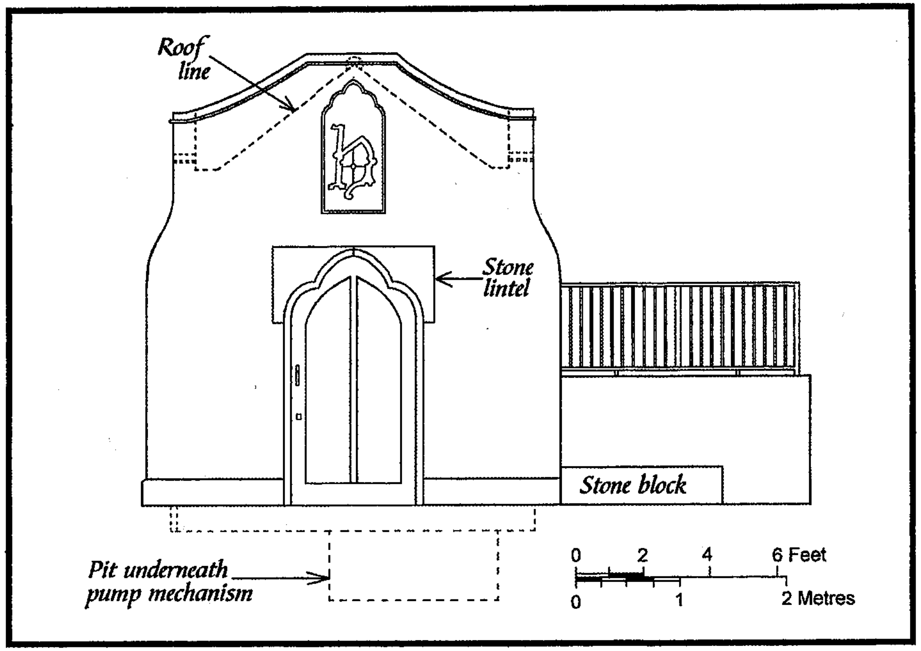

Figure 3. Southern or front elevation of the Pump House.

Plate 5. View of the Pump House from the south-west showing the monogram in the niche above the entrance door.

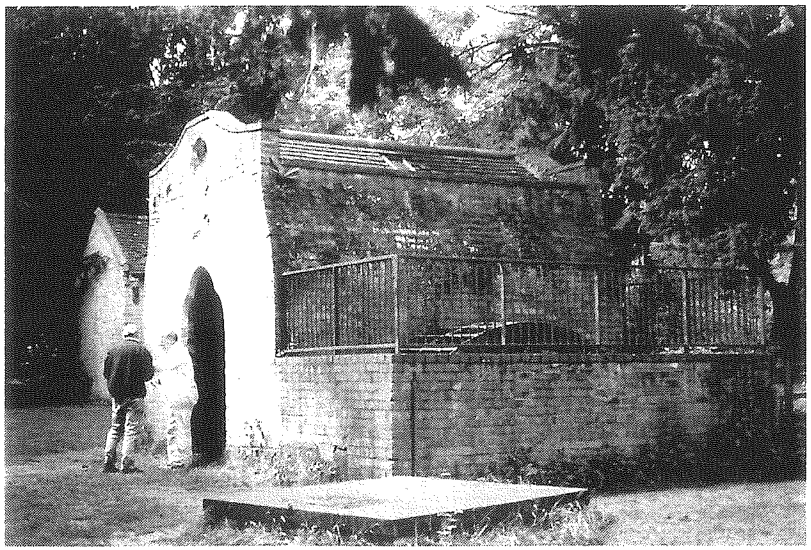

Plate 6. View of the Pump House from the south-east showing the position of the waterwheel. The concrete block in the foreground is the cover on the chamber that houses the hydraulic ram.

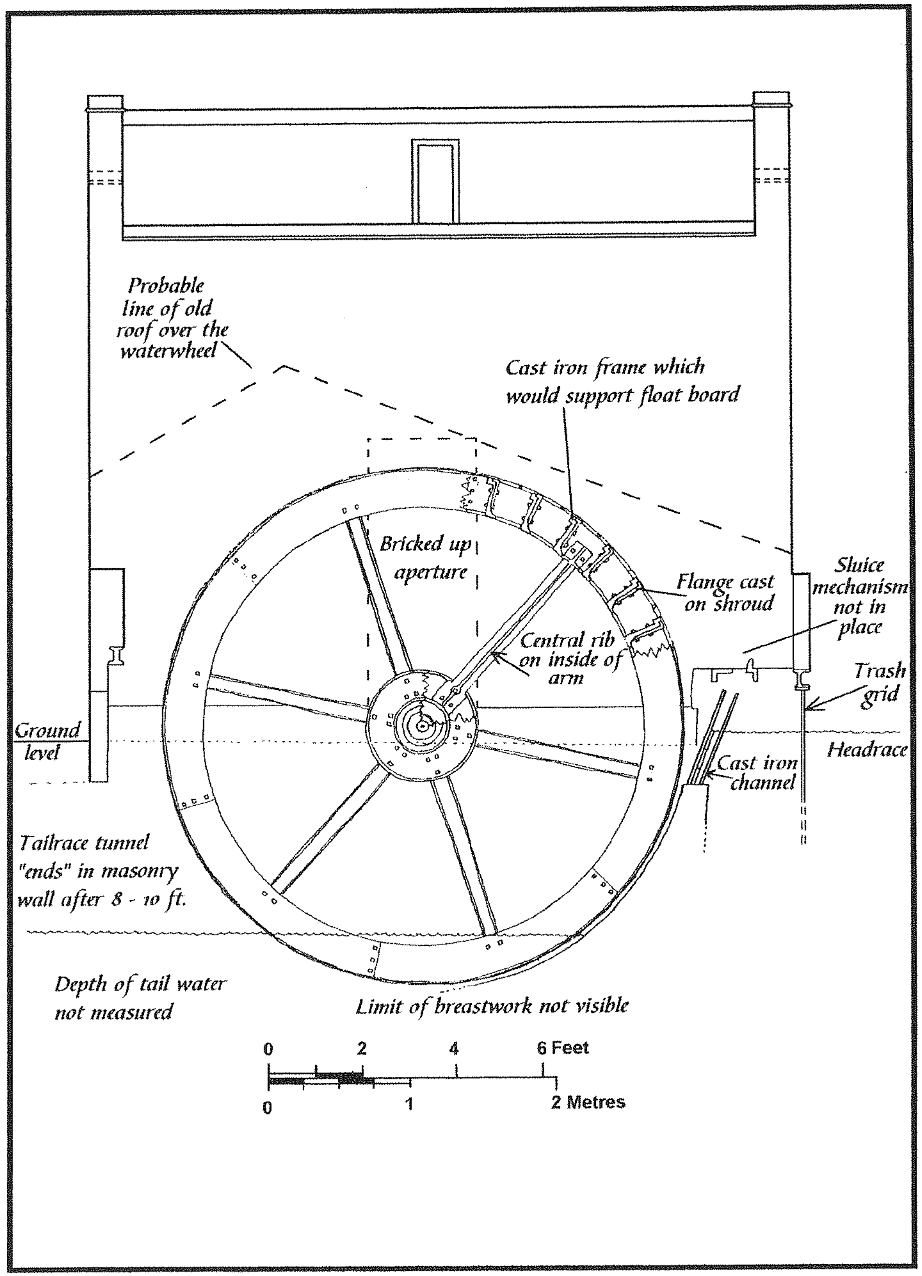

Figure 4. Eastern elevation showing the position of the waterwheel.

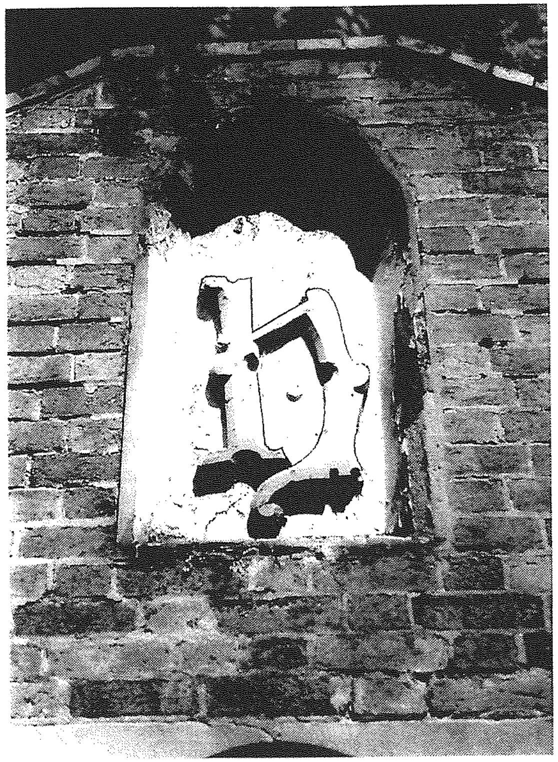

Plate 7. The Gothic letter 'h' in the niche over the entrance door to the Pump House.

A Description of the Inside of the Building

The entrance to the building has a step of approximately six inches down to the floor level, which is covered with 7½ inch square quarry tiles. On entry an immediate impression is made by the pump machinery which dominates the inside space of the pump house (the pump mechanism and its mounting frame will be described later). The pump mechanism is mounted over a two feet deep, rectangular pit which measures approximately ten feet long by five feet wide and is orientated lengthways with the long side of the building. This pit is offset towards the eastern wall which separates the pump from the waterwheel, leaving about a foot gap between the pit and the actual wall. At the southern end of this pit is an opening between the bottom of the pit and the tailrace. The north-west corner of the building is occupied by a small fireplace and flue (see Figure 5). This would have been used in winter months to prevent freezing taking place inside the pump mechanism thereby causing damage. The two windows have modern sheet steel shutters on their inside as a protection against possible vandalism.

The north-east corner of the building is occupied by a two feet six inch high brick plinth which measures about a foot square. This was used to mount the bearing for the sluice control mechanism for the waterwheel. This mechanism has been dismantled to

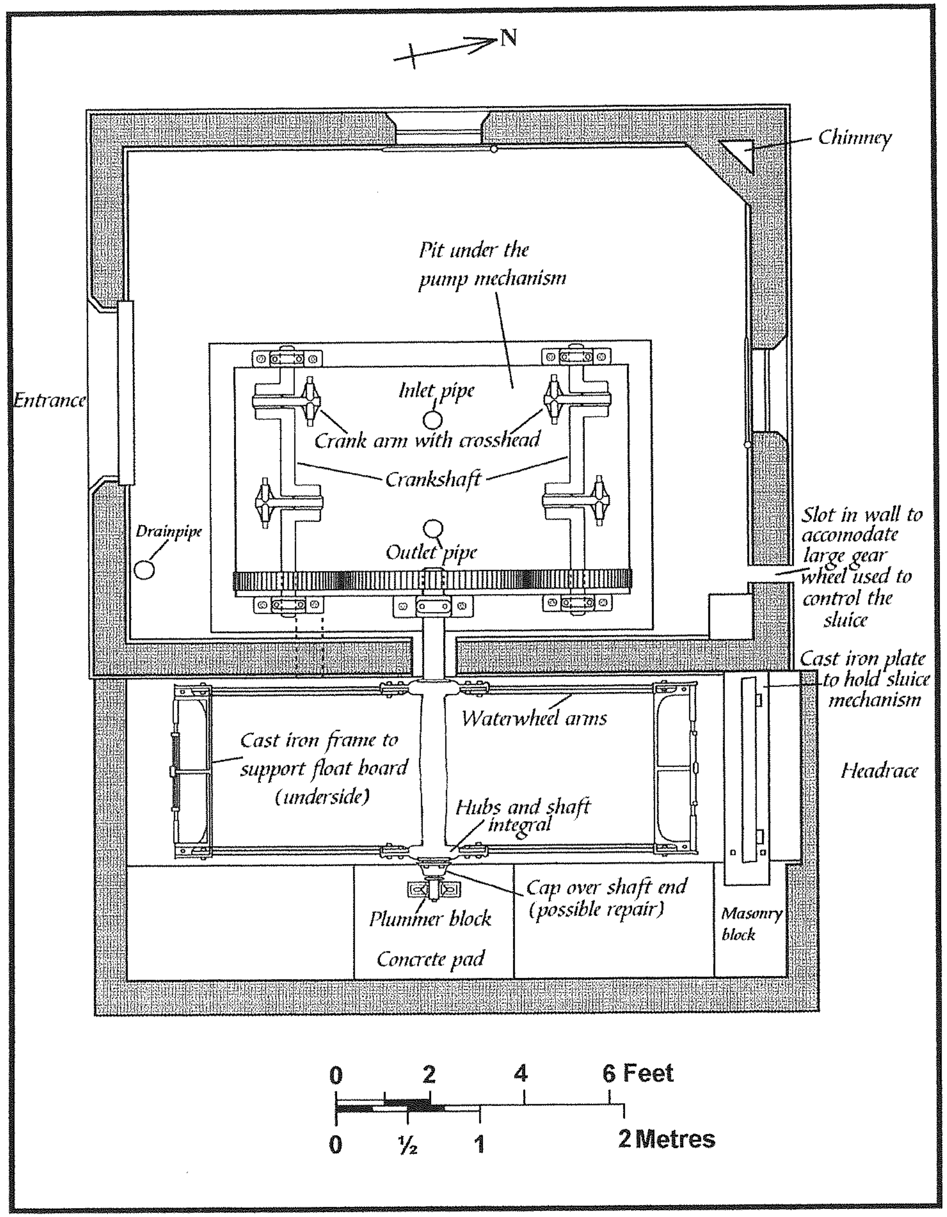

Figure 5. Floor plan of the Pump House showing the position of the waterwheel, the main gearing and also the crankshafts and crank arms that changed the rotary motion of the waterwheel into the reciprocating motion needed to drive the pistons in the pump cylinders.

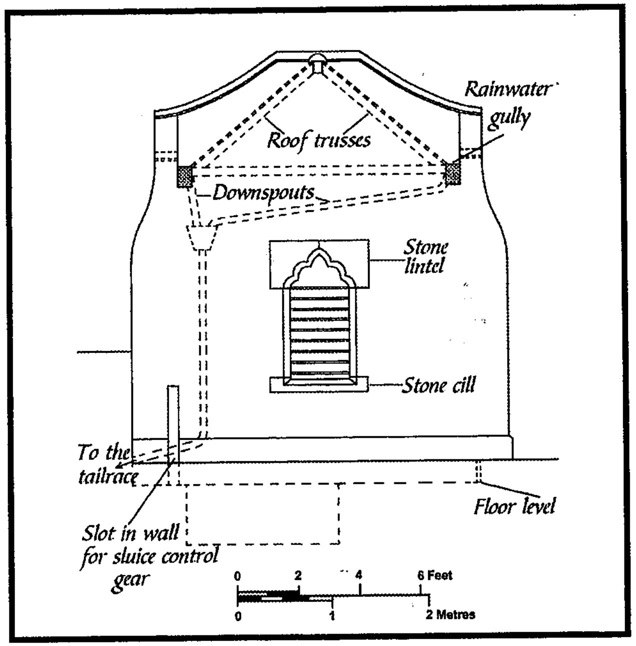

Figure 6. Northern or rear elevation of the Pump House, showing the position of the downspouts on the inside of the southern wall and all the roof components.

prevent vandalism, however all the constituent parts of the mechanism (except for the top half of the bearing) are to be found in the building. In the rear northern gable end wall, within six inches of the brick plinth for the sluice control bearing, there is a three foot high slot, four inches wide, which was necessary to provide the necessary clearance for the large gear wheel which was part of the sluice control mechanism (see Figures 5 & 6).

The internal construction of the eastern wall separating the pump from the waterwheel is different from the other walls. There are three blind arches which are each about four feet wide with just over a foot of brickwork between them. The arches are about a total of nine feet in height with vertical sides which are seven and a half feet high. The flattened, curved tops of the arches are constructed of brick headers. These arches were, no doubt, incorporated into the design of the pump house to provide extra strength to the wall adjacent to the waterwheel.

The roof is constructed of two main timber supports that run longitudinally along each side wall which, in effect, support the drainage gullies. On to these supporting timbers are mounted eleven wooden trusses each of which has a cross beam connecting the two ends of the truss. There are no purlins as such but there is a ridge beam and the trusses are overlaid with tongue and groove boarding underneath the roofing felt. The two skylight frames occupy the space between the six and seventh rafters from the southern end of the building. The downspouts from the drainage gullies are mounted on the inside of the southern gable end wall. The western downspout angles across the gable end to join the eastern one which drains vertically downward before being directed into the tailrace at floor level (see Figure 6).

The Historical Antecedents of the Waterwheel

The waterwheel which drives the pumps is a most unusual design, chosen to suit the particular difficulties of the site. It must be remembered that William Barron had started with level and waterlogged ground. To reduce the ground water level by a little over four and a half feet had meant lowering the drainage channel through the park and beyond for a length of one mile. This is hardly an ideal situation for a waterwheel. Although there is plenty of water, there is a relatively low head available to turn a wheel and no fall to carry away the tail water so a wheel would be required to work as efficiently as possible while partly submerged. Indeed, this would seem to be a location which would be better suited to a steam powered pump. However, as the scheme included the installation of a hydraulic lift in the house which presumably would be in use night and day, it appears that a power source requiring less attendance and maintenance was required.

Just who arrived at the chosen design for the wheel has yet to be discovered. Of course, it could have been the iron founder, John Harrison, but, if so, he did not feel able to publicise this achievement in subsequent advertisements for his company or to take out any patents for its unusual features. There is an over elaboration in the castings which possibly suggests the influence of an 'amateur' engineer and this might indicate that at least some of the design was the work of Fitzroy Stanhope, the fourth Earl's youngest brother. He is credited with the invention with two horse drawn carriages, the Stanhope gig, which was very popular in London in the 1830s, and the Stanhope phaeton. Although in a somewhat different field, it is not too difficult to imagine him taking a great interest in a water pumping device for his brother's new garden!

Of course, the design is far from being new to Elvaston Castle. The principle is exactly the same as was proposed by Faustus Verantius, also an amateur engineer and inventor, in his drawing of a tide mill driven by a horizontal waterwheel which was published in *Machinae Novae* in c.1610 (see Figure 7). Here, the wheel is totally submerged and water flows past both sides of the wheel but must only exert a force on one side. To minimise the resistance of the water on the 'return' side of the wheel, the hinged floats open to let the water flow freely through. No published details of a horizontal wheel using this principle have so far come to light so it is pleasing to be able to record the existence of a vertical wheel of this type a long way from Verantius's home in Rome.

Around 1730 there was an attempt by two Frenchmen, Gosset and de la Deville of Laon, to adapt the vertical waterwheel for operation when completely sumberged. This waterwheel had hinged floatboards arranged so that at the bottom of the wheel the float boards presented their face to the current, but, as the wheel rotated upwards towards the top, the float boards presented their edge to the current. Thus the current would have a greater effect on the lower than on the upper part of the wheel and so the wheel would rotate even if completely submerged. Although a successful trial of this type of wheel was reported by Bélidor at Paris in 1730 no further reports of its use have been found (see Figure 8). It does seem more likely that Fitzroy Stanhope had access to such books as Verantius's *Machinae Novae* and Bélidor's *Architechture Hydaulique,* possibly in the library at Elvaston. It would seem in keeping with his charachter for him to have decided to utilise this obscure type of waterwheel for the pumping machine at Elvaston rather than the more prosaic Harrison.

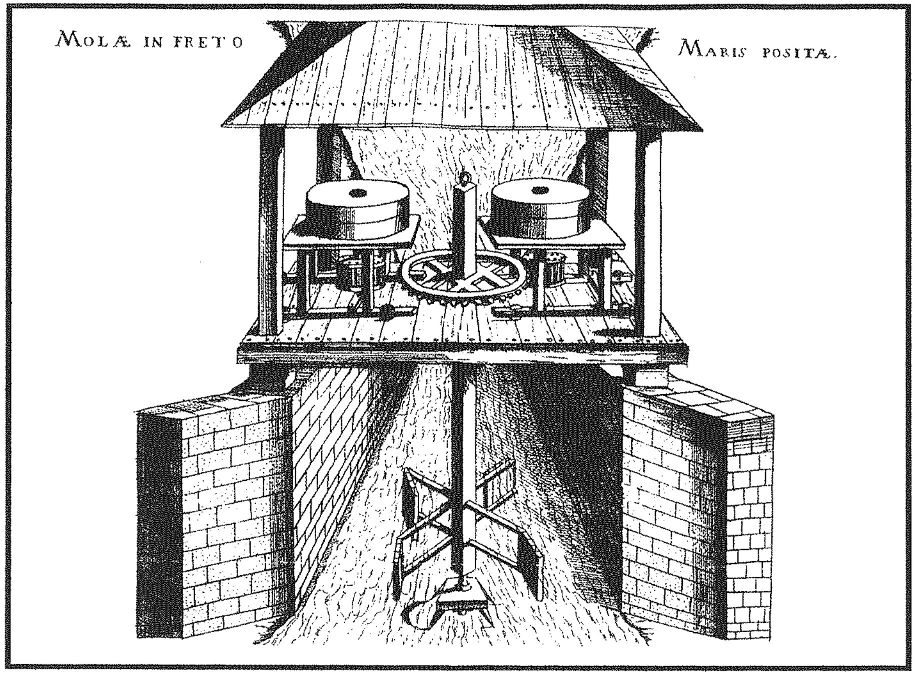

Figure 7. Verantius's drawing, c.1610, of a tide mill with a horizontal waterwheel having hinged float boards.

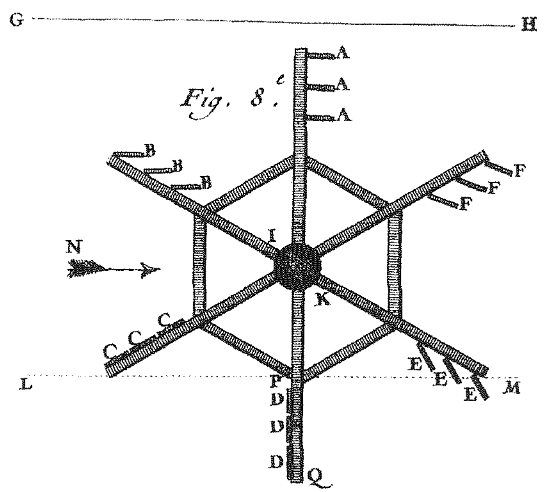

FIGURE 8. Undershot water wheel designed by Gosset and de la Deville in the 1730s to rotate when completely submerged. *M* indicates the normal level of the stream; *GH* indicates the water level when the wheel was completely flooded. The floats of the wheel were hinged so that at the bottom of the wheel (*D,D,D*) they presented their faces to the stream, while at the top (*A,A,A*) they presented only their edges. Because flowing water would have a greater impact at the bottom of the wheel than at the top, it would turn even when fully submerged.

A Description of the Waterwheel

The basic structure of the wheel is fairly conventional. Overall, it measures 12 feet in diameter by fractionally under 4 feet wide. Apart from the float boards and the straps which form their hinges, it is all of cast iron. The shaft and hubs are cast in one piece, the shaft being 6 inches in diameter at the hubs and 7 inches in diameter at its centre. It appears that the outside end of the shaft has sheared off at some time as a cast capping piece, incorporating a gudgeon, has been fitted over the broken end of the shaft and is pinned to the hub. The hubs are circular with a deep flange around their rims on the inside of the wheel. There are six arms to each side of the wheel, bolted to the hubs, and each has a strengthening rib cast along the centre of its inner face. The arms are bolted to 11 inch deep shrouds which are made in six parts and bolted together centrally between the arms. The outside faces of the shrouds, arms and hubs all have slightly raised, decorative ribs. The outer shroud plates show some damage and have been plated or welded in at least three places. Whether this damage occurred in use or during transit to and from Leicester has not been established.

Plate 8. The Elvaston Castle pumping machine waterwheel, 2000.

On the inside faces of the shrouds are flanges, cast with the shrouds, to hold the frames which provided the mountings for the thirty-six floats. These flanges are radial but have a 2 inches deep return at their outside ends. Quite what is the purpose of these returns is not clear as the frames which held the floats are bolted to the flanges so the returns play no part in securing them. The frames which held the floats are quite complex, heavy castings with elaborately shaped stays and ribs. For example, the bars which include the float hinges are basically 1½ inches square but are ribbed below, rounded where the hinges are situated, chamfered along one edge to allow for the movement of the float boards and provided with two stops to limit that movement. They are also notched at their centres to allow the fixing of shaped castings which connect the float frames together around the circumference of the wheel (see Figure 9). These castings would also limit the movement of the floats, probably far more effectively than the rather small stops on the hinge bars. However, once again, these castings are unnecessarily elaborate as a simple strap around the wheel would have been just as effective and much less costly. Some of the frames were obviously renewed during the 1970s restoration and at least one has been broken since.

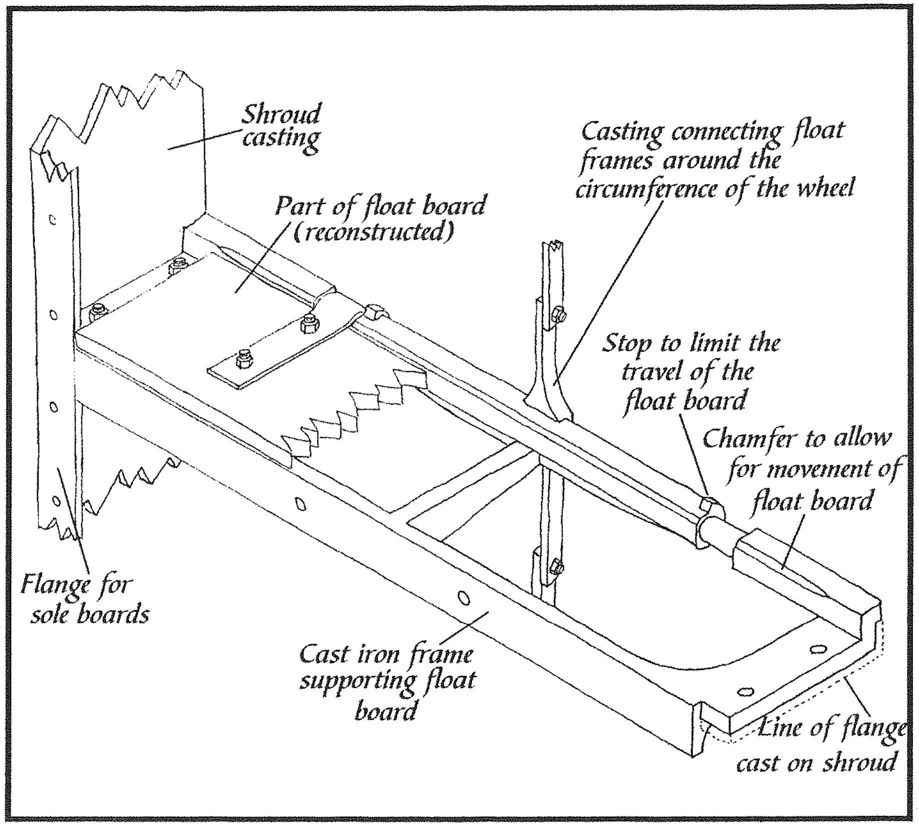

Figure 9. One of the float frame castings on the waterwheel.

Plate 9. Close up of the float frame castings with the float board brackets hanging vertically. (Note the repair to the rim casting.)

Above the level of the water in the wheel pit, no sole boards or floats remain. Presumably, once the restoration work of the 1970s had failed to make the system work satisfactorily, the wheel was left to stand and the elm boards would have dried out and deteriorated quite rapidly. Among the debris in the wheel pit it is clear that at least part of the continuous sole survives below the water level. Above water, only the bolts which held the sole boards to the inner flanges on the shrouds remain, indicating that the boards were 1½ inches thick. Of the floats, only the wrought iron straps which formed the hinges, plus the bolts which held the float boards, remain intact. The separation of the straps indicates that the float boards would have been $1^1/_8$ inches thick.

The sluice controlling the flow of water onto the wheel is incomplete though nearly all the missing parts are stored inside the pump house. What does remain are the cast iron, angled channels which held the gate and a slotted cast iron plate across the head race. This has two holes for mounting the outer bearing of the shaft which carries the pinions to work the racks as well as guides for the racks themselves. Some boarding is in place in the channels to maintain the head of water in the lake. The bottom of the channels end on a sill which is about 16 inches below the breast of the wheel.

It is unfortunate that the firm which restored the waterwheel, Dorothea Restorations Ltd., appears to have no surviving record of their work or of how successful the project was. Equally, although members of Derbyshire Archaeological Society and Leicester Industrial History Society also worked on the project, no account of their involvement or the outcomes seems to be available. Therefore, without actually being able to witness the wheel in action, it is only possible to surmise how well it might have functioned.

The wheel was started by turning a small handwheel mounted on the pump framing inside the pump house. Through a pair of gears inside the building, one complete turn of the handle would lift the sluice gate about 4½ inches. The racks are about 3 feet 2 inches long, very long for this situation and would perhaps be more appropriate for a drop hatch working off a variable head. However, there is nothing to indicate that this was ever tried here, nor would it be really feasible in this situation. Water flowing under the gate would be largely held in the compartments between successive floats by the shrouds, continuous sole and close breastwork below. Thus, a combination of weight of water and impulse would start the wheel turning. Fairly shortly, and certainly before a float reached bottom dead centre, the resistance of the water in the wheel pit would overcome the effect of the inflow and begin to push the float board open. As each float rose through the tail water, it would remain open, eventually hanging vertically until past top dead centre when it would close again ready for the next inflow (see Figure 10).

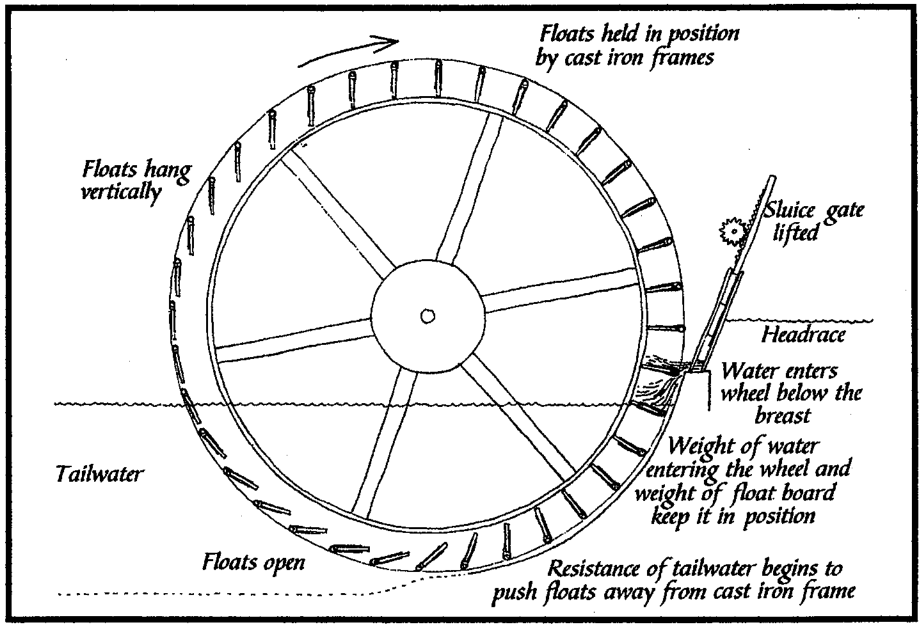

Figure 10. The action of the float boards during a revolution of the waterwheel.

Unlike a conventional situation where the tail race would be graded to carry water away from the wheel as quickly as possible, here it was deliberately retained in the pit. Indeed, the tail tunnel 'ends' in a masonry wall about 8ft. beyond the wheel pit and although there clearly is an outflow, it is intentionally restricted. In the first few revolutions of the wheel, the water level in the wheel pit would have increased rapidly until it flowed through the hole in the pump house wall connecting the pit with the well below the pump.

Very soon the intake pipe of the pump would be sufficiently covered for the pump to operate and maintain an appropriate level of water in the wheel pit. Just what this level was is hard to estimate but there cannot have been much more than one foot difference between the levels of the sill under the sluice gate and the tail water. As there are no other known surviving wheels of this design, only a complete restoration will make it possible to understand how easy it was to balance the flow of water under the sluice gate with the capacity of the pump and the restricted outflow from the wheel pit.

A Description of the Pump Machinery

The pump mechanism consists of two main parts, the individual parts of the pump machinery and the support structure or framework on which all the parts of the pump are mounted. This cast iron framework on which the pump is mounted is set above the pit in the pump house floor and is ten feet long by four and a half feet wide. It provides a platform, just under three feet from the ground on which are mounted the main components of the pump. Below this platform three sides of the framework consist of cast iron panels whose centres are open giving some access into the pit. There are three panels along the long sides and two panels on the two short sides. The long side nearest the waterwheel has no panels at all and is left completely open to accommodate the drive gearing from the waterwheel (see Figure 11 below).

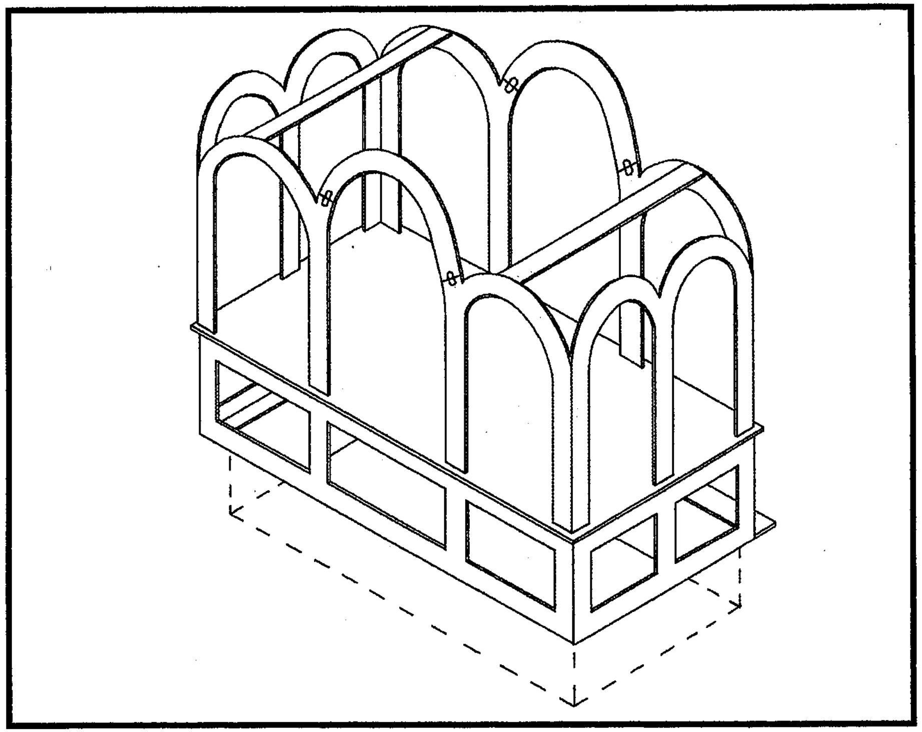

Figure 11. The cast iron framework on which the pump mechanism is mounted

Above the level of the platform the pump machinery is enclosed in a series of cast iron open arches on all four sides. The long sides of the framework have three arches and the short sides two. Each of the two arches on the short sides are two feet six inches wide and have a height of just over five feet. However, the arches on the long sides are not equal, the two end ones are the same dimension as those on the short sides, but the central arch is wider at three feet three inches, and is six feet six inches tall. Although the arches on the short sides are made as one complete casting, the long sides consist of three separate castings, namely each of the two end arches are made from a single casting and they are joined together by another casting that forms the curved part of the top of the central arch (see Figure 11). Apart from their aesthetic appeal, at least some of these arches have a function which is to ensure that the movement of the piston rods in the pumping cylinders remains vertical at all times. Beams are supported at the centres of the arches either side of the large central arches in the long sides of the support framework and run directly over the pump cylinders. In the appropriate positions above the cylinders there are four plummer blocks mounted on the beams through which the piston rods are fitted. At the front of the platform, centrally positioned, is the maker's name and the date of manufacture that reads 'HARRISON - DERBY 1834'

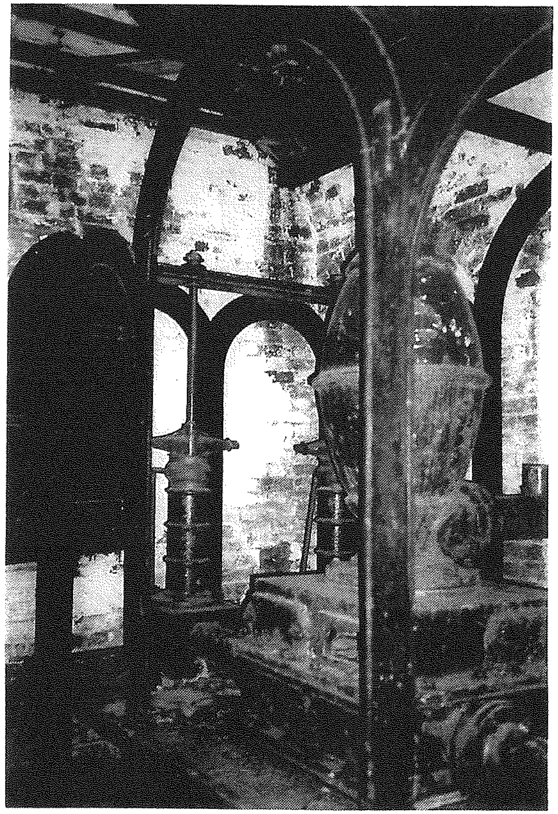

Plate 10. The main pumping machinary showing the cast iron framework enclosing the valve chest surmounted by the pressure vessel and two of the pump cylinders.

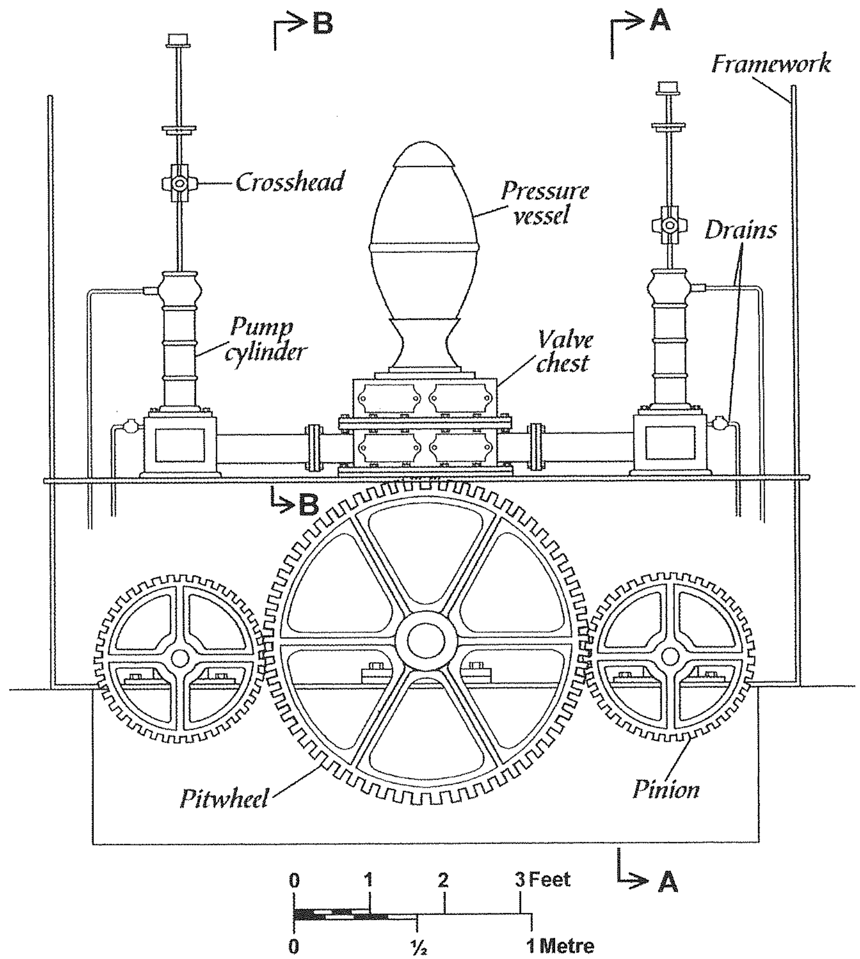

Figure 12. A view of the pump machinery with the crankshafts and crank arms removed to allow the pitwheel and drive pinions to be seen

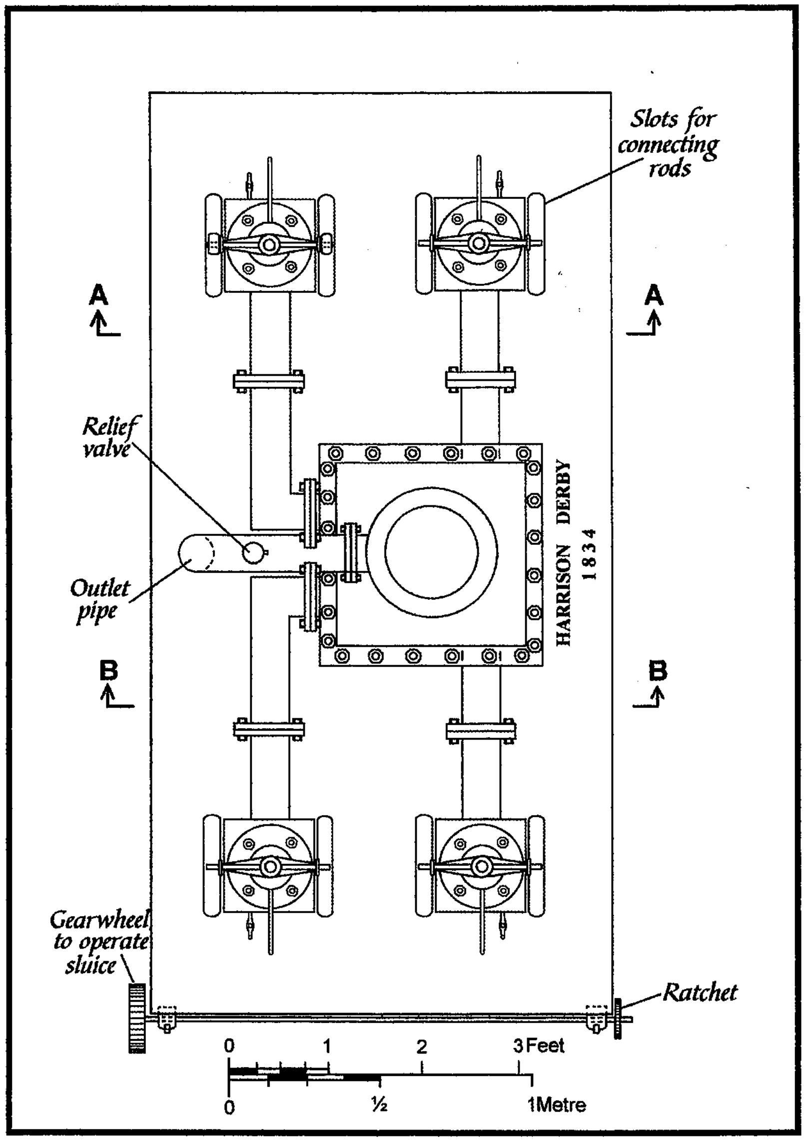

Figure 13. A plan view of the four pump cylinders, the central valve chest and the accumulator tank. Note the ratchet, shaft and gear wheel which were part of the sluice control system.

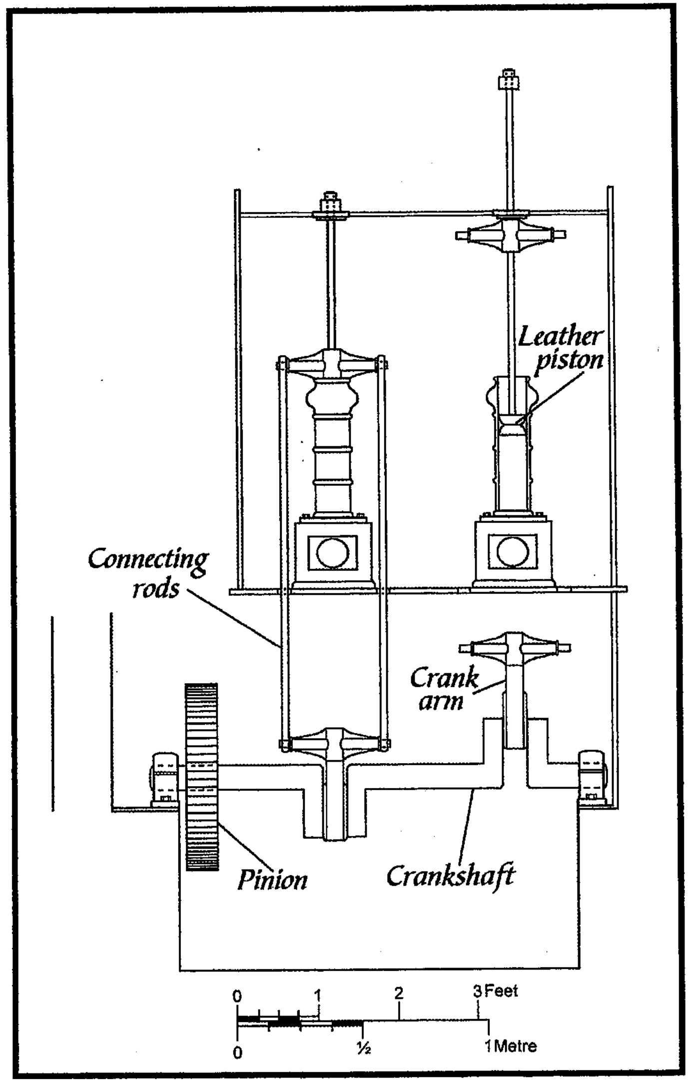

Figure 14. A sectional view, AA, of two pump cylinders with their crankshaft and crank arms, together with one set of connecting rods shown attached to the crank arm and the crosshead on top of the piston rod. (currently, although connected to the crosshead, the only pair of crank arms are disconnected from their crank arm.)

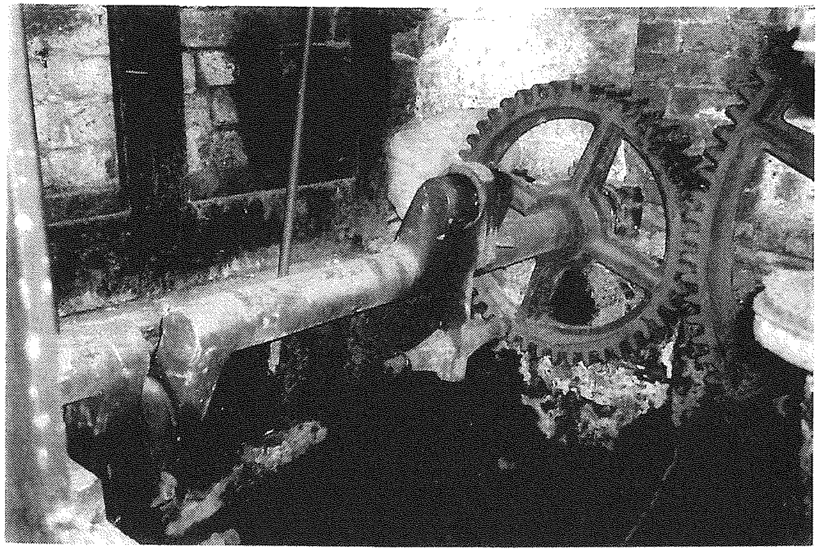

Plate 11. The pump drive arrangement showing the crank arms and crankshaft connected to a pinion which meshes with the pitwheel.

The pump machinery itself has a square valve chest mounted centrally on the platform, surmounted by a large pressure vessel. There are four actual pumping cylinders also mounted on the plinth, two either side of the central valve chest. Each cylinder has two drain pipes used to empty the system when not in use. The pressure side of each piston is drained through a cock attached to the bottom of the cyolinder, another drain from the top of each cylinder allows any water that might seep past the piston to be immediately drained away.The drive from the waterwheel enters the pump house via the main shaft which is supported by a bearing mounted at floor level alonside the edge of the pit. Keyed on to the main shaft just inside the pit is a 54 inch diameter, six arm, cast iron pit wheel having 84 teeth (pitch approximately 2 teeth per inch). Meshing with the pit wheel on either side are two 30 inch diameter, four arm, cast iron pinions, each one having 48 teeth (pit wheel/pinion ratio 1.75). The centres of the two pinions are about two inches lower than the centre of the pit wheel (see Figure 12). These two pinions each drive a crankshaft supported in bearings mounted on the opposite side of the pit. Each crankshaft has two sets of offset crank arms, arranged opposite to each other, which at one time would have each driven a pair of connecting rods. These in turn were linked, through slots in the plinth, to the cross heads mounted on the piston rods which protrude from the top of each pump cylinder (see Figure 14). At the moment there is only one pair of connecting rods present but these are disconnected from their associated crank arm. Currently the two pinions are assembled with respect to the pit wheel in such a way that the pump cylinders will act in pairs.

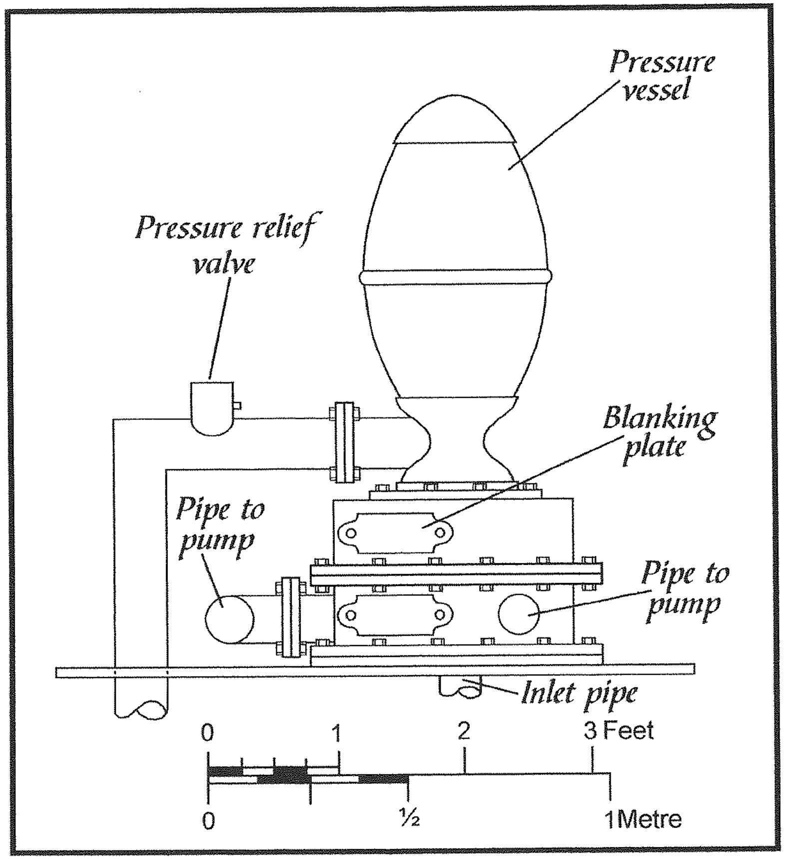

Figure 15. The valve chest and accumulator tank, viewed at BB, showing the outlet pipe and associated relief valve.

The water inlet pipe is fitted directly underneath the central valve chest and allowed water to be taken from the pit below. Currently there is a branch in this input pipe connected to a pipe which enters through the side of the pit. It is believed that when the restoration took place in the mid 1970s this branch pipe was inserted connecting the input to the water in the lake. The central valve chest of the pump mechanism consists of two similar chambers mounted one on top of the other. The bottom chamber has four one way non-return valves in its base and ports in its side walls connected to further five inch diameter pipes leading to the pumping cylinders. The top chamber also has four similar one way non return valves in its base (which forms the top of the bottom chamber) but all possible ports in the side of this chamber are covered with blanking plates. On top of this chamber stands the three feet six inch high, egg shaped, accumulator tank or pressure vessel from which comes the five inch diameter delivery pipe which supplied water to the tank on top of the water tower near the house. The pressure vessel contains a reservoir of air which is compressed when water is pumped into it and can then be used to maintain pressure in the delivery pipe when water is not being pumped. In the delivery pipe, near to the accumulator tank, is a pressure release valve which provides the necessary safety against excess pressure damaging the pipe work in the delivery system (see Figure 15). This delivery pipe used to pass under ground to a main storage tank on top of a tower in the courtyard of Elvaston Castle which then fed the fountains in the gardens and the lift in the house. However, during the 1970s restoration work, the outlet pipe was diverted such that it passes through the gap between the bottom of the pit and the tailrace directing the pump output into the tailrace.

The mechanism for controlling the flow of the headrace would normally have been mounted on the northern end of the cast iron frame surrounding the pump and on the brick plinth in the north-east corner of the building. There is a one inch diameter cast iron shaft mounted along the northern end of the framework just below the level of the platform that the pump cylinders are mounted on. The accessible end of this shaft is squared off in order to fit a winding handle. Close to the squared end of the shaft is a five inch diameter ratchet with 24 teeth while nearby there is a pawl mounted on the pump frame. At the far end of the shaft there is a small four armed gear wheel with 21 teeth (see Figure 13). In normal operation this gear wheel would mesh with a much larger gear wheel on a shaft running outside the pump house and over the top of the headrace sluice. This larger gear wheel has six arms with a diameter of 35 inches and 96 teeth (providing a gearing ratio of 4.57). Outside, on the shaft over the sluice, are two small gear wheels of 6½ inch diameter and 14 teeth which would have meshed with the two, 38 inch long, rack gears with 29 teeth. These rack gears would have been fastened to the sluice gate thereby raising or lowering the sluice. The various gear ratios are such that one revolution of the control shaft attached to the pump frame would raise (or lower) the headrace sluice by about four and a half inches. All the components for this sluice control mechanism, except for the top half of the bearing block, are stored inside the building.

The Operation of the Pump

As the waterwheel revolved then the pitwheel, pinions and crankshaft revolved such that the crank arms caused the pump pistons to move up and down within their cylinders by the reciprocating action of the connecting rods. When the pistons were driven upwards a partial vacuum was created underneath the piston which drew water up through the inlet pipe from the pit, through the first non-return valve, X, (see Figure 16A) and along the pipe into the pump cylinder, whilst at the same time keeping the second non-return valve, Y, closed . When the pistons then descended, the pressure created drove the water in the cylinders back into the first section of the valve chest so closing the first non-return valve, X, and opening the second non return valve, Y, allowing the water to flow into the top section of the valve chest (see Figure 16B). The water then flowed through the delivery pipes under the pressure of the pump. As this pressure supplied by the pumps varied depending on the position in the pumping cycle, the accumulator tank was utilised to maintain pressure in the delivery pipe thereby smoothing out the flow and preventing any tendency for the delivery flow to stop and start which would have given rise to the phenomenon known as 'water hammer', capable of potentially damaging the delivery system.

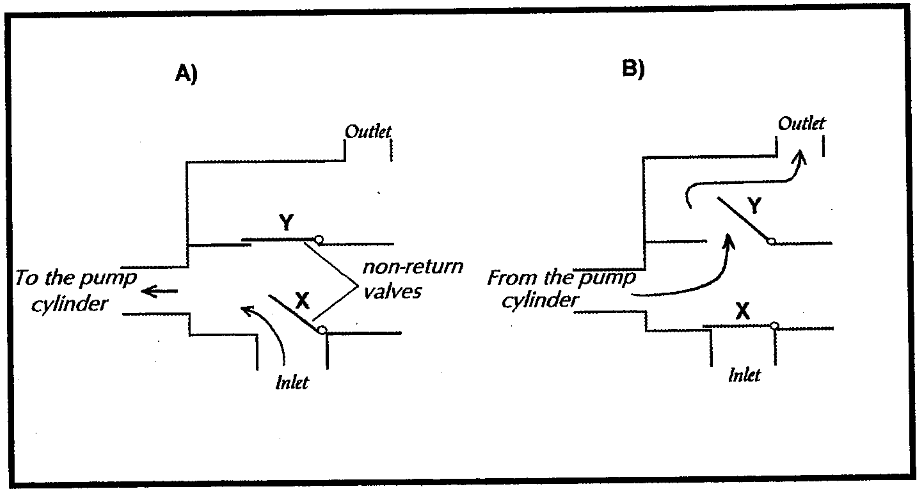

Figure 16A & B. The operation of the inlet valves, within the valve chest, during the inlet and outlet stages of the pumping cycle.

The Pump Configuration

As noted earlier, the gearing is currently arranged to have the pump cylinders act in pairs. At present those cylinders that are diametrically opposite each other around the central valve chest act in unison. Obviously the gearing could be configured to have different actions by altering the relationship of the crankshaft pinions to the pitwheel.

The key to the correct configuration lies inside the lower section of the valve chamber where the water flows both into and out of the pumping cylinder . If the lower section of the valve chest was all one space then water flowing into some of the cylinders would be mixed with water flowing out of some of the other cylinders, a totally non sensical situation. Therefore the space in this lower valve chest must be partitioned in some way (it should be noted that this interior space has not been inspected).

As the two cylinders connected to the same crankshaft are always out of phase with each other due to the design of the crankshaft (i.e. one is 'sucking' when the other is 'blowing') then there must be a dividing wall between their associated valves in the lower part of the valve chest. This dividing wall must run north to south, parallel with the long side of the pump platform. With just this single dividing wall it is possible for the pump to operate with the gearing configured so that the two crankshfts rotate in phase. This means that the pump cylinders directly opposite to each other on either side of the valve chest work in unison. However, this is not how the present configuration has been set up. Currently the gears are arranged so that pump cylinders diametrically opposite each other work in unison. This implies, if those responsible for the assembly of the pump were aware of the ramifications, that there is also a dividing wall running east to west in the lower part of the valve chest. If this is true then all four sets of valves in the valve chest have their own compartment and are completely isolated from each other.

However, if this is the situation, it would be possible for the four pump cylinders each to act in turn in a complete cycle thereby giving a much more constant delivery flow compared to the way in which the pump has been currently assembled (see Figure 17B). It must be considered that this is likely to be the correct assembly for the gearing of the pump as it allows the four pumps each to pressurise the system in turn once per cycle.

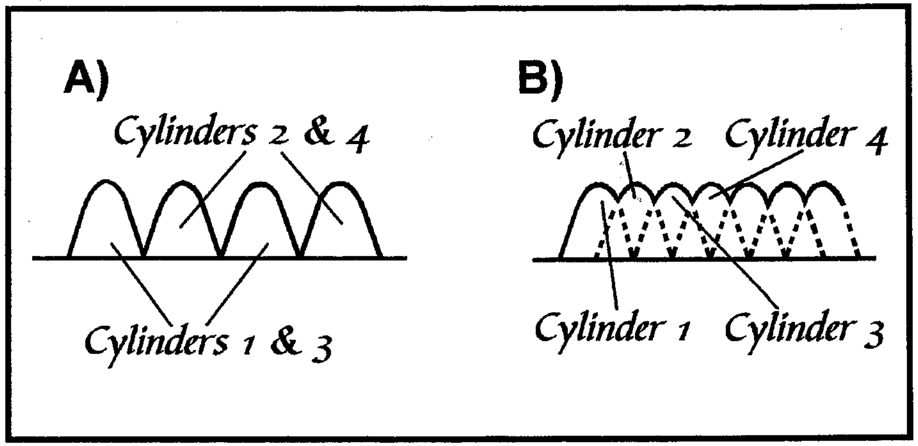

Figure 17. Pump output A) as presently configured, B) possible best configuration.

The Operation of the System

It should be noted that the waterwheel tailrace has been deliberately constructed so that it is incapable of passing the full flow of water used to drive the waterwheel. This ensures that when in operation the tailwater would back up such that the pit under the pump filled with water, thus providing a reservoir of water for the pump to use. This means that the waterwheel would always be running with its bottom portion submerged in the tail water, a condition that has been allowed for in the design of the waterwheel floats.

Of course, if this situation remained unchanged, the water would continue to rise and eventually it would flood the pump house and surrounding land. However when the water reaches a sufficient height for the pump to operate, the output of the pump is engineered so that a state of equilibrium is reached with the rising tailwater. In other words, the output capacity of the pump plus the water escaping along the tailrace is equal to the water supplied to the waterwheel by the headrace. The system was designed to work this way, including the special design of waterwheel, because there is so little fall to carry the tail water away from the wheel. The way the pump has been set up in the restoration of the mid 1970s with only one pump cylinder connected to the waterwheel would never pump sufficient water to prevent overflowing due to the deliberately designed restricted tailrace. This mistake has been compounded by modifications that took the pump's input from the lake and diverted its output into the tailrace; a reversal of the configuration that was designed to meet the peculiar conditions of the site. Under these circumstances the pumping system would never be able to work without the tailwater overflowing.

The Future

The state of the building is starting to deteriorate significantly due mainly to the poor condition of the roof and associated rain gullies. Unfortunately there are gaps in the roofing felt and water is entering the building causing rot in the timbers and is also effecting the brickwork. At the moment this weather damage has not progressed too far and its affects could be halted by some fairly minor repairs to the roof. If this maintenance is not carried out in the near future a much greater expense will need to be spent on the building.

The pump machinery appears to be in good condition as it was restored only some 25 years ago. The only parts missing are three sets of connecting rods and the top half of the bearing for the sluice control shaft. Fortunately the presence of the remaining pair of connecting rods would provide the necessary pattern if the missing parts cannot be discovered.

The waterwheel was also restored in the mid 1970s so nearly all the metalwork appears to be in a serviceable condition, however, all the wooden parts, that is the sole boards and floats need replacing in new timber. In an attempt to prevent vandalism the sluice gate and its control have been removed and the sluice has been boarded to maintain the water level in the lake.

It is to be hoped that this very interesting pumping system will be restored to working order at some time in the future. If so, a full understanding of the system which was designed to meet the special needs of the site will be necessary. A recent application for a Lottery Grant to restore the gardens ought to include the fountains and thus this most unusual and possibly unique waterwheel powered pump.

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Acknowledgement

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LEAMINGTON MILL

By W. G. Gibbons

Very little has been recorded about the early history of Leamington Mill (SP 322656). However, the earliest reference to a mill in Leamington is in the Domesday Book of 1086 when Roger de Montgomery, who was the Earl of Shrewsbury, held two mills in Leamington valued at 24 shillings. Nothing more can be said about these mills except that they were probably watermills and were probably located on the River Leam. It is also a possibility that these two mills were to be found on the one site. In the medieval period it was usual for a waterwheel to drive just one pair of millstones which was known as 'a mill'. So it is possible that the entry in Domesday citing the presence of two mills at Leamington in 1086 may well have been referring to one building with two waterwheels and two pairs of millstones.

Later, in the Middle Ages, there is a record of a mill in Leamington being leased to Richard Gerard for a term of 57 years in 1520. Over a hundred years later there is another reference to the mill in 1635 and then, after another fifty years, there is mention of a miller

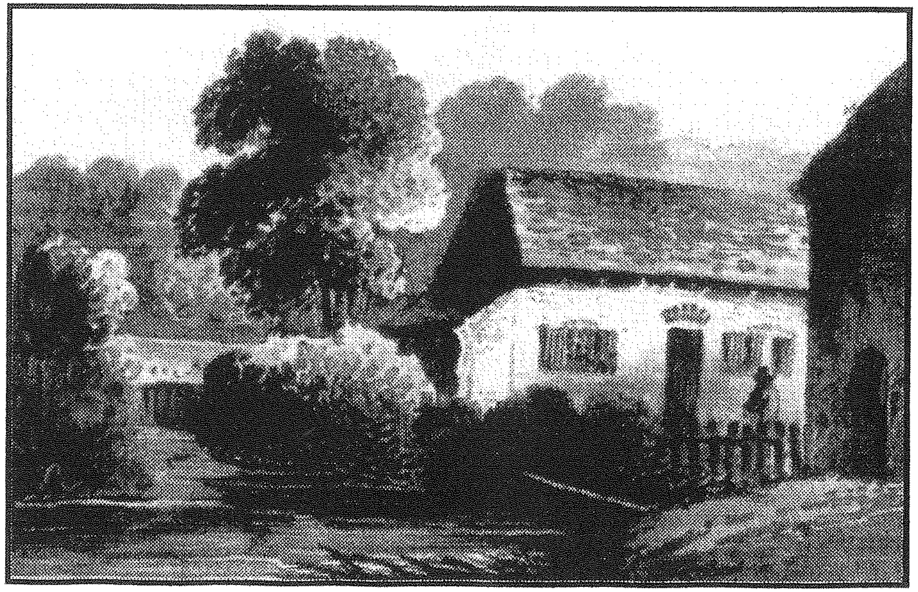

Plate 1. The ancient mill at Leamington, demolished c.1830.

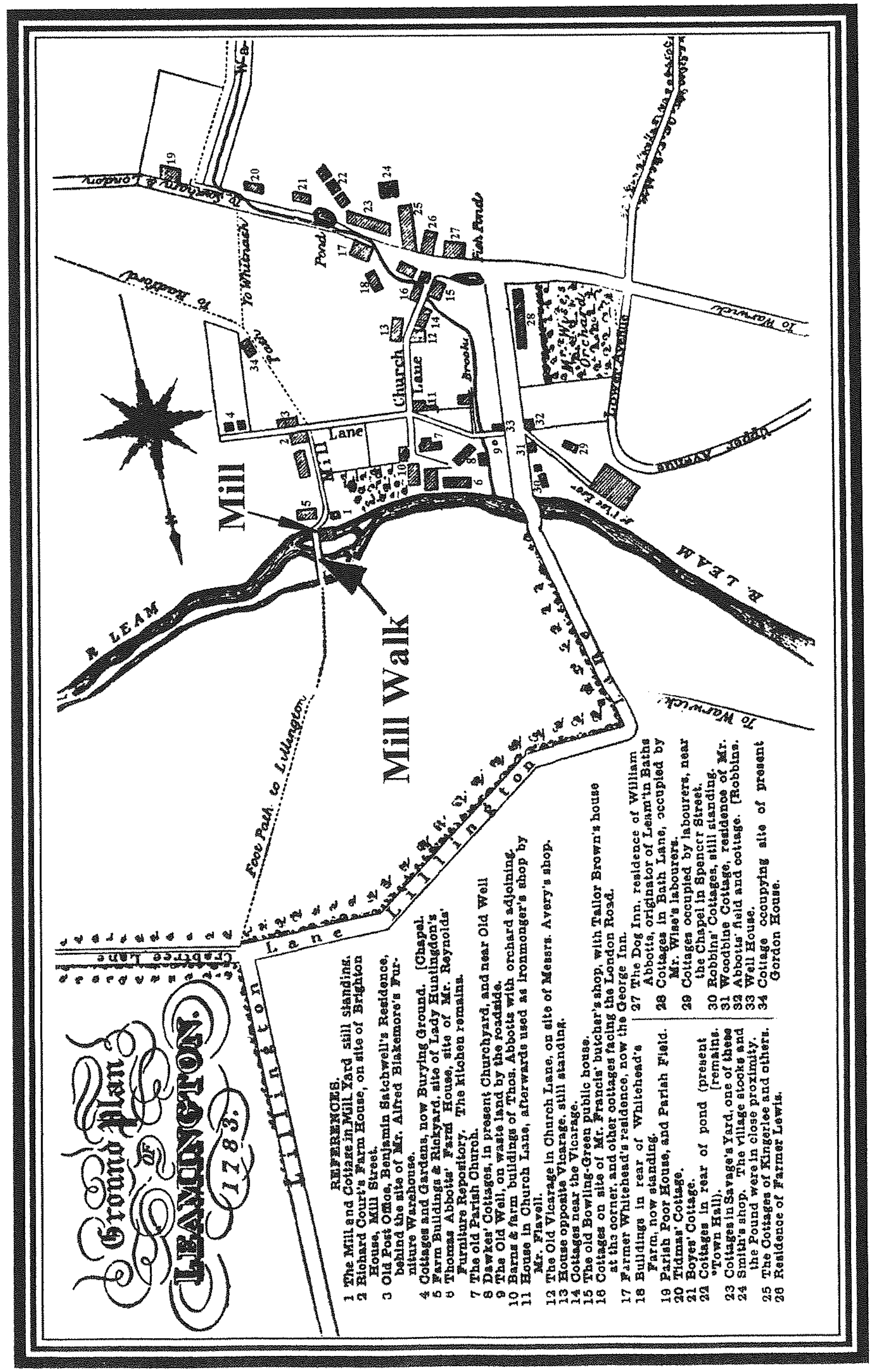

Figure 1. A map of the area around Leamington Mill in 1783.

in Leamington called William Page. As good watermill sites were a definite asset to a community they continued to be developed and modified over long periods, consequently it is likely that the watermill referred to in the Middle Ages continued to occupy the site that was first mentioned in the Domesday Book.

In the early eighteenth century the miller at Leamington Mill was William Satchell who had a son called Benjamin who was born on 3rd January 1732. Benjamin Satchwell was a greatly respected person in the area and it was his vision and drive that brought about the birth of Leamington as an inland spa. He was a boot and shoe maker by trade, living and working in a thatched cottage in New Street from where he also acted as the town's postmaster. He died in 1810, aged 78, and his imposing tomb can be seen in the parish church graveyard.

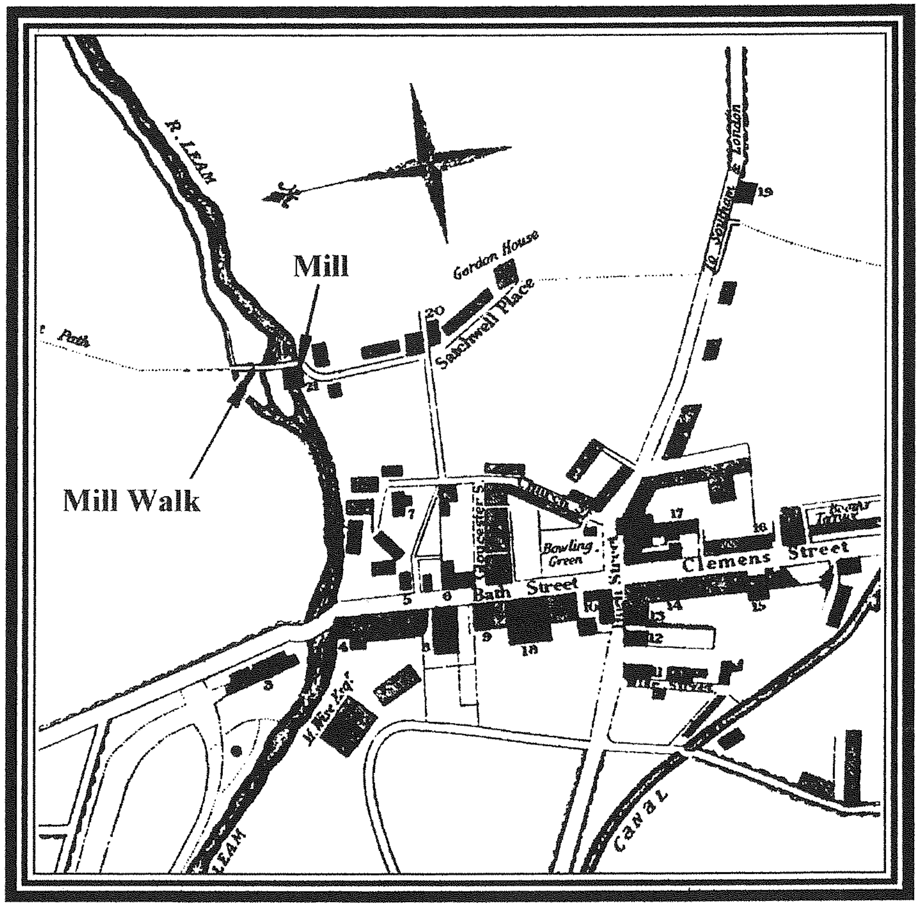

Figure 2. Map of the area around Leamington Mill in 1818.

With the passage of time the mill came into the occupancy of the Oldham family, with James Oldham recorded as the miller in 1828. Not long after this date James was succeeded by his son, Thomas, who was responsible for demolishing the old mill buildings about 1832 enabling him to rebuild a new up-to-date flour mill together with enlarging his capacity to provide water to the ever increasing town population of Leamington. By the start of the Victorian age the town had developed from a mere hamlet into a prosperous and fashionable watering place.

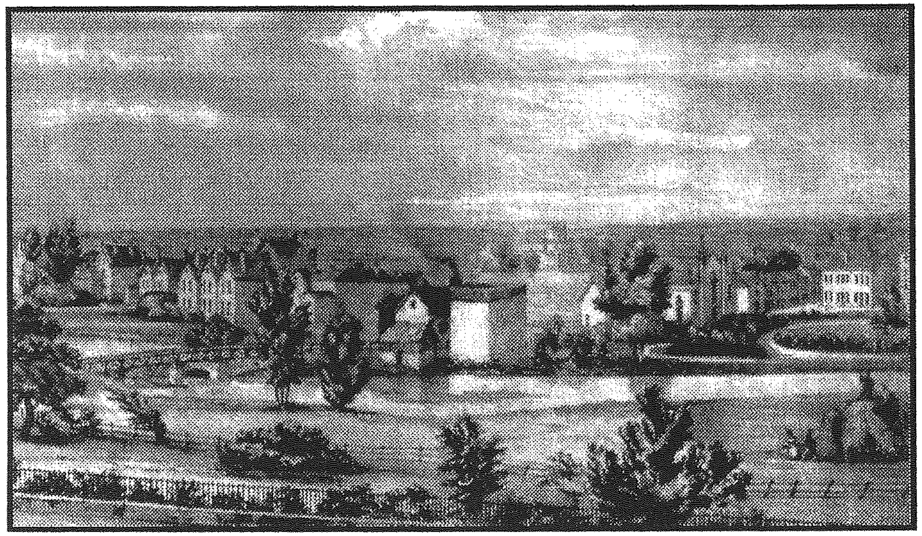

Plate 2. View from Newbold Terrace c.1840. In the centre is Leamington (or Oldham's) Mill with the water storage tank on top of the tower. On the left is the long Mill Walk causeway behind which are the houses of Leam Terrace.

Thomas Oldham died in 1849, aged 76, when he was succeeded by his son John who added still further to the property and augmented the water supply to the town. It was during John Oldham's lifetime that the 'modern' waterworks were built at Campion Terrace and the old waterworks supplied from Leamington mill became disused. In 1869 he erected, with permission from the local Board, the large and 'unsightly' swimming bath across the river at the floodgates; this was supplementary to a smaller bath which extended across the mill race. After 1884 the mill was operated under the name of J. Oldham & Co. and the last record of milling on the site of Leamington Mill was in 1892.

In 1898 the whole of the Leamington Mill property, comprising in excess of four acres of land containing the mill buildings and an adjoining meadow, was purchased by the local council from the trustees of the Earl of Aylesford for £4,085 and demolition of the mill began in April 1899. Apart from the demolition of the buildings, a steam engine and a large water storage tank had to be removed. As well as demolition work the old river-water filter beds had to be filled in and all the land levelled to create the Mill Gardens (on the other side of the River Leam to Jephson Gardens). It is likely that the various

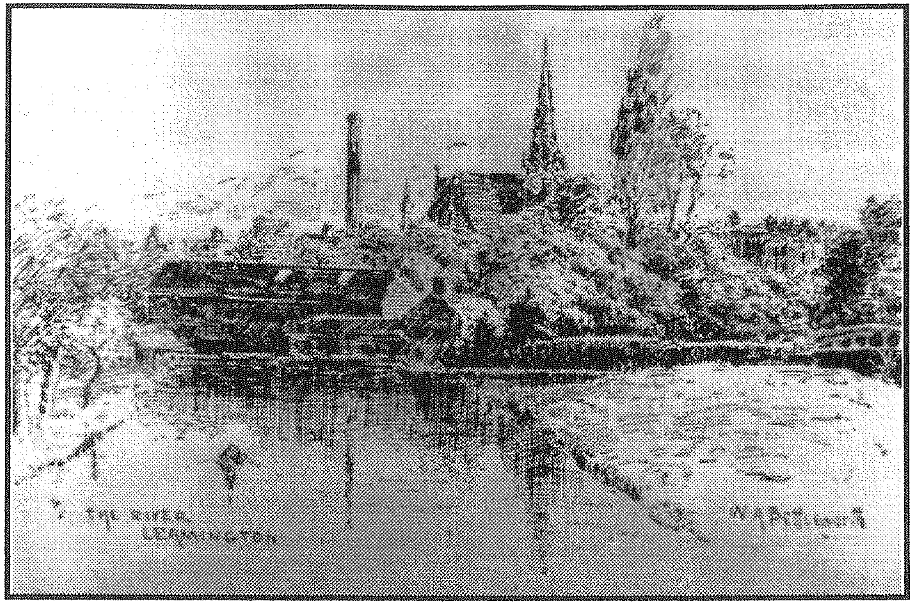

Plate 3. Drawing of Leamington Mill in the late 19th century.

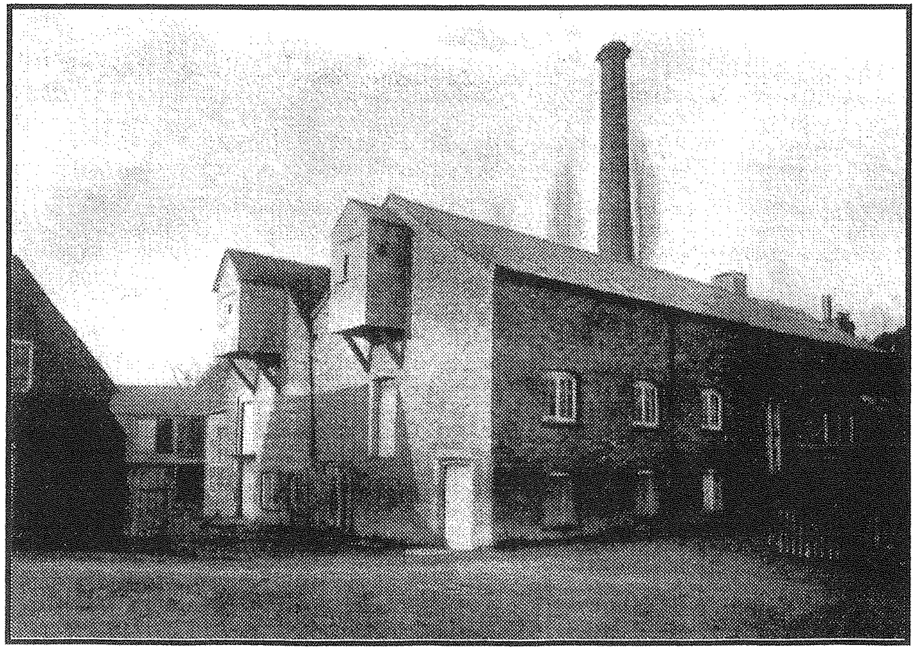

Plate 4. Leamington or Oldham's Mill prior to demolition.

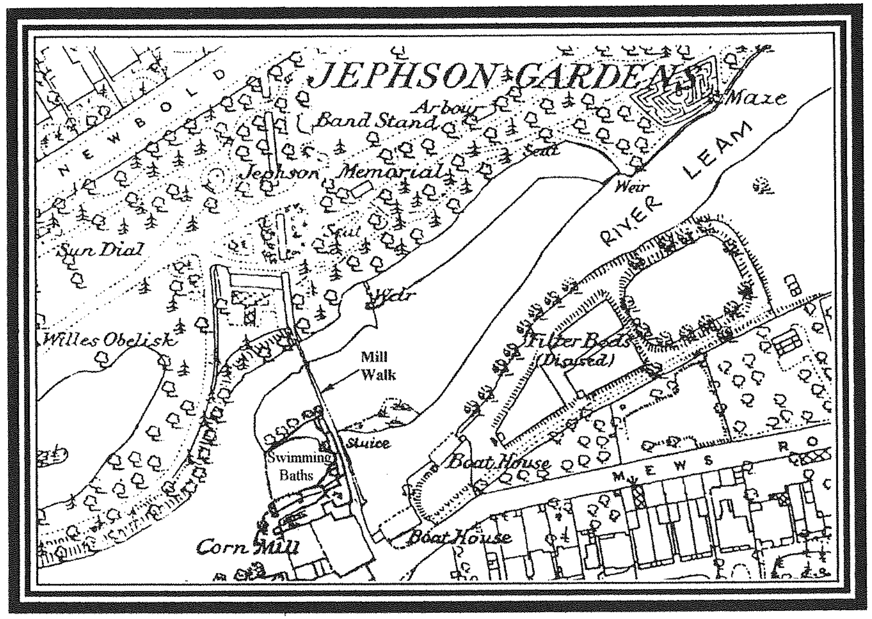

Figure 3. Ordnance Survey map of 1885 showing the corn mill and the filter beds that became Mill Gardens.

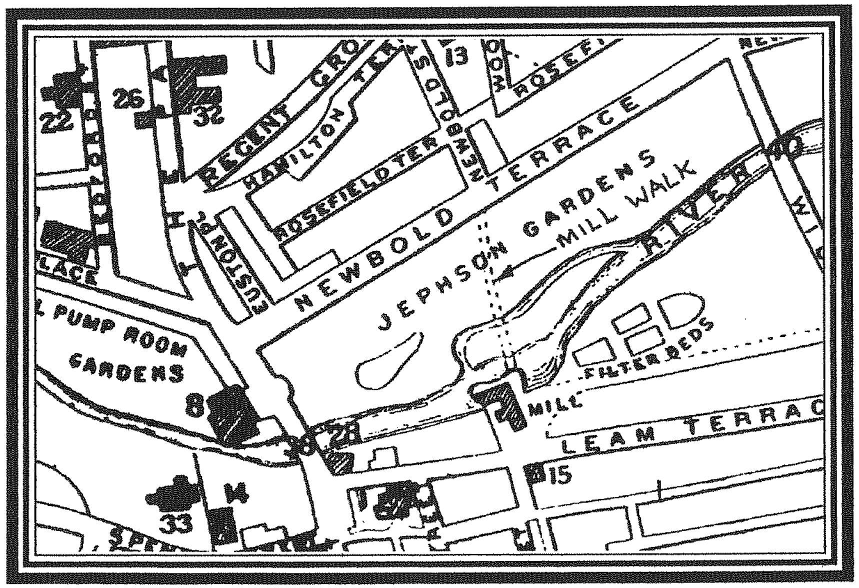

Figure 4. Plan showing the mill and Jephson Gardens, 1887.

watercourses were also altered at this time and, when the flood gates were removed, traces of the earlier mill were discovered.

The alterations that took place at the beginning of the twentieth century were mainly the responsibility of the Borough Surveyor, Mr. W. de Normanville, and the Chairman of the Parks and Gardens Committee, Mr. J. Heath Stubbs. These alterations commenced in October 1901 and the new weir and suspension bridge which were erected on the old mill site were opened on June 1903. The Leamington Courier reported the event as follows:-

> 'The long projected and long delayed scheme for the purchase and improvement of the mill property has at last been carried into effect, and few will deny that the present appearance of the river at this spot is an improvement upon the unsightly chimney and buildings of the mill, and the hideous wall of the swimming bath extending across the old flood gates.'

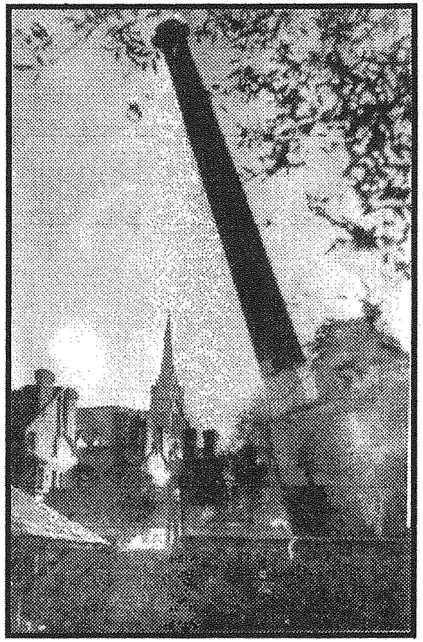

Plate 5. The felling of the mill chimney, 29th June 1899.

This note refers to previous attempts to secure and beautify the mill site which has been going on for about half a century. One scheme had been proposed by a Dr. Lietch which had been prepared about 1840, and another was projected in 1863 by Mr. Morgan, the surveyor of the local board. Obviously the local politicians had long wanted to remove what to them was an unattractive industrial building from the midst of the spa town. However, although it no doubt spoilt the projected image of the town, it is noticeable that

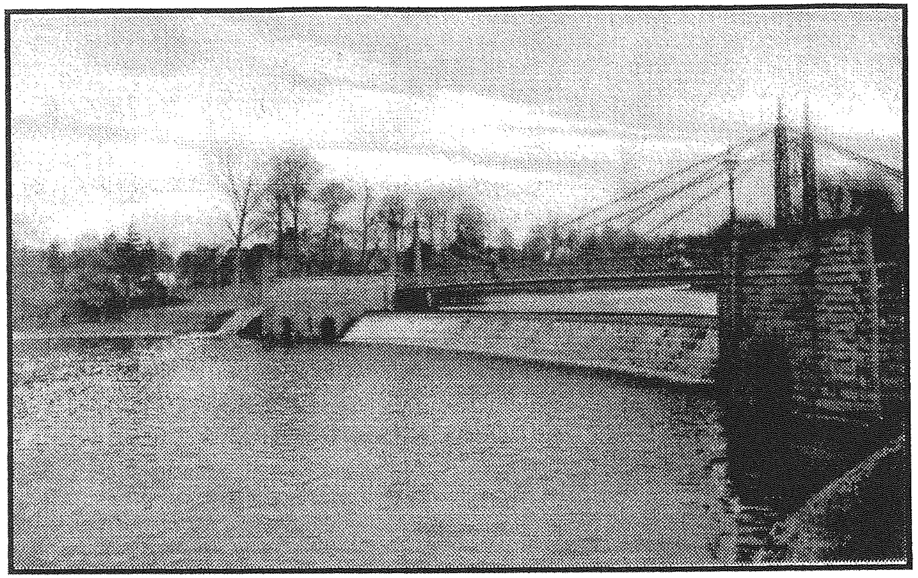

Plate 6. The new suspension bridge and weir built on the old mill property in 1903.

no action taken to demolish the mill came to fruition until the mill was probably no longer commercially viable. This would probably have arisen due to the introduction of the new and much larger roller mills at the end of the nineteenth century. From the river's point of view Mr. Morgan's scheme was very similar to the one which was eventually carried out except that instead of converting the meadow between the back water and the river into ornamental water, it was to be added to the Jephson Gardens.

Not long after Leamington Mill was demolished the local paper published some memories from 'an old Leamingtonian' of local characters that used to be associated with the mill

> 'I remember an eccentric character, his name was Mr. Russell, who lived near Gordon Passage (at the rear of George Street), and who used to take an early bath in the River Leam, being accompanied by one of his workmen, who carried a ladder and during the winter months broke the ice to enable Mr. Russell to enter the water. I have seen him myself on my way to the Lillington brickyards, during the summer of 1861, entering the water at the floodgates near the mill, and it was then understood that the spot must be reached before 5.30 a.m. or else it would be too late to see him. He was an elderly man, of stout build, over 70 years old.
>
> Another local eccentric was the famous Rev. John Craig, vicar of All Saints Parish Church in Leamington. I remember Mr. Craig when I was a scholar of the National School. I only once came in contact with the vicar while playing a concertina on my way home one evening. I met him on the wooden footbridge at the bottom of Mill Walk - he asked me to play several hymn tunes. (Mill

Walk carried the ancient footpath which connected the village of Lillington with Whitnash). Referring to the Mill Walk reminds me that two very young girls committed suicide by leaping with their hands tied together into the water at the floodgates.'

Mr. J. C. Manning, a local historian also mentions this incident and states that a certain Johnny Harmer said that a young woman who lived in one of his cottages in New Milverton had committed suicide by throwing herself into the Leam. He said the circumstances were romantic. It was a love affair and resulted in a double suicide. The young woman and a female companion agreed to die and tying themselves together with a handkerchief were found in the water locked in the embrace of death. A letter on the bank of the river contained these lines:-

'I promised once more on Sunday night;
To walk again with my heart's delight;
On the river's banks where the billows roar
There we did part to meet no more.'

These details of the end of the mill and the above memories are captured for posterity in the files of the local newspaper but other material relating to the old mill are remarkably meagre. In spite of all the pressure during the last half of the nineteenth century for the improvement of the mill site unfortunately no one saw fit to refer to the mill's past when discussing its future.

After the passage of yet another century since the mill was knocked down the only surviving physical evidence of the existence of Leamington Mill is the remains of some brickwork just downstream of the weir built in 1903, but this is usually out of sight below the water level of the river.

ELEPHANT TALES

By Barry Job

It was the great American showman Phineas T. Barnum who said that 'elephants are the hook on which the circus hangs.'[1] Indeed, it was he who publicised the most famous elephant of all: Jumbo. In maturity he was a massive African elephant nearly 11 feet tall and weighing 8 tons, but he first came to London Zoo in 1865 as a small youngster. He was put into the care of a keeper called Matthew Scott and over the years the two became inseparable. Jumbo grew and grew yet was extremely patient giving young children rides on his back. But, as is the way of male elephants, in later years he was prone to moods and sudden rages. The zoo authorities were fearful of a tragic accident and so were pleased to accept an offer by Barnum for the elephant in 1882.[2] This led to a public outcry, questions were asked in the House of Commons and, Queen Victoria was said to be 'very sad'. Jumbo's American tour created a sensation and a huge profit for his owner, until disaster struck in 1885. Whilst walking along supposedly unused railroad tracks a freight train came hurrying down the line. The other elephants escaped, some said Jumbo pushed them to safety, but Jumbo hit the train head on. The locomotive and railcars were derailed and Jumbo died within a few minutes, with his trunk holding Matthew Scott's hand.[3]

At Etruria, in the heart of the Staffordshire 'Potteries', can be found the Etruria Industrial Museum. However, it is known locally as 'Jesse Shirley's Bone and Flint Mill' after its founder and the two main products; ground bone and ground flint for the pottery industry. From the late eighteenth century the site in Etruria was occupied by Ball's dye works.[4] In 1820 Bourne and Hudson began storing and sorting bone here, with a limited amount of processing being accomplished. In October 1852 John Bourne died and the works was formally taken over by his son Jesse Shirley who had been running the business during Bourne's lengthy illness. In 1856 a range of mill buildings was created for Jesse Shirley by the iron master George Kirk of Etruria, this allowed a variety of processes to be carried out on the site. The motive power is a beam engine called 'Princess', believed to have been manufactured by Sherratts of Salford in the 1820s and installed second-hand in 1856. The mill then worked continuously until 1972 when work was transferred to modern machinery elsewhere on the site. Ground products are still produced for the pottery industry with the engine and original mill being leased for a nominal rent by the City of Stoke-on-Trent. This forms the nucleus of the Etruria Industrial Museum, it is open to the public with 'Princess' being steamed at regular intervals.

The pottery industry became established in North Staffordshire during the seventeenth century because of the accessibility of raw materials.[5] A range of good quality clays can be found locally plus excellent bituminous coal. Lead and salt, important glazing materials can be found in the neighbouring counties of Derbyshire and Cheshire.[6] Initially coarse red clay ware was produced but as England's population increased and prosperity rose there was increased demand for finer and whiter domestic ware, local clays were

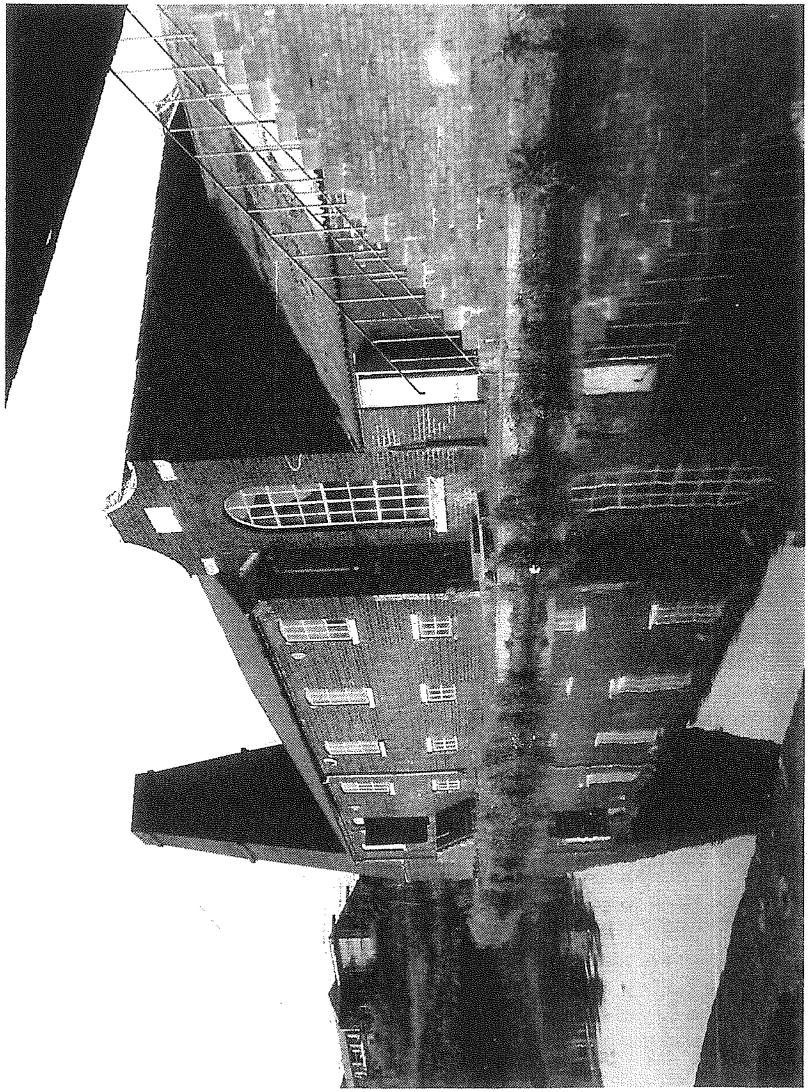

Plate 1. Jesse Shirley's bone and flint mill at Etruria, c.1985.

replaced by imports from Devon and Cornwall but the skill of the local potters retained the industry in North Staffordshire.[7] The growing popularity of tea and coffee drinking was initially met by the importation of fine tableware from the Far East. But it was not long before the English potters began to experiment with imitations of the Chinese ware and consequently began to search for new ceramic materials.

An attractive story quoted by Simeon Shaw[8] attributes the discovery of the use of ground flint to the potter Thomas Astbury. In 1720 whilst travelling to London on horseback, at Dunstable he was forced to seek assistance as his horse was rapidly going blind. The ostler of the tavern he was staying at effected a remedy by burning a flint pebble until quite red, grinding it to a powder, then blowing it into his horse's eyes. Shaw records that the horse benefited greatly from this treatment, but Astbury noted the ease with which the hard pebble was ground after being heated, the pure white colour of the resulting powder and its clay nature when moist. On his return home he quickly experimented with the new material initially producing a white flint bodied dip ware. Flints are very heavy and only obtainable from a distance, so could only be considered for incorporation into the body of the ware itself after the inadequate transport system of the day had been improved. Earthenware pottery subsequently contains about 50% ground flint, it is this which produces its strength and whiteness.

The discovery of the use of bone is, unfortunately, not recorded, but there is no doubt that potters were encouraged by the success of flint, an unlikely ceramic material in its original state, to experiment with other materials. Certainly Josiah Spode was using ground bone, on a commercial scale, well before 1800. Bone china typically consists of 25% china clay, 25% Cornish stone and 50% ground bone, the latter producing the characteristic translucent quality.

The processes for grinding flint or bone are essentially the same. These hard materials must first be heated or calcined in a kiln. At temperatures in excess of 1000 degrees centigrade water is driven off and the crystalline nature is destroyed to leave a white and soft porous material which can be more easily ground. After Astbury's discovery flint was initially ground dry between millstones or crushed under stamps as used in the metal mining industry. These methods were found to be unsuitable, especially because of the dust they produced. Flints are composed of silica and the effects of silicosis or 'Potter's rot' soon began to be felt.[9] With the realisation that an operative's working life could be as short as two or three years it is not surprising that men could not be persuaded to undertake the work, and an alternative method of grinding had to be found. In November 1726 Thomas Benson, of Newcastle-under-Lyme, took out a patent for grinding flints under water to reduce the dust. He refined the process in later patents and it is this method which was employed by Jesse Shirley. Essentially the calcined bones or flints are tipped into a circular pan containing water (see Figure 1). A vertical shaft, driven by 'Princess', rotates a number of sweep arms in the pan. Suspended on the arms are vertical timbers which push blocks of siliceous stone around the pan. Thus the bones or flints are tumbled together and the frictional contact grinds them to a powder after about 24 hours. The thick liquid or 'slop' could be run off for further processing and sale.

Experimentation with different bones showed that cattle bones were the most preferable, certainly sheep bones tended to have a high mineral content and horse bones gave the ware a greenish hue. In reality various bones could be mixed with the cattle bones provided they were in small quantities. Old millers would tell disturbing tales of human bones being included in consignments and the workers at Jesse Shirley's mill

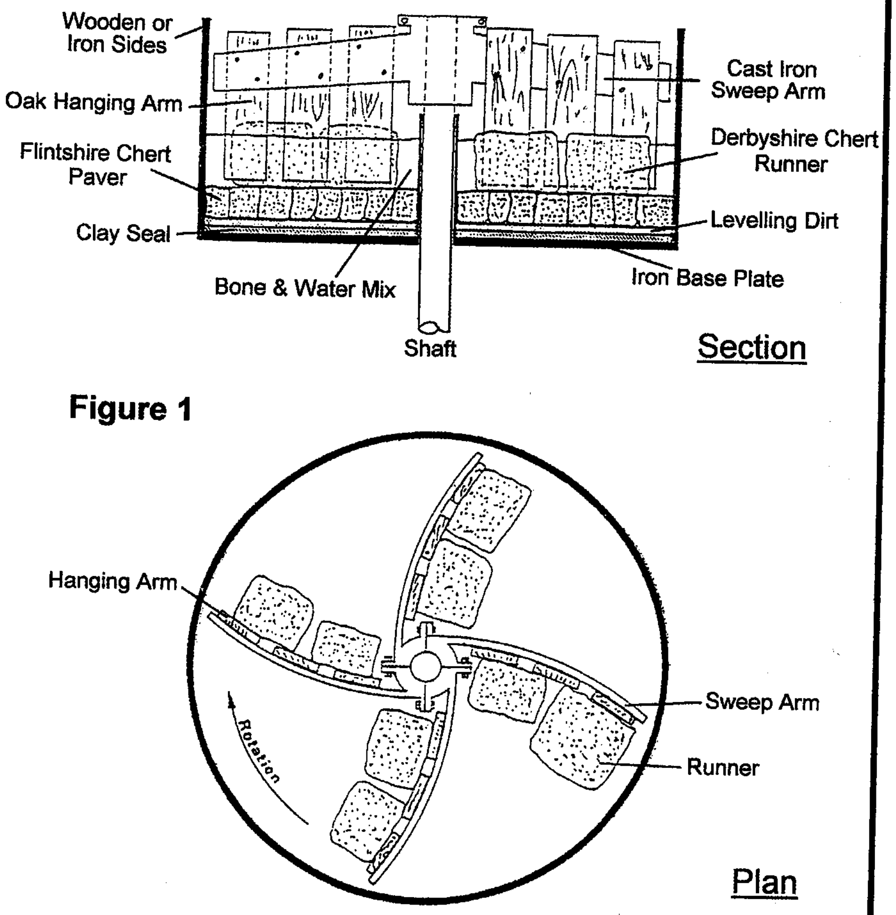

Figure 1

GRINDING PAN

decorated their canteen with whale and elephant bones rescued from the grinding pans. These interesting bones have been preserved at the Etruria Industrial Museum and this article attempts to discover the probable origin of the elephant bones.

The origin of the elephant bones was, according to tradition within the workforce, a circus elephant which died in Hanley about a century ago. The Potteries has had a long association with Barnum's circus, and research commenced by looking at this famous show. When he brought his 'Greatest Show on Earth' to England in 1896 he turned to the Stoke-on-Trent firm of W. R. Renshaw to supply the 68 railway vehicles he required.[10] Renshaws provided premises for the circus headquarters in Cliffe Vale and Barnum's first provincial tour began in 1898. The season ended in Stoke in November, the circus having travelled nearly 300 miles. It was here that a most unfortunate incident occurred. The circus entourage paraded from Stoke Station to Boothen Racecourse where Barnum's first elephant, a 25 year old Ceylonese male called Nick, went berserk. The Staffordshire Sentinel local newspaper reported that: 'The surest way to prevent the animal from doing mischief to man and beast was, it was felt, to kill it...'[11] Surprisingly it was said that at the insistence of the New York Society for the Prevention of Cruelty to Animals that strangulation was determined upon; the poor beast was first secured to the ground with chains and ropes.

> 'But unfortunately things did not go as well as anticipated, as the rope around the beast's neck broke almost directly after 50 or more men began to haul at it. There was a general stampede, those who knew most what might happen being the most anxious to widen the gap which distanced them from the troubled brute. Another rope was procured, the noose again slipped over its head and soon the huge animal rolled over a corpse. Dr. Stanton, the veterinary surgeon, directly it had come to the ground, fired a shot into the brain of the animal and another into its head from behind the left ear, the carcass being secured by Mr. Cross, the Liverpool naturalist.'

Could the elephant bones at the Etruria Industrial Museum be the remains of Barnum's elephant Nick? The preserved bones are too small to belong to a mature male so we must look for another candidate. Barnum's show over-wintered in Garner Street, Etruria, in preparation for another tour the next year. This concluded in Hanley after travelling some 4000 miles. Barnum then moved to Europe, but, following an horrific train wreck in Germany, he took the show back to America. In Britain it was replaced by Buffalo Bill Cody's Wild West Show, which used the same, repainted, railway vehicles to commence touring in 1903. They also used the same winter headquarters and it was said not to be unusual to see wigwams and Red Indians around Etruria! But these huge shows were expensive to run and sufficient public interest could not be sustained year after year. Buffalo Bill left Britain after his 1904 tour, so the origin of the Museum bones must lie elsewhere.

Smaller shows travelled by road, and a frequent visitor to the Potteries was Bostock and Wombwell's Menagerie, indeed, the Bostock family originally came from near Leek. They had an early unfortunate event with an elephant in 1872. This was summarised by a Staffordshire Sentinel headline which ran 'A Boy Killed By An Elephant in Hanley.'[12] It transpired that the elephant, a 12 year old African female, was being taken to some stables at the Angel Inn. Thomas Hulley, the elephant keeper, was a few yards away while a group of children were feeding her with nuts and bread. One boy, George Stanton, was said to have thrown a stone into the beast's mouth. She became enraged and, seizing the boy, crushed him against a wall. He died from his injuries the next day. There is no

Plate 2. Roger Johnson, museum technician, holds one of Jimona's bones at the Etruria Industrial Museum (Jesse Shirley's Bone Mill).

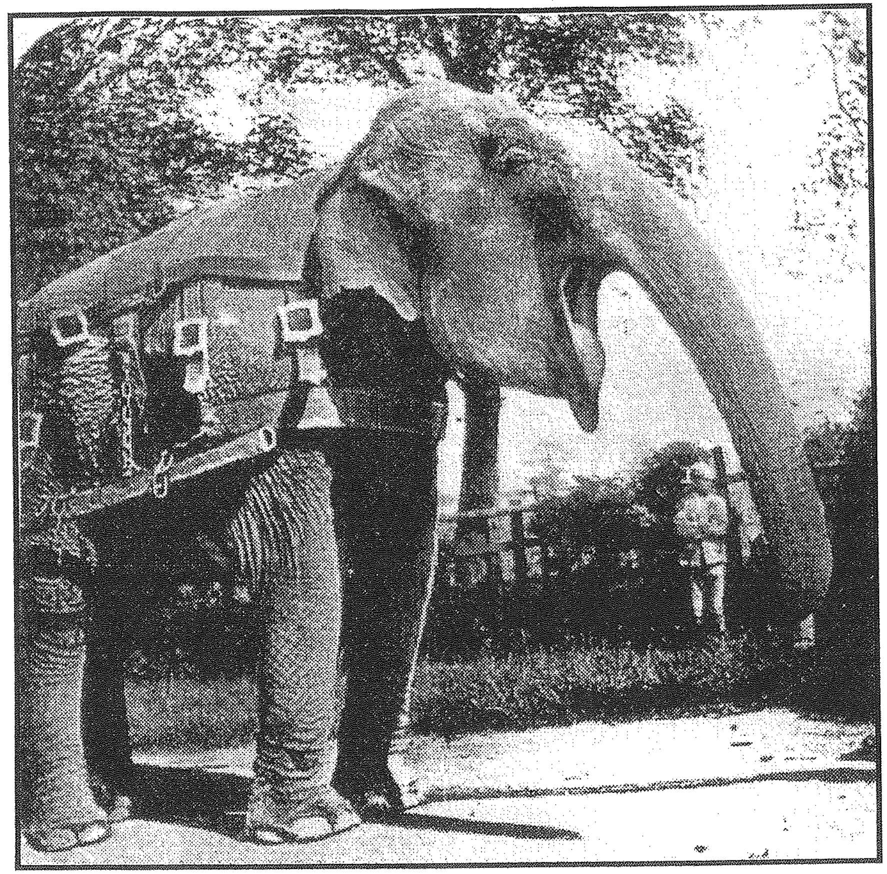

Plate 3. Jimona with Bostock and Wombwell's menagerie.

indication that the elephant, a valuable commodity, was put down as a result of this incident, particularly as it might have been considered that George Stanton contributed to his own death, so we must look elsewhere.

When E. H. Bostock wrote his memoirs he recalled another elephant incident, although writing some 30 years later he called her Abdella. This is clearly an error for reports written at the time record her as Jimona 'or Mona for short'. In 1898 she was already 38 years old and the Staffordshire Advertiser[13] records her as being nearly 9 feet tall and weighing 3½ tons (a fraction of Jumbo's weight). The Staffordshire Sentinel[14] reports that she was yoked to the bandwagon in Glass Street, Hanley. She was standing close to the vicarage wall and reached over to pull some leaves from an Irish yew tree. These are highly poisonous and she quickly became ill and was sent to the premises of a veterinary surgeon in York Street.

'Poor Mona appeared to be in much pain. She sighed a great deal and those who knew her ways said she wanted a bit of company. Mona and the junior elephants and the camels had moved to the next venue in Stoke, so the order was given to bring a young elephant and four camels back to Hanley to be a solace to Mona in her sufferings. On their arrival in the yard the young elephant gave a sympathetic call. Mona called back in low tones, which were interpreted as a final adieu to her comrades, then fell on her side and expired.'

She was said to be an extremely powerful elephant who exhibited much intelligence and was a great favourite with visitors. Alive she was said to be valued at £2000, although in death her remains were not wasted. The carcass was skinned by the menagerie butcher, the meat certainly being fed to the lions and tigers. The skin was sent to the London taxidermist company of Rowland Ward. This was purchased later by the Royal Museum of Scotland for £115 and she has been on display there ever since. The author would suggest that her bones were sold to Jesse Shirley's mill.

Thus research reveals that the only elephant to die in Hanley around the turn of the century belonged to Bostock and Wombwell's Menagerie. The elephant bones at the Etruria Industrial Museum undoubtedly belong to Jimona, an Indian Elephant which died in Hanley in 1898. A few of her bones were retained, the rest were ground and mixed with cattle bone and thus were distributed throughout sets of bone china cups and saucers made about a century ago! Now, I wonder where those whale bones came from?

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