

# COED TREWERNAU MILL: THE WORKING PARTS

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## Introduction

This very small corn mill with its wooden working parts was doubtless once typical of many rural mills in Wales. It must have served a very small and scattered population, probably ceasing work over a hundred years ago. Since then, the combination of the demand for scrap metal, the propensity of the Clywedog Brook to flood, and the ease with which some of the more lightly-constructed woodwork could be taken for the fire of the adjoining cottage, have all taken their toll. However, what remains is an extremely rare and precious survival, and warrants strenuous efforts to ensure its protection.

All measurements are given in feet and inches as these were the units used in the construction of both the mill and its machinery. Within the mill, the terms 'upstream' and 'downstream' relate to the direction of water as it flowed over the waterwheel.

## The working parts

The mill stands on the north-east bank of the Clywedog Brook, and there used to be an external waterwheel on the north-western end of the building. Details of the end of the leat and

small header pond have been lost, and the former wheel-pit and tailrace had been completely infilled and levelled. There remains a prominent aperture in the 30ins. wall for the wooden wheel-shaft. This shaft-hole is roughly circular, approximately 29ins diameter, but the shaft itself ends within the building, the external part completely rotted away or removed (Plate 1). Several feet above this is a recess which once accommodated a beam supporting the pentrough.



PLATE 1 The end wall, showing the shaft-hole for the waterwheel and positions of the trough support and water control to the wheel

A vertical measurement between the top of this cavity and the approximate centre of the hole for the wheel-shaft indicated there had been a waterwheel, probably overshot, of about 10ft.

diameter. A wheel any larger than this could not have been accommodated because of the level of the stream into which the short tail-race once discharged. A third aperture, high on the same end wall, was for the shaft controlling the water supply to the wheel, this having been operated from the stone floor of the mill (Plate 1).

An excavation of the central part of the former waterwheel pit<sup>5</sup> yielded two pieces of cast-iron shroud of the wheel. The curvature of the outer edge of the larger piece confirms the diameter of the wheel as being 10ft. The cast shroud is plain, and 12ins. deep, including the flanges to accommodate the wooden sole-boards. Part of the 5¼ by 3¼ins. oak arm is still attached to the external face of the larger shroud fragment by two bolts with 1½in. square heads (Plate 2).

The 12ins. shroud segments were joined by a two-bolt overlap, midway between the arms. There was also found an iron tie-rod, ⅝in. diameter, which formerly connected the two shrouds. This gives the width of the wheel as 4ft. 3ins. Enough evidence remained to conclude there were two sets of six oak arms, 30 wooden buckets and wooden sole-boards. The timber thickness of the buckets was 1in., and of the risers and the continuous sole 1½ins. A further excavation in the wheel-pit<sup>6</sup> showed that most of the outer wall had been robbed, but the width of the pit was established at 5ft. 6ins.

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<sup>5</sup> Excavation was carried out on August 18th 2018 by the “Mucky Gang” of the Welsh Mills Society, comprising John Crompton, Andrew Findon, Tim Haines, John Peck, Mel Walters and Alan Stoyel.

<sup>6</sup> Further excavation was by the Haines Walters family on September 8 - 9th 2018.



PLATE 2 Larger fragment of waterwheel shroud from excavation

Inside the mill the working parts are almost complete. The gear is of the standard, two-step under-driven type with two pairs of stones on a hurst which is level with the stone-floor (Plate 3). The metalwork has been stripped, so the damsels, spindles and their associated footstep bearings are missing, as are the water control lever and shaft.

Within the mill the wheel-shaft, presumably of oak, is in good condition, although the outer, rotted, end has dropped out of position. The shaft is octagonal, 16ins. across the faces, and 16ins. square where it carries the pitwheel. The inner bearing has two gudgeon rings holding a cross-tailed gudgeon with a pintle  $4\frac{1}{2}$ ins. long and 3ins. in diameter (Plate 4).



PLATE 3 General view of hurst and pitgear



PLATE 4 The inner bearing of the wheel-shaft with the sprattle beam supporting the upright shaft

The very fine wooden clasp-armed pitwheel, 7ft. 3ins. in diameter, (Plate 5) is also in good condition, except for the lowest quarter which has rotted away completely. The thickness of the wheel at the perimeter is  $4\frac{1}{2}$ ins., and the oak arms are approximately  $11\frac{1}{2}$  by  $4\frac{1}{2}$ ins, each comprising two baulks of timber. The face of the wheel is bevelled and once had 68 oak cogs of 4ins. pitch,  $3\frac{1}{2}$ ins. face and 2ins. projection, but most of these are now missing.



PLATE 5 The clasp-armed wooden pitwheel

The upright shaft is of oak and only 36ins. long. Both it and the wooden gears it carries are in very good condition, and they will turn freely. Where it bears the wallower and spurwheel it is 12ins. square changing to circular, approximately  $10\frac{1}{2}$ ins. in

diameter, elsewhere. The base of the shaft is fitted with a cross-tailed gudgeon clasped by two iron rings, with a  $2\frac{3}{8}$ ins. diameter pintle (Plates 4 & 5). The shaft is supported by an arched wooden sprattle-beam which forms part of a timber frame. The timbers for the upper bearing are particularly crude, and are incorporated in the flooring between the millstones (Plate 6).



PLATE 6 The timbering supporting the top of the upright shaft, from above. The bedstone is on the right-hand side

The solid wooden wallower is of elm and was constructed in four pieces (Plates 7 & 8). There are two joined semi-circular blocks both above and below a continuous median horizontal parting. The two joints holding the semi-circular blocks are

each secured by vertical wooden pegs, cut off flush with the surface, and iron straps. The two resultant discs are fitted together, with their respective joints set at 90 degrees to one another, and held by a series of vertical coach bolts, effectively clamping the cog shanks in their mortices. The 8ins. bevelled face carries 30 cogs of fruitwood, probably apple, of 4ins. pitch, each cog of 4½ins. face and 2ins. projection. These cogs have buried shanks, further secured by pegs which are cut-off flush with the surface of the gear.



PLATE 7 The spurwheel and wallower

Midway between the shank pegs in the wallower is a series of vertical coach bolts with square nuts which are mostly at the lower end. An interesting and very significant feature of this

gear is that the series of iron coach bolts has been moved towards the centre by  $1\frac{1}{2}$ ins., and an extra ring of wooden cog-shank pegs has been added, similarly displaced inwards by 1in., leaving remnants of the earlier pegs in place (see under Discussion).



PLATE 8 The wallower from below

The fine wooden clasp-armed spurwheel has oak arms and elm cants (Plate 7). Each arm is made up of two baulks of timber, each  $3\frac{1}{2}$ -4ins. square. It had 68 cogs of fruit-wood, probably apple, although most of these have been removed. They have a pitch of  $3\frac{1}{4}$ ins., a face of  $3\frac{1}{2}$ ins. and a projection of 2ins.

On the assumption that the centre of the downstream stone nut was  $7\frac{3}{4}$ ins. from the pitch circle of the spurwheel, the nut had 15 cogs or staves. The gear ratio from the pitwheel to this pair of stones was therefore 10.28. No accurate centre for the upstream stone nut can be deduced in this case because the bedstone and bridge-tree have been removed. No pitch circle radius can thus be measured to see if this pair of stones ran at a different speed from the other one.



PLATE 9 The front bridge-posts of the downstream pair of stones with brayer and tentering control

The hurst frame is wholly of oak, 5ft. 6ins. wide, the top of the hurst being boarded - continuous with the stone floor. Both rear bridge-posts are of oak, each with double mortices

measuring 19ins. by 2½ ins. for the bridge-tree. Both bridge-trees are missing. The front end of each bridge-tree rested on a brayer - a horizontal beam, the ends of which occupied mortices in a pair of front bridge-posts. Tentering (altering the gap between the millstones) was performed by a screw control acting on the end of the brayer nearer the centre of the hurst. The brayer and its tentering control survive for the downstream stones, as does the wooden meal spout (Plate 9). All four front bridge posts are in place. The holes for traditional wooden twist pegs (for adjusting the feed to the millstones) are evident for both pairs of stones.

The most easily removable wooden parts have gone. Missing is all the stone furniture, most of the softwood boarding on the front of the hurst, those cogs which could be salvaged without much effort, and other items such as the wooden twist pegs. There never appears to have been a sack-hoist, but there is an external loading door to the stone floor, facing the Clywedog Brook.

Of the millstones, the downstream bedstone is still in position, and is a domed conglomeratic grit stone, 4ft. 2ins. in diameter, dressed for clockwise rotation, with 9 harps of 4 furrows. It is interesting that it still has its wooden eye (Plate 10). The rotation direction of this stone indicates that the waterwheel was overshot, as distinct from pitchback or high-breast. The runner stone is missing. Between the two pairs of stones, incorporated in the floor, is the crude timbering holding the upper bearing of the upright shaft (Plate 6).

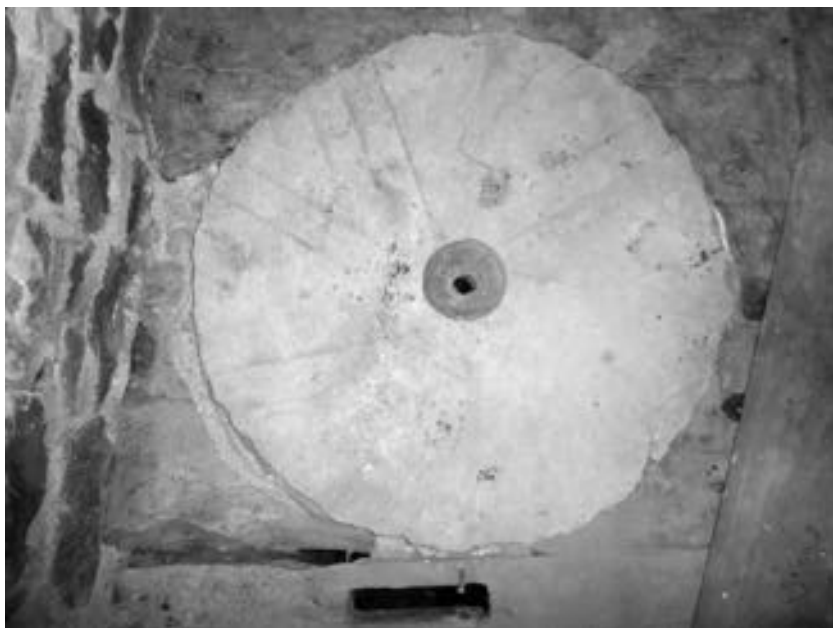


PLATE 10 The downstream bedstone with wooden eye

On the upstream side the bedstone is missing, but the runner is roughly in position, facing downwards. It is domed, approximately 4ft 6ins in diameter and of a coarse conglomerate, with mortices for a stiff-rynd (Plate 11). The stone probably came from either the Penallt area of the Forest of Dean or from Anglesey. The lithology of the conglomerate fragments suggest the former. There was no ancillary machinery, for cleaning, dressing or hoisting on this floor.

An interesting feature is that the waterwheel and machinery is not symmetrically positioned with regard to the building. It is displaced upstream by approximately 2ft. 9ins., leaving a significant space, still within the hurst frame, downstream of

the machinery. This space is lit by a window and is now completely empty. Mortices in the timbers, and a timber set into the wall, suggest it was formerly occupied by some ancillary machinery or equipment, possibly a jog scry for removing chaff and coarse flakes of bran for feeding to the pigs. There is a 16ins. by 2½ ins. mortice in the basal beam of the hurst, and other mortices in old timbers forming the floor above which are probably re-used.



PLATE 11 The upstream runner stone from below showing rynd recess

## Discussion

There are several features of this mill which point to the working parts being of early date, although small adaptations have been made, as was the case in most mills. As parts wore out and needed replacement, it was logical to renew them using the latest technology.

The mill building appears to be of late 18th century date, and the mechanical layout, including the pitwheel, upright shaft, wallower and spurwheel are thought to be original features. The wallower shows interesting signs of modification, however, which will be discussed further. The spurwheel required a recess in the mill wall to accommodate it. This recess is curved to match the curvature of the wheel, and does not appear to have been cut out later. This, together with constructional details of the spurwheel and the other working parts, strongly suggest that the gear is contemporaneous with the building.

Certainly the pitwheel, wallower and spurwheel are relatively early, as defined by the pitch of the cogs.<sup>7</sup> The pitwheel and wallower have a 4ins. pitch and that of the spurwheel is 3¼ins., both of which measurements are typical of the late 18th century.

The waterwheel had cast-iron shrouds, and probably cast-iron naves, the rest of it being of wood. There is little dating

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<sup>7</sup>Alan Stoyel, *Perfect Pitch: The Millwright's Goal. An aid in the interpretation and dating of the working parts of watermills and windmills*, The Wind and Watermill Section of the Society for the Protection of Ancient Buildings, 1995.

evidence, other than that the shroud is plain, with no moulding, the wooden arms were attached to the outer face of the shrouds, and all the bolts had large square heads and nuts. None of these features can be said to be date specific, but together they suggest a very late 18th century or fairly early 19th century date.

The magnificent wooden, clasp-armed pitwheel might be expected to be contemporaneous with the spurwheel, but this might not be the case. Wooden pitwheels are now quite a rarity, because they were so prone to rot. They were working in damp conditions, and they were often the only gears which were affected by flooding. They were generally the first in a train of gears to be replaced. When a pitwheel was renewed, it usually involved a pitch reduction in order to conform with current practice of the time. However, if the pitch of a gear was altered, anything with which it was to engage would need to have a matching pitch. Generally, therefore, the replacement of a pitwheel involved a new wallower as well.

Determination of the age of the wallower is not a simple matter (Plate 12). The two generations of both coach bolts and wooden pegs are indicative of a reduction in diameter.

It might be thought that such a reduction in size would enable the gear to turn faster, but, if so, there would need to be fewer cogs on the wallower than previously. This modification has maintained the same number of cogs, thus keeping the ratio of the gears the same. What has altered has been the pitch. There appears to have been a reduction in the pitch circle diameter of approximately 2ins. This suggests that the pitch of the

wallower cogs has been reduced from approximately  $4\frac{1}{4}$ ins. originally, to the present 4ins.



PLATE 12 Detail of wallower

As the number of cogs has not changed, it is doubtful if so much trouble would have been taken for a quarter of an inch reduction in pitch alone. Was this modification made to an existing wallower in this mill, or could it have been reduced in size before it was installed here? In view of the obvious alterations to the wallower, has the pitwheel been replaced? The constructional details of the latter, and its 4ins. pitch, suggest a date no later than around 1800. A similar date can be ascribed to the spurwheel.

It is suggested that the wallower has been altered from a  $4\frac{1}{4}$ ins. pitch to the present 4ins. by turning the wheel on a lathe, converting it from a spur gear to a bevel. The wheel would then have been re-cogged, using the pre-existing mortices for the shanks of the new cogs. The question remains as to whether this was done during the life of the mill. If this wallower was in its present location before it was modified, the pitwheel must have been replaced, as the original one would have been a contrate (or face) gear.

There is no evidence of any alteration having been made to the pitwheel. Its features, including the pitch of its cogs, are consistent with an early date. Although there is a possibility that the original pitwheel was a contrate one and that the wallower was modified when it was replaced by the present one. This change would have had to have been made very soon after the initial installation of the machinery. The inference is therefore that the wallower had already been modified from a spur gear when it was installed here as part of the original set-up.

The oak hurst frame appears to be contemporaneous with the building, and, because the tentering was by a brayer for both pairs of stones, this again suggests a date prior to about 1800. A further indication of significant age is the doming of the millstones.

The rynd recess in the upstream runner stone (Plate 11) is of an early type. The pattern is between a 'horned' and a cruciform one, and would be appropriate for the early or the middle of the 18th century, and could have come to the mill second-hand.

One feature which does appear to be of a later period is the cross-tailed gudgeon at the base of the upright shaft. It is doubtful if this was installed any earlier than about 1800.<sup>8</sup> However, this could well be a later modification. The timber waterwheel shaft would doubtless have been replaced during the life of the mill, and cross-tailed gudgeons would have been fitted to that as a matter of course at the time of renewal.

It is interesting to note that the cogs of all the gears show very little wear. Presumably this means that the mill never did much heavy work, or that the cogs were replaced late in the mill's working life. The lack of wear on the spurwheel cogs shows that the stone nuts, either of wood or of iron, had cogs and not teeth. It is even possible that the stone nuts were in the form of lantern pinions with wooden staves.

The rynd mortice seen in the upstream runner stone (Plate 11) is of an early type. The pattern is between a 'horned' and a cruciform one, and would be appropriate for the early to middle of the 18th century. This suggests that it is contemporaneous with the mill building, or that it came here second-hand.

## **Conclusions**

Nearly all the remaining working parts within the mill appear to be of a mid- to late-18th century date. It is probable that these working parts are contemporaneous with the mill

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<sup>8</sup>Martin Watts, personal communication.

building. Later replacements are the waterwheel shaft, the cross-tailed gudgeons and probably the waterwheel.

The wallower shows intriguing evidence of the use of an existing spur or contrate gear with a larger pitch, which was modified and re-cogged to mesh with the present pitwheel. It is thought more likely that the modification was carried out as part of the installation of the rest of the machinery rather than later.

The runner millstone appears to be from the Penallt area in the Forest of Dean, and may have come to this mill second-hand, as the rynd pattern is probably of a slightly earlier date than the mill and its machinery.

These working parts are an exceptional survival of rural mid-to late 18th century millwrighting and are of great interest.