THE MIDLAND WIND AND WATER MILLS GROUP

(affiliated to the Society for the Protection of Ancient Buildings)

This Journal is published by the Midland Wind and Water Mills Group, which is concerned with the study of the history and technology of mills, and, in principle, with their preservation and restoration. Its area is the region loosely defined as the Midlands, especially the central counties of Staffordshire, Worcestershire and Warwickshire.

The Group, which functions as an autonomous society, holds monthly indoor meetings, with talks and discussions, during the winter, and arranges several tours to mills during the spring and summer. Members periodically receive a Newsletter and the Journal, and can purchase other publications at preferential prices.

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Wind and Water Mills

The Occasional Journal of the Midland Wind and Water Mills Group

affiliated to the Society for the Protection of Ancient Buildings

Number 5
Summer 1984

Wind and Water Mills, although the journal of the Midland Wind and Water Mills Group and therefore naturally concerned with the mills of the Midlands, 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, but submissions by others will be willingly considered.

D.G.T.
D.T.N.B.

Cover illustration:
FLADBURY MILL c.1900, see p.2

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CONTENTS PAGE

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FLADBURY MILL, WORCESTERSHIRE, & THE FLADBURY ELECTRIC LIGHT AND POWER COMPANY

by J.A. CRABTREE

Fladbury is an ancient village on the River Avon, midway between Evesham and Pershore. It had a mill at least from the time of Domesday, which can only have been powered by the Avon.

The oldest part of the present mill (grid ref. SO 997460) has been dated by F.W.B.Charles, an expert on old buildings, as late 17th century. The majority of the buildings he assigned to the early 18th century; a discontinuity between the mill and the house suggests that they were built at separate times. The outline agrees with that shown on a map of 1789.

In 1633 the manor of Fladbury, presumably including the mill, was owned by the diocese of Worcester as it had been since the 8th century. It was then leased to William Sandys who almost immediately started on a scheme to make the river navigable from Tewkesbury to Stratford. Sandys was a royalist, and during the Civil War the navigation seems to have been taken over by William Say, M.P., who completed it as far as Evesham. The fixing of navigation levels would have affected many mills, so it is quite likely that Fladbury Mill would have been totally rebuilt at that time.

At the opposite end of the weir, on the lock island, is another mill known as Cropthorne Mill. It appears to be of a rather later date and considerably less power, having one wheel pit, five feet wide.

Fladbury was equipped with two undershot waterwheels, each about 15ft. by 8ft. One of the wooden upright shafts, removed in 1945, was dated 1818, and the few remaining iron parts appear to be of early 19th century design.

The modern history of Fladbury Mill could be said to start with the arrival of the Stephens family. George Stephens came as a ten-year old boy to work at Cropthorne Mill with his father who had bought it in 1832. He continued to run the mill after the death of his father in 1855 and moved to Fladbury Mill in 1864. While trade remained good, he appears to have run both mills, but by the end of his life in 1892 most country mills were feeling severe competition from the large roller mills. All the machinery was removed from Cropthorne Mill which was sold off as a house.

About this time equipment was installed for cider making at Fladbury Mill, housed under an iron-framed loading bay on the south side. It appears that the mill was sometimes referred to as the cider mill in the years up to the Great War.

George Stephens became a County Councillor and promoted the building of the river bridge which replaced a deep ford between Fladbury and Cropthorne. This gave the village a through road, which together with the arrival of the railway some years before, made it possible for people with distant business interests to live in Fladbury.

One such person was L.H.Elkington, a chartered accountant with a Birmingham practice. By 1888 he was living at the Manor House, and in that year arranged with the Stephens family to take a supply of electrcity from the mill for his own house and two others in the village. Power must have been taken from one of the wheels since there was no turbine at that time. A statement to this effect by Mr. G.T.Stephens to the Evesham Journal in 1934 gives no further detail.

By 1899 it had been decided to establish a company to offer a supply to the whole village. It was called the Fladbury Electric Light & Power Co. Ltd. File No. BT31/16282/63942 at the Public Record Office gives details, as follows:-

Directors as at Jan. 1901:-

Elkington L.H.	Chartered Accountant	Fladbury
Deakin S.H.	Jeweller	Birmingham
Stephens A.L.	Miller	Charlton
Stephens T.	Miller	Cropthorne
Wagstaff	Gent.	Fladbury

By 1905 Elkington had resigned and the secretary was R.H.Abell of Abell & Smith, Electrical Engineers of Worcester. A total of 855 shares of £1 each had been taken up out of a nominal capital of £2,000, mostly subscribed by the directors and another local man, A.T.Hundy. The Company was wound up voluntarily in September 1927, following its sale to the S.W.S. Electric Supply Co. The plant installation was by Young's of Birmingham, a small but well-known firm of Engineers & Millwrights. Their quoted price was £860 which closely agrees with the paid-up capital so presumably they supplied everything including the electrical equipment and building work. According to the 1934 newspaper interview of G.T.Stephens, a further £300 was spent out of income on unspecified improvements which were intended to overcome operating problems.

Power was supplied only from one hour before sunset until 11p.m. and from 6.30 a.m. on winter mornings until daylight. There were seven street lamps for which the yearly charge for power was £1 each. Other users paid ten shillings per lamp. Lighting for a late night event required the agreement of the secretary and beer and sandwiches for the attendant. In later years the standard charge was increased to a system known as "A penny per night per light per haps"!

The power station consisted of two Armfield 40 inch "British Empire" turbines of the double discharge type. Each was rated at about 25 hp. at the full head of 6ft. 6in.

The waterwheel at the far end of the mill was removed and the pit widened to accomodate the two turbines on the downstream side of a bulkhead wall. They each drove a separate 3 inch cross shaft by mortice bevel gears. At light loads only one turbine was used, the other being available to drive the mill if required. At heavier loads, or if the head was reduced by flooding, the mill turbine could be clutched in to help drive the dynamo.

An iron shed over the turbine pit housed the hand control of the water, the dynamo and the switchgear. There was access from the mill, but after hours the attendant used a narrow plank bridge over the tailrace bolted to the downstream wall of the mill.

An article in Berrow's Worcester Journal in 1902 describes the original dynamo as being rated at 220 - 250 V, 80 A, over-compounded to allow for the drop in the 450 yards to the centre of the village. This of course assumed a constant speed, which in turn required an ever-watchful attendant. An occasional visitor to the power house in the 1917 - 1925 period has described the driving belt as less than 6 inches wide, which suggests that the actual load was well below the full 20 kW.

The intention was to maintain 220 V at the 'centre of distribution' in the village, served by underground cable. From there, overhead cables radiated to the houses at distances up to 180 yards, or a total of 630 yards from the power house.

In 1902 the village had a population of 425 and there were 280 lamps in all. The maximum capacity of the dynamo is given as 320 lamps, presumably assuming that all were switched on. Income is given as £120 instead of £140 as one might expect. Perhaps the shareholders were given a free supply. Working expenses, given as £70 per year, would at that time be for attendance only.

The dynamo in use in the early twenties was described by the same visitor as being about 3ft. diameter and resembling a radial aircraft engine. Presumably therefore, it was an open-type machine with four or six poles. Bearing in mind the £300, it might not have been the original one since it sounds rather sophisticated for an 1899 machine of that size. There was another, smaller, machine of similar design as a standby.

Consumers on a flat-rate charge would have no direct interest in saving electricity. Light bulbs were relatively expensive however, and no doubt it was soon found to be a bad idea to have a lot of lights on when a voltage surge occured.

An attendant sitting for hours beside a whining dynamo must have found it hard to remain always as alert as his directors might have wished. Local boys with not much to do would sometimes go and sit with him to talk or play draughts, so helping to keep him awake. This soon led to the thought that he could go for a 'quick one' at the pub three hundred yards away, leaving the boys in temporary charge. This was often entirely satisfactory to all concerned, but on occasion the boys could get confused, turn the wheel the wrong way, and quickly blow every lighted bulb in the village. There was plenty of time for them to scatter across the fields before Authority could get back from the pub.

After such events there was an inquest, in later years conducted by Mr. Abell. During one such investigation, about 1925, it was found that the turbine gate had partly broken away from its control rods, making it hard to operate. The repair with various wrought iron straps can still be seen. It must have been an unusual job to do, inside an opening in the brickwork about a yard square, seven feet below normal water level, and with the river held back by a make-shift stank at the weed rack. The weed rack itself was fortunately sound having been replaced in 1914 by draining the pound. By 1925 it may have been thought that the main sluices were best left undisturbed. They were eventually replaced in 1961 after one had given way and blown through.

The Electric Light Co., after paying the attendant and the various repairs, was barely profitable. The shareholders must have been thankful to sell out to S.W.S. Co. in 1927.

The electrical equipment, with its high copper content, was probably scrapped at that time, though the turbines remained in place and became rusted solid.

When the Company sold out, milling and cider making had almost ceased. The mill became disused and the staircase from the house was sold. During the war it was boarded-up and derelict, and in 1945 the remaining milling machinery was scrapped. From then until the early 50's it became a small factory, making toys and labels.

The old turbines were not removed until 1979 when the pit had to be rebuilt. The turbine normally used for electricity generation remains on site, while the other was given to Armley Mill Museum at Leeds. In their place a 1937 Gilkes plant of 12½ kW is being installed to run the house heating.

In considering the difficulties of the Fladbury Company it may seem unreasonable that no automatic control of voltage was provided. Nearly all contemporary schemes elsewhere, including one at Blockley, 15 miles away, needed to use batteries, since the possible peak demand was well above the available water power. With plenty of power at Fladbury except for brief flood periods, the high capital cost of a battery would seem an extravagant form of voltage control. Unfortunately, no satisfactory alternative existed in 1899.

On higher falls with no tailwater problem, a Thomson Vortex turbine with its inherent speed regulation would have been a good choice, but this very feature ensures that even a moderate reduction of head makes it impossible to maintain normal speed, even at very low output. For such a low fall as 6ft. 6in. it would also be very large and expensive compared to a mixed flow turbine.

Turbine governors of that period were too slow in action to be of much help. Voltage control by weakening the dynamo field was used from about 1920, but in 1899 the available dynamos required a strong field to prevent excessive sparking.

If nothing had been done until 1910, much better machinery would have been available. However, by that time, there was a closer prospect of competition from gas, and from large scale electricity systems which were beginning to grow. A small local scheme would probably then have appeared to have too short a life to be worth the risks. It is likely that if Elkington and his partners had not acted when they did, the village would have had no electricity until the twenties, as happened in many much larger places.

(See cover illustration)

WATERMILLS AND WATER-POWERED WORKS ON THE RIVER STOUR, WORCESTERSHIRE AND STAFFORDSHIRE

PART 2. WOLVERLEY AND KINVER

by MICHAEL V. COOKSLEY

INTRODUCTION

This is the second part of a series of articles, which will be published by various authors, to survey the water-powered sites of the River Stour. Part 1, Stourport and Kidderminster, has already been published in this Journal (1), and the sites and figures are numbered accordingly. The survey is a continuation of that carried out on the Belne and Wannerton Brooks in North Worcestershire (2) (3). As previously the aim is to establish the location, nature and history of each water-powered site and not to be a comprehensive survey of the industrial development. However, it is hoped that these surveys will provide a basis for a more detailed study of such development.

AREA

The area covered by this part of the survey comprises the two parishes of Wolverley in Worcestershire and Kinver in Staffordshire; both were in existence in Saxon times and their boundaries have been modified only slightly since. The parishes were included in the Domesday Survey of 1086, when there was one mill in Wolverley and two in Kinver. The area adjoins Kidderminster in the south and is contiguous with that covered in Part 1.

The river Stour enters Kinver from the east, and broadly where it turns south it is joined by the Smestow Brook flowing down a dominantly north-south valley. This major brook, with its tributaries, has many mill sites which will be treated separately. There are several minor streams which join the Stour in the survey area. The two longest flow from the west, whereas those from the east are very short; see Fig. 10.

These water courses provided the power for twelve definite water-mills and at least four possible mills. Although the sites may be a disappointment to the casual visitor there is a challenge for the more enquiring which will be very rewarding. There are several reasons for the dearth of physical remains. Some sites ceased to be mills at a very early date, i.e. by the 17th century. Others became industrial sites and their original lay-out considerably modified. Then these sites, with the exception of Cookley, have been abandoned. The only mill with any actual machinery, and the only water-wheel, is Sleepy Mill which has considerable remains of a corn mill.

Wolverley became attached to the Cathedral at Worcester and there are references to mills in the Cathedral archives. The settlement at Wolverley was actually on the Horseley Brook near its confluence with the Stour. Nearby on the Stour is Wolverley Upper Mill which is thought to be the site of the Domesday Mill.

Kinver is an ancient site with an iron age fort. The name itself is derived from Celtic origins. The present village was developed as a 13th century new town which probably explains why the church is on an isolated hill-top site overlooking the valley. Kinver was the centre of the Royal Forest of Kinver with its hunting lodge which later became Stourton Castle. It is possible that there was a Lord's mill near Stourton with the Town Mill near the present village, probably at the foot of Kinver Hill which leads up to the church.

In the parish of Wolverley there has long been a secondary settlement at Cookley. This has led to some confusion since the early iron mill at Cookley has

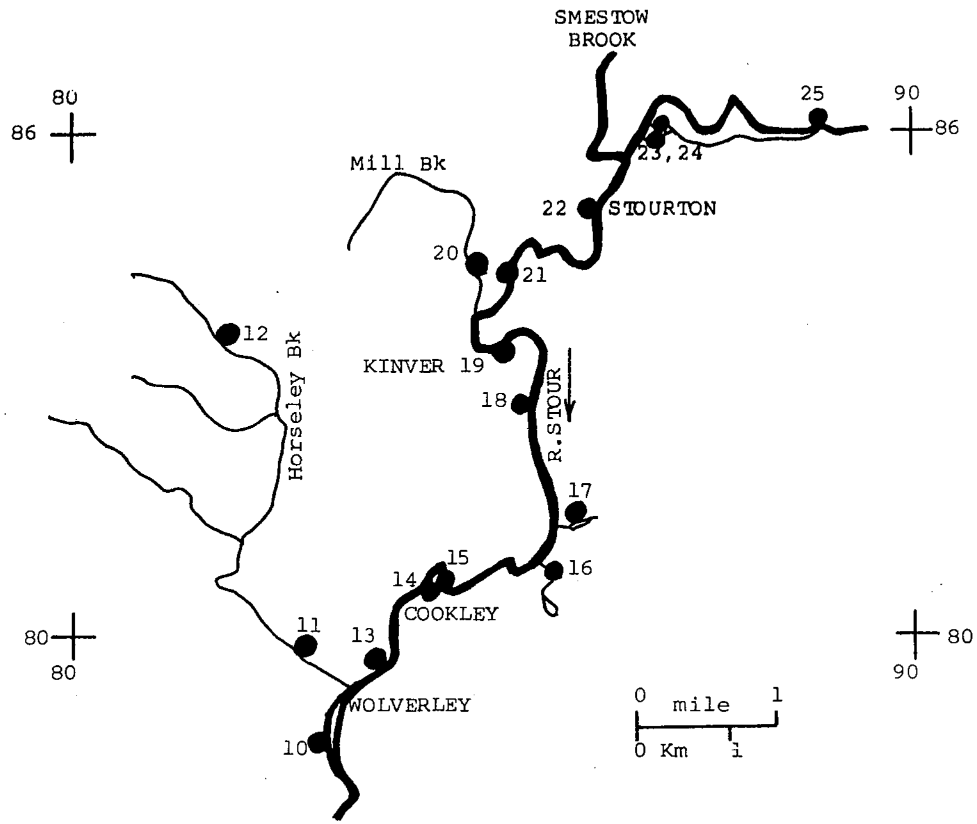


Fig.10. Mill sites in Wolverley and Kinver.

at times been referred to as being in Wolverley and become confused with Wolverley Upper Mill. At Cookley matters were further confused since there were two iron-working sites which were later combined to form a larger works which in part still survives. At Wolverley itself there was an Upper Mill and a Lower Mill and these are not always easy to distinguish.

The river falls 75 ft. or 23 metres over the two parishes. There were eleven mills on this section of the river but the two mills at Prestwood were operating from the same head of water. This might also apply to the two mills at Cookley. This would mean that nine heads of water were included within the fall of the river or about 8 ft. at the most for each mill. The fall at three mills is known:

Stourton	$6\frac{1}{2}$ ft.
Cookley	6 ft.
Upper Wolverley	7 ft.

These are in close agreement with what would be expected. The mills were mainly breast-shot where information on the type of wheel is available. At Stourton however larger undershot wheels 23 ft. in diameter were used. Prestwood wire-mill wheels were fed by a leat in order to riase the level sufficiently to enable the 17 ft. wheels to be overshot.

REFERENCES

As mentioned in the previous article on the River Stour, the papers of H.E.S. Simmons in the Science Museum Library, London, form the basis for this study, together with 18th century maps of Staffordshire and Worcestershire, Ordnance Survey Maps and 19th century Directories. Extensive notes and maps prepared by Mr. H.W.Gwilliam have been particularly helpful, and his courtesy in lending them is gratefully acknowledged.

The predominant industry was the iron industry. In the 17th century this was dominated by the Foley family, and to a lesser extent in the 18th century by the Knight family. Extensive records of both families have survived. The Foley records are mainly in the Hereford Record Office and the Knight papers are in the Kidderminster Public Library. Many other sources relating to the iron industry are also available which often refer to the iron works in the area under consideration.

This information has been in part collated:

B.L.C.Johnson,'The Charcoal Iron Industry of the Midlands',M.A.Thesis,Birmingham University (1950).

R.A.Lewis,'Two Partnerships of the Knights',Ph.D.Thesis,University of Birmingham (1949).

M.V.Cooksley,'The Iron Industry of Kinver' (1976),(typescript in Staffordshire Record Office(S.R.O.))

J.H.Parker-Oxspring,'Andrew Yarranton. Worcestershire Worthy 1619-1684',(1979), (MS in Worcestershire Record Office;also Microfilm MF104,S.R.O.)

INDUSTRY

The mills of this section of the River Stour continued the industrial emphasis previously described for the Stourport-Kidderminster area of the valley.

In medieval times corn mills were converted for use as fulling mills or iron mills. This was particularly noticeable for Wolverley where there were references to fulling mills in 1240 and 1253. Also iron from Wolverley formed part of the rent to the Cathedral at Worcester (4).

There is evidence from Kinver that in the 17th century the iron industry expanded as the textile industry of the area declined. Eventually most of the water-mill sites were involved with the iron industry.

This mid-section of the Stour became a specialized area for the slitting of iron. Bar iron was rolled to a thin section and then slit by rotary cutters into rods which were mainly used for nail manufacture. Although it was not the first actual slitting mill, the first commercially viable slitting mill to make an impact on the iron industry was set up at Hyde, Kinver, in 1627. This was owned by Richard Foley and operated by his brother-in-law Richard Brindley. Both men were linked with tales of industrial espionage in obtaining the secrets of the process from various European countries. Despite opposition by Clement Daubenny, who petitioned the King with a claim of a prior patent, and opposition by local landlords, the mill survived.

In 1633 there was an interesting Bill of Complaint to the Chancery Court in which it was claimed that John Whorwood had erected a slitting mill about 1625 and leased it to Sir Basil Brooke and Richard Foley. The places mentioned in the case suggest it was not the same mill as at Hyde. Nothing else about this mill has come to light so perhaps in this instance the local opposition was successful.

The need for rod for nail manufacture grew and other slitting mills were set up in the area. Probably the next was Cookley slitting mill for which a date of 1647 has been suggested. This was operated for the Myddleton family which had interests in the iron industry in Shropshire and North Wales. Wolverley Lower Mill was set up as a slitting mill in 1669. Other mills were later converted to slitting, starting with Stourton Forge in 1692. Kinver Mill was a corn mill which was converted about 1760. In 1776 the last large slitting mill was erected at Whittington to replace the forge. This was only just before the change to direct rolling of bars instead of slitting and the introduction of steam engines at the larger works.

In the late 18th century on this section of the river there were:

2 corn mills

2 forges

1 wire mill (two actual sites)
5 slitting mills

Four of the five slitting mills were in Kinver and one in Wolverley parish.

As mentioned above it is fortunate that many records concerned with iron works have survived and in some instances yearly accounts are available for periods as shown below:-

	(A)	(B)	(C)
Lower Wolverley	-	1692-1697	1792-1850
Upper Wolverley	1669-72	1692-1697	1726-1809
Cookley Slitting Mill	-	1692-1697	1726-1850
Cookley Forge	-	1692-1705	1726-1850
Whittington	1669-72	-	1726-1809
Hyde	1669-72	-	-
Stourton	-	1692-1705	-

A: Philip Foley
B: Ironworks in Partnership: (Foley)
C: Knight Partnerships

In reading the following account of the history of the sites it must be appreciated that it is very incomplete and therefore liable to be confusing; it is often not certain which site is concerned in a particular reference, and it is confusing that some references are concerned with landlords, some with lessees (who are often the industrial empire-builders), and some with the operators (who might be senior employees of the lessees).

The numbering of sites is consecutive with that of Part 1 of this article.

GAZETTEER

The mills which have been identified are as follows:-

10. Wolverley Lower Mill
11. Mill on Horseley Brook
12. Mill at Compton
13. Wolverley Upper Mill
14. Cookley Slitting Mill
15. Cookley Forge
16. Sleepy Mill
17. Mill at Caunsall Pool
18. Whittington Mill
19. Kinver Mill
20. Mill on Mill Brook
21. Hyde Mill
22. Stourton Mill
23. Prestwood Upper Mill
24. Prestwood Lower Mill
25. Bells Mill

10. Wolverley Lower Mill SO 828788

The development of this site began on 5th April 1669 when Joshua Newborough and Philip Foley bought three copy-hold meadows(5). There had been a corn-mill here, but it was now the site of a plating works where trials were carried out on tin plating. The process was developed by Andrew Yarranton with commercial backing by, among others, Philip Foley. The works was operated by Mr. Woolf. These trials continued until at least 1672(6). Besides the plating works there was also a slitting mill.

Later there was a slitting mill and a small forge at Lower Wolverley. The forge disappeared about 1736. The slitting mill was much more important. After several changes in the lease it formed part of the Ironworks in Partnership when this was formed in 1692. Aftter this the slitting mill was operated by Talbot Jewkes from 1703 until his bankruptcy in 1730. Stephen Podmore took over until it passed to John Podmore in 1736. Moses Harper operated the works from then until the Knight partnership acquired the mill in 1792(5). The Knight partnership still held the mill in 1810 when the company was reformed as John Knight and Company. The mill was converted to wire manufacture(5).

There are two water courses at this site, both with a considerable flow of water. In many instances it is difficult to decide which was the original river bed and which man-made. At this mill it seems likely that the course near the mill was the artificial channel. The site is most readily approached by a foot-path from the canal towpath. This crosses the river by a bridge and then after passing some disturbed ground which shows evidence of collapsed buildings, and perhaps another water course, crosses the leat by another bridge. Immediately on the left after this bridge is a building constructed of slag blocks but it is probably modern, using materials from an old building.

11. Mill on Horseley Brook Possibly SO 819803

This corn mill was established by John Fleming at Drakelow, near Cookley Wood, in 1482/3. The actual site has not been identified.(8).

12. Mill at Compton Possibly SO 814835

The upper reaches of the Horseley Brook cross from Wolverley into Kinver parish. This site is based on field names and no other evidence has yet been found(11).

13. Wolverley Upper Mill SO 834795

This has been suggested as the site of the Wolverley Domesday mill. At present there is no confirmation of its continued existence although in the Middle Ages there was a fulling mill and probably an iron mill within the parish of Wolverley(4). The first reference to this mill was as a forge about 1660 when it was operated by Henry Glover(6). In 1661 it was leased to Joshua Newborough by the executors of Robert Winchurch, with the agreement of Henry Glover. The forge was shown on a map dated 1662(9). The mill was transferred from Thomas Foley to Philip Foley in 1669 when it appears in Philip Foley's accounts as a partnership between him and Joshua Newborough. It remained in Foley hands but it is not known who operated it. The mill formed part of the Ironworks in Partnership when this was formed in 1692. The Foley control probably ceased when the accounts stopped in 1697. By 1727 it was held by Edward Knight and formed part of the Stour Valley Partnership which was to be dominated by the Knight family. This partnership was dissolved in 1810 and the forge was discontinued. The mill was used for corn milling and it was reported to be still operating in 1933.

In 1945 there was a breast shot wheel 14 feet by 6 feet(10). This was used to generate electricity for Woodfield House(25) and pump water to Wolverley Court(10).

The site lies close to Wolverley Forge Bridge over the canal. See Fig. 11. From the bridge two paths pass through the area and most of the remains can be seen from these. There is a wharf on the canal bank from which two tramway tunnels pass into the working area of the forge. The mill house is adjacent to the path which goes down to the river. Beyond this house are some cottages which have been converted into another house. The weir was next to the bridge over the river and part of this weir remains by the bank furthest from the forge. Beyond this again is another bridge over an overgrown spillway. The water intake was also near the bridge. Over the site are ruined buildings of various ages. There are several remnants of brick buildings, some sand-stone blocks and one retaining wall near the house is constructed of slag blocks.

14. Cookley Slitting Mill Probably SO 841805

This was probably set up as a corn mill in the 16th century(8). In 1647 the corn mill was converted for slitting iron by Mr. Winchurch of Abingdon(13). Two years later it was described as a corn mill and slitting mill owned by Sir Edward Sebright. The slitting mill formed part of the iron-industry empire of Sir Thomas Myddleton. It was shown on a map dated 1662 to be downstream from Cookley Forge(9). In Philip Foley's accounts it appears that Mr. Winchurch was slitting iron for the Foley organisation at 'Cookley Slitting Mill'(6).

In 1673 the mill formed part of the group of ironworks run by John Finch of Dudley(12). However in 1692 it was in the Foley-controlled Ironworks in

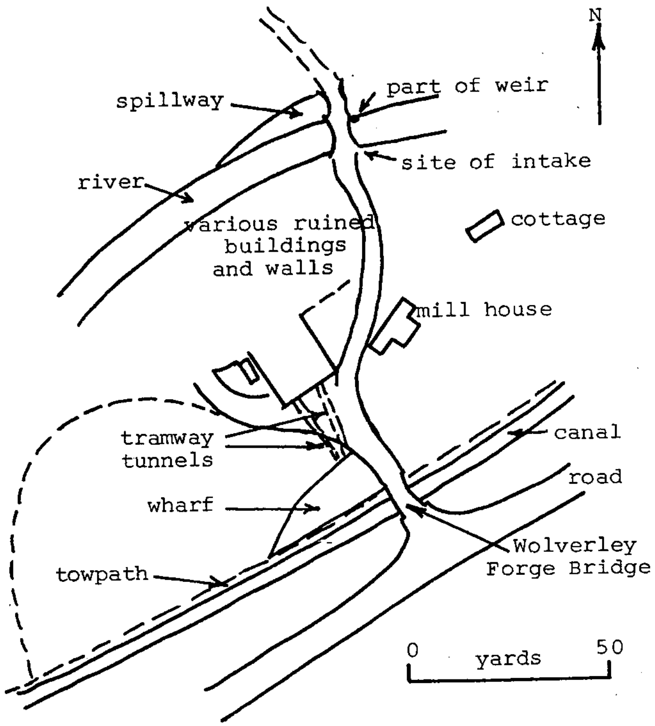


Fig.11. Wolverley Forge or Upper Mill.

Partnership. Soon after this slitting ceased at Cookley and when Richard Knight leased the works from Sebright in 1706/7 it was described as 'late slitting mill which was made a forge'. The forge however was small and by 1725 Knight had combined it with the other Cookley Forge and the works was usually referred to after that as Cookley Forges.

The site lies within the later Cookley Iron Works. A map dated 1884 shows part of the works as Debdale Forge and this is located in the area where this mill might have been sited(14).

15. Cookley Forge SO 841806

This site was a double corn mill which was leased for three lives to John Attwood. When this lease expired in 1656 Joshua Newborough established a forge(8). The forge was included in Yarranton's map of 1662. In 1673 it formed part of the ironworks group run by John Finch(12) and in 1692 was included in the Foley Ironworks in Partnership. It then passed to Richard Wheeler until his bankruptcy in 1703, and was next owned by Rebecca Smith. The Knight family took over in 1715/6. Under their control the works was combined with the nearby slitting mill. In 1754 it was reported that the mill had 6 feet head of water operating a wheel $8\frac{1}{2}$ feet in diameter(15).

After 1815 the production of tinplate became a speciality for which Cookley became famous(16).

Despite the advent of steam power and the enlargement of the works water power continued to be used. The works moved to Brierley Hill in 1885/6 and the site became derelict. However the works was reopened for various iron manufactures and has managed to survive.

The water wheels remained in use until 1910. The floodgates to control the supply to the wheels collapsed in 1952(16).

16. Sleepy Mill SO 855806

This mill was built by Samuel Jewkes in 1660 on Wolverley Heath(8), as a corn mill. It remained a corn mill until this century but a recent owner claimed that there were traces of iron working on the site.

Joseph Williams was the miller at least from 1854 to 1872 and was succeeded by Alfred Jennings at least from 1876 to 1908. The mill then ceased work. The mill house probably dates from about 1830 with some evidence of a building of about 1750.

The small brick-built three storey mill can be seen from the A449 just north of the Island Pool public house. It stands beside the drive up to the mill house. The mill is built into a bank behind which is a pool. It is complete but in a poor state. The overshot wheel is fed by a pentrough from the pool. The wheel is 14 ft. in diameter and 4 ft. 6 in. wide. The pit and spur wheel are cast iron. The main vertical shaft is wooden. There are two pairs of stones located on the first floor. Access is gained to the lower floor by a door at the drive level. Another door on the other side enters the building at the level of the top of the bank. From this middle floor a ricketty stair leads up to the top floor.

The water-supply was from a series of pools. At the edge of the garden to the right of the drive when entering the property are the remains of an over-grown leat. It has been suggested that the main pool, Island Pool, which is situated across the main road from the public house, was also the site of a mill, possibly associated with the 17th century iron industry.

17. Mill at Caunsall Pool SO 858812

This would appear to be an obvious mill site and was shown as such on Taylor's map of 1772, but no other documentary evidence has yet been forthcoming. Iron-working slag has been found on the site.

18. Whittington Mill SO 852825

This mill was on a manor, within the parish of Kinver, which was owned by the Grey family of Enville from the mid-15th century. The first record of a mill was in 1619 when a corn mill was converted to a forge by George Taylor(16). This was soon acquired by Richard Foley from whom it had passed by 1669 to Philip Foley. In 1692 it was included in the Ironworks in Partnership.

In 1705 the forge was acquired by Richard Knight who incorporated it in the group of ironworks which the Knight family came to dominate(5).

The site was converted to a slitting mill in 1771-1776, and a drawing exists of the arrangement, collected by Matthew Boulton and reproduced by Tann(28). There were two undershot wheels, one driving 'rollers' and the other driving 'slitters'. Adjacent to the mill at one corner was a 'House for packing the Slitted Iron'; at the other corner a 'House for holding the Shears and barrs of Iron'. Upstream were 'Furnaces for heating the Iron that is to be Slitted'.

The mill was relinquished by the Knight family in 1810 when the partnership was re-formed. The works was then operated by a partnership of Jacob Turner, Thomas Bolton and Thomas Shinton. In 1814 Thomas Shinton left the partnership(10).

The Turner interest continued until the sale in 1838 when Henry Turner was declared a lunatic. The works was then run by Hartshorne and Neale but they soon became bankrupt. The site was acquired by Benjamin and James Williams in 1840(17).

By 1851 there had been considerable alterations and a survey was carried out to decide what machinery belonged to the landlord and what belonged to B. and J. Williams. The 'brest' shot water wheel which had cast iron shrouds and wrought iron buckets belonged to the landlord(18). The ironworks had expanded with the use of steam engines and the installation of puddling furnaces.

The ironworks closed about 1884 and from then until 1892 the site was occupied by the Whittington Patent Horse Nail Company(17).

The site has been considerably tidied in recent years. A row of cottages on the Windsor Holloway has been converted into one dwelling and a warehouse on the canal bank converted into a house. The gardens of these two houses cover the rest of the area of the iron works. The water channel for the slitting mill can be seen in the garden of the converted warehouse where it forms a feature beneath an out-door swimming pool.

19. Kinver Mill SO 849833

Although a contender for the site of one of the Domesday Survey mills very little is known at present about the early history of this mill. It was a corn mill in 1754(15) which was a few years later converted to a slitting mill by George Stokes. George Stokes was bankrupt in 1812 and the mill was offered for sale by the Commission of Bankruptcy(10). The water supply to the mill was improved by Benjamin and George Stokes in the early 19th century by forming Sterrymoor Pool on the side stream called Mill Stream which enters the Stour at the upper end of Kinver village.

By 1820 this pool was known as Mr. Turner's Mill Pool(17) and Henry Turner's name is found in the church warden's accounts and in directories. The church warden's accounts list the property as empty in 1838 and 1839(17). The mill itself was run by T.M.Woodyatt, who from September 1840 to May 1841 was dealing with Turtons of Kidderminster regarding a new water wheel and shaft. The installation was completed on 19 May. The wheel was breast-shot, 10 ft. diameter by 15 ft. wide, with four sets of four arms dividing into three sections, each with 32 floats(29). The premises were used by T.M.Woodyatt as a screw manufactury and there are references in various directories from 1845 to 1860. After his death his executors sold the business to Nettlefold and Chamberlain (forerunners of GKN) who closed the works(17). The next few years are confused with little help from directories until in 1888 when Joel Siddaway was making spades and shovels there. He was followed by J. Mills and Son, and then in 1896 by Thomas Timmings. After 1912 the Timmings family gave up the works and the site became a saw mill.

A building remains at Kinver Mill but the water courses have been filled in and no machinery has survived.

20. Mill on Mill Brook SO 844844

Between Kinver Mill and Hyde Mill a stream joins the Stour from the west which is called Mill Brook. The name may be an association with Kinver Mill. However, where the lane which is sometimes known as Hyde Gate crosses this stream field names would indicate the site of a mill(11), although even in 1629 there was no mention of a mill in documents relating to the site.

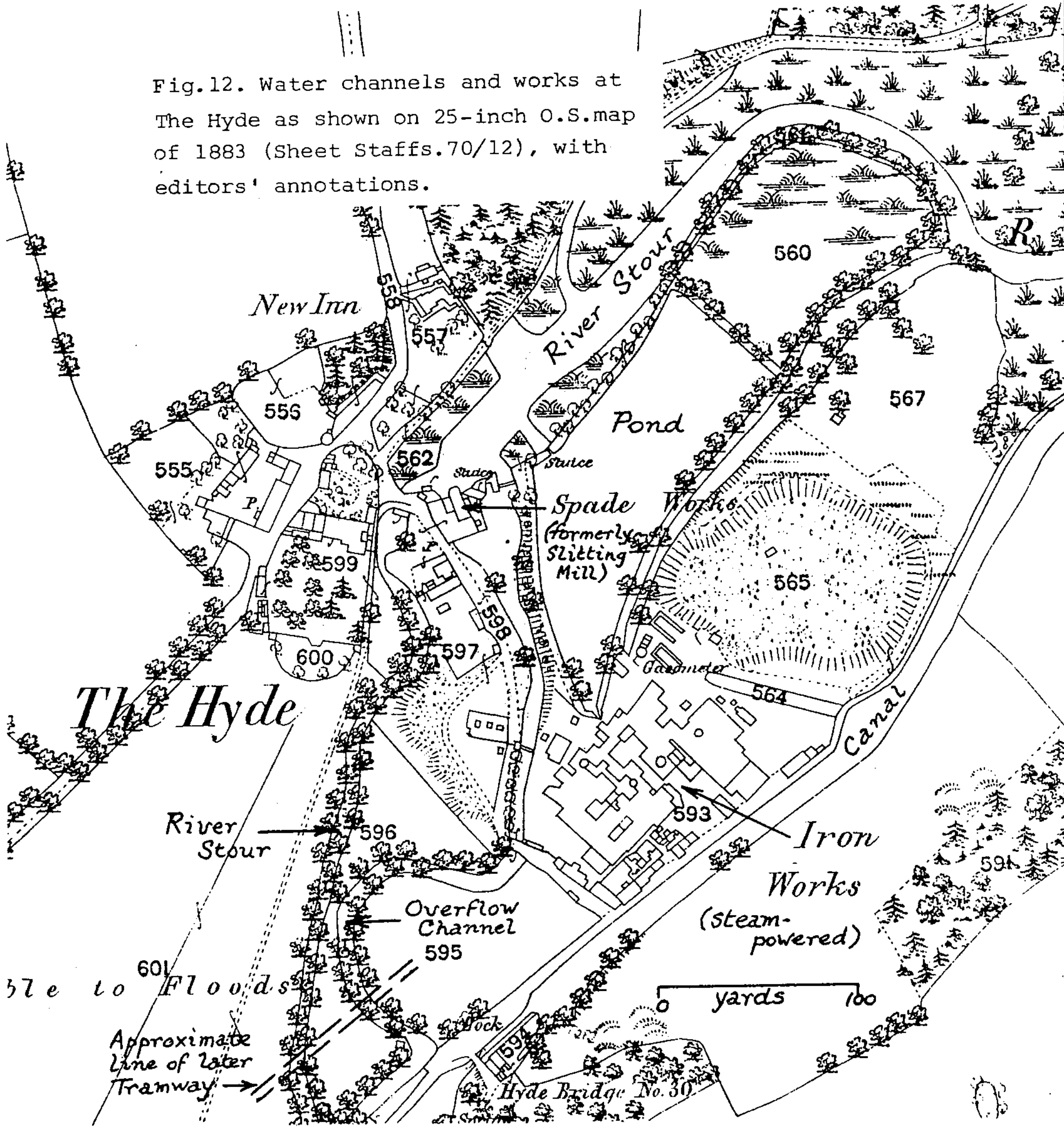
21. Hyde Mill SO 860845

This is believed to be a corn mill which was converted to a fulling mill about 1580. The first definite reference is the conversion to a slitting mill in 1627 by Richard Foley when the mill was occupied by his brother-in-law Richard Brindley(19).

The mill was sold to Richard Brindley in 1647 and remained in the hands of various members of the family until John Brindley became bankrupt in 1730. When the various legal matters had been resolved George Draper was in charge of the slitting mill. In 1736 it was sold to Jeremiah Caswell. After his death in 1769 the mill was run by his daughter Eleanor Caswell, who later married the vicar of Kinver, Rev. Paul White. Soon after this the Homfray family took an interest and the partnership of Messrs. White and Homfray was formed. Later when this partnership was dissolved Francis Homfray took over and extended the works by building a new works in 1789 with a steam operated hammer forge.

This works was extended in 1831 and over the next forty years became the largest ironworks in this area with 20 puddling furnaces and two steel furnaces. There is a sluice gate in the corner of the ponds nearest the site of the steam works. It would have been quite feasible to make the head of water operate a wheel or turbine but there is no documentary evidence that this was used. It is

Fig.12. Water channels and works at The Hyde as shown on 25-inch O.S.map of 1883 (Sheet Staffs.70/12), with editors' annotations.



probable that the sluice gate was for a water-supply to the works.

In the 20th century an electric tramway was constructed to Kinver from Stourbridge. This passed through the site of the steam works and much slag was used to build the track. A depot was built at the Hyde and there are some remains in the woods. Where the tramway crossed the river there are rails still in situ in two places.

The water mill still continued but by 1828 was a corn mill and a spade mill under one roof. This part of the works was run by various members of the Parkes family until about 1865. The operators over the next few years are uncertain. The buildings and arrangements of the whole site are shown on the 1st. edition 25-inch O.S. map of 1883, reproduced with annotations in Fig. 12. About 1888 Thomas Nash and Sons were running the mill. It was about this time that the larger iron works closed and by 1897 the site had been levelled. The water-driven works outlived its neighbour and finally closed about 1912. Since then the site has become derelict and very overgrown. The outline of a building can be traced with two water courses passing through it. The weir was beneath the bridge over the river next to the mill site. The original bridge was destroyed in a flood in 1942. Beside the mill building is a spillway for the surplus water. In view of the importance of the site (see the section on industry) it should be examined carefully and possibly archaeologically excavated.

22. Stourton Mill SO 860850

The first reference to this site is a lease dated 1669 from Wortley Whorwood to John Finch of three grist mills with the liberty to convert them to an iron furnace or forges. In 1673 John Finch relinquished his lease of the forge which had been erected and took over Wolverley Forge. Philip Foley acquired Stourton Forge and sub-let it to various tenants until in 1692 it formed part of the Ironworks in Partnership(12).

The forge was converted to a slitting mill in 1698 when Thomas Cook was the head workman. The ownership of the mill passed to the Cook family who remained at the mill until 1762 when it passed to Richard Marston. In 1754 Charles Wood visited the mill and commented that it had $6\frac{1}{2}$ feet head of water(15).

The mill was offered for sale in 1779(10) and by 1782 was occupied by Francis Homfray (senior). In his diary for 1792 he recorded that the mill had a head of 6 ft. 10 in. and 3 ft. fall. Also he compared the cost of slitting with the new process of rolling rods which his son had installed at Hyde Mill. As a result he set up Stourton Mill for rolling and the slitting equipment was moved to Gothersley Mill on the Smestow Brook(19).

Francis was followed by Jeston Homfray but rod making ceased early in the 19th century. The two water wheels were offered for sale in 1829. They were undershot wheels 23 ft. diameter, 3 ft. 9 in. wide with cast iron rings and naves and wrought iron floats or ladles and struts, and cast iron shafts(20).

The site was cleared soon after and now forms part of the garden of Stourton Castle.

23 & 24 Prestwood Wire Mills SO 866859 and 868861

These mills were unusual for the Stour valley because there are leats of considerable length which supplied the water to the mills. The mills are thought to have been erected about 1720(21). The first actual reference is in 1752 when a reward was offered for information concerning thefts of iron from the mills(22). An indication of their existence before this was the examinations by the Church-wardens in 1741 of two wire-workers who had moved to Kinver.

In 1759 John Ryland, Joseph Smith and John Kettle took a 21-year lease of the mills from John Webster(23). Little else is known about the wire mills until the water wheels were offered for sale in 1829(20), as follows:-

Tongs Mill: overshot wheel 16 feet diameter and 9 feet wide.

Lower or Block Mill: overshot wheel $17\frac{1}{2}$ feet diameter and 4 feet 6 inches wide.

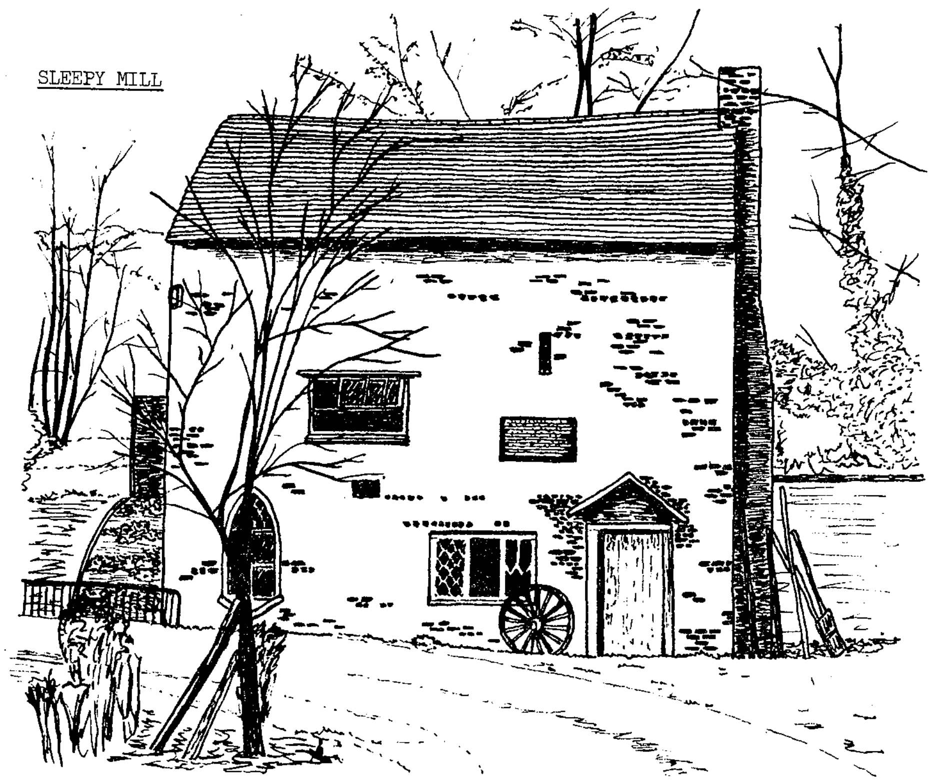
The mill leat was later reused for a hydro-electric scheme for Prestwood Hall. In part the leat is still in good condition.

25. Bells Mill SO 882859

On the boundary between Stourbridge and Kinver is Bells Mill. This mill was shown on 18th century maps(26), (27), but by 1832 (24) was stated to have been taken down. However at the site there is an apparent mill which takes the form of two cottages and an out-house on a piece of land jutting out into the river. This is connected to the opposite bank by a bridge under which passes most of the river flow. Some water also passes through a channel approximately under the out-house. The present occupier of the site has tried to discover details about the structure but the only information obtained was that it was Foley-owned. The area immediately up-river appears to be a dried-up mill pool. On the river bank opposite the 'mill' is a sluice gate which would regulate the water flow into the channel which is the beginning of the Prestwood Mills leat. The first hundred yards or so of the river and leat are approximately straight and parallel. At this point on the river there is a weir with brick built abutments on both banks. There is on the opposite bank to the leat the dried-up former bed of the river which would have met the present river just below the weir. The river then commences to meander.

One of the 18th century maps(27) indicates that the Prestwood Mills leat left the main river above Bells Mill. If this is accurate this would suggest that the original Bells Mill was at the site of the weir and that the leat to the mill has been dug out to form the present straightened river bed. The part which has not been cut away now forms the piece of land on which another mill was erected at a later date. There is of course considerable speculation in this interpretation of the site and its relationship to the leat of Prestwood Mills.

SLEEPY MILL



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THE TEMPLE FARM WHEEL, TEMPLE BALSALL, WEST MIDLANDS

by MIKE PITKIN

The various Warwickshire estates given over to the Templars in the 12th century have been calculated to have totalled some 8,000 acres, much of the land falling within the old Forest of Arden. One such estate was Temple Balsall. As the headquarters for the whole of the Templars estates in the county, the Preceptor at Temple Balsall was responsible for the day to day running of all the farms.

In 1308, when the Templars at Balsall were arrested, an inventory carried out listed the domestic buildings as 'the Hall, the Preceptor's room built onto it, a pantry, buttery, kitchen, larder, bakehouse, brewhouse and dovehouse'. No mention was made of the farm buildings except for a mill which 'urgently needed two new mill stones and a new roof'. The precise location of the mill is unknown but several possible sites have been identified on the adjacent River Blythe and it is always possible that several mills have been constructed over the years (watermills of timber construction were notoriously liable to being swept away by flood waters!) One of the meadows, just north of the Old Hall, is perhaps further evidence of its location, being named on a survey of 1759 as 'Mill Meadow'.

At the time of the dissolution of the monasteries, Temple Balsall, being the property of an ecclesiastical establishment, was surveyed by Henry VIII's Commissioners. Their report included considerable detail of the Hall and farm buildings but no mention of a mill.

After 1674 the estate began to be administered by the Trustees to what was by then the Lady Katherine Leveson estate. Only a small area of the estate, some 72 acres, containing the Hospital, church and immediate surroundings together with various areas of woodland was directly controlled. The remainder was leased, there being seven different tenants by 1759.

None of the current buildings on the Home Farm existed before 1740. The present Temple House was built in this year and it seems likely the buildings referenced A and B on Fig. 1. were constructed at about this time. Building A, more recently referred to as the 'Butler's House', is also known to have been built from bricks salvaged during the partial demolition of the Old Hall in the late 1730's. The barns were rebuilt over their original foundations in 1755.

The barn to the south west of the courtyard was still largely intact in 1983 and reflected the character of the structure as originally built. It followed the typical pattern of barn construction with the threshing floor centrally located between opposed large double doors. All of the other buildings around the courtyard had been so modified over the years as to make identification of their original purpose, by site inspection, very difficult. It would seem likely from their description in the Governors' Order Books, however, that thery were at the outset mostly used as barns.

Subsequently the courtyard was completely enclosed and a cattle hood erected. Further buildings were erected to form lower courtyards. A second hood was erected on one of these (though it is not certain which) in 1840.

In 1851 the Governors 'ordered that Mr. Couchman prepare a plan and estimate of a water wheel and alterations he applies to have made at the Temple Homestead' and in the following year 'ordered that the plan and estimate of water wheel and the alterations shown us by C. Couchman and signed by us to be carried out, the amount not to exceed six hundred and ten pounds, seventeen shillings'. Mr. Couchman was an important, go-ahead land agent of the period, leasing or managing estates in several counties. He tenanted Temple Balsall until 1887 and was certainly responsible for instigating the building of the farm wheel at a time when such installations were 'fashionable' improvements in the Victorian era of agricultural expansion.

Fig. 1. Temple Farm in 1886.

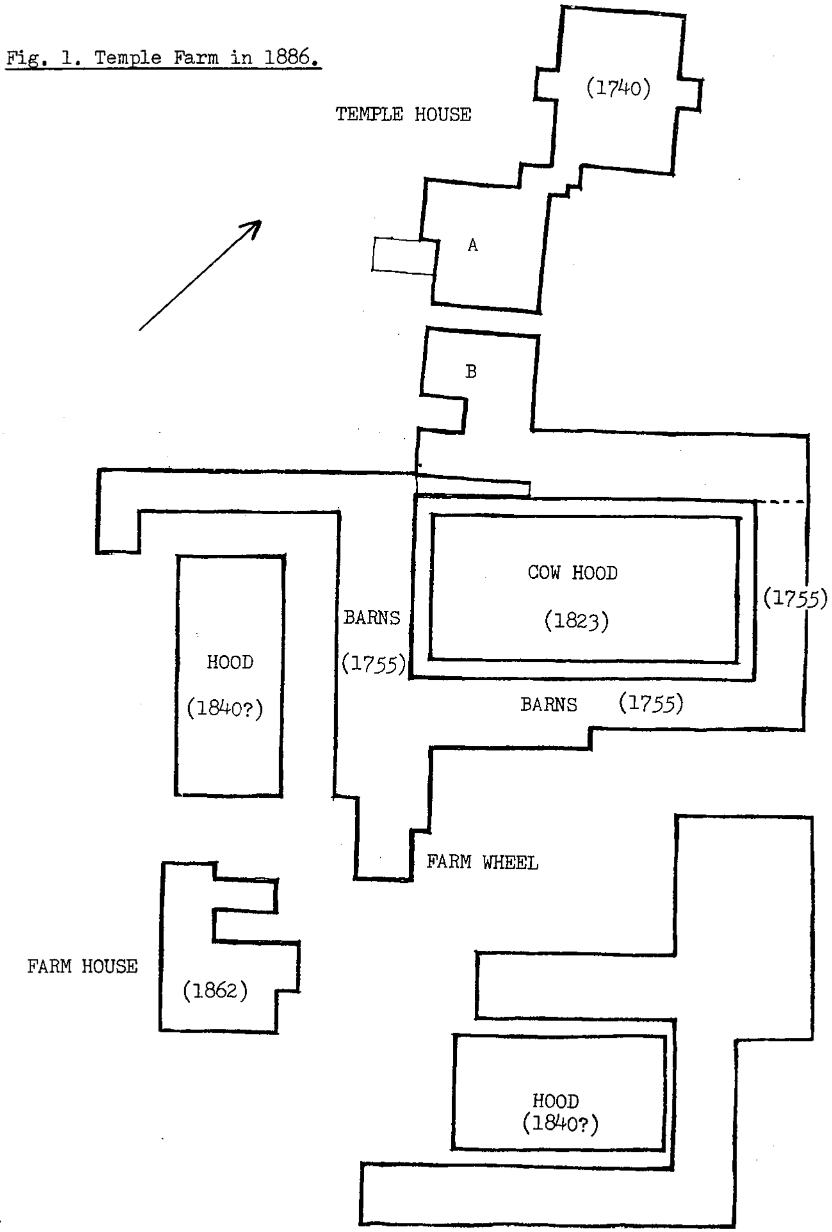
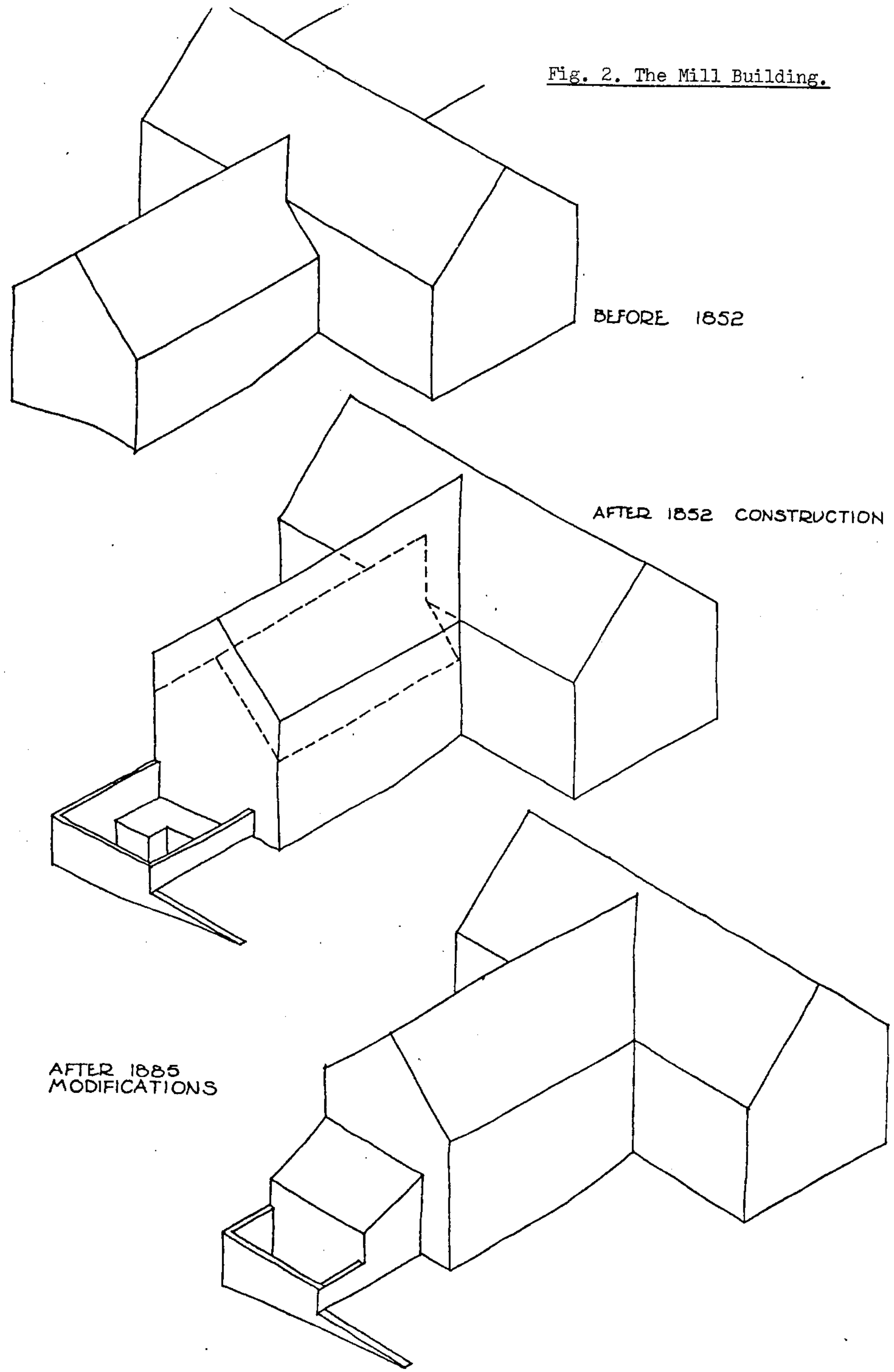


Fig. 2. The Mill Building.



The siting of the wheel is somewhat unusual. Obviously to make full and proper use of the water power it was necessary to locate the wheel near to the existing barns where, presumably, some hand operated machines were already in use. Unfortunately this location was some considerable height above the nearest supply of running water, a small tributary of the river Blythe. There were, however, the remains of a mediaeval fish pond about 100 yards to the north east of the proposed siting. The contents of the pool would provide an adequate flow of water for only a very short period and in order to replenish this supply a feeder stream was accurately cut to follow the existing land contours for a distance of about 1 mile back to the previously referred to tributary. A 3ft. wide culvert carried the water supply from the pool below the yard to a bolted up cast iron pentrough which terminated in a double sluice arrangement above the wheel. The first sluice was a means by which the flow of water could be entirely cut off, the second controlled by pulleys and an endless wire from the first floor inside the building achieving a 'fine tune' on the flow, presumably in order to run at the most efficient speed compatible with the machinery being operated. The cast iron face to the pentrough carries the wording 'W.G.MASSEY - NEWPORT - SALOP' and it is likely that this company was responsible for the original installation. This comment is made advisedly since in addition to being millwrights Masseys were important iron and brass founders who may well have supplied castings to other millwrights. The wheel itself is pitchback 18ft. in diameter and 3ft. 4in. wide and constructed from bolted up castings with 64 wrought iron buckets. The tail race from the wheel pit also ran below ground to a drainage ditch which eventually entered the stream from which the supply originated.

The mill building appears to have had something of a chequered history, having suffered considerable alterations over a period of years. Although it does not appear on the 1759 survey, it was certainly built as a single storey structure sometime before the installation of the wheel, presumably for some use ancillary to the barn to which it was attached. Differences in the size and type of brick, the infilling of original windows and door openings and indications that the first floor beams were inserted through enlarged holes in the original walls, would seem to suggest a sequence of building operations along the lines indicated in Fig. 2. The upper part of the building and the wheel pit were constructed as part of the original wheel contract. The roof trusses could well date from a much earlier period than the 1850's but it is possible that these were simply lifted from the original building and repositioned after the construction of the upper brickwork. A further indication of the building's unsuitable origin is found in the fact that the walls are of single brick thickness only. Although this is not unique, mill buildings were more normally constructed of heavier masonry in order to counteract the vibrations set up by the turning of the wheel.

The gearing is all of iron and is something of a hybrid, being neither of the more normal 'spur' or 'lineshaft' arrangements. In order therefore to understand its operation, the reader's attention is drawn to the schematic drawing Fig. 3 which has been cross referenced to the text. The drive from the water wheel A was transmitted through a cast iron shaft of cruciform section to a two piece pitwheel B some 8ft. in diameter. This in turn drove a 2ft. 4in. diameter wallower C mounted on an upright shaft, also of cruciform section, which brought the drive up to ground level and a bevelled crown wheel D 4ft. in diameter fitted with wooden teeth. A 2ft. 6in. diameter bevelled gear E meshing with the crown wheel and mounted on the end of the main underground shaft No.1 took the drive into the mill building and beyond into the barns. Moving along this shaft in sequence, and starting from the cogpit, was located a pulley F which has been variously described as a means of bringing in auxiliary power and as a drive to some machinery standing in the yard. Mr. Charles Watts, a gardener on the estate from 1910, can recall a saw out in the yard being driven by the water wheel and so maybe the latter of the two alternatives is the more likely. (There is, of course, no reason to preclude the possibility of both situations having occurred over the years.)

Inside the mill wall a 5ft. diameter spur gear G meshed with a 2ft. 6in.

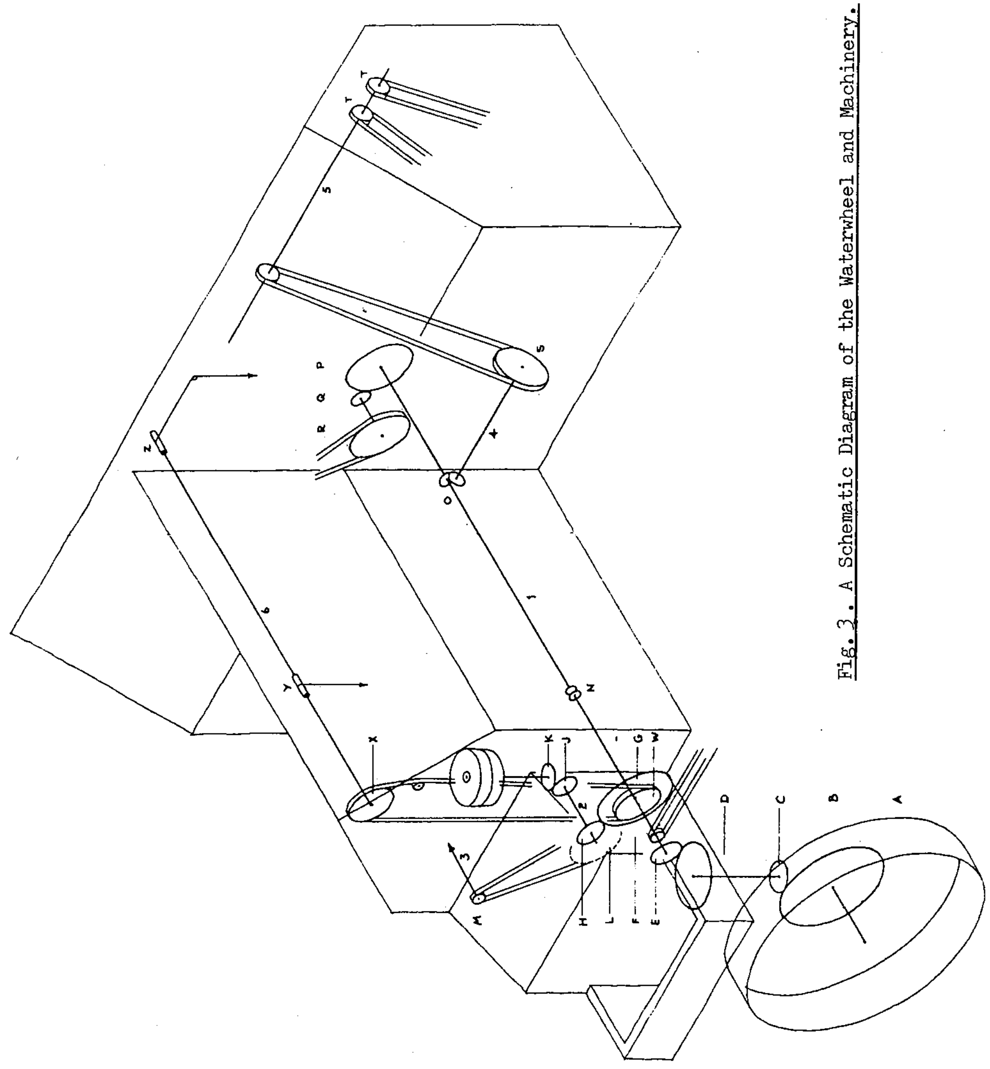


Fig. 3. A Schematic Diagram of the Waterwheel and Machinery.

diameter pinion H on a second horizontal shaft 2. This shaft terminated at its inside end with a 2ft. 6in. bevelled gear J which drove the stone nut K to a single pair of 4ft. diameter Peak stones which were probably originally mounted above a wooden hursting. The stones were used to produce animal feeds. Its other termination, back in the cogpit, held a pulley L 4ft. 6in. in diameter which in turn drove a pulley M at first floor level and a short shaft 3 which returned inside the mill. In a conventional flour mill this drive would probably have operated a dresser, but no such machinery was required for the preparation of animal feeds. It is likely, therefore, that the coupling plate was attached to a piece of equipment such as a corn bruiser or an oat roller or, just conceivably, a winnowing machine.

Returning to the first shaft, the next piece of equipment in the train was a dog clutch N capable of isolating all subsequently referred to underground shafting, then through a series of connecting plates and plummer blocks into the barn to a pair of bevelled gears O which divided the drive. The 'in line' shaft continued to the opposite barn wall and a pit which contained a series of spur gear P, pinion Q and pulley R which powered the threshing machine. A great number of these machines had been developed since the original produced by Andrew Meikel in 1786 and at the time of the Temple Balsall installation many proprietary types were available. Mr. Burman, a former tenant of the farm, has recollections of the machine being a 'Ransome' but the yard foreman, a Mr. Norman Townsend, who was instrumental in its demolition remembers it as a 'Fisher Humphries'. The latter of the two was particularly popular in the area. The shafts onto which the spur gear and pinion were keyed, extended through wall boxes into a wheel pit in the adjacent barn, but there is no evidence to suggest that anything was ever mounted upon them. Tracing back to the pair of bevels O, a further underground shaft 4 extended some 12ft. at right angles to the main shaft, to a pit with a 3ft. 8in. diameter pulley S which transmitted drive through the first floor structure of the barn to an overhead shaft 5 running the length of the building at wallplate level. Various pulleys T mounted on this overhead shaft would have been utilised to drive the barn machinery at ground and first floor levels. Around 1910 a mangel pulper was known to be in use on the ground floor and a chaff cutter on the first floor. The same set-up still existed in the 1930's and 1940's when, in addition, various portable devices were also driven.

It is possible that the secondary train from the bevel gears O onwards was not constructed as part of the original installation. A reference to repair work carried out by R. Summers in 1878/1879 included 'new shafting' which could possibly have been this entire section or alternatively, it could equally well have referred to an addition to the high level shafting 5 only (no separate description or costing was included in the reference). Either is equally possible. The bevel on the 'in line' shaft is a two piece casting which could have been easily attached with a minimum of disruption, whilst different patterns of pulley on the high level shaft 5 could possibly indicate different dates of installation. The fact that a bricklayer was employed to assist 'engineer Summers' would seem to favour the first of the alternatives, for his services would have been required to construct the brickwork floor duct and pulley pit.

In 1881 it became necessary for the culvert from the water wheel pit to be relayed and three years later R. Summers was asked to prepare a report on the condition of the mill installation. The report obviously indicated that several repairs and modifications were either necessary or desirable, and in addition a recommendation was made to incorporate shafting to drive two sack hoists. In the following year the recommendations were implemented. A replacement wallower C and crown wheel D were hung from the upright shaft which was shortened and supported on a modified form of carriage bearing. A new cast iron girder was also installed with adjustable bearings to pick up the top of the upright shaft and the outer end of the underground shaft 1, a new pinion E was also substituted for the existing. The original timber hurst was removed and a new cast iron unit put in its place. The design is typical of many installed by Summers, particularly the forked columns and the iron pan which both supported and levelled the bed-stone. The completely new work included the setting up of an additional high

level shaft to operate the two proposed sack hoists through a 'slack belt' mechanism. The drive originated from a pulley W 3ft. in diameter which, mounted on the main underground shaft 1, drove a similar pulley X located in the apex of the mill roof. This rotated when the drive belt was tensioned by a sideways movement of the intermediate jockey pulley induced by a pull on the metal control arm. Pulley X was fixed to one end of the horizontal shaft 6 which ran along the ridge of the mill and into the barn. Sack hoist drums Y and Z were mounted on this shaft, the first above the trap doors adjacent to the hurst and the second above the threshing machine. A wooden rope/chain guide and a small pulley displaced the lifting point horizontally to operate the hoist above the trap door in the barn.

Summers' continued to do the almost annual repairs to the mill up to 1893, when another firm of millwrights, J. Hands and Company took over. A fractured shaft was replaced in 1893, a new floodgate fitted in 1902 and a second replacement shaft installed in 1917, but with these exceptions, repairs otherwise seemed to be of a minor nature. Repair work was taken over in 1925 by Ball Brothers until the last recorded work was carried out in 1932. The wheel appears to have carried on, without further formal maintenance, until about 1945 or 1946 when it was closed down because of the flooding it was creating on the nearby Lodge Farm.

After this time a tractor was hitched to the barn shafting to drive the various fixed and portable equipment then in use.

Eventually the whole system fell out of use and the barns and mill buildings became part store sheds and part dumping area for unwanted equipment. Farming activities were now concentrated around the lower courtyard E on Fig. 1.

The fate of the older buildings including the farm wheel was now in some doubt. After a proposal for housing development using these barns and the mill as a 'community centre' had been rejected it was ultimately decided to demolish them, despite their listing as buildings of architectural interest. They were offered to the Avoncroft Museum of Buildings in 1983, but moving all the barns would have been a financial impossibility and it was decided to save just the water wheel, gearing and shafting, plus the mill building. This will be re-erected at Avoncroft when time and funds allow - saving a unique piece of Victorian ingenuity. It is, however, regrettable that it will no longer be seen in the context of its original setting and purpose adjoining those fine 18th century barns which have already been swept away.

THE DRESSING OF MILLSTONES: ENGLISH PRACTICE AS DESCRIBED BY BRYAN CORCORAN IN 1882

Introductory Note

On 23 September 1882 the London Lodge of the Amalgamated Millers Trade Society held a meeting in London, the purpose of which was to hear a paper by Mr. Bryan Corcoran entitled 'On Modern Milling'; over 200 people attended and provided a very full discussion of the paper. All of the proceedings was published in The Miller of 2 October 1882, pp.609-616, together with diagrams provided by Mr. Corcoran. In his paper, Mr. Corcoran had a section on the use and dressing of millstones, and it is this which is reproduced below, subject to some editorial abridgement and selection, and re-drawing of his diagrams.

The Bryan Corcoran who gave the paper represented the third generation of Corcorans in the business of maunfacturing millstones. His father, also Bryan, had taken over his father's business at some time in the first half of the nineteenth century and traded as Bryan Corcoran & Co. at various offices in Mark Lane, London, until taking a partner Mr. Witt around 1870 when the firm became Corcoran, Witt & Co. Around 1885 this firm was claiming to have been 'established over a century', but no longer had a Corcoran in it; Bryan Corcoran senior had left it in 1875 and set up on his own for a short period before either retiring or dying, and his son Bryan Corcoran junior (who was the lecturer at the meeting in 1882) had set up his own firm of millstone makers, also in Mark Lane, around 1875. So the author of this paper had a background which should certainly have established him as a leading authority in the subject of millstones, and he was introduced as such to the meeting.

The whole of the paper and the discussion is recommended reading, but the section reproduced here is of particular interest because it answers questions about millstone dress which have caused some confusion among present-day mill enthusiasts, in particular that relating to the direction of rotation of the stones relative to the sharp edge of the furrows and the so-called 'scissors' action. It may have been Sir William Fairbairn who first introduced the scissors idea in his 'Treatise on Mills and Millwork' in 1865. On p.154 of Part 2 he says:

> 'The direction of the grooves (i.e. furrows) being the same in both upper and lower stones, as they lie on their backs in the position proper for being cut, it is obvious that, when the former is reversed and set in motion, their sharp edges will meet each other after the manner of a pair of scissors, and thus grind the corn more effectually when it is subjected to the action of the unbroken surfaces between the channels.'

This suggests a direction of rotation, relative to the sharp edges of the furrows, opposite to that shown so clearly by Bryan Corcoran. Millers with whom I have discussed the matter all agree with Corcoran, and the scissors concept is probably misleading.

D.G.T.

'DRESSING STONES

It is necessary that the faces of the millstones should be perfectly true planes, and I believe that if they are so, and the runner properly balanced, it is almost an impossibility to kill the flour, and at the same time make broad

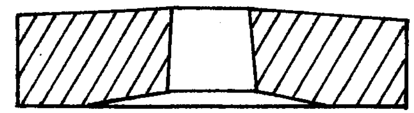


Fig. 1

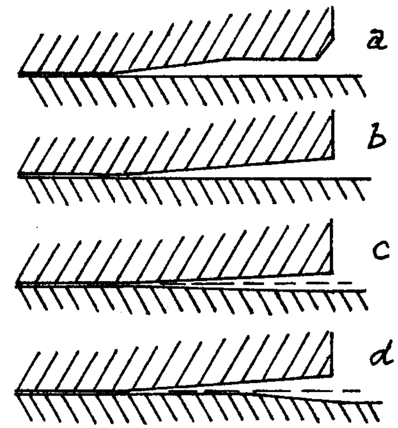


Fig. 2

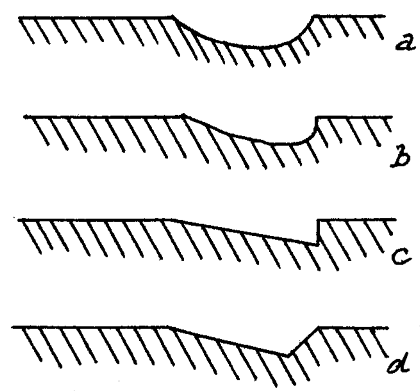


Fig. 3

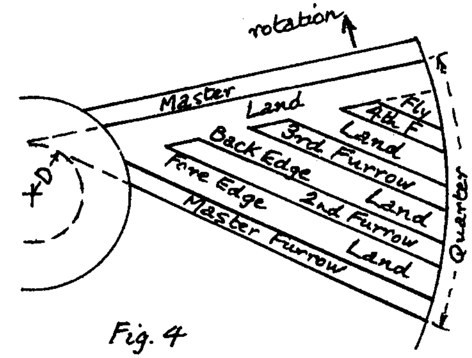


Fig. 4

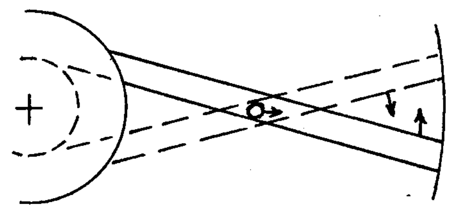


Fig. 5

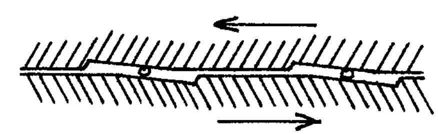


Fig. 6

bran. The eye of the runner (see Fig.1) should be smaller at the back, tapering to a larger diameter at the face, especially for middlings, &c., which do not feed so freely as wheat.

The SWALLOW, or bosom (again see Fig.1), may be of various shapes to roll the wheat over and over with light pressure, to reduce it all to an even size, or, as in the case of gradual reduction, to bring the whole feed gradually from wheat to flour, or any intermediate stage, &c.; but whatever the shape, it should be as true as though turned in a lathe, otherwise it will cause an irregular reduction of the wheat. I advise that the bedstone be a plane or staff right up to the eye (as shown in Fig.2a where a cross-section of the swallow is shown, with the eye at the right-hand side of the diagram; alternatively as in Fig.2b), unless it is found advantageous to have a different gradient in one stone or the other (Fig.2d). I think it is better to have all that is necessary in the runner, as it is easier to keep one swallow true than two (Fig.2c). The depth may vary according to circumstances, but where it has to touch the wheat, one-eighth of an inch at the eye is usually ample.

FURROWS, whatever their shape, should be true, and the greater the care with which they are made and kept, the less deep they need to be. Many shapes are advocated, such as those shown in Fig.3. I see no advantage in the first (Fig.3a); the second (Fig.3b) is not easily made; the third (Fig.3c) houses dead feed, and in making the square back edge, the face is very apt to be chipped, and make greys in the flour; the fourth (Fig.3d) is what I always make and recommend.

DRIFT is the eccentricity of the furrows, or the direction in which they lie; it is reckoned by the distance of the fore edge before the centre of the stone. In the ordinary dress the stone is equally divided into 'quarters' or 'harps'. The sketch (Fig.4) shows one 'quarter' of a 4-ft. stone with $3\frac{1}{2}$-in. drift (marked D in the sketch), 10 quarters, four furrows $1\frac{1}{8}$ in., lands $1\frac{3}{4}$ in., and fly $2\frac{1}{8}$ in. to run 'right-handed', or 'with the sun'; all the furrows are parallel and parallel to each other. The drift regulates the sweeping action of the furrows. The diagram of Fig.5 represents a master furrow of runner and bedstone crossing each other, and a grain of wheat travelling down in the furrows; the arrows show the direction in which the stones travel and the way the wheat is swept.

A grain of wheat does not actually travel down the furrows as shown above, but entering a furrow is caught and passed between the lands as shown in Fig.6, till relieved by the next furrows, and caught by the next lands, gaining impetus to travel towards the skirt from the rotating runner, and thus continuing its journey till it gets out in a state of reduction according to the setting of the stones, dress, &c.'

THE MAKING AND DRESSING OF FRENCH-BURR MILLSTONES IN FRANCE IN 1903

Translation and commentary by OWEN H. WARD

Between 1838 and the end of the nineteenth century there was a spate of publication, probably with restricted circulation, of French books and treatises on the practice of milling in that country; often included were advice or directions on the preparation, selection and maintenance of the "heart of the mill", the millstones. Naturally the traditional French millstone from such places as la Ferté sous Jouarre holds pride of place in most of the publications - especially since many of them were written by owners and merchants of those very articles. Other accounts borrowed or copied long passages from such publications, without acknowledgement.

A more academic treatise appeared in 1903; the authors felt perhaps less jealous of the secrets of the trade, but at all events they describe processes in rather more precise detail than do most earlier authors, although the narrative lacks their vigour. This "Traité de Meunerie" undertaken by Aimé Girard but left unfinished by him was completed and published by Léon Lindet. Both writers were teachers at the Institut National Agronomique; the latter wrote several articles on the history of the cornmill.

This translation is deliberately a whit pedantic - a quality which delicately informs the original. The authors' account of millstone preparation is here translated from the point at which the pieces of stone reach the works, from the quarry usually situated in the hills above; it may well be based on practice at la Ferté, though it varies in detail from another, shorter, description of practice there in 1858.

Readers will notice some slight variations from English custom, e.g. the absence of stitching or cracking on the lands of the skirt, and also that this account does beg a few questions. The illustration gives additional information.

When they are brought to the works the 'cleaned' stones are subjected to a very careful selection process; experience teaches how to carve burrs of very different qualities from the same quarry, indeed from the same block, or even from the same fragment. In order to sort the stone according to these qualities one proceeds first of all to 'rough dress' them. This expression defines the operation which aims to improve, by levelling however imperfectly, the face already 'cleaned' in the quarry, so as to make it easier to assess the characteristics of the structure, the colour and so on of the stone.

To carry out this operation, the 'rough dresser', selecting a 'cleaned' block, stands it on the ground, leaning slightly backwards, face uppermost; then, having supported it by a convenient stone, and placing himself behind it, he chips the surface away little by little using a pointed hammer, or pick. From time to time, to judge the quality of his work, he passes over the worked face a staff coated, on the edge, with English Red, which, on contact with any raised area leaves a sufficient quantity of colour to make such areas obvious; each prominence is then once more chipped away, and the face of the stone by this process is stripped of its outer crust, until the working surface is acceptably flat.

It is after 'rough dressing' that allocation is finally made. For this purpose 'rough dressed' stones from the same source, and which have already been matched with one another in a general way, are set out under cover to shade them from bright daylight, and they are liberally wetted. Under the influence of this damping their distinguishing characteristics of colour, porosity and so on stand out with remarkable clarity.

The texture is clearer, the natural colouration is accentuated, and long experience has taught how these external characteristics correspond to the qualities of the stone, so that it becomes easy enough to see how much use can be made of each of the 'rough dressed' fragments. The burrs are therefore once more sorted according to the work for which each is best suited when built in to the face of the stone, whether for fine or preliminary grinding.

After this final sorting the burrs, reduced to the dimensions similar to those they will have in the millstone, are stacked to await the day when they will be worked on.

These dimensions vary a great deal; the finer the stone, the smaller the burr is inclined to be. There are three recognised sizes;
- the one foot burrs, which should measure 33cm by 33cm, although the length of the sides can vary provided that the surface is somewhere approximating 1000sq.cm
- the half-foot burrs, whose surface should measure about 500sq.cm
- and the 'lambs', whose surface should be something like 275sq.cm

It is by using burrs sorted in this way that every stone is constructed now-adays. Their assembly has to be the object of particularly patient care. So, when an order for a stone reaches the yard, it is the duty of the yard foreman himself, as we have said, to select and arrange the blocks which must make up the 'heart', the waist and the skirt. When the selection has been made the pieces which have been chosen go to be 'made up'. (Some other documents, e.g. manufacturers' leaf-lets, prefer to emphasise consultation with the purchaser over the selection of burrs.)

To 'make up' a millstone is to take the fragments which the yard foreman has chosen from amongst the piles of sorted burrs in such a manner as to provide a stone of the quality previously agreed with his client; to reduce these pieces to the state of regular burrs; to join them perfectly to one another; and to obtain from them in the end a block which on one side presents a regular face and on the other leaves the rough backs of all the blocks exposed. The worker responsible for this task is known as the 'maker up'.

The stones brought to him are of two sorts; relatively soft stones for the 'heart' and harder and less porous stone for the waist and skirt. He spreads them out on the ground and decides, for each of them, the best position in the compos-ition of the millstone.

Once his layout has been decided, he takes one of the stones of which the 'heart' is to be made (usually there will be no more than four or five); on the face of this stone he draws an arc to represent that portion of the circumference of the eye which it is to encompass; then using a hammer and cold chisel, beginn-ing with heavy blows, and then shorter ones, he chisels away the stone which lies inside the curvature of his arc; finally, with repeated short, sharp blows, he squares the right angle formed between the vertical side which he has cut away and the working surface so as to produce as sharp an edge as possible. On this surface he then marks, with the help of a T-square, his 'outline', that is to say the geometric shape which he intends to give to the block. Then, using the same procedure as before, he cuts away and smooths the sides of the stone in such a way as to make them perfectly flat and to finish the corners as cleanly as possible. As for the face opposite the working surface, this is left in its original state.

Having finished his first block, he works in turn on the two or three other blocks of which the 'heart' is to be made, then using cement of a very high quality he binds them together soundly one after the other with joints which are almost invisible. Across the eye he beds in a strip with a vertical iron pin in the middle of it, which occupies the centre of the millstone. Onto this he spikes a flat rule which, pivoting on this centre, will allow him, later on, to determine the circumference of the millstone and to shape to this circumference the peripheral burrs.

When the 'heart' has been constructed in this way and cemented together, it is propped up vertically against the wall, where it is supported with the help of wooden battens, and in the way already described the 'maker up' proceeds to shape

and put in place one at a time the burrs of which the waist is made; then it is the turn of the skirt. By running the scriber, still fitted in the centre, around the stone the worker determines precisely the shape of the peripheral burrs, and by the same process as for the other parts of the millstone, and still working with hammer and chisel, he gives to each burr the correct shape for it to be fitted in to the body of the millstone. Then when the shaping of each burr has been completed he secures it by cementing it to those which are already located in the structure.

The number of burrs employed in 'making up' a stone, as also the shape and disposition suitable for each of them, vary a great deal according to circumst-ances; the figure of thirty-four gives the reader an idea of the labour involved in their assembly. It represents a millstone 140cm in diameter (about 4ft. 7in.), completely built, and having five blocks for the 'heart' and forty-eight around it. (Presumably 48 was a misprint for 29.) The surrounding stones are, as a rule, in two rows; some of them, called 'panels', are of sufficient length to link the 'heart' with the outside edge.

The backs of the burrs are now ready to receive the small stones and cement which, as we shall soon see, are needed to complete the construction of the mill-stone by distributing the weight evenly to all its parts. In order to facilitate this 'packing' operation care is taken when the stones are cemented to embed in the joints small, flat stones the jutting edge of which can be used to key in the backing.

However precisely the joints have been cemented, the burrs of which the stone is made nevertheless need, in order to form a perfectly rigid body, to be held in place by a metal framework. Two bands, or hoops, of iron, both of them shrunk around the cylindrical edge of the millstone, constitute the framework. Of these two bands one is placed at the moment the last stone has been inserted in the face, the other is only fitted later on when the stone has been backed.

Both are made of sheet iron 3mm thick; they measure 7cm to 8cm across, and their diameter is slightly less than that of the stone which they surround. The difference (which is called the 'tensioning allowance') is usually accounted for when measuring the interior of the band; for a millstone of 150cm the allowance is 2cm; for a stone of 130cm it is 1.5cm. It is by taking advantage of the expansion caused by heating the band red hot that the circle of a lesser diameter can be fitted around the stone.

The latter having been turned over on the ground, face down, the band which must encircle it is placed on a peat fire alongside it. When, in these conditions, and brought up to red heat, the band has reached its maximum expansion, it is picked up with the help of two pairs of banding tongs and promptly, before it has a chance to cool down, it is lowered over the stone to about 5mm below the prepared surface, helped on its way by hammering. The construction is then left for a while in the open air; as a consequence of its cooling the band contracts and clamps the burrs together in such a way as to ensure a perfect solidity to the assembly.

Thus banded, the stone is taken to the 'facer'; he renders the working face as flat as it can be by the use of the mill bill. Raised up on wedges or blocks of stone some 40cm above the ground, the millstone is first levelled precisely, and is then tackled by the 'facer'. With the help of a mill bill, that is to say a hammer with a sloping, bluff working face, he works patiently at the stone already prepared for him by the 'maker up'. He thus breaks down the high spots which, one after the other, present themselves and, in the same operation, exposes the texture which the stone will finally have.

From time to time, using the process already described, he passes a staff covered in English Red over the surface and marks the high spots so that he can dress them away with the mill bill until they are completely flattened.

When, as it passed over the surface of the millstone, the staff marks all parts of it evenly the surface is considered to be sufficiently level; the mill-stone is 'faced'.

Moreover, as the stone is being 'faced' the swallow is formed. The 'hearts' of both runner and bedstone are slightly hollowed in the form of a shallow cone, so that the grist works its way more easily in between the stones. As a rule 1mm to 2mm are taken from the bedstone, and 3mm to 4mm from the runner; just enough, in other words, to allow the grain of wheat to 'somersault' easily. From the edge of the eye the swallow goes on diminishing until, at 15cm to 20cm from the circumference it blends into the level planned for the skirt.

Following this operation the stone is furrowed, which means the dressing on the working face of the stone of a pattern of channels. There are two kinds of furrow; one kind, leaving the eye to end up at the circumference of the skirt, is known as the 'master furrow', the other kind, smaller and narrowing as they go, are called tributary furrows. These are cut between the principal furrows.

The cross-section of either is the same - they are hollowed out following two intersecting profiles. One of the profiles, known as the 'spine' is cut either vertically or at an angle very slightly obtuse to the working face of the stone; the other, called the 'working slope' is laid out at an oblique angle to the first, and forms in fact an inclined plane which slopes regularly up from its base and dies away to blend with the horizontal plane of the millstone. This furrow does not have parallel sides - it becomes narrower as it approaches the skirt.

Alongside each furrow there occurs a flat strip; these are known as lands.

The angle and the depth to which the furrows are cut vary according to the miller's taste, the nature of the grist, etc. Usually the depth of the furrows is the same for the runner as for the bedstone; measuring some 6mm at the eye, the depth diminishes imperceptibly to 3mm at the outer edge. The 'working slope' can be seen to lose about one third of its width on its way from the centre to the periphery; commonly it is 5cm wide at the eye, but sometimes 4cm and sometimes 6cm, from which it follows that the angle of the 'working slope' can vary - in the first case it is described as an 'ordinary slope', in the second case a 'steep slope' and in the third a 'gentle slope'.

Finally, and whatever its width, as a result of the angle of inclination of the 'working slope', the furrow may cause the spine to describe, not a right angle, but an obtuse angle with the land. The furrowing is in this case called 'oblique spine furrowing'.

Into the surface a variable number of furrows may be cut, but however many there are they are cut in the same manner. Each master furrow, with its tributary furrows and lands which separate them, form a harp, and the system of furrowing is described according to the number of harps first of all, and then the number of furrows in each harp. Millstones which measure 140cm in diameter are the most usual these days, and they may contain 16 identical harps. Each of the master furrows is accompanied in a typical example by two tributary furrows, which are separated from one another by an equal number of lands; the stone is therefore said to be divided into 16 by 3; stones 150cm in diameter are, as a rule, divided into 17 by 3; those 130cm in diameter, into 15 by 3 etc.

The method used to execute the furrowing is worth a moment's attention. In the first place, before cutting out the furrows, the craftsman, using a red marker, carefully draws on the surface of the stone the width and direction of each furrow. To determine their draught when, for example, planning a 140cm stone, he describes within the eye a circle concentric with it and measuring 6cm in diameter; tangential to this circle, which is called the draught circle, he subtends a base line which forms the boundary of the first land; alongside this line he describes a second one, parallel to it, corresponding to the cutting edge of the second land; then, between these two parallel lines he projects a third at a slight angle to both, so as to outline a band which, near the centre or heart of the stones, measures perhaps 5cm, and at the outer edge of the skirt only 3.2cm. In miller's parlance this is called 'putting the breadth at the heart'. It is this land, wider at the eye than at the skirt, which is taken out to make the first master furrow. Through the point where this furrow meets the eye is drawn a new line tangential to the draught circle; the space between this line and the first is called the harp. On this harp, but stopping where they meet the second tangent, bands are drawn parallel to the direction of the first land, and it is the furrows cut out along these bands which are called tributary furrows.

(Translator's note: It is very questionable whether the use of tapered furrows

was general practice; there is very little archaeological evidence of it.)

So that, in the end, in each harp there are four lands, becoming shorter and shorter, to the last of which is given the name of fly, and three furrows - one master and two tributary. The same arrangements are reproduced in the remaining harps.

To cut these furrows a procedure identical to that which has been applied to the 'facing' of the stone is followed. A mill bill is used first of all to hollow out the deepest part and then gradually to level out the 'slope' which, by an inclined plane, rejoins the following land. The depth of the lateral furrows is generally constant from one end to the other, but it is different for the master furrows, as has been said already; at the 'heart' they are 5mm or 6mm deep, then the bottom rises gradually so as to reduce the depth of the furrow to 3mm or 4mm.

On each harp the tributary furrows can be drawn either to the right or to the left of the 'master' furrows. In the first case the stone is said to be right-handed, in the second case, left-handed. A stone is said to be 'furrowed to the right' when, placing the right hand on the stone, with the index finger on one of the master furrows, the other fingers are found to lie along the tributary furrows parallel to it; if such a superimposition does not occur then the stone is 'furrowed to the left', and it is by laying the left hand on the millstone, the index finger along the chief furrow, that the other fingers will lie in the smaller furrows.

Identical as to the disposition of their surfaces, the two stones of a pair differ from one another by certain peculiarities. In the first place it is customary to choose, for the composition of the bedstone, a stone less trenchant and less hard than for the runner.

(Although the reason is not obvious, it is certainly not rare to find a softer bedstone even in Britain; in the west of the country one frequently finds a French stone running on a Welsh stone.)

In the second place the eye of each stone is of a different diameter one from the other; for the bedstone the eye is only required to take the stone spindle, and generally measures only 20cm to 25cm in diameter. For the runner, on the other hand, because the grain must easily be fed through it, the eye is given a diameter of 40cm to 45cm at the working face; but because it must at the same time have the form of a truncated cone this diameter is reduced at the upper surface to about 30cm. It is across this eye that will later be sealed in place the stirrup, or rynd, which resting on the stone spindle is responsible for maintaining the runner in equilibrium above the bedstone. The stone has two recesses cut into it to receive the rynd, at either extremity of one of the diameters of the eye, and near the working surface.

Faced and furrowed, the stone is however far from being complete; the burrs of which it is composed are of variable thickness, and as a consequence the millstone possesses, in its various parts, different weights. If things were left in this state the runner stone, badly balanced, would be seen as it rotated to strike the bedstone in those places where it was heaviest, whilst the lightest parts, on the other hand, would lift above the runner and would have no purchase on the grain; the backs of the burrs are in any case still in a raw state and give rise to an undulating surface to which it is necessary to give a regular shape.

To this final operation is given the name of 'backing' or 'stabilising'. It consists of bedding into the back of the stone small pieces of burr stone set in fine concrete, of which the weight is so calculated that, when it is added to that of the burrs already in situ, the weight is evenly spread. Until a few years ago the stones were sealed in plaster of paris; nowadays cement is, rightly, preferred.

So the millstone is placed face down on a pedestal; it is encased with a band of sheet iron of a depth which makes up the thickness which is finally to be given to the stone (25cm to 30cm and the filling is built up using stones of various sizes and with concrete made from three parts of aggregate and one of cement. With a trowel a smooth coating of cement is laid onto the edges and the uppermost surface of the stone, and to guard against defects in balance which could, in spite of everything, still be discovered, three (or four) hollow boxes made of cast iron are fitted at the three corners of an equilateral triangle described on the stone. These boxes are easily closed by a lid which is screwed down, and into them the miller, when a fault in equilibrium is noticed, can put a heavy substance (lead, for example) so as to re-establish the balance.

When backing takes place is usually the time when a second iron band is fitted round the stone, similar to the one that was put on when the stone was 'made up'.

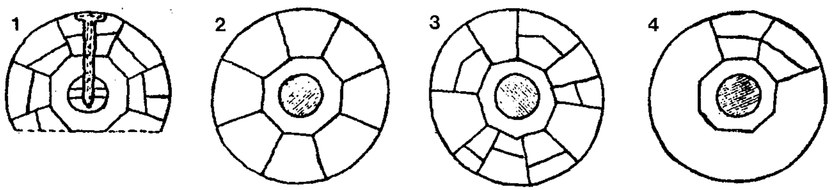
Finally, again as part of the same exercise, two cylindrical hollow cast iron canisters, or short lengths of tube, are sealed into the edges of a runner stone at the opposite extremes of the same diameter and with a horizontal axis. These are called peg holes, and they are intended to take the pegs on the arms of the stone-crane which is used to raise this stone whenever the work demands it - when, for example, it is time to re-dress the stone.

Sometimes too (and this is a manner of proceeding which is to be recommended) into the eye is set a cast-iron socket in the form of a truncated cone carrying two flanges designed to support the rynd by means of bolts and nuts.

When the millstone has been completed by the procedures which have just been described, it has to be gone over again with the bill and, to perfect its finish, it has to undergo a final facing operation known as 'smoothing' executed with a mill bill.

However, even after this last operation, the millstone is not ready to provide adequate service for the miller. The rough finish which the dressing left on the surface is hard and sharp; in this condition the millstone would reduce the grain to a mash and it is essential to remove the roughness. Usually it is the miller who takes on the job of achieving this result, and it is by using the stones for milling that he does so. To this operation he gives the term 'bedding in'. After installing his stones he first feeds them with bran, then with some lesser material more gritty than bran, even fine sandstone, and wears down the surface until it is smooth enough for his use.

French practice in the assembly of burrstones for furrowing.



1. The flat rule is still fitted to the wedge across the eye of the stone and is used to determine the circumference of it.
2. A somewhat idealistic stone, with a 'heart' and a perfect set of burrs around it.
3. An arrangement which, though more complicated, is capable of providing a stone with its grinding surface better graduated from eye to skirt.
4. An illustration of how not to do it: the angle where four joints meet is bound to weaken. The comparison with arch construction throughout the process is inescapable.

THE 'NORSE' WATERMILLS OF SHETLAND

by JOHN & RHODA BEDINGTON

Watermills with horizontal waterwheels are a rare occurence in Britain, almost all known examples being in the islands of Scotland. In the Shetland Islands (which lie approximately 120 miles N.E. of the N.E. tip of the Scottish mainland) horizontal waterwheels have always been the rule, and vertical ones the exception. John Hume[1] in 1977 lists the remains of seventy-four in Shetland, of which only three had vertical waterwheels. The design of the Shetland horizontal watermill is traditionally supposed to have originated in Scandanavia, hence the name 'Norse'. Indeed, Norwegian influence is strong in Shetland: the islands belonged to Norway from c.800 A.D. to 1471 A.D. and many place names are Norse. The antiquarian Goudie points out[2] that the terms for various parts of the Shetland mill are much more similar to their Norwegian than their Gaelic equivalent: the word 'ludr' being used, for example, in both Norway and Shetland for the main room (as opposed to the wheelhouse) of the mill. Rousell[3] states that the design of mill has been repeated for at least seven hundred years.

Our acquaintance with these mills comes mainly from a visit to the islands in 1981, when we saw remains of some twenty mills, though Rhoda had previously seen several others in 1979.

Although a few examples stand alone, the mills normally occur in groups of between two and ten. At Troswick, for example, we found remains of seven mills together on approximately ¼ mile of stream[4] and the occupier of one of them (which was preserved) told us there had once been another three. Typically, the mills are on a part of the stream near where it flows into the sea and therefore has reasonable volume and speed, and is near the cultivated land. None of the twenty mills that we saw were further than 1 mile from the sea, most within ½ mile.

Evidently some mills were owned by individuals (e.g. the man at Troswick mentioned above). Others were owned, or at least used, by a number of families who took it in turns to grind their corn. An old man at Sandness described to us how the mills at Huxter (see below) were used in this way when he was young: the women brought the families' corn to the mill on a pack-animal and sat on the seat just inside the mill door and knitted while the mill ground[5].

The design of the Shetland Norse watermill is a wonder of simplicity. The climate is wet and cool and very windy. Very few trees exist, and the soil is poor. Agriculture was (and still is) primitive. Prior to the exploitation of oil, the people's standard of living was low, and there was little capital available. (The only woodland of significant size and the only vertical water-mill that we ourselves saw on the islands were both on one of the rare large estates, at Weisdale,(Mainland Island)[6]. The Norse mill, which could be built from stone and driftwood, and roofed with straw and turf, was ideal in these conditions. The only iron needed was for the stone spindle, rynd, the lower bearing and the hoops on the wheel hub.

The site of a mill needed to be at a place where the stream was falling quite steeply and had sloping banks: there a little leat of a few yards gives the necessary head of water, and the mill (which consists of a single room) can be arranged so that it is entered at ground level and the waterwheel is beneath, at the far end from the door (see Fig. 1).

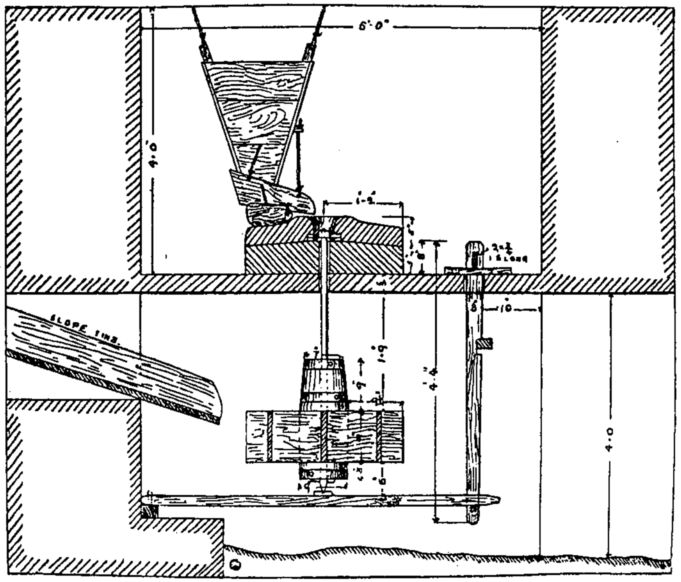


FIG.1 Cross-section of Shetland Mill, from Goudie's paper (ref.2)

The walls are built of dry stone and are about 2ft. thick though Hume mentions one mill at Gord[7] which was made of cast concrete: it is the only mill which he says may be of the early 20th century: all other Norse mills in Shetland he describes as "nineteenth century or earlier", and the three conventional mills as "nineteenth century". The roofs have wooden rafters and horizontal slats. In most cases the covering has disappeared but turf covered in turn by straw thatch (held down by cords weighted with stones) was the traditional covering: this can be seen at the mill (preserved in its working position) at the Croft Museum at Southvoe, Dunrossness[8] and also at the bottom one of the group of three mills at Huxter[9] The mill at Vementry[10] possibly had just turf: the mill at Westing[11] on Unst, had been repaired with corrugated asbestos overlaid with turf, and the preserved mill at Troswick with tarred felt. The bottom mill at Huxter had a small window over the door. In other cases we saw, the lighting, if any, was limited to a small window, or shutter, in the roof. Since the floor area of the average mill was only about 11ft. 6in. x 6ft. 6in., doubtless there was sufficient light if the door were left part open.

The water was diverted down the leat by a board across the stream. The layout of the mill machinery can be seen from the diagram. The inclined chute from the leat was of wood in all the examples that we saw, except the one at Troswick, which is of concrete. The usual fall is about 6ft. but we noticed that Westing mill had only 3ft. fall on the chute and another 3ft. in the leat[12] The jet of water from the chute falls on one side only of the tirl (as the Norse kind of

waterwheel is called in the Shetlands). The tirl consists of a number of flat wooden blades (usually 9) morticed into a wooden hub fixed on the bottom of the (iron) stone spindle. The blades are about 8in. deep and are set at a slight angle (about 15°) to the vertical. The diameters of the tirls we measured varied from 2ft. 3in. to 3ft. 6in., about 3ft. being most common. We did not see any working, but we think they would have revolved at about 60 r.p.m[13] Two of the Huxter mills, and the preserved mill at Troswick have concrete hubs. Westing had two rings of wire bracing the outer tips of the blades to each other. The spindle of the stones is of iron (or steel) and of very slight cross section-only about $\frac{3}{4}$in. The lower journal of the spindle runs in a metal insert in a wooden beam, from the end of which a wooden pole rises through the mill floor and is raised or lowered by wedges to adjust the gap between the stones.

The bearing of the spindle in the bedstone is a wooden block. The rynd has a slot thus for the top of the spindle, thus dispensing with the relatively complicated driving irons of the conventional mill. A millstone at one of a group of three mills at Eshaness[14] however, appears to have had an X rynd: maybe it was used for shelling oats.

Quite a lot of millstones remain, even frequently in mills where the tirl, shaft and the roof have gone. Diameters of the stones normally varied from 2ft. 6in. to 3ft. The preserved mill at Troswick had stones of 3ft. 4in. but the tirl was larger than normal and had 12 blades. In one of the ruined mills at Troswick we found a 2ft. 3in. bedstone and a 2ft. 9in. runnerstone. Unfortunately our geology is not good enough to identify the types of stone used, but we think they were local. The most usual type are grey and appear to be a type of sandstone. The runnerstone at Vementry had a bluish tinge. At least the runnerstone of the bottom mill at Huxter had flecks of shiny material like mica in it[15] so did the stone at Eshaness mentioned above, and we also noted it had 'red pebbles' in it. Hume states that at Ireland[16] (Dunrossness) and both stones at Burravoe, on Yell[17] were of concrete.

There is no dressing on the stones, though according to Goudie the surfaces were roughened from time to time with a pick. Often the bedstone is convex and the runner concave. The face of the 2ft. 6in. runnerstone in the ruined mill at Burrafirth on Unst[18] for example was dished to a depth of 2in. and that of the 2ft. 9in. stone (with the smaller bedstone) at Troswick, mentioned above, to a depth of 1in. The bedstone normally has an eye of 2 to 4in. diameter and the runnerstone about 4 to 5in. diameter. We noticed that two of the runnerstones at Troswick and the one at Westing had a raised ring of stone around the eye, perhaps to lessen spillage of grain from the eye.

Stone furniture is extremely simple. There is no tun. The stones are supported by the large rough flagstones that form the ceiling of the wheelhouse and are surrounded by an open trough of wood, stone or concrete. The hopper (typically about 2ft. by 1ft. 6in. at the top, 3in. square at the bottom, 2ft. 6in. deep) is suspended by strings or laths from the rafters. The small wooden feedshoe hangs from the hopper and the cord regulating its height goes to a twist peg on the front of the hopper also. The shoe is shaken by a trail stick bumping on the rough upper surface of the runnerstone as it revolves. Thus the damsel and horse of the conventional mill are dispensed with. The feedshoe at Westing was of leather. There are of course no grain bins: these mills are only high enough for a man to stand up.

The man at Troswick told us it took about half an hour to grind a hopperful of grain: since the hopper there must have held about 1 cwt. that seems remarkably quick, and approaching the capacity of conventional mills: however, he also said that often the grain had to be put through the stones twice, so perhaps the capacity was really 1 cwt. per hour rather than per half hour; moreover the stones and tirl at that mill were bigger than average. The same mill also had a hand held sieve, apparently for sieving out the coarser bits of bran.

The climate has made it impossible to grow wheat satisfactorily in Shetland (an unsuccessful attempt was made by Rev. John Turnbull in the nineteenth century)[19] The grain crops were bere (like barley) and oats. Bere meal was used instead of wheat for bread, but it was a grain that was particularly troublesome to thresh.

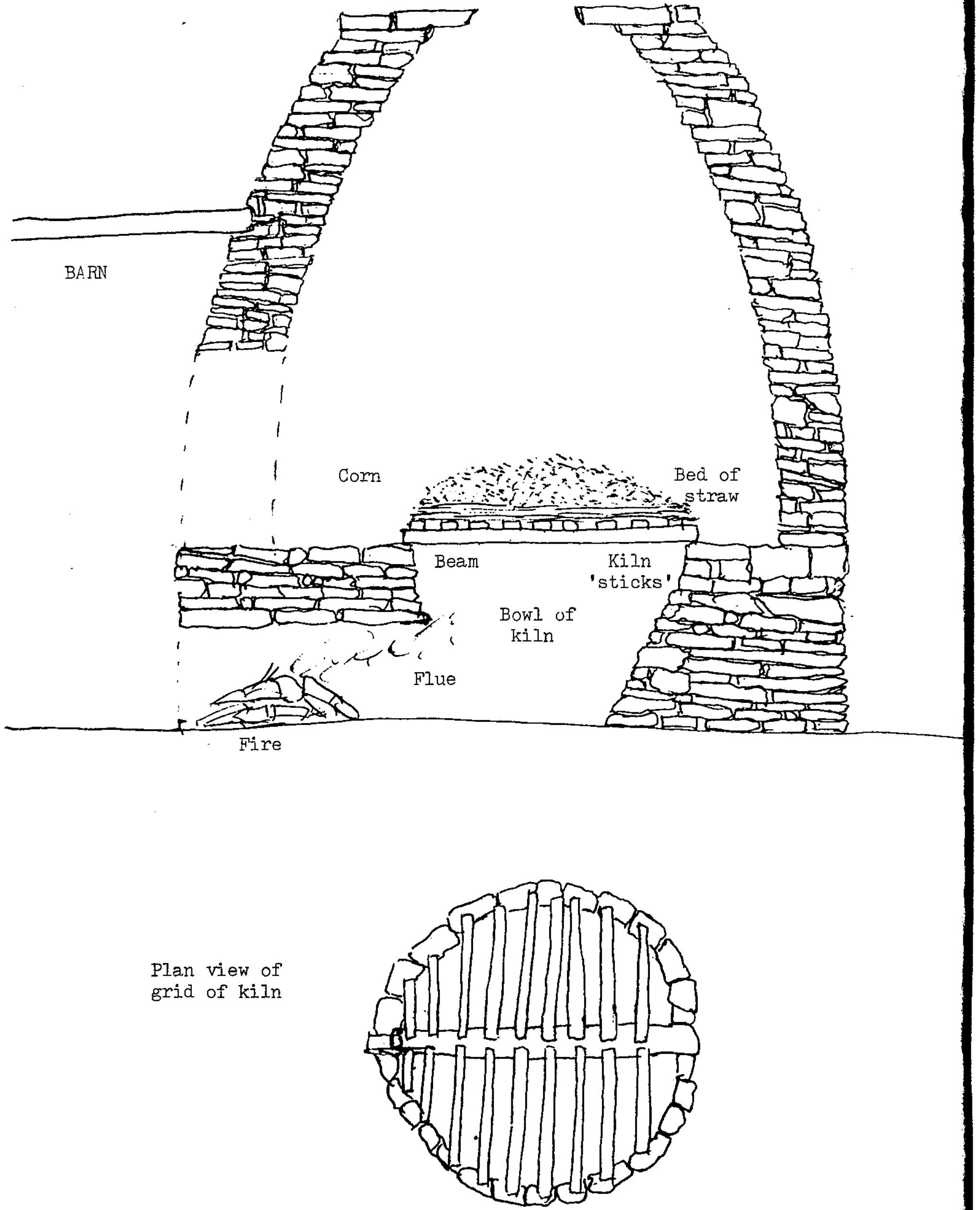


FIG.2. Circular grain-drying kiln in Shetland.

According to Nicholson the bere "was first threshed to separate the grain from the straw; then the grain was itself heavily threshed to remove the loose husks and 'beards' or anns, a process known as 'hummelling'. Winnowing followed, on a special mat called a flaakie, and a final beating in a tub with a shovel was required to remove the last of the troublesome anns."

He adds that:

"In such a damp climate it was essential to dry the grain by artificial means before milling. Each croft had a kiln, an oblong stonewalled box situated in the barn. Across the top of the kiln were ribs of wood that were covered with straw before the grain was spread on top. A fire was lit at the free end of the kiln, the smoke escaping into the barn through a flue in the back wall."

We did not ourselves see one of these simple kilns, though the man at Troswick apparently had one. We did however see two slightly more sophisticated circular kilns (see Fig.2), one at the Croft Museum and the other not far away, at Levenwick.[20] An old lady at Sandness told us she could remember a kiln in use when she was 'a wee lass'.

Sir Walter Scott estimated that there were some five hundred Norse mills in use in Shetland in 1814 and Goudie considered the number still correct in 1886. Henry Eveshed in the Transactions of the Highland and Agricultural Society (quoted by Goudie) in 1874 said there was a mill for every dozen families. The vast majority of them seem to have fallen out of use in late Victorian times. Whilst Goudie speaks of them as commonly in use in 1886, he said in 1903 that they had become 'entirely obsolete'.[21] This seems to be an overstatement however. The mills at Huxter were clearly working seriously between the two world wars: whether they had never stopped or had been revived in times of economic hardship is not clear. The mill at Vementry, the mill at Westing and the intact mill at Troswick seem to have been preserved out of sentiment and possibly also for use, though Vementry has become derelict again. Doubtless there were other preserved mills we did not see. The Southvoe mill is deliberately preserved as part of the Croft Museum and like the Troswick one, is workable. The mill at Burrafirth, a mere ruin, has a possibly unique use- a shelter for raising cabbage plants. Incidentally, it appears that no significant amount of grain for grinding is grown in Shetland now. Oats are still cultivated but they are harvested by reaper and binder and, we were told, the sheaves are fed whole (i.e. unthreshed) to the sheep.

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3. "Norse building customs in the Scottish Isles" 1934. quoted by J.R.Nicholson 'Shetland' (David & Charles) 1972
4. 'Mainland' Island. between grid references HU 406172 and 409167
5. The two systems of ownership is confirmed by Goudie, op. cit.
6. Grid ref. HU 394531
7. Grid ref. HU 206574 ('Mainland' Island)
8. 'Mainland' Island: grid ref. HU 400145
9. 'Mainland' Island: grid ref. HU 172572
10. 'Mainland' Island: grid ref. HU 312598
11. Grid ref. HP 572056
12. Goudie (op. cit.) considered 3 to 4ft fall normal.
13. This was the estimated speed of a fairly similar horizontal mill seen by John in Roumania.
14. 'Mainland' Island: HU 213794

15. Presumably the micaceous schist which Goudie mentions as being the usual material for millstones.
16. 'Mainland' Island: grid ref. HU 377217
17. 'Mainland' Island: grid ref. HU 523800
18. Grid ref. HP 606141
19. per Nicholson op. cit.
20. Approx. grid ref. HU 406217
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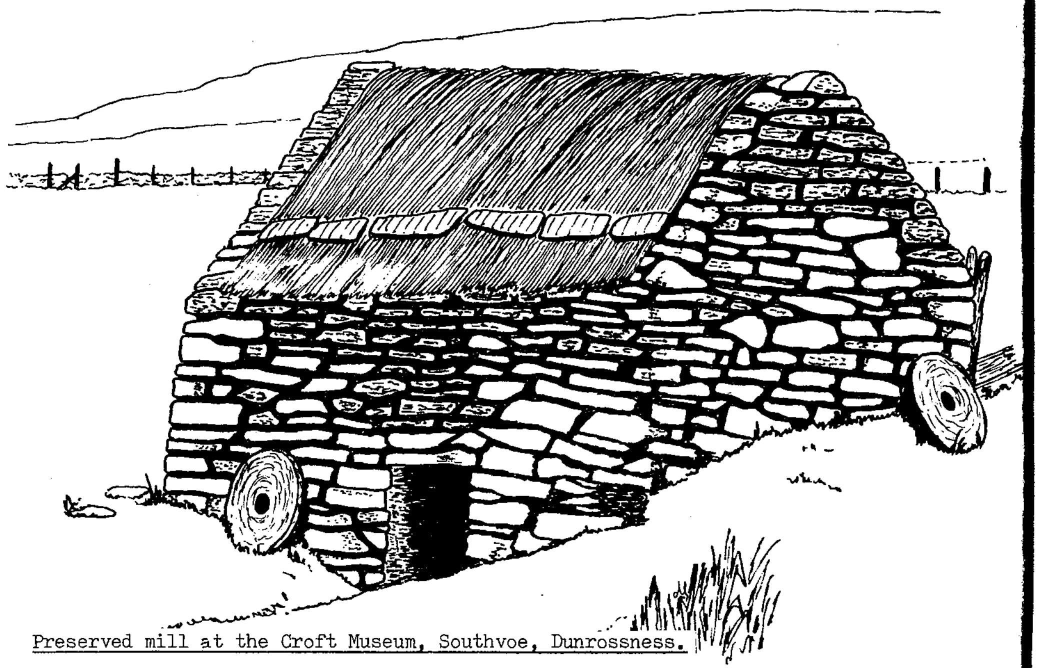


Preserved mill at the Croft Museum, Southvoe, Dunrossness.

WINDMILLS IN MALLORCA

by TONY COOKE

Mallorca has hundreds of windmills used for pumping water for irrigation, but what follows is a description only of the Mallorcan corn-grinding windmills. These mills are of particular interest from an English perspective, in that their design was unaffected by the industrial revolution and exhibits mediterranean features such as the use of a bowsprit and rigging. The information here comes in part from the author's own observations and in part from his tranlation of "Els Molins De Vent de Mallorca", by Sanchis Guarner, from the original Catalan. Direct translations of Catalan terms where given are shown in quotes.

Very many mill towers are still to be seen though few mills retain machinery and sails. Mills are often to be found built within 100 metres of one another along the edge of an escarpment; sometimes as many as 6 in a row.

Mill structure varies little and so a generalised description follows.

The Tower

The tower has vertical stone walls 12 - 15 metres high and 0.6 - 0.7 metres thick. The external diameter of the tower is 4.5 - 5 metres. Depending on the height of the tower it may be divided into 3 or 4 floors. In most cases the single storied miller's house is built around the base of the tower. A door opens out from the tower onto the flat roof of the house, which acts as a platform from which the miller can adjust the sails. A recess is often to be found above, or at the side of, this doorway, carrying an image of the patron saint of the millers' guild, St. Barbara. A spiral stairway runs from ground level up to the top of the tower. The cap is conical and thatched.

The Windshaft

The windshaft is of evergreen oak, 4 - 5 metres long, some 0.7 metres thick at the neck and tapering from the brakewheel to the tail. It projects about 1 metre from the tower wall. 3 stocks of evergreen oak or olive wood are morticed through the windshaft at an angle of 60° to one another, and project about a metre on either side.

The sail-spars are 7 - 10 metres long and each is fixed to its stock with 3 olive wood pegs and 2 iron bands.

Sunk into the windshaft is a bowsprit, the "ox", which forms a forward extension of the windshaft 4 - 5 metres long. Each of the 6 sail-spars carries a common sail.

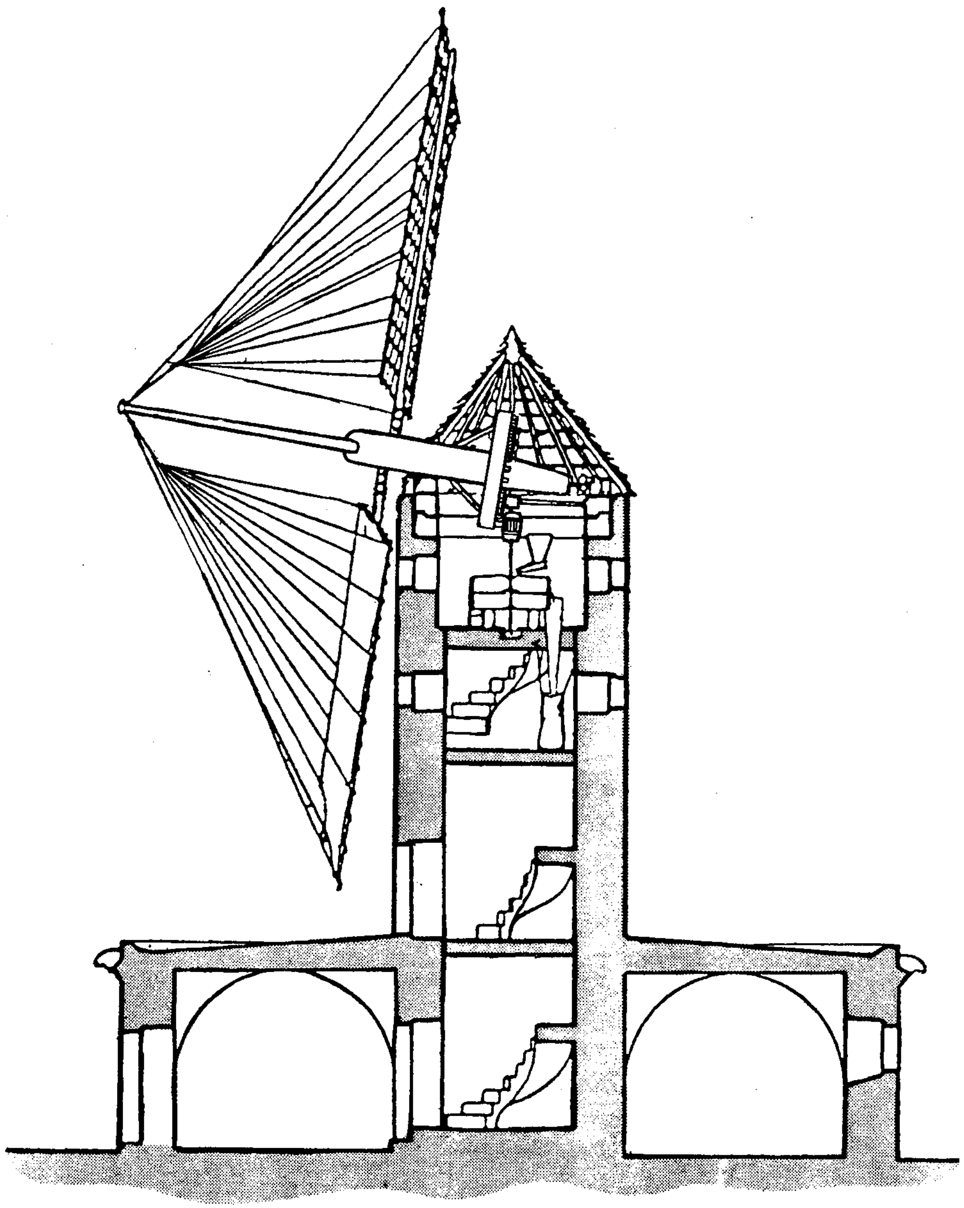
The Rigging

A rope is tied from the outer end of each sail-spar to the outer end of the next, keeping them equidistant. From the end of the bowsprit run 6 ropes one to the outer end of each sail-spar, thus keeping them in the same plane and allowing them to be much lighter structurally than they would otherwise need to be.

From the hemlaths run thinner ropes, 6 from each, which are gathered together and tied to another rope which in turn is tied at its other end to the end of the bowsprit. This arrangement gives the sails strength and stability and allows the angle and twist of the sails to be adjusted.

Although 6 common sails is the norm for Mallorcan corn mills there is evi-

VERTICAL SECTION OF TYPICAL CATALAN MILL SCALE 1: 100



dence of isolated examples of the use of triangular jib sails. A mill in the town of Alcudia had 8 sail-spars, each with a jib sail, in combination with a bowsprit and rigging. This was perhaps an introduction of mill construction methods from Andalusia in south western Spain or from southern Portugal, where mills have 8 spars with usually just 4 of them carrying jib sails.

A mill at Inca had 6 spars, each of these having an accessory spar branching off from half-way along its length, at an angle of 45°. The outer ends of these 6 accessories were all tied to a rope running between all the spar ends. A rope ran from the end of each of the 12 spars to the end of a bowsprit. Large jib sails were carried on each of the 6 main spars and smaller jib sails were carried on the end of each of the accessory spars. This odd structure may perhaps have been an adaptation of a mill first constructed with 6 common sails.

Turning the Mill

The dead curbs are of olive or oak. The upper face of the lower curb and the lower face of the upper curb are curved in a complimentary way. Both curbs have in their inner faces a series of holes set at 0.25 metre intervals. To turn the mill an iron peg is inserted into one of the holes in the upper curb and another into the nearest hole in the lower curb. Then a wooden lever, about 1.5 metres long is used, with the peg in the lower curb acting as a fulcrum, to push against the peg in the upper curb, and thus turn the mill cap through a few degrees. The peg in the lower curb is then moved to the next hole along and the levering is repeated as necessary until the mill is oriented as required. The cap is then fixed in position by placing large iron loops over pairs of adjacent pegs in the upper and lower curbs.

The jib-sailed Alcudia mill had a tail post like Andalusian mills.

The breast bearing of the windshaft is of stone or iron which in turn rests on a block of wood called the "under-throat" which rests on the upper curb. The "throat" of the windshaft is supported on either side by "cheeks" of olive wood fixed to the upper curb. Between the 2 "cheeks" and the "throat" of the windshaft are 2 wooden "strugglers".

The tail of the windshaft tapers to about 0.3 metre in diameter. Into it is set an iron shaft, the other end of which is seated into a block mounted on the tail beam.

The brakewheel is of oak, about 2 metres in diameter and 0.3 metre thick. The 42 teeth project about 0.1 metre. 4 slightly curved struts of olive wood run from the front surface of the brakewheel to the windshaft at its neck.

The barrel shaped lantern pinion wheel is of elm about 0.7 metre high and 0.4 metre in diameter. This drives a single pair of stones, almost 2 metres in diameter and 0.3 metre thick.

Relationship with other mills

The other Ballearic islands, Menorca, Ibiza and Formentera all have windmills like the typical Mallorcan mill described above. Malta, Gozo and Sicily all have very similar windmills.

Windmills throughout the Mediterranean have simple conical caps and vertical-walled stone towers. Most have rigging and either a bowsprit or a windshaft which projects several metres beyond the tower so as to function as a bowsprit. Most have more than 4 sail-spars. Greek, Andalusian and Southern Portugese windmills all have triangular jib sails, though on the Greek island of Aegina in the early 19th Century and on Rhodes in the 15th Century, there were windmills with 8 common sails.

History

There are passing references to windmills on Mallorca in documents dating from 1395 and 1505. A map of Palma from 1644 shows several tower mills each with a conical cap and six common sails.

A legal document of 1680 details a dispute over the construction of a windmill in the Es Jonquet district of west Palma, where mills are still to be seen. In the 18th Century a millers' guild was formed. The last commercial use of windmills in Mallorca was just after the Spanish Civil War.

Future

Like most mediterranean windmills, those of Mallorca fell out of use more recently than their British counterparts and are, compared with Britain, unrecorded and unloved. A rich field of study is open here for us to record and encourage conservation. The author would appreciate any information on mediterranean windmills which readers may be able to supply.

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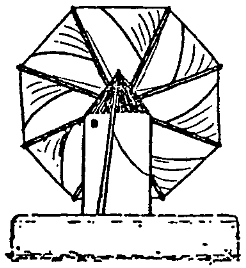
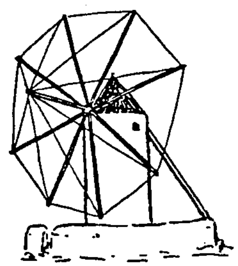
ALCUDIA MILL

with sails

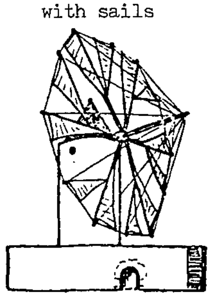


without sails

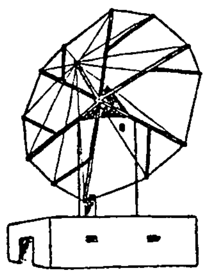


INCA MILL

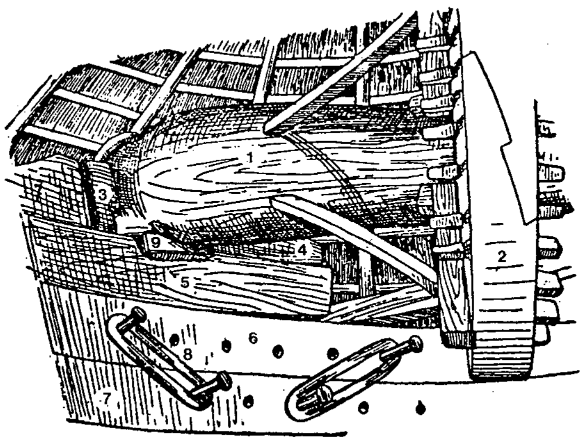
with sails



without sails



Neck bearing of windshaft.
1. windshaft
2. brakewheel
3. 'struggler'
4. 'cheek'
5. 'under-throat'
6. upper curb
7. lower curb
8. iron loop
9. stone or iron bearing



WATERMILL RESEARCH AND DEVELOPMENT IN NEPAL

by JOHN K.G. BOUCHER

In my previous article on Himalayan mills (ref 1), I made passing reference to research work in Nepal. Since then I have had the opportunity of visiting Kathmandu, where I was able to observe the research being undertaken into devoping more efficient horizontal water mills as part of the wider drive for an 'appropriate technology'.

Over four fifths of the Kingdom of Nepal lies in the Himalayas, and ninety percent of the population of 15 million lives by agriculture. The number of horizontal mills in use has been conservatively estimated at 25,000. Some put the number at nearer 35,000, with a possible upper limit of 50,000. Quite obviously they form a major energy source, and although more powerful turbines are being introduced in some areas, together with small diesel engines and mains electric motors where circumstances and finance permit, horizontal mills are likely to remain working in large numbers for many generations to come.

Organisation

The development work is being undertaken by three groups. Indigenous input is given by the Research Centre for Applied Science and Technology (RECAST) at Tribhuvan University, Kathmandu, under the leadership of Mr. Chandra Bahadur Joshi (Reader). Mr. Joshi made me most welcome and kindly supplied much of the information I have used to prepare these notes. RECAST also has a field testing station just outside Kathmandu, where the improvements and new designs are assessed.

Technical assistance is being given by various international agencies, in particular UNICEF and the Swiss Association for Technical Assistance (SATA). These bodies are sponsoring the development of manufacturing facilities for improved horizontal mills, crossflow and other turbines, and other products for rural development generally.

The main efforts in the field of small water power are directed towards using water more effectively as a renewable energy resource, and can be subdivided into a number of headings

(i) Simple improvements to traditional mills
(ii) Development of the MPPU (Multi Purpose Power Unit)
(iii) Development of alternative forms of simple turbines
(iv) Introduction of larger turbines of varying design and power output to serve wider communities.

Traditional Mills

The Nepalese mill as may be expected differs in detail from the Hazara mill previously described, although the general principles and the scale of operation are similar. Fig 1 shows a typical Nepalese mill in the Kathmandu valley, although minor variations occur elsewhere in Nepal.

The most obvious differences when compared to the Hazara mills are in the number and shape of the waterwheel blades, and in the mill feed arrangement and collection of flour. Less obvious is the bearing arrangement which utilises a metal pintle sitting in a cast iron cup, or alternatively, a simple stone bearing.

Between ten and sixteen flat wooden paddle blades are morticed into a cylindrical barrel shaped wooden hub. The paddles are typically 8in. deep and are inclined at between 40° and 50° to the vertical. Water is fed to them through an open

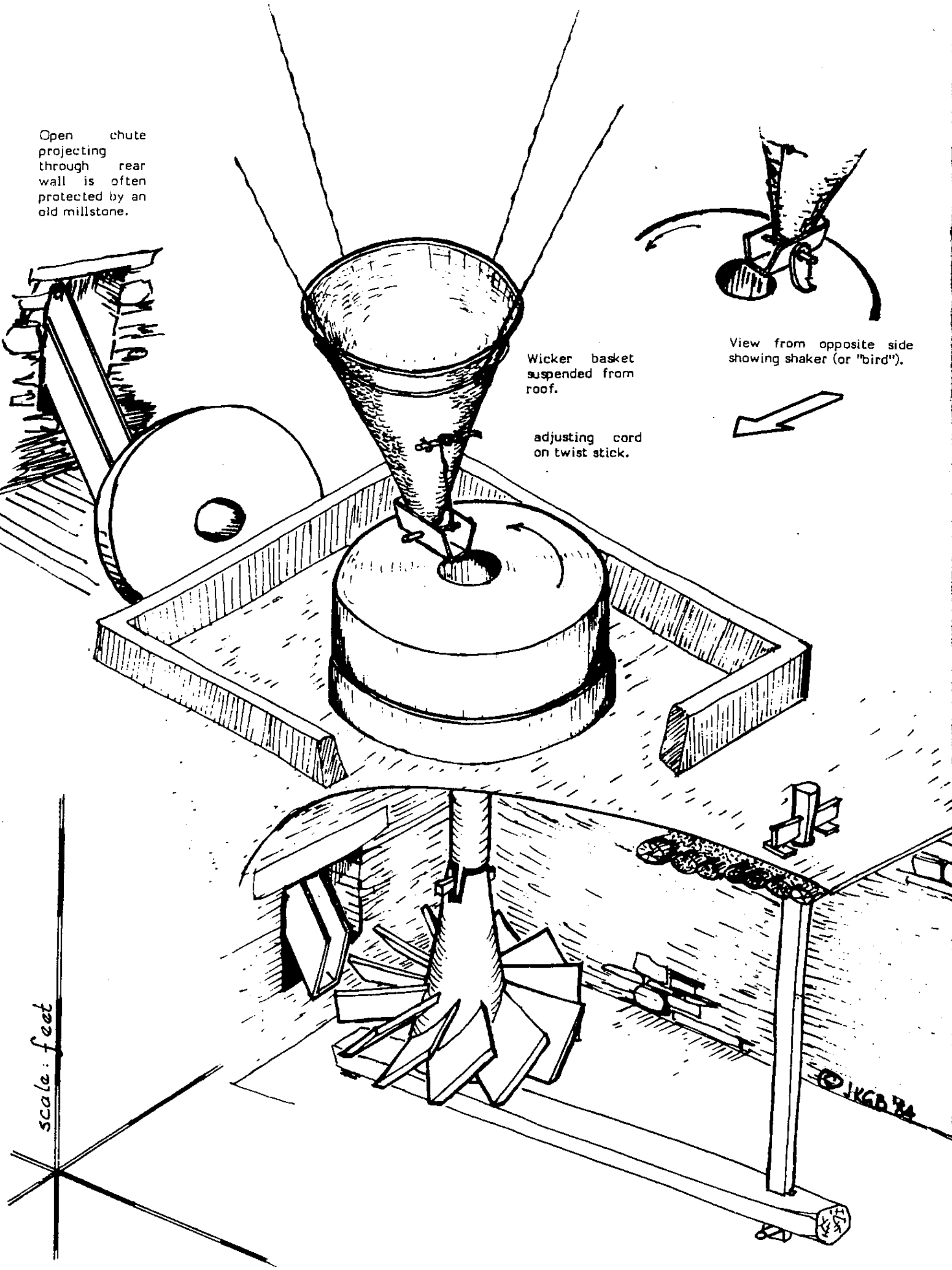
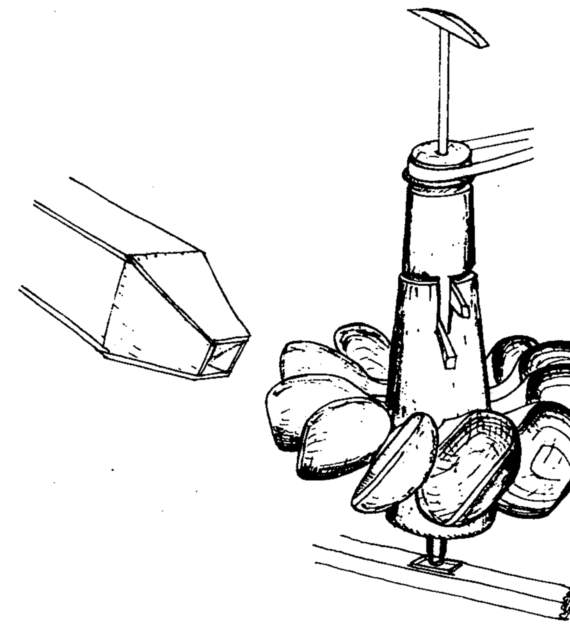


Fig 1 A Traditional Water Mill from the Kathmandu Valley - Nepal

Fig 2a The Improved Horizontal Wheel



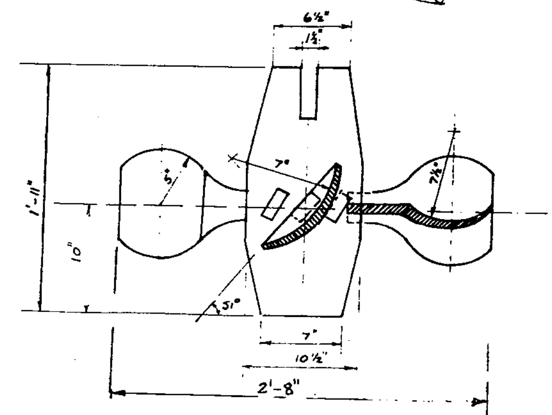


Fig 2b Idealised Dimensions for the Improved Wheel

top chute. A sample survey made in 1982 (ref 5, table 5) recorded water heads varying between six and twenty feet, fed through chutes set at angles of between 38° and 56° to the horizontal.

The mill feed is from a conical wicker basket suspended by four cords from the roof. Grain flows through an adjustable shoe which is vibrated by a dangling arm, sometimes called a 'bird', rubbing along the top surface of the runner stone.

Simple Improvements

The first objective of the researchers was to raise the efficiency of the traditional mill without making any more changes than necessary, in order to minimise the expense; even a cost of a few rupees would be a significant amount to a subsistence farmer, and to make the improvements attractive they had to be kept simple and within the orbit of the village craftsmen.

The first stage of improvement therefore was to replace the flat paddles, open chute and pintle bearing with shaped buckets, closed pipe and ball bearing.

The spoon shaped blades (Fig 2a) were scientifically designed to maximise hydraulic efficiency, but still carved from wood and of the same tenon size as the earlier flat paddles, so that they could be directly inserted into the mortices in the hub after withdrawal of the original paddles. In fig 2b they are shown fitted to an ideally shaped new hub.

The closed pipe enables higher water pressures to be developed, and a shaped spout directs the water onto the wheel in the best manner. The ball bearing, a single ball placed between the base of the hub and the bridging tree, has been shown to be a simple way of reducing resistance at this point.

Tests carried out on a traditional mill and on the mill after first stage improvements showed an 80% improvement in efficiency, test results being as tabulated below:

Type of Mill	rpm	HP	Efficiency %	Productivity (kg/hr)
Traditional	156	1.120	21.0	14
Improved	230	2.024	38.2	21

In addition to improving the hydraulic efficiency, vats were introduced to contain the flour around the stones and thereby improving the recovery rate of the product. A small belt drive to a bicycle wheel dynamo was also added to provide electric lighting for night time working.

The cost of these improvements was about Rupees1400/-(£70), bringing the total cost of a mill (including shed at R3000/-) to about R7000/-(£350) in Nepal, excluding water supply. (Ref 3). The benefit claimed from the improvements amounted to R4400/- per annum resulting from increased productivity, saving of lamp oil and reduction in waste.

Unfortunately, the spoon shaped blades made from wood have proven to have a rather limited life, and they have not lived up to their early promise. This, combined with the difficulties of manufacture, has led to the development of an all metal wheel with metal blades, described in Ref 6.

Further Development - the MPPU

The second stage of improvement was to review the whole concept and develop a small modular mill which could be manufactured in large numbers in factory conditions but be easily carried by porter, donkey, or even light aircraft to remote areas and quickly re-assembled on site. In view of the various types of equipment that could be driven from it the mill became known as the Multi Purpose Power Unit - MPPU.

The new mill has been thoroughly described and compared with older, traditional types in an excellent little book 'MPPU, Multi Purpose Power-Unit with Horizontal Water Turbine', written by A.M.Nakarmi and A.Bachmann (Ref 4). Fig 3 is an extract (by courtesy of the authors) which shows the concept diagrammatically, and anyone interested is recommended to obtain a copy of the book which is well illustrated by drawings and photographs. (It is described as volume 1 - I am hoping that the publication of volume 2 will not be delayed too long!)

The MPPU can be adapted to drive, in addition to mill stones, a small dynamo, and one or more of a range of ancillary items such as rice hullers or oil expellers,

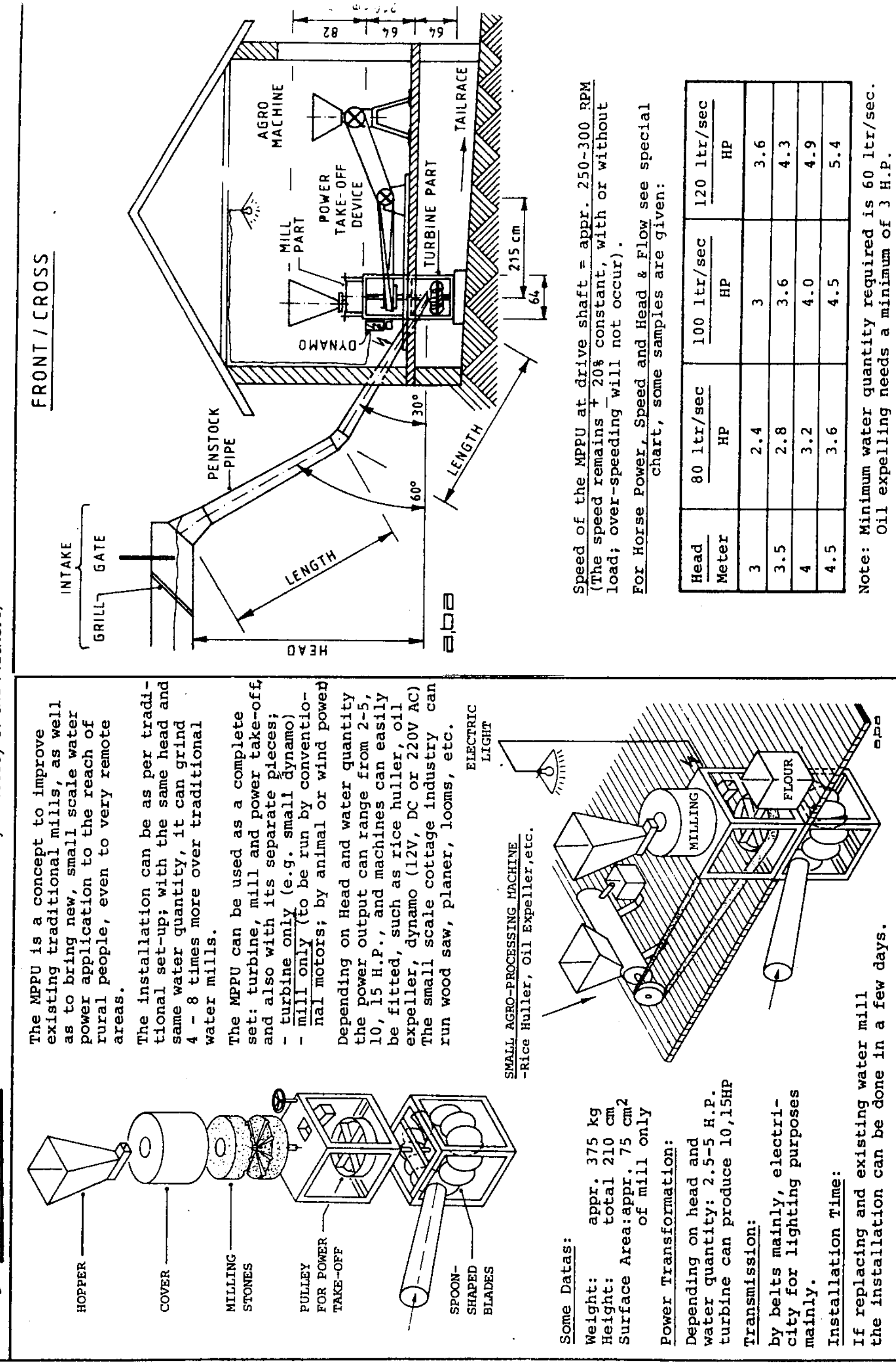


Fig 3 The MPPU concept (extract from reference 4 by courtesy of the Authors)

and even woodworking machinery. The basic cost of the unit is about R14,000/- (£700).

One common complaint about the improved mills, however, is that because of the increased speed of rotation the taste of the stone ground flour has deteriorated. Engine driven mills have the same problem!

Vertical Wheels

A small number of vertical wheels are recorded in Nepal (Ref 5), but these all appear to be impulse wheels of, typically, 6ft. diameter and revolve at high speed. Water is fed to them down a long chute in the same way as it is to horizontal wheels. Modern wheels fabricated from sheet steel have been tried, but do not seem to have been particularly successful.

Turbines

Various types of turbine are being tried with varying success, ranging from small pelton wheels to Barker's turbines, but the most promising appear to be the crossflow types with horizontal shafts. A number of factories have been established in Kathmandu for their production, under the auspices of UNICEF and similar bodies.

It is interesting to note, however, that a total of 80 MPPU's have been produced in the three years since their introduction, compared with 150 cross flow turbines in over ten years, a rate of only half as many per annum. This indicates the general good acceptability of the MPPU, and perhaps demostrates the benefits of remaining as close as possible to well understood technology.

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Further reading

'Living With The Desert' by Elizabeth Beezly and Michael Harverson, Avis and Phillips, 1982.

This book contains an excellent chapter on water mills (and another on wind mills) as found in Iran and parts of Afghanistan, bordering on to Pakistan, and provides further interesting comparison with the Himalayan types of horizontal mill I have described. The use of the Aruba penstock is a distinct difference from Pakistani and Nepalese mills which probably reduces the hydraulic loss resulting from the use of a long flume.