Argos Hill Windmill Trust

ARGOS HILL WINDMILL
How She Worked

Mill Tour Guide Information
& Technical Details

Martin Bates

Third Edition
2023

Contents — Page

Contents	Page
Introduction	*4*
Brief Timeline	*4*
External Features	*5*
The Mill Site	*6*
Restoration of Mill	*7*
Tour of the Mill	*8*
Operation of the Mill	
Grain Storage & Preparation	*10*
Sweeps & Striking Gear	*10*
Fantail	*11*
Windshaft & Drives	*11*
Milling Process	*12*
Tentering Gear	*13*
Wire Machine	*13*
Missing Oat Crusher	*13*
Operating Procedure	*14*
About Millstones	*15*
Museum Exhibits	*16*
Windmill Utilisation	*18*
Maintenance	*19*
Structure of the Mill	
Vertical Section	*20*
Construction	*21*
Load Bearing Structure	*22*
Floor Plans	*24*
Construction & Repair Details	*26*
Modifications	*26*
Construction Techniques	*27*
Types of Wood	*27*
Mill Dimensions	*28*
Rear Elevation	*29*
Sweep Construction	*30*
Striking Gear Operation	*34*
Fantail Design	*35*
Restoration of Fantail	*36*
Construction of Fantail Wheels	*37*
Machinery of the Mill	
Brake & Sack Hoist	*38*
Feed Bins	*39*
Tailstone Drive & Feed	*40*
Generic Tentering System	*41*
Comparison of Tentering Gear	*42*
Tentering System Analysis	*43*
Restoration of Head Stone Gear	*44*
Auxiliary Drives	*45*
Restoration of Auxiliary Drives	*46*
Smutter Design	*47*
Conservation of the Smutter	*48*
Flour Dresser Design	*49*
Restoration of Wire Machine	*50*
Door Lock	*51*
Other Windmills	
Types of Windmill	*52*
Other Local Mills	*52*
Post Mills	*53*
Smock Mills	*54*
Tower Mills	*55*
Local Millwrights	*56*
Phoenix Iron Works	*57*
Modification of Post Mills	*58*
Windmill Terminology	*59*
Restoration Notes	
Restoration Notes 2016	*61*
Restoration Notes 2017	*62*
Restoration Notes 2018	*63*
Restoration Notes 2019	*64*
Restoration Notes 2020	*65*
Restoration Notes 2021	*66*
Restoration Notes 2022	*67*
Philosophy of Repair	*68*
Further Work 2022	*69*
References & Acknowledgements	*70*

Introduction

Argos Hill windmill near Mayfield in East Sussex was built around 1835, and is, at the time of writing, undergoing restoration by Argos Hill Windmill Trust.

It is a post mill, meaning that the whole upper part of the windmill rotates to face the wind when working. The sweeps (a local term for sails) drive two sets of millstones to produce flour from wheat or animal feed from other grains. As a later example of this type of mill, it incorporates many of the refinements that were developed over time to improve the performance of windmills in general, as well as some unusual or unique features, and is particularly important in that it retains much of the original working machinery.

This booklet is intended to explain the construction and operation of the mill in detail, and was compiled to support and inform tours of the mill and act as a reference for future guardians of the mill. It is based on a close study of the extant structure and mechanisms of the mill, and may be updated as the restoration of the mill progresses and more evidence comes to light. For ease of use, it is organised in self-contained sections, so as a result some repetition may be found. It draws on a range of sources, all of which are gratefully acknowledged. A virtual 3D tour of the mill and further information may be found on the Friends of Argos Hill Windmill website at http://www.argoshillwindmill.org.uk

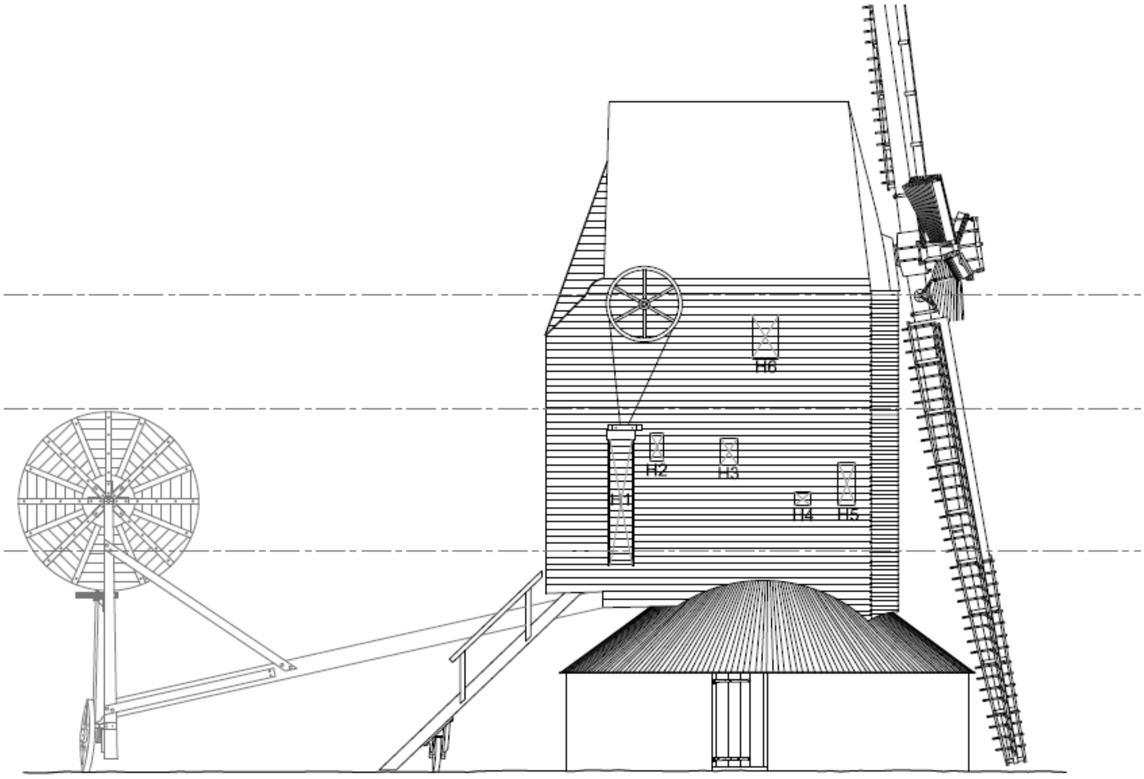
This edition of the booklet also includes information on other windmills in the area, and compares their different features and development. A yearly summary of the restoration work completed at Argos Hill is included in the appendices.

Brief Timeline

1656	Windmill at Argos Hill first noted in historical records
1724	Windmill marked on an early map
1835	Current mill built for and worked by Aaron Weston
1861	Succeeded by his son, also Aaron Weston
1888	Succeeded by his nephew Raymond Weston
1912	Sold to and worked by George Wickens
1923	Mill stopped work temporarily
1925	Worked by Mr Richardson of the Neve family
1927	Mill ceased regular work
1929	Fantail blown off in a gale
1930	Mill possibly worked occasionally
1932	Shutters removed from the sweeps and mill became derelict
1955	Uckfield RDC took possession, initial restoration by Sands
1957	Roof of roundhouse renewed
1963	Mill damaged by lightning
1966	Front frame renewed
1967	Stock fractured in gale
1969	Fly frame restored with new tail pole by Ernest Hole & Sons
1987	Extensive damage in hurricane
1990	Restoration with dummy sails
1994	Exterior repainted and red covering on roof renewed
1999	Friends of Argos Hill Windmill set up
2002	Mill placed on English Heritage "Buildings at risk" register
2005	Sweeps removed and mill was concealed in a protective scaffold
2008	Wealden District Council threat to dismantle the windmill
2010	Argos Hill Windmill Trust formed
2011	Wealden District Council lease the mill to AHWT
2012	Steel frame installed to support the mill body by Jeremy Hole
2013	Planning and fundraising for the restoration by AHWT & FoAHW
2014	Major grants awarded by the Heritage Lottery
2015	Structural repairs completed
2016	Steps, tailpole and sweeps installed, and mill officially opened
2019	Fantail rebuilt and restoration of internal machinery continues..

"Argos Hill is one of the most complete and important post mills in England today, and a fine example of the Sussex tradition in millwrighting" (Vincent Pargeter, 2001)

External Features



Drawing credit: Douglas Moat Consulting

A windmill is a building and a machine, all in one. Argos Hill post mill consists of three main parts, as shown above in a scale drawing of the side elevation. The buck (mill body) supports the sweeps and contains the milling machinery. The roundhouse contains the trestle that supports it, and the fantail assembly drives the buck round to face the wind.

The **mill body** contains the mill stones that are driven by the sweeps (sails), and is clad with white painted weatherboard, into which hatches are inserted that are removable from within. These allow the interior to be thoroughly ventilated when milling is in progress, to allow the dust to escape. Some openings are glazed, including those at the front and rear. A large wheel on the upper right side (as facing the front) is used to operate the striking gear (see below). The roof of the buck is covered with zinc sheeting, painted red, which provides durable weatherproofing and a distinctive appearance. A set of heavy oak steps is attached at the rear, hinged to the buck, providing access to a recessed split stable door. The buck has a rear extension, added after its original construction, to provide extra space for machines that clean the grain before milling (smutter) and separate the flour and bran afterwards (wire machine).

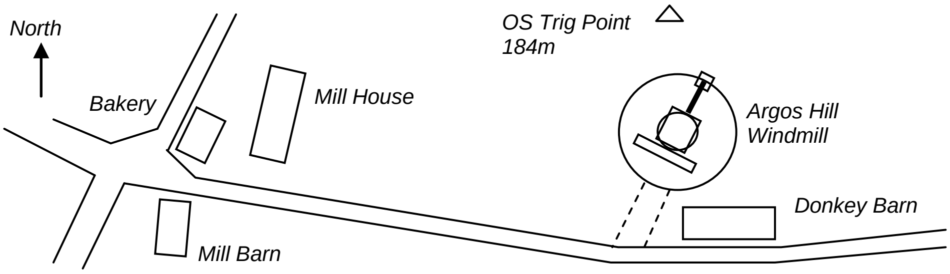
The four **sweeps**, mounted on a windshaft in the apex of the roof, carry sets of shutters which, when closed, capture the force of the wind and turn the stones. These are opened and closed via the striking gear, a system of gears, rods and cranks. They are opened when the mill is not working to let the wind through, and a counterbalance allows them to open automatically if the wind becomes too strong.

The **roundhouse** encloses a massive trestle that supports a main post upon which the buck rotates; it also provided storage for materials and stock. It now has a conical tarred oak plank roof supported upon on a stone built circular wall, rendered and tarred on the outside and lime plastered and limewashed inside. Its floor now consists mainly of recycled scaffold boards. It has two doors, so that the moving sweeps can be avoided when entering or leaving the mill.

The **fantail** is carried on a long tailpole attached to the buck. If the wind veers when the mill was working, its fan blades are exposed to the wind, driving a set of heavy duty cartwheels, via a low gear system, around a circular track so the mill faces into the wind again. The steps also have a set of truck wheels, so that they can rotate with the buck.

The Mill Site

While there is evidence that there had been windmills on Argos Hill in earlier centuries, the current mill was built around 1835, owned and operated for most of its working life by the Weston family. The original site was six acres, including the properties shown on the site map below. The mill is well situated at the top of a steep, south facing ridge about 2km north-west of Mayfield village. It can be seen that it was some distance (65m) from Mill House, which was more conveniently built at the junction of lanes to nearby Five Ashes (south), Rotherfield (west), Mark Cross (north) and Mayfield (east). The properties on the site together provided storage, milling, stabling and baking facilities with transport links in all directions, and could be considered a form of vertically integrated business.



The **Mill House** (left, pictured in 1928) is a 17th century farmhouse was occupied by millers and their families from 1692 until 1955. In 1822, Aaron Weston married into the family and built the mill in around 1835, being listed as the owner of the mill and house in 1837. On his death, the mill was taken over by his son, also named Aaron, whose gravestone may be seen in the churchyard in Mayfield (below right). The mill was last owned by Joseph Fuller, who operated it until the 1930s.

The **Bakehouse** (left) was part of the farm estate, dating from before 1831, and was operated by relatives of the Weston family until 1913. It continued as a bakery and shop until 1940, delivering to local customers, and was still in operation in 1948.

The **Mill Barn** (right) is a weatherboard and tile building on the opposite side of the road to the Bakehouse that was a part of the farm. The upper floor was a granary, the lower floor a cowshed and a sunken range on the roadside was a piggery. It was converted to residential use after 1947.

The building known locally as the **Donkey Barn** (left), a weatherboard and stone conversion, is immediately adjacent to the mill access gateway. The name suggests stabling and storage, and seems very likely to have been built to serve the mill. It has a new extension actually built under the turning circle of the mill!

At the junction of Argos Hill Lane with the main road to the east of the mill is an 18th century house called the **Chequers** which was originally a beerhouse and forge. These facilities could have been very useful to the mill business, their family and staff.

Restoration

After going out of use in 1927, the mill was effectively abandoned until 1955, when it was transferred to the local authority to maintain. Some restoration work was then carried out by Sands & Son of Heathfield, with further work by in 1969 by E. Hole & Son of Burgess Hill to repair storm damage and complete the first round of conservation. New stocks, dummy sweeps, tailpole and flytackle were fitted, and the mill and museum in the roundhouse opened to the public.

Joseph Fuller, the last miller at Argos Hill, in about 1930

However, the mill was damaged in the great storm of 1987, and subsequently public funding to maintain historic buildings generally began to decline. By 2002, the mill was on the English Heritage Buildings at Risk register; the sweeps were removed and the structure enclosed in protective scaffold. A steel support structure was installed to prop up the buck pending more permanent repairs.

Argos Hill Windmill Trust Ltd was formed by local enthusiasts in 2010 with the intention of saving the mill. It secured a lease from Wealden Council for a peppercorn rent in 2011, started fundraising and obtained a grant from the national lottery to proceed with major restoration works. JHE (Jeremy Hole Engineering) Ltd were engaged to repair the structure of the mill body, and to build and install new sweeps, starting in 2014.

Volunteers worked alongside Tony Hole and his son Jeremy to repair the roof, rebuild the tunnel, replace weatherboarding, construct new steps and restore the roundhouse floors and walls. In 2016, the steel supports and scaffold were removed, the mill officially opened and the new sweeps turned in the wind again.

Original Mill Restoration Plan

The following plan was published by the trust at the outset of the project:

Phase 1	Make waterproof and structurally sound, including repairs to trestle, framework, roundhouse, re-weatherboarding, re-painting and installing new steps
Phase 2	Install sails that are capable of free-wheeling, complete with some shutters and striking gear
Phase 3	Renew tailpole and fantail to static condition
Phase 4	Return to full working order by repairing all machinery and re-instating the full turning circle

Phases 1 and 2 were completed in 2016 and Phase 3 in 2018. At the time of writing, Phase 4 is under way.

The Future

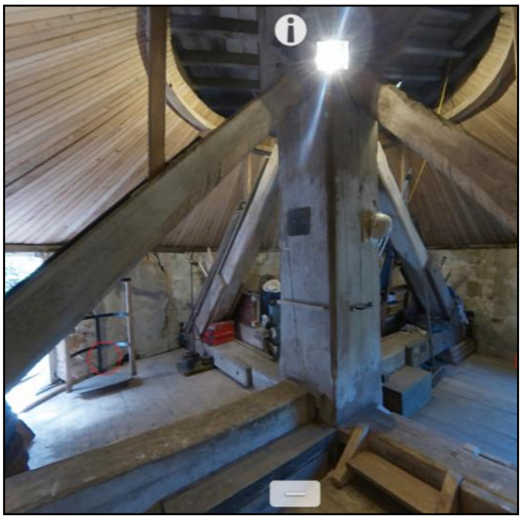
While restoration work is progressing well at the time of writing, some significant problems remain outstanding for the project. The local authority only owns the actual footprint of the mill, with neighbours owning sections of the turning circle. Under the terms of the lease the Trust has right of access to the mill for the purposes of repair and maintenance. However, agreement to allow the mill to move over the turning circle, or for the trust to purchase the necessary land, has not been obtained. The lease does provide wayleave over a subterranean development on the east side, but substantial remodelling of the whole turning circle, and removal of obstructions, will be necessary to allow the mill to turn into the wind again.

The mill before restoration

The picture left shows the right side of the mill body, roundhouse, steps and sweeps. The buck has numerous removable solid hatches to provide light and ventilation, since the mill would be very dusty when at work. The red zinc plated roof and black roundhouse form a pleasing colour scheme, although the roof was probably originally white. The wheel and chain box are part of the striking gear that opens and closes the shutters that are visible on the right.

Roundhouse

At ground level, the roundhouse contains the trestle, consisting of the main post and supports, upon which the main body of the mill rotates. A conical roof ensures dry storage for sacks of grain, meal, bran or flour. A large sack balance hangs in the roundhouse to weigh feedstock and product. No doubt the roundhouse also provided shelter for workshop operations. It has two doors so the sweeps could be avoided whatever the wind direction.



The picture above shows the trestle inside the roundhouse and the circular roof aperture which gives access to the trapdoor on the spout floor. Circular oak ring beams supports the edges of the roof boards and forms a wall plate on top of the sandstone block walls. In some post mills, the trestle is raised on tall brick piers to create a clear working space underneath the cross tress.

The picture above shows the rear of the mill with the tunnel covering the ladder access to the bin floor, the rear extension, main steps and tailpole. The sack slide can be seen attached to the right side of the steps. Note the doorway is offset to the right to ease access from the steps.

Rear Extension

The rear extension of the buck is an unusual feature of Argos Hill mill. Most other local post mills are somewhat larger, suggesting that it was found necessary to enlarge the mill after initial construction when it was discovered that there was insufficient space to accommodate the smutter and wire machine that were installed later to improve the product quality. The awkward location of the smutter at the top of the stairway supports the idea this was a later addition.

The extension provides extra space on the stone and spout floors and shelters the rear door. As part of the modifications, a 'tunnel' was built to enclose the ladder to the bin floor. This may have allowed the bins to be arranged more conveniently at either side of the mill body, with the access from the rear.

When viewing the interior of the mill, note the wear on the ladders which suggests that they are original. Extra rails and ropes have been added recently for safety. The wear on the sack hoist rollers is particularly severe, since the sack hoist chain had to be guided through traps that are not aligned due to the overall layout.

Spout Floor

The lowest level of the mill itself, the spout floor, is accessed from the steps at the rear. Here, the meal was collected from the stones in the bins on the left, and output from the wire machine and smutter spouts collected in sacks.

Most of the mill functions can be controlled from this floor via extended ropes and cords. The tentering gear, main post and samson head which supports the mill structure are also visible on this floor (see picture).

Stone Floor

Up the steps from the spout floor, the stone floor has two pairs of millstones, enclosed in wooden vats that collect the meal. The front (breast) stones are made of Derbyshire Peak gritstone, and were generally used for coarse grinding of animal feed. The rear (tail) pair are French Burr stones (see picture), composed of quartz segments bonded together by plaster cement and steel bands, that produced finer flour for human consumption. The sides of the tail stone vat are original, but with new lid sections. The windshaft may be seen overhead, to which the large brake and tail wheels are attached, fore and aft, which drive the stones. The smutter and wire machine are also on this level, accommodated in an extension to the rear of the mill.

The picture above shows the tailwheel and tailstones, with the brake lever on the right running towards the front of the mill.

Bin Floor

The picture above shows the front of the bin floor with the sack hoist drive mechanism and its shaft overhead.

On the top level of the mill, accessed by a narrow ladder at the rear of buck, the grain and meal are stored in five large bins that have their spouts on the stone floor. One at the front left stored wheat to feed the tail stones via a wooden chute on the stone floor. At the front right is a pair of bins that could store oats and barley to be fed to the breast stones via sacking spouts to make animal feed. The rear right bin fed the smutter via a chute (now missing) mounted above the access stairway from the spout floor. The remaining bin, rear left, fed the wire machine via a box section on the spout floor. The grain bins are arranged around the windshaft that passes under the floor, and the front milling bins are separated from the rear processing bins by a void accommodating the tail wheel. A storm hatch at the front of the mill above the windshaft gives access to the sweeps and striking gear from the bin floor.

OPERATION OF THE MILL

Grain Storage and Preparation

Wheat and other feedstock would be delivered in sacks from local farms and granaries by cart. The sacks could be stored in the roundhouse and lifted into the buck via a trapdoor or hoisted directly on to the mill spout floor via a sack slide mounted on the steps of the mill. The sack hoist, fitted in the apex of the roof, consists of a rope or chain on a winding drum (bollard) driven from the brakewheel via a slack belt. When the hoist is activated, an idler pulley is applied to the hoist drive belt by pulling on a rope passing down to the floors below via guide pulleys, so it can be operated from each of the lower floors. Sacks are raised via self-closing split traps in the stone and bin floors, the grain or meal then being discharged into the appropriate bin.

The smutter (see right) is used to clean the grain before milling, removing dust and harmful fungal growth which may arise from storage in damp conditions. It is fed from the rear right bin above via a chute and a small shuttered inlet that can be seen on the front of the machine (see right) above the drive pulley. It was driven from the tail wheel via a side pinion, shaft and pulley belt on the right side of the stone floor. A small cord operated wooden rocker allows the smutter inlet to be opened from the spout floor below.

The smutter has a horizontal wire mesh drum with internal rotating brushes that sweep the dust out through the wire mesh, allowing clean grain to fall out of the far end of the drum via a spout into a grain sack on the floor below. The dust is drawn into the smutter box below the drum by a fan driven by a secondary drive belt, and is then blown out of the side of the mill.

Sweeps & Striking Gear

Power to the stones is provided by patent sweeps (sails) (see left) that are mounted on long beams (stocks) that pass right through the cast iron canister. These were originally wood (pitch pine) but are now hollow steel sections for strength and durability (broken stocks were a fairly common problem in old windmills). On to these are bolted the sweeps, with the main member (whip) carrying a framework of battens to support a set of shutters. These are set at an angle to the plane of rotation (weather) to produce the turning force. A reduction in this angle of weather along the length of the sweep ensures that the ends of the stocks that support the sweeps are not subject to excessive bending force and turbulence is reduced. There is space for 16 short shutters on the leading edge at the far end of each sweep, and for a total of 35 longer shutters on the trailing edge.

Thus, the sweeps have space for a maximum of 51 shutters each, but at present carry fewer to reduce the strain on the structure while the mill is inactive and cannot turn. The shutters are attached perpendicular to the whips with angled cranks which allow them to opened and shut, or set at some intermediate angle. When they are closed, maximum torque is produced on the windshaft, but when opened (fully or partially), wind is spilled and torque reduced. Solid windboards on the inner ends of the sweeps provide a minimum turning force to turn the sweeps when off load, so the braking system must be able to resist this force in high winds.

The cranks are all connected to shutter bars which move longitudinally on the stocks to open and close the shutters. These are operated simultaneously from a cross piece at the centre of the sweeps called the spider, which is mounted at the front end of a push-rod that passes through the centre of the windshaft to a rack and pinion at the tail end. This in turn is operated from the large chain wheel mounted on the side of the mill that is turned by a loop chain passing down through a box section, allowing the shutters to be opened and closed by pulling down on either side of the striking chain on the spout floor. A suitable weight can be attached to the chain so that, if the wind becomes too strong, the pressure on the shutters will raise the weight allowing the shutters to open and spill the wind automatically. Conversely, when the wind drops, the weight will close the shutters again. This system is collectively known as the striking gear; it allows the speed of the sweeps to be controlled without having to stop them.

Fantail

The mill is designed to move into the wind automatically; this had to done by hand in older mills. A fantail carriage is attached to the tail pole that projects from the rear of the mill. It carries an eight-bladed fan that drove a set of cartwheels via bevel gears, shafts and reduction gearing, following a circular track round the mill. When the mill is facing into the wind, the fan and buck remain stationary; if the wind veers to one side, it catches the fan, driving the wheels such that the buck faces into the wind again, and stops. The fantail also serves to stabilise the mill by bracing the buck against the force of the wind.

The picture left shows a previous rebuild of the fantail. The cartwheels are unusual, in other mills they are cast iron.

Windshaft and Drives

The windshaft is a massive cast iron tube with an integral poll end (canister) through which the stocks pass. The open neck (front) bearing is about 12” in diameter, resting on a gunmetal (bronze) semi-circular block. This sits on the weather (breast) beam, which therefore carries most of the weight of the windshaft and sweeps. The tail (rear) thrust bearing is about 6” in diameter (see right) and bolted to the tail beam. It has a sliding contact connected to the lightning conductor which runs down the rear of the buck.

The drive from the windshaft is taken off the brake (breast) wheel and tail wheel, both about 8 feet in diameter with cogs made of hard wood (apple or hornbeam). The cast iron brake wheel lies just behind the neck bearing and is of compass arm construction (with radial spokes) in two halves bolted together and retained with iron wedges around the windshaft (see left). The brake wheel has a large wooden (elm) brake shoe mounted in linked sections around its rim that is operated by a long wooden lever on the right of the stone floor. When the mill is running, it is supported in the off (up) position by a hook and pin. Unhooking and dropping the brake lever pulls the brake shoe on; a heavy weight can then be hung on the brake lever to hold it on. The brake can be operated from the bin floor below by a rope extension. It must be applied carefully when stopping the mill to avoid overheating of the brake shoe, or, worse still, snapping off the stocks.

The tail wheel is of clasp-arm construction of oak and elm: two pairs of cross pieces are clamped around a square section of the windshaft supporting a wooden rim made in sections (felloes). The cogs are made with shanks that extend right through slots in the rim to be retained by small pegs. These wooden cogs engage with smaller cast iron pinions mounted on vertical square shafts (quants) that drive the upper runner stone. The gearing ratio means the runner stone rotates about twice per second.

The combination of wood and iron teeth provides quiet running with minimal need for lubrication. The wooden cogs are to some extent self-adjusting, since high spots will wear away, and improve meshing, but they then need regular replacement. The stone nuts can be disengaged from their upper bearing (glut box) to disconnect the drive by inclining the drive shaft away from the tail wheel. This serves to protect the fragile wooden teeth on the drive wheels in case the brake does not hold, as well as selectively disabling the stones. A screw clamp on the glut box retains the upper quant bearing in its working position. The runner stone rotates on a spindle and thrust bearing mounted below on the bridge tree, but is driven from above by the quant. Hence the runner stone is ‘overdriven’ while its weight is carried on the bearing below.

The Milling Process

The primary purpose of the mill is to produce flour from wheat by crushing it between the French Burr stones to release the flour. Wheat from the storage bin on the upper floor is released into a chute which directs it into a hopper supported on a frame (horse) fitted over the tail wheel stones (see left). The chute incorporates a mesh floor which appears to provide an additional stage of screening for the feedstock. The dust and contaminants were collected beneath the chute from a separate spout for disposal. The hopper holds about a bushel (8 gallons) of grain, which will take about 15 minutes to mill.

A shutter (spattle) in the hopper is opened to allow the grain to fall on to a sloping feedshoe, which channels it into the eye (the hole in the centre) of the circular runner stone. The shoe end has a tappet which is held against the square quant by a cord attached to a spring on the inside of the vat. This vibrates the shoe to shake the grain into the eye at a rate proportional to the stone speed. As the quant speeds up, the grain feed rate is correspondingly increased. A control cord attached to the shoe passes over a pulley system to the floor below to allow the feed to be controlled from the spout floor by drawing the tappet away from the quant.

The pitch of the shoe, thus the feed rate, can also be adjusted by means of a crook string that is hooked over a rack on the horse. The hopper incorporates a simple alarm system that alerts the miller that the level of the grain in the hopper is getting low. One end of a leather strap is fixed inside the hopper, and a string to the other end, which is in turn attached to a vertical hinged arm with a bell attached. When the hopper is full, the weight of the grain on the strap holds the bell arm away from the quant; when the level falls below the strap, it can rise, allowing the bell arm to fall against the rotating quant to sound the alarm.

The runner stone (right) has a semi-circular bar (yoke) fitted across the eye of the stone which mates with a cast iron block (mace) into which the forked lower end of the quant fits from above to drive it. The runner stone is supported from below on the stone spindle, which has a square upper end which fits into the mace, and stands on a thrust bearing (bridging box) mounted on the bridge tree below. The hemispherical lower end of the spindle fits into a gunmetal bearing block mounted in a cast iron box retained with set screws, which allow its exact position to be adjusted so that the spindle is precisely vertical and the runner stone horizontal.

The upper bearing of the stone spindle is housed in a neck box wedged into the eye of the bed stone, sealed with a hackle plate to prevent grain falling through. Small weights may be placed on plates on the runner stone perimeter to achieve optimum balance. The height of the runner stone is controlled by the tentering gear (see below) so that a small gap (nip) less than the width of a wheat grain is maintained. A pattern of radiating furrows on the stone faces have sloping edges that force the grain onto the 'lands' between the furrows where fine 'stitching' on the surfaces abrades the grains. The furrows then propel the resulting meal to the edge of the stone (skirt) where it is collected in the wooden vat surrounding the stones. It is then propelled around the edge by a iron tag attached to the runner stone, through a slot on the left side into the meal spout and into the meal bin on the spout floor.

During milling, the meal is heated by friction; it had to be allowed to cool in the meal bin before bagging. If the feed was too rapid, or the stones worn, the meal could be overheated or even burnt, spoiling its quality. The milling operation also had to be carefully managed to avoid the stones coming into contact, causing excessive wear and possibly sparking; since flour dust is combustible, a fire could result.

Milling Speeds

The sweeps rotate anticlockwise when viewed from the front of the mill, meaning that the stones also rotate anti-clockwise when viewed from above. The optimum sweep speed is assumed to be 15 revolutions per minute, 4 seconds per rev. This means one sweep passes each second. The tail stone speed can be calculated:

Sweep speed:	***15 rpm***
Tail wheel gear:	*112 teeth*
Tail stone nut:	*16 teeth*
Gearing ratio:	*112 / 16 = 7*
Burr stone speed:	*7 x 15 =* ***105 rpm***

The maximum speed of the tail runner stone is therefore just under 2 revs per second. The brake wheel has the same number of cogs as the tail wheel (112) but the breast stone nut has only 13 teeth, so the Peak runner stone runs at a proportionately higher speed (112 / 13 x 15 = 129 rpm), a bit faster than 2 revs /sec. The odd number of teeth on the stone nut means that the same pairs of teeth meet less frequently, possibly resulting in more even wear on the brakewheel cogs.

Tentering Gear

A major refinement to the milling mechanism uses a governor to control the separation of the stones to compensate for variation in the wind strength and resistance to the rotation of the stones. This tentering gear can be seen from the spout floor, fitted below the stones. The governor on the tail stones is driven by a leather pulley belt from the stone spindle, so it rotates at a speed proportional to the runner stone, with a gearing ratio of about 0.5, giving a speed of around 1 rev/sec. A pair of lead weights is attached to lever arms and a collar, which is raised as the stone speeds up. The collar engages with the forked end of a long wrought iron arm (steelyard) which crosses below the stones and is pivoted through a steel loop.

The other end of the steelyard is connected to an adjustable screw which passes down through the brayer, a beam that supports one end of the bridge tree, which in turn supports the bridging box and runner stone spindle. The other end of the bridge tree is mortised into a supporting beam allowing a small amount of rotation. The weight of the runner stone (over one ton when new), plus the quant and stone nut, is thus supported by this system of levers with a large mechanical advantage, so it can be held up by a small downward force (less than 10kg) at the end of the steelyard, provided by the lead weights. A movable hook on the steelyard is also provided for an additional adjustable balance weight.

When stationary, the runner stone is slightly raised. This allows the sweeps to start with reduced loading, helping to overcome the inertia of the runner stone. As the mill speeds up, the governor weights fly outwards raising the collar; the upward movement of the steelyard fork produces a small downward movement of the runner stone, bringing it into the working position. As grain is fed in, the resistance will increase and the speed decrease; the governor can raise the stone to maintain speed. The tenter-screw must then be adjusted for optimum meal quality, giving the maximum yield of flour without overheating. Assuming the working gap (nip) is about 1mm, with the governor weights in mid-range, the difference between the starting and working positions produced by the tentering mechanism has been calculated (see below) to be about 0.3 mm; that is, the gap when stopped is about 1.3mm.

The front peak stone is driven and controlled in a similar fashion, with some differences in detail. The design of the governor and spindle bearing seems a more sophisticated, the hopper horse is cast iron rather that wood and an additional lever in the brayer hanger provides direct control of the tentering. The breast stone system seems to have been upgraded later in the life of the mill, maybe when the rear extension was added. It is assumed that the control of the meal quality here was less critical, since these stones were typically used to produce animal feed.

Wire Machine

The meal produced by the milling process contains a mix of flour and bran, the remnants of the outer shell of the grain; the flour must be separated out. The wire machine (flour dresser) sieves the meal into three main parts: fine (white) flour and bran, with ‘middlings’ being a mixture of the two. It contains an inclined wire mesh cylinder and rotating brushes that force the meal components through the mesh (see picture). Fine flour is forced out first, then middlings, leaving coarse bran to emerge at the far end. These are collected from separate spouts for bagging on the floor below. The wire machine is driven from the tail wheel via a skew gear and inclined shaft which can be disconnected by a lever. Its inlet spattle (shutter) can be opened from the spout floor below via a rocker and cord.

The Missing Oat Crusher

Mountings for an auxiliary machine are present on the spout floor of Argos Hill Windmill. It has an elaborate drive system taken off the tailwheel by a side pinion with lever engagement, crown gears, shafts and pulley drive. The most likely candidate for this missing machine is an oats roller mill. These are still present in several other local mills. The overall dimensions, spacing of the mountings and position of the drive shaft on this machine appear to be consistent with those seen on the spout floor. A hatch above the machine position is aligned with the outlet of the middle right grain bin, which probably contained oats to be fed to the stones or the roller machine.

Operating Procedure

Initially, the feedstock needs to be hoisted up to the bin floor using the sack hoist. If wheat is to be processed for baking, it will need to be hoisted three times: once to be loaded into the smutter feed bin, secondly to fill the wheat bin to feed the tail stones for milling, and finally to load the meal into the wire machine feed bin. The sack hoist can be operated from the spout floor via a rope extension so that sacks can be guided up from the store in the roundhouse or directly from a cart at the rear via the sack slide on the steps. The trapdoors do not align perfectly, so some manhandling would be needed, and severe wear seen on the guide rollers indicate the high frequency of this operation.

The miller largely controls milling operations from the spout floor. The brake can be released by a sharp tug on the brake rope to throw the hook aside and allow the brake lever to fall. The speed of the sweeps is controlled using the striking gear chain to adjust the pitch of the shutters. A suitable weight can be hung on the striking gear chain that allows the shutters to open and spill the wind if the speed is too high. The cord that controls the grain feed rate to the stones can be adjusted using a twist peg; this is shaped like a doorknob with a pin through it onto which the cord is wound. The inlet spattles on the smutter and wire machine are also operated from below via cords attached to twist pegs. The tentering gear is adjusted by means of the tenter-screw on the end of the brayer to obtain the optimum meal consistency.

The miller would carry out the following sequence of actions during a milling session, assuming the wheat had already been cleaned in the smutter and loaded into the wheat bin:

On the stone floor:

- *Open the shutter on the wheat bin spout and fill the hopper via the feed chute*
- *Engage the stone nut and close the glut box screw*
- *Pre-set the outlet shutter aperture of the hopper for a suitable feed rate*
- *pre-set the feed rate from the feedshoe using the crook string*

On the spout floor:

- *Release the brake using the brake rope extension*
- *Close the shutters using the striking gear chain & hang weight*
- *Release the shoe feed control cord to start the grain feed*

When running:

- *Monitor the meal output quality and rate*
- *Adjust the tentering gear setting if necessary*
- *Adjust the striking gear setting if necessary*
- *Adjust the grain feed rate if necessary*
- *Refill the hopper when the alarm sounds*

To finish milling:

- *Open the shutters to spill the wind*
- *Apply the brake (slowly!) and attach the brake weight when stopped*
- *Disengage the stone nut*
- *Sweep out the surplus meal from the stone vat if necessary*

To process meal:

- *Scoop out the meal from meal trough when cool into sacks*
- *Hoist the meal sack and empty into the dresser bin*
- *Attach flour, middlings and bran sacks to wire machine spouts*
- *Engage the wire machine drive and start the sweeps as above*
- *Open the wire machine spattle and close when sacks are full*
- *Return the sacks to roundhouse for weighing or measuring products*

Working Conditions

The miller had to be strong and skilled, and worked in a hazardous environment. He would have to work when the wind was right, on any day or night. The mill could be worked by the miller alone, but sometimes he had an assistant or apprentice, often a son. The machinery was dangerous when moving, with a great deal of inertia, and could easily crush human limbs and bodies (the miller’s son was killed at Crowborough Mill in 1862).The dusty air could cause lung disease. No naked flames could be used in the mill, since flour dust is explosive, so the miller would have to be so familiar with the layout that he could operate it in the dark.

About Millstones

Heavy circular millstones driven from the sweeps grind the wheat or other grains to produce meal and feed. They needed to be dressed with a suitable pattern of furrows to work efficiently, and re-dressed frequently.

The spare runner stone displayed at Argos Mill is shown left. The yoke and mace upon which it rotates can be seen at the centre. It is cut with a set of 10 harp shaped sectors, with the furrows running diagonally. When rotating upon a bedstone dressed in the same way, the furrows cross over in a scissor action which crushes the grain on the sloping edge of the opposing furrows to release the flour without grinding the husk.

The orientation of the furrows in Peak stone shown above indicates that it rotated in a clockwise direction, unlike the stones at Argos Mill, which rotate in an anticlockwise direction. For milling flour, burr stones are cut with additional fine grooves on the lands between the furrows, called stitching, to provide extra abrasion of the meal. A straight edge would be used to check the profile, with red ochre smeared on it to mark the high spots to be removed. Ideally, the runner stone should be slightly concave so the edges are as close together as possible with actually meeting.

A used French Burr stone displayed at Nutley Mill is shown right. Note the sectional construction and iron hoops used to hold it together. Exposure to the weather has caused pitting of the surface. The stone is made from a hard volcanic quartz that was only found near Paris in France, and only in relatively small pieces. It was sometimes shipped to England as ballast by trading vessels, and the stone assembled locally using plaster and iron bands to hold the sections together. The weight of the stone could be increased by incorporating rubble on top of the burr sections and finishing with a smooth plaster upper surface. At Argos Mill, four iron plates are incorporated to hold balance weights which helped to ensure smooth rotation.

A thrift (wooden handle) with a bill (tempered steel chisel) inserted is used to dress the stones. These can be seen (left) stored ready for use in a tool rack on the stone floor. Different bills (long, short and pointed) are available for coarse or fine working. These have to be carefully tempered to be hard enough to work the stone. Over time, as the material is removed, the stones become thinner. The bed stone had to be raised on its wooden wedges after re-dressing and levelled using a set square and plumb line or similar technique. The runner stone yoke might need re-fixing (with molten lead) after dressing if proud of the surface and the stone itself would be discarded when its weight became insufficient to work properly.

The runner stone spindle needs to be set vertical by adjusting the four set screws in the bridging box. A ‘jackstick’ was used to check that the bedstone and spindle were exactly perpendicular (see right). Its square hole fits over the spindle upper end, and a quill would be inserted in the far end and the spindle rotated to check if the edge was level all around. If so, the quill would click evenly when striking each furrow. If not, the bed stone wedges would be adjusted accordingly. The mace would then be fitted on the square tip of the spindle and the runner stone fitted, with the yoke engaging with the mace. The tentering gear must then be adjusted to achieve a minimal gap between the stones.

The dressing and adjustment of the stones was critical to produce good flour quality. It seems that the stones would need re-dressing after 200 – 500 hours use, and could therefore need attention every few weeks. Since re-dressing would take at least a day, this is a significant loss of production time, plus the cost of employing a specialist stone dresser, as this was a highly skilled job. As stones would become thinner each time, they would eventually have to be replaced. The stones installed at the mill are about 12” thick. A new runner stone might be 18” thick, weighing well over one ton. The runner stone needs to have a minimum weight, maybe ½ ton, to work effectively, while the bed stone could be thinner. Stone replacement would be quite a big operation, involving transporting and fitting new stones using only manual labour, but millwrights generally had plenty of experience in handling such heavy loads.

Roundhouse Museum

The roundhouse protects the trestle from the elements, and provides feedstock storage and working space for the sale of the products of the mill.

Sack Balance

A large sack balance (right) is mounted on one of the quarterbars in the roundhouse. This would have been used to weigh sacks of grain coming into the mill. It has an impressive ornate wrought iron hanger with the painted inscription ‘S BANFIELD BRIGHTON’ on its balance beam.

Imperial measures of weight used at the time are:

16 ounces (oz) = 1 pound (lb)
14 lbs = 1 stone (st)
8 st = 1 hundredweight (cwt) = 112 lbs
20 cwt = 1 ton

One hundredweight is equivalent to 51 kilograms (kg).
One imperial ton is 1016 kg and 1000kg is 1 metric tonne,
so the metric tonne and imperial ton are very nearly the same.

The sack balance has a set of weights of ½, 1, 2 and 4 stones, but these may not be original. A smaller balance was also found in the mill, probably used for flour sales in small volumes.

Flour Measures

The flour produced could be measured by volume rather than weight. A set of four measuring containers are in the mill collection. The volumes are:

- *1 quart (2 pints)*
- *Half gallon (4 pints)*
- *1 gallon (8 pints)*
- *Half bushel (4 gallons, not pictured)*
- *1 bushel (8 gallons)*

The quart, gallon and bushel measuring drums are embossed with standard marks VR (Queen Victoria) or GR (King George) and LCC. The latter might be London County Council if the measures were purchased from a London supplier such as W Dell.

Bushel Measure

The largest drum found in the mill was measured to confirm its volume:

Diameter = 34 cm, Radius = 17 cm, Height = 40 cm
Volume = 3.14 x 17^2 x 40 = 36,298 cc, 1 gallon = 4546 cc
*Volume = 36298/4546 = 8 gallons = **1 bushel***

The dry weight of a bushel of wheat is approximately 63 lbs (28.5 kg) or **4½ stones.**
A standard sack of grain contained 4 bushels, weighing: 63 x 4 = 252 lbs = **18 stones**.
This was referred to as a ‘coomb’, a standard measure for trading purposes.

Rate of Production

Typical rate of throughput of the mill:	*4 bushels of grain (1 sack) per hour*
Proportion of flour obtained:	*70% (30% bran and middlings)*
Rate of production of flour:	*252 x 0.7 = 176 lbs per hour*

The rate of production would obviously depend on the wind strength and mill speed. At the optimum rate of production, it would take about a minute to produce a 3 lb bag of flour. Assuming the grain hopper can hold up to 1 bushel, it will need refilling every 15 minutes. The miller was traditionally paid with an agreed proportion of the product (typically one fourteenth). This might explain the division of 1 stone into 14lbs.

Right: the appearance of barley, oats & wheat as harvested

Fantail Parts

Parts of the fantail drive system were stored in the roundhouse, including the fantail hub (right), cartwheel spindles (left). The drive system includes a pair of bevel gears on the fantail driving a vertical shaft and split drives to the cartwheels via worm gears (right) that reduce the speed and increase the torque at the wheels by a large factor. These were later fitted to the rebuilt fantail.

Crowborough Postmill Parts

Crowborough post mill burnt down in the 1940s. The remains of the main post is displayed at Argos Mill, comprising the lower end, upper end with pintle and samson head casting (left). An example of an all wood auxiliary gear wheel and a wooden pulley also survive. A spare runner stone (see previous page) allows the radial pattern of surface dressing to be seen, plus the cast iron yoke and mace head which is engaged with the stone spindle from below.

Skids (chocks) for cartwheels

The presence of a sack slide on the steps of the mill and wear on the upper door frame suggest that sacks of feedstock were regularly loaded directly from carts at the bottom of the steps using the sack hoist. An extension to the slide, which would have allowed sacks of grain to be unloaded direct from the cart, has been reconstructed. The pair of skids would have been used to immobilise the cart while unloading; if necessary, these could also have been used to immobilise the fan carriage, assuming its drive was disconnected or the fan disabled, since it was carried on a pair of standard cartwheels.

Sack Stencils

A set of stencils for marking sacks with numbers, made of thin brass. Number '9' is missing (maybe the 'S' was used for this?), and notice the archaic form of the '5'. Lettering stencils might have been needed as well, and removed elsewhere.

Millers Tools

The following selection of millers tools, spare parts and measuring equipment were also found at the mill:

1	*Flour Sieve*
2	*Clips (from tips of sweeps)*
3	*Damsel (runner stone shaft)*
4	*Hook (purpose?)*
5	*Shutter Pivot and Harp*
6	*Turnbuckle for brayer adjustment*
7	*Shutter crank*
8	*Handle for adjusting mechanism*
9	*Part of horse bridle*
10	*Short Mill Bill for stone dressing*
11	*Long Mill Bill for stone dressing*
12	*Ferrule from wooden shaft*
13	*Square and plumb bob*
14	*Replacement Brake Wheel Teeth*
15	*Stencils for marking sacks*

16	*Shutter plates*
17	*Shutter cranks*
18	*Jack Stick for levelling stones*
19	*Jack Stick for levelling stones*
20	*Adze for woodworking*
21	*Jack Stick for levelling stones*
22	*Template for marking out stone*
23	*Part of scales for weighing flour*
30	*Mill Bill*
27	*Small pick*
28	*Thrift with Mill Bill*
29	*Shutter Crank*
31	*Ring Spanner*
32	*Adjustable Hook*
33	*Chain with lockable links*

Windmill Utilisation

A windmill can only work when the wind is strong enough; to estimate the proportion of time the mill could be operational, data on typical wind speeds at Argos Hill and the wind strength needed to drive one set of stones was required. It was also be assumed that the auxiliary machines, which need less power, can be utilised at lower wind speeds.

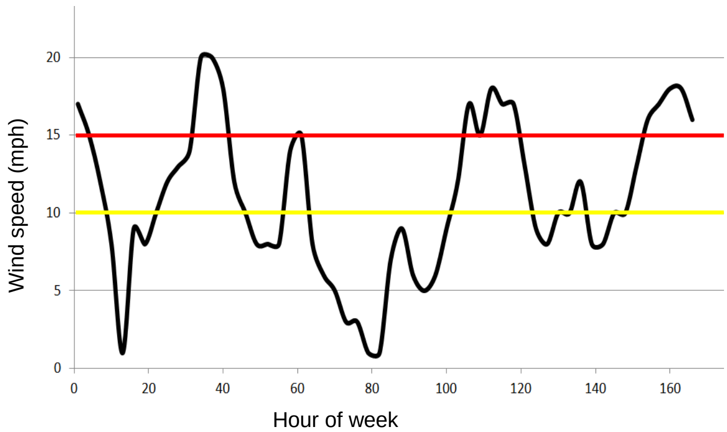
An analysis of working wind conditions at Fosters Mill, a working mill in Cambridgeshire, has been made by Steve Temple as evidence to a planning inquiry into a proposed development near the mill. This a tower mill, which would be more powerful than a post mill, since it is taller with larger sweeps. Nevertheless, it can provide a useful guide. The analysis states that, when the mill was unobstructed in the past, it could work on about 130 days per year, when the wind speed was in excess of 13 mph, that is, about 1/3 of the time. Allowing for the fact that a post mill will produce rather less power at the windshaft, a wind speed of 15 mph might be the minimum required. We will assume 10 mph is sufficient to drive the auxiliary machines, which need less torque.

Unfortunately, historical records for wind speed at specific locations are not easily obtainable. Therefore, the local wind speed data for an arbitrary week (5-11 April 2018) at Mayfield was obtained as a forecast (see table right), a total of 168 hours. The wind speed is specified at three hour intervals, the first at 1.00 hours and the last at 22.00 hours, over seven days. The periods where the wind exceeded 15 mph are highlighted in red, totalling 16 periods, or 48 hours, amounting to **29%** of the week. It can be seen that, during the sample week, milling could realistically be carried out during three complete blocks of time lasting 9, 15 and 15 hours, 39 hours in total, a reasonable working week. In addition, it exceeded 10 mph for 17 periods, 51 hours, or **30%** of the week.

	Wind Speed (mph)						
Hour	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
1.00	17	12	8	3	6	13	10
4.00	15	13	8	3	9	9	10
7.00	12	14	8	1	12	8	13
10.00	8	20	14	1	17	10	16
13.00	1	20	15	7	15	10	17
16.00	9	18	8	9	18	12	18
19.00	8	12	6	6	17	8	18
22.00	10	10	5	5	17	8	16

Note that this represents the maximum time available for milling, which would only be needed while grain was in stock and the demand was sufficient. Actual working hours would be some fraction of this. Over a typical week then, working at 18 stones (4 bushels) per hour, the mill could in theory grind up to 48 x 18 = 864 stones. This is equal to 864/8 = 108 cwt (hundredweight) of wheat, producing the equivalent to 75 cwt of flour. This adds up to a maximum of 180 tons of flour per year. Freese quotes a 1798 survey that suggests and average of 32 coombs, or 72 cwt, of grain were processed by mills in Buckinghamshire in an average week, suggesting the mills were working at 2/3 of maximum capacity, a reasonable proportion of the maximum utilisation, allowing for other necessary activities in the mill.

Night-time hours are assumed to be between 19.00 and 7.00 hours, shown in blue in the table. If necessary, the miller must work day or night, for the wind is just as likely to be blowing at night. There would be more daylight in summer, but unfortunately there tends to be less wind during this season, when high pressure is more frequent. This spring sample period would, however, tend to be windier than average.



This data was plotted out in the graph left to illustrate the wind variation over the whole week. The red line indicates the wind speed assumed to be required for milling, while auxiliary functions of the mill could be carried out at lower wind speeds, indicated by the yellow line. The smutter and wire machine and later in the life of the mill, the oat crusher, could operate when the power produced by the sweeps was lower than that required to drive the stones. This would extend the working hours, and there would be regular maintenance to do during calm weather. If the miller carried out his own stone dressing, this could also be fitted in, whereas, if an itinerant was used, this would be more difficult to fit into a calm period.

At the time of writing, the Argos Mill is in a fixed position, facing approximately south-west, meaning that, for the stones to run, the wind has to be of sufficient strength and in exactly the right direction. Furthermore, not all the shutters are fitted (for safety reasons) and the airflow around the mill is now seriously obstructed by trees. Therefore, it is rare that the wind is right for working the mill while volunteers are on site, so the opportunities to test the stones are currently very limited. It can be seen in the sample period, the wind speed never exceeds 20 mph in any case. However, in the past, when the sweeps were unobstructed, we can see that the stones might typically be used for 2/3 x 48 = **32 hours per week**, and the auxiliary machines for additional periods. A total working week of 50-60 hours would probably be worked in the 19th century, milling for about half of that time, but depending on wind conditions. At Argos Hill, a little extra daylight working time might be obtained due to its advantageous position of the mill on a steep ridge facing the prevailing wind.

Maintenance

The mill needed regular maintenance to continue operating. Maintenance of the millstones was a major consideration. The stones would need frequent re-dressing, the drive system maintained and adjusted for wear, bearings lubricated and the wooden structure maintained, repaired and even modified to allow upgrades to the mill machinery.

The **wheat grain** contains a soft kernel which is ground into flour, and a harder husk which is removed between the stones without being ground up, producing bran. The **millstones** are inscribed with a radiating pattern of furrows that provides cutting edges and drives the meal towards the edge of the stones, while separating the flour and bran. They needed to be re-faced at regular intervals to maintain operating efficiency and meal quality; to do this, the **runner stone** would be lifted off its spindle using a block and tackle and 'scotch wedges' and overturned. If placed over the centre of the crown tree, which is located between the stone pairs, the weight would be supported, and the **bed stone** could be dressed at the same time.

The **furrows** on both stones had to be re-cut by hand using **steel bills**, leaving lands in between to crush the grain. Stitching, or fine grooves, were also cut in the lands to provide fine grinding of the meal. A specialist journeyman stone-dresser was typically engaged for this job. Ideally, the runner stone would be slightly concave to reduce the gap (**nip**) towards the edge to produce a finer meal. Over time, the stones are reduced in depth and weight. The runner stone needed to be a minimum weight to work effectively so it had to be replaced with a new stone. The old stone could then be used as a bedstone, since this did not need a minimum weight. The bed stone could be raised on its **wedges** to compensate for any reduction in thickness, and the tentering gear re-adjusted. If the undersides of the bedstones are inspected on the spout floor, a variety of wedges can be seen that have been inserted for levelling and bringing the stone nut into correct engagement with the drive cogs after re-dressing. A set of **grindstones** are fitted on the stone floor for sharpening the tools; these can be driven from the smutter drive pulley by moving its drive belt.

The runner stone must **balance** correctly on its spindle when working, to maintain a consistent nip and avoid direct contact with the bed stone. The burr runner stone incorporates four recesses on the upper surface faced with steel plates; these hold balance weights that can be added or removed for correct operation. The runner stone bearing (**footstep bearing)**, contained in the bridging box, would also need lubricating at the same time that the runner stone was lifted for re-dressing. This is a simple hemispherical bearing on the lower end of the runner stone spindle inserted into a matching bronze block. This held in a **bridging box** with screw adjustment in both horizontal directions to locate it precisely so that the runner stone is horizontal.

The need for **lubrication** is minimised in the main **stone drive system** by using wooden (apple or hornbeam) teeth on the main windshaft gears to drive the cast iron stone nuts. Animal fat would have been used if necessary. Wear on the contact surfaces of the wood cogs would tend to spread the point load and improve the meshing, but the wooden teeth would need to be replaced at regular intervals. This arrangement was also quieter than the meshing of cast iron gears. Wooden teeth and belt drives are also used in the auxiliary drive systems. Leather was general used for the drive belts, and this would sometimes need replacement. The auxiliary drive shaft bearings are either brass lined cast iron or hardwood. Surprisingly, the governors are mounted directly into oak support beams with no proper bearings.

The **windshaft** has a large open bronze bearing at the front end (for ease of lubrication) about 12 inches in diameter supporting the sweeps, and a simple thrust bearing at the rear end about 6 inches in diameter. Prior to the advent of petroleum based products, animal fats and oils (eg pig fat) were used for lubrication of the metal bearings.

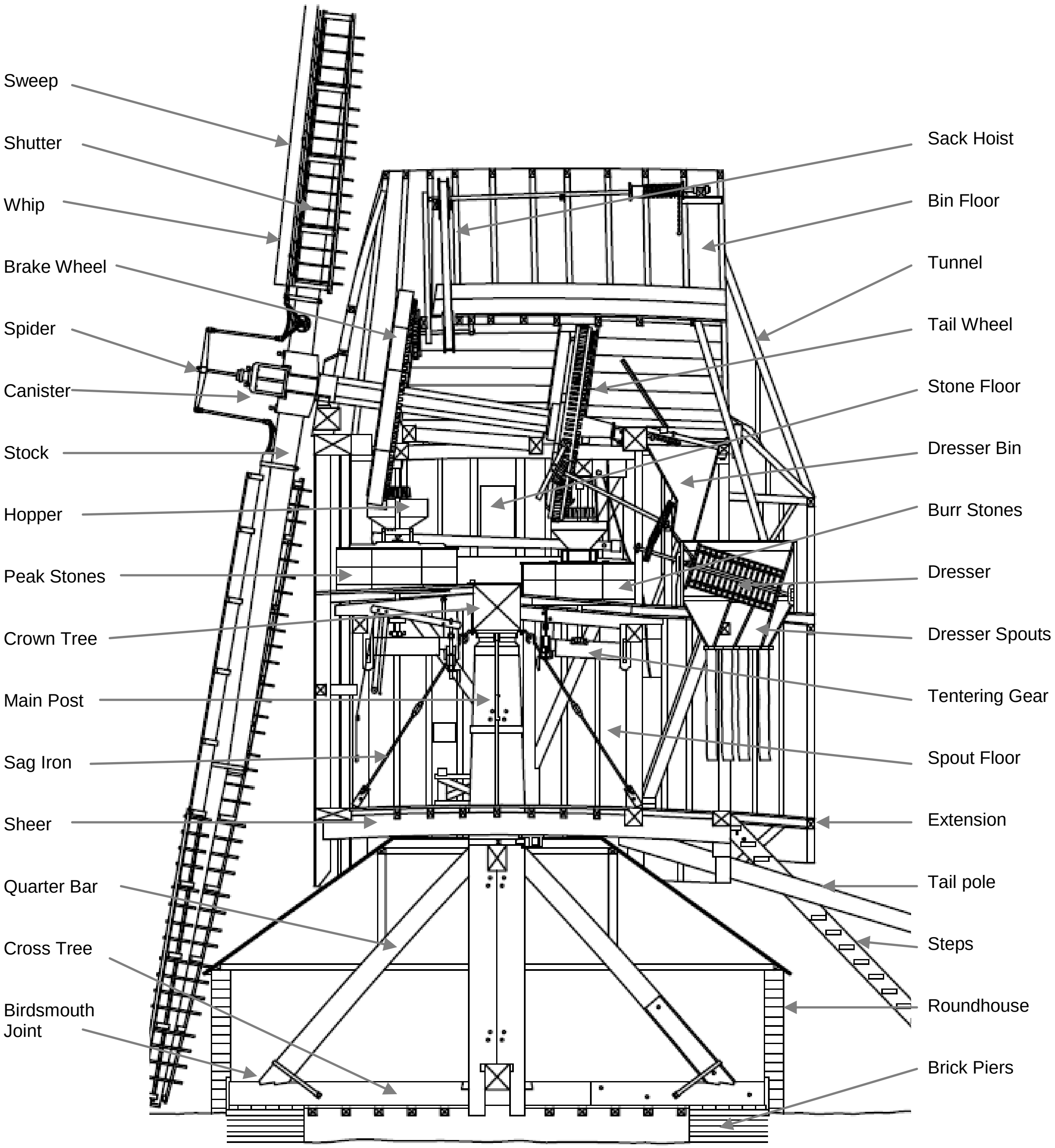
The post mill has a massive plain **bearing** at the top of the main post to allow rotation of the buck. The **pintle** that engages with the cast iron plate of the **Samson head** (visible on the spout floor) supports the whole weight of the buck; it consists of a simple cast iron peg about six inches in diameter, surrounded by a circular bearing surface that can be lubricated via a hole in the crown tree (this is under a brass plate). The pintle and Samson head, as well as the foot of the main post from Crowborough Post Mill can be inspected in the mill collection. The pintle incorporates a cross tail gudgeon inserted into the top of the main post, which in this case made from a single oak tree trunk, retained by iron hoops shrink fitted onto the post in the same way as wrought iron wagon wheel rims, by heating, positioning and quenching. The insertion of a cross tail into the composite post at Argos Hill would have been more straightforward, as suitable rebates would have been created in the top of the four post members before pegging it together.

Wooden structures need frequent maintenance. **Weatherboard** needs painting or tarring, and replacing occasionally. Wood rots if damp, so replacement or re-enforcement may be needed after some years. Woodworm is evident in many of the **structural** and operational members; lime wash appears to have been used inside as a preservative and hygiene measure. Argos Mill has particularly benefitted from a **zinc roof** covering in its later years, which may have been important in its survival. The roof was originally white; the red roof is thought to have originated during the second world war, as a waymarker for allied aircraft, to differentiate it from Cross in Hand windmill, which has a white roof. The **roundhouse** had a tarred softwood roof before being replaced with the current oak boards. **Ropes and cords** would also need occasional replacement.

The **rear extension** on the mill appears to have been added after the original structure was built, to accommodate the smutter, wire machine and improve access to the bin floor. Extra storage space and millers desk were also added on the spout floor. A set of rollers on the rear of the collar of the buck were probably installed at this time to resist the extra weight on the rear of the mill. The fantail would also have taken extra weight, so may have needed upgrading; it has been noted that its wheels had extra heavy duty tyre plates fitted. The front **Peak stones** are fitted with a cast iron, rather than a wooden, horse which suggest a later upgrade when these stones were probably more frequently in use. The drive systems to the **auxiliary machines**, presumably installed after the mill was originally built, use cast iron crown gears with wooden cogs of quite sophisticated design.

STRUCTURE OF THE MILL

Vertical Section



(Drawing credits: Douglas Moat based on original by Vincent Pargeter)

The sectional drawing above shows the internal structures of the mill, with the buck rotating upon the main post. This is supported in the upright position by a massive trestle within the roundhouse. The sweeps are attached to the windshaft, which provides the drive to the stones via two large gear wheels (brake wheel and tail wheel) and cast iron crown pinions that drive the stone spindles from above. The positions of the grain bins and sack hoist on the upper bin floor, the flour dresser and feed hoppers on the stone floor and the tentering gear on the spout floor are visible.

The construction of the mill is described in more detail on the next page. The internal structures and machinery can be viewed in the virtual tour at http://www.argoshillwindmill.org.uk.

Construction

The **trestle** forms a stable support for the main post, with two massive oak **cross trees** forming the horizontal members, one passing over the other, with diagonal **quarterbars** providing the bracing which keeps the post vertical. Note that the weight is taken by the quarterbars, not the main post, and is thus transferred onto the **four brick piers** that support the ends of the cross trees. **Birdsmouth joints**, where an angled beam is inserted into the side of the other beam, are used at the lower ends of the quarterbars to resist the tendency for the joint to slide. These consist of a mortise and tenon combined with a double notched rebate. The birdsmouth joints are reinforced with iron straps, and three of the four have been further reinforced on either side with oak planks bolted to the original quarter bars and cross trees with matching birdsmouth joints as part of a previous phase of restoration.

The vertical **main post**, unusually, consists of four pitch pine square sections pegged together, rather than the more usual single oak post. It is possible that by the time of construction (1835) a single oak post of sufficient size was not readily available; many of the large oaks in the area would have already been felled for shipbuilding long before. The **composite post** had some advantages; the grain in each component could be arranged in opposition, so that bowing of the whole over time would be minimised. Large pine posts would have been readily available, since they were widely used as masts for sailing ships. The composite construction of the main post may also have made it easier to fashion the upper load-bearing angled joints with the quarter bars prior to assembly. These are retained by a wrought iron **collar** immediately above the joints, which also conveniently acts as a track for the set of **rollers** fitted later between the sheers to resist the tendency of the mill to tilt back under the force of the wind and the weight of the additional rear extension. The lower end of the main post floats over the cross tree intersection, with the corners extending over the cross trees forming **horns**, allowing it to be firmly retained in position by wedges driven between the horns and rebates in the upper faces of cross trees. These could be adjusted to ensure that the main post is exactly vertical. The quarterbars are in compression, therefore of oak, and the crosstrees in tension, so pine could be used.

The **buck** rotates on the main post, its whole weight supported on the **Samson head,** a large cast iron plate fixed to the underside of the **crown tree**, a massive transverse oak beam that supports the rest of the frame of the buck. A massive cast iron gudgeon pin with a lubricated flange, **the pintle**, is fitted to the top of the main post; this mates with a socket in the Samson head to provide the main bearing of the buck. The buck frame consists of a rectangular frame of oak beams, built around the crown tree. **Side girts**, which run front to back, are supported on the ends of the crown tree, with vertical **corner posts** fixed to the ends of the side girts. Cross beams and upper and lower side girts complete the frame. Joists that support the stones are mortised into the crown tree, and transverse **sprattle beams** support the upper stone spindles. The buck frame is reinforced by further beams and braces, many of which were replaced or repaired during restoration, especially at the front and rear walls of the buck. Further minor structures support the bins and tentering gear, with vertical oak ribs extending upwards from the upper side beams to support the roof. Much of the original timber is oak, while most of the new beams and boards are red pine and softwood.

The **sweeps** are attached to the **windshaft** by insertion of the stocks (main sail shafts) through the **canister** (poll end), a massive square casting. The windshaft is supported fore and aft in plain semi-cylindrical gun metal (phosphor bronze) bearings. The **breast bearing** is fixed at the centre of the **weather beam**, which completes the front of the main buck frame. The weather beam and whole front of the mill project forward at the centre, forming a V-shape, supported at the centre by the vertical prick post. The weather beam is also reinforced by diagonal compression braces that meet under the windshaft bearing. Vertical rear corner posts and a transverse **tail beam** support the tail bearing to complete the framework that supports the back end of the windshaft.

A pair of **sheers** runs fore and aft under the spout floor either side of the main post, with transverse beams connecting them at the rear. The **steps and tailpole** are attached to these, with the **fantail** at the other end of the tailpole, to the so the whole buck is braced against the wind. The fantail drives the mill around a circular track to face the wind. The **rear extension**, a later addition, is attached to the main frame, not integral to it, and projects over the rear steps. The extra weight would have unbalanced the mill, so the cast iron rollers were added to the back of the collar to compensate.

The **weatherboard** cladding on the exterior is now double overlapped for strength and durability; that is, more than half of each board is covered by the one above, and is now painted with several coats of lead paint. In order to minimise rain penetration, the weatherboarding overshoots the sides at the front corners, and similarly the side boards overshoot the back ones at the rear corners. In addition, the exposed end grain on the front corners are protected with lead flashing. A complex herringbone overlapping joint is used at the centre of the breast to protect the prick post at this point. During the most recent restoration, the breast was fitted with an extra layer of butt jointed boards for additional stiffness.

Load Bearing Structure

A simplified section of the mill is shown on the next page. Its purpose is to identify the essential load bearing elements of the structure in order to understand the way in which the considerable weight of the sweeps, windshaft and stones are supported by the structure of the buck and the weight transferred to the main post. The basic design is a rotating rigid box with the crown tree at its centre, stabilised by the tailpole and fantail, and the collar around the main post formed between the sheers. Note that the rear extension to the buck has been omitted from this analysis as it was not part of the original structure.

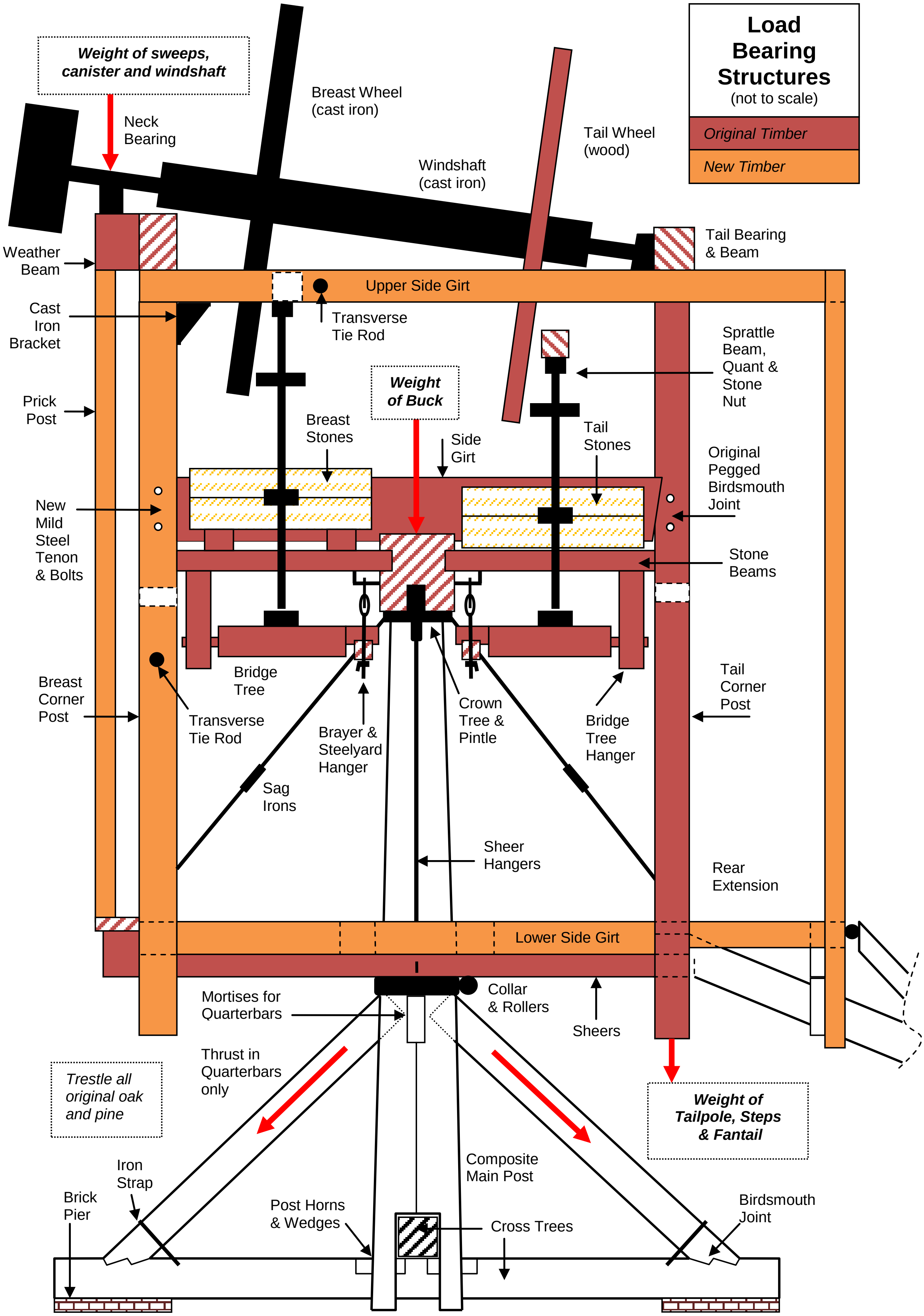
It is estimated that the buck weighs at least 20 tonnes, supported entirely on the main post via the samson head fitted to the underside of the crown tree, a massive lateral beam (10’6” x 21” x 24”). The ends of the crown tree support the side girts (10’ x 15” x 8”) which carry the corner posts (15’ x 9” x 8”) at their centres. At the tail ends, the pegged birdsmouth (angled) mortise and tenon joints originally supported the downward thrust from the tail corner posts. The side girts have been reinforced during the last restoration phase by the insertion lengthwise of mild steel plates, which now provide extra tenons bolted into the corner posts. The breast corner posts support the weatherbeam at their upper ends, a massive v-shaped member (10’6” x 18” x 15”) that projects forward and supports the neck bearing of the windshaft on an oak pillow block; this raises it to the required angle (8º) such that the ends of the sweeps clear the roundhouse when in motion. This bearing supports the weight of the sweeps, canister and front part of the windshaft including the cast iron breast wheel, estimated to be at least 3 tonnes. The weatherbeam is therefore additionally supported by angled braces that help to transfer the load to the ends of the side girts. The tail bearing of the windshaft is supported by the transverse tail beam (12” x 12”), with upper side girts completing the upper frame. The upper side girts and front corner posts are retained by transverse tie rods with turnbuckle links to resist lateral spreading under the weight of the windshaft.

This weight on the weatherbeam is counterbalanced by the tailpole and fantail at the rear of the mill. The tailpole is attached to the sheers, heavy beams that run front to back under the spout floor either side of the main post. These are clasped around the main post by cross pieces that are moulded to form a circular collar around the main post to stabilise the buck. The tailpole has a large tenon inserted into a rear cross beam and supported at the required angle by a yoke and retained by large bolts (see right). The sheers are supported at their centres by vertical wrought iron tie bars tensioned with turnbuckles hanging from lugs on the Samson head (sheer hangers). In addition, diagonal sag irons attached to the ends of the crown tree support the corners of the buck (see below), plus the frame incorporates numerous diagonal compression braces.

The mill stones are supported by longitudinal beams mortised directly into the crown tree, and balance each other by being equidistant from it. The far ends of these are supported on cross beams that are mortised into the corner posts with inverted birdsmouth joints. The bedstones are wedged into a fixed position, while the runner stones are supported on the bridge trees from beneath, the far ends of which are attached to the stone beams via mortises in vertical hangers that allow some rotation. The joints are generally arranged such that vertical loads are supported by the horizontal beams using lapped or mortise and tenon joints; angled rebates are used in the quarterbars and side girts (birdsmouth joints) to resist sliding.

The main joints were originally pegged through the tenons with oak trennels (tree nails). Many have been subsequently reinforced with cast iron or mild steel brackets in the course of different phases of restoration to maintain the overall structural integrity of the buck. Minor joints are often secured with wedges hammered into the joint. In reality, considerable sag can be seen in the structure, which is particularly evident in the side girts. If the stone floor is viewed from the top of the access stairs, it falls away distinctly towards the rear the mill. Many of the reinforcing elements were fitted to counter this effect. The quartered main post is pegged together with dowels, reinforced by cast iron hoops at the collar and Samson head. Wedges between the horns and the cross trees allow it to be correctly centred.

The mill is designed to face the wind at all times, with the pressure on the sweeps resisted by the tailpole and fantackle. If the mill does not face the wind, a strong side wind can overturn a post mill, since the trestle is not generally fixed to the supporting piers. Alternatively, under repetitive stress, the upper joints of the quarterbars may dislocate. This is a common failure mode in poorly maintained mills, causing total collapse. Similarly, if the mill is tail-winded when the wind veers too rapidly for the fantail to respond, severe damage can result. In particular, the sweeps can be forced forward out of the windshaft bearings, especially if the neck bearing is not, as at Argos Hill mill, restrained by an upper collar or yoke.



Load Bearing Structures
(not to scale)
Original Timber
New Timber
Weight of sweeps, canister and windshaft
Neck Bearing
Breast Wheel (cast iron)
Tail Wheel (wood)
Windshaft (cast iron)
Weather Beam
Tail Bearing & Beam
Upper Side Girt
Cast Iron Bracket
Transverse Tie Rod
Spratttle Beam, Quant & Stone Nut
Prick Post
Weight of Buck
Breast Stones
Side Girt
Tail Stones
Original Pegged Birdsmouth Joint
New Mild Steel Tenon & Bolts
Stone Beams
Bridge Tree
Breast Corner Post
Transverse Tie Rod
Brayer & Steelyard Hanger
Crown Tree & Pintle
Bridge Tree Hanger
Tail Corner Post
Sag Irons
Sheer Hangers
Rear Extension
Lower Side Girt
Mortises for Quarterbars
Collar & Rollers
Sheers
Thrust in Quarterbars only
Trestle all original oak and pine
Weight of Tailpole, Steps & Fantail
Composite Main Post
Iron Strap
Brick Pier
Post Horns & Wedges
Cross Trees
Birdsmouth Joint

Floor Plans

The plans of each floor of the mill body are shown on the facing page. It is essentially a rectangular box frame covered in weatherboard, but with a pointed breast (front wall) that is primarily designed to ease the airflow over the front of the mill, but which also helps the sweeps to clear the roundhouse upon which the buck revolves. The breast projects about 18” at the centre, forming an angle of about 16º at the apex.

Bin Floor

The weatherbeam is a single massive oak span that supports the neck bearing of the windshaft. This would have been selected and worked to provide the required angle at the vertex. The shape means it will tend to rotate down at the front under the weight of the windshaft and sweeps (about 5 tonnes) so is propped from below by diagonal braces meeting below its centre, which spread some of the load to the corner posts and side girts. It was later reinforced by large cast iron brackets where it meets the upper side girts. Behind the weatherbeam, the brake wheel occupies the void at the front of the mill at this level.

The bins that store the grain or meal prior to processing are arranged neatly along the sides of the bin floor with a central walkway accessed from the rear tunnel. Their funnel shaped rectangular spouts project downward, with the voids between them accommodating the windshaft and tail wheels. There are five bins in total, the front right grist bin being divided in two. The position of the bin spouts (highlighted on the plan) is determined by the destination of the contents. The wheat bin (front left) feeds a chute leading into the tail stone hopper. The grist bins would usually contain oats or barley; a sacking spout leads into the breast stone hopper from the front grist bin, while the rear section has an aperture that aligns with a hatch in the stone floor leading down to the position of the oat crusher on the spout floor. The limited size of the grist bin feeding the crusher implies a smaller throughput in this later machine. The grain cleaner (smutter) spout would have needed a chute (not present) to feed the smutter inlet. Only the dresser bin spout is complete; this extends down through the stone floor to the wire machine inlet spattle (the diagonal lines in the diagram represent the edges of the sloping sides of the lower bin conical sections). The precise design of the missing spouts and chutes would be speculative if reconstructed.

The sack hoist drive is located at the front of the bin floor, with a wooden gear that engages with the top of the brake wheel. Pulleys drive an overhead shaft and bollard (winding drum) which would have carried a chain that passed down to the lower floors, through trap doors in each floor, to which sacks would be attached. It is activated from below via a rope, crank and jockey wheel that tensions the pulley belt. A sack slide (not replaced at present to aid visibility) was fitted below the trap, with sacks guided over a roller fitted to the frame of the rack and pinion of the striking gear.

Stone Floor

The millstones and drive gear are housed on this floor. The boards of the stone floor are flush with the upper surface of the crown tree, and the stone beams that support the bed stones are mortised directly into the sides of the crown tree. Notice the stones are symmetrically placed to maintain the balance of the buck on the main post. The rear extension on this floor contains the auxiliary machines, with the smutter (grain cleaner) rather inconveniently positioned at the top of the ladder from the spout floor. When it was working, its drive belt and chute would have been hard to avoid, a hazardous arrangement. The wire machine, now partially restored, occupies the left rear extension.

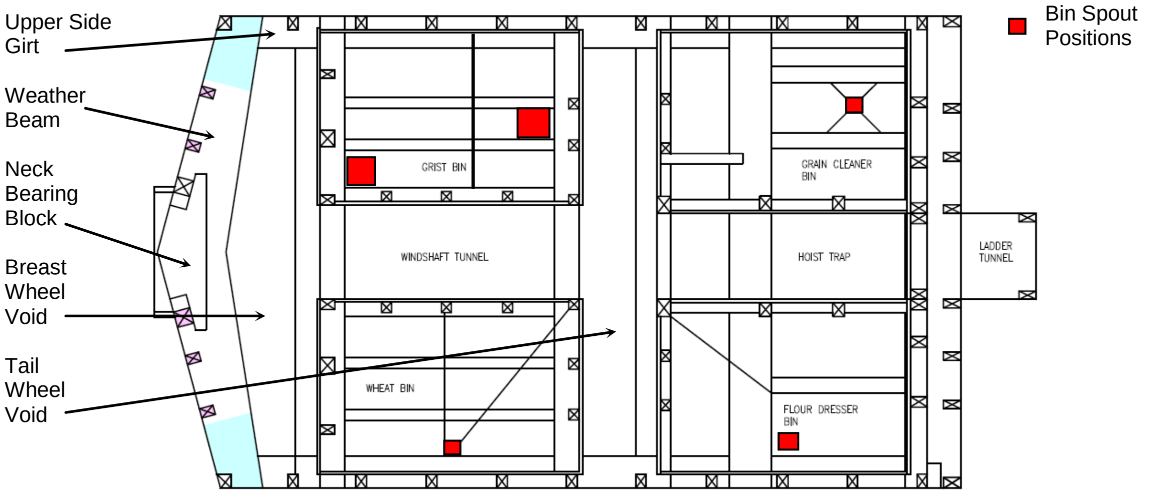
Spout Floor

The spout floor is principally supported on two large longitudinal beams (sheers). The front ends of the sheers are lapped onto a breast beam that replicates the profile of the weatherbeam. The weight at the front end is counterbalanced by the tailpole (with fantail attached) that is lap jointed onto the rear sheer tie beam and bolted through a yoke under the doorway on the rear cross beam at an angle of 18º. Short tie beams complete a circular collar around the main post to stabilise the buck in all directions.

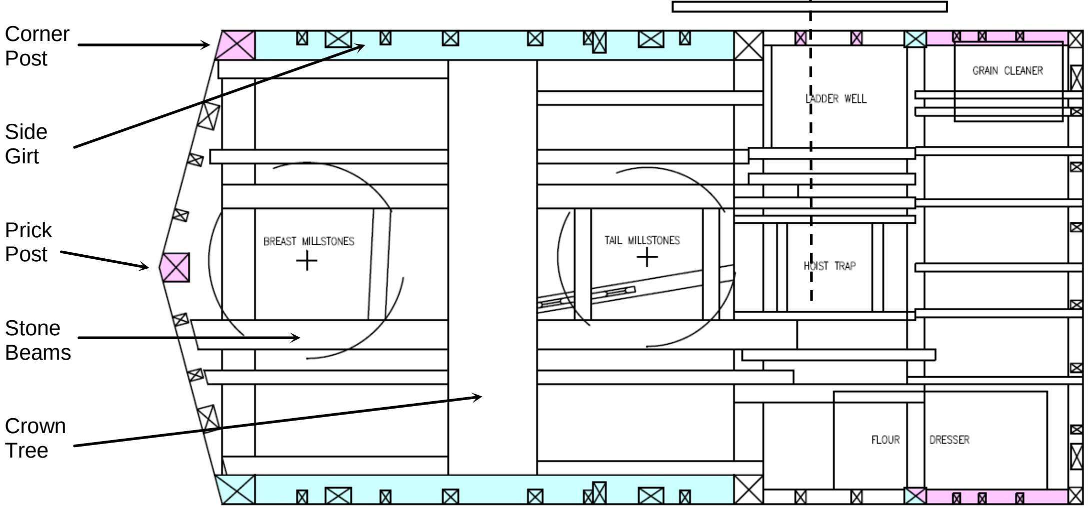
The sack hoist trap is positioned over the aperture in the roundhouse roof, so is not fully aligned with trap above (sacks can be lifted through this trap or up the sack slide on the steps). The doorway is conveniently covered by the rear extension, and is offset to the right to avoid the tailpole which projects centrally through the steps.

The striking chain is, rather inconveniently, operated through an opening into the chain box in the wall under the steps up to the stone floor. The other control ropes and cords (brake, sack hoist, stone feeds, smutter and wire machine inlets) are brought down from the upper floors to be operated from this floor, as well as the tentering gear. Sacks of grain and meal are filled, stored and manhandled on this floor, so the spout floor is clear of obstructions other than mountings for a crusher/roller machine, the meal troughs on the left side and the millers desk fitted into the extension on the right side of the door.

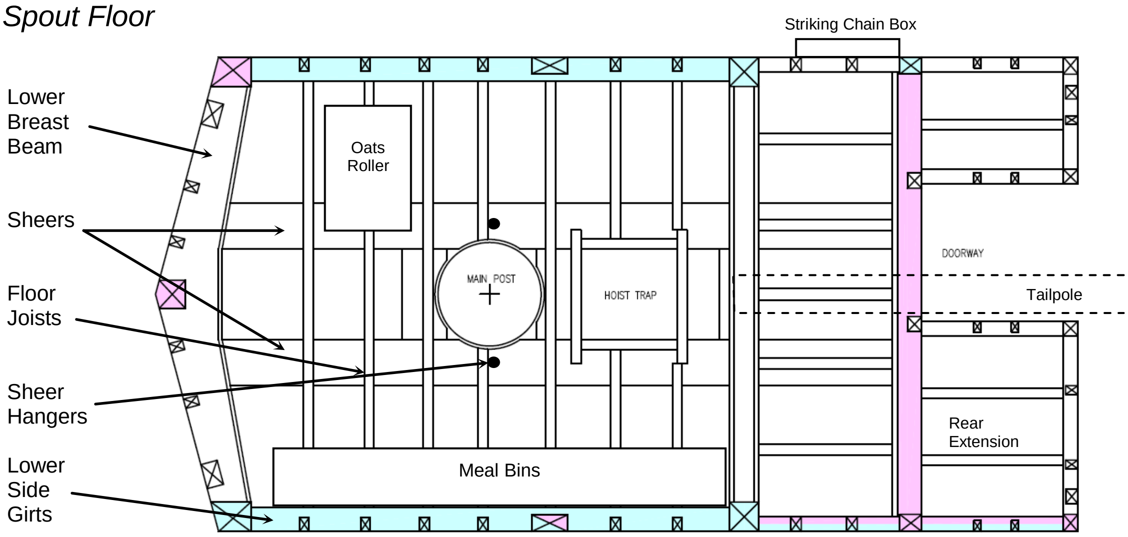
Bin Floor



Stone Floor



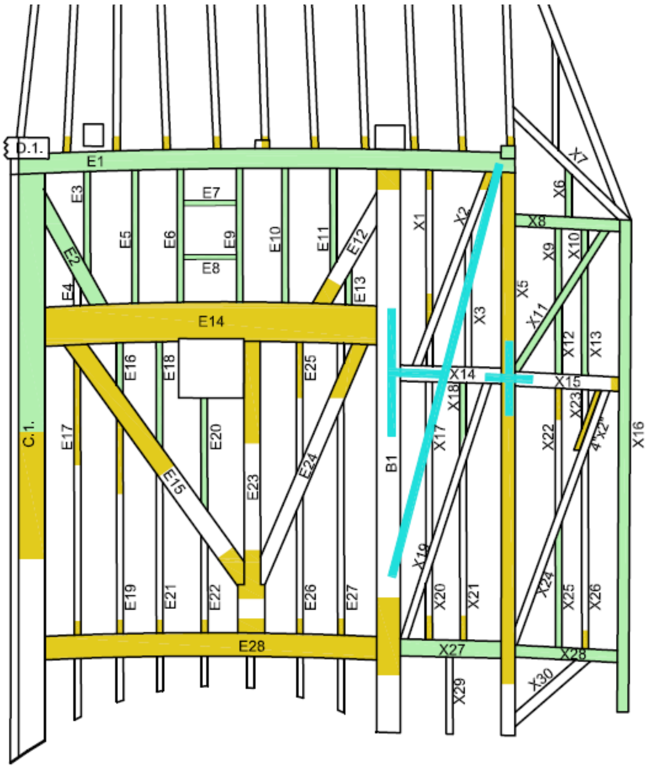
Spout Floor



Drawings: Douglas Moat

Construction and Repair Details

A scale drawing of the left side framework below shows the load bearing members of the original design, plus the extension at the rear of the buck. Original timbers are shown in yellow (including the side girt and spout floor side beams), new in green. The actual sag of the ends of the side girts is shown as it exists. Note how extensive diagonal bracing is used to resist further sagging at the corners and to support the overhanging extension. The curved ribs (original oak spars) of the roof are seen projecting upwards. Transverse tension bars that help retain the upper side girts are fitted at the breast and tail, these appear to be original.
(Drawing: Douglas Moat)



Above: Reinforcing brackets fitted to the top of the left breast corner post. The earlier cast iron bracket (1925) to the right supports the end of the weatherbeam. The new wrought iron bracket on the left supports the junction of a new timber corner post and upper side girt installed in 2015.

Above: Clamps on the end of the crown tree providing attachments for the diagonal tension rods that resist sagging at the front and rear of the mill body.

.

Modifications to Mill

It seems from a study of the mill structure and working machinery that a major upgrade was carried out at some stage of its working life. There is no documentary evidence to hand to date these improvements, but it is probable that they were undertaken to improve the efficiency of the mill later in the C19th when competition from imported wheat was increasing. The high quality of the workmanship in these machines and drives indicates a significant investment and optimism about future returns.

Modifications appear to have included the following, but not necessarily carried out at the same time:

- *Building the rear extension*
- *Building the bin floor access tunnel*
- *Improving the bin layout*
- *Installing the smutter*
- *Installing the wire machine*
- *Installing the crusher (later)*
- *Installing the auxiliary drive systems*
- *Upgrading the breast stone gear*
- *Generally reinforcing the original structure*

Construction Techniques

In 1835, only **manual methods** of construction would have been available. The timbers would have been hand-sawn in a pit in the woods, using long saw with a handle at each end. The master would have been above and an apprentice or labourer below, covered in sawdust! The axe and adze would be used for rough shaping, draw blade and spokeshave for finishing and bevelling, mortar and chisel for creating joints and rebates and auger and bit for drilling holes.

Heavy timbers and stones could be manhandled using A-frames and block and tackle. A single rope passing several times though a pair of pulley blocks gives a corresponding mechanical advantage. This technology was used in the rigging of sailing ships to support the masts and raise the sails.

The **main structural timbers** would in general be assembled using mortise and tenon joints held together with pegs driven through an offset hole to tighten them, as seen throughout the mill. Alternatively, wedges could be used in the joints to tighten them, as seen at the lower end of the main post. More complex joints such as the birdsmouth joints as seen on the cross trees might be necessary, in this case to take the weight of the mill body. The joinery skills required to make wooden machinery would have been commonly available, not only among millwrights but also wheelwrights and builders.

Iron components were only used when necessary, such as to secure the tops of the quarterbars with a wrought iron hoop. These could be made locally, but more complex castings such as the windshaft and samson head would have been made by specialist iron foundries of which there were several in Lewes at the time. Similarly, precision casting needed for the fantail drive gears would need expert manufacture. Large bolts and/or iron straps for securing the sweeps to the stocks would also be needed. Cut nails could also be made at the local forge, where a sheet of wrought iron was split into wedge shaped nails and heads formed, These would be used to secure the floorboards and weatherboard cladding. Any screws and bolts would have been hand turned, and expensive.

Bitumen based **paints** would have been used on iron components, and white lead based paint for the weatherboarding.

Types of Wood

OAK
Oak is a dense strong hard wood containing high levels of tannin which resists rot and insect attack. It is used in windmills for the main structural components, such as the main post, side girts and weatherbeam. It is usually worked when freshly cut (green), it then hardens over time and can last for centuries, as can be seen in surviving medieval timber framed buildings. Oak was grown extensively in Sussex among coppiced woodland, but much was consumed prior to the beginning of the 19th century for shipbuilding.

PINE
Pine is lighter and cheaper than oak, with a straight grain, but if grown slowly in a cold climate is denser and stronger while still being easy to work. It is suggested that Red Pine used at Argos Hill for the main post, crosstrees and framework of the mill body may have been imported from the Baltic. The new pine beams in the mill have the same reddish colour.

ELM
Elm is a strong, medium density wood with a interlocking grain which resists splitting. It has in the past been used in making wheel hubs and longbows. In the mill, it is used for the brake shoes on the brake wheel and felloes (rim sections) of the tailwheel. Elm also resists rotting in water, and was used to make waterwheels.

APPLE, HORNBEAM & HOLLY
These are hard woods which are used to make the cogs of the gears in the mill. They the resist wear caused by meshing with cast iron gears, and run very quietly and smoothly compared with all metal gears. Apple and holly are generally rather small trees, which limits the size of parts made from these woods, while hornbeam can provide larger parts.

LIGNUM VITAE
This a very hard, durable, high density tropical hardwood used to make bearings. Wooden bearings are used in the auxiliary drives in the mill, which may well be made of this material. The tree is now a protected species resulting in very limited supplies but wooden bearings are still made by specialist companies for low speed applications. Another traditional application is bowling balls.

SOFTWOODS
The floors, weatherboarding and most of the minor structural members in the mill are made of softwood, usually conifers with a straight grain such as pine, spruce and larch. Cedar is more durable, and beech has a fine grain and is often used in furniture making. Bulk softwood for building is mostly imported from the Baltic or Canada, and has been for many years.

Mill Dimensions

General	*Total height*	*38 feet (approx.)*
	Mill body height	*30 feet*
	Mill body depth	*20 feet 6 inches*
	Mill body width	*10 feet 6 inches*
	Length of main post	*20 feet*
	Windshaft length	*16 feet*
	Windshaft angle	*8 degrees*
	Roundhouse diameter	*24 feet*
	Turning circle diameter	*78 feet*
Sweeps	*Stock length*	*33 feet*
	Sail weather at canister	*18 degrees*
	Sail weather at tip	*4 degrees*
	Shutters per sweep	*51*
	Shutter width	*8 inches*
	Ideal sail speed	*14 - 18 rpm*
Fantackle	*Tailpole length*	*34 feet*
	Tailpole angle	*18 degrees*
	Fantail diameter	*10 feet 6 inches*
	Number of fantail blades	*8*
	Fantail blade angle	*28 degrees*
	Cartwheel diameter	*4 feet 6 inches*
	Drive ratio	*1:120*
Breast Stones	*Brake wheel diameter*	*8 feet 4 inches*
	Brake wheel cogs	*112*
	Breast stone nut teeth	*13*
	Breast millstones	*Derbyshire Peak*
	Breast millstone diameter	*4 feet 4 inches*
	Breast millstone drive ratio	*8.6 : 1*
Tail Stones	*Tail wheel diameter*	*8 feet*
	Tail wheel cogs	*112*
	Tail stone nut teeth	*16*
	Tail millstones	*French Burr*
	Tail millstone diameter	*4 feet*
	Tail millstone drive ratio	*7 : 1*

Weight of the Buck

This can be roughly estimated from the dimensions of the main components, assuming a density of slightly less than 1 tonne per cubic metre for oak and somewhat less for pine (1 tonne = 1000kg):

	Tonnes
• *Crown tree, side girts, weather beam (~1m^3 oak each):*	*3t*
• *Each set of stones and associated gear*	*3t*
• *4 sweeps, 2 stocks*	*3t*
• *Canister, windshaft, brakewheel & tailwheel:*	*3t*
• *Steps & tailpole (half):*	*3t*
• *Frame, weatherboard, flooring, ancillary gear:*	*5t*

Total: Approx. 20 tonnes

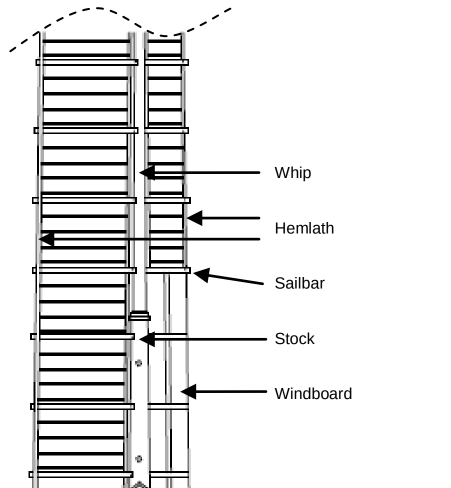
The weight would be at the maximum when working with the grain bins full and sacks stored in the buck.

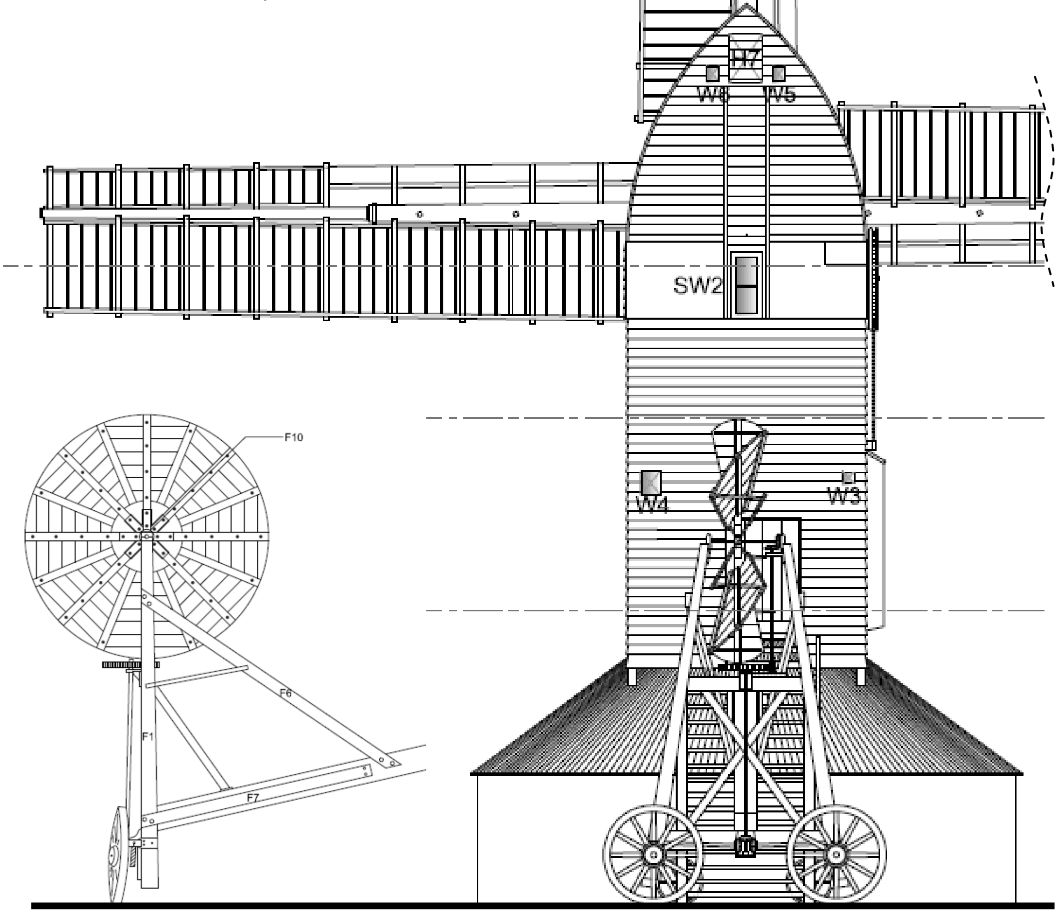
Scale drawings of the mill were prepared by Douglas Moat consulting engineers prior to the current phase of restoration. The south elevation shows the overall configuration of the rear of the mill, sweeps and fantail.

A complete sweep is shown below. The sweeps are divided into nine bays, eight of which support four shutters on the trailing side of the whip. The leading side has four bays of short shutters and a solid windboard at the inner end. The shutters can be opened to spill the wind and closed absorb its force.

The rectangular sweep surface is twisted towards the tip that the wind generates torque at the windshaft when the shutters are closed. The windboard is also set at an angle to provide a minimum torque when the shutters are open.

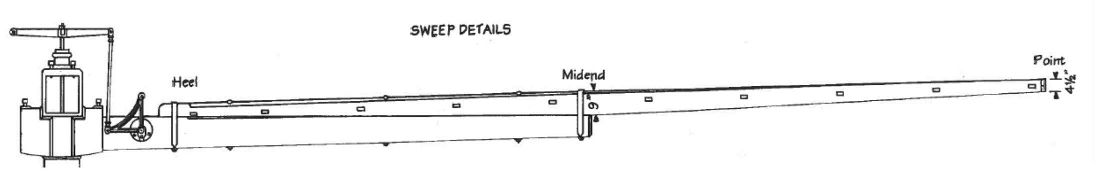
A side view of the fantail (below) shows the eight blades which seem to form a continuous circle, but are also set at an angle to the plane of rotation to drive the fantail wheels via the split drive.



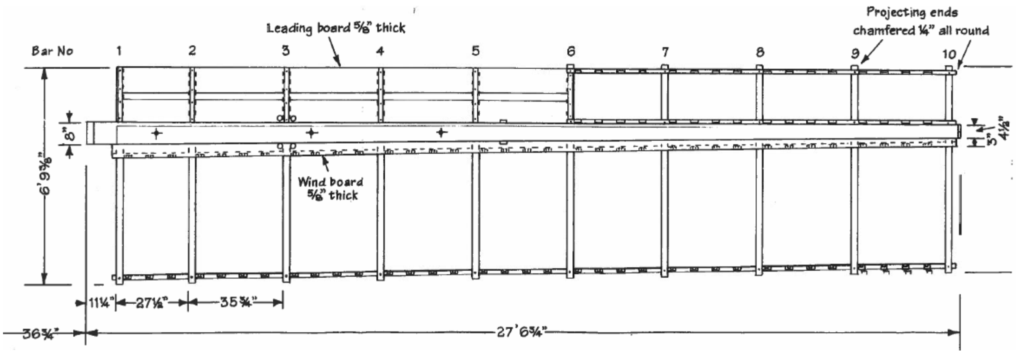


Sweep Construction

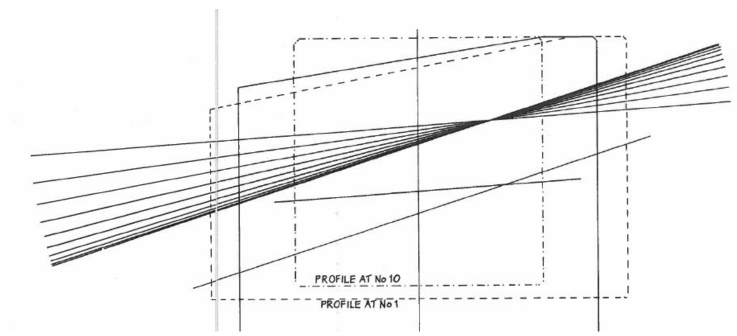
The **side view of the sweep** (below) shows the canister on the left which has two box sections through which the steel stocks are inserted. The main spar of the sweep, the whip, is attached to the front of the stock with straps at each end. The whip extends outward, its profile reducing in thickness from its mid-point to reduce its weight. The striking gear (cross and harp irons) is visible at the canister end, operated by the striking rod which passes through its centre. Ten mortises for the sail bars are visible in the side of the whip.

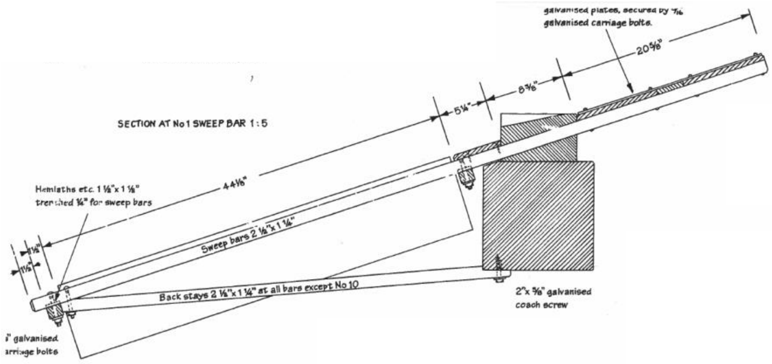


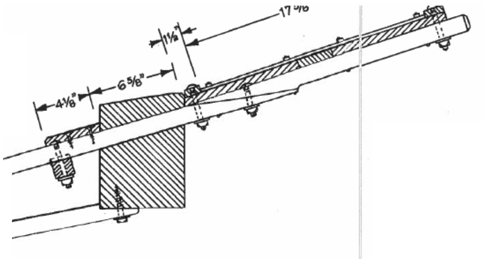
The **plan view of the sweep** (below) has three main elements: nine bays to accommodate the main shutters on the trailing side, four bays for the shorter leading edge shutters and a section of solid boards at the inner end of the leading edge. Each bay has four shutters, except the innermost which has three, with the shutter bearings fitted at suitable intervals. Hence each sweep has 35 long shutters and 16 short ones. The shutters need to be fixed at an angle to the plane of rotation to provide the turning force on the sweeps.



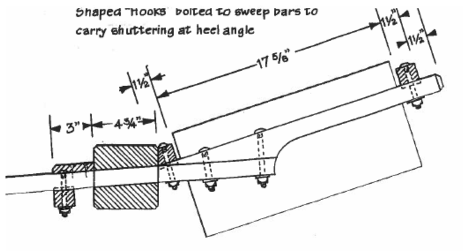
For optimum efficiency, the angle needs to decrease towards the point end, to reduce drag and equalise the forces along the length of the whip. The 10 shutter bars must therefore be inserted at various angles through the whip to provide the weather of the sweep. The **whip profile and weather angle** for each shutter bar is defined in the drawing below. The pitch is maximum at the canister end (18º) and minimum at the point end (4º).

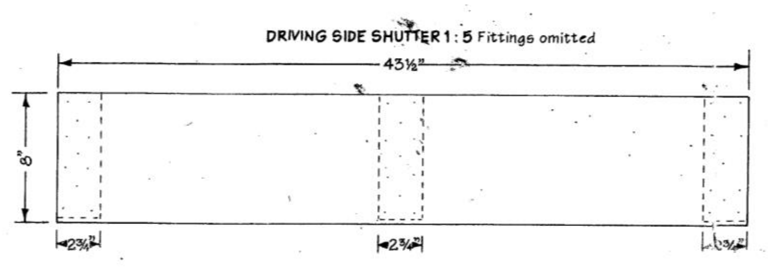


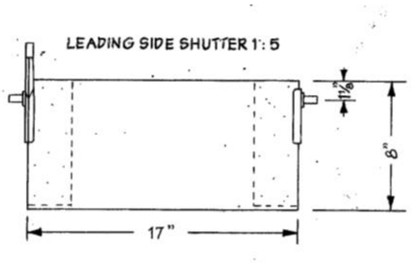




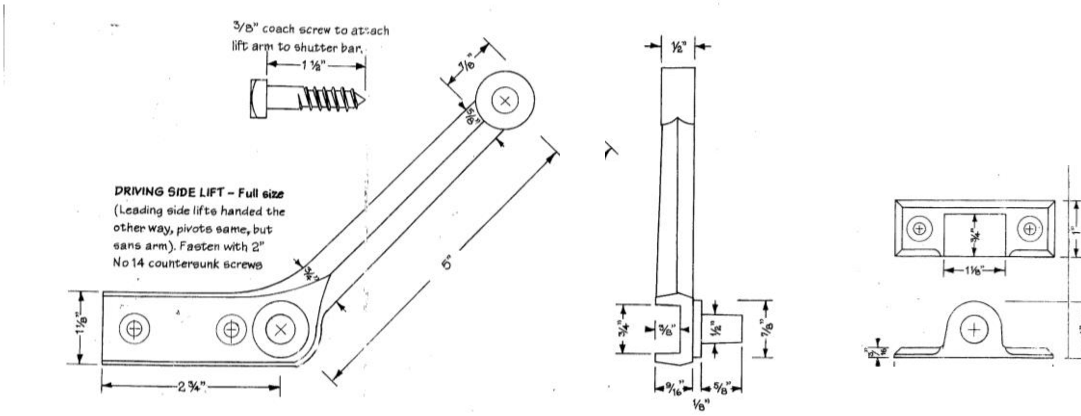
A cross section of the **sail bar assembly** at the canister (heel) end of the sweep is shown above. The shutter bar passes through the whip at an angle of 18º. The trailing edge (hemlath) is braced by a backstay fixed to the back of the stock. At the midpoint (above right), the windboard is carried on an extension of the sailbar. At the outer leading edge (right), the short shutters are supported on canted sail bar extensions (right) to provide extra torque, closed with a longitudinal hemlath.



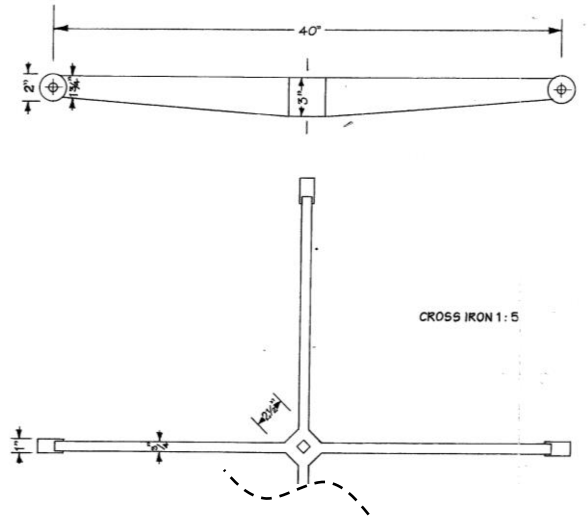


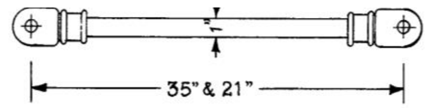


The **shutters** (above) are made from 8" weatherboard reinforced with transverse fillets with a matching chamfer to provide rectangular ends for fitting the swivels and crank arms. The shutters rotate on pins at their corners, the inner one incorporated into a cast iron crank (below). Here referred to as a lift, the crank forms a 45º angle with the plane of the shutter, with the eye attached to the timber shutter bar with a coach screw, providing 90º of rotation in the shutter. The bearing at each end (right) is variously called a cleat or thimble. The 'driving side' shutters are longer and trail the whip when the sweeps rotate.

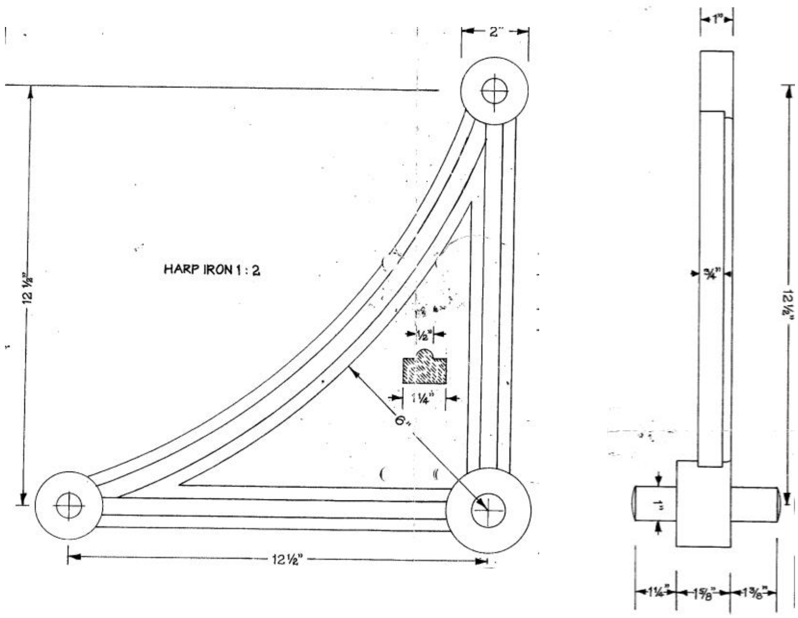


The **cross iron or spider** (right) is cast iron with four symmetrical arms, and fixed to the forward end of the striking rod, carrying sling irons which connect to the harp irons. The **sling irons** (below) are made from 1” wrought iron rod with ¾” threads at each end screwed into lugs for attachment to the shutter rods using clevis pins secured with split pins. Each pair of sling irons is a different length to match the crossover of the stocks.

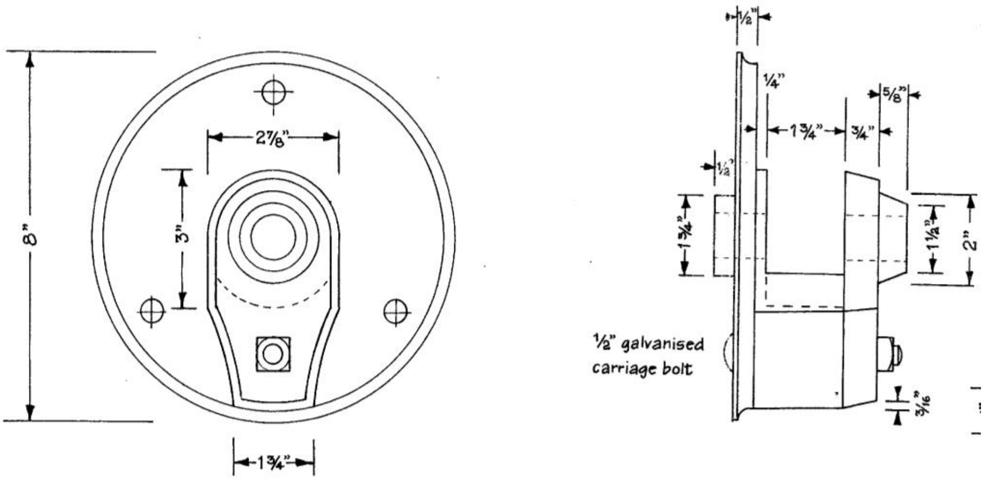




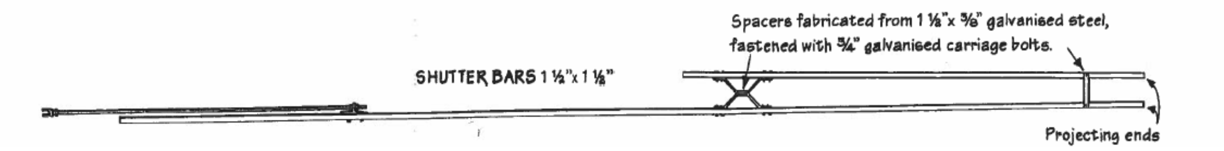
SLING IRONS 1 : 5 Two sizes
Ends same as shutter rods



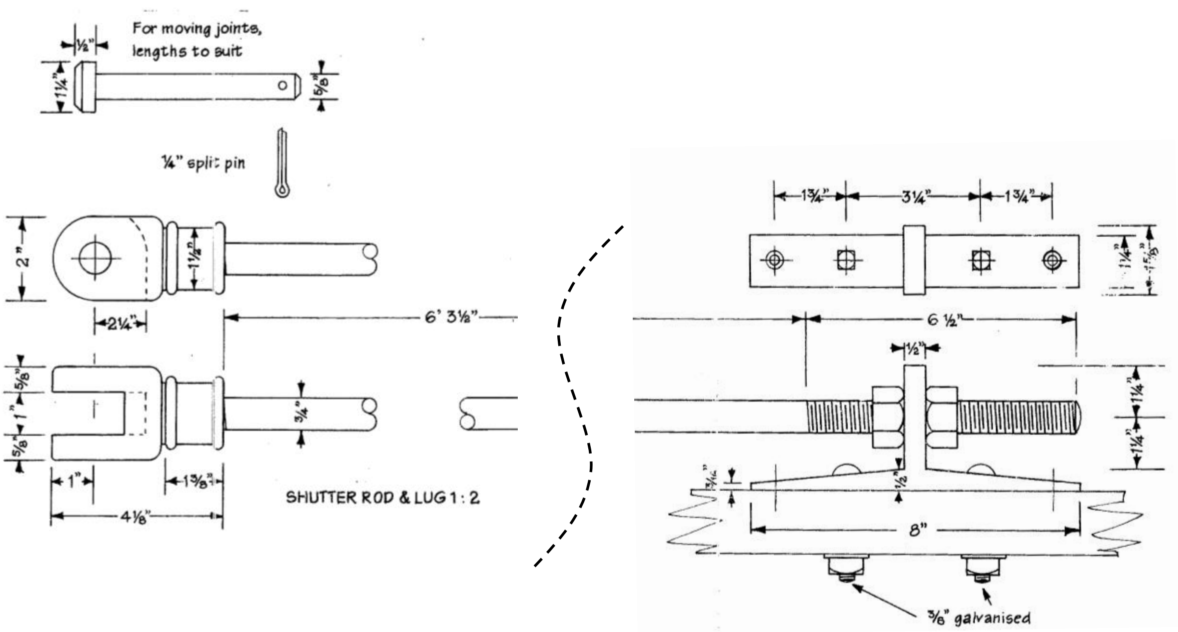
The **harp iron** (left), sometimes called a triangle, rotates on a circular bearing plate (below) that is attached to the side of each stock, translating the reciprocal motion of the sling irons through a right angle to drive the striking rods.

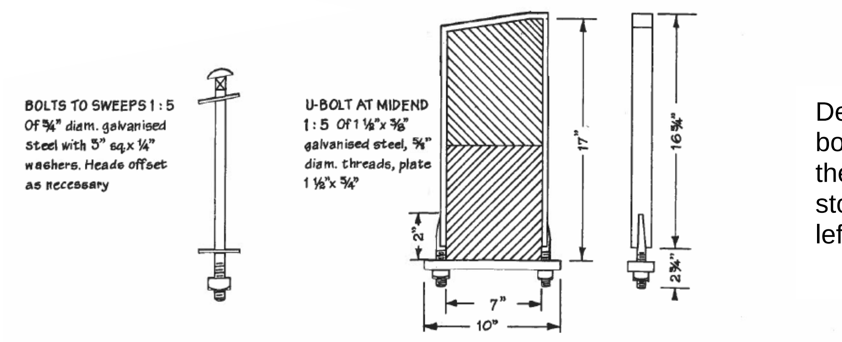


The **shutter bar assembly (below)**, which operates the shutters, is formed from 1½” battens, with a tandem bar at the point end to operate the leading edge cranks. The shutter crank ends are loose screwed to the shutter bars at intervals when the shutters are fitted so they operate together.



The **shutter rods** (below) connect the harp irons to the shutter bars. About 6’ long, they are formed from ¾” wrought iron rods threaded at the harp end to attach a lug and clevis pin swivel. At the shutter bar end, a longer thread is provided so that the effective length of the rod can be adjusted, with pairs of lock nuts to fix it to the **shutter bracket** that is bolted to the shutter bar. When the shutters have been fitted to all the sweeps, each shutter rod must be adjusted in turn to ensure that the shutters close fully together.



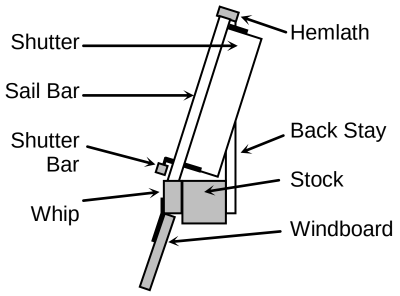


Details of the U-bolts used to attach the whips to the stocks are shown left.

These drawings were made by Vincent Pargeter, and supplied to Hole & Son for parts of the mill to be remade for the current restoration.

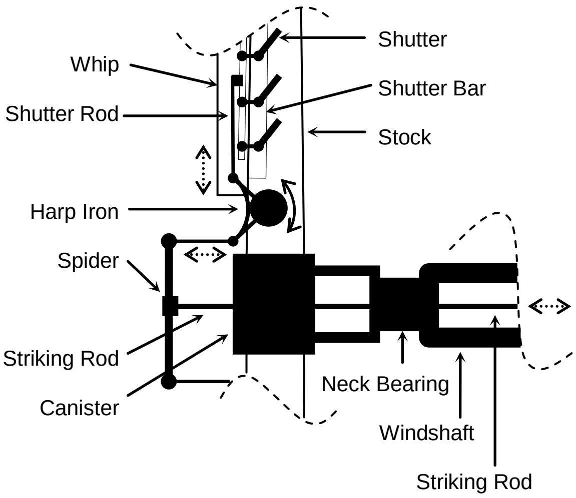
Striking Gear Operation

The sweeps are mounted on a pair of hollow steel stocks, rather the original pine, for increased strength and durability. These pass right through the canister, secured with large pinch bolts, with the whip of each sweep bolted to the front of the stock. A framework is attached to the whip and stock to support solid windboards and hinged shutters at an angle to the plane of rotation, such that the wind produces a turning force. This ‘angle of weather’ varies along the length of the sweep, reducing towards the tip. The striking gear is designed to open and close the shutters, and thus to control the speed of the sweeps. The sweeps are slightly angled forward so each is vertical at its highest point for maximum exposure to the wind and to clear the roundhouse at the lowest point. Most of the drive torque will be created in the upper half of their turning circle, since the mill body, roundhouse and ground will obstruct the airflow in the lower half. The sectional diagrams below show the essential features of the sweeps and striking gear, but are not drawn to scale. The front and rear sections of the windshaft are shown separately.



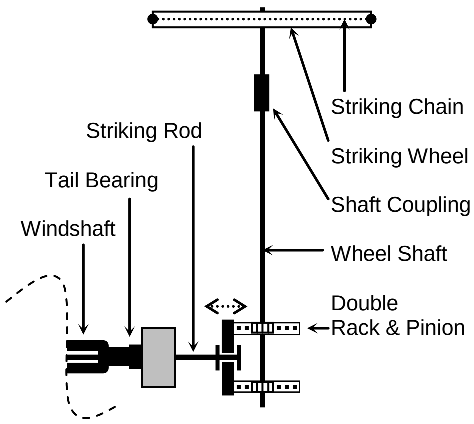
Shutters

A cross section of the sweep is shown left, with the shutter mounted on swivels between the whip and the hemlath at the trailing edge of the sail. Solid windboards are mounted at the canister end, with leading edge shutters near the tips. The back stay retains the sailbars at the correct angle of weather.



Sweep End

The shutters are mounted across the shutter bays at right angles to the stocks with swivels at each end. They carry 45º crank arms at the stock end that are pinned to shutter bars; these move lengthwise alongside the whips, opening and closing the shutters. Only three are shown, representing the numerous shutters that are fitted both sides of the whips. The shutter bar is operated by the shutter rod connected to a right angle crank (harp iron), which is in turn operated by the four-armed spider. As the striking rod moves in and out, the harp iron rotates, pushing the shutter bar to and fro, and operating the shutters. The shutters are shown in the diagram in their mid-position.



Tail End

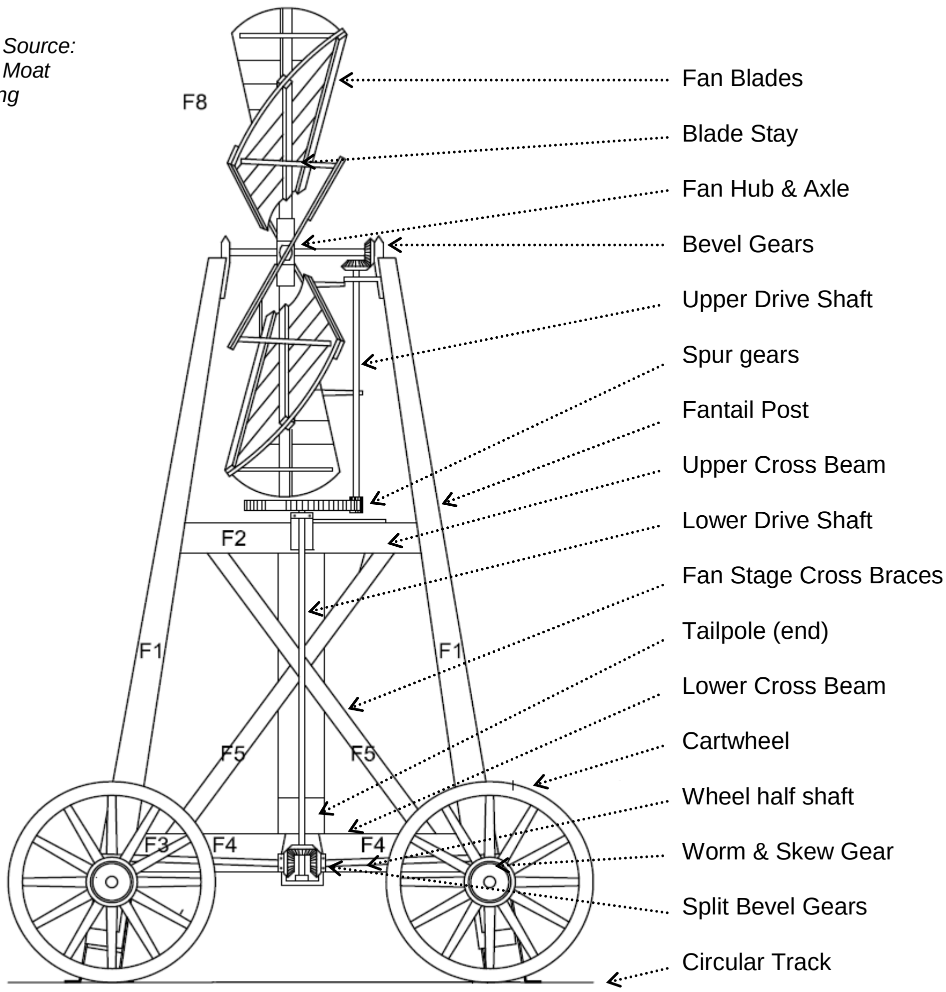
The striking gear is operated by a chain loop carried on the weight wheel on the side of the buck. The chain is accessed in a box section from the spout floor, so the wheel can be turned either way. The wheel shaft carries a pair of pinions that drive racks connected to the ends of a rack arm. The striking rod is attached to the centre of the rack arm via a swivel so that the rod can rotate with the sweeps. As the chain is operated, the double rack and pinion converts the rotation of the wheel into a reciprocating motion of the striking rod.

Pictured right is the tail end of the striking gear showing the double rack and pinion and sack hoist roller that is supported on the same frame

Fantail Design

The fantail ensures that the mill faces into the wind at all times, using a drive train that connects the fan with the cartwheels with an overall reduction gearing ratio of 120. For each complete revolution of the fan, the fantackle will move slightly less than an inch and a half along the circular track until the fan is aligned with the wind direction. When the sweeps face the wind, the fan is in the lee of the buck and stops turning. The fan needs to turn over 2000 revs to turn the mill through 360º (see calculation below).

Drawing Source: Douglas Moat Consulting



Eight fan overlapping blades, comprising boards slotted into to a radial oak spar, are mounted on a cast iron hub (fanstar) which is integral with a horizontal cast iron axle and bevel gear. They are maintained in position by wrought iron stays fitted between the corners of the blades. They have been reconstructed so that the centre section is removable to reduce the turning force while the fantail is a fixed position. The gear meshes with an horizontal bevel gear driving a vertical shaft which carries a small pinion at its lower end, which drives a larger cast iron compass arm spur gear and lower drive shaft.

The cartwheels that drive the fantackle are mounted on the lower ends of the posts that form the main supports for the fan. A gearbox, mounted centrally on the horizontal beam at hub level, splits the drive between the wheels at the bottom end of the lower drive shaft via symmetrical bevel gears, half shafts and worm gears that engage with skew-tooth gears mounted on the wheel hubs.

Gearing Reduction Ratio
Hub gears: 20/20 =1
Spur gears: 72/12 = 6
Split gearbox: 20/20 = 1
Worm gears: 20/1 = 20
Overall:** 1x6x1x20 **=120

Motion on Track
Cartwheel diameter = 4' 6"
Wheel circumference = 4.5π feet

Distance per rev of fan =
*(4.5π x 12) / 120 = **1.4 inches***

Overall Drive Ratio
Turning circle diameter = 78 feet
Circumference = 78π
Revs of wheel = 78π/4.5π = 17.33
Revs of fan to turn mill
*= 120 x 17.33 **= 2080***

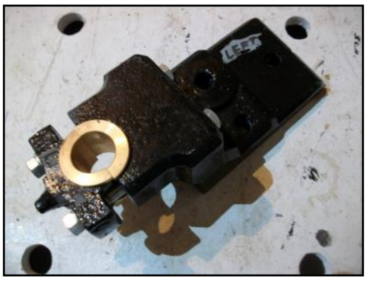
Restoration of the Fantail

Restoration of the fantail as shown left was completed in September 2018. At this stage it did not include the wheels and their drive shafts, since the turning circle could not be reinstated at this time.

The new fantail was constructed according to detailed, dimensioned drawings made of the old frame which still existed in decayed form at the start of the project. Some of the previous fantail remnants were retained for reference, such as the complex rebated joints.

The original fittings had already been refurbished by Playfoot Engineering, comprising the cast iron fan hub, drive shafts and gears and supporting brackets. All bearings had new phosphor bronze shells fitted (see below) and shafts reground as necessary. The new materials needed were Douglas pine beams, stainless steel bolts and screws and rustproof paint.

The fan blades were reconstructed earlier in the year. Their boards were removed prior to fitting to the hub of the fantail to reduce their weight and wind resistance.



The main vertical framework (posts and crossbars) was initially constructed horizontally, and with the mortises drilled and then chiselled out by hand. The hub shaft and the upper vertical drive shaft were then offered up but did not mesh correctly; an extension to the bracket supporting the top of the vertical shaft was required to bring the crown gears into mesh (see picture below).

The frame was then taken apart, the posts erected vertically, and the crossbars and hub drive fitted at the top. When adjusted to the correct geometry and the bottom of the posts clamped to the existing support brackets at ground level, the joints were secured with hardwood dowels driven through offset holes in the tenons in the traditional manner. The diagonal pairs of braces (vertical and horizontal) were then fitted; the joints onto the posts were particularly complex, where the ends of the braces had to be cut to fit round the posts at an angle. The lower crossbar was firmly attached to the tailpole with a single large bolt reinforced with refurbished dog irons and an angle bracket salvaged from the old cradle.

The lower vertical drive shaft with its large spur gear could then be fitted to the gearbox sitting on the tailpole bolted to the crossbar. The blades were hoisted by hand into position by rope using the hub and shaft as a winch, and bolted into position. A ladder and platform were then added to provide easy access to the fan when removing the blades or fitting their boards and to the drive components for maintenance.

The fantail wheel axles, drive shafts and a segment of original iron tyre are shown right prior to reassembly.

The fantail wheels are massively constructed in the manner of traditional gun carriage wheels to bear the weight of the fantail. The hub (left) is turned from elm because it has a complex grain which resists splitting in any one plane. It is reinforced with wrought iron bands and mortises cut for the spokes. Twelve spokes are cut from ash, which has a straight regular close grain that resists bending.

These are finished with a spokeshave and glued and hammered into the hub (right). The rim is formed from layers of oak boards that have to be steamed to make them flexible and glued together in sections called felloes. Each of six felloes are glued onto the ends of a pair of spokes to make up the rim (below).

The felloes are held together by heavy wrought iron strakes that are fitted hot to draw the sections together when the iron cools. These are fixed using large square cut nails that are also hammered in hot (right).

The finished wheels are shown below mounted in the roundhouse at Argos Hill ready for painting. Note the felloes are reinforced with rivets to resist lateral splitting. The square nails provide grip when the wheels are driven around the turning circle.

The wheels were painted white and the driving skew gears bolted onto the hubs, and, in 2022, the wheels were refitted to the fantail carriage (right). The stub axles have projecting webs that required slots to chiselled in the legs of the frame; they could then be fixed with screw bolts and the wheels mounted. The split drive shafts are terminated with worm gears that engage with the hub gear, with the ends supported in bearings attached to the outside of the leg. These are right and left handed so that the wheels rotate in the same direction. The position of each component needed to carefully adjusted for correct function of the drive system.

Pictures: Chris Bottomley

MACHINERY OF THE MILL

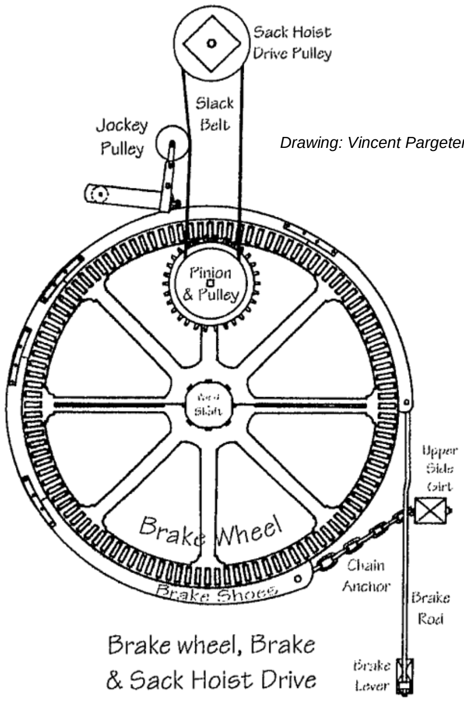
Brake & Sack Hoist Drive

A scale drawing of the brake wheel assembly is shown right. The brake wheel is of cast iron in two halves with six T-section compass arms bolted together and wedged onto the windshaft. The hardwood cogs that engage with the tail stone nut are set in the rear face of the rim, retained by wrought iron cut pegs.

The brake shoe is formed of a set of elm brake shoes mounted around the rim and hinged together with wrought iron plates. The lower end is attached to the upper side girt via a heavy chain, while the upper end is attached to the brake lever below via a wrought iron rod. This long wooden lever is pivoted at the front of the mill so that the brake is applied when the far end is held down, when the shoes are tightened onto the cast iron brake wheel rim.

The inside edges of the brake wheel cogs engage with the teeth of the sack hoist drive pinion. This is made from a solid elm disc with hardwood teeth, with a wooden pulley on the same shaft. This connects with a pulley mounted on the sack hoist shaft above via slack leather belt. The hoist is activated by pulling on the rope attached to the jockey pulley crank. The belt is tightened by the pressure from the idler wheel, and the sack hoist shaft turns. This has a bollard (not shown) mounted at its rear end, with a chain passing down through the self-closing hatches to the spout floor to attach to the sacks

Drawing: Vincent Pargeter



The picture left shows the fixing chain and connecting rod of the brake at the front of the stone floor.

Drive Ratio

Assuming tailwheel speed of 15 rpm
Bollard speed = 112/30 x 15 = 56 rpm
Bollard diameter = 6", circumference = 19"
Sack lift speed = 19/12 x 56 = 87 feet per minute
A lift of 30ft will therefore take about 20 seconds

Restoration of the Sack Hoist

The bollard mountings at the rear end were badly worm-eaten, so were replaced with oak, and a new sack chain fitted. The original leather slack belt was repaired by a leatherwork specialist. One side of the jockey wheel crank mountings also had to be repaired; a new oak block was fitted over one end of the swivel pin to retain it. The rope was renewed and routed along the roof and down alongside the tunnel steps to the lower floors through existing guides and pulleys. A counterweight was fitted to the crank arm to ensure that it returned to the rest position after actuating the hoist.

The picture above shows the sack hoist mechanism with the jockey wheel, crank and rope on the left, and the top of the brake wheel, drive gear, pulley and belt on the right.

The pinion that engages with the brake wheel has hardwood teeth mortised into a solid elm hub that are retained by wire nails through the shank ends. Prior to repair, it had numerous broken teeth, so all were renewed in applewood, the cracks in the hub filled with resin and the whole coated in PVA to preserve and reinforce the teeth. Refitting this gear necessitated the removal of its square shaft, which allowed its bearings (hardwood blocks) to be checked for soundness and lubricated. A new hardwood bracket was installed to support one end of the beam upon which the forward bearing is mounted using a screw bolt, so the height of the drive pinion could be easily adjusted. The pinion was then refitted with new wedges, square on the shaft to ensure consistent meshing with the brake wheel cogs, and was successfully tested by manual operation of the sweeps.

Meal Bins

Views down into the grain bins from the roof space are shown here. They were built into the space above the stone floor using 9” x 5/8” tongue and groove boards to store grains for the different stages of milling.

Only **smutter (grain cleaner) bin** needed extensive repair, all the others basically sound. In order to access the auxiliary drive for repair, the sloping lower boards around the spout were stripped out of the smutter bin. Many were decayed or missing in any case, and some of the framing also needed repair. The boards covering the drive gears had been replaced with sacking, perhaps to facilitate access to the smutter drive gears.

The partly restored smutter bin is shown right, with the spout below and the smutter drive compartment above. The spout itself was removed and repaired as a unit, and refitted to be removable by cutting through its main supporting beam, which can now be slid out to remove the spout as required. The surrounding boards were repaired extensively with acrylic filler and PVA to stabilise the decayed timber. The auxiliary drive is seen in the upper part, later covered with recovered boards. The vertical sides were usable after treatment with preservative. The form of the bin was modified with a platform to stand on to facilitate access to the gear train. All repaired sections of board were made removable for access and repair.

The **wheat bin** (left) occupies the front left corner of the mill, with an access ladder and relatively small spout with sliding spattle. This feeds the tail stone hopper via an open chute that incorporates a sieve in its floor to remove dust, which had been restored earlier.

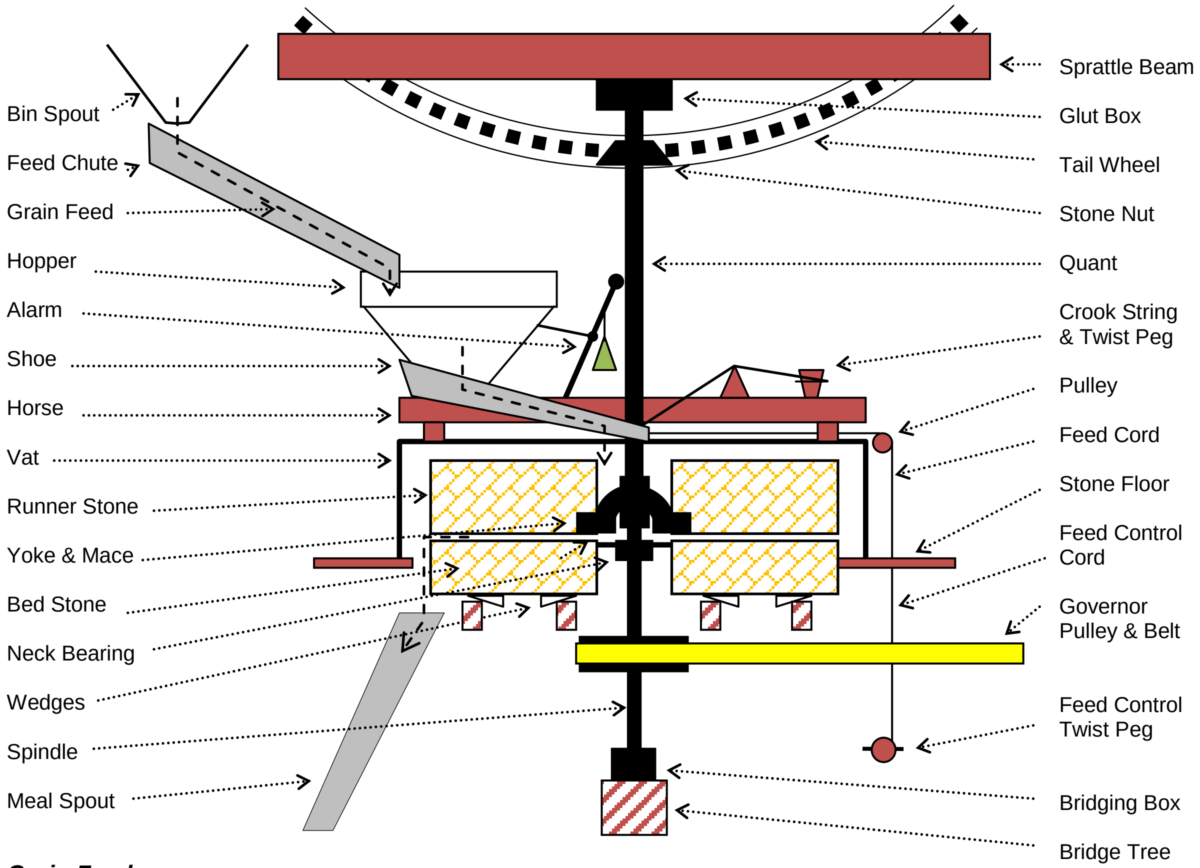
The **flour dresser bin** (right) has a long spout which feeds directly into the dresser drum, with a sliding spattle and agitator to control the feed rate.

The **grist bin** (left) has a flat floor providing extra capacity and ease of access. A large square aperture has a sacking spout feeding the peak stone hopper below at a relatively high rate with animal feed such as barley and oats.

The **crusher bin** (right) is a subdivision of the grist bin with a large aperture which is assumed to feed an oat crusher on the spout floor via a long sacking spout which passes through a hatch in the stone floor. The sacking spouts could be easily controlled by a wrap-around chord.

Tail Stone Drive & Feed

The tail stone drive and grain feed system is shown diagrammatically below (not to scale). The runner stone is supported on an iron bar (yoke) and block (mace) which engages with the top of the stone spindle. The forked lower end of the quant also engages with the mace from above to turn the runner stone and spindle; this is driven via the stone nut from the tail wheel. The governor for the tentering gear is driven via a belt from the lower spindle.

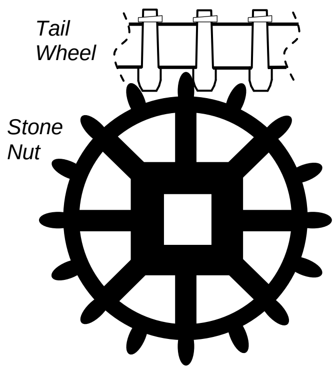


Grain Feed

The grain to be milled is stored in the wheat bin above and fed via an open chute into the hopper (indicated by the broken arrows); this has a mesh floor to provide additional sieving to separate dust from the wheat. The hopper feeds the sloping shoe, which vibrates against the square quant to feed the grain at a controlled rate into the eye of the runner stone. The feed rate can be adjusted by altering the pitch of the shoe using the crook string. The meal is collected within the stone vat and falls through a slot on one side of the bed stone via the meal spout into the meal bin, where it is allowed to cool before bagging.

Another control cord is fitted which allows the feedshoe tappet to be drawn away from the quant to reduce the feed; this passes down through the floor to a twist peg on the spout floor from where the feed can be controlled. There is also a spattle (shutter) on the hopper outlet. Note that a blanking plate is needed in the eye of the bed stone to stop the grain falling through, while allowing the spindle to rotate. An alarm system is fitted which rings a bell when the hopper is empty, consisting of a strap inside the hopper connected by a cord to a vertical arm with a bell attached. The weight of grain in the hopper holds down the strap, but when the level falls, the strap rises and allows the bell arm to fall against the quant, making it ring.

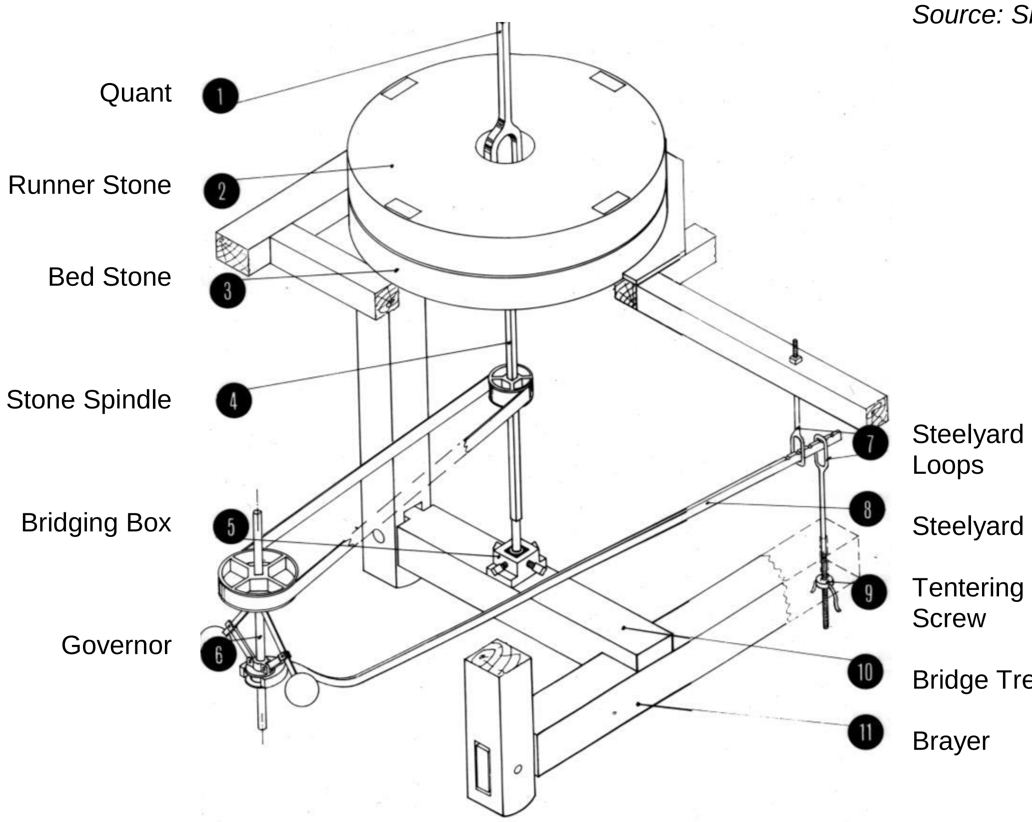
Stone Drive Gears



The diagram left shows the wooden cogs of the tail wheel driving the hollow cast iron stone nut (not to scale). The brake wheel gearing is similar, but with fewer teeth on the stone nut. The pitch of the teeth is 2.5”, with the tail wheel cogs about 1” thick at the root. The teeth on the stone nut are narrower, about 0.5” at the root, and appear elliptical in profile. These providing ample clearance between adjacent teeth, which is acceptable because the drive does not reverse in normal operation, so backlash is not an issue. One advantage of combining wood and iron is that the hardwood cogs will wear to match the iron teeth, thereby spreading the load over the face of the cog. The number of teeth of this stone nut (16) divides exactly into the number of tail wheel cogs (112). Therefore, the same teeth mesh every 7 revs of the stone nut. The clearance between the gears is determined by the spacing of the stone nut upper bearing from the sprattle beam. The replaceable hardwood cogs must be carefully shaped before fitting into its rim for a driving fit; they are then retained by small wooden pegs through the ends of the shanks, or cut nails in the case of the brakewheel.

Generic Tentering System

Source: Shillingford



The generic tentering system shown above is similar to those found at Argos Mill, except that the brayers are longer and junctions with the bridge tree have a semi-circular profile to allow for free movement. The runner stone spindle is supported on the bridge tree in a thrust bearing (bridging box). This is freely mortised into the bridge tree hanger at one end, while its other end rests on the brayer, which is also pivoted on a vertical hanger. Its free end attaches to the steelyard via a screw adjustment and loop. As the mill speeds up, the governor weights fly outwards, raising the end of the steelyard that engages with its collar. The steelyard screw end loop, brayer and bridge tree free ends fall, hence the runner stone.

This system of levers has a mechanical advantage of approximately 150, which applies pressure to the grain between the stones, while regulating the speed of the mill. If the wind speed increases, the milling pressure will rise, increasing resistance. If the mill slows as a result, the governor will reduce the pressure to maintain speed. The tentering mechanism also allows the mill to start with minimum loading, gradually increasing the pressure until the optimum stone position is reached.

The miller uses the tentering screw to adjust the tentering range to suit the wind conditions and optimise the meal quality. The steelyard on the tail stones at Argos Mill also has a movable hook for a counterweight to balance the system. A weight of a few kilograms is sufficient to support the runner stone that may weigh over 1 tonne when new. The weight of the stone will reduce over time as it is re-dressed; the position of the steelyard loops is adjustable to compensate by reducing the mechanical advantage slightly.

Part of the tentering gear of the tail stones is shown left, with the brayer end and adjusting screw visible. This is attached to the end of the steelyard, which is suspended on a nearby loop, creating a lever with a large mechanical advantage to support the weight of the runner stone.

Underside of the bridge tree which supports the tail runner stone that can be seen above, its end mortise supported by a pair of hangers and cross bar.This is all original oak. Note the wedges uses to retain the bridge tree tenon.

Comparison of Tentering Gear

Argos mill is a typical post mill, having a pair of burr stones for milling flour and a pair of peak stones for feed milling. Flour milling ceased at some point in the life of the mill, while feed milling continued, and it appears that the peak stone gear was then upgraded while the burr stone gear is original. The peak stones now have a cast iron horse, presumably replacing wood. The amount of corrosion on the burr stone components compared with that on the peak stone certainly suggests greater age.

The French burr bedstone has a square eye (see picture right), as might be expected in stones assembled from separate pieces of quartzite. The bearing is retained by a square hackle plate fixed with wingnuts, these, perhaps, being a later modification. It is retained by a characteristically shaped single scooped wooden wedge with a hole in the handle to aid extraction when the bearing needs servicing. The square neck box would typically be packed with gun cotton or shredded twine soaked in grease for lubrication.

The peak stone has a circular eye (see below right), with the neck box retained by four suitably formed wooden segments around a central cast iron mount for the four hardwood wedges that form the bearing surfaces. This neck bearing appears to be of a more sophisticated design than that seen in the French burr bedstone, probably part of a later upgrade.

The tentering gear of the peak stones has an interesting modification (see left). A wooden lever has been inserted into steelyard hanger, which is controlled by a cord and pulley system at the far end, tied off on a toggle. This allows the tentering gear set point to be more easily adjusted compared with using the turnbuckle on the end of the brayer. This would suggest that the peak stones needed more frequent adjustment.

The governors on the breast and tail stones also provide evidence of progress in the design of milling gear. Both have an upper drive pulley with a flange on the lower edge to retain a 1” belt driven from a cast iron pulley on the stone spindle. As they rotate, the weights fly out and raise the collar and consequently the steelyard end yoke that controls the runner stone height via the tentering gear.

The governor on the tailstones (left) is probably original, since it has a wooden pulley and arms that are relatively crudely constructed using standard wrought iron bar, such as might be produced by the local blacksmith. The collar, however, appears to be a higher quality manufactured casting, perhaps a standard component.

The breast stone governor (right) appears, on the other hand, to consist entirely of manufactured components. The drive pulley is cast iron, with integral mounts for the weight arms. The collar bearing is also of a more sophisticated design, with the steelyard yoke arms retained in lugs clamped around the sliding collar.

The mounting of the upgraded breast stone governor (left) appears to be constructed of more recent timber than the tailstone gear, but crudely repaired. The tentering gear fitted to both stones gives the impression of having been somewhat improvised, so the mill might possibly have been constructed originally without automatic tentering on either stone. In addition, there is evidence (redundant mortises, bolt holes etc) that the whole tailstone tentering gear has been reversed at some point.

Analysis of the Tentering Mechanism

The quality of the meal produced by the mill depends on maintaining a suitable stone speed and separation. A typical wheat grain is 2-3mm in diameter, so the mill stones must rotate with a gap of about 1mm to produce flour. The tentering mechanism allows this gap (the nip) to be controlled automatically when the speed of sweeps and milling resistance varies. To achieve this, the upper runner stone is supported on the bridge tree whose position is controlled by the tentering gear; the nip is reduced automatically as the mill speeds up. The centrifugal governor connected to the far end of the steelyard helps maintain a constant speed and nip when the working position is reached.

Starting & Milling

While the mill is starting, the load on the sweeps is minimised by the raised position of the runner stone. When the mill is running, the considerable angular momentum of the runner stone, windshaft and sweeps will act as a flywheel to help maintain the runner stone at a constant speed, overcoming variations in milling resistance. However, if this resistance becomes too high, or the wind speed drops, the tentering gear compensates to reduce the load and maintain the speed. The tentering gear maintains a balance between speed, load and meal quality.

The tentering gear has a turnbuckle adjustment at the connection between the steelyard and brayer to allow the set point of the tentering gear to be adjusted to obtain a suitable grade of flour at the meal spout. This must be constantly monitored by the miller, and the tentering screw adjusted if necessary. In addition, the exact positions of the steelyard loops can be adjusted to compensate for the reduction in the runner stone weight after re-dressing and maintain the balance.

Mechanical Advantage

The length of the levers in the tailstone tentering gear was measured (in cms) in order to calculate the mechanical advantage and the range of vertical movement of the runner stone, assuming the governor collar rises by 100mm (4”):

Nominal range of governor collar = 100mm
Steelyard ratio = 220/8 = 27.5 (centre pivot arm)
Bridge Tree ratio = 100/60 = 1.66 (end pivot beam)
Brayer ratio = 175/50 = 3.5 (end pivot beam)
Overall lever ratio = 160 (product of lever ratios)
Range of runner stone movement = 100/160 = 0.6mm

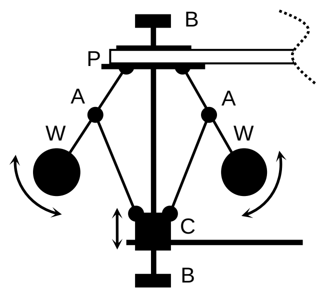
Assuming the governor operates with the collar at its working position (raised 50mm from rest), the nip will reduce by 0.3mm from, say, 1.3 mm at rest to 1.0 mm while milling.

Governor Weights

When the runner stone is stationary, the governor weights, plus the weight of the steelyard and collar, must be sufficient to maintain the runner stone in its raised (stationary) position. To calculate the effective weight required at the collar to support the runner stone:

Overall mechanical advantage = 160
Approximate weight of runner stone = 1000kg
Downward force required on steelyard = 1000/160 = 6kg

Governor Operation



The tailstone governor has a vertical spindle in fixed hardwood bearings (B) carrying a rotating pair of lead weights (W) attached to 12” swinging arms, with a sliding collar (C) suspended from their mid-points by 9” collar arms. The attachment point (A) may be varied to adjust the mechanical advantage for optimum effect. It is driven via a wooden pulley (P) and leather belt from a smaller cast iron pulley on the stone spindle with a speed ratio of about 0.5.

The steelyard fork engages with the collar, which is at its lowest point when the stones are stationary. The weights must be heavy enough to hold the collar down against the weight of the runner stone, their effective weight being approximately doubled by virtue of the position of the attachment point.

The weights are about 5kg each, but the weight of the steelyard itself and an additional hanging weight on a sliding hook allow the system to be fully balanced if required, so the mass of the governor weights is not critical.

When the stones are up to speed, the spindle is driven at about half the speed of the runner stone (60 rpm max) causing the weights to fly outwards. This causes the collar to rise and the runner stone to be brought into the working position. If the speed falls, the governor will raise the runner stone and hence reduce the milling resistance.

If the swinging arms are at 45º, the collar is raised by about 3” (75mm). If it is assumed that the mean working position will be at 2” (50mm), the resulting reduction of the nip between the stones is about 0.3mm.

Restoration of Head Stone Gear (2019)

The peak stones in the head of the mill were found to be completely seized up at the start of this phase of restoration. The governor would neither rotate nor would the weights lift and its drive belt was missing. The brayer screw end was blocked from rising by the later installation of a diagonal sag iron. The neck bearing was seized up due to ingress of water causing corrosion of the bearing surface and the stones were stuck together by rainwater binding the meal left between them. The glut box was set too far forward so the upper quant bearing could not be properly engaged and the feed shoe spring and cords were incomplete.

The brake wheel cogs were replaced over the course of the year with seasoned applewood carefully shaped to match the existing ones. It was therefore now possible to restore the head stone gear to working order. First, the quant was lifted out with aid of a hydraulic car jack and laid aside pending treatment of the stone nut working surfaces to reduce wear on the cogs. The stones were then separated (with some difficulty) using steel log splitting wedges, a crowbar and extension. The jack was then used to lift the front of the stones enough to insert the ‘scotch wedges’ that were original to the mill. There was now sufficient clearance between the mace and the bridge in the runner stone to allow the neck bearing to be forced out from below. It was not possible to separate the mace from the spindle and hackle plate, but this was deemed unnecessary at this time.

The neck bearing consists of a cylindrical upper end of the spindle casting (about 4” in diameter), held within four shaped hardwood wedges, one of which is removable (and was missing), presumably to allow routine lubrication of the bearing. These are retained within an octagonal cast iron housing, which in turn is wedged into the eye of the bed stone by four shaped oak segments. The bridge tree was dropped by releasing the screw end of the brayer and taking out the wedges supporting the bridge tree hanger beam. The lower spindle end was thus released from the bridging box, which could be removed by unscrewing the four bolts attaching it to the bridge tree.

The bridging box (above) consists of a square iron casting with set screws on four sides, which allow the spindle footstep bearing to be precisely positioned within it, in order to level the runner stone. A gunmetal block supports the hemispherical lower spindle end in a matching recess incorporating a slotted oilway on one side. It was removed for restoration off site. The bridge tree at the brayer end was moved to one side so that a jack could be applied to the bottom of the spindle via a scaffold pole of suitable length. This successfully forced the spindle neck out of its bearing (right), which could now be inspected, sandpapered to remove rust and oiled. In the meantime, the bridging box had been refurbished, lubricated and refitted, and the spindle could then be dropped back into its housing and could now be rotated freely.

The brayer screw end was impeded by the sag iron attached to the crown tree end that supports the lower front left corner of the buck. It was decided to move the brayer end to the other side of the sag iron (see left), with the brayer slide to be repositioned accordingly and more securely attached. To prevent the tentering screw handle fouling the sag iron when screwed up, a sleeve, made of steel tube, was inserted between the screw handle and the brayer end, and the screw hanger repositioned away from the sag iron by drilling a new hole in the brayer end. This was possible as the manual tentering lever hanger is mounted on a slide rod, allowing it to be repositioned. This has two pulleys in its far end, allowing a cord to be looped around a static pulley mounted on the corner post and tied off to a wooden cleat. Its wrought iron hanger already had a set of bolt holes which allowed a higher position to be selected. The position of the oak brayer hanger at the bridge tree end was adjusted to improve the alignment of the brayer. This and other hangers were reinforced by the insertion of stainless steel threaded bar where splits in the timber had developed over time on their mortised ends.

The gap between the hackle plate and the upper surface of the neck bearing was packed with rope soaked in petroleum jelly (non-toxic) to prevent meal from entering the bearing. The runner stone was then eased back onto the mace and the quant refitted. The glut box was re-fixed further back on the spratle beam in what appeared to be a previous position, requiring the bolt holes to be re-drilled (see right). The stone nut then had the correct clearance at the tailwheel cogs, and the stone turned with the sweeps. The bed stone fixings were reinforced and the rest of the stone gear re-installed. The renovated governor was re-fitted with a new drive belt, and the tentering gear adjusted for correct operation.

Auxiliary Drives

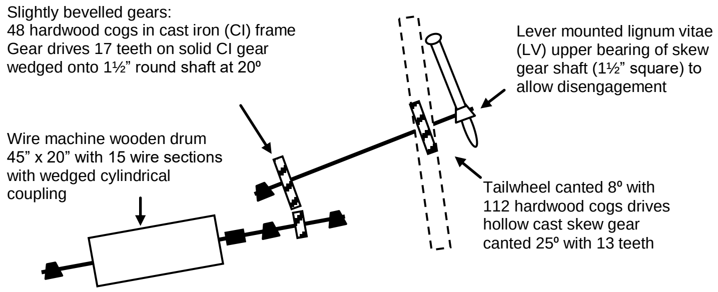
Diagrams below (not to scale) show the drive trains for the smutter (grain cleaner), crusher (oats roller) and wire machine (flour dresser). They mostly use pairs of gears of which one is solid cast iron (CI) and the other has hardwood cogs in a CI frame, for smooth running with minimum lubrication. These gears are wedged onto round or square wrought iron shafts carried in mix of brass lined and hardwood bearings, assumed to be of lignum vitae, a tropical hardwood.

Wire Machine Drive

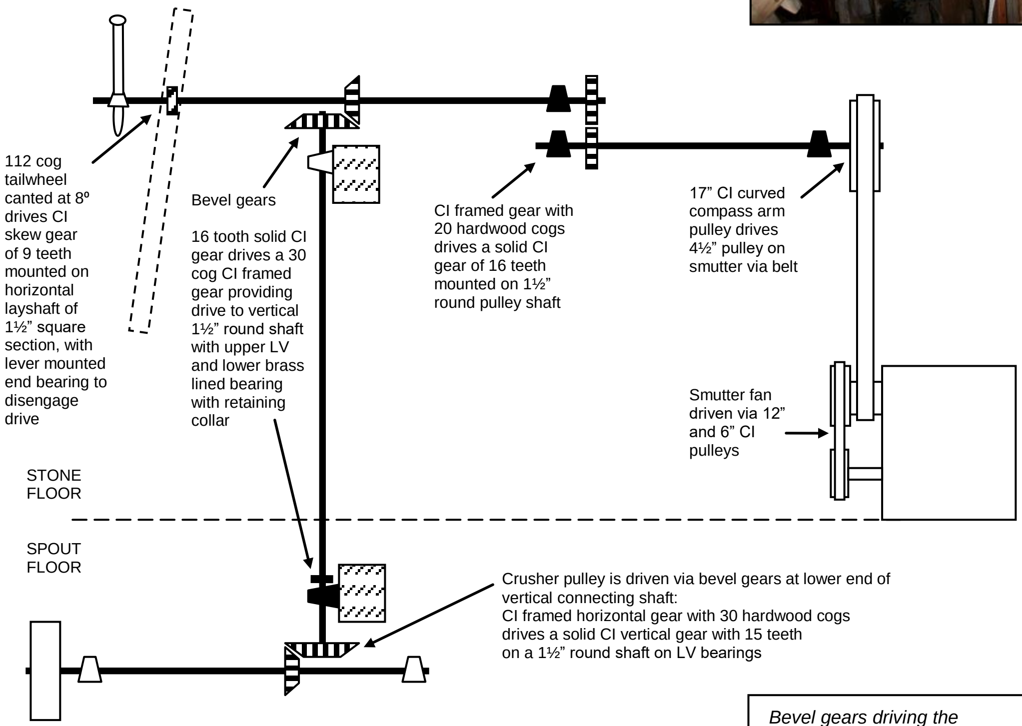
The dresser is driven via two angled shafts and gears from the tailwheel.
The gearing ratio is 112/13 x 48/17 = 24.3.
If the sweeps turn at 15 rpm, the dresser runs at about 24 x 15 = 360 rpm.
Note the odd number of teeth on one gear ensures a variable meshing sequence.

Brass lined bearings in cast iron housings mounted on supporting beams or posts

Wooden bearings assumed to be lignum vitae mounted on supporting beams or posts



Dresser drive from tailwheel



Smutter and Crusher Drive

Drive from the tail wheel is distributed on the right side of the mill via a system of perpendicular shafts and belts on mostly hardwood (LV) bearings.

Smutter drive ratio = 112/9 x 20/16 x 17/4.5 = 58.7
At windshaft speed of 15rpm, smutter speed is then approx. 60 x 15 = 900 rpm
and fan speed = 900 x 12/6 = 1800 rpm
Crusher drive ratio = 112/9 x 16/30 x 30/15 = 13.3
and crusher pulley speed = 15 x 13.3 = 200 rpm
This will be multiplied by the pulley ratio of the final drive.

Bevel gears driving the vertical shaft

Restoration of Auxiliary Drives

The auxiliary drive system provides power to the smutter, dresser and crusher from the side cogs on the tail wheel via a lever-engaged cast iron pinion, off to the left in the picture below. The bevel gear the takes the drive down to the crusher on the spout floor. The gears to the right of centre drive the smutter pulley off to the right. These are supported in gunmetal bearings that are braced with wrought iron straps bolted to the side members. This part of the drive is normally concealed under the sloping side panels of the smutter bin.

The downshaft terminates in bevel gear (left) driving the crusher pulley (right), whose shaft is supported in hardwood bearings. The driven gear can be disengaged via a horizontal lever mounting on the rear end of the pulley shaft to reduce the load on the system if the crusher is not in use.

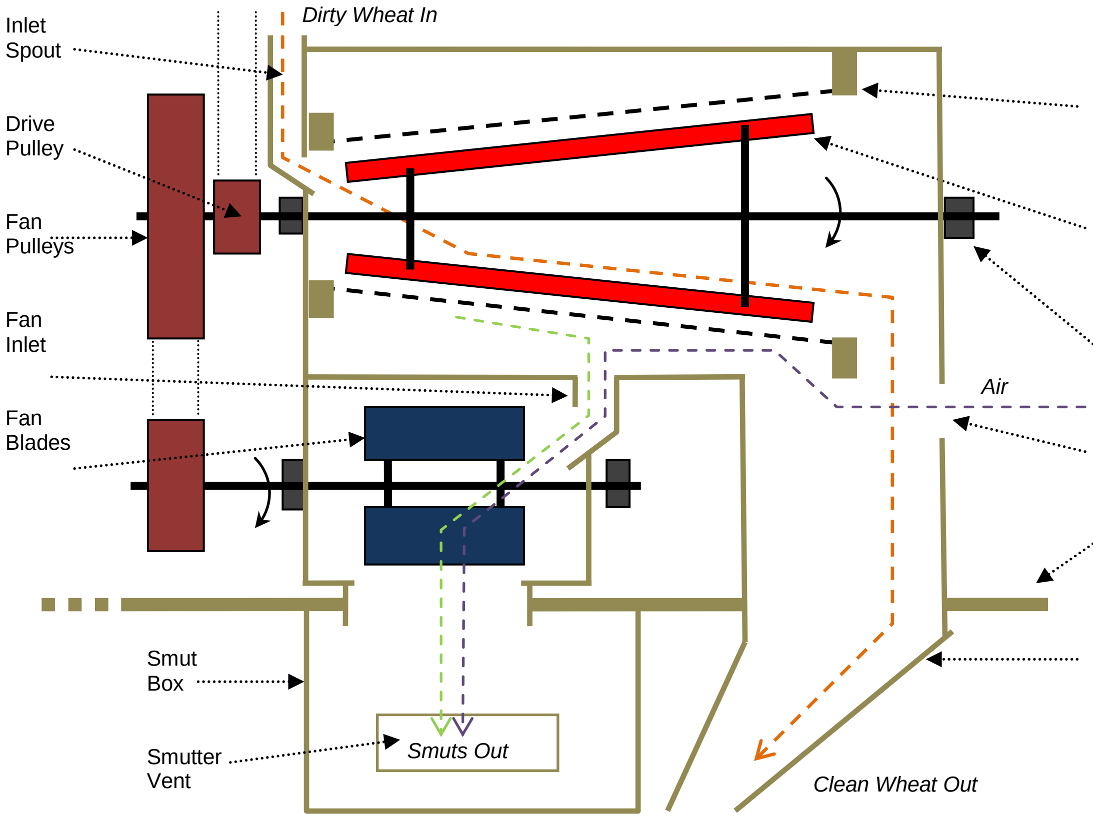
The system was initially found to be seized up, so the bearings were disassembled, checked and lubricated. The brass bearings were lubricated with grease, the hardwood with linseed oil. The gunmetal bearing supporting the upper smutter drive gear was found to show excessive wear, indicating it was either recycled or subject to heavy use. This might be expected if the crusher was used more in the later years of the mill. The lower bearing was less worn, suggesting the smutter had less use when the mill switched to production of animal feed. The bearing supporting framework was found to be very poor quality timber, with the main support having old mortises which will weaken it. However, replacement would have been too complicated, so it was left alone, since the drive would not in future see regular use.

The lower bearing of the smutter drive was found to be completely adrift, since one side was mounted on the upper side girt which was replaced when the buck framing was rebuilt during the latest restoration, while the other is mounted on the bearing frame. The bearing had to be raised on blocks and spacers to engage correctly with the upper gear, the new upper side girt drilled though to take the original mounting bolt. The old frame also had to be rebated to fit the nut on the other side of the bearing mount. The **drive gears** were all formed of hardwood cogs engaging with cast iron pinions. Fortunately, the hardwood cogs were generally sound, again indicating limited use of the drive system. These were treated with Cuprinol preservative and linseed oil, and the ironwork treated with Fertan.

The **side cogs** on the tailwheel that drive the system were generally sound, but a few were broken or missing. They are retained by plain steel pins driven transversely through the shanks, and engage with both the dresser and auxiliary drive pinions. The shanks of the broken cogs were drilled out and the cogs replaced in applewood as necessary. It was found that some had been secured with nails from the front side only, making their extraction difficult, since they could not be driven out from the back side. Damage to the rim was unavoidable to cut around the nail heads for extraction. When the cog was replaced, the correct retaining through steel pin was reinstated and the damage repaired. This poor quality work supports the idea that shortcuts were made in upgrading the mill in the late C19th. This suggests that the miller himself or inexpert millwrights were trying to minimise costs during the upgrade. The felloes forming the rim were treated for woodworm where necessary, but their integrity did not appear to be compromised.

Smutter Design

The smutter cleans the wheat before milling to remove dust, mould (smuts) and chaff. It is located (inconveniently) at the back right of the mill at the top of the access stairway to the stone floor. The longitudinal section below (not to scale) shows how it would have worked, based on its construction. The main working component is a horizontal conical mesh drum containing rotating brushes and agitators. The smutter is driven from the side cogs of the tail wheel via gear that can be engaged by lever, and thence via a lay shaft and pulley located above the machine. A belt drives the small inboard pulley on the brush spindle at about 900 rpm. The same spindle carries a larger outboard gear and belt that drives the fan pulley below at about 1800 rpm.



The grain is fed into the smaller end of the drum (top left of the diagram) from the back right bin with a spout over the stairway via a shuttered aperture in the front panel of the smutter. The drum contains pairs of rotating brush bars and agitators; the solid agitator bars break up the smuts and tumble the grains, with the brushes forcing the resulting dust out through the mesh. The drum mesh is made of a grid of stout steel wire, with a pitch of approximately 1/10", supported by 5 sectional elm rings spaced by longitudinal oak strips. The ends of the drum are supported in pairs of semi-circular baffles, with sacking used to seal the joint (a remnant was found attached to the drum end). The drum is constructed in lengthwise halves bolted together, making it easy to remove from the machine to service the smutter components.

The brush and agitator bars are bolted onto two cast iron hubs of different size, each with four offset arms carrying the bars in opposing pairs. The two brush bars appear to use badger hair as (seen in the flour dresser) and the two agitator bars carry wrought iron blades. Damage to these blades suggests that stones were often present in the grain. The inlet end of the drum is lined with solid zinc sheet for the first six inches, where the mesh had been damaged or was worn out.

The fan fitted beneath the smutter drum case creates a draught to actively extract the dust from the drum. Air is also drawn in via a vent at the rear of the machine that passes through the stream of grains as it falls into the outlet spout . This will have the effect of drawing any remaining chaff and large smuts back into the lower part of the drum case, from where all the waste is blown in a smut box below and out of a vent on the side of the mill. This box can be accessed from the spout floor via a side panel to clean it out. The routes of the grain, smuts and chaff through the machine are shown as dotted lines on the diagram. A long spout delivers the clean wheat into a sack on the spout floor.

The smutter, in common with the flour dresser, was probably designed and supplied Dell & Son of London.

Conservation of the Smutter (2018)

Smutter showing belt drives, drum and fan below

The smutter was found to be substantially complete and in working order, except that its side and top panels, pulley belts and upper drum end baffles were missing. These can all be easily replaced if required. The bearings were fully functional after light lubrication. All parts of the smutter had evidence of woodworm infestation, but with remarkably little structural or functional damage resulting. The grain outlet spout below the machine was also in good condition. The side cogs of the tail wheel would need renovation to operate the drive system. At the time of writing, the exhaust vent in the mill side has not been reinstated. There may also have been an air inlet vent in the mill back wall but there is no evidence of this in the records available (old photos of the back of the mill), so air would probably have been drawn from the mill interior, helping to clear flour dust. A new (hardboard) inlet spattle was present on the grain inlet which could have been operated by a rocker and cord from the floor below, but there was no evidence of this actually being connected up, there being no hole in the floor or twist peg fitted below, so this will also not be reinstated.

The smutter drum was removed by releasing the four bolts that hold the halves together and rotating them. The mesh was sound, where not covered by the zinc sheet, if somewhat corroded. The drum halves were treated with 'Fertan' to preserve the steel mesh, including the wood, to ensure full penetration and to act as a preservative, as were all other accessible iron parts. The softwood frame and remaining panels of the smutter itself were treated with PVA to seal the surface, deter pests and reinforce the joints. The drum bolts appeared hand forged with irregular nuts, but the general construction of the smutter was of a similar high standard to the dresser, and was probably from the same supplier. The smutter was reassembled with the internal components visible to visitors.

The picture right shows the brush and agitator with offset attachment to the smutter spindle; the offset showing that it was driven in the anticlockwise direction.

The picture left shows half of the smutter drum after preservation, with five elm rings supporting the coarse mesh lining.

Smutter Data

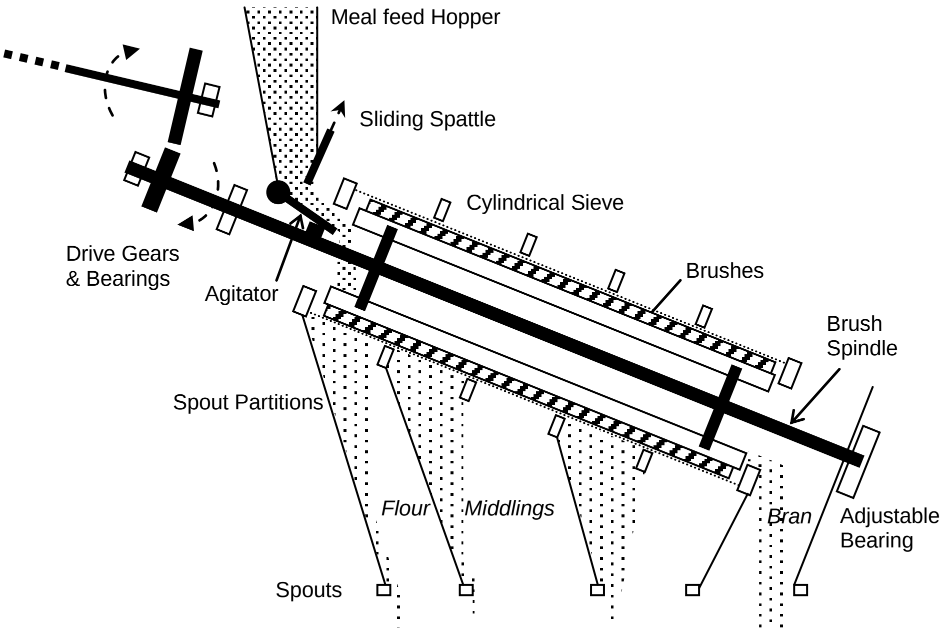
External Dimensions:	*Drum case: 29" x 21" x 21", overall height: 37"*
Drive pulleys: 17" to 4½"	*Fan pulleys: 12" to 6¾" (see page 33)*
Drum speed = 900 rpm	*Fan speed = 1800 rpm (approximately, with a sweep speed of 15 mph)*

Terminology: Note that the term smutter specifically refers to a vertical machine with cloth filter, the horizontal machine being more correctly described as simply a 'grain cleaner'.

Flour Dresser Design

The flour dresser, or wire machine, takes the form of a cylindrical sieve used to separate white flour from the meal after milling. It was probably installed when the mill was extended at the rear, along with the smutter, to improve the productivity of the mill and quality of the produce. Judging by the design details of the machine's construction, such as the quality of some of the castings and joinery, the machine would have been installed in the late 19th century.

The machine consists of an inclined drum with a graduated mesh lining containing a set of six longitudinal rotating brushes designed to force the meal through the mesh, the various grades of flour and 'middlings' being collected below via a set of spouts below, with the remaining bran emerging at the far end. The sectional drawing below (not to scale) shows the main working parts. The exact arrangement of the spout baffles is somewhat conjectural, as they were either missing or removed.



The meal is fed from a hopper filled from the bin floor above. It has a sliding spattle at its outlet that can be opened from the spout floor below via a cord and rocker (see photo above). It also has an outlet agitator in the form of a flap with a heavy iron bracket attached, which is struck by a lug fitted to the dresser spindle coupling once per revolution to actively feed the meal into the dresser drum. This is presumably designed to provide a feed rate proportional to the speed of the brushes, which may vary with the wind strength. The brushes are bolted onto slotted radial arms on the spindle; their positions can be adjusted so that they are pressed firmly onto the inside of the mesh drum, while still allowing free rotation. They consist of softwood battens with animal hair bristles of two different types, four with light brown bristles (pig?) and two with grey bristles (badger?). They are marked 'Wm. R. Dell & Son, 26 Mark Lane, London', the supplier of the machine, and probable designers.

The spindle is driven from the tail wheel side cogs via a lever engaged skew gear, drive shaft and gearing, at a speed of about 360 rpm.The brush spindle is supported at the lower end by a plain oak bearing fitted into a mobile stretcher whose position can be adjusted so that the brushes can be correctly centred in the drum to provide the necessary pressure to force the flour through the mesh while allowing free rotation. It is not clear it was wedged or designed to be self-centring. The whole dresser was enclosed by softwood panels, with the front, top and end panels removable and retained by rotating catches.

The brushes rotate inside the mesh lined drum, its cylindrical frame consisting of 15 equally spaced hardwood rings (simplified in the picture above) and end rings that are rebated to fit into circular end baffles which take the weight. It was found that originally there were five grades of mesh, occupying three ring sections each, finest at the top end to produce flour and then four grades of middlings, with the remaining bran falling out of the lower end of the drum. However, the remnants of the spout assembly seemed to have only four apertures (see next page), suggesting that only two grades of middlings were actually collected, as shown in the diagram. Freese suggests that typically the finest mesh would have had 120 holes per inch (0.2mm hole pitch), with further meshes at 70 (0.4mm), 50 (0.6mm) and 30 (0.8mm) producing 'firsts', 'seconds' and 'thirds' (the actual original mesh was too corroded to measure accurately). The four spout apertures would have originally had sacking sleeves attached to guide the flour, middlings and bran into separate sacks or tubs.

Restoration of the Wire Machine (2018)

The machine was reasonably intact when initially inspected, except that, where the back of the mill structure had collapsed, the spindle bearing panel had come away and the weight of the drum had forced down the spout assembly. The end panel and bearing were fortunately found within the mill, along with the side panel. The spindle end was temporarily supported until the bearing panel could be refitted, and the collapsed spouts also provided with temporary reinforcement pending rebuilding. A pair of new joists was fitted longitudinally below the machine to support the rear end.

Attempts were made to separate the spindle coupling in order to remove the complete drum and brush assembly, but it was too corroded. The coupling appears to consist of a cast iron ring with keyways machined into the shafts and coupling, with a steel wedge driven in to lock it, which could not be extracted. Fortunately, the drum was constructed in two halves, held together with six coach bolts. These were easily removed and the drum halves extracted. The remnants of the original mesh were cleaned off, and the frame treated with dilute PVA to seal and preserve the wood, reinforce the joints and enhance the grain. Each half was relined with a coarse (2mm) stainless steel woven mesh (see left) for demonstration purposes (a finer mesh can be added later to produce flour). Originally, a sackcloth seal was used upper end of the drum to prevent leakage of meal.

The brushes (see right) were then removed from their arms, and the spindle and arms treated with Fertan to neutralise the surface rust. The brush bars were treated with PVA. Interestingly, the coach bolts fixing the brushes to the spindle arms appeared hand forged, perhaps to provide extra-large heads, while the bolts holding the drum halves together were more regular and hence seem machine made. The lower drum support cradle board was quite worm damaged, so was reinforced with a square batten, which now takes the weight, resting on the new beams. The upper end of the drum must fit into the circular aperture seen in the picture above, so the lower cradle board had to be re-fitted at the correct angle and supported to retain the drum correctly in place, using angled side boards which also form the sides of a new bran spout.

Due to the collapse of the lower thrust bearing, the spindle had dropped out of its upper bearings, so the upper and centre bearing were dismantled. Both were retained by bolts with square nuts of crude manufacture. The centre bearing had a brass load-bearing lower half, with a hardwood upper shell that was cracked; this was glued back together with epoxy adhesive. The upper hardwood bearing was in better condition. With some difficulty, the spindle and brushes were lifted back into the correct position, and the bearings greased and reassembled. The lower bearing panel was then refitted and aligned such that the spindle was able to rotate freely while brushing the inside of the drum, with the agitator was also working correctly.

The dresser frame was further reconstructed as necessary to support the rear spindle frame in position. The front rails survived, allowing the original dimensions to be restored by re-attaching them to the rear panel. The far side panelling was largely absent, and was replaced with boards nailed directly to the mill side wall. The extension floor falls away due to sag in the mill frame, so the reconstruction needed to accommodate this. The spouts (shown left before reconstruction) were reconstructed using as many of the original boards as possible.

In order to rotate the spindle manually, several teeth were temporarily removed from the cast iron shell of the gear on the drive shaft, allow the spindle to rotate. If the dresser is to operate as originally, the following steps are needed:

1. *Replace many broken side cogs on the tail wheel (picture right)*
2. *Refit the cogs in the drive gear (generally in good condition)*
3. *Fit graduated mesh sections in drum (expensive & tricky)*
4. *Carefully adjust spindle position for correct working*
5. *Replace brush bristles if necessary*
6. *Re-instate mill turning circle for reliable driving conditions*

Skew gear drive to the dresser

Door Lock

The mill door had the remains of an original door lock on the right hand door post, the design of which is believed to be unique to Argos Mill. The fact that the lock is fitted in the door frame, rather than on the door itself is in itself very unusual. It is extremely simple, and was probably devised by the millwright, miller or blacksmith. Its operation can be deduced from the extant parts. The lock was restored to working order in 2017.

It consists of a pair of vertical spring steels tines fixed to the inside of the door post, with a key hole and slot for a flat retaining bolt. The original key survives, its relatively crude forging suggesting work by a local blacksmith. The lock enclosure was also recovered from the mill, which has a pair of pins on the back plate. When offered up to the door frame, it was discovered that one is positioned to receive the hollow end of the key shaft, and a second adjacent one that acts as a ward pin that only allows the correct key to turn in the lock.

The lock was used to secure a bar across the door, which also survives. This is attached to the left door post by a large eye bolt, allowing it to hang away from the door when released. The other end has a slot which would have carried a flat bolt that passed through the door frame and was secured by vertical spring steel tines. The end of the bolt was notched either side so that it would be retained by the tines when the door was locked. When the key was inserted and rotated, the tines were pushed apart to release the flat bolt. A replacement part has been made to show this operation.

The key has a single notch in the tab on either side of the shank, which allows it to pass the ward pin mounted on the back plate when it is rotated. If the key is the wrong shape, the ward pin should prevent the key turning and releasing the bolt. Most early ward locks have multiple pins or plates which require a key with a more complex pattern of slots on the tab, such as that seen in a typical medieval church lock. By comparison with most other contemporary locks (early 19th century) it is crude, but probably effective.

The original key and a replacement flat draw bolt are shown left. Note the notches in the flat bolt where it is retained by the spring tines, and the notches in the key which match the ward pin that projects from the back plate of the lock enclosure.

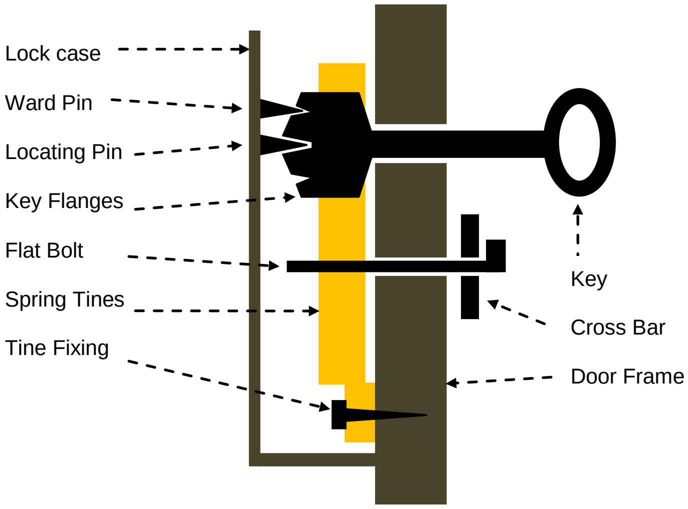
A model (right) was constructed during a previous phase of restoration to demonstrate the operation of the lock.

Door Lock Operation

The diagram shows a vertical section of the door lock (not to scale) showing the main features.

The key rotates on the locating pin, with the ward pin ensuring the slot in the key flange matches, so only the correct key will work. The pair of spring steel flat tines is fitted on each side, which engage with rebates in the flat bolt when locked. The bolt retains the cross bar that is fitted across the width of the door and secured to the other door post. When the tines are spread by the rotation of the key, the flat bolt may be withdrawn and the bar released.

The lock could easily be defeated by someone who knew how it worked, but would probably have been sufficient to deter the casual intruder.



OTHER LOCAL WINDMILLS

Types of Windmill

Post mills are the earliest type of windmill, developing from small medieval post mills, becoming larger and more efficient over time. Typically, they feature a cast iron windshaft (wood in older mills), and two pairs of stones arranged head and tail (one set each of peak and burr stones) driven via wooden brake and tail wheels (later cast iron) driving cast iron stone nuts, as seen at Argos Hill. Wooden tentering gear is usually fitted, but some may have cast iron components.

In early windmills, common sails were used, which were simply a wooden frame covered with canvas, furled and reefed by hand, but they had to be stopped to reduce the amount of canvas in high wind, and could easily go out of control. Therefore, sweeps were later built with shutters that could open and close automatically, depending on the wind strength, controlled by adjustable leaf springs fitted to the shutter bars near the poll end. These control the shutter pitch via the shutter bars and cranks, allowing the shutters to open as the wind increases over a set speed. However, they still have to be stopped to adjust the spring tension and the operating point. A more complex arrangement known as patent sails, as fitted at Argos Hill mill and many other mills, sees the shutters controlled via striking gear from inside the mill, so the set point can be adjusted by changing the weights on the striking chain without stopping the sails.

The main disadvantage of the post mill design is that the weight of the stones, sweeps and buck itself (typically over 20 tons) has to be supported on a single bearing and moved into the wind. Smock and tower mills avoid this problem by rotating only the cap of the mill that contains the sweeps, fantail, striking gear and windshaft, with the stones, auxiliary machines and other materials remaining stationary within the main body of the mill. The cap would normally be mounted on a set of rollers which rested on a curb atop the mill tower, driven by the cap mounted fantackle. A vertical shaft transfers the drive from the windshaft to a large spur wheel at a lower level, from which the stone nuts are driven. These are usually mounted below the stones, or ‘underdriven’ as opposed to the ‘overdriven’ stones in a post mill. These mills could therefore be taller, with larger sails providing more power and the tower more working space.

Smock mills usually have a brick base with the upper levels and cap made of timber framing and weatherboard. Tower mills were built up to the cap level of brick or stone. The brick tower was more durable, but the timber superstructure lighter and less expensive, depending on the materials available locally. Smock mills usually incorporated external staging around the mill body at a suitable level to give access to the sweeps and striking chain. Auxiliary engines were sometimes later fitted in smock and tower mills to drive a third pair of stones, not usually a practical option in post mills. Often compact oat crushers (see page 19) were also installed later to all types of mill to prepare animal feed without having to engage the stones.

Other Local Windmills

In this section, some other local windmills are compared with Argos Hill mill. A total of 231 sites of existing and lost windmills in East Sussex are identified online. Most are gone entirely, but some survive as conversions to residential use, such as Caldbec Hill in Battle and the tower mill Jack at Clayton.

Thirteen surviving windmills are open to view in Sussex: 7 post mills, 3 smock mills and 3 tower mills.

Post Mills:	*Argos Hill, ***Nutley** (near Crowborough), ***Jill** (Clayton), ***Windmill Hill** (Herstmonceux), ***Oldland** (Hassocks), ***High Salvington** (Worthing) and Lowfield Heath (near Crawley).*
Smock Mills:	*West Blatchington (Hove), Chailey Common and Rottingdean.*
Tower Mills:	****Polegate, *Stonecross** and Halnaker.*

The ***seven** mills indicated have been restored to working order, and can produce stoneground flour, comprising **five** post mills and **two** tower mills. The remainder are lacking working gear to a lesser or greater extent. A representative selection are briefly described below; most restored mills have their own website, while a link to the relevant Wikipedia page is given for the rest. The website of the Sussex Mills Group has a complete list of local sites at:

http://www.sussexmillsgroup.org.uk/wind.htm

POST MILLS

Nutley (c1817 on this site)

Nutley windmill is an early, relatively small post mill with an open trestle that is not enclosed with a roundhouse. It is thought to be 300 years old, with the main single oak post dated to 1570, probably recycled from an earlier mill. It was modernised in the 1880s; common sails were replaced by spring shutter sweeps. The mill currently has one pair of each. The mill is winded by hand, by raising the steps off the ground and pushing it round. It has two pairs of stones, as per Argos Hill, but no system of storage bins to feed the stones, and has a cast iron windshaft recycled from another mill; another obvious difference is that the weatherboard is tarred rather than painted.

http://www.bridgecottageuckfield.co.uk/about-udps/nutley-windmill/

Jill (1821)

Jill is fully restored and working post mill standing on the Downs at Clayton near Brighton, was re-opened after complete restoration in 1986. It is quite similar to Argos Hill, having white weatherboard buck of standard form, tarred brick roundhouse, patent sweeps, tailpole mounted fan tackle, two pairs of stones arranged head and tail, and a composite main post. Unlike Argos Hill, it has a double height roundhouse, with the trestle raised above head height on brick piers, providing a clear storage area at ground level. The striking chain wheel is mounted on the rear of the mill, and it has a wooden windshaft with cast iron poll end (canister) attached. It also lacks the built in storage bins on the uppermost floor, but has the advantage of cast iron bridge trees, suggesting a more recent upgrade. The mill machinery has been completely rebuilt to a very high standard. Jack, a brick tower mill (see below) stands nearby, the names for Clayton mills given by visitors due to their appearance, standing on top of the downs. Jack has no working parts, but the cap and fantail have recently been refitted by new owners. It has featured regularly on film and TV.

https://www.jillwindmill.org.uk/

Windmill Hill (1841)

Windmill Hill windmill near Herstmonceux is the largest post mill in Sussex; it has been recently restored to working order by the owners with the aid of a large lottery grant, becoming fully operational again in 2015. It features a double height roundhouse, patent sweeps and sheet metal cladding. It has the reverse arrangement to Argos Hill, with a wooden brake wheel and cast iron brake wheel. It has a unique sweep governor which was designed to operate the striking gear automatically. Originally hand winded, it now features a tailpole mounted computer controlled electric drive.

http://www.windmillhillwindmill.org/

Oldland (c1703)

Oldland post mill at Keymer is claimed to be the oldest working windmill in Sussex, restored to working order in 2008, with most of the internal machinery rebuilt rather than original. The buck is white painted weatherboard of standard form, with a single storey octagonal roundhouse. It has spring shutters and is winded by hand. The cast iron windshaft was manufactured in Lewes in 1873. Pictures of a scale model and a video of flour production using the breast stones may be seen on the website.

http://www.oldlandwindmill.co.uk/newsite/

High Salvington (c1750)

This post mill, located on the downs north of Worthing, worked until 1897, and has been restored to working order as of 1991. It was purchased by the local authority in 1959 and structural repairs undertaken by Edwin Hole & Son. After storm damage in 1976, a trust was formed to undertake completion of the restoration, including replacement of the trestle, crown tree, brake wheel, sweeps and rebuilding the roundhouse. The mill is manually winded by tailpole, with wheeled steps.

http://www.highsalvingtonwindmill.co.uk/

Cross in Hand (c1840, 1868 on this site)

New Mill at Cross in Hand (pictured in 2006) is only about 4 miles south of Argos Hill, a large post mill with a double height roundhouse. It has a single main post and a cast iron windshaft and originally had a tailpole mounted fan tail and, at one time, three sets of stones . It has corrugated iron cladding, which is not attractive but has helped to preserve the structure. It was working as recently as 1969, and retains its working gear, but is currently lacking its sweeps and fantail. The mill is in private ownership, but, unfortunately, there is little evidence of active restoration work at present. It is, as far as is known, the last remaining unrestored mill still standing in the area.

https://en.wikipedia.org/wiki/New_Mill,_Cross_in_Hand

SMOCK MILLS

There are no working smocks mills in Sussex, but some survive as house conversions, for example at Rye, Battle and the Ridge, Hastings.

Cranbrook (1814)

Union Mill, a fully restored and working smock mill is located at Cranbrook in Kent (right). It is seven stories tall, on a four storey octagonal brick base, with the usual staging at the base of the weatherboard body. Originally, it had a wooden windshaft and common sails, later upgraded with a cast iron windshaft, patent sails and new fantail. It had two pairs of stones, with a third pair added later, powered by steam engine.

http://www.unionmill.org.uk/

Punnets Town (1859 on this site)

Blackdown mill at Punnetts Town, a weatherboard 8-sided smock mill with a single storey brick base, is only about 6 miles south-east of Argos Hill. It has 3 sets of stones, auxiliary engine and an oat crusher. It was restored by the last miller in the 1940s and contains all necessary machinery, but currently, the sweeps and cap mounted fantail are incomplete, but the owner is currently working to repair the mill.

https://en.wikipedia.org/wiki/Blackdown_Mill,_Punnetts_Town

West Blatchington (1820s)

Situated on the downs above Hove, this smock mill is unusual in that it is built on top of a brick and flint barn complex, with six, rather than eight, sides in tarred weatherboard. It was originally fitted with common sails, and later with patent sweeps, on a cast iron windshaft with a unusual screw brake and cap mounted fantackle. It had two millstones, driven from below (underdrift) from a vertical drive shaft and horizontal crown wheel. The original working gear was largely removed in 1937, but agricultural machinery, which was driven from the sweeps, may still be seen, as well as a windmill museum.

https://en.wikipedia.org/wiki/West_Blatchington_Windmill

TOWER MILLS

Stone Cross (1876)

This is a five storey brick tower mill (pictured in 2016) finished in white render, with a domed cap and fantail, and fitted with three pairs of stones. It was built in 1876 and worked until 1937. It was initially restored by the owner in 1966 – 77, and restored to working order in 2000 by the Stone Cross Mill Trust.

http://www.stonecrosswindmill.co.uk/

Polegate (1817)

Ovenden's Mill (pictured in 2016) is a four storey brick built tower mill, partly tile hung, with patent sails, fantail cap and two pairs of stones. It was built in 1817, and worked until 1943 by wind, and until 1965 using an auxiliary engine. Eastbourne and District Preservation Trust then bought the mill, and engaged Holes Millwrights of Burgess Hill to repair it. Restoration work is on-going.

http://polegatewindmill.com/

Halnaker (c1740)

Located on the downs near Chichester, this is relatively ancient brick tower mill which carries four common sails, originally on a wooden windshaft, later upgraded to cast iron, and winded manually. It was first mentioned in manorial records as early as 1540. It was restored in 1934, by Neves of Heathfield, with further work by Holes in 1954 and 2004. It is owned by West Sussex County Council.

https://en.wikipedia.org/wiki/Halnaker_Windmill

An early 20th century view of Argos Hill from the southeast showing the Chequers at the junction of Argos Hill Lane and the road from Mayfield to Mark Cross. Note the lack of trees surrounding the mill compared with today; this would allow the wind to blow unimpeded from all directions to drive the mill.

LOCAL MILLWRIGHTS

Medhursts of Lewes

Samuel Medhurst first registered as a millwright in 1824, and set up in business with his brother William in High Street, Lewes. They are thought to have been involved in building numerous local post mills, and worked closely with the Phoenix Iron Works which was established on the banks of the river Ouse in 1832. They provided ironwork for the post mill at Cross in Hand, which was rebuilt by Medhursts, where the crown tree bracket bears the words 'S MEDHURST MILLWRIGHT LEWES JUNE 1855'. He devised the tailpole mounted fantackle for this mill, and subsequently installed the same at Argos Hill, where some of the ironwork is identical. A bridge iron at Windmill Hill also bears the initial of his son Boaz, who succeeded Samuel, but died in 1878. When Samuel died in 1887, there were no male family members surviving to continue the business. It seems likely that the windshaft at Argos Hill was cast in Lewes, and that Medhursts were involved to some degree in the construction or modification of Argos Mill. It is known that the Phoenix Iron Works in Lewes supplied local millwrights.

Medhurst premises in Western Road, Lewes, circa 1860

F. Neve & Sons, William Sands & Sons of Heathfield

Stephen Neve took on an existing millwrighting business in Warbleton in 1858. His son Frederick continued this line of work based in Heathfield from about 1910, and his sons Jack and Walter continued until Walters death in 1961. Neves built several smock mills in East Sussex, as well as being involved in the construction of Stone Cross tower mill in 1876, and moving a smock mill from Biddenden and rebuilding it at Punnetts Town as Blackdown Mill. Neves accounts have a detailed record of work done at Argos Hill from 1921, just before it went out of regular use in 1927. This includes repairing the tailpole and fantackle, new bearings and gears for the fantail, maintaining the drive gearing and brake, re-forging the horns of one quant, making new cogs, and fitting a new governor (presumably to the breast stones) and finally fitting angle irons to the corner posts in 1925. The mill deteriorated in private ownership for 30 years due the cost of repairs, so was passed into the ownership of the local authority in 1955. Sands of Heathfield then carried out an initial phase of restoration, with the assistance of Jack and Walter Neve, to secure the mill and open it to the public.

Hole & Sons of Burgess Hill

The millwrights who have worked most recently on Argos Hill mill are Holes, specifically Tony Hole and his son Jeremy. The company was founded in 1885 by Earnest Hole to provide support services for steam powered agricultural machinery, but gradually became involved in the repair and maintenance of windmills and watermills.


Tony Hole on site at Argos Hill 2016

His son Edwin (Tony's father) started work in 1922 aged 17, and the firm subsequently devised many novel agricultural and industrial machines. The windmill work increased from the 1930s when many mills were ceasing production, but selected examples were being repaired and renovated. From the 1950s this became a major part of their activities, with Holes working on most of the surviving mills in Sussex.

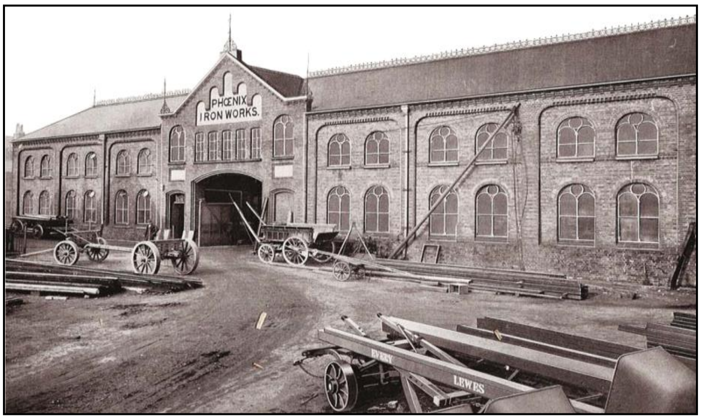
At Argos Hill, in 1969 they restored the fantackle and fitted new sweeps. The wooden stocks were subsequently damaged by lightning strike and storm, so, in 1978, fabricated hollow steel stocks were designed and fitted. Tony and Jeremy completed the latest phase of restoration in 2016.

Nameplate on the trestle from 1970s

Phoenix Iron Works

The Phoenix Iron & Steel Works, which supplied cast iron components to local windmills, was located on the western bank of the river Ouse at Lewes. It was founded in 1832 by John Every, shortly before the construction of Argos Hill windmill.

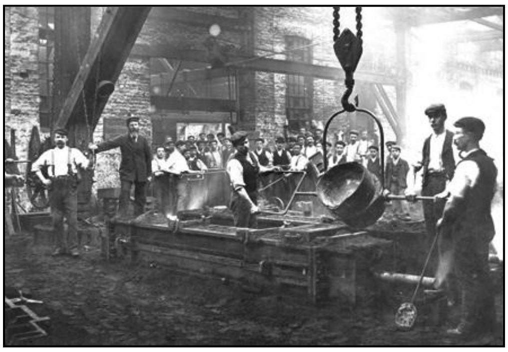
The business moved to purpose built premises (right) in 1861, and supplied much of the ironwork used in local buildings, such as street furniture, seafront shelters, bridges, railway stations and Brighton and Eastbourne piers. The original works were largely destroyed by fire in 1948.



The river allowed heavy materials and products to be transported by water, with later using a pair of steam cranes. Turnpike roads built in the 18th century would have also facilitated the movement of iron agricultural and industrial products around the county.

Stone Cross windmill (built 1876) in particular contains a great deal of high quality cast iron: the curb and rollers, the windshaft and poll end, drive shafts and gears, and the tentering gear.

The Phoenix Ironworks continued a long tradition of ironworking in Sussex, which peaked in the 16th century, when cannon were supplied to the navy of Henry VIII and Elizabeth 1. Early windmills contained wrought iron products produced by local blacksmiths. However, in the 19th century, would have been few, if any, other local suppliers of large castings.



Reference:
www.lewesphoenix.org

William R Dell & Son, Mark Lane, London

The wire machine at Argos Hill (AH) has the maker's inscription shown left. Similar machines have been seen in other local mills, such as Stone Cross. It would appear that the company supplied such stand-alone machines to various mills, and is identified on the Mills Archive as a supplier of millstones and milling machines. The address is in the city of London, near Fenchurch Street station. William is credited with co-inventing a 'conical wheat brush machine' (presumably the smutter seen at AH) in 1844, going on to establish his own business as a supplier in 1856. In 1873, his son purchased an engineering works in Croydon and went on to develop roller milling machinery, as well as importing American milling related products. The firm continued in business until the 1920s.

Ref: https://millsarchive.org/modern-milling/category/modern-milling-machinery/entry/manufacturers/91

Modification of Post Mills

Post mills were originally fairly small with one pair of stones, with common sweeps and hand luffing, and manual tentering adjustment. Under the medieval system, these mills were under the control of the lord of the manor. As property rights developed, farming families acquired the means to develop more sophisticated mills, and were able to build larger, more powerful and versatile mills. A standard form emerged by the beginning of the C19th featuring two sets of stones, peak & burr, for producing animal feed and flour. These mills would normally have had a main post, crown tree and windshaft of oak, due to the strength, and durability of the wood, and availability of large trees, which, in Sussex, were grown in otherwise coppiced woodland. These major components could be reinforced with wrought iron at critical points, supplied locally. This type is represented by Nutley Mill.

During the early C19th, as demand increased, post mill technology developed accordingly; common sails were often replaced with spring shuttered or patent sweeps, the latter requiring a complex arrangement of the striking gear as seen at Argos Hill (AH) (side weight wheel with double rack & pinion) and Jill (rear weight wheel with single rack & pinion and bevel gears). Tentering gear was originally made from oak, as seen on the tail stones at AH, with a relatively crude, probably locally made, governor. Later on, as foundries such as the Phoenix Iron Works at Lewes, opened, cast iron (CI) tentering gear could be produced, which would have provided a more robust structure and precise operation.

Cast iron governor at Windmill Hill

The horse on the breast stones at AH was upgraded to cast iron, while wood was retained on the burr stones. At Jill, the peak stones tentering gear was upgraded to a CI bridge tree, while the burr stones still have a wooden tentering gear. Cast iron horses are fitted at Stone Cross tower mill, but are not common in local post mills; the stone furniture has been rebuilt in wood in many. The sack hoist is generally an original feature in post mills, which was normally installed within the ridge space of the roof. Originally, an oak bollard was used (Nutley), possibly reinforced with wrought iron strakes, later cast iron (AH). These tended to be driven from the windshaft or brake wheel via a slack belt. This could be tensioned with a jockey wheel (AH) or raising the pulley end of the bollard (Nutley).

Timber peak stones bridge tree at Jill windmill

Additional machinery was often installed in local post mills to improve the quality of the flour produced, and to supply the premium product, white flour. Typically, a smutter and wire machine were added, and later, an oat crusher, but there is a great deal of variation in how this was achieved. At AH, cogs were added to the outer rim of the wooden tail wheel that engaged with skew gears on either side, driving the smutter and dresser via CI framed gears, with a final belt drive to the smutter. A vertical shaft also provided drive to an oat crusher on the spout floor via bevel gears (right). At Jill, a lay shaft was added laterally behind the brake wheel that engages with its existing cogs via a skew gear (right). This drives a dresser mounted across the rear of the mill. At Windmill Hill, the smutter is also belt driven from a similarly mounted skew gear and pulley. Brill windmill has a stub mounted skew gear driven from the brake wheel, with a two stage belt drive to a rear mounted dresser. AH therefore seems unusual in the complexity of the auxiliary drive system. At other mills, perhaps where the buck was built slightly larger, additional machines have been fitted inside the existing body, while at AH an extension was necessary. This also incorporated a rear tunnel to access the bin floor, which allowed large feed bins to be built in. The wire machines (flour dresser) installed at other post mills in the area seem to be similar to that at AH, as supplied by William Dell of London. The construction quality of this is impressive; for example, the longitudinal bars holding the rings of the drum in place are carefully string moulded. The method of driving these machines, however, varies a great deal, depending on its position and the drive system used for the auxiliary machines.

Skew gear and transverse layshaft driving additional machines at Jill

Pictures: Guy Blythman/Mills Archive

There is a fascinating specialist terminology associated with windmills.
This list contains those relevant to Argos Mill, with some regional variations (alternatives in brackets).

BACKSTAY	Batten forms a prop to hold the SAIL BARS at the correct angle of WEATHER
BAY	A section of the SWEEP between sail bars containing four SHUTTERS
BEARING BLOCK	Solid bronze (gun-metal) block forming the female part of a plain bearing
BED STONE	Stationary lower stone wedged in level position
BELL CRANK	Mounted at ends of shutter to provide lever at 45° to the plane of the SHUTTER
BEVEL GEARS	Gears mounted at an angle to each other, usually 90°, with inclined cogs
BILL	Hardened pick used to dress stones
BINS	Store the grain to feed the stones
BIN FLOOR	Located at top of mill
BOLLARD	Winding drum of SACK HOIST located on BIN FLOOR
BRACE	Diagonal reinforcing bar under compression to resist sagging
BRAKE WHEEL	(Head Wheel) Large vertical cast iron breast stone drive wheel
BRAN	Remnant of wheat husk after milling
BRAY(ER)	Long tapered pivoted beam that supports the free end of the BRIDGE TREE
BREAST	V-shaped front of mill body
BRIDGE	Bar fitted across stone EYE to engage with mace and support the RUNNER STONE
BRIDGE TREE	Short pivoted beam that carries the BRIDGING BOX
BRIDGING BOX	Contains lower footstep thrust bearing of the SPINDLE in adjustable position
BUCK[1]	(Mill Body) Term for the mill body of East Anglian origin, but a useful description
BURR STONE[2]	Composite millstone of hard quartz bearing rock
CANISTER	(Poll End) Box casting at the front end of the WINDSHAFT that carries the STOCKS
CLASP ARM	Form of gear wheel with pairs of arms clamped around a shaft (using square flange)
CLEATS	Mountings that support the end swivels on the SHUTTERS
COCK HEAD	Square top of stone spindle that fits into the mace
COGS	Wooden gear teeth
COLLAR	The circular section at the centre of the SHEERS, surrounds the main post and stabilises the mill body
COMPASS ARM	Form of gear wheel with radial arms mortised into shaft (as per cartwheel)
CORNER POSTS	Vertical pine posts that form the corners of the mill body
CRANK	Angled arm that changes the drive direction in the striking gear rods
CROSS TREES	Two horizontal beams that cross under the horns of the MAIN POST and support the QUARTERBARS
CROWN TREE	A massive oak transverse oak beam that supports the whole mill body
DERBYSHIRE PEAK	One piece millstone of hard limestone used for milling animal feed
DRESSING	Cutting furrows and stitching into a millstone with a set BILLS for milling, and separating flour from bran
EYE	Hole in the centre of a millstone to receive the grain for milling
FACE GEAR	Gear wheel with cogs on the side of the rim
FAN	Mounted on FANTAIL to generate drive to WIND the mill
FAN BLADE	Individual element of FAN made of FAN STOCK and transverse boards
FAN STOCK	Oak spine of FAN BLADE with slit for boards
FAN STAR	Cast iron hub that carries the FAN BLADES
FAN CARRIAGE	Structure that supports the FAN and WINDING drive
FANTAIL	Complete mechanism attached to tailpole that winds the mill
FLY POST	Cant posts that support the FAN axle at the upper end, main structural element of FAN TACKLE
FRENCH BURR	Type of millstone composed of sections of quartz stone for milling wheat into flour
FURROWS	Main grooves in the face of a millstone created by dressing
GLUT BOX	Cast iron dislocatable bearing that provides the upper QUANT bearing
GOVERNOR	Centrifugal weights lift a collar to adjust the RUNNER STONE height automatically
GRIST	Meal used for animal feed
GUDGEON PIN	Iron pin projects from the end of a shaft forming male part of a bearing
HACKLE PLATE	Prevents dirt entering the spindle neck bearing in the bed stone
HANGER	Vertical tie beam or rod supporting a load from above
HARP IRON	Right angle CRANK that connects the SPIDER to the SHUTTER BARS
HEMLATH	Batten forms leading or trailing edge of SWEEP framework
HOPPER	A square wooden funnel or tapered bin that feeds grain to the STONES
HORNS	Extended corners of the lower end of the main post that engage with the CROSS TREES
HORSE	Frame mounted on the stone vat that that supports the HOPPER and SHOE
JACK STICK	Attached to the top of the SPINDLE to check it is vertical and the BED STONE level
JOURNAL	Plain bearing (as compared with modern ball or roller bearing)
LANDS	Raised parts of the dressed stone between the furrows
MACE	Cast iron block engages with QUANT and RIND from above and stone SPINDLE from below
MAIN POST	A compound post, supporting the mill body, allowing it to turn on the SAMSON HEAD
MEAL	Milled wheat consisting of flour and bran
MEAL BIN	Receives the MEAL from the MEAL SPOUT
MEAL SPOUT	Directs the MEAL collected from the stone vat into the MEAL BIN
MIDDLINGS	Kentish term for STOCKS, and Sussex term for coarse flour from dresser
(MILL)STONE	Large disc of stone for grinding grain into meal or grist
NECK	Narrow section of shaft forming part of a plain bearing
NECK BEARING	The front main bearing of the windshaft that rests on the WEATHERBEAM
NIP	Gap between stones when working
PATENT SAIL	Shutters are controlled from within the mill by STRIKING GEAR
PEAK STONE	One piece mill stone of hard Derbyshire millstone grit limestone
PICK	Pointed mill BILL
PIERS	Brickwork blocks that support the ends of the CROSSTREES and the weight of the mill
PILLOW BLOCK	Oak block that raises the NECK BEARING to the correct height
PINTLE	Cast iron pin mounted atop MAIN POST to engage with SAMSON HEAD forming main bearing
POST MILL	The whole body of the mill turns to face the wind on a post

PRICK POST	Vertical post at centre of breast
QUANT	Square wrought iron vertical shaft transfers drive from wheel to stone with forked lower end
QUARTERBARS	Prop the MAIN POST on four sides at an angle of about 45°
RACK & PINION	Converts rotation of STRIKING WHEEL to reciprocating motion of STRIKING ROD
ROUNDHOUSE	Circular building protecting the TRESTLE and MAIN POST and providing storage
RUNNER STONE	Rotating upper stone driven via the QUANT and STONE NUT
SACK CHAIN	Used on the SACK HOIST to attach to the sacks, wound on the BOLLARD
SACK HOIST	Used to lift sacks of grain to the BIN FLOOR
SACK SLIDE	Used to slide the sacks up and down the steps to and from a cart
SAG IRONS	Diagonal wrought iron rods fitted under tension to help maintain structural integrity
SAIL BARS	Battens form sail framework at right angles to the WHIPS
SAMSON HEAD	A cast iron plate attached to the underside of the CROWN TREE to engage with the PINTLE
SHEERS	Longitudinal beams supporting the spout floor and forming the collar of the BUCK
SHOE	Short vibrating chute that feeds the grain into the eye of the stone
SHUTTER BAR	Operates shutters via gudgeon pins connected to the BELL CRANKS
SKIRT	Edge of millstone
SIDE GIRTS	Large oak beams mounted at the ends of the CROWN TREE to support the mill sides
SHUTTERS	Pivoted wooden slats mounted at right angles to the WHIP to catch the wind
SKEW GEAR	Gear with angled cogs to drive an angled shaft
SMOCK MILL	Windmill built of wood on a brick base, only the cap turns into the wind
SMUTTER[3]	(Wheat Cleaner) Cylindrical brushed sieve to separate wheat from dirt & fungus
SPATTLE	Shutter of the outlet of a spout or hopper to control flow of grain
SPIDER	(Cross Iron) Cross piece at front end of STRIKING ROD operates shutter cranks
SPINDLE	Wrought iron shaft supports the MACE and RUNNER STONE from below
SPUR GEARS	Plain horizontal gears mounted in the same plane, one larger than the other
SPOUT	Wooden box section nozzle or tube to guide grain or meal into sack or hopper
SPOUT FLOOR	Lowest floor of BUCK where meal is collected from stones
SPRATTLE BEAM	Cross beam that carries the GLUT BOX, the upper bearing of the QUANT
STAFF	Straight edge used to check the surface level of the stones
STEELYARD	Long wrought iron bar connects the TENTER-SCREW to the GOVERNOR collar
STITCHING	Fine grooves cut on the lands of the millstones
STOCKS	A pair of hollow steel (traditionally pitch pine) tapered square shafts that carry the SWEEPS
STONE FLOOR	Middle floor of buck where stones are located
STONE-NUT	Small horizontal stone drive pinion attached to QUANT
STORM HATCH	Allows access to the canister and sweeps from within the mill
STRIKING CHAIN	Enclosed in chain box, operates STRIKING WHEEL from spout floor
STRIKING GEAR	Operates the shutters of PATENT SAILS
STRIKING ROD	Long wrought iron rod passes through WINDSHAFT to operate SHUTTERS
STRIKING WHEEL	Allows striking gear to be operated via a hanging chain
STUD	Vertical rail within the framing of the mill body for attachment of WEATHERBOARD
SWEEP	Southern term for the SAILS, they generate the torque at the WINDSHAFT from wind pressure
TAIL	Rear end of windmill
TAIL BEAM	Supports the tail bearing of the WINDSHAFT
TAILPOLE	Long beam projecting from rear of mill to connect the FANTAIL to the BUCK
TAIL WHEEL	Large vertical wooden tail stone drive wheel
TAIL WINDED	Wind from behind forces the mill to turn in the wrong direction
TEETH	Used here for fully cast iron gears
TENTERING GEAR	System of levers that controls the stone speed and NIP automatically
TENTER-SCREW	Screw adjustment at the end of the BRAYER control the meal quality
THRIFT	Wooden handle for BILL
TOLL	Portion of mill product taken as payment
TOWER MILL	Windmill built of brick or stone, only the cap turns into the wind
TRENNELS	Dowels that hold joints together, from ‘tree nails’
TRESTLE	Heavy wooden structure that supports the main post
TUN	Alternative name for STONE VAT
TWIST PEG	Rotating wooden knob around which a control cord terminated
VAT	(Tun) Wooden enclosure that surrounds the stone and collects the meal
WEATHER	Variable angle of the plane of the SWEEP from heel to toe
WEATHER BEAM	(Breast Beam) V-shaped oak beam that supports the NECK BEARING of the WINDSHAFT
WEATHERBOARD	Feathered overlapping boards forming the outer skin of the mill body
WINDBOARD	Solid boards permanently attached to whips to provide minimal turning force
WINDING	Turning the mill into the wind
WINDMILL	Uses wind for power (as compared with watermill)
WINDSHAFT	Cast iron shaft that carries the SWEEPS, BRAKE WHEEL and TAIL WHEEL
WIRE MACHINE	Flour dresser with cylindrical wire mesh to grade the meal
WHIP[4]	Square shaft made of pitch pine forming the spine of the SWEEP
YOKE[5]	(Bridge) Semi-circular cast iron bar fitted across the eye of the runner stone

Notes

[1] Referred to only as ‘Mill Body’ by Pargeter & de Little

[2] Described by Pargeter as ‘Freshwater Quartz’ or ‘Chert’

[3] Referred to as a ‘Wheat Cleaner’ or ‘Grain Cleaner’ by Pargeter & de Little ,
a smutter being specifically a vertical machine but used here in a generic sense

[4] Referred to by Pargeter as ‘Sweep Rod’

[5] No consistent terminology found in references, used here as descriptive

Restoration of Argos Hill Windmill

These notes record the work of restoration of the mill after the millwrights (Tony and Jeremy Hole) had completed the main structural repairs. This comprised fitting a steel frame to prevent collapse, partially rebuilding the frame of the buck, constructing new sweeps and refitting the striking gear. A major obstacle is that only the footprint of the mill itself is owned by Wealden Council and leased to the Argos Hill Windmill Trust. Ownership of the turning circle is split between two adjacent properties. While wayleave is in place over the eastern sector, the current landowner of the western sector will not permit transit of the fantail at this time. For the same reason, access to the mill is restricted, hampering restoration efforts. In the meantime, work on the mill will proceed in the hope that the mill will be able to turn into the wind and become full operational at some point in the future

Restoration Notes 2016

The main volunteer work on the **buck** was the replacement of the **weatherboarding**. This was painted off site with several coats of lead paint (a rare material now) and fixed with 3" or 4" galvanised wire nails as required. On the **sides**, 8" and 10" weatherboard was used, with narrower 7" boards used front and rear. All boards were overlapped and nailed through at the lower edge of the top board, centre of next board down and top edge of the board below that (it was decided not to hide the nail heads). Templates were used to ensure consistent spacing and the alignment checked at intervals by measuring down from the roof line.

The buck has several **hatches** in the sides of the buck, mostly on the spout floor where the miller spent most of his time. These are to provide ventilation and light while milling. They were re-created after the weatherboarding was completed by cutting through the boards with a jigsaw. The hatch covers were re-built with the lowest board overhanging the lower edge and a galvanised strip overhanging the upper edge to provide weather resistance. Glazed windows also needed to be rebuilt on the stone floor, with one on the left side which lights the stones, a small one in the breast which allows the sweeps to be observed and a larger sliding frame in the lower end of the ladder tunnel.

On the **breast**, an interlaced herringbone overlapping joint was used at the centre instead of using an exposed prick post, as previously existed. This is consistent with other post mills of this type, and the joints used on smock mills. The whole breast was reinforced with horizontal butt jointed 9" boards before the weatherboard was fitted. The boards were cut to overshoot the sides by about 4" and the end grain covered with lead strip.

On the **rear**, the tunnel had to be completely rebuilt, with reference to remaining fragments for dimensions. The **sides** were fitted to overshoot the rear, so these boards had to be cut to fit the inside profile of the side boards. All end grains and gaps were filled with durable white flexible mastic. The **window** in the tunnel was rebuilt completely, with a lead covered sill for rain proofing. The lightning conductor from the rear peak of the roof was refitted down the left side. New **oak steps** had been built off-site, these were refitted after removal of the scaffold. They are pivoted at the top end to allow the steps to rise and fall as the buck rotates. A new **tailpole** was then fitted and painted, ready to receive a new **fantail** carriage. For now, it is fixed to the ground by wedges, but it has been confirmed that the buck does rotate freely, the pintle having been previously well lubricated via the hole in the crown tree.

The **roof** of the buck was found to be in fairly good condition, with original zinc sheet protecting the roof boards beneath quite effectively. To secure the roof, the existing clout nails were replaced by alloy nails retained with toothed washers, with mastic applied under each nail head to seal the hole. The whole roof was then repainted with red oxide.

The **roundhouse floor** needed complete replacement, mainly due to woodworm infestation. It is divided into quadrants by the cross trees. The north-eastern quadrant was repaired with new butt jointed 8" floorboards, except under the spare millstone, which was too heavy to move safely. Fortunately, it rests on a concrete plinth previously laid at the threshold of the rear door. The remaining quadrants were re-laid using recycled scaffold boards, a more cost effective and robust solution, fixed with galvanised wire nails. The floor joists were replaced as necessary with recycled softwood, with some existing oak joists found to be adequate, despite woodworm damage.

The **floor** is supported on sleeper walls with timber wall plates, with a circular plinth running round the wall. The sleeper walls were poorly constructed, but only minor repairs were carried out. It was decided to rely on the structural integrity of the new floor and joists. The old floor rotted at the edges because the wall was rendered right down to the floor, trapping the damp which inevitably penetrates the stone walls. Airbricks had been fitted previously at the centre of each wall quadrant, but were blocked. These were cleared and the floor edge joists rebuilt with a gap to allow air circulation under the new floor. A d**amp-proof** course was fitted on top of the plinth under the edge joists to combat damp penetration. No chemical preservation treatment was carried out, it was decided to rely on keeping the new underfloor space well ventilated.

The **roundhouse walls** are made of local sandstone, so penetrating damp is inevitable. They are rendered and tarred on the outside, and outside repairs required at this time were minimal. On the inside, some parts had been rendered with cement mortar, this was removed as far as possible, substantial cracks in the sandstone wall repaired and the walls re-rendered where necessary with new lime plaster. A ventilation gap was left around the lower edge of the lime render, with some patches left un-rendered so that the sandstone block construction could be seen. The joints in the oak boards of **roundhouse roof** were filled with bitumen mastic and repainted with black bitumen based paint. New power and lighting was installed in the roundhouse, but not in the buck as it a fixed link would prevent rotation.

Minor works were carried out inside the buck during 2016/7. The **flooring** in the buck had previously been repaired where necessary, replacing rotten boards and filling gaps. **Signs** were made for visitor information and safety, and some improvements made for reasons of safe visitor access, specifically extra bars on the railing around the side and top of the steps to the stone floor.

A **new cover** was made for the peak stones vat, since no original could be found. Similarly it was noted that the **sack slide** between the bins was missing, but this was left as it improved visibility of windshaft components when viewed from the tunnel steps. 'Fertan' **rust proofing** liquid, a dilute citric acid based solution, was applied on all iron and steel surfaces that were accessible, including the windshaft, brakewheel, stone nuts and quants, auxiliary drive components, sack bollard, sag irons and various reinforcing brackets. Boards above the **storm hatch** had been left exposed after the roof was restored, so these were covered in self-adhesive flashband and painted to improve weatherproofing. The striking gear shaft and cranks that were easily accessible from the storm hatch were lubricated at the same time.

The **sack hoist** components are all present, and the idler wheel crank can be operated from all floors by rope. However, the shaft carrying the wooden toothed gear that engages with auxiliary radial cogs on top of the brake wheel was seized up, so that the gear could not be engaged. This could be fairly easily remedied, but there is no mechanism for disengaging it so it must have run continuously, and using on the slack belt and jockey wheel to enable the hoist. Also on the bin floor, recycled scaffold boards were attached to the edges of the bins to reduce the risk of children falling in, and to protect the patina on the original woodwork. **The bins** have been cleaned out and need only minor repairs at this stage.

The **striking wheel** shaft had been cut through to allow its removal at an earlier stage, so was re-connected using a cylindrical collar and grub screws. This proved inadequate, since the weight on the wheel was taken by the collar, which was also misaligned with the stub of the shaft operating the double rack and pinion within. A new bearing plate had been fitted to the outside of the supporting beam, and this was then duplicated on the inside to provide additional support for the wheel. These plates were re-aligned with the shaft stub and the collar re-connected using a bolt drilled right through the shaft. A bolt was fitted to secure the **striking chain** so that the shutters would be fixed in the open position. This will ensure that if the sweeps are tail-winded, they stay open. If blown shut, the mill could turn in the reverse direction, which renders the brake ineffective and risks serious damage, such as the windshaft being forced out of its bearings. A hook and weight were added that allow the shutter control can be partially automated by the weight on one side of the chain holding the shutters closed when working, but allowing them to open if the wind becomes strong enough to raise the weight. This feature was standard in mills with patent sails. The striking gear has operated successfully after these repairs and modifications.

The main cogs in the **tailwheel** appeared in reasonable condition, and it might be possible to drive the tail stones without further work. The auxiliary cogs that are fitted radially on the rim and drive the smutter and wire machine were in worse condition, while the intermediate gears on the **auxiliary drives** have cast iron bodies with wooden teeth and are generally sound. The more sophisticated design of these gears is evidence that these were installed some time after the original build, when the **smutter and wire machine** were added in the rear extension. The smutter gear also drove the oat crusher on the spout floor via an elaborate system of shafts, gears and pulleys, all in good condition.

The end of the shaft of the wire machine (dresser) had dropped due to the decay of the rear of the buck, pulling the drive shaft and gear away from its correct position by a couple of inches. It was temporarily propped at approximately the right level, but the shaft remained jammed. Restoration would require removal of the drum, straightening the drive shaft and relining the drum with suitable mesh. It was otherwise in reasonable condition. The **dresser spouts** were also forced down by the collapse of the dresser mounts, and were also temporarily propped. They were quite worm-eaten and likely to need replacement.

The **smutter** is in better condition, and could be restored to working order with minimum effort. However, a vent must be created in the mill side through the smutter box located below the machine on the spout floor, to allow the waste to be blown away. It was decided to defer this until such time as the smutter and drive is fully restored.

Components of the **original door lock** were discovered in the mill, including the key, the box containing a pair of spring tines and the massive wrought iron bar used to secure the door. By matching these with markings and old bolt holes on the door frame it was possible to restore it to working order (see details above). A new draw bolt was made, the box and bar attached as before and the door frame repaired around the key and bolt slots.

The **tail runner stone** appeared to rotate freely on its bearing, so it was hoped that a test milling operation could be attempted. The **meal spouts** for both sets of stones are missing. A new spout was constructed for the tail stones, so that visitors can see how the meal was collected from the stones. The **tailstone governor** was cleaned up and restored and a new drive belt ordered from Cross In Hand Saddlery. The **tentering screw** turnbuckle was inverted so its handle clears the sag iron which was installed in previous restoration and prevented adjustment of tentering set point. The tailstone tentering gear otherwise appeared to be in working order, but was temporarily disconnected so that the runner stone could be raised and lowered manually to engage the stone nut and allow the stone to be moved by hand. The top of the **quant** was ground down slightly to ease its engagement into the glut box. The tailstone **feed chute** was found on the stone floor, but was in poor condition and would need rebuilding later; in the meantime, it could be fitted back in position for viewing.

The restoration of the **fantail** was started late in the year. The eight blades were remade, constructed of softwood boards fitted to an oak spar, which was machined with a slot to hold the boards at required angle. These would be bolted into the fan hub and retained in position by wrought iron stays between the tips. The **fantail carriage** reconstruction was started; this supports the fan at a height of about 3m and carries the shafts and gears to transfer the drive to the wheels (see design details in fantackle section above). The drive train components needed renovation, including replacement bearing linings, but are otherwise appear complete; these were sent to Playfoot Engineering for refurbishment over the winter break.

Having repaired the striking gear, the **tailstones** have were turned by the sweeps (briefly and off load) for the first time under the current restoration program, maybe for the first time in 80 years. The **tentering gear** was disconnected for this test at the collar of the governor, and the steel yard end fixed in its lowest position to raise the runner stone clear. The new leather **governor drive belt** was then fitted and a test attempted with the tentering gear connected, which was unsuccessful. It appears that **additional shutters** will need to be fitted to get enough power from the sweeps to turn the stones on load and mill grain. The necessary swivel mounts will need to be added to the sweep end bays to allow the extra shutters to be mounted. These were ready and waiting in store.

The **sack hoist** restoration was also started (see page 38). The hoist had previously been fitted with a new **chain** to lift a dummy sack, replacing temporary rope. The heavy wear on the metal sheathing on the hoist rollers indicates that a chain rather than a rope would have been used for the sack hoist. The rope re-purposed as the hoist **control rope**, which allows it to be activated from the floors below, operating the jockey wheel mechanism remotely. This was re-routed via a pulley above the bin floor access ladder, and down through and existing hole by the trapdoors on the stone floor (the miller could thus operate the control rope with one hand and guide the sack hoist chain with the other, especially when loading sacks up the sack slide on the steps). An additional weight (a broken mace) was attached to the rear of the sack hoist crank to ensure that it would return to its rest position after engagement of the jockey wheel, against the resistance and weight of the control rope. The drive gear was stuck in a semi-engaged position, and was freed by drilling out the wedges fixing it to the lower pulley shaft. It can now be engaged, or disengaged, with the brake wheel cogs, as required, by sliding it along its shaft and inserting new wedges.

When the mill was working, the drive gear would have been permanently engaged, with the slack belt tightened by the jockey wheel to activate the hoist. This **leather drive belt** was sent for repair; it was declared somewhat weakened by age and wear, but it was expected that it would be strong enough to drive the sack hoist with a light dummy load. The **bollard supports** were replaced with new wood (oak/apple), the old ones were completely worm eaten. After initial testing, it was found that the teeth in the sack hoist drive gear were too weakened by woodworm and would have to be replaced. They are retained in the solid elm hub by wire nails through their shanks, which had to be extracted and the 30 teeth withdrawn, to be replaced with new applewood. When reassembled, the whole was treated with PVA to preserve the wood and reinforce the seating of the cogs. The sack hoist gear shaft was removed in order to refit the gear and the bearings lubricated upon reassembly, along with the bollard shaft bearings. The wooden pulley gears required no attention. In the meantime, the **brakewheel cogs** were gradually being hand crafted and replaced, a few at a time, with new applewood. These have to be individually fitted into the cast iron brakewheel frame and retained by cut nails driven into the inner edge of the shank. When complete, the **sack hoist** should be operational, and the breast stones could also be tested.

The rebuilding of the **fantail** was started in February (see page 41). The **metalwork** was returned in the new year from Playfoot Engineering with all bearings freed up, shafts re-ground and phosphor bronze linings renewed, with shafts and hubs in grey primer; these were finished in black rustproof paint. The fantail posts were laid out horizontally and the mortises and tenons for the cross beams cut by hand, assembled and locked with dowels. The **fan axle** bearings were then fitted to the upper ends of the posts. The bracket supporting the upper bearing of the downshaft was found to be welded into the incorrect position (too low) so a riser plate was manufactured to bring the bevel gears into correct mesh. The rest of the drive train was then fixed to transmit the drive down to the gearbox. The **fantail frame** was then raised to the vertical over the tailpole, the hub lifted into position by block and tackle and the diagonal bracing fitted. The split drive gearbox was fitted on top of the end of the tailpole, ready to receive the wheel drive shafts at a later date. The overall geometry was checked and a new steel tension rod fitted beneath the cross bar to lock the structure. The beams were pre-painted but given a final coat after assembly and the joints filled. The frame was fixed to existing bolts concreted in the ground pending future completion of the fantail by fitting the drive wheels.

At the same time, work continued to renovate the **grain feed** components within the mill. The **feed shoe** from the breast stones, weakened by woodworm attack, was reinforced with an extra sole plate. The **breast hopper** spout was repaired with plastic wood and both coated with PVA solution to strengthen the joints, help the surface to resist further pest attack, and show the grain of the original wood. The **tail stone shoe, hopper and horse** fortunately needed minimal repair but ware similarly treated with PVA, and the control cords renewed. The **tailstone feed chute** was very fragile, and was therefore extensively reinforced, while retaining as much of the original wood as possible. It was then refitted to show how grain was fed to the hopper from the wheat bin spout.

The **flour dresser** (aka wire machine) was then partially restored. The far end of the **brush bar shaft** had been left unsupported during the rebuilding of the rear of the mill, and it had dropped away from the upper bearing and the weight of the drum had forced the dresser spouts down out of position. A pair of new longitudinal beams was fitted to support the underside of the machine. The stretcher containing the low end bearing was found elsewhere in the mill; this was refitted, the **upper bearing** repaired and the shaft and dresser drive gear lifted back into engagement, such that the brush bar could now rotate correctly. The **drum halves** were refurbished with new coarse stainless steel mesh linings and refitted, but leaving out the bolts that hold the drum halves together, so the brushes can be easily accessed in future; these would be need to be renewed for the dresser to function. The original panelling was replaced in the **spouts** as far as possible (some were broken or decayed), and were supported in place by new boards. These would also need further reinforcement or replacement if the dresser were to work.

Thus, during the latter part of the year, the restoration of the **sack hoist**, **fantail and flour dresser** were completed. Replacement of the cogs in the brake wheel was in progress, to be completed in the new year.

The **smutter** was renovated in early 2019 (see page 37 for details). It required little repair, but had evidence of extensive earlier woodworm infestation. It was cleaned and preserved with woodworm treatment and PVA applied to the wooden components. 'Fertan' was applied to the iron parts, and the bearings lubricated. The drum is formed of two halves bolted together (with four handmade bolts), and was easily removed. The mesh lining, made from a heavy gauge wire, was in good condition, as was the hardwood drum frame. The rotor consisted of a cast iron shaft and hubs with offset brush mounts, these carrying one pair of pig bristle brush bars and one pair of solid iron agitator blades. These were quite damaged, showing the smutter had had regular use. After conservation, the upper drum half was left off to display the rotor, which can be rotated by hand for demonstration purposes. The replacement of the **brake wheel cogs** continued during the summer, and was complete by the end of the year.

The **tail stone vat** is octagonal, built in two halves held together by hooks at front and back, fitting closely around the stones (see page 7). Its renovation involved removal of worm eaten parts and replacement or reinforcement, particularly around the rear where the two halves meet. The section where the feed shoe control cord pulley is fitted was renewed to provide a more secure mounting, and the joints between the sections of both halves reinforced with screws and PVA glue, so the halves can be removed without breaking apart. The top panels needed little attention as they had already been renewed in a previous phase of restoration. New blocks were screwed to the floor on four sides to retain the vat symmetrically around the stones; it was noted that the floor is sloping around the stones, so some additional remedial work may be need to ensure that meal is collected correctly from the vat when milling is attempted, and carried to the exit slot on the left side. Further repairs were made to replace rotten floor boards and fill gaps between them. In addition, the rear roof extension was secured on the smutter side and panelled on the dresser side to conceal the lightning conductor. Extension leads were fitted in the buck to better provide lighting and power.

The job that most of the team were busy with this summer was renovation of the sweep **shutters**. Despite being only fitted only three years previously, the shutters already in place in the inner bays (see picture on the back cover) needed repainting. The remaining shutters were taken out of store; these had very old grey primer only on them, so were given two coats of lead primer/undercoat and one of gloss. It was found that we were a few short of the full complement of shutters (35 long and 16 short on each sweep), so ultimately a few new ones will have to be built to complete the set. A few new **cranks** will be needed too, since these break occasionally. It is anticipated that the outer shutters will be removed during each winter for safety, so need to be removable. The alloy **shutter bearings** were repainted with white 'Hammerite' prior to refitting. Many of these were fitted for the first time in the outer bays of each sweep, requiring drilling and fixing with stainless steel screws. The crank eyes were fitted to the shutter bars with stainless screw bolts. A simple gauge was made to ensure consistent spacing between the swivels. Repairs to decayed or damaged shutter bar ends were already necessary. At the same time, the **striking gear** components (spider, striking rod and harp irons) were lubricated with engine oil via the storm hatch. When fitting the shutters is complete, the shutter bar attachment screws will need adjustment to ensure that all four sweeps operate together, allowing the shutters on each to fully close.

A wooden **guard** was originally fitted on the right side of the tail wheel, which appeared modern, but worm-eaten. This had been removed at early stage, and was now replaced in new wood in anticipation of the drive wheels working on a more regular basis, to allow safe passage past the tail wheel when rotating. The sack hoist drive was completed by fitting a new stretcher support block and screw to allow the height of the front bearing to be adjusted, hence the vertical engagement of the drive gear. New wedges were fitted and a suitable horizontal position established, and the hoist was successfully tested in September. However, more shutters need to be fitted to drive the tail stones, this was deferred until next season.

Work on the restoration to working order of the **head stones** was started in late 2019. The quant was lifted out and the stones, which had become stuck together over time, were separated using steel wedges, then the runner stone lifted using a car jack. The bridging box and governor were removed for cleaning and refurbishment off site. The neck bearing could then be forced out by jacking the lower end of the spindle, cleaned and oiled. The runner stone was then eased back onto the mace and the spindle re-engaged with the bridging box. The **glut box** was refurbished and repositioned further back on the sprattle beam to allow the stone nut to correctly engage with the brake wheel, and the quant re-fitted.

Both **bridge tree hangers** were reinforced with threaded rod, and the head stones brayer end slide repositioned to prevent the front left sag iron impeding the tentering adjustment. The tentering screw and lever hangers were repositioned for the same reason. It was noted that the head stones were not level, due to the sag that had developed in the buck towards the breast and tail while the structure was neglected. The crown tree side of the head bed stone was lowered to compensate, and new shaped segments fitted around the perimeter to secure it, which also allowed the meal to be collected and directed into the spout slot on the left side. The **tentering gear** was then re-adjusted for correct stone separation, including adjustment of the height of the bridge tree tenon block. This was reinforced at the same time by the insertion of a new oak spar and wedges.

During the winter, new boards were close fitted around the **breast bedstone** over the surrounding gap, to gather the meal, but requiring new recesses in some of the original floorboards at the rear. This arrangement was finished with a concave moulding around which the original stone vat sections could be located to retain the meal when milling. A **new spout** was inserted into the original meal slot on the left side, with the top of the vat modified with a hinged section to view the meal slot. A canvas sleeve could then be used to direct the meal into a suitable receptacle on the spout floor below.

At the end of the visitor season the **fantail blades** were removed for the winter, and repainted. Inserts were made to cover the slot in each blade spar while the boards are not fitted (most of the time to prevent undue stress on the gears when windy). It was planned to re-fit the rest of the **shutters** and test both sets of stones during the following season. By this time the mill body was in need of cleaning off, but no decision made as to the method of access to upper parts.

Restoration and maintenance was interrupted in March 2020 by lockdown due the **Coronavirus pandemic**, with work resuming in July. Several regular volunteers were obliged to shield for the duration.

In the meantime, wheelwrights completed the construction of a pair of gun carriage style **fantail wheels**, these being delivered complete but unpainted. Each comprises an elm hub, ash spokes and six laminated oak felloes forming the rim, with wrought iron strakes nailed on to form hot to draw the felloes together and form the tyres. They were mounted for painting on a temporary scaffold within the roundhouse. The wheels were painted with aluminium primer and multiple coats of white specialist durable paint with black tyres. The drive gears were also painted with black anti-corrosion paint and will be bolted on to connect with the worm drive gears when remounted on the fantail legs. The stub axles, skew gears, drive shafts and mounting brackets have been refurbished and new bearings manufactured for the drive shafts ready to fit next season.

The **control cords** on both the stone sets were replaced with a stronger material, and adjusted for correct operation of the feed shoes in anticipation of testing the stones when a suitable wind was available. On one occasion, the wind was strong enough **to test** the sack hoist, but would not turn the stones. For this more shutters will have to be fitted next season to overcome the disruption of airflow due to surrounding trees and hedges.

The **shutter rods** on the sweeps were adjusted one by one to allow all the shutters to fully close simultaneously. This required the bracket connecting the end of the shutter rod to be unbolted from the wooden shutter bar and unscrewed from its lug at the harp iron. The rod could then be lowered to the ground and the locknuts on its end thread released (with difficulty). These were then lubricated and repositioned with the effect of shortening the rod to draw the shutters cranks further in when closed. After refitting onto the sweep, the nuts were given a final adjustment and locked. In one case, the bracket had to be refitted to a more suitable position on the shutter bar to allow correct operation. The outer shutters and swivels were then removed for storage over winter and repainting.

In August, the **drive shaft** to the dresser was dismounted, and it was discovered that the gunmetal bearing at the dresser end was badly worn and should be replaced. The hardwood bearing at the upper, tailwheel, end was on the other hand in good condition. Fortunately, a used bearing from the fantail was found to be usable and would fit the housing for the lower end. The housing was refurbished and the shaft refitted (with difficulty!). New applewood cogs for the lower drive gear are needed, since many are worm damaged. When the damaged side cogs on the tailwheel are replaced the dresser can be driven by the wind, but for demonstration purposes only, unless graded mesh is fitted and the spouts full repaired.

A major outstanding job remaining is to refurbish the **smutter and crusher drive**, a complex system of shafts and gears mounted on the right side of the mill. These are fitted behind the smutter bin and will be difficult to extract, and could be left to a future date. Another task that could be undertaken is to dismantle **the tailstone bearing** for inspection and refurbishment, checking the bedstone and adding a method for collecting the meal when working.

The outer long trailing and short leading **shutters** were removed in the autumn for repainting with one coat of undercoat/primer and high performance gloss. This required the removal of the thimbles forming the outer bearings and the crank bolts; the outermost shutters on each sweep were left in situ to support the shutter bars. The thimbles were repainted with Hammerite anti-rust paint. The finished shutters were stacked in the roundhouse for refitting next season. It will then be established how many new shutters and cranks will needed for a full set. It is hoped the stones can be driven by wind when all have been refitted.

The mill was **fumigated** due to a repeated infestation of small flies. It was found by consulting an entomologist that they were harmless, but a nuisance nevertheless. Operations were again **suspended** in early November due to a renewed lockdown, and the mill mothballed.

Work on the mill restarted in April, with the reopening delayed due to ongoing Covid restrictions. Precautions were observed by volunteers such as social distancing and hand washing, while the national vaccination program was in progress, prioritising the over 70s.

The main task planned this year was to wash down the **mill body** and repaint, but this was delayed due to difficulty in obtaining permission to bring a cherry picker on site, so only the fantail could be cleaned, which did yet need repainting. It was discovered that the upper bearing end on the **vertical drive shaft** had broken off during shutdown, due to the fan being allowed to freewheel. This bearing appeared to be separately turned and fitted to the square section shaft via locating pin which itself had been pinned through, weakening the joint. This will probably need welding by our contracting engineers to make a solid repair.

Repair and painting of the remaining shutters was continued. It was found that there was enough to fill each sweep except for one bay, that is, the outer three bays could be filled leaving the fourth empty for now. It is hoped that this would be enough, given a favourable wind, to turn the stones. For a complete set, about 16 long shutters would have to be made to the original design, and new cranks cast by specialist suppliers (a batch of 30 is planned). Drawings by Vincent Pargeter of the sweep components were available to assist this process. The striking gear will also need fine adjustment of the shutter rod screws to ensure all shutters closing fully. Each sweep was positioned in turn at ground level to allow its outer shutters to be cleaned, repainted and refitted.
Unfortunately, during this operation, the **striking gear** failed due to the single through bolt which attached the chain wheel shaft end to the coupling on the pinion shaft shearing off. A more robust coupling method will probably be required to stand up to the torque generated by the chain wheel. A temporary repair was made using a single grub screw originally fitted by the millwrights.

Inside the mill, minor improvements were made, such as repairing the rear **meal bin** on the spout floor where the sag irons had been cut through the bottom of the bin, reinforcing the supporting brackets and re-fixing the back boards. A hand rail was fitted to the stairs up to the stone floor, and the hand rope moved to the tunnel up the bin floor. Work was started on replacing broken wood cogs on the **dresser drive gear**, many weakened by woodworm, with new applewood cogs. The 48 cogs have dovetailed shanks retained in a cast iron frame by chamfered pegs, which are driven out to withdraw the cog. A high degree of precision is needed in making replacement parts.

In late September, the **fantail** blades were removed for cleaning, repainting and overwinter storage. At the same time, the lower fantail drive shaft with its upper crown gear was removed allowing the split drive housing, which had been temporarily mounted on the tailpole extension, to be removed for storage, pending the rebuilding of the split drive to the new carriage wheels, also in store on site. The vertical split gear housing will need careful mounting with a spacer to ensure the rotation of the crown gear without fouling its supporting bracket. The upper drive shaft would need specialist repair before the fantail drive could be rebuilt. All other components (including carriage wheel spindles and drive shafts with worm gears) were ready for re-assembly with new bearings.

Repairs to the rear right **smutter bin** which fed contaminated grain to the smutter were begun. To provide access to the bin from below, and also to the auxiliary drive gear, the spout was removed as a unit for repair and reinforcement. A supporting beam into which the spout frame is rebated was cut through and displaced to allow the spout assembly to be withdrawn. This will also improve the headroom for visitors on the stairs below. The chute from the bin spout to the smutter was missing, and will need rebuilding from scratch, but it is not planned to replace it at this time since this would impede the stairway. The bin was cleaned out, a section of sacking liner removed as it was in poor condition, and the panelling repaired. The aim was to preserve the appearance of the working bin, even though badly damaged by woodworm, and allow the spout and adjacent lower panel to be easily removed or refitted, as required, so the interior of the bin can be viewed and the auxiliary drives and striking wheel shaft accessed for repair. The boards comprising the lower part of the bin were repaired, and the spout reinforced, damaged boards replaced and then treated with Cuprinol preservative, gaps filled and PVA applied reinforce the joints to ensure structural integrity when re-fitted. The spout and adjoining bin hatch could then be refitted, or removed, as required, to provide access to the auxiliary drives. If the bin were to be actually used, it would have to be lined with polythene or hardboard, but this is unlikely to be necessary.

On October 19, with most of the shutters refitted, sufficient wind from the south east was available to allow the sweeps to **turn the breast runner stone** for the first time. The 112 brakewheel cogs had been replaced with new applewood by David Stiff and the bearing extracted and serviced during 2019. The drive to the stone nut performed perfectly when driven continuously for several revolutions of the sweeps, only jamming on one cog when restarting, which was easily trimmed.

Cleaning and repainting the mill body was deferred until next year, since the method and access rights could not be established this season.

Restoration of the **spare shutters** was completed in the season, but further ongoing repairs to the sweeps were necessary, as well as routine cleaning and maintenance. It was still not possible to fit a full set of shutters. In March, new concrete pads were made for the **cast iron wheels** which will allow the steps to rotate. The wheels were repainted and attached in their correct position, supporting the steps for the first time. Plans were made for reopening to visitors for the first time in two years.

The restoration of the **auxiliary drives** resumed, with a view to driving the smutter and crusher pulley. The bearings supporting the smutter drive were disassembled and checked for wear. All hardwood bearings were found to be in good condition, and were simply lubricated with linseed oil. The horizontal shaft on the spout floor could be disengaged for servicing via a lever supporting the near end. This is wedged in the engaged position when crusher drive is operational.

The gunmetal **bearings** supporting the gears transferring the drive to the smutter pulley required more work. The lower bearing was completely adrift, since the upper side girt to which it attaches had been replaced by the millwrights, and the bearing not refitted. The upper bearing was quite worn, suggesting that it was recycled rather than fitted new. However, it was not replaced since the drive would not be in regular use. It was refitted and its mounting stretcher wedges adjusted to optimise its engagement with the crown gear driving the downshaft. The lower gear was then reattached to the upper side girth by drilling it through and refitting the original coach bolt. The bearing was wedged to the correct height to engage correctly with the upper drive gear. The hardwood cogs in the crown gear and upper gear were treated with Rentokil and linseed oil. The cast iron pinions and shafts were treated with Fertan. The drive was then fully functional, awaiting the replacement of side cogs on the tailwheel and new belts for the smutter.

It was noted that some of the supporting members of the gear train were recycled timber, with the main horizontal support in particular having large old mortises, compromising its integrity. This was further evidence of cost cutting (or even fraud) when the mill was extended. The drive system overall gives the impression of being improvised rather than carefully designed. The tongue and groove panelling on the outer and forward sides of the bin were removed so that the supporting framework could be repaired or replaced. The original boards forming the lower part of the bin feeding the spout were repaired as far as possible despite heavy worm damage in order to retain those original parts visible from the stone floor when the spout is removed.

The **smutter feed bin** was rebuilt entirely since much of the lower part was missing or beyond repair due to worm damage, while the original vertical sides survived. Sacking formed a temporary cover to the smutter drive shaft; this appeared to date from the final days of the mill, but was reluctantly discarded. An existing hatch was recycled as a platform which would allow easy access to the bin interior and the smutter drive. The sloping sides including the smutter drive system covers were rebuilt by repurposing as many of the original boards as possible. A new access hatch and surrounding boards was built from surplus weatherboard. Worm damaged original boards were patched with brown acrylic filler, and the whole interior of the bin painted to provide a uniform appearance.

The smutter and dresser are driven from **side cogs** on the tail wheel. These are retained by steel pins driven through the rim and lengthwise through the shank, which is designed to be easily driven out when replacing the cog. Several of these cogs were broken and were replaced in applewood. Unfortunately, some were retained by nails driven in from the front face on the tailwheel which could not then be driven out easily, resulting in damage to the rim during removal. These were replaced using through pins and the damage repaired. Where the cog was broken off, the shank had to be drilled out (with difficulty!), otherwise it could be levered out. Enough cogs were made late in the season to replace the broken ones and hopefully drive the smutter, which will need new drive belts.

The **fantail wheels** were fitted later in the summer and the fantail drive reassembled. The wheels rotate on stub axles mounted on cast iron plates bearing a projecting fin designed to transfer some of the weight to the carriage leg, requiring a slot to be chiselled out. Each wheel has a skew gear mounted on the hub that engages with a worm gear on the outer end of split drive shaft, driven from the bevel gearbox at the centre. The ends of the horizontal drive shafts are supported in plain bearings mounted on projecting brackets bolted to the outer faces of the legs. It was found that one drive shaft appeared original, while the other was relatively new. This proved to have been made about 4” to long, suggesting a previous fantail carriage was built too wide. The shaft of this drive was cut through, shortened and welded back together our specialist engineers to match the current geometry of the frame and match the original. The drive components could then be aligned for testing while the wheels are unloaded (off the ground).

The **flour measuring tubs** found inside the roundhouse were restored. These are made of thin wooden sheets formed into cylinders with riveted seams and softwood bottoms. The bushel and half bushel measures are reinforced with iron strapwork fitted with integral forged handles. The bottom of the half gallon measure was missing, so was replaced in 4mm ply and painted to match. Otherwise, splits and holes were repaired with brown acrylic filler and treated to colour match. The bushel measure needed a small steel plate patch on the lower rim, using scrap metal sheet found in the mill. The iron reinforcement bands were re-fixed as necessary using small wire nails formed into rivets. These were then treated with ‘fertan’ and all finished off with Danish oil to preserve the wood and improve the appearance.

A cherry picker was obtained on loan later in the season which allowed minor repairs to the sweeps where sections of the windboards, hemlaths and shutter bars had rotted. The outer shutters were removed for the winter to reduce the risk of damage in high winds.

Philosophy of Repair

The main object of restoration has been to preserve the **original structure** and features of the mill, while repairing and restoring its **machinery** to running order where possible.

The **roundhouse** is substantially intact. The original stone built walls support a roof of tapered oak tongue and groove planks, which probably replaced an original tarred softwood original. These have been newly tarred but this does not stick well to oak, and self-adhesive flashing has been used to cover the holes where steel supports were inserted to prevent the collapse of the buck, so modern materials have been necessary to make the roof watertight. The oak wall plate and upper ringbeam appear original and are in reasonable condition. The oak planks are warped and twisted causing leakage, and might need to be replaced, or the support structure strengthened. When major works are completed, the display of artefacts in the roundhouse can be improved.

Parts of the **frame of the buck** have been replaced and a side girt reinforced with steel plate, leaving the frame a mix of original and new timber. The **weatherboard** cladding had to be completely renewed, and was completed probably to a higher standard than the original, with lead flashing on the front corners and an authentic herringbone joint at the centre of the breast. The existing original **zinc roof** survives, and was crucial to the survival of the mill by providing enough protection to delay collapse until restoration was started in 1955. The **steps and fantail** have been completely rebuilt, with new carriage wheels and fan blades built to a working standard. The original drive shafts and gearing will be recommissioned with minor repairs and modifications to fit the new framework, including new gunmetal linings to the bearings.

Completely new **sweeps** were constructed by the millwrights Hole & Son and fitted to galvanised steel stocks. It was decided that the durability of steel outweighed the authenticity of replacing the stocks with timber. However, most of the original shutters survived, and could be easily repaired, except where the cast iron crank had sheared off. The original **striking gear** was refurbished, the main problem being the freeing up of the striking rod within the windshaft, which took Jeremy Hole several hours and a great deal of brute strength! Unfortunately, the weight wheel shaft had to be cut through to facilitate the replacement of the weatherboard. The new coupling collar proved a weak spot in the mechanism, and difficult to access. A through pin subsequently sheared off, so a more robust solution will be needed to tolerate the torque and shock at the end of travel when operating the shutters.

The original **windshaft** bearings, brake assembly and brake wheel were in good condition, but all 112 brake wheel cogs had to be renewed in applewood. The glut box on the breast stones had to be repositioned to align the quant correctly. The peak stones had to be separated and the bearing serviced, but the stones themselves were in good condition. The **tentering gear** was functional after minor repairs, but had to be modified slightly because it was impeded by the sag irons which had been fitted in an earlier phase of restoration. The lower spindle bearing was good, so the runner stone was eventually able to turn under wind power. The tentering gear should work correctly if enough wind power is available and grain could be milled. Similarly, the tailstones only required minor repairs to become functional, and the original tailwheel cogs did not need replacing, showing less wear than the brakewheel cogs. The bearings were functional, therefore have not yet been serviced. The original stone furniture is largely intact, but needing selective reinforcement to for adequate functionality, plus a new cover for the breast stone case made from recycled timber.

The **internal machinery** was affected to varying degrees with woodworm. This was generally treated with Rentokil and sealed with dilute PVA which also helped to reinforce joints in the wood. Cross-point woodscrews were generally used so that new repairs were obvious, and largely reversible. Acrylic filler was also used to give integrity to otherwise fragile original joinery, which would otherwise have to have been scrapped and rebuilt from new. The original mill fittings were made to a range of standards, from high quality joinery seen in the dresser and smutter (bought in machines from Dell & Son of London) to makeshift repairs, such as recycled the backboards of the meal bins which had dovetail joints still visible from a previous life, possibly as cupboard backs! Generally, a standard of joinery was therefore used to match the existing work, using mainly recycled timber from the mill itself.

Work completed by end of 2022

Substantially Intact	*Trestle, roof, crown tree, windshaft, tailwheel, brakewheel, brake, stone furniture, stones*
Partial rebuilds	*Body frame, floors, dresser, smutter feed bin*
Rebuilt	*Weatherboard, weather beam, sweeps, stocks, steps, tailpole and fantail*
Repairs to	*Side girts, corner posts, stone cases, tentering gear, auxiliary drives*
Service of	*Breast stone bearing, tentering gear, striking gear, smutter*
Outstanding	*Turning circle reinstatement and full operation*

Further Work

At the time writing (December 2022), the main work on the mill is well advanced, ensuring the mill will survive for the time being and continue to be opened to the public. The structure of the buck, weatherboarding, roundhouse and sweeps are sound, and the internal machinery preserved. Outstanding work, mostly inside the mill, includes:

Stones	Both sets of stones are now workable, and have been turned under wind power. Some extra work would be needed to put them into full operation and mill flour. However, until the mill can rotate, a strong wind from the south west will be needed, with all shutters fitted. However, the tail stones have not yet been separated to check on their condition or the bearing serviced. Cleaning out the stones after occasional milling will be difficult, so grain will not be milled yet.
Feeds	Feed hoppers and shoes are workable on both stones, the feed chute to the burr stones and smutter bin repaired. The smutter feed chute would have to be rebuilt from scratch, but could not remain in position in any case as it would obstruct the stairs. The feed to the breast stones is achieved via a sacking chute that in poor condition and could be replaced, but any feed grain will, in practice, be loaded direct into the stone hoppers for milling small quantities.
Dresser	The wire machine is repaired but not in full working order. The brushes are worn out and would need replacement to make them operational. In addition, graded mesh would need to be installed and side panels rebuilt from scratch. The spouts would also need to be fully restored with new internal baffles and sacking spouts. Some cogs in the dresser drive gear have been removed to allow it to turn by hand; all will have to be renewed due to worm damage. The dresser drive shaft is now operational, but some rim cogs on the tailwheel will have to be renewed to run the dresser successfully.
Smutter	The smutter brushes would have to be renewed for it to work properly and will need a suitable belt to complete the drive from the tailwheel, and a belt to drive the fan fitted. An exhaust vent for the chaff would also need to be inserted in the mill side wall for the smutter to function as intended. The smutter pulley can also drive a grindstone mounted below the ladder, whose bearings would need refurbishment and a pulley belt fitted to bring it into use.
Drives	The smutter and dresser are driven from side cogs on the tailwheel via lever engaged pinions and layshafts. The repair of these will need to be completed to drive the auxiliary machines successfully. The wooden cogs on the dresser drive gear are also yet to be replaced.
Sweeps	The sweeps and striking gear are now fully operational, and most shutters refitted, or ready for refitting. A small number need to be rebuilt to make up a full set, plus a small number of new cranks need to be cast to replace broken ones. The stocks, whips and frames also need cleaning and repainting regularly. It will always be desirable to remove at least some of the shutters during winter for safe keeping and repair. Due to their delicate structure, the sweeps will need constant maintenance.
Fantail	The fantail structure and new wheels are complete, but the final drive is yet to be fully assembled. The new wheels have been fitted clear of the ground so they can turn with the fan when the drive is fully assembled and adjusted. If the turning circle were to be reinstated, load bearing tracks for the fantail wheels and step trolley wheels would be needed, since the maximum load would be several tons. It is hoped that next season they can be lower onto the ground and allow the mill orientation can adjusted to allow the sweeps to turn and drive the internal machinery.
General	All the weatherboard needs cleaning and repainting regularly using a cherry picker. The roundhouse roof is still prone to leak where holes were cut for the temporary steel frame. It has been treated with bitumen sealant, but this appears incompatible with the oak roofing boards, dries out and cracks too easily. Leaks have been patched with flashband for now. Improvements could be made to the presentation of the museum artifacts, and information signage in the mill improved.

Regular volunteers were:
*David Stiff (master craftsman & team leader) **
*Geoff Daughtrey (legal & general) **
*Alain Beaupain (off-site joinery & storage) **
*Chris Bottomley (Yorkshire common sense) **
Jim Pointer (electrical installation & painting)
Brian Pike (windmill expertise and experience)
John Bowerman (storage, tractor & local knowledge)
John Moat (doughnuts & structural engineering)
Martin Bates (internal repairs & documentation)

Thanks also to:
Tony & Jeremy Hole, JE Engineering (structural repairs)
Jenny Beaupain & Friends (visitor catering)
*Richard Howes (website & support) **
Judith Connor, Cross In Hand Saddlery (leatherwork)
John Turp, Playfoot Engineering (running gear restoration)

** Members of Argos Hill Windmill Trust*

Geoff, David, John, Chris & Jim working on the fantail (Sep 2018)

References & Acknowledgements

This booklet is dedicated to the members and supporters
of Argos Hill Windmill Trust and Friends of Argos Hill Windmill
who saved the mill

About the author:
Martin Bates MSc PGCE
is a volunteer and tour guide at Argos Mill
He is a retired lecturer in electronic engineering
and author of textbooks on microelectronics

Reports

'The Post Mill, Argos Hill, A Brief History, Technical Appreciation & Recommendations for Repair'
by Vincent Pargeter (Prepared for Wealden District Council Nov 2001)
'Argos Hill Windmill, A Guide to the Mill, its History and Restoration' pub. by The Argos Hill Windmill Trust 2016
'Sussex Windmills & Watermills', leaflet pub. Sussex Mills Group
Sussex Industrial History No 43 'Argos Hill Post Mill, Past, Present & Future' by Bob Bonnett
Templetech Ltd, Analysis of Wind at Fosters Mill, Steve Temple, 2017

Books

'Windmills & Millwrighting' by Stanley Freese
'England's Vanishing Windmills' by AEP Shillingford
'Windmills of England' by RJ Brown
'The Windmills of Sussex' by Martin Brunnarius
'The Windmills of England' by Rodney de Little
'Windmills of Sussex' by Derek Nicholas

Expert advisors

Philip Hicks, Sussex Mills Group
Brian Pike, Nutley Mill
Jenny Beaupain, Friends of Argos Mill
David Stiff, restoration team leader
Richard Howes, website manager

Thanks to

John Moat of Douglas Moat engineering consultants for scale drawings
Guy Blythman & the Mills Archive for interior photographs

Links *http://www.argoshillwindmill.org.uk*
http://www.sussexmillsgroup.org.uk
https://en.wikipedia.org
https://millsarchive.org

plus individual windmill websites

This booklet is a work in progress, any comments or corrections will be gratefully received.
It is based in part on secondary sources, all of which are gratefully acknowledged.

For a free copy of the PDF of the current version, or to purchase hard copy, contact:
martinpaulbates@btinternet.com

All proceeds from this publication will support the restoration of Argos Hill Windmill.

Filename: Argos Mill Booklet 2023

Argos Hill Windmill 2017

Picture credit: Historic England