The Development of Milling and of Windmills in Particular

WINDMILLS -
Their Construction and Mechanics

CHAPTER ONE

CHAPTER 1

THE DEVELOPMENT OF MILLING, AND OF WINDMILLS IN PARTICULAR

THE EARLIEST MILLING DEVICES

Early man, on ceasing to be a hunter, settled down to grow grain - but had to find a method to convert it into an edible meal. His initial attempt was to beat it with a piece of wood but progressed later to pound it in a pestle and mortar. This gave way to rubbing the grain between two stones, one - the base - being stationary. These SADDLE STONES were known at the time of the Pharaohs of Upper Egypt. A considerable time elapsed before a method was contrived of rotating the upper stone, as a more efficient way of producing meal.

The reciprocating *beehive* quern of China and upper Egypt, where the upper stone was turned back and forward, was first devised before the truly rotating system was developed. Many variations on the theme were tried. Among other sites, in the ruins of Pompeii and of Ostia Antica, the old port of Rome, the remains of early Roman mills can still be seen; these *hourglass* querns were much larger and heavier, designed to be worked by teams of slaves.

With the introduction of rotary querns, the way was open to use other forms of power to drive them. Animals such as the donkey, bullock, camel or mule, harnessed to the upper or runner stone, replaced the human arm and increased the output of the mill. The use of water power was the next development and improved output still more dramatically.

The first water wheels were horizontal contraptions, set into the side of the river bank or channel. They were driven by the flow of water against simple paddles, fixed on the circumference of the wheel, with the vertical axle of the water wheel attached directly to the top of the upper stone. The *Norse Mill*, used till quite recent times in the Scottish Islands, Scandinavia and other European countries, is a latter-day example of these ancient watermills.

The development of the lantern pinion took the drive from the water wheel through a right angle for the first time. This permitted the use of vertical wheels, with buckets in place of the simple paddles. In turn, wheels increased in size, often with two working in tandem, to impart even greater power. Larger stones and higher speeds, giving increased output and finer grinding, were now available.

Thus, the power transmission of the modern gear train was achieved. The Romans were conversant with these later transition stages and a report by the writer Vitruvius describes a horizontal wheel in about 10 BC.

However, one disadvantage inherent in watermills was the need to be situated near a water course with a sufficient head of water. Where there was little or no water to spare, as in the Middle East, hand querns and animal driven mills held sway for many centuries, and are commonly used even in the present day.

There is no known inventor of the windmill, nor do we know for certain where they first appeared, but harnessing the wind was something that interested man from earliest times. There is evidence of a form of wind machine being used in Persia in the tenth century, and an Arab geographer mentions the presence of windmills as early as the seventh century. These, however, were horizontal vanes, attached to an upright shaft fixed directly in the runner stone of the quern. The whole assembly was encased in a three-sided building, the upper portion of which had slots through which the wind was directed onto the horizontal vanes.

The principle of this mill appears to have been carried by prisoners of Ghengis Khan to China, where a similar device is recorded. However, the Chinese windmills differed in one or two material ways from the Persian version. There was no box enclosing them, and the vanes, made of matting, were feathered, i.e. they were set at an angle to the shaft, the twist so formed allowing them to catch the wind without the aid of deflecting-slots on the driving side.

THE DEVELOPMENT OF MILLING

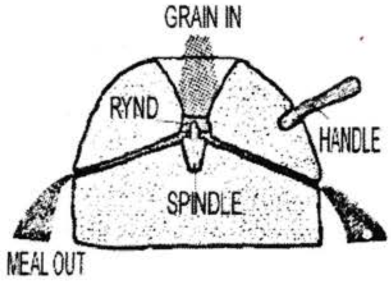
PESTLE & MORTAR

Using the SADDLE STONE
After an Egyptian Statuette

Bronze Age &Early Iron Age
SADDLE STONE

Late Iron Age & Roman QUERN

A QUERN from a Romano-British site near Hopton, Derbyshire
The upper stone is 15 inches in diameter.
Note the recess for the handle.

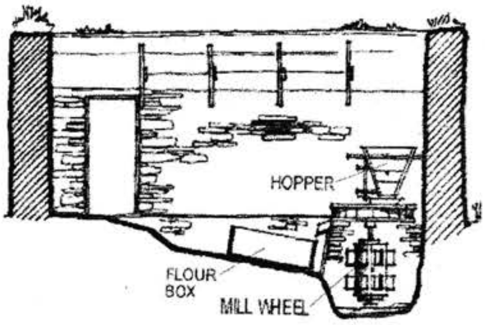


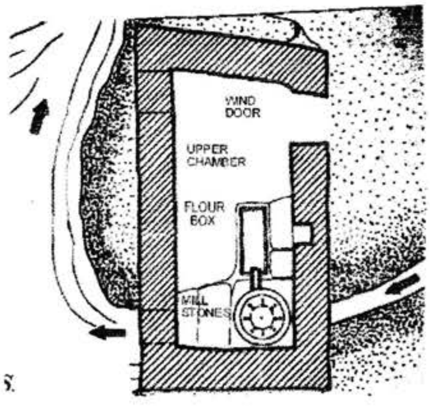
Cross section of a BEEHIVE QUERN showing the main elements of the RYND, SPINDLE and HANDLE and the passage of the MEAL.

Above, left: A late development of the HOURGLASS QUERN. Staves inserted in the holes in the top stone would be turned by four or more slaves. Grain poured into the funnel-like top stone emerged as meal lower down in a wooden trough (now missing).
Roman Mills remains at *OSTIA ANTICA, ROME.*

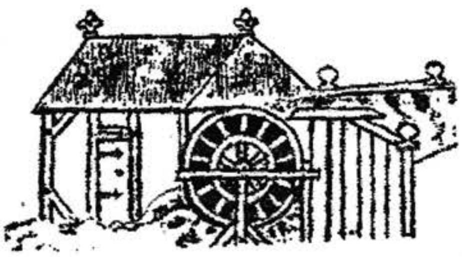
Above, right:
Remains of a HORSE MILL of which only the harness beam and spur wheel survive. *MARTIN MILL, DOVER.*

THE HORIZONTAL WATERWHEEL *Click Mill*, at DOUNBY, in the ORKNEYS.

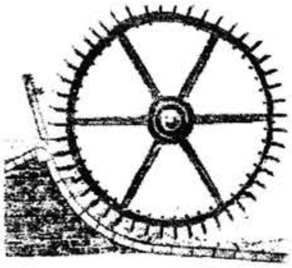




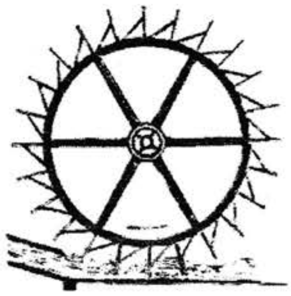
THE VERTICAL OR VITRUVIAN WATERWHEEL showing main types of waterwheel



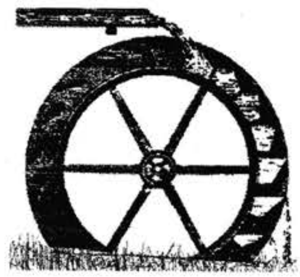
Mediaeval Watermill



Breast shot Waterwheel

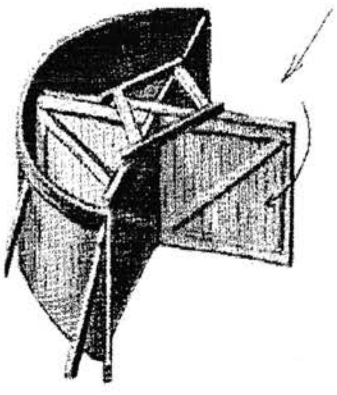


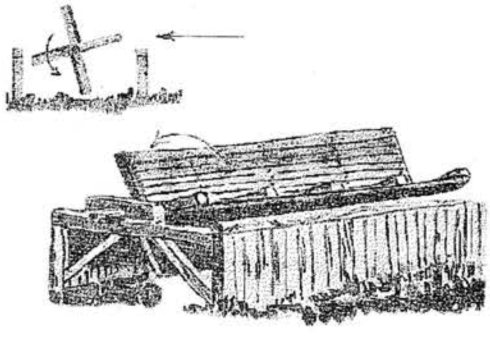
Undershot Waterwheel



Overshot Waterwheel

THE EARLY WINDMILL. Two forms of HORIZONTAL WINDMILL.



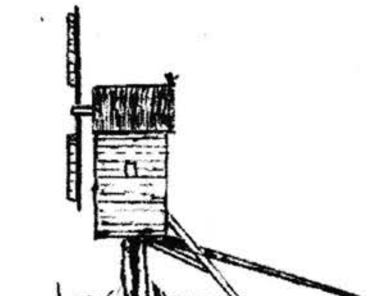


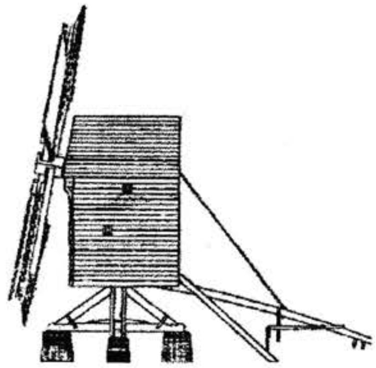
BELOW: POST MILL DEVELOPMENT

12th Century, north European
A SIMPLE POST MILL
(No trestle, post unsupported)

14th Century English
A SUNKEN-TRESTLE POST MILL
(Trestle partially buried underground)

16th Century English
An OPEN-TRESTLE POST MILL
(Trestle on brick piers).





ARRIVAL OF THE POST MILL.

Northern Europe, a naturally windy part of the world, developed its own windmills quite independently and at approximately the same time. The first appearance of the windmill in Europe is lost in history; certainly none were recorded as such in the Domesday Book. The earliest authentic written evidence in England, is a rental note of 1185 in Wardly, in Yorkshire while a windmill is recorded at Bishopstone, Sussex, in 1191.

Other early references are to an illegal windmill built by Dean Herbert on glebe lands at Bury St. Edmunds in 1191, which was pulled down by order of Abbot Sampson, and to one recorded as standing at Dunwich, Suffolk, between 1185 and 1191. Many records fail to distinguish between wind and water mills: there is some confusion whether a mill granted to the monks of Lewes in Sussex in 1154 was indeed a windmill.

However, it was certainly a windmill that the Convent of Torrington sold to the Dean and Chapter of Chichester between 1180 and 1197. Never-the-less, none of these refer to windmills as to a curiosity, so we may assume that they had been plentiful, if not common, for a period prior to these records being made.

Though the *earliest* definitive reference to a <u>windmill</u> is to one in France in 1180, by far the greatest number of early records extant, referring specifically to windmills, are to be found in England. A further one hundred years passed before similar records were to be found in Continental Europe. Holland, often considered the home of the windmill, can offer no site before 1294.

It was the fourteenth century before windmills reached Spain, Portugal and Asia Minor. However, these were of Arab design, carried there by the Saracen invasion, which explains why the windmills of these and other Mediterranean countries differ so greatly from the north European mill.

In England, by the beginning of the thirteenth century, charters granted to Convents began to include permission to erect windmills. Then, just as Castle and Abbey had their mills, so Free Towns considered it their right to build their own mills, where the flour for the citizen could be produced, free of any tax by Baron or Abbot - only to be mulcted later for municipal purposes.

The first European windmills were probably built near the sea and, with the advantage of a prevailing wind, had no need for any system of luffing, or turning the sails into the wind. They consisted merely of a fan on a vertical shaft set in the ground, which drove the stones, the whole being housed in a fixed wooden hut. The millstones were driven in a similar fashion to that used in watermills, except that the power came from above rather than from below.

It must have become apparent, soon, that a method of turning the mill into the wind was imperative, if maximum efficiency was to be obtained from the wind when it blew. The answer, when it came, was recognisable as a post mill, where the body with sails and machinery is carried on a centre post and is luffed manually by means of a tailpole.

However, problems associated with the simple post set in the ground led, before long, to the trestle evolving to carry the weight of the mill and stabilise the post in all weather conditions. The cross trees of the trestle were originally buried in the ground, but this caused premature rotting of the timbers. The gradual raising of the trestle followed - first to be placed on the soil surface, but later hoisted onto ever higher piers, primarily to prevent contact with the soil but also to enable larger sails to be used for increased power.

THE INCREASED PACE OF DEVELOPMENTS.

Developments and improvements in the efficiency of milling grain had been slow, with one or two centuries passing between each stage. However, the pace began to increase. The BUCK, or body of the mill, underwent refinements. The ridge roof gave way to a rounded version, to permit the use of a larger brakewheel and allow greater braking effect. The height of the buck was increased to enable the erection two or even three floors, and so allow ancillary machinery and more millstones to be installed. The construction of pannier-like extensions on each side, widened the buck to the same effect.

A constant problem was the wear sustained by the horizontal windshaft in the neck bearing, which caused the sails to droop and foul the walls of the buck. Mounting the windshaft at an angle to the horizontal overcame this. It reduced the vertical pressure on the neck bearing, converting it to a thrust load on the tail. At the same time this stabilised the mill by transferring the centre of gravity rearwards. Further, it allowed larger sails to be installed, producing more power.

Sails, too, underwent modulation. The very early woven rushes had long given way to cloth or canvas sheets, fixed on a lattice framework. These, in turn, evolved into the COMMON SAILS which could be adjusted for wind conditions by altering the lacing that held them to the frames. This improvement also allowed the miller to tend the sails from the ground rather than having to clamber over the sail frame to do so. An uncomfortable and highly dangerous task in wintry or inclement weather.

Refinements in the LUFFING of the mill also developed. A LADDER for entry became a necessary addition, as mills grew larger. The TALTHUR, a lever on the tailpole, raised these steps and allowed a single man to turn the mill with the tailpole. However, as the mills grew ever larger and heavier, other aids were incorporated to ease the task of luffing (or WINDING, the more modem term). A simple YOKE, through which the miller could put his whole weight to the effort of turning the mill, sufficed at first. Heavier mills required a harness for donkeys, mules and bullocks to haul the tailpole. Finally, manual WINCHES, using pegs fixed in the ground to which cables were anchored, hauled the mill into wind. The latter also did away with the need for animals to be kept available in the ever likely event of the wind changing direction.

Finally, the demand for storage, both for grain and the milled flour, and the constant need to protect the timbers of the trestle from the ravages of the elements, brought forth the ROUNDHOUSE. These commenced as rude wattle and daub enclosures, and gradually grew into brick or masonry structures of up to three storeys in height. They provided more storage space and enabled the mill to be raised on piers of eight feet or more in height.

All these developments, over a very long period, produced a more efficient machine. None-the-less, they left the post mill recognisable as the first cousin of the original mediaeval windmill of the twelfth century. What had changed, though, was the proliferation of windmills over the drier and flatter parts of this country and of northern Europe in general. Every village had its mill and each town was blessed with four or more: it was often possible to count, from just one vantage point, forty mills, their arms twirling merrily in the wind.

However, from the start of the seventeenth century, over the next two hundred and fifty years, a veritable spate of improvements and innovations followed. They would leave that early mediaeval windmill as far behind as, in transport terms, the modern jet airliner has left the Wright brothers' invention of the biplane.

MEMORIAL BRASS. <u>One of the earliest known depictions of a windmill.</u>

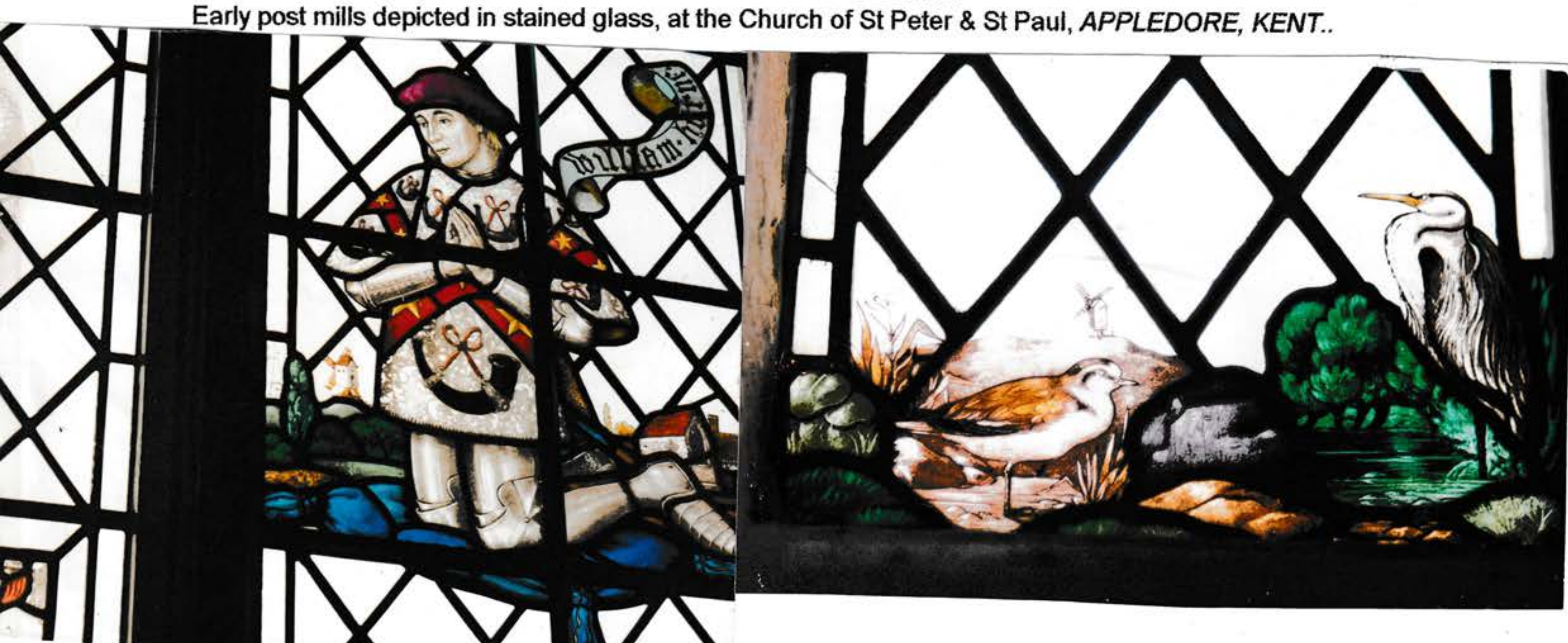
Flemish Memorial Brass to Adam de Walsoken in St. Margaret's Church, *KINGS LYNN, NORFOLK.* It depicts the MILLER JOKE: *A miller returning home from the market, his mule heavy laden with a sack of grain, took compassion on the tired animal and thinking to relieve its burden somewhat, took the sack upon his own shoulders before mounting the mule for the remainder of the journey!*

Above: RUBBINGS OF WINDMILL GRAFFITI. (c1500).

Rubbings from St Mary Magdalene Church, Newark, Nottinghamshire, shown here at half actual size.

Below: MEMORIAL GLASS.

Early post mills depicted in stained glass, at the Church of St Peter & St Paul, *APPLEDORE, KENT..*



The last remaining example of a **SUNKEN-POST MILL**, to be found in England. The only parts surviving are the main POST, with QUARTER-BARS embedded in a low mill mound.

WARTON, LANCASHIRE.

Left: The remaining TRESTLE.

Below:
Close up of the QUARTER BARS.

Right:
Primitive **OPEN TRESTLE POST MILL** supported on low **BRICK PIERS**.
Its early date is indicated by the rectangular BUCK, with its RIDGE ROOF, short LADDER and manual winding by TAILPOLE and TALTHUR.
This is the oldest surviving *dated* windmill in England, built prior to 1636.

BOURN MILL, CAMBRIDGESHIRE.

THE COMING OF THE CAP MILL.

When the first stirring of the Industrial Revolution began to be felt in the minds of those early engineers of the seventeenth century, the only mechanical devices known to man were windmills and watermills and the clock. So, their energies initially turned to windmills, as a mechanism patently in need of improvement.

Many innovations mentioned earlier were initiated in England, the results of the skills of those early engineers. However, some unknown genius (said to be a Dutch millwright of circa 1550), invented a *versatile roof*, in which a cupola carrying the sails was turned manually by means of a tailpole, without moving the body of the mill. Nevertheless, it was in England that the device was seized upon and developed to the ultimate degree.

An internal capstan mechanism, which engaged with a cog ring on the curb at the top of the tower, quickly replaced the tailpole of the cap mill. A further improvement was the fitting of a chain and wheel in place of the capstan, to be operated, more conveniently, from the ground outside the mill.

In 1745, Edmund Lee patented the fantail, which automatically turned the cap to face the sails into the wind whenever the wind veered in direction. English millwrights took to the fantail wholeheartedly, adapting it to both cap and post mills in a variety of ways. Nevertheless, the tailpole, and internal (and external) winches continued to be the most popular methods of winding the continental European mill, and still are in use in Holland and most of the Continent. The fantail was not introduced into the former country till the 1920's, and even then did not prove over popular.

The invention of the cap gave benefits immediately apparent. A more substantial and stable mill could be built, with a much larger body allowing greater storage space. The increased height enabled the fitting of larger sails, to reach the stronger breezes blowing above roof and tree top level. Immensely greater power, thus generated, allowed the installation of a multiplicity of stones, as well as cleaning and dressing machinery. They also enabled the millwright to use materials less vulnerable to the elements: stone and brick in preference to wood.

Developments less obviously noticeable, were taking place in parallel to these major innovations. The early windshaft was of wood (as was most of the machinery), with the stocks morticed through the windshaft. This was a weak point but is an arrangement still commonplace abroad. In England most of the wooden windshafts had their front ends cut off and an iron poll end fitted, to carry the stocks.

The lantern pinion had long given way to trundle wheels and pin gears. Now, square faced cogs, forming spur wheels, in turn gradually replaced these by the seventeenth century. Andrew Meikle, a Scottish millwright, superseded wood by iron and, in 1755, produced the bevel pinion after the work of Camus three years earlier.

Tentering, or the adjustment of the gap between the stones, has to be corrected constantly, as the strength of the wind - and so the speed of the stones - varies. This was carried out manually, by the movement of a lever and, originally, a *tenter boy* was employed to adjust the stones continually to the miller's instructions.

The lag governor, a primitive form of governor, was introduced early in the eighteenth century and James Watt had already investigated the use of governors in relation to steam engines. Thomas Mead, in 1787, patented the first centrifugal, rising-ball governors, specifically for use in windmills, adapting them from the mechanism in use in clocks. This gave automatic and constant control of the tentering mechanism, and was effective even at light variations of wind speed.

IMPROVEMENTS TO THE SAILS.

The sails themselves were the objects of a variety of innovative advances. Common sails were improved by several degrees. The miller was enabled to set them in the same way as a yachtsman adjusts his sails, using pointing lines with eyes in the canvas. In 1772, Andrew Meikle attempted to give the miller still more control by his invention of the spring sail.

In this, the canvas was replaced by a series of shutters, adjusted by a single lever on each sail, to tension a spring against the wind pressure on the shutters. Nevertheless, there was an inherent weakness in this type of sail, and in practice, the common sail proved more powerful, though admittedly less convenient.

Spring and common sails, both suffered from the disadvantage that each sail had to be set by hand individually, with the mill at rest. This often necessitated braking the mill in full sail and was a time consuming and generally dangerous job, the cause of many an accident.

In 1789, Captain Stephen Hooper, from Thanet in Kent, patented the roller-reefing sail, in which a number of small roller blinds were substituted for the shutters of the spring sail. He also invented a method of adjusting the tension of the blinds, through a system of levers attached to a striking rod. The rod passed right through the windshaft and was activated by an endless chain at the rear of the mill. By this means the speed of the sails could be adjusted, for the first time, whilst they were in motion.

Unfortunately this invention proved none too robust. However, William Cubitt, (later Sir William), an eminent engineer, incorporated improvements in Hooper's striking mechanism with Meikle's shutters. In 1807, he introduced his *Patent Sails* which soon became the most common type to be found in England though, again, it is still almost unknown abroad. This method not only allowed the sails to be regulated whilst running, but also allowed automatic adjustment of the speed of the sails, as the wind speed varied.

Diverse minor improvements to the sails and their controls continued to be made. A Suffolk millwright, by the name of Catchpole, produced an effective air brake, known as *Catchpole's Skyscrapers.* These, whilst giving additional sail area when closed, when opened helped slow the sails quickly, if it was necessary to stop them turning.

Charles Hammond, a miller of Clayton, near Brighton, in 1873, devised an improvement to Cubitt's sails. He incorporated a sail governor to even out wind speed fluctuations - an idea first suggested by Thomas Mead, in a patent of 1787. Cheal, a millwright of Lewes, Sussex, invented a combination of Cubitt's and Meikle's devices and produced the spring-patent sail. While Captain Stephen Hooper, mentioned earlier, was the most successful of several who devised the annular, or circular sail. However, none of <u>these</u> innovations proved of lasting benefit or of conclusive efficiency and did not gain universal popularity.

John Smeaton, an English civil engineer introduced cast iron generally into windmills. In 1754, he produced an iron windshaft and, after that in England, very nearly all windshafts were made of cast iron. Again, it was a practice not taken up as widely on the Continent. Smeaton also devised the system by which the sail backs are clamped directly to an iron cross attached to the windshaft. This method enabled more than four sails to be used, as the cross could be multi-armed.

The use of multi sails - five, six, eight and even ten-sail mills have been constructed - increased the power available to the miller. In theory, these gave more regular and even drive to the stones, but they did have their disadvantages. Too many, for instance, could affect the flow of the wind over the sails, causing dead spots. Five sailers, too, had a problem if one sail came to grief, as the mill was then unbalanced and could not be worked. However, with even numbers, the opposite sail to the damaged member would be removed, to allow the mill to continue in work.

Weathering the sail, or incorporating a slight twist in the plane, allowed the miller to make use of lighter airs and the more efficient use of strong winds. However, the principle was discovered empirically by the old millwrights and the application varied in different districts. It was left to John Smeaton to investigate and pioneer the scientific study of the size and varying angle of weather, and to arrive at the optimum for a given sail.

ANCILLARY MACHINERY

Nicholas Bolter of Saxony originated the process, named after him, of separating the bran from the wholemeal, by passing it through a fine woolen cloth. The French were responsible for the extension of the process of flour dressing to remove all extraneous material. The resulting white flour was in great demand in Society in the France of the Sun King. Over the period 1765 to 1850, numerous machines were invented, intent on improving the separation of bran and offal from the meal. The ubiquitous wire machine, invented by a Mr Atown of Norfolk, in 1786, being only one of many such devices.

Post mills originally drove just one pair of stones. About 1650, a second was added, as head-and-tail stones, the latter driven from a secondary wheel on the rear of the windshaft. The introduction of spur gears and intermediate gearing, produced the great spur-wheel which allowed two stones to be worked side by side. Indirect drive to the stones via the wallower was a later innovation, in consequence of the introduction of cap mills.

The earliest mills used local stones, but soon Derbyshire Peak millstone grit became standard in England, and was even exported. *Cullin* stones, of laval composition, were so called from a corruption of the name, Cologne in Germany, from which they were exported. They were similar, but neither of these stones was especially suitable for wheat-flour milling, particularly if it was to be reduced to white flour.

French Burrs, a freshwater quartz, were normally quarried in relatively small pieces, and previously had been unusable. With the growing ability to produce stronger iron and steel bands, however, it became possible to bind together the small pieces to form full sized millstones. They began to be used commonly from about 1750. The characteristics of the Burr stone lent it to being eminently suitable for flour milling and it soon found a place in very nearly every mill.

With the introduction of auxiliary power and higher speeds, however, manufactured composition stones, constructed of emery, cement and Burr, were found to be more suitable and economic.

THE MEDITERRANEAN MILL.
JIB SAILS on a typical Portuguese Tower Mill.
OBIDAS MILL, near LISBON.

THE NORTH EUROPEAN POST MILL.

Centre: OPEN TRESTLE Post Mill
at *CHILLENDEN, KENT*

Right: Post Mill with MIDLANDS-TYPE
ROUNDHOUSE.
KIBWORTH HARCOURT MILL,
LEICESTERSHIRE

THE SMOCK MILL.

Left: An early Smock Mill
on a low SILL BASE with
COMMON SAILS and a
BRACED TAILPOLE
to wind the CAP.
WEST WRATTING MILL,
CAMBRIDGESHIRE

Right: Mid nineteenth century
Smock Mill with FANTAIL
PATENT SWEEPS, a STAGE
and a TARRED-BRICK BASE.
LOWER MILL,
WOODCHURCH, KENT

THE TOWER MILL.

Left: An early barrel-shaped
Tower Mill of three storeys with
vertical walls of painted, local stone, a
THATCHED CAP, COMMON SAILS
and winded manually from a TAILBOX.
ASTON MILL,
CHAPEL ALLERTON, SOMERSET.

Right: A later multi-sailed seven storey
Tower Mill with a strong batter to
its brick walls. It has an OGEE CAP,
five PATENT SAILS, a FANTAIL
and a wrought iron STAGE.
MAUD FOSTER MILL,
BOSTON LINCOLNSHIRE.

THE TOWER MILL

The development of the cap mill, slow at first, gained momentum during the eighteenth century, as the problems of cap design and the gear train from windshaft to stones were overcome. Smock windmills, initially proved more popular in England, possible due to the plentiful supply of timber and the tradition this country had of building in wood.

But tower mills, which had proliferated on the Continent, began to be built in greater numbers by the middle of the century. Predominating in the counties north of the Thames, they reached the zenith of their design in Lincolnshire, while smocks continued to be the speciality of Kent and Sussex. However, all three types of mill - post, tower and smock - continued to be built till the end of the windmill era.

The early tower mills were short and barrel-shaped with a large triangular cap; the introduction of batter in the walls allowed an increase in height, while a smaller cap was possible. With growing confidence, millwrights built windmills slender and taller to get the full benefit of the wind. Increasing height demanded a wide stage at a suitable height, to enable the miller to reef the sails and wind the cap.

The advent of the fantail and automatic shuttered sails, though, did away with the need for this. However, the stage continued to be retained for convenience, for use during repairs, to paint and to service the mill. Many were then rebuilt as a narrow walkway, no more than a third of the width of the original.

The design of the cap appears to have taken a regional style. The Kent cap resembles the top of a post mill, while those in Norfolk, an upturned boat; Sussex favours a beehive, Cambridge and Lincolnshire the ogee in variety. Suffolk must have one that is round, while the western parts of the country rely on variations of the old triangular pattern. The cap is the crowing glory of the windmill, and its design owes much to the convictions of the local millwright. Travel undoubtedly broadened the minds of some - for, often, mills are to be found with a cap quite different from that of its immediate neighbours.

The function of the cap, besides carrying the sails round to face the wind, is to protect the tower and the machinery below the roof. One of the most difficult areas to secure against the elements, is the weather beam and the fore end of the windshaft. Another is the curb on which the cap revolves.

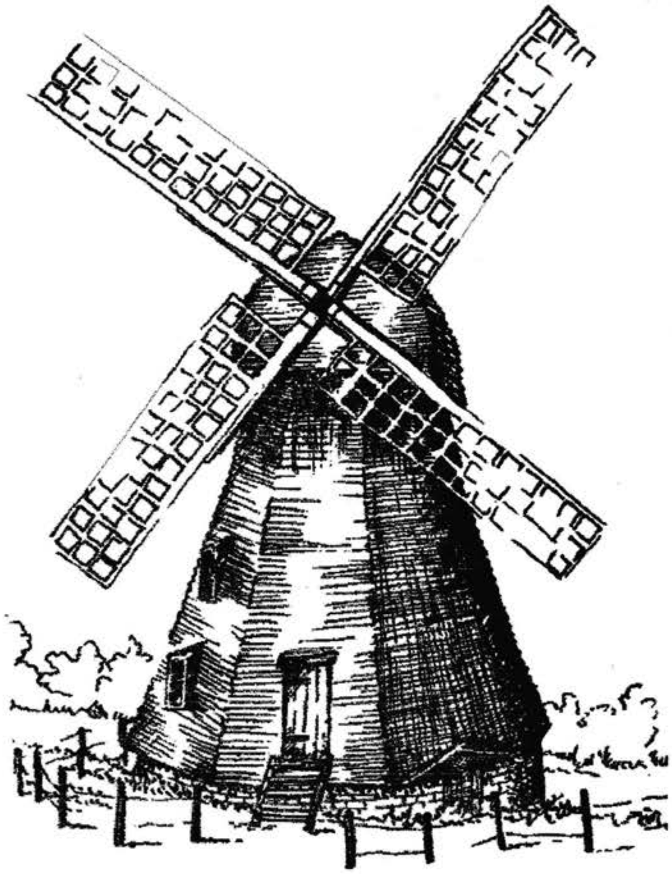
The post-mill type of cap gives the best protection to the cap frame and internal fantail timbers, but is not aerodynamic. The round cap has the best airflow properties, but leaves exposed the ends of the cap sheers and breast beam. No matter how well protected by petticoats, these members eventually rot. The millwright chose the pattern he knew best and protected the timbers as well he could - it would, but, be a compromise at any time.

THE FALL AND RISE OF THE ENGLISH WINDMILL

Almost unique in our times, three windmills within sight of each other, in East Sussex: (left) *HOGG HILL MILL, ICKLESHAM* in the process of being restored, with *GIBBET MILL, RYE*, which has been converted into a house, viewed from the remains of *ST LEONARDS MILL, WINCHELSEA*, demolished in the hurricane of 1987.
These three mills tell it all: dereliction, conversion and restoration - the fate of the windmill.

BELOW:

THE WONDERS THAT CAN BE WORKED WHERE THERE IS A WILL .....



THE DERELICT WINDMILL, IN 1973 .... AND FULLY RESTORED, IN 1989!

The transformation of the windmill at *LACEY GREEN, BUCKINGHAMSHIRE*, the oldest surviving smock mill in England, built in circa 1650. It had been moved from Chesham to its present site in 1821 and worked till 1915, when it ceased and was abandoned. When in a derelict state and on the verge of collapse, it was resurrected by a team of local enthusiasts and put back to full working condition, grinding flour again by windpower in 1992, for the first time in three-quarters of a century.

THE END OF WIND POWER

While most European countries developed their windmills to a high state of efficiency, the absolute pinnacle of design was probably reached in nineteenth century England. Nonetheless, this peak coincided with the appearance of several factors that would combine to kill the windmill within the century.

The Industrial Revolution, which virtually began life in the windmill, with the inventive fervour of the following two hundred years, was to be the cause of its death. The coming of steam, imports of cheap grain from across the Atlantic, the building of the railway network, and the invention of the steel roller mill, all played their part in the decline of the windmill.

Steam was first used to drive millstones in the 1780's, initially as supplementary power. Steam could be generated and used at will and had many advantages over the free, but so wayward, wind. As a result, millers introduced steam plants to be used in periods of calm; but when a mill reached a point where it required expensive repairs, whether due to storm damage or age, the steam mill replaced it.

The final blow came when steel roller mills were introduced from Hungary, where they had been in use since the late eighteenth century. The first to be built in England was at Black friars, on the Thames, in 1784. These had an output far exceeding that of even the largest windmills. They could be sited beside the great ports, where the new imports of foreign wheat were disembarked.

This *hard* grain had the added advantage of producing *strong* flour, which made lighter bread, and was in greater demand than the softer, English wheat-flour. The arrival of fast, efficient transport, in the shape of the train, which would carry this new flour from the ports to every part of the kingdom, bypassing the local windmills, helped steam roller mills dominate the flour trade.

Though superseded in the towns, windmills continued to produce flour for the country districts, throughout the nineteenth century, until they were hit by twin disasters which fell early in the twentieth. First, the introduction of motor transport and improved road communication, which enabled roller-milled flour to reach even outlying villages. Secondly, the stringent restrictions laid on flour producers by new laws of hygiene. From then on, the windmiller was reduced to grist milling of animal feeds alone.

With the reduction in demand for their product, from 1885, windmills increasingly went out of use and, by 1912, they were being destroyed at an incredible rate. The Great War accelerated the process, through the shortage of materials and labour to repair them.

Though there was a period, during the 1930's, when some concern was aroused at the disappearance of windmills, time and the elements took their toll of mill after mill. An important part of our national heritage slipped, almost unnoticed, into oblivion. The destruction continued apace during and after World War II and in the unthinking razing of historic buildings of all kinds in the following decade. However, the mood began to change and, by the mid-sixties, serious thought was given to preserving the few remaining whole mills.

The period since 1965 has been outstanding for the complete rebuilding of windmills that has taken place. The amount of restoration attempted of quite derelict mills, by groups of enthusiasts working together, happily often with assistance from official bodies, is amazing. Since 1980, there has been an acceleration in this attitude and the resurrection of windmills, from the point of veritable oblivion, is gratifying to see.

Sadly, side by side with this noble work, too many mills are still being *converted* into dwelling houses, in the mistaken belief that this saves the mill. There are still too few windmills returned to full working order, using wind power as a motive force. However, a start has been made in the right direction, and each year more are joining the trickle of mills producing stone ground flour by the traditional method, once more.