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Bell Alarms and Sack Hoists in Windmills

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The late H. O. CLARKE (Member) and
REX WAILES, F.S.A., C.ENG., F.I.MECH.E. (Past President)

(*Read at the Science Museum, London, 10 January 1973*)

Before he died, the late H. O. Clark and I collaborated in the drafting of several possible papers for the Society, and this is one of them. The diagrams that he made have been redrawn by Mr. K. C. Lord, (Member), and the photographs are mainly from my own collection, many taken for me by Mr. Hallam Ashley. Plate XIV (a) is by Mr. H. O. Clark and Plate XVI (b) is by Mr. Max Hoather (Member). I am greatly indebted to Mr. T. B. Paisley (Vice-President) for preparing the slides which illustrated the Paper.

It was common practice in English windmills to provide bell alarms to give audible warning of a shortage of grain at the stones. Although of infinite variety, they can be placed definitely in two distinct classes, depending upon the principle adopted. The first comprises a bell in the shoe or the hopper, and the second makes use of a strap traversing the hopper and so arranged that by various Heath Robinson devices it rings the bell.

An example of the first class, exceedingly simple and direct, but one not often seen, was in Spital Hill Tower Mill, Gainsborough, Lincolnshire. Here the bell was mounted on the upper end of a vertical round pillar, bolted to the bottom board of the feed shoe of a pair of stones by means of an old-fashioned flat "harp" spring, similar to those that were once found on shop doors. When at work, the bell was drowned in grain, but when the shoe was empty the bell could ring its warning (Fig. 1). In Butterwick Tower Mill, Lincolnshire, the bell on a similar spring was clipped to the hopper itself (Fig. 2). The principle is the same in that the bell is drowned in grain, and when this runs low, vibration from the shoe causes it to ring.

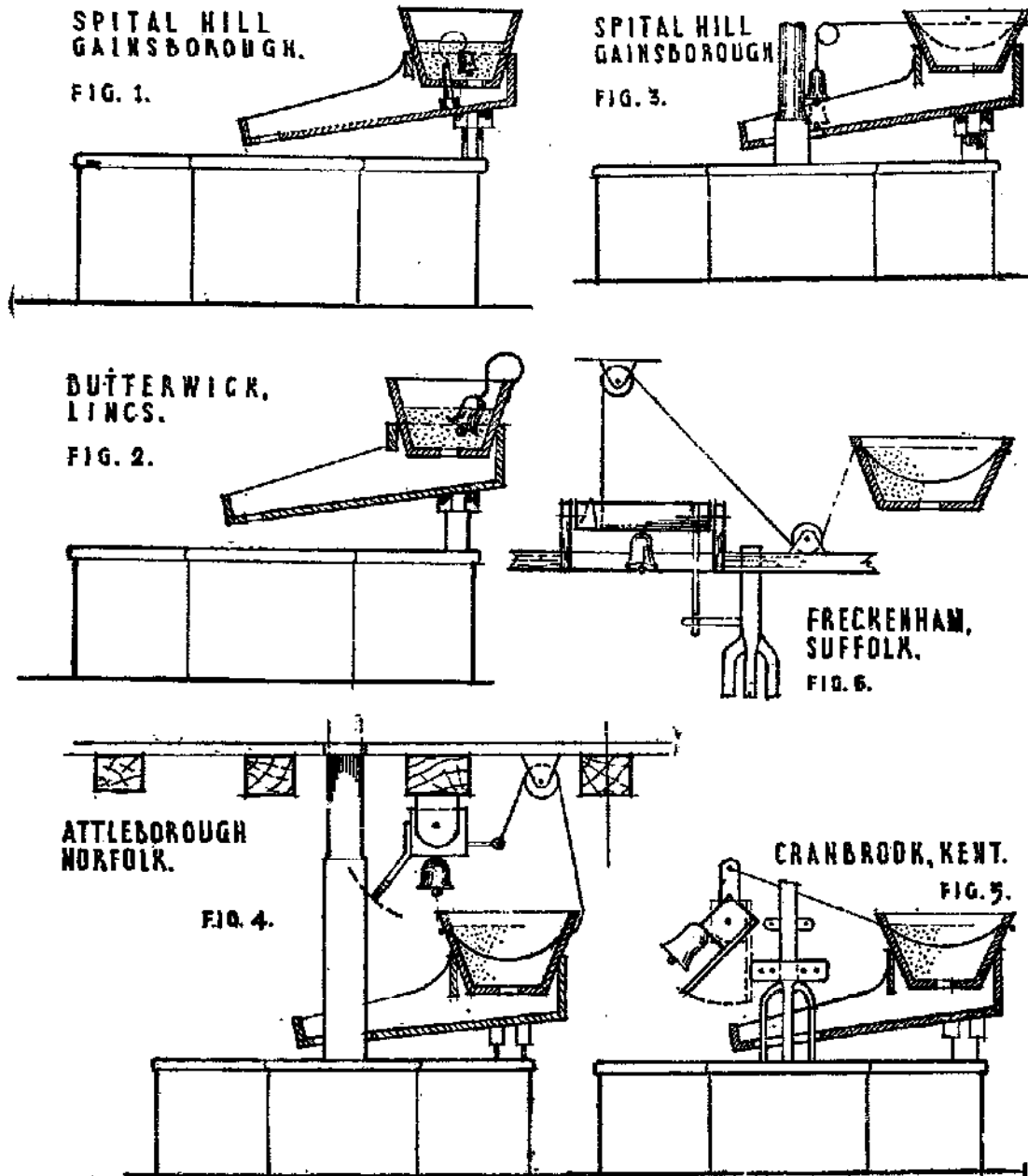
These two examples illustrate the more direct methods, but by far the most common was that in which a strap was stretched across the hopper and was used to operate the bell mechanism. A very direct and effective method was that seen in the post mill at Sprowston, Norwich.¹ The strap, 1½ to 2 in. wide, was anchored at one side of the hopper and on the opposite side it passed through a slot, and a cord at this end of the strap passed over a pulley, suspending the bell. The grain in the hopper bore down the strap until it was restrained by a knot tied in the cord outside the hopper, and the bell was raised. When the grain ran short, the weight of the bell overcame the weight of the remaining grain on top of the strap, and fell until its rim touched the four-armed damsel of the underdrift stones, which rang the bell.

In the case of overdrift stones, the quant was used to effect the same result. On a second pair of stones at Spital Mill, Gainsborough, was the arrangement shown in Fig. 3. With a full hopper, the bell was pulled up to a level with the round portion of the quant, and when the grain ran low the bell dropped and was rung by the squared portion.

¹ *Trans. XXVI 239, Fig. 43.*

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A modification of this idea was to be seen at Attleborough Tower Mill, Norfolk (Fig. 4). The bell was screwed to a square wooden spindle with an iron pivot at each end, working in wood bearings, fixed to the ceiling of the stone floor. A U-shaped staple was driven into the spindle, which also

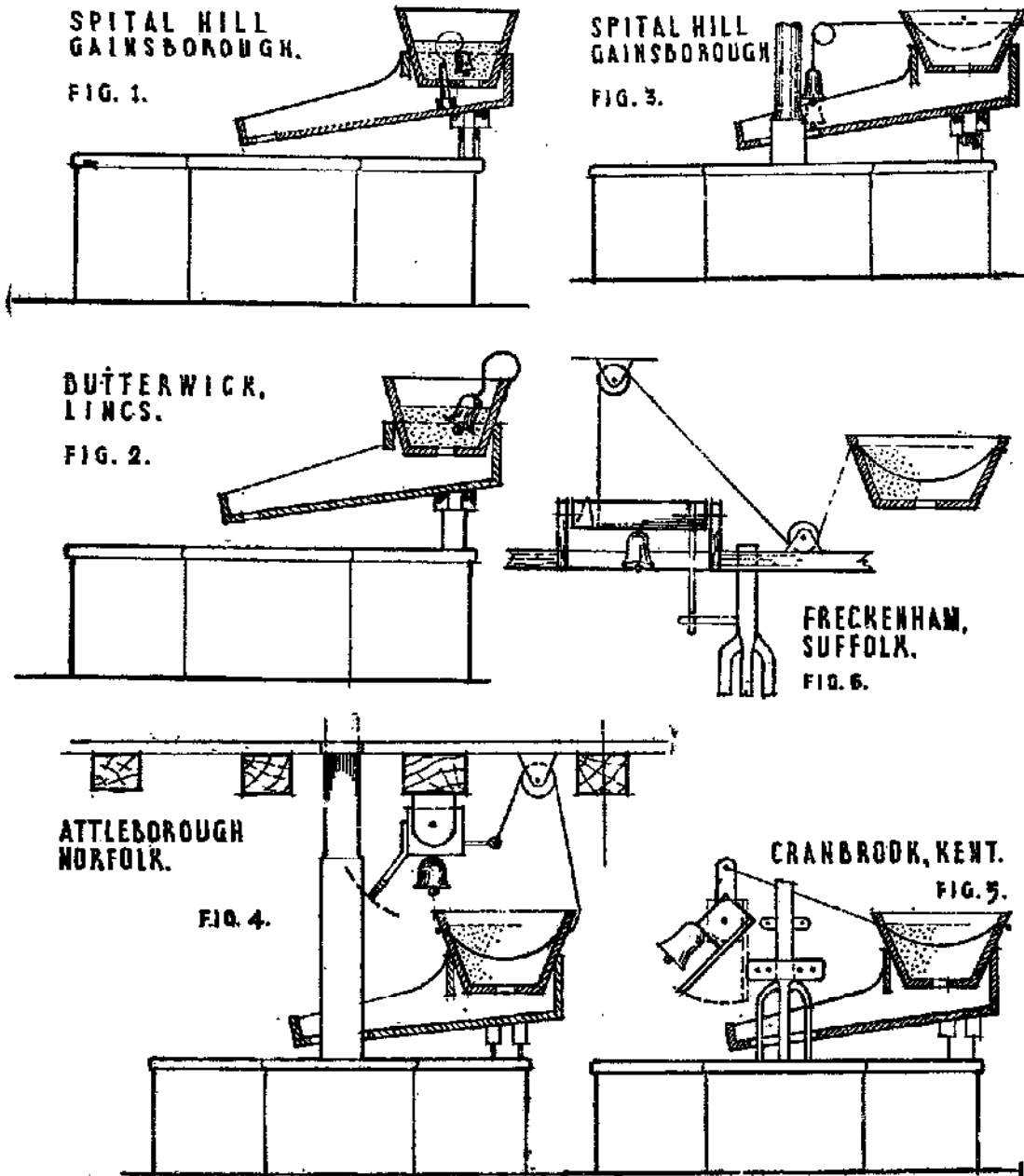


Figs. 1-6. Bell Alarms in English Windmills.

carried a lever, to which was attached a cord running over a pulley to the hopper strap. The lengthening of the cord allowed the pivoted wooden spindle carrying the bell to turn until the staple touched the side of the rotating square quant.

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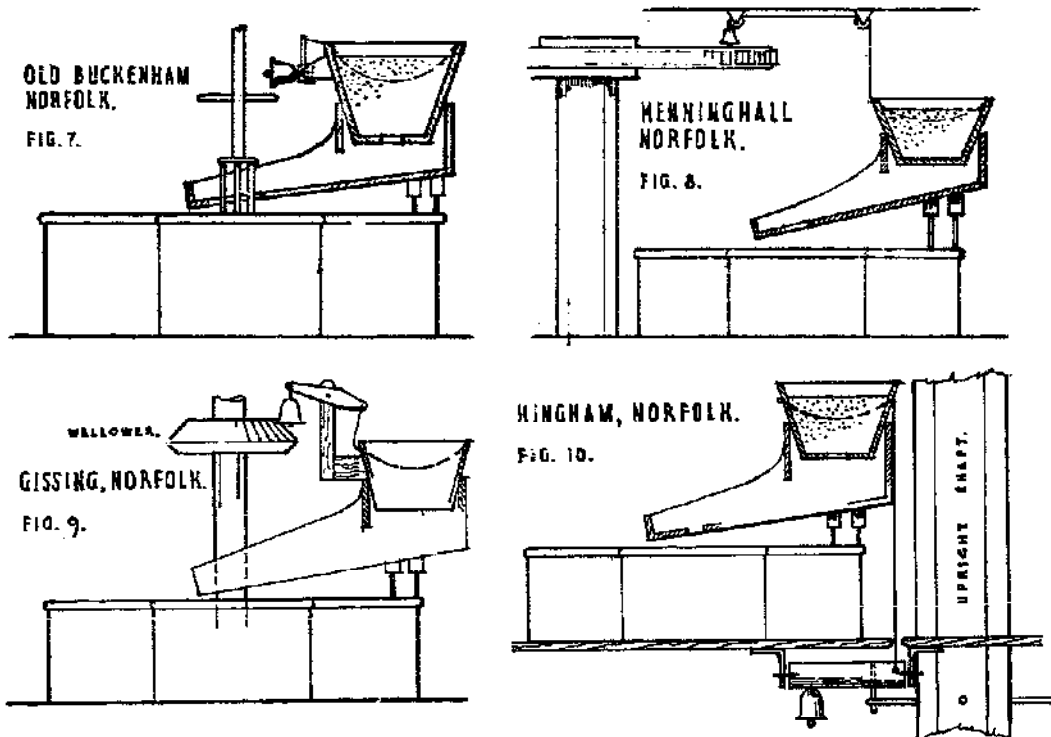
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Alarms were commonly to be found operated by a pin through the damsel or quant, and a typical example was that in the smock mill at Cranbrook, Kent (Fig. 5). Here a bell was fixed to a pivoted wooden spindle, carried on the horse. A crank, fixed to the spindle, received the end of the hopper strap, and normally held the bell up at an angle. When the grain ran low, the bell took up a vertical position, and a flat board on the spindle was hit by a two-armed wooden cam clipped to the damsel. A modification of this arrangement could be seen in the derelict smock mill at Freckenham, Suffolk (Fig. 6). The bell spindle was round and on it were a few turns of the cord, leading over a pulley to the hopper strap. A pin passing through the damsel struck another pin driven into the bell spindle twice each revolution.

An extremely ingenious device, using a pin in the damsel was to be seen in the tower mill at Potter Heigham, Norfolk.¹ The bell was fixed to a slender rod, pivoted at the end remote from the



Figs. 7-10. Bell Alarms in English Windmills.

hopper, the other end of which could traverse a slot worked on the outer face of the hopper itself. The cord from the hopper strap in work sustained one end of the pivoted lever, and with it the bell, so that a pin in the lever cleared another pin in the rotating damsel. When grain ran short, the lever dropped at one end, allowing the pins to engage and ring the bell. A somewhat primitive arrangement was to be seen in the derelict tower mill at Old Buckenham, Norfolk (Fig. 7). A pin in the rotating damsel engaged with the rim of the bell itself. The arrangement of a swinging frame for the bell and its attachment to the hopper strap followed the usual practice.

A further development still used a strap, but some other part of the mechanism was used to strike the bell. The simplest, and incidentally the most direct, could be seen in North Mill, Wymondham

¹ *Trans.* XXVI, 239, Fig. 43.

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Norfolk (Plate XIII (c)).¹ Here the bell was suspended by a cord the other end of which was connected to the hopper strap. When the bell dropped, the damsel struck it. In this mill the bells had different notes for each pair of stones, thus giving the miller definite information as to which hopper was requiring replenishing.

In the derelict tower mill at Kenninghall, Norfolk (Fig. 8), the bell dropped on to the spokes of the wallower. The action was direct, but on the other pair of stones in the same mill the millwright had introduced variety.² In this case, the cord was led over a pulley to a crank driven into a pivoted wooden spindle carrying the bell, and a bell-crank fixed into the spindle dropped to engage the spokes of the same wallower. In the post mill at Gissing, Norfolk, (Fig. 9), a pivoted lever with one end connected to the hopper strap and the other carrying the bell allowed the latter to be struck by the teeth of the wallower. This arrangement was self-contained, and only required fixing bodily to the side of the hopper.

All the above alarms were on the stone floor, and therefore not in the best position to give the alarm, since the miller spent most of his time elsewhere in the mill; so bells located on the meal floor were more easily heard. At Hingham Tower Mill, Norfolk, there was the arrangement shown in Fig. 10. The cord from the hopper strap led straight down by a hole in the floor to a crank pin driven into a pivoted spindle carrying the bell, and an iron pin, which engaged four other iron pins driven into the wooden upright shaft. At Thurston post mill, Suffolk (Plate XIII (a)), the bell was carried in a neat fitting alongside the brake wheel. The cord from the hopper strap drew down the lever and raised it on the other side of the spindle, out of engagement with the rim of the brake wheel; but when grain ran low the further end of the lever dropped, touched the rim and rang the bell.

At Drinkstone post mill, Suffolk, the bell drops on to the stone nuts of both head and tail wheels, while at Horham post mill, Suffolk, a lever fell and touched a pin driven into the edge of the wooden pulley driving the governor of a pair of stones. In Friston post mill, Suffolk (Plate XIII (b)), the bell was allowed to touch the great spur wheel.³ At Syleham and Worlingworth post mills in Suffolk the bell alarm was operated by the arms of the brake wheel and those of the wallower respectively.⁴ At Addlethorpe tower mill, Lincolnshire, the bell fell against the shoe, and illustrations of bell alarms in East Ruston (Plate XIII (d)) and Neatishead tower mills can be seen in *Trans.*, Vol. XXVI, Plate XL, Fig. 3 and XLI, Fig. 1.

But the prize for all bell alarms is that in Upminster smock mill, Essex, and I quote from *Trans.*, XXXI, 167.

"The bell for *each* pair of stones is hung on the end of a thin wooden rod pivoted on a beam in the ceiling. Above the bell, a cord is attached to the rod and passes up and over a pulley on the beam and down to the hopper. A wood batten is nailed to the upright shaft and, when corn runs low in the hopper, the weight of the bell allows the rod on which it is mounted to fall against this batten, which hits the rod and rings the bell."

SACK HOISTS

Sack hoists were not universal. We remember one occasion when a man took a sack of corn on his back, proceeded half way up the tail ladder of a post mill, and then stopped in the most casual way to have a conversation with a friend. On another occasion, a miller grasped a full sack to his body, picked it off the ground, carried it across the mill and placed it on the top of another full sack. These

¹ *Trans.* XXVI 239, Fig. 43.

² *Trans.* XXVI 239, Fig. 43.

³ *Trans.* XXII 54, Fig. 25.

⁴ *Trans.* XXII 52, Figs. 23 and 24.

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two incidents represented actual everyday practice in these mills, and one can readily believe this manhandling of sacks was chiefly a matter of knack and practice. The most primitive aid to sack movement is undoubtedly the sack slide, and some were still to be found in use, especially in post mills, where finished stuff was brought by sack barrow to the head of the ladder, pushed on to a smooth track formed of two or three widths of boards, hinged to the treads on one side of the tail ladder. A landing platform was sometimes arranged at the lower end at a convenient height for a man to take the sack on his back for loading into the wagon. In tower mills, boarded sack slides were also used to some extent to work sacks from the first floor into wagons. The slide in these cases was merely one or two boards set on the slope. The whole gear was portable and very similar to that used by brewers' drays for unloading casks. These designs were not reversible, and so were of little or no use for raising sacks and, in order to do this, a chain or rope drum suitably driven was provided. Not all mills possessed one; they appear to be unknown in the Iberian Peninsula for example, where grain was carried upstairs in plaited straw baskets, the shape of a carpenter's tool bag, and, after emptying into the hopper, the basket is returned downstairs with a kick. In many mills abroad, France, Sweden and the U.S.A., an endless rope passes over a pulley, mounted on the end of a wooden drum, and having a mechanical advantage of about 6 to 1.

The earliest printed description of a sack hoist is quoted in Diderot's *Encyclopedia* of 1765 from *L'Art de Charpentrie* by Maturin Jousse, Second Edition, 1702. In this case, the hoist was driven by a spur wheel on one end of the hoist drum, which could be engaged with the inner side of the brake wheel cogs in a post mill. At the other end of the hoist drum was a frame like a skein winder, round which could be wound a rope; when there was no wind, the hoist could be operated by hand by means of this rope, the frame serving as a skeleton pulley. A similar hoist, but without the hand-gear, could be seen in Keysoe Mill, Bedfordshire (Plate XVII (a)) and in this case the drive could also be used for the flour dressing and other machinery, and the final drive to the hoist was upwards by belt to the hoist drum.

Sack hoists can be placed into three distinct classes, the hoisting drum being driven by

- (i) a slack belt or chain;
- (ii) friction drive;
- (iii) friction clutch.

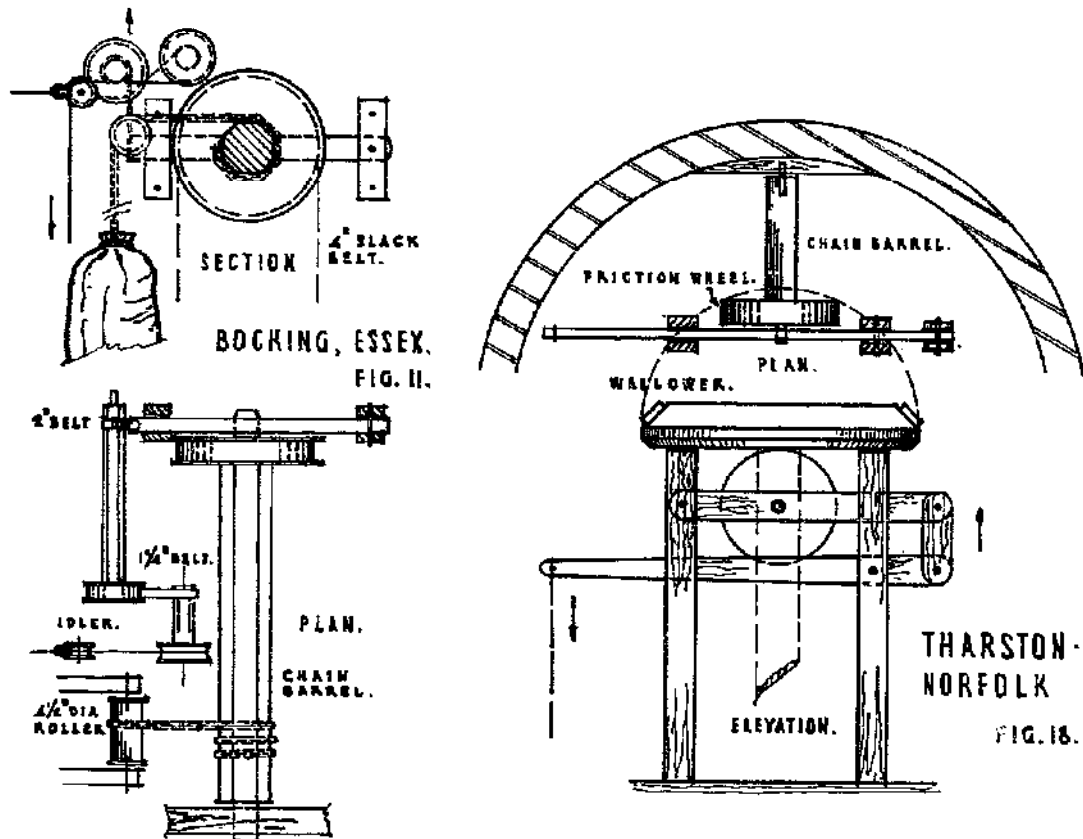
Drums were invariably used for accommodating the sack chain; but an alternative drive was found at Harby tower mill in Leicestershire, where a V-wheel of wood with driving snugs of wrought iron to engage the links of the chain was used. Sack chains were also the rule, and all had the usual ring on one end for making a running noose for attachment to the neck of the sack. But "in a number of cases in Lincolnshire (Plate XVII (d)) an endless chain passing over a Y-wheel was used for hoisting, a hook being used to connect it to a chain round the neck of a sack; while at Bankes's five-sailed tower mill at Alford iron teeth in a wooden V-pulley held every fifth link of the endless chain."

A sack hoist must serve all floors of the mill, and so requires a clear thoroughfare. Where the chain passes through the various floors, the openings are closed and thus made safe by automatic half-trap doors, which are opened by the rising sack and fall to after its passage. When lowering sacks, these doors can sometimes be held open by a staple-shaped piece of round iron. At Harby Mill, Leicestershire, already quoted, there was a proper boarded liftshaft, and the arrangement in the mill was such that it was only necessary to raise sacks to the extreme top of the mill tower.

The sack hoist must be capable of being operated from any floor, and this was done by means of a hand-cord, which passed through holes in the floors adjacent to the hoist shaft. In Butterwick tower mill, Lincolnshire, the miller worked a common horseman's stirrup to the hand-cord for foot operation, leaving both hands free for the sacks.

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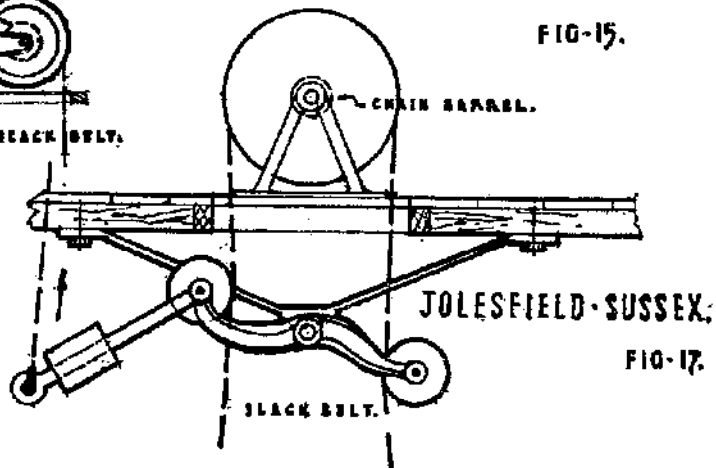
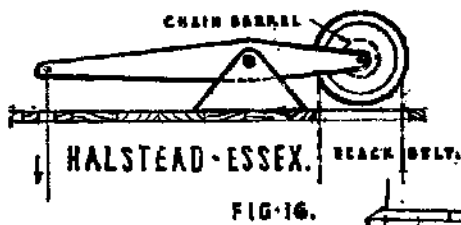
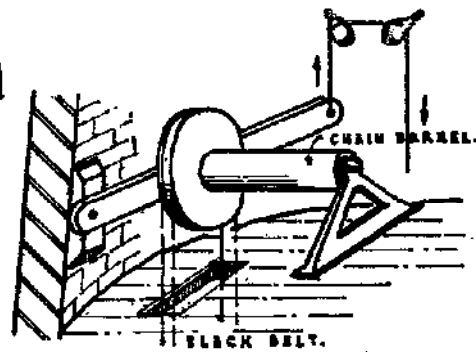
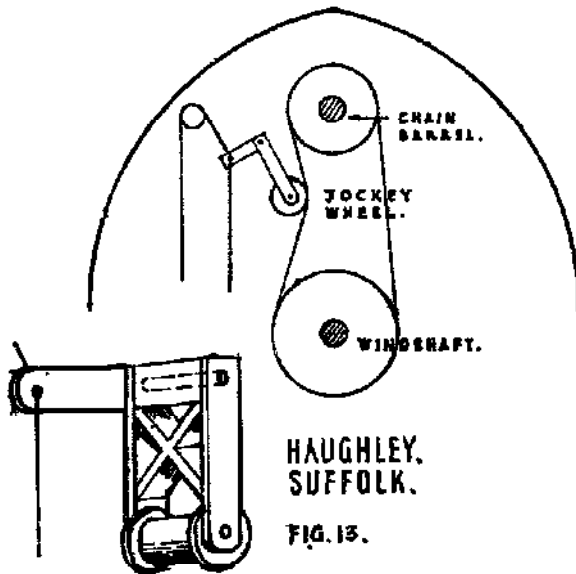
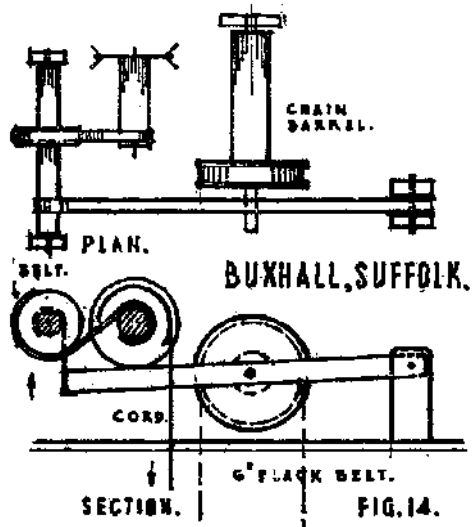
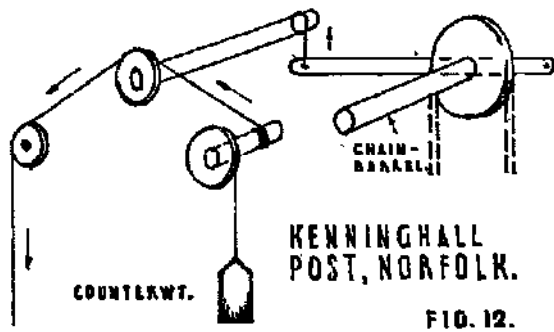
A typical example of the slack belt drive can be seen at Bocking post mill in Essex. It comprises an octagonal chain drum, 8 ft. 6 in. long by 6 in. over the flats with a wooden journal turned on each end (See Fig. 11). The rear journal runs in a hole in a flat bearer of wood bolted to two of the



Figs. 11 and 18. Sack Hoists in English Windmills.

roof spars. The other end runs in a hole in another wood bearer, pivoted at one end and capable of movement in the vertical plane at the other. To this end of the barrel is fixed a wooden pulley over which runs a 4 in. belt to a 3 ft. diameter pulley on the windshaft between the brake wheel and the neck journal. The apparent great length of the barrel is required to bridge the gap between the point at which the drive was applied and the position of the sack shaft, which is here about half way along one side of the mill body. The sack chain passes over a 4½ in. diameter wooden roller, running in wooden bearings and thence down the shaft. The control cord comes up alongside the sack traps, over an idler sheave fixed in the roof, and under another 12 in. wood pulley round which it makes two or three turns and is then made fast. This 12 in. pulley is in one with a short octagonal barrel 3 in. across the flats, on which is fixed a 1¼ in. belt, which passes round an 8 in. pulley on another 3 in. octagon axle. At the front end of this axle another 2 in. belt is wrapped, and depends so as to connect to the end of the rocking frame carrying the main belt drive. A pull on the hand-cord raises the chain barrel by means of the compound rollers, tightens the belt and causes the chain to be wound up and raise the sack. The mechanical advantage of the hand-cord gear is considerable, being $12/3 \times 8/3 = 96/9 = 102/3:1$, and this is again doubled by the leverage of the

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Figs. 12-17. Sack Hoists in English Windmills.

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transom carrying the main belt. This class of hoist is of extremely good design. Its parts are admirably suited to being placed in the apex of a post mill roof, where they are out of the way and the simple and ingenious combination of two wheels and axles gives the miller perfect control over the hoist. All the parts are simple and easily made entirely of wood and, in order to avoid the use of a lathe, all the barrels are made octagonal in cross section, instead of round, without apparent disadvantage. There is no ironwork whatsoever, except a few common bolts and nails, and this class of hoist gives no trouble in use, since the main drive has generously proportioned pulleys and a wide belt. The design in this respect is correct, since in the idling periods the belt hangs away from the continuously rotating windshaft. In this mill it is interesting to note that the pulley on the windshaft is covered on the rim with a series of wood slats, nailed on in order to give some extra grip, possibly necessitated by the escape of lubricant from the adjacent neck bearing.

It is found sometimes that the hand-cord has a tendency to stick, and does not readily return to the off position. To overcome this difficulty, the rocking frame, carrying the main pulley, is made especially heavy at the moving end so as to drop the main pulley smartly, or else an extra weight is added elsewhere. At Kenninghall post mill, Norfolk, a balance weight, passing over a separate pulley, had the same effect, (see Fig. 12).

At Haughley Mill, Suffolk, there was a hoist of this type in which the axis of the chain drum was maintained on the level, and the tightening of the belt was effected by a double flange wooden jockey pulley, carried in a neat and well-designed wooden frame pivoted at one end. A lever on the jockey frame was connected through a system of inclined sheaves to the hand-cord, (see Fig. 13); for a similar arrangement at Mayfield see Plate XIV (*d*).

It was not uncommon to find similar drives using ordinary short link chains instead of belts, and examples could be found at Shelford and Tuxford, Nottinghamshire, and Gissing in Norfolk,¹ Harby in Leicestershire, Lowfield Heath in Surrey, Stanton in Suffolk and elsewhere.

In tower mills, where there are entirely different conditions, there is more variety in design. The principle of slack belt was commonly found and the chain drum could have either movable or fixed pivots. A good example of a swing frame axle was to be seen at Buxhall tower mill, Suffolk, (Fig. 14). Here a chain barrel of wood was fixed to the same shaft as a pulley, carrying a 6 in. belt running over a pulley on the floor below. The pulley end of the barrel was carried in a horizontal swinging frame, the outer end of which could be swung through the medium of two wheels and axles, the second of which connected to the drum cord, and the other to the swing frame.

This tackle was set up in 1860, and the original bill of materials and labour still exists.

October 11	A new sack tackell roul 4 ft. 8 in. long 7 in. dia. with gudgeon and hoops, turned up	..	16/-
October 11	A pr. chairs and brasses and 1 cupling brass for do.	..	13/-
October 13	A new wood rigour 19 in. dia. 6 in. thick fitted on sack tackell roul.	..	12/-
October 27	New sids to sack tackell rigour turned up and turning up rigours	..	7/-
October 27	54 ft. of best hoisting chain for sack tackell 44 lb.	..	£1. 2/-
November 6	A peace of do. (leather) 5 ft. 8 in. long 1½ in. wide for sack tackell.	..	3/-

Note. A roul is a roller, a chair and a brass is a plummer lock, but it is not clear what a cupling brass is. A rigour is a flanged pulley.

A more direct and undoubtedly simpler class of sack hoist was to be seen at Haddiscoe Mill, Norfolk, (Fig. 15). Here the end of the swing frame, carrying the end of the sack drum, was directly connected with the hand-cord. With large pulleys and wide belts, the command over the load was quite good, both for hoisting and lowering. A common size of pulley would be in the region of 3 ft. diameter, and the belts ranged in width from 4 to 6 in.

At Halstead Mill in Essex, (Fig. 16), the barrel pivot was carried at the end of a pivoted wooden

¹ *Trans.* XXVI, 240, Fig. 44.

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lever. This is the most direct method, but may require counter-balancing to bring the system smartly back to the off position as at Billingsford (see Plate XVII (b)).

In some cases, vertical barrels, working on the slack belt principle, were to be found. In the tower mill at Kenninghall, Norfolk,¹ a double-flanged pulley on the upright shaft drove the pulley on the chain barrel, the upper bearing of which was fixed to the tower. A pivoted bearing at the lower end had a counter-weight passing over a pulley to maintain the gear in the off position, and a compound wheel and axle, working the lower end of a wooden lever, tightened the belt as desired.

In a number of cases the drum-shaft was a fixture, and a jockey pulley was employed to tighten the belt. A typical example was to be seen at Sutton tower mill, Norfolk. Here a horizontal chain barrel with a belt pulley ran in three pedestals fixed to the top floor. A flat belt ran off a pulley on the floor below, driven by a pair of bevels, from the upright shaft. An iron frame of bellcrank form swung from two of the pedestals carrying the upper pulley. The hand-cord was connected to one end of this bellcrank, and at the other was a jockey pulley. At Potter Heigham tower mill, Norfolk, the vertical slack belt was controlled by a jockey pulley carried in a trolley, capable of sliding in a grooved track on the intermediate floor. A heavy counterweight, worked by cords, was used to bring the carriage back to the off position, and a similar device could be seen at Hingham tower mill, Norfolk. But here the carriage was moved by a long lever, to the end of which was connected the hand-cord, and again a counterweight was used to return the carriage.

At Jolesfield smock mill, Sussex (Fig. 17), there was an elaboration of the jockey pulley drive of an advanced design, indicating a later installation. Here the driving pulley was on a horizontal shaft on a lower floor, and driven from the upright shaft, and the belt was vertical with the chain barrel on the floor above. To the ceiling was fixed a neat cast-iron A-frame, in which rocked an ornamental cast-iron frame with two jockeys, one for each side of the belt. A continuation of the rocking frame formed a combined counterweight and hand-cord attachment, and the general design is clear from the figure.

In nearly all cases where a chain barrel is combined with a rising and falling friction drive, it is the underside of the wallower that is used. At Tharston and Carbrook tower mills, Norfolk, (Fig. 18 and Plate XVI (a)), a smooth track was formed on the underside of the wallower, engaging with a friction pulley on one end of the chain barrel. The barrel had one bearing fixed to the tower and the other to a compound system of wooden levers, which enabled this end to be raised with sufficient pressure to get a friction drive to the barrel. The hand-cord was connected to the long arm of the compound lever, and similar arrangements could be seen at Stokesby Mill, Norfolk, and elsewhere. The principal differences lay in the levers and there were many methods of applying the very considerable pressure required. One ingenious example was at Fulstow tower mill, Lincolnshire (Fig. 19), where again the underside of the wallower was used. The friction wheel was carried on one end of a pivoted wooden bar and pressure was applied by a lever on a spindle carrying a small pulley on which was wound a few turns of a short chain. It is interesting to note that one support for this lever spindle was carried on the moving main lever itself. At Old Buckenham tower mill, Norfolk², a simple wooden lever was provided to apply the pressure, and the action was more direct than the preceding example. It should be remembered, however, that some of these apparently complicated systems of levers were really necessitated by the relative positions of the hoist drum and the control cord.

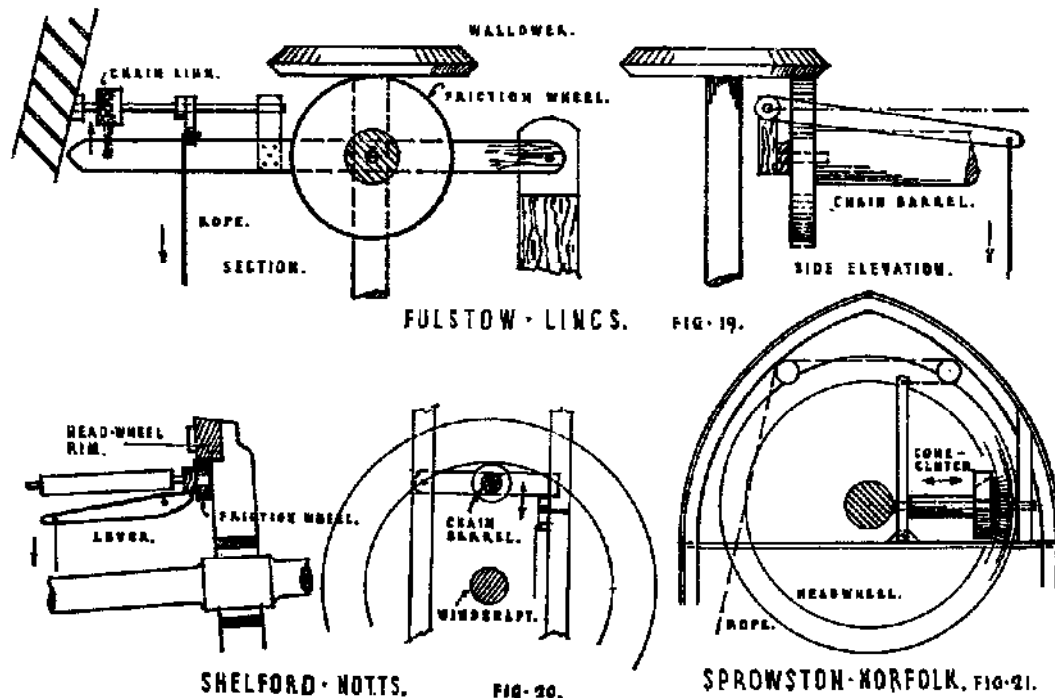
At Shelford post mill, Nottinghamshire (Fig. 20), was a modification of the friction-driven barrel. The chain barrel was fixed in the apex of the roof and carried at one end a parallel friction pulley,

¹ *Trans.* XXVI 251, Fig. 49.

² *Trans.* XXVI 240, Fig. 44.

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arranged to work against the inner rim of the brake wheel. A simple lever transmitted movement to the friction drum from the hand rope.



Figs. 19-21. Sack Hoists in English Windmills.

In the case of tower mills, the friction wheels themselves are often true pitch cones. The surfaces are generally of wood, but sometimes one of them is of cast iron, and in some cases have had to be covered in a crude manner with leather or other material to increase the coefficient of friction, while in other cases, in place of a system of compound levers to increase the pressure of the hand-cord, double wheels and axles have been provided instead and in a very similar manner to the slack belt hoists.

In addition to the gear drive already quoted there were several quite remarkable drives in post mills. At Chinnor Mill, Oxfordshire, a spur gear was mounted on the windshaft itself and drove the sack hoist through another similar gear. At Oldland Mill, Ditchling, Sussex, two face gears engaged with the cogs of the brake wheel on either side. They drove back by belts to the same transverse shaft, and from this the drive was taken to a second shaft at right angles to the first and up to the chain drum by belt and pulley. At Madingley Mill, Cambridgeshire, an iron pinion engaged with the outside of the brake wheel cogs and the shaft drove the sack hoist through a friction gear. At Wittersham Stocks Mill, Kent, the drive was taken from the inner corners of the brake wheel cogs, and in Paul Sharpe's Mill, Biddenden, and at Frittenden Mill, both in Kent, the sacks came up the stairway and a hinged ladder was pushed by them. At Broxted Mill in Essex, the drive was by skew gear from the brake wheel to a countershaft and a slack belt. Newton Mill, Nottinghamshire, had two hoists, one friction-driven from the brake wheel, and the other by slack chain from a pulley in front of the tail wheel. The latter had a ratchet wheel fitted to the end of the drum.

Chesterton tower mill, Warwickshire, is notable in that it has a sack hoist driven by a friction disc on the upright shaft, quite separate from the lantern wallower. Many tower mills had sack

hoists driven from bevel rings, either below the wallower or above or below the great spur wheel. In Essex, Baker Street smock mill, Orsett (Plate XVII (c)), had a down-turned wooden face gear below the dust floor, which drove a wooden spur pinion, mounted on a wooden stub-shaft, together with a pulley and a belt drive to the sack drum above. At Maggots End Mill, Manuden, a down-turned face gear drove a trundle face gear on a square wooden shaft at right angles to it, and thence by belt to the sack hoist. At Stansted Mill an upturned face gear on the upright shaft drove a wooden spur pinion on the sack belt spindle. All these three gear drives were the most primitive seen in any tower mills. In Kent at Benenden Mill the bevel wheel, driven from below the wallower, transmitted the drive through two friction wheels, and at Legbourne wind and watermill the water-powered sack hoist was driven from an iron friction ring below the great spur wheel. In Cambridgeshire at Over Mill the slack belt was normally tensioned, and the drive had to be pulled off instead of on. At Shade Mill, Soham, there were two independent drives from the friction ring, one for each of the two bins. At Ingles' Mill, Willingham, a nut from the great spur wheel drove down to a pair of bevels in the ceiling of the ground floor, and these transferred the drive to a horizontal countershaft and it was taken upwards by slack belt. In Suffolk at Wortham smock mill, on a section of the upright shaft which was older than the mill, there was an upturned compass-arm wheel with six stop-chamfered arms for driving the sack hoist, and Peasenhall smock mill at one time had an upturned wooden bevel friction-ring on the upright shaft. (See also Plates XV (a) & (b), and Plate XVI (b).

At Sprowston post mill, Norfolk,¹ the hoist was fixed on a level with the windshaft and just in front of the brake wheel (see Fig. 21). A pinion on the barrel shaft engaged with the teeth of the brake wheel, hence the barrel spindle was always rotating, while the mill was running. To this spindle was fixed the male portion of a cast-iron cone-clutch. The loose barrel carried the mating half of this clutch, and could be moved bodily lengthwise by a long vertical lever. The position of the hoist being some distance from the shaft necessitated a number of guide sheaves for both sack chain and hand cord. The continuously rotating clutch spindle and the difficulty of adjusting the cone clutch to be quite free was a disadvantage, and may have accounted for the infrequent occurrence of this type of hoist. The same advantages appeared in another cone clutch drive at Hickling tower mill, Norfolk, but here the clutch shaft was driven from the underside of the crown wheel.

The following half tone illustrations of sack hoists have appeared in the *Transactions* :

Vol. XXII, Pl. VI, Peasenhall and Framsdon post mills.

Vol. XXIII, Pl. XII, Wortham smock mill.

Vol. XXVI, Pl. XXXIX, Fig. 4, Walpole Highway tower mill.

Vol. XXVIII, Pl. XXXI, Fig. 2, Chesterton tower mill.

Vol. XXVIII, Pl. XXXVII, Fig. 4, Wrawby post mill.

Vol. XXIX, Pl. XLI, Fig. 2, Chillenden post mill.

Vol. XXXI, Pl. XVIII, Fig. 2, Stock tower mill.

Vol. XXXI, Pl. XIX, Fig. 1, Aythorpe Roding post mill.

Vol. XXXIII, Pl. XXVI (a), Dale Abbey post mill.

¹ *Trans.* XXVI 251, Fig. 49.

The figures in Vol. XXVI are all from diagrams made by H. O. Clark.

PLATE XIII



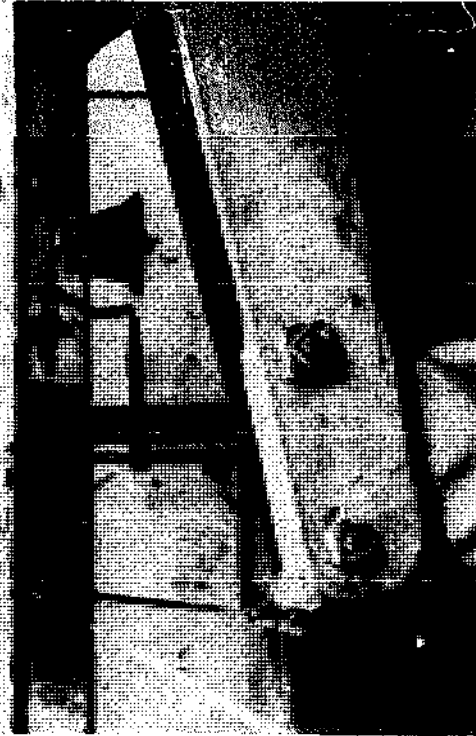
(a) Thurston Post Mill, Suffolk. Lever struck by brake wheel



(b) Friston Post Mill, Suffolk (1938). Lever struck by tail wheel



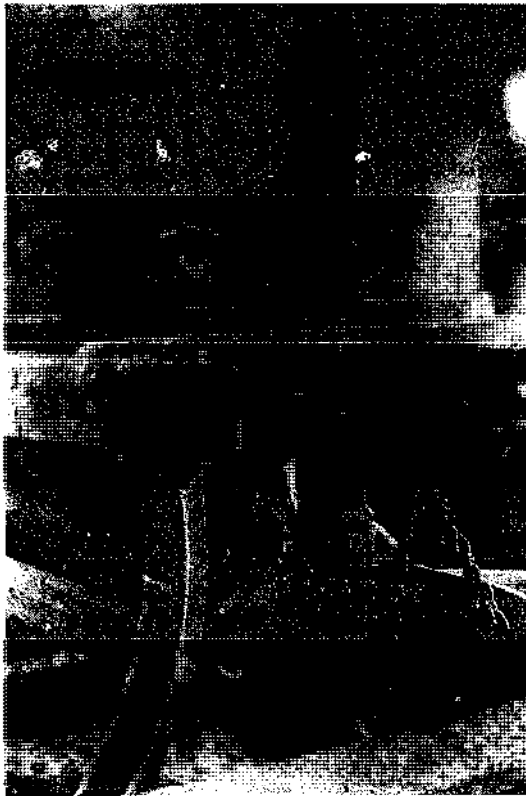
(c) North Mill, Wymondham, Norfolk. Bell falls against damsel



(d) East Ruston Tower Mill, Norfolk. Bell struck by pin on damsel

BELL ALARMS

PLATE XIV



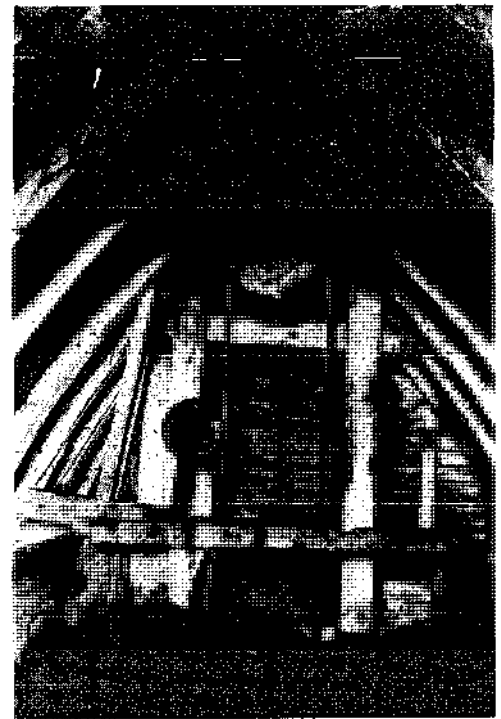
(a) Saltfleet Tower Mill, Lincs. Bell falls against ribs on quant
(Photo H. O. Clark)



(b) Westgate, Lincs. Bell falls against teeth of the great spurwheel



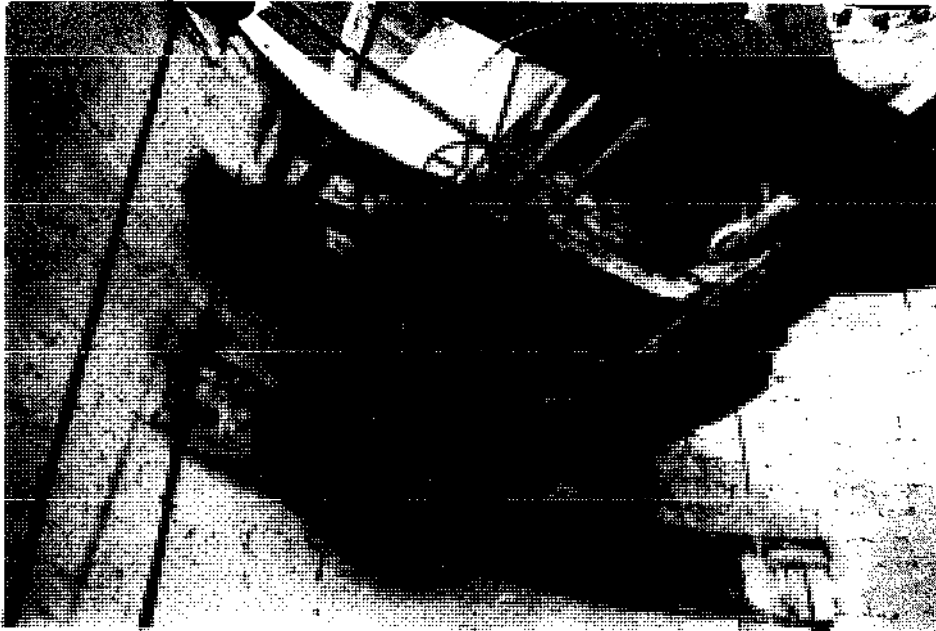
(c) Hickling Tower Mill, Norfolk. Down-turned bevel gear on wooden wallower drives wooden bevel wheel and slack belt



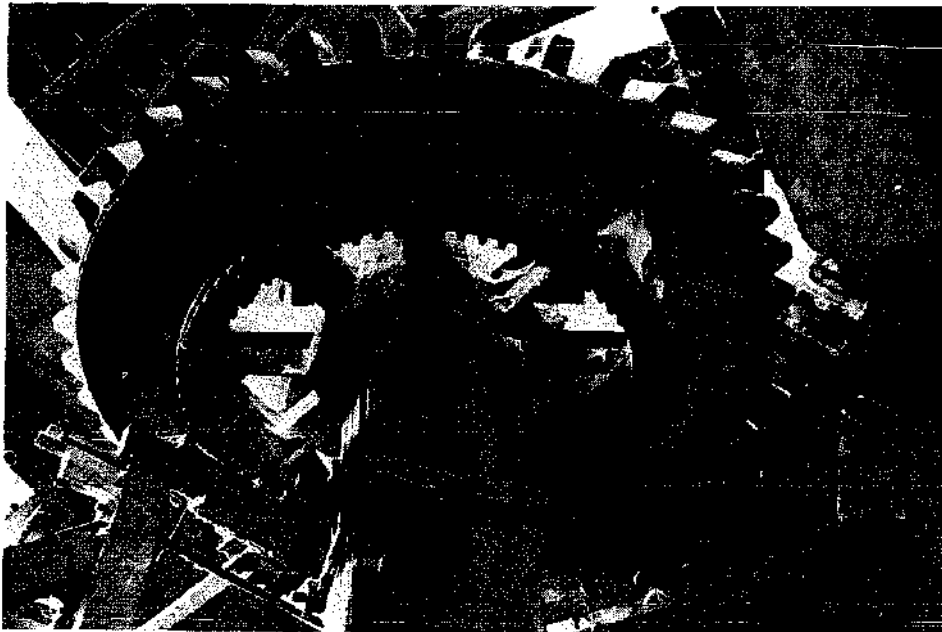
(d) Argos Hill Post Mill, Mayfield, Sussex. Spur pinion engages flanks of brake wheel and slack belt is tensioned by jockey pulley

BELL ALARMS (*above*); SACK HOISTS (*below*)

PLATE XV



(a) Final slack-belt drive



(b) Primary drive by bevel ring below wallower
SACK HOIST, DENVER TOWER MILL (NORFOLK)

PLATE XVI



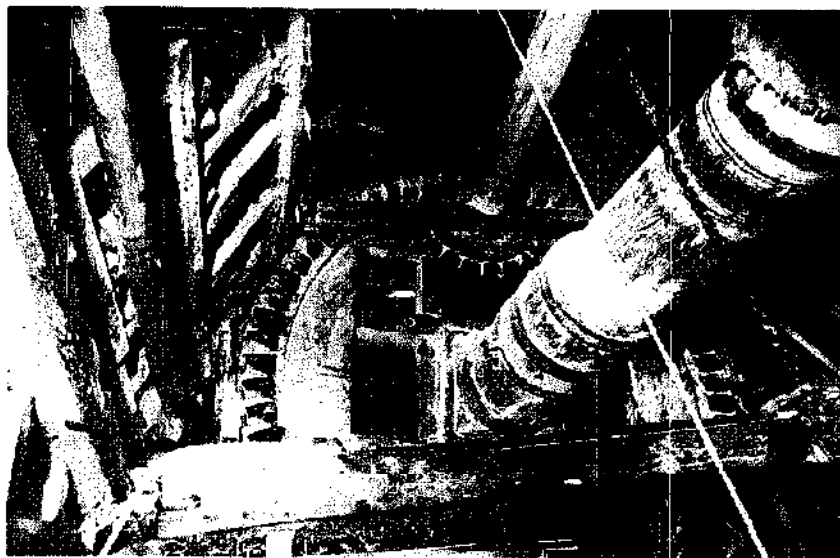
(a) Carbrooke Tower Mill, Norfolk. Bevel friction drive from underside of wallower



(b) Blundeston Tower Mill, Suffolk. Bevel ring on upright shaft; final drive by slack belt

Photo: Max Heather

SACK HOIST DRIVES



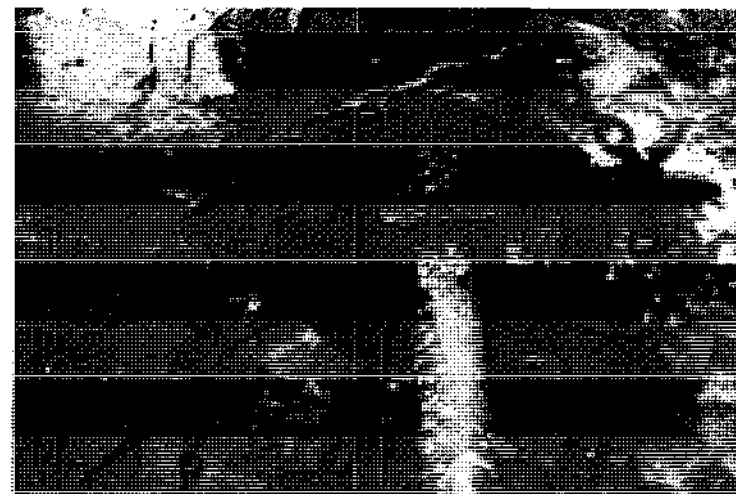
(a) Keysoe Post Mill (Bedfordshire). Spur pinion engages flanks of brake-wheel cogs. Final drive by slack belt (not shown)



(b) Billingford Mill, Norfolk. Weight holds sack hoist off



(c) Baker Street Smock Mill, Orsett, Essex. Down-turned facegear drives spur wheel. Final drive by slack belt



(d) West Butterwick Mill, N. Lincs. Sack hoist worked by endless chain

SACK HOISTS