

*The Mill made open that the
whole Engin may appear*

Fig. 1. An early fixed windmill (from the 1652 reprint of Walter Blith's *England's Improvement*).

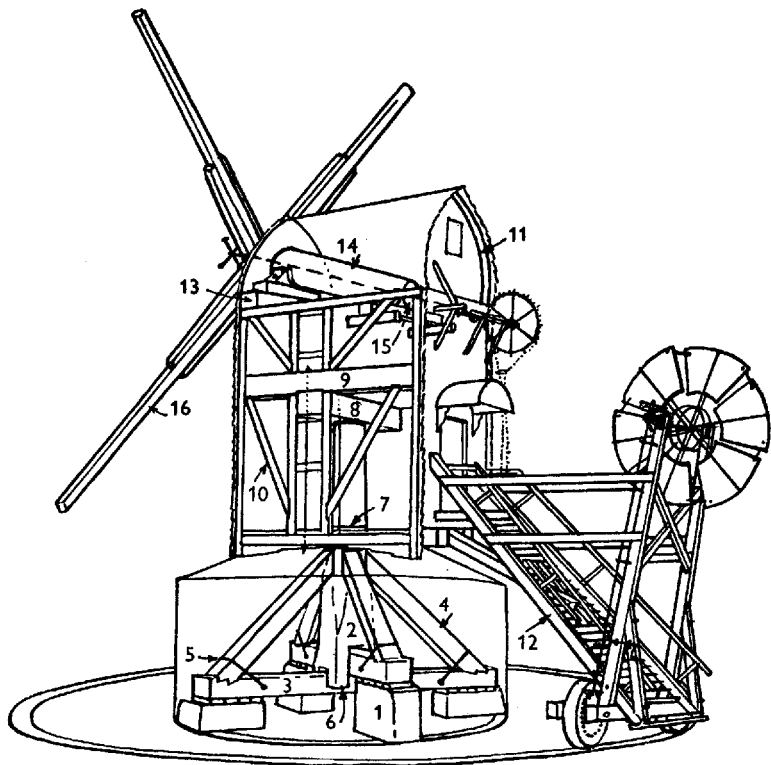


Fig. 2. A typical East Anglian post-mill.

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|----------------------|---------------------|---------------------|
| 1. Brick pier | 7. Centering wheels | 12. Steps or ladder |
| 2. Main-post | 8. Crown-tree | 13. Weather-beam |
| 3. Cross-tree | 9. Side-girt | 14. Wind-shaft |
| 4. Quarter-bar | 10. Brace | 15. Tail-beam |
| 5. Retaining strap | 11. Cap-rib | 16. Sail-stock |
| 6. Heel of main-post | | |

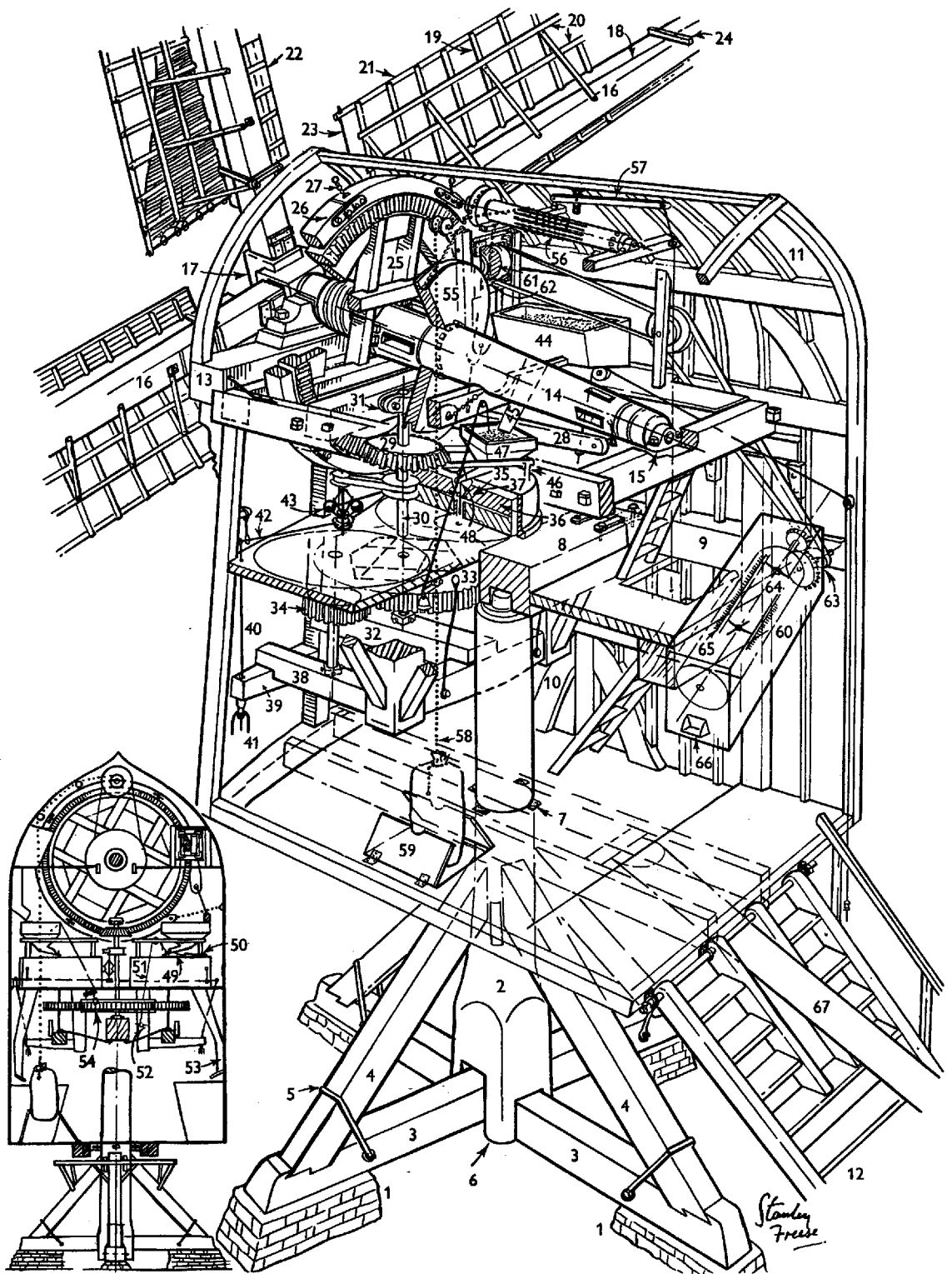


Fig. 3. Detail of Brill windmill.

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|----------------------------------|------------------------------|-------------------------------|---------------------------|
| 1. Brick piers | 18. Sail-shaft or whip | 35. Cross-bar or bridge-piece | 52. Feed adjustment screw |
| 2. Main-post | 19. Sail-bars | 36. Upper or runner-stone | 53. Meal spout |
| 3. Cross-trees | 20. Uplongs | 37. Rhynd or mace | 54. Bell alarm |
| 4. Quarter-bars | 21. Hemlath | 38. Bridge-tree | 55. Sack-gear 'take off' |
| 5. Retaining straps | 22. Wind-board | 39. Brayer | 56. Sack bollard |
| 6. Heel, or tongue, of main-post | 23. Curtain-rail | 40. Tentering rod | 57. Sack control lever |
| 7. Centering wheels | 24. Sail cleat | 41. Tentering screw | 58. Sack chain |
| 8. Crown-tree | 25. Brake-wheel | 42. Steelyard | 59. Sack trap |
| 9. Side-girt | 26. Brake | 43. Governors | 60. Dresser case |
| 10. Diagonal brace | 27. Brake-chain | 44. Grain bin | 61. Auxiliary 'take-off' |
| 11. Cap-ribs | 28. Brake-lever | 45. Grain spout | 62. Auxiliary gear-frame |
| 12. Steps or ladder | 29. Wallower | 46. 'Horse' | 63. Dresser gears |
| 13. Weather-beam | 30. Upright shaft | 47. Hopper | 64. Dresser |
| 14. Wind-shaft | 31. Glut-box on spindle-beam | 48. Damsel | 65. Wire brushes |
| 15. Tail-beam and bearing | 32. Bridge-beam | 49. Feed shoe | 66. Dresser spout |
| 16. Sail-stock | 33. Great spur-wheel | 50. Spring stick or 'rabet' | 67. Tail-pole |
| 17. Poll-head or canister | 34. Stone-nut | 51. Feed adjustment cord | |

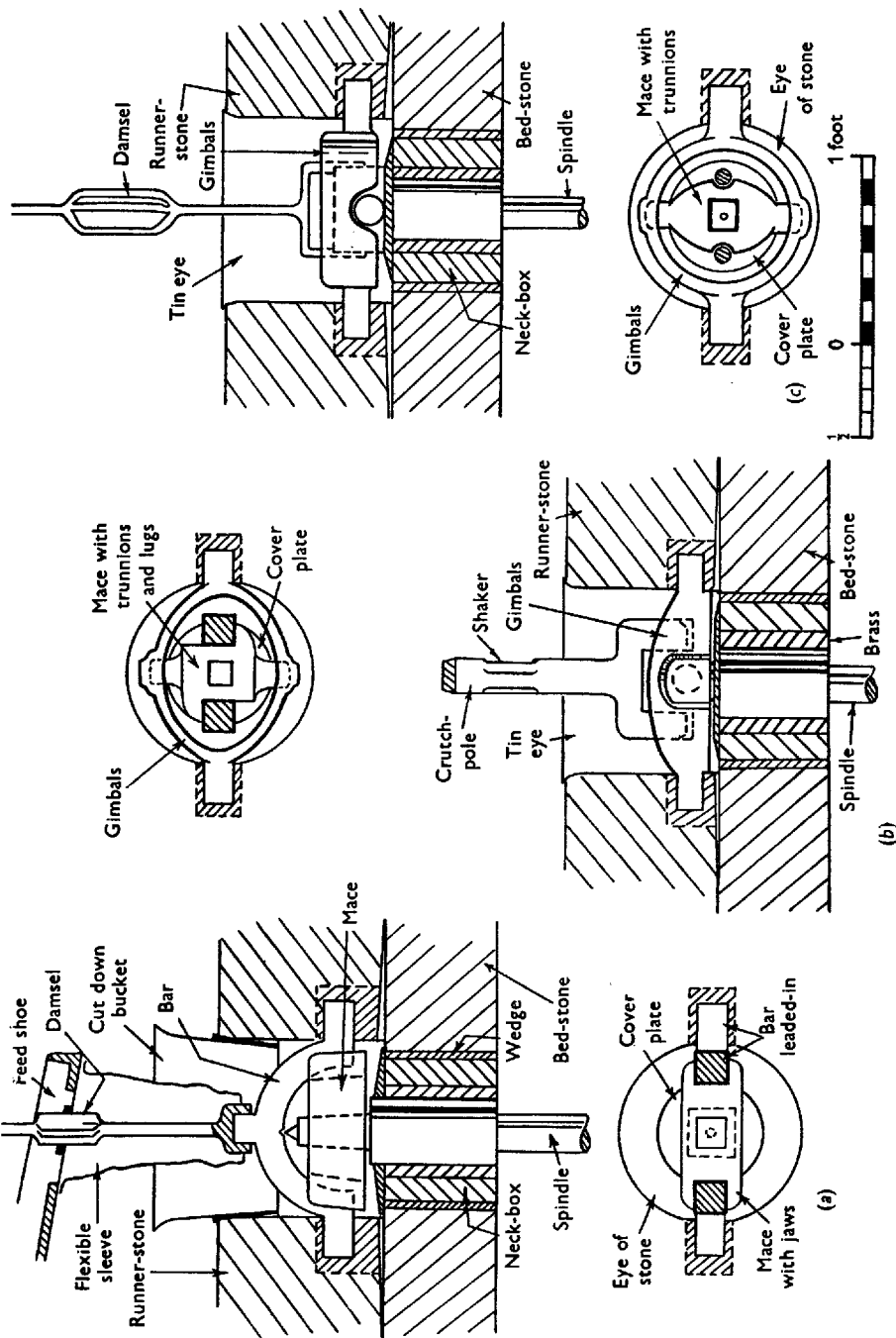


Fig. 4. (a) Underdrift stone, with centre-bar and mace; the damsel can also fit over the bar on to the mace, as in (c). (b) Overdrift stone, with gimbal. (c) Underdrift stone, with gimbal.

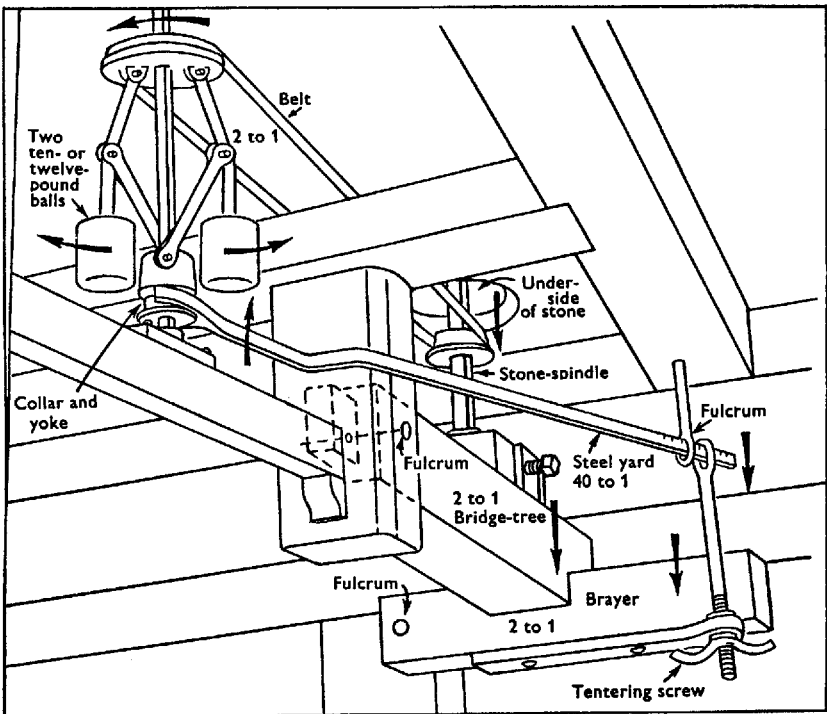


Fig. 5. Tentering gear controlling the tail-stones of Syleham Mill; the heavy arrows indicate direction of movement when the governors accelerate.

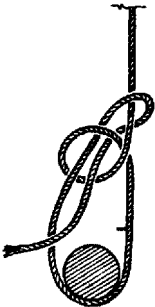


Fig. 6. The
bowline knot.

COGGING THE MILL

But while all these many and various preparations are going forward, an important self-contained job is being done by an expert amongst experts—a master craftsman of the countryside is making and fitting the many wooden cogs in the great wheels as they come to him from foundry or joiner's bench. For these a stock of 2 in. apple- or beech-boards was kept in hand by old-time millwrights; but such watermill cogs as were continually exposed to moisture were of oak.

The cutting of anything from 70 to 140 mortises in a big wooden wheel is one of the most skilled arts of the millwright, always presenting pitfalls for a careless workman. All need to be precisely the same size and shape, and all evenly spaced to a hair's breadth; for a faulty mortise will not hold a cog for long.

When cogging a wheel in the workshop, it is convenient to mount it keyed on its axle with one end of the axle resting in a block secured to the doorpost, where plenty of light falls, and the other end on a portable bench, so that the wheel may be revolved in a true circle as and when desired.

An iron wheel, or an old wooden one, will be mortised already, but a new wooden one will next require marking out for this purpose. A rigid horse is set alongside the wheel, to take a scribe or marker, and an improvised crank-handle is tightly fitted on to the axle, to turn the wheel so that the marker will describe a circumferential line along which the cogs are to be spaced. The exact centre-line of every mortise is then marked off very carefully upon this line by setting a sharply pointed pair of dividers to the dimension previously calculated to give the required spacing, and working care-

fully round the circle till the starting point is reached again. If there should be a small error at the finish, the dividers will be adjusted accordingly, so that eventually, and not without a good deal of trouble, the correct markings are established.

Now the full outline of each mortise can be set out; and the corresponding outlines on the back of the rim (where the shanks of the cogs will project) are traced round it with a try-square. The mortises are drilled with an auger, then chiselled with the broadest practicable chisels, bearing in mind the taper of the mortise; and little discrepancy will be found if a good tradesman has been deputed to the task.

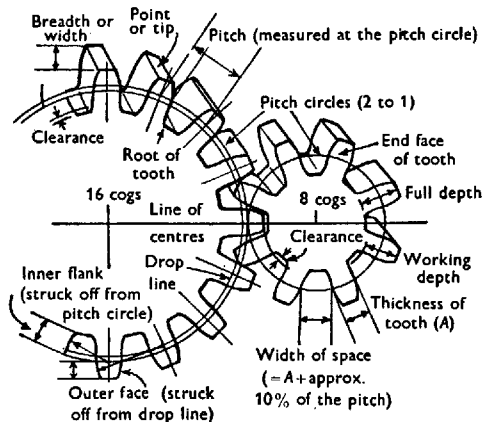


Fig. 7. Detail of cog-wheels.

Fitting 'Blank' Cogs

Cog 'blanks' are sawn from a heavy plank, preferably apple-wood, which must have been felled over nine years (or the cogs will eventually shrink), and the shanks of the cogs are accurately sawn to shape. All the cogs are driven into their mortises up to the shoulders with a heavy mallet; and any cogs found to be slack or easy-fitting are scrapped and done again. A trimming tool is now set in the stand, to turn up the two end-faces of all the cogs and give them their true breadth (see Fig. 7).

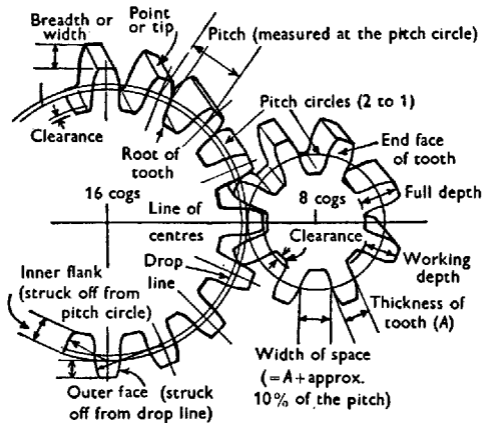


Fig. 7. Detail of cog-wheels.

Finding the Centre-lines

The required *depth* of the cogs is next marked on their ends with a scribing tool while the wheel is turned; and they will then be sawn off accordingly, leaving only the contact surfaces or flanks of the cogs to be fashioned by describing the requisite outline or profile on the end of each cog in readiness for chiselling off. For this purpose the 'pitch-line' and the 'drop-line' are engraved on the ends of all the cogs (Fig. 7) by a 'gouge' fixed in the stand. The *pitch-line* is explained in most mechanics' handbooks; and in the case of a spur-wheel and pinion, the pitch-lines or circles in the two wheels to be meshed are proportional in diameter to the respective number of cogs, and they touch at the 'line of centres' as shown in Fig. 7.

Shaping the Contact Surfaces

The verges of the tips or faces of the cogs, on a spur-wheel, can be inscribed with a try-square, since the butt of the tool will rest squarely on the ends of the cogs; but on a bevel wheel, these are on a curved plane or frustum, and the margins of several cogs must be established by striking off opposing arcs from the corresponding corners of two or three *alternate* cogs, so that they intersect near the inner edge of the frustum. This will locate the outline of the *intermediate* cog, and so on, but to save repeating all round the wheel, the adjustable scribing arc (Pl. 22*a*) is set so that its end-plates rest upon the shoulders of two cogs, whilst its central arm is lined up with the marked edge of the intermediate cog, thus enabling this marking to be constantly reproduced.

Now the surplus wood can be sawn away, leaving the flanks to be trimmed down to an exact curvature with a broad gouging chisel for the inner flank if this is concave, and a plain one for the outer face. These chisels should be extremely keen-edged because the wood is hard, and they must run true and parallel with the outlines across the breadth of the cog, or the work will be ruined; and the skilled craftsman can fashion a practically perfect set of bevel cogs without plotting the profiles of their small or inner ends, trusting to the eye to cut an evenly tapered surface from end to end.

So tightly should all the cogs hold in the mortises, without fixing, that all this work should have caused them no disturbance; but they must now be pinned through the tail-ends of their shanks, by drilling every cog through its breadth to receive pins (which might take the form of 4 in. or 5 in. nails) as required. The greater the breadth, incidentally, and the more numerous the cogs, the higher the power they will transmit without damage, because of the broad bearing surface; but thick short cogs, which give rise to more noise and vibration, are easier to make.

The re-cogging of the 4 ft. wheel illustrated (Pl. 22*a*), with about 80 cogs, was expected to occupy 3 weeks, including dismantling and removing wheel and shaft to workshop and reassembling.

Having finally installed the wheel in its appointed place, it only remains to set the mill going and *listen*—any faulty cogs will soon be heard. Mr Walter Rose of Haddenham mentions in his book *The Village Carpenter* (1937) that his people, true to old-time tradition, dispensed with the nails in favour of the alternative method of driving a wedge between each pair of shanks (Pl. 22*b*) and he was proud to say they never heard faulty cogs, nor did their cogs come adrift.

Inaccuracy increases with use; and if one cog breaks, several more may go each time round, before the mill can be stopped.