

5.5 MILL WHEELS

5.5.0 Introduction

The various wheels in a mill transmit the movement of the wind shaft to the machinery. The wheels also ensure that the machinery is provided with the correct speed of rotation relative to the speed of the sails.

Depending on the type or the function of a mill, the number of wheels can vary markedly. Their sizes too come in a wide variety, ranging from a 60-centimeter-diameter disc wheel in a post mill to a 6-meter-diameter water wheel in a polder mill.

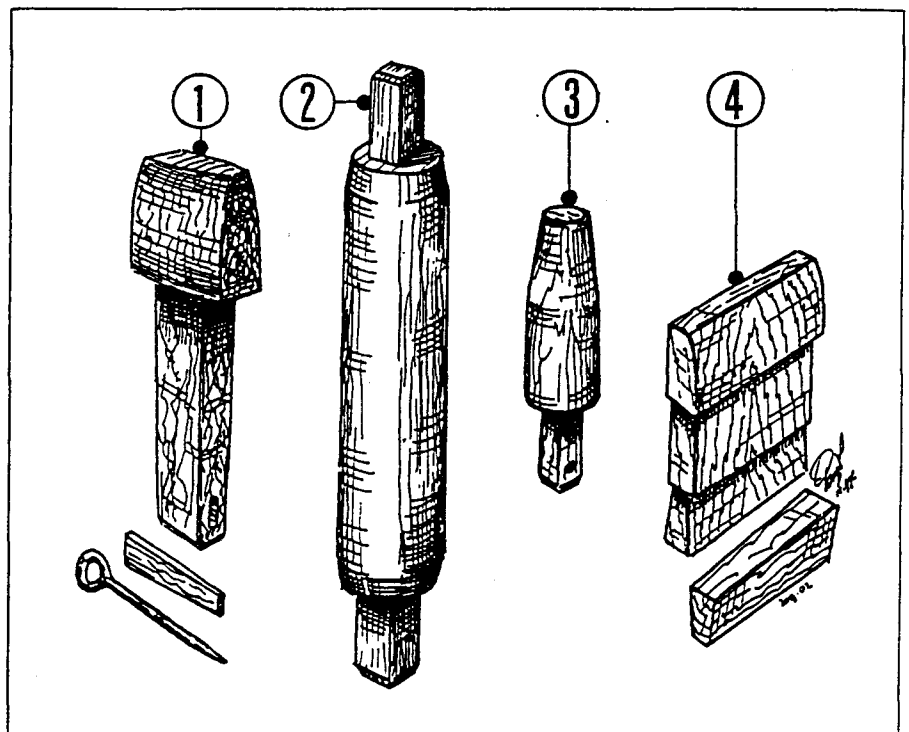


Fig. 5.5.0.1
Cogs and staves
1. cog with pin and wedge
2. stave
3. thole-pin
4. cog for a mortised wheel

pitch

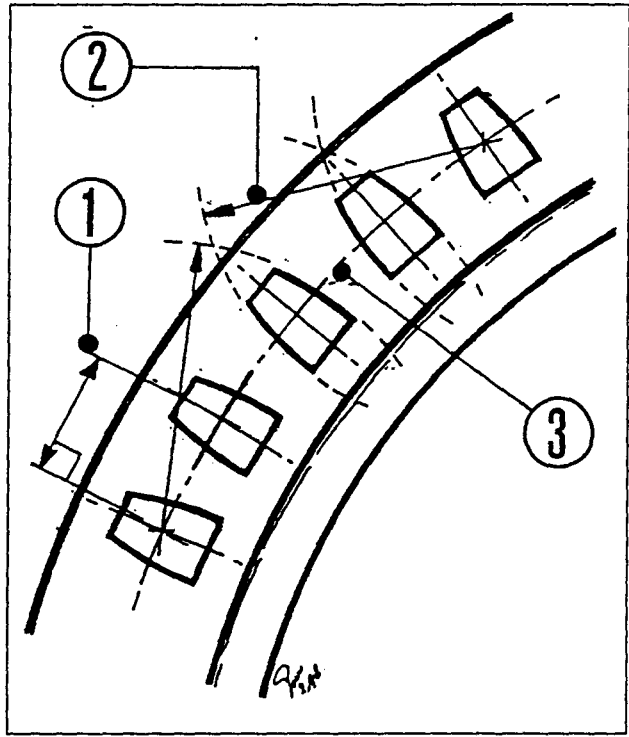
In the choice of shape and size, regional customs play a role in addition to wheel function and load. But there are several features that every wheel has:

1. The center-to-center distance between the cogs (or staves) of a wheel (see 5.5.1). This distance, called the *pitch*, must be exactly the same for all cogs in that wheel (see Fig. 5.5.0.2). If the cogs are not 'in pitch', it can be heard from the banging and clanging of the driving gear. This loosens the cogs or causes them to wear irregularly.

2. Regular wear can only be achieved when a cog of the one wheel makes contact (with equal frequency) with all the cogs or staves of the other wheel. This means that the number of cogs of both wheels may not be divisible by each other.

Fig. 5.5.0.2
The Pitch

1. the distance between the centers of the cogs or staves is called pitch
2. the droplines for the cogs
3. pitchcircle



*ilex, palm wood, green wood
bulletree, pockwood
pure beeswax*

*filling-in pieces
keepers*

If they are, a cog of the one wheel will continually come into contact with the same cog or stave of the other wheel, with irregular wear as a result.

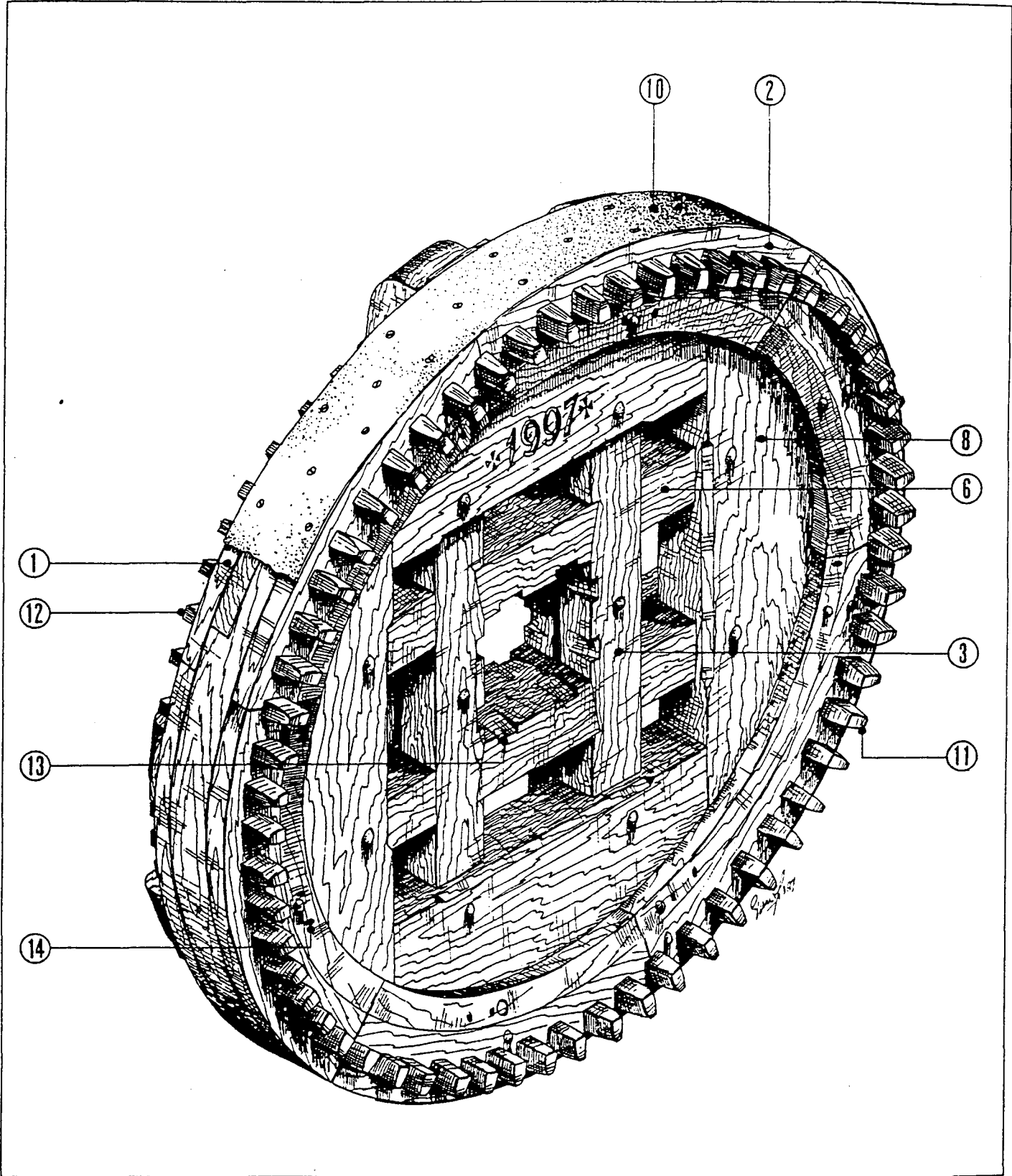
3. The types of wood used to make meshing cogs may not be the same because if they are it will result in excessive wear, even when the wood used is very hard. Good combinations are, for example, *ilex* and *palm wood*, *green wood* and *bolletrie*, and *green wood* and *pockwood (guaiac)*. Cogs and staves are lubricated with *pure beeswax*.

5.5.1 Brake wheel or shaft wheel

Except for tjasker mills, every mill has a brake wheel (a post mill sometimes has two). The brake wheel is affixed with heavy wedges to the *filling-in pieces* of the wind shaft. The wedges are secured by means of *keepers* to prevent them from coming loose or falling out.

Fig. 5.5.1.1
>> Brake wheel
(see for the missing numbers fig. 5.5.1.2)

1. back-rim	8. cant	13. hollowing out for wedge
2. front-rim	10. lining	14. clasp arm locking pin
3. (double) clasp arm	11. cog	
6. (single) clasp arm	12. shank	



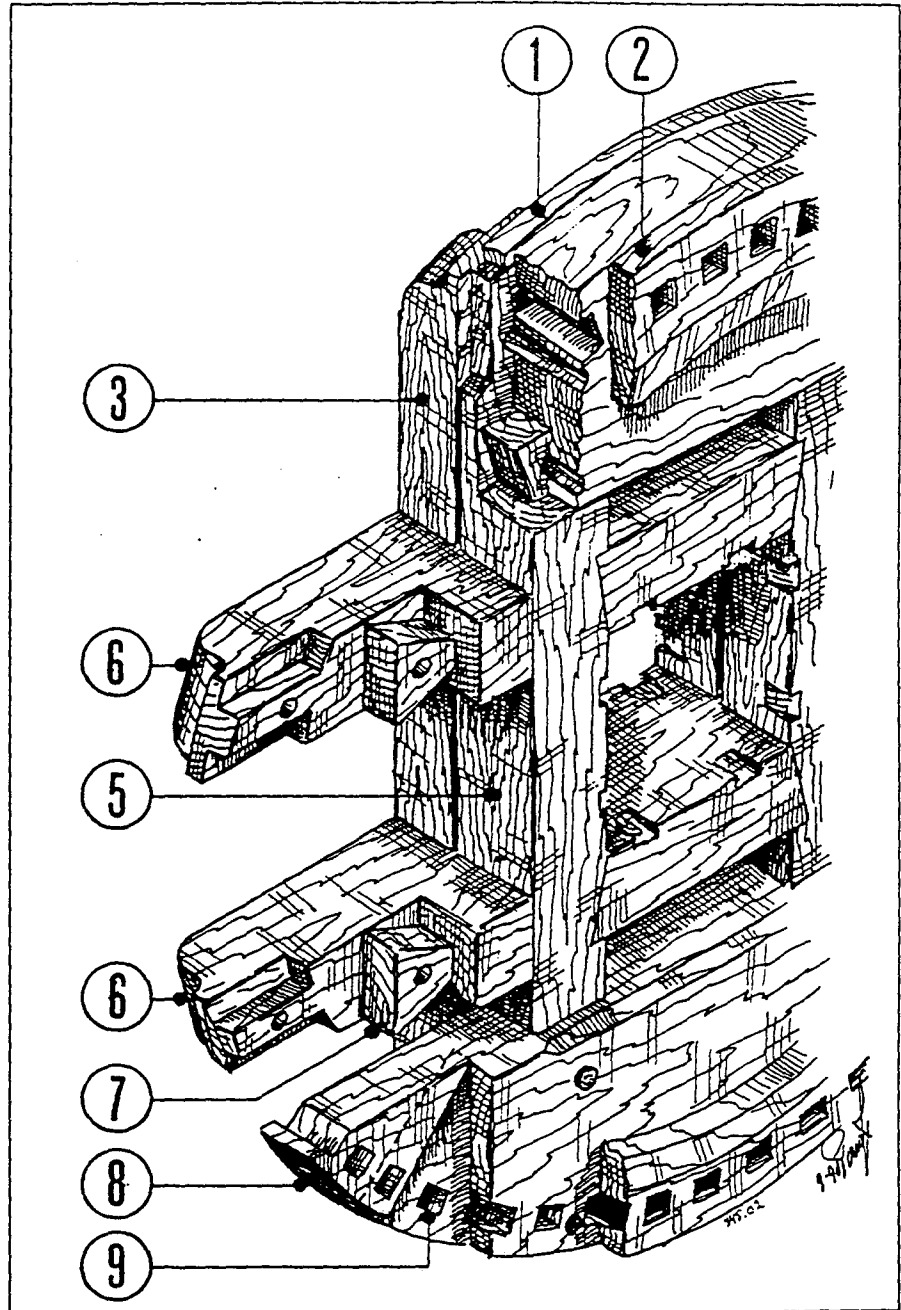


Fig. 5.5.1.2
Construction of a brake wheel

- | | |
|-----------------------|--------------------|
| 1. back-rim | 6. clasp arm |
| 2. front-rim | 7. dove-tail joint |
| 3. (double) clasp arm | 8. cant |
| 4. (double) clasp arm | 9. cog hole |

clasp arms The wheel construction begins with the assembly of the four heavy *clasp arms*, which are almost as long as the diameter of the wheel. The arms are joined in twos parallel to each other. The wind shaft is inserted through the square opening in the center, the *scupper hole*. There are two methods for joining the clasp arms. The simplest method is to embed the (single) clasp arms in cross-halved fashion. The other possibility is a *double clasp arm* construction. Here two clasp arms consist of a single piece, whereas the other two are made up of two halves. The four half clasp arms hold the two whole clasp arms. A two-centimeter gap, the *split*, is left between the half arms.

scupper hole

double clasp arm

split

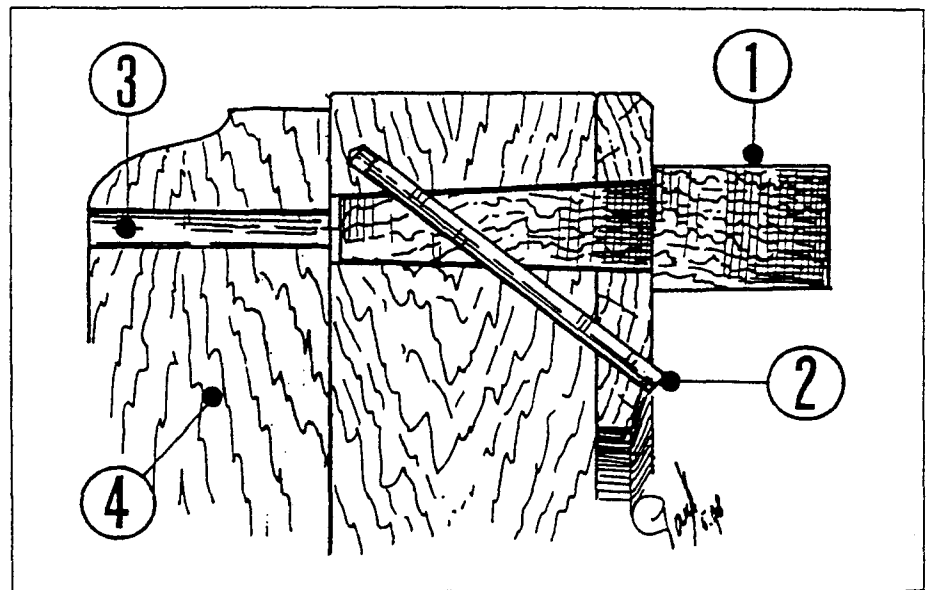
cants *Cants* are placed at the end of the clasp arms. These give the wheel its round shape. As a rule, there are four cants. The cants are affixed to the clasp arms with heavy bolts. The clasp arms and cants are usually made of oak.

front rim A ring of heavy slabs, the *front rim*, is affixed to the cants on the tail-side of the wind shaft. The side of the brake wheel pointing to the tail of the mill is regarded as the front of the wheel. Such slabs are also affixed to the back of the cants between the clasp arms. Together these form the *back rim*. The front and back rims make the brake wheel wider, thus increasing the gripping surface of the brake.

back rim

Fig. 5.5.1.3
Fastening the arm cogs

1. armcog
2. locking pin
3. hole for removing cog, so-called 'pushhole'
4. clasp arm



dam Holes are made in the rims and cants. The cogs are inserted in these holes. The pressure on the cogs during grinding may cause the wood between the cog holes, the *dam's*, to split, break loose or fall out. That's why the front and back rims are made of elm wood. This type of wood is very difficult to split; it is hard, tough and sufficiently strong.

head and shank A cog consists of a *head* and a *shank*. The tapering shank of the cog passes

wooden pin
iron locking nail
arm cogs

locking pin

fed

working side
pressure side

amply through the back rim, allowing the cog to be secured with a *wooden pin* or an *iron locking nail*. In their turn, the pins or locking nails are secured with a small nail. The cogs at the clasp arms, the so-called *arm cogs*, cannot pass through the entire wheel. Their shanks are shorter and they are secured at the front of the wheel. A wooden *locking pin* is inserted diagonally through the front rim into the shank of such a cog (see Fig. 5.5.1.3). To remove such a cog, the miller must first drill out the wooden nail. A hole has been drilled in the clasp arm in the direction of the cog hole so that the miller can knock out the cog out of the wheel with an iron bar. Arm cogs also occur in other wheels with clasp arms.

Loose cogs must be '*fed*'. This is done by cutting a strip of sail cloth the width of the cog shank and wrapping it around the left-hand and right-hand side of the cog. Next, the shank is struck into place again in the cog hole. The side where the cog is driven is called the '*working side*'; the other side is called the '*pressure side*'.

As a rule, cogs are made of ilex, pockwood or green wood, but other types of wood are also used.

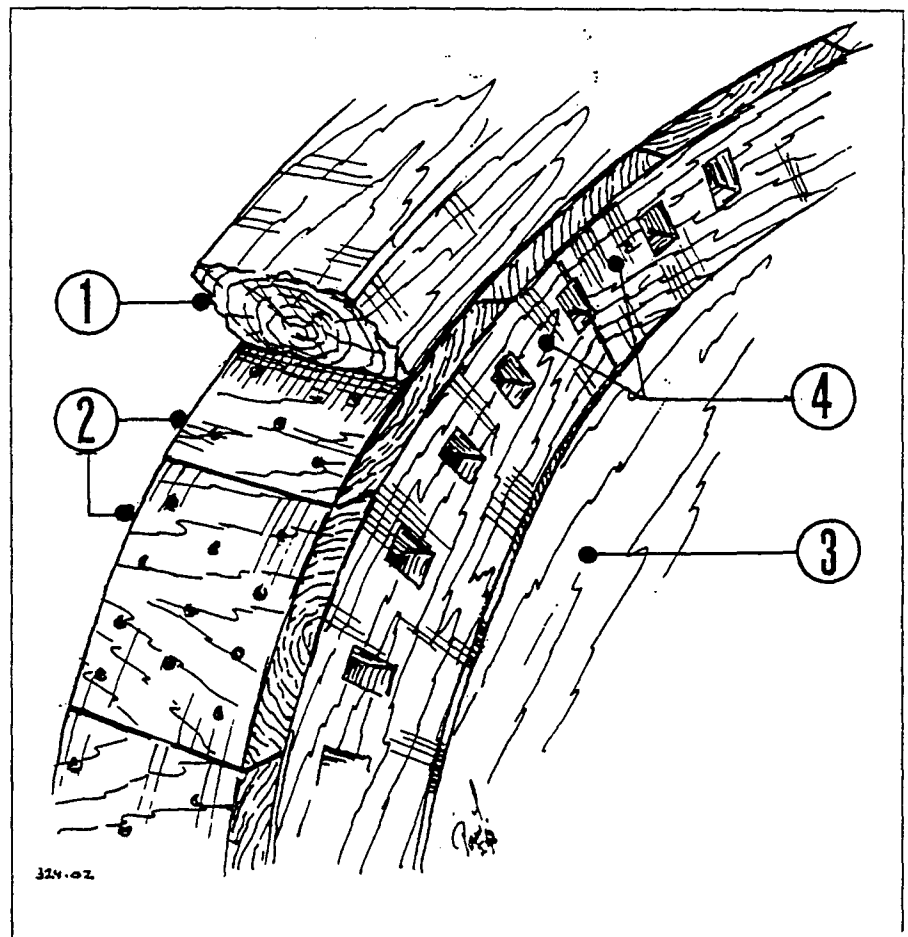


Fig. 5.5.1.4
Lining

1. *brake shoe*
2. *lining 'belaying slats'*
3. *cant of the brake wheel*
4. *dam's*

lining

A *lining* is applied to the addendum circle of a wheel to prevent the wear of cants and rims during the braking of the mill. This lining can be made of wood or iron. The diameter of an excessively worn wheel can be restored to its correct size by placing a ring of short cross boards, the *belaying slats*, around the addendum circle (see Fig. 5.5.1.4).

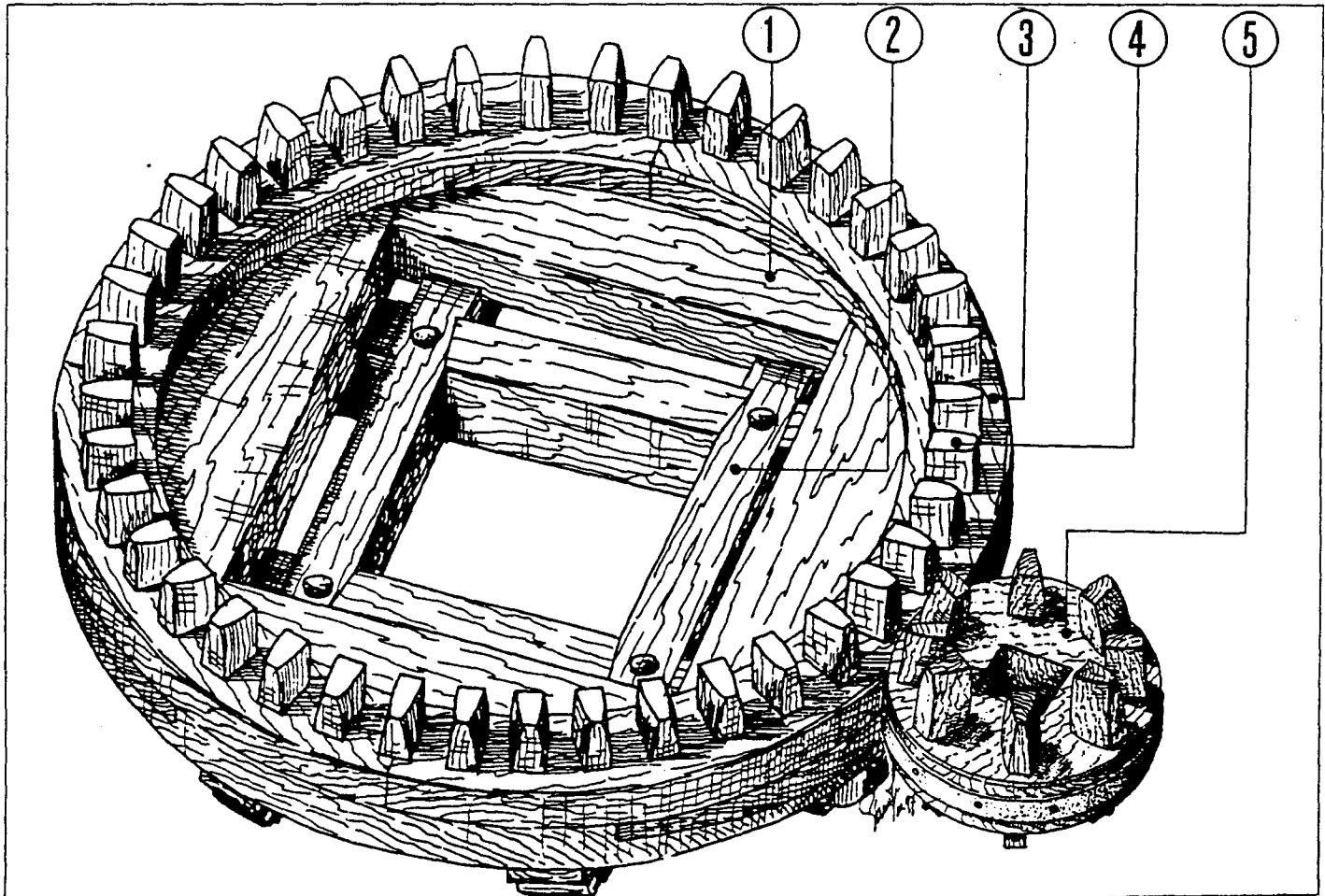
belaying slats

Wallower

The only difference between an upper wallower and a lower wallower is the place on the main shaft (see Fig. 5.5.2.1). The wallower is affixed to the main shaft with wedges. Here too the wedges are secured with keepers. A wallower usually consists of four clasp arms which, as in the brake wheel, are joined cross-halved. The cants are mounted on the clasp arms and connected to each other with a hook-and-butt joint. A ring, the rim, is mounted on the cants. The same types of wood are used for the clasp arms, cants and rims as in the case of the brake wheel. They are used for the same reason.

Fig. 5.5.2.1
Wallowers

- 1. cant
- 2. clasp arm
- 3. rim
- 4. cog
- 5. small wallower for a meadow-mill



lining

belaying slats

There is another way to make a wallower. Four elm wood cants about 15 cm thick are connected to each other with dowelled joints and then sawn into the shape of a circle, as in Fig. 5.5.2.2. In the center a square opening is left for the main shaft. The slab on the addendum circle is strengthened with one or two iron strips. Such a wallower is said to be 'planked solid'.

Square holes are made along the addendum circle of the wallower. The cogs are placed in these holes. The shape and attachment of these cogs is more or less identical to the shape and attachment of the cogs in the brake wheel.

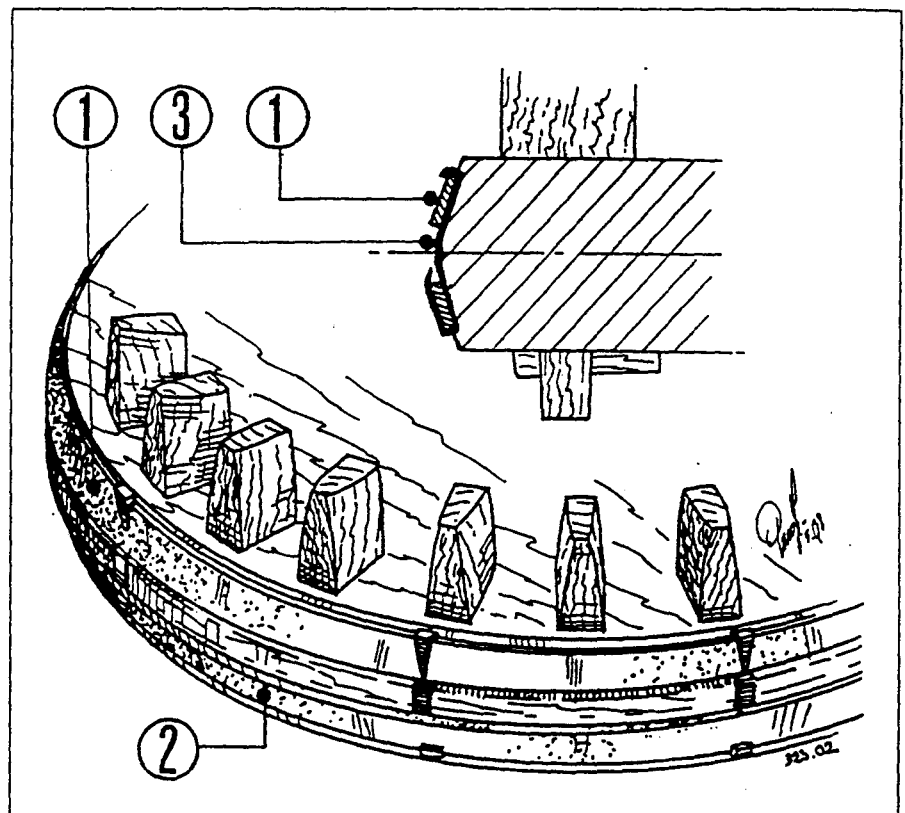


Fig. 5.5.2.2
Iron rings around the
wallower

1. iron ring
2. iron ring
3. retainer

Disc wheel

disc wheel, staves wheel
upper disc wheel
lower disc wheel
stone nut

Disc wheels or *staves wheels* (see Fig. 5.5.3.1) are used at various places in the mill. The disc wheels above and under the main shaft are called the *upper disc wheel* and the *lower disc wheel*, respectively. The disc wheel on the stone spindle in a corn mill is called a *stone nut*. The construction of all these disc wheels is more or less the same.

elm slabs, staves
cants
scupper hole

A disc wheel consists of two *elm slabs* with *staves* between them. Each of these slabs consists of four *cants*, which are connected to each other with doweled joints. In the center of the disc wheel is a *scupper hole*. Iron strips are fastened

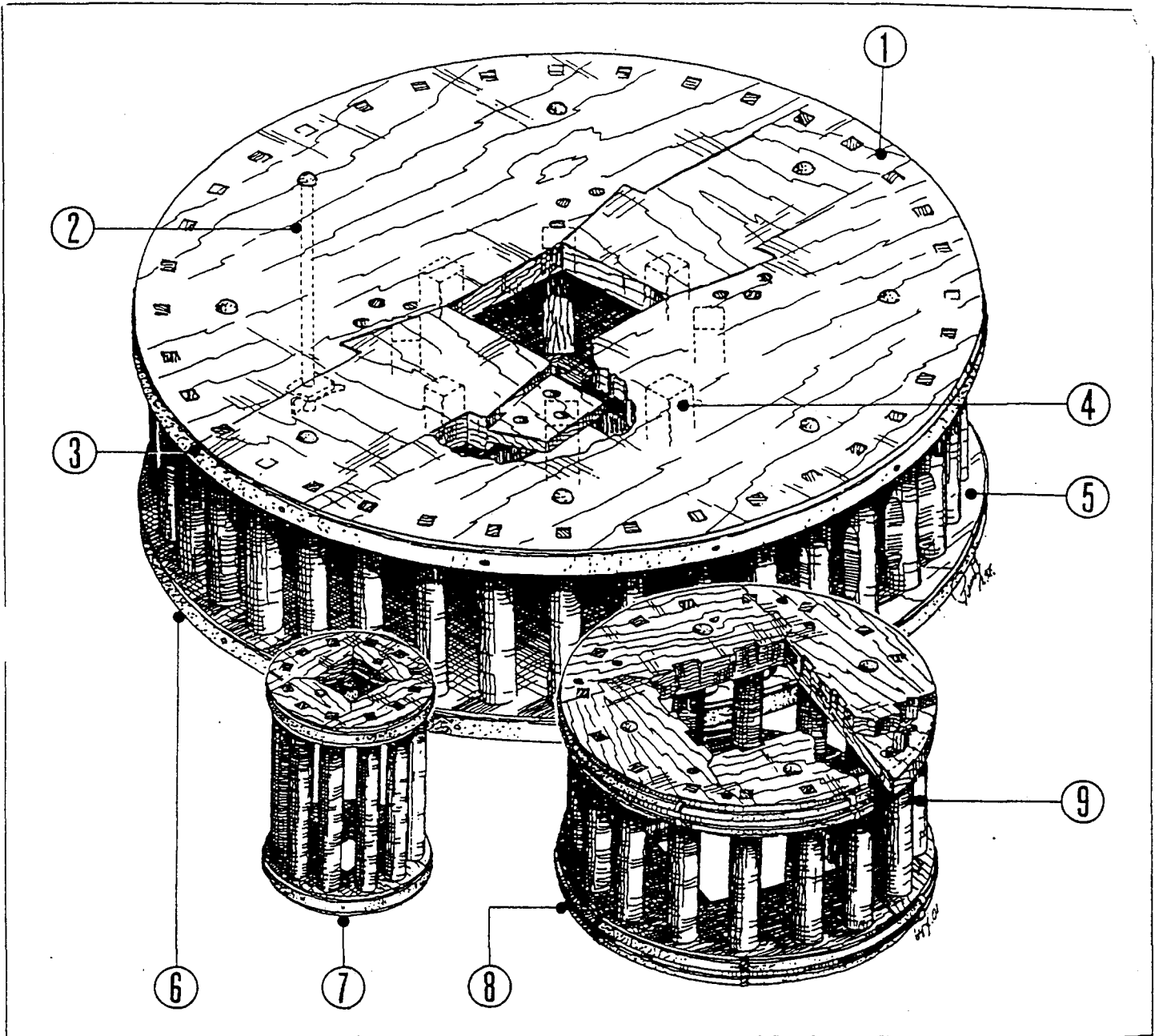


Fig. 5.5.3.1
Disc wheels or staves wheels

- | | | |
|---------------|------------------|-------------------|
| 1. upper slab | 4. support stave | 7. lantern pinion |
| 2. draw-bolt | 5. lower slab | 8. stone nut |
| 3. iron strip | 6. iron strip | 9. stave |

around the addendum circle of the slabs. These strips firmly keep the slabs joined together.

Square holes are made along the addendum circle of each slab. The pegs of the staves go into these holes. Here too the slabs are of elm wood to prevent the cogs lying between these holes from cracking. On the inside of both slabs (i.e. the bottom of the upper slab and the top of the lower slab) the holes are enlarged to form a round hole which is slight conical in shape to allow the square part to come out exactly in the center of the hole.

Both ends of the usually round staves are fitted with a square peg (in the Netherlands called a 'breast'). The pegs fit exactly into the square holes of the two slabs. The round part of the staves has been narrowed conically with the same slant as the round part of the holes in the slabs has been broadened conically. As a result, the staves fit exactly into the holes and so form a single piece with them. The two slabs are fastened to each other with four heavy bolts.

The disc wheel is affixed to the shaft with wedges struck between the shaft and the edges of the scupper hole. To prevent the pressure of these wedges and the tensile force of the bolts driving and pulling the two slabs at the scupper towards each other, four spacer sleeves, the so-called *support staves*, are usually placed near the scupper hole around the shaft.

support staves

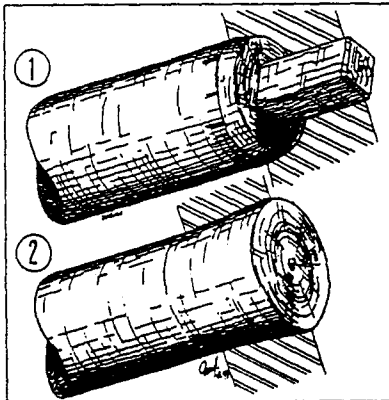
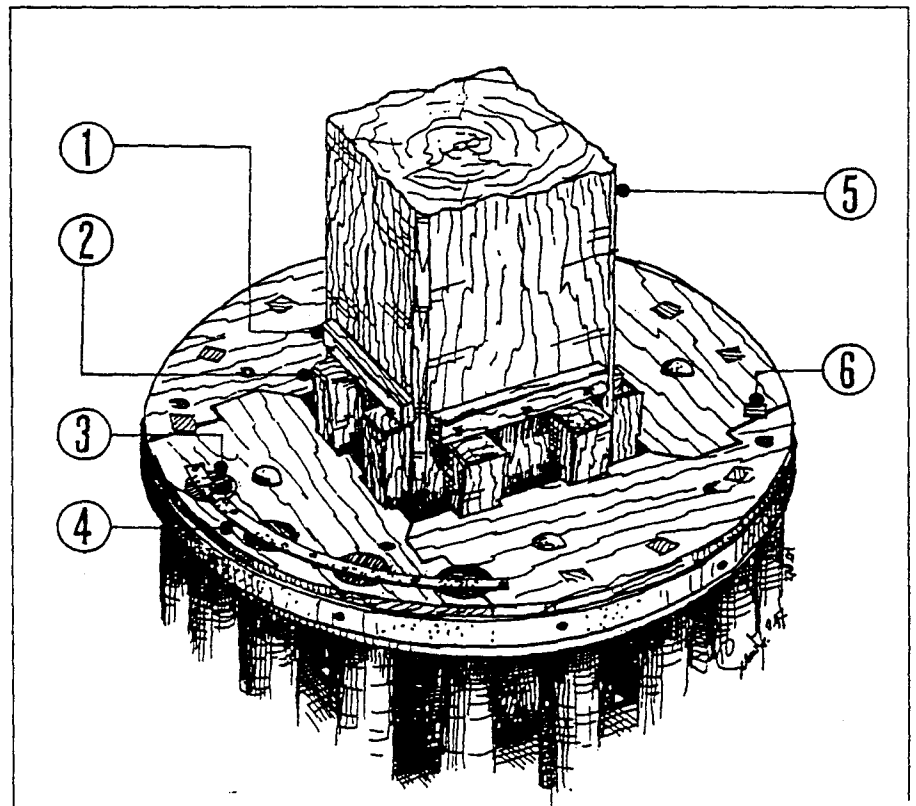


Fig. 5.5.3.2
Examples of staves
1. normal peg (breast)
2. peg of shuttle stave

Fig. 5.5.3.3
Disc-wheels with shuttle-staves
1. keeper
2. wedge
3. shuttle stave
4. locking strip
5. main shaft
6. peg of a normal stave



shuttle staves

A disadvantage of the disc wheel is that a cracked or broken stave is difficult to replace. It would mean having to loosen the whole disc wheel and disengaging the slabs. To solve this problem, millers sometimes applied so-called *shuttle staves* (schietsstaven) (see Fig. 5.5.3.2 and 3). The underside of a shuttle stave has the same shape as an ordinary stave. However, on the top it lacks a square peg. The shuttle staves are put in place from the top of the upper slab. The staves are secured on the top with a locking strip or ring which is affixed to the top of the upper leaf of the disc wheel. When the diameter of a disc wheel is smaller than its height, it is called a *lantern pinion*.

lantern pinion

Staves are generally made of palm wood, bulletree or ilex.

Great spur wheel

*great spur wheel
takrad*

The *great spur wheel* can be found in corn mills on the underside of the main shaft. It drives one of several stone nuts. 'Takrad' (great spur wheel) is the term used for this wheel in Groningen province.

Unlike, for instance, the brake wheel and the wallower, this wheel does not have cogs fixed at right angles to the addendum circle. Its cogs are directed outwards, so that the shanks point to the heart of the wheel. The construction of the great spur wheel begins with the cross-halved joining of four clasp arms. For the further construction of the wheel there are four variants.

removable dams

In the first variant cants are attached to the clasp arms. One or two rims are placed on these cants. Cogs are inserted between the rims in the notches made for that purpose. Unlike in the rims of the head wheel, no cog holes are made in the rims of the great spur wheel. Instead, chocks for fixing the cogs, the so-called *removable dams*, are installed between the rims. These dams are fastened between the rims with bolts which pass through both rims. The cogs are struck into place between the dams and then secured. Apart from these removable dams, fixed dams also occur (see Fig. 5.5.4.1).

In the second variant, no cants are used, but the rims are attached directly to the clasp arms. To give the rims sufficient support and the wheel sufficient rigidity, an extra set of clasp arms is installed at the top. The rim is thus clamped between a total of four double clasp arms. In this variant, too, the cogs are clamped between the dams.

The types of wood used are the same as those used for the head wheel: usually oak for the clasp arms and cants and elm and green wood or ilex for the cogs.

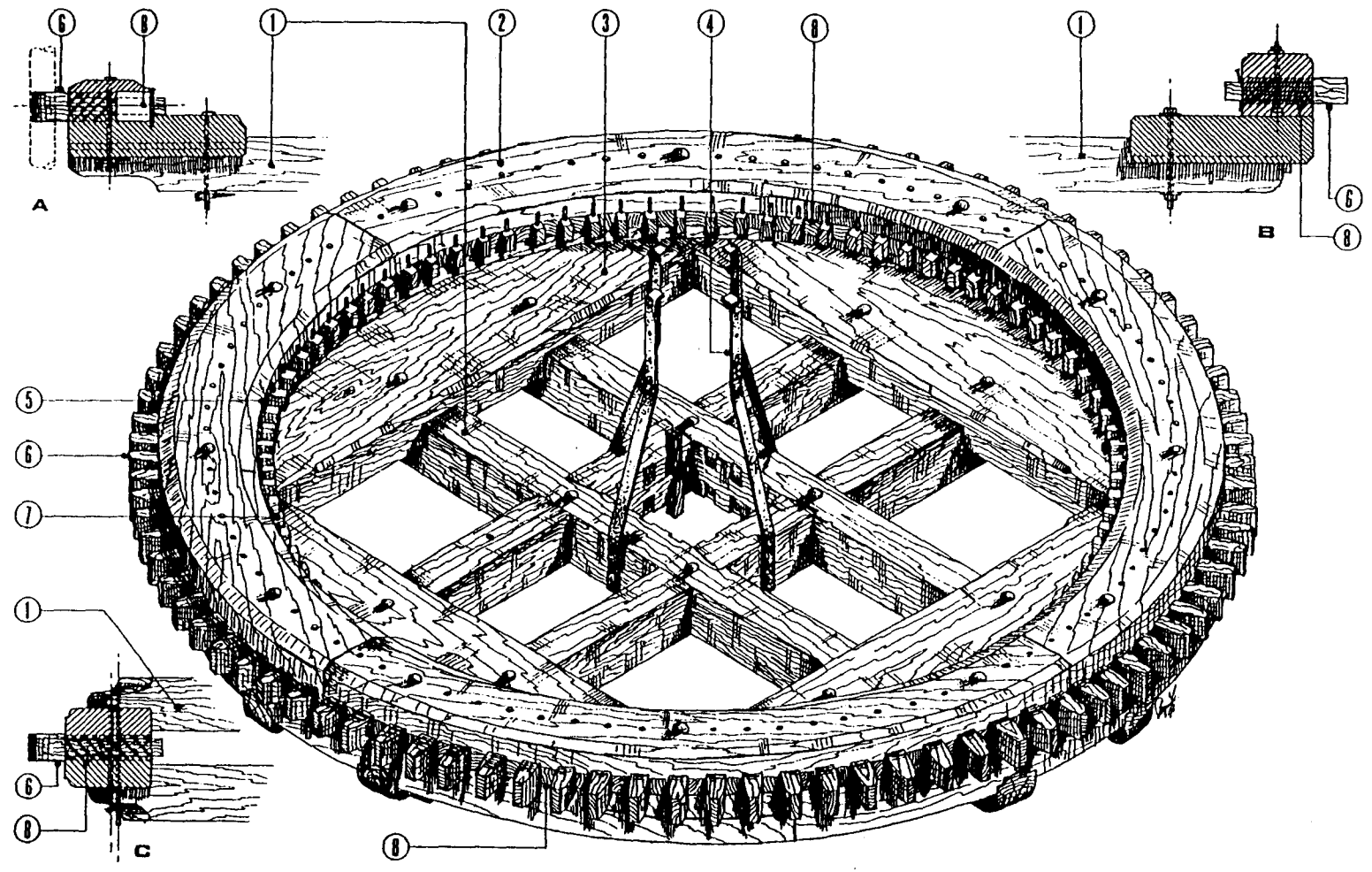


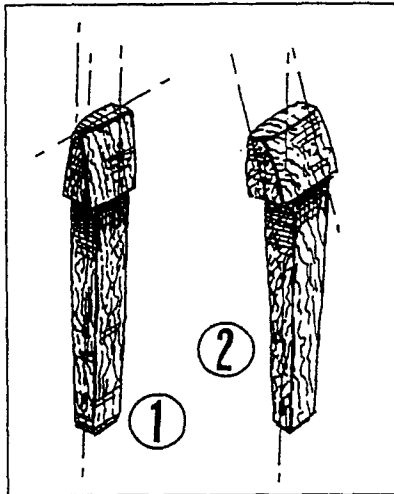
Fig. 5.5.4.1
The great spurwheel

- 1. clasp arm
- 2. rim
- 3. cant
- 4. hang-iron

- 5. pin, wedge
- 6. cog
- 7. shank
- 8. dam

- A. Spurwheel with a single rim (with cants)
- B. Spurwheel with double rim (with cants)
- C. Spurwheel with double clasp arms and rims (without cants)

Fig. 5.5.6.1
 Example of a straight cog
 (1) and a cog for conical
 works (2)



5.5.6 Conical cog wheels and disc wheels

The sides of cog heads are rounded off. This reduces the interface of two meshing cogs. As a result, both wheels mesh smoothly and easily and so cause little wear. If they are not rounded off, the driving gear would suffer considerable wear and even a complete breakdown.

The rounding off of cogs is easiest in cogs meshing perpendicularly (cogs and staves) or in cogs meshing in line. If both wheels do not mesh perpendicularly or in line, the cogs have to be rounded off differently in order to keep the interface as small as possible. This is, for instance, what happens in transmitting the operation of the head wheel to the upper wallower or the upper disc wheel. For the head wheel is slanted. To ensure that the cogs (cogs and staves) mesh perpendicularly or in line, the cogs (or staves) are placed at an angle. This results in *conical cog wheels* or *conical disc wheels*.

5.5.7 Cast-iron wheels

Especially in mills driven by water power, many wooden wheels and shafts were replaced over time by cast-iron wheels and shafts. A cast-iron wheel is cast as a single piece. If wooden cogs are to be used, the holes for them are made during casting. In the center of the wheel is a heavy round part, the nave (or hub), which contains a keyway for fastening the wheel to the shaft. On the outside there are six to eight spokes, with at their ends a cast-iron ring, the rim. As in wooden wheels, the cogs are inserted in this rim and secured on the inside with swallow-tailed locking blocks.

Smaller wheels usually have cast-in cogs. It never occurs that two meshing wheels both have cast-iron cogs. The cogs of one of the wheels, generally the driving wheel, are made of wood, in most cases hornbeam. In a perpendicular transmission, the cast-iron driving gears often have both a conical or a straight design. Some windmills also have full or part iron driving gears.

5.5.8 Sack hoist wheels

cog sack hoist, friction drive sack hoist

There are two types of sack hoists: the *cog sack hoist* and the *friction drive sack hoist*.

*sack hoist wheel
sack hoist windlass*

In a cog sack hoist a wallower is mounted around the main shaft in accordance with the description given above. A wallower, the *sack hoist wheel*, is also installed on the *sack hoist windlass*. The sack hoist wheel can be pulled in the cogs of the wallower around the shaft.

*friction ring
willow blocks*

The friction drive sack hoist also has two wheels but no cogs. The wheel around the main shaft, the *friction ring*, is composed of clasp arms and cants. A wear-resistant layer of *willow blocks* is placed on the cants. This layer is easy to replace. The addendum circle of the sack hoist wheel is fitted with a wear-resistant layer of willow wood. In many mills, a metal lining or an old car tire is placed around the sack hoist wheel.

*gable wheel
gables*

In many cases, a *gable wheel* is attached to the other end of the sack hoist windlass. This wheel has no cogs, but it has wooden or metal *gables*, between which the gable rope runs, mounted around the addendum circle. The gable wheel consists of two clasp arms inserted through the sack hoist windlass or of four clasp arms mounted around the sack hoist windlass. A series of cants or a rim is placed on the periphery of the gable wheel. The gables are mounted on that. The wheel is usually made of oak.
