

5.2 THE SAILS

5.2.0 Introduction

Since the first appearance of windmills, their sails were made of wood. Not until the second half of the nineteenth century were wooden sail stocks gradually replaced by metal ones.

The *sail system* consists of two stocks passing crosswise through the poll end. Each *stock* has two *ends*. A sail system therefore has four ends (in other countries it may consist of more ends). The *sail bars* are inserted into these ends.

Up to the seventeenth century the sail bars had the same length on both sides of the stock. They were inserted diagonally through the stocks, while the shape of this slant changed little, if at all. Today such a sail system is called *transverse rigging* (see Fig 5.2.0.1).

Such a transversely-rigged (or medieval) cross is far from perfect, because only a very small portion of the available wind is transformed into useful energy. Nevertheless, millers used this system for some 500 years.

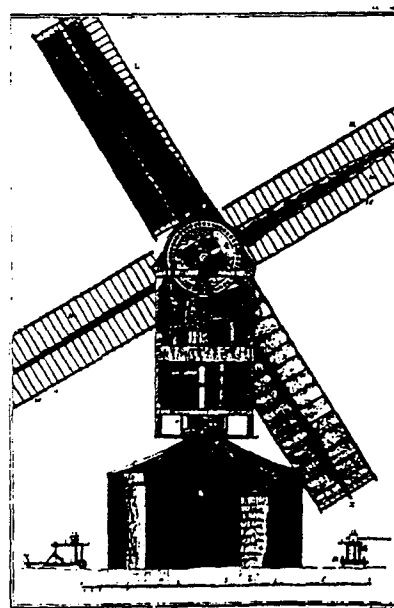
In the seventeenth century, through trial and error, a better sail system was developed in Holland. This became known as the *old Dutch sail system* or *common sails*. In this sail system, sail bars are only placed in the left-hand side of the stock (based on the end pointing downwards). The slant in which they are placed in the stock is shaped like a screw. Located on the right-hand side of the stock are removable *wind boards* or *leading boards*. This *old Dutch sail system* (or these *common sails*) yielded a much better result. Most Dutch mills are still equipped with it.

*sail system*  
*stock, ends*  
*sail bars*

*transverse rigging*

*old Dutch sail system / common sails*

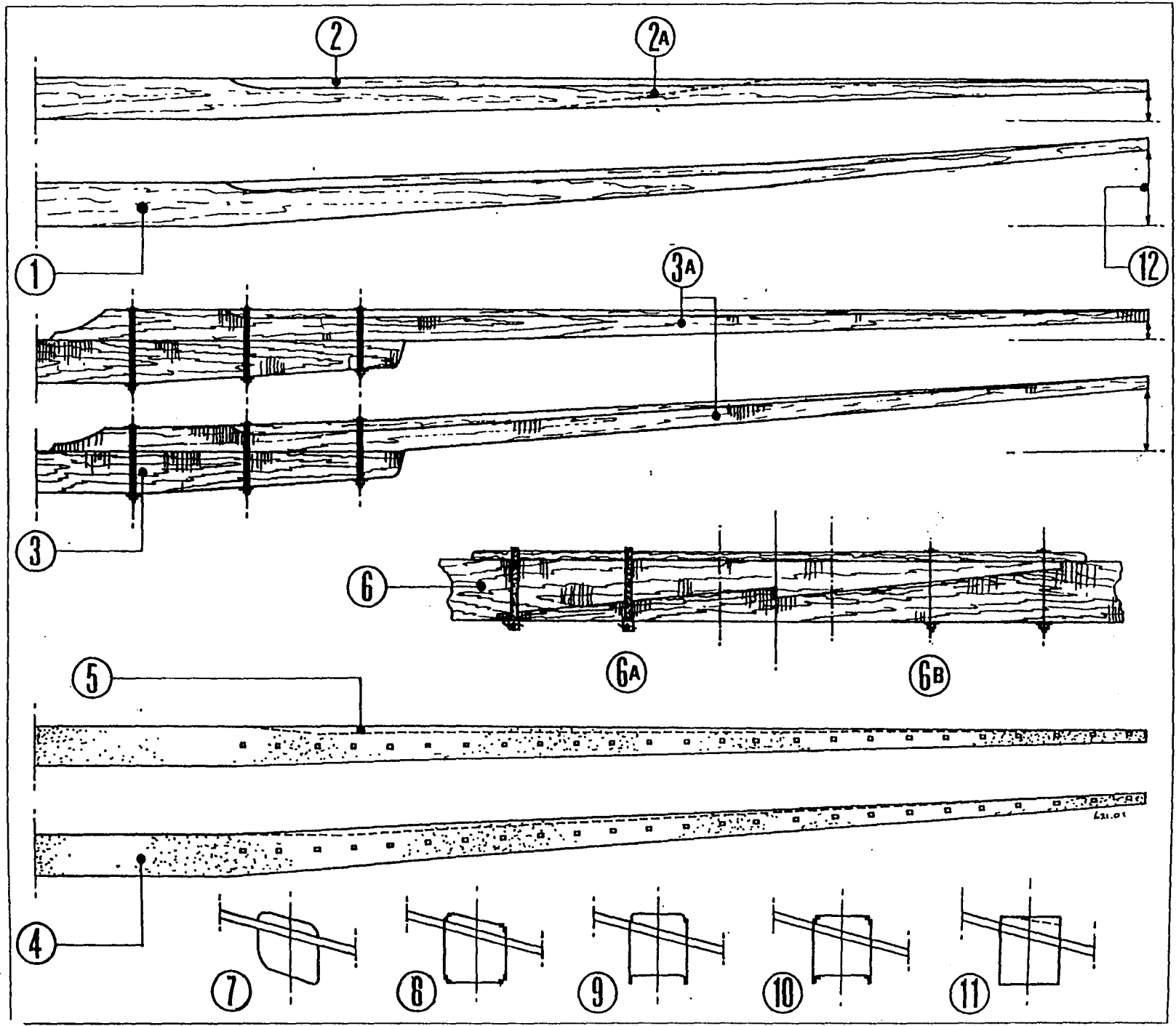
*wind boards / leading boards*



*Agriculture, Economic Risaque.*  
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Fig. 5.2.0.1

Example of a mill with a so-called transverse rigging. The sail bars on both sides of the stock are equal in length and there are no leading boards.



5.2.1 Wooden stocks

*sail stock*

*sail whips*

*two-piece wooden stock*

Wooden stocks were used until in the nineteenth century. The oldest form consisted of three parts. The *sail stock* (or *middling*), an oak beam of 6 to 7 meters in length and in the center about 40 to 30 centimeters thick, was placed in the poll end and on both sides was extended to the desired sail length by means of *sail whips*. These sail whips were fixed to the front of the stock or middling with the aid of straps and bolts.

In the nineteenth century a *two-piece wooden stock* was introduced. Such a stock consisted of two equal ends which were joined together by means of a long hook-and-butt joint. The center of the joint was therefore in the poll end. Metal stock plates, bolts and straps were used to strengthen the stock.

Occasionally a tree was tall enough to allow a one-piece stock to be made from it for smaller mills.

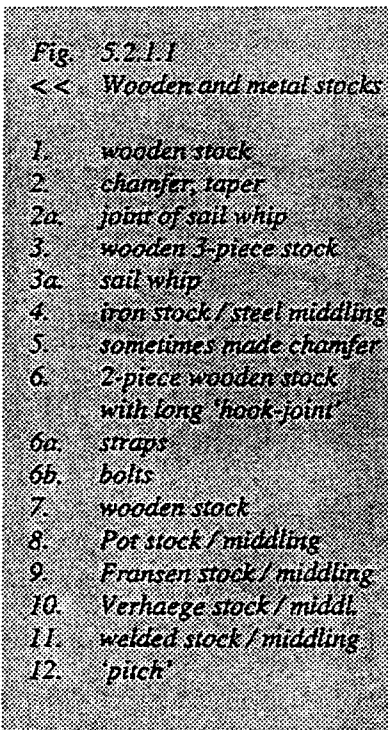
5.2.2 Metal stocks

*Pot*

From the second half of the previous century, more or less at the same time as the emergence of iron wind shafts, the wooden stocks were gradually replaced by iron, riveted stocks. The firm of *Pot* based in Elswijk (near Kinderdijk) was the best known supplier of iron stocks. 'Pot stocks' consist of long boards fastened to each other with rivets on four angle-irons.

The plate thickness of metal stocks varies, reckoned over the full length, from 12 millimeters in the poll end to about 6 millimeters near the tips of the ends. The part of the stock inserted into the poll end is strengthened with several cross partitions. These take the pressure exerted by the poll wedges (see 5.2.3).

After 1945 stocks were no longer riveted but welded. The firm of Bremer based in Adorp, Groningen, was the first to do so. Others quickly followed. Nowadays (in 2000) various companies supply welded stocks.



### 5.2.3 Attachment of stocks

*chocks / cheeks*

*poll wedges*

*T-irons*

*inner stock, outer stock*

*tracking  
pitch*

*chamfer*

*imbalance  
pull through*

Both stocks are inserted into the holes of the poll end and anchored as follows. First, per stock two *chocks* or *cheeks* on both sides of the poll end prevent the stock from sliding out of the poll end. Further, the stock is wedged into the poll end with 16 wooden *poll wedges* (8 per stock). Finally, the poll wedges are secured with *T-irons* ('*spitijzers*') (see Fig. 5.2.3.1).

Wooden poll ends would soon crack under the enormous pressure of the poll wedges. This was avoided with the use of four or six iron straps which were clamped along the stock holes in order to take the pressure exerted by the poll wedges.

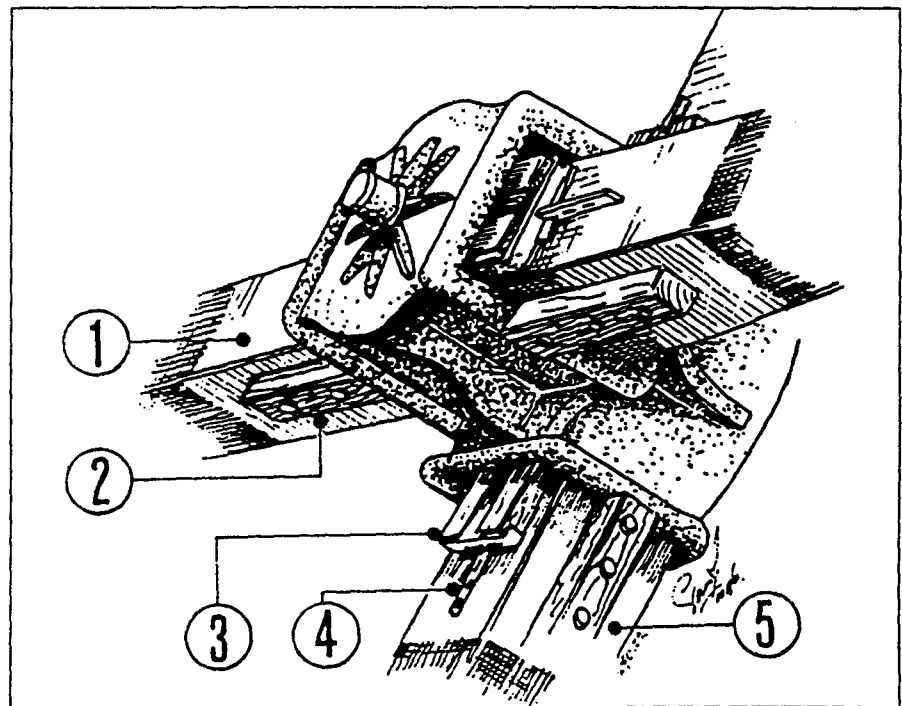
The *inner stock* is different from the *outer stock*. The stocks are inserted behind each other through the poll end, with the inner stock closest to the mill body. The front of the outer stock is practically straight, but not so the back. For, the thickness decreases from about 40 centimeters in the poll end to about 10 centimeters near the tips. To ensure that the four ends turn as much as possible in the same plane (*tracking*), the inner stock is bent forwards (see Fig. 5.2.1.1, we call this *pitch*). To give them a bit of streamlining, the front and back of the wooden stocks were beveled off to enhance the conduction of the wind (this is called *chamfer*).

When, on a windless day, after turning to and fro a little, the sails remain in the same position, they are said to be *imbalanced*. This problem can be resolved by making the lighter ends heavier. Stocks must be '*pulled through*' (hoisted up, cleaned and painted in the middle part which is normally unreachable, because it is wedged in the poll end) at least once every ten or twelve years. This means that they are alternately, in vertical position, stripped of T-irons, wedges and chocks and then hoisted up in order to treat the part in the poll end against corrosion.

Canister  
poll End

Fig. 5.2.3.1  
Attachment of stocks

1. outer stock
2. chocks or cheeks
3. poll-wedge
4. T-iron ('spitijzer')
5. inner stock



5.2.4 Old Dutch sail system

*sail bars*  
*sail bar wedges*  
*driving side of the sail*  
*weather*

The ends have, according to a specific sequence, a number of holes in which *sail bars* are placed. They are fixed with *sail bar wedges*. A nail in front of each sail-bar wedge prevents the wedge from coming loose (see Fig. 5.2.4.1).

In order to exploit the incoming wind as much as possible, the *driving side of the sail* (left side; the total number of sail bars per end) is shaped like a screw, the *weather*. (see 5.2.5). The weather, which has been roughly determined by the sequence of the sail bar holes in the stock, can be accurately adjusted with the sail bar wedges. The slant is strongest near the poll end.

*hem laths*  
*outer hemlath, inner hemlath*  
*reefing lath*

Per end the sail bars are connected to each other by means of three *hem laths*: one *outer hemlath* or *rear hemlath* and two *inner hemlaths* or *center hemlaths*. In most cases, a so-called *reefing lath* is placed between both inner hemlaths. The outer hemlath is located in front of the sail bars and the two inner hemslaths behind them. The latter is necessary to permit the sail surface to be placed against the frame.

In many cases, the upper sail bar of the inner stock has been shortened up to the second center stock, otherwise the end might strike the front cowl as it revolves. This is called the *wafer*.

*wafer*  
*Not on ours*

*board side*  
*hooks*

The sail bars pass through the stock. Their ends come out the other side of the stock, the *board side* or *leading side*. Some bars (in some cases all of them) are longer and mounted with wedge-shaped clamps, the *hooks* or *jibs*. The hooks are used to determine the slant of the board side. Because the bars of the frame pass through the stocks according to an angle of weather, the hooks become increasingly broader towards the tip of the end.

*board lath*  
*front hem*  
*wind boards, sliding board*  
*slide board spring*

On the board side, a *board lath* lies directly against the stock. This board lath is fixed to sail bars sticking out of the stock. The *front hemlath* is fixed to the ends of the hooks. Between the board lath and the front hem lath are several removable *wind boards*. The lower wind board, the *sliding board*, can be easily inserted or removed. For this purpose, many mills are equipped with a *slideboard spring*.

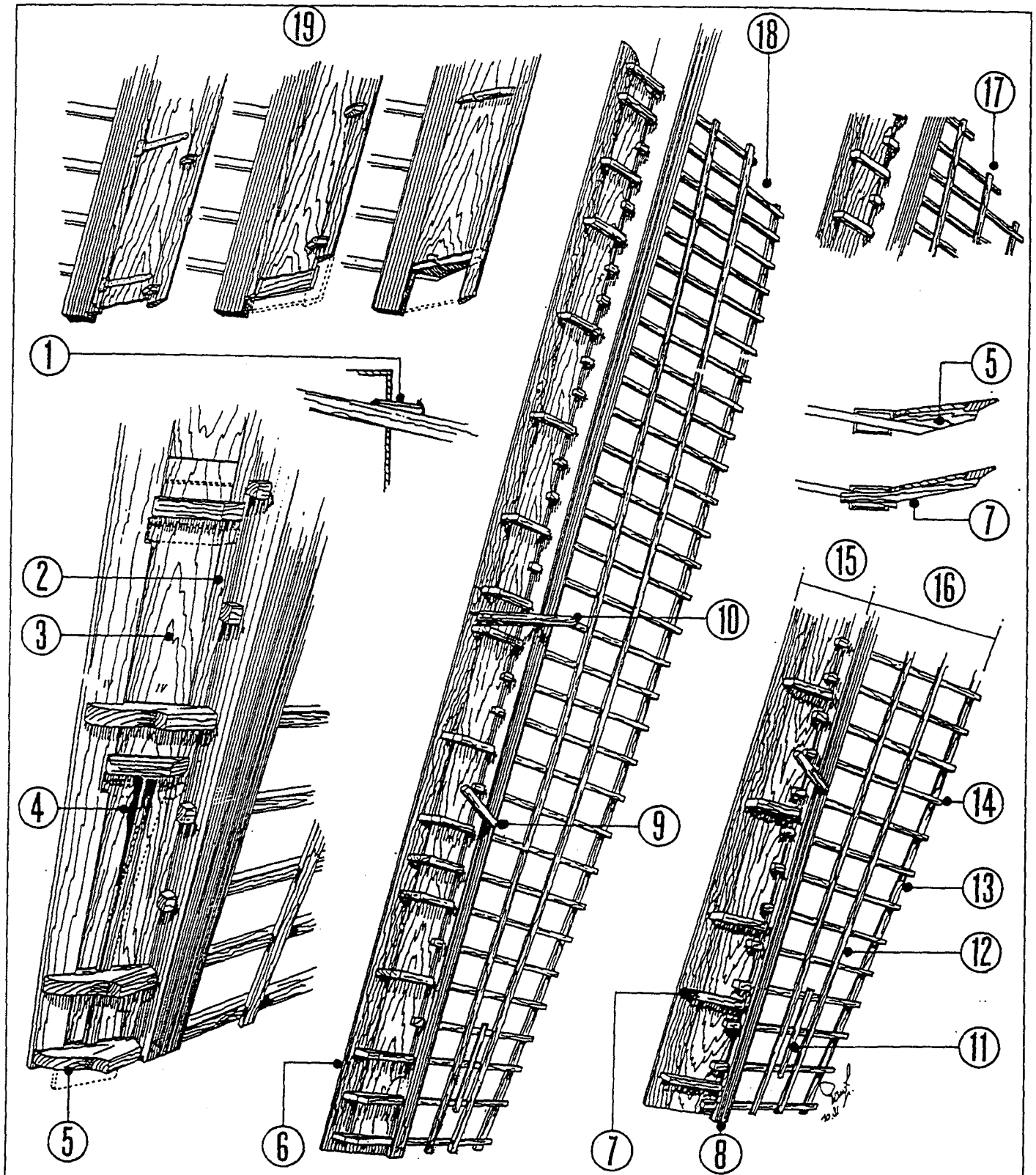
5.2.5 Weather and wind boards

*weather*

In order to exploit the force of the wind as much as possible, the frame has a hollow shape. We call this the *weather*.

As in the frame, the position of the wind boards also has a particular shape. The wind board at the shaft is more slanted than at the tip of the stock. The width of the stock plus wind board is the same across the full length of an end. This means that the wind boards from the poll end to the tip become ever broader because the stock becomes smaller over that same length.

The method of setting the sails and positioning the wind boards depends on the function of the mill. Mills which are required to produce a lot of power, like hulling mills, sawmills and polder mills with a large conveying height, have a deep or hollow weather. This means that the angle between the deepest part of the



frame and the plane in which the stocks turn is relatively large. In such a case, the frame is relatively broad. The wind boards of such a heavily loaded mill are placed relatively far in front and are broad.

*strike up*

Such a mill *strikes up* easily, produces a large tensile force and, in a given wind, turns slowly. The mill responds slowly to gusts of wind. A mill with a heavy tensile force turns calmly. But in the wind catch of such a mill, you notice how much power is in the sails. To operate properly, the mill requires a great deal of wind.

This is in sharp contrast with mills which are required to produce little tensile force, like oil mills, corn mills with a low rate of acceleration, and polder mills with a small conveying height. These mills have a shallow or level weather. Such a mill strikes up less easily, delivers less tensile force, but turns more quickly in a given wind. The mill responds to gusts of wind immediately. A lightly-loaded mill runs irregularly, but can easily be stopped with the brake.

Fig. 5.2.4.1  
 << Old Dutch sail system (or common sail)

- |                       |                                    |
|-----------------------|------------------------------------|
| 1. sailbar wedge      | 11. reefing lath                   |
| 2. board lath         | 12. inner hemlath / center hemlath |
| 3. sliding board      | 13. outer hemlath / rear hemlath   |
| 4. slide board spring | 14. sail bars                      |
| 5. hooks (jibs)       | 15. board side                     |
| 6. front hemlath      | 16. driving side                   |
| 7. ('scheerhout')     | 17. (double) wafer                 |
| 8. sail stock         | 18. wafer                          |
| 9. short cleat        | 19. diff. sliding board locks      |
| 10. long cleat        |                                    |

## 5.3 MILL SAILS

### 5.3.0 Introduction

*mill sails*

Traditionally *mill sails* were placed on the frame in order to obtain a sufficient surface for catching the wind and to regulate the revolving speed of the sails. On the one hand, this occurred by enlarging the sail surface in a weak wind, and, on the other, by decreasing the sail surface in a strengthening wind by partly rolling up the sails. This is called *spreading* and *reefing* the sails. In a hard wind, the sails are rolled up entirely.

*spread and reef sails*

*Set sails*

*linen*

In the past, as far as is known, sails were made of *linen* (flax cloth). Linen sails were also used on ships. Linen can be stretched in all directions and is therefore quite strong. A disadvantage of the elasticity of linen is that in a strong wind the sails tend to bulge through the frame.

*cotton cloth*

In the nineteenth century American *cotton cloth* was introduced. This material is woven more strongly and is sturdier and heavier. As a result, it lies smooth and straight on the frame. However, it is not as strong as linen. Moreover, wet cotton sails become stiff and are difficult to handle. Cotton is also less weather-resistant than linen. On the other hand, cotton is much cheaper, and that's why, despite its disadvantages, cotton has replaced linen.

*synthetic fiber*

In recent times, however, cotton has gradually been replaced by *synthetic fiber*. This material does not have the disadvantages of cotton. It absorbs very little moisture and is weather-resistant. It is thinner and lighter and so easier to handle.

*sail cloth, selvage of the leading side, trailing side, left and right lower edge cord, right upper edge cord, left upper edge cord, chain, jaw, pointing lines, goat's feet or wearing pieces, cord loops*

A sail consists of a *sail cloth*, *selvage of the leading side, trailing side, left and right lower edge cord, right upper edge cord, left upper edge cord* or *chain, jaw*, several *pointing lines* with *goat's feet* or *wearing pieces* and *cord loops* (see Fig. 5.3.1.1). Usually the color of the sails is brown. In some regions, white sails are used, and occasionally red or yellow ones.

#### 5.3.1. Provisions on the stocks

*sail arm*

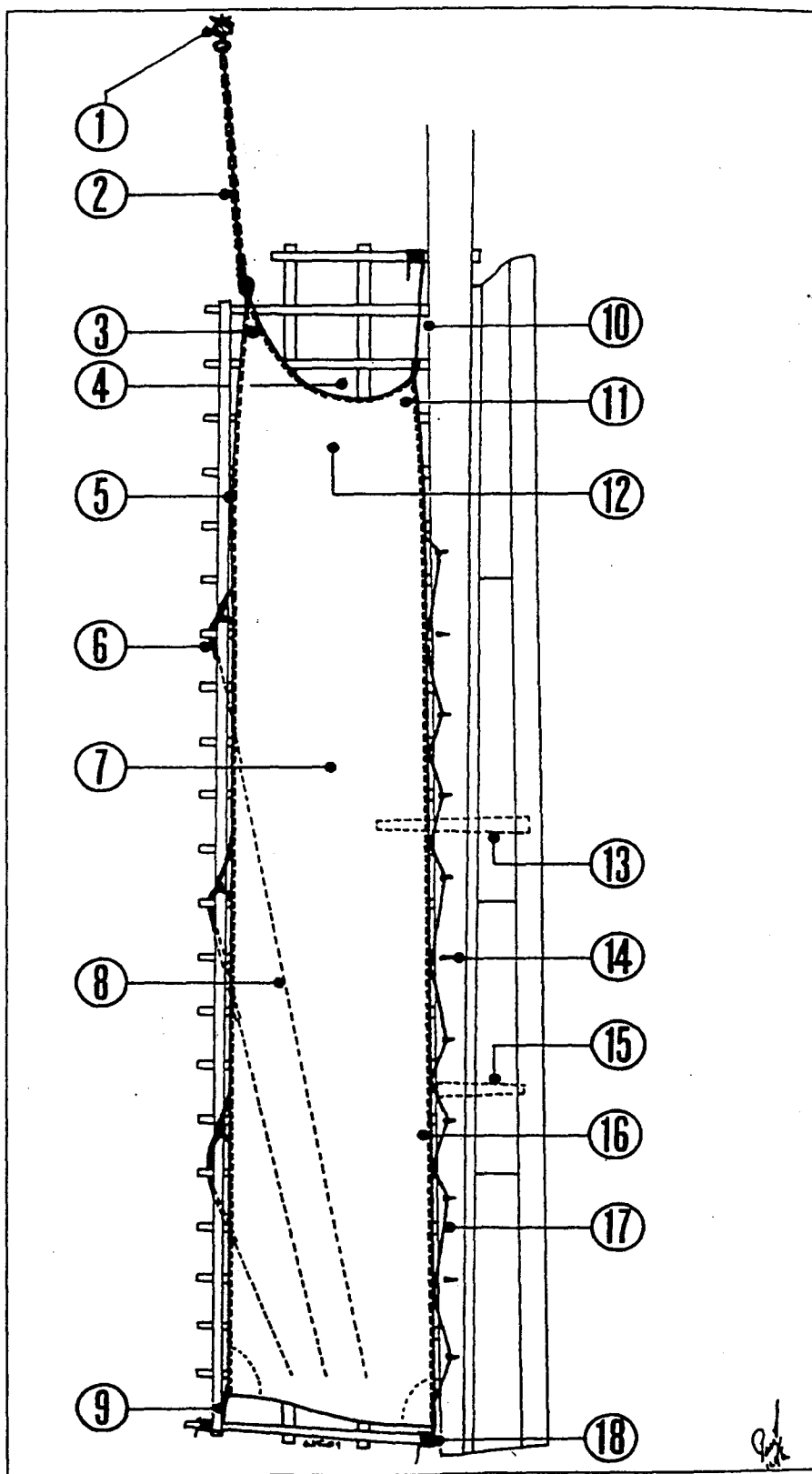
The sails are placed on the frame. For fastening the sails to the inner stock, for each sail a *sail arm* has been mounted diagonally on the outer stock. For hanging the sails on the outer stock, there is a sail eye on the inner stock.

*clamp irons  
rabbet, clamp  
short, long cleat*

To keep the sails on the frame during turning, at each end there are a number of *clamp irons*, behind which the cord loops of the sails are tied. At the tip of each end there usually is a *rabbet* or a *clamp* for fastening the right lower edge cord of the sail. Finally, on the back of each end there is a *short* and a *long cleat*. The rolled up sail is clamped behind that.

Fig. 5.3.1.1  
Mill sails

1. sail arms
2. sailchain or upper left cord
3. so called 'long tack'
4. jaw
5. trailing side / driving side
6. goat's feet or wearing peaces
7. sail cloth
8. pointing line, sail-rope
9. left lower edge cord
10. short tack rope
11. short tack
12. head of the sail
13. long clear
14. clamp iron
15. short clear
16. selvage of the leading side
17. clamp iron
18. right lower edge cord



### 5.3.2 New sails

Before a new sail (see Fig. 5.3.1.1) is ordered from the sailmaker's, a drawing must be made of the sail. This drawing must contain the following information:

- the distance between the upper and the lower sail lath;
- the width of the frame, reckoned between the stock and the outer hem lath;

The dimensions of three places: the upper part, the middle part and the lower part;

- the distance between each of the clamp irons;
- the distance between the lower clamp iron and the top of the stock;
- whether a rope or a sail chain is used in the upper left corner;
- the shape of the jaw (this may vary markedly in different areas of the country. Refer, if possible, to old photos, as an enormous amount of original material has been lost).

#### *leeched*

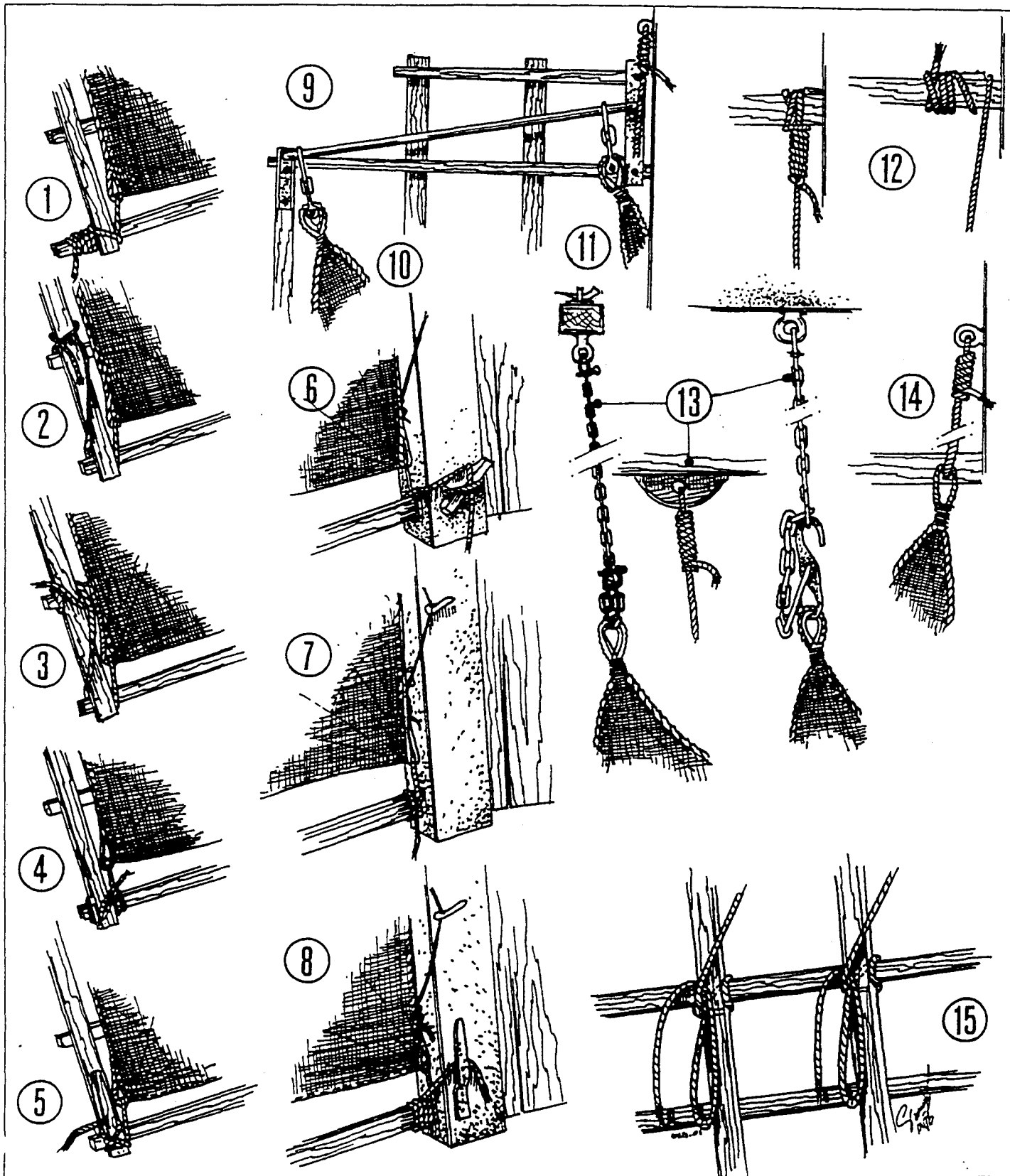
The made-to-order sail is *leeched*, i.e. a rope is sewn round the sail, except on the underside. The best sewing thread for that is indigestible nylon or polyester thread.

The rope, too, is now often made of synthetic material (polypropylene) It resembles natural rope. As in the case of synthetic sail cloth, it scarcely shrinks or stretches and it is weather-resistant.

Fig. 5.3.1.2

>> Various attachment points of mill sails

- |   |  |
|---|--|
| 1-5. attachment of lower left edge cord                   | 12. attachment of upper right edge cord to the upper sail lath |
| 6-8. attachment of lower right edge cord                  | 13. attachment of upper left edge with a chain or rope         |
| 9. sail rail  | 14. attachment of right-hand cord to a sail eye                |
| 10. long corner in the case of spread sail (sail rail)    | 15. fastening of pointing lines                                |
| 11. long corner in the case of rolled-up sail (sail rail) |  |



### 5.3.3 Reefing positions

If the wind permits this, the miller spreads as much sail as possible in order to deliver maximum energy to the grinding machinery. In the case of a weak or moderate wind, four *full sails* are often used (see Fig. 5.3.3.1).

*full sail*

In case the wind rises and the mill is, according to the miller, turning too rapidly (corn mills over 60 bouts and polder mills over 80 to 90 bouts), he must *reef the sails*, i.e. partly roll them up.

*reef sails*

Here it must be kept in mind that the outer stock exerts a greater leverage on the wind shaft than the inner stock. In other words, the outer stock puts more force on the wind shaft than the inner stock. That's why the millwright must always start reefing the outer stock first.

The following reefing possibilities are available (see Fig. 5.3.3.1):

- sail rolled up to the first pointing line: *first reef*;
- sail rolled up to the second pointing line but kept long: *sword point*;
- sail rolled up to the second pointing line but kept short: *half sail*;
- sail rolled up to the third pointing line but kept long: *dagger point*;
- sail rolled up to the third pointing line but kept short: *storm sail*;
- all sails rolled away: *empty frame* or '*bare feet*';
- the sliding boards can be removed as final reefing possibility.

*first reef*  
*sword point*  
*half sail*  
*dagger point*  
*storm sail*  
*empty frame* or '*bare feet*'

All kinds of combinations between the above possibilities may be used, providing:

- the same reefing position is used per stock;
- as much reefing as possible is done on both stocks.

This means that revolving with two full and two empty ends is generally not recommended. In such a case, four half sails is much better. Theoretically there may be no difference between the two reefing positions but in practice that difference does indeed exist. For with two full and two empty sails, the mill will turn less regularly than with four half sails. In a strong gust of wind, a mill with two full sails will turn much more rapidly because the tips of both rigged ends will respond more fiercely to gusts of wind. It is also known that the cap or the upper house of a mill rigged in this way tends to start moving to and fro, especially when there is some wind obstruction. That's why four half sails are preferred. The mill will then revolve much more regularly and the tail and the braces will suffer less.

When the mill is turned straight in the eye of the wind, the sails may start slapping. For in front of the mill trunk the wind is slowed down, thus lifting the sail from the passing end of the frame. Closely past the trunk, the sail, in full wind, slaps back on the frame. This phenomenon frequently occurs in mills turning idly, certainly when the mill has wind obstruction. It can be prevented by turning the mill less close into the wind (to the left). Reefing too is a means to prevent the sail from slapping.

Fig. 5.3.3.1  
Various reefing positions >>

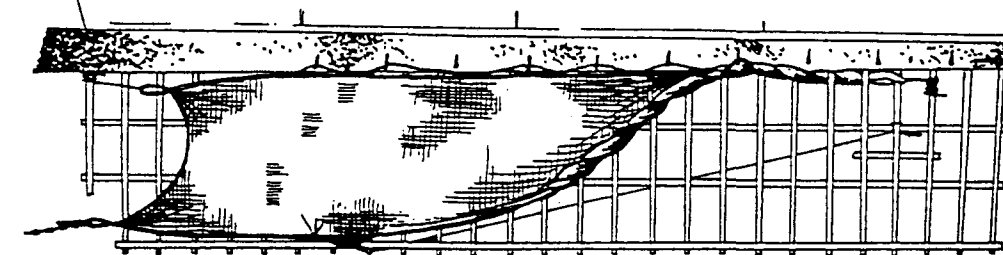
1. *full sail*
2. *first reef*
3. *sword point*
4. *half sail*
5. *dagger point*
6. *storm sail*

Illustration should show rolling sail cloth

Underneath,  
No tover  
as it appa.



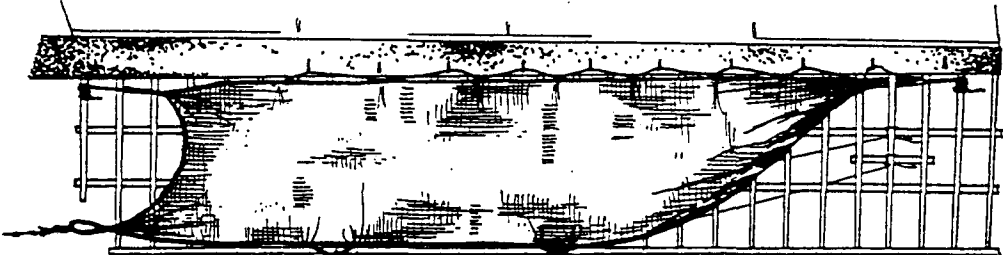
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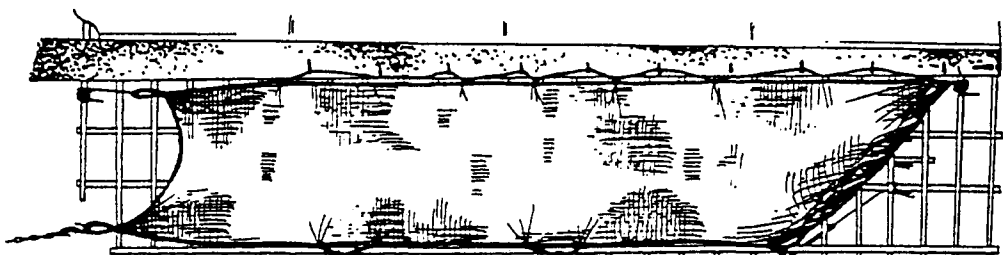
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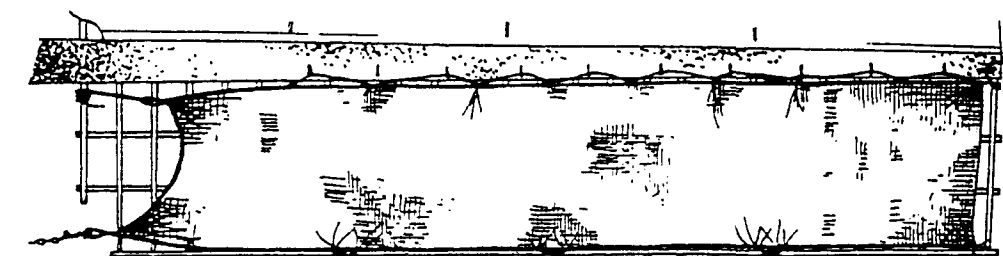
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④



⑤



⑥

### 5.3.4 Hanging the sail

Wait for a day when there is little wind, turn the mill into the wind and go to work as follows.

Place the sail package in the mill yard or on the stage. Unfold it completely and then loosely roll it up lengthwise. Fasten the right under edge line to the lowermost sail lath, with the sail at the correct height (10 to 15 cm above the lowermost sail lath). Then place the left and right upper edge line over your shoulder (so that, if necessary, you can immediately let go of the sail) and take it up with you. Do not tie the sail to your body under any condition. When you get on top, put the right upper edge line on the uppermost sail lath and tighten it firmly and fasten it with several turns around the sail lath. If there is a fastening point even higher up, use it, as this will make it easier to roll up and clamp the sail. Next, fasten the top left-hand corner of the sail to the chain or the rope hanging from that sail arm or the eye of the other stock. You may need some help from a colleague out of the left storm hatch in the cap. (From that place it is easier to fasten the rope to the sail arm or the sail eye). Then walk down while placing the loops behind the clamp irons. When you get down, check to see if there are folds in the sail. If so, the top left-hand corner of the sail is hanging too low or too high. Only by once more hanging the top left-hand corner will you be able to smooth out the folds. Do not touch the top right-hand corner which was fastened earlier, otherwise the entire sail will end up hanging too high or too low.

- When removing the sail, you must fasten any sail chains firmly to the sail lath.
  - When hanging repaired sails, reserve the best ones for the inner stock, as these are used most (see 5.3.3).
  - If cotton or synthetic/cotton sails are still being used, after about 3 years it is recommended to smear the front of them with brown impregnating agent (brand name: Hydrolyn). This will make the sails waterresistant again and increase their life cycle. (Dilute the Hydrolyn with benzine, otherwise the sails will become like planks.) In former days millers used to make the cotton sail cloth moist with water and then smeared them with linseed-oil, sometimes mixed with tiver. They used a long-handled scrubbing brush for this.
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## 5.4 SAIL SYSTEMS

### 5.4.0 Introduction

In the nineteen twenties technology was at an advanced stage. The production of consumer goods gradually became independent of wind and water power. Many industries and households used electric power. Vast numbers of polder mills were replaced by mechanical pumping stations. Furthermore, because of the continuous settling of the peat soil, the water had to be pumped higher. Corn millers discovered the ease of using milling stones driven by engines. They no longer had to wait for the wind, and the time-consuming work on the sails, the luffing gear and the catch was a thing of the past. The performance of windmills lagged far behind that of machines driven by new power sources like electricity.

For mills to survive, improvements on them were absolutely necessary.

In 1891 the mill 'Eva' of the village of Usquert in the northern part of the province of Groningen became (as first mill in the Netherlands) patent sails and a fantail. The cloth sails were replaced by shutters which could be opened and shut according to the power of the wind.

After the First World War, in 1918, the knowledge of aerodynamics had progressed very far. The Dutch Mill Society, founded in 1923, was very much concerned about the survival of mills and held a competition aimed at raising the performance of mills. This resulted in numerous designs for sail improvements.

Most of the improvements involved streamlining the sails. Other systems involved replacing the frame by a rotating shutter ('jib-sail'). Some sail improvements caused the mills which had been equipped with them to revolve too rapidly in a strong wind. This problem was largely solved by applying skyscrapers (air brakes) (see 5.4.8).

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### 5.4.1 Patent sails

*patent sails*

*Patent sails* are not an improvement of sails in terms of a better result—rather they make matters easier for the miller. Patent sails (but with 'old Dutch' wind boards) do not offer a better performance than a common sail system, but they do save the miller a lot of time (and attention), time that would otherwise be spent reefing sails. For, with patent sails the wind-catching surface is automatically changed. So, the biggest advantage of patent sails is a gain in time. With a single action the wind-catching surface is nearly reduced to zero. A second advantage is the more regular revolution of the sails (provided everything is well lubricated and adjusted).

*shutters  
hemlaths  
sail rod*

*fork irons, spider  
bell crank levers, rein irons  
central striking rod*

*rocking lever  
weight chain  
mizzen*

Patent sails were developed in the early nineteenth century in England and applied towards the end of that century in Groningen via Denmark and northern Germany. In patent sails, the sails have been replaced by a series of wooden shutters. These *shutters* are placed crosswise on the stock between modified 'sail bars'. On two sides there are *hemlaths* between which the shutter rods turn (see Fig. 5.4.1.1). At each end the shutters are jointly connected by a *sail rod*, which ensures that they all assume the same position. The sail rods of the four ends come together via *fork irons* at the cross, where they are connected to the *spider* with *bell crank levers* and *rein irons*. The *spider* is located right in front of the cross and connected to the *central striking rod* (see Fig. 5.4.1.2) which passes through the whole cross and comes out again behind the tail pin. There the central striking rod is connected to the *rocking lever*, to which an endless chain, the *weight chain*, is connected. The chain hangs above the central striking rod via a pulley to a fixed beam, the *mizzen* (see Fig. 5.4.7.2). When the miller pulls one of the chain 'ends', the shutters close. The mill can now revolve. By hanging a weight on the chain, the miller prevents the shutters opening again. By adjusting the weight, the miller can, during grinding, change the moment when the shutters open again and so change the number of bouts of the mill.

The miller stops the mill by removing the weight. By pulling the other end of the chain, he opens the shutters. The chain is fastened to the tail.

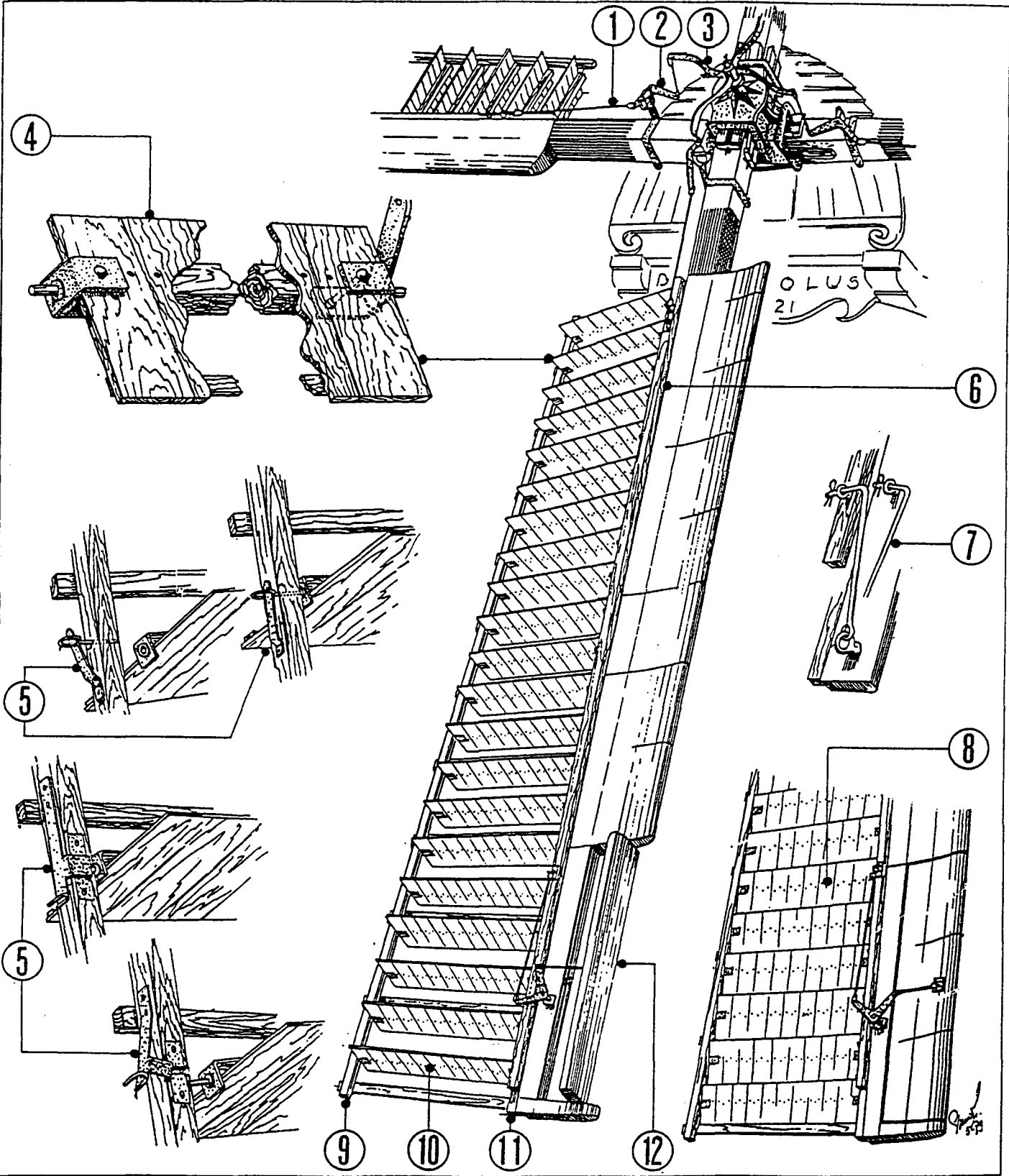
The disadvantages are:

- Even when the mill is not turning, the cross must be placed straight in the wind. A slanting wind places a load on the horizontal stock and hence on the entire sail system and the cap.
- When the wind is blowing straight from the rear, the shutters are, despite the fastened chain, pressed closed due to the play of the whole system. The shutters are closed due to the eccentric placing of the shutter axles (see Fig. 5.4.1.1). The mill could then start revolving in reverse.
- The miller can prevent this by securing the sail rods. In the event of a storm, however, the miller cannot rely on this method of securing and the mill must be turned straight into the wind.
- The paintwork of the sails and the lubrication of the numerous points of rotation require a lot of attention.

Fig. 5.4.1.1

*Patent sails >>*

1. *central striking rod*
2. *bell crank levers*
3. *spider*
4. *shutter*
5. *various lock(controls)*
6. *sail rod/shutter bar*
7. *lockcontrol against closing of the shutters*
8. *closed shutter*
9. *left hemlath*
10. *open shutters*
11. *right hemlath*
12. *skyscraper, air brake*



The province of Groningen has the largest number of mills with patent sails in Holland: 41 mills (nearly half) are equipped with patent sails on one or both stocks. Friesland has 10 mills with patent sails. The use of modern weather- and wind-resistant material has simplified the major servicing of the mills.

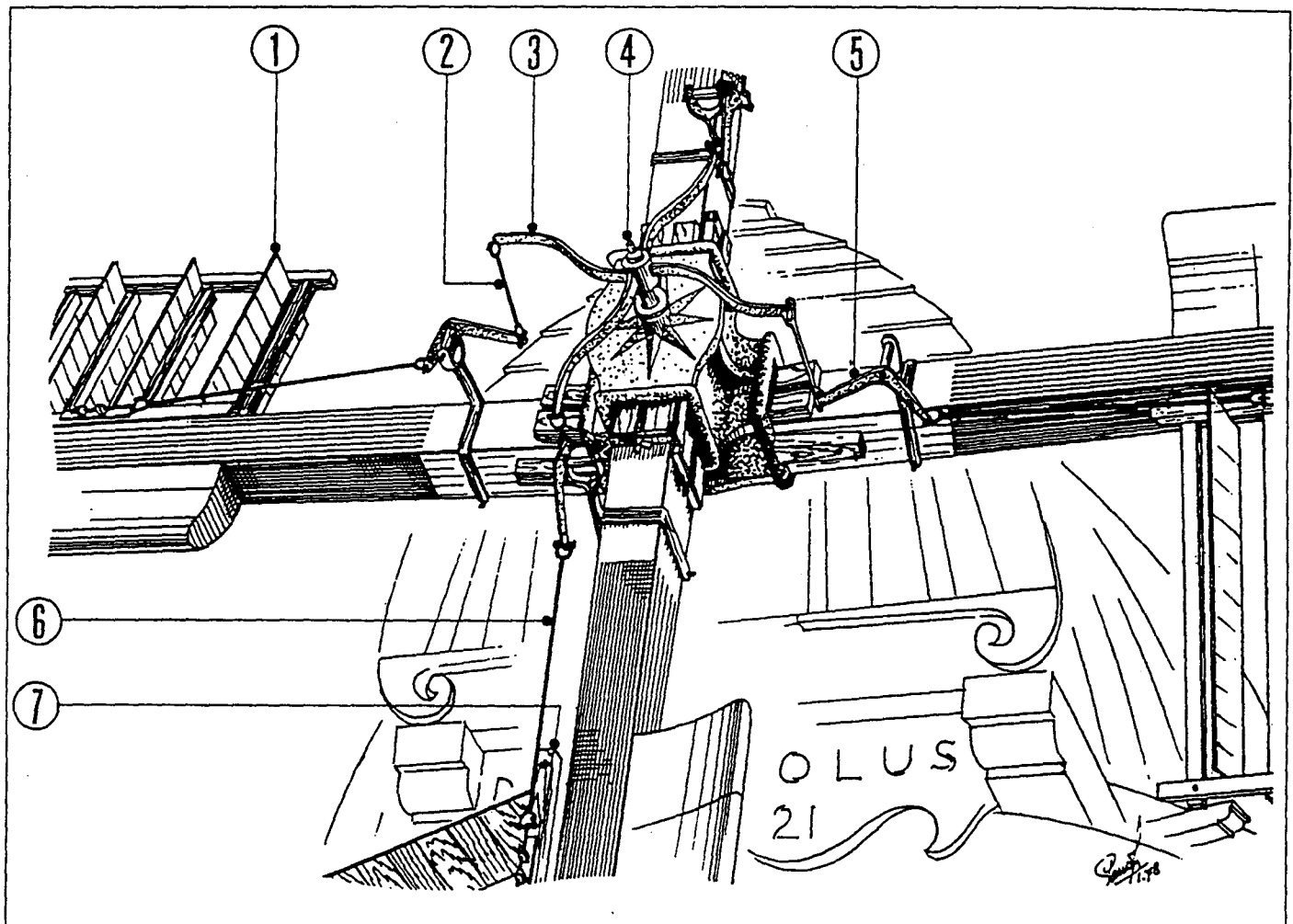


Fig. 5.4.1.2

*Canister with spider*

1. shutters
2. rein iron, bridle iron
3. spider
4. central striking rod
5. bell crank lever
6. fork iron
7. sail rod / shutter bar