HANDBOOK WINDMILLER

The Guild of Millers

COLOPHON
HANDBOOK WINDMILLER

Het Gilde van
Molenaars

Published by: The Guild of Millers, www.gildevanmolenaars.nl

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Revised 2016, 2018. Translation 2025
Many volunteer millers and other experts contributed to this review.

The financing of this translation was achieved by a generous subsidy from the Cultural Heritage Agency of the Ministry of Education, Culture and Science of the Netherlands.

Cultural Heritage Agency
Ministry of Education, Culture and Science

CIP DATA: ROYAL LIBRARY, THE HAGUE

Handbook
Handbook Windmiller / G.J. Pouw (et al.), The Guild of Millers - III.
Loose leaf - With letters patent
Keywords: millers, training, course

Printing: DE BUNSCHOTER, Bunschoten/Spakenburg ISBN
90-9005722-6
SISO 653-2
Keyword: Miller (training for)
D/1992/12/2000

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Foreword

Our slogan "Become a miller" calls for action. The route to becoming a volunteer miller has a clear approach and will require a lot of action from you over the next few years.

During the course, you will learn how to work with the mill. The training approach is a practical one; above all, it involves a lot of doing. But theoretical knowledge is also required. The topics you need to have knowledge about include: the weather, the driving gear and standing parts, working safely, and the different types of mills and their functions.

The theoretical knowledge is contained in these two folders. In addition, you can attend theory evenings organised by each department within the Guild. Many books that will give you a deeper understanding of a particular topic are also mentioned. If you want to explore the subject in depth, then you should obtain these books for reference. And you can, of course, ask an instructor for an explanation.

You complete the basic course by taking a national exam administered by the examination committee of *De Hollandsche Molen* Foundation. The training takes 2 to 3 years on average.

Both folders for the basic training were completely revised in 2016. Some chapters had to be completely rewritten. Furthermore, distracting text and language errors have been removed. And the course material has been brought more in line with the exam requirements. As a result of the improvements, both folders can be considered to be an important reference work not only for trainee millers, but also for millers who have long practised this craft. Taken as a whole, the folders form part of the Guild's history.

This new edition describes what the craft of water milling entails, which gives it a cultural and historical value. With its combination of practice and theory, the revised publication is unique within the milling world. No other publication pulls together all that information so compactly.

All that remains for me to do is to wish you much pleasure and success as you pursue your training. Do not be put off by all the new things that will come your way. Above all, take pleasure in a working mill and remember that, after obtaining the certificate for miller, you may work in a mill yourself. What could be more fun and challenging! By doing so, you are helping to preserve this part of our intangible cultural heritage for our future generations. That is something you can be very proud of!

Erik Kopp,
President of the Guild of Millers 2015-2024.

Chapter 2 Introduction

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Fig. 2.0.1
Open post mill

2.1 WHY VOLUNTEER MILLERS?

As early as 1923, the preservation of mills was coordinated by the establishment of the Association *De Hollandsche Molen*. Years of hard work have passed since then, sometimes with scant success due to a lack of understanding but ultimately with a wonderful result of more than 1,000 mills having been preserved in the Netherlands. Hundreds of mills have been restored over the years and have come under the management of associations, foundations and municipalities that oversee mill preservation.

But restoration and management alone, however necessary and useful, are not enough. For few other historic landmarks does the saying 'standing still is going backwards' apply so strongly. Exposed to wind and weather, this decline happens incredibly quickly with mills. Practical experience has shown that a restored mill that never turns will need another restoration after only ten to fifteen years. In other words, mills are best preserved by keeping them turning regularly. And that requires properly trained millers.

Fig. 2.0.2
Partly enclosed post mill

2.2 BECAUSE MILLS MUST TURN!

A mill is exposed to all types of weather because of its function. When not in use, there is usually little or no supervision. Minor defects such as loose hatches, leaks, rust, the poor condition of parts of the thatch or weather-boarding and the like are then not noticed in time. When these do become evident, the damage is usually already extensive. When mills are operated regularly, these defects are more likely to be noticed and can then often be fixed at little expense, often by the miller him or herself. Periodic maintenance also tends to be more timely in that case, which obviously has a strong cost-saving effect.
In addition, a turning mill enlivens the landscape much more than a stationary one. Mills in working condition also better display the ingenuity of our ancestors who used these tools to initiate industrialization and drain large areas of our land.
That's why mills must turn!
The government of the Netherlands also recognizes the importance of working mills and skilled millers: since 2014, the craft of milling has been on the Netherlands' National Inventory of Intangible Cultural Heritage.

Fig. 2.0.3
Enclosed post mill

2.3 THE GUILD OF MILLERS

In 1967, a number of mill enthusiasts who shared a clear guiding principle as far as mill preservation was concerned — namely, to keep mills working — came together. The only proper use of a mill that is consistent with its preservation as a living historic building is one in which the mill as a machine remains untouched. This means that the original function of the mill (milling grain, sawing wood, draining a polder, etc.) must be preserved.

Increasingly, however, there arose the problem of professional millers ageing or stopping altogether. In our current society, mills — whether industrial mills, polder mills or watermills — are hardly 'profitable' and cannot manage without government subsidies or other financial support. For that very reason, many skilled millers had to close the mill door behind them for good. At that time, the number of windmills with a professional miller was less than 5% of the Dutch mill stock and this percentage continued to decline. This meant that people capable of making the mill perform its function were needed. In the first place, these were primarily the remaining skilled millers, of course. But in addition to them, volunteer millers had to be trained.

For that reason, the aforementioned group of mill enthusiasts decided to establish the Guild of Volunteer Millers in 1972.

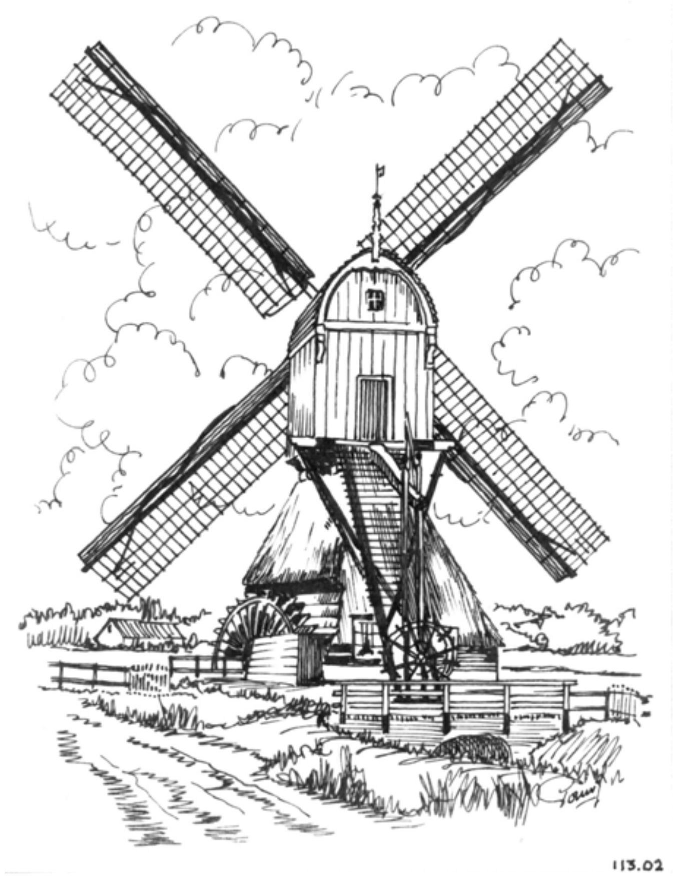


Fig. 2.0.4
Hollow post mill

That their arguments proved valid and did not stem only from idealism is evidenced by the fact that the government allocates substantial subsidies towards the cost of annual mill maintenance, on the condition that they turn regularly!
The Guild's articles state that its objective is to serve the interests of mills in the Netherlands. To this end, the Guild provides training as a volunteer miller for its members, and it looks after the interests of all members who are undergoing or have already completed this training and are operating mills or working at mills. Furthermore, knowledge and experience about the production processes of windmills and watermills is collected, documented, maintained, and disseminated.

The Guild seeks to achieve its objective by:

- organising both practical and theoretical instructional meetings for the transfer of knowledge by instructors and other experts;
- recruiting, appointing and supporting instructors and trainee millers;
- supervising members who follow the training and assisting them in making the necessary contacts for this purpose;
- acquiring existing informational material and preparing (or arranging for the preparation of) new information material related to grinding with mills, and making this material available to members;
- organising the entrance examinations and guiding its members through the national examination, conducted by a committee of experts under the auspices of *De Hollandsche Molen*;
- advising on and setting examination requirements in consultation with *De Hollandse Molen*;
- liaising and cooperating with other national and regional mill authorities to achieve the best possible outcome for all activities associated with mills.
  (See also Articles of Association of the Guild of Millers.)

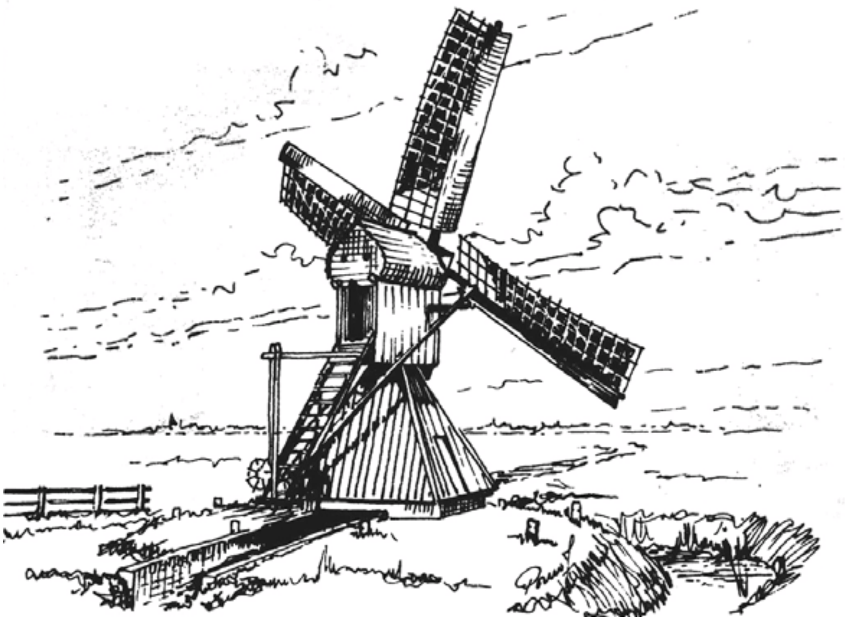


Fig. 2.0.5
Spider mill

2.4 WHAT DOES IT TAKE FOR GUILD MEMBERS TO BECOME A MILLER?

As described above, what is required is genuine interest and enthusiasm, at least. To successfully complete the training, you will not only have to attend instructor's classes on a regular basis, but you must also visit working mills. This means not just watching but rolling up your sleeves — even when it's raining or blowing a gale and, of course, not in your best clothes. A miller must gain experience under all weather and other conditions.
Initially, the plan was that students would seek out a skilled miller on their own initiative and learn the trade from him/her, after which they could take the exam on that miller's recommendation and subject to having the necessary theoretical knowledge. However, the diminishing number of skilled millers led to the compilation of a list of volunteer instructors willing to instruct members-in-training.
Since there are not enough operating mills to be found in all regions of the country, some students will have to travel for this.
While it is certainly recommended to learn the practice from an expert-miller instructor or volunteer instructor, it is not, however, mandatory. This can also be done with another experienced successful volunteer who is not on the list but is willing to help.

Fig. 2.0.6
Hollow post stage mill

The duration of the training depends greatly on the student's own commitment and the frequency with which he/she attends the instructional meetings. Those whose interest in mills developed later in life should count on the training taking a good two years. You will need to have learned to work with a grinding mill in all seasons and to have gained sufficient experience under all weather conditions at a mill where you have spent a minimum of 150 hours working. Upon successful completion of the exam administered by the *De Hollandsche Molen* examination committee, the candidate will receive the ' Miller Certificate'. Most of those who pass will then go on to work as a miller themselves. Even then can the Guild be helpful, such as with finding a suitable mill or with deepening your knowledge of mills. Virtually all graduates also remain members of the Guild after obtaining their certificate. In this way, lively and instructive contact is maintained between independently operating millers and members-in-training.

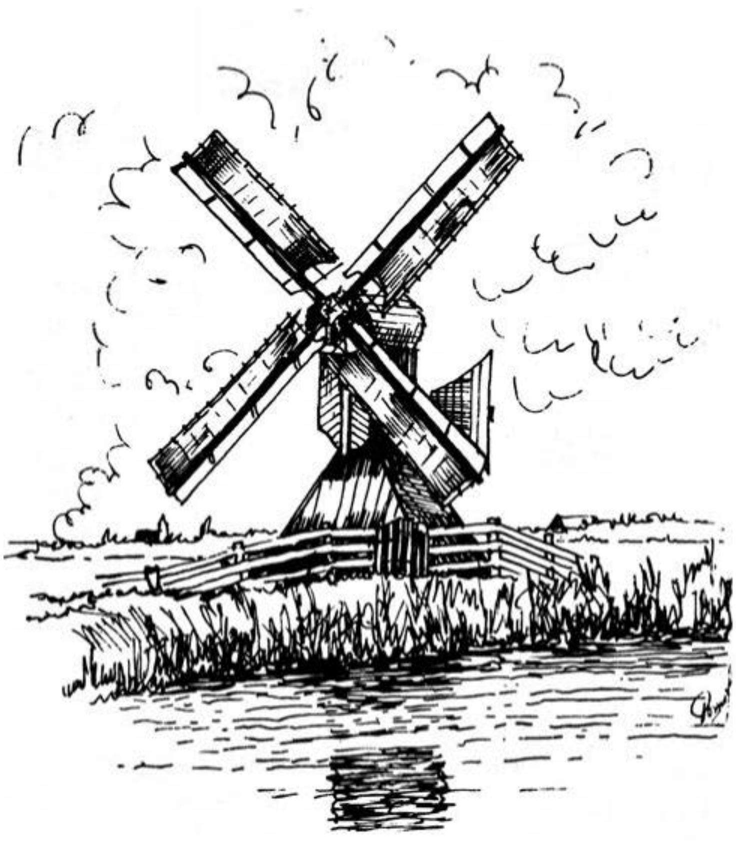


Fig. 2.0.7
Meadow mill

2.5 THE TRAINING

Most mills in the Netherlands are no longer operated by professional millers. Volunteers take their place, even at industrial or other mills that are still or again in full or partial operation. They work with a precious machine and are engaged in a very old craft. So it is not surprising that a great deal of knowledge must be learned and experience gained before you get to the point where you can take responsibility for milling.

Strictly speaking, the training for millers is limited to being able to run the mill unloaded; that is, without putting the machinery present into operation. Nevertheless, knowledge of the machinery found in the various mills is an important part of the training. This is in part due to the fact that many millers, during their training or thereafter, go on to work at a mill that is still capable of milling. Or they may act as a host and explain the operation of the mill to interested visitors.
There are very few professional millers left to learn the trade from, but fortunately enthusiastic volunteers have acquired a lot of knowledge of the craft from them. The instructors and trainee millers of the Guild are the appropriate people to teach the students the practice and theory. It is recommended that most of the time during the initial training period be spent at a designated instruction mill.

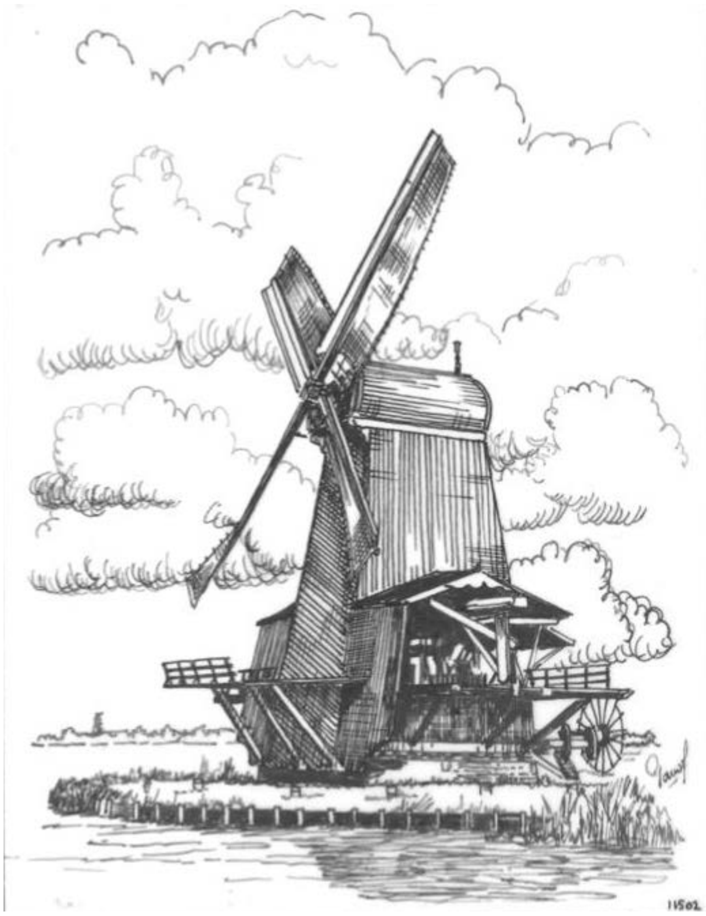


Fig. 2.0.8
Paltrok

You then learn to present and clamp sails and how to wind. A lot of attention is also given to stopping the mill — the braking. Other subjects covered include knowledge of the winding mechanisms, the sail systems, lubricants, minor maintenance, and safe working practices.
The weather is also important. How the weather behaves can only be learned in practice, although theoretical knowledge of the weather provides insight into the why and how of the weather phenomena you observe.
Once you have mastered the basic skills, it's a good idea to visit other mills, as well, or even spend a day watching them in operation. In this way, you receive practical training and gain experience in operating mills. The requirement to have 150 hours of practice at a mill should be considered a minimum. It goes without saying that you should have experienced all kinds of weather situations once in all seasons, and therefore you should have filled in your mill journal for at least an entire year before applying for the entrance exam. After passing the entrance exam, participation in the national exam follows.

In recent years, some volunteers have also learned from skilled millers how to grind grain, saw wood, or press oil. And they, too, pass on the knowledge and skill of their craft to the next generation. Among other things, this development led to the formation of the Craftsmen's Guild of Grain Millers (AKG), which established its own training programme for grain millers. Wood sawyers and oil pressers also exchange their knowledge and experiences.
Although being able to work with operational mills is not the Guild's goal, that development is nevertheless welcomed.

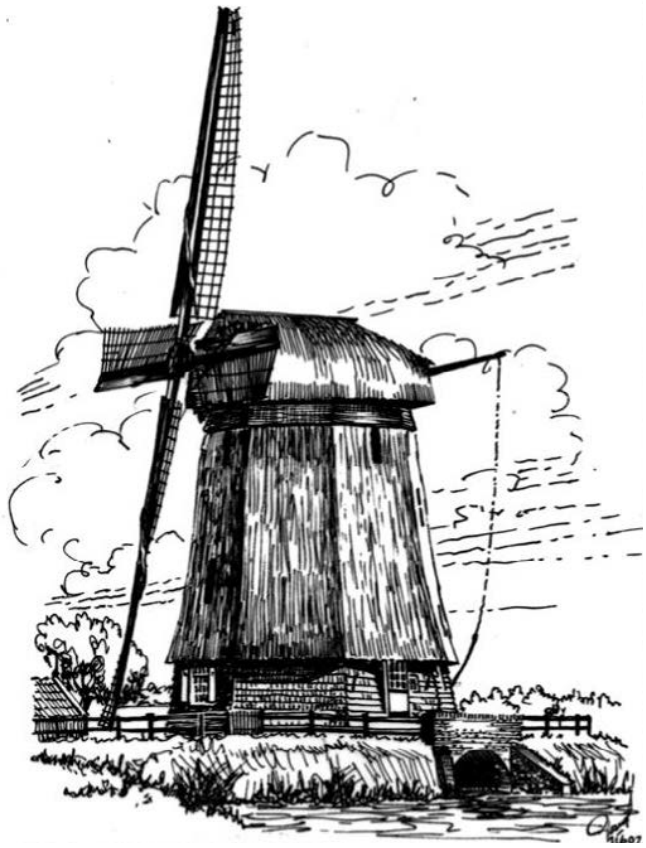


Fig. 2.0.9
Octagonal inside winder

It goes without saying that some theoretical knowledge of various mills and components is also necessary. A volunteer miller lacks the knowledge and innate feel for the mill that used to be passed down from father to son. The need for theoretical knowledge has been recognized by the Guild from the beginning. One of its first steps was to find mill experts willing to put the much-needed theory onto paper. In addition, over the years since the establishment of the Guild in 1972, there have been professional millers and volunteer millers who have further expanded the knowledge they acquired and put it down on paper. Some of this was published by the Guild as pamphlets and provided great support for the instruction. In 1993, much of the available knowledge and experience was brought together in the compilation of this Handbooki for the Miller. And, in 2012, the Guild published a series of Lesson Plans to support miller training. Furthermore, the Guild is helpful in providing practical and theoretical information.

The many efforts of the Guild of Millers have certainly helped put an end to the trend of mills standing idle and decaying. Lots of mills are turning and/or milling away again on a regular basis! Because mills must turn; that is their strength and that is what they were built for!

Fig. 2.0.10
Octagonal outside winder

2.6 THE MILL AS A HISTORIC BUILDING

Millers should not only have practical skills and some theoretical knowledge but they should also be aware that, in many cases, they are working with a protected historic building. What does that mean?

There are more than 60,000 nationally listed buildings in the Netherlands, including about 1,150 mills. These are protected by the government because of their heritage or cultural-historical value, such as because of rarity or typology or because they are located in a water management or urban development structure. To prevent this value from being lost, these mills are recorded in the Listed Buildings Register.
The administrator of the Listed Buildings Register is the Netherlands Cultural Heritage Agency (RCE), an implementing agency of the Ministry of Education, Culture and Science. The RCE connects heritage policy, science and practice. It implements laws and regulations, advises municipalities in permit procedures, handles grant applications, and makes knowledge available. For these tasks, the RCE employs two mill specialists.

The starting point for the national government in dealing with mills and the remains of mills is their heritage value, their place in the landscape, and their function in society. It is an objective appreciation of what is currently there, tailored to the individual mill.
Keeping the mill working, preferably as if it were still in full economic operation, is not the only goal of the policy. The national government is in favour of keeping mills turning and milling as long as the protection of heritage values is observed in the process.
The publication 'A Future for Mills' formulates a number of points of reference for dealing with mills, consisting of, for example, the location, the building and any driving gear, the building's history, and the history of the location. This publication is available digitally or for free at www.cultureelerfgoed.nl

The term 'listed building' is not limited to the mill itself, but also includes the interior, the individual mill components, the landscape around the mill, and stories about the mill. A bedstead, box stock, kitchen garden, old crown wheel, sack stencil, flour shovel, fish trap or electric motor are mill components that sometimes date back to the construction period, are of high value, and are therefore irreplaceable.
Every miller should be aware of this value; take a walk through the mill and survey the mill's collection.

Archaeology
Digging a trench on the mill grounds for drainage or excavating old foundations also reveals information about the mill. But what does the miller do with that archaeological information? In the case of such activity, he/she must always first ask him or herself whether it's a good idea to do this on any random Saturday.

Mills are valuable and expensive, so people try to keep the mill running with as few resources as possible. Sometimes this has unintended negative consequences for the historic building and its value. It is often the case that repairs, interventions or changes are made without people being aware of what this actually signifies for the mill. Examples of this are installing heating in the mill, installing new machinery, changing functions, replacing parts, or cleaning a mill’s structural stonework.
All the changes made to the interior or exterior of a mill not only wipes away traces of its history but also leaves them behind. Mills are structures with many building traces that have a story to tell. The challenge, then, is to add your own chapter without throwing away old stories. Replacing floors or repainting an interior wall so that the mill looks neat again can have many implications for the heritage value. When an intervention is undertaken, appreciate and document the current heritage values and add something to that in a sustainable way without throwing away historical layers in the process.
If in your role as a miller you want to change anything about the mill, consult with the owner. The owner can contact the municipality or the government department to see to what extent a permit is needed and to obtain knowledge.

The miller is undeniably part of the chain. Running the mill regularly or carrying out minor maintenance work keeps the mill in good condition. Running the mill safely and especially responsibly, as well as preventing unsafe situations, is very important for the continued existence of the mill. While fulfilling your role as a miller, a variety of issues may come your way. It is important to recognize these and ask yourself how to deal with them without negatively affecting the mill's heritage.
Every mill owner must realize that a mill is a wonderful historical machine that he/she must preserve for those who come later.

2.7 THE MILLER AS HOST AND AMBASSADOR

As mentioned earlier in this chapter, when the miller receives visitors at the mill, he/she also acts as host and ambassador. The miller fulfils this role either alone or with fellow millers and/or mill guides. And it is no small role. The impression visitors get of the mill depends largely on the people they meet there and the hospitality they experience. That makes hospitality an extremely important aspect. What does that mean, exactly? And as a miller, how do you fulfil your role as host and ambassador?

Hospitality means being focused on and keeping in mind the wants and needs of your guest, the visitor. If you ask a visitor what he or she thinks of when they think of hospitality, the following things come to mind: receiving personal attention, feeling at ease, being treated as one wishes to be treated, and experiencing friendliness and a warm atmosphere.
But hospitality encompasses more. Hospitality plays a role in all aspects of the visit. It starts with searching for information about the mill on the internet: can visitors quickly and easily find what they need?
Several factors influence how welcome a visitor feels. These include information (information is provided), hygiene (the toilets are clean), safety (free from obstacles), attention (the visitor's presence is noticed), friendliness (the visitor is received by a person who shows engagement), and price (the price corresponds to what the visitor receives in return).

Who actually are the visitors who come to the mill? Visitors come in various combinations and have diverse backgrounds. They may come individually or in a group. They may come from the Netherlands or from other countries. They may be tourists or business customers. However, consciously or unconsciously, every visitor comes with certain expectations that can be very different. You can categorize these as follows:

- Expectations about content: what topics the visitor wants to see or learn more about.
- Expectations regarding the 'institution', such as the mill: most people will think of a mill as an operating mill, where a miller works who keeps it running.
- Expectations regarding their own well-being: visitors expect a warm welcome from a friendly employee, a toilet and perhaps a cup of coffee.

If these expectations are not met, a visit is not necessarily less successful. But visitors do need time to adjust their expectations. In any case, it is good to be aware that every visitor to the mill has expectations (and wishes!).

Millers and mill guides who look after visitors form the mill's calling card. Their appearance and actions determine the success of the visit. For good service, you at least need to have sufficient knowledge and information on several levels:

a. Substantive and touristic information for the visitor.
b. House rules (or code of conduct) for employees and house rules (or visiting conditions) for visitors.

c. Own duties and authorities.
d. Security and safety.

a. Substantive and touristic information for the visitor
First and foremost, this concerns information about the history and operation of the mill and its own activities. In addition, knowledge is needed about the organization that owns the mill, such as the mill foundation. This is where the role of ambassador comes in. As an ambassador, the miller is the representative and promoter of both the mill and the managing organisation/owner. For example, is the mill foundation engaged in a fund-raising campaign? Are special activities being organized? Include this information in your contact with the visitor. Finally, it is important to be aware of what there is to do in your town, village or region, where to have lunch, where the bus stop is, and what the bus departure times are.

b. House rules for employees and for visitors
House rules mean: what employees may or may not do, what visitors may or may not do. Many organizations have house rules for their staff; these rules concern the (company) clothing or badge to be worn, for example. House rules can also relate to adherence to agreements or safety rules. An organization can also establish house rules for visitors. By placing or posting these house rules (or visiting conditions) at the entrance, visitors will immediately know what is or is not allowed.

c. Own duties and authorities
As a miller, you need to know what your duties and authorities are. In addition, it is important to know their scope; in other words, where does your job end.

d. Security and safety
As a miller, you are aware of the various safety issues and everyone's duties in case of emergency. This is discussed in detail in Chapter 10. To ensure that fellow millers know the state of affairs, a good handover is necessary (what happened today: in terms of the technical state of the mill, visitors, millers, other things).

Listening is an important skill for the host. There are different ways of listening. For example, you can hear what is being said but not do anything with the words. However, you can also actively listen and ask a question every now and then to check your understanding of what has been said. With active listening, you also pay attention to the visitor's non-verbal communication. What is perhaps meant or being asked between the lines? Another skill is empathy: you put yourself in the visitor's position to understand their wants and needs. What does this visitor want? A detailed story or a few highlights? As a miller, you have a lot of knowledge and you are happy to share it. But the visitor may only want to know a few things. So you should enquire what the visitor's wishes are for this visit. Non-verbal behaviour can also tell you a lot, by the way. For example, a visitor loses attention and looks at the next floor. Perhaps they have heard enough and want to move on?

Chapter 3 Literature List

For a broadening of the required knowledge, it is recommended that, in addition to the information in this Handbook, you read other books that contain a great deal of valuable information. The broader the basic knowledge, the better your chances during the exam. Keep in mind, though, that much of the information in these books is also outside of the exam requirements. Books whose titles are in bold are especially recommended as supplements to this Handbook. Therefore, we recommend that you obtain these books for review or, if still available, purchase them. Some books are available through the Guild of Millers web shop. Books are also regularly offered second-hand through The Guild Letter or at millers' meetings.
If a library does not have a book itself, in many cases it can be requested from the central library service. Please inquire at the lending desk.
The following is a selection from the many books on mills that have been published (in Dutch only).

Title	Author or publisher
De Brabantse Molens	S.H.A.M. Zoetmulder
De Groninger Pelmolen	B. Dijk et al.
De molen in ons volksleven	A. Bicker Caarten
De Molens van Limburg	P.W.E.A. van Bussel
De Molens van Zuid Holland	Provincie
De Tjasker	L.H. Blom
De Veluwse Papiermolen	C.Th. Kokke
De werking van de pelmolen *	P.H. Havik
De windmolens	A. Ronse
De wind- en watermolens in Overijssel	F.D. Zeiler, G.J.
Perfors De Wolken en het Weer	G.W.Th.M. de Bont
Een toekomst voor molens *	Rijksdienst Cultureel Erfgoed
Eeuwen onder Wind en Wolken	P. Bauters
Elseviers Gids voor het Weer	G.D. Roth
Friese Molens	Stichting De Fryske Mole
Gelders Molenboek	Walburg Pers
Getijmolens	B. Boonman
Groninger Molenboek	B. van der Veen Pzn.
Hellend Scheprad	A. Sipman
Het Nederlands malend korenmol. boek	J Gunneweg et al.
In en om de Grutterij	A.J. Bernet Kempers
Informaties *	**Het Gilde van Molenaars**
Kijk op Molens	J.Th. Balk
Korenmolens *	P.W.E.A. van Bussel
Kracht van Wind en Water	P. Bauters
Molenbouw	A. Sipman
Molens	**F. Stokhuyzen**
Molens, Altijd in beweweging	**Dutch Windmill Society**
Molens in Drenthe	A. Bicker Caarten et al.
Molens in Noord-Holland	Provincie
Molens in Nederland	W.A. Roose
Molens moeten draaien *	**T. Kreuning et al.**
Molens van Nederland	H. Besselaars
Molenwielen	A. Sipman
Nieuw Utrechts Molenboek	J. den Besten et al.
Opleiding Watermolenaar *	**J. den Besten**
Oliemolens	A.J. Bernet Kempers
Over molens der familie Honing *	P. Boorsma
Rond zingende stenen *	D.J. Abelskamp

Rosmolens Westvlaamse kuststreek	L. de Vliegher
Spieren, water, wind	J.J. Kamphuis
Stenen Poldermolens in Rijnland	A. Bicker Caarten
Van Haver tot Gort	R. Helmers
Veiligheid op Wind- en Watermolens *	**Dutch Mill Society**
Watermolens in Nederland	P. Nijhof
Weer of geen Weer	J. Buisman
Wieksystemen **	**G.J. Pouw**
Wij en het Weer	C.J. van Ham
Windmolens	G. Husslage
Windmolens in Nederland	P. Nijhof
Zeeuwse Molens	W. Staat
Zicht op molens	W.A. Roose
Zingende Stenen *	D.J. Abelskamp
Zwaaiende Wieken	H.A. Visser

Publications in bold constitute recommended literature.
Books marked * are online available and can be downloaded from the website:

* The Guild of Millers
www.gildevanmolenaars.nl

** To order by depositing €12.50 at
NL40 ABNA 0554 4450 50 in the name of E.N. Pouw-Schipper in Naarden, stating 'Wieksystemen'.

Some websites (most if not all in Dutch only):

Information about mills	www.molendatabase.nl
Information about mills	www.allemolens.nl
Guild of Millers	www.gildevanmolenaars.nl
The Dutch Windmill Society	www.molens.nl
Craftsmen's Guild of Grain Millers	www.molenaarsgilde.nl
The Oil Pressers' Guild	www.olieslagersgilde.nl
The Sawyers' Guild	www.houtzaagmolen.nl/platformhoutzagers.php
The mill biotope	www.molenbiotoop.nl
The Netherlands Cultural Heritage Agency (RCE)	www.cultureelerfgoed.nl
KNMI meteorology publication	http://library.knmi.co.uk/knmipubmetnumber/knmipub184a.pdf

Many mills also have their own website. These can usually be found in the Mills Database via a link to the information about that mill.

Chapter 4 What are the different types of mills?

Those who are not so closely involved with the mills found in the Netherlands often have the idea that all mills are the same. But nothing could be further from the truth. Experts even say that no two mills are alike!
Mills have many uses and take on many forms in the Netherlands. Various classifications can be made, such as their energy source, their design, their location, their function, etc.

Contents page:

Classification by:

NOTES

4.1 ENERGY SOURCE

The first classification is based on the energy source from which the mill derives its power: wind, running water or muscle power.

4.1.1 Windmill

As their name implies, windmills obtain their energy from the wind. For this purpose, the mill is equipped with a sail cross. The assembly consists of two heavy wooden or metal beams (the stocks) to which the latticed frame and wind boards (leading boards) are attached. Together, these parts form the four wings (wieken) as they are popularly known (in Dutch). In professional jargon, they are referred to as the four sails, swifts or sweeps (enden, literally 'ends,' in Dutch) or the sail cross. The latticed frame can be further fitted with sailcloth to increase wind capture. The stocks are fixed in the end of a large wooden or cast-iron shaft, mounted in the cap of the mill. The machinery is driven via a wheel that is also mounted on this shaft.

Fig. 4.0.1
Frisian mounts

4.1.2 Watermill

A watermill draws energy from the flowing water of a river or stream on which the mill is built. The water is directed through a system of sluices to the waterwheel, which is equipped with a number of transverse paddles or buckets. The speed or the weight of the water bring about a rotational movement of the wheel. The wheel itself is fixed to a heavy horizontal shaft that drives the machinery. A modern version of the watermill is equipped with a turbine instead of a wheel.

4.1.3 Horse mill

The horse mill is usually a small mill, but some are quite large. Inside the mill is a heavy vertical shaft to which is attached a drawbar with a horse collar at the end. One or two horses can be harnessed to this. On this shaft there is also a large cog wheel, a type of gearwheel. The various machines are driven via this wheel.
The horse mill has its origins in hand-driven mills or rubbing stones where production is obviously very limited. As early as Graeco-Roman times, people were looking for better methods and grinding tools powered in other ways. Wonderful examples of these kinds of primitive tools are to be found in the museums of such places as Pompeii (Italy) and Niedermendig (Germany).

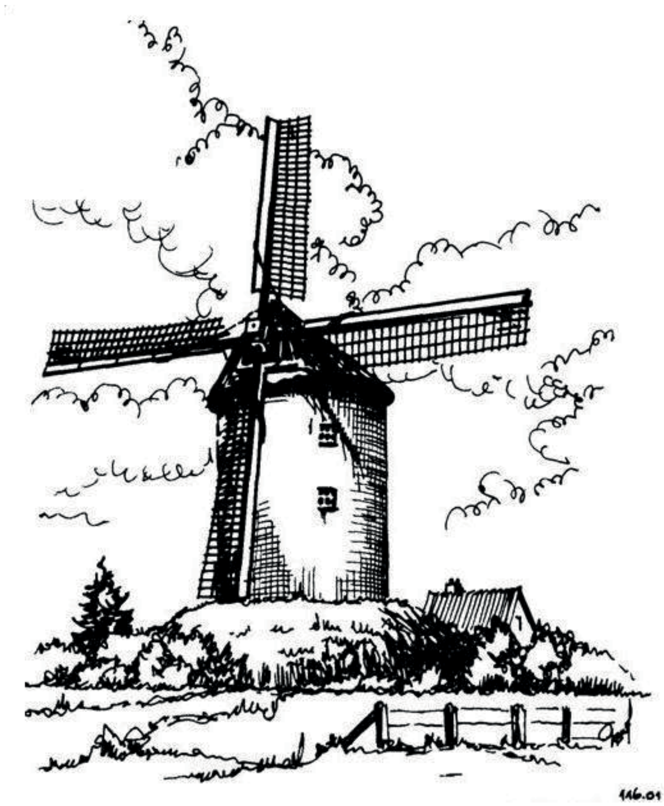


Fig. 4.0.2
Tower mill

4.2 BASIC FORM

No country has as many different types of mills as does the Netherlands. The mills can be described as functional in every respect. Nothing about them is superfluous, apart from sparse embellishments.

4.2.1 Windmills

In the following classification, we proceed from the basic form of the structure and the model. We then arrive at the following classification.

1. Square mills.
   1a. The post mill.
   1b. The hollow post mill.
   1c. The spider mill.
   1d. The meadow mill.
   1e. The paltrok.

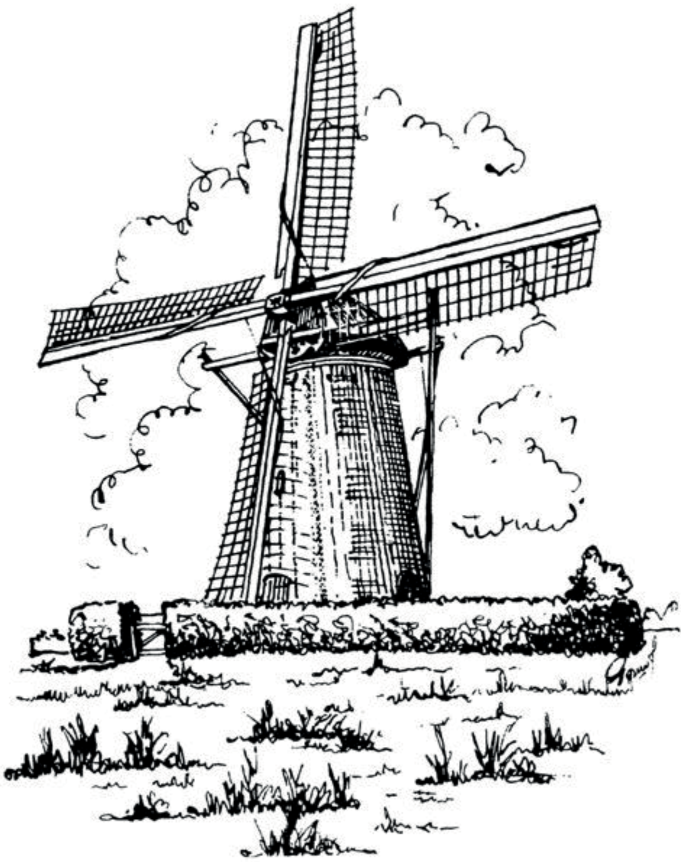


Fig. 4.0.3
Round stone ground-sail mill

2. Octagonal mills.
3. Hexagonal mills.
4. Polygonal mills.
   4a. The twelve-sided mill.
   4b. The sixteen-sided mill.
5. Round mills.
   5a. The tower mill.
   5b. The round stone mill.
6. Various windmills.
   6a. The post tjasker.
   6b. The trestle tjasker.

All the basic forms and models mentioned are discussed in the relevant chapter.

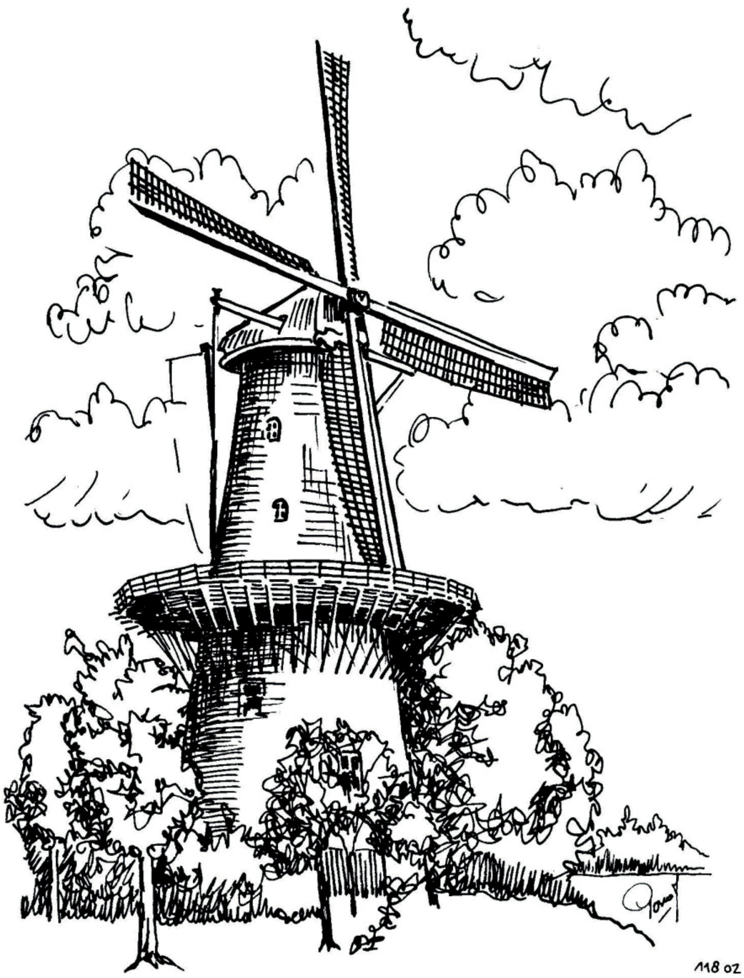


Fig. 4.0.4
Round stone stage mill

4.2.2 Watermills

For watermills, this classification by basic form does not apply. For these, the starting point is the type of wheel by which the mill is driven and the number of wheels. Watermills sometimes have multiple wheels and multiple functions.

1. According to wheel placement.
   1a. The undershot mill.
   1b. The breast-shot mill.
   1c. The overshot mill.
   1d. The turbine mill.
2. According to location of the mill on the banks.
   2a. Single watermill.
   2b. Double watermill.

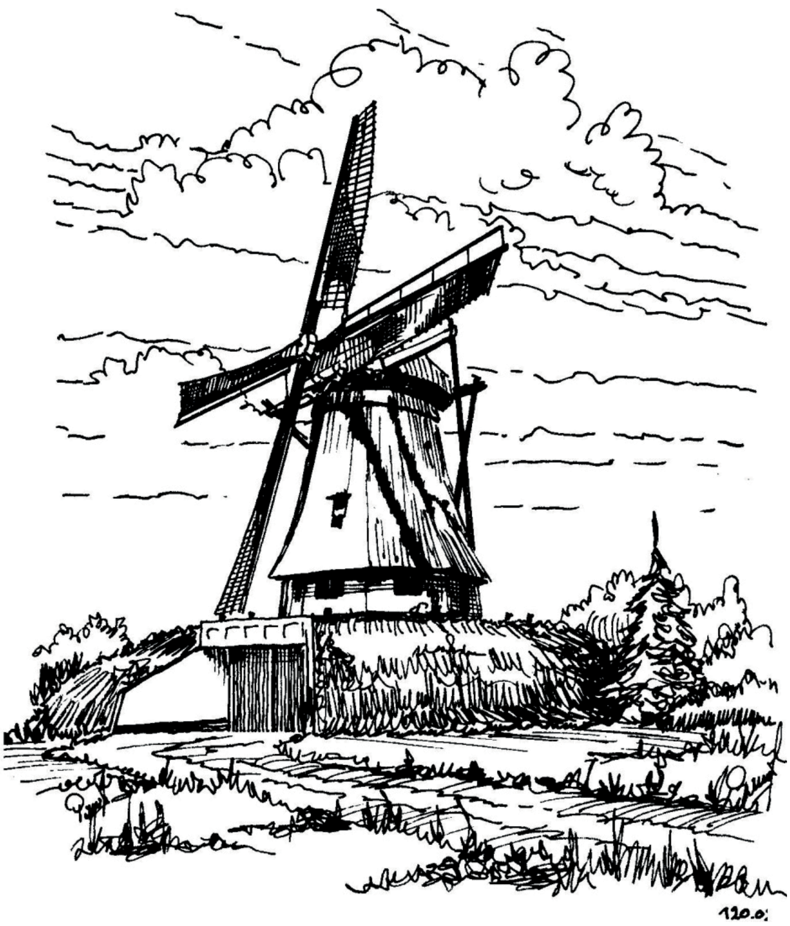


Fig. 4.0.5
Octagonal mound mill

4.3 DESIGN AND PLACEMENT

A third classification is based on the method of construction and the placement of the mill.

4.3.1 Ground-sail mill

This type of mill is built so that the sails skim just above the ground. This allows the miller to present and remove sails from the ground and set the mill facing the wind, etc.
This type of mill includes all (except four) polder mills, all post mills and the smaller grain mills. Grain mills that are built on a rampart, a mound or some other elevation of sand and earth also belong to the category of ground-sail mills.

4.3.2 Mound mill or mill on a mound

This mill is significantly higher than the ground-sail mill. Instead of a stage (see Chapter 4.3.3), an earthen embankment has been erected around the mill, with entry points cut out of this embankment. These entrances are the wagon entrances. From this higher earthen embankment, the miller can access the windmill's sail cross and tail. Through the vaulted wagon entrances cut out from the mound, a horse and wagon can be driven in and out of the mill without being hindered by the turning sails — a big advantage over the ground-sail mill. There is also space for storage of grain, etc., in this lower part of the mill.
The bulk of the mills of this type are located in the south of the Netherlands. People there call them 'mountain mills'. The designation of 'mound mill' is more commonly used in the eastern part of the Netherlands.

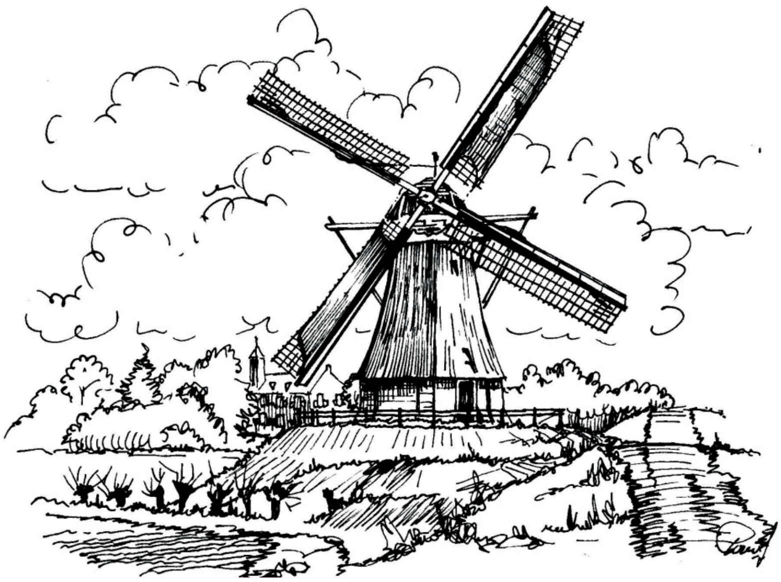


Fig. 4.0.6
Elevated hexagonal ground-sail mill

4.3.3 Stage mill or gallery mill

This mill is placed on a high base to facilitate better wind capture.
For the miller, a wooden platform is placed around the body of the mill, which, depending on the region of the country in which the mill is located, is called a gallery, balcony or stage.
The height of the base can vary greatly, from about two to as much as eighteen metres. The lower bases are found within or on the outskirts of villages, while the very tall mills found their origin and application within and on the outskirts of rapidly growing cities with their high buildings.

4.3.4 Mill with a stage on a shed

Considering the construction of the actual mill, this is an ordinary stage mill but with the base of the mill formed by a central section with one or more sheds on either side, which may vary in size and length depending on the function. Such a shed is necessary because the machinery is not able to be accommodated within the octagonal or hexagonal basic form of the mill base. All these mills are so-called industrial mills, with more than a thousand being known from the heyday of the Zaan region. The longest sheds were found at those mills that were equipped for manufacturing paper.
A good example is the only paper windmill that is still in existence, *De Schoolmeester* (The School Teacher) in Westzaan. The drying shed is 60 metres long.
It can also be said of this mill that it is the only surviving

Fig. 4.0.7
Octagonal stage mill on a stone base

specimen with 'flat boarding'. This means that the flat roof of the shed also serves as a stage.

4.3.5 By river, stream or mill pond

The distinction mentioned here in relation to the location obviously applies only to watermills.
Mills placed on a stream or river exploit the flow rate of the water. If there was insufficient flowing water, a reservoir was built, behind which the water is stored in a buffer or (mill) pool. The mill is located below the weir; the pool is behind or above the mill. In addition, there were also tide mills in the Netherlands. These depended on the difference in level between low tide and high tide. Using a system of sluices, they took advantage of this difference to drive the mill.

Fig. 4.0.8
Octagonal mill attached to a shed

4.4 CONSTRUCTION MATERIAL

The fourth classification is based on the main material used for the construction of the mill body. The classification is as follows.

4.4.1 Wood

When wood is used, the mill body itself is formed by using heavy and lighter beams to construct a rigid and strong skeleton. The covering of the body is applied to this structure.
In octagonal and hexagonal mills, the main structural parts are the almost vertical uprights with a number of connecting beams and crosses between them. In almost all cases, the entire wooden structure is founded on a base formed of brick.
Timber construction was mainly used in regions with soft soil. The mills that formerly stood on the ramparts of Amsterdam were wonderful examples of mills constructed from wood. Two of these have survived: De Gooyer and De Blom, from the Rijkeroord rampart in Amsterdam.
In addition to the octagonal and hexagonal mills, another important group exists, namely the square mills. These include the post mill, the hollow post mill, the spider mill, the meadow mill, and the paltrok mill.
The post mill consists of a large rectangular body in which all the machinery is located. This body rests on a base consisting of an assembly of heavy beams and it rotates around the main post.
The hollow post mill also has a rectangular part called the cabin but it contains only the drive for the mill. This cabin rests on a pyramidal (lower) tower composed of four corner posts with a number of connecting beams between them. The cabin here revolves not around a solid wooden post but a wooden hollow post constructed from eight heavy beams. This is how it gets its name.

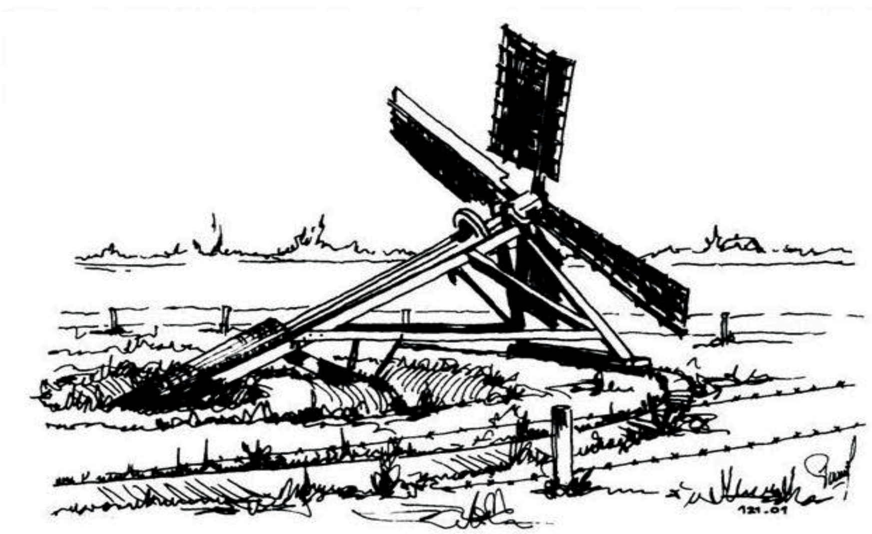


Fig. 4.0.9
Trestle tjasker

There are two more mill types that have a strong resemblance to the hollow post mill in their design and function, namely the spider mill and the meadow mill.

The wooden mill grouping also includes the paltrok. This is only used for sawing wood. The structure of the mill consists of a large four-sided, slightly tapered buck/body from which the saw floor protrudes on either side. These protruding parts of the saw floor are equipped with a covering called a canopy or canopies. The entirety rests on the king pier or king foundation column which is placed in the middle below the mill and has a heavy rotunda around it.
The last type in this grouping is the smallest among mills, the tjaskers. These are very simple polder mills.

4.4.2 Stone

It goes without saying that brick or natural stone was used for construction. Almost all of these mills have a circular base but 6, 8, and 12-sided mills also exist. The so-called tower mill is shaped like a cylinder while the others are shaped like a truncated cone.
The use of natural stone occurs mainly in those areas where this material is widely (in other words, cheaply) available, such as in southern Limburg and in the Achterhoek area.
Heavy stone mills were originally built only where the composition of ground allowed for sufficient bearing capacity. During the heyday of mill building, stone was also used for building mills in other parts of the Netherlands. Back then, those commissioning them had sufficient financial strength to afford a costly foundation.

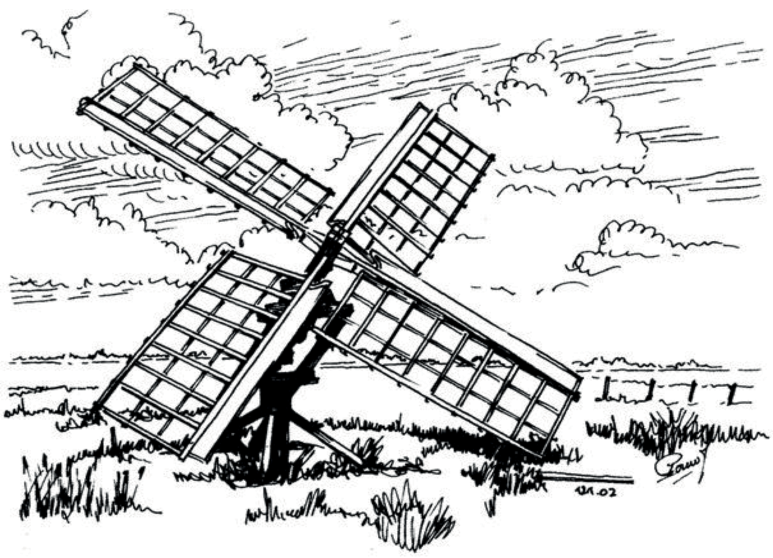


Fig. 4.0.10
Post tjasker

A strict separation of the building materials used is not always possible. There are mills that, given their size and the material used, belong to both groups. These are mainly the mills with a base constructed from brick up to the stage while the actual mill above is made of wood.
Other examples in this context include watermills and horse mills, which can also be constructed of both stone and wood. A special example of this are the watermills executed in half-timbered construction. This method of construction is found mainly in southern Limburg.

Fig. 4.0.11
Watermill with overshot wheel

4.5 WINDING SYSTEM

Yet another classification is one which looks at the way in which the sails can be turned to the wind, which is called winding.
Here we can use the following classification.

4.5.1 Place of operation

4.5.1.a Inside winder

This mill is turned to face the wind from inside.
The capstan wheel used to do this is located on the cap floor and is united with the cap structure. The oldest type of mill equipped with this is the tower mill of which there are still four in the Netherlands. Three of these are still inside winders while the fourth has been converted to an external winder.

The winding mechanisms in *De Buitenmolen* (The Outdoor Mill) in Zevenaar and the *Grafelijke Korenmolen* (The Count's Grain Mill) in Zeddam are true masterpieces of the millwright's work and well worth a visit.
The largest group of internal winders is formed by the rugged and heavy polder mills built for the reclamation of the North Holland polders. Several mills in the neighbouring provinces of South Holland and north-western Utrecht still clearly show that they were originally inside winders.

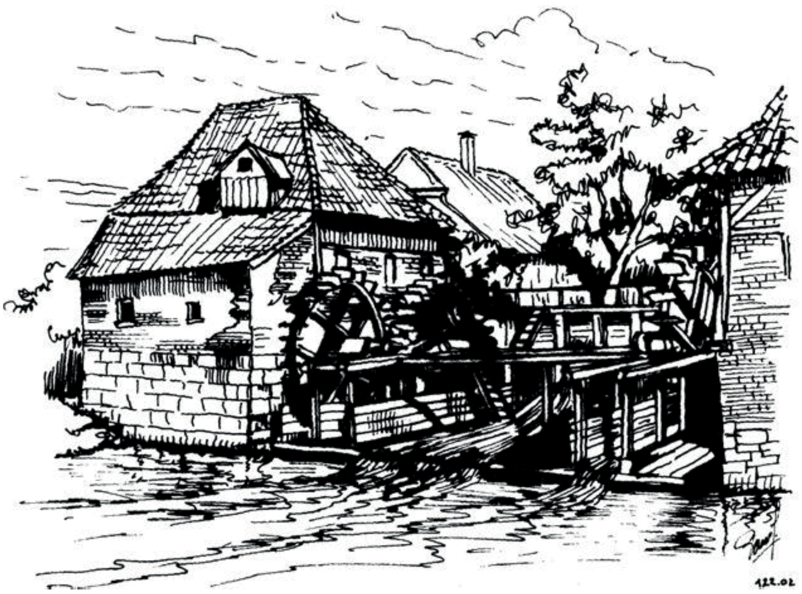


Fig. 4.0.12
Double watermill with undershot wheels

4.5.1.b Outside winder

An outside winder can be recognized from afar by its tail, a large structure of beams at the back of the cap. This tail serves to face the mill into the wind. The assembly consists of the tail pole, two long and two short braces, the short stretcher and the long stretcher.
The long stretcher is sometimes called the centre beam, depending on where the beam is installed in the cap. Both the short and long stretchers form part of the cap structure. The long stretcher is to be found throughout the entire country, while the centre beam is found in the Zaan region and parts of Friesland, Groningen and Drenthe. In the north of the Netherlands, the term long stretcher is still used even when this beam runs through the middle of the cap.

4.5.2 Location of the pivot point

4.5.2.a Cap winder

This can be either an inside or an outside winder, as this term only indicates which part of the mill is being winded. In the case of the cap winder, this is the cap together with everything connected to it. To make it possible to turn the cap with its sails into the wind, the cap lies loose on the mill body. In order to facilitate winding, often a provision in the form of rollers or carters is installed between the cap and the shell.

4.5.2.b Under winder

This is a designation that is used very little, if at all. That is because it involves only one type of mill, namely the paltrok. This type of mill in its entirety is set facing the wind. Only five paltrok mills still exist in the Netherlands.
The mill rests with the bulk of its weight on the king foundation column placed centrally under the mill. Around the king foundation column is the rotunda on which, as in the case of the cap winder, a number of rollers are attached. All of this is about one and a half metres above the ground.

4.5.3 Implementation of the winding gear

4.5.3.a Collar winding gear

Mills with a collar winding gear can be classified into two groups.
The first group is equipped with one collar. This includes post mills and meadow mills. In a sense, the paltrok mill can also be counted among them (see section 4.5.3.c).
The collar on post mills is formed by four beams joined by mortise and tenon and that are fixed around the main post. This collar, which must support some of the weight of the buck/body, is supported by quarterbars. The sheer beams (or sheers) of the body rest on the collar. However, the bulk of the weight of the body rests with the so-called crowntree on the main post. The crowntree is the main and heaviest beam of the body. This rotates on the top of the main post.
In meadow mills, the upper body rests on the lower collar, which is located on the substructure. The upper body is held in place by the hollow post.

A second group of collar winders is formed by the hollow post mills. These mills have two collars, a lower and an upper collar. The lower collar is almost identical to that of the post mill except that it rests on the substructure or tower.
The upper collar, like the lower collar, is also attached around the hollow post but then at the very top of it. Support is provided here by four heavy consoles. Both collars together carry the weight of the cabin or body of this type of mill, with the upper collar bearing the greatest weight.
Spider mills do have two collars but only the lower collar has a load-bearing function.

4.5.3.b Dead curb winding gear

This type of winding gear is found on cap winders. There are two versions: the dead curb with cap sliding on sheers or on skids. In the first type, the cap lies — using the sheer beams and the support for the cap — directly on a wooden ring, here referred to as the curb ring. In turn, this curb ring rests on the uppersill or stone mill body.
In the case of the dead curb winding system, the cap lies on skid plates. A number of radially positioned heavy wooden blocks, called the skid plates, are attached to the winding track. Over these skid plates lies a second wooden ring, the cap circle, on which the sheer beams and headstock are laid.

4.5.3.c Live curb

This type of winding gear is found at many mills, at cap winders as well as paltrok mills. Again, as with the dead curb winding gear, a wooden ring (the winding track) is laid on the uppersill or the stone mill body or rotunda. A large number of wooden or iron rollers encased in wooden or iron frames, called cages, lay on this. A second ring, the cap circle, rests on these rollers.
There is also a distinction to be made in the type of rollers; specifically, there may be ordinary live curb or the so-called shot curb. A detailed description of both types can be found in Chapter 5.9.
Paltrok mills have a winding mechanism with rollers as well as a collar. The mill rests its weight mainly on the collar of the main post on which the tail pole rests. The winding rollers only serve to support the mill — and then only at the front.

4.6 FUNCTION

Much craft work used to be done pertaining to windmills and watermills. The mills can also be classified based on these crafts. Thus, in addition to polder mills, we distinguish the so-called industrial mills. However, grain mills are not counted by some as industrial mills but instead considered to be a separate group.
At the risk of leaving out some that may have been important in a particular region of the Netherlands, the following list of mills by function is restricted to the most important activities. The following mills are in no particular order:

Bluing mill	Manufactured bluing or washing-blue: an old-fashioned addition to the rinse water of the laundry to provide additional bleaching.
Boring mill	The barrels of cannons and guns were bored in this mill.
Malt mill	Worked for brandy distilleries and ground sprouted grain.
Gunpowder mill	Crushed carbon and saltpetre into a cake, which was then broken up and sieved.
Cement mill	Crushed marl and lime into powder for the manufacture of cement.
Chicory mill	During the French era, importation of coffee was not possible. Ersatz coffee made from ground chicory roots was then consumed by the population.
Chocolate mill	Ground cocoa beans into cocoa powder. Mainly ground grains into animal feed.
Grain mill	This type ground various grains — for example,
Groat mill	buckwheat — for the groat mills.
Hemp stamper	Processed raw hemp using stampers. These mills were also referred to as stuff (stock, pulp) mills.
Wood mill	Crushed various species of wood into powder for use in paint and textile factories.
Copper Mill	Machined blocks of copper into copper plate.
Corn Mill	Milled various grains into consumer meal, later into animal feed.
Chalk mill	Processed raw chalk and other hard raw materials into powder for the paint industry.
Lath sawyer	Small format saw mill, used to cut small lumber for carpentry shops.
White lead mill	Ground raw white lead into fine powder for the manufacture of white lead paint.
Marble mill	Crushed and pounded pieces of marble into a fine abrasive powder, or marble chips.
Flour mill	Zaan dialect for grain mill.
Mustard mill	Manufactured mustard from mustard seed.
Malt mill	Ground barley for gin distilleries.
Oil mill	Processed various oil seeds in such a way that oil could be extracted from them by pressing.
Paper mill	Manufactured various types of paper from rags.
Hulling mill	Stripped both barley and rice of their thin husk, also called the hull.

Pumping mill	Pumped water from an artesian well (an artificial well).
Polder mill	Drained the polder of excess water.
Porcelain mill	Specially for potteries, ground china clay into a usable material.
Tanning mill	Ground oak bark into powder for use in tanneries. Also called bark mills.
Scouring powder mill	Crushed shells into a fine abrasive powder.
Polishing mill	Performed various grinding operations. Was mostly combined with the drilling mill.
Snuff mill	Crushed specially processed tobacco leaves into the so-called snuff powder.
Spice Mill	Ground various spices into powder.
Roman cement mill	Ground raw trass (cement) into powder for the preparation of masonry mortar.
Spline sawmill	Sawed special small woodwork for home construction and shipbuilding.
Paint mill	Processed various raw materials into base materials for use in the paint industry.
Fulling or Felting mill	In this mill, wool was transformed into cloth by felting.
Watermill	See polder mill. Note: Watermill is also used for water-powered mills.
Foundry mill	This was mostly part of an iron foundry. It powered bellows and raised huge hammers.
Sawmill	This was used to cut beams and planks from the raw log.
Chamois leather mill	Various leathers were processed here, including sheep leather to chamois leather.

4.7 REGIONAL CHARACTERISTICS

A final classification of the mills is one that takes regional characteristics as a starting point.
We will not go into it too deeply, as this is better addressed elsewhere in another context. However, we do not want to leave some very salient features unmentioned.
What will be immediately apparent in a close comparison of mills located in different parts of the Netherlands is the distinctive colours of the paintwork. The shapes of the cap and shell also often showed regional characteristics. But the execution of various parts also differs, such as the way the short and long braces are applied to the tail pole.
For detailed information, please refer to the various provincial mill books.

NOTES

Chapter 5 Standing parts

Contents page:

5.1 THE POST MILLS

5.1.1 Introduction

The post mill is the oldest type of vertical windmill in Western Europe, most likely originating in the second half of the 12th century in northern France, west Flanders and southern England. One hundred years later, after 1250, the post mill also appeared in the Netherlands.
To date, details of the dimensions of those oldest post mills are lacking. It is certain, however, that in the beginning they had only one stone pair and a second one was added during the 17th century. In old pictures, we can see that the sail cross was double sailed. During the 17th century this developed into the familiar Old Dutch sail system. We can establish that the appearance of the post mill has hardly changed since its arrival in the Netherlands.
As of 2016, there are 48 post mills still in the Netherlands, most of them in the south of the country.

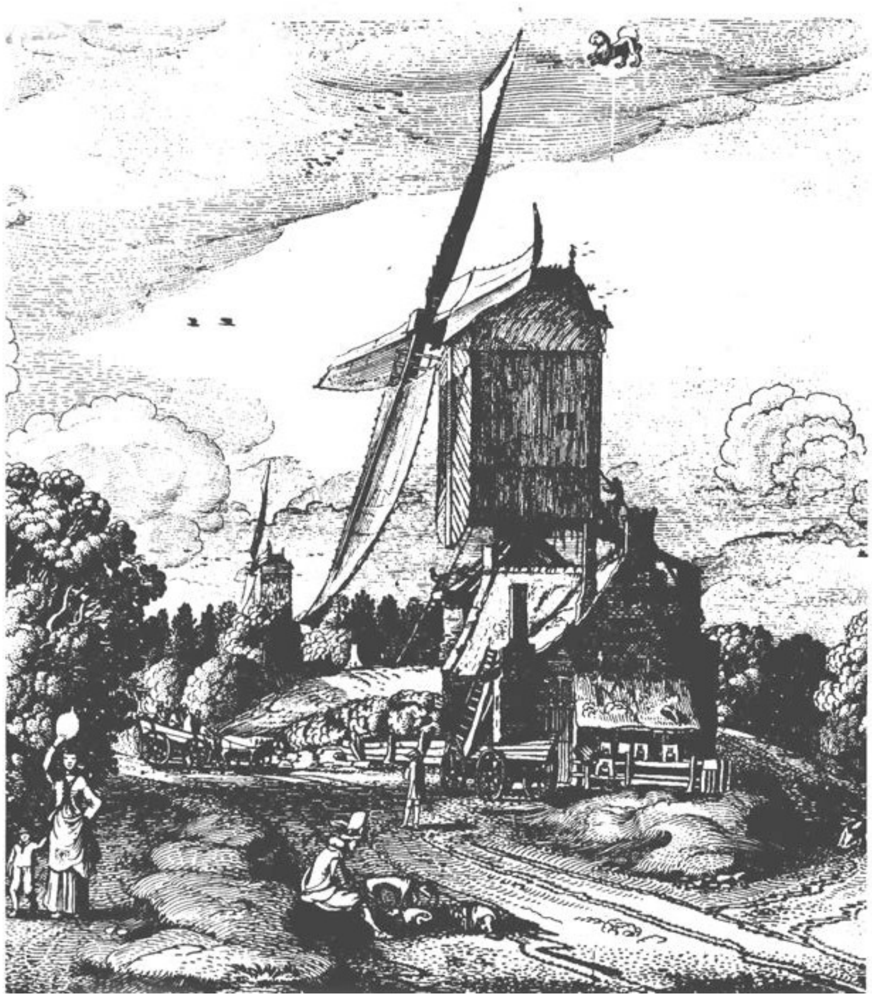


Fig. 5.1.1.1
Etching by Jan van de Velde circa 1617, depicting 'Summer'

A post mill with a double-sailed sail cross. Actually, it is already a sail cross in the transition to the familiar Old Dutch system. However, the sails are still lying across the latticed frame from leading hemlath to ending hemlath.

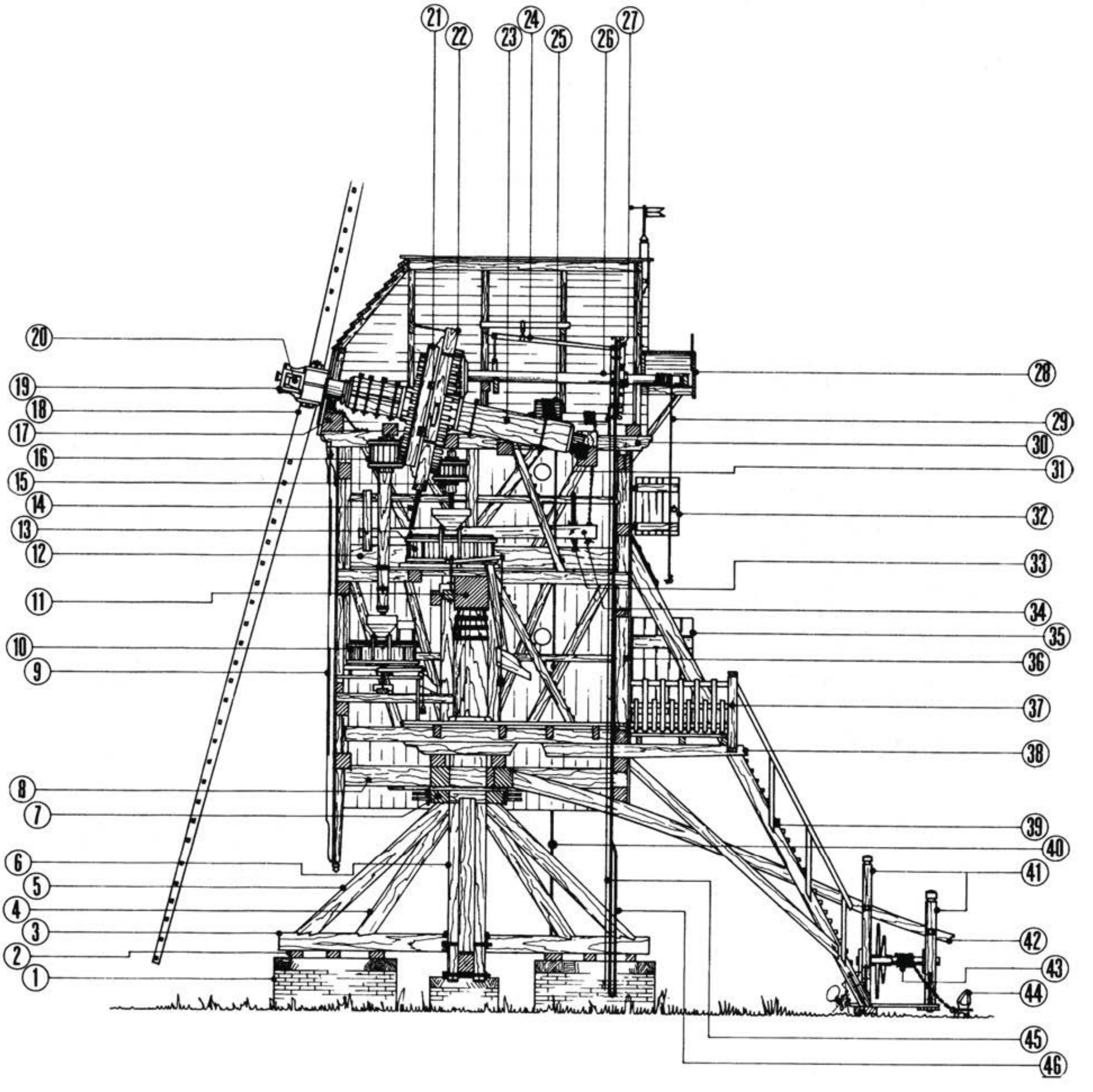


Fig. 5.1.1.2
Cross section of a post mill

Fig. 5.1.1.2
Cross section of a post mill

1. *pier or pillar*
2. *template*
3. *cross-tree*
4. *inner quarterbar*
5. *outer quarterbar*
6. *main post*
7. *collar*
8. *shuttle tree or sheer beam*
9. *prick post*
10. *tail mill*
11. *crowntree*
12. *side girt or 'bressumer'*
13. *head mill*
14. *sword iron*
15. *short stone spindle*
16. *long stone spindle*
17. *weather beam with half-bearing stone*
18. *inside stock*
19. *cross-eye*
20. *outside stock*
21. *head wheel*
22. *brake*
23. *wooden windshaft*
24. *control pole, sack hoist spindle*
25. *brake barrel*
26. *sack hoist spindle*
27. *Y wheel*
28. *lucam*
29. *hoisting rope*
30. *upper side girt*
31. *gudgeon with tail brass and tail beam*
32. *sack hoist hatch*
33. *hook or swinging catch*
34. *brake lever*
35. *mill door*
36. *corner post*
37. *guard-rail*
38. *platform bearer*
39. *stringer*
40. *brake rope*
41. *hinged strut*
42. *tail (beam)*
43. *windlass*
44. *winding bollard*
45. *control rope of the hoisting system*
46. *sack hoist*

5.1.2 The trestle

pier, cross-tree, main post
quarterbar, collar

The base of the post mill consists of the piers, cross-trees, main post, quarterbars and collar. The piers were made of stone and the other parts from oak, with a heavy, dead straight, oak trunk used for the main post.

high pier, low pier

The mill rests on piers, which vary in height from 30 to 200 cm. They are four masonry blocks, two pairs differing in height and often pointing to the four main wind directions, with the high piers mostly pointing N-S and the low piers pointing W-E (see Fig. 5.1.2.1).

template

On each pier are three or four thick, sometimes chamfered, wooden beams called the templates, on which the cross-trees lie. These cross each other in the middle, one over the other, without any connection.

Fig. 5.1.2.2
The trestle

1. *high pier*
2. *template*
3. *cross-tree*
4. *horn*
5. *bridle iron*
6. *cross-tree*
7. *low pier*
8. *cross-tree wedge*
9. *Key wedge*
10. *inner quarterbar*
11. *outer quarterbar*
12. *collar*
13. *supporting face of steady bearing*
14. *friction face of steady bearing*
15. *rounded part of main post*
16. *Pintle or gudgeon*
17. *bearing surface*

crown tree
18, 19, 20. common placements of the quarterbars with examples of quarterbar headers

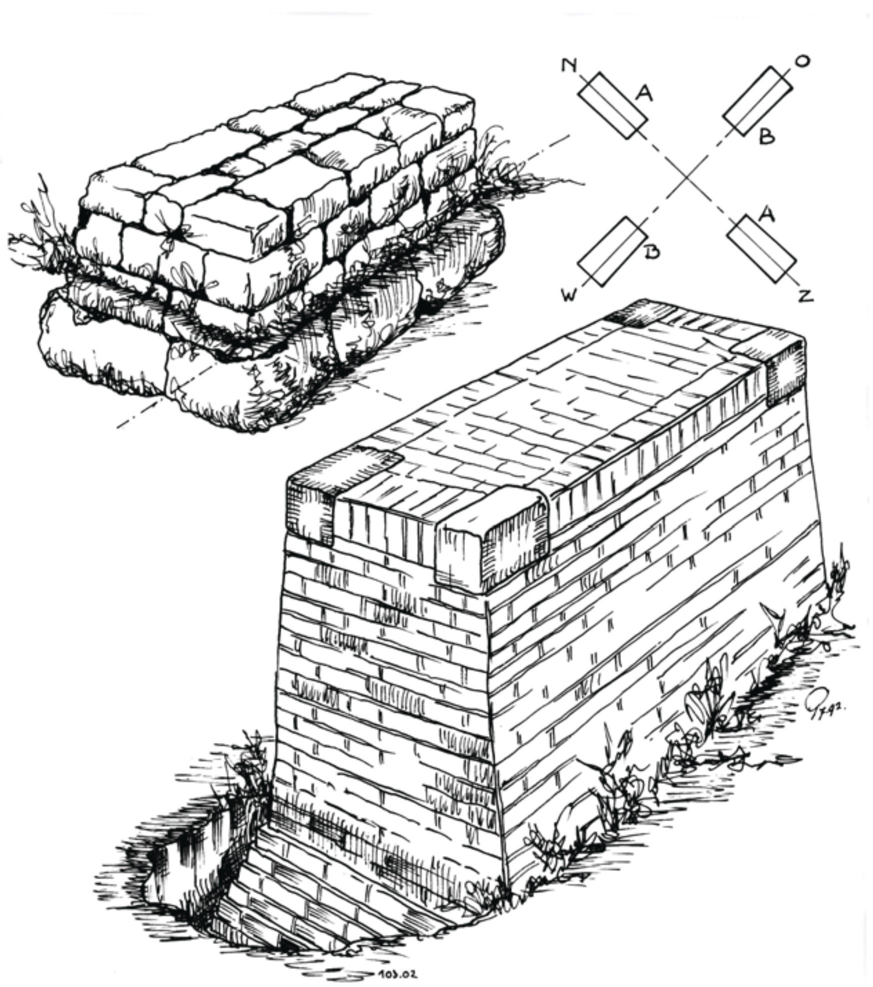


Fig. 5.1.2.1
The piers

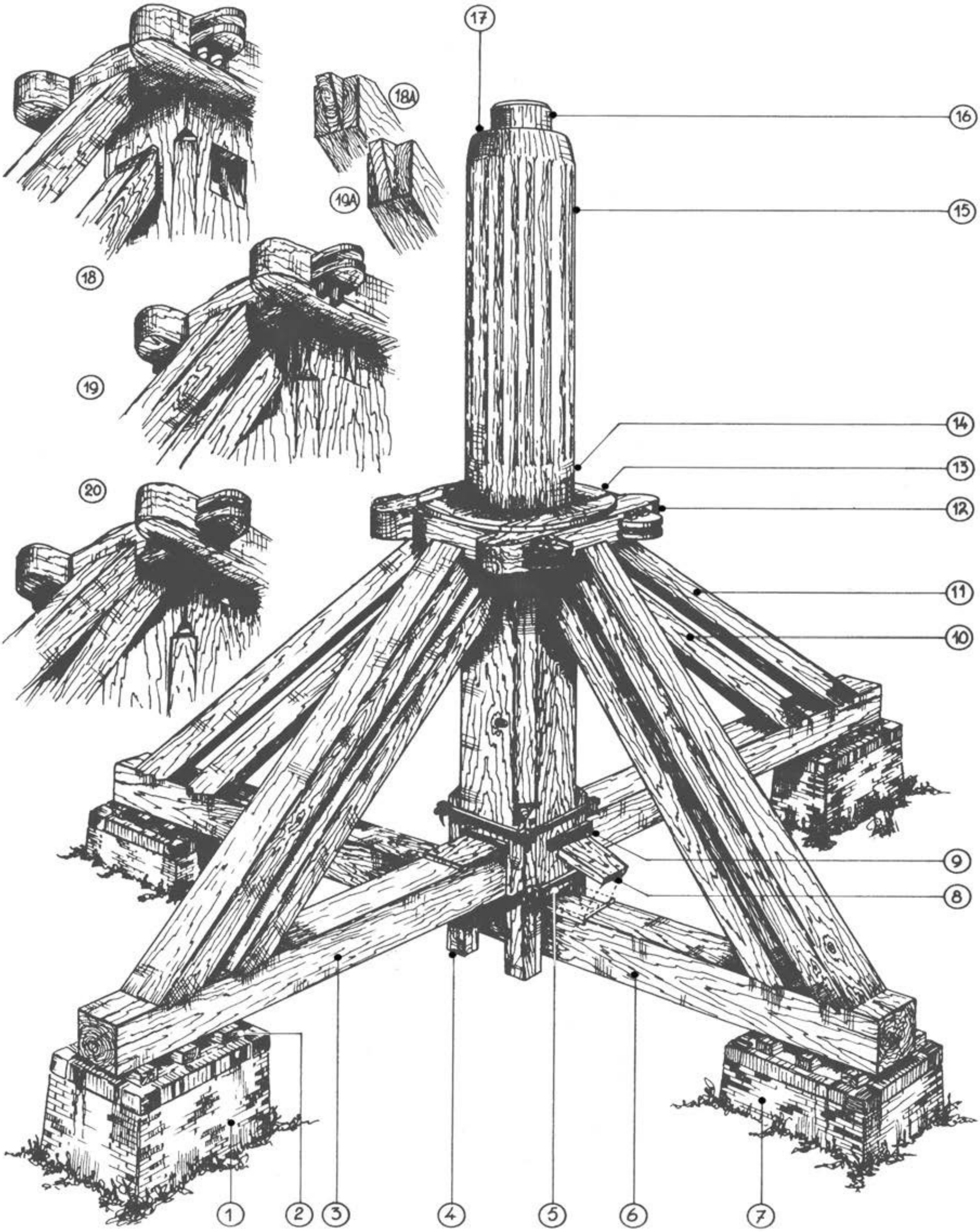


Fig. 5.1.2.2
The trestle

The main post is notched from below. The four corners or horns thus formed grasp over the intersection of the cross-trees (see Fig. 5.1.2.2). Halfway up the main post is the collar, four blocks joined together with double mortise and tenon and locked with double keys. The collar is fitted around the main post on four sides with dovetail joints.

pintle

Above the collar, the main post is rounded and at the top has a pintle, a part of the main post, which has a smaller diameter over which the crowntree rotates.

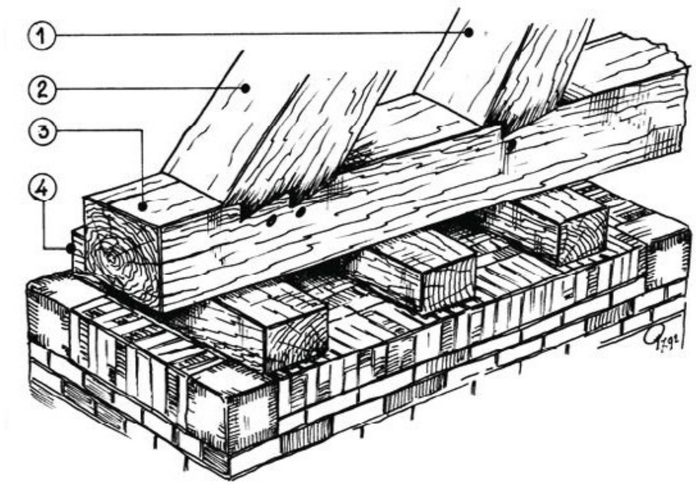


Fig. 5.1.2.3
Cross-tree and pier

1. *inner quarterbar*
2. *outer quarterbar*
3. *cross-tree*
4. *template*

outer quarterbar
inner quarterbar

The four outer quarterbars are set with two teeth and a tenon into the cross-trees (see Fig. 5.1.2.3). The top ends grip around the collar with a notch. The four inner quarterbars are each set into the cross-trees with one tooth and one tenon. The upper ends carry the main post by means of a tenon or tooth (see Fig. 5.1.2.2, nos. 18, 19 and 20). The angle of the quarterbars to the cross-trees can vary from 45° to 55°.

buck

The main post must not rest on the cross-trees; they would bend and break. The main post, and thus the entire buck, hangs on the quarterbars, which therefore have both a load-bearing and a bracing function.

To counteract lateral movement of the main post, the cross-trees next to the main post are sometimes enlarged with overhanging parts or heavy blocking.

cross-tree key

We also see so-called cross-tree keys, which are guiding wedges that are knocked through or into a notch of the cross-trees against the main post (see Fig. 5.1.2.4). In the beginning, when the post mill was developing, the cross-trees were not laid on pillars but buried in the ground.

Covering the base did not come into use until the 16th century. People then began to cover the base partially or completely with wood or thatch, later improved with stone encircling walls. The conical roof installed above the encircling walls is called the roundhouse.This provides a dry shelter for the miller, as well as protection for the base (see Fig. 5.1.2.5). Thus, we know of three manifestations of the post mill: open, partly enclosed and enclosed.

roundhouse

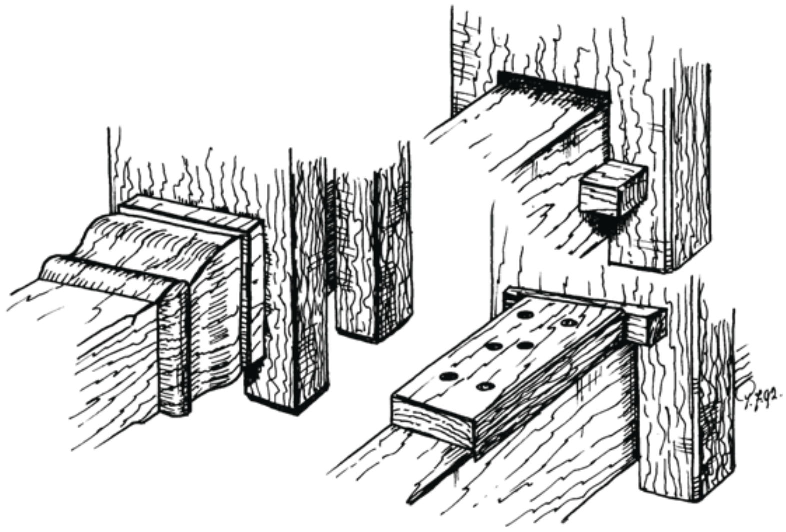


Fig. 5.1.2.4
Underside of main post

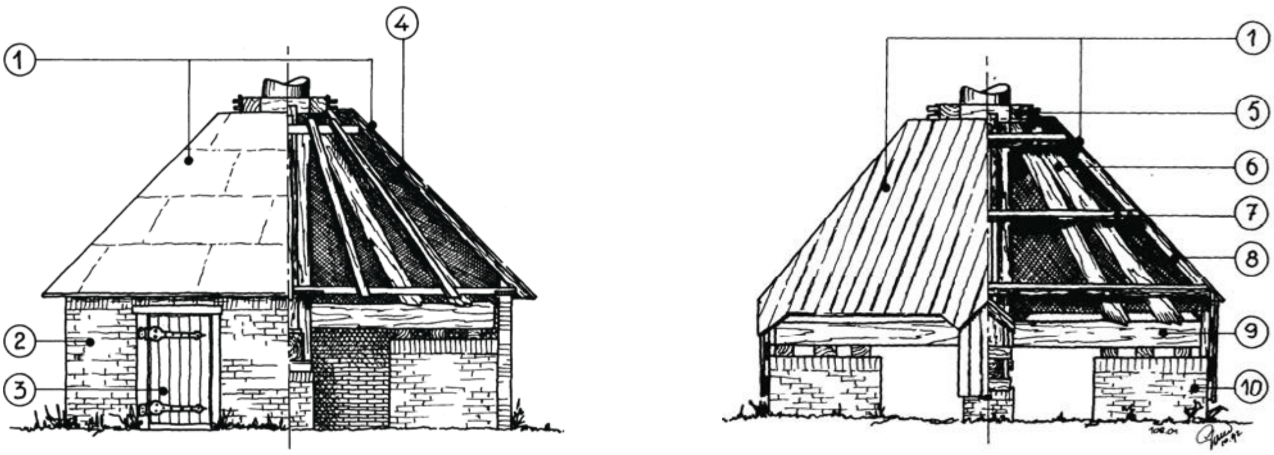


Fig. 5.1.2.5
Covering of the trestle

Left enclosed trestle
Right partly enclosed trestle

1. *roof boarding, roofing felt on wood or thatched roof*
2. *encircling walls*
3. *access door (2 or 4)*
4. *blade*
5. *collar*
6. *quarterbars*
7. *purlin*
8. *rafter*
9. *cross-tree*
10. *pier*

5.1.3 The buck

5.1.3.a Crowntree and collar

buck, crowntree, bolster, lubrication hole

At the top of the main post, in the middle of the buck, is the heaviest and most important beam, the crowntree. It carries most of the buck and is sometimes strengthened in the middle by the often beautifully profiled bolster, which is often introduced later. During the winding, the buck rotates by means of the crowntree on the top of the main post. To facilitate proper lubrication here, there is often a lubrication hole in the crowntree and/or in the bolster (see Fig. 5.1.2.1).

sheer beams, sheers, trimmers, wood wear

The sheer beams (or: sheers) run the full length underneath the buck. They are joined with trimmers in such a way that the resulting rectangular hole fits generously around the main post. This hole is made to fit around the main post by inserting a heavy chock, the wood wear, which can be replaced when it is too worn. The wear prevents excessive movement of the buck in the horizontal plane.

Under the sheer beams are often a pair of elongated plates, called the sliding plates. These enable a small part of the buck to rest on the collar, thus relieving some of the load on the crowntree, which bears most of the buck's weight.

short joist

The short joists are fixed to the sheer beams with notches and bolts. They run along the main post across the full width of the buck.

forward and rear sill

On the ends of the sheer beams lie the forward and rear sills, respectively, with the forward sill forming part of the breast framing and the rear sill belonging to the tail framing.

Fig. 5.1.3.1
Collar and crowntree

1. *sheer beam*
2. *rear trimmer*
3. *wood wear*
4. *front trimmer*
5. *sheer beam*
6. *tail*
7. *mortise for the tail*
8. *front corner post*
9. *forward sill*
10. *short joist*
11. *short joist*
12. *hole for main post*
13. *sliding plates*
14. *side girt*
15. *crowntree*
16. *bolster*
17. *hole for pintle*
18. *bottom side rail*
19. *bracing*
20. *rear corner post*
21. *rear joist*

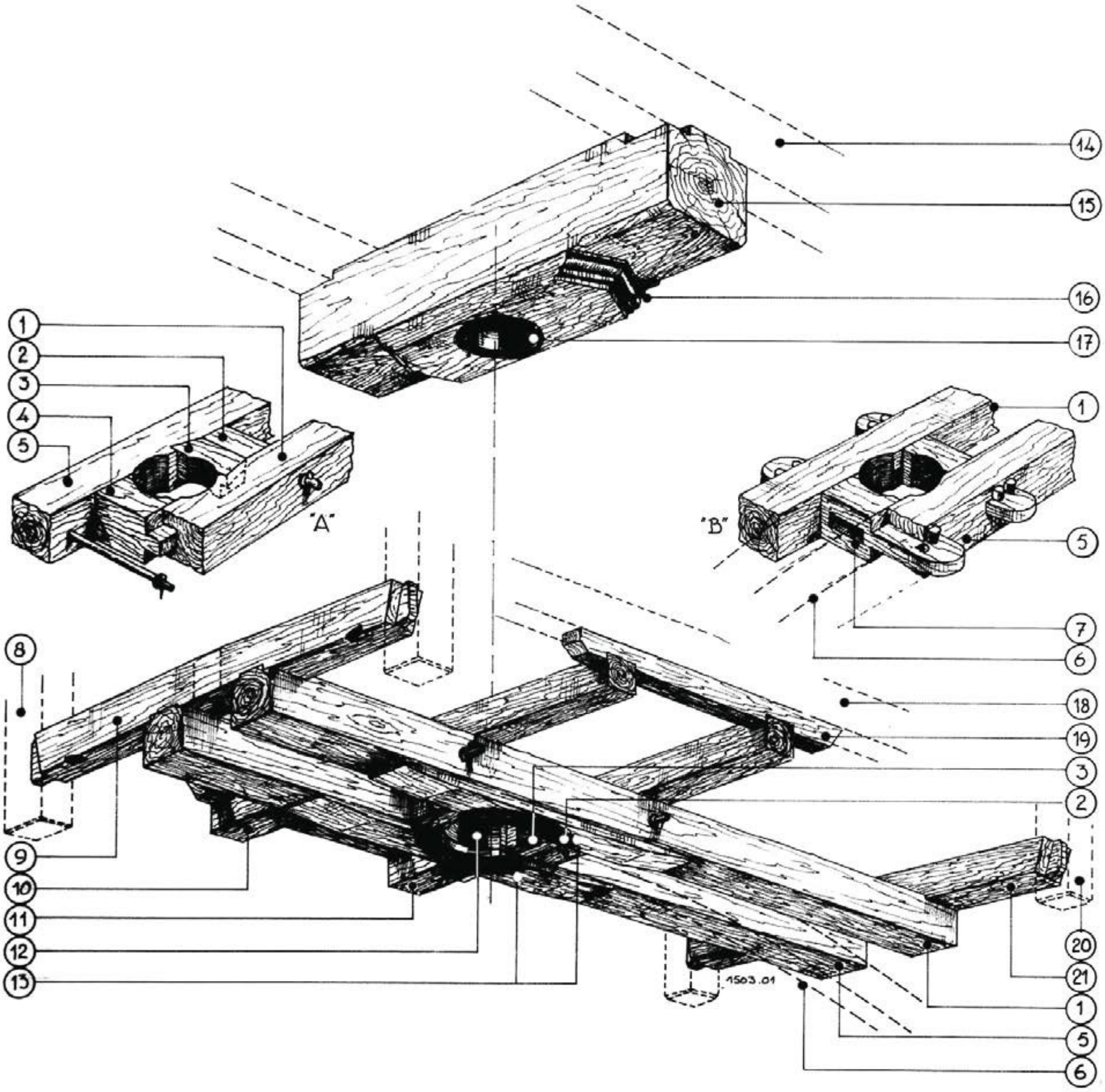


Fig. 5.1.3.1
Collar and crowntree

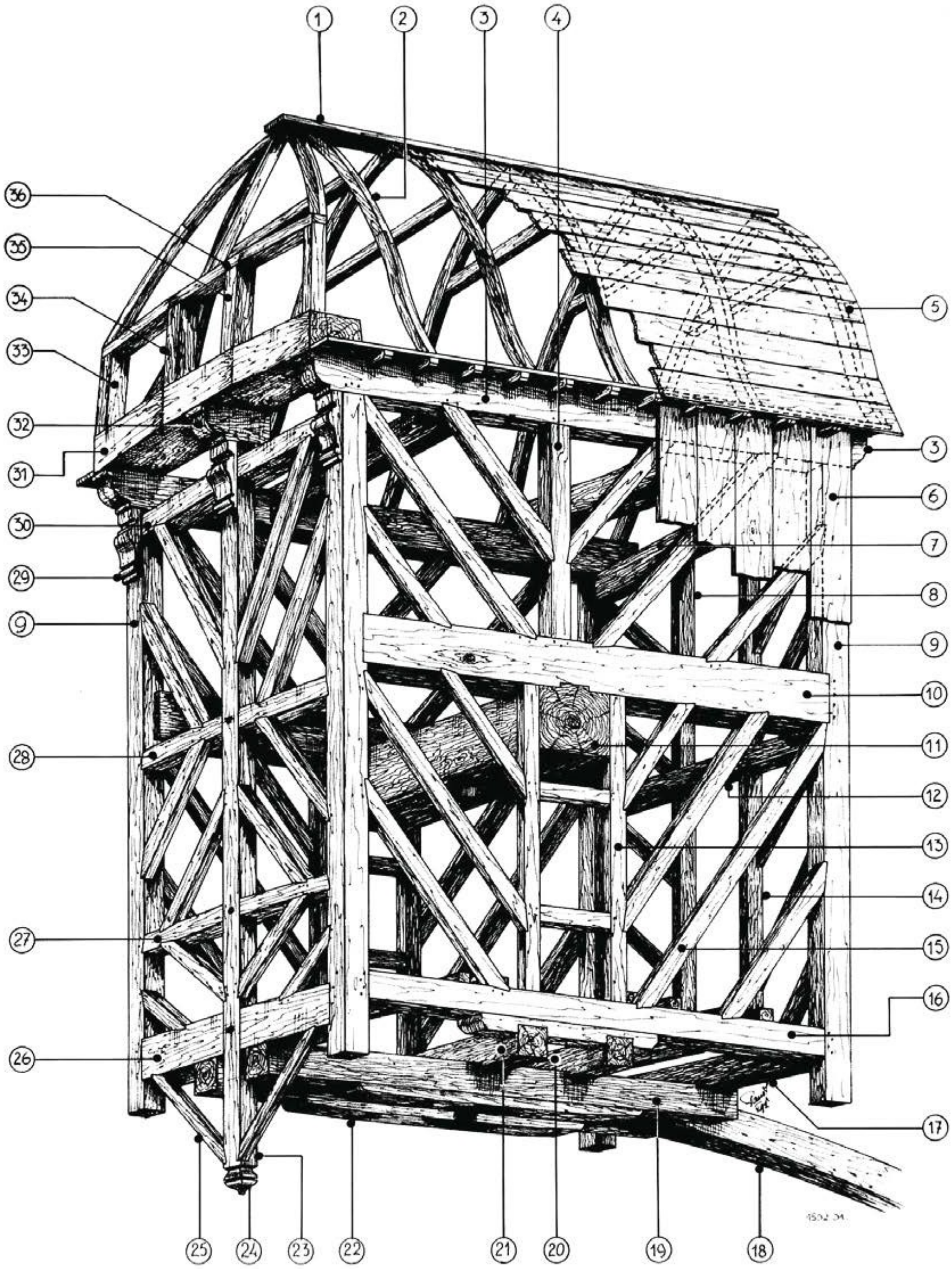


Fig. 5.1.3.2
The post mill body

5.1.3.b The side walls

side wall
side girts

Both sides of a post mill are called side walls. At the ends of the crowntree, and joined to it by dovetails, are the side girts (or 'bressumers'). They are not centred on the crowntree. The distance to the front, the breast framing, is smaller because the heavy sail cross is hanging on that side (see Fig. 5.1.3.2).

vertical member
ties

Two vertical members hang on either side of the crowntree. They are fitted to the side girt with a dovetail joint and are joined together by short ties. Sometimes they are angled (found in Zeeland). On older post mills we see only one post, also called the vertical member, worked into the head of the crowntree.

lower side girt

The vertical members stand on the lower side girts that rest on the short joists. Sometimes the vertical members extend below the lower side girts.

corner posts
notched tie bolts
upper side girt, intermediate upright
raking studs

Four corner posts hang from the ends of the crowntree and bottom side girts with heavy wood joinery and notched tie bolts. At the tops of these are the upper side girts that are partly supported by the intermediate uprights. Raking studs are used to reinforce the side walls against leaning and sagging.
On old post mills, the side girts are often sagging under the heavy load of the buck, which can cause it to weigh too heavily on the collar. In that case, to restore proper weight distribution between collar and main post, the sliding plates can be made thinner or a bolster timber fitted or thickened. In either case, the entire buck must be jacked.

5.1.3.c The breast framing

breast framing

The front of the buck is called the breast framing. It is formed by the two forward corner posts that hang from the side girts and lower side girts.

upper cross beam
meal beam, forward sill, prick post
acorn

They are joined together from top to bottom by the upper cross beam, the meal beam and the forward sill. In the middle we find the prick post, which is anchored with notches and bolts in the three aforementioned beams and ends well below the forward sill with a simple decoration, the acorn.
To counteract the breast framing from leaning, we generally find raking studs in an A-shape (or inverted V-shape) from the prick post.

Fig. 5.1.3.2
The post mill buck

1. *ridge board*
2. *spar*
3. *upper side girt*
4. *intermediate upright*
5. *roof boarding*
6. *boarding*
7. *upper tail beam*
8. *hatch post*
9. *corner post*
10. *side girt*
11. *crowntree*
12. *door beam*
13. *vertical member*
14. *door-post*
15. *raking studs*
16. *lower side girt*
17. *rear sill*
18. *tail (beam)*
19. *sheer beam*
20. *short joist*
21. *short joist*
22. *sliding plate*
23. *prick post*
24. *acorn*
25. *prick post brace*
26. *forward sill*
27. *cross beam*
28. *meal beam*
29. *console*
30. *upper cross beam*
31. *weather beam*
32. *support*
33. *slanting stud*
34. *weather stud*
35. *weather stud*
36. *head rail*

5.1.3.d The tail framing

tail framing

upper tail beam, door beam
rear sill
door post, hatch post

The back of the buck is called the tail framing. It is formed by the two rear corner posts hanging behind from the side girts and lower side girts. They are joined together by the upper tail beam, the door beam and the rear sill (see Fig. 5.1.3.3).

The two door and hatch posts are below and above the door beam, respectively. The tail framing is further reinforced with girts and raking studs.

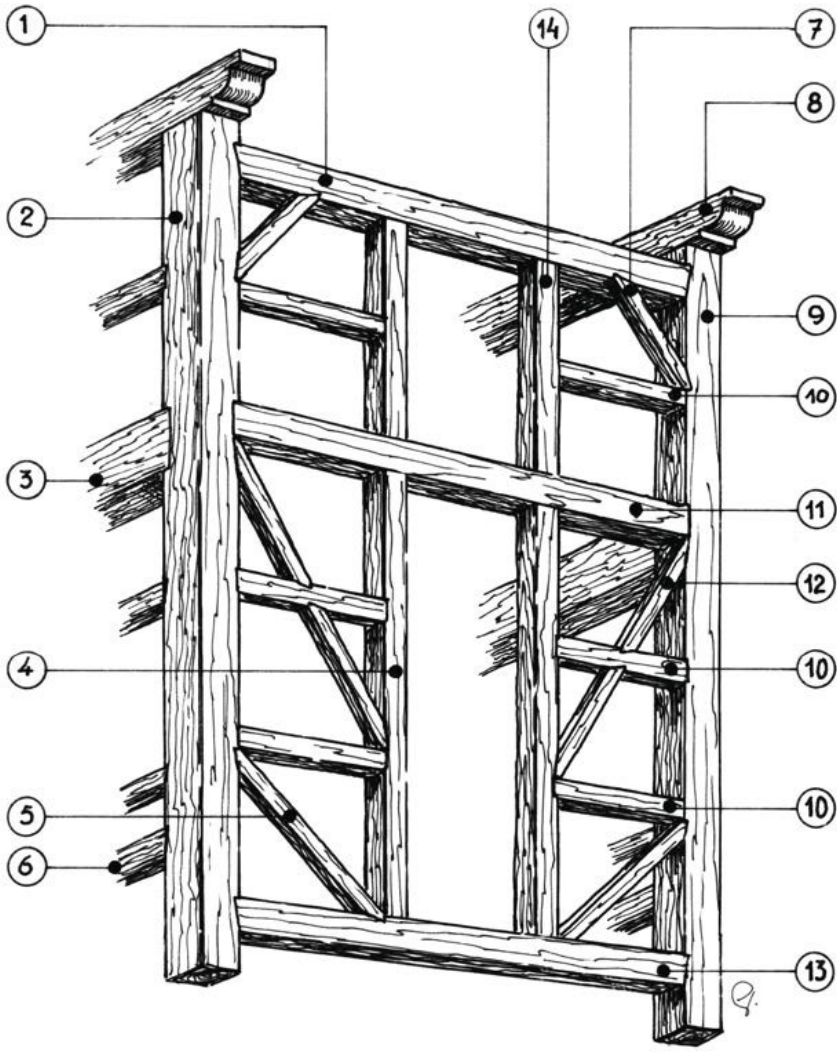


Fig. 5.1.3.3
The tail framing

1. *upper tail beam*
2. *corner post*
3. *side girt*
4. *door post*
5. *raking stud*
6. *lower side girt*
7. *corbel*
8. *upper side girt*
9. *corner post*
10. *tie*
11. *door beam*
12. *raking stud*
13. *rear sill*
14. *hatch post*

5.1.3.e Beams on and between the upper side girts

Between the corner posts, just below the upper side girts, is the rear beam that
tail beam — connects the rear corner posts. In front of this is the tail beam — usually made
of warped wood — which is located on and between the upper side girts and is
tail bearing — adjustable horizontally. In the middle of the pillow block is the tail bearing. Also,
spindle beam, sprattle beam — the spindle beam or sprattle beam is often made of warped wood; it is
adjustable and located between the upper side girts. In the middle of the spindle
beam is the upper bearing of the stone spindle. Between the tail beam and the
tie beam — spindle beam is the tie beam or cross beam. This sits between the upper side
girts and it absorbs the outward forces created by the wedging of the tail beam
and the spindle beam.

weather beam — The weather beam on the upper side girts is located in the front, above the
breast framing. In the middle of the weather beam, on the stone bed, is the hard
stone neck bearing of the windshaft. Ninety percent of the weight of the
windshaft and the sail cross rests on this. In order to absorb that weight
properly, the weather beam, which is already very heavy, is additionally
support — supported at some mills by a support that rests on the prick post so that, via this
prick post, the upper tie beam, the meal beam and the forward sill also help to
absorb the pressure on the neck bearing.

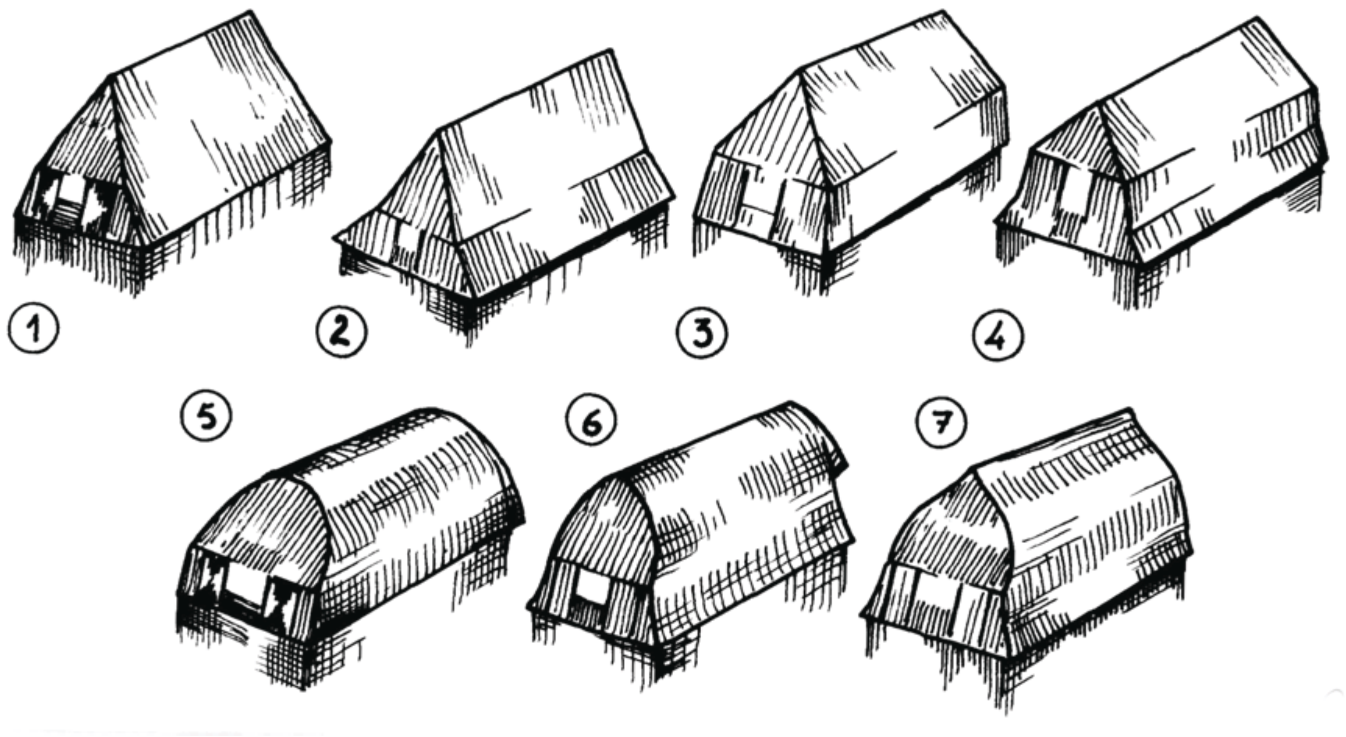


Fig. 5.1.4.1
Roof shapes

1. *saddle roof*
2. *broken saddle roof*
3. *mansard roof*
4. *broken mansard roof*
5. *barrel-shaped roof*
6. *bell-shaped roof*
7. *pointed bell-shaped roof*

5.1.4 The cap

slanting stud
weather studs, head rail, cap spar
ridge-piece

The frame of the cap is formed by the backward pitched slanting studs, between them the weather studs, above them the head rail, the cap spars and the ridge-pieces (see Fig. 5.1.3.2). If the cap spars are straight, then we refer to a saddle roof. Curved rafters create a bell or barrel shape.
Usually the rafters are curved to allow more room for the brake wheel and the brake (see Fig. 5.1.4.1).

rear gable
sack hoist spindle, lucam

The part of the cap on the tail framing is perpendicular to the upper tail beam and is called the rear gable. The bearing point for the outward projecting sack hoist spindle is located in front of the lucam, which is placed against the rear gable (see Fig. 5.1.4.2).

finial,
wind vane

The top of the rear gable is sometimes fitted with a finely crafted finial that projects above the cap and is usually equipped with a wind vane. Other post mills have only a wind vane, which is sometimes finely crafted.

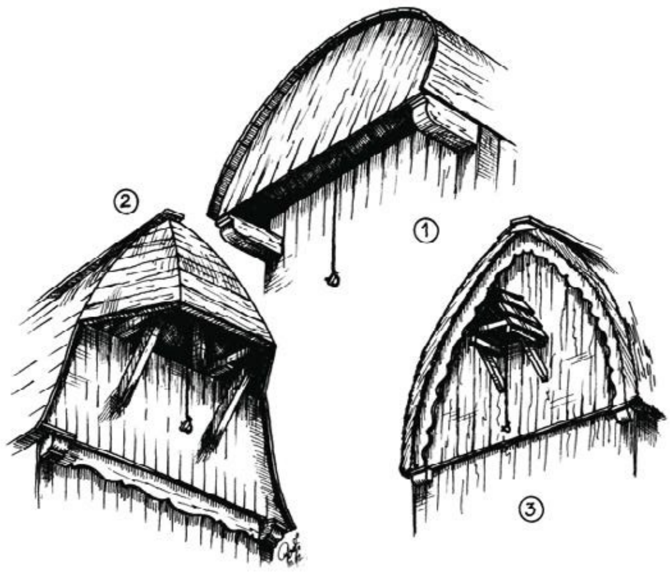


Fig. 5.1.4.2
Lucam shapes

1. *continuous cap*
2. *continuous roof spire*
3. *lucam*

5.1.5 The tail and the stairs

tail, tail pole

The tail or tail pole serves primarily as a lever to enable the mill to be winded (see Fig. 5.1.5.1). It sits with a mortise and tenon joint or notch joint in the rearmost trimmer between the sheer beams and, further to the rear, it hangs with a bolt or a bracket beneath the rear sill. The tail often has a slight 'S' shape.

stairs stringers
balcony, gallery
cross beam, diagonal braces

In the second place, the stairs are suspended from the tail. The attachment of stair stringers varies by region. Sometimes they are attached to the door posts or to the platform (balcony, gallery), whether or not via a cross beam or to the corner posts. When attached to the corner posts, the stairs get wider and wider towards the top. When a cross beam is used, two diagonal braces run from the ends to the stringers.

bottom tread, hangers windlass, winding reel

The stringers are connected at the bottom by a heavy wooden block, the bottom tread. From there, two hangers go to the end of the tail. The hinged struts carry the stairs and serve as the attachment point of the windlass or the winding reel.

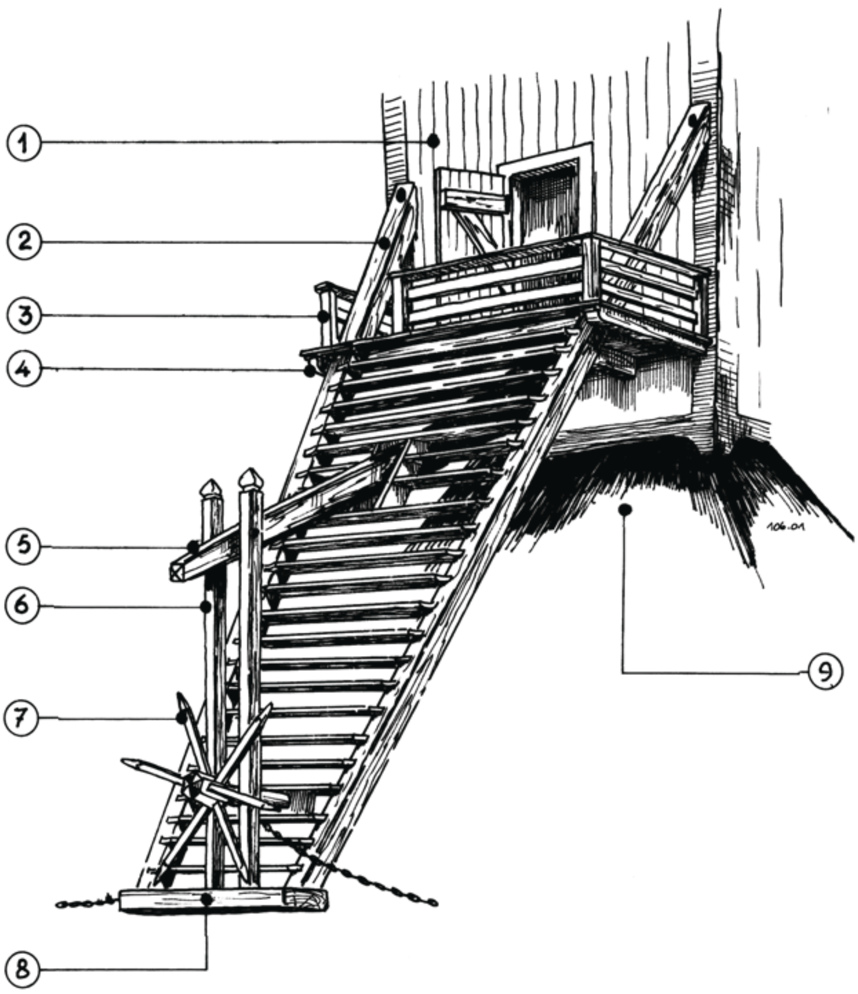


Fig. 5.1.5.1
Stairs with continuous stringers

1. *body*
2. *stringer*
3. *guard-rail*
4. *platform bearer*
5. *tail (beam)*
6. *hinged strut*
7. *capstan wheel*
8. *bottom tread*
9. *shelter*

tread boards winding platform bracing poles

Sometimes a double set of hinged struts are hung from the tail. These are then connected at the bottom by a trapezoidal construction of planks. These boards are called the tread boards. The whole thing forms the winding platform (see Fig. 5.1.5.2).
Finally, at several post mills we still find so-called bracing poles. These are two heavy beams hinged to the tail and which can be set at an angle to it (see Fig. 5.1.5.3). They take over the job of the anchor chain and winding chain after the mill has been set to face the wind.

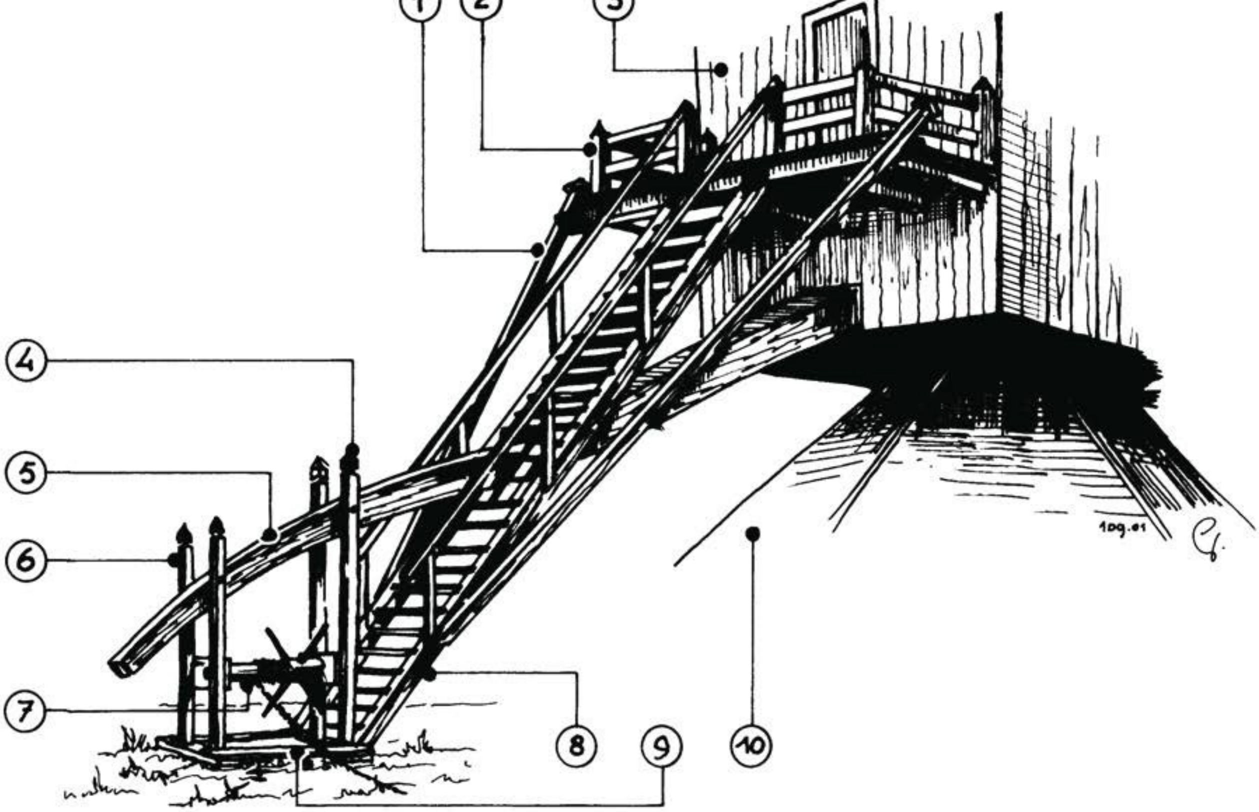


Fig. 5.1.5.2
Stairs with parallel stringers

1. *diagonal brace*
2. *guard-rail*
3. *body*
4. *hinged strut*
5. *tail (beam)*
6. *hinged strut*
7. *windlass*
8. *stringer*
9. *winding platform*
10. *shelter*

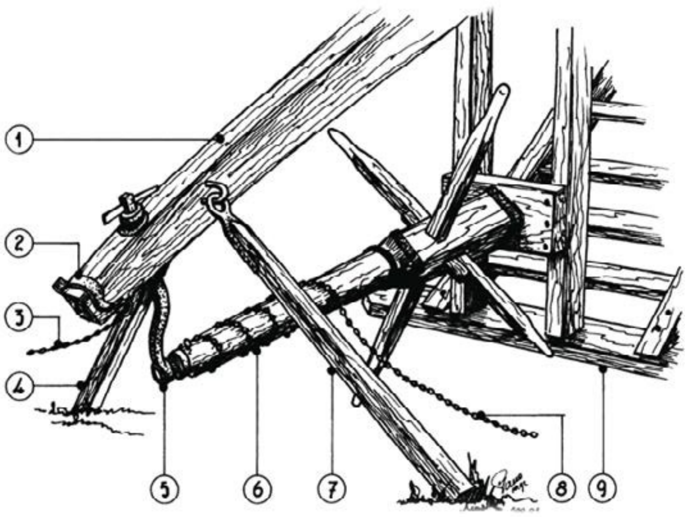


Fig. 5.1.5.3
Bracing poles

1. *tail (beam)*
2. *shore*
3. *anchor chain*
4. *bracing pole*
5. *barrel hanger*
6. *barrel*
7. *bracing pole*
8. *winding chain*
9. *bottom tread*

5.2 THE HOLLOW POST MILLS

5.2.1 Introduction

hollow post mill, wip mill

The oldest and most characteristic polder mill is the hollow post mill or wip mill (see Fig. 5.2.1.2). This type of mill is mainly still found in the province of South Holland and the adjacent western part of the province of Utrecht. There were also a lot of them in the Tielerwaard region and the Land of Heusden and Altena areas. Fortunately, some of these are still in existence. They were also familiar in North Holland but here the number has dwindled to just three: in Obdam, Weesp and Haarlem. The same is true of north-western Brabant. There only a few remain, at Werkendam, Woudrichem and Dussen. Additionally, Gelderland has the two hollow post mills of Hellouw and the newly built hollow post mill in Persingen.

As already learned in Chapter 5.1, the post mill is the oldest type of windmill. Given its construction, this mill is generally only suitable for driving machinery located inside the buck, such as mill stones. In the 15th century, the need arose for machinery that could be used to relieve dyked areas of excess water. This probably led to the modification of the post mill to make it suitable for raising water to a higher level with a scoop wheel, thus draining the farmlands dry. This function required that the power and rotary motion of the windshaft be transferred to the base of the mill where the scoop wheel was to be placed. The massive post was replaced with a heavy wooden, hollow post through which a shaft, the central spindle, could transfer the rotary motion downward. Furthermore, the hollow post mill is still clearly related in form to the post mill (see Fig. 5.2.1.1).

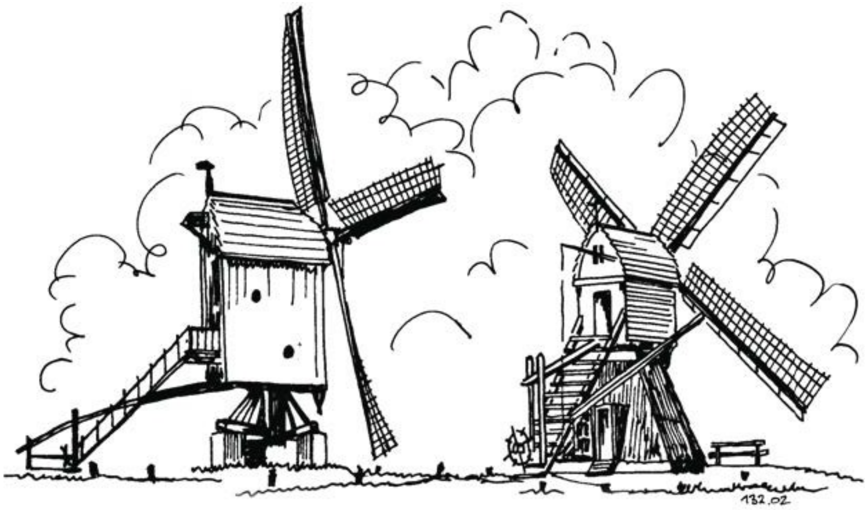


Fig. 5.2.1.1
Post mill and hollow post mill

If you look at a picture of a hollow post mill next to a post mill, the lineage is readily apparent.

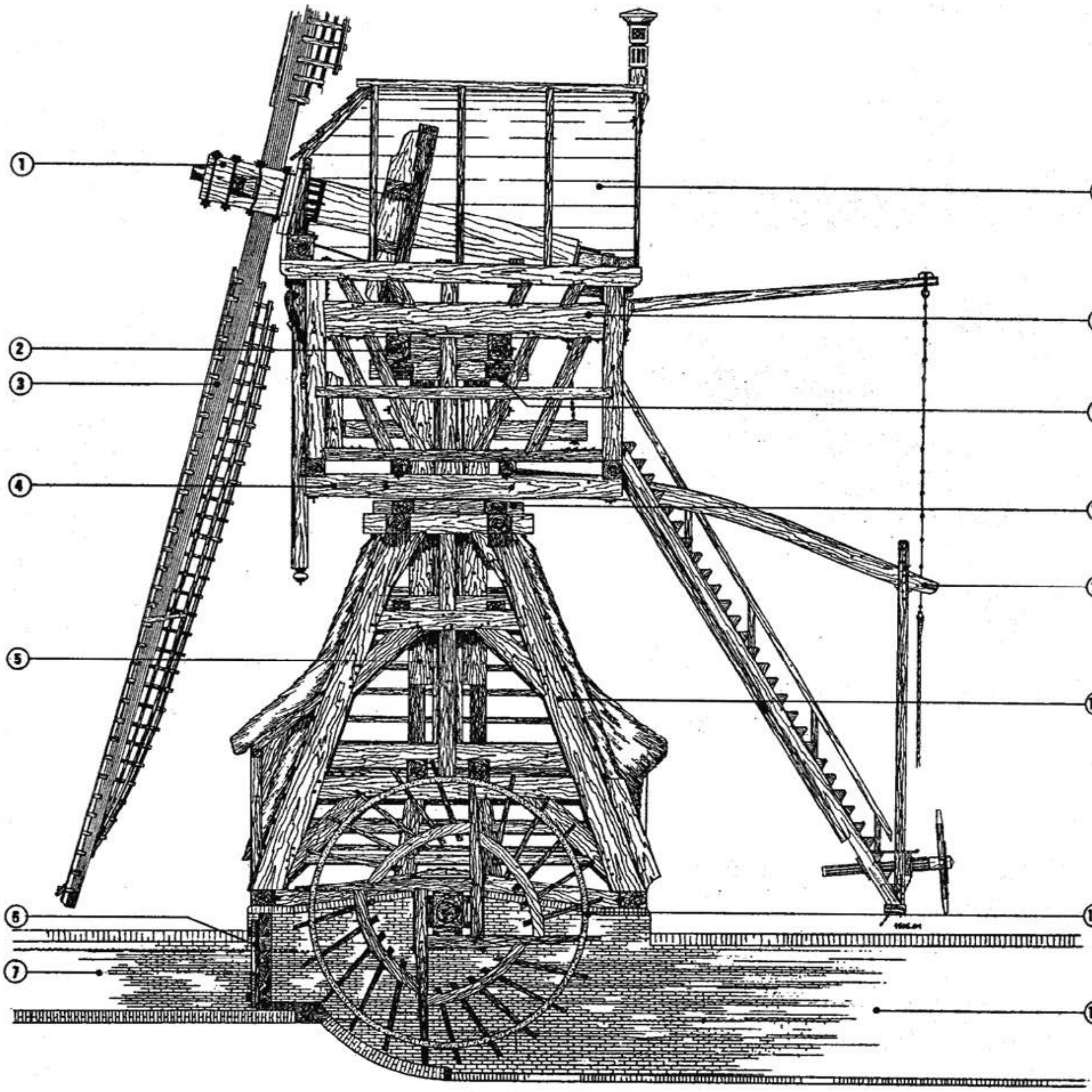


Fig. 5.2.1.2
Cross-section of a hollow post mill

Clearly visible are the tower, the cabin, the stairs, the sail cross and the scoop wheel.

1. *windshaft*
2. *upper girdle*
3. *sail cross*
4. *lower girdle*
5. *hollow post*
6. *sluice flap*
7. *tail race*
8. *cap*
9. *side girt*
10. *upper collar*
11. *lower collar*
12. *tail (beam)*
13. *tower post*
14. *scoop wheel*
15. *rear mill race*

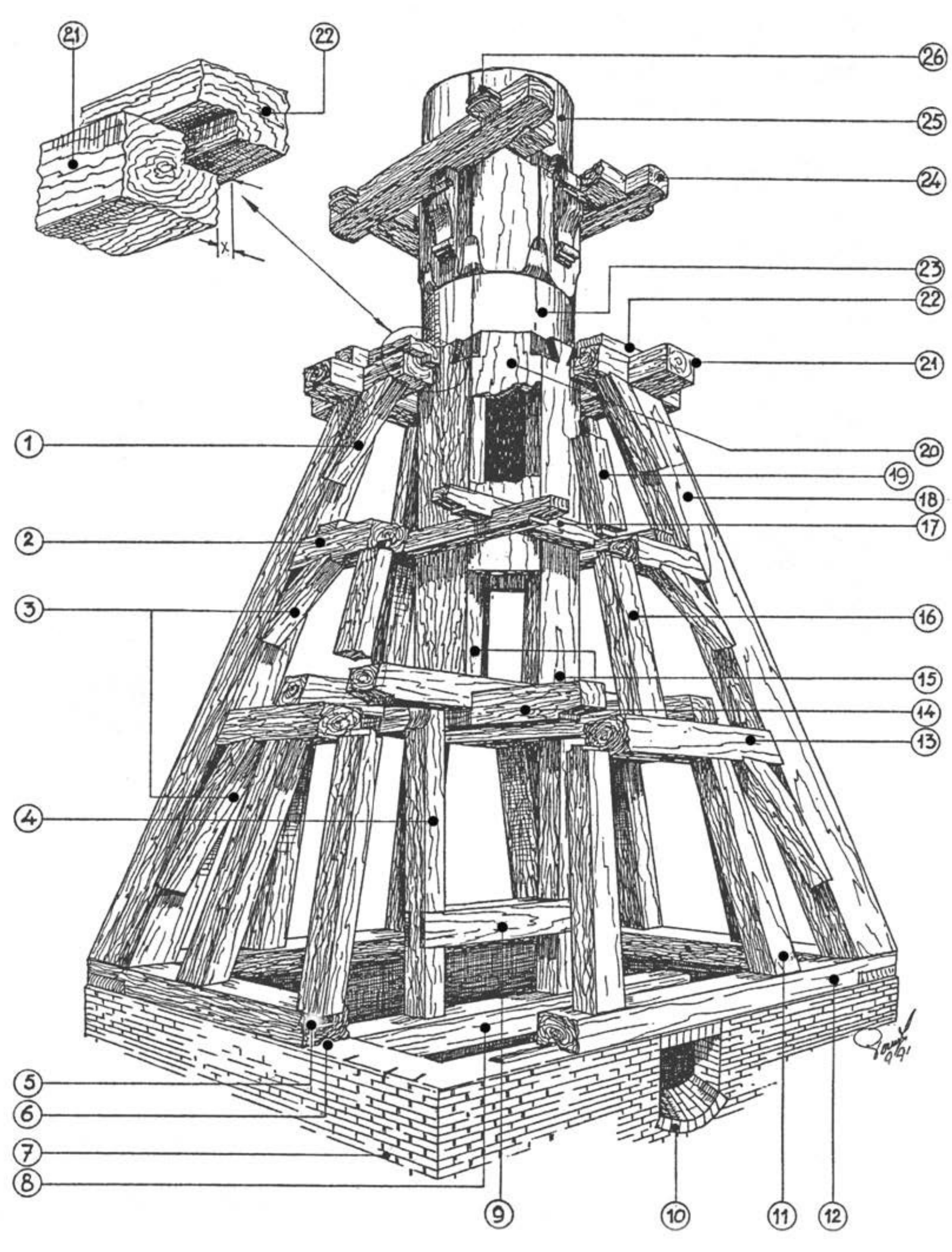


Fig. 5.2.2.1
The tower

Fig. 5.2.2.1
The tower

1. *'dog ear'*
2. *upper cross beam*
3. *corbels*
4. *vertical strut*
5. *mortise and tenon joint*
6. *mortar rebate*
7. *quarter wall*
8. *summer*
9. *transom*
10. *wheel shaft hole*
11. *lower casing post*
12. *soleplate*
13. *lower cross beam*
14. *cross tree*
15. *hollow post*
16. *lower middle stud*
17. *loose cross tree*
18. *corner post*
19. *upper middle stud*
20. *post side*
21. *Uppersill*
22. *lower collar*
23. *rounded hollow post piece*
24. *upper collar*
25. *rounded hollow post top*
26. *double tenon joint*

It is not possible to say with certainty when the hollow post mill was developed, but there were already references to polder mills from the end of the fourteenth century. Statements that clearly relate to hollow post mills are known from a later date. For example, there is a document, issued on 13 May 1430 by Countess Jacoba van Beieren, that allowed a large hollow post mill to be built near Schoonhoven to drain the Bonrepas polder.
Although the hollow post mill is similar to the post mill, its construction is nevertheless very different — especially with regard to the lower part, the tower.

5.2.2 The tower

body

The tower carries the body and is an extremely stable structure. Fig. 5.2.2.1 shows how heavy everything is. Initially, early in the 15th century, hollow post mills were built with their base directly on the ground with some wooden chocks under the most loaded points without a stone foundation. Following the structure from below, the quarter walls are what is seen first.

quarter wall

pile

These were erected from the base, consisting of a considerable number of piles topped by a heavy wooden floor for the breadth of the masonry to be placed thereon. From this floor, the quarter walls are raised to the desired height above ground level. The masonry extends to a height that varies between 25 and 200 cm above ground level. In many cases, you have to use a small stepladder to step over the quarter walls and soleplates or the undersill to get into the mill. In mills with quarter walls higher than 75 cm, the soleplates and quarter walls are sometimes interrupted so that access doors can be placed at ground level.

soleplate, undersills

Very high quarter walls in many cases are indicative of an elevation of the mill carried out in the past.

spillway side, inner spillway wall

On the spillway side, the quarter wall is part of the inner spillway wall; this is also seen in Chapter 11 where the polder mill is discussed. For the passage of the water shaft to the scoop wheel, a so-called waterwheel shaft hole was made in the masonry. This hole comes in all shapes and sizes. It is sometimes even so large or placed in the wall in such a way that it requires the upper soleplate to be interrupted or made in two parts or curved over the hole. A good example of this is the hollow post mill of Noordeloos (see Fig. 5.2.2.2).

scoop wheel, waterwheel shaft hole,

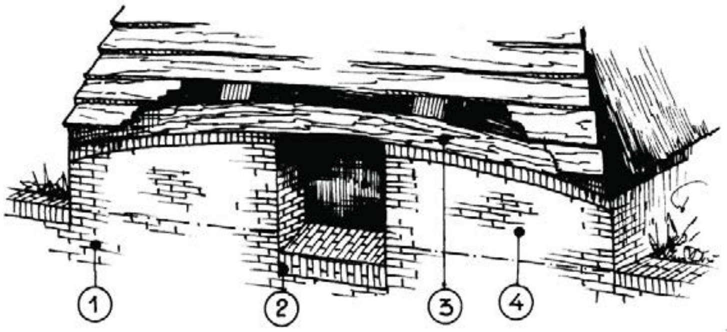


Fig. 5.2.2.2
Waterwheel shaft hole at the Noordeloos mill

1. *part of the spillway wall*
2. *waterwheel shaft hole*
3. *curved soleplate*
4. *quarter wall*

undersill

The four soleplates rest on the quarter walls and are joined together at the corners with wrought iron notched tie bolts, together forming the undersill. At the larger hollow post mills, an anchoring between the masonry and the undersill is absent. In some smaller mills, the underneath of the undersill has a semicircular, mortared rebate.

mortar rebate

This mortar rebate prevents the soleplates from moving sideways (see Fig. 5.2.2.1).

tower posts
uppersill
corner posts

At the corners of the undersill, the four corner posts or tower posts are joined by mortise-and-tenon. The posts are joined to the uppersill at the top in the same way. To withstand the vertically directed pressure and to to give the entire structure the necessary rigidity, another set of beams was added between the corner posts. For cross bracing, the corner or tower posts are connected by the lower and upper cross beams. To counter leaning, corbels are fitted under the cross beams and to the corner posts.

tower
upper cross beams
lower cross beams
'dog ears' or braces

For each side of the tower, the following posts have been installed: Two studs between the soleplates and the lower cross beams; above them, between the lower and upper cross beams and the uppersill, are also the lower and upper vertical members. To increase the bearing surface of the corner posts for the uppersill, two more heavy 'dog ears' or braces were installed in the corners where the corner posts meet the sill.

cross tree
loose cross tree

For placement of the hollow post, cross-trees lie crosswise on the lower cross beams, worked over and into each other two by two. In a similar fashion, the loose cross trees lie on the upper cross beams.

summer
vertical strut framing
transom

The former have the function of supporting the hollow post while the loose cross trees provide lateral support. This almost completes the lower tower. However, missing still is the summer that is lying exactly in the middle through and at the bottom of the mill with the tops recessed into the quarter walls. Between this summer and the cross trees is the vertical strut framing, which consists of two heavy vertical struts with the horizontal transom between them.

vertical struts
main upright shaft

Although this is not their direct function, in practice the vertical struts carry part of the weight of the hollow post along with the load of the body that rests on it (see Fig. 5.2.2.3). Their actual function is to carry the weight of the main upright shaft. Supported by two or three skid plates, the bearing block sits on the transom. The button is a beam that is rotatable on one side around a pin in which the bearing is arranged for the said shaft (see Fig. 5.2.2.1 and Fig. 5.2.2.3).

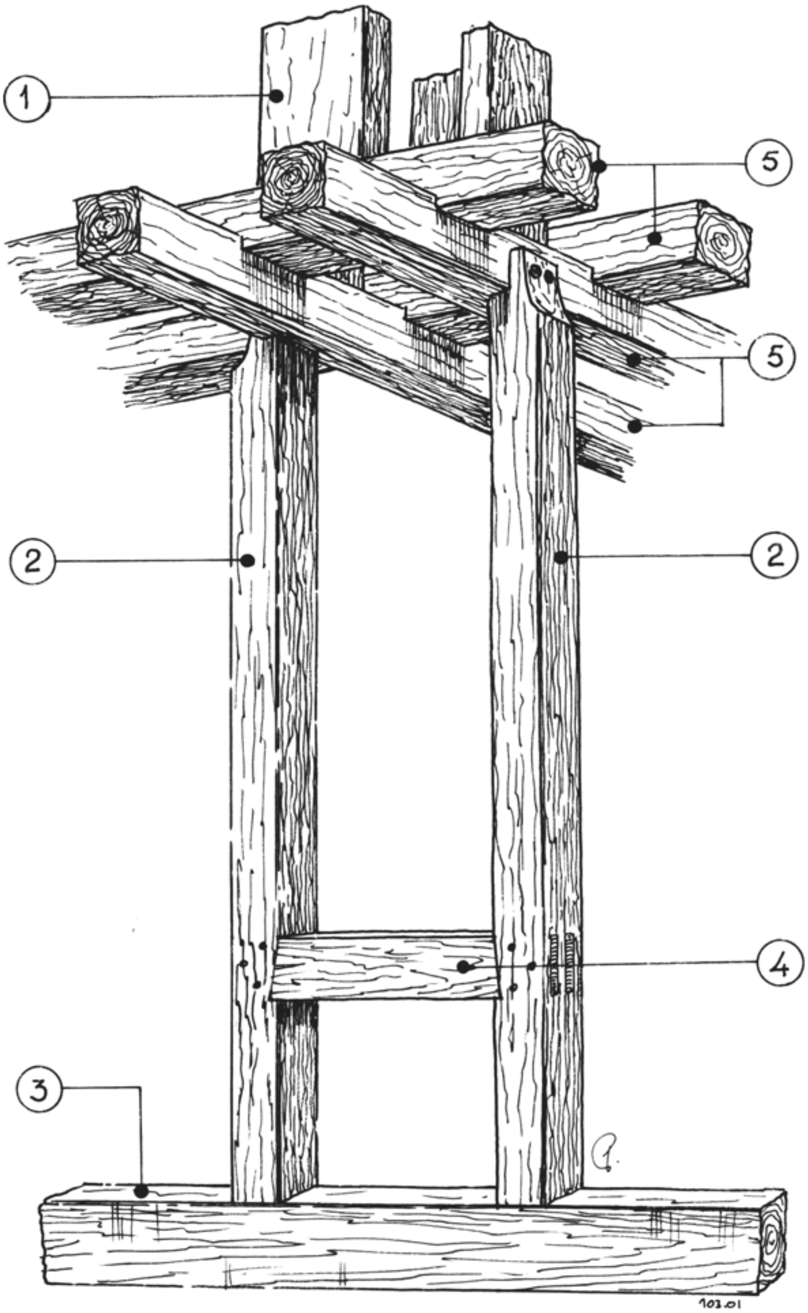


Fig. 5.2.2.3
The vertical strut framing

1. *hollow post*
2. *vertical strut*
3. *summer*
4. *transom*
5. *cross trees*

hollow post

heavy hollow posts

grappling-irons

filling pieces, post sides

The tower is only complete when the octagonal hollow post is also in place. In the case of a large hollow post mill, the hollow post is composed of four heavy hollow posts with four filling pieces or post sides between them to complete the octagonal shape. The entire hollow post is held together using heavy wrought-iron nails and a number of wrought-iron grappling-irons.
The hollow posts are mortised into the centering frames at the bottom, while the filling pieces do not extend further than just below the individual cross trees. In some small hollow post mills, the hollow post is constructed from eight post sides (see Fig. 5.2.2.4).

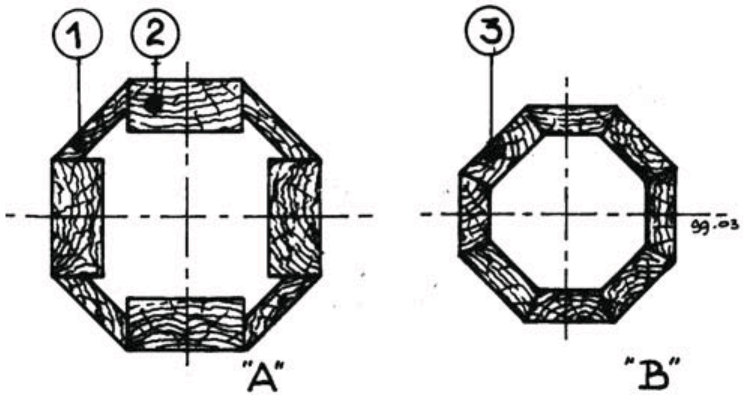


Fig. 5.2.2.4
Cross section of two hollow posts

A. for a heavy hollow post mill
B. for a light hollow post mill
1. *filling piece or post side*
2. *hollow post*
3. *post side*

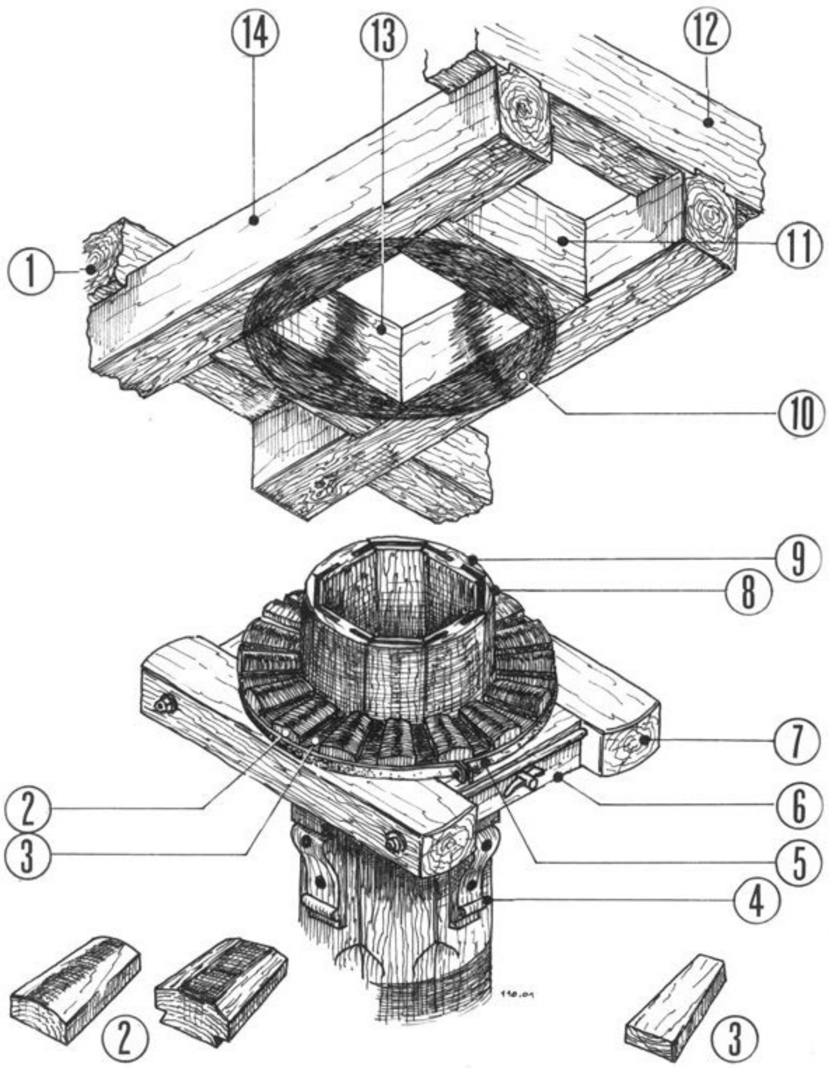


Fig. 5.2.2.5
Upper collar with upper girdle

1. *side girt*
2. *skid plates*
3. *filling pieces*
4. *console*
5. *clamping ring*
6. *trimmer of the upper collar*
7. *upper collar beam*
8. *post side*
9. *hollow post*
10. *friction surface of the upper collar*
11. *trimmer*
12. *side girt*
13. *trimmer*
14. *Sheer of the upper girdle*

The hollow post is rounded at the top and at the part just above the lower collar over a length of about 50 to 60 cm. At these places, the upper girdle and lower girdle of the body rotate around the hollow post. Directly below the topmost rounded part, the upper collar is fitted around the hollow post (see Fig. 5.2.2.5). The four collar beams are joined with double mortise and tenon joints.

upper collar

To prevent it from pushing down, under the influence of the weight of the cabin, the collar is fixed to the hollow post on the four inner sides with dovetail joints, supported by consoles of considerable size.

dovetail joints, consoles

lower collar

The lower collar is also secured around the hollow post with dovetail joints, but this collar also rests on and in the uppersill (see Fig. 5.2.2.6). The hollow post is also rounded just above the lower collar. The tower of the large drainage mills is set up for habitation.

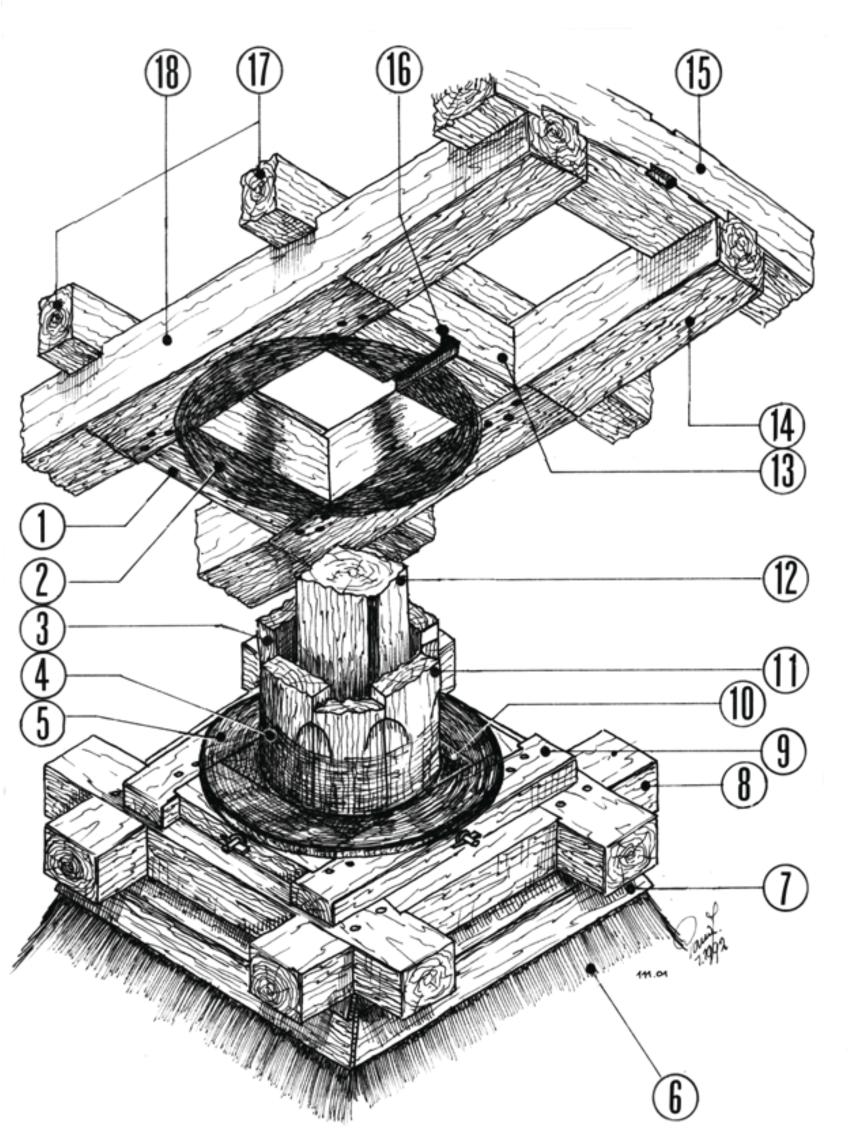


Fig. 5.2.2.6
Lower collar with lower girdle

1. *trimmer*
2. *friction surface of the lower collar*
3. *post side*
4. *friction surface of the lower girdle*
5. *support surface of the lower girdle*
6. *thatch of the tower*
7. *soffit board*
8. *uppersill*
9. *lower collar*
10. *filling piece*
11. *hollow post*
12. *main upright shaft*
13. *trimmer*
14. *lower girdle*
15. *front joist*
16. *lubrication hole*
17. *middle joists*
18. *lower girdle*

5.2.3 The body

body

The house or body is a rectangular body topped by a barrel-shaped roof (see Fig. 5.2.3.1). For the required rigidity of the structure, the entirety is made of fairly heavy studs and beams relative to its size. This is necessary due to the large forces exerted on the cabin while milling, but especially when braking the mill. Below the cabin, there are two full-length lower girts, joined together by two short crossbeams, called trimmers. They form a square frame that fits around the hollow post. The framework thus created is called the lower girdle, and it rests on the lower collar. Slightly higher up in the cabin are two full-width girts. These are also connected to each other by two trimmers. This assembly, the upper girdle, also fits around the hollow post but rests on the upper collar (see Fig. 5.2.3.1 and Fig. 5.2.2.5).

lower girdle

trimmers

upper girdle

During winding, the entire cabin with its contents slides over both collars by means of these steady bearings and rotates around the hollow post. Here it is important that the upper collar is responsible for about two-thirds of the weight.

As the girdle beams sag — for example, due to the process of ageing — the lower collar starts to bear more and more weight, making the mill increasingly difficult to wind. This can be overcome by adding (higher) skid plates to the ring of the upper collar. This restores the weight distribution between the two collars to the correct ratio (see Fig. 5.2.2.5).

skid plates

The base of the cabin is further formed by the four joists that lie on the lower girdle — in other words, the front joist, the two middle joists and the rear joist. The rear joist, twice as long as the other joists, protrudes on either side outside the cabin for the attachment of the stair braces.

joist

middle joist, rear joist

5.2.3.a The side frames

side girts

Side girts rest on the ends of the upper girdle. Most of the cabin's weight hangs from them. For that reason, they are heavy duty.

To obtain proper longitudinal weight distribution of the cabin, the side girts are off-centre on the collar beams. The distance to the front, the breast framing, is shorter because the heavy sail cross is hung on that side. On old hollow post mills, the side girts and upper girdle are visibly warped under the influence of the weight of the cabin that has been resting on them for many years.

Attached to the ends of the side girts are the corner posts that are also supported by the front and rear joists. The corner posts are connected underneath by the lower side girts and above by the middle rails. To the left and right of the corner posts are upper side girts that project beyond the cabin at both the front and the rear. These can therefore be seen from the outside. Usually they are ornately finished with an ogee and painted in different colours. In many cases, beautifully shaped consoles have been added beneath the overhangs of the upper side girts in order to increase the bearing surface of the corner posts. Between the aforementioned horizontally placed beams, the side frames are further reinforced with middle studs and raking studs.

corner posts

lower side girts, middle rails

upper side girts

ogee

middle studs, raking studs

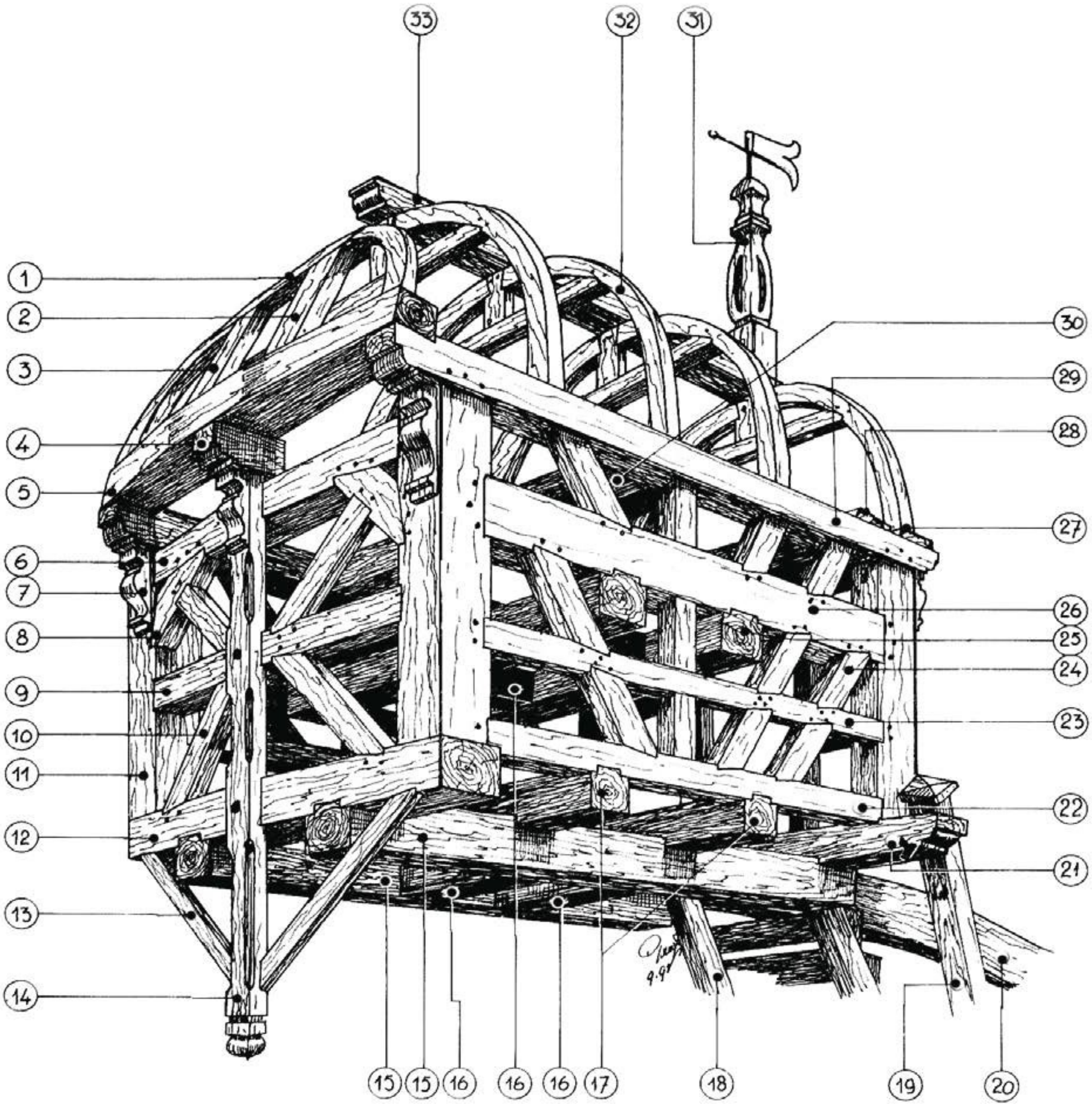


Fig. 5.2.3.1
The cabin or body

1. *gable beam*
2. *weather stud*
3. *neck stud*
4. *keyhead*
5. *weather beam*
6. *upper tie beam*
7. *console*
8. *corbel*
9. *tie-beam*
10. *cross-brace*
11. *corner post*
12. *front joist*
13. *prick post brace*
14. *prick post*
15. *sheer*
16. *trimmer*
17. *middle joists*
18. *stringer*
19. *step brace*
20. *tail pole*
21. *rear joist*
22. *lower side girt*
23. *rail*
24. *raking studs*
25. *sheer*
26. *side girt*
27. *rear beam*
28. *tail beam*
29. *upper side girt*
30. *spindle beam or sprattle beam*
31. *finial*
32. *cap spar*
33. *ridge-piece*

5.2.3.b The breast framing

breast framing
corner post
upper tie beam, tie beam, cross beam, prick post
wedge bolts
prick post braces
keyhead
acorn
corbels
cross braces

The front of the cabin is called the breast framing. It is formed by the two forward corner posts, which are attached to the ends of the side girts and stand on the front joist. These corner posts are connected near the top and halfway up by, respectively, the upper tie beam and the tie beam or cross beam. The prick post hangs vertically across the centre of the framing. The prick post is fastened to the aforementioned beams with wedges and heavy wedge bolts, and the part that protrudes under the joist is braced on both sides with two prick post braces. At the top of the prick post, as support for the weather beam, there is a keyhead the thickness of the upper side girts. Additionally, the prick post is often embellished on the sides with wide rim edges and an acorn underneath. Reinforcement against leaning of the breast framing is obtained by applying corbels at the corners between the corner posts and the upper tie beam and, further, with cross braces or raking studs placed diagonally between the horizontal beams and the corbels. The position of these raking studs may vary from region to region.

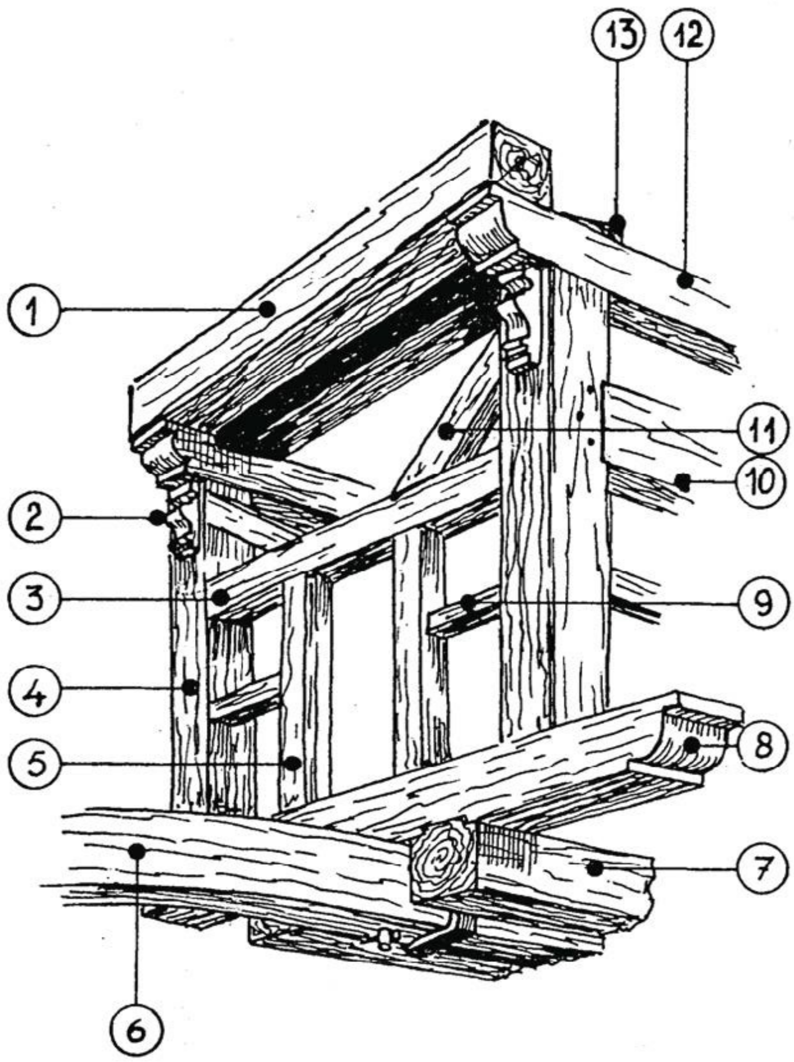


Fig. 5.2.3.2
The tail framing

1. *rear beam*
2. *console*
3. *door beam*
4. *corner post*
5. *door post*
6. *tail pole*
7. *shear beam*
8. *rear joist*
9. *cross rail*
10. *side girt*
11. *corbel*
12. *upper side girt*
13. *tail beam*

5.2.3.c The tail framing

tail framing
rear corner posts
door beam
door posts
cross rail

The rear of the body is called the tail framing (trapbint), named (in Dutch) after the stairs (trap) to which it is attached. It is formed by the two rear corner posts that hang from the side girts and stand on the rear joist. A horizontal door beam connects the corner posts, supported by two upward facing corbels. Below the door beam are two door posts, both of which are supported on the side by a (short) cross rail. Compared to the breast framing, the tail framing is much lighter because less heavy forces are exerted on it.

5.2.3.d The beams on or between the upper side girts

rear beam
tail beam

The rear beam lies on the upper side girts above the tail framing (see Fig. 5.2.3.3). This beam is the first to join the two upper side girts. Immediately in front of that is the tail beam, which lies on and/or between the upper side girts. The tail beam is adjustable, both longitudinally and laterally.
In the centre of the tail beam, which is often bent downward in the middle, a space is cut out for the tail bearing for the windshaft (see Fig. 5.2.3.4).

spindle beam
sprattle beam

Approximately in the middle on the upper side girts is the spindle beam or sprattle beam. Just like the tail beam, this is adjustable to enable adjustment of the main upright shaft. In the middle of this spindle beam, a space is cut out for the carters of the upper bearing of the main upright shaft.

weather beam

Finally, the weather beam is above the breast framing at the ends of the upper side girts (see Fig. 5.2.3.1). In the middle of the weather beam, on the chair block, is the neck bearing for the windshaft. About 90% of the weight of the shaft and the sail cross rests on this. To bear that weight, the weather beam is very heavy and is supported in the middle against sagging by the console on the prick post. Thus, via this prick post, the upper tie beam, tie beam and front joist also bear the heavy shaft and the sail cross.
In larger cabins, there is another tie beam in front of the tail beam.

tie-rod

This absorbs the outward forces caused by the wedging of both the tail beam and the spindle beam. For that purpose, a long tie rod is also often installed parallel to the tie beam and inserted through both upper side girts.

5.2.3.e The cap

front gable

Over all of this is the cap, which consists of a number of rafters and the front gable (see Fig. 5.2.3.1). Depending on the region where the mill was built, the shape of the cap is almost barrel or onion-shaped. In the latter case, the curve is slightly wider than the cabin itself. The top of the rafters are joined together with the ridge-piece or the ridge beam

ridge-piece, ridge beam
weather boarding
rear gable

The rear rafter is not placed inside the weather boarding, but outside it. Thus, it is visible from the outside and is called the rear gable. The rafter is often ornately shaped and painted a different colour.

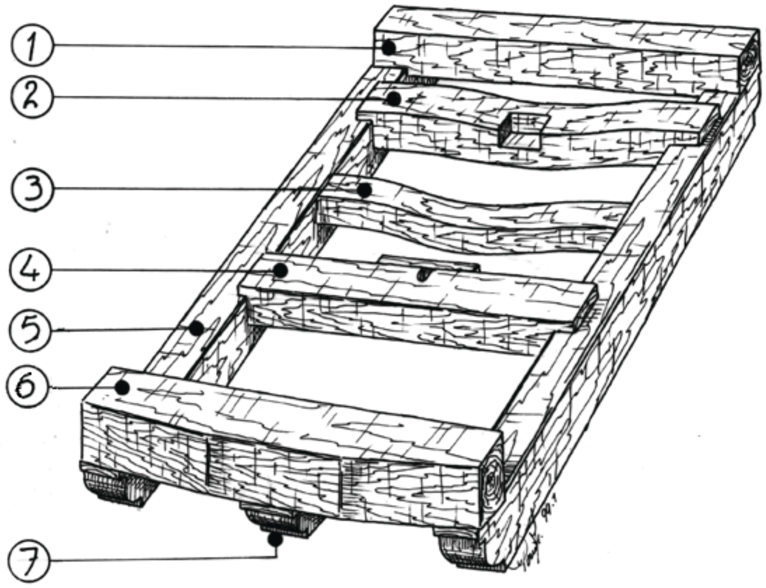


Fig. 5.2.3.3
Beams on and between the upper side girts

1. *rear beam*
2. *tail beam*
3. *cross or tie beam*
4. *sprattle beam, spindle beam*
5. *upper side girt*
6. *weather beam*
7. *keyhead*

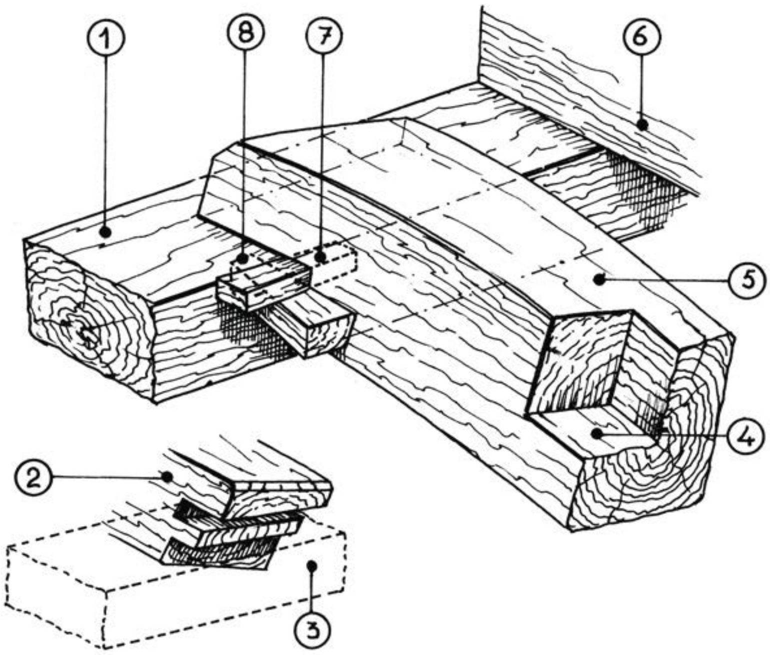


Fig. 5.2.3.4
Support of the tail beam

1. *upper side girt*
2. *head of the tail beam*
3. *upper side girt*
4. *housing for the tail brass*
5. *tail beam*
6. *rear beam*

7 and 8. adjusting wedges

neck stud, weather stud
corner stud

At the front on the weather beam is the front gables, pitched slightly backwards. This gables are formed by the neck stud and weather stud and the corner studs that are on the ends of the weather beam. The latter have the same curvature as the cap. The neck stud is additionally supported by a small brace or corbel. The weather stud is removable in most cases

gable beam
hipped-gable roof
finial
wind vane

made to allow insertion or removal of the windshaft. The neck and weather studs are connected at the top by the gable beam. Above this beam there is still the strongly backwards pitched hipped-gable roof, extending in a pointed shape below the ridge-piece or ridge beam. Towards the end of the ridge beam is the finial, usually a beautifully worked post of considerable size. Finally, on the finial there is often a wind vane, also beautifully carved from metal.

5.2.4 The tail

tail pole
stair stringer
capstan platform
step
hangers
notched tie bolts
stair braces

The most important beam of the tail structure is the tail pole (see Fig. 5.2.4.1). It is a slightly "S" shaped beam, suspended from the rear joist of the buck with a heavy bracket or wedge bolt through the rear joist (see Fig. 5.2.3.2). The front end is inserted into the rear trimmer of the lower girdle with a heavy tenon. The two stringers hang down diagonally from the rear joist of the cabin. At the bottom, they are joined together by the platform for the capstan, a wooden block of substantial size. The stair steps themselves can be encountered in different designs. The entire staircase is held in the desired diagonal position by two hangers that are hung from the back of the tail pole. At the bottom, they are attached to the shoe by notched tie bolts. The suspension at the top is made adjustable to keep the platform for the capstan clear of the ground when the tail pole sags. Since the tail serves for winding the mill, it is subject to lateral forces. To absorb these forces, two stair braces (usually crosswise) are installed against the stringers from the ends of the rear joist.

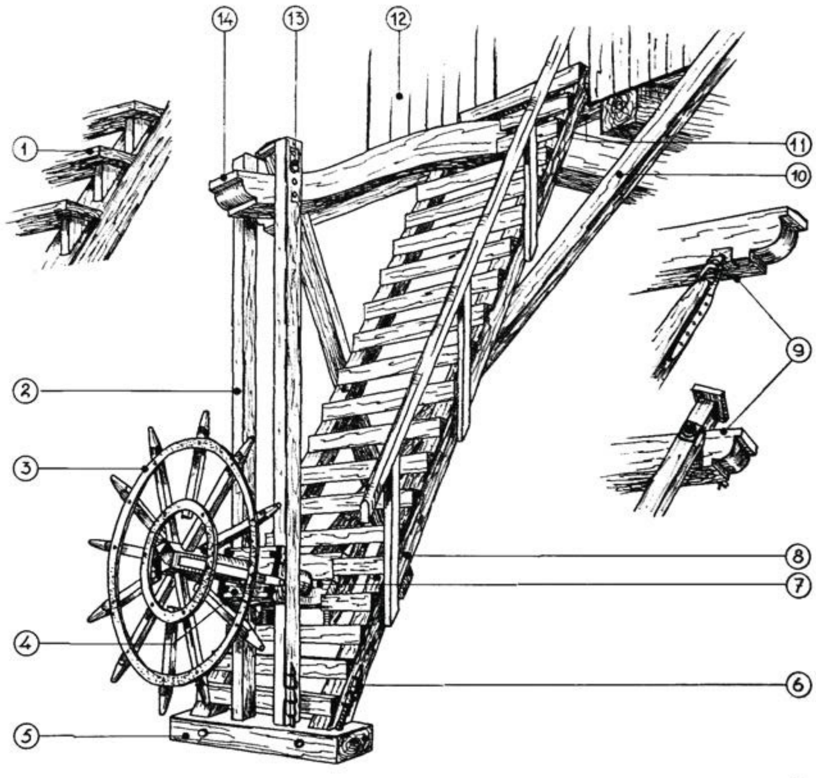


Fig. 5.2.4.1
The stairs

1. *stair step*
2. *hangers*
3. *capstan wheel*
4. *front stay*
5. *platform for the capstan*
6. *Notched tie bolt*
7. *rear stay*
8. *stringer*
9. *stair brace mounting*
10. *step brace*
11. *rear joist*
12. *cabin*
13. *adjustment bolt*
14. *tail pole*

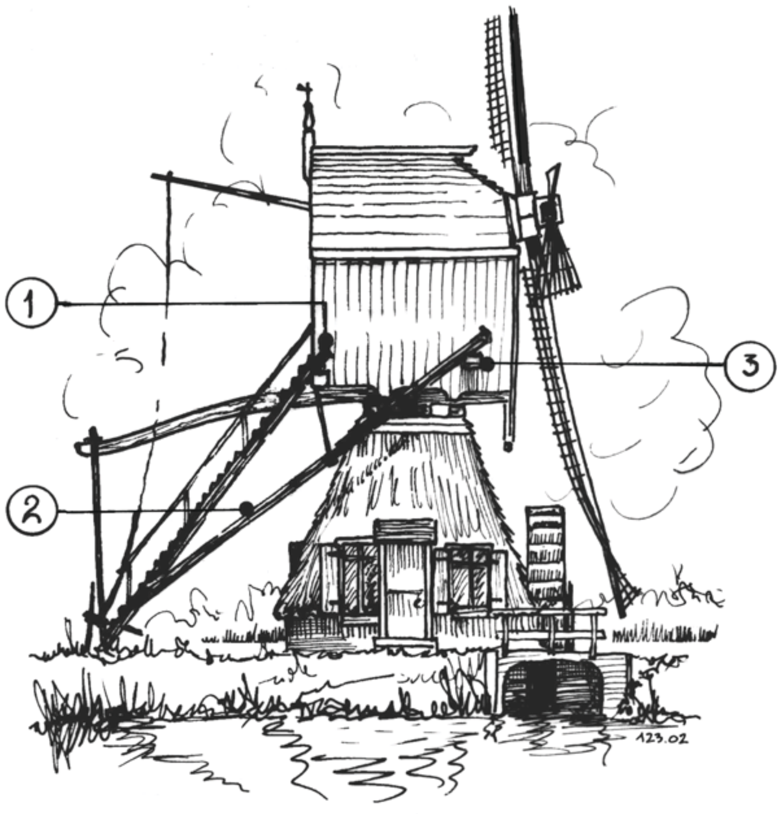


Fig. 5.2.4.2
Hollow post with long braces

1. *short brace, step brace*
2. *long brace*
3. *cross beam*

long braces

In addition to the step braces already mentioned, long braces are found at a number of South Holland hollow post mills. These run from the bottom of the stairs to a stretcher inserted through the cabin (see Fig. 5.2.4.2).
This does not yet complete the staircase. Blocks of wood which have a round hole cut out in them, called the front stay and rear stay, are attached between the stringers as well as the hangers. The barrel of the winding wheel or capstan wheel turns in these stays. In the Alblasserwaard and surrounding areas, another so-called winding platform is often fitted to the left of the stairs. This is a simple wooden platform, about the height of the barrel of the winding reel (see Fig. 5.2.4.3).

front stay, rear stay
barrel, winding wheel, capstan wheel
winding platform

5.2.5 Special versions

hollow post grain mill

The hollow post mill was not only used for draining polders. Hollow post mills were also used for grinding grain and as sawmills for smaller woodwork. The hollow post mills used for this purpose were built from scratch or made from a disused polder mill. For example, the grain mill *Nieuw Leven* (New Life) in Hazerswoude is a former polder mill. This mill is special in as much as it has a stage and is otherwise entirely complete and capable of grinding. The second surviving hollow post stage mill is *'t Haantje* (The Rooster) in Weesp.

hollow post stage mill

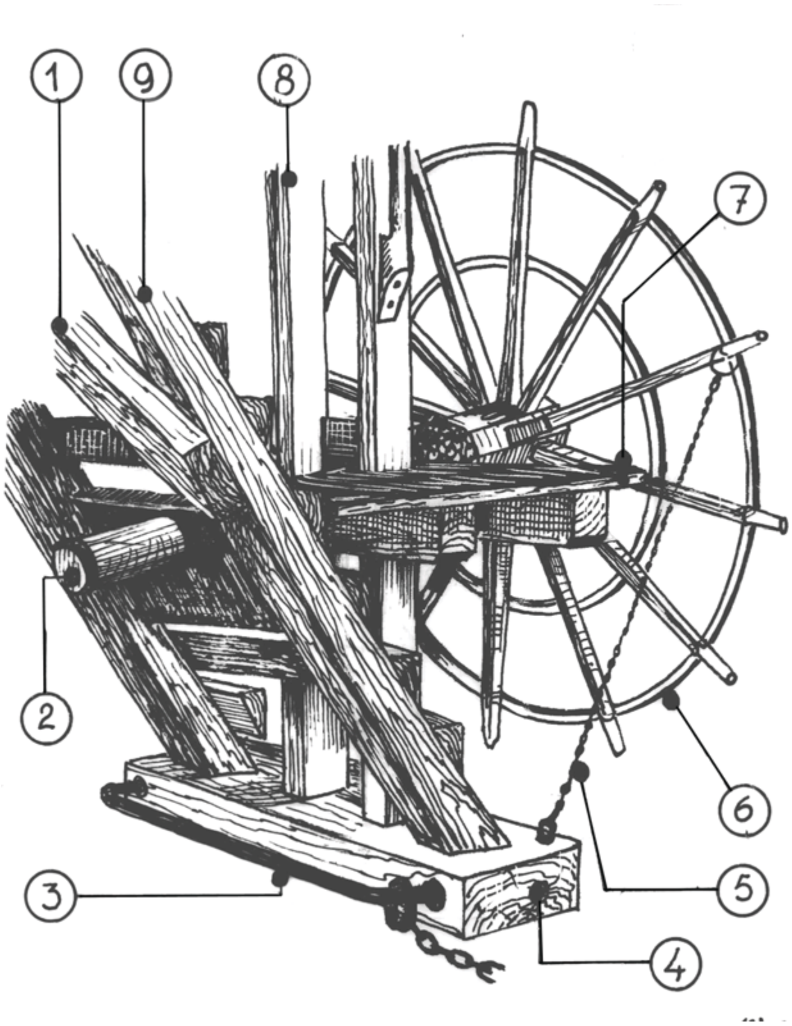
ground-sail mill

Since 2015, the Netherlands once again has a hollow post grain mill in the design of a ground-sail mill. This is the newly built *Thornsche Molen* in Persingen (Gelderland province).
This hollow post grain mill is constructed as a ground-sailer so there is no stage. It also resembles an ordinary hollow post mill but is built on walls that are one-and-a-half to two

metres high. The construction of both the body and the tower is almost identical to that of the hollow post mill for polder drainage. However, space for the spur wheel and the stone nut is limited. The attached cross-sections show this clearly (see Fig. 5.2.5.1).

Fig. 5.2.4.3
Tail with winding platform

1. *step brace*
2. *barrel*
3. *iron rail with anchor chain*
4. *platform for the capstan*
5. *spoke chain*
6. *winding wheel or capstan wheel*
7. *winding platform*
8. *hanger*
9. *stringer*



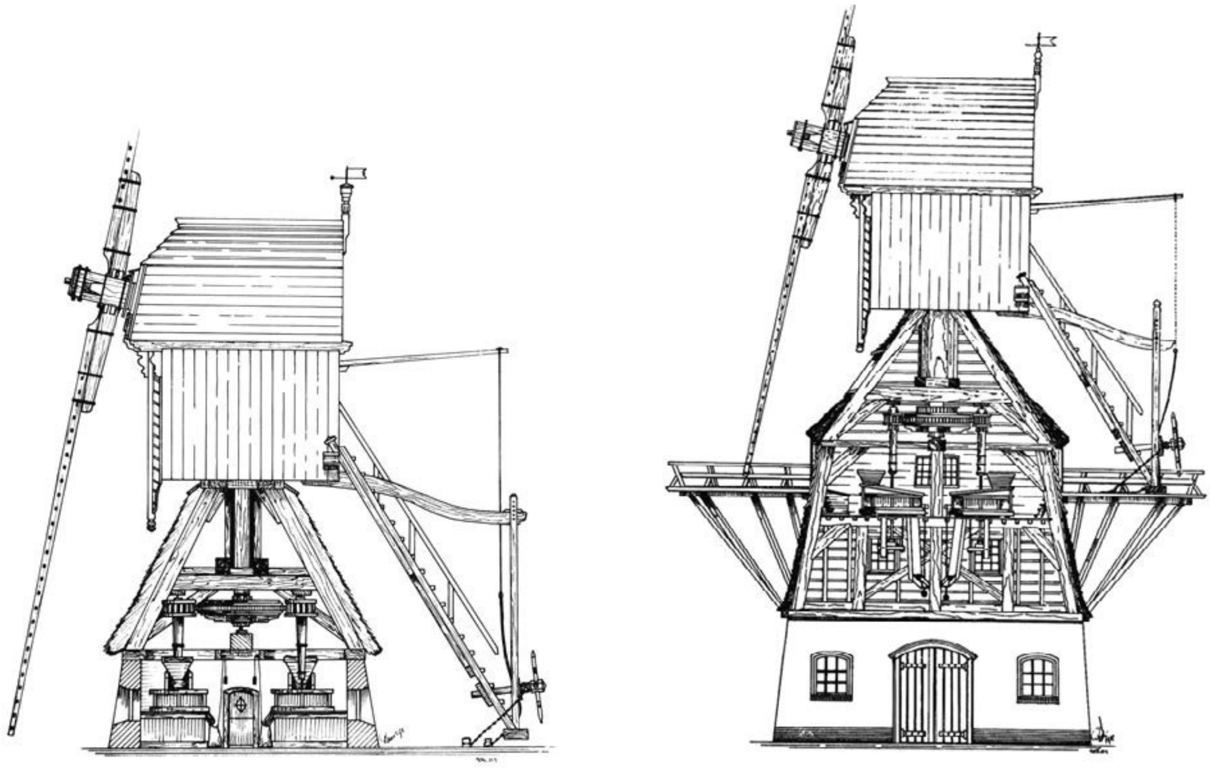


Fig. 5.2.5.1
Two types of hollow post grain mills:
On the left a ground-sail mill and on the right a hollow post stage mill

5.3 THE PALTROK

5.3.1 Introduction

The paltrok, like the post mill and the hollow post mill, belongs to the four-sided (square) mills. From its inception, this type has been used exclusively in the Netherlands as a sawmill. At the end of the 16th century, Cornelis Corneliszoon van Uitgeest constructed the first mill that could saw wood using wind power. Until then, this had been done manually in the Netherlands, a time-consuming and heavy job. A mill in which Cornelis Corneliszoon had applied his inventions was erected in Zaandam in 1596 and was given the name *Het Juffertje* (The Missy). There it was significantly improved and enlarged and finally grew into the model as known today. From 1615, the paltrok started its advance in the Zaan region. It proved to be a huge success. Each paltrok took over the work of about 50 hand sawyers, and the demand for sawn lumber increased. This industrial revolution experienced over 100 years of growth. The peak was reached around 1730 when in the Zaan region no fewer than 200 paltroks were sawing timber. This timber industry flourished on a smaller scale in Amsterdam and Dordrecht where paltroks were also used. After 1750, a decline slowly but surely set in and by 1800 the number of paltroks in the Zaan region had fallen to fewer than half. As of 2016, there were only two left, namely *De Held Joshua* (Joshua, the Hero) and *De Gekroonde Poelenburg* (The Crowned Poelenburg). In Amsterdam there is *De Otter* (The Otter), in Haarlem *De Eenhoorn* (The Unicorn) and in the Open-Air Museum in Arnhem, *Mijn Genoegen* (My Pleasure).

5.3.2 The lower winding

masonry base, king pier
central pier
cross-trees
diagonal braces
support beams
winding track
king

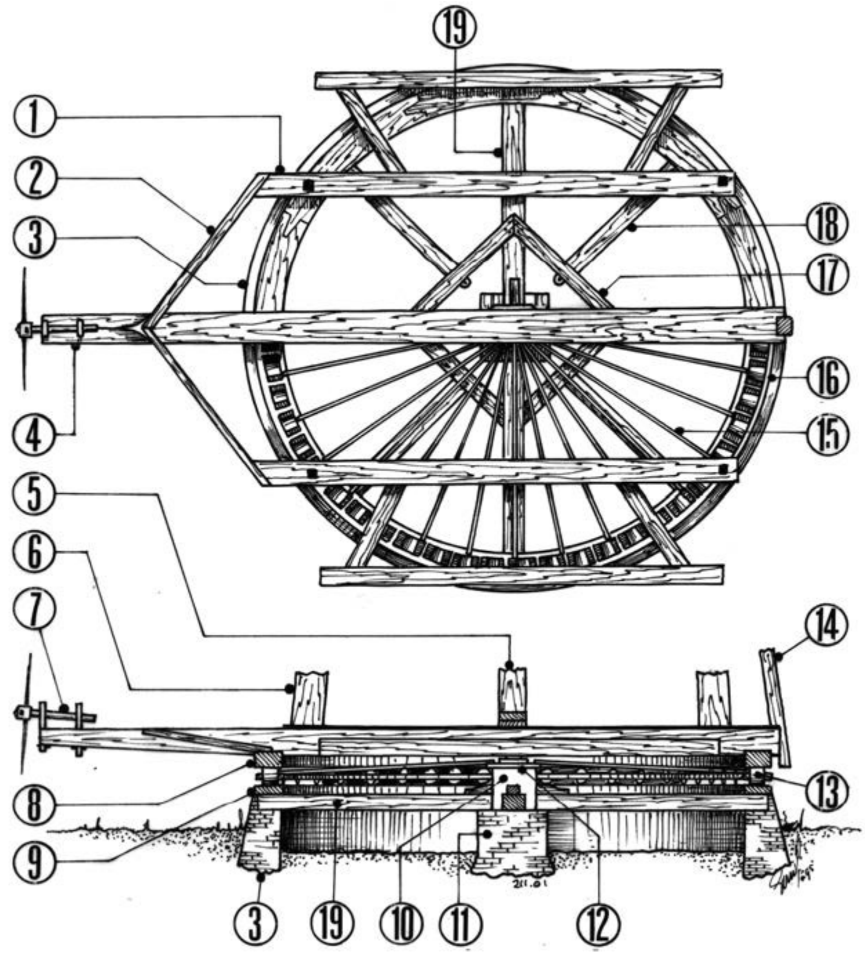
Below the mill is a low masonry base about nine metres in diameter with a king pier or central pier at the centre measuring at least one meter square. This carries almost the entire weight of the mill. On this pier is a thick oak board on which rest two cross-trees, scarfed into each other. The ends of the cross-trees are encased in the masonry base. The cross-trees are joined together by four diagonal braces. These are connected to the masonry base by four stretchers or support beams as well (see Fig. 5.2.3.1).
The winding track, which is joined by dovetails to the ends of the cross-trees and braces, lies on the masonry base. A large oak block, the king, rests on and across the intersection of the cross-trees. It has a rounded finish at the top end and is fitted with a large round pin on top. The king forms the pivot point of the mill.

roller-ring
tracking beams
collar
curb

There are about 50 elm wood winding rollers on the winding track, encased in the wooden roller-ring. There is no keep flange. The roller-ring is held in place with the help of the tracking beams that go radially to the centre point. There they are attached to a wooden collar piece that fits around the rounded part of the king. The wooden curb lies on the rollers. This forms the base of the entire mill.
The paltrok rests almost entirely on the king and leans on the winding rollers only at the front. In strong winds, it can easily rock backwards. So we see a combination of live curb and collar winding gear (see Fig. 5.9.4.1).

Fig. 5.3.2.1
The base of the paltrok

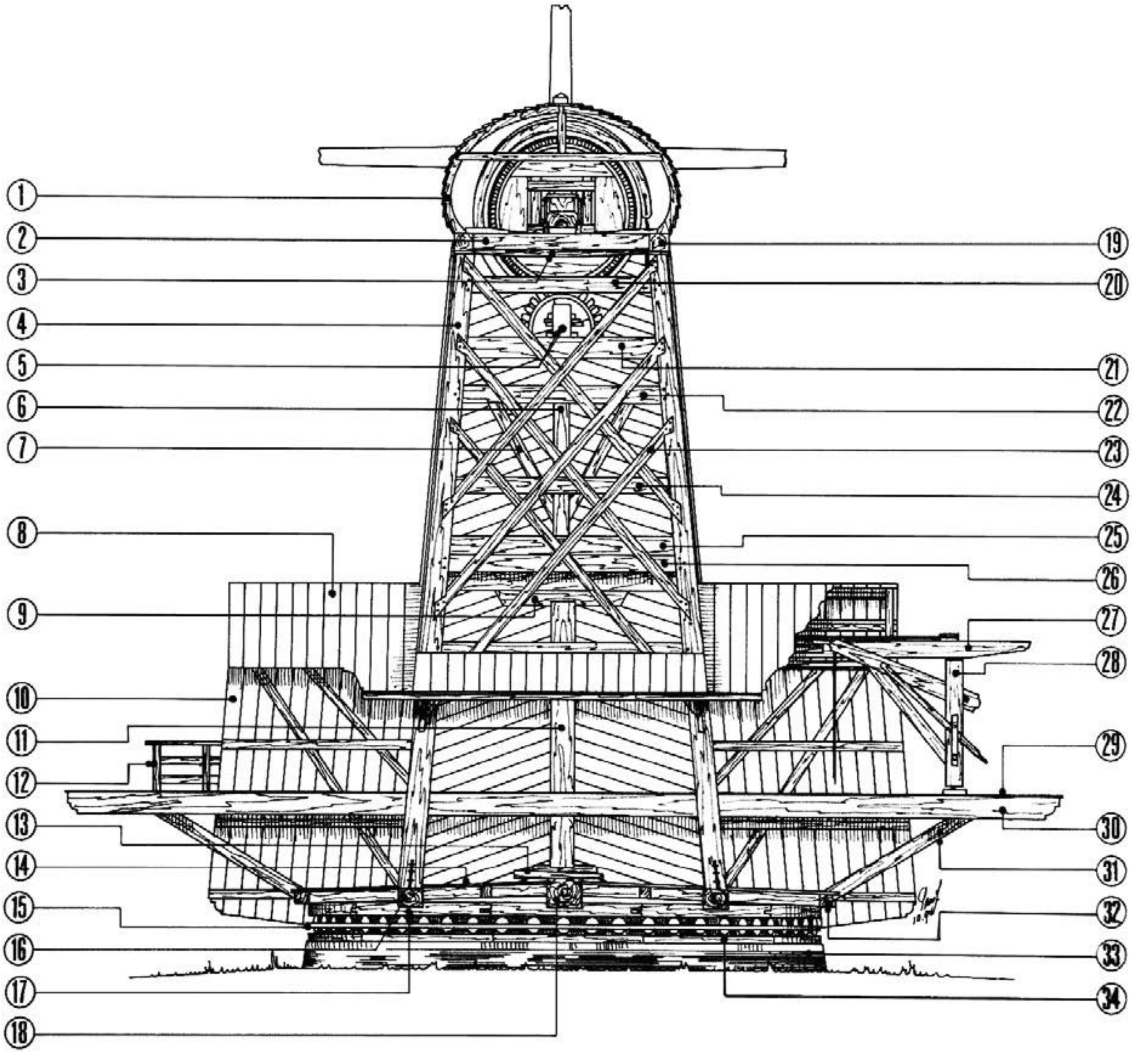
1. *shear*
2. *brace*
3. *masonry base*
4. *tail pole, winding beam or turning beam*
5. *king-post*
6. *shear post or corner post*
7. *winding reel*
8. *curb*
9. *winding track*
10. *king*
11. *king pier*
12. *collar piece*
13. *winding roller*
14. *prick post*
15. *tracking beam*
16. *roller-ring*
17. *diagonal brace*
18. *brace or support beam*
19. *cross-tree*



5.3.3 Structure of the paltrok

sheers, tail pole — *brace* — *rear platform* — *bottom rig floor* — *king-post* — *adjustment wedges, king beam*

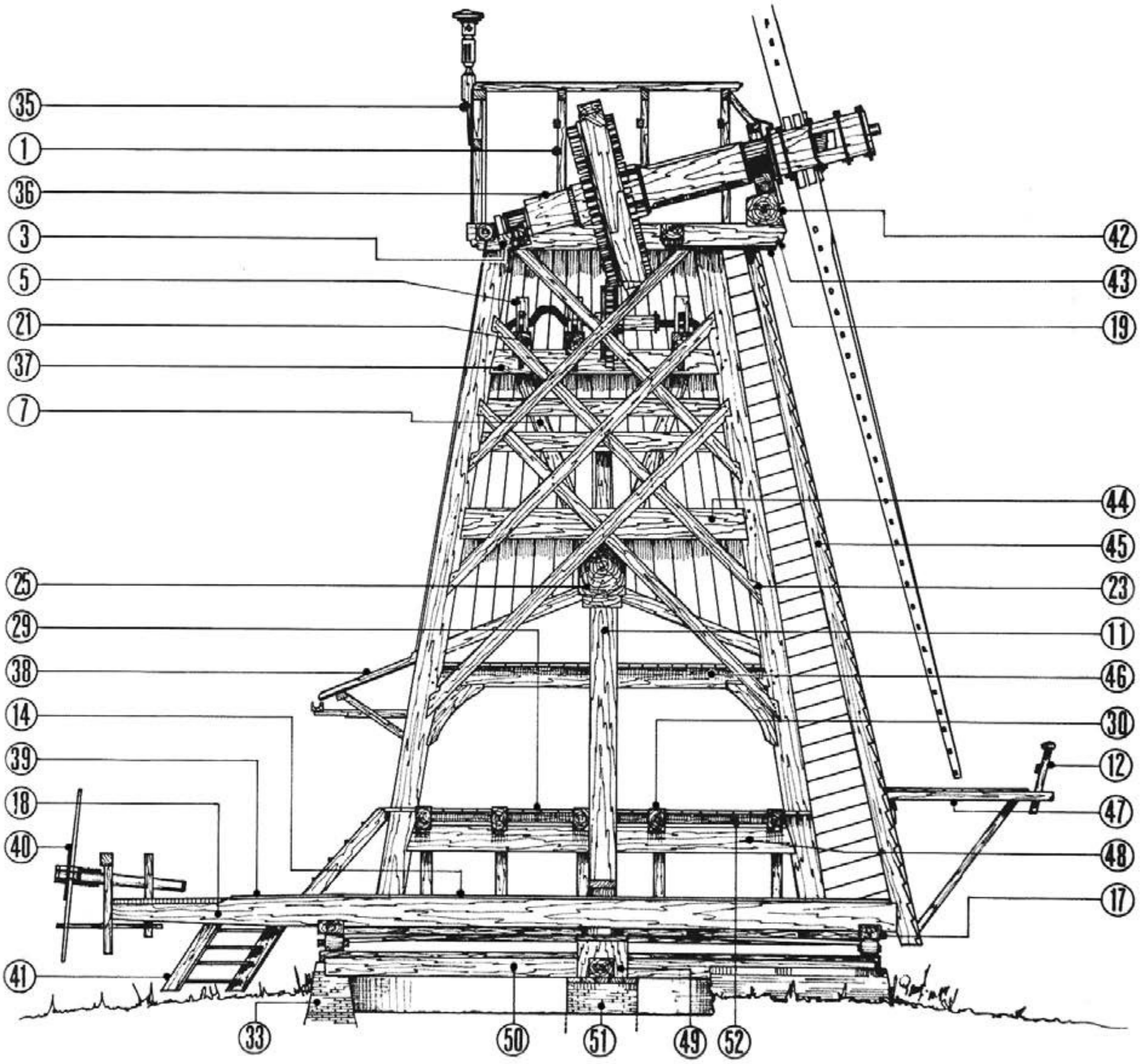
Three heavy beams lie side by side on the curb. To the left and right of the centre are the sheers, and across the centre is the tail pole. A round hole at the bottom of the tail pole fits over the pintle of the king. This structure holds the mill in place. A winding reel is attached at the end of the tail pole, which extends three to four metres beyond the curb. To absorb lateral forces when winding, a brace runs from the end of the tail pole to each of the two sheers. Nailed to these braces and part of the tail pole are floorboards that make up the rear platform (outside the mill) and the bottom rig floor (under the mill).
In the middle of the mill is the king-post, which rests on the tail pole via large, sometimes double adjustment wedges. Attached to the king-post is the king beam.



heavy beam	This heavy beam (comparable to the crowntree in the post mill) must bear by far the majority of the mill's total weight. Only a small portion of the weight rests on the winding rollers.
corner posts	At the ends of the king-post are the so-called heavy beams (similar to the side girts in a post mill). The four corner posts hang from these.
binders, cross bracing, raking studs	At the bottom are the corner posts with tenons on the ends of the sheers. They are connected across the four sides by horizontal transoms, the binders. Further rigidity is obtained with cross bracing, stud posts and raking studs.

Fig. 5.3.3.1 and Fig. 5.3.3.2
The structure of the paltrok

1. *cap spar*
2. *rear tie beam*
3. *tail beam*
4. *shear post or corner post*
5. *crank bearing*
6. *upper cross beam*
7. *raking stud*
8. *pentice roof*
9. *pillow*
10. *hanging roof*
11. *king-post*
12. *platform railing*
13. *adjustment wedge*
14. *bottom rig floor*
15. *roller-ring*
16. *shear curb*
17. *tail pole*
18. *winding beam or cross*
19. *upper side girt*
20. *top girt*
21. *crank beam*
22. *support beam*
23. *cross bracing*
24. *intermediate girt*
25. *king beam*
26. *binder*
27. *cantilever tail pole*
28. *crane*
29. *sawing floor*
30. *carriage stage*
31. *carriage props*
32. *bottom rig floor beam*
33. *masonry base*
34. *winding track*
35. *finial*
36. *windshaft*
37. *crank support*
38. *pentice roof*
39. *rear platform*
40. *winding reel*
41. *stairs*
42. *weather beam*
43. *support*
44. *heavy beams*
45. *prick post*
46. *saw jig floor*
47. *reefing stage*
48. *carriage stage beam*
49. *king*
50. *cross-tree*
51. *King pier*
52. *beam under sawing floor*



heavy beam
base beams,
The binders above the heavy beams, called base framing, are utilized to support the base beams.

saw jig floor,
The tie beams under the heavy beams support the saw jig floor.

carriage stage
The carriage stage is constructed on the lower binders, about 1.5 metres above the masonry base. It projects several metres beyond the curb on both sides.

carriage props
The carriage props support the overhanging parts of the carriage stage.

sawing floor
The sawing floor lies on the carriage stage.

pentice roof
On either side of the mill body (buck) is a timbered covering, the pentice roof, consisting of the deck canopies and hanging canopies. So, the sawyer team worked outside but always out of the wind.

prick post
The front of the paltrok, the breast, is not flat. The prick post hangs against the end of the tail pole, ending below the cap. From this forward-standing prick post, the face is lapped with sloped sections.

reefing stage
girders
The reefing stage, a simple stage from which the sail cross can be reached, hangs in front of the breast. The platform consists of five platform girders resting on a girt fixed to the face. The girders are supported by braces that also lean against the face.

5.3.4 The cap

upper side girts
cap spars
support beam
The base of the cap is formed by the upper side girts, the support beam and the rear beam. On the upper side girts are the cap spars, which are joined together by the ridge-piece. The upper side girts are joined by mortise-and-tenon to the corner posts and protrude over them at the front. On top of this lies the weather beam, anchored. Behind the weather beam lies the support beam between the upper side girts. The strut that goes into the support beam is attached in the middle, below the weather beam. The prick post ends below the strut and, as already seen, is supported at the bottom by the tail pole.

rear beam, rear tie beam
The rear beam or rear tie beam is anchored to the back of the upper side girts. In front of it, between the upper side girts, lies the tail beam, which is adjustable horizontally.

The shape of the cap is defined by three circular sections that make it protrude sideways beyond the upper side girts; it is fairly flat from above. The cap is clad with horizontal over-seam sections, the overlapped weather boarding.

NOTES

5.4 THE SPIDER MILL

5.4.1 Introduction

The province of Friesland contained many small, shallow polders that could be drained by a small mill. Originally, spider mills were used for this purpose and later also *môunts* or smock mills, the small Frisian octagon (see Fig. 5.7.3.c).
The sail of a spider mill is between 7 and 15 metres, which makes some spider mills larger than the smallest of the hollow post mills. Although the spider mill evolved from the hollow post mill, it can certainly be seen as a distinct type in its own right.
Of the 28 spider mills in the Netherlands (per 2016), 26 are set up as polder mills: 23 in Friesland, two in Gelderland and one in Overijssel. Two of them have a different function. The first is a grain mill in the village of Koudum in the province of Friesland. The second is a sawmill in Wedderveer, in Groningen province. Both spider mills are attached to a shed.

5.4.2 The square spider mill and the octagonal spider mill

If a small hollow post mill and a spider mill would be set side by side, the external differences would be clearly visible.
In a spider mill, the breast framing and tail framing are much closer together, making the cabin shorter and thus stronger. Braces and corbels can therefore be omitted. The sheer beams carry the entire weight of the cabin. Therefore, the upper girdle does not rest on the upper collar but only ensures that the cabin remains upright.
The base of both mills is almost the same size. Because the tower of the spider mill is lower, the four sides lie flatter. Therefore, the four corners seem to project further out. The head is correspondingly higher so that the spider mill ends up being as high as a small hollow post mill. Partly because the cabin is shorter, the windshaft is steeper to allow the sail cross to rotate freely away from the projecting corners. Therefore, in square spider mills, the sail cross tilts back significantly. The octagonal spider mill originated in western Friesland. A cap with a less strongly sloping sail cross can be placed on these. This also allows the lower tower to be covered with thatch instead of roof tiles, for example.

square spider mill
octagonal spider mill

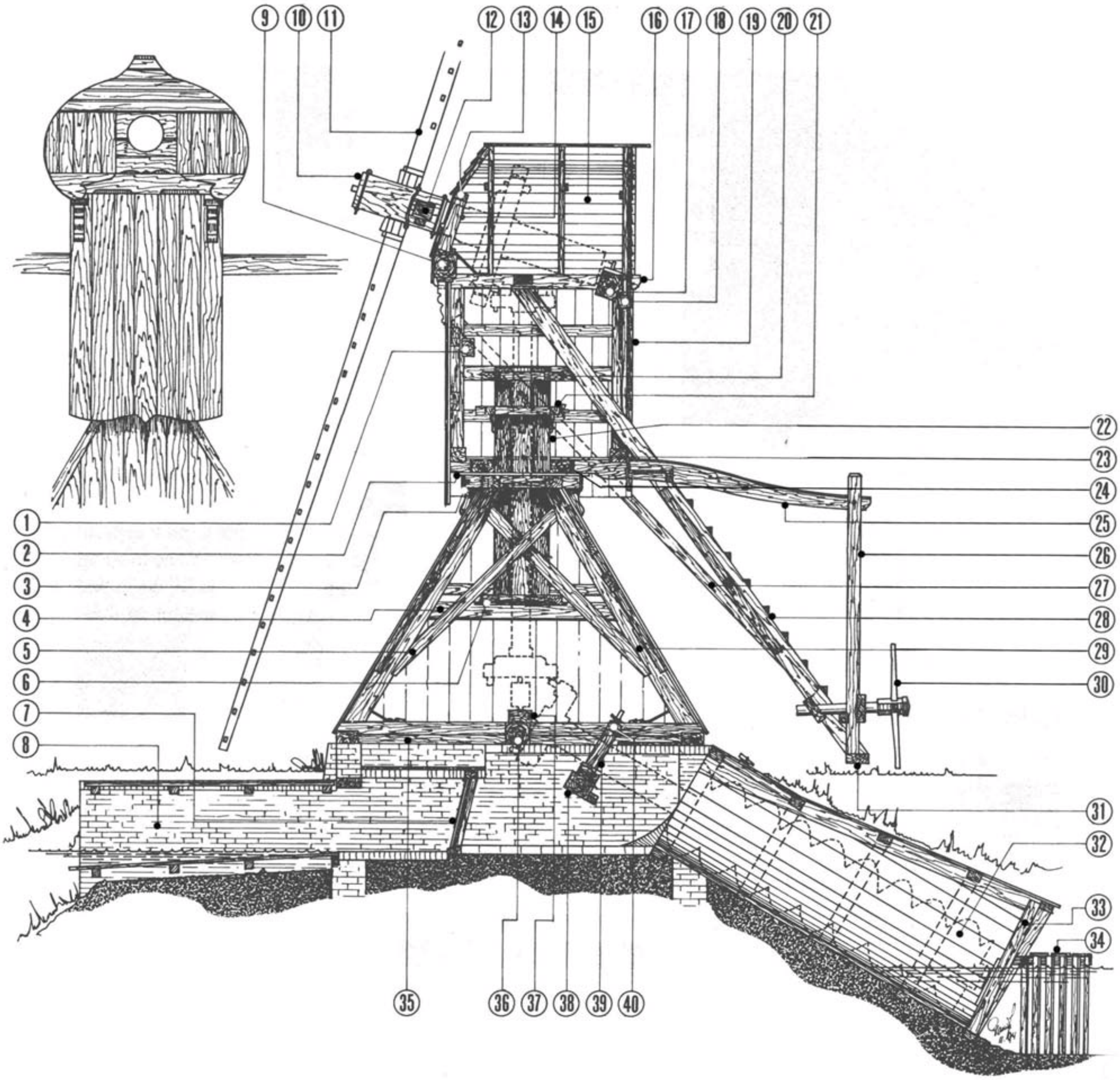
5.4.3 Other features

collar plate
hollow post collar

- The cabin rests directly on the uppersill, although sometimes a collar plate is fitted between them to prevent wear. The function of the hollow post collar is merely to hold the hollow post together; the collar does not have a load-bearing function.
- The hollow post consists of eight equal hollow post parts and also has no load-bearing function.

head beams

- In the tower there are four head beams which, unlike the cross trees of the hollow post mill, here only have the task of supporting the hollow post.
- The stringers rest with a keep on the rear joist and run past the rear corner posts to continue on to below the upper side girt.



- The spider mill often has a long stretcher, usually attached to the side girts against the forward corner posts.
- The spider mill does not have an extended rear joist that serves as a short stretcher.
- The brake lever is located above the lower collar and is usually lifted with a brake rope that is secured. A pull brake holds the brake lever down.
- Spider mills do not have a finial.

Fig. 5.4.3.1
The spider mill (previous page)

1. *long stretcher*
2. *tie*
3. *uppersill*
4. *cross beam*
5. *Cross-brace*
6. *cross tree*
7. *sluice flap or door*
8. *discharge pipe*
9. *weather beam*
10. *windshaft*
11. *outside stock*
12. *inside stock*
13. *gable beam*
14. *neck and weather studs*
15. *cap*
16. *upper side girt*
17. *tail beam*
18. *rear beam*
19. *tail framing*
20. *lower girdle*
21. *hollow post collar*
22. *hollow post*
23. *rear joist*
24. *collar plate*
25. *tail pole*
26. *hanger*
27. *step brace*
28. *stringer*
29. *corner or tower post*
30. *winding reel*
31. *bottom tread*
32. *screw beam*
33. *well beam*
34. *debris grille*
35. *sill*
36. *lower spindle beam*
37. *bearing block*
38. *neck beam*
39. *neck and weather studs*
40. *transom*

5.5 THE MEADOW MILL

5.5.1 Introduction

With a sail cross of no more than a few metres, the meadow mill is one of the smallest mill types. In North Holland, in particular, such mills were widely used in polders whose plots did not settle equally in all places. As a result, the centrally set water level could not be controlled to everyone's wishes. Farmers proceeded to drain their own plot of several hectares with their own meadow mill.

5.5.2 The construction

A meadow mill has a square trestle and a lower collar. The upper body rests on the lower collar and is held in place by the hollow post. The tail is attached to the back of the upper body, to the left of centre. This counteracts the tendency for veering (clockwise) winding and keeps the mill straight facing the wind.
Many meadow mills built later are equipped with a tail that flips over in high winds and then locks itself with a tension spring and catch. The tail is then perpendicular to the wind in a plane parallel to that of the sails so that the upper body winds itself 90° out of the wind with the sail cross. As a result, the sail cross comes to a halt. Meadow mills usually do not have a brake.
Meadow mills can be equipped with either sails or (half) wooden boards.

vane pump

As a lifting implement, a meadow mill is equipped with a vane pump, a centrifugal pump with four horizontal blades.

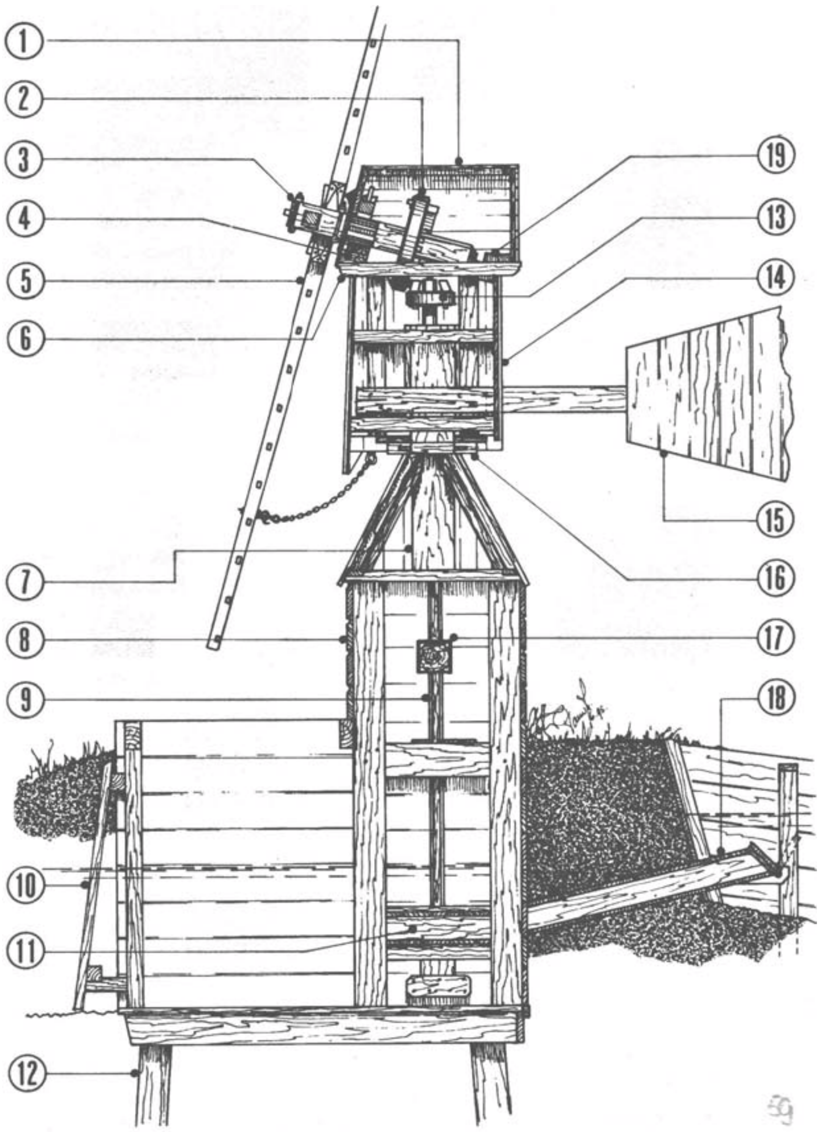


Fig. 5.5.2.1
The meadow mill

1. *cap*
2. *head wheel*
3. *windshaft*
4. *weather beam*
5. *stock*
6. *upper side girt*
7. *square hollow post*
8. *lower body*
9. *spindle*
10. *debris grille*
11. *vane pump*
12. *foundation*
13. *crown wheel*
14. *upper body*
15. *tail*
16. *lower collar*
17. *connecting block*
18. *discharge pipe*
19. *tail beam*

5.6 THE TJASKER

5.6.1 Introduction

tjasker

enclosed Archimedean screw

It is certain that the tjasker originated in the province of Friesland. There is (still) less certainty when it comes to its age. The tjasker is thought to originate in the sixteenth century, possibly as a derivative of the hand-operated enclosed Archimedean screw that is known to date back to before our era. During the 19th century and the first quarter of the 20*th* century, there were a large number of tjaskers in Friesland, which, like the meadow mills in North Holland, drained plots of a few hectares. The Kop van Overijssel region also had tjaskers.
With the advent of the iron wind engine, however, from the 1930s tjaskers were in danger of disappearing on a large scale and even of dying out altogether. In 1957, only three still existed: two in Friesland and one at the Open-Air Museum at Arnhem. But during the 1970s, the tjasker experienced a strong comeback. About 20 new ones have been built since that time — and not just in Friesland. As of 2016, Friesland currently has 13 tjaskers, with the others in the provinces of Groningen, Drenthe, Overijssel, Gelderland, North Holland and South Holland.
Now tjaskers are often used in nature conservation areas to achieve higher water levels. So in contrast to the past, they are now used to pump water in rather than for draining water out.

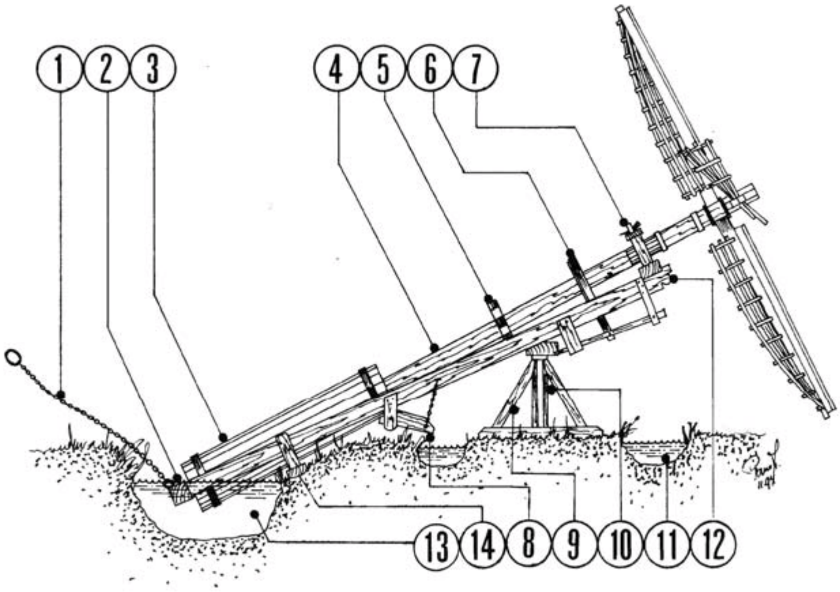
5.6.2 Structure of the tjasker

frame
weather beam, water bolster
pivot, screw shaft
barrel beam, screw beam
fillets
brake wheel, brake
lever
pawl wheel
pawl
barrel

The structure is as unique as it is simple. The tjasker consists of an oblong frame, whose front is the weather beam and whose back is the water bolster. The inside of the water bolster is fitted with a metal pot in which the pivot of the screw shaft (also called barrel beam or screw beam) rotates.
At the front, the screw shaft rests on the weather beam, rounded in-situ and fitted with iron fillets. The weather beam is equipped with neck and weather studs joined at the top by a wooden key. This framework holds the screw shaft in place. The sail cross projects through the square head of the screw shaft. Behind the weather beam, where the screw shaft is also square, is the brake wheel, fixed to the screw shaft. Around the brake wheel is the brake, which consists of an iron band. This band is attached to a simple hand-operated lever attached to the right side of the frame.
Nowadays, sitting behind the brake wheel is sometimes a pawl wheel that is also fixed to the screw shaft. Teeth are cut out in this wheel, which is about the same size as the brake wheel. A pawl attached to the left side of the frame prevents the mill from turning round the wrong way. Incidentally, this pawl is a feature found only on newly-built tjaskers. The three oldest existing tjaskers do not have a pawl. The barrel — a wooden framed screw or auger with two or three rings — is constructed at the back of the screw shaft that is rounded off there as well. The tjasker is an enclosed Archimedean screw. This barrel lies with its underside in the water, and as the mill turns, the auger (or screw) in the barrel draws the water up. What is special about this mill is that it does not require any gearing. One and the same shaft encompasses both the sail cross and the lifting apparatus.

Fig. 5.6.3.1
The post tjasker

1. *winding chain*
2. *tail beam, water bolster*
3. *barrel*
4. *screw shaft*
5. *pawl wheel*
6. *brake*
7. *weather beam*
8. *discharge spout*
9. *brace*
10. *central post with bearing block*
11. *inner ring ditch*
12. *frame*
13. *outer ring ditch*
14. *shoe*



5.6.3 The post tjasker

post tjasker
braces
post

The post tjasker, by far the most common, rests largely on a sturdy post driven into the ground and supported by four braces. The entire tjasker rotates around this post, which means that both the ditch from which pumping is done and the ditch into which the water is discharged must be circular. The outer (low) ring ditch is connected to the polder ditches and the inner (high) ring ditch is connected to the storage basin. Thus, a post tjasker pumps from the outside inwards. The inner ring ditch is almost always dry and is therefore also called a gutter.
On top of the post, a pivot is cut out over which the bearing block fits generously.

shoe

This is a thick block, in which a hole is drilled, that is attached under the frame. Most of the weight of the post tjasker rests on the post. Via the shoe, a small portion rests on the bank of the outer ring ditch (see Fig. 5.6.3.1). This shoe is a support attached to the frame under the barrel. The barrel and the water bolster are inserted into the water.
The post tjasker is winded by pulling a chain attached to the water bolster. In this way, the entire mill, winding on the post, is set to face the wind with its sail cross. A post tjasker is winded quite easily and is much less sensitive to the wind than is a trestle tjasker. Therefore, it does not need to be secured. The disadvantage is that when setting and removing the sails, often work must be done halfway above the ring ditch.

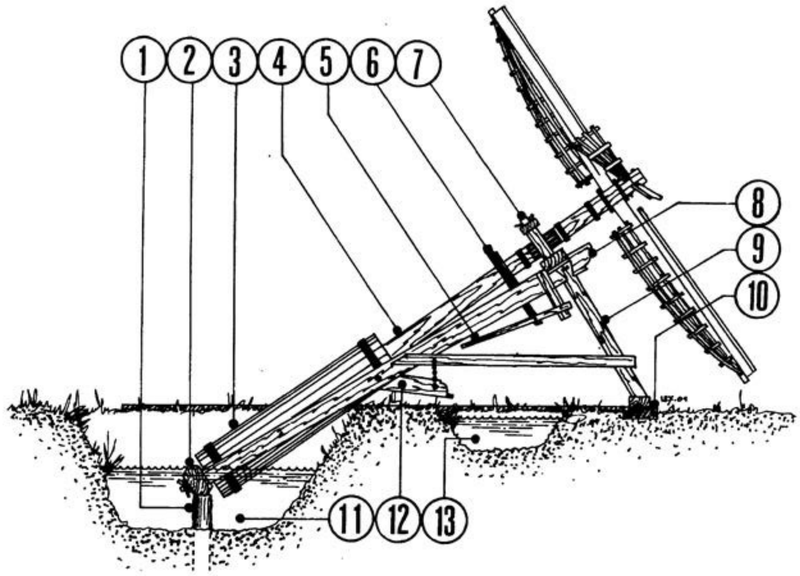


Fig. 5.6.4.1
The trestle tjasker

1. *post*
2. *water bolster*
3. *barrel*
4. *screw shaft*
5. *brake lever*
6. *brake*
7. *weather beam*
8. *frame*
9. *trestle*
10. *winding track*
11. *pond*
12. *discharge spout*
13. *outer ring ditch*

5.6.4 The trestle tjasker

trestle tjasker, trestle

The trestle tjasker rests with its front on the trestle, which is a wooden structure that is attached under the frame and the weather beam.
Because the sail cross is so far out from the pivot point, this mill likes to stand with its back into the wind. Placing wheels under the trestle, as is sometimes seen today, promotes that turning of the mill. If the mill comes off them while winding, it just stands backwards. The trestle should always be properly locked or secured. The back of the trestle tjasker rests underwater on a post driven into the grinding basin (see Fig. 5.6.4.1) and is fastened to it with what is known as a water bolster. The trestle tjasker is set facing the wind by driving or moving the mill around with the trestle over the winding track, using this post as the pivot point.

water bolster

winding track

A trestle tjasker pumps from the inside out. In order for tjaskers to do their job, special earthwork is necessary, which differs for both types.
The site drawings may clarify matters (see Fig. 5.6.3.2 and Fig. 5.6.4.2). The tjaskers can be constructed with sails as well as (half) wooden boards.

Fig. 5.6.3.2
Watercourses of the post tjasker

a. pumping out
b. pumping in
1. *outside water*
2. *gutter*
3. *outer ring ditch*
4. *inner ring ditch*
5. *post*
6. *inlet channel*
7. *polder water*

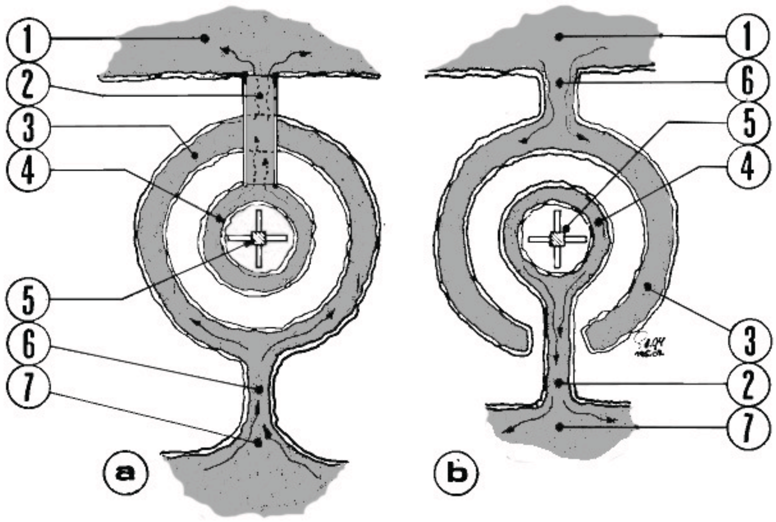
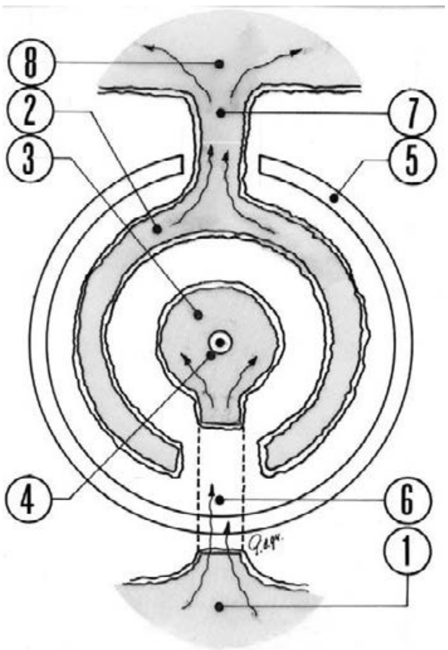


Fig. 5.6.4.2
Watercourses of the trestle tjasker

1. *polder water*
2. *outer ring ditch*
3. *pond*
4. *post*
5. *winding track*
6. *culvert*
7. *outside water*
8. *outside water (high)*



5.7 THE CAP WINDER

5.7.1 Introduction

directional cap

A cap winder is a stone or wooden mill whose cap can be rotated so that the sails can be turned to face the wind. All of the mills to be discussed below are of the cap winder type. Precisely where and when the directional cap was invented is unknown but in the Netherlands there is a representative of the medieval mills, the tower mill at Zeddam, that is more than 500 years old. This unique mill was built around 1450, proving that the directional cap — in other words, the cap winder — existed back then. From research in old archives, which mention even older tower mills that have since disappeared, it can now be assumed that the cap winder was invented in the second half of the 14th century. In 1382, Geervliet (in South Holland) already had a stone grain mill whose cap had rollers.

5.7.2 The tower mill

tower mill

A tower mill is a round stone mill the body of which is constructed vertically or nearly vertically, making it cylindrical. Presumably this type of mill was invented at a time of much conflict, when the burning and destruction of post mills was widespread. A tower mill is less flammable and easier to defend.
There are still four in the Netherlands, these being in Zeddam, Zevenaar, Lienden (Gelderland province) and in Gronsveld (Limburg province). The mills in Gronsveld and Lienden date from the 17th century but the other two are a little over 200 years older.

inside winder

All four of these tower mills were built as inside winders; however, the Gronsveld mill was fitted with tail winding in the 18th century.

cap floor

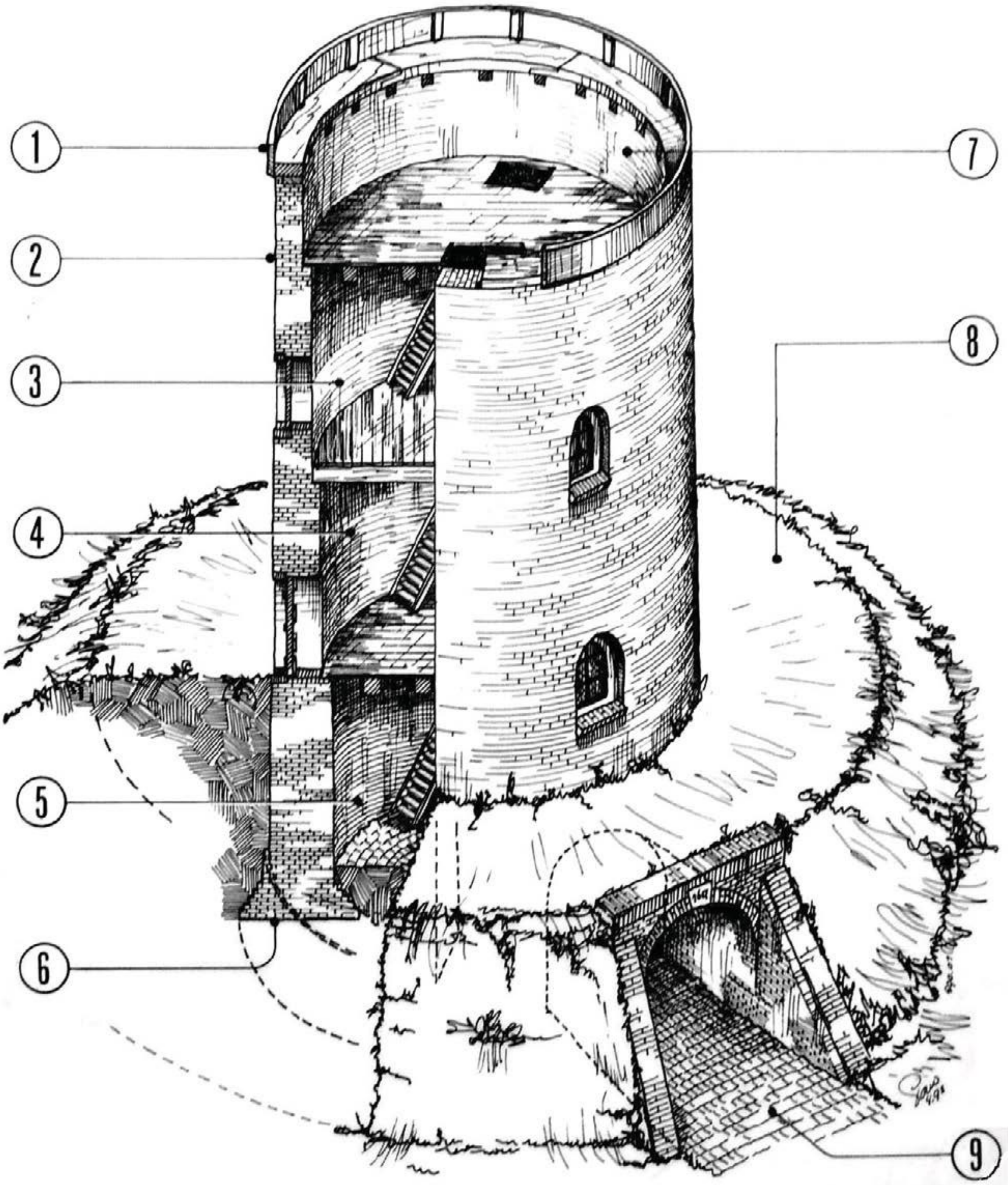
In a tower mill, the floor area of the ground floor is almost as large as that of the cap floor.

stone floor

The tower mill originally had only two storeys. The mill stones were on the cap floor which was thus also the stone floor; below it was the meal floor. As at the oldest post mills, there was only one pair of mill stones driven directly by the brake wheel (see Chapter 12.3). Since the stones are now not pivot mounted (so are not included in the winding), they had to be placed exactly in the middle. This system has disappeared from all the tower mills that are still in existence. Later, additional floors were set up and a main upright shaft was added. In the spacious cap, the winding gear was duplicated (see Chapter 5.8.2) so that the heavy cap could be winded with two persons.

Fig. 5.7.2.1
The tower mill (next page)

1. *curb railing*
2. *masonry*
3. *stone floor*
4. *meal floor*
5. *entrance*
6. *foundation*
7. *cap floor*
8. *mill mound*
9. *gate*



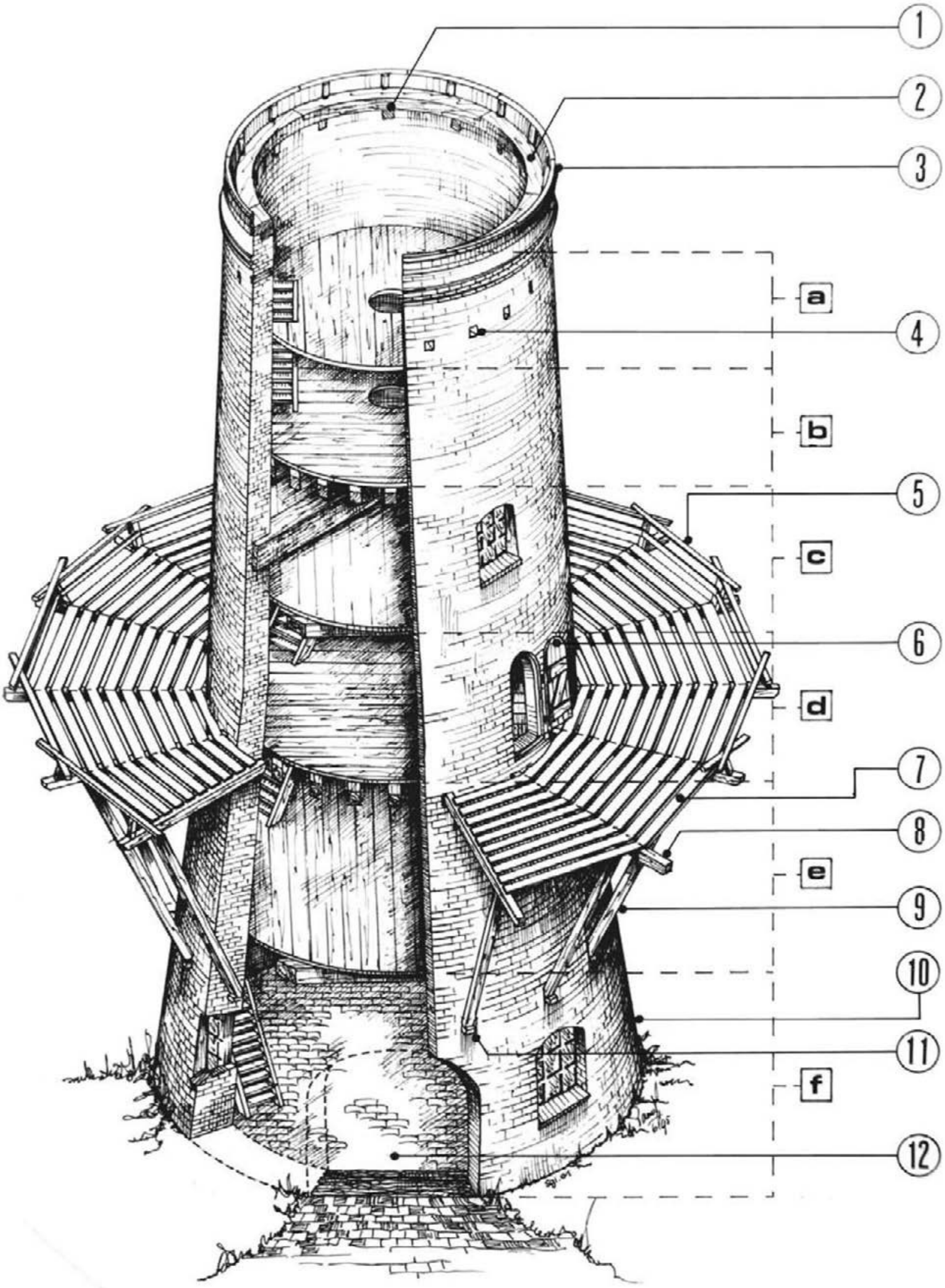

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Fig. 5.7.3.1
The round stone mill
(previous page)

a. cap floor
b. sack hoist floor
c. stone floor
d. meal floor
e. grain or grinding floor
f. entrance

1. bracket
2. winding track
3. curb railing
4. putlog-holes
5. stage railing or gallery railing
6. reefing stage door
7. stage
8. girder
9. brace
10. mill body
11. console
12. gate

5.7.3 The stone mill

round stone mill

The body of the round stone mill is shaped like a truncated cone; in other words, the circumference becomes ever smaller towards the top. It could have originated after the invention of the tail pole winding. The inside winding gear was discontinued so that the cap could be smaller. With the use of a main upright shaft and spur wheel, the pairs of grinding stones were placed lower, so this also allowed the upper part of the mill body to become smaller in size. This gave the round stone mill the shape of a truncated cone.

bell shape, bulge shape
bottle shape, octagonal stone mill
twelve-sided stone mill

The cone shape can be more or less exaggerated; in other words, the diameter can decrease a lot or very little toward the top. There are also stone mills with a bell, bulge or bottle shape (*Johanna Elisabeth* in Vlierden). Stone mills were also built as octagonal (*Keetmolen* in Ede) and as twelve-sided (*Lijkermolens* in Rijpwetering). In almost all cases, the masonry is executed in such a way that the stone layers slope outward. It was thought that this method of masonry building promoted rainwater run-off.

putlog-holes

Three-quarters of a metre below the top of the masonry there are often putlog-holes all around; these are rectangular holes in the body which are usually sealed with wooden blocks. During maintenance on the cap, these holes allow you to insert beams onto which scaffolding boards can be laid outside.

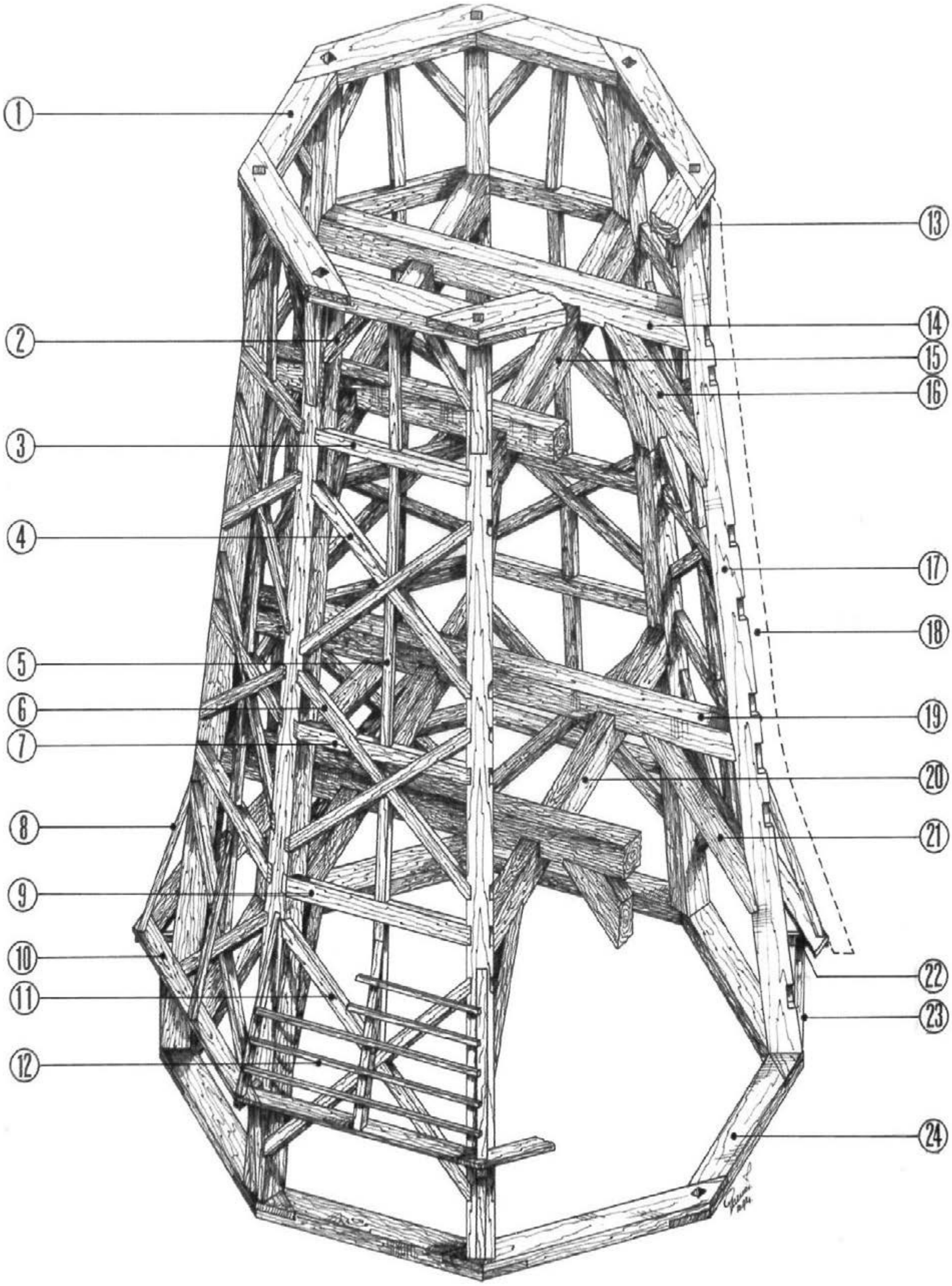
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Fig. 5.7.4.1
Structure of the octagon

1. *uppersill*
2. *'dog ear'*
3. *transom*
4. *cross bracing*
5. *stud post*
6. *cross bracing*
7. *transom*
8. *sprocketed eave*
9. *transom*
10. *thatch plank*
11. *cross bracing*
12. *thatch-lath*
13. *sprocket or thickener*
14. *separate binder or tie beam*
15. *fixed binder or tie beam*
16. *corbel*
17. *octagonal post, cant post*
18. *thatch*
19. *separate binder or tie beam*
20. *fixed binder or tie beam*
21. *corbel*
22. *bracket*
23. *stud*
24. *undersill*

5.7.4 The wooden octagon

octagon
undersill, sill pieces

The octagon has the shape of a regular octagon. The base is formed by the undersill which consists of eight wide plates, the sill pieces that are interconnected. There are also mills with no undersill. These can be found in North Holland, Friesland, the eastern part of the country, and elsewhere.

octagonal post, cant post
uppersill
keyhead

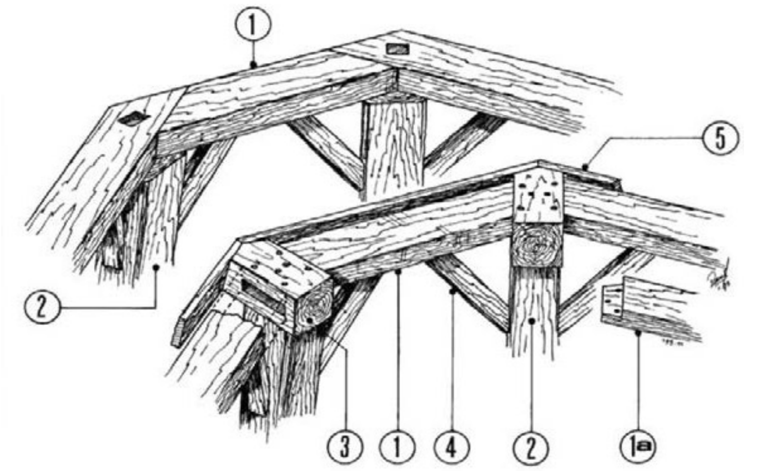
In the eight corners, the octagonal posts or cant posts are angled inwards and connected at the top by the uppersill. Especially in older octagons, each octagonal post features a keyhead, an intermediate block that forms part of the uppersill. These keyheads connect the posts to the uppersill pieces as well as these parts mutually.

Fig. 5.7.4.2
Examples of uppersills

1. *uppersill*

1a. *sill with keyhead*

2. *octagonal post*
3. *keyhead*
4. *'dog ear'*
5. *soffit board, thatch plank*



binders, fixed framing, loose framing, truss layer, tie beams

Between undersills and uppersills, the octagonal posts are connected by two or three layers of binders which together form the framing. The octagon consists of two fixed framing and two loos framing. Each truss layer consists of four framing beams laid in parallel pairs and which connect the opposing octagonal posts. At the intersections, the two lower, fixed binders are connected to the two upper, individual binders. Binders are also called tie beams.

floor board, corbel

On the individual binders are laid the floor boards, sometimes also supported by floor joists. In each corner, between an octagonal post and a binder, a corbel is inserted.

fixed panel, octagonal panel

The framework of heavy beams constructed so far is completed by filling in the eight sides. These are the planes between two adjacent octagonal posts. The sides between two parallel binders are called the fixed panels; the rest are called octagonal panel.

transoms, cross bracing, stud post

The octagonal posts are connected by two or more horizontal transoms and by cross bracing. The transoms as well as the cross bracing are often joined together by stud posts.

dog ears

Finally, in the corners between the octagonal posts and the uppersill, the dog ears are attached to support the uppersill.

sprocket, brackets, sprocketed eaves, thatch planks

The octagon has now gained enough rigidity to handle its task. On the outside of the octagonal posts, under the overhanging uppersill corners, the sprockets or firring pieces are attached. This gives the octagon, along with the brackets and the sprocketed eaves on top of them at the bottom of each octagonal post, its waisted shape. Wide parts called thatch planks were placed on or under the brackets for finishing. The entire structure is then clad all around.

5.7.4.a The North Holland octagon

piers, footings, columns, quarter walls,

The North Holland octagon rests on eight piers (footings, columns) with a pile foundation underneath. Between the piers, quarter walls are installed to below the undersill. The quarter walls have no load-bearing function and therefore barely any foundation.

footing wood, footing stone

On each pier is a footing wood or a footing stone on which the undersill rests. Starting at the undersill, thin wooden exterior wall planks (called weatherboarding in North Holland) are lapped onto the octagonal posts, ending at the bottom against the thatch planks.

water board

From the thatch planks, the thatch or weather boarding is laid over the sprocketed eaves and the octagonal posts up to the top. Here, the thatch or weather boarding just below the uppersill is covered by the water boards.
The styles of the North Holland octagon are straight; the mill is barely tapered. It looks much more substantial than its South Holland counterpart and makes a solid impression.
The doors are always located on the undersill.

5.7.4.b The South Holland octagon

The 18th and 19th-century octagons in South Holland and adjacent areas have an undersill that sits on an octagonal stone wall.

stone base

This wall has no reinforcements at the corners and is basically a stone base — with a surrounding foundation and often built on the outside with a slight inward slope — that is sometimes up to 200 cm in height.

curved octagonal posts

On top of the octagonal wall is the undersill topped by the curved octagonal posts, which may vary by region, without sprocketed eaves. The mill is also covered with a thick thatch on top of the thatch planks. Access doors are usually located in or below the undersill.

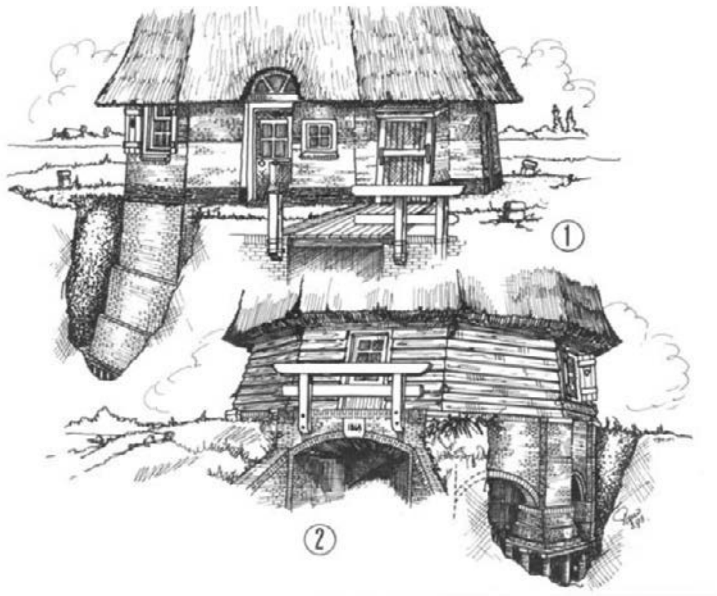


Fig. 5.7.4.3
Examples of quarter walls or siding

1. *South Holland base, with quarter walls*
2. *North Holland foundation with overlap weather boarding*

5.7.4.c The Frisian octagon

In the north, especially in Friesland, the pier system is used as it is in North Holland. There, piers (penanten) are called klippen.

brickwork supports

The quarter walls are bricked on the outside of the undersill up to the thatch planks such that the undersill rests on a rim cut out in the quarter walls. This is true of low quarter walls as well as the high masonry stone octagonal base (see Fig. 5.7.4.4).

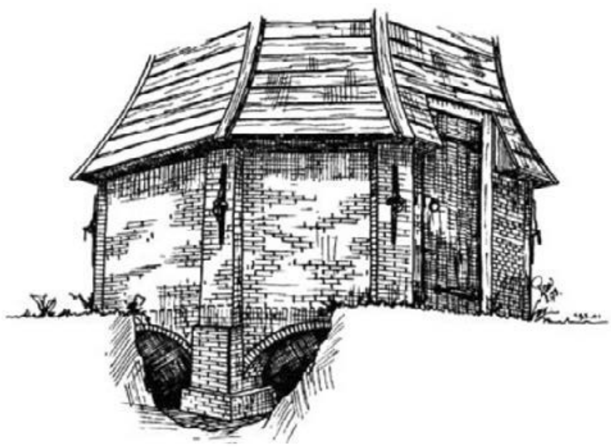


Fig. 5.7.4.4
Example of a Frisian base and quarter walls

small smock mill

Besides the larger octagon, the so-called small smock mill (mounts or monniksmolen) is especially seen in Friesland. This mill has a small octagon with a sail between 9 and 17 metres. The small smock mills are kept from blowing over by a pair of heavy boulders anchored by chain to two or more corner posts, which may or may not be buried.

5.7.4.d The octagonal wooden base

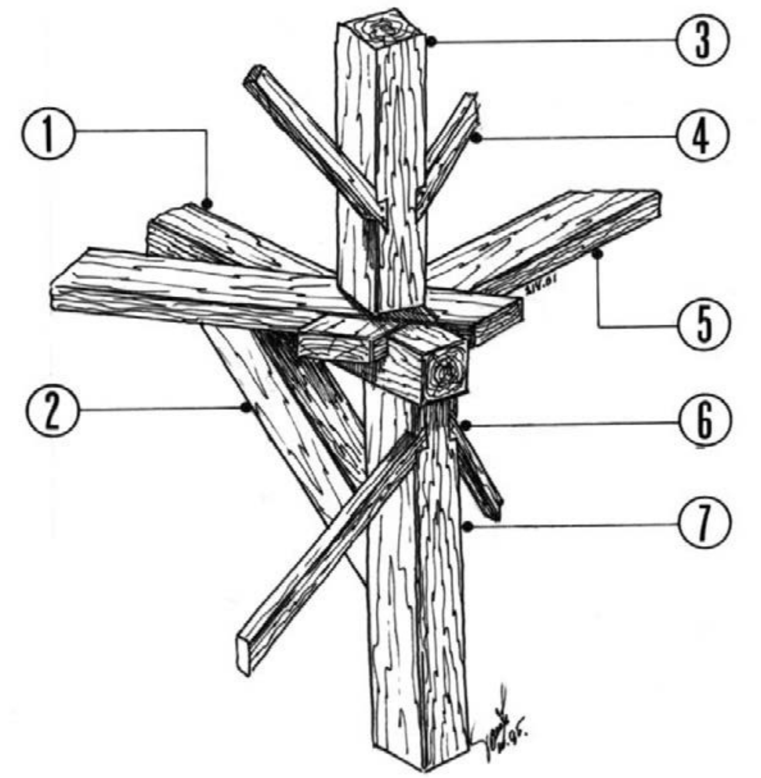


Fig. 5.7.4.5
Transition from an octagonal wooden base to the octagon

1. *binder*
2. *corbel*
3. *octagonal post*
4. *cross bracing, octagon*
5. *intermediate sill*
6. *cross bracing, octagonal base*
7. *post, octagonal base*

wooden octagon

To be assured of good wind capture, mills in towns and villages were built higher than in the countryside. Stone mills are simply raised to the desired height but wooden octagons are placed on a stone or wooden octagonal frame base or trestle.

intermediate sill
continuous octagonal posts

In the case of the stone octagonal base, the undersill is placed on a recessed rim in or on top of the wall. In wooden mills, the octagonal wooden base merges with the octagon via an intermediate sill (see Fig. 5.7.4.5).
Some mills have continuous octagonal posts, which are so long that an intermediate sill is not necessary.

5.7.4.e The hexagon

hexagons

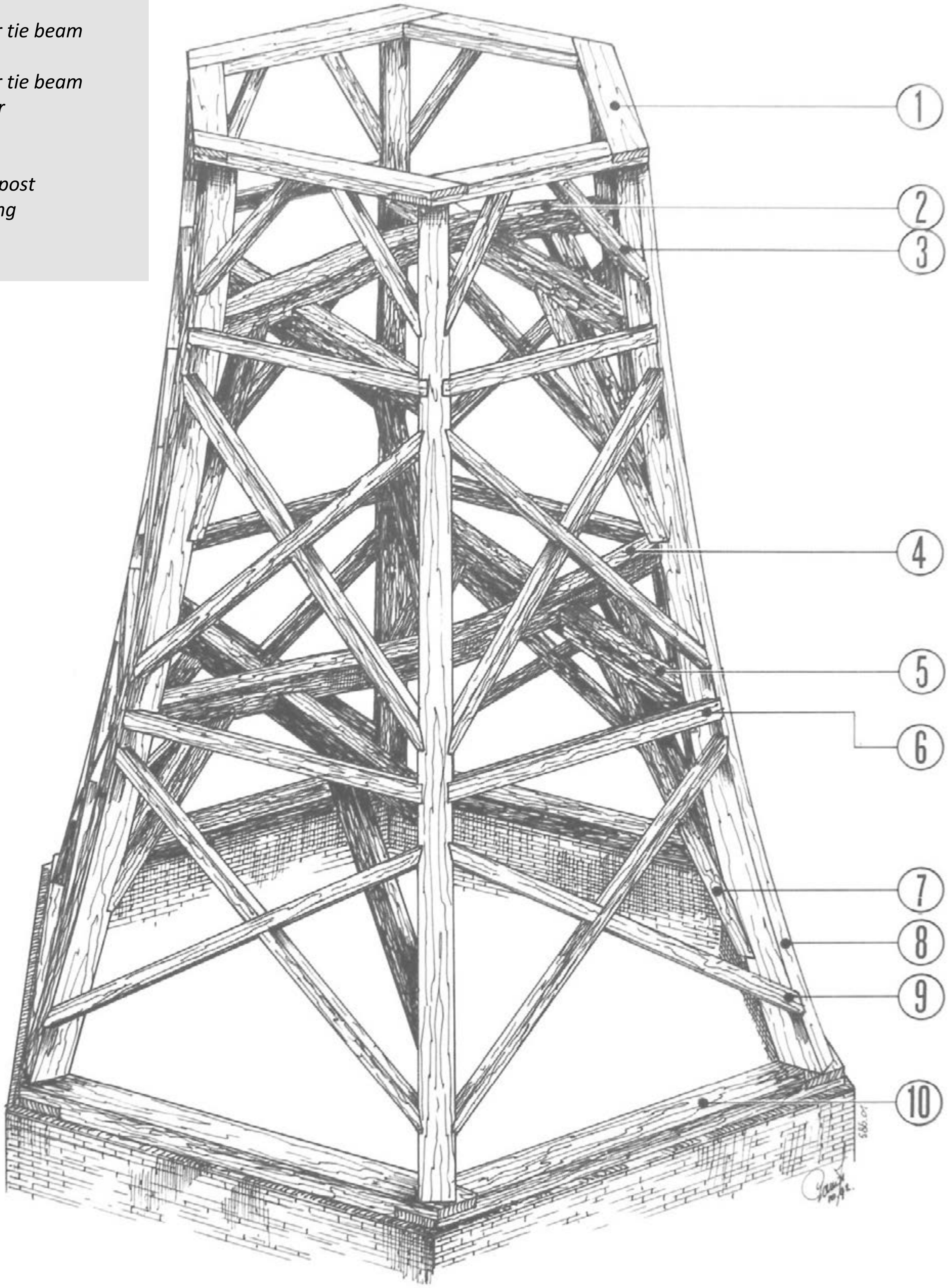
king truss

straddle beams

In comparison to the many octagons found in the Netherlands, the number of hexagons is rather modest; only eight remain in the Netherlands. Apparently, more confidence was placed in the octagon, which is not surprising. The hexagonal mill is simpler in structure and requires less material. Among other things, it saves two lower sill and uppersill pieces, two posts and two sides with transoms and cross bracing. However, the hexagon has less rigidity. It has only three trusses: two fixed trusses and one loose truss, the king truss. The truss layers consist of only three binders, specifically two parallel fixed and one separate binder, also called a tie beam.This construction has the disadvantage that it would have to run exactly through the centre of the mill, wherever the central spindle is located (see Fig. 5.7.4.6 and Fig. 5.7.4.7).
The oldest and best solution that still guarantees the most strength is simply to cut a beam from a crooked tree that bends around the central spindle. Another less robust solution is to interrupt the separate binder and to bridge the interruption with straddle beams (see Fig. 5.7.4.7). The hexagon may have evolved from the octagon for reasons of economy; it did not make its appearance until after 1650, especially in North Brabant and Gelderland. For practical reasons, some sawmills were also built as a six-sider (see Chapter 15.3.8).

Fig. 5.7.4.6
Structure of the hexagon

1. *uppersill*
2. *separate or tie beam*
3. *'dog ear'*
4. *separate or tie beam*
5. *fixed binder*
6. *transom*
7. *corbel*
8. *hexagonal post*
9. *cross bracing*
10. *undersill*



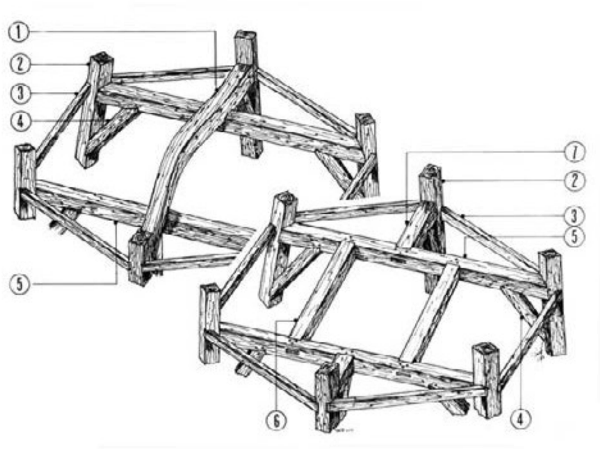


Fig. 5.7.4.7
Construction of the tie beams for a hexagonal mill

1. *tie beam*
2. *hexagonal post*
3. *transom*
4. *corbel*
5. *fixed binder*
6. *trimmer joist*
7. *short or half tie beam*

5.7.4.f The sixteen-sider

wooden sixteen-sider

The only wooden sixteen-sider in the Netherlands is in Horn (province of Limburg). It may have come from Germany. It is a mound mill with a round stone base that rises more than 1.5 metres above the mound. Entry to the mill is via stairs. Of particular note are the windows in the base.
On the stone base there are sixteen oak posts, eight made from a single piece and eight constructed from three pieces, which together support the round uppersill. This also serves as a winding track. Six rings of purlins, light alternating with heavy, are inserted between the posts. Corbels are fitted only in the corners, between the heavy purlins and the eight posts made from a single piece. The floors are supported by heavy purlins. The fourth and sixth rings consist not of sixteen, but of eight purlins. These always connect three adjacent posts, widening in the middle to the sixteen-sided shape. Mortises were cut in this widening to serve as connections for the interrupted sixteen-sider posts. These posts, purlins and corbels make up the entire bracing. This so-called side-bracing was apparently too weak a structure. Therefore, cross bracing was later added on the inside.

5.7.4.g The mill attached to a shed

square wooden base

Many industrial mills have sheds, built next to the mill or around the octagonal base. Sometimes the octagon stands on a heavy cubic wooden framework, the square wooden base. The upper connecting beams of this base have the function of an intermediate sill.
The mill's machinery stands within the square base (see Fig. 5.7.4.8).

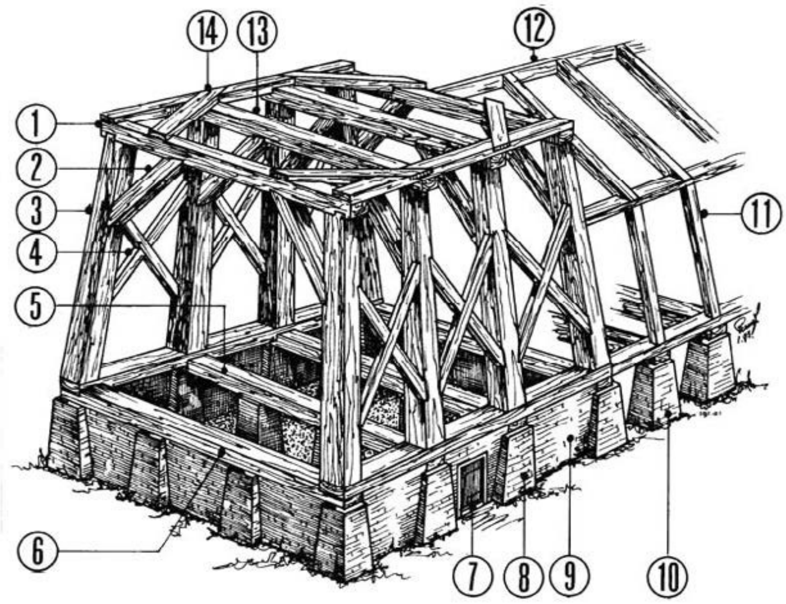


Fig. 5.7.4.8
Structure of a square base with shed

1. *fixed binder*
2. *corbel*
3. *corner post*
4. *cross bracing*
5. *floor joist*
6. *undersill or soleplate*
7. *stall door*
8. *pier or footing*
9. *stall wall*
10. *pier or footing*
11. *shed post*
12. *ridge-piece*
13. *binder*
14. *intermediate sill*

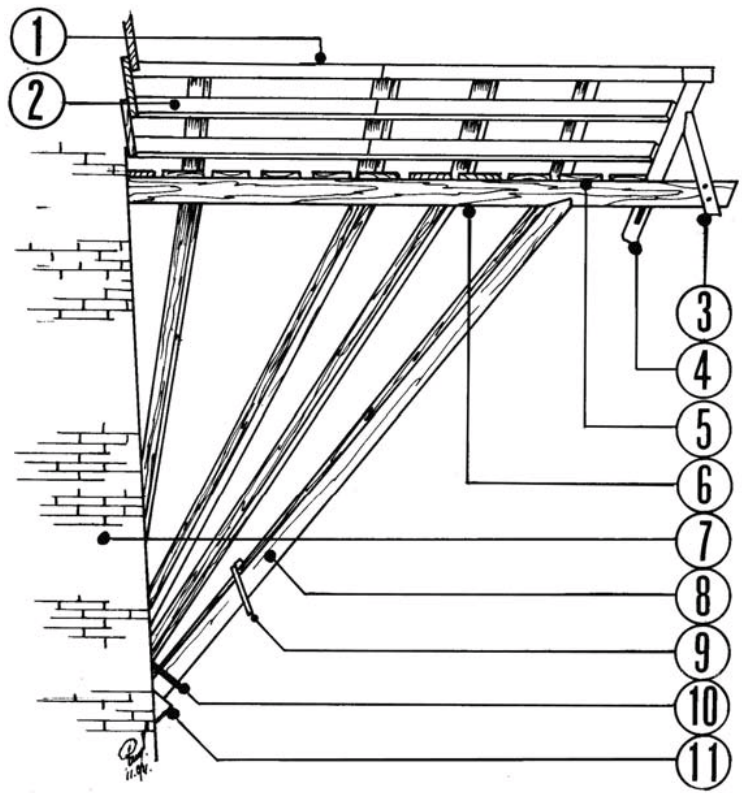


Fig. 5.7.5.1
Stage with a brace under each girder

1. *Gallery or stage railing*
2. *middle railing slat*
3. *small shore*
4. *gallery or railing post*
5. *stage plank*
6. *girder*
7. *stone mill body*
8. *brace*
9. *drip plate*
10. *wall anchor*
11. *console*

5.7.5 The stage

stage, gallery, balcony

Because a miller must be able to operate the sail cross, the winding gear and the brake rope while grinding, a stage (gallery, balcony) is built around a taller mill. The stage is usually octagonal, even on most round stone mills (see Fig. 5.7.5.1).
Some large round stone mills have a twelve-sided or even a sixteen-sided stage.

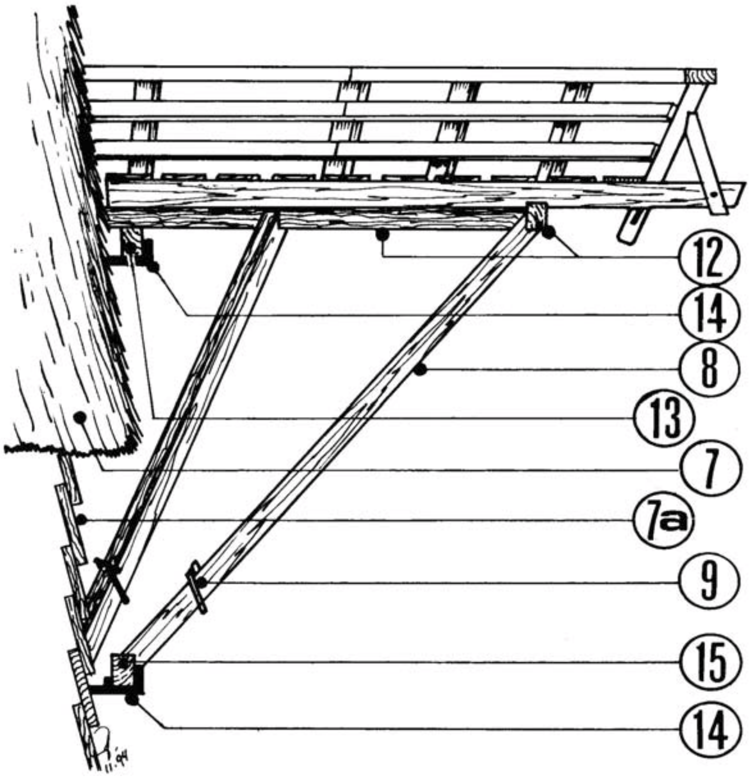


Fig. 5.7.5.2
Stage with lower, inner and outer ring of beams

7. thatched mill body
7a. overlap weather boarding
8. stage shore
9. drip plate
12. outer ring of beams
13. inner ring of beams
14. locking anchor
15. lower ring of purlins

inner ring of beams
girder
outer ring of beams

At the desired height, girders are inserted into the body. Sometimes they rest on a ring of beams placed around the mill, the inner ring of beams. The outer ends of the girders extend about 3.5 metres outside the mill and rest on a ring composed of beams, the outer ring of beams. These are supported by braces. Sometimes the outer ring of beams is missing; in that case, each girder has its own brace.

consoles

In stone mills or mills with a stone roundel, the braces find their support in the masonry or on consoles protruding from the body.

lower ring of purlins

At all wooden and some stone bases, the braces lean on a ring of beams applied around the body, the lower ring of purlins.
The number of braces may vary. In the northern part of the country, the stage is mainly supported only from the corners of the octagon via an outer ring of beams that is always present at these mills.

auxiliary braces, 'crow's foot'
drip plates

From the eight braces, the outer ring of beams is then further supported by auxiliary braces. A brace with two auxiliary braces is called a 'crow's foot' (see Fig. 5.7.5.3). The bottom of the braces are often fitted with drip plates to prevent rainwater seeping into the mill.

stage struts

Vertical braces are used with low stages and in the Zaan region. These are called stage struts.

planks
stage railing, gallery railing

The girders are covered with stage planks, which are nailed about 2 cm apart for rainwater drainage. A circumferential, usually outward sloping, stage or gallery railing is placed on the girders along the edge of the outer stage planks.

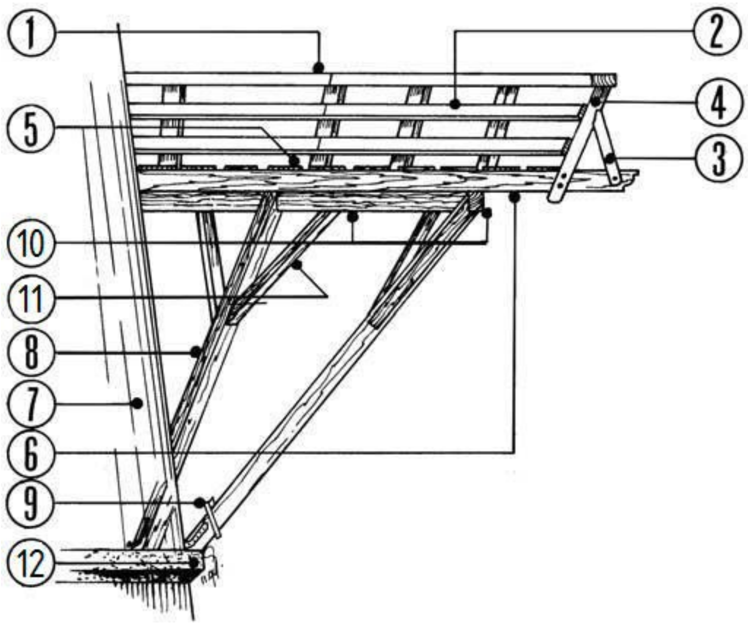


Fig. 5.7.5.3
Stage with crow's feet

1. *gallery or stage railing*
2. *middle railing slat*
3. *small shore*
4. *gallery or railing post*
5. *stage plank*
6. *girder*
7. *mill body*
8. *corner brace*
9. *drip plate*
10. *outer ring of beams*
11. *crow's foot*
12. *collar*

5.7.6 The cap

cap, cap winder

In all cap winders, the cap lies loose on the body and rotates 360° to all wind directions. This is done by means of the winding gear (see Fig. 5.7.6.1).

sheer beams
weather beam, support beam
long stretcher, sprattle beam, tail beam
short stretcher, rear beam

The base of the cap is the cap circle that forms part of the winding gear. The heaviest parts of the cap are the two sheer beams. On or between them from front to back there lie a number of crossbeams: the weather beam, the support beam, the long stretcher, the spindle beam or sprattle beam, the tail beam and the short stretcher (rear beam). Preferably the sheer beams were sawn from trees that had grown in a curved fashion in order to use that curvature to provide enough room for the brake wheel and the brake while still keeping the weather beam as short as possible.

support, upper cross beam, trimmer, outrigger beam

The heaviest beam, the weather beam, is anchored with dovetail joints and bolts on the front ends of the sheer beams. It is additionally supported by one support or, on some mills, two or three supports: upper cross beam, trimmer, outrigger beam. The weather beam is additionally secured with swan neck irons so that it cannot tilt outwards.

front gables
neck and weather studs

The front gables are on the weather beam, perpendicular to the slope of the windshaft. A gable consists of two angle-rafters, the neck and weather studs, and the gable beam on top of them. The neck stud is additionally braced or has been made heavier at the base to absorb lateral pressure from the rotating windshaft. The weather stud has traditionally been removable for the insertion and removal of a wooden windshaft or an iron shaft, complete with the filling pieces.

storm hatches, weather shutters

The whole structure is closed at the front with the two-corner studs on the outside and the two storm hatches or weather shutters. The latter are removable to enable work on the sail cross or the cap.

stone bed
knot-free board, bearing stone

In the middle of the weather beam is the stone bed, a stack of wedges and planks, the top one of which must be knot-free so that the bearing stone can set as evenly as possible. This is at the same angle as the windshaft. However, due to the wedge shape of the chair block and the pressure of the windshaft, the bearing stone wants to move forward. To counteract this, in front of the bearing stone and against the neck and weather studs is the neck bearing board, a thick wooden or metal plate, or an iron brace.

neck bearing board

support beam

The support beam connects the sheer beams by means of fixed timber joints. In the support beam, the rear end of the support is fixed so that it cannot move upwards.

The next beam is the long stretcher, which is anchored on the sheer beams, extends on either side well beyond the sheer beams and the cap, and is part of the tail structure. Because the long stretcher is sometimes on top of the support beam, the latter is often (but not always!) omitted. In this case, the long stretcher takes over the task of the support beam (see Fig. 5.7.6.2).

sprattle beam, spindle beam, top bearing

The sprattle beam or spindle beam is adjustable horizontally so that the top bearing of the central spindle can be brought into the centre of the cap. A space is cut out in the centre of the spindle beam for this top bearing, the top bearing or upper bearing. In certain regions of the country, especially in the north and in the Zaan region, the long stretcher goes through the centre of the cap. It is then called a centre beam. The spindle beam is often omitted in these cases. The upper bearing is then fitted in the long stretcher which, however, is not adjustable. Therefore, the adjustable iron beam is sometimes retained anyway and it can be seen hanging below the long stretcher between the sheer beams.

centre beam

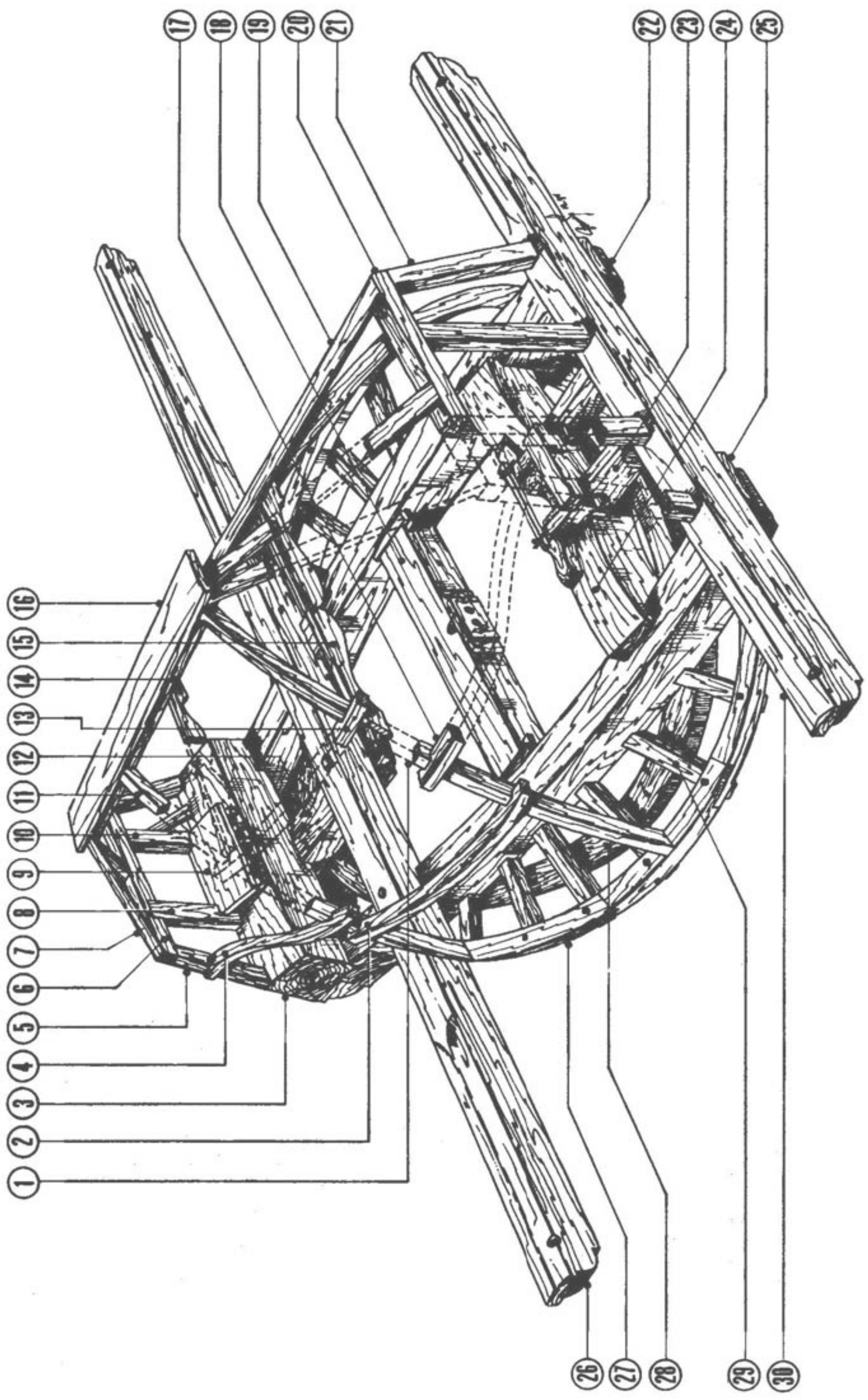


Fig. 5.7.6.1

Opbouw van een molenkap met een lange spruit (* geen lesstof)

1. *kapspant*
2. *gording*
3. *windpeluw*
4. *gording*
5. *hoek- of zwaardstijl*
6. *voorkeuvelensbalk*
7. * *wolfskeeper*
8. *weerstijl*
9. *steenbed*
10. *keerstijl*
11. *kapspant*
12. *steunder, of burgemeester*
13. *gording*
14. *vorst- of nokbalk*
15. * *hanebalk*
16. * *huig- of vorstplank*
17. *gording*
18. *bus- of ijzerbalk*
19. * *achterwolf*
20. *achterkeuvelensbalk*
21. * *hoekstijl*
22. *rechter voeghout*
23. *broekbalk*
24. *penbalk*
25. *linker voeghout*
26. *lange spruit*
27. *spantring*
28. *overring*
29. *roosterhout*
30. *korte spruit*

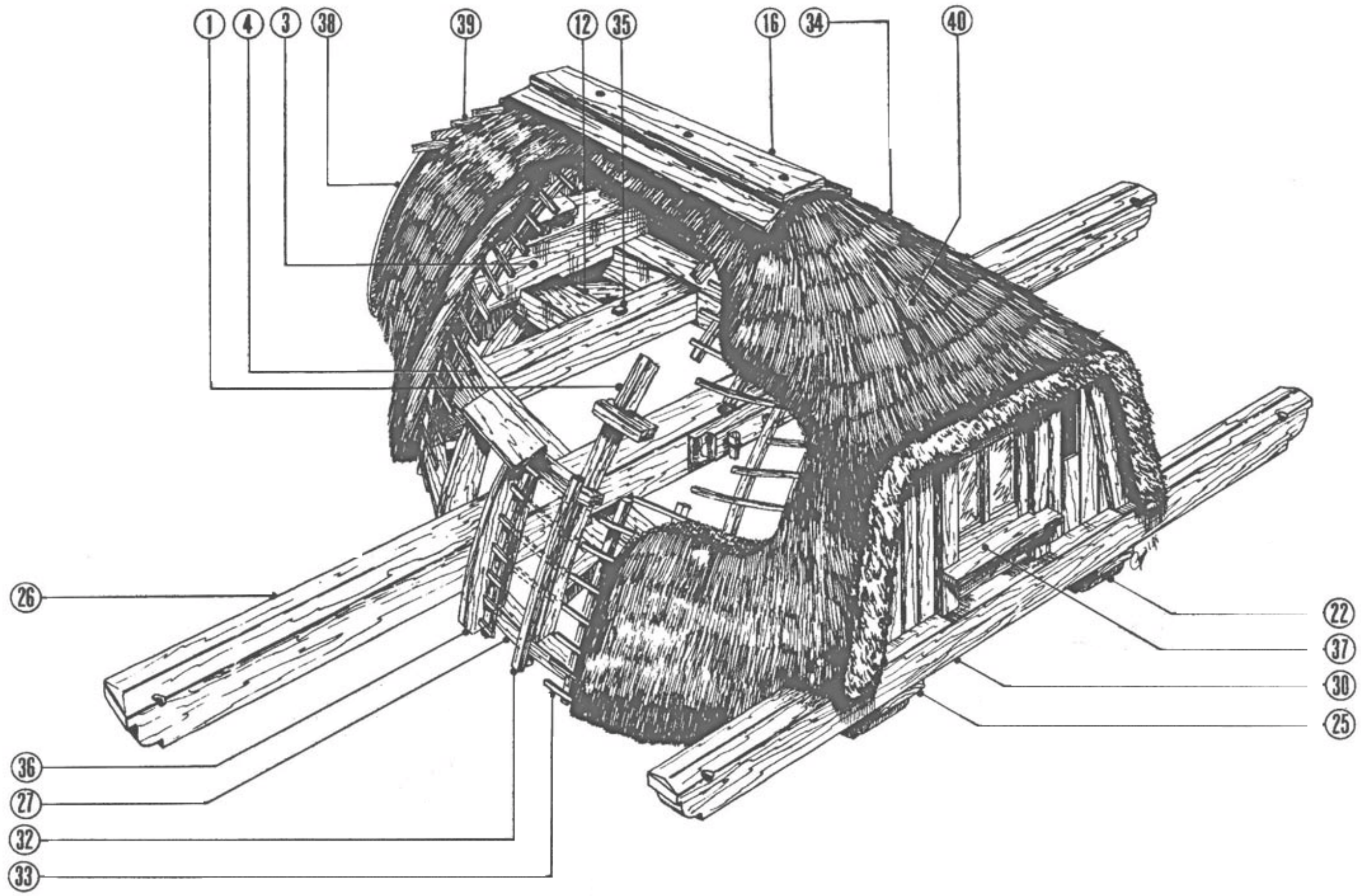


Fig. 5.7.6.2

Opbouw van een molenkap met een lange spruit of middenbalk

1.	*spant*	16.	*huig- of vorstplanken*	27.	*spantring*	34.	*rietdek*	38.	*zwaardplank*
3.	*windpeluw*	22.	*rechter voeghout*	30.	*korte spruit*	35.	*steunderbalk*	39.	*stormschild*
4.	*gording*	25.	*linker voeghout*	32.	*rietspoor*	36.	*spruitluik*	40.	*wolfsdak*
12.	*steunder*	26.	*lange spruit of middenbalk*	33.	*rinkellat*	37.	*achterkeuvelens*		

tail beam
tail brass

The tail beam is also adjustable and lies on and between the sheer beams. In the centre lies the tail brass in which the rear end of the windshaft rotates. The tail beam is usually recessed into the sheer beams at the same angle as the windshaft and is often curved downwards. The pillow block not only carries the tail bearing, it also absorbs the pressure that the wind exerts on the sail cross.

tail bearing
thrust pad
short stretcher or rear beam

Another support, the thrust pad, is often installed between the tail beam and the short stretcher. This transfers some of the wind pressure on the tail beam to the short stretcher or rear beam.

The final connection between the sheer beams is the short stretcher or rear beam. This is located on the rear ends of the sheer beams. Like the long stretcher, it is part of the tail but it is half as long as the long stretcher and thus does not extend as far beyond the sheer beams and cap. The name rear beam is used for the inside winders. This beam does not protrude outside the cap.

rear gables
rear gable beam

The rear gables, which are usually fitted with cross-windows and/or hatches, are positioned vertically on the short stretcher. The rear gable beam forms the upper end of the rear gables.

tail pole
capstan wheel
winding wheel, winch
long brace,
short braces

In the middle of the short stretcher, the tail pole hangs down at a backward angle. The tail consists of the tail pole just mentioned, with the capstan wheel or winding wheel at the bottom, as well as the winding reel or the winch, the two long braces between the long stretcher and the tail pole, and the two short braces between the short stretcher and the tail pole (see Chapter 5.8.4).

cap circle, curb railing
strengthening piece

The cap as described so far lies with the sheer beams and support(s) on the cap circle which has a diameter that falls well within the curb railing.The cap circle forms the base of the cap. Its function is to distribute the large weight of the cap and transfer it to the winding gear (see Chapter 5.9.2). Between the sheer beams and the curb there are sometimes strengthening pieces at the front, which raise the curb at the front by about 10 cm. These may have been installed to prevent the cap from leaning forward if winding causes the cap circle to wear harder above the weather beam than at the rear.

puncheons, stretchers, outriggers
spar ring
cap spars, cap-ribs, thatch-laths
hip end, ridge pole or ridge-piece,
purlins

Puncheons (stretchers, outriggers) are fitted to the curb and these are worked into the sheer beams using pegs that have their inner end pointing toward the centre of the curb. The spar ring lies on the outer ends of the puncheons and carries both the cap spars (cap-ribs) and the thatch-laths or thatch layers. The hip end, the hipped-gable roof, the roof ridge or ridge-piece and the purlins, which connect the front and rear gables to the rafters, give the roof its often beautiful shape.

thatch rails
thatch-laths
beard

This completes the framework of the cap. Finally, the thatch-laths are nailed in a wavy pattern over the thatch rails. When the cap is covered with wood, the thatch rails and thatch-laths are omitted.

Below the weather beam is the sometimes beautifully carved beard, which normally shows the year of construction and the name of the mill. The beard protects the part of the winding gear under the weather beam from the effects of weather. The four sheer heads, the head of the support(s) and the puncheons are often finished off with an ogee.

In the south of the Netherlands, in many cases the beard lies entirely in front of the sheer heads, protecting them as well.

5.8 THE DIRECTIONAL CAP

5.8.1 Introduction

In connection with the ever-changing direction from which the wind blows, mills are built so that the cap and sail cross can be turned to face the wind. This turning of the cap is called winding. At most mills, this can be done outside. However, there are also some types of mills where this is done from the inside.

5.8.2 The stone inside winder

inside winder, cap winder

An inside winder is a cap winder where the mill is turned, from the cap, to face the wind. The first inside winders in the Netherlands were stone tower mills. The tower mill of Zeddam from 1450 and the one at Zevenaar from before 1565, both still in existence, were equipped with indoor winding mechanisms when built. This had to be the case because tail pole winding did not exist in the 14^{th} and 15^{th} centuries. That method arrived only in the second half of the 16^{th} century. According to the current state of archival research, we can assume that inside winding is about 200 years older than the external winding. In both the tower mill of Zeddam and the outer mill of Zevenaar, the winding mechanisms are doubled-up (see Fig. 5.8.2.1).

twin winding gears

The caps of the mills are so large and heavy (Zeddam is 8.55 metres in diameter and Zevenaar is 7.30 metres) that winding is hard work for one person despite the gearing on a cog ring on the masonry. There is not enough room for two people to operate one large winding wheel in front of the brake wheel. What's more, the cap could buckle or jam against the curb railing. With two winding mechanisms in the cap located to the left and right of the sheer beams between the puncheons, the load during winding is evenly distributed across the entire cap. One drawback is that two people are needed to wind, but that would not have been an issue in those days.

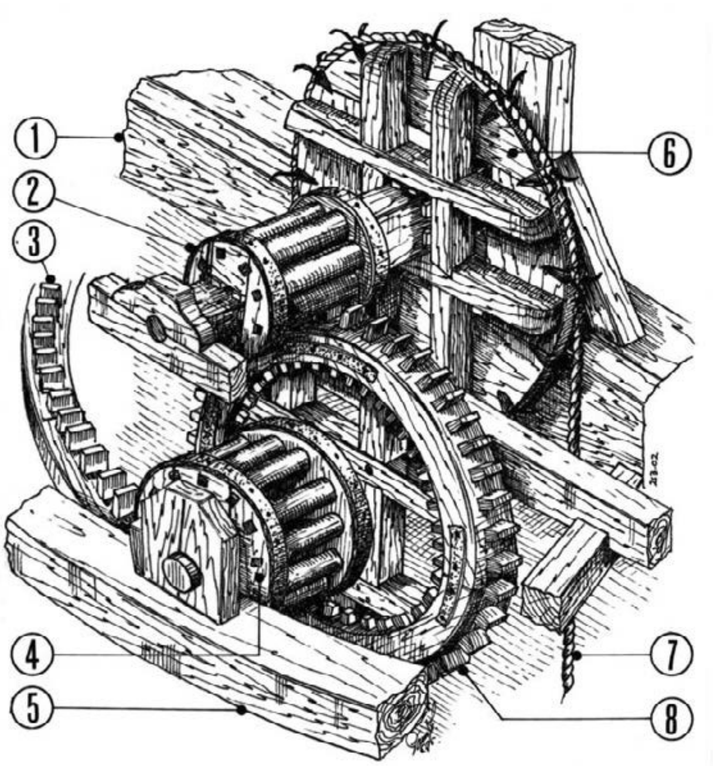


Fig. 5.8.2.1
Example of a winding gear as used in a tower mill

1. *shear beam*
2. *lantern pinion*
3. *cog ring*
4. *2nd lantern pinion*
5. *curb*
6. *Y wheel*
7. *winding rope*
8. *barrel wheel*

endless hand rope, winding rope
Y wheel, lantern pinion
cog wheel
cog ring

The winding is done by means of an endless hand rope or winding rope in a Y wheel that drives, via a small lantern pinion, a large cog wheel attached to a lower bearing shaft. A second lantern pinion on this shaft engages the cogs of the wooden cog ring that lies on wooden brackets within the wall of the mill. So all of this is duplicated. Today this winding mechanism is only found in the mills at Zeddam and Zevenaar (see Fig. 5.8.2.1). These oldest constructions are much more complicated than the 'simple' inside winding gear of a wooden octagon frame described below.

single inside winding mechanism

The third tower mill with inside winding gear, in Lienden, is from a much later date (1644). The walls of the mill are slightly tapered (and therefore it is not actually a tower mill) so the diameter of the cap is smaller (6.60 metres) than the tower mills described above. The mill at Lienden has a single inside winding gear of much the same construction as found in the wooden octagons.
The fourth and last tower mill in the Netherlands, in Gronsveld (Limburg province) also used to have an inside winding gear. It was replaced in the 18th century by the current outside winding gear.

5.8.3 The wooden inside winder

Wooden octagonal inside winders are found almost exclusively in the province of North Holland. Over 60 of these large octagons are still standing there. The only internal winder outside North Holland is the Hondsdijkse Mill in Koudekerk aan den Rijn. Also, here and there in the Netherlands, octagonal structures that originally had an internal winder but were set up as external winders after relocation can still be found. With their spacious caps (about 6 metres in diameter), which they need to accommodate the winding mechanism, they form an impressive sight in the landscape. In all octagonal internal winders, the winding mechanism hangs between the sheer beams just behind the weather beam. It is positioned as far as possible from the centre of the cap in order to exert more force. On most internal winders, a second beam was laid in addition to the regular support beam. They are spaced about 40 cm apart between the sheer beams. These are the windlass frame beams. The support gets its assistance from the outermost windlass frame beam, sometimes from both.

windlass frame beams

hanger

The hangers that are securely braced on both sides hang beneath the windlass frame beams, where they are fitted using a mortise and tenon joint (see Fig. 5.8.3.1).

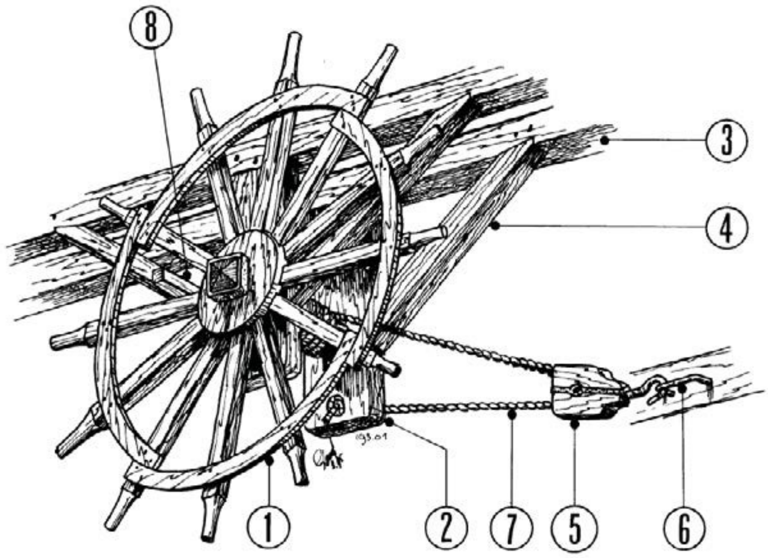


Fig. 5.8.3.1
Winding gear of an internal winder

1. *capstan wheel*
2. *hanger*
3. *windlass frame beam*
4. *brace*
5. *pulley block*
6. *winding hook*
7. *winding rope*
8. *pawl*

barrel, bollard, winch drum

These hangers, hanging straight behind each other, are both fitted with an eye into which the barrel (bollard, winch drum) of the capstan wheel is inserted. Behind the hanger at the capstan wheel, an iron pin protrudes through the barrel, preventing it from spinning out of the hangers during winding.

capstan wheel

The capstan wheel contains 10-14 spokes and is reinforced at the handles with a number of wooden felloes that are usually nailed side by side on the spokes — not in line but overlapping instead, which is stronger. Some of the internal winders have a slightly different construction.

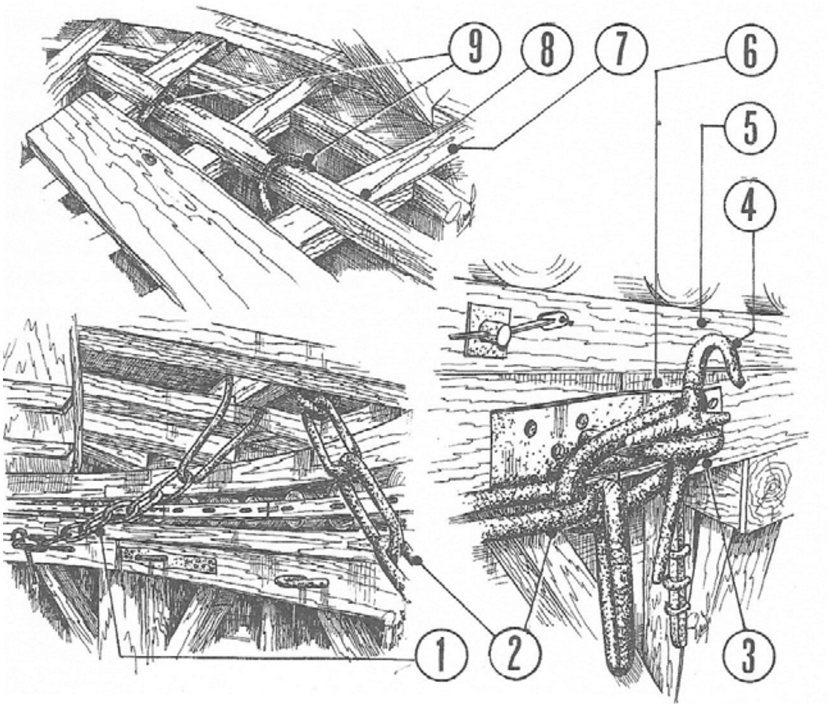


Fig. 5.8.3.2
Anchor chain and dead chain

1. *anchor chain*
2. *dead chain*
3. *winding hook*
4. *fixing iron*
5. *winding track*
6. *uppersill*
7. *puncheon*
8. *chain beam*
9. *anchor chain and dead chain*

winding rope *pulley block* *winding hook*

Winding is done with the winding rope, which is attached with the fixed end at the bottom of the outer hanger — in other words, as far as possible from the centre of the cap. The other end of the winding rope runs via the pulley block to the barrel. The pulley block hangs using a hook in a winding hook of which 16 are hammered in the uppersill: two per sill piece. Without the use of the pulley block, operating the capstan wheel would be very difficult. The distance from the winding rope to the centre of the cap is less than half of the same distance for an external winder. Therefore, more than twice the winding force is needed to set the cap in motion (see also Chapter 5.8.4). Using a pulley block doubles the power applied by the miller.

anchor chain, dead chain *fixing iron* *pawl*

Each internal winder has an anchor chain and a dead chain. These hang from a beam attached on the puncheons, parallel to the left sheer beam. Each link in both chains is so large that it fits over a winding hook and can be secured with a cross-shaped iron, the fixing iron. When the miller has turned the sail cross to face the wind, he or she secures the cap against rocking back and forth by means of the anchor chain and the winding rope. The miller then secures the capstan wheel with a pawl.

The winding rope, which is subject to heavy wear, is the weakest link in this process and is therefore always to the right (as viewed from the centre of the cap). When grinding, the cap wants to wind veering (clockwise). But despite this precaution, the winding rope does sometimes break. In such a case, the cap could jerk to the left due to the sudden loosening. This now is prevented by the dead chain which, together with the winding rope, is slid to become more tight or less tight by one of the links over a conveniently located winding hook and secured with a fixing iron.

5.8.4 The external winder

After the second half of the 16th century, many cap winders were fitted with a tail that could subsequently be used to wind below, from outside the mill. In fact, this was a modification of the winding as it had been used for centuries at post mills and later at hollow post mills.
Tail pole winding quickly gained popularity, especially at the South Holland octagonal polder mills, many of which were built in the late 16th and early 17th centuries.

external winding gear

While the external winding gear was more expensive in material and maintenance than the internal winding gear, a mill with external winding gear could be built with a smaller cap and a narrower octagon. This saved on material costs and also reduced the wind obstruction caused by the mill body. But the main reason for the introduction of the tail, of course, was that the miller could now perform all operations at ground level and no longer had to go upstairs to wind.
The octagonal polder mills of North Holland have remained faithful to internal winding up to today.

tail pole, long braces
short braces

The tail of a cap winder consists of the tail pole, two long braces to the long stretcher and two short braces to the short stretcher (see Fig. 5.8.4.1). The tail pole hangs down at a backward angle with a notch and a heavy bolt on the short stretcher. The lower end is usually thicker because it contains the hole for the bollard or barrel. In addition, the lower end of the tail pole is subjected to the heaviest load during winding and grinding.
The long braces lie with a notch on the ends of the long stretcher and are secured to it with a wedge bolt. Likewise, the short braces on the short stretcher.

copings, caps

Rectangular boards, the copings or caps, are nailed to the tops of the braces. They prevent water from penetrating the top ends of the braces and causing the joint with the long stretcher to rot too quickly.
Both the short and long braces support with a notch in, or butt against, the tail pole and are clamped to it with through bolts.

hangers

Roughly in the middle, the long braces hang with chains or rods — the hangers — from the short stretcher to counter sagging.
Sometimes the short braces and the tail beam are connected by an additional beam, the strutting. This is mainly seen in South Holland, especially in the flat lands in river areas. Here, the long braces hang from the strutting. Since the lower end of the tail pole is subjected to the most stress during winding, the long braces are placed close to the winding hole. As a result, the compressive and tensile forces are transmitted directly to the long stretcher. For the most part, winding takes place via the long braces and the long stretcher. Here, the distance in the horizontal plane between the winding chain and the centre point of the cap is important. The greater that distance, the greater the winding moment.

strutting

winding chain

If the tail of a mill hangs further from the mill body, then the capstan wheel hangs further from the pivot point. This makes winding lighter but further distance has to be travelled.
The short braces and short stretcher transfer less winding power. Their function is mainly as reinforcement of the tail structure. The short braces prevent the tail from bending laterally during winding.

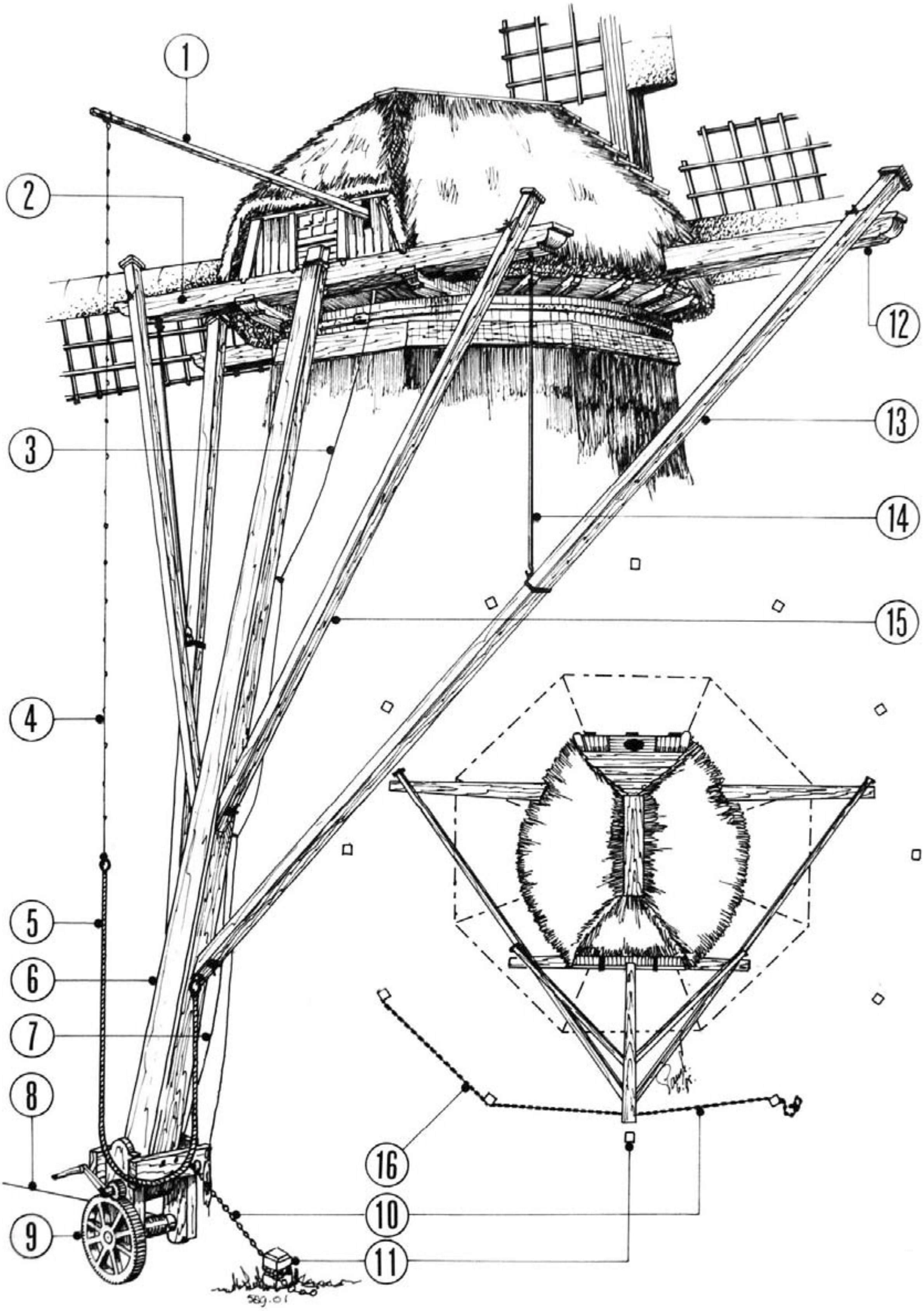

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Fig. 5.8.4.1 (previous page)
External winding gear

1. *brake handle or fang staff*
2. *short stretcher*
3. *release rope*
4. *brake chain*
5. *brake rope*
6. *tail pole*
7. *pawl rope*
8. *winding wire*
9. *geared hand winch*
10. *anchor chain*
11. *winding bollard*
12. *long stretcher*
13. *long brace*
14. *hanger*
15. *short brace*
16. *winding chain*

5.8.5 Capstan wheel, winding wheel, winding reel, windlass

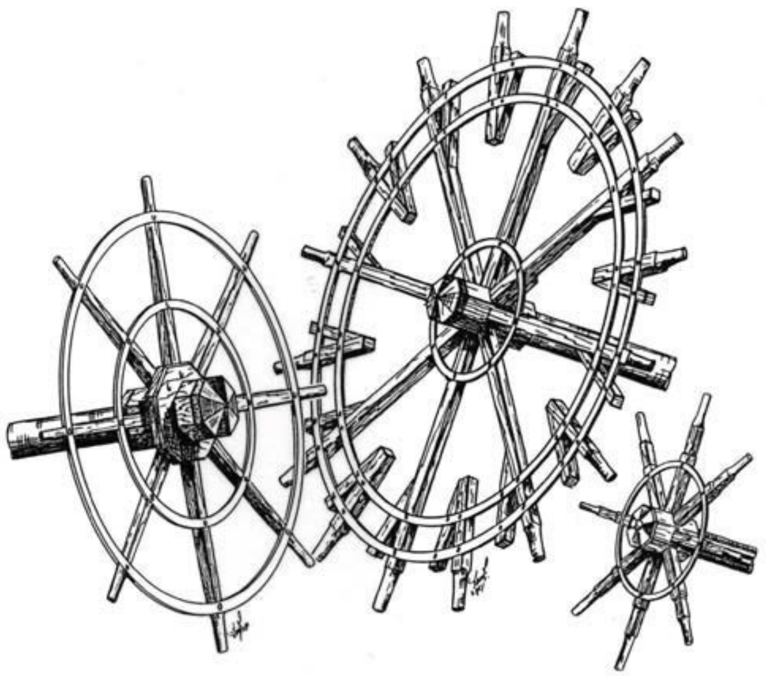


Fig. 5.8.5.1
Some examples of winding wheels and a winding reel

winding wheel, capstan wheel, winding reel, windlass, barrel

stay plates

winding chain, winding wire

The winding wheel, the capstan wheel, the winding reel and the windlass have a barrel, or winch drum that, when viewed from the horizontal plane, is inserted into the tail beam at an angle. The hole in the tail beam is sometimes protected by a metal bushing as well as stay plates at the front and back. Due to the angled position, the barrel will automatically slide inwards during the unrolling of the winding chain or winding wire. During winding, the barrel slowly slides outwards again.

fillets
spokes,
collar

The wooden barrel is fitted with steel fillets against excessive wear. A number of spokes are placed around the head of the barrel and, as a rule, are additionally secured with a wooden or metal collar for reinforcement.
The larger the wheel, the more spokes. For example, the capstan wheel of *De Wachter* at Zuidlaren has a record number of 32 spokes! Two continuous spokes were inserted crosswise through the head of the barrel, scarfed into each other and secured at the rear with a cotter-pin.
Further reinforcement of the capstan wheel is obtained by adding one or more metal rings, the felloes.

felloe
grips, winding reel

The outer felloe on a winding wheel or capstan wheel is secured along the grips so that the miller can walk into the wheel. With a winding reel, the felloe is located about halfway between the spokes and 'walking winding' is not possible.

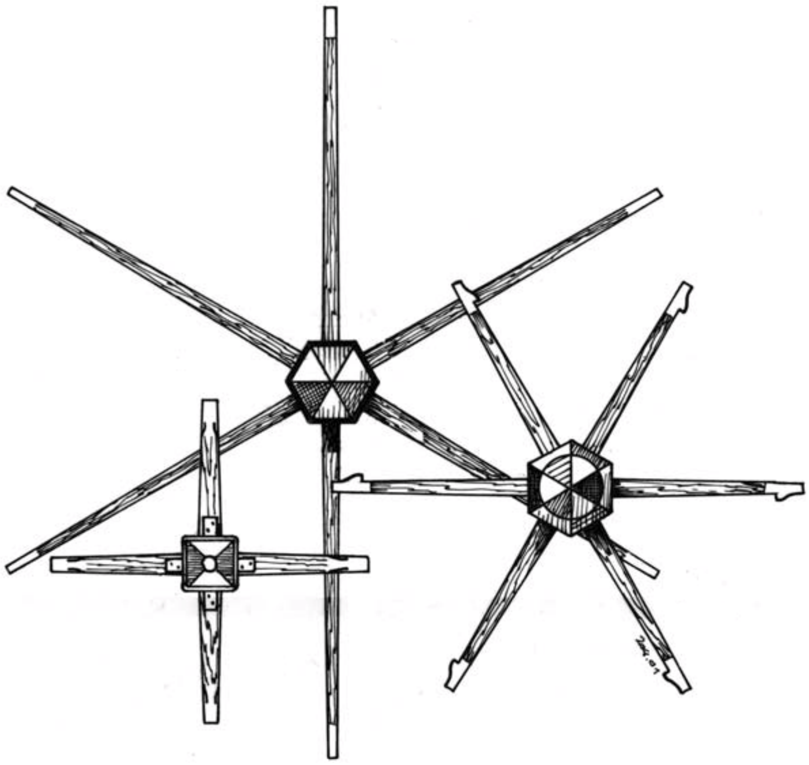


Fig. 5.8.5.2
Three examples of a winding reel

Furthermore, a winding reel generally has fewer spokes than a capstan wheel, usually six. The simplest form of a winding reel has only two continuous spokes which, moreover, are not scarfed in but inserted back-to-back through the barrel. This version is also called a windlass. Thus, the spokes here are not in one plane.

windlass

On many large mills, the winding is so heavy that the miller often uses their feet to turn the wheel round. To facilitate this footwork, many South Holland mills have a winding platform.

winding platform

This is a small wooden platform, suspended at the bottom of the tail or attached at the level of the barrel, on which the miller can operate the capstan wheel with their hands and/or feet. Other millers walk in the capstan wheel. To facilitate this walking, walking blocks are installed between the spokes and the outer felloe. Because the capstan wheel is angled, it is relatively easy to walk upright, without leaning back, in the capstan wheel.

walking blocks

5.8.6 Geared hand winches

geared hand winch
winding horse
crank
winding drum

The arrival of the geared hand winch or winding horse made winding easier. Using cast iron gearwheels, the transmission could be made smaller. The ironwork of the geared hand winch basically consists of a shaft, on which one or two cranks can be placed, with a small gearwheel engaging a large gearwheel that is fixed to a second shaft with the winding drum.

The small gearwheel (of 10 or 12 teeth) is often mounted on the crankshaft so that it can slide. This allows the winding drum to be released so as to reposition the (steel) *winding wire, winding chain*

winding wire or chain. As a result, the chain unwinds in a very light manner. Sometimes there is a twofold reduction in speed so that there is a choice between fast and heavy winding or slow and light winding.
A pawl on one of the shafts secures the winch and thus the tail. The geared hand winch has many versions throughout the Netherlands and is attached to the tail beam in many ways, but always horizontally.

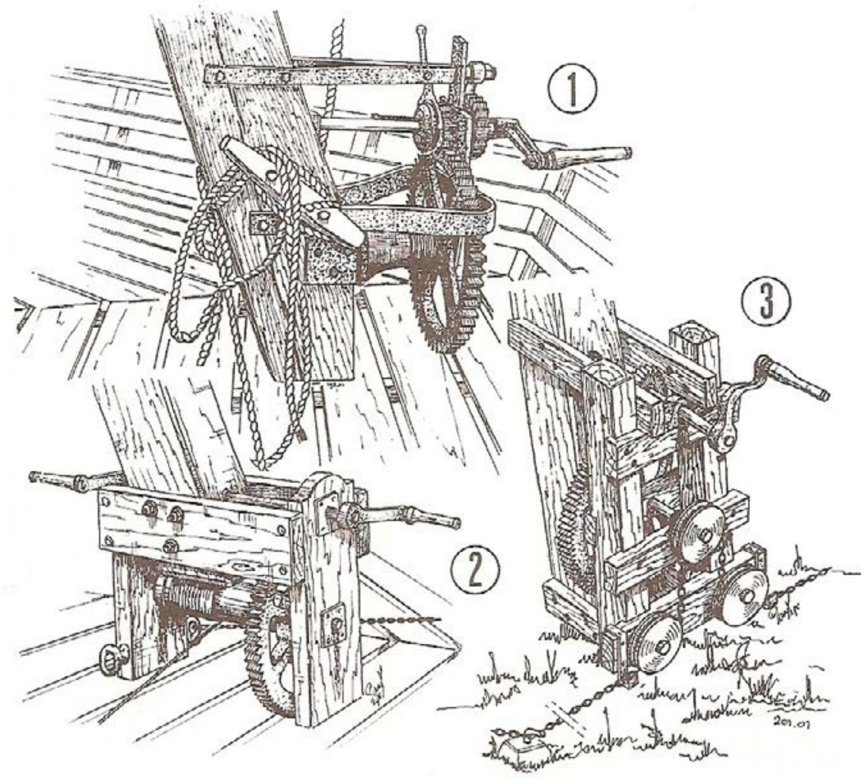


Fig. 5.8.6.1
Examples of geared hand winches

1. *all-metal winch*
2. *wooden winding horse*
3. *winch with continuous chain*

encircling chain

On some mills there is a so-called encircling chain around the mill that is held in place by iron pins or hooks protruding above the ground or stage. The chain runs around the shaft of the winch via two guide rollers, and only the crank needs to be turned for winding. Repositioning the anchor chain and winding chain is therefore a thing of the past. Even simpler is to replace the crank with an electric motor, as is found at some mills. The miller then only has to press a button to wind.

5.8.7 The self-winder

self-winder

fantail

There is also one mill in the Netherlands, namely *De Sterrenberg* (The Star Mountain) in Nijeveen (in the province of Drenthe), that uses self-winding. This is a mill of German origin that was rebuilt in Nijeveen in 1977. In Germany, self-winding is still widely used. A self-winder has no tail but it is an outside winder. A fantail turns on the back of the mill cap, perpendicular to the sail cross.

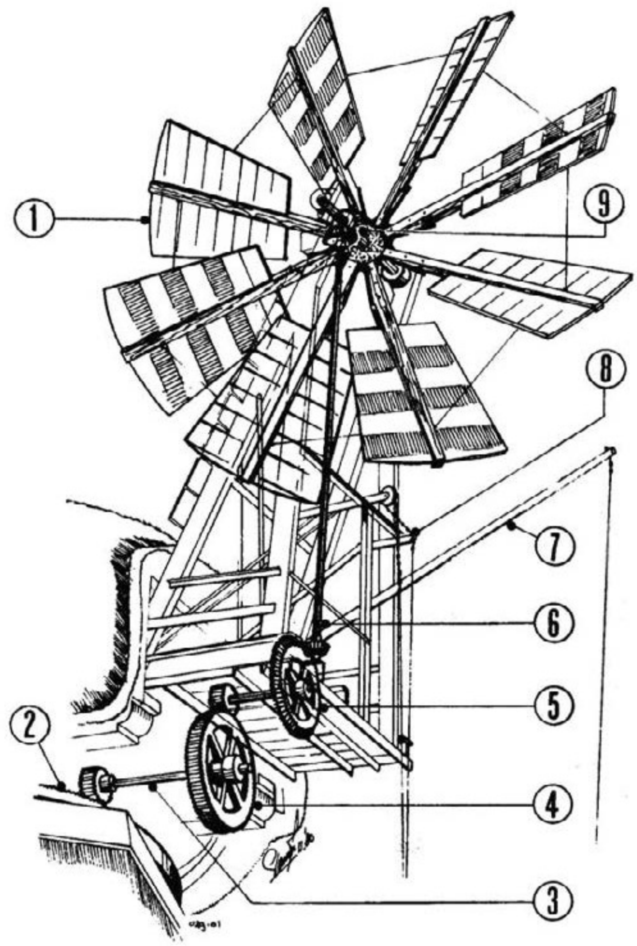


Fig. 5.8.7.1
Circular sail for a self-winder

1. *fantail*
2. *rack*
3. *bollard*
4. *winding wheel*
5. *layshaft*
6. *vertical shaft*
7. *fang staff*
8. *shutter pole*
9. *drive for the winding gear installation*

If the sail cross is exactly facing the wind, then the wind blows equally strong along both sides of the fantail and it is therefore stationary. But as soon as the wind veers or backs, the fantail is set in motion.
Via a series of speed reductions, this motion is transmitted to a cog ring, which is located around the winding track. Thus, the mill automatically winds itself with the direction of the wind. To ensure smooth operation, all the ironwork of the winding mechanism must be kept well greased.

5.8.8 The wheel-and-chain winding gear

wheel-and-chain winding gear

A winding system that bears some resemblance to the fantail is the wheel-and-chain winding gear. However, this system is not self-winding because there is no fantail. Instead, the winding wheel located at the rear of the cap is designed as a Y wheel. A circulating chain is attached around this Y wheel. By pulling on this chain, a cog ring around the winding track winds the cap. This type of winding gear was no longer found in the Netherlands, but it was reinstalled during the restoration of the Kilsdonkse Mill in Dinther.

5.9 WINDING GEAR

5.9.1 Introduction

Although there were or still are windmills in many places around the world that cannot wind, there is no evidence that this also occurred in the Netherlands. The first windmills in Western Europe were post mills. The winding gear as used on mills in the Netherlands has already been briefly indicated in Chapter 4.5.3.

They are conveniently listed below.

We can divide the winding gear into two groups:

A. Live curb:
- wooden and cast-iron live curb, shot curb;
- paltrok winding gear.

B. Sliding or friction winding gear:
- collar winding gear;
- dead curb winding system;
- the dead curb with cap sliding on sheers.

On cap winders, the following is found:
- wooden or cast-iron live curb;
- shot curb;
- dead curb with skids winding system;
- the dead curb with cap sliding on sheers.

On post mills, hollow post mills and spider mills there is exclusively:
- collar winding gears.

On paltroks:
- winding gear of the paltrok.

5.9.2 Winding gears on cap winders

5.9.2.a The winding track

winding track

The winding track consists of a number of round sawn wooden pieces joined by scarfing to form an accurately circular ring. The top of the winding track of a live curb is not purely horizontal but slopes slightly outward because the wooden or iron rollers that rotate on it are conical in shape. When sliding winding gear is used, the winding track is horizontal. In wooden octagonal frames, the winding track is attached to the uppersill. With stone mills, the winding track rests on the masonry and is anchored to it by means of brackets inserted between the top row of stones, the roller layer. Other anchoring structures for the winding track are also seen.

brackets

To counter excessive wear and impressions caused by the great weight of the cap, a ring of sheet iron, from 6 to 12 mm thick, was subsequently installed on the winding track of many mills.

5.9.2.b The curb railing

curb railing, keep flange

The curb railing or keep flange is a wooden ring that is constructed of a number of pieces and which is firmly secured against the outside of the winding track. To make the parts of the curb railing into a cohesive whole, often an iron clamping band, the flange hoop, is firmly tightened around the curb railing. The curb railing serves to hold the cap in place. During winding, the cap wants to overwind — that is, slide sideways off the winding track. In addition, the cap experiences backward pressure caused by the wind on the sail cross while milling. These unwanted movements are countered by the curb railing. Hence, the name keep flange.

flange hoop

overwinding

The curb railing is secured around the winding track with long cotter bolts, called the curb bolts, which go diagonally down and across the winding track and the uppersill. At stone mills with no uppersill, the curb bolts pass horizontally through the winding track.

curb bolts

To reduce friction between the curb and the inside of the curb railing, vertically spaced hardwood carters, curb carters, are fitted in the curb railing at regular intervals.

curb carters

truckles

At some old mills, truckles in the curb railing or the disused recesses for them, instead of carters, can still be found.

At mills with wooden or cast-iron live curb and at mills with a dead curb with skids winding system, the curb railing is necessary.

At mills with a shot curb and in the case of the paltrok, the curb railing can be done without (see Chapter 5.9.2.e).

In the case of a dead curb with cap sliding on sheers, there is not even room for a curb railing (see Chapter 5.9.2.g).

5.9.2.c The cap circle

The curb is the base of the cap and forms part of it. It is constructed similarly to the winding track but heavier since it has less support. The inner circumference is equal to that of the winding track. The outer circumference is several inches smaller than the inner circumference of the curb railing, such that the curb fits within the curb carters.

During winding, the outer circumference of the curb slides across a number of curb carters.
Like the winding track, the curb is also chamfered outward and upward when a live curb is used because of the cone shape of the rollers. Also, many curbs have a complete or partial ring of sheet iron under the track because of the wear that occurs.
The cap circle of a dead curb with skids winding system is horizontal at the bottom. At mills with a dead curb with cap sliding on sheers, the cap circle is absent.

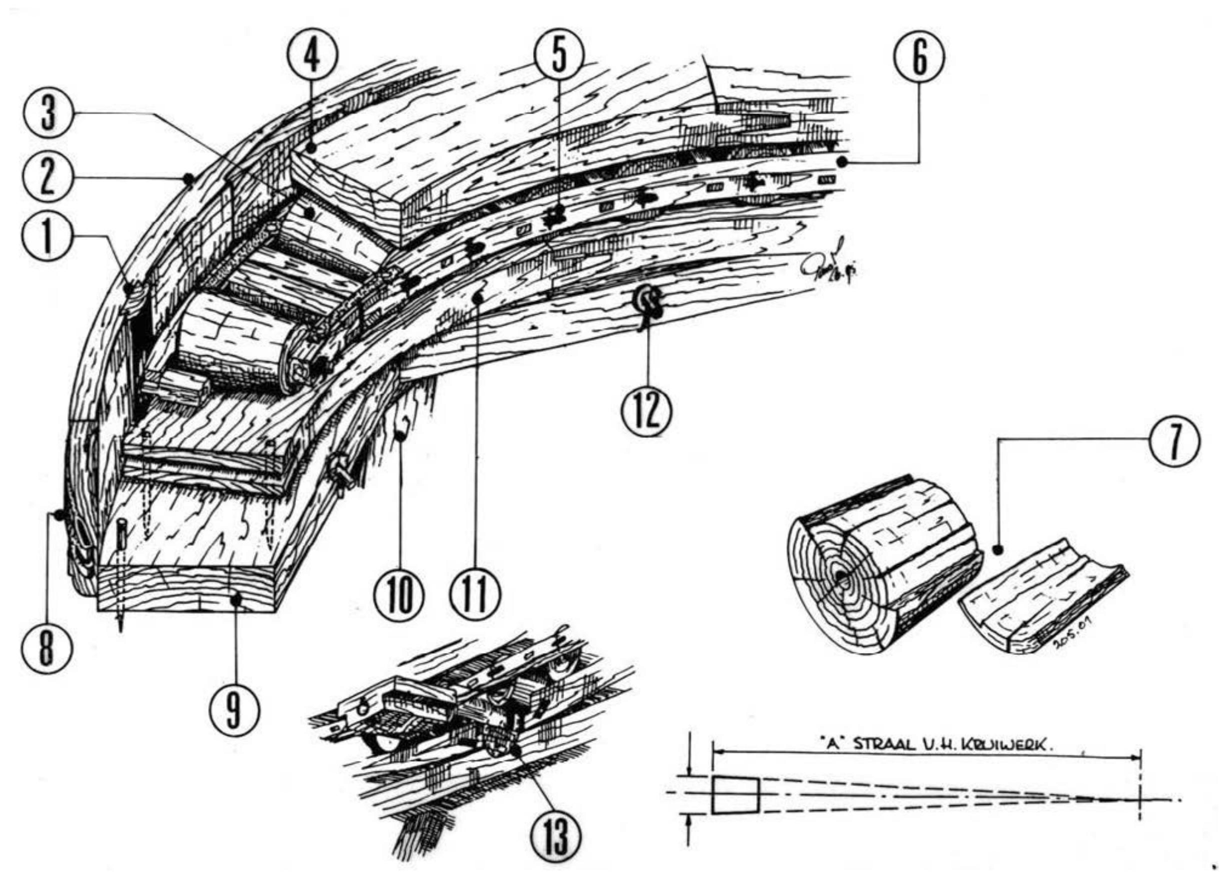


Fig. 5.9.2.1
Example of a live curb

1. *curb carter*
2. *curb railing*
3. *winding roller*
4. *cap circle*
5. *roller shaft*
6. *roller wagon*
7. *snapped roller*
8. *flange hoop*
9. *uppersill*
10. *octagonal post*
11. *winding track*
12. *curb bolt*
13. *roll compartment*

5.9.2.d Wooden or cast-iron live curb

live curb

The weight of the cap presents a heavy burden for the rollers of a live curb. Especially when they pass under the weather beam. The wood species that can tolerate this best is elm wood. Even so, the rollers regularly break.
In the second half of 19th century, (stronger) cast-iron rollers began to be used. The rollers are slightly conical because they must travel a circular path. Therefore, as mentioned above, the winding track and cap circle slope outward so that the rollers carry their load over the full length.

cap roller, roller wagons
roller-ring

The cap rollers are encased in a number of roller wagons that make up the roller-ring. The roller wagonscap rollers consist of an inner and outer rim, separated by spacers. The rollers are mounted, equally spaced, between the rims by means of removable shafts. To minimize rubbing against the outer rim, the rollers are rounded off on-site or fitted with spacer rings.
The number of rollers depends on the size of the cap and ranges from about 20 in small mills to 40-54 in large mills and 55-65 in North Holland inside winders.

roller compartment

It must be possible to replace a broken winding roller. To allow for that, the winding track has a removable part called the roller compartment. On the spot, the uppersill is semi-circularly hollowed out. Another method of replacement is a square hole in the curb at the level of the tail beam, through which the roller can be taken out.

Winding gears with wooden or cast-iron rollers should be lubricated at the following locations (see also Chapter 7.5):
- the outside of the roller wagonscap rollers;
- the outside of the cap circle;
- the top ends of the rollers.

Lubricating the rollers' axles is less important; they should not rust.

5.9.2.e The shot curb

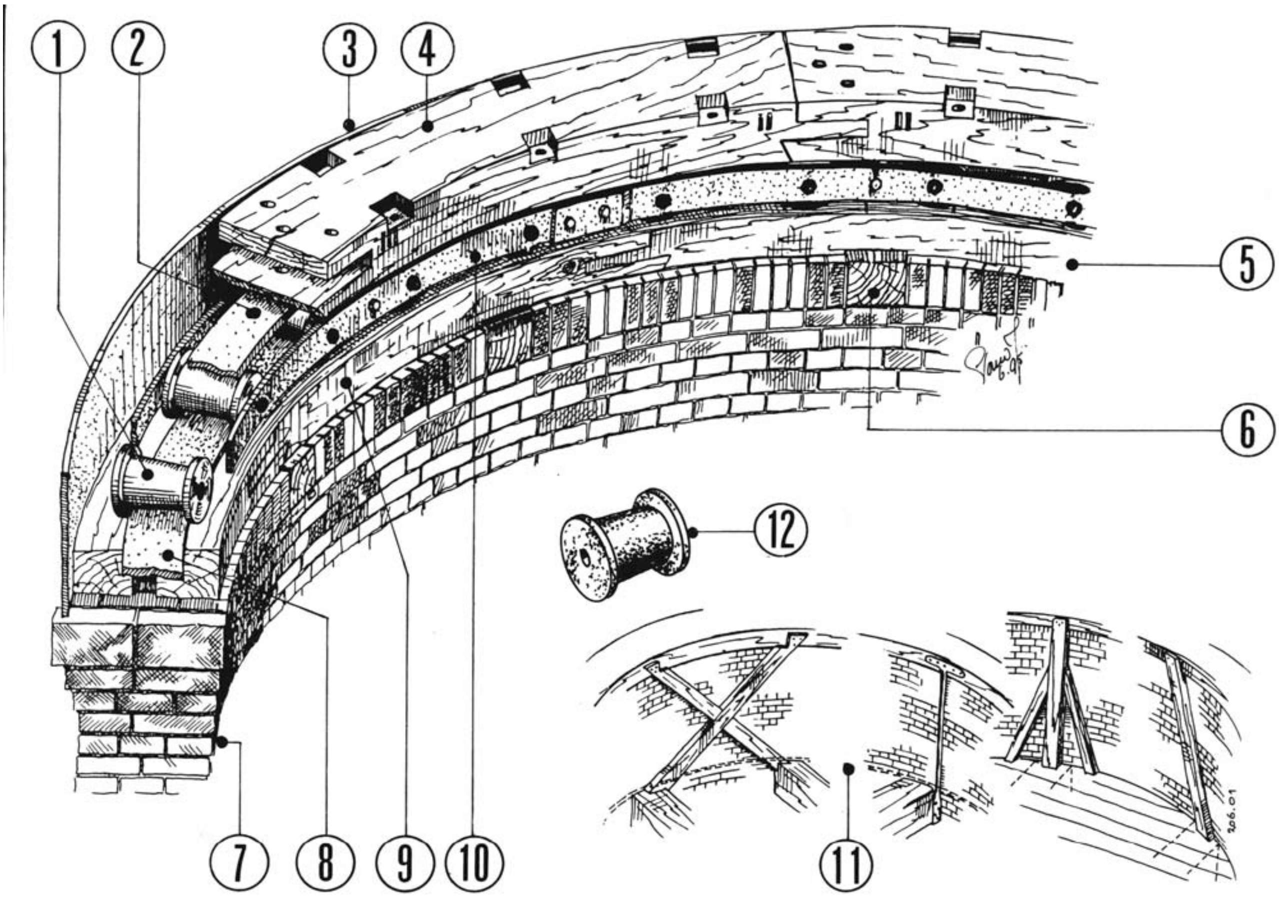


Fig. 5.9.2.2
Shot curb

1. *winding roller*
2. *top rail*
3. *curb railing*
4. *cap circle*
5. *winding track*
6. *bracket*
7. *masonry*
8. *bottom rail*
9. *winding track*
10. *roller-ring*
11. *various versions of winding track fixings*
12. *winding roller*

shot curb
iron rail

In the case of a shot curb, both the winding track and the underside of the curb have an iron rail about 10 cm wide and 2.5 cm thick. Between these rails run relatively small iron or cast-iron rollers that are also so short that they need not necessarily be tapered, although this does occur. These rollers cause virtually no torsion during winding. They are fitted on either side with flanges that are 2 cm wide and run along both sides of the rails, preventing the cap from being overwound. The curb railing can therefore be done away with, although it is maintained for sealing purposes. Sometimes a curb railing of sheet iron is sufficient. The rollers are supported between two iron rings that are spaced with tension bolts and bushings.
A shot curb runs very lightly and requires little maintenance. One drawback is that the cap easily rattles back and forth during milling. This puts extra stress on the tail.
Lubrication of a shot curb: - the roller axles must be kept greased.

5.9.2.f Dead curb with skids winding system

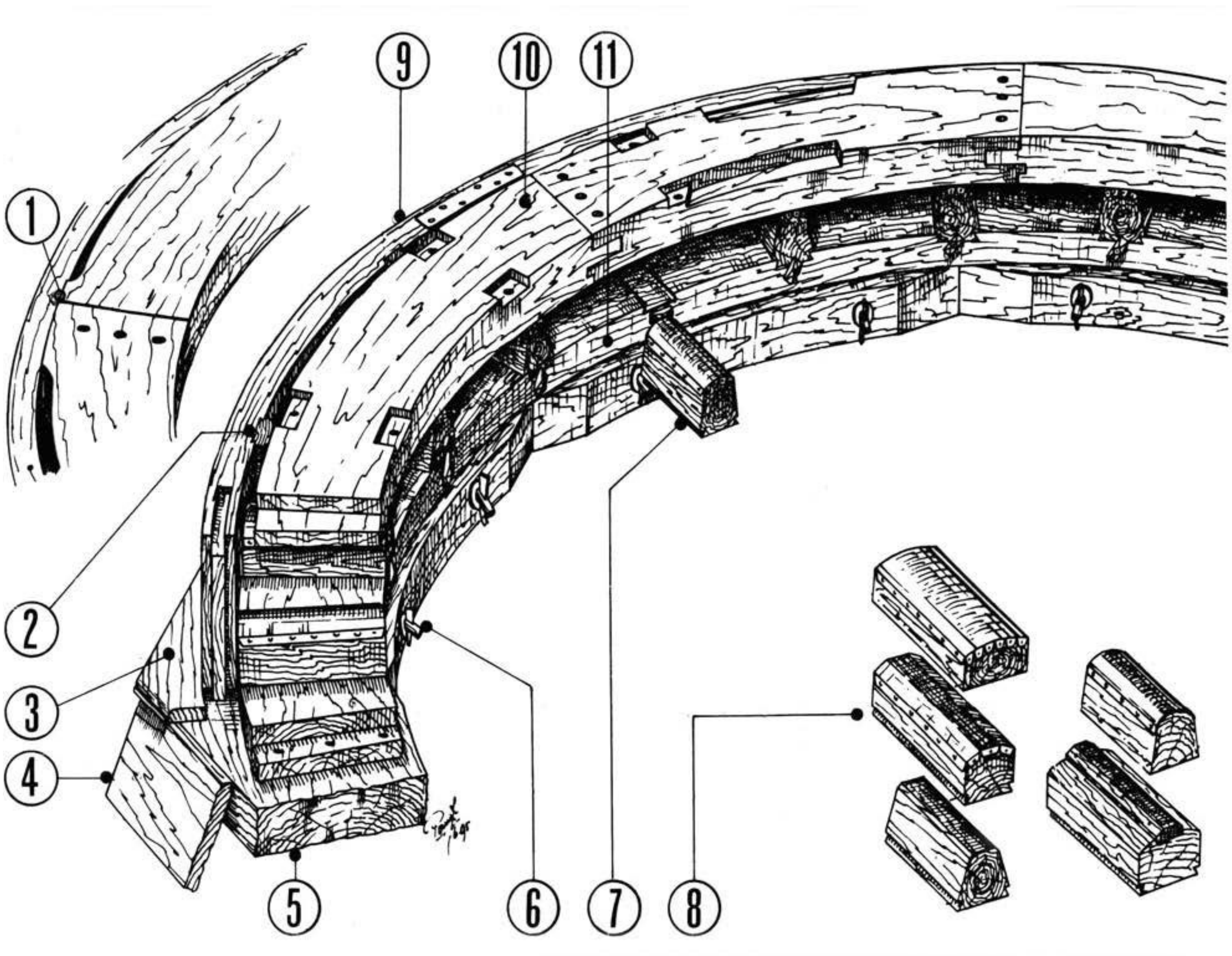


Fig. 5.9.2.3
Dead curb with skids winding system

1. *cap circle with carter*
2. *curb carter*
3. *soffit board*
4. *thatch plank*
5. *uppersill*
6. *curb bolt*
7. *winding block/sklid block*
8. *various skid forms*
9. *curb railing*
10. *cap circle*
11. *winding track*

dead curb with skids winding system, sliding or friction winding gear

The dead curb with skids winding system is a sliding or friction winding gear. The construction is simpler (thus cheaper) than the live curb. The winding track, which is laid horizontally, is cut out or dovetailed straight at equal distances. The winding skids are pushed into these recesses.
In most cases, the skids are beechwood blocks of 10 to 15 cm wide. To prevent wear and tear, the rounded top is often covered with thin sheet iron. On top of that lies the curb with the cap.

The skids are easily replaced by pulling them out of the winding track inwards.
An advantage of a dead curb with skids winding systemis that the cap stays quietly in place while milling and thus the tail is not put under additional strain. A disadvantage is heavier winding when lubrication is not done properly and regularly. After prolonged disuse, the cap sometimes is difficult to coax 'out of its nests'.

Lubrication of the dead curb with skids winding system:
- the underside of the cap circle.
- the outside of the cap circle.

5.9.2.g The dead curb with cap sliding on sheers

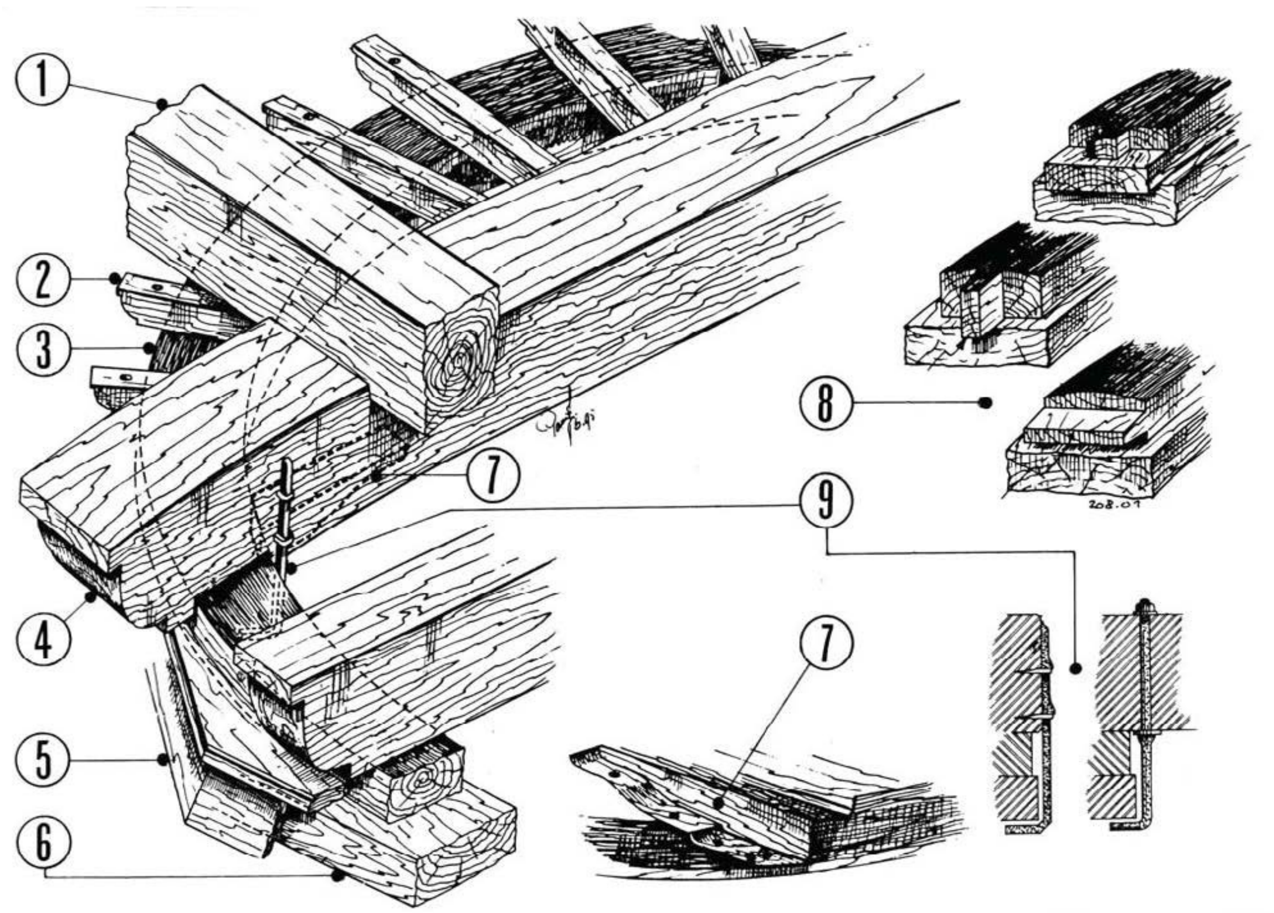


Fig. 5.9.2.4
The dead curb with cap sliding on sheers

1. *long stretcher*
2. *puncheon*
3. *curb ring*
4. *sheer*
5. *thatch plank*
6. *uppersill*
7. *poll wedge*
8. *various winding track joints*
9. *retaining hooks*

dead curb

The dead curb with cap sliding on sheers that is common in the northern provinces has a very simple construction. We usually find this sliding or friction winding gear at mills with small caps.

The winding track of a dead curb with cap sliding on sheers is called a cog rail.

curb ring

The sheers rest directly on the curb ring. There is no cap circle.

Sometimes the sheer beams are notched 3 to 5 cm where they lie on the curb ring. There are also versions where they are simply laid on the curb ring.

In some cases, the sheer beams have a metal lining against wear. The support and puncheons slide over the curb ring during winding.

keep clamp

To prevent overwinding, solid keep clamps that slide along the inside of the curb ring are attached under the sheer beams. The cap of a small mill could

retaining hooks

go upwards in a severe storm. Therefore, iron retaining hooks were sometimes installed in or against the sheer beams. These run across the curb ring and uppersill and are bent at right angles at the bottom.
On mills with a dead curb with cap sliding on sheers, both the curb railing and the curb are missing.

Lubrication of the dead curb with cap sliding on sheers:
- the top of the curb ring.
- the inside of the curb ring (if keep clamps are used).

5.9.3 Collar winding gears

collar winding gears

Collar winding gears are found on post mills, hollow post mills and spider mills. They are completely different in construction and thus a different group of winding mechanisms than those discussed so far.

5.9.3.a Post mill winding gear

The post mill has a single collar. It is supported by the quarterbars (see Chapter 5.1.2). In theory, only a small part of the body of a post mill rests on the collar, usually via the sliding plates attached under the sheer beams (see Chapter 5.1.3). For the most part, however, the body is supported by the crowntree, whether or not reinforced by a bolster timber, which rests on the top of the post. A semi-circular lubrication hole is recessed into the rear trimmer, between the sheer beams.

lubrication hole

A similar lubrication hole is located in the crowntree or bolster.

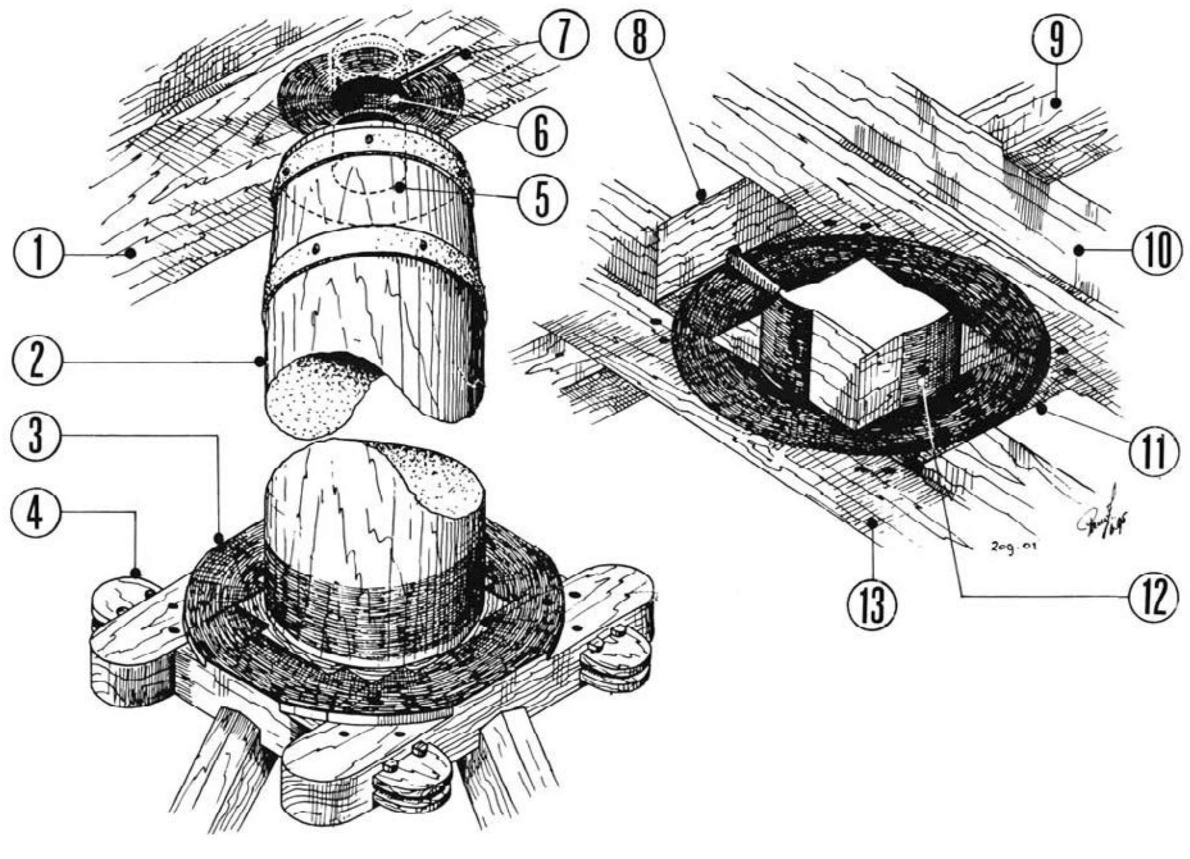
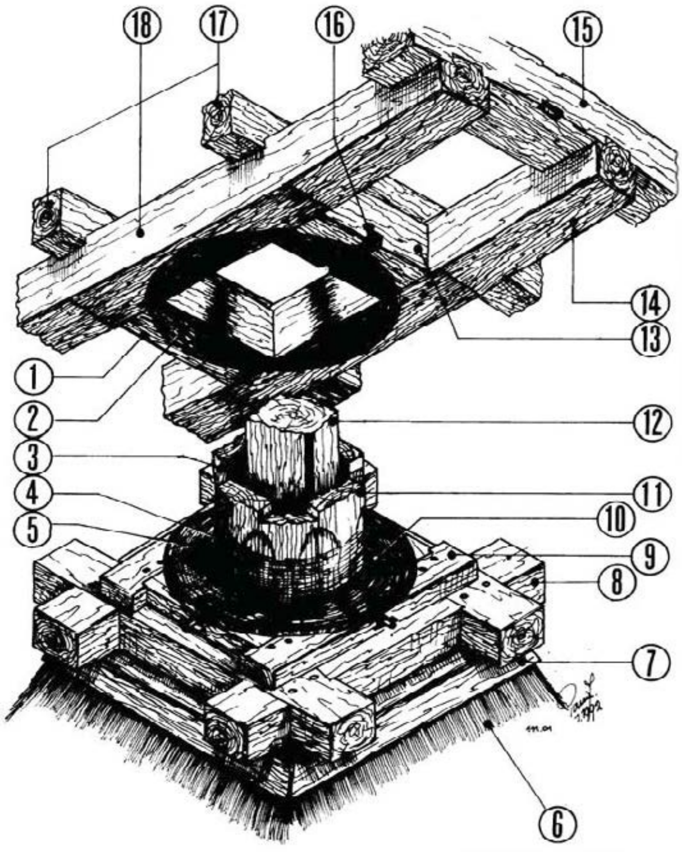


Fig. 5.9.3.1
Collar and pintle of the winding gear of a post mill

1. crowntree	*5. pintle*	*8. rear trimmer with lubrication opening*	*12. friction surface of the post*
2. post	*6. pintle socket with bearing surface*	*9. middle joist*	*13. sheer beam (r)*
3. bearing surface of the collar	*7. lubrication opening*	*10. sheer beam (l)*	
4. collar		*11. front trimmer*	

Fig. 5.9.3.2
Lower collar with lower girdle

1. *trimmer*
2. *friction surface of the lower collar*
3. *post side*
4. *friction surface of the lower girdle*
5. *support surface of the lower girdle*
6. *thatch or weather boarding of the tower*
7. *thatch planks*
8. *uppersill*
9. *lower collar*
10. *filling piece*
11. *hollow post*
12. *main upright shaft*
13. *trimmer*
14. *sheer*
15. *front joist*
16. *lubrication hole*
17. *middle joists*
18. *sheer*



The hollow post mill has two collars, the lower collar and the upper collar (see Chapter 5.2.2).
The lower collar rests on the uppersill and is attached to the hollow post with dovetails.
During winding, the lower girdle slides over the lower collar.

consoles

The upper collar rests on four heavy consoles attached to the hollow posts (see Chapter 5.2.2). Hardwood skids are usually fitted to the upper collar. The upper girdle slides over these skids.
Most of the weight of the cabin should, in theory, rest on the upper collar. However, many hollow post mills wind heavily because this weight distribution has been disturbed over time. Another major cause of heavy winding is lubricating too little or not at all.

Hollow post mills should be lubricated at least twice per year as follows: For the lower collar:
- the contact surfaces between the lower girdle and the lower collar, via the lubrication opening in the front trimmer of the lower girdle;
- the contact surfaces between the lower girdle and the hollow posts and sides. For the upper collar:
- the contact surfaces between the upper girdle and the skids; in the absence of skids, there is a lubrication opening in the trimmer of the upper girdle;
- the contact surfaces between the upper girdle and the hollow post uprights and post sides.

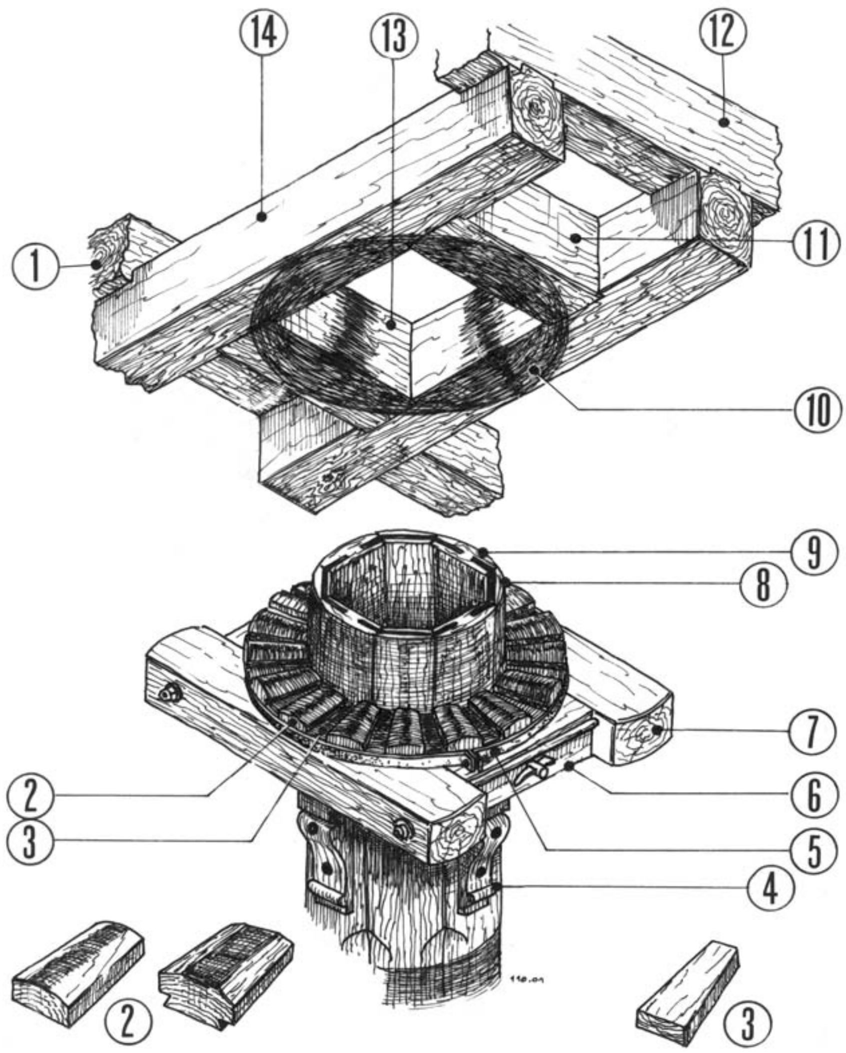


Fig. 5.9.3.3
Upper collar with upper girdle

1. *side girt*
2. *carters*
3. *filling pieces or insets*
4. *bracket*
5. *clamping ring*
6. *trimmer of upper collar*
7. *upper collar beam*
8. *post side*
9. *hollow post*
10. *friction surface of the upper collar*
11. *trimmer*
12. *side girt*
13. *trimmer*
14. *Sheer of the upper girdle*

collar plate

Spider mills do not rest with their cabin on the hollow post. The cabin originally rested directly on the uppersill but, to counter wear, a wooden plate called the collar plate was often added later between the lower girdle and the uppersill. Here, the collar plate has the same function as sliding plates do at the post mill. The so-called 'upper collar' fitted around the top of the spider mill's hollow post has the sole function of holding the eight cross trees together.

Lubrication of the spider mills: For the lower collar:
- the contact surfaces between the lower girdle and the top of the collar plate;
- the contact surfaces between the lower girdle and the hollow post.

5.9.4 Paltrok winding gear

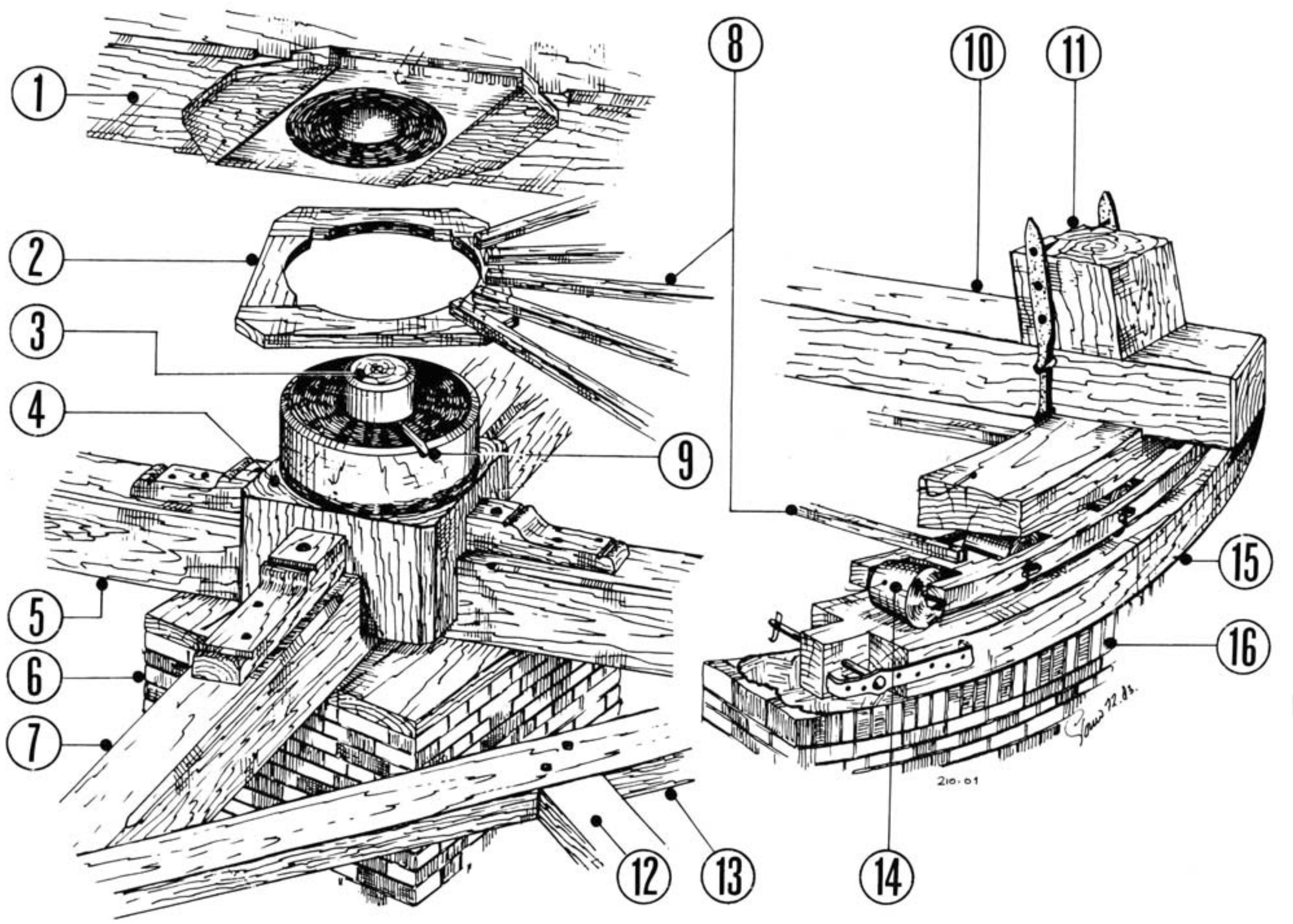


Fig. 5.9.4.1
Paltrok winding gear

1. *tail beam or tail pole*
2. *collar or collar piece*
3. *pintle*
4. *central post with rounded part for collar piece*
5. *cross-tree*
6. *pier, footing or pad*
7. *cross-tree*
8. *tracking beam*
9. *lubrication opening*
10. *sheer*
11. *sheer post*
12. *stretcher*
13. *diagonal brace*
14. *winding roller*
15. *winding track*
16. *masonry base*

For the winding gear of a paltrok (see Chapter 5.3.2) is similar to that of the live curb. This winding gear includes already familiar parts such as the winding track, roller-ring and curb (in Dutch, a paltrok's curb and an upper winder's cap circle are the same term, overring). But there is no curb railing because the central post makes sure the entire mill stays in place.
The winding track, with a diameter of about 9 metres, is usually heavier than that of cap winders. The size is about 12 x 32 cm and it is composed of crooked-grown wood.

roller-ring

The paltrok winds in its entirety over about 50 elm wood winding rollers that are supported in eight roller wagons, together forming the roller-ring. In a paltrok, winding rollers are further apart than they are in cap winders. Because they have fewer weight to bear, the number of rollers is relatively small relative to the large diameter of the roller-ring.

tracking beams
collar piece

As already described in Chapter 5.3.2, the roller-ring is held in place using the tracking beams which are fastened radially to the collar piece. The collar lies around the rounded part of the central shaft.
The curb, which is also composed of crooked oak slabs, lies on the rollers. This is also a heavier version than that found in cap winders.
To replace the rollers, a rectangular hole called the roller compartment is usually made in the curb at the tail pole.
Usually the winding gear of a paltrok mill is classified as a live curb. However, most of the mill's weight rests on the central post via the tail pole. When winding, this tail pole rotates around the rounded pin of the central post — in other words, a collar. The winding rollers bear only a small portion of the weight. They function as support, especially for the front of the mill. With proper weight distribution, the curb at the rear does not touch the winding rollers. So this can be considered a combination of collar winding gear and live curb.

Lubrication of the paltrok:
- the pintle and supporting surface of the central post: a lubrication hole is present in the working floor for this purpose.
- the side of the round part of the central post.
- the axle of the winding rollers (every now and then) to prevent rusting.

NOTES

Chapter 6 Driving gear

Contents page

6.1 SHAFTS AND SPINDLES

6.1.0 Introduction

shafts spindles
windshaft
central spindle
sack hoist
stone spindle, spherical spindle
waterwheel shaft
screw beam
cam shaft
crankshaft

Mills have shafts which are made of wood or iron. Horizontal shafts are simply called shafts, vertical shafts are called spindles.
All mills have a windshaft to which the sail cross is attached. A second important shaft is the central spindle.
The central spindle is not found in all mill types.

- In addition to having a sack hoist spindle for hoisting bags of grain and lowering bags of meal, grain mills are also equipped with one or more stone spindles and spherical spindles, which are associated with the grinding stones.
- Polder mills that drive a scoop wheel have a waterwheel shaft.
- Polder mills that drive a screw have a screw beam.
- Oil mills, paper mills, paint mills and snuff mills have a cam shaft.
- Sawmills have a crankshaft.

The chapters covering the various mill functions will discuss these specific shafts and spindles in more detail.

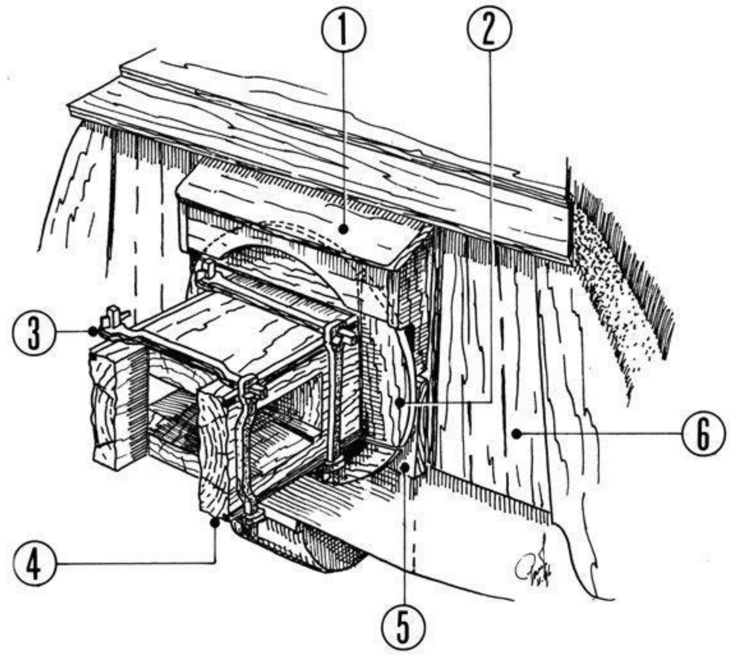


Fig. 6.1.1.1
The anti-watering casing

1. *anti-watering casing cap*
2. *collar*
3. *bridle iron*
4. *canister (partial)*
5. *neck bearing board*
6. *shutter*

6.1.1 Windshaft

canister, neck, tail, pin
wooden wind shaft
cast-iron windshaft

A windshaft consists of the canister, neck, tail and pin.
For the first seven centuries of their existence, mills had wooden windshafts.
Only since the 19th century has it been possible to manufacture cast-iron shafts.

6.1.1.a Wooden windshaft

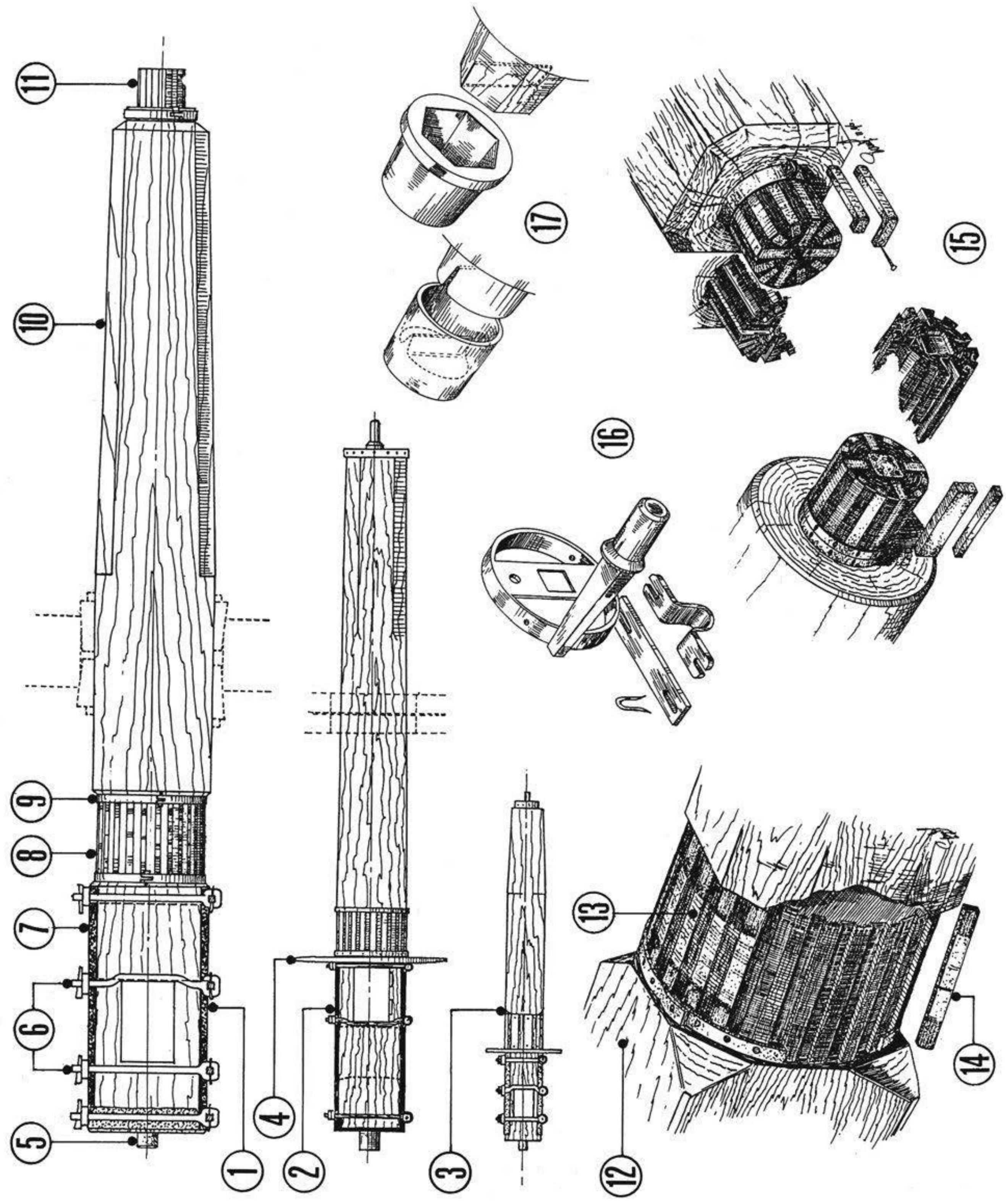
rod holes
anti-watering casing collar
shins
pin cap

Only oak logs 80-90 cm thick were considered for a wooden wind shaft. The square canister was made from the root end because that is where the trunk is thickest and the wood structure is strongest. Large holes were cut into the canister and the rods were later inserted into these holes (see Fig. 6.1.1.2). However, these rod holes weaken the canister. Therefore, the canister was reinforced with iron corners and a number of straps. There was a collar around the shaft to counter water penetration. This collar pivoted under a body, called the anti-watering casing, which was attached to the front gable (see Fig. 6.1.1.1). The rounded part behind the canister is the neck, which rotates on the neck brass. Iron strips (shins) were inserted into the neck at equal distances to counter rapid wear of the wood.
The back of the windshaft, the pin, also often had shins. The pin was also fitted with a so-called iron cap which was wrapped tightly around it. This also supported the rear surface of the pin.

Fig. 6.1.1.2
Wooden windshafts

1. *wooden windshaft for a large mill*
2. *wooden windshaft for a smaller type of mill*
3. *wooden windshaft for a spider mill*

4. *collar*
5. *pin*
6. *bridle irons*
7. *canister*
8. *neck with shins*
9. *spindle strap*
10. *tail*
11. *pin*
12. *wooden wind shaft*
13. *neck with shins*
14. *loose shin*
15. *two examples of the pin*
16. *tail bearing for a spider mill*
17. *two examples of caps*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6.1.1.b Cast-iron windshaft

Cast iron has been in use since the Middle Ages. Relatively small objects, such as round (cannon) balls and household utensils, were cast. When the Industrial Revolution took off in the early 19th century, people — especially in England — learned to cast large iron objects and structural parts. Consequently, the first cast-iron windshafts originated from England. But soon these English imports came to an end and from 1836 the NSM (*Nederlandsche Stoomboot Maatschappij*), later Fyenoord, supplied Dutch shafts. These Fyenoord shafts were particularly short. They extended only slightly beyond the sprattle beam (see Fig. 6.1.1.3).

Some manufacturers of cast-iron windshafts:

L.I. Enthoven	The Hague	Prins van Oranje	The Hague
Fyenoord	Rotterdam	D.A. Schretlen	Leiden
Kon. Ned. Grofsmederij	Leiden	Wed. Sterkman	The Hague
Penn & Bauduin	Dordrecht		

The period of casting windshafts lasted relatively briefly, until the early 20th century. At that time, with the demolition of many mills, plenty of second-hand ones became available.
As a result of this reuse, the various products are more or less scattered throughout the country. However, no old windshafts have been available since the 1980s. Consequently, new shafts are now being cast again for the purpose of mill reconstruction or restoration. The Hardinxveld Foundry in Hardinxveld-Giessendam is the largest producer today.
As mentioned, the windshaft is made of cast iron, which is by no means unbreakable. During extremely hard braking, a cast iron canister can break off between the neck and the brake wheel and come down with the sail cross and all. Moreover, the brittleness of cast iron is temperature-dependent. In winter, especially with frost, the chance of breakage is greater.

brittleness

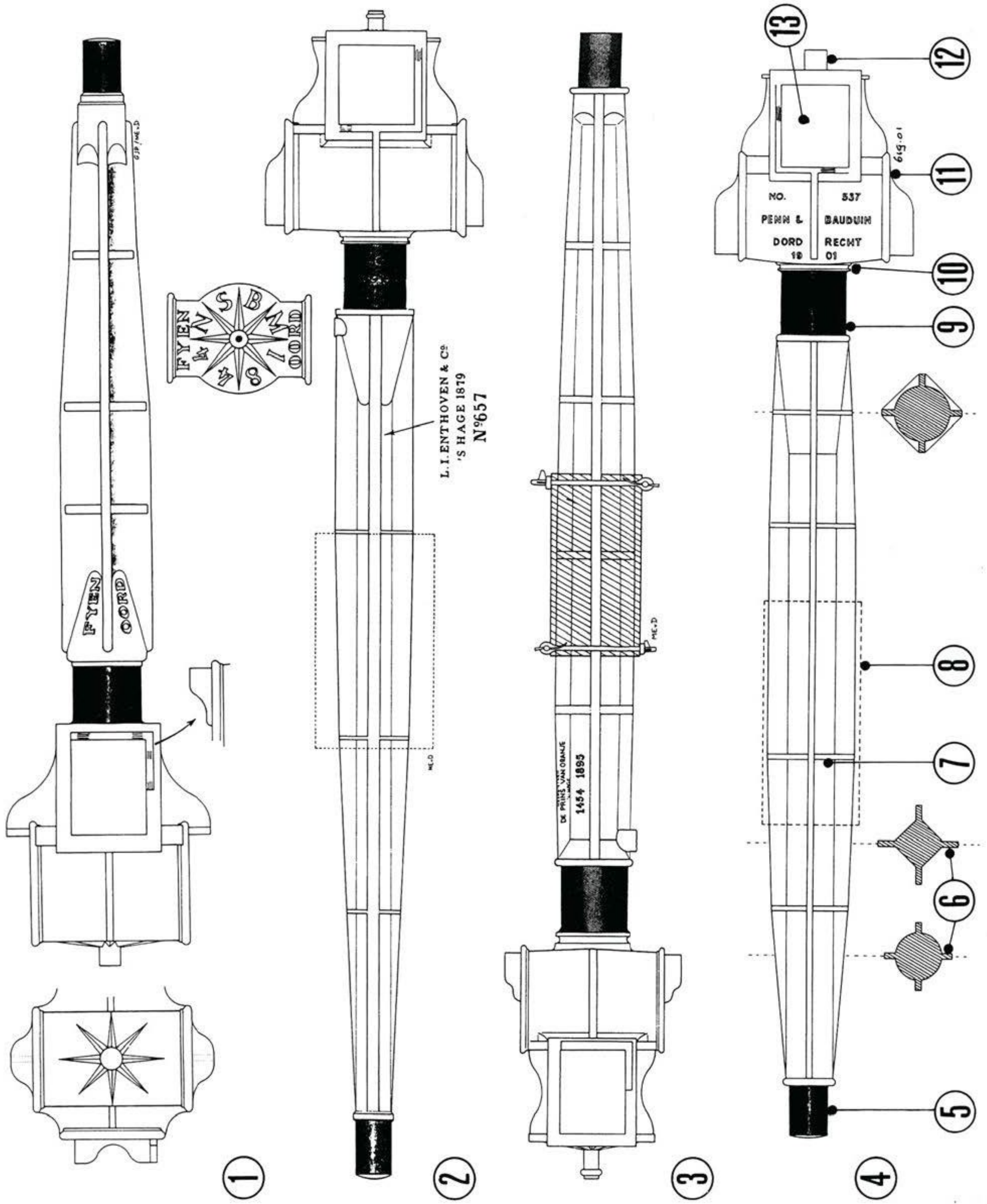
pin

A pin is located on the front face of the canister, which is often decorated with a star. Often the make of the shaft is evident from viewing the design of the front surface from the outside. The part between the neck and the pin, the tail, is reinforced around the shaft body with four ribs. At the location of the brake wheel, these ribs are lined with four filling pieces which are clamped with iron straps.

tail, ribs
filling pieces

Fig. 6.1.1.3 (right)
Cast-iron windshafts

1. *Fyenoord shaft*
2. *L.I. Enthoven & Co. shaft*
3. *Prins van Oranje shaft*
4. *Penn & Bauduin shaft*
5. *pin*
6. *ribs*
7. *shaft body*
8. *filling pieces*
9. *neck*
10. *collar plate groove*
11. *canister*
12. *pin*
13. *rod hole*


FYEN OORD
L.I. ENTHOVEN & Co
'S HAGE 1879
No657
1454 1895
NO. 537
PENN & BAUDUIN
DORDRECHT
1901
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6.1.1.c Wooden windshaft with cast-iron mortised head

mortised head

There is a third type of shaft, the wooden windshaft with cast-iron mortised head. The mortised head consists of a normal canister, a neck and four wings. The tail and pin of a wooden windshaft lasted a lifetime, as they were permanently located inside the mill. But the wooden canister and neck, which were continuously exposed to wind and weather and subject to wear and tear, were replaced by a mortised head.

wings

To do this, the (old) wooden windshaft was sawed off behind the neck and given the necessary notches into which the wings were inserted. With heavy bolts through the shaft and through the wings, and iron straps around the shaft, the two parts formed a single unit (see Fig. 6.1.1.4). Several mills in the Netherlands are equipped with them.

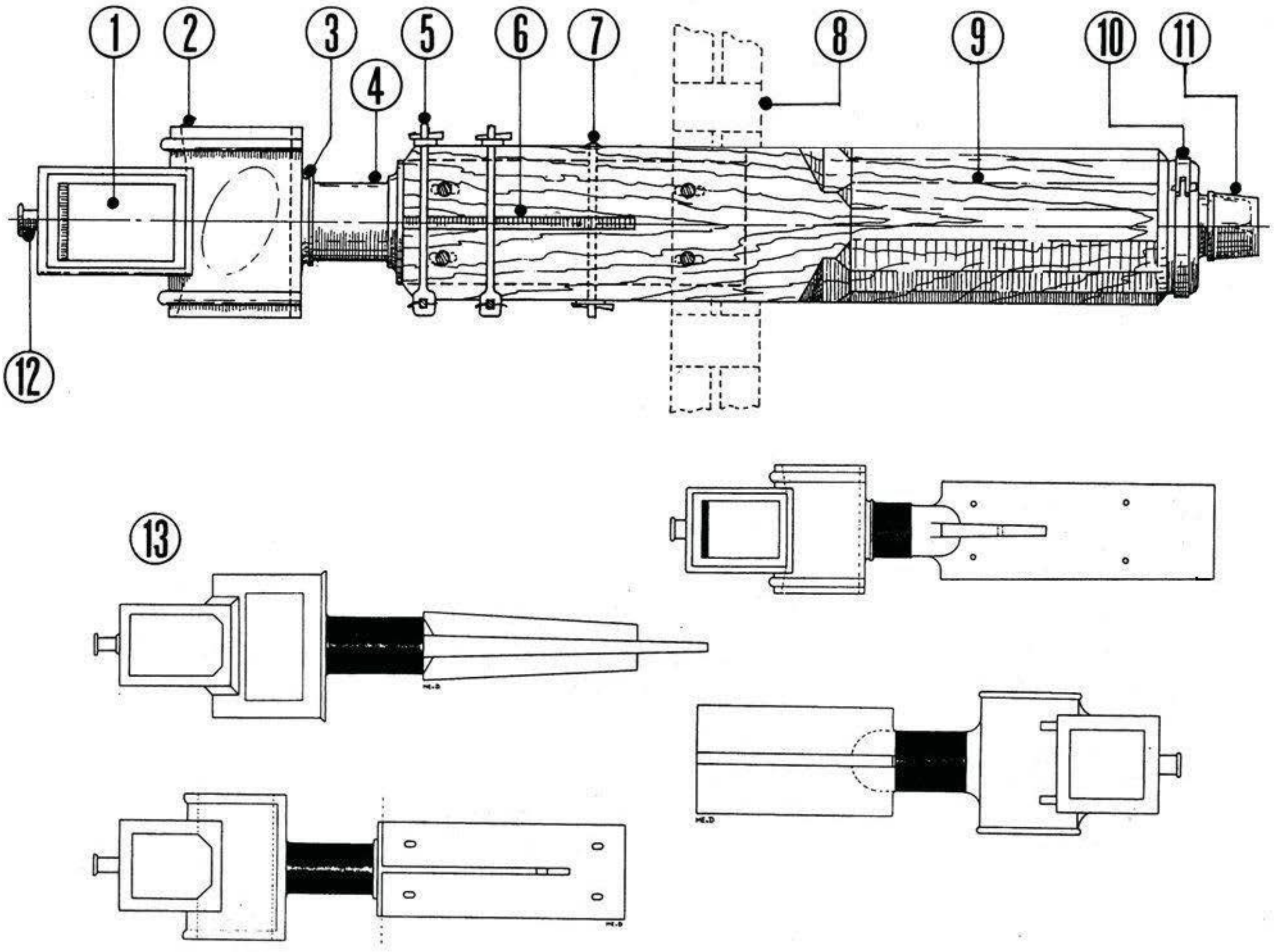


Fig. 6.1.1.4
Wooden windshaft with mortised head

1. *rod hole*
2. *canister*
3. *collar plate groove*
4. *neck*
5. *bridle iron*
6. *wing of the canister*
7. *bar bolt*
8. *brake wheel*
9. *tail*
10. *spindle strap*
11. *pin with cap*
12. *pin*
13. *some examples of mortised heads*

6.1.1.d Neck bearing

neck bearing
Belgian bluestone
neck brass
stone bed wedges, filling planks
knot-free spruce
stone bed
neck stud, weather stud
stone clip
rubbing clamp
neck bearing board
collar plate groove

Windshafts have bearings in two places, namely at the neck and at the pin. Behind the canister, under the neck, is the neck bearing. This bearing usually consists of a neck brass made of Belgian bluestone, a hard type of limestone. However, other materials were also used, such as lignum-vitae or a cast-iron or wooden bearing block with a bronze shell (see Fig. 6.1.1.5).
The neck brass, which carries a weight of 8 to 9 tonnes, rests on the weather beam via the stone bed. With this stone bed, which usually consists of a number of stone bed wedges, blocks and filling planks, the windshaft is raised to the correct height. Knot-free spruce is selected for the top filling plank so that the neck brass can 'set' in it. This prevents breakage of the neck brass.
Due to the inclined position of the windshaft, the stone bed is wedge-shaped. Therefore, the neck brass wants to move forward. This is prevented by the neck bearing board which is anchored to the neck and weather studs with hefty bolts and heavy strips. In the south of the Netherlands, a neck bearing board is sometimes used instead of a stone clip. Wooden wedges hold the neck brass in place between the neck and weather studs. A rubbing clamp is nailed against the neck stud. This prevents the windshaft from rolling to the right, especially during heavy braking.
Just outside the neck bearing board, the windshaft has a round groove, called the collar plate groove, which prevents rainwater from seeping in along the inclined shaft. Sometimes a metal collar is also added for this purpose.

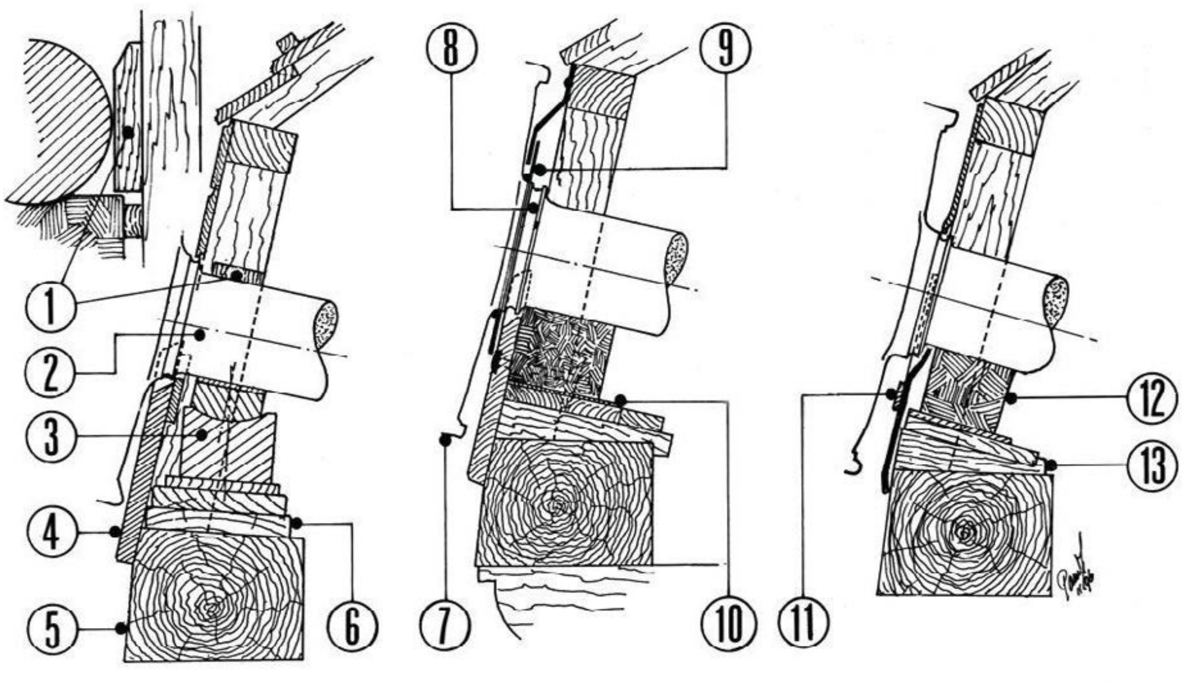


Fig. 6.1.1.5
Neck bearing set-up

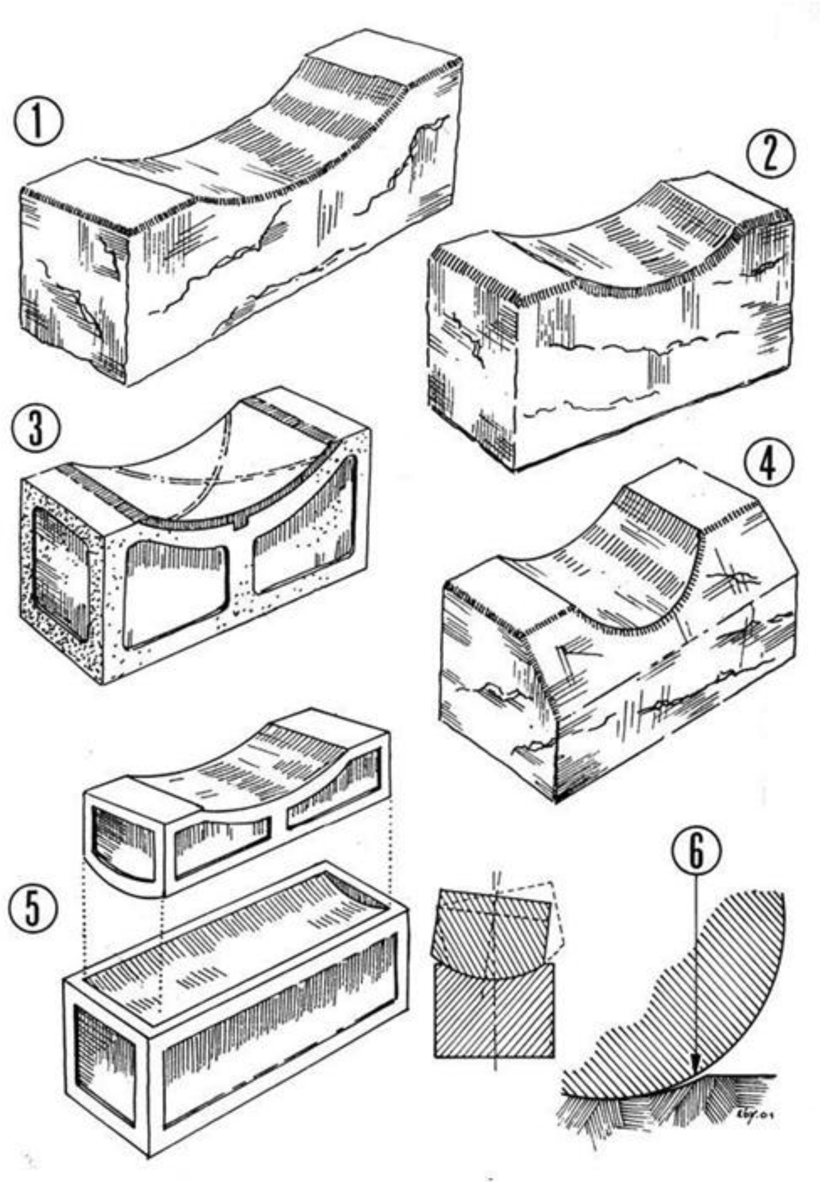
1. *rubbing clamp*
2. *neck*
3. *rocker bearing*
4. *neck bearing board*
5. *windlass*
6. *filling blocks*
7. *canister*
8. *collar plate groove*
9. *metal collar*
10. *knot-free board*
11. *stone bracket*
12. *neck brass*
13. *stone bed wedges*

lubricating film

In a new neck brass, there is a cavity that is no more than 2-3 cm deep. The neck of the windshaft rotates in this. This cavity should be slightly wider than the neck of the shaft to ensure proper lubrication (lubricating film) between shaft and neck brass (see Fig. 6.1.1.6). A deeply worn neck brass carries the windshaft over a surface that is too large and moreover precisely fitting, which hinders lubrication and, more importantly, heat dissipation. The shaft can then become so hot that it causes a fire to start! If the shaft is not carried across the full width of the neck brass, because the neck brass is crooked, the neck can also become too hot. Furthermore, the neck brass may break.
Failure to lubricate or inadequate lubrication can also cause overheating. The neck is usually lubricated with pig lard.

Fig. 6.1.1.6
Neck bearings

1. *stone for wooden shaft*
2. *stone for iron shaft*
3. *iron bearing with bronze or white metal lining*
4. *Flemish stone*
5. *rocker bearing*
6. *inlet gap for lubricating grease*



6.1.1.e Dekker bearing

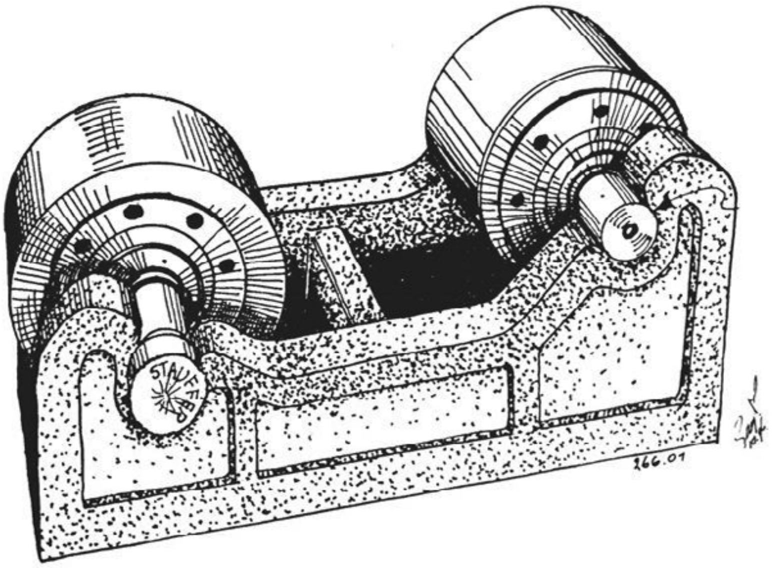


Fig. 6.1.1.7
Dekker bearing

Dekker bearing

A special neck bearing is the Dekker bearing (see Fig. 6.1.1.7). It consists of a cast-iron bearing with two rollers. The right-hand roller, near the neck stud, is slightly smaller and a bit higher than the left-hand one. The windshaft rotates on both rollers. If a Dekker bearing is used, the neck of the windshaft is fitted with a two-piece hard steel sleeve to prevent excessive wear of the cast-iron neck.
The Dekker bearing proved to be unsuccessful in practice. The major problem was that the bearing could not handle the heavy pressure of the windshaft and, due to lack of lubrication, quickly became hot.

6.1.1.f Tail bearing

tail bearing

The second bearing of the windshaft is the tail bearing (see Fig. 6.1.1.8). Although it has to carry much less weight (about 20%), it is usually made of Belgian bluestone as well.

tail brass

The tail brass is anchored to the tail beam with wedges. This beam is located on and between the upper side girts or sheer beams, at the same angle as the windshaft, and is adjustable in the horizontal plane to be able to:
- bring a shaft that sagged back to the front again.
- place the shaft exactly in the centre of the cap.

The tail bearing has several versions (see Fig. 6.1.1.9):

trouser block/beam
tile stone
bronze tile plate
thrust-block

- The tail brass is hollowed out across its full width. Into this hollow fits the gudgeon of the windshaft. Behind the tail brass, in the trouser block/beam is usually found a loose Belgian bluestone tile: the tile stone or a bronze tile plate. Both are fitted with a lubrication slot. The rear end of the pin rotates against this. The thrust-block, together with the tile stone, absorbs the backward pressure that the wind exerts on the sail cross.

bridge brass
pivot
bulb plate

- The tail brass is not hollowed out across its full width. The part not hollowed out acts as a tile stone, as it were. This kind of stone is referred to as a bridge brass.
- The pin features a hard steel pivot. In this case, the pin rotates back into a full-width, hollowed-out tail brass. But the tile stone has now been replaced by an iron plate with a hardened steel bulb in the middle, the so-called bulb plate, against which the pivot of the pin rotates.

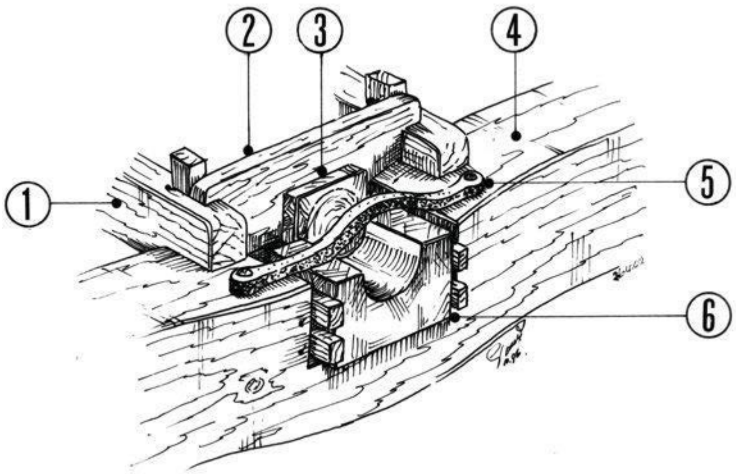


Fig. 6.1.1.8
Tail bearing

1. *trouser block/beam*
2. *thrust-block*
3. *tile stone*
4. *tail beam*
5. *keep iron*
6. *tail brass*

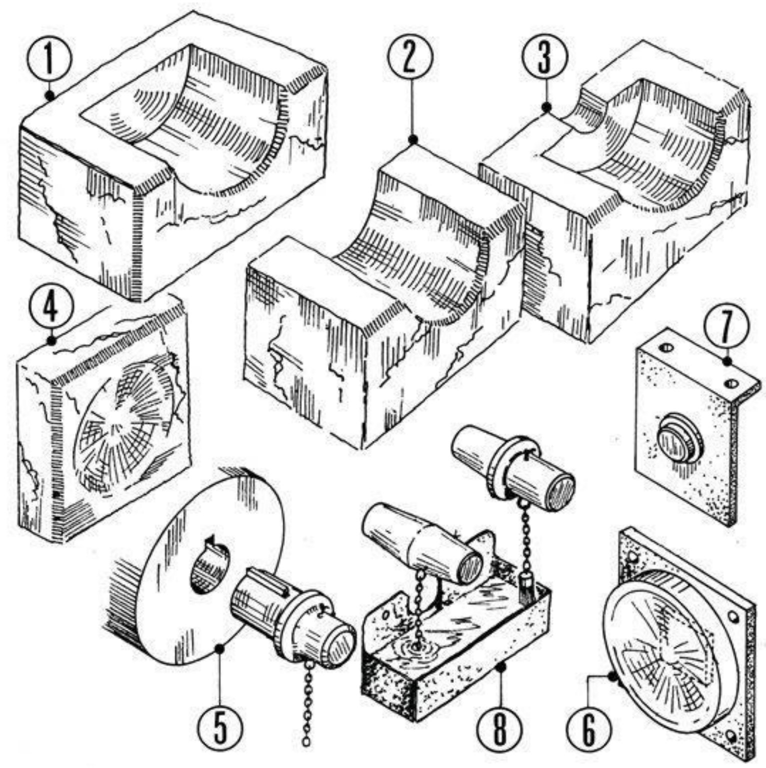


Fig. 6.1.1.9
Tail bearings

1. *bridge brass*
2. *tail brass*
3. *bridge brass with cut-out for the striking rod*
4. *tile stone*
5. *pin with interchangeable pivot*
6. *bronze tile plate*
7. *tile plate with hardened steel bulb*
8. *lubricating oil cup*

dipping
keep iron

Due to the large difference in weight between the neck and the pin, the shaft could dip during strong gusts of wind at the back of the sail cross. When dipping, the sail cross tilts slightly forward, causing the pin to come out of the tail bearing. The pin can move up or sideways during braking. To prevent this, a keep iron is attached over the pin on the tail beam.
For the same reasons as described for the neck bearing, the gudgeon can also run hot. A dry or worn pawl makes itself known with a loud screeching noise.

6.1.1.g Bearings and lubrication

pig lard
lubricating oil cup

Shaft bearings are lubricated with pig lard, either melted or unmelted. The pivot, which presses against the bulb plate, is lubricated by means of a rotating chain that, with each revolution of the windshaft, takes some engine oil from a small lubricating oil cup under the bulb plate.

6.1.2 Central spindle

central spindle

All cap winders, hollow post mills and spider mills have a central spindle. This vertical shaft serves to transmit the rotation of the sail cross via cog wheels (or cog wheels and pinions) to the machinery located lower in the mill.
Machinery in the winding section of certain mill types, such as post mills and paltroks, functions without a central spindle directly on the brake wheel. And the machinery of the tjasker, the enclosed Archimedean screw, is located on the waterwheel shaft.

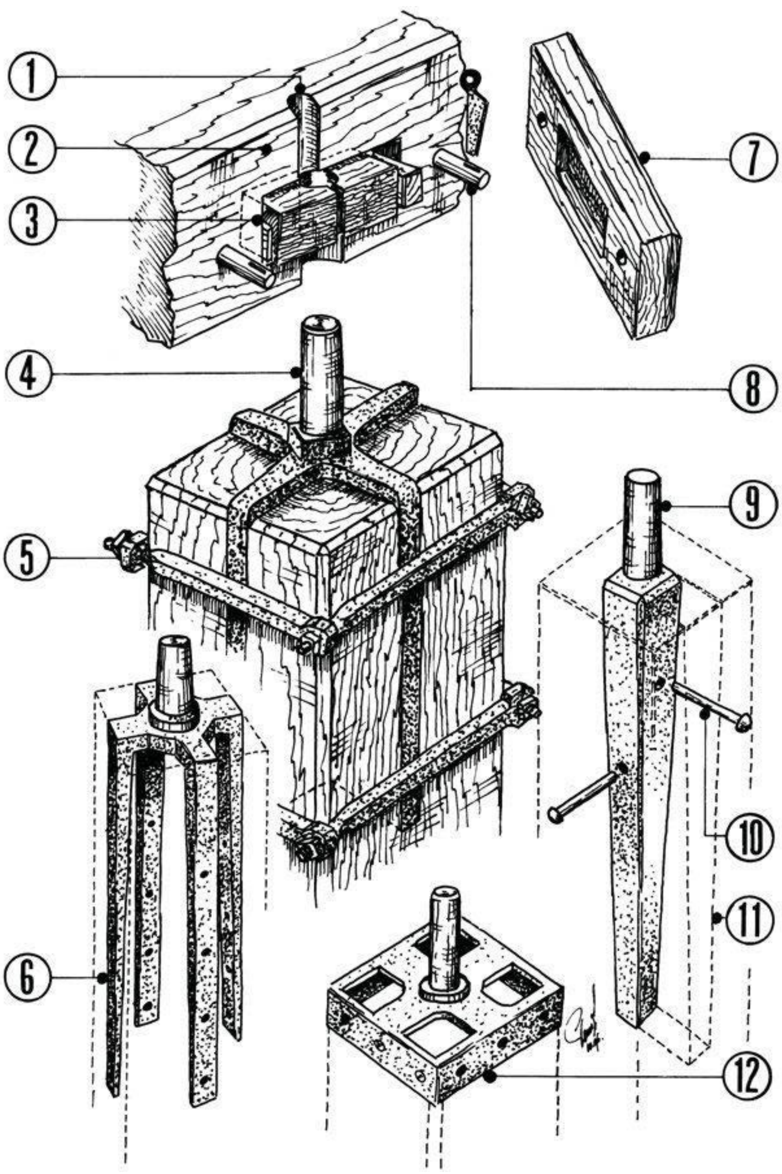


Fig. 6.1.2.1
Top bearing of the central spindle

1. *lubrication hole*
2. *tie beam, spindle beam, or sprattle beam*
3. *lignum-vitae, trunnion carters*
4. *trunnion spindle with wings encased in the spindle*
5. *bridle iron*
6. *crown spindle*
7. *lock plate*
8. *bar bolt for lock plate*
9. *insert spindle*
10. *locking pin*
11. *closure*
12. *gudgeon over insert spindle*

The length of the central spindle varies from about 3 metres (in a cap-winder sawmill) to about 16 metres (in a paper mill). The thickness is proportional (about 50 x 50 cm in a paper mill). The central spindle is at the heart of the mill. This is because the cap with the brake wheel must be able to wind around the upper wallower or the upper stone gear. The brake wheel must engage in the upper wallower or upper stone gear at any cap position. The sprattle beam, which houses the top bearing, is adjustable so that a correct adjustment of the central spindle can be made.

sprattle beam

6.1.2.a Bearings and lubrication

crown, trunnion

sprattle beam, spindle beam
trunnion carters

bearing plate, spindle plate, lock plate

bearing post

tightening rope, tightening wood

The top bearing of the central spindle, the crown or trunnion, consists of a steel pin with four wings attached, which fit into the spindle. In the middle of the sprattle beam, also called a spindle beam a rectangular space is hacked out into which two lignum-vitae or bronze trunnion carters are inserted. Between these carters that are semi-circularly hollowed out on one side, the trunnion rotates (see Fig. 6.1.2.1).
The carters are locked by the bearing plate, spindle plate or lock plate, which is secured to the sprattle beam with two clamps and wedges or with bolts. The backward pressure of the top bearing on the spindle plate is partly absorbed by one or two bearing posts. These bearing posts are clamped between the spindle plate and the tail beam (on hollow post mills, between the spindle beam and the tie beam or connecting beam). They are kept in place by a tightening rope with tightening wood between the two posts (see Fig. 6.1.2.2)
Some lard is placed around the trunnion for bearing lubrication. A Stauffer grease pot is also often used for this purpose

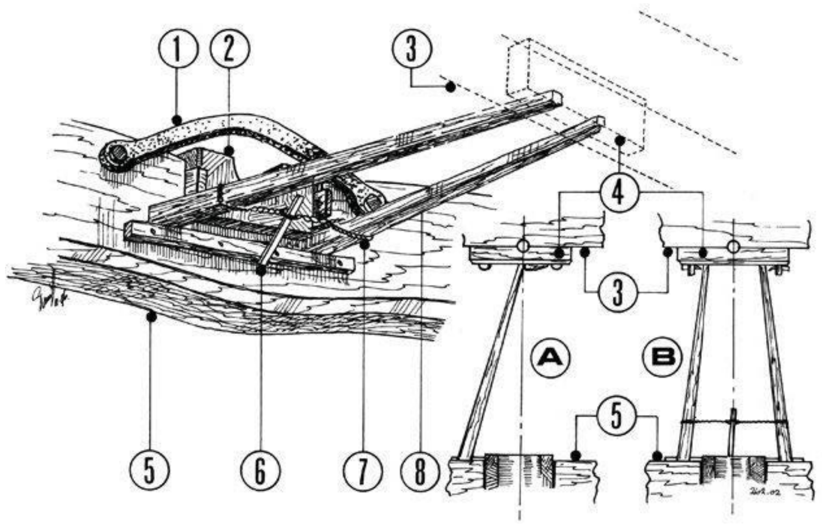


Fig. 6.1.2.2
Bearing posts

A. securing with a single bearing post
B. securing with two bearing posts
1. *keep iron*
2. *tail* brass
3. *tie beam, spindle beam or sprattle beam*
4. *bearing door or lock plate*
5. *tail beam*
6. *tightening wood*
7. *tightening rope*
8. *bearing post*

crown iron, pintle

A crown iron containing a hardened steel pivot that rotates in the pintle is inserted into the bottom of the central spindle. The pintle consists of a cast-iron compartment into which a second compartment of hard steel with lead is cast. In this second compartment there is a round hole cut out to fit the pivot. Sometimes this hole has a bronze lining. At the bottom of this hole is a hard steel plate, the tile on which the spherically finished pinion of the spindle rotates (see Fig. 6.1.2.3).

tile

Thick machine oil is used for lubrication in the pintle. The pintle is enclosed in a horizontal beam. The name of that beam varies: in polder mills, the central spindle rests on the pillow block; in grain mills, on the bridge beam or bridge tree, etc.

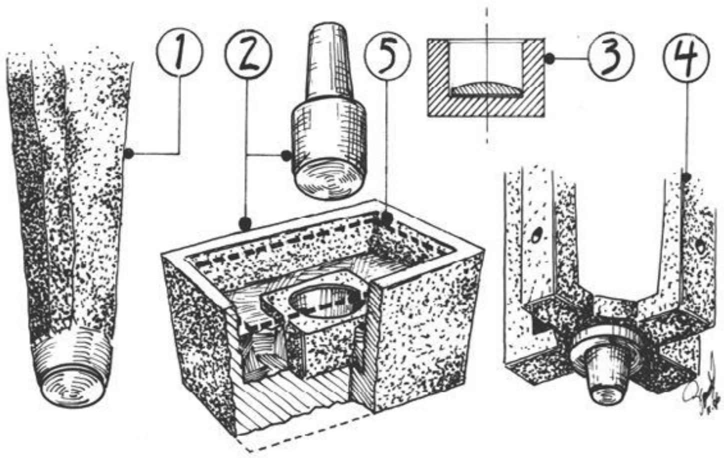


Fig. 6.1.2.3
Underbearing of the central spindle

1. *wrought iron pivot journal*
2. *loose pivot journal with pintle*
3. *cross-*section of pivot bearing pot with tile
4. *crown iron with double forks*
5. *machine oil fill level*

Other shafts and spindles

These shafts and spindles are covered in the chapters describing their respective mill types and functions.

6.2 THE SAIL CROSS

6.2.0 Introduction

In the first windmills, sails were made entirely of wood. It was not until the second half of the 19th century that wooden stocks began to be gradually replaced by metal stocks.

sails, sail cross
cross, whips
sail bars

The sails, sails cross, or cross for short, consists of two rods inserted crosswise through the canister. Each stock has two whips. Thus, a sail cross has four whips (sail crosses with more whips can be found outside of the Netherlands!). The sail bars are inserted into these whips.
Until the 17th century, sail bars were the same length on both sides of the stock. They simply protruded at an angle through the stocks, with little or no slope in this angle. Nowadays, such a sail cross is called square-rigged (see Fig. 6.2.0.1).

square-rigged

A square-rigged, or medieval, cross is far from perfect, as it converts only a very small portion of the available wind into useful energy. Yet the millers that went before us made do with it for some 500 years.

Old Dutch sail system

During the 17th century, a better sail system was developed in the Netherlands out of practice and probably with much trial and error. We refer to this as the Old Dutch sail system. In this sail system, sail bars are inserted into the stock only on the left side (standing in front of a downward facing whip). The angle at which they are inserted into the stock has a spiral slope. To the right of the stock are removable wind-boards. This Old Dutch sail system produced a much higher yield. Most Dutch mills are still equipped with them.

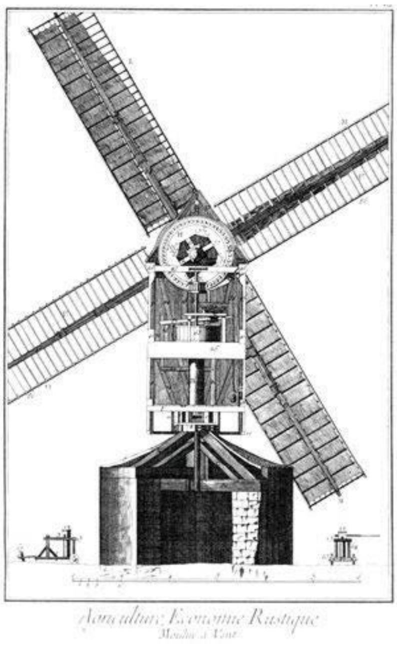


Fig. 6.2.0.1
Example of a mill
with a square-rigged sail cross.

The sail frame is the same width on either side of the stock and the wind-boards are missing.

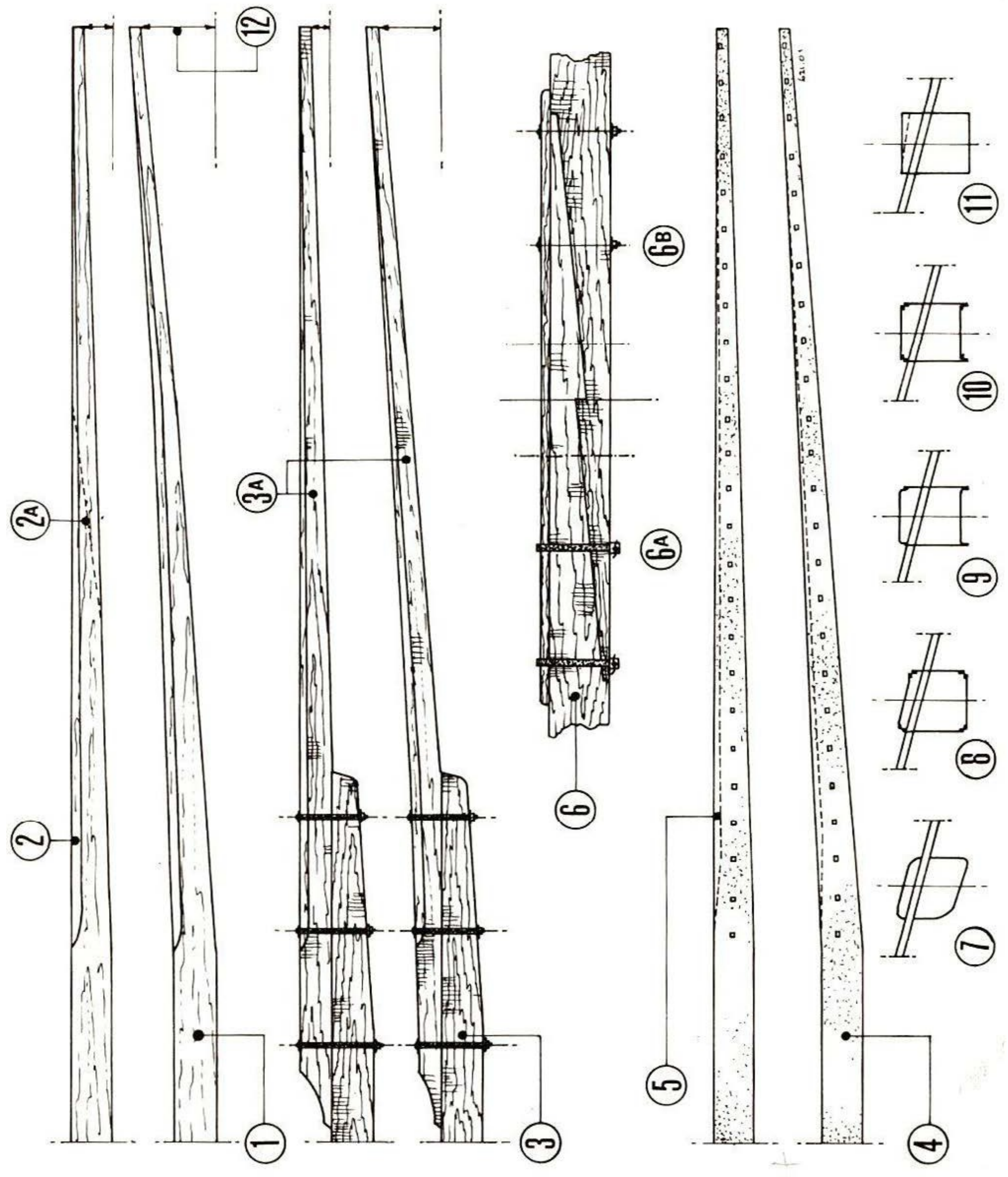


Fig. 6.2.1.1
Wooden and iron stocks

6.2.1 Wooden stocks

breast

arms

two-piece wooden stock

reel cross

Wooden stocks were manufactured until the 19th century. The oldest form of stock consisted of three parts. The breast, an oak beam 6 to 7 meters in length and about 40 x 30 cm thick in the middle, was inserted into the canister and extended on both sides to the desired sail length by means of arms. These arms were clamped onto the front of the breast using straps and bolts.
In the 19th century, the two-piece wooden stock was introduced. This type of stock consisted of two equal whips, which were joined together by means of a long scarf joint. So the centre of the joint was in the canister. The joint was reinforced by metal stock plates, bolts and straps.
Sometimes a tree was long enough to make a one-piece stock for smaller mills. An unusual two-part stock is found in the reel cross. Here, the four whips are not inserted through, but along, the wooden canister. In the case of a cast-iron shaft with a reel cross, the whips protruded into the canister, but lay side by side in two separate holes separated by a partition. The first metres of two parallel whips are parallel to the canister.
The whips are anchored around the canister with a number of studs and straps. They form a solid unit around the canister, which was thus not weakened by large stock holes. An additional advantage was that with this construction, the canister could be much smaller than was usual up to that period. And in the event of breakage, often only one whip needed to be replaced.
In the Netherlands, there is one mill with a wooden reel cross, specifically the *Robonsbosmolen* (Robons forest mill) at Alkmaar (see Fig. 6.2.1.2).

Fig. 6.2.1.1
Wooden and iron stocks

1. *wooden stocks*
2. *feathering*

2a. long scarf joint

3. *3-piece*

stock 3a. arm

4. *iron stock*
5. *feathering sometimes applied*
6. *two-piece wooden stock with long scarf joint*

6a. straps
6b. bolts

7. *wooden stock*
8. *Pot stock (cross section)*
9. *Fransen stock*
10. *Verhaeghe stock*
11. *jointed stock*
12. *dish*

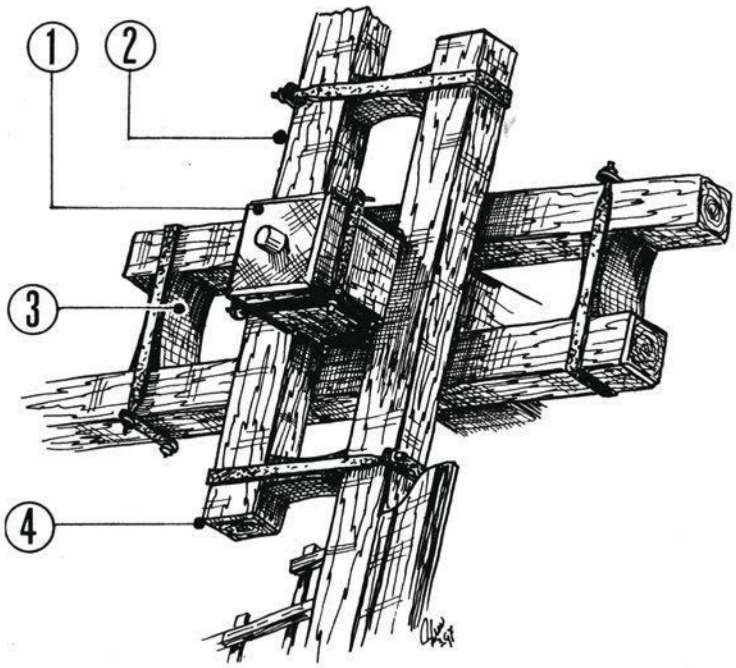


Fig. 6.2.1.2
The reel sail cross

1. *wooden wind shaft*
2. *half stock*
3. *stud*
4. *strap*

6.2.2 Metal stocks

From the second half of the 19th century, more or less simultaneously with the emergence of iron windshafts, wooden stocks were slowly but surely replaced with iron, riveted stocks. The Pot company of Elshout (near Kinderdijk) was the best-known supplier. The Pot stocks consist of long plates riveted together on four diagonals. Another company, Fransen, based in Vierlingsbeek, made stocks from iron plates with turned edges, against which flat strips were riveted, thus without diagonals. A similar process was followed by the Belgian firm Verhaeghe, based in Ruddervoorde. The Fransen stock seemed much slacker than the Pot stock but it was more resilient. The sheet thickness of metal stocks varies, over its full length, from about 12 mm in the canister to about 6 mm at the tops of the whips. The part of the stock located in the canister is reinforced with several longitudinal plates. These absorb the pressure of the fixing wedges (see Section 6.2.3).

Pot stock, Fransen stock, Verhaeghe stock

After 1945, stocks were no longer riveted but welded. The Bremer company from Adorp in Groningen was the first to supply welded stocks. Nowadays, divisible steel stocks are also made: the two whips are bolted together. The company Vaags of Aalten was the first to do so. Divisible steel stocks proved no success and have been replaced by now.

6.2.3 Attachment of the stocks

sail clamps; fixing wedges, spit irons

Both stocks are inserted through the holes of the canister and anchored in the following manner: First, two sail clamps per stock, located on either side of the canister, prevent the stock from sliding out of the canister. Furthermore, the stocks are knocked into place in the canister with 16 wooden fixing wedges (8 per stock). Finally, the fixing wedges are secured with spit irons (see Fig. 6.2.3.1)

inside stock, outside stock; dish

The inside stock differs from the outside stock. The stocks are inserted one after another through the canister, with the inside stock closest to the mill body. The outside stock is almost straight at the front, but not at the back. Indeed, the thickness of a stock decreases from about 40 cm in the canister to about 10 cm at the ends. In order to still have the four whips rotate (track) in the same plane as much as possible, the inside stock rod is bent forward. This curved shape of the inside stock is called dish (Fig. 6.2.1.1).

feathering

To give some streamlining to the stocks, the wooden stocks were bevelled at the front and back to promote guidance of the oncoming wind. This bevelling is called feathering. Pot stocks were feathered only at the front.

unbalanced, stripping

If — after some turning back and forth when there is no wind — the sail cross always stops in the same position, it is unbalanced. This shortcoming can be overcome by strengthening lighter whips. Stocks should be stripped at least every ten to twelve years. In other words, one by one in a vertical position they are stripped of spit irons, wedges and sail clamps and then hoisted up so that the part in the canister can be treated against rusting.

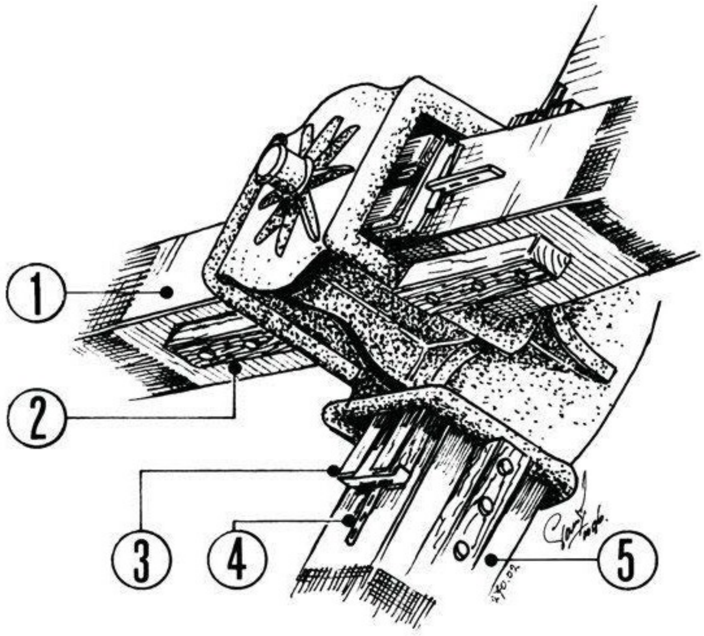


Fig. 6.2.3.1
Attachment of the stocks

1. *outside stock*
2. *sail clamp*
3. *fixing wedge*
4. *spit iron*
5. *inside stock*

6.2.4 Old Dutch sail system

sail wedges

In the whips, according to the particular slope, there are a number of holes through which sail frame bars are inserted. They are clamped with sail wedges. A nail behind each sail wedge should prevent it from working itself loose (see Fig. 6.2.4.1).

sail frame
sail bars
camber

To get maximum use from the oncoming wind, the sail frame (the total number of sail bars per whip) proceeds according to a spiral shape, the camber (see Section 6.2.5). The camber, already roughly determined by the slope of the sail bar holes in the stock, can be accurately adjusted with the sail wedges. At the canister, the sail bars are backward facing, while at the top of a whip they face forward.

hemlath, uplong
sail cleat

The sail bars are joined together per whip by three battens, namely one outer or rear batten, the hemlath and two inner or middle battens, the uplongs. In many cases, there is another sail cleat between the two uplongs. In some regions this cleat is missing, and in other regions two of them may be used. The hemlath is in front of the sail bars, and the two uplongs are behind them. The latter is necessary in order to lay the sail flat on the sail frame.

simple stepped heel
double stepped heel

Often the upper sail bar of the inside stock is shortened up to the outermost middle uplong, because the end might touch the front gable while turning. This is referred to as a simple stepped heel. The two top sail bars may also be shortened, the uppermost one to the innermost middle uplong and the one below it to the outermost middle uplong. This is referred to as a double stepped heel of sail frame frame.

leading side
wind bound brackets

All sail bars go right through the stock. Their ends emerge on the other side of the stock, the leading side. Several sail bars (sometimes all of them) are longer and on these are attached wedge-shaped clamps, called wind bound brackets. Wind bound brackets are used to determine the slant of the leading side. Because the sail frame protrudes through the stock according to a camber, the wind bound brackets become increasingly thicker toward the top of a whip.

board slat,
leading hemlath
thin wedge-shaped clamps
wind-boards
inner board
catch spring

On the leading side, the board slat lies directly against the stock. Sometimes it is absent. The board slat is attached to the sail bars inserted through the stock. The leading hemlath is attached to the ends of the wind bound brackets. In the western part of the Netherlands, thin wedge-shaped clamps are sometimes used instead of wind bound brackets between the first and the tenth sail bar. These are solid pieces of wood inserted into the stock on the leading side, separate from the sail bars, board slat and leading hemlath. A number of removable or folding wind-boards are installed between the board slat and the leading hemlath. The bottom wind-board, the inner board (storm board or under wood) is usually fitted with a catch spring or wedges and is therefore easily removable.

Fig. 6.2.4.1
Old Dutch sail system

1. *sail wedge*
2. *board slat*
3. *inner board*
4. *catch spring*
5. *wind bound bracket*
6. *leading hemlath*
7. *thin wedge-shaped clamp*
8. *stock*
9. *short sail cleat*
10. *long sail cleat*
11. *sail cleat*
12. *inner or middle uplong*
13. *rear hemlath*
14. *sail bar or sail frame bar*
15. *leading side*
16. *sail or sail frame*
17. *double stepped heel*
18. *simple stepped heel*
19. *various wind-board interlocking*

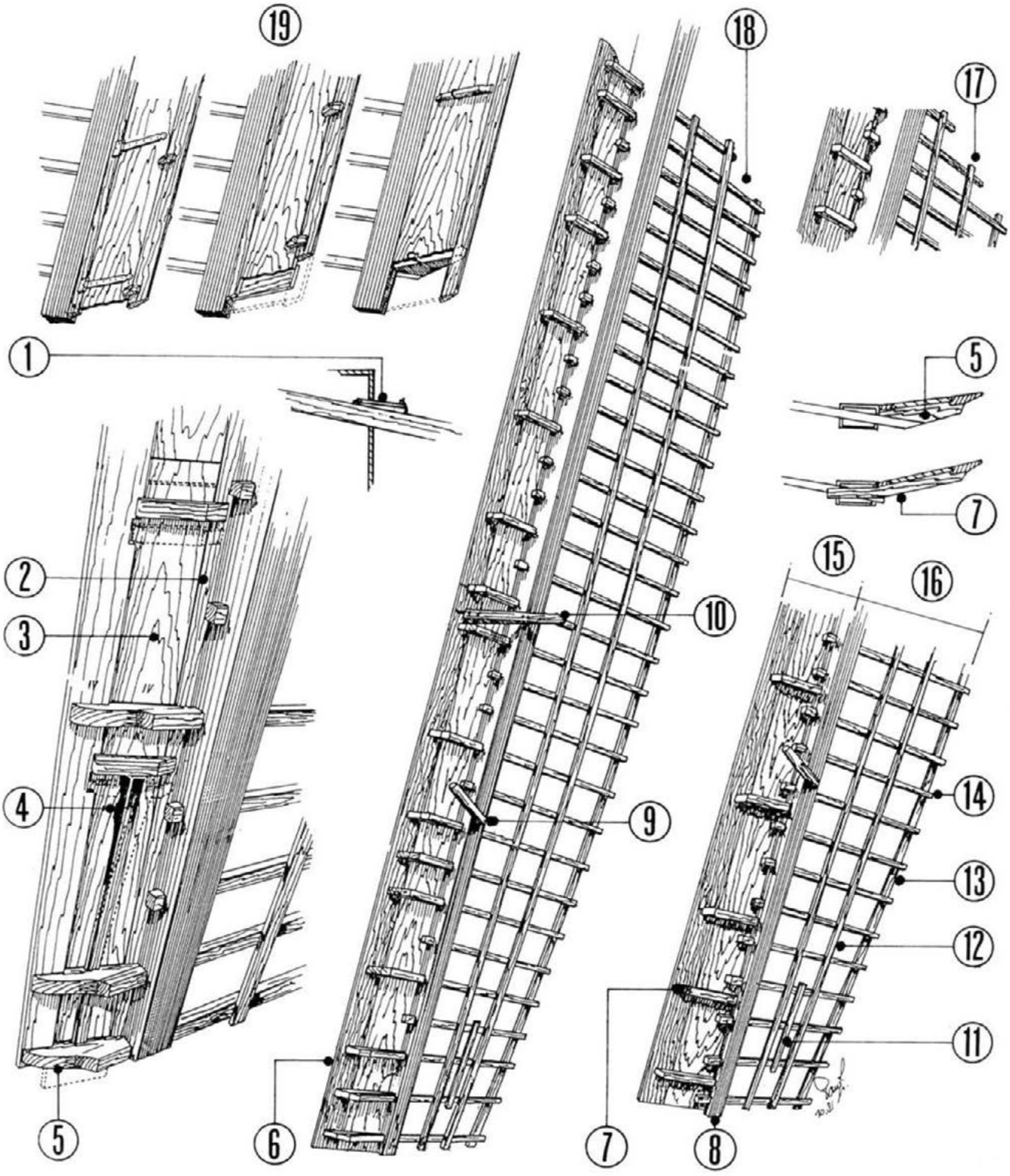


Fig. 6.2.4.1
Old Dutch sail system

6.2.5 Camber and wind-boards

camber

To get maximum use from the wind power, the sail frame was given a concave slope. The sail bars are furthest backward facing about three-quarters from the end of the stock, while at the top of the whip they even face forwards. We call this the camber (see Fig. 6.2.5.1).
In addition to the slope in the sail frame, there is also a slope in the position of the wind-boards. The wind-board at the shaft is somewhat flatter than that at the top of the stock. The width of stock plus wind-board is the same along the entire length of a whip. This means that, from the canister to the top, the wind-boards become wider and wider because the stock narrows over that same length.

hollow slope

The means of attaching the sail frame to the stocks and the position of the wind-boards depends on the function of the mill. Briefly, there are four factors which determine the behaviour of a mill:
- the position of the sail frame relative to the pivotal plane (the depth of the camber, the hollow slope);
- the position of the wind-boards relative to the pivotal plane
- the position of the sail frame and that of the boards relative to each other.
- the width of the sail frame and the width of the leading side.

A sail cross pulls well if the wind-boards are angled more obliquely than the sail frame.

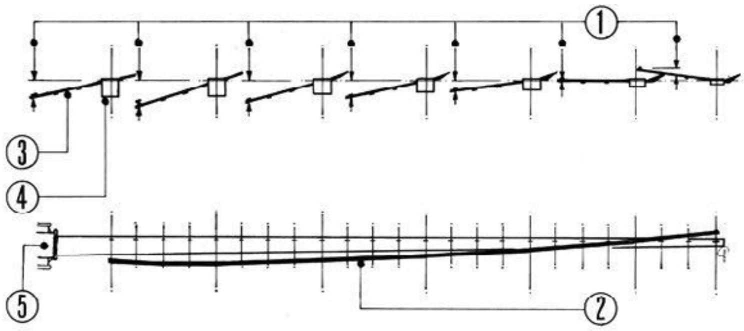


Fig. 6.2.5.1
Camber and hollow slope

1. the hollow slope angles
2. the camber line
3. sail frame bar
4. stock
5. canister

Mills for which a lot of power is required — such as hulling mills, sawmills and polder mills with a large pumping head — have a deep or concave camber. In other words, the angle between the deepest part of the sail frame and the plane in which the stocks rotate is relatively large. In such a case, the sail frame is relatively wide. The wind-boards of a heavily loaded mill are positioned relatively far forward and they are wide.
Such a mill runs easily, produces a large tractive force and, at a given wind force, turns slowly. The mill responds slowly to gusts of wind. A mill with great tractive force turns calmly. But when the brake is applied in such a mill, the great power of the sail cross is noticeable. To function properly, the mill needs a lot of wind.

The situation is clearly different in mills which require little tractive force, such as oil mills, grain mills with a small gear transmission, and polder mills with a modest pumping head. These mills have a shallow or flat camber. That is to say, the angle between the deepest part of the sail frame and the plane in which the stocks rotate is relatively small. The sail frame is relatively narrow. The wind-boards of such a lightly loaded mill are flatter and they are narrow.
Such a mill does not run as easily and produces less tractive force but, at a given wind strength, turns faster. The mill responds instantly to gusts of wind.
A lightly loaded mill runs irregularly but is easily braked. The mill needs relatively little wind to function properly.

6.3 MILL SAIL CLOTH

6.3.0 Introduction

mill sails

furling

Traditionally, mill sails have been placed in front of the sail frame to regulate the rotational speed of the sail cross. In weak winds, the wind-catching area is increased by unfurling the sails. With increasing wind, the wind-catching area is reduced by partially rolling up the cloth. This is called furling. In strong winds, the sails are completely taken down.

linen

cotton cloth

Sails used to be made of hemp and linen (flax cloth). This was also used for sailing ships. Linen is stretchable in all directions and therefore strong. The disadvantage of stretching is that the sail bulges through the sail frame in strong winds. Cotton cloth was introduced in the 19th century. This material is more firmly woven and available in different weights per m^2.
As a result, it remains smooth and flat on the sail frame. However, it is not as strong as the stretchable linen and it is also less weather-resistant. When it gets wet, it absorbs a lot of moisture and shrinks considerably. In addition, wet cotton sails are stiff and difficult to handle. On the other hand, cotton is much cheaper and therefore, despite its disadvantages, it supplanted linen.

synthetic fibre

In turn, cotton has gradually given way to synthetic fibre today. Synthetic fibre lacks the disadvantages of cotton. This synthetic material barely absorbs moisture and is weather-resistant. It is thinner and lighter in weight and therefore more manageable. The material is available in half cotton/half polyester or all-synthetic cloth (WK77).

thickened wear piece, single cleat loops, braided cord

A sail consists of: sailcloth, luff, leech, lower left and right thin cords, upper right tie rope or short tack rope, upper left tie rope or long tack rope or chain, a number of pointing lines with thickened wear pieces, and single cleat loops or braided cord (see Fig. 6.3.1.1). The shape of the curve in the upper part of the sail is also an important characteristic of a sail. Common colours are brown and white. In some regions, red or yellow sails are also used.

6.3.1 Features on the stocks

sail arm
sail eye

The sails are placed in front of the sail frame. There are some fittings on the stocks for this purpose. To attach the upper left corner of a sail to an inside stock, a sail arm is attached transversely to the outside stock. For hanging the upper left corner of a sail on the outside stock, there is a sail eye on the inside stock.

single cleats, cleat

To keep the sails in front of the sail frame while turning, there are a number of single cleats on each whip, behind which the braided cords of the sails are tied. At the end of each whip, a cleat is sometimes attached to secure the lower right tie rope of the sail.

short sail claet, long sail cleat
sail rung
sliding iron

Finally, on the back of each whip are a short sail cleat and a long sail cleat. The rolled-up sail cloth is clamped behind them. Some mills have a sail rung or a sliding iron above the first sail bar. No sail arms, eyelets and chains are then needed, and rolling up properly to the top corners is a bit easier.

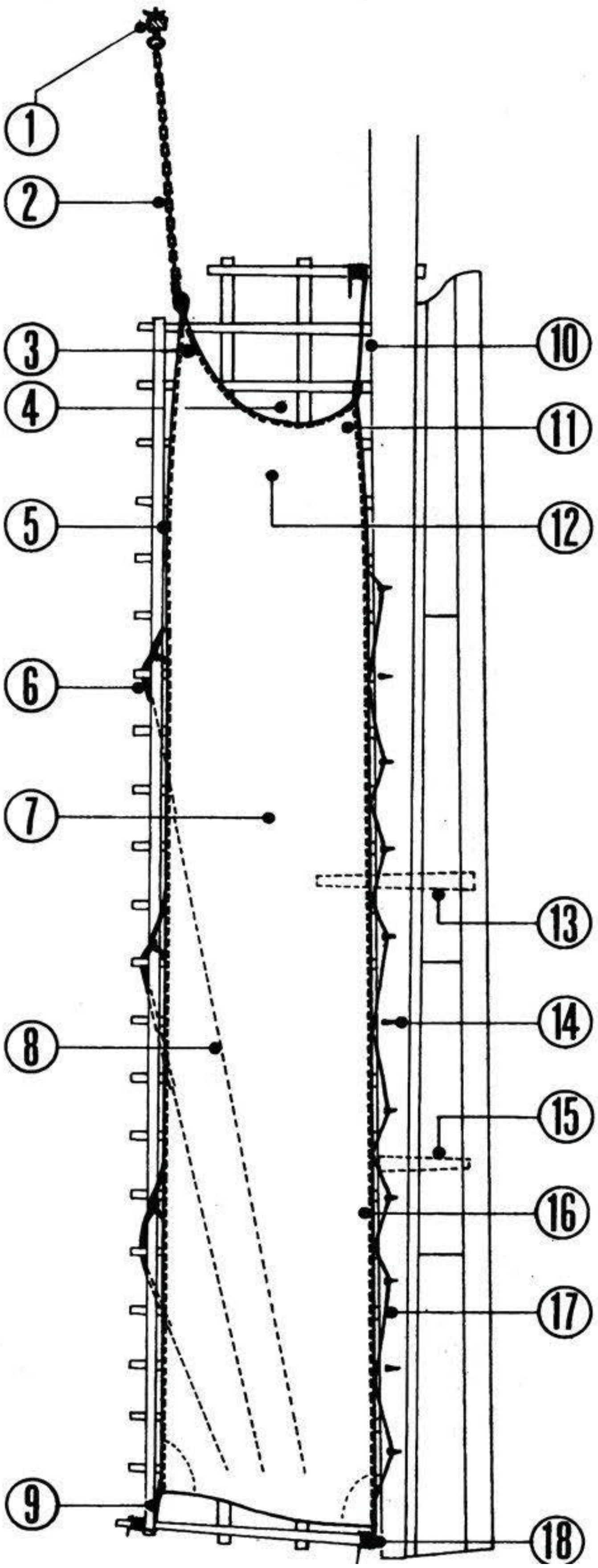


Fig. 6.3.1.1
The mill sail

1. *sail arm*
2. *sail chain or long tack rope*
3. *long neck*
4. *curve in the upper part of the sail*
5. *leech*
6. *thickened pointing liner or wear piece*
7. *mill sail*
8. *pointing line*
9. *lower left tie rope*
10. *short tack rope*
11. *short neck*
12. *canvas*
13. *long sail cleat*
14. *single cleat*
15. *short sail cleat*
16. *luff*
17. *single cleat loop*
18. *lower right tie rope*

6.3.2 New sails

Before ordering a new sail (see Fig. 6.3.1.1) from the sail manufacturer, the sails should be measured. Based on this, the sail-maker creates the sail drawing.
The following measurements should be taken:
- the distance between the upper and lower sail bars;
- the width of the sail frame measured between the stock and the outer hemlath. This width should be measured in three places: at the top, in the middle and at the bottom;
- the number of single cleats and the distance between them;
- the distance between the bottom single cleat and the bottom sail bar;
- when using an iron rail: the distance between the lowest point of that rail and the bottom sail bar.

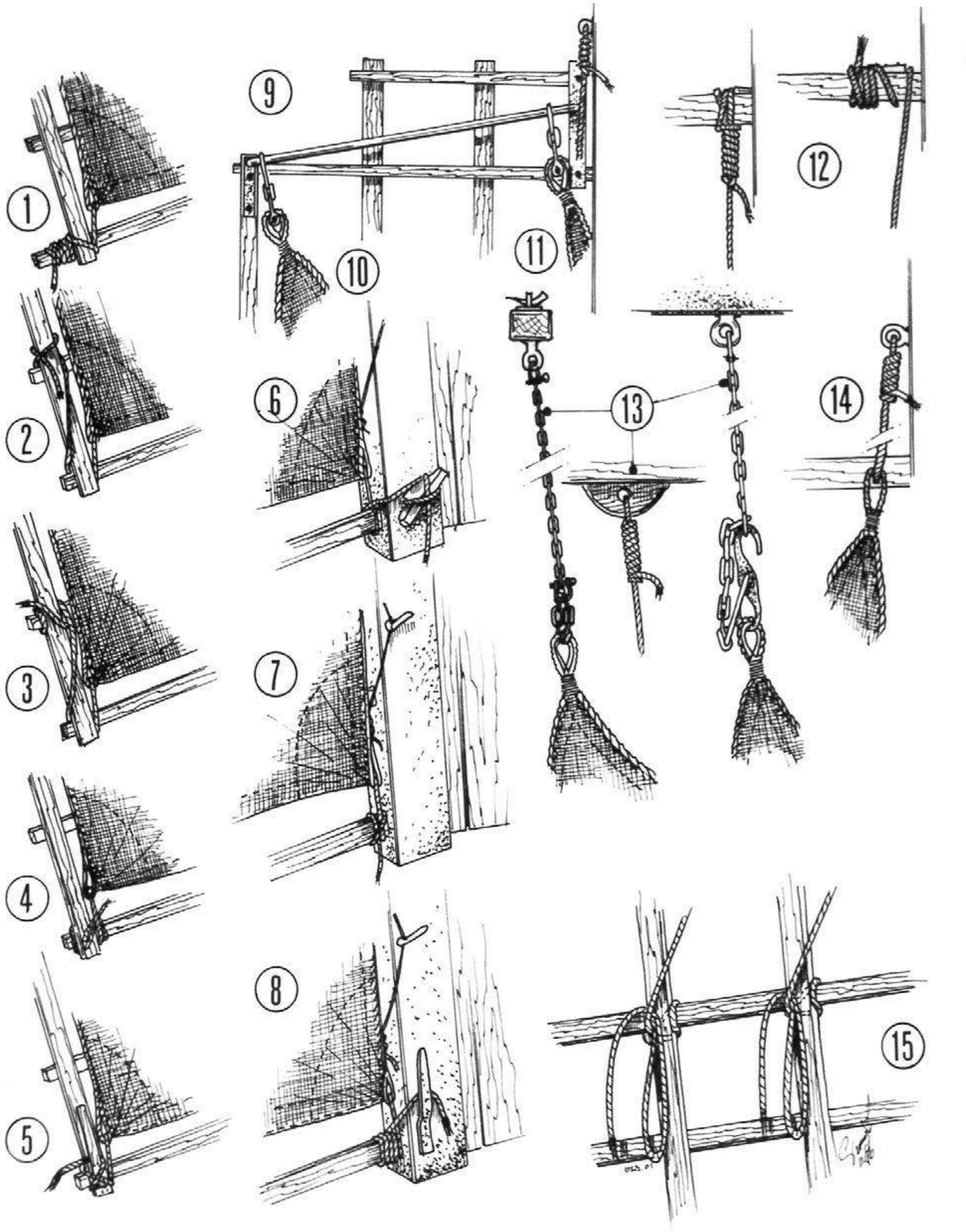
Specify further:
- the use of a rope or sail chain in the upper left-hand corner;
- the desired number of pointing lines;
- the shape of the curve in the upper part of the sail. This can vary greatly by the various regions of the Netherlands. Consult old photographs regarding this if possible; a great deal of what there was originally has already been lost.

The sail, which is cut to size, is braced; a rope is sewn all around the sail, except at the bottom, for reinforcement. The best sewing thread for this is nylon or polyester thread.
The rope used today is often synthetic (polypropylene). It has the appearance of hemp rope. Like synthetic canvas, it barely shrinks or stretches and it is weather-resistant.

For the maintenance of mill sails, see Section 7.6.6.

Fig. 6.3.1.2
Various methods of attaching mill sails

1 to 5. attachment of lower left tie rope
6 to 8. attachment of bottom right tie rope
9. sail rail
10. top left corner of a set sail
11. top left corner of a rolled-up sail
12. attachment of upper right tie rope to the upper sail bar
13. attachment of top left corner with a chain or a rope
14. attachment of upper right tie rope to a sail eye
15. securing the pointing lines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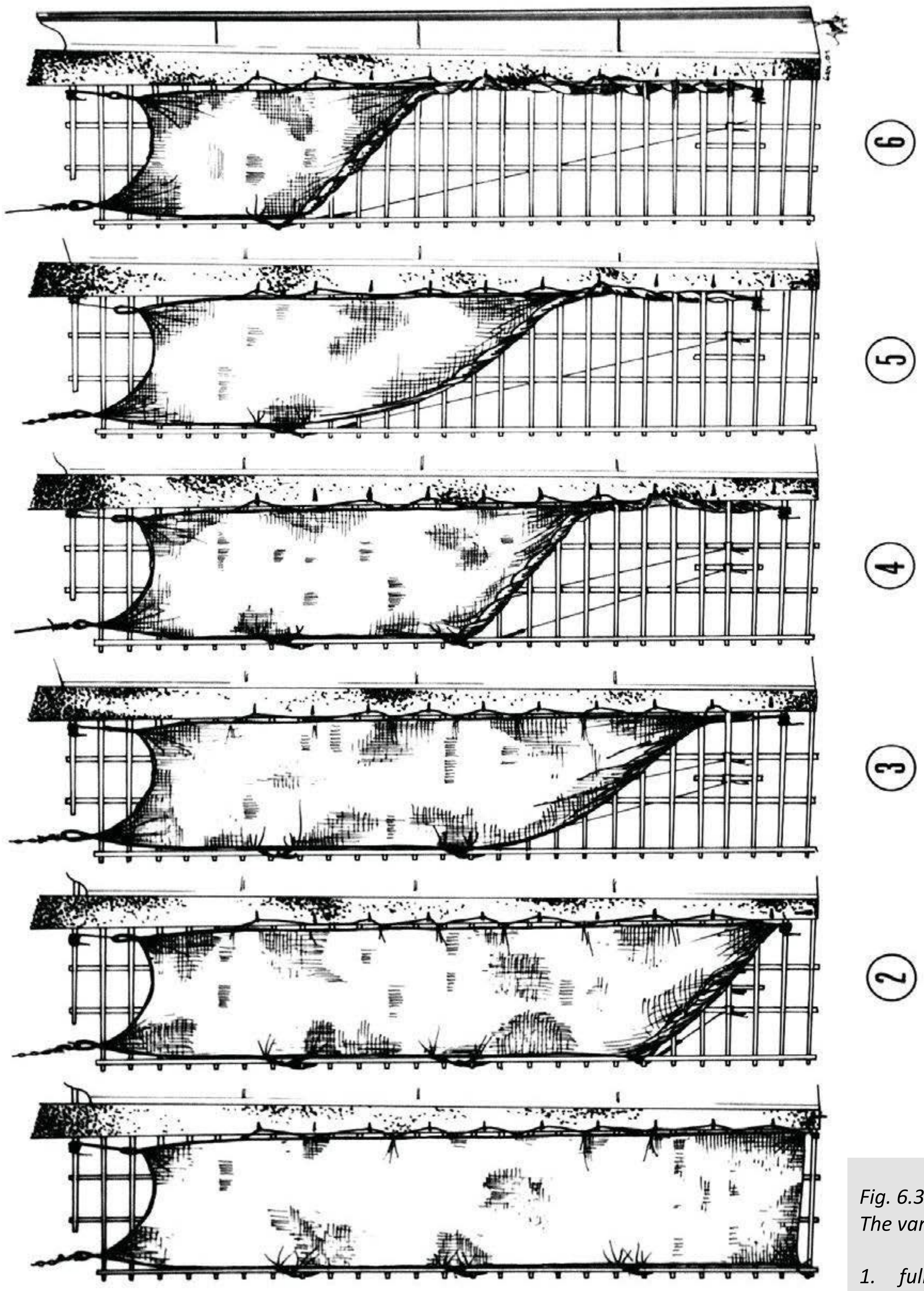


Fig. 6.3.3.1
The various furling positions

1. *full sail*
2. *first reef*
3. *sword point*
4. *dagger point*
5. *three quarters*
6. *quartered*

6.3.3 Furling positions

Insofar as the wind allows, the miller sets as much sail as possible in order to supply maximum energy to the grinding machinery. In weak to moderate winds, this is usually four full sails (see Fig. 6.3.3.1).

full sails

If the wind increases and, in the miller's judgement, the mill is turning too fast, the miller must furl: roll up part of the sails. Here it must be remembered that the outside stock has a greater leverage on the windshaft than does the inside stock; in other words, the outside stock twists more severely on the windshaft than the inside stock does. Therefore, the miller furls first on the outside stock unless the inside stock or its sail frame is of poor quality. Sometimes, due to sail flapping, the choice is made to also furl first on the inside stock.

furling

The following furling options are available (see Fig. 6.3.3.1):

- sail rolled up to the first pointing line: first reef; *(first reef)*
- sail rolled up to the second pointing line, but left long: sword or long point; *(sword point, long point)*
- sail rolled up to the second pointing line, but kept short: dagger or half point; *(dagger point, half point)*
- sail rolled up to the third pointing line, but left long: three quarters; *(three quarters)*
- sail rolled up to the third pointing line, but kept short: quartered; *(quartered)*
- all sails rolled up: empty. *(empty)*
- As a final furling option, the storm boards can be removed.

The rolled-up part of the sail is usually inserted between the sail bars once, sometimes twice.

All kinds of combinations of the aforementioned possibilities are applicable, provided that:

- the same furling position is used at both ends of a stock;
- furling is done on both stocks as much as possible.

This means that running with two full and two empty whips should generally be discouraged. Four halves is much better in such a case.

Indeed, with two full and two empty, the mill turns much more unevenly than with four halves. In a strong gust of wind, a mill with two full sails takes off much faster, since the tops of the two clothed whips react most strongly to wind gusts. Furthermore, it is well known that the cap or cabin of a mill clothed in this way tends to rock back and forth more, especially if there is some wind obstruction. Hence the preference for four half-sails. The mill then runs much more evenly, and the tail and braces suffer less.

When the mill is directly facing the wind, sail flapping can occur.

The wind is slowed down in front of the mill body, resulting in the sail of the passing whip being lifted off the sail frame. Just beyond the body, the sail, now in the full wind, collapses back onto the sail frame. This phenomenon occurs mainly in mills turning without a load. Wind obstruction also increases the likelihood of sail flapping.

Sail flapping can be counteracted by winding the mill slightly anticlockwise so that the lower end has a little more wind from behind or by furling.

6.3.4 Setting or hanging a sail

Beforehand: it is strongly recommended to use fall protection equipment when doing this work!
Wait for a day of little wind, then wind the mill facing the wind and secure the stock chain.
Then the sail that is to be hung is readied. Place the sail package on the mill yard or stage and unfold it completely. Place the pointing lines on it.
Roll up the sail loosely lengthwise or fold it up width-wise, in large zigzag folds, starting at the outer selvedge. The curve in the upper part of the sail then ends up on top of the pile. Then place this roll or pile close to the stock.
If working alone, first secure the lower right tie rope to the bottom sail bar so that the outer selvedge is a good hand width above it. If you are working together with someone then the correct height can be determined later.

Then secure the upper right tie rope to the thimble in the upper left-hand corner. Place the loop thus formed over one shoulder (not crosswise!) and walk upwards, pulling the sail along with you. In this way, you have both hands free and, in case of an emergency or for other reasons, you can easily slip this loop off your shoulder. The sail may not be tied to your body under any circumstances.

On arriving at the top, first put one leg through the sail frame and set your foot behind the sail bar underneath it. This gives you a firm stance. Then detach the upper right tie rope from the thimble, wrap it around the upper sail bar and pull it tight. If the bottom right-hand corner is not yet fixed, determine the correct height in consultation with the person below. Wrap the rope around the sail bar a few more times and secure it. If there is another sail eye above the upper sail bar, use that because it facilitates rolling up and clamping.
After this, attach the upper left-hand corner of the sail to the chain or rope which is hanging from the sail arm or from the eye of the other stock.
Now walk back down and simultaneously place the loops behind the single cleats. From below, check the sail for folds. If there are any, then the upper left-hand corner of the sail will be hanging too high or too low. You can only smooth out the folds by rehanging the upper left-hand corner. For example, if the fold is hanging from the upper right-hand corner to the lower left-hand corner, the upper left-hand corner needs to go upwards. If the fold is hanging from top left to the bottom right, then the upper left-hand corner needs to come downwards. Leave the upper right-hand corner untouched otherwise the entire sail will end up hanging too high or too low.

- If the sail to be carried is ready and rolled up, you can reduce the weight to be carried somewhat by first pulling the lower part of the sail up a little bit and hanging it in a loop through the sail frame and then walking up with the upper part.
- Another method is to use a separate pulley from the hatch to hoist up the sail on the upper left tie rope.
- When taking down sails, the sail chains should be tightly secured to a sail bar.
- When re-hanging (repaired) sails, you should reserve the best one for the inside stock as that is used most often.

If a mill is equipped with a iron rung that limits the adjustability of the upper left-hand corner, then, to smooth out folds, the upper right-hand corner must sometimes be adjusted slightly.

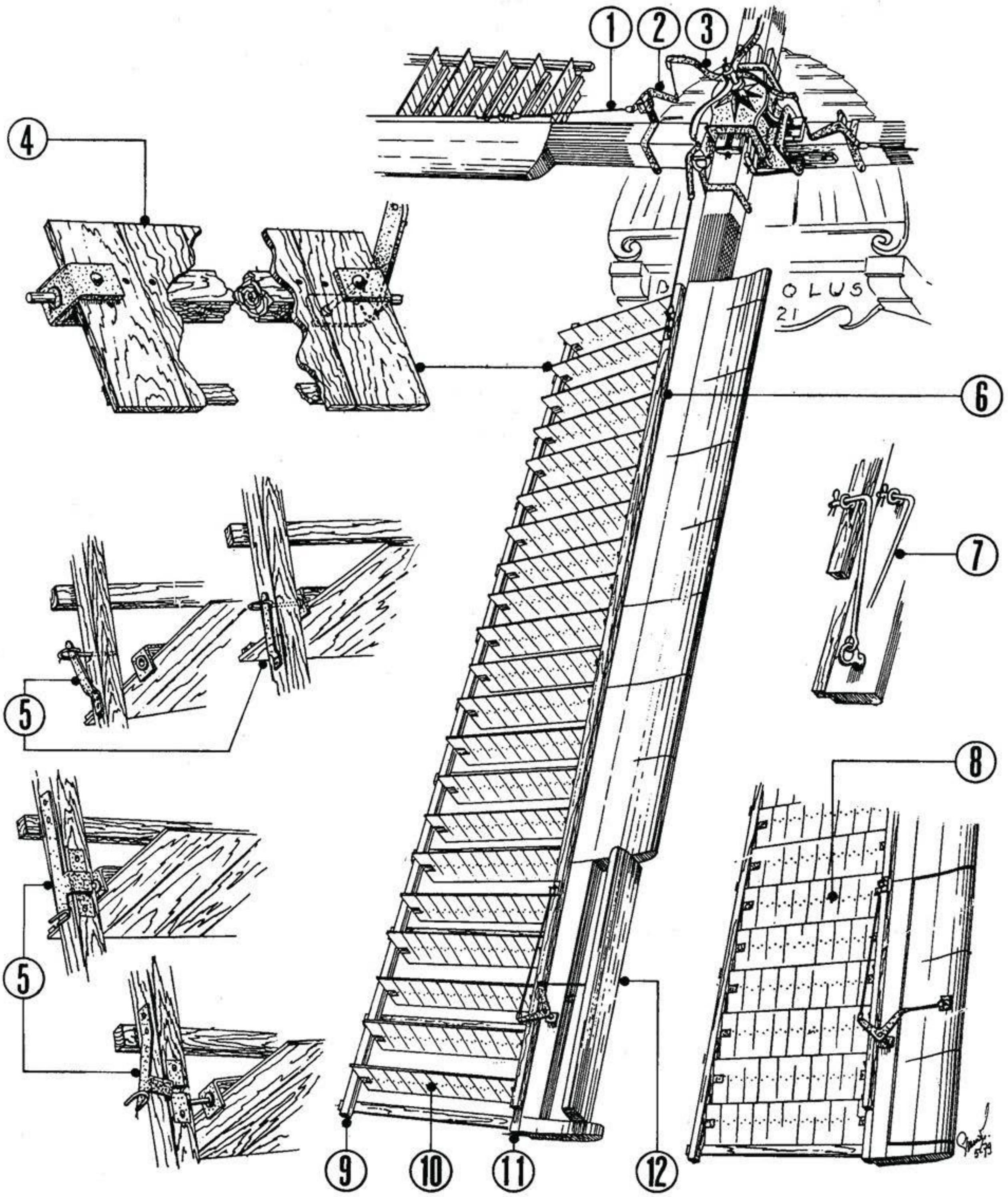
6.4 SAIL SYSTEMS

6.4.0 Introduction

In the early 20th century, technical progress leapt forward. The production of consumer goods gradually was done independent of wind and waterpower. Many industries and households were electrified. Polder mills were replaced on a large scale by mechanical pumping stations. Added to this was the fact that the constant settling of the peat soil meant that more water in the soil had to be pumped up higher.
Corn millers discovered the convenience of motor-driven pairs of stones. They no longer had to wait for wind and the time-consuming work on the sail cross; the winding gear and the brake were a thing of the past. Windmill performance lagged seriously behind that of machines powered by new energy sources such as electricity.
To preserve mills, some things would have to be improved. As early as the end of the 19th century, self-reefing had been introduced in Groningen. This involved replacing the sails with flaps, which could be opened and closed with a single action.
After World War I, in 1918, the knowledge of aerodynamics had advanced rapidly. In the Netherlands and Germany, research into mills was carried out by, respectively, A.G. von Baumhauer and Kurt Bilau. The association '*De Hollandsche Molen*', founded in 1923, took a strong interest in the fate of mills and launched a competition aimed at increasing mill efficiency. This stimulus resulted in numerous designs. Later, others also designed various sail improvements.
Improvements were mainly looked for in terms of streamlining the sail cross. Other systems involve replacing the sail frame with a rotatable flap.
Some sail improvements were so efficient that many mills equipped with them ran too fast in high winds, resulting in an extra load on the brake. This problem was largely solved by the application of air brakes or control boards.
In this Handbook we limit ourselves to the sail systems that still exist in the Netherlands.
We can broadly classify all sail improvements into two groups:

- improvements on the lattice side of the windmill: these mainly involve increasing the ease of operation for the miller;
- improvements on the wind-board side of the sail cross: these relate primarily to efficiency improvements of the sail cross through better streamlining.

The Bilau sail system can be counted among both groups.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6.4.1 Self-reefing

Self-reefing (patent sail) is not a windmill improvement in the sense that it delivers higher efficiency; it primarily serves as a convenience for the miller.

self-reefing

A self-reefing (but with Old Dutch wind-boards) sail cross provides no greater performance than a clothed Old Dutch sail cross but it does save the miller a great deal of time that would otherwise be required for setting, furling, unfurling, removing, etc. the sails.
In fact, self-reefing automatically controls the changing of the wind-catching surface. So the biggest advantage of self-reefing is saving time. A second advantage is the more regular running of the sail cross, provided everything is properly lubricated and adjusted.

flaps
uplongs
flap shafts
shutter bar
crank levers, spider
striking rod
reefing lever
weight chain
mizzen beam

Self-reefing was developed in England in the early 19th century and first applied in the Netherlands in Groningen at the end of that century. In self-reefing, a sail is replaced by a series of wooden flaps. These flaps are perpendicular to the stock between modified 'sail bars'. The hemlath have been replaced by uplongs in which the flap shafts can rotate (see Fig. 6.4.1.1). At each whip, the flaps are interconnected by a shutter bar that ensures they all take the same position. The shutter bars of the four whips meet via fork irons at the canister, where they are connected to the spider by means of crank levers. The spider is located directly in front of the canister and is attached to the striking rod that runs through the entire windshaft and reappears behind the gudgeon. There the striking rod is coupled to the reefing lever, to which an endless chain, the weight chain, is connected. Above the striking rod, the chain hangs via a pulley from a fixed beam, called the mizzen beam. When one of the 'ends' of the chain is pulled from below, the flaps close. The mill starts to turn. However, because the flap shafts are not in the centre of the flaps but are slightly above them, the wind wants to push the flaps open. This is prevented by hanging a weight on the weight chain. During grinding, the miller can change the moment (speed of the mill) of opening ('self-reefing') by adjusting that weight. Putting more weight on the chain keeps the flaps closed longer and increases the speed of the sail cross. With less weight, the flaps open earlier and the sail cross loses speed.
To stop the mill, the miller removes the weight. Pulling on the other end of the chain opens the flaps. The chain is secured to the tail.
The disadvantages are:

- Even when stationary, the cross should be facing the wind. Oblique oncoming wind loads the horizontal stock and thus the entire sail cross and the cap.
- If the wind comes straight from behind, the flaps are pushed shut by the play in the entire system, despite the secured chain! The mill can then start to turn backwards! This can be prevented by securing the shutter bars.
- The paintwork and the many pivot points require a lot of maintenance. However, the use of modern weather and wind-resistant materials has simplified the intensive maintenance.

Most of the mills with self-reefing in the Netherlands are in the province of Groningen. Almost half are equipped with self-reefing on one or both stocks. Friesland also has a number of mills with self-reefing.

Fig. 6.4.1.1
Self-reefing

1. *long coupling rod or tie rod*
2. *crank lever*
3. *spider*
4. *flap*
5. *various latches*
6. *shutter bar*
7. *latch hook to protect against slamming*
8. *closed flaps*
9. *outside uplong*
10. *opened flaps*
11. *inside uplong*
12. *air brake*

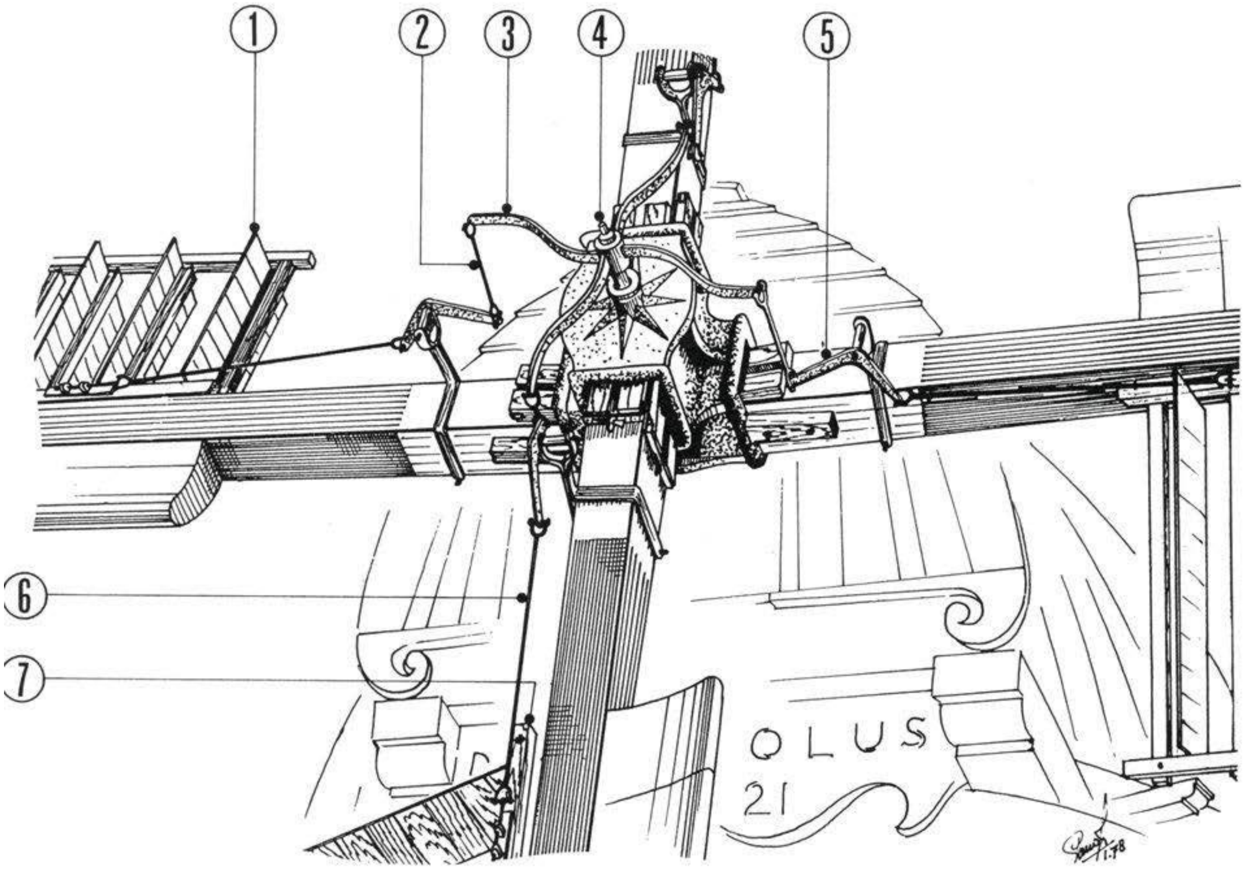


Fig. 6.4.1.2
Canister with spider

1. *flaps*
2. *short coupling rod or tie rod*
3. *spider*
4. *striking rod*
5. *crank lever*
6. *long coupling rod or fork irons*
7. *shutter bar*

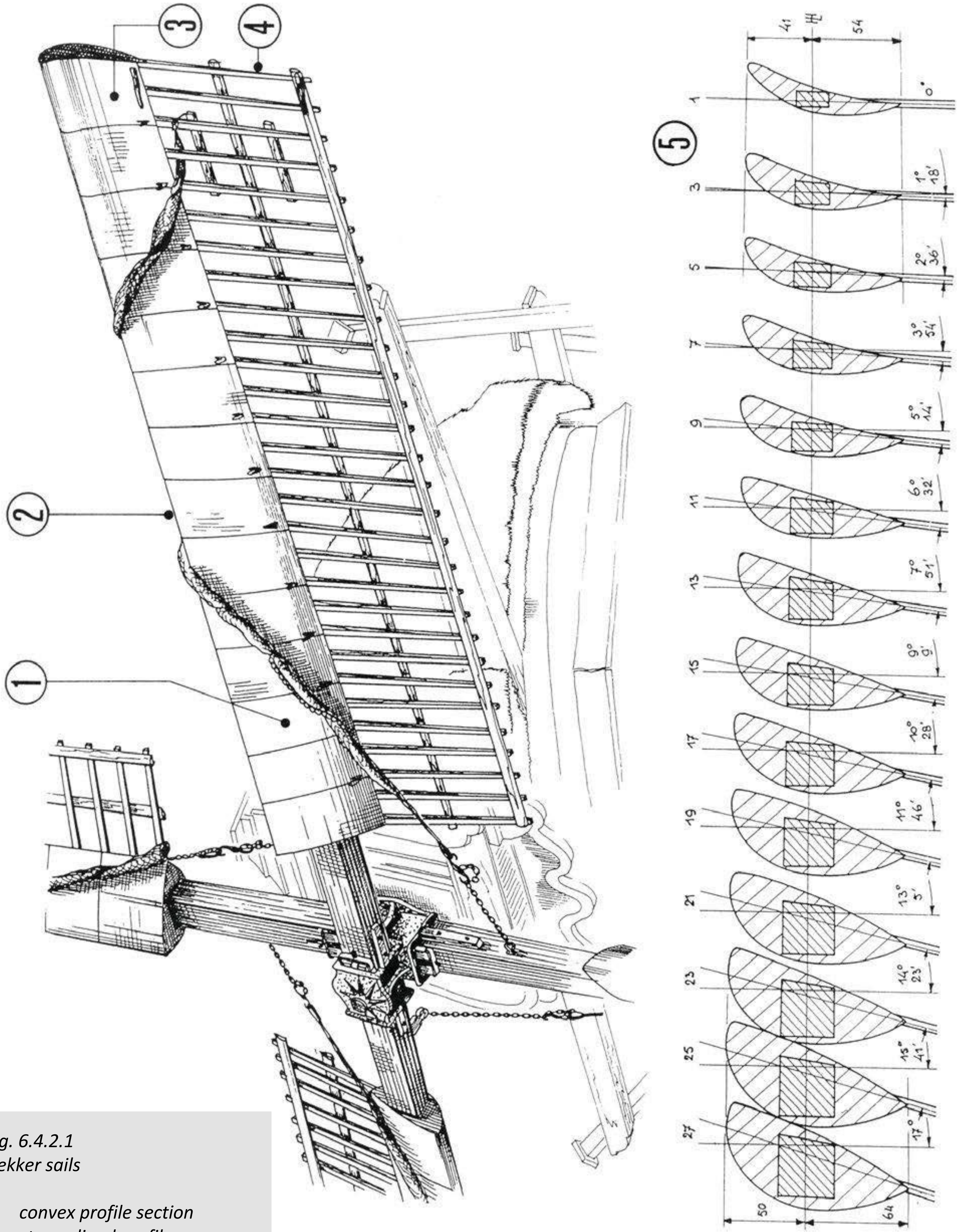


Fig. 6.4.2.1
Dekker sails

1. *convex profile section*
2. *streamlined profile*
3. *concave profile section*
4. *sail with one uplong*
5. *the various profiles*

6.4.2 Dekker and half-Dekker streamlined stock

6.4.2.a Dekker sails

The streamlining of the Old Dutch sail cross is far from ideal. The leading side and the stock cause disturbing air swirls.

Dekker sail

Millwright A.J. Dekker from Hazerswoude developed the Dekker sails. He enclosed the stock in a profile that extended from the front leading hemlath to the first uplong (see Fig. 6.4.2.1). He left the section of sail frame from the first inner uplong to the hemlath intact. The sails were retained but became narrower. The streamlined profile itself consisted of zinc or aluminium sheets nailed to pre-formed wooden profiles. These profiles were attached to the sail bars. The profile had a flat/concave front, a pointed nose and a convex back.

streamlined profile

Dekker's streamlined stocks increased the efficiency of the windmill's sail cross and thus its performance. Especially in low winds, the difference compared to the Old Dutch sail system was great. In contrast, with increasing winds it was necessary to furl earlier. The mill became prone to running away; in other words, it reacted quickly to changing wind strengths. People then tried to counteract that with control boards.

The disadvantages of Dekker sails are:

- Sail flapping occurs easily. Flattening the camber reduces sail flapping somewhat, but does not eliminate it. This problem was never completely solved. Heavily loaded mills are less affected than lightly loaded ones.
- Maintenance cannot be performed on the built-in stock. On the other hand, the stocks are less exposed to weather and wind. Renewing sail bars is also problematical.
- The sail cross catches a lot of wind when stationary. This makes the system less storm-proof.

In the years 1928-1934, many mills (83) were 'Dekkerised'. First to be Dekkerised were polder mills, followed later by grain mills. There are now about fifteen mills in the Netherlands which are still equipped with Dekker streamlined stocks.

6.4.2.b. Slot sail or half-Dekker sail

slot or half-Dekker sail

air gap

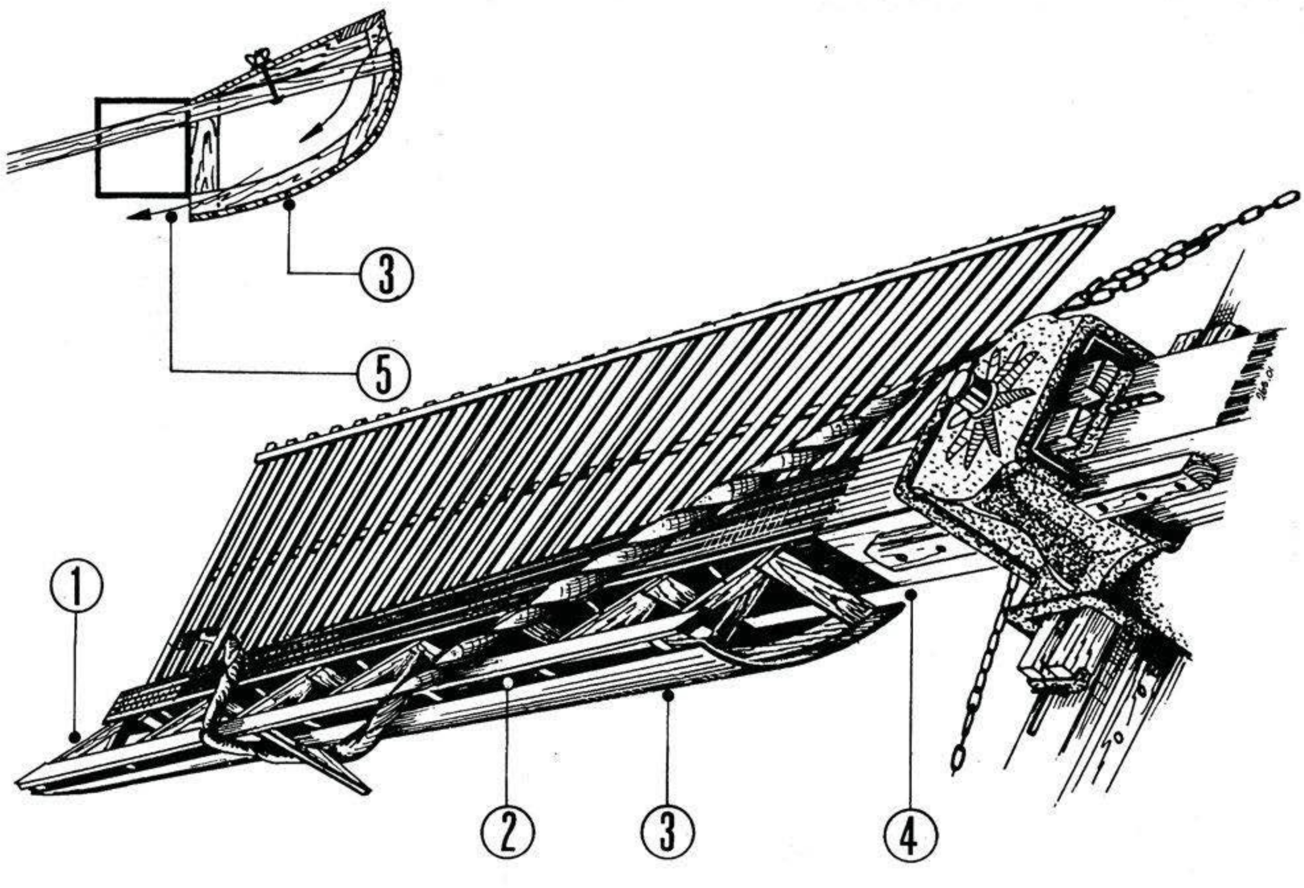
A second streamlined stock by Dekker was the slot sail or half-Dekker sail. Here the leading hemlath with the wind-boards was retained. Only the rear of the stock was streamlined (see Fig. 6.4.2.2). The streamlined profile, made of metal or wood, was installed so that an air gap, through which the wind could flow away, was left both in front of and behind the stock. One advantage was that the wind-boards could be made wider and positioned further forward. This gave the mill greater tractive force and a more regular motion.
Other advantages over the former Dekker sail were:

- The stock remains accessible for maintenance.
- It causes less sail flapping.
- It is cheaper and weighs less.
- It is more appealing to the eye.

But because the principle of the slot was protected by a patent belonging to an engineer called Fauël (see Section 6.4.4) it was not allowed to be applied. Only the streamlining behind the wind-boards remained, hence the name: half-Dekker sail. In the end, it amounts to nothing more than a streamlined stock with an Old Dutch front. Even so, some mills are equipped with it: The Broekzijd Mill at Abcoude and the Groenendijk Mill at Hazerswoude.

Fig. 6.4.2.2
Slot sail

1. *removed wind-boards*
2. *front slot*
3. *streamline cladding*
4. *rear slot*
5. *airflow*



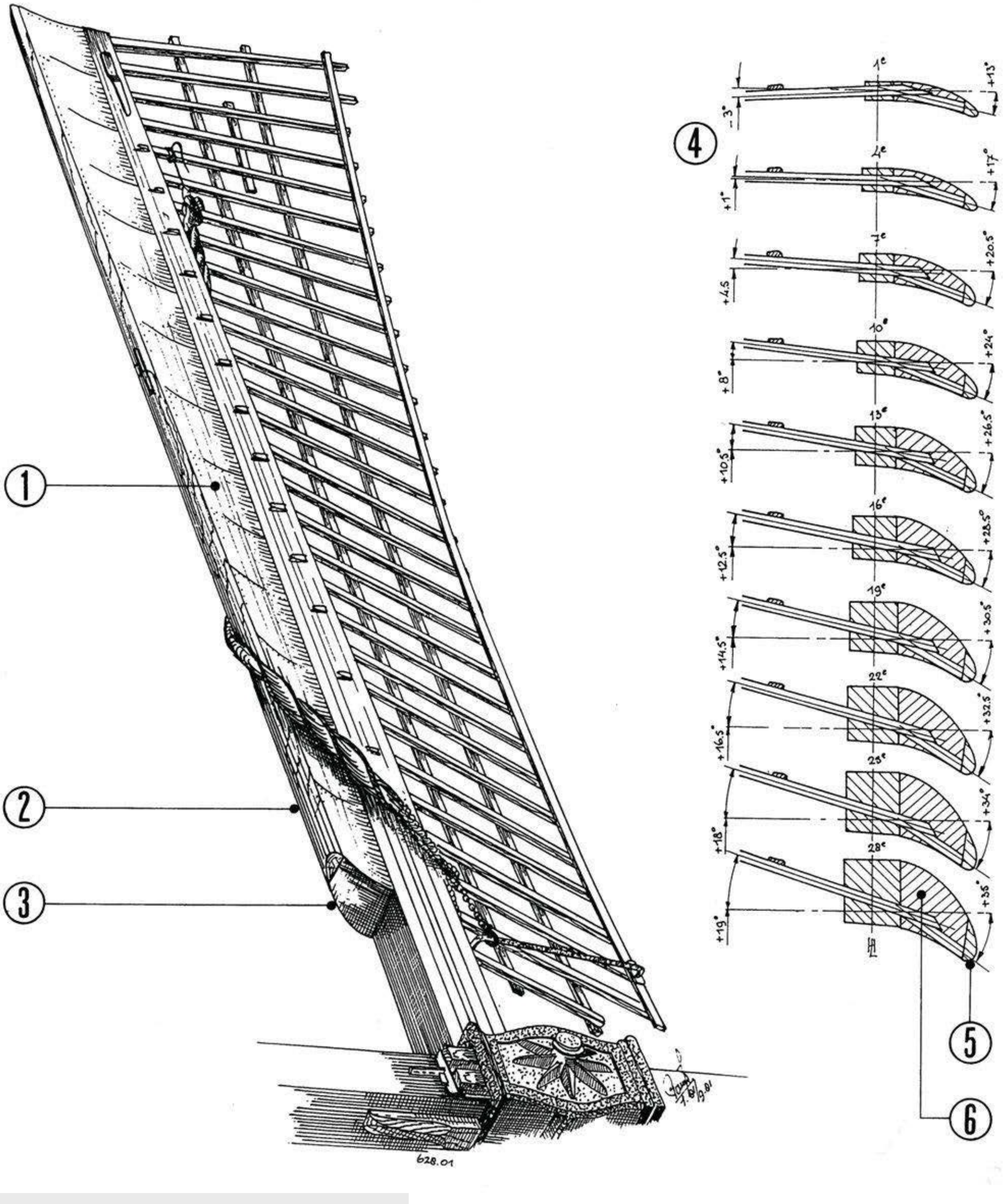


Fig. 6.4.3.1
The Van Bussel streamlined leading edge

1. *concave front*
2. *wooden ledge section*
3. *convex back*
4. *the various profiles*
5. *blunt front*
6. *profile or jib support beam*

6.4.3 Van Bussel streamlined leading edge

Van Bussel sail, Van Bussel nose

Chris van Bussel, a millwright in Weert, saw the disadvantages of the Dekker sails and in 1934 he came up with an improvement that became known as the 'Bussel sail' or 'Bussel nose'. In this variant, the stock is not clad but is provided with a streamlined leading edge. The sail frame remains unchanged (see Fig. 6.4.3.1).

profiles, jib support beams
spoon shape

The nose is concave in front, convex behind, and blunt. The streamlined profile is composed of several pre-formed profiles or jib support beams on which a thin sheet of iron or aluminium is nailed. This spoon shape, as Van Bussel himself called it, has great advantages over the Dekker sail:

- Sail flapping is greatly reduced.
- The hollow/convex profile gives the mill a greater tractive force and the mill runs faster.
- The mill turns more in a more regular manner.
- It is cheaper because less material is needed; therefore, it is also lighter.
- It has a much nicer appearance; three sides of the stock remain visible.
- Van Bussel's blunt nose is aerodynamically better than Dekker's pointed nose.
- It is more storm-proof because the wind-catching surface is smaller.

Disadvantage:

- With this system, unloaded or lightly loaded mills can more quickly run out of control.
  This is why grain mills usually have air brakes in the Van Bussel nose. These flaps open as the wind increases so that the mill rotates evenly (see Fig. 6.4.8.1).

Van Bussel noses thus provide an efficiency improvement for the sail cross. Because the sails are maintained, the ease of operation for the miller does not increase.
In the years after 1936, many grain mills were 'Busselised'.
At polder mills, the system was used less frequently. Currently, more than 80 Dutch mills are equipped with this system.

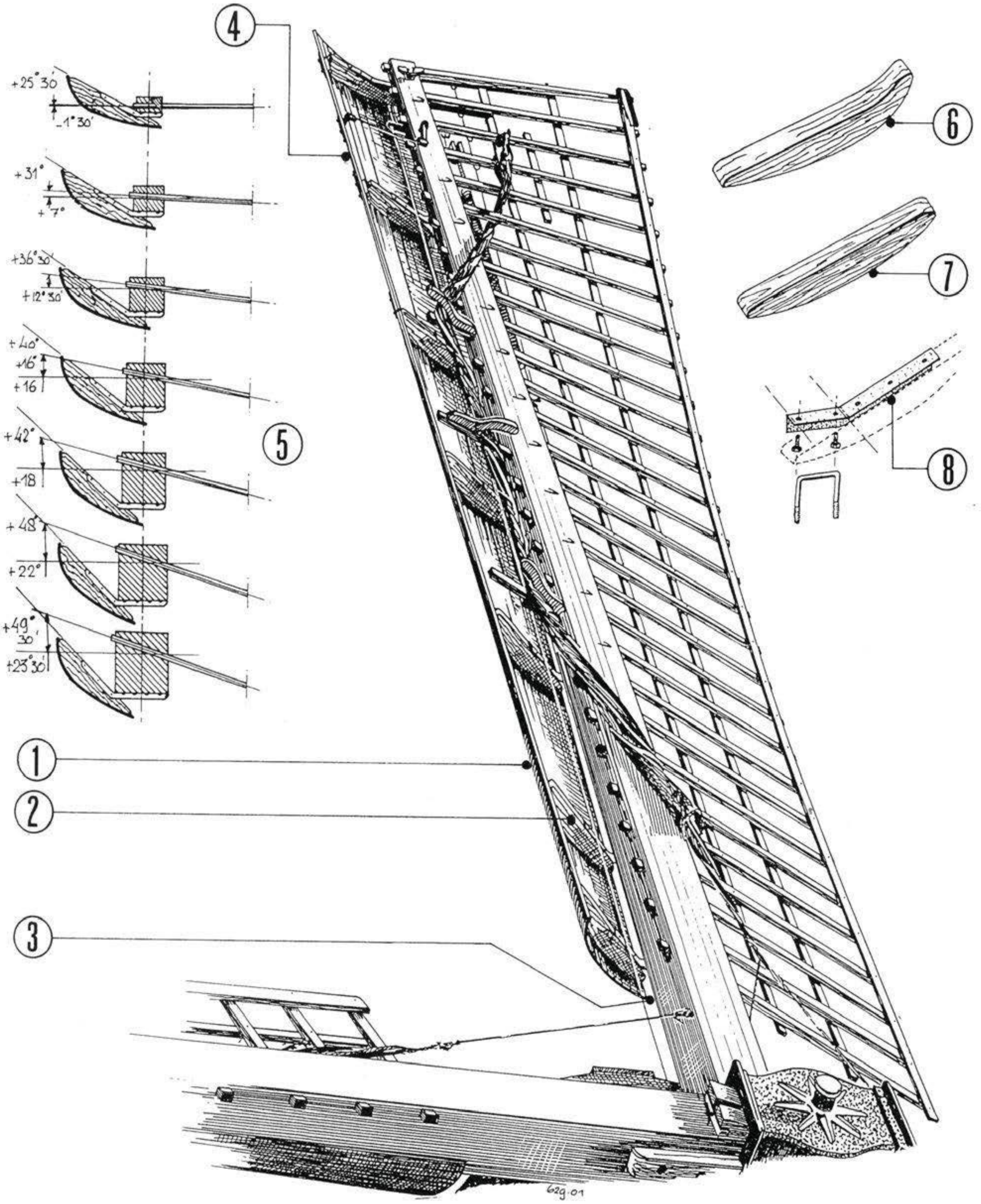


Fig. 6.4.4.1
Jib sails

6.4.4 Jib sails

jib sail

In 1946, Fauël's jib sail made its appearance. Again, this was an improvement to the wind-board side. Fauel himself came up with the name 'jib'. He had looked closely at sail boats. As early as 1936, he was experimenting with a jib sail on the sail cross of grain mill *Den Arend* (The Eagle) in Bergambacht, with promising results. Because Fauël also had other jobs and due to the outbreak of World War II, it wasn't until 1946 that a mill was equipped with this system.
In a jib sail, the wind-board section of the Old Dutch set-up is completely replaced by a curved wooden profile that ends behind the stock and leaves a wide air gap open (see Fig. 6.4.4.1). The jib consists of narrow planks which are screwed, by means of tongue and groove, to fit preformed jib support beams.

jib support beams, jib supports

These jib support beams are mounted on angle-irons, the jib supports, which are attached to the stock. Each jib support has a different angle to give the jib a rotation favourable for wind conduction.
The jib is an open streamlined leading edge. The concave inner side captures and conducts wind, giving rise to tractive force while the convex rear provides the desired streamlining. A jib, by virtue of its shape, pulls even a stationary sail cross.
The curvature of the jib may vary. In the case of jibs based on a circular arc (single-radius profile), the deepest point of curvature is in the centre of the jib. However, most jibs are made according to an elliptical curve (double-radius profile). These have the deepest curvature more to the front, creating an aerodynamically better streamline.

Benefits of jib sails:
- A mill with jibs runs very easily, even in low winds. Because a strong airflow is created between the jib and the stock when turning, the underpressure behind the sail increases greatly, resulting in a large tractive force.
- Due to this increased underpressure, sail flapping is a thing of the past, provided the jib is properly constructed.
- There are no changes to the stocks and sail frame.
- Everything remains easily accessible for maintenance and repair.

Disadvantages:
- Above a speed of 50 to 60 whips, the sail cross reacts strongly to suddenly increasing winds and to gusts. A mill with jibs will soon start to run away.
- Another disadvantage is that the brake is sometimes unable to stop the mill under all conditions.
This drawback can be overcome with air brakes (see Section 6.4.8).

Of all the sail system improvements, the jib sail is the most widely used in the Netherlands. There are over 150 mills equipped with jib sail systems.

Jib sails, like Dekker sails and the Van Bussel nose, increase efficiency. But there is a difference in their operation. A jib, by virtue of its shape, will always want to set the sail cross in motion when the wind strikes it, even when the mill is stationary.
Dekker and Van Bussel's streamlined profiles only start to do their work when the wind is flowing past them, that is, when the sail cross has gained some speed.
Compare this to the profile of an aircraft's wing: Only when there is sufficient speed does lift occur.

Fig. 6.4.4.1
Jib sails

1. *jib*
2. *jib support beam*
3. *air gap*
4. *air brake*
5. *various jib support beam positions*
6. *jib support beam with double-radius profile*
7. *jib support beam with single-radius profile*
8. *jib support*

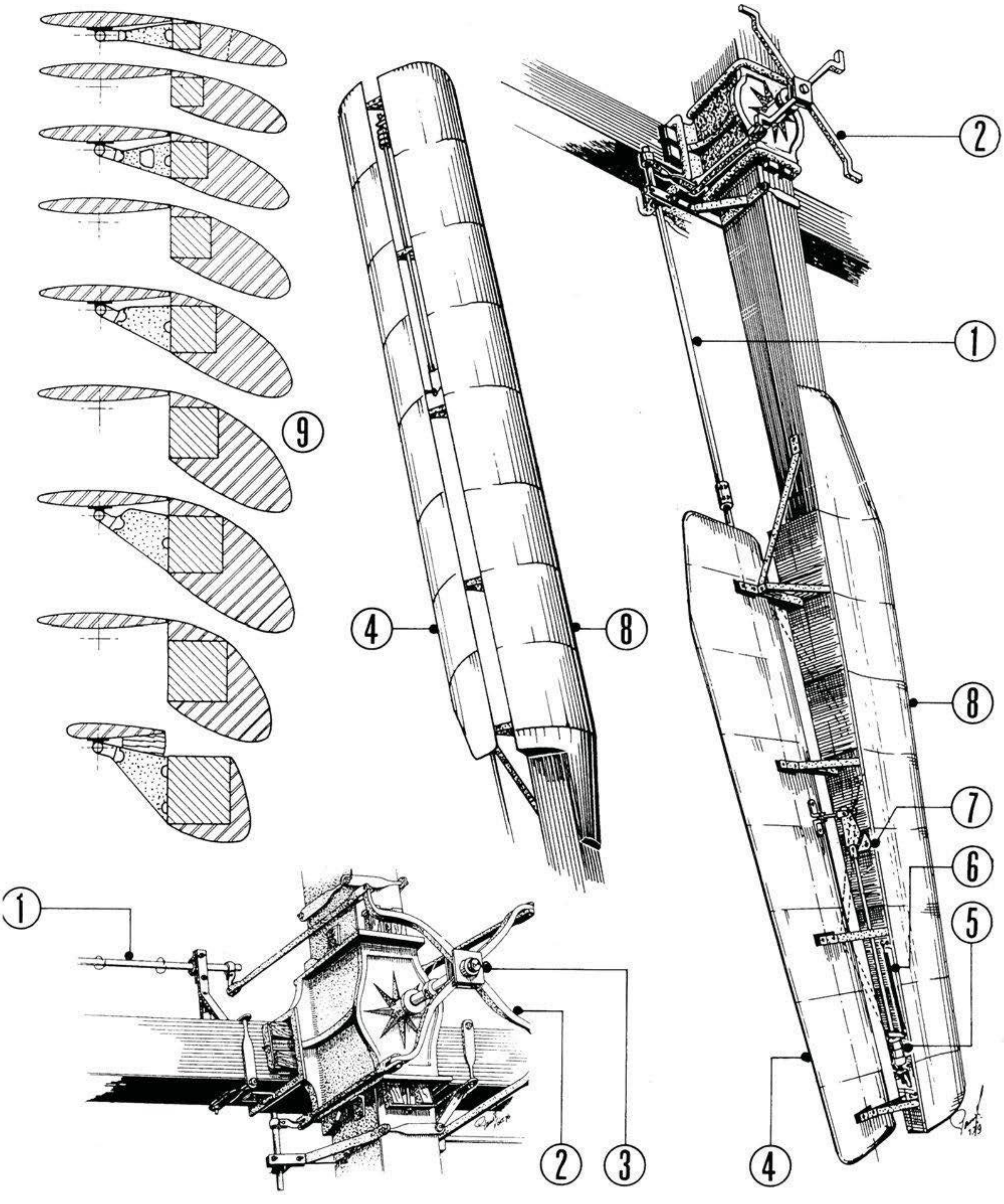


Fig. 6.4.5.1
Bilau sails

6.4.5 Bilau sail system

Bilau sail

In the early 20th century, the German major Kurt Bilau performed many calculations on mills and developed a revolutionary sail system called 'Ventikanten', better known in the Netherlands as Bilau sail, in Germany around 1930. The grain mill at Ovezande near Goes was the first Dutch mill to be equipped with this system, in 1935.

streamlined flap

weight chain

Bilau based it on the principle of an aircraft wing (see Fig. 6.4.5.1), clad the stock with an aerodynamically tested sheet iron fairing, and replaced the sail frame with one long streamlined flap. The flap is narrower than the sail frames and about the same width as the nose profile. The flap turns on four or five bearing supports attached to the stock. When closed, the back of the flap and the nose form one streamlined unit. The flaps are operated by a weight chain, etc., as described in Section 6.4.1. When the mill is stopped, the flaps are open. Pulling the chain closes the flaps and makes the mill turn. A weight on the chain keeps the flaps closed.

centrifugal governor

In addition, sometimes each whip was provided with a centrifugal governor. This is a fine-tuning adjustment to keep the set sail speed constant in wind gusts.

centrifugal weights
tension spring
rocker

This governor is located at the front of the stock. It consists of a number of centrifugal weights held in a rest position on a guide rod by a tension spring. In a gust of wind, the speed of the sail cross increases and the centrifugal force causes the weights to attract a rocker attached to the stock, causing the flap to open ('gap'). This disrupts the streamlining, causing the mill to drop back to the set speed. The tension spring returns the weights and thus the flap to their former positions.

The governor works most favourably when the flaps are already slightly open at the desired rotational speed so that the tractive force of the spring and the centrifugal force balance each other out.

weight chain

Now the centrifugal weights operate not only the flaps but — via the spider, the striking rod and the reefing lever — also the aforementioned weight chain with the weight. By increasing or decreasing this weight, the miller can determine the moment of opening and, therefore, the rotational speed of the sail cross. Advantages:

- The Bilau sail runs in low winds, develops great tractive force, and provides high efficiency.
- The flap of the Bilau sail only needs to open slightly to totally disrupt the streamlining (see Fig. 6.4.5.1), with the result that the rotational speed decreases rapidly.
- The ease of operation for the miller is great.

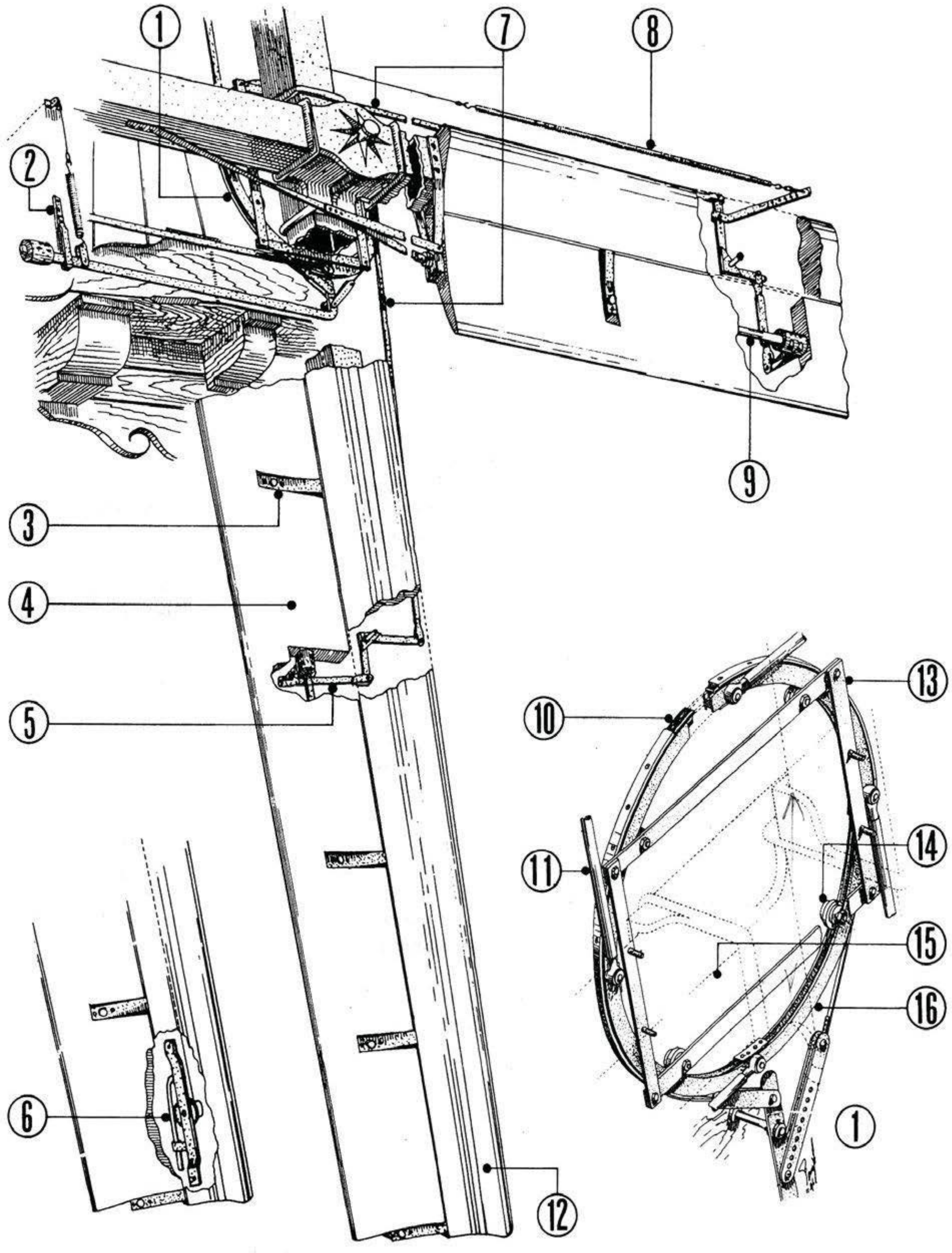
Disadvantages:

- The major drawback is the heavy and expensive construction. The old stocks were not designed to handle so much extra weight (about 1 tonne!). People underestimated the great forces involved in braking, so these old stocks sometimes broke or buckled at the location of the sail frame bar holes.
- When at a standstill, the cross catches a lot of wind. Consequently, the system is not very storm-proof.

As far as is known, there were about 14 mills in the Netherlands equipped with this system in the 1930s. For many years, Mill *De Hoop* (The Hope) at Norg in Drenthe was the only remaining mill with the Bilau sail system but in 2010 this system was also reinstalled on the outer stock of the mill at Ovezande.

Fig. 6.4.5.1
Bilau sails

1. *flap shaft*
2. *spider*
3. *striking rod*
4. *flap*
5. *governor weights*
6. *governor spring*
7. *rocker*
8. *streamlined leading edge*
9. *the various profiles*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6.4.6 Van Riet sail system

The millwrights Van Riet, from Zeeland, and Ten Have, from Gelderland, built their eponymous sail systems according to the same principle as Bilau. Both were based on a one-piece rotating flap.

Van Riet system,

streamlined stock

Around 1935, Van Riet developed a system that, of these two systems, most closely resembled Bilau's. This system also features a wing-shaped flap that, when closed, connects to a streamlined stock. The shaft of this flap is supported in a number of metal bearing supports attached to the stock.
The whole thing almost completely approximates the shape of an aircraft wing. However, this version of the Van Riet system has only been used once, namely on the mill at Nispen (North Brabant province).

closing winch, brace wires
striking rods, spur pinion
guide rollers,

brake band

In this version, the system is operated by means of a locking mechanism consisting of a small closing winch, brace wires and several striking rods. The striking rods are attached to a spur pinion (see Fig. 6.4.6.1), which is encased in four guide rollers over which it can rotate. The guide rollers are mounted on an iron framework fixed behind the canister on the inner stock. Around the spur pinion is a brake band that can be tightened with a steel wire. This steel wire runs through the cap and exits next to the geared hand winch at the base of the tail. There are different versions of the spur pinion but they all operate in the same way.
To start grinding, the miller must first close the flaps with the small closing winch attached to one of the stock ends.
So this end should always be down.

governor spring

After a few turns of the winch, the flaps are closed. With two or three more turns, the governor spring is tensioned. The miller uses this tension to determine the moment of opening the flaps during grinding.
When the wire cable coming from the spur pinion is pulled during grinding, the spur pinion is slowed down slightly by the brake band. The flaps open and the mill can be braked.
Later, in Oud-Zevenaar, Van Riet replaced the mechanism of the spur pinion with that of the spider as used, among other things, in self-reefing: that is, with a bored-through windshaft.
In still later versions, the spur pinion returned, but the streamlining was simplified (see Eindewege version, Fig. 6.4.6.2). The flap became a simple flat or slightly curved rotatable metal plate.
The Van Riet system never caught on particularly. This system is still to be found at the mound mill in Nispen, at *De Oude Molen* (The Old Mill) in Colijnsplaat, and at mill *Nooit Gedacht* (Never Expected) in Eindewege.

Fig. 6.4.6.1
Van Riet sail, Nispen version

1. *spur pinion*
2. *lever operation*
3. *flap bearing support*
4. *flap*
5. *short striking rod or tie rod*
6. *closing winch*
7. *striking rods*
8. *governor spring*
9. *flap shaft*
10. *brake band of the spur pinion*
11. *striking rod*
12. *streamlined leading edge*
13. *striking rod frame*
14. *guided roller*
15. *inner rod*
16. *spur pinion*

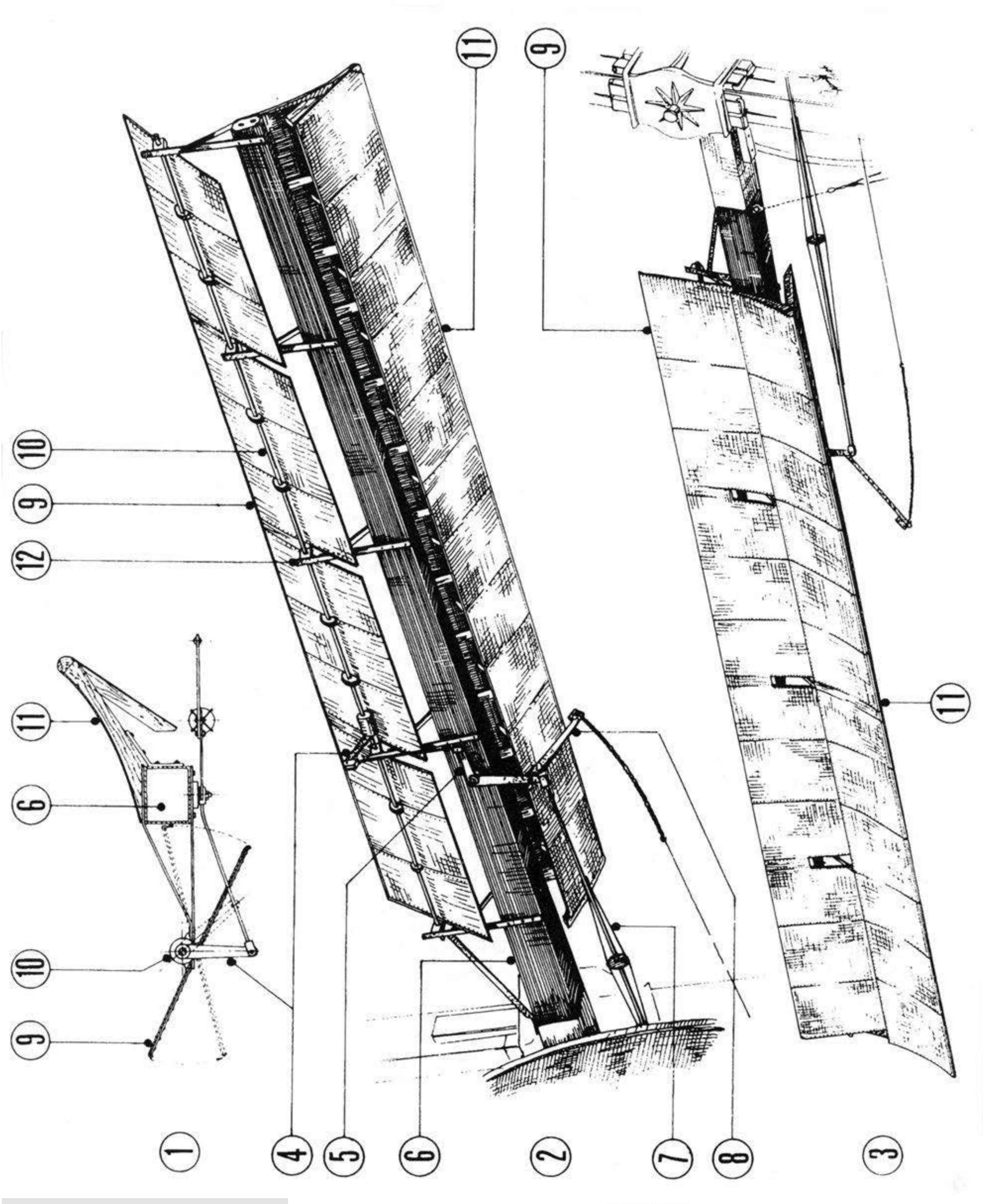


Fig. 6.4.6.2
Van Riet sail, version at Eindewege

6.4.7 Ten Have sail system

hollow wooden flaps

shaft flap
shaft support

This system was devised in the late 1930s by millwright Ten Have from Vorden (Gelderland province). He replaced the Old Dutch sail frame with somewhat hollow wooden rotatable flaps, each consisting of four linked sections. The flaps consist of thin strips nailed to ribs that define the concave shape. Through the aforementioned ribs runs the flap shaft which is supported on five slightly curved metal flap shaft supports. Over these supports, directly against the stock and at the ends, there is a heavy hemlath. The flaps connect precisely to the framework formed by this and together form an even wind-catching surface. With a few exceptions, the Ten Have system is applied to only one stock, namely the inside stock.
The outside stock is then fitted with the Old Dutch sail frame, with or without Van Bussel streamlined noses or jibs.
In many cases, a stock with Ten Have flaps is combined with streamlined cladding from the Van Bussel system.

fork irons

reefing lever
rocking lever

weight chain

To operate the flaps, Ten Have initially applied a spur pinion; later he used a bored-through shaft with a striking rod.
The flaps are opened or closed with fork irons laid parallel to the stock. These tie rods are connected to the spider in front of the canister, which is operated by the striking rod. Again, the operation is similar to that described for the self-reefing sail system. Ten Have applied two different systems to move the striking rod forward and backward through the windshaft.
In the first case, he pulled the rod forward or backward using a reefing lever or rocking lever on the back of the cap (see Fig. 6.4.7.2 & Fig. 6.4.7.3). In the second case, this was done using a circular chain which, via gear wheels and a feed rack, was used to move the striking rod forwards or backwards (see Fig. 6.4.7.4). As the speed of the sail cross increases, the flaps want to open, mainly due to the underpressure occurring behind the flap. To counteract this, a weight is hung on the weight chain. The size of the weight allows the moment of opening the flaps to be set.

Fig. 6.4.6.2
Van Riet sail, version
at Eindewege

1. *cross section*
2. *sail with open flap*
3. *sail with closed flap*
4. *crank*
5. *crank lever*
6. *inner rod*
7. *striking rod*
8. *arm for governor spring*
9. *flap*
10. *flap shaft*
11. *streamlined leading edge*
12. *flap bearing support*

When leaving the mill, the inside stock with the flaps is always horizontal with the flaps open. This way, the wind cannot get a grip on the flaps from any direction. If the stock with the flaps is vertical, the wind from the side, in particular, does have a hold on the flaps.
In the Netherlands, as many as 28 mills were equipped with Ten Have sails as of 1996. This sail improvement is to be found especially on grain mills in the eastern part of the Netherlands; Gelderland province has 21 of them. Grinding with this system is considered by millers to be extremely pleasant.

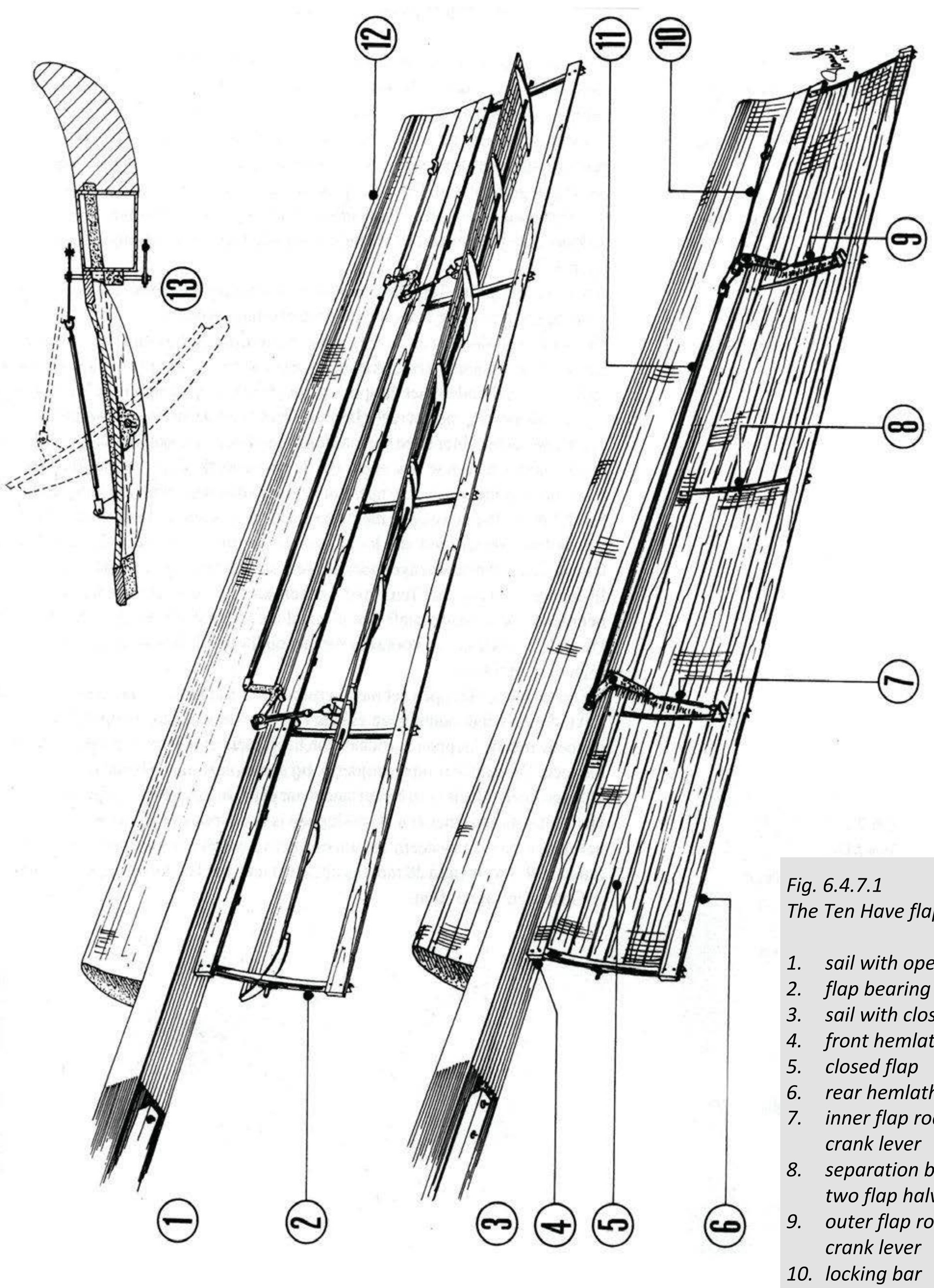


Fig. 6.4.7.1
The Ten Have flap

1. *sail with open flap*
2. *flap bearing support*
3. *sail with closed flap*
4. *front hemlath or coupling lath*
5. *closed flap*
6. *rear hemlath or coupling lath*
7. *inner flap rod with crank lever*
8. *separation between the two flap halves*
9. *outer flap rod with crank lever*
10. *locking bar*
11. *flap coupling rod*
12. *streamlined leading edge (Van Bussel)*
13. *cross section*

Fig. 6.4.7.2.
Reefing lever behind on the cap

1. *mizzen beam*
2. *reefing lever, rocking lever*
3. *fang staff*
4. *weight chain*

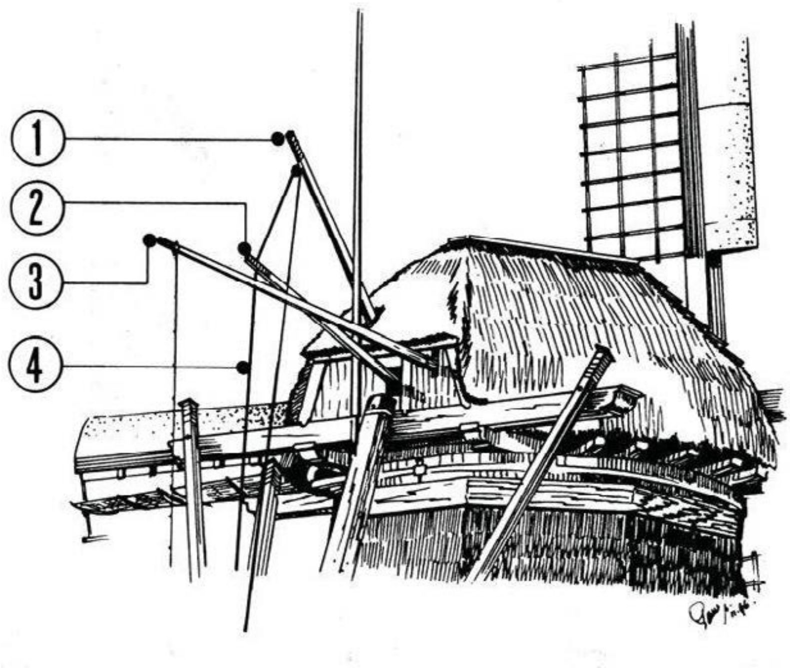
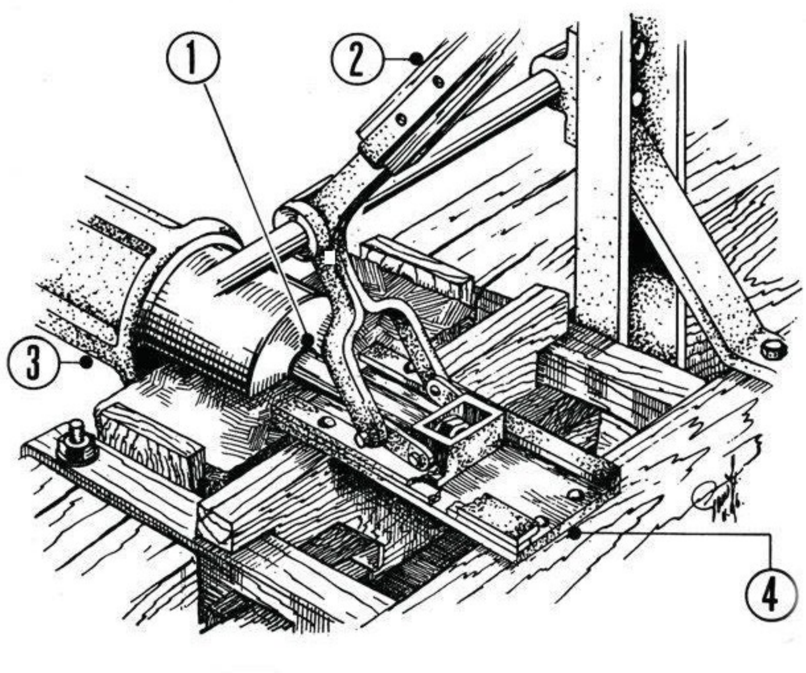


Fig. 6.4.7.3
Operation with reefing lever

1. *striking rod through the shaft*
2. *reefing lever*
3. *windshaft*
4. *guide striking rod*



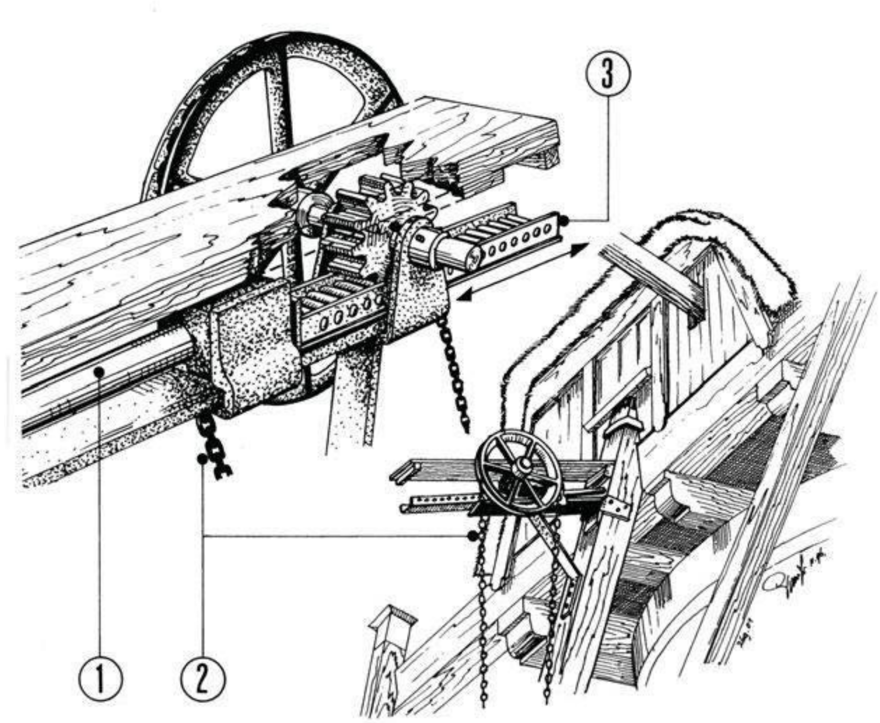


Fig. 6.4.7.4
Operation with a rack and pinion

1. *striking rod*
2. *weight chain*
3. *rack and pinion*

6.4.8 Air brakes

Sail improvements led to mills being able to grind with less wind. Soon, however, it became clear that streamlined sails were more difficult to brake in strong winds, if at all. Mills with improved sail crosses already had to stop under conditions in which mills with Old Dutch sail crosses could still continue grinding. The benefit of more operational days with weak winds threatened to be offset by fewer operational days with strong winds.
Grain millers saw that their improved sail crosses reacted too violently to wind gusts, resulting in a more irregular grinding process.
This problem was solved by applying air brakes or control flaps

air brakes, control flaps

Air brakes and control flaps are parts of the streamlined leading edge of the sail cross that are rotatable about their longitudinal axis. Opening them disrupts the streamlining of the sail cross and slows the mill down. However, in some mills with self-reefing, such as the mill 'Eureka' in Wetsinge, the air brakes are not in the streamlined leading edge. Instead, the lower two or three shutters act as air brakes, which in that case are arranged transversely to the other shutters.
Because the air brakes in this construction are further away from the streamlined leading edge, the braking effect is lesser, however.
Air brakes are most commonly used in sail improvements such as Dekker, Van Bussel, and Fauël's jib sail system. Also, some mills with Old Dutch sails are equipped with air brakes because they are so efficient.

Operating the brake or control flaps is done in two ways: manually or automatically.

manual operation

spur pinion, air brakes

Manual operation uses a bored-through shaft with a tangential rod and a spider on the shaft head as previously described for self-reefing. Sometimes they are operated with a spur pinion. Regarding air brakes in particular: if the mill goes too fast the miller opens the air brakes and reduces the speed. Braking and furling are then possible.

automatic operation, centrifugal force

Automatic operation uses the centrifugal force produced by a rotating sail cross.

governor arm

adjustable tension spring

Attached to the coupling rod of the air brake is a governor arm with a weight attached. Also attached to this governor arm is an adjustable tension spring that neutralizes the weight and causes the flap to close.

With a rotating sail cross, the weight wants to move toward the stock-end under the influence of centrifugal force. This is initially countered by the tension spring but as the rotational speed increases and the centrifugal force increases, the spring is stretched and the flap opens. The speed of the sail cross decreases and the tension spring closes the flap again. With this construction, we prefer to speak about control flaps or boards instead of air brakes.

control flaps, control boards

Control flaps regulate the course of the sail cross by neutralizing the effect of wind gusts. Adjusting the tension spring more or less tightly determines when the flaps open.

Furthermore, the tension springs of two opposite whips are often interconnected by a steel wire and an equalizer to obtain simultaneous opening and closing of both control flaps.

A disadvantage of automatic operation is that the mill is difficult to brake in high winds. As soon as the brake slows down the mill, the spring closes the flaps and the speed increases again. This puts extra stress on the brake.

air brake damper

As a solution to this, a hydraulic air brake damper is installed on the governor arm. This delays the closing of the air brake and allows the miller to brake the mill before the flap is closed again.

In sail systems with self-reefing, the air brake rod is attached to the shutter bar in front of the flaps so that shutters and air brake valves operate synchronously. This allows them to be operated both automatically and manually: The wind pressure on the flaps as well as the centrifugal force exerted on the weight of the shutter bars cause the flaps to open and thus the air brakes, too. The size of the weight on the weight chain determines the speed at which this occurs. But by manually operating the weight chain, the miller can also open the flaps and thus the air brakes at any time.

In the presence of brake or control flaps, the following applies at all times: Prolonged running with opened flaps ('gaps') causes improper loading of the sail cross. This is not a testimonial of good millership: furling should take place! It is a good practice when leaving the mill to open the air brakes, which reduces the influence of the wind on the sail cross.

Fig. 6.4.8.1 (next page) Air brakes and control flaps

1. *wooden air brake in Old Dutch wind-board*
2. *flap in jib sail of a spider mill*
3. *control flap in a jib sail*
4. *control flap in a Dekker streamlined sail*
5. *air brake in a Van Bussel nose with self-reefing*
6. *governor mechanism with hydraulic damper*

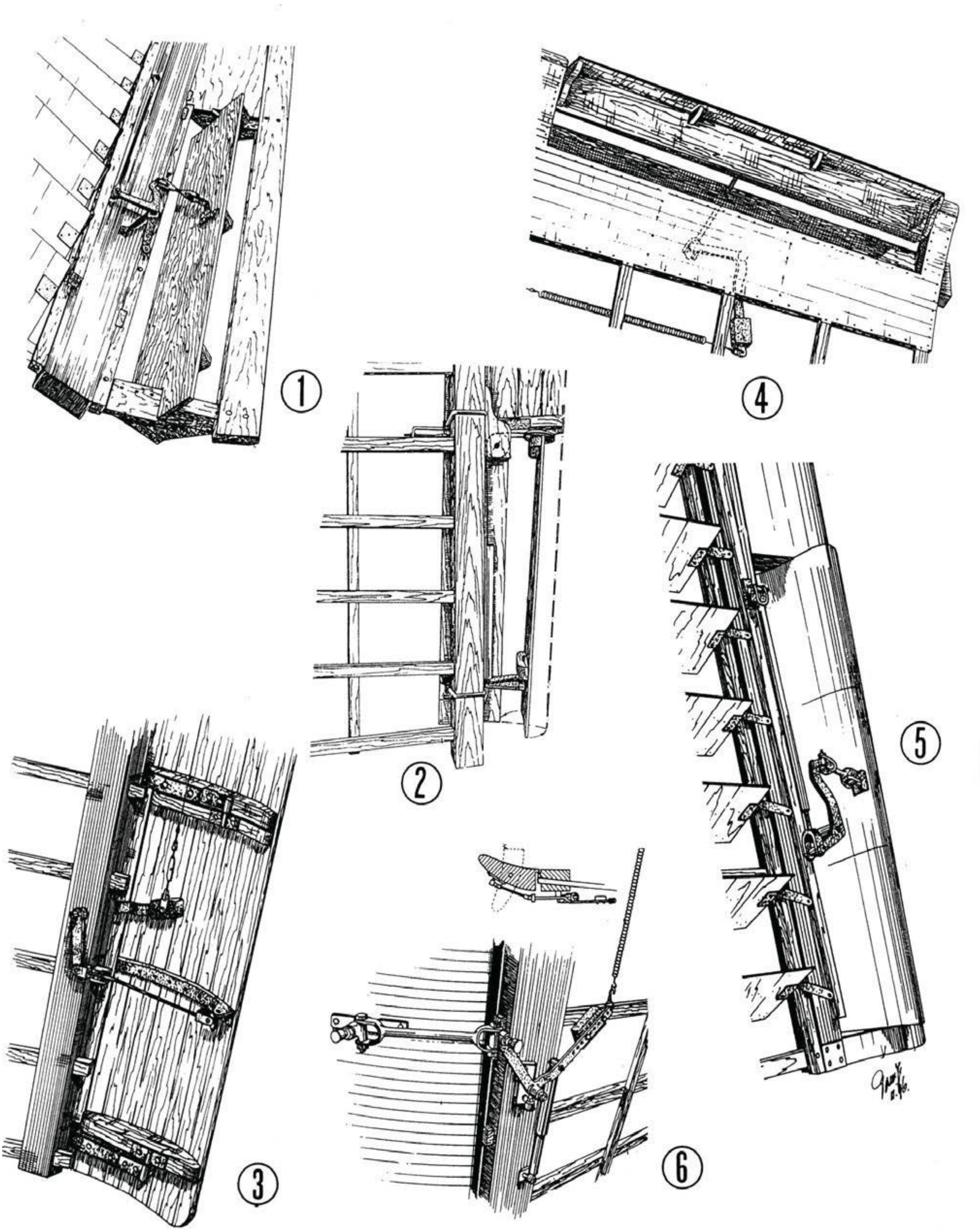


Fig. 6.4.8.1
Air brake and control flaps

6.5 MILL WHEELS

6.5.0 Introduction

The various wheels in a mill allow the motion of the windshaft to be transmitted to the machinery. The wheels ensure that the machinery is given the correct revolution speed relative to the speed of the sail cross. Depending on the type or function of the mill and the machinery present, the number of wheels can vary greatly: from three to four in a post mill to eleven in an oil mill. There is also a great deal of variation in size: from a 60-cm diameter stone gear in a grain mill to a waterwheel with a diameter of 6 metres.

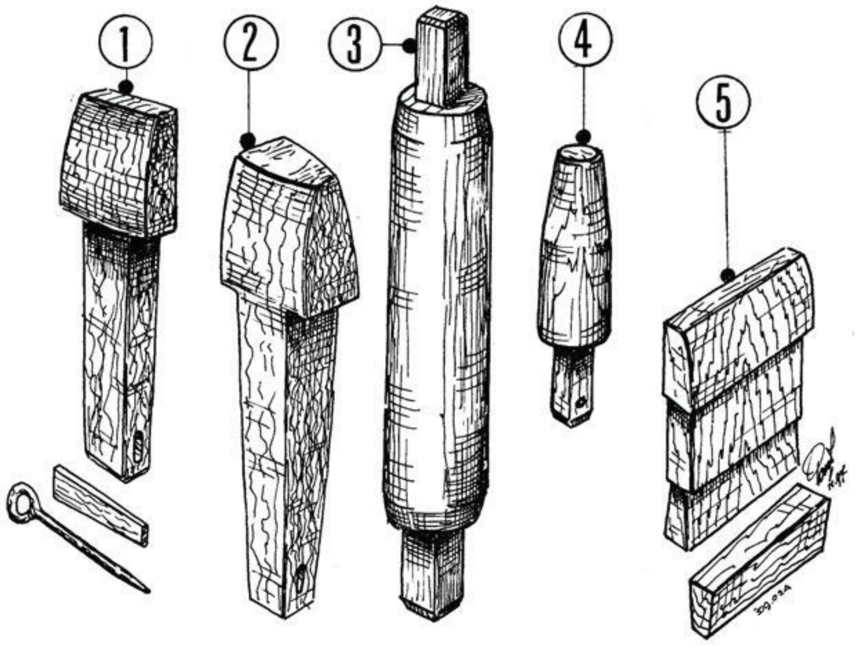


Fig. 6.5.0.1
Cogs and rods

1. *square-cut cog with cog nail and peg*
2. *cog for a right-angle drive*
3. *rod*
4. *pin*
5. *cog for a cast-iron wheel*

When choosing shape and size, regional habits play a role in addition to function and load. There are different types of wheel forms, specifically:

crown wheel
- Crown wheels: the cogs are perpendicular to the plane of rotation;

rim wheel
- Rim wheels: the cogs are in the turning plane (spur wheel, sack hoist wheel);

lantern pinion, trundle wheel
- Lantern pinions; two discs with perpendicular rods between them (trundle wheels).

However, there are some characteristics that apply to every wheel:

pitch
- The centre-to-centre distance between the cogs or rods of one wheel, called the pitch, must be exactly the same for all the cogs of that wheel (see Fig. 6.5.0.2) but also of the other wheel that engages with this wheel. If the cogs are not 'on pitch' this can be heard in the pounding and thumping of the running gear. This causes the cogs to loosen or wear unevenly.
- Wear that is more even is also achieved when a cog of one wheel comes into contact with all the cogs or rods of the other wheel equally often.

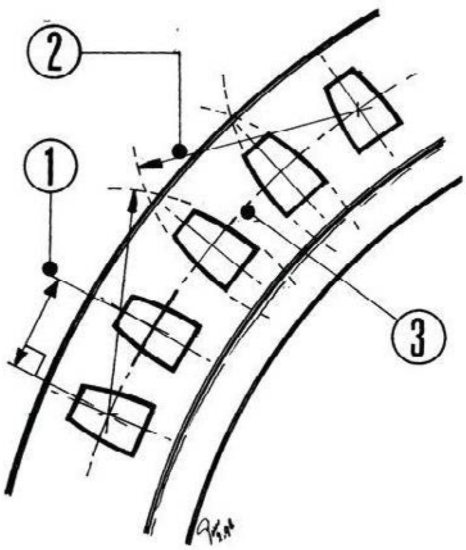


Fig. 6.5.0.2
Pitch

1. *pitch: the distance between the centre lines of the cogs (or rods)*
2. *scribe lines for the cogs*
3. *pitch cone*

This means that the numbers of cogs or rods of both wheels may not be divisible by each other. If the numbers are interdivisible then a cog of one wheel comes into contact with the same cog or rod of the other wheel more often than with the latter's other cogs or rods, resulting in uneven wear.
- The species of wood for intermeshing cogs or rods are preferably not the same because, in practice, this too has been found to lead to faster wear, even if the types of wood used are very hard.

holm-oak, boxwood, iron-wood, balata, lignum-vitae, pure beeswax

Good combinations include: holm-oak and boxwood; iron-wood and balata; iron-wood and lignum-vitae. Cogs and rods are lubricated with pure beeswax. Other maintenance and inspections on mill wheels are discussed in Chapter 7, Practical considerations.

6.5.1 Brake wheel or head wheel

filling pieces

keepers, locking slat

Every mill, with the exception of the tjasker, has a brake wheel , which is commonly called a head wheel or shaft wheel in post mills. Some post mills have two. The brake wheel is secured to the filling pieces of the windshaft with heavy wedges. These wedges are secured against loosening and falling out with the so-called keepers, or locking slats.

Fig. 6.5.1.1
The brake wheel
(For missing part numbers, see Fig. 6.5.1.2)

1. *rear rim*
2. *front rim*
3. *halved arm*
6. *cross arm*
8. *cant*
10. *liner or hoop*
11. *cog*
12. *shank*
13. *wedge keep*
14. *locking pin (arm cog)*

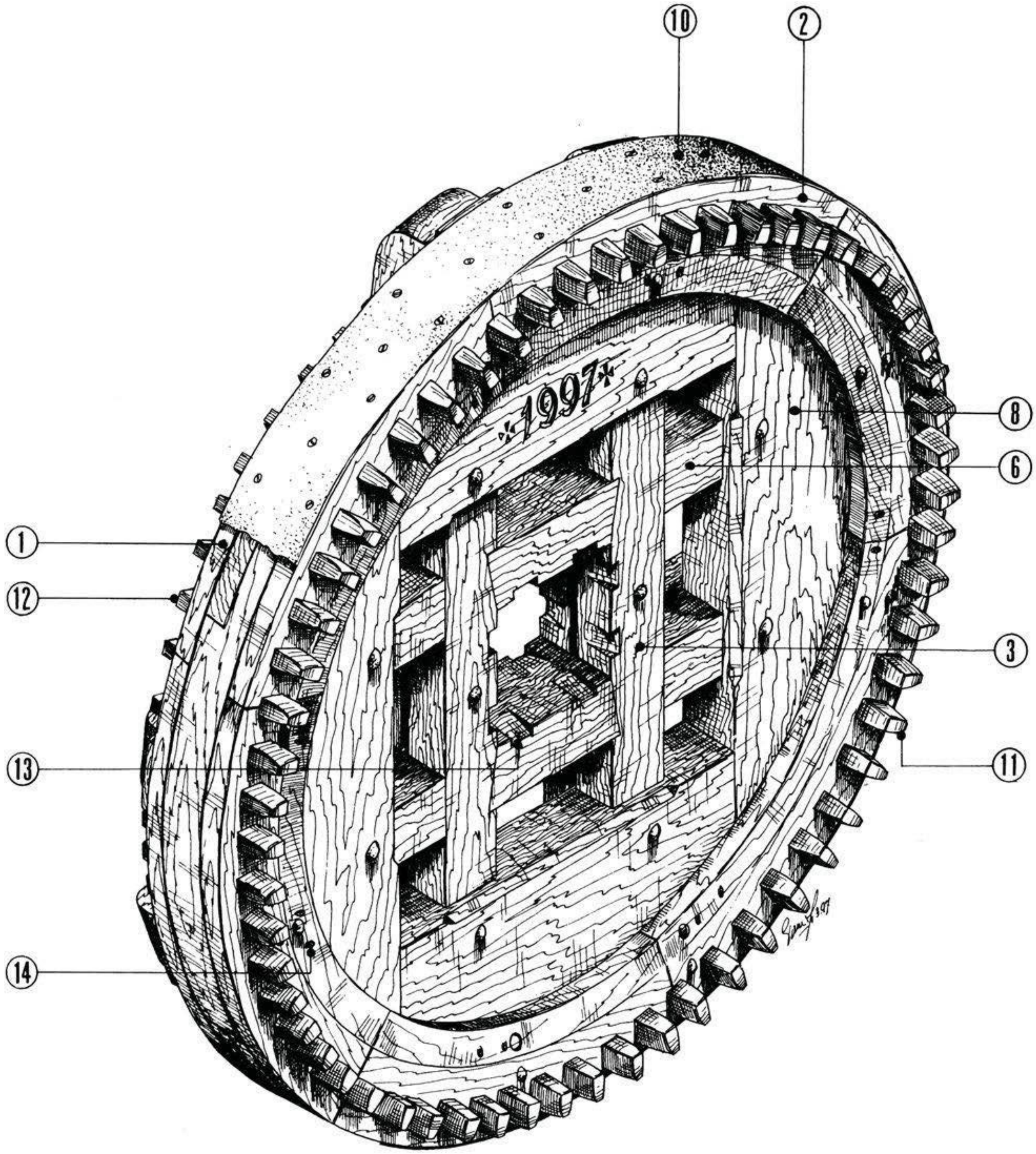


Fig. 6.5.1.1
The brake wheel or head wheel

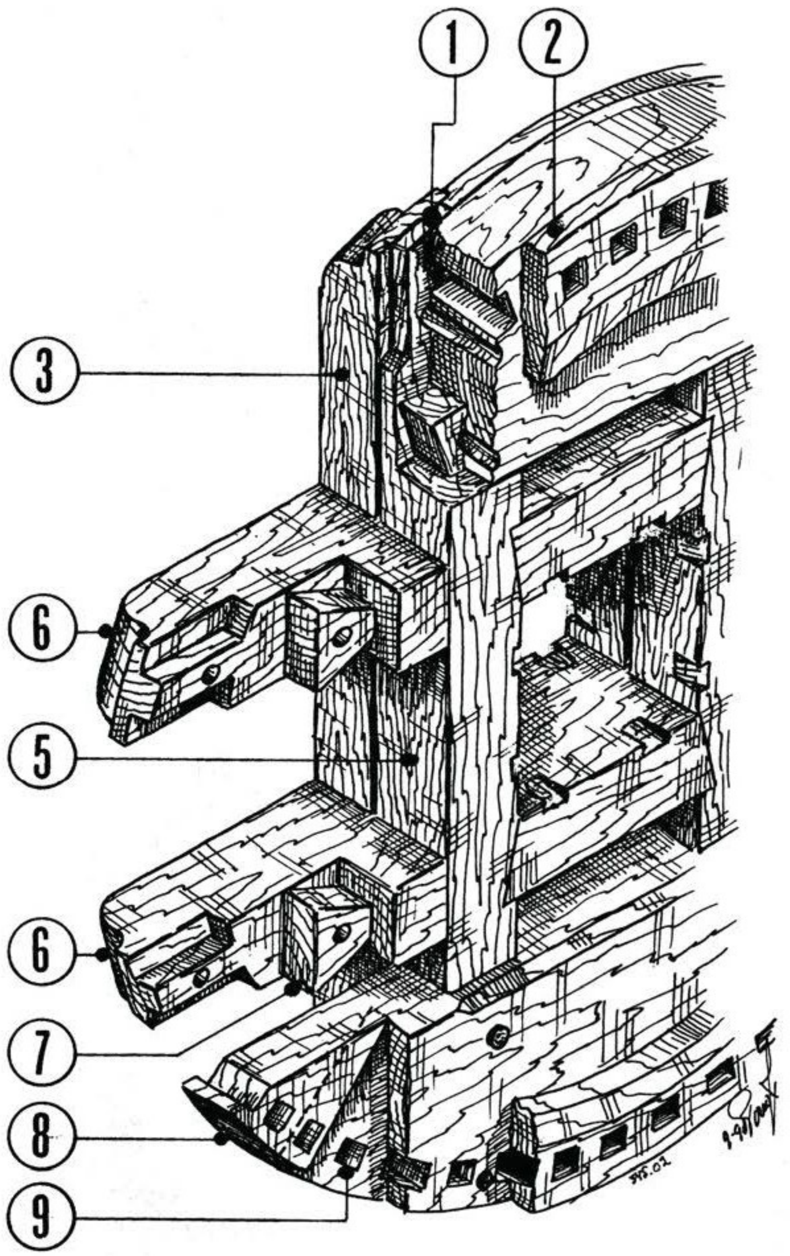


Fig. 6.5.1.2
Structure of a brake wheel

1. *rear rim*
2. *front rim*
3. *halved arm*
5. *halved arm*
6. *cross arm*
7. *dovetail*
8. *cant*
9. *cog hole*

cross arms	The construction of the wheel begins by assembling the four heavy cross arms that are almost as long as the diameter of the wheel. The arms are assembled
shaft	together, parallel and two-by-two. The mill shaft is inserted through the square
shaft hole	opening in the centre, the shaft hole.

cross arms The construction of the wheel begins by assembling the four heavy cross arms that are almost as long as the diameter of the wheel. The arms are assembled together, parallel and two-by-two. The mill *shaft* is inserted through the square opening in the centre, the *shaft hole*.
There are two methods for assembling the cross arms together. The simplest is the cross-lapped interlocking of the cross arms. The other possibility is a construction with *halved arms*. In doing so, two cross arms are made of one piece while the other two consist of two halves. The four half-cross arms clamp the two whole cross arms. A gap of about 2 cm, the *cavity*, is left open between the half-cross arms.
To cope with the immense pressure of the wedges used to secure the wheel to the axle, the joints between the cross arms are often fitted with an angled tooth. In addition, extra supporting chocks (*support chocks*) are sometimes added at the corners. At the ends of the cross arms are the cants (*cant*), which ensure that the wheel has its round shape. As a rule, there are four cants but wheels with six or eight cants are also possible. The cants are connected to the cross arms by means of dovetail joints. Then they are interconnected by scarf joints (*dovetail joint, scarf joints*). The cants are secured to the cross arms with heavy bolts. The cross arms and cants are generally made of oak.
Against the cants, on the gudgeon side of the windshaft, a ring of heavy plates called the front rim (*ront rim*) is attached. The side of the brake wheel facing the mill's tail beam is considered its front side! Such plates may also be present on the back of the cants, between the cross arms; together these form the rear rim (*rear rim*). The front and rear rims increase the width of the brake wheel, thus increasing the gripping surface of the brake.

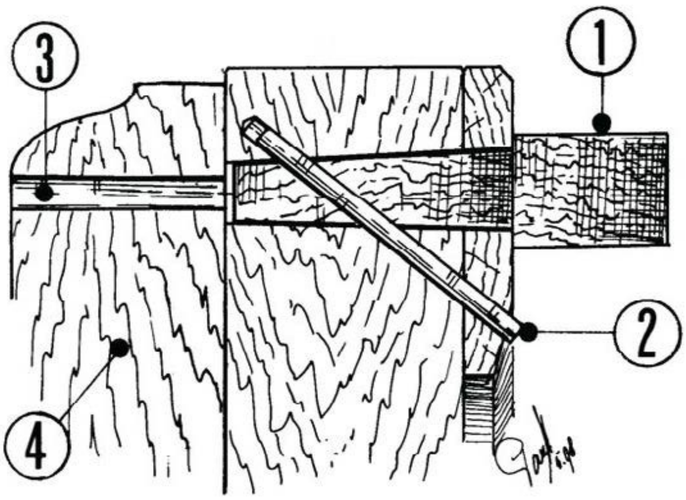


Fig. 6.5.1.3
Fixing arm cogs

1. *arm cog*
2. *locking pin*
3. *knock hole*
4. *cross arm*

Holes are made in the rims and cants, into which the cogs are inserted. Clearly, these holes are not beneficial to the strength of the various parts. Due to the pressure on the cogs during grinding, the wood between the cog holes (the insets) split, break loose and fall out, with the result that the cogs become loose. For that reason, the front and rear rims are made of elmwood. This type of wood is resistant to splitting, and is hard, tough and sufficiently strong. The rims are connected by heavy bolts to the cants and the cross arms. Older wheels usually lack the rear rim, which was the original version.

insets
elm-wood

cog, head, tail
cog nail, peg

A cog consists of a head and a tail. The tapered tail protrudes through the rear rim. This allows the cog to be secured with a wooden cog nail or an iron peg. The cog nails or pegs are then secured with a small tack.

arm cogs

The cogs at the location of the cross arms, the so-called arm cogs, cannot protrude through the entire wheel. Their shanks are shorter and are secured from the front of the wheel. A wooden peg is inserted at an angle into the tail of such a cog, through the front rim (see Fig. 6.5.1.3). To remove an arm cog, you first have to drill out the wooden nail. In the cross arm, a hole was drilled in the direction of the cog hole so that the cog could later be knocked out of the wheel with an iron bar. Arm cogs are also found on other wheels with cross arms.

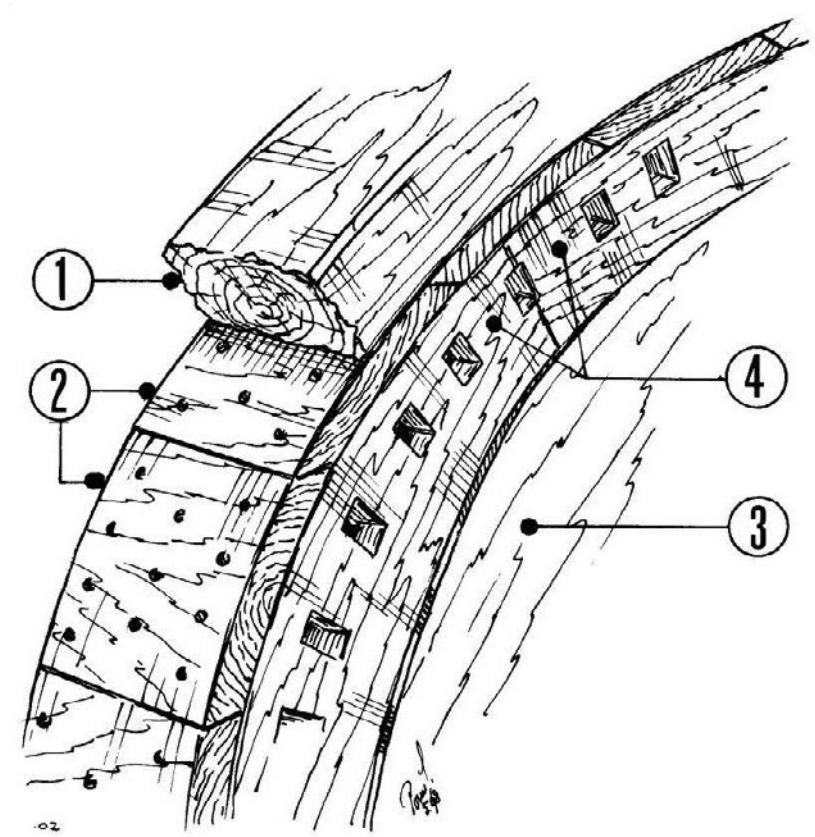


Fig. 6.5.1.4
Lining pieces

1. *brake block*
2. *lining pieces*
3. *cant of the brake wheel*
4. *insets*

Cogs are generally made of holm-oak, pock-wood or iron-wood but other types of wood are also used.

hoop
liner

On the outer circumference of the wheel a covering is applied, called the hoop or liner. This prevents cants and rims from wearing out when braking the mill. This liner can be made of wood or iron. An overly worn wheel can be brought back to the correct diameter by means of a ring of short transverse boards, the lining pieces on the outer circumference (see Fig. 6.5.1.4). Also seen is a combination of lining pieces with an iron liner as a covering. The liner or cover is fairly easy to replace if the wear is too far advanced.

lining pieces

In most post mills, the head wheel or shaft wheel has a row of cogs on the front of the wheel as well as a row of cogs on the back of it. To enable that, a heavy elm-wood rim is attached to the cross arms, into which the second course of cogs are inserted (see Fig. 12.3.2). This second course of cogs is used to drive the tail mill.

6.5.2 Wallower

upper wallower, gear wheel

A wallower is a crown wheel that transmits motion to another shaft. The difference between an upper wallower and a gear wheel concerns only the location on the central spindle; the construction is the same in both cases (see Fig. 6.5.2.1).

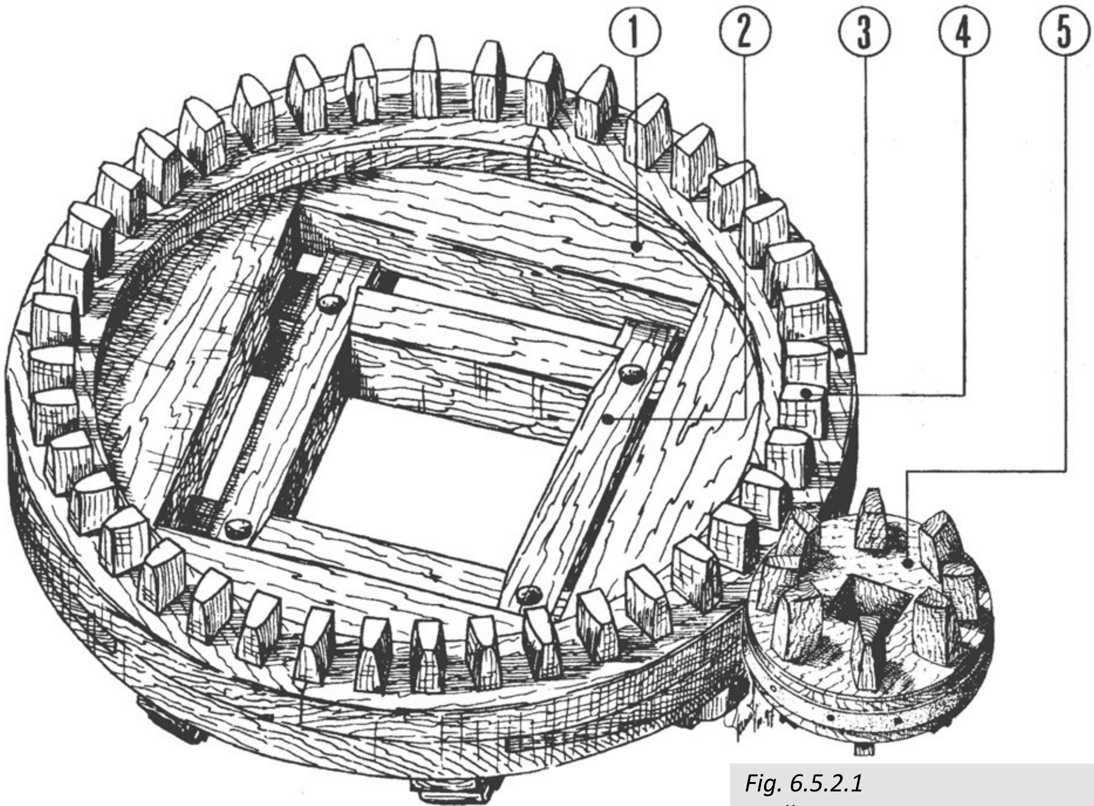


Fig. 6.5.2.1
Wallowers

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

The wallower is secured to the central spindle with wedges. Here, too, the wedges are secured with locking slats. A wallower usually consists of four cross arms that, like the brake wheel, are cross-lapped together. The cants are fitted to the cross arms by a dovetail joint. These cants are joined together by a scarf joint.

On top of the cants is a ring, the rim. The same species of wood used for the brake wheel is also used for the cross arms, cants and rims.

half-moon segments
mortise and tenon joint
clamping bands

There is also another way to manufacture a wallower. In this process, four elm-wood half-moon segments, roughly 15 cm in thickness, are assembled together with mortise and tenon joints and then sawed in a circular form (see Fig. 6.5.2.4). A square opening is left in the middle for the spindle. At the perimeter, the plate is reinforced with one or two iron clamping bands (see Fig. 6.5.2.2).

Square holes, into which the cogs are inserted, are made at the perimeter of the wallower. Their shape and means of fastening are approximately the same as those for the cogs in the brake wheel.

light and heavy-duty work

A special type of wallower is found in Archimedean screw drainage mills equipped with so-called 'light and heavy-duty gears' (see Fig. 6.5.2.3).

In mills thus equipped, the gear wheel is fitted with two concentric rows of cogs that naturally have the same pitch. The outer row has a greater number of cogs than the inner row, of course, and therefore does the heavy work. This is because, with one revolution of the central spindle, the screw is rotated over a greater angle and acquires a greater speed.

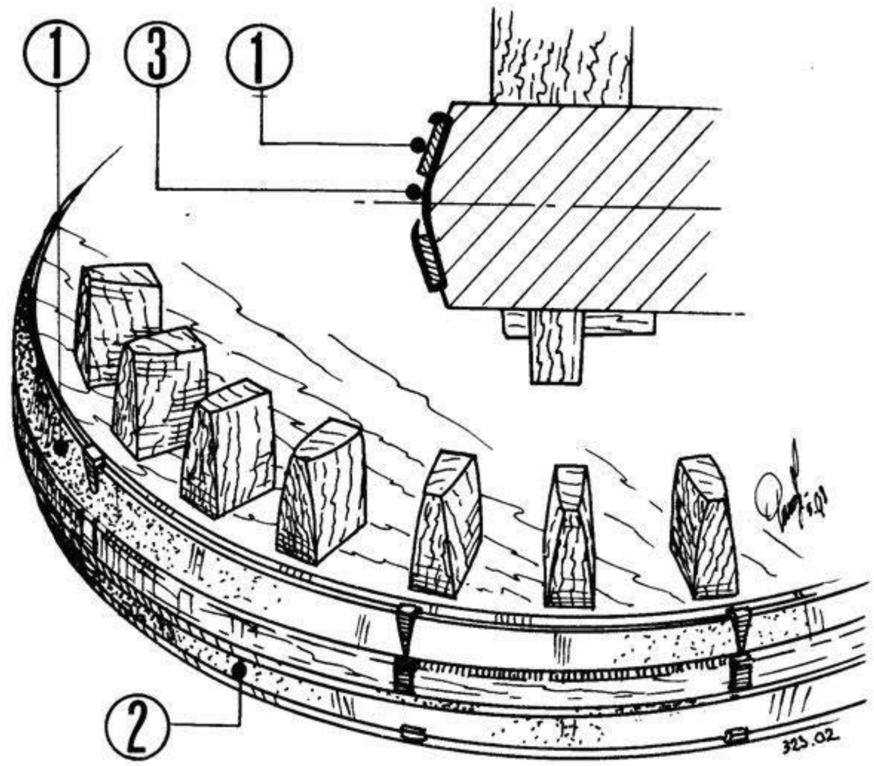


Fig. 6.5.2.2
Clamping bands around the wallower

1. *top clamping band*
2. *bottom clamping band*
3. *locking strip*

bearing block	By moving the upright shaft using the bearing block so that the cogs of the crown wheel engage with the inner row of cogs of the gear wheel, the speed of the screw is slowed down. The mill is then operating in light gear. Which gear is deployed depends in part on the available wind. The distance between the two rows of cogs is such that the cogs of both rows on either side of those of the crown wheel can turn freely, such as when the mill is turning "for the prince" (turning with no load).
pins *pin-wheels*	Small wallowers with round cogs, the pins, are used for small machinery that runs lightly; gears are called pin-wheels.

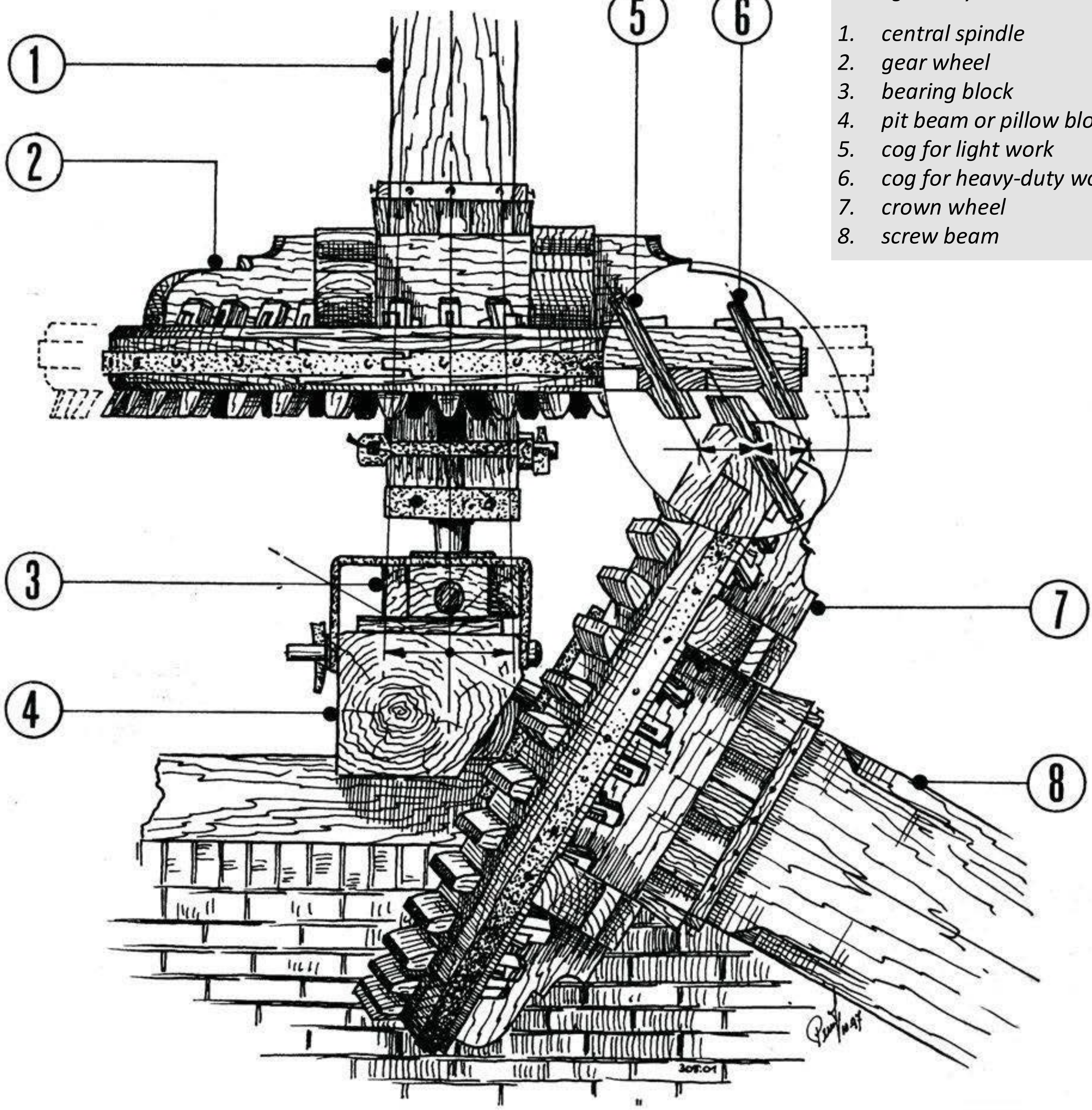


Fig. 6.5.2.3
Drive for a screw with heavy and light-duty work

1. *central spindle*
2. *gear wheel*
3. *bearing block*
4. *pit beam or pillow block*
5. *cog for light work*
6. *cog for heavy-duty work*
7. *crown wheel*
8. *screw beam*

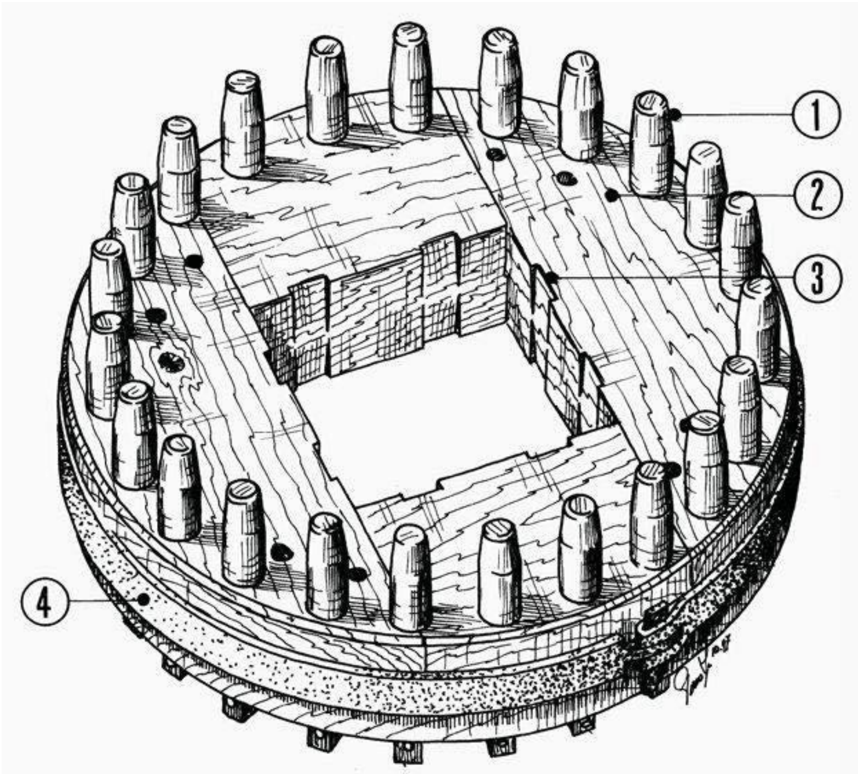


Fig. 6.5.2.4
Pin-wheel

1. *pin*
2. *cant*
3. *wedge keep*
4. *spindle strap*

6.5.3 Stone gear or trundle wheel

trundle wheel
stone gear
upper stone gear, lower stone gear
stone lantern pinion

Lantern pinions or trundle wheels (see Fig. 6.5.3.1) can be found at various locations in the mill. The stone gears at the top or bottom of the central spindle are called the upper stone gear or lower stone gear, respectively; the stone gear on the stone spindle in a grain mill is the stone lantern pinion. The construction of all these trundle wheels is more or less the same.

elm-wood plate

A stone gear or trundle wheel consists of two elm-wood plates with rods between them. Each of the two plates consists of four half-moon segments. These half-moon segments are assembled together with mortise and tenon joints. A shaft hole is also cut out in the centre here. Around the outer perimeter of the plates, iron bands are clamped to hold the whole thing firmly together. Along the perimeter of each plate, square holes are punched; here is where the pegs for the rods go. Here, too, the plates are made of elm-wood to prevent the insets between these holes from cracking. The holes are widened in the inner, facing sides of both plates to form a shallow round hole that is slightly conical, with the square part precisely in its centre. The usually round bars are fitted with a square peg at both ends. These pegs fit exactly into the square holes of the two plates.

rods

The round part of the rods is also made slightly conical at the ends. As a result, the rods fit precisely into the holes in the plates, forming a rigid whole. The two plates are held together with four heavy-duty tie-rods.

tie-rods

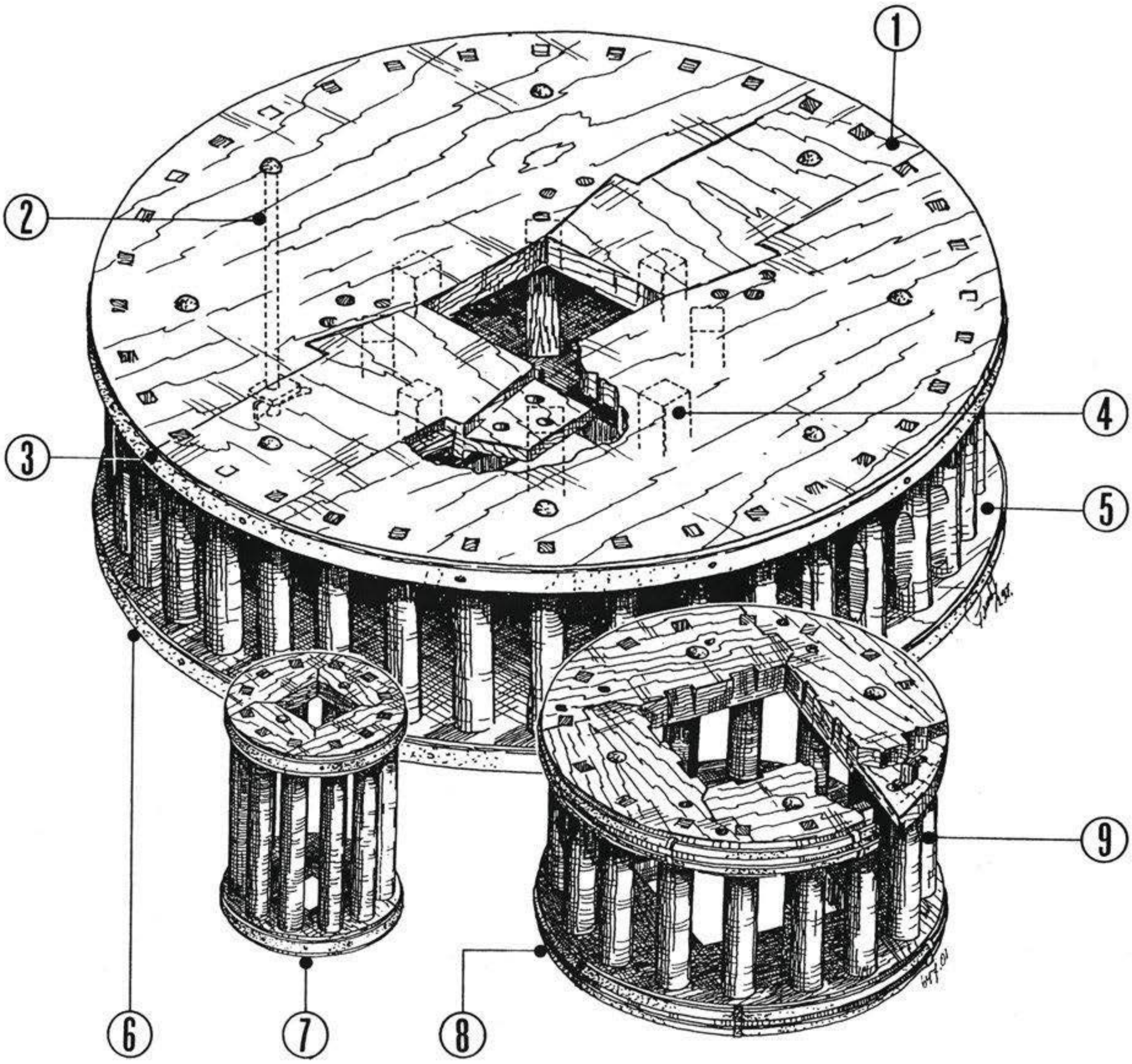


Fig. 6.5.3.1
Trundle wheels or lantern pinions

1. *upper plate*
2. *tie-rod*
3. *clamping band*
4. *stay*
5. *bottom plate*
6. *clamping band*
7. *lantern pinion*
8. *stone nut*
9. *rod*

stays

The stone gear is secured to the spindle by knocking wedges between the spindle and the edges of the shaft hole. Due to the pressure of these wedges, combined with the tractive force of the draw bolts, the two plates at the shaft hole are driven and pulled toward each other. To prevent this, four spacers called stays are usually placed close to the shaft hole around the spindle.

turning of the rods

The advantage of a stone gear over a wallower is twofold. In the first place, a stone gear is stronger because the rods are supported in two places. As a result, they are less susceptible to bending. Secondly, due to their round shape and square peg, the rods can be turned a quarter turn when worn, creating a new track. This so-called turning of the rods can be done as many as eight times. In fact, the rods can also still be placed upside down in the stone gear. However, turning upside down is not possible with slip sticks.
One disadvantage of a stone gear is that a cracked or broken rod is difficult to replace. To do this, you have to loosen the entire stone gear and separate the plates. To overcome this problem, so-called slip sticks were sometimes used (see Fig. 6.5.3.2 & Fig. 6.5.3.3).

slip sticks

A slip stick has the same bottom shape as an ordinary rod. At the top, however, the square peg is missing. The rod is slightly widened conically at this end. In the top plate of the stone gear there are no square holes but round holes that conically tapered downwards. The slip sticks are now inserted into place from above, through the top plate.
At the top, the rods are secured by a locking strip or ring that is fastened to the top plate of the stone gear.

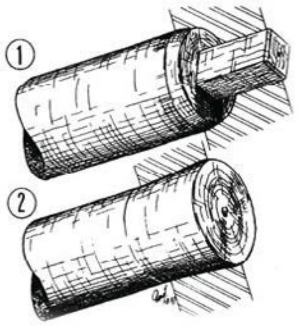


Fig. 6.5.3.2
Example of rods

1. *normal rod head*
2. *slip stick head*

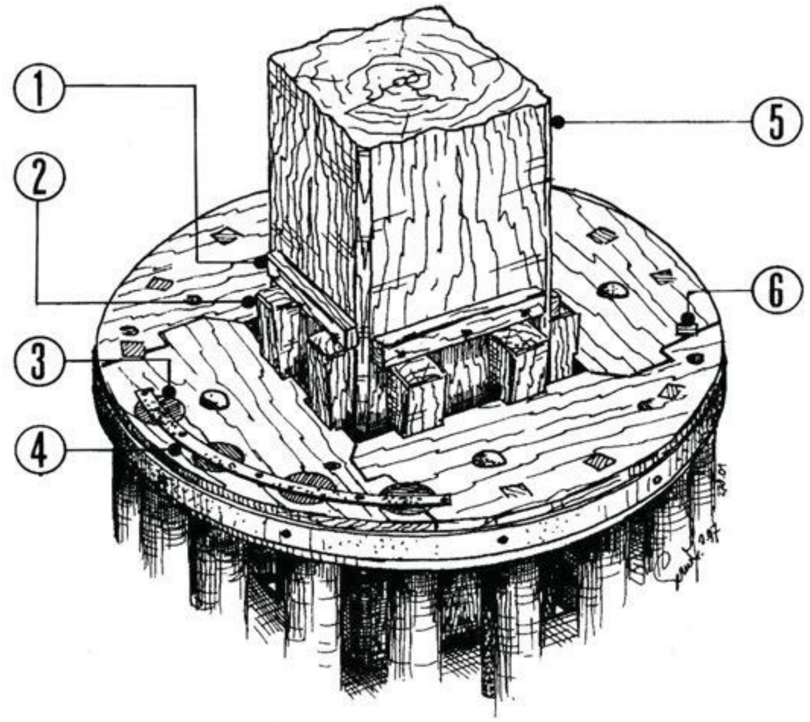


Fig. 6.5.3.3
Trundle wheel with four slip sticks

1. *locking slat*
2. *wedge*
3. *slip sticks*
4. *locking strip*
5. *central spindle*
6. *pin of an ordinary rod*

By loosening this iron locking strip now, you can easily turn or replace a rod. Slip sticks are also used in lantern pinions that can be taken out of operation in a simple way. Then a construction with four or five slip sticks and ordinary rods for the rest is used. Rods — just like cogs — are generally made of boxwood, balata or holm-oak.

cradle

lantern pinion

Finally, a word about other names for lantern pinions or trundle wheels. In the south of the Netherlands, the upper stone gear is generally called the cradle. When the diameter of a stone gear is less than the height, we refer to it as a lantern pinion.

6.5.4 The spur wheel, 'takrad', ravens wheel, and stone wheel

spur wheel
'takrad', ravens wheel
stone wheel

In grain mills, the spur wheel is found at the bottom of the central spindle. It provides the drive for one or several stone nuts. The 'takrad', the ravens wheel and the stone wheel have the same construction but different names. 'Takrad' is the name used in Groningen for the spur wheel. The ravenwiel is the spur wheel for a hulling mill. The stone wheel is found in industrial mills which are equipped with edge runner stones, such as oil, spice and paint mills. The stone wheel then sits on the spindle that sets these stones in motion.
Unlike the brake wheel and the lantern pinion, for example, these are not crown wheels but rim wheels whose cogs face outwards and whose shanks point towards the centre of the wheel.
The construction of the spur wheel also starts with the cross-lapped interlocking of four cross arms. For the further construction of the wheel, there are two variants.

loose insets

In the first variant, cants are attached to the cross arms. On these cants there are then one or two rims between which the cogs are inserted into the notches cut out for that purpose. Unlike the brake wheel, no holes are cut for fitting the cogs into the rims of the spur wheel. Chocks called loose insets are applied instead to secure the cogs between the rims.
These insets are secured between the rims using bolts that protrude through both rims. The cogs are fixed between these insets and then secured. In addition to these loose insets, there are also fixed insets (see Fig. 6.5.4.1).
In the second variant, no cants are used and the rims are attached directly to the cross arms. In order to give the rims adequate support and the wheel sufficient rigidity, a second set of cross arms is attached at the top. Thus, the rim is clamped together between a total of four double cross arms. Insets are also installed between the cogs in this variant. The species of woods used are the same as those used for the brake wheel: mostly oak for the cross arms and cants, elm for the rims, and iron-wood or holm-oak for the cogs.

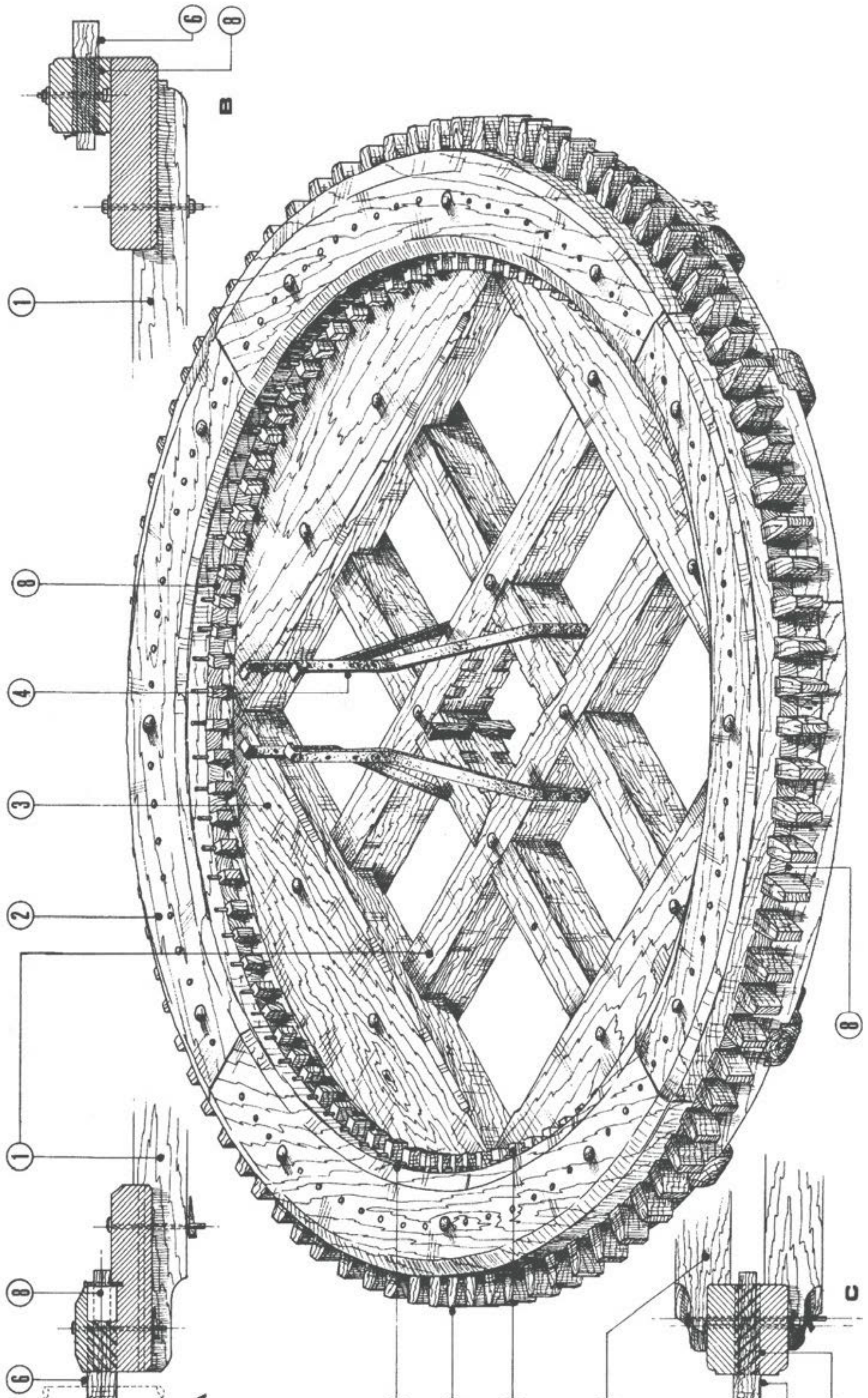


Fig. 6.5.4.1
Het spoorwiel

1. *kruisarm*
2. *velg*
3. *plooistuk*
4. *hangijzer*
5. *kamnagel*
6. *kam*
7. *kamstaart*
8. *dam*

A. *Spoorwiel met een enkele velg (met plooistukken)*
B. *Spoorwiel met dubbele velg (met plooistukken)*
C. *Spoorwiel met dubbele kruisarmen en velgen (zonder plooistukken)*

6.5.5 Sack hoist wheel or one-piece spur pinion

sack hoist wheel, one-piece spur pinion

A sack hoist wheel or one-piece spur pinion (see Fig. 6.5.5.1) also has outward facing cogs but it is much smaller in diameter. As a rule, such a wheel consists of two elm-wood plates between which the cogs are clamped. These elm plates are made of four parts and are constructed in the same way as the plates for lantern pinions. The cam holes are sometimes formed by recesses in the two plates but in other cases, as with the spur wheel, are formed by spaces between loose insets.
Application of sack hoist wheels:
In post mills, to drive the hoisting system. In paltrok mills, to drive the crankshaft. In oil mills, several one-piece spur pinions drive the stirrer above the lifters. In rare cases, they are applied to the stone spindle in grain mills.

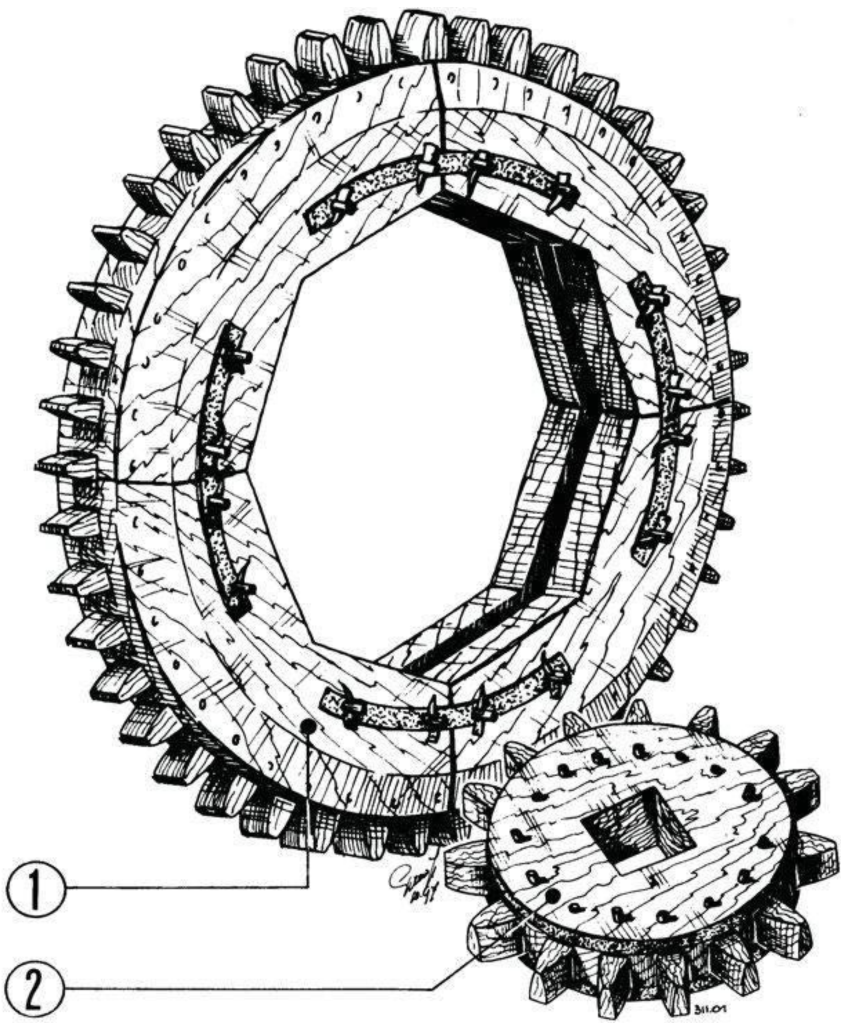


Fig. 6.5.5.1
Examples of sack hoist wheels

1. *camshaft rim wheel for a spur pinion*
2. *barrel wheel*

6.5.6 Waterwheel or pit wheel

waterwheel, pit wheel

waterwheel shaft

The waterwheel or pit wheel (see Fig. 6.5.6.1), in polder mills equipped with a scoop wheel transmits the motion of the central spindle to the scoop wheel. It is therefore attached to the waterwheel shaft, as is the scoop wheel.
A diameter of 5 to 6 metres is not exceptional for this wheel and makes it the largest of the wheels used in windmills in terms of size.
Most waterwheels are equipped with halved arms as is described for the brake wheel. On the outer circumference, as a rule, there will be eight cants. To ensure that these cants are all about the same length, many waterwheels have curved cross arms. The cross arms then come closest together at the shaft hole and diverge further and further outwards. The cants are attached to the cross arms with dovetail joints. Scarf joints are used between the cants themselves.
As with the brake wheel, a front and a rear rim are present on the cants.
Older wheels usually lack the rear rim. The cogs are inserted through the cants and rims.
The species of woods used are the same as for the brake wheel: oak for the cross arms and cants, elm for the rims, and holm-oak or iron-wood for the cogs.

Fig. 6.5.6.1
Waterwheel or pit wheel

1. *cog*
2. *rear rim*
3. *front rim*
4. *curved cross arm*
5. *curved halved arm*
6. *shank*
7. *cog nail*
8. *cant*
9. *knock hole for arm cog*
10. *bar bolt*
11. *support block*
12. *shaft hole*
13. *filler chock or filler plate between the halved arms*

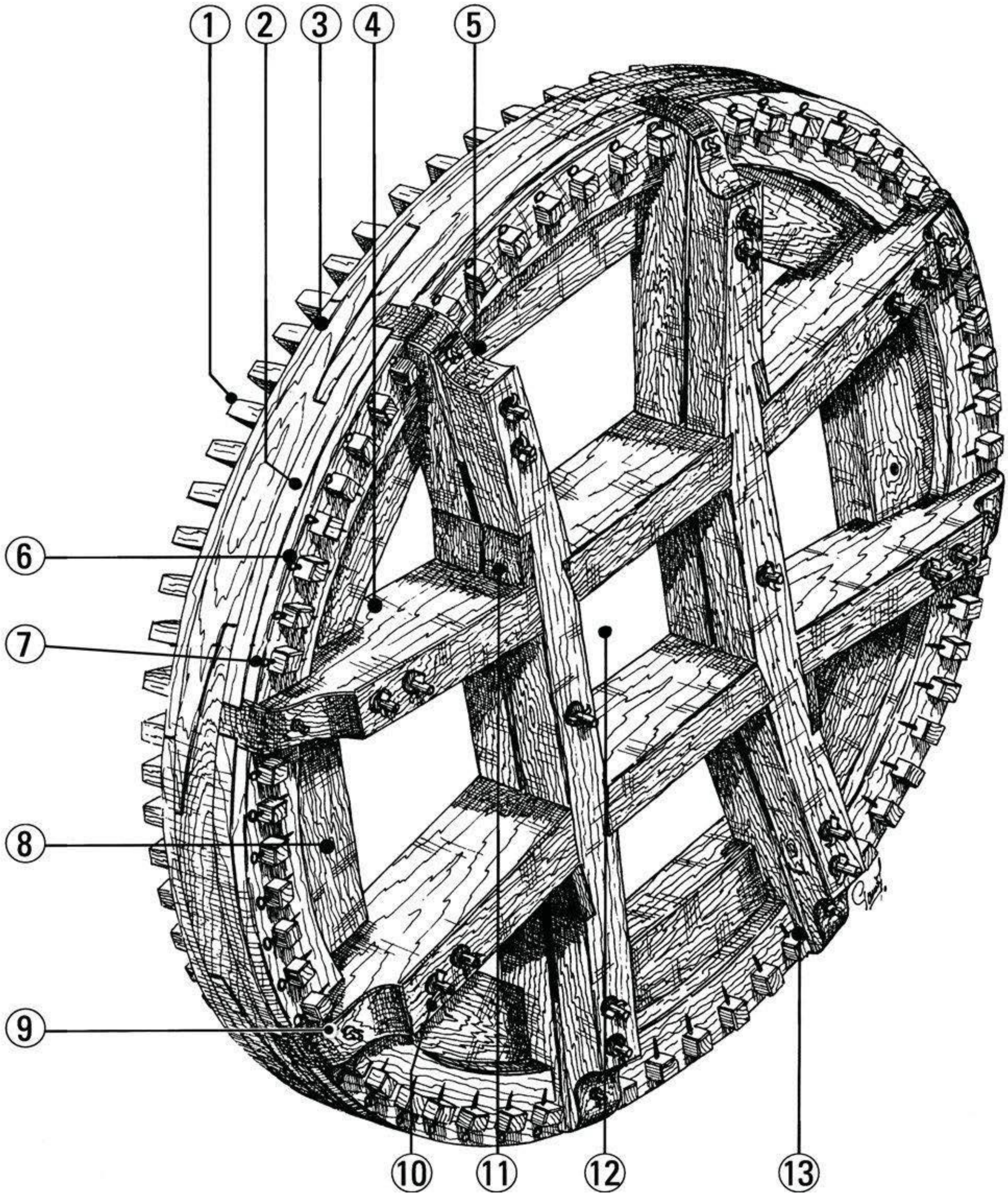


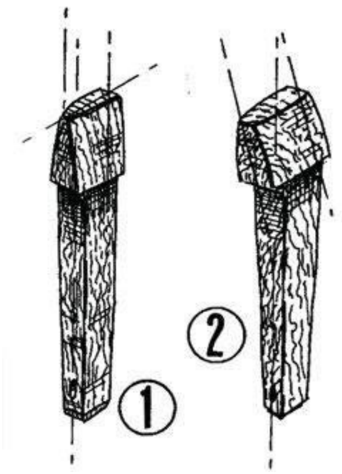
Fig. 6.5.6.1
Waterwheel or pit wheel

6.5.7 Crown wheel

crown wheel

The crown wheel sits at the top of the screw beam and is driven by the gear wheel, which may or may not be equipped with a cog ring for both light and heavy-duty work.
The construction corresponds to that of the lantern pinion: cross arms and cants with a rim on top. The rear rim is usually missing. The cogs are inserted through the cants and rim.
Because of the inclination of the screw, the cogs of the crown wheel often face outward, improving the engagement with the cogs of the gear wheel. The same species of wood are used for the crown wheel as for the wallower (see Fig. 6.5.2.3).

Fig. 6.5.8.1
Example of a straight cog (1) and a cog for conical work (2)



6.5.8 Conical cog wheels and lantern pinions

The sides of cog heads are always rounded off. The contact surface of two intermeshing cogs is thereby reduced. As a result, both wheels rotate properly and smoothly together so that little wear occurs. If this is not done, the running gear thrusts, resulting in a lot of wear and tear or even dislocation.
Rounding off cogs is easiest for cogs that interact perpendicularly (respectively, cogs and rods) or for cogs that interact in line with each other.
If both wheels do not work together at right angles to each other or in line with each other, then the cogs must be rounded off in some other way to keep their contact surface as small as possible. This is the case, for example, for the transmission from brake wheel to upper wallower or upper stone gear or from gear wheel to crown wheel. Indeed, the brake wheel and certainly the crown wheel have an angled position. To ensure that cogs (respectively, cogs and rods) still interlock perpendicularly to each other or in line with each other, the cogs or rods are given an angled position. In this way, conical cog wheels or lantern pinions are then created.

conical cog wheels, lantern pinions

6.5.9 Cast-iron wheels

cast-iron wheels

hub

locking chocks

hornbeam

Especially in water-driven mills, many wooden wheels and spindles have been replaced over time by cast-iron wheels and spindles. A cast-iron wheel is cast in its entirety. When wooden cogs are used, the holes for these are recessed when casting. In the centre of the wheel is a heavy round part, the hub, that contains a keyway by which the wheel is fastened to the spindle or axle. Attached to the hub are six to eight spokes with a cast-iron ring, the rim, on the ends of these spokes. As with wooden wheels, the cogs are inserted through this rim and secured on the inside with trapezoidal locking chocks.
Smaller wheels usually have cast-on cogs. It never happens that two intermeshing wheels both have cast-iron cogs. In one of the two wheels, generally the driving wheel, the cogs are made of wood. Hornbeam is often used for this purpose. In right-angled transmission, cast-iron running gears are often tapered as well as straight.
Some windmills also have full or partial iron running gear.

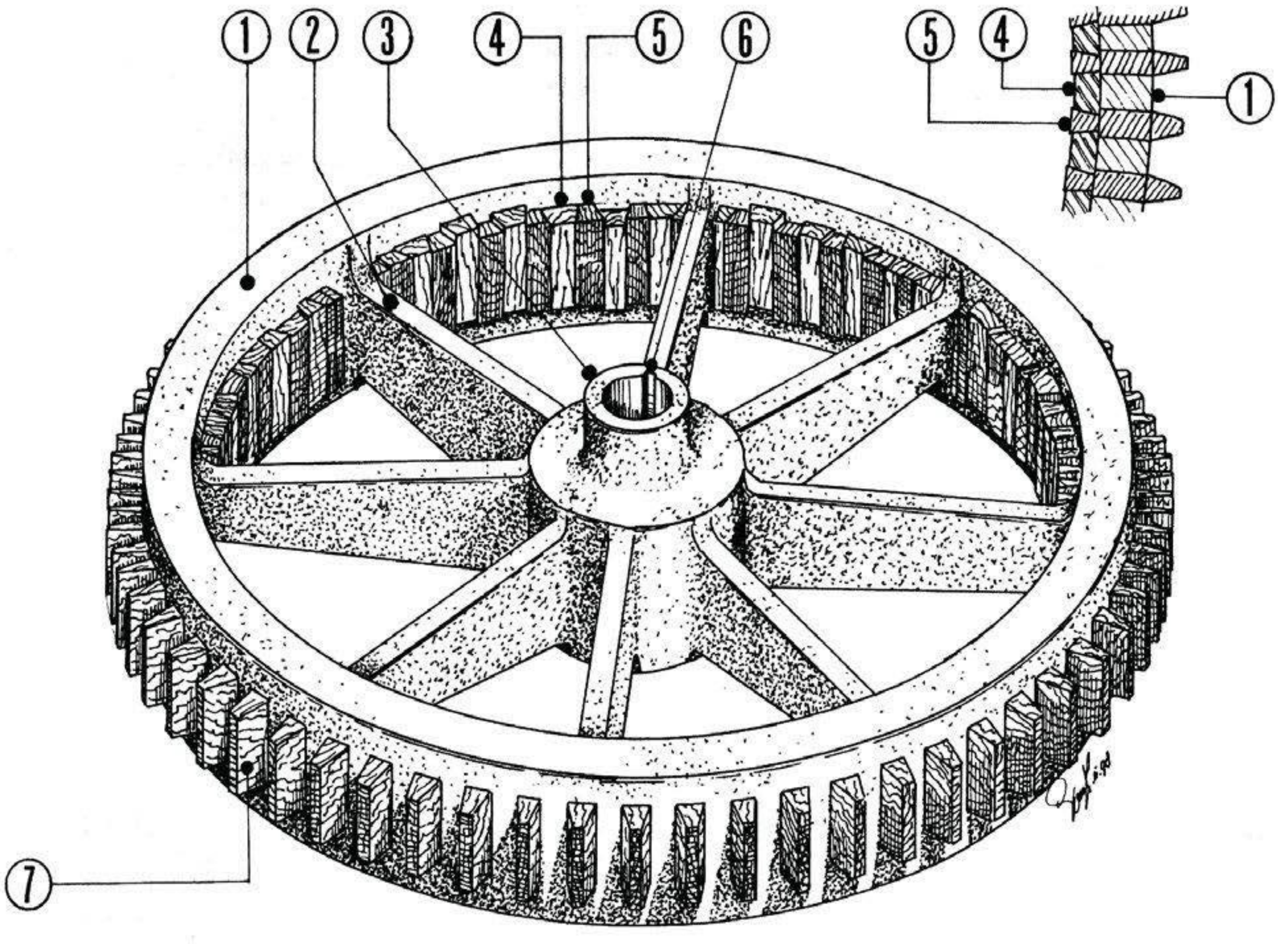


Fig. 6.5.9.1
Cast-iron wheel

1. *rim*
2. *spoke*
3. *hub*
4. *locking chock*
5. *shank*
6. *keyway*
7. *cog*

6.5.10 Wheels of the hoisting system

geared sack hoist
friction sack hoist
sack hoist wheel

There are two types of hoisting systems: the geared sack hoist and the friction sack hoist (see Fig. 12.8.1 & Fig. 12.8.1.1 to Fig. 12.8.1.3). In a geared sack hoist, a wallower is fitted around the central spindle. Also around the sack hoist spindle is a wallower, the wooden pulley that can be pulled into the cogs of the lantern pinion around the spindle.
This is sometimes used with pins instead of cogs.
In post mills, the hoisting system is driven by a spur pinion on the sack hoist spindle that is pulled between the cogs of the head wheel.

friction ring

A friction sack hoist also has two wheels but these do not have cogs. The wheel around the central spindle, the friction ring, is composed of cross arms and cants. A wearing course of blocks of willow wood that can be easily replaced are fitted on the cants. The wooden pulley will have a wear layer made of willow on the outer perimeter. In many mills, however, there is a metal liner or an old car tyre around the wooden pulley.

Y wheel

A Y wheel is usually attached to the other end of a sack hoist spindle. This Y wheel consists of two cross arms inserted through the sack hoist spindle or four cross arms fitted around the sack hoist spindle and secured with wedges. At the circumference of the Y wheel there are cants or a rim. Attached to that

forks

are wooden or metal forked stanchions between which runs the endless hand rope. This circular rope can be used to manually operate the hoisting system.
A Y wheel is usually made of oak.

6.6 THE BRAKE

6.6.0 Introduction

brake

The brake can be used to bring a turning mill to a standstill. Moreover, the brake ensures that a stationary mill will not turn, even in a storm. In view of these two very important tasks of the brake, the miller must be very familiar with the functioning and operation of the brake.
The miller must regularly check that the brake is in good condition and functioning properly because if there is a brake failure when the mill is being braked then the mill is effectively unstoppable.
The miller must be able to perform minor adjustments and maintenance work on the brake. For checking and adjusting the brake, see Chapter 7, Practical Considerations.

There are two different types of brakes, each of which has two versions:

The block brake — a rim of blocks around the brake wheel:
a. the Flemish brake;
b. the Dutch brake or stud brake.

The band brake or hoop brake — a strap around the brake wheel:
a. the wooden band brake;
b. the steel band brake.

6.6.1 Block brake

block brake,

brake blocks, brake shoes

A block brake usually consists of a number of brake blocks that are interconnected and lie like a rim around the brake wheel.
These brake blocks or shoes are preferably cut from warped willow or poplar wood. This wood is soft and tough but above all wear-resistant.

6.6.1.a Flemish brake

Flemish brake
bottom brake block, toe brake block
shoulder brake block, brake head
first brake block
capstan bolts

The Flemish brake (see Fig. 6.6.1.1) encloses almost the entire brake wheel and usually consists of four or five brake blocks: bottom brake block, toe brake block, shoulder brake block, brake head and first brake block. If there are four pieces, then the shoulder brake block is missing. The bottom brake block is attached directly or indirectly with capstan bolts to the right-hand upper side girt or to the right-hand sheer beam. The capstan bolts prevent the brake from rotating along with the brake wheel.

iron strap-work
fixed brake, rigid brake

The brake blocks are interconnected on both sides with arched iron strips, the iron strap-work. These iron strap-work pieces are generally attached to a brake block for some 50 to 60 cm. With a fixed or rigid brake, one pair of iron strap-work pieces joins two brake blocks together. As a result, these cannot move (hinge) relative to each other.

loose, hinged brake

With a loose or hinged brake, each coupling consists of two pairs of iron strap-work pieces connected together by a bolt. This bolt is located between the two brake blocks that can now move relative to each other, with the bolt as the hinge point.

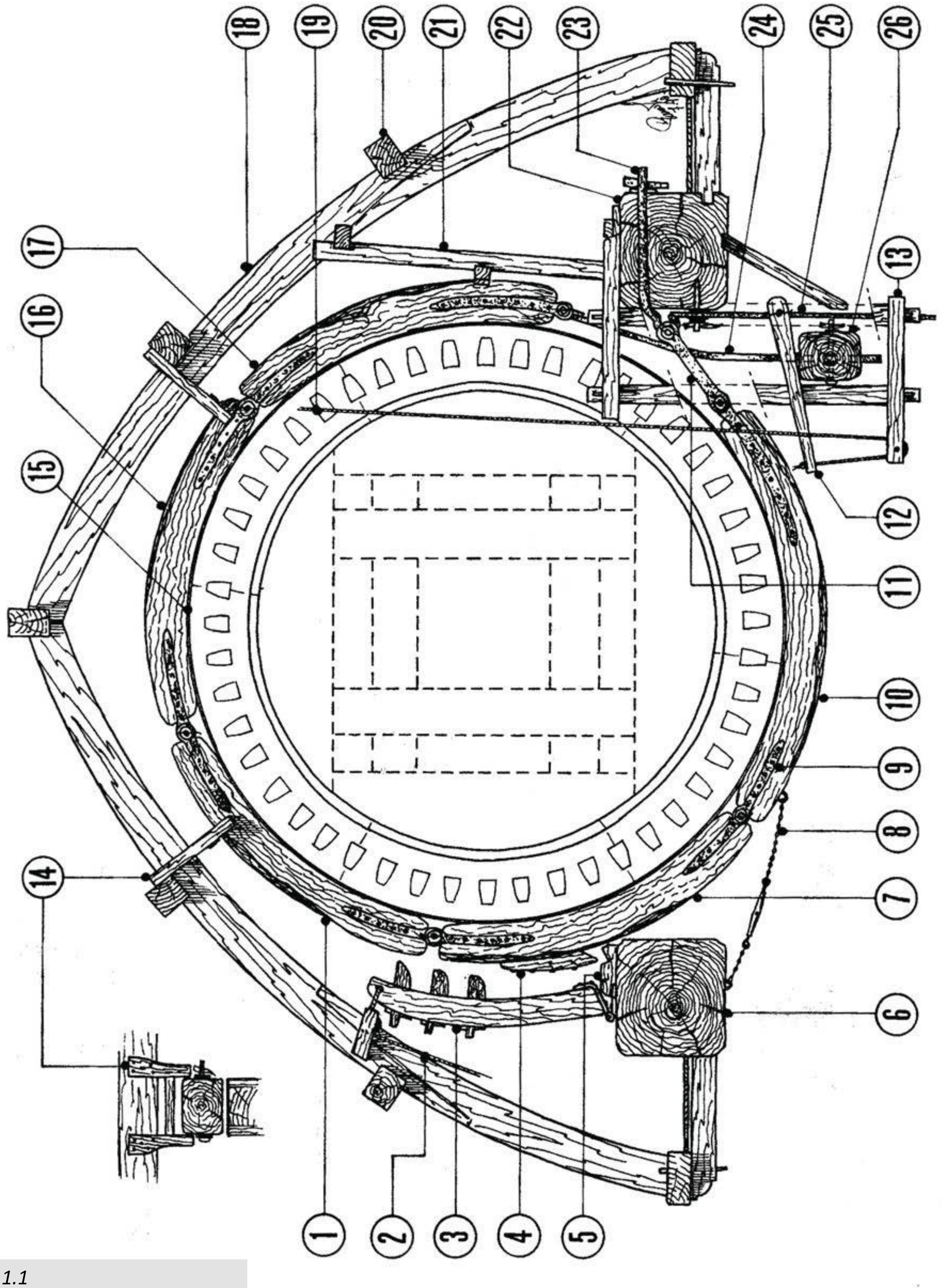


Fig. 6.6.1.1
Flemish brake

continuous iron strap-work

Sometimes a hinged brake has iron strap-work running the full length of the brake shoe. This is referred to as continuous iron strap-work.
The iron strap-work pieces are inserted in the middle of the sides of the brake blocks and secured with heavy nails and at least two through bolts. Due to wear on the brake blocks, the iron strap-work pieces get closer and closer to the brake wheel. When the iron strap-work almost touches the upper wheel, it must be moved. The bottom brake block wears the fastest because it is the first and most heavily loaded when the brake is applied.

6.6.1.b Dutch brake or stud brake

Dutch brake, stud brake
stud space

The Dutch brake or stud brake (see Fig. 6.6.1.2) lacks the bottom brake block. In this brake, a space called the stud space is carved into the left-hand sheer beam and the toe brake block for placing a wooden stud.

stud

The stud points toward the bottom of the cogs of the brake wheel and is secured against falling out.
The stud has the same function as the capstan bolts in the Flemish brake. When the mill is braked, the stud applies additional pressure to the toe brake block against the brake wheel. Because of this, a stud brake brakes more fiercely than a Flemish brake. Therefore, the toe brake block wears out the fastest. That is why, in the cap floor of a mill with a stud brake, you usually find a number of spare studs: due to the wear and tear of the toe brake block, eventually the stud will no longer be in its correct position. This problem can be remedied by replacing the stud with a longer one. The stud brake also features fixed or hinged iron strap-work. The stud brake is mainly found in North Holland.

Fig. 6.6.1.1
The Flemish brake (previous page)

1. *shoulder brake block*
2. *pawl rope*
3. *pawl*
4. *brake catch*
5. *bed*
6. *left-hand sheer beam*
7. *toe brake block*
8. *tension chain*
9. *iron strap-work piece*
10. *bottom brake block*
11. *brake anchor*
12. *release lever*
13. *hanger guide*
14. *brake guide*
15. *hoop or liner*
16. *brake head*
17. *first brake block*
18. *cap rafter*
19. *release lever rope*
20. *cap purlin*
21. *first clamp strut*
22. *right-hand sheer beam*
23. *capstan bolt*
24. *sword iron*
25. *detent or hook*
26. *brake lever*

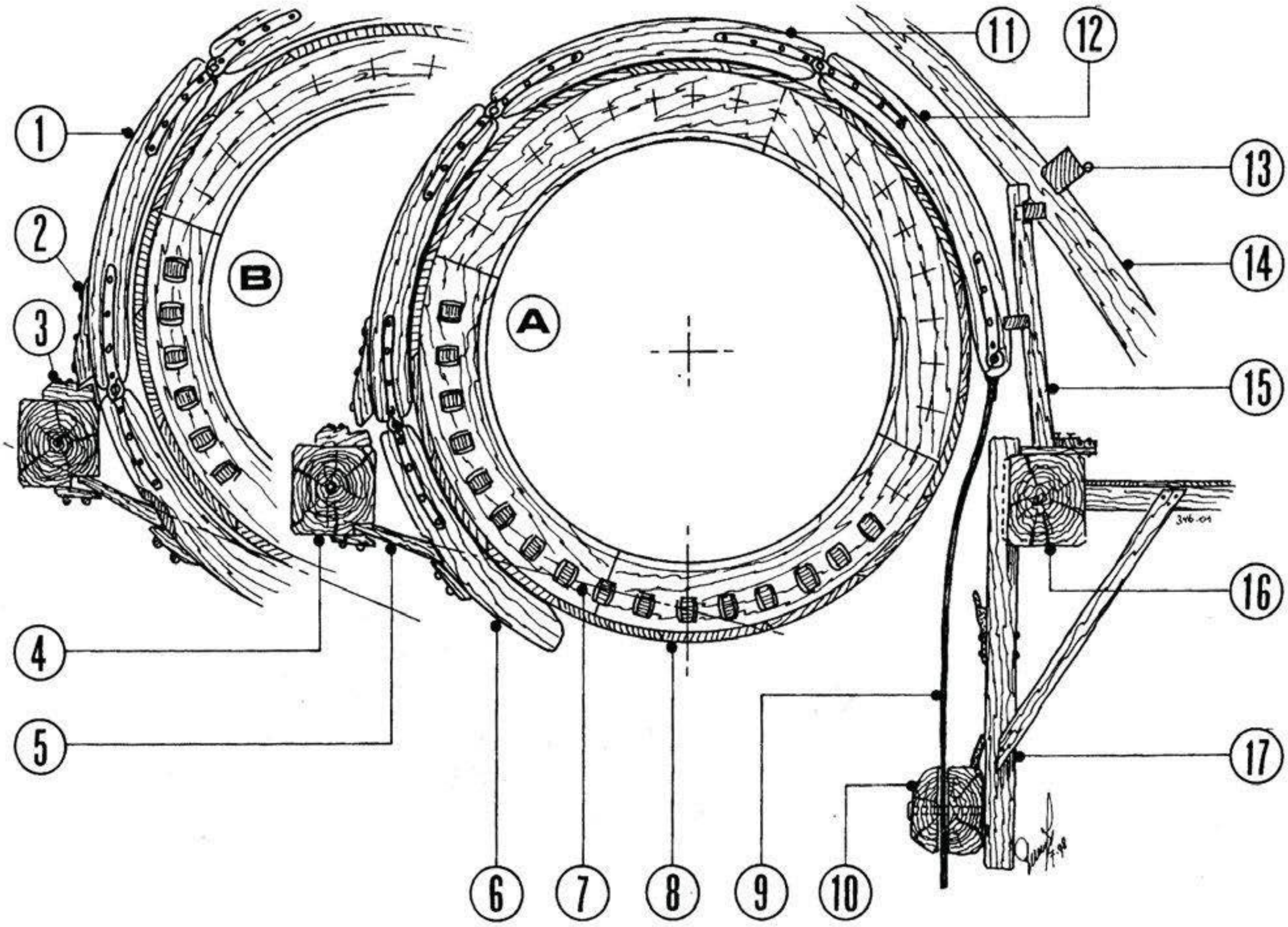


Fig. 6.6.1.2
Dutch brake or stud brake

A. brake applied
B. brake released

1. *shoulder brake block*
2. *brake catch*
3. *bed*
4. *left-hand sheer beam*
5. *stud*
6. *toe brake block*
7. *stud/cog tangent*
8. *wooden liner*
9. *sword iron*
10. *brake lever*
11. *brake head*
12. *first brake block*
13. *cap purlin*
14. *cap rafter*
15. *first clamp strut*
16. *right-hand sheer beam*
17. *rear hanger*

Fig. 6.6.1.3
The stud

1. *stud space in toe brake block*
2. *stud space in left-hand shear beam*
3. *stud, placed between shear beam and brake block and enclosed stud spaces*
4. *stud space plate with lock*

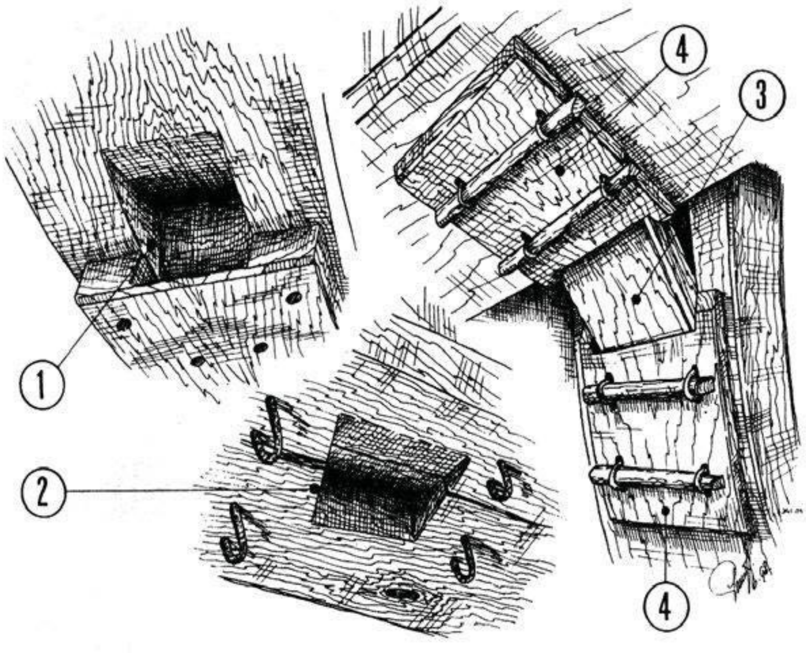
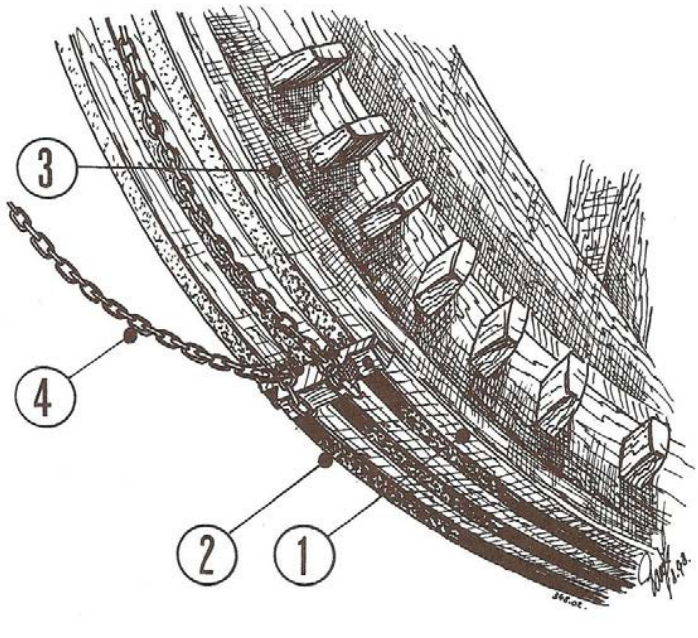


Fig. 6.6.2.1
Wooden band brake

1. *band brake or hoop brake*
2. *metal strap*
3. *brake wheel*
4. *tension chain*



6.6.2 The band brake or hoop brake

band brake, hoop brake

The band brake or hoop brake (see Fig. 6.6.2.1) is a one-piece wooden or metal strap that surrounds almost the entire outer circumference of the brake wheel, roughly like the Flemish brake.

6.6.2.a Wooden band brake

wooden band brake

In a wooden band brake (see Fig. 6.6.2.1), the brake blocks are replaced by a 4-cm thick curved one-piece wooden plank. This type of brake is made of elm wood that is quite bendable and does not break easily. To promote its ductility, transverse cuts are sometimes made in it. This weakens the brake though. To counter splitting or breaking, iron straps are sometimes nailed to the outer perimeter. The band brake is suspended with capstan bolts from the right-hand sheer beam or the right-hand upper side girt.
Wooden band brakes are quite rare in the Netherlands. A number of mills in Zeelandic Flanders are equipped with them.

6.6.2.b Steel band brake

steel band brake

The steel band brake (see Fig. 6.6.2.2) consists of an iron plate (about 6 mm in thickness) bent around the brake wheel, usually in one piece. This brake is also fastened with capstan bolts to the right-hand sheer beam or the right-hand upper side girt.
The steel band brake often has a wooden filler made of willow at the beginning, near the capstan bolts, to ensure that the brake properly surrounds the brake wheel.
With a steel band brake, the brake wheel obviously cannot be fitted with an iron liner.

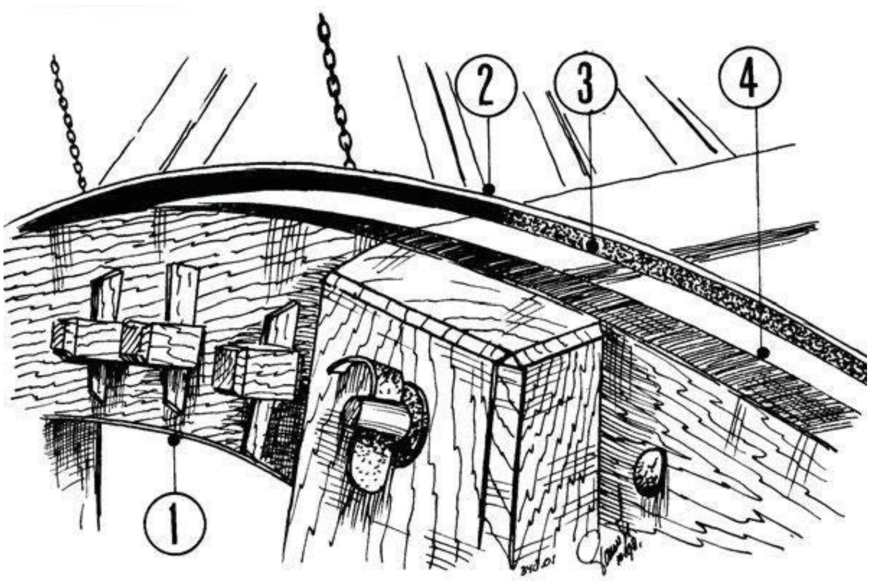


Fig. 6.6.2.2
Steel band brake

1. *brake wheel*
2. *steel band brake*
3. *interior band brake*
4. *brake wheel friction surface*

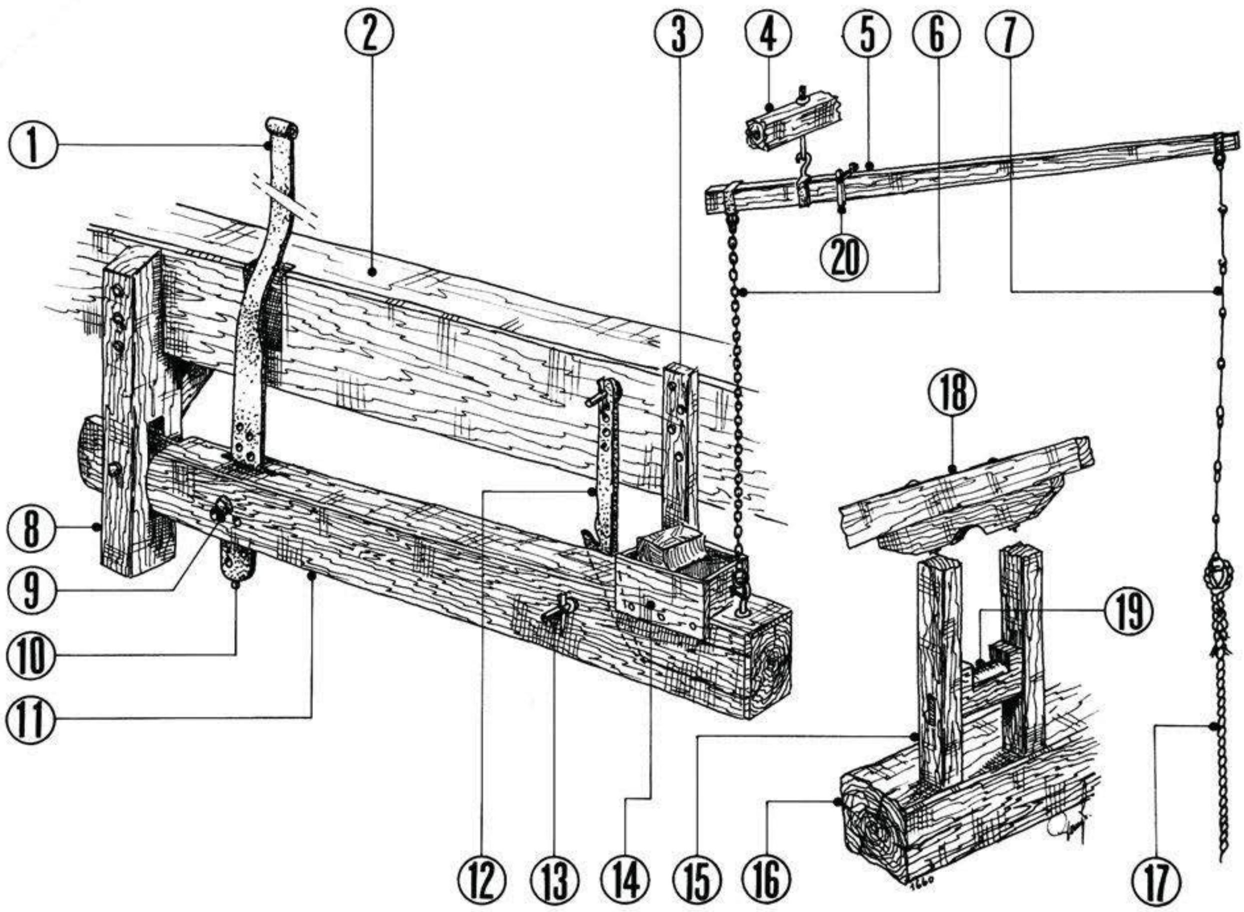


Fig. 6.6.3.1
The brake lever with accessories

1. *fastening eye for first brake block*
2. *right-hand sheer beam*
3. *rear hanger*
4. *rear gable beam*
5. *brake handle or fang staff*
6. *interior brake chain*
7. *brake chain*
8. *brayer beam or front hanger*
9. *bar bolt*
10. *sword iron*
11. *brake lever*
12. *hook or detent*
13. *detent peg*
14. *weight box*
15. *gable stud*
16. *short stretcher*
17. *brake rope*
18. *brake handle*
19. *support*
20. *drip plates*

6.6.3 Sword iron, brake lever, brayer beam or front hanger, rear hanger and hanger guide

6.6.3.a Sword iron

sword iron

The sword iron forms the connection between the actual brake and the brake lever (or brake beam). It is a heavy iron strip that has an eye at the top. Through this eye is inserted a bolt that connects the sword iron to the iron strap-work of the first brake block. On the underside, the sword iron has a series of holes. A bolt through one of those holes connects the sword iron to the brake lever (see Fig. 6.6.3.1). This series of holes is needed to change the position of the brake lever.
In a few cases, the 'sword iron' is partially made of wood and is then sometimes reinforced with iron sheathing.

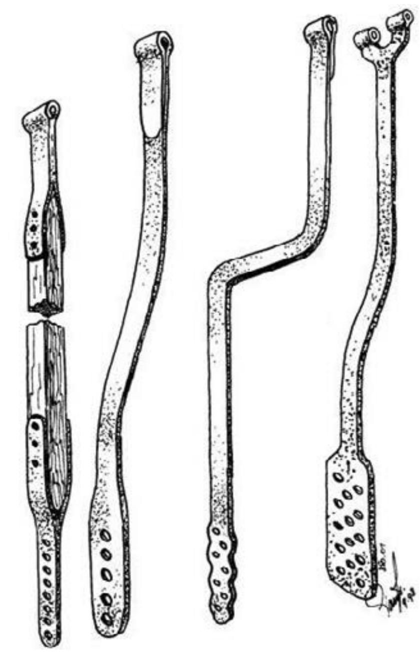


Fig. 6.6.3.2
The sword iron is found in various shapes and sizes

6.6.3.b Brake lever

brake lever

The brake lever is part of the operating mechanism of the brake. It is a heavy oak beam with a diameter of about 20 x 30 cm and a length that depends on the space available in the mill. Via the sword iron, the brake lever is connected to the brake.

brayer beam or front hanger

The brake lever has two pivot points. The first pivot point is located in the brayer beam or front hanger (see Fig. 6.6.3.3). In this brayer beam, the front end of the brake lever is hinged with a wooden pin. About 60 to 80 cm behind it is the second pivot point, the connection point of the brake lever and sword iron. For this connection, a vertical slot is made in the brake lever through which the sword iron is inserted. At right angles to this slot, a horizontal hole is bored through the brake lever. Through this and through one of the holes of the sword iron, a key bolt is inserted and secured. The various holes in the sword iron allow the sword iron and brake lever to be adjusted relative to each other (see Fig. 6.6.3.1 & Fig. 6.6.3.2).

The brake lever is made as long and as heavy as possible. This increases leverage and thus braking power. Extra weight is often added to the rear of the brake lever by mounting a casing on it and placing a heavy object in it, such as an old neck brass. In an average-sized mill, the brake lever pulls the sword iron with a force of about 500 kg.

In most cap winders, the brake lever hangs below the right-hand sheer beam. In hollow post mills, it hangs under the collar beams. In post mills, the brake lever hangs between the upper side girt and the bressumer. In some cap winders, the brake lever hangs above the sheer beam.

At the rear end of the brake lever is a device that allows the brake lever to be released (see Section 6.6.6). When the brake is released, the brake lever pushes up the sword iron and the brake blocks come free from the brake wheel. When the brake is applied, the brake lever pulls the sword iron down, thus clamping the brake blocks around the brake wheel so that the mill is braked.

6.6.3.c Brayer beam or front hanger

brayer beam or front hanger

The fixed pivot point of the brake lever is located in the brayer or front hanger (see Fig. 6.6.3.3). In a cap winder, the brayer beam is hanging and is supported by several braces on the right-hand sheer beam, which is a rather weak construction. In a post mill and a hollow post mill, the brayer beam can be attached in two places: to the side girt and the bottom side rail or to the upper side girt and the side girt, which is a more robust construction.

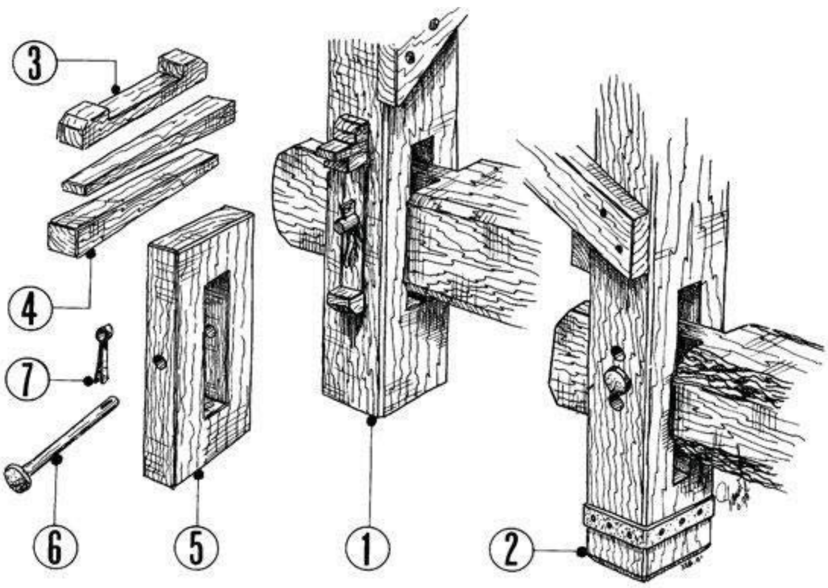


Fig. 6.6.3.3
Brayer beam or front hanger

1. *brayer beam with slider*
2. *brayer beam with fixed pivot*
3. *notched wedge*
4. *guiding wedges*
5. *slider or frame*
6. *key bolt*
7. *key*

The pivot point of the brake lever in the brayer beam has two common versions.

In the first, there is a vertical slot in the brayer beam into which the pin of the brake lever is inserted. At right angles to that slot, a key bolt is inserted through the brayer beam and through the eye in the pin of the brake lever, around which the brake lever is hinged.
In the second, there are two perpendicular vertical slots in the brayer beam. In the slot perpendicular to the longitudinal direction of the brake lever is fitted a wooden block, the slider or frame with a hole in it. The gudgeon of the brake lever is inserted into this hole. A bolt through the slider and through the eye in the gudgeon of the brake lever forms the pivot point.
The slider is secured to the brayer beam with wedges and notched wedges, which makes it adjustable. This provides the ability to adjust the height of the brake lever.

slider, frame

6.6.3.d Rear hanger and hanger guide

rear hanger

hanger guide

release lever

pawl pin, weighted pawl rope

The rear hanger (see Fig. 6.6.3.1) attached to the right-hand sheer beam serves to guide the brake lever when the brake is released or applied. Often the rear hanger is extended into a wooden framework, the hanger guide, within which the rear end of the brake lever moves (see Fig. 6.6.3.4). In many cases, the hanger guide also includes the pivot point for the release lever.
A guiding sheave is then attached to the underside in the extended transverse section for guiding the release lever rope (see Fig. 6.6.3.4). Often the rear hanger or the hanger guide is still equipped with a so-called pawl pin or weighted pawl rope with which the brake can be blocked against unauthorized use.

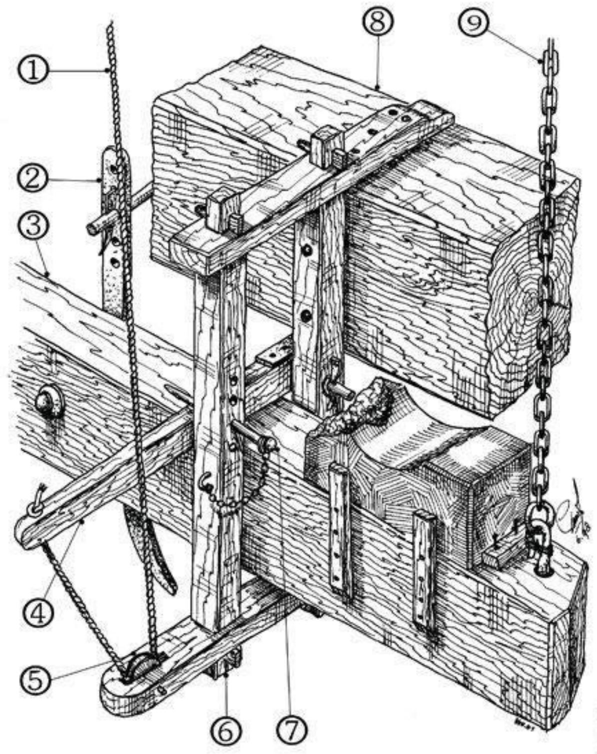


Fig. 6.6.3.4
The hanger guide

1. *release lever rope*
2. *hook or detent*
3. *brake lever*
4. *release lever*
5. *guiding sheave for release lever rope*
6. *hanger guide*
7. *pawl pin*
8. *right-hand shear beam*
9. *interior brake chain*

6.6.4 Brake catch and bed, first clamp strut, brake guides and chains

When the brake lever is released, the sword iron pushes up the first brake block or the beginning of the band brake.
Then the rest of the brake comes off the brake wheel. However, this only happens thanks to a number of guides without which the brake would get stuck and rub against the top of the brake wheel due to its own weight.
It is the guides that are being discussed here. If they are properly adjusted, then when the brake is released there will be a space of about 1 cm between the brake and brake wheel along the entire brake surface.

6.6.4.a Brake catch and bed

If via the sword iron, the brake lever pushes the brake away from the brake wheel, it is important that the space created between the brake wheel and brake is distributed evenly around the entire circumference, otherwise the brake will continue to catch. This does not happen automatically because the brake's own weight would keep it rubbing against the top of the brake wheel while underneath by the bottom brake block there would be a considerable gap between brake wheel and brake. This is avoided as follows:

brake catch, toe bed

Attached to the toe brake block of the brake (to a band brake at a corresponding height) is a wooden chock, the brake catch or toe. A wooden chock with an angled keep, the bed, is also attached to the left-hand sheer beam or the left-hand upper side girt. When the brake is released, the brake catch is on the bed. Together, they prevent the brake from descending too far. In addition, due to the angled bottom they keep the toe brake block or band brake at the correct distance from the brake wheel. As a fine adjustment, you can, if necessary, apply one or more thin boards between bed and brake catch.
If a metal band brake is used, the brake catch and bed are also made of metal (see Fig. 6.6.4.1).

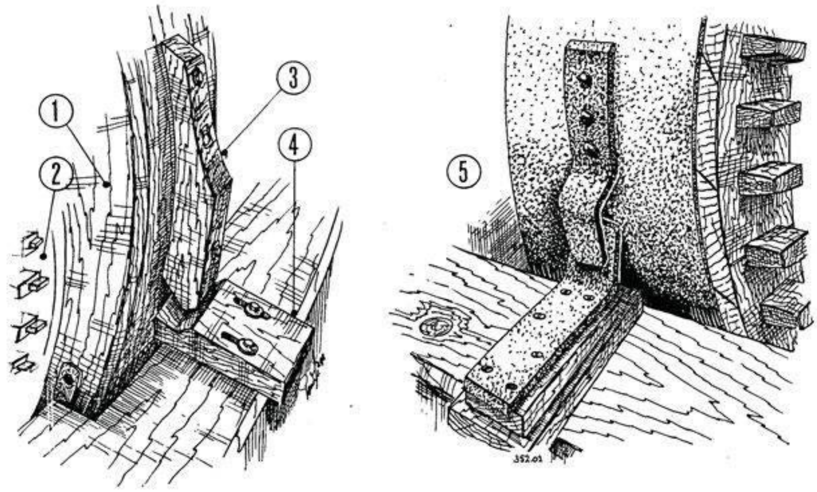


Fig. 6.6.4.1
Wooden and metal brake catch and bed

1. *toe brake block of the brake*
2. *rear of the brake wheel*
3. *brake catch*
4. *bed*
5. *metal brake catch and bed*

6.6.4.b First clamp strut

first clamp strut

The first clamp strut is on the right-hand sheer beam or on the right-hand upper side girt and is attached at the top to a purlin. The job of the first clamp strut is to guide the first brake block (or the beginning of the band brake) and prevent it from being pushed too far sideways away from the brake wheel when the brake is released. In this way, the brake also detaches from the brake wheel at the top. Often the first clamp strut is laterally adjustable in connection with wear of the brake wheel and brake.

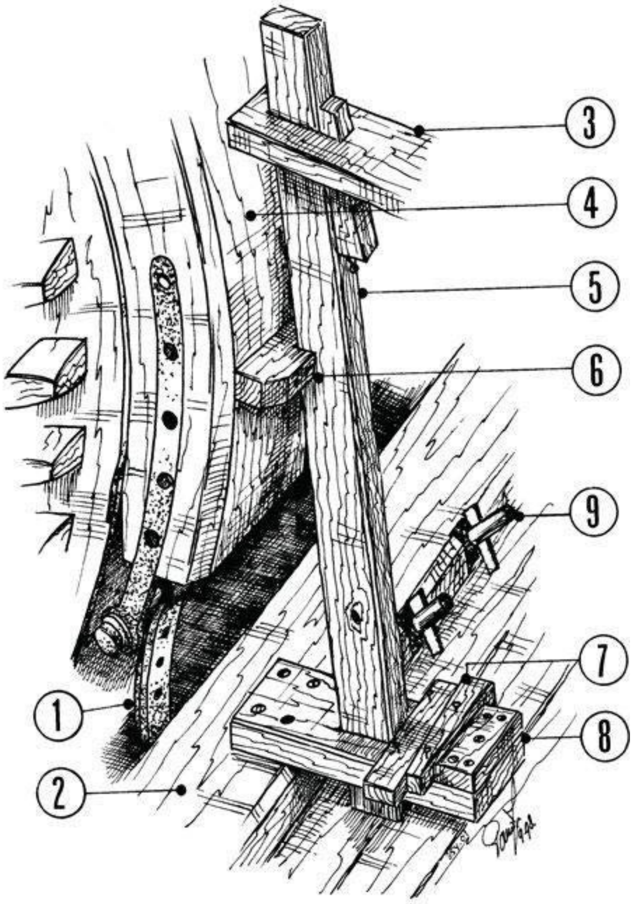


Fig. 6.6.4.2
First clamp strut

1. *sword iron*
2. *right-hand shear beam*
3. *support for cap purlin*
4. *first brake block of the brake*
5. *first clamp strut*
6. *notched wedge for brake block*
7. *adjustment wedges*
8. *support*
9. *capstan bolts*

6.6.4.c Brake guides

brake guides and chains

To prevent forward and backward movement of the brake, brake guides and chains are attached to the cap rafters or purlins (see Fig. 6.6.1.1).

6.6.5 Method of hanging the released brake lever

To keep the released brake lever in its released position, several devices are possible.

6.6.5.a Hook or detent

hook, detent

A hook or detent is a more or less sword-shaped piece of iron of 1 to 1.5 meter in length. It has a number of holes at the top. The detent is suspended from the right sheer beam (in a hollow post mill or post mill, from another beam) by a bolt through one of these holes. The designation 'short sword iron' for the hook is unjustified, despite its sword shape.
At about 25 to 40 cm from the lower tip of the hook, a slanting downward notch is made in hook, creating the actual hook. A bolt is inserted through the brake lever at the location of the hook, with the head of this bolt protruding a few centimetres on the hook side.

When the brake lever goes up as the brake is released, the protruding bolt slides up along the convex back of the hook and pushes it slightly forward. Once the bolt has passed the notch, you can carefully lower the brake lever. The bolt then ends up in the notch and the released brake lever is hung. The miller should always check carefully that the bolt is indeed hanging in the hook and, for example, not resting on its tip. The latter is extremely dangerous because if the bolt shoots off the wrong side of this tip, the turning mill will be braked in an uncontrolled manner, possibly resulting in shaft breakage!

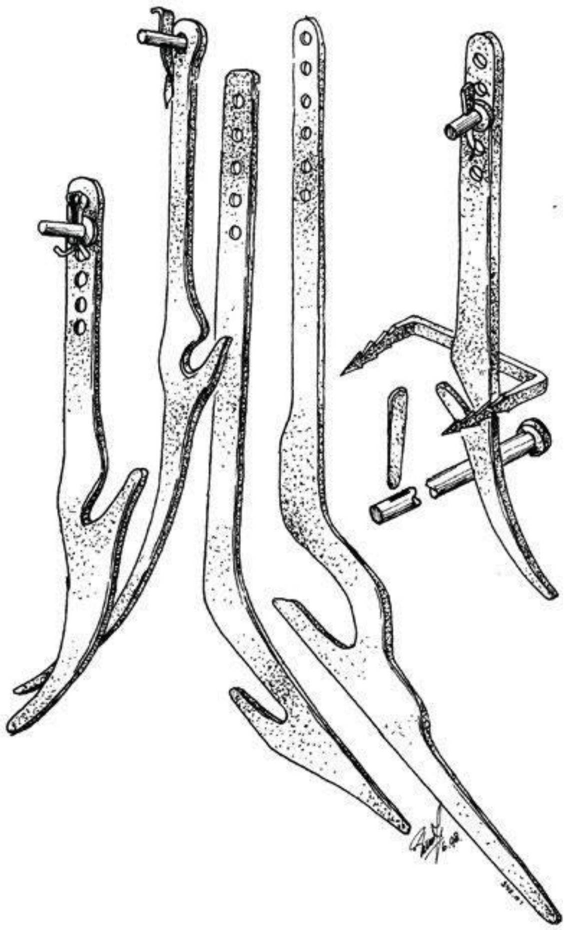


Fig. 6.6.5.1
The hook or detent comes in many shapes and sizes

When braking, the brake lever must first be raised a little with a short pull. This causes the bolt to shoot out of the hook and the hook to swing forward. During the swing, the miller quickly lowers the brake lever slightly to prevent the bolt from ending up back in the notch once it has returned to its normal position. This requires the necessary practice.
Thus, when using a hook to hang the brake lever, the brake lever only needs to make a vertical movement. The hook or detent can be found on mills all over the Netherlands.

6.6.5.b Thumb

thumb

We know of another device for hanging the brake lever, namely the thumb. ('hook and eye') This is attached to the rear hanger (see Fig. 6.6.5.2). It is an iron pin that sticks up at an angle and is carved into the bottom of the beam. Just below the top end, the pin has a bolt that protrudes through the rear hanger. So the top end sticks out slightly above the bolt. The whole thing is reminiscent of an upward pointing thumb, which explains its name.

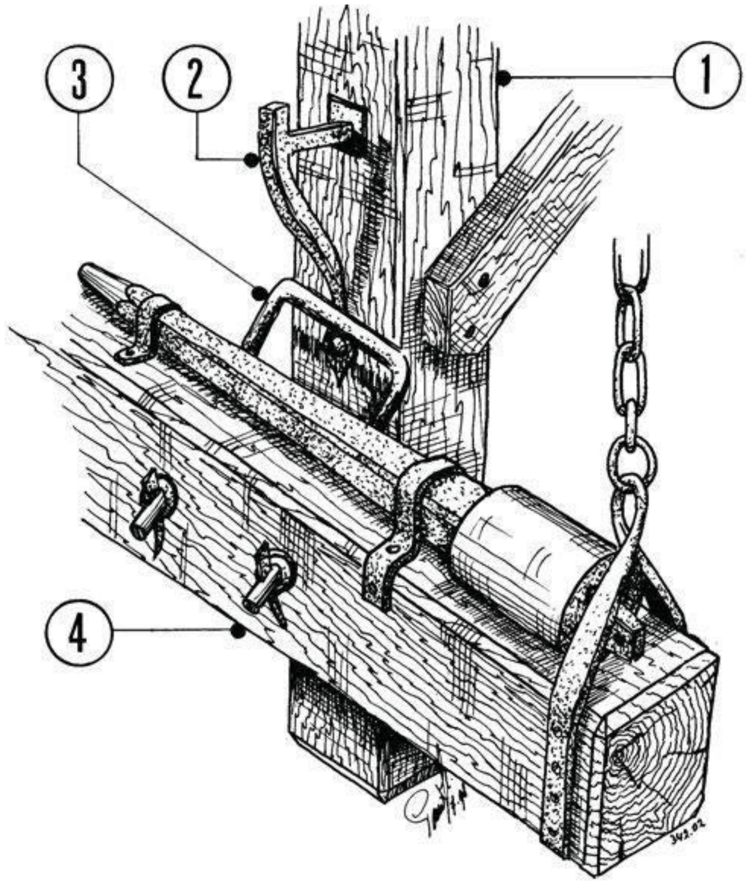


Fig. 6.6.5.2
The rear hanger with thumb

1. *hanger*
2. *thumb or hook*
3. *bracket or eye*
4. *brake lever*

bracket

A bracket is attached to the right-hand side of the brake lever at the location of this thumb. When releasing the brake lever, the bracket slides up past and against the thumb. Once the bracket passes the thumb, you can lower the brake lever again. The bracket will then hang in the thumb and the brake lever is suspended.
Again, the miller should check that the bracket is not stuck on the top of the thumb. This can result in the bracket shooting off the wrong side of the thumb tip. The mill will then be braked too suddenly, which can result in breakage of the upper shaft.
To brake the mill, the brake lever must be raised slightly so that the bracket is released from the thumb tip. To prevent the bracket from falling back into the thumb when lowering the brake lever, first move the brake lever slightly to the left. This is done by using the brake rope to pull the brake handle slightly to the right. Thus, when a thumb is used, the brake lever must be able to make a sideways movement in addition to a vertical one.

This affects the system used to release the brake lever (see Section 6.6.6). The thumb is mainly found in the northern part of the Netherlands.

6.6.5.c Clamp

clamp

body

The third possibility is using a clamp to hang the released brake lever. This clamp is recessed into the rear hanger and is chamfered at the top towards the rear hanger. A piece of hardwood is applied to the clamp to counter wear and tear. A body with the same shape as the clamp is carved into the brake lever at the level of this clamp.

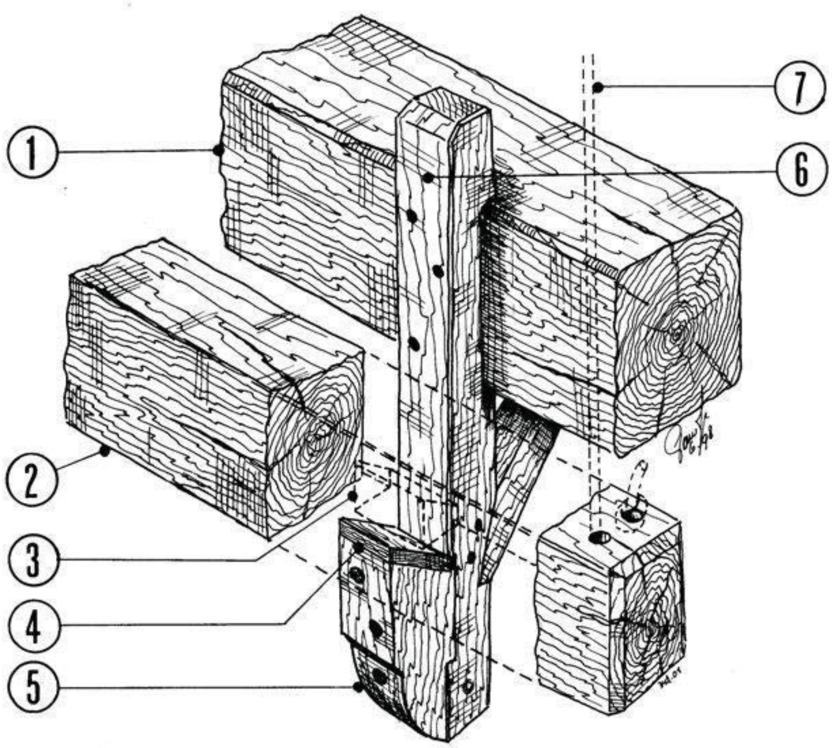


Fig. 6.6.5.3
Rear hanger with clamp

1. *right-hand shear beam*
2. *brake lever*
3. *body in the brake lever (dotted lines)*
4. *hardwood plate*
5. *clamp*
6. *hanger*
7. *inner brake rope, inner brake chain*

Thus, the top of this body also slopes toward the rear hanger. When suspended, the released brake lever hangs over the clamp, with the chamfered top edges of the body and the clamp preventing the brake lever from falling off the clamp during grinding.
When braking, proceed in the same way as with the thumb. Even when using a clamp, the brake lever must be able to make a sideways movement to allow the brake lever to descend.
The brake with clamp is found mainly in North Holland.

6.6.6 Releasing and applying the brake

There are several systems for releasing the brake, some with regional origins.

6.6.6.a Brake handle or fang staff

brake handle, fang staff

interior brake chain

brake chain

brake rope

The brake handle or fang staff (see Fig. 6.6.3.1) protrudes from the back of the cap of a cap winder or from the cabin of a hollow post mill. The fang staff is suspended from the rear gable beam or tail beam with a bracket or bolt. The inner end of the fang staff is connected to the rear end of the brake lever with the interior brake chain.
Attached to the other end of the fang staff is the brake chain that easily reaches the ground, mound or stage. To improve the grip, the bottom end of the brake chain is fitted with a rope, called the brake rope, or (in the northern part of the Netherlands) with wooden beads.
When the brake rope or brake chain is pulled, the outer end of the fang staff moves downwards but its inner end moves upwards. The brake lever then moves upwards via the attached interior brake chain. The fact that this does not require too much effort is due to the leverage of the brake handle: the part outside the mill on which the miller pulls is about 3 to 5 times as long as the part that is inside the mill and on which the brake lever hangs. Moreover, the upward movement of the rear end of the brake lever is also 3 to 5 times smaller than the downward movement of the outer end of the fang staff. If the miller pulls the fang staff down half a metre, the brake lever will go up about 10 to 15 cm.
One disadvantage of the brake handle is that it is always subject to wind and weather. Because the brake handle points upward at an angle when the mill is stationary, water runs into the mill when it's raining. This can be largely prevented by fitting drip plates or a piece of rope around the brake handle just outside the cap. The brake handle can be found throughout the Netherlands but it is little used in Brabant, Limburg and the Achterhoek regions, where the brake barrel is often used (see Section 6.6.6.d).
The brake handle can be used with all three methods of hanging the brake lever (hook, thumb or cleat) because the brake lever can also be moved sideways with the brake handle.

To release the brake on a mill equipped with a thumb or cleat, the miller pulls the brake chain, which causes the rear end of the brake lever to move upwards. The miller then walks slightly to the left (facing the sail cross), causing the inner end of the fang staff and thus the brake lever to move to the right. The rear end of the brake lever touches the rear hanger in the process. Now the miller can gently lower the brake lever so that its rear end will hang in the thumb or rest on the cleat.
Applying a brake that is equipped with a thumb or cleat is done as follows: the miller releases it first. Then the miller walks slightly to the right (facing the sail cross). Via this lateral movement, the inner end of the fang staff moves to the left, taking with it the rear end of the brake lever. The brake lever can then be lowered past the thumb or cleat.

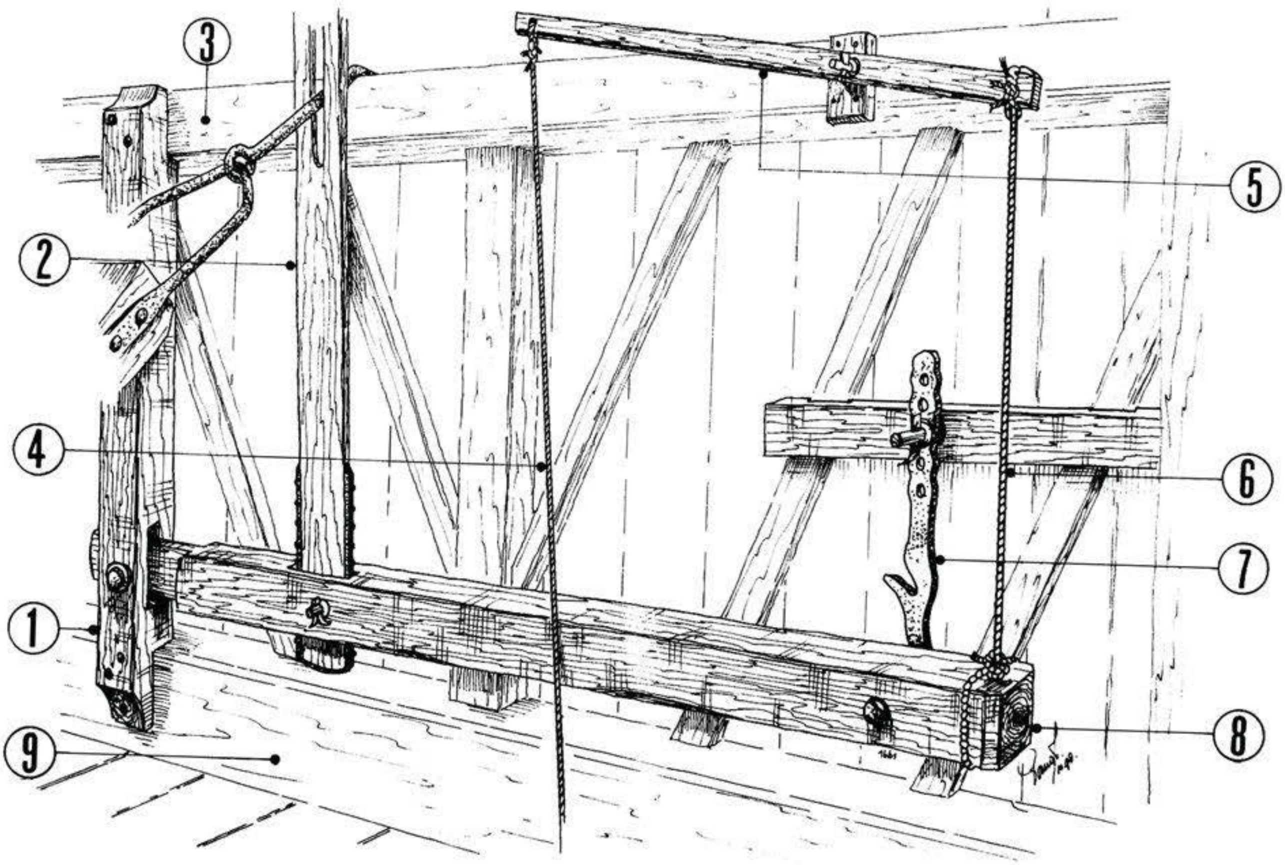
6.6.6.b Interior fang staff

interior fang staff

The interior fang staff works on the same leverage principle as the ordinary fang staff or brake handle. With the interior fang staff, the brake lever can only be moved up and down, not sideways. This means that only a hook — not a thumb or clamp — can be used for hanging the brake lever. There are different versions of the interior fang staff:
At a post mill, the interior fang staff hangs from a span piece or upper side girt, parallel to the brake lever (see Fig. 6.6.6.1).
The long end of the staff points in the direction of the weather beam. The first metres of the brake rope are inside the body. Then the rope exits the body and the remainder is hanging outside. This allows the brake to be operated both inside the body and at ground level.
At a paltrok, the interior fang staff hangs parallel to the brake lever under the crank floor (see Fig. 6.6.6.3). The paltrok has a brake rope with two ends. One end of the rope exits the mill through a hole in the cladding of the breast framing and hangs down to the platform. It is used only when setting or removing sails or winding the mill. The other rope hangs inside the mill up to the sawing floor, so that the mill can be braked there as well. The paltrok has no hook or detent but the brake is kept released by securing the brake

tightener

rope. Just above the saw jig floor, a tightener is inserted through the brake rope. The hole in the saw jig floor through which the brake rope hangs down has a keep in the shape of a keyhole. When the brake is released, the tightener is just below the floor. The brake is held in a released state by pulling the brake rope sideways into the slot, whereby the tightener remains secured under the floor and prevents the brake rope from being pulled back up by the weight of the brake lever when released.
A third type of interior fang staff is found at a few hollow post mills in the Alblasserwaard region. The interior fang staff is attached (perpendicular to the brake lever) to the tail framing with the pivot point at the beam above the door (see Fig. 6.6.6.2). The brake rope exits the cabin on the left through a hole in the floor.



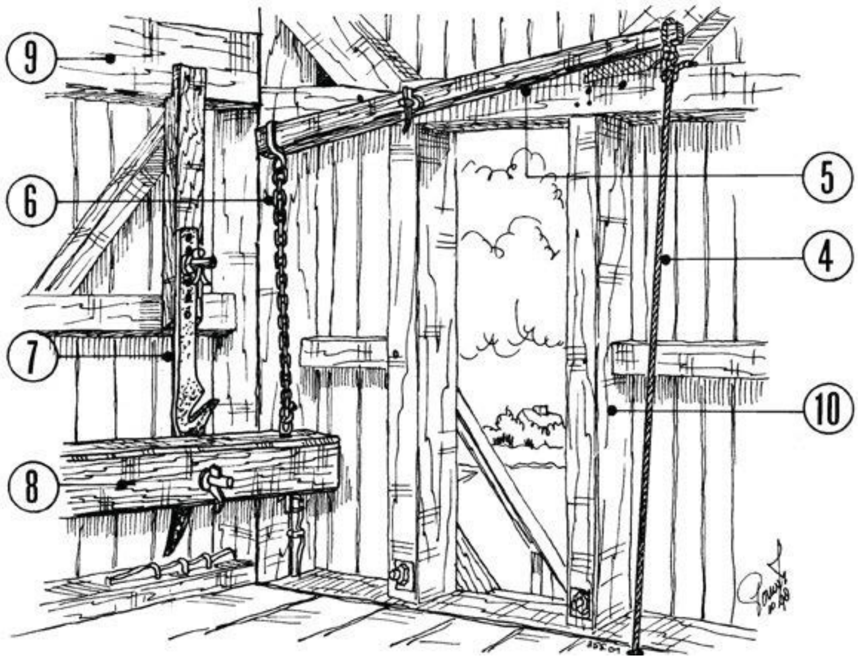


Fig. 6.6.6.1 & Fig. 6.6.6.2
The interior fang staff of the post mill and the hollow post mill

1. *brayer beam*
2. *sword iron or sword board*
3. *upper side girt*
4. *brake rope*
5. *interior fang staff*
6. *interior brake chain or rope*
7. *detent or hook*
8. *brake lever*
9. *side girt*
10. *door jamb*

Fig. 6.6.6.3
The interior brake handle of the paltrok

A. System as applied in the paltrok Held Jozua (Jozua the Hero)
B. System as applied in the paltrok De Eenhoorn (The Unicorn)

1. *brake rope to the platform outside*
2. *brake rope to the sawing floor*
3. *cross-piece or tightener**
4. *shear post*
5. *sword iron or sword wood*
6. *beam for hanging the brake handle*
7. *brake handle chain*
8. *brake lever*
9. *brake handle*
10. *crank beams*
11. *crank truss*
12. *inner brake rope, inner brake chain*
13. *pull brake shoe*
14. *heavy frame*
15. *king beam*

**left: brake rope with brake applied*
right: brake rope with brake released

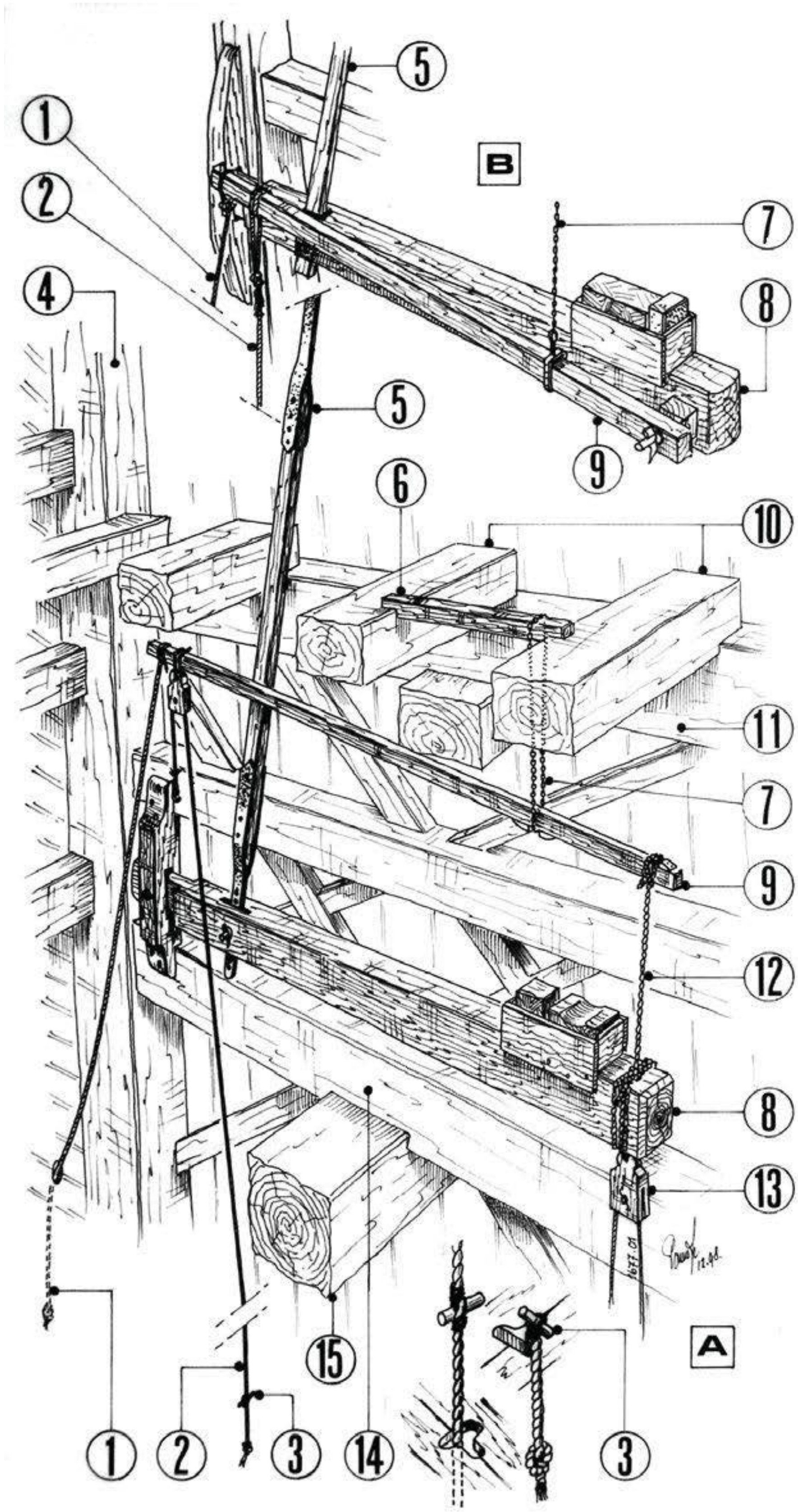
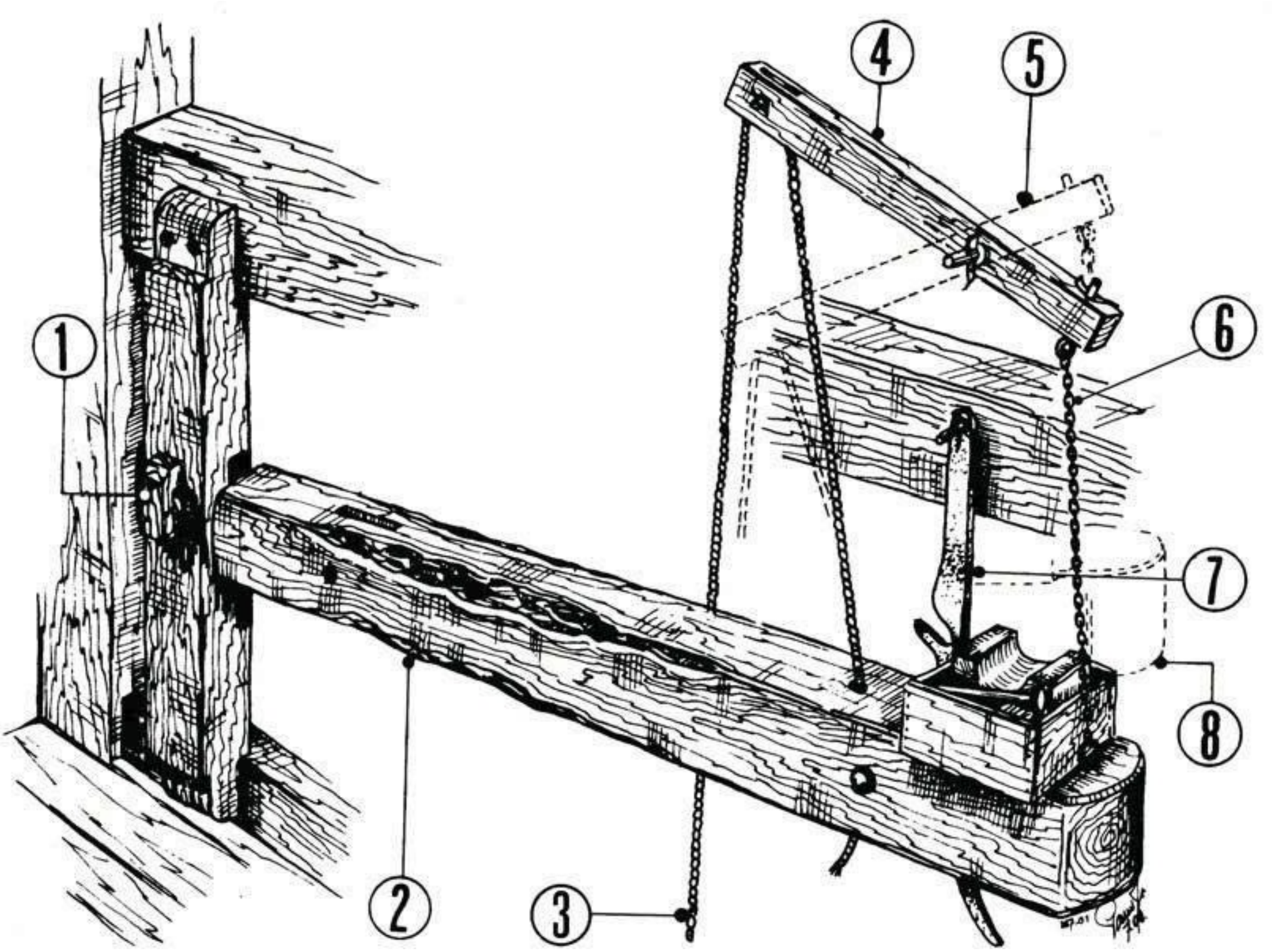


Fig. 6.6.6.4
The brake with an equalizer

1. *pivot with locking chock*
2. *brake lever*
3. *brake rope*
4. *equalizer with brake applied*
5. *equalizer with brake released*
6. *interior brake chain*
7. *detent or hook*
8. *brake lever with brake released*

6.6.6.c Equalizer

The equalizer is used at both post mills and hollow post mills. Against the right-hand upper side girt of either the body or the cabin is attached a balance beam, called the equalizer, with its pivot point approximately in the middle. At the rear, the equalizer is connected to the brake lever using a chain. At the front, the equalizer has a vertical slot into which a disc is inserted. The brake rope runs over this disc, with the end of the rope attached to the brake lever. The brake rope exits the body or cabin through a hole in the floor, sometimes passing through the brake lever via an opening made in it. With the brake applied, the equalizer has an angled position: the front of it, where the disc is, pointing upwards, the back downwards. When the brake rope is pulled, the brake lever is pulled up by two mutually supporting forces. The first force is transmitted directly by the brake rope itself, since its end is attached to the brake lever. The second is transmitted via the equalizer and the chain. Indeed, when the brake rope is pulled, the front of the equalizer moves downwards because the brake rope passes over the disc. The back of the equalizer must then move upwards and take the brake lever with it via the chain.
If an equalizer is used for braking, the brake lever can actually make only a vertical movement and not a lateral one. Therefore, only the detent is appropriate for hanging the brake lever.



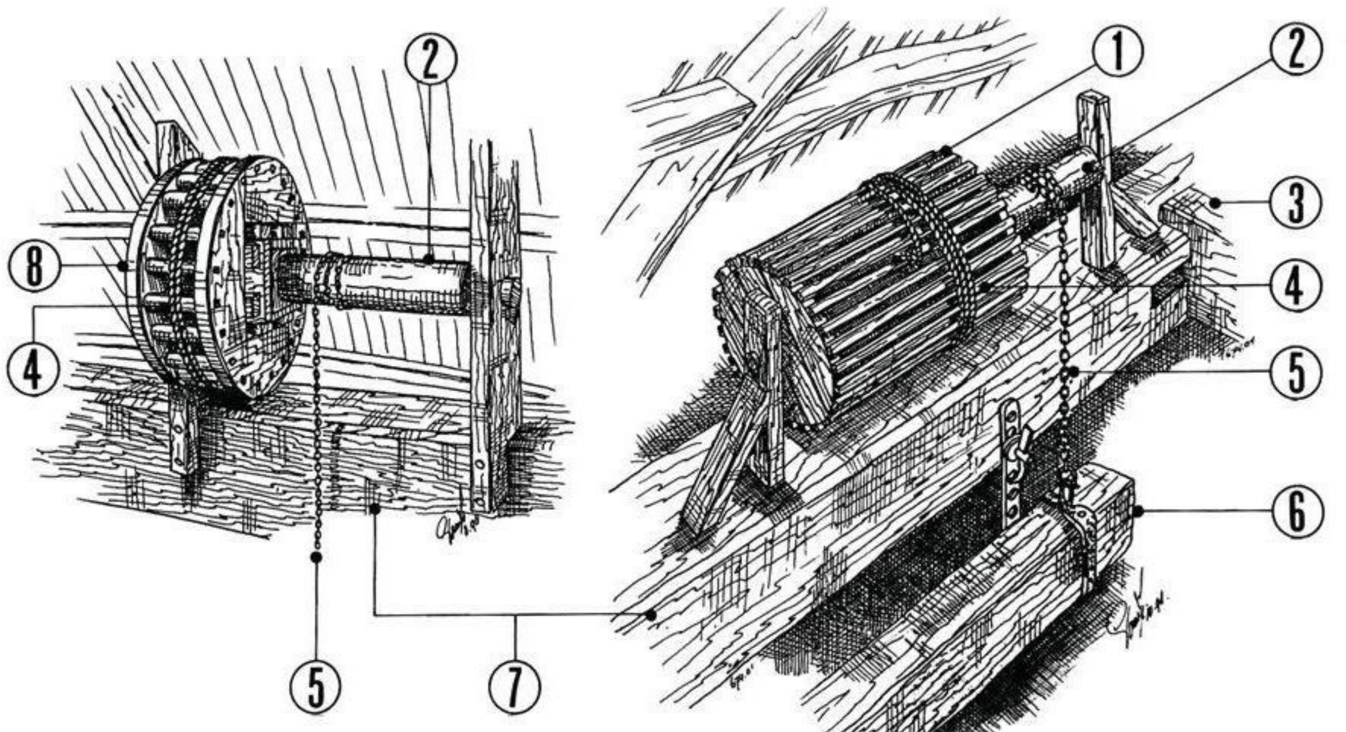
6.6.6.d. Brake barrel

brake barrel

In the southern and eastern parts of the Netherlands, the brake handle is often replaced by a brake barrel. There are two yokes mounted on the right-hand sheer beam (cap winder) or the right-hand side girt (post mill or hollow post mill) in which a sturdy shaft is mounted. On the rear part of this shaft is attached a rope, chain or cable that is wound around the shaft several times and then attached to the brake lever. Around the front part of this shaft is a wooden barrel consisting of two discs on which slats are nailed parallel to the shaft. The brake rope or chain is attached around this barrel and wound around it several times. Its winding is opposite to that of the rope that goes to the brake lever. The brake rope always exits on the right-hand side of the cap, cabin or body.
If the brake rope is pulled it is unwound from the drum, but the rope connected to the brake lever, on the other hand, is wound on so that the brake lever is released. Since there is quite a difference between the respective diameters of the barrel and the shaft, the movement of the brake rope is transmitted to the brake lever rope in a delayed manner. This delay is similar to the delay realized in the brake handle due to leverage.
Also with a brake barrel, the brake lever can only be hung in a hook or detent because the barrel allows only vertical movement of the brake lever.
An advantage of the brake barrel is that the entire structure is located inside the mill and it is therefore not subject to weather conditions.
On some mills, there is no barrel but instead a Y wheel to drive the shaft.

Fig. 6.6.6.5
The brake barrel

1. *barrel*
2. *barrel shaft*
3. *tail beam*
4. *brake rope*
5. *interior brake chain*
6. *brake lever*
7. *right-hand shear beam or side girt*
8. *stone gear as brake barrel*



6.6.7 The brake of the tjasker and the spider mill

6.6.7.a Brake of the tjasker

The brake of the tjasker is as simple as the mill type itself (see Section 5.6.2). The end of a curved iron band is attached to the left-hand side of the framework. The band runs over the so-called brake wheel attached to the waterwheel shaft to the right-hand side of the frame. The other end of it is attached to a lever there.
The brake is released by moving this lever up. If you push the lever down then the mill is braked. The end of the lever is then pressed under a pin or chock, keeping the brake applied.

6.6.7.b Brake of the spider mill

The peculiarity of the brake at a spider mill is its operation.
The spider mill has no brake handle, no equalizer and no barrel. The brake rope is attached directly to the brake lever and runs to the first floor via a rotating shaft on the tail beam.
In addition, the brake lever lacks a hanging option such as a detent or a cleat. The brake is released and the brake rope is then easily secured to a cleat. This keeps the brake released.
Because of the small amount of space in the cabin of a spider mill, there is no room for a weight box on the brake lever. To nevertheless provide the brake lever with sufficient braking force, a second rope with a pulley is attached to the end of the brake lever.
This allows the brake lever to be pulled downwards. Thus, it is a pull brake (see Fig. 6.6.8.b). When the brake has been applied, this second rope is fastened to a cleat and further tightened by tucking it behind a notched wedge.

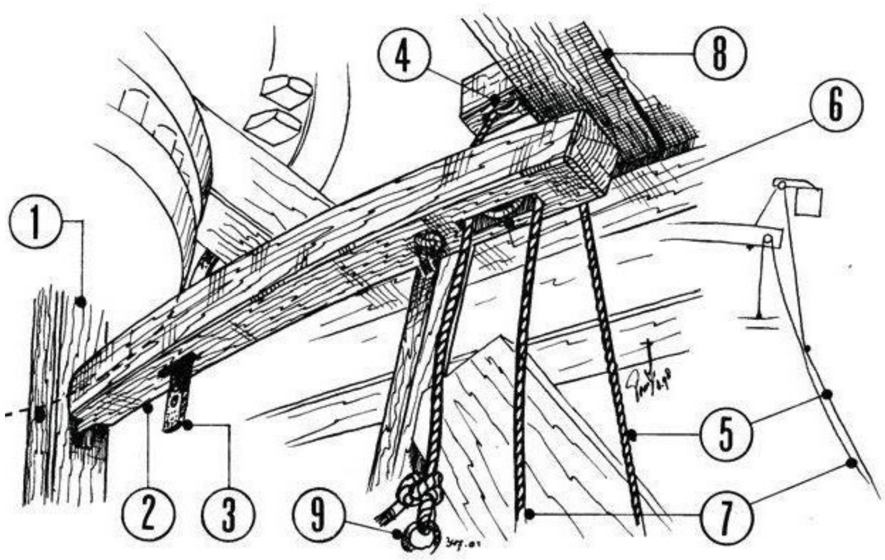


Fig. 6.6.7.1
The brake in a spider mill

1. *corner post as hanger*
2. *brake lever*
3. *sword iron*
4. *pulley for the brake rope*
5. *brake rope*
6. *pulley for pull brake rope*
7. *pull brake rope*
8. *tail beam*
9. *fixed point for the pull brake rope*

6.6.8 Securing the brake and the brake wheel

There are also some devices with which the brake and brake wheel could be secured when the mill was stopped at the end of a milling day.

6.6.8.a Release lever

release lever

Using the release lever, a sturdy piece of wood with a diameter of about 7 x 10 cm and a length of 75 to 100 cm, the brake lever can be secured when in the applied state. The release lever in a cap winder is attached to the hanger guide with a bolt (see Fig. 6.6.3.4). At a hollow post mill, it is usually on a corner post of the cabin.
The release lever can rotate, at right angles to the brake lever, around this bolt. When securing, using the release lever rope that is attached by its loose end, pull the release lever tightly over the rear end of the brake lever and secure the rope to the bottom of the tail (beam). This pushes the brake lever down a little further so that the sword iron tightens the brake even more forcefully.

release lever rope

The release lever can still be secured in the cap by means of a rope, the weighted pawl rope or a pin, and the pawl pin (see Fig. 6.6.3.4) can be inserted above the tightened release lever into one of the holes in the back wall of the cabin (hollow post mill) or in the hanger guide (cap winder). This prevents external unauthorised persons from being able to disengage the release lever and release the brake.
The release lever is mostly found in South Holland and Utrecht.

weighted pawl rope, pawl pin

6.6.8.b Pull brake

pull brake

The pull brake occurs only in the Zaan region and at spider mills. Attached to the rear end of the brake lever is a rope that runs through several sheaves on the rear hanger and goes to the underside of the tail beam in the cap.

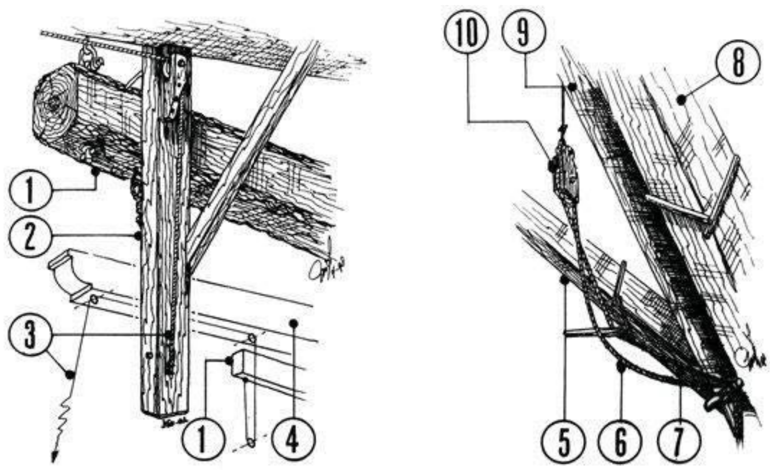


Fig. 6.6.8.1
Pull brake

1. *brake lever*
2. *rear hanger*
3. *pull brake rope*
4. *right-hand shear beam*
5. *right-hand long strut*
6. *loose part of the pull brake rope*
7. *fixed part of the pull brake rope*
8. *left-hand long strut*
9. *tail beam*
10. *pull brake shoe*

At that location is a pulley over which the rope of the pull brake can be tightened and secured to the tail beam.

6.6.8.c Pawl

When the wind comes from behind, the sail cross tends to rotate backwards. If the wind is very strong, the brake wheel can even release the brake. To do this, it only needs to overcome the force exerted by the weight of the brake lever.
At all costs, therefore, the brake wheel must be prevented from being able to rotate backwards. The device used for this purpose is the pawl (see Fig. 6.6.8.2). This is a solid beam hinged to the left-hand sheer beam (in a hollow post mill, on the upper side girt) in the immediate vicinity of the brake wheel. Three or four cogs with the same pitch as that of the brake wheel are inserted into this beam.

pawl

These cogs have a flat top. When the mill is stopped at the end of the grinding day, the pawl with its cogs is 'housed' between those of the brake wheel. The underside of the pawl cogs are rounded.
This round finish ensures that if the pawl is not pulled away before releasing the brake, the cogs of the brake wheel push the pawl out of the wheel. However, after each passage of a cog from the brake wheel, the pawl falls back such that a distinct thumping sound can be heard.

pawl rope

Pull the pawl out of the brake wheel using the pawl rope. This rope is attached to the top of the pawl and exits through a number of rope sheaves at the bottom of the tail. A second rope with a counterweight attached causes the pawl to drop into the tail wheel when the pawl rope is released.
The pawl is found mainly in the western part of the Netherlands. For the pawl on the tjasker, see Section 5.6.2.

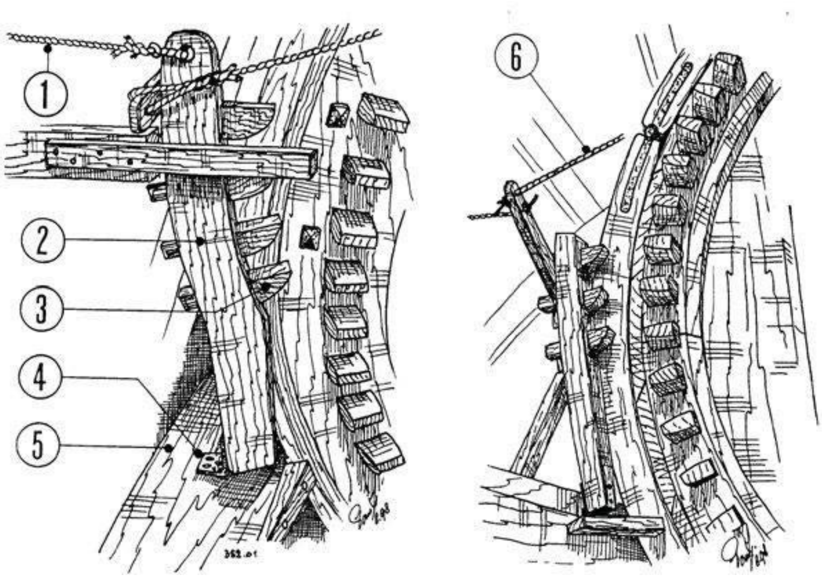


Fig. 6.6.8.2
Pawl

1. *pawl rope*
2. *pawl*
3. *dome-shaped cogs*
4. *pivot*
5. *left-hand sheer beam or upper side girt*
6. *rope for the counterweight*

Note: The pawl should only be used to secure a stationary mill against reverse turning. Never try to stop a mill that is already turning backwards by retracting the pawl because this will undoubtedly result in breaking the cogs of the pawl and some of the cogs of the brake wheel!

Chapter 7 Practical considerations

Contents page:

NOTES

7.0 INSPECTION OF THE MILL FOR TURNING CAPABILITY

7.0.0 Introduction

Any miller who intends to turn or grind a mill should first check that the mill is capable of turning or grinding. Defects, wear and tear, and the like slowly but surely creep into the mill. Therefore, an inspection is always required before turning. Those who know their own mill well and run it regularly can make do with a brief inspection, with more extensive checks done every so often. For example, you should pay more attention to bird nests in the spring and to loose wedges during long dry periods.
If you are going to turn at another mill for the first time or at a mill that has been idle for a considerable time, a comprehensive inspection is needed to determine whether the mill is capable of turning. If possible, also ask other or former millers for information, check the logbook, etc.

7.0.1 Inspection of the cap

What is most important is the cap floor. Check the floor for objects that do not belong there: wedges, parts, wood splinters, dirt, etc. These can indicate there are defects or parts to be checked.

7.0.1.a The brake

As applicable to the mill, check:

1. The condition of the brake blocks, iron strap-work eyes, coupling bolts and sword iron. Pay particular attention here to small cracks, which signify the beginning of breakage.
2. The fit of the brake blocks around the brake wheel and the position of the strut
3. The brake catch and bed, first clamp strut, brake guides and chains.
4. The rear hanger with the hook and pin in the brake lever, the cleat or thumb with bracket, the hanger guide.
5. The brake handle, its suspension and the attachment of the brake rope, brake chain or steel cable. Is the brake handle hanging roughly horizontally?
6. The interior brake chain or the interior brake rope and its attachment to the brake handle and to the brake lever.
7. The brake barrel, the tail gudgeons and the uprights in which it is suspended, and the attachment and condition of the chains and/or ropes. See if there is sufficient rope around the drum.
8. The hanging of the front hanger or brayer beam from the right sheer beam.
9. The hanging of the brake lever in the front hanger or brayer beam.
10. The brake lever itself and the lip, with which it rotates in the front hanger or brayer beam.
11. The pawl and the release lever.

7.0.1.b The brake *wheel*

Check:

1. The condition of the brake wheel. Look out for cracking at the cross-arm intersections and in the rims between the cogs.
2. The cogs:
   a. Check whether they are loose, cracked or have an irregular wear surface.
   b. Check whether they are sufficiently lubricated with beeswax.
3. The wheel wedges: Check whether they are securely fastened and secured with keepers.
4. The hoop:
   If made of wood: Check whether it is still firmly attached and no nails are sticking out. If made of metal: Check whether there are no cracks in it and no nails or screws sticking out and whether the lacing pins are tight.
5. Check the straps around the filling pieces.

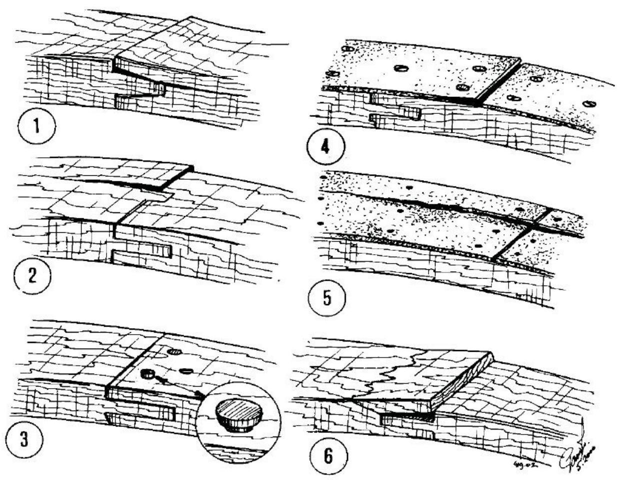
7.0.1.c The windshaft and its bearings

Check, if applicable:
1. The neck brass and tail brass for breakage. If the parts are wedged neatly against each other and the shaft does not run hot, then this is not a problem.
2. Both bearings
   a. Check for adequate lubrication with lard. Is there enough lard present in the mill?
   b. Check for an even lubrication pattern (no shiny tracks).
3. The pivot of the gudgeon for sufficient oil of good quality.
4. The filling pieces for rubbing against the centre beam, long stretcher or sprattle beam.
5. The collar plate groove, that it is not inside the cap, allowing water to enter.

7.0.1.d The winding gear

Check, if applicable:
1. The condition of the winding gear.
2. The winding track: Is this clean and are the winding track and cap circle sections level?
3. The winding gear for adequate lubrication.

Fig. 7.0.1.1
Some examples of possible defects in a winding track.
1. *joint opened up by drying*
2. *cross floor section worked up on the weld*
3. *raised gudgeon or bolt*
4. *dislodged plate*
5. *cracked winding track plate*
6. *broken lip joint*



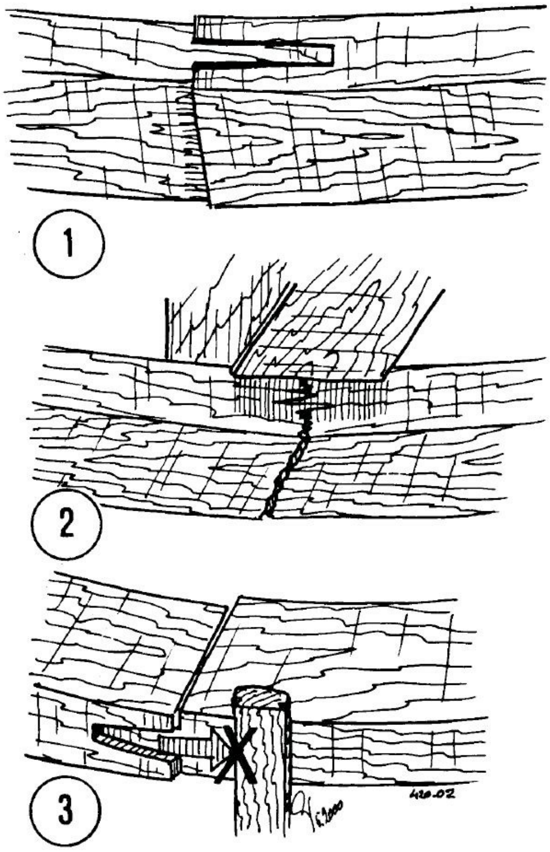


Fig. 7.0.1.2
Some examples of defects in the curb.
These can be the same as those for the winding track.

1. *opened-up joint*
2. *broken curb*
3. *laterally shifted parts of the curb; this hooks behind the curb carters*

7.0.1.e Central spindle

Check, if applicable:
1. The top bearing for play and adequate lubrication.
2. The bottom or pivot bearing for sufficient oil.
3. The straps.
4. The bearing posts and the bearing plate (lock plate).

7.0.1.f The crown wheel or stone gear.

Check, if applicable:
1. The condition of the crown wheel or the stone gear: Are cogs or rods adequately waxed and showing a regular wear pattern? Are the cogs secure?
2. The wedges and their securing.
3. Whether the upper wallower / upper stone gear run up against the brake wheel. In that case, the windshaft has sunk too far backwards or too far downwards.

4. Whether the cogs of the brake wheel touch the lower blade of the upper stone gear. In that case, the windshaft has sunk too far downwards.

If all of this is in order, the driving gear in the cap is capable of turning.

7.0.2 Visual inspection around the mill

Next, inspect the mill from the outside. Check for objects in the yard. Then look out for the following points:

7.0.2.a The sail cross and accessories

Check, as applicable:

1. The condition of the stocks, sail bars, hemlaths, uplongss, sail wedges, wind-boards and their attachment or the sail improvement system on the stocks.
2. The fixing wedges, the spit irons and the sail clamps.
3. The sails, by unrolling them one by one. In doing so, look at the sailcloth and at the rope-work. Note: First set the mill facing the wind!
4. Check the stock chains for their condition, thickness and any worn links.
5. The lightning conductor cable on the terminal connection and the condition of the rubber sheath.

7. 0.2.b The tail structure

Check, as applicable:

1. The condition of the tail beam, braces and their interconnections.
2. The winding system such as, for example, the capstan wheel, winch, etc.
3. The condition of the winding chain, the anchor chain and the spoke chain.
4. The attachment of the anchor chain.
5. Winding bollards.

7.0.2.c Stage

Check, as applicable:

1. The stage bracing, stage platforms and fasteners.
2. Stage boards.
3. Stage railing.

7.0.3 Checking the mill for lubrication

Lubrication of some parts can be done during the inspection prior to turning; therefore, have the lubricants at hand.

If there is a lot of lubrication to be done — for example, the entire winding gear or all the cogs and rods — it is an extensive job. Take the time for that!

For detailed instructions regarding lubrication, see Section 7.5.

7.0.4 The first revolutions

Keep the sails clamped for a while longer and let the mill start to move gently. Immediately apply the brake again to test whether it works well. If it is in order, release the brake again. Then go to the cap and pay attention to the parts just inspected. Listen to see if the running gear runs well and whether the brake is not rubbing. Also pay attention to whether each wheel is still neatly centrally attached. If a wheel's circumference rubs significantly back and forth or up and down, it must be re-hung by the millwright.
If all of this is in order, then set the sails on the mill.

7.0.5 Testing the brake

The brake is now tested at a higher speed of the sail cross. Wait until the sail cross runs a reasonable number of whips in the prevailing wind. Then apply the brake and establish whether the mill responds well to it. The number of whips which may pass before standing still after commencing braking depends, among other things, on the wind strength, the brake and the size of the sail cross. As a rule of thumb, approximately 1/6 of the number of whips may still pass.

Some brakes tend to hum when they bring the sail cross to a halt. In itself, this is not alarming. In any case, it is a clear signal that the brake is working. However, humming should not degenerate into the brake knocking. Knocking is a sign that the brake is biting because the braking is too severe.
Release the brake as soon as it bites and the problem will be over.
If it is not possible to bring the mill to a halt within twenty to thirty seconds and the mill has stood still for a long time, then the cause may be rust coming loose from the hoop or lining. In that case, bring the mill back up to speed and then allow the brake to rub for some time (but not too long!) against the brake wheel. In extreme cases, you can try to scour the lining smooth with some sharp sand between the brake and the brake wheel (see Section 7.3.7.d). Usually the mill brakes better after that.
However, if it is not a mill that has stood still for a considerable time, then there must be another cause. The fault may be caused, for example, by a brake lever that is too light. In that case, try braking with a weighted brake lever. If that does not help, then it is time to alert the millwright.
For other causes of poor braking, see Section 7.3.

7.1 WINDING

7.1.1 Determining the wind direction

wind direction

When the miller arrives at his mill, he has already formed a picture of the weather and has seen what the wind direction is relative to the sail cross. The sails must be set straight into the wind.

The best way to determine the correct position is to look for the calm spot behind the mill body. That is where the tail should be. The sail cross is then facing the wind.

The wind indicator on the back of the cap can also be an aid in determining wind direction but, because of the overhanging stock whip, it often does not point accurately. In addition, a wind indicator may turn stiffly or even be seized up with rust.

Other tools in determining wind direction are flags, smoke from chimneys, waves on the water, fluttering reeds or grass, etc.

clockwise winding

Usually the mill is not facing the wind properly so the miller has to wind. If the miller, standing at the capstan wheel, feels the wind on his right cheek, he must wind clockwise. The tail must then move to the left.

anticlockwise winding

If the miller, standing at the capstan wheel, feels the wind on his left cheek, he must wind anticlockwise. The tail must then move to the right.

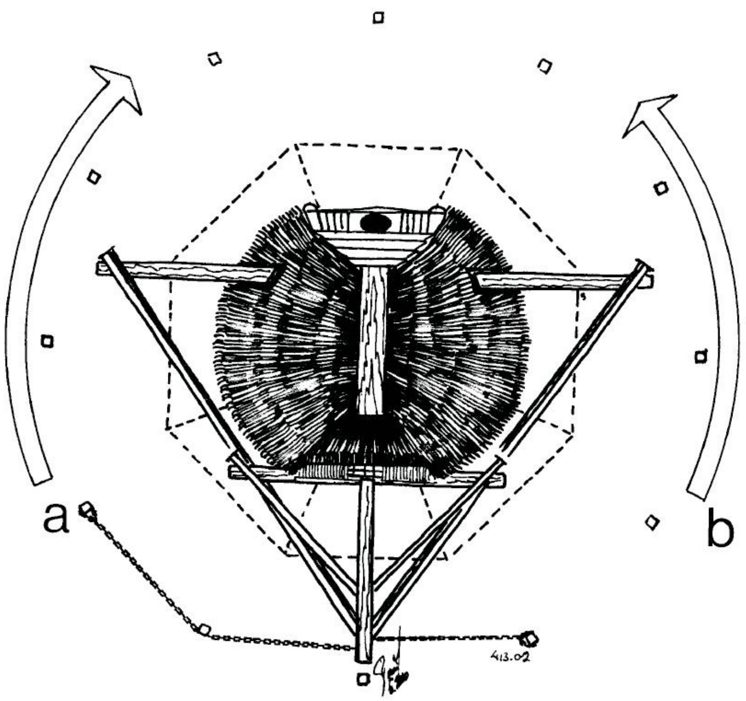


Fig. 7.1.1.1
What is meant by winding clockwise or anticlockwise.

a. clockwise
b. anticlockwise

7.1.2 Pre-check of different mill functions

It is important to realize that when a mill is working, the central spindle and thus the rest of the running gear is turning in conjunction with the winding! This results in specific points of attention for different mills.

polder mill

Before winding a polder mill, check the watercourse for the presence of (coarse) debris. A simple batten between the scoop wheel or Archimedean screw and the spillway wall or pond can cost cogs and rods. Sometimes the sluice door is held open using a piece of wood to let water in. These should be closed in advance.
In case of frost, check whether the scoop wheel or Archimedean screw has frozen up (for de-icing the scooping devices, see Chapter 11.5.5). In that case, you cannot wind without risking breakage of the driving gear. Nonetheless, if you still want to wind, you must take the mill out of operation.

grain mill

Before winding a grain mill, all runners must first be distanced from the bedstones. After all, as a safety measure, these were put into the work before leaving the mill and tentered, which means the runners rested on the putlogs. If you wind in this situation, the running gear is too heavily loaded and it can become damaged.
When you want to run 'for the prince' — in other words, unloaded — you set the pairs of grinding stones out of operation. It is absolutely wrong to allow a lightered runner to turn without grinding. This is a heavy load on the cogs and rods, which are alternately slowed down and driven by the flywheel action of the stone. This also puts additional stress on the pivot bearing, which can lead to hot running and severe wear on it.

oil mill

When you wind an oil mill, all piles and stampers must be shored. When winding, the cam shaft also rotates but, in the case of clockwise winding, in the opposite direction, whereby the spokes of the cam shaft can press down on the lifters of the stampers and piles. The edge runner stones are also put out of operation (see Fig.
7.1.2.1). Both are usually done before the mill is shut down.

hulling mill, sawmill

A hulling mill and a sawmill can be winded without endangering the driving gear. For the sawmill, it is still the case that the saw-teeth must be detached from the wood. If that is not the case, pull the saw carriage back slightly using the ratched wheel. The pawl feeder and dragging gear are also put out of operation.

7.1.3 Actions before winding

Disconnect the stock chain and lightning conductor cable and place them near where the sail cross will rotate, but in such a way that people cannot trip over them. They are then immediately at hand in case of an emergency.

spoke chain

The winding chain is then released by loosening the spoke chain. It is best to hang up this spoke chain because if it drags behind the tail, its eye can easily get caught, for example, between parts of the stage. At some mills, the capstan wheel is blocked with a longitudinal member. A pawl is used with a geared hand winch.

longitudinal member

The anchor chain is then taken off and placed on the ground or on the stage. If the anchor chain is attached to the tail, it is a good practice to hang it on the tail or put it on the shoe while winding and to not let it drag.

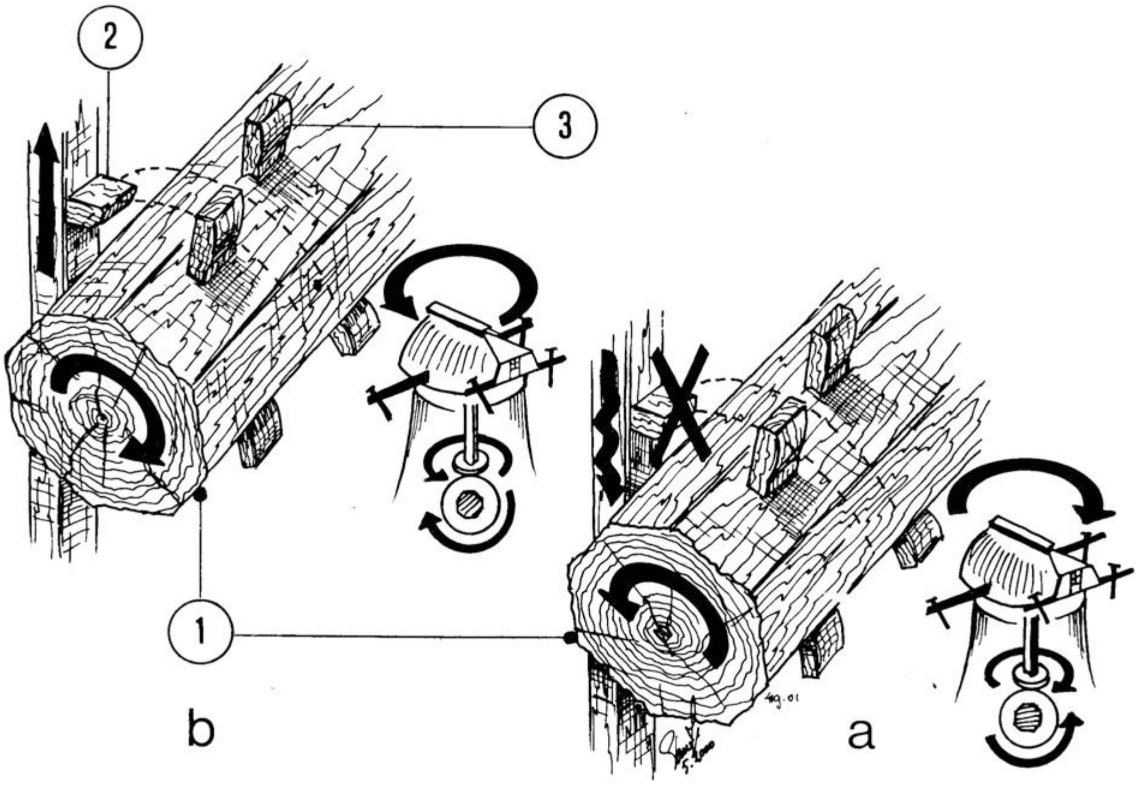


Fig. 7.1.2.1

Winding an oil mill: When an oil mill is wound clockwise (a), the cam shaft rotates counter to the normal direction of rotation. If the piles and stampers have not been shored, the spokes can cause damage.
When an oil mill is wound anticlockwise (b), the cam shaft rotates normally.

1. *cam shaft*
2. *lifter*
3. *spoke*

Now wind the winding chain, if necessary, off the windlass. Once the windlass is properly lubricated, the chain can be unwound by pulling it vigorously. If, standing by the tail facing the mill, you have to wind to the right (clockwise), place the winding chain to the left. If you must wind to the left (anticlockwise) then place it to the right. The loop, ring or hook at the end of the winding chain is put around the next winding bollard. If the winding chain is so long that you can skip a winding bollard, then you should put the chain around the outside of the intermediate winding bollard (watch out for loosening), otherwise the tail will be pulled too much toward the mill body. In addition, it will wind more lightly.
On a stage mill, as well, the winding chain should remain as perpendicular as possible to the windlass so as not to pull the tail toward the mill body. The hook at the end of the winding chain is inserted behind a stage girder.

Safeguards like a pawl and a release lever are only taken off when the mill is facing the wind. Otherwise, if the wind comes from behind, the mill might turn backwards.

7.1.4 Winding

Windlasses, winding reels, capstan wheels and geared hand winches can all be operated manually. The miller winds the mill with muscle power. In a (large) capstan wheel, moreover, you can walk and, in that case, wind the mill with your own body weight. In this case, the capstan wheel is often equipped with walking supports (see Fig. 5.8.4.1). The miller should then walk into it upright, keeping one hand as close to the centre of the wheel as possible to maintain a grip in case the capstan wheel suddenly slips. With the other hand, the miller grasps the spokes.

The smaller winding wheels and windlasses have fewer spokes and you cannot walk in them. Here, the miller has to wind using hand power.

winding platform

Sometimes a winding platform is built onto the tail. From there, the miller can operate the winding wheel or capstan wheel by hand and especially by foot.
When running out of winding chain, the rapidly turning winding wheel can be a hazard.

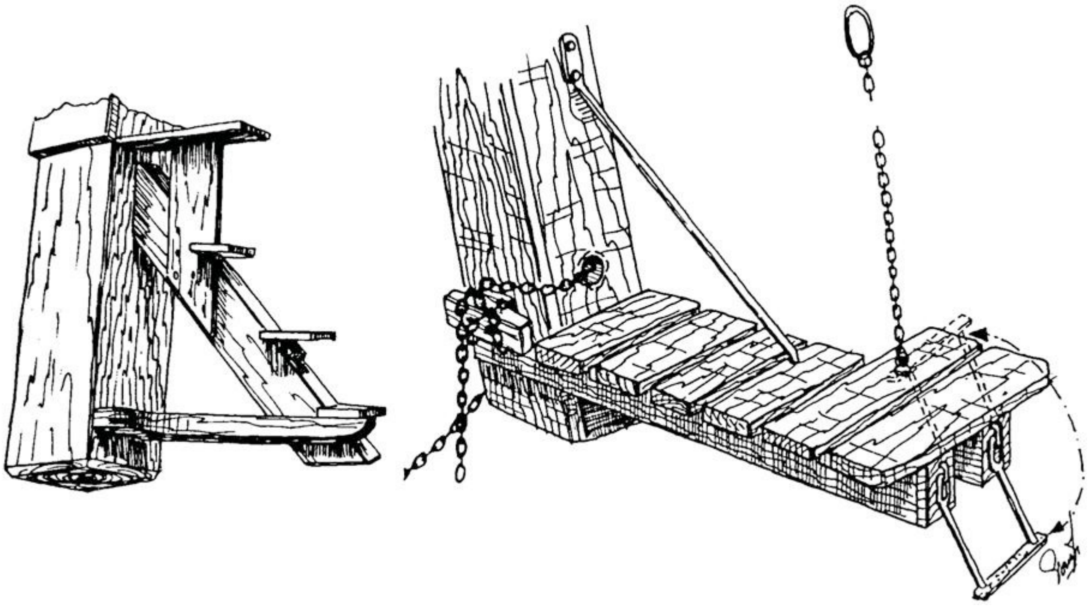


Fig. 7.1.4.1

Two examples of winding platforms

Geared hand winches come in many designs. When winding up the cable, take special care to start as far from the outside as possible. This eases winding, and the tail is less pulled toward the body. When releasing and running out the winding wire, the rapidly turning crank can pose a hazard; the crank can hit someone or fly away. If the pawl locks unintentionally during running out, gears can be damaged. Many geared hand winches therefore have a provision to slide the driving gear out of operation, making unwinding easier.
Capstan wheel and winding reel can turn either clockwise or anticlockwise. The iron fittings at the corners of the tail beam or seat plate and the aforementioned walking supports generally allow only one correct direction. The attachment point of the spoke chain also determines the winding direction.

During winding, the miller should avoid having the wound turns ending up on top of each other around the barrel. The diameter of the barrel then becomes larger, in a manner of speaking, which makes the mill heavier to wind. The chain can also suddenly spring back to its normal position, possibly causing the miller who is walking in the wheel to fall over. Another danger is that the loop at the other end of the chain suddenly shoots up to below the collar of the winding bollard. In this case, too, the miller could fall over due to the sudden slipping of the capstan wheel. Moreover, double winding the winding cable or rope is bad for the material. If the winding cable becomes stuck between the previous windings, it is difficult to loosen it.

If the mill is facing the wind, as a rule the winding chain is laid in such a way that the mill can be wound clockwise (from the tail: to the left). And it is laid out as long as possible. In veering winds, you can then immediately start winding without first having to wind up or extend the chain.
If the mill has had to be wound clockwise to face the wind, then the winding chain can be left as is. If the mill had to be wound anticlockwise to face the wind and you do not expect the wind to veer further, the winding chain is thus rewound again for clockwise winding.
The anchor chain is laid opposite the winding chain — so, as a rule to the right — and always as short and tight as possible to prevent the cap and tail from jerking.
Only in two situations do you lay the winding chain ready for anticlockwise winding:

1. if a warm front is approaching whereby the wind continues to back;
2. when the depression extends south and winds will back from south-west via south to north east to north (see Chapter 8).

In these situations, the anchor chain should be lying short and to the left.

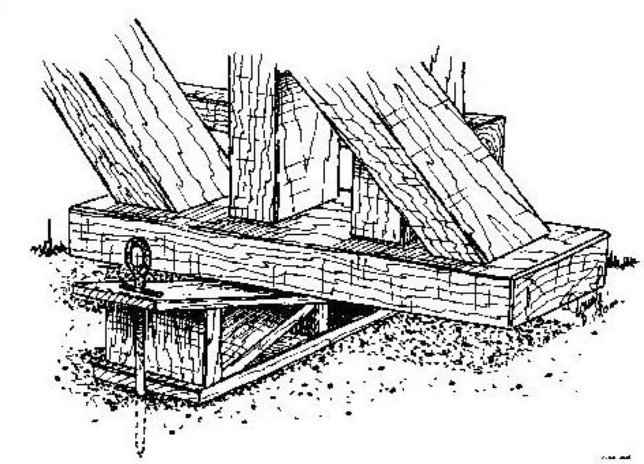
The winding chains should never be secured with any kind of knot. A knot can become so stuck that it cannot be undone. Place the chain in a loop or use a harp shackle.
With either the capstan wheel or the geared hand winch, you should pull both chains tight. The wheel is blocked from turning back by means of the spoke chain or longitudinal member. The winch is blocked using the pawl.
To prevent the cap from moving turbulently, especially in the north and east of the Netherlands, a beam is placed between the tail beam and the mill body.
This also reduces the load on the connections between the braces and the stretchers.

tail support
pitched wedge

This tail support should be placed as low as possible against the tail beam (see Section 10.1.3, Fig. 10.1.3.7). Another solution is to place a pitched wedge under the stairs or the tail beam to prevent movement of the tail.
Once the mill is stationary, the sails can be set.

Fig. 7.1.4.2

Pitched wedge under the shoe of a hollow post mill to counter rocking of the tail



7.1.1 Winding an internal winder

Before the miller of an internal winder goes up to wind, he must have already determined below at which octagonal post or side the sail cross should be set. Once up above, the miller cannot see if the mill is properly facing the wind but he can feel it. The situation described is when the miller is winding clockwise (see Fig. 7.1.5.1).
If you feel some wind at C and almost nothing at A, and nothing at all at B and D, then there is still a long way to wind. If you feel wind at C and a little at A, then you are almost there. Finally, if you feel about the same amount of wind at A, B, C and D, then the mill is facing straight into the wind. After winding, secure the anchor chain and death chain to a winding hook with iron cross (see Fig. 5.8.2.2).
In an internal winder, the winding rope lies to the right during grinding (see Fig. 5.8.2).

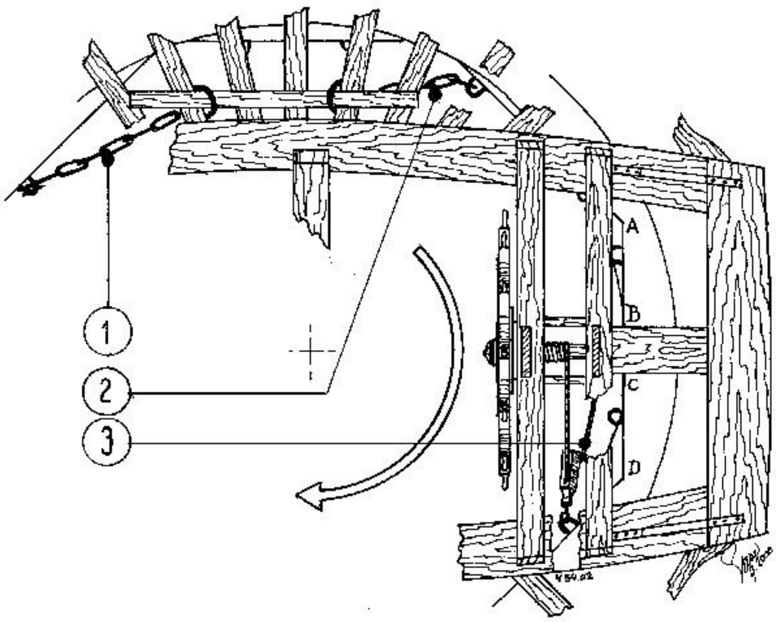


Fig. 7.1.5.1
The internal winding gear

1. *anchor chain*
2. *death chain*
3. *winding rope*

7.2 USING THE SAIL CLOTH

7.2.0 Introduction

You set as much sail cloth as is needed for the mill to operate optimally. This can vary greatly for the different mill types. Furthermore, how much sail you can use also depends on a number of other factors:
- whether the mill is doing heavy or light grinding;
- whether the mill is turned loaded or unloaded;
- what the strength of the wind and the type of weather is.

Sometimes the wind is so strong, such as wind force 6 or 7, that the mill can operate without sails. In most cases, however, you have to set sails or 'clothe the mill'. Obviously, the mill is facing the wind when it is clothed.

7.2.1 Setting a sail cloth

The following describes how a full sail is set.
The clamped sail cloth is secured to a sail bar with a clove hitch or with half hitches. With most sail systems you have to loosen the sail at the back of the sail frame, which is standing between the stock and the mill body. For stocks with jibs or with only one sail cleat, you loosen the sail standing in front of the sail frame.
Once the knot is untied, remove the rolled-up sail from the sail frame and sling it with a generous swing from behind both sail cleats to the front of the sail frame. In doing so, care must be taken not to rub the sail along the leading hemlath and the single cleat during the swing. With jibs, the rolled-up sail is already at the front of the stock. It is usually clamped behind three sail cleats.
Hold the rolled-up sail in both hands and unroll it a few metres from the top. This is a special move which is achieved using short clockwise motions. The cloth then unrolls itself on its own accord from the top. Make sure the roll does not become loose somewhere in the middle, allowing the wind to get hold of it. In that case, the sail can become a large balloon and be unmanageable for the miller.
The top metres of the cloth are now unrolled, with the rest still lying as a roll in front of the sail frame. It is then not necessary to secure the rolled-up sail from below in advance. There are no risks to the miller if the mill is properly facing the wind and the sail is still at least half rolled up and thus will catch virtually no wind. Inserting the lower end between the sail frame, as sometimes happens, therefore provides little extra benefit. If you unroll the cloth completely first, the chances of the wind getting hold of it are much greater. Moreover, the cloth is then largely on the sail frame. This makes walking up more difficult.
The miller now climbs up on the left side of the sail, between the stock and the first uplong. This is the safest. The closer the miller gets to the stock, the smaller the risk of breaking a sail bar. In some locations in the south of the Netherlands, the miller climbs up between the sail and the stock.
Once he has reached the top, the miller begins to hook the loops behind the single cleats. It is often better not to use the top loop. The sail then 'lies' better. In addition, it rolls up easier when taking the sails down. The miller now comes down again, holding onto the sail bars with his left hand while he

holds the sail firmly with his right hand and hooks the loops securely. While coming down, he also checks the fixings for the wind-boards. If a single cleat sits unfavourably, he does not hook a loop behind it. It is also incorrect to put one loop behind two single cleats. This could result in folds in the sail, as the sail does not lie flat on the sail frame. When the miller is below again, he pulls the lower right tie rope tightly under the bottom sail bar and attaches it to this sail bar or to the clamp, single cleat or spring present there.
He now unrolls the sail completely by pulling the lower left tie rope to the left and slightly downwards with not too much force, causing it to unroll of its own accord. If the miller uses too much force, that will be too hard on the bottom piece of the sail which might even tear. Unrolling is best done with the right hand. The left hand is then ready to grasp the released pointing lines. These should not blow away. Using the pointing lines, the miller sets the sail to full width in front of the sail bars.
Setting sails on mills equipped with sail rails is made easier by occasionally applying a little grease to the rails.
To tighten dry sails, the miller needs little force; wet sails stick a bit more to the sail frame and require a bit more force. Simply pulling the pointing lines often leads to nothing. You are then pulling too hard at the bottom and not hard enough at the top. You can also operate the upper two ropes with one hand for each while leaving the lower pointing line hanging. It can never blow away to the extent of causing problems. The miller wraps the pointing lines with their wear piece (the thick part) around the hemlath. This does not need to be above the highest possible sail bar, but neither must it be almost vertical down past the hemlath.
The ropes are then either already wrapped around the sail bar by one turn or they are left hanging inside the upper right arm in front of your body so that you have both hands free to secure the ropes.
Now secure the pointing lines at the intersections of a sail bar with the sail cleat and/or with both uplongs with the same sail bar. First the top pointing line, then the middle one, and finally the bottom one.
Securing is done as follows: Lead the rope along the front to the lower left side of the intersection, then along the back to the upper right-hand side of it, then in front of the sail bar straight down and finally behind the uplong to the lower left again (see Fig. 6.3.1.2). Pull the pointing line tight (but not snare-tight!) and insert the loose end of it doubled between the uplong and the fixed part that you just pulled tight, so that a loop is formed. Then you only have to pull the loose end in order to release the pointing line again. That loop remains reasonably clamped between the uplongs and the fixed part of the pointing line, but it may still become dislodged during the turning of the mill. When you pull the loop at the bottom left-hand intersection to below the sail bar, the pointing line is trapped to the point where it will not come loose on its own. But this, in turn, makes it less easy to pull loose. The loop and the loose end should preferably be left the same length. Do not put the loose end through the loop, as there is a risk of creating a knot when pulling it loose. Sometimes you secure the top two pointing lines together at one intersection — for example, if a sail cleat is missing.
Finally, secure the lower left tie rope. Several methods are used for this purpose (see Fig. 6.3.1.2). Do not tighten this rope so tight that the sail comes loose from the sail frame.
Important: If you do not set sails at all whips, the empty whips should also be checked to ensure that the sail rolls are tightly clamped in the cleats and are properly secured. This prevents wear at the location of the cleats and the sails coming loose during turning.

If the ropes and sails are wet when clothing, you must check after a while to make sure everything is still secure. Wet sails and ropes actually become longer as they dry out.
In moderate or strong winds, at the same time as clothing each whip, place the inner board that may have been removed. The next whip will then come down despite the fact that the mill has become unbalanced due to the installed wind-board. If the wind is weak, however, then — especially if you are alone at the mill — it is better to clothe all whips first and only then to place the leader boards. The four full sails then provide enough power to compensate for the imbalance. This method saves a lot of pushing and pulling on the sail cross and walking back and forth between the sail cross and the brake rope.
However, you can also clothe stock by stock instead of whip by whip. Then you never have to push up, against gravity, more than one wind-board at a time.

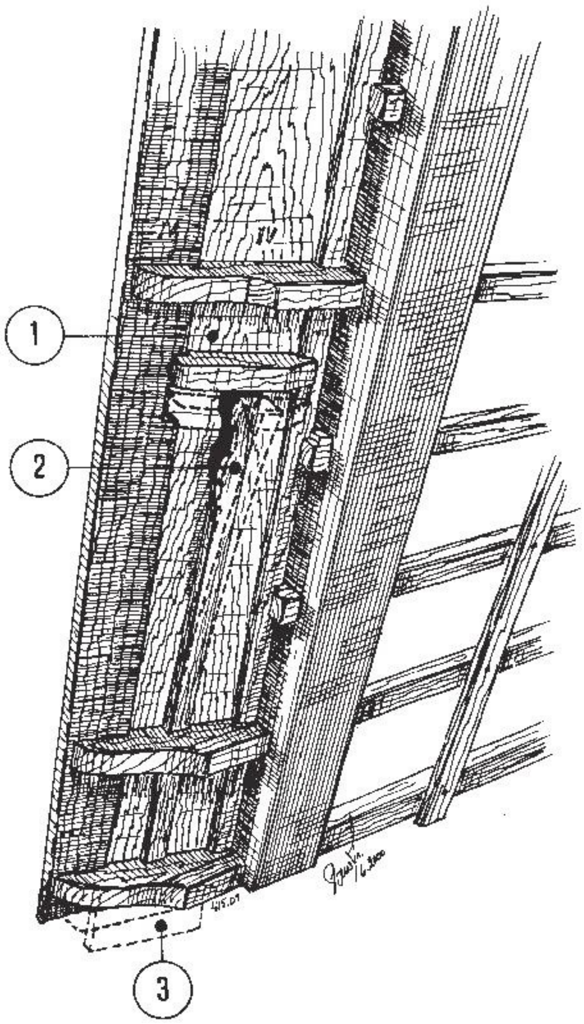


Fig. 7.2.1.1
Inner board

1. *inner board*
2. *wooden catch spring*
3. *position of the board when inserted or removed*

7.2.2 The sail setting

In general, a polder mill grinds at a higher speed than a grain mill. And a small polder mill with a sail cross of about 16 metre may turn much faster than its big brother with a 28 metre sail cross. A polder mill can easily run at 80 to 90 whips or more, whereas an average grain mill typically runs at no more than about 70 whips. And a post mill turns slightly faster because of its smaller gear ratio.
On a mill that is not performing work and thus running 'for the prince' — unloaded — you need to set less sail than when the mill is loaded.
When, during a sudden downpour, a miller tries to brake a mill running with four full sails, he puts maximum strain on that mill's brake. Sometimes he finds it difficult to bring the mill to a halt under these conditions. Squally and gusty weather will often be a reason to adjust the sail setting. So, in that situation, the type of weather and not the wind strength determines the amount of sail area. In weak winds and under normal conditions, four full sails are carried and all inner boards are placed.

7.2.2.a Sail setting for an unloaded mill

Under normal circumstances, when the mill is running for the prince and the wind is weak, four full sails are set. Because an unloaded mill will quickly suffer from flapping it is sensible to set it a little under the wind as the wind increases and to furl it in time. If the wind blows harder and the mill turns faster, the machinery does not help slow the mill down and the reliability of the brake is of great importance.
During a gust of wind, the speed of the sails of an unloaded mill increases significantly faster than those of a loaded mill. It is therefore recommended that the sail setting be adjusted accordingly. This is because a sudden gust of wind will have much less hold on a sail cross without sails than on a sail cross with sails. However, this should not be a reason for anyone to then always run with (too) little sail, simply for convenience. This does not reflect proper millership.

7.2.2.b Sail setting for a loaded polder mill

On a loaded polder mill, you set as much sail as is necessary for the scooping devices to deliver their maximum efficiency.
A polder miller furls in bigger steps than a fellow grain miller. For example, the grain miller immediately resets from four full sails to two full sails and two (long) half sails. On polder mills, first reefs are not usual.
In the exceptional case of pumping 'at the cutting edge' because of the high polder level, you need to be constantly alert to sudden gusts of wind. If, when you are standing by the brake rope, you hear such a gust of wind, you will have just barely enough time to brake quickly before the sail cross accelerates. Once the mill is turning too fast, the brake may not be up to the job. You should wait for a wind lull (a short reduction in wind strength) in order to be still able to brake. Do not panic, however. A gust of wind usually lasts no more than a minute.

wind lull

With a polder mill, the danger lies more in the fact that the water cannot flow in fast enough, causing the scooping devices to be positioned too shallow in the water and to experience less resistance. This makes the mill turn even faster. Another danger is that when the speed is excessive, the scoop wheel conveys water over the top. This also reduces resistance and increases speed. This just exerts unnecessary strain on the driving gear and bearings without any increase in capacity.

7.2.2.c Sail setting for a loaded grain mill

A good product must necessarily be ground at grain mills. To achieve this, the sail cross of a grain mill must turn as constantly as possible. The determining factor for a good product is the peripheral speed of the runner. If a grain mill is turning too fast, a setting with two first reefs may be enough to reduce the speed by, say, five revolutions. The runner stone then turns about 30 to 40 revolutions per minute slower in that case. At a grain mill, you set sails in smaller steps than at a polder mill. At a grain mill, you never grind in such a way that the miller has to stand by the brake rope, as it were, to prevent running out of control. In any case, the miller is not in a position to work like this. His place is on the meal floor near the nip, especially in gusty weather. To achieve a good product, he has to continuously tenter and lighter.

7.2.3 Sail flapping

Sail flapping (see Section 6.3.3) is most common when you set four full sails. The sails may start flapping when the mill is turning. That is to say, when passing the body the sails briefly come loose from the sail frame and then recoil back onto the frame after passing. If that happens occasionally, it is not a big issue. However, if a large part of the sail regularly comes loose from the sail frame and recoils with a hard blow, wear and tear will result and the miller should intervene. Sail flapping can also cause the loosening of the sail bars in the stock or it may even lead to a part of bad sail work breaking off.

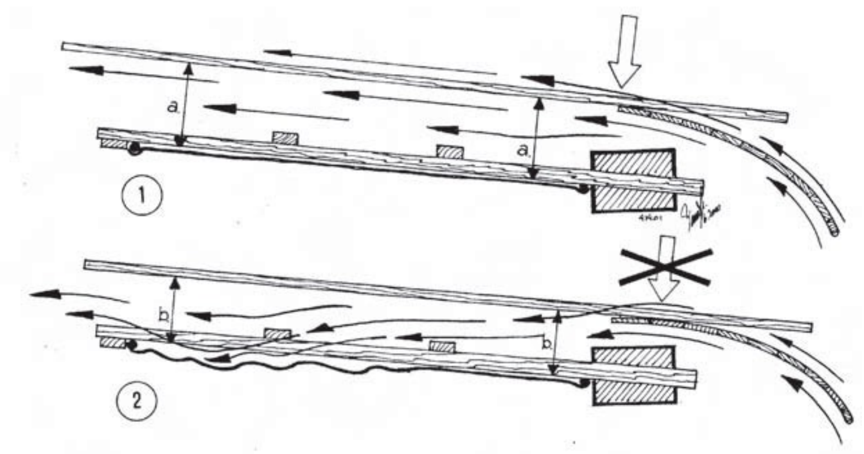


Fig. 7.2.3.1
The airflow with a properly mounted jib and an incorrectly mounted jib

1. Correct.
The row (straight batten) is kept parallel to the sail frame bars; the distances a-a are equal.
The point of contact is exactly on the edge of the jib.

2. Incorrect.
The point of contact is 10 to 12 cm inside the edge of the jib.
The jib deflects airflow into the sail, which results in sail flapping.

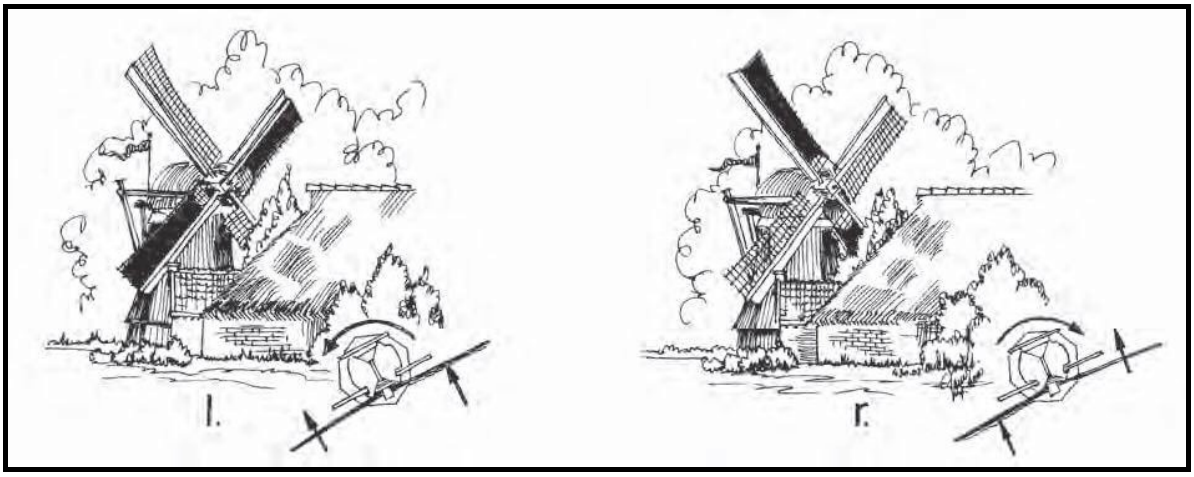


Fig. 7.2.4.1
Cause of turbulent movement of the cap in obstructed winds

l. In this situation, the body wants to turn anticlockwise
r. In this situation, the body wants to turn clockwise

Sail flapping occurs:
- with obstructed winds in any form;
- with an incorrect camber: a deep sail position is more likely to produce sail flapping;
- with incorrect streamlining or an incorrect position of the jibs (see Fig. 7.2.3.1);
- with the Dekker streamline profile;
- if the mill is standing too wide (the wind is backing too much);
- when the sail cross passes close to the mill body;
- when the mill is running unloaded.

In most cases, you can reduce or neutralise the sail flapping by winding the mill slightly anticlockwise, which allows the wind to strike more broadly. Although this does reduce the sail speed slightly, it combats sail flapping.
Should the sails continue to flap despite this measure, you must reduce (furl) the sail. When winding the mill, many millers always set the mill slightly under the wind to prevent sail flapping. However, this is not necessary in all cases.
Sail flapping is mostly heard but it can also be seen: stand to the left of the mill and pay attention to the rising bottom end.

7.2.4 Furling

7.2.4.a Introduction

The following main rules apply to all mills:
- Furl when the sail cross turns too fast.
- Furl per stock at both ends.
- Try to avoid large differences in sail settings at the four ends.

It is best if the same sail setting is used at all the ends. This ensures that the canister and cap are evenly loaded. Thus, it is a bad habit to grind often with two full sails. In that situation, the mill is unevenly loaded. After all, the tips of the ends respond most strongly to the wind. In this process, the rotating sail cross always comes into the lee with one tip four times per revolution while the opposite tip gets the full wind.

rocking

This creates a leverage effect that causes the cap to move back and forth, a rocking or jerking movement. It is not only the canister that is put under strain by this. The tail, the long stretcher, the stage and the octagon itself also suffer greatly as a result. When the wind is obstructed, for example by a building, the wind pressure on the bottom tips is always less than that on the upper tips and it exacerbates the back-and-forth movement and wear and tear (see Fig. 7.4.2.1). Rocking occurs more easily at mills with a lightly winding live curb. A cap with a sliding winding gear is less subject to this.
Only in exceptional cases is the setting of two full sails a good idea, such as during gusty, squally or stormy weather. Then, before the arrival of a thunderstorm or squall, you can quickly furl or roll up the sails. When the miller is in a hurry and has set two full and two half sails, he takes away the two full sails first in order to quickly remove most of the sail area.

7.2.4.b Furling: on which stock?

Generally speaking, the most sail is set on the inside stock. Or, furling is usually done first on the outside stock. The canister is then subject to less strain. This was especially true in the days of wooden shafts but has now become less important since almost all windshafts are made of cast iron nowadays. However, people still pay heed to this good habit.
The North Holland internal winder is an exception to this. To avoid sail flapping at this type of mill, it is preferable to furl on the inside stock first because it rotates so closely past the wide body. A second reason for an exception is the condition of the stocks or the sail frame. If these are in poor condition, then one furls first on the stock in the worst condition, even if it is the inside stock.
When you have set four full sails and have to take the sails down very quickly, you first furl all the sail on the outside stock (or the weakest) and only then the sail on the inside stock (or the strongest).

stopping

If, due to a thunderstorm or squall, you are forced to stop after taking down the sails from one of the two stocks, you leave the mill standing with two full sails on the vertical stock. This is not a nice situation but it is better than one or two full sails on the horizontal stock. If you have very little time, then take down the sail from one whip and set this above!

7.2.4.c Grinding without sails

If the wind continues to increase during the day, you furl as evenly as possible over the sail cross. Eventually it may blow so hard that the mill finally ends up grinding with clamped sails. When grinding on 'empty' for a long time, millers in North Holland prefer to put the sails 'in the lines'. This is the best idea for preserving the sails.

sails in the lines

Laying in the lines is done as follows:
Place the full length of the tightly rolled-up sail along the stock on the sail frame and secure the bottom corner ropes in the usual manner. The miller goes up with a rope that is more than one whip long and is fitted with an eye splice. He places the eye splice behind the top single cleat, inserts the rope through the sail frame and lets go of it so that it hangs behind the sail frame.

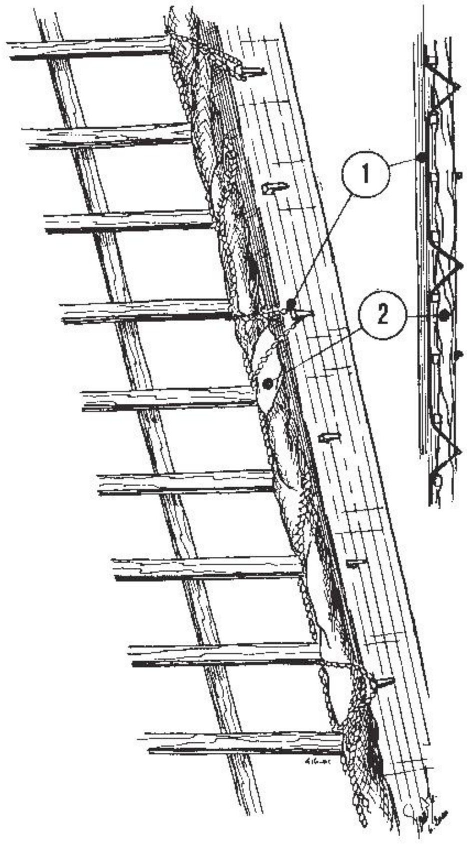


Fig. 7.2.4.2
Sail laid in the line

1. *pointing line or extra rope*
2. *fully rolled-up sail*

Then, as he climbs down again, at every second or third single cleat he successively passes, he pulls the rope forward in a loop through the sail frame and places it behind that single cleat. At the single cleats in question, he knocks the rolled-up sail with his fist into the corner between the stock and the sail frame and pulls the rope taut. On arriving below, he secures the end of the rope to a sail bar. The rolled-up sail is now firmly secured.
Grinding with four sails 'in the lines' is called 'grinding with bare legs' in the Zaan region of the Netherlands.
If you do not lay the sails in the lines but keep grinding (for a long time) with clamped sails, then upon each revolution the sails will slide along the leading hemlath or the streamlined profiles, incurring wear and tear. This is especially true for Old Dutch sail crosses and, to a lesser extent, for Dekker profiles and Van Bussel noses. This wear can be prevented to an extent by pulling the sails as tightly as possible around the leading hemlaths or the streamlined profiles. And repeat this at least once more during the day.
On jibs, it is not necessary to put sails in the lines. After all, there the sails are not clamped around the jib but within the jib. So they never scrape along the leading hemlath.
Incidentally, grinding with clamped sails affects the speed of the sail cross. For an Old Dutch windmill, this effect is minor but a sail wrapped around a Dekker blade or a Van Bussel nose disrupts the streamlined profile so that the mill loses some of its tractive force.
A sail cross with jibs loses tractive force when the rolled-up sails are wrapped around the jib and secured behind the sail frame. You can use this as an additional furling option if the mill is still turning too fast without a sail.

7.2.4.d Grinding without inner boards

If the mill still turns too fast with empty sail frames, additional furling is carried out by removing the inner boards, in two steps if necessary. In the first step, the boards of the outer stock (or the worst one) are removed and in the second step, those of the other are removed. It is very unusual to take out boards while sails are still set. Most inner, storm or wind-boards are removed simply by pulling the catch spring towards you. The inner board then lowers slightly and can be pulled out of the rebate at the front. Many mills have boards without a spring. Such boards are often secured in a way that makes them difficult or impossible to remove. Inner boards in jibs are usually secured with two bearing blocks and/or locking clamps.
Because boards are only removed in high winds, the miller must proceed with caution so as not to be blown away with board and all. The miller must tilt a removed board horizontally as quickly as possible and keep it level so that the wind does not get a grip on it. When transporting, walk between the wind and the wind-board.
Or clamp the end of the board vertically under your arm and let the wind carry the other end. That way, it catches the least wind.

7.2.4.e Grinding under the wind

furling with the tail

The mill may still turn too fast even when you have applied all the furling options described above. In that case, put the mill under the wind, which is also called 'furling with the tail' (not to be confused with 'braking with the tail', an emergency measure used only when the brake is broken (see Section 7.3.10). You furl with the tail by winding the mill anti clockwise so that the wind strikes in a veering manner. After all, wind veers as well as increases in strength during squalls and gusts. This veering of the wind causes the mill to come even further under the wind and it should therefore start to turn more slowly. But with the simultaneous increase in wind force, the sail cross generally maintains its original speed.

above the wind

If the mill is wound above the wind (in other words, clockwise) out of the wind, then a veering gust that is gathering in strength will come straight at the sail cross. Then the mill will turn faster and be harder to brake.
Setting under the wind is usually done no further than half a side (for an octagon) or about 1 winding bollard. If you go further, the mill and in particular the neck bearing will be loaded in a manner that is too lopsided. In that case, it is sensible for the miller to stop.

7.2.5 Taking down sails and clamping

Stocks used to be made of softwood. The harder wooden fixing wedges caused dents in this softwood. Therefore, the horizontal stock was not put away with the wedges underneath. So the problem was with the stocks, not the wedges. With iron stocks, this problem does not arise at all. The compression of the wedges due to the weight of the stock is disproportionate to the great force caused by the striking of the fixing wedges. Also, the inside stock was usually set vertically to reduce the load on the wooden canister during storms. In the case of cast-iron canisters, however, this hardly matters.

Thus, although the need is no longer there, the aforementioned habits are still often observed. If this is done consistently, the result is that the sail cross is always put away in the same position. Consequently, water always runs into the same stock, and the sail bars of the same whip and wind-boards are more likely to rot. With iron shafts and rods, it is therefore better to change the position of the sail cross regularly. This prevents rainwater from always staying in the same place in the same stock. Moreover, some millers also set the sail cross a little way off, which allows rainwater to drain better.

In mills with a bored-through shaft, however, rainwater may enter through the shaft when the inside stock is vertical. During wet periods, it is a good idea to set the outside stock vertically.

Before starting to remove the sail, you must first check that the mill is still properly facing the wind! If necessary, first wind before loosening anything.

You begin removing the sail behind the stock by simply pulling loose the pointing lines, even when turning with furled sails. After all, the knot is made in such a way that it immediately loosens with just one short tug on the loose end. Swing the pointing lines towards to the front of the sail frame, taking care not to get them caught behind a sail bar. Now the lower left tie rope is loosened. Then take hold of the sail by the leech, fold the pointing lines double at the bottom so they do not protrude under the sail, and roll the sail up to the left with the pointing lines inside. With your right hand, now loosen the lower right tie rope and continue rolling up.

On (polder) mills it is sometimes customary to take hold of the sail by the middle and roll it up double. This works faster, especially in emergencies. After you have rolled up the sail with several turns, step to the right while continuing to roll up, until you get past the leading hemlath. It is not wise to pull all the loops loose from the single cleats in one motion because this will cause the sail to continually rub along the upper single cleats as it is rolled up, causing unnecessary wear. It is also dangerous because the wind can catch hold of the loose sail. When also the last loops are loose, pull vigorously on the already mostly rolled-up sail, whereupon the sail effortlessly rolls itself up right to the top. If necessary, you can give it an extra swing for that purpose.

Rolling-up should not be done too tightly: this not only causes extra wear on the sail but it also prevents the sail drying out when wet. Next, the sail is clamped. This involves taking hold of it at the bottom, swinging it up forcefully beside the leading hemlath and tossing it around the leading hemlath in a single movement behind the sail cleats (smackwoods). On a windmill with an Old Dutch sail cross or Van Bussel noses, this requires some practice. On jib sails, there are usually three sail cleats on the front of the jib. This makes clamping much easier.

sail cleats, smackwoods

You insert the rolled-up sail from the bottom sail cleat between two sail bars and pull it back towards itself one sail bar lower. Then you tie the sail to one of the lower sail bars. This involves fastening the free-hanging lower tie ropes with half-hitches, a clove hitch or in some other way, depending on what is customary in the various regions of the country.
Some millers first wrap the lower end of the sail around a sail bar one more time. This can cause extra wear and tear and rainwater cannot drain out of the sail at the lower end.

When taking down the sail whip by whip, you also remove the inner board or storm board if necessary. As with the use of the boards, this makes the mill unbalanced but in such a way that the descending whips are heavier because their wind-board has not yet been removed.

7.2.6 Taking down sails in emergency situations

When rolling up, establish a regular habit of leaving the sail lie as flat as possible on the sail frame to prevent the wind from getting behind the sail and ripping it out of the miller's hands. Never try to hold a sail where the wind has blown. You could be dragged along with the sail. If the sail is unexpectedly knocked sideways by the wind, you can try to regain control of the sail as follows if waiting for a lull in the wind takes too long: Walk up into the sail frame as high as possible and pull the sail slightly towards yourself. Roll up this part and tuck it under your arm. Then come down two or three sail bars and repeat the same action until you are below again.

If you have set partially furled sails in strong winds — for example, a half rope or a three quarters — and you want to roll them up and clamp them, do not first unroll the rolled-up part of the sail but loosen the remaining pointing line(s) and roll these further together with the already partially rolled-up sail. In strong winds, you can also choose not to loosen the pointing lines all at once and roll them into the sail, but to do them one at a time.
This helps keep the sail better under control. Now the pointing lines are not next to each other in the rolled-up sail but that is less important.

If you are surprised by a squall and there is still an opportunity to roll up one or more sails, then working quickly is more important than working neatly. Loosen the pointing lines, place them in the middle on the sail, make a fold in the sail there and roll it double with a few big turns. If clamping does not succeed on the first try, wrap the sail around the leading hemlath and secure it. Then put this empty whip on top and see if there is still time to clamp a second sail.
After the squall has subsided, the provisionally rolled-up sails are to be rolled up better and properly secured.

It is highly recommended to practice the above actions once in calm weather. Working quickly is of great importance here: the more sail you can roll up before the squall breaks loose, the better.

7.3 OPERATING THE BRAKE

7.3.0 Introduction

The brake is arguably the most important part of the mill. Therefore, the miller should check the brake regularly. This does not only apply to a mill that has not been running for quite some time. A brake that is in regular use also requires care and attention. It should not occur that, in severe weather, the miller notices that the brake is not working properly for whatever reason. In principle, the brake should be able to stop the mill under all normal conditions. If the miller is going to turn a mill that is unfamiliar to him, then the brake also requires his additional attention.

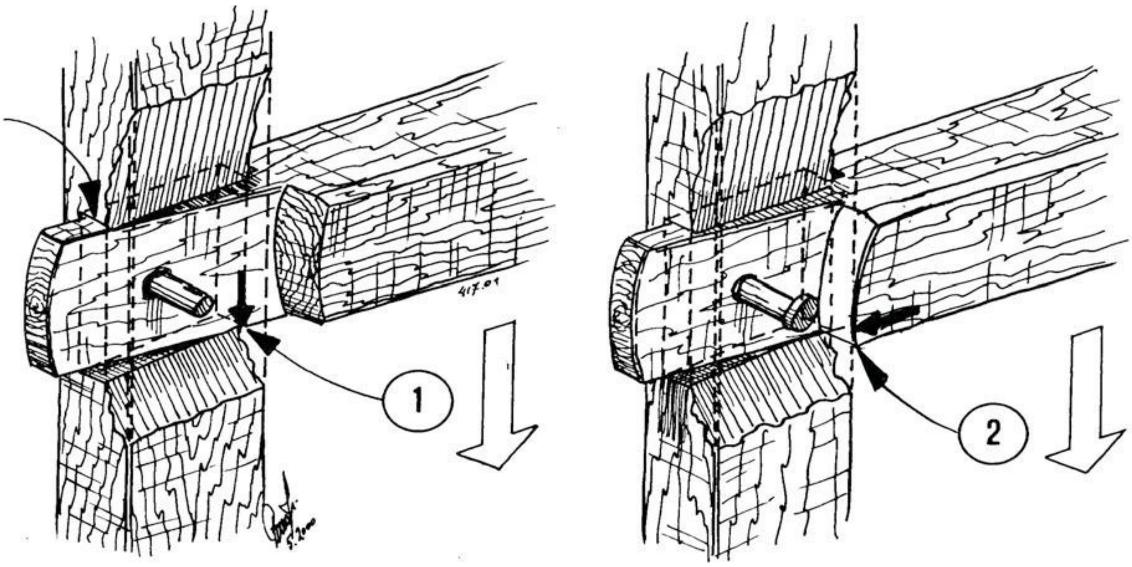
7.3.1 Inspection of the brake

7.3.1.a An inadequately functioning or worn-out brake

A brake does not function adequately or is non-working if, for any reason, the brake lever cannot be lowered far enough or cannot be lowered at all. As a result, the brake lever does not clamp the brake blocks tightly enough around the brake wheel. The mill is then not capable of being braked.
You can easily check this by sitting on the brake lever. When you do this, you should be able to feel that there is still sufficient spring in the brake lever.
in other words, you should be able to notice that the brake lever can descend even more without the front hanger moving back and forth.

Fig. 7.3.1.1
The so-called jamming of the brake lever into the front hanger

1. *the pin of the brake lever bumps against the lower and upper sides of the hole in the front hanger*
2. *the rounding of the brake lever pinches against the rear side of the front hanger*



Wear in the brake blocks is a common cause of brake problems. This wear gradually increases the inner circumference of the circle formed by the brake blocks. In other words, the brake becomes wider around the brake wheel. As a result, the brake lever must descend further to still provide sufficient braking force. That can lead to yet further problems:

7.3.1.b The brake lever jams in the front hanger

front hanger, brayer beam

jamming of the brake lever

If the pin of the brake lever is not long enough at the front hanger or brayer beam, or if the rounding of the head on either side of the pin is insufficient or is too close to the pivot point, then the brake lever will make contact with the hanger when descending. Also, the pin may become stuck on the underside of the hole in the brayer beam. This is called jamming of the brake lever. This defect usually occurs when the rear end of the brake lever must descend too far down to apply the brake sufficiently tightly (see Fig. 7.3.1.1).

7.3.1.c The sword iron becomes jammed

The sword iron usually has a number of bends that allow it to move freely past various structural parts of the mill. At such a bend, the sword iron can become stuck on, for example, the sheer beam, the upper side girt or the collar. Fixing this kind of problem is a job for the millwright. Another shortcoming (in smaller mills) is that the part of the sword iron which protrudes through the brake lever touches the floor of the cap or cabin.

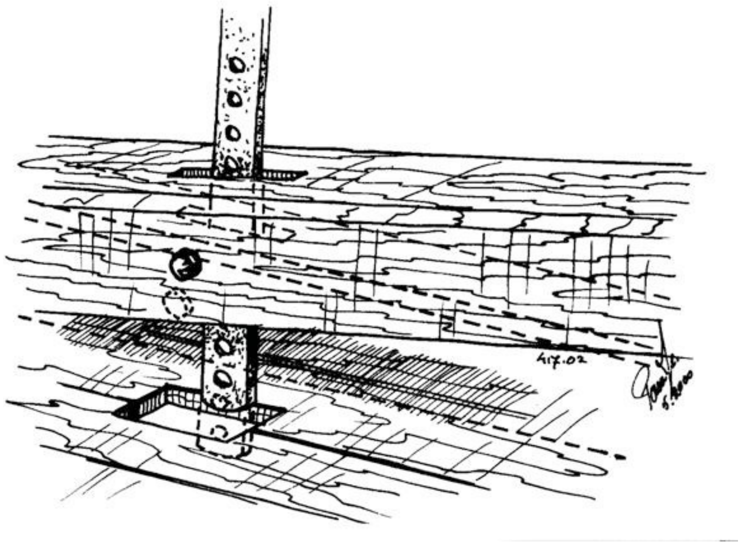


Fig. 7.3.1.2

Hole in floor for sword iron at low hanging brake lever in hollow post mills

7.3.1.d The rear end of the brake lever becomes stuck

Due to wear of the brake blocks, the rear end of the brake lever can end up resting on the floor of the cap or buck but also, for example, on the underside of the hanger guide.
At least 10 cm high clearance must be left between the brake lever and the floor or underside of the hanger guide. If this space is smaller, the brake lever must be raised (see Section 7.3.7.c).
The brake lever may also become jammed in the top of the

hanger guide. If you then want to brake the mill, this fails because the brake lever does not descend.
If the hanger is attached too far back and the brake lever is too short, you may end up pulling the brake lever out between the posts of the hanger if you lift it too far. As a result, the brake lever may then become stuck against one of the posts of the hanger guide. It can then no longer descend, making it impossible to brake the mill.
Also, the brake lever may be hanging down so low that the hook will be on top of it. The brake can then no longer be released and the mill cannot be braked.

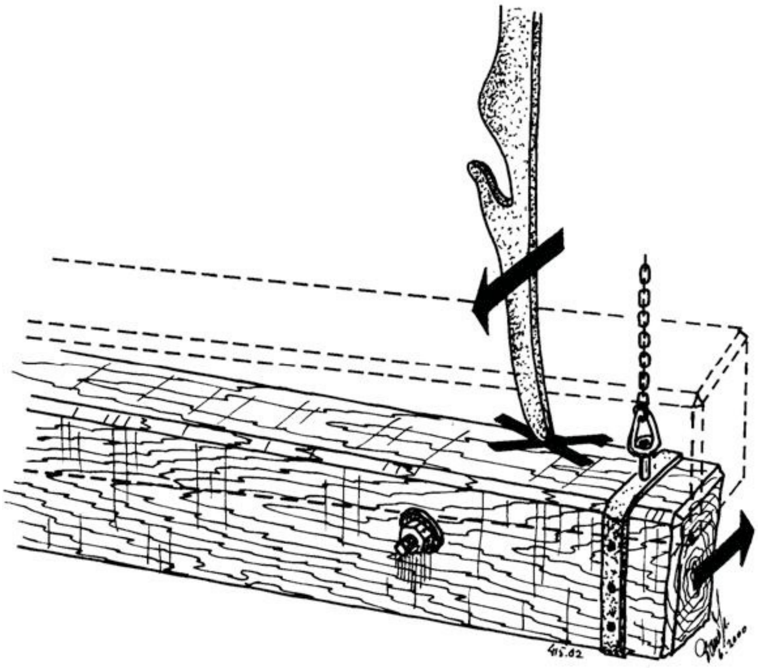


Fig. 7.3.1.3

Problem with the brake when the brake lever hangs so low that the hook ends up on the beam

7.3.1.e The brake handle or fang staff is rubbing

If the brake handle ends up on the tail beam while you are braking, the brake lever cannot descend any further. If the brake lever is properly adjusted, this shortcoming can be solved by lengthening the chain between the brake lever and the brake handle. However, when the brake is applied, the brake handle should hang approximately horizontally to prevent rainwater from entering.
If the brake lever is not adjusted correctly, it must first be moved.
Nor can the brake lever descend any further if you have failed to clear away material lying under the brake handle or the brake lever.
Finally, the brake handle can become stuck on the weather boarding of the cabin or on the shutters of the rear gable.

7.3.1.f Problems with the brake barrel

The brake barrel no longer works if the inner brake rope or chain is completely unwound from the barrel shaft before the brake lever reaches its lowest position. The remedy for this shortcoming is simple: Install a longer rope or chain and then make one or two more turns around the barrel shaft. Again, you first need to establish whether the brake lever is properly adjusted.

7.3.1.g Problems with the equalizer

The equalizer no longer works when it lines up with the chain to the brake lever. Extending the chain from the equalizer to the brake lever is usually the solution to this shortcoming but, again, you should first establish whether the brake lever is properly adjusted.
Another shortcoming is the equalizer catching against a beam of the cabin or buck.

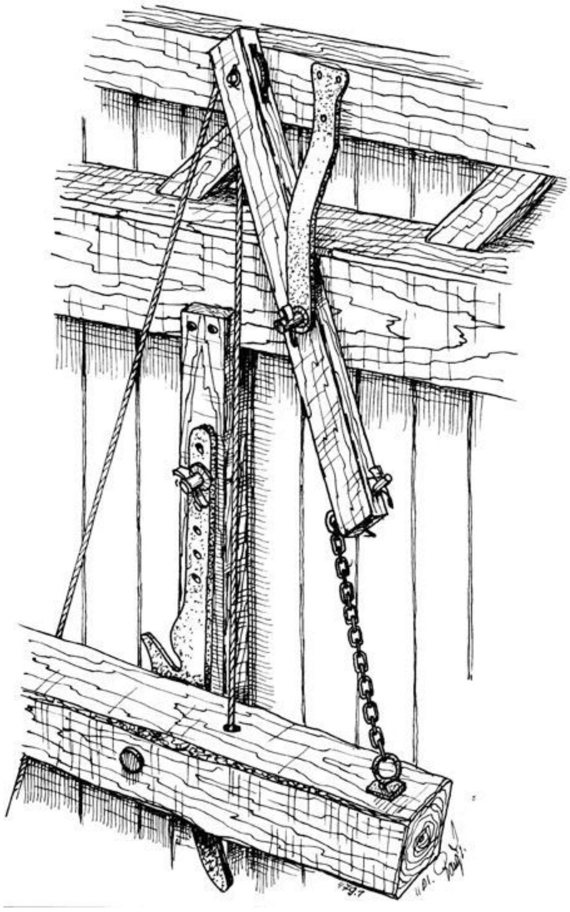


Fig. 7.3.1.4

Example of a non-working equalizer

7.3.2 Checking the capstan bolts, iron strap-work and brake blocks

7.3.2.a The capstan bolts

From time to time, you should check that the capstan bolts are still tight and have absolutely no play. Their pins or nuts may have become loose or been pulled into the sheer beam or the upper side girt. The connection between capstan bolts and the iron strap-work, the brake anchor, should also be checked; this is heavily loaded when the brake is tightened.

brake anchor

In some mill types, the capstan bolts sometimes protrude outside through the upper side girt and are then often covered. Checking the capstan bolts is then more difficult but it's even more important than when everything is dry in the body or cabin.

7.3.2.b The iron strap-work

The iron strap-work forms the links of the brake, and here again it is the case that the brake is as strong as its weakest link.
Because the brake shoes are in constant motion when the brake is released or applied, wear occurs to the eyes and bolts of the iron strap-work. This wear can become quite serious after several decades. Therefore, check regularly to see whether the bolts and eyes have become badly worn.

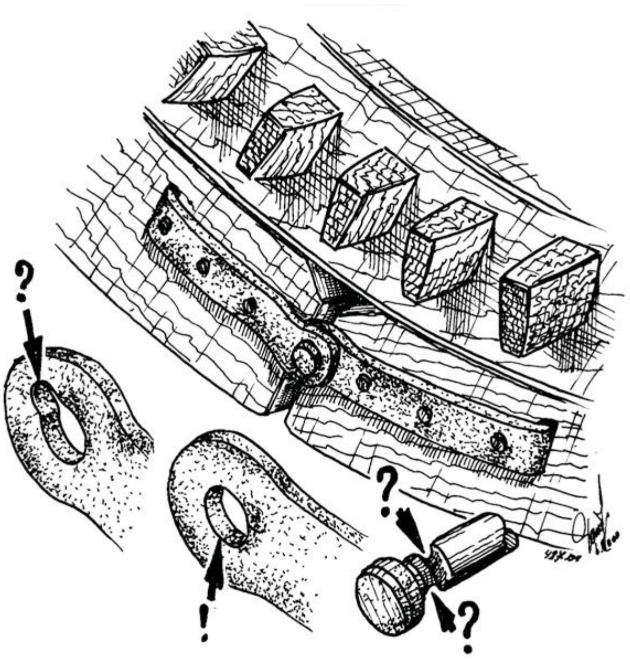


Fig. 7.3.2.1

Examples of wear on iron strap-work and the bolts of the brake

Further, check that all nuts are still properly tightened and that pins have not broken off, fallen out or worked themselves loose.
Due to the constant pulling force applied to them, the eyes of the iron strap-work, for example, may be bent open or subject to cracks. If rings have been used, this will not be visible! Therefore, unscrewing the nuts, loosening the pins and removing the rings may reveal that the condition of the eyes is poor.
Check that the brake shoes are not worn down so far that the iron strap-work touches the brake wheel. If it does, it is time to alert the millwright. Check that the attachment of the iron strap-work to the brake shoes is still secure, especially if only nails were used for attachment. The constant pulling force applied to these nails causes them to work their way out of the wood. Be aware that knocking those nails back in is not an adequate solution because the nail no longer has grip in the oversized hole. A better remedy is to install bolts through the entire brake shoe and through both iron strap-work pieces (on either side of that brake shoe).

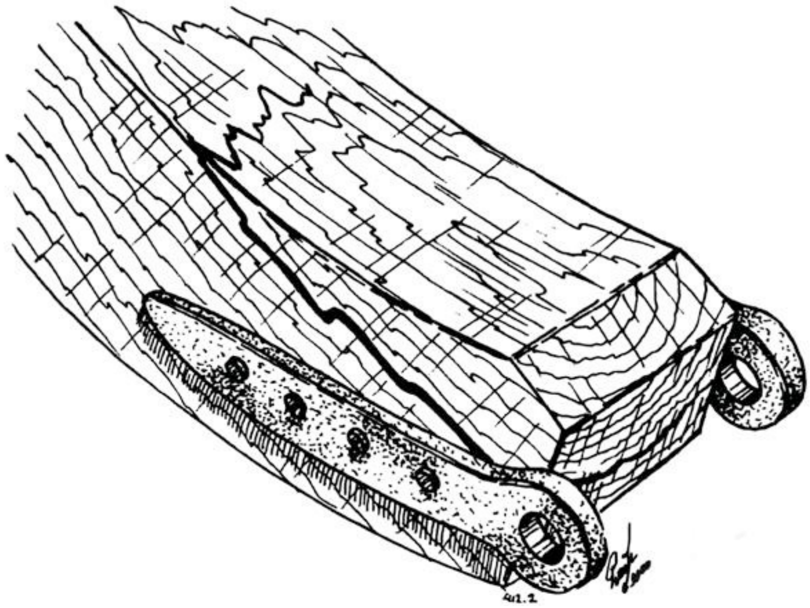


Fig. 7.3.2.2

Example of crack formation in a brake block

7.3.2.c The brake blocks

The individual brake blocks or the band brake should be checked regularly for cracks or breakage. Due to the round shape of a brake block, the wood grain runs through it more or less diagonally at the location of the iron strap-work. The brake block can then crack or break in that spot, especially if the brake is already considerably worn.
You must also keep an eye on the thickness of the brake blocks. If the thickness has decreased so much that the iron strap-work is almost touching the brake wheel and cannot be moved outward, then the brake blocks should be replaced.
What you must also pay attention to with the brake blocks or band brake is the position relative to the brake wheel. Indeed, it is not inconceivable that the

brake blocks or the band brake will eventually end up partially adjacent to the brake wheel, resulting in a reduced braking surface. This comes at the expense of the braking force. An additional consequence of this is that the brake blocks wear irregularly or crookedly. This may be caused by a change in the position of the windshaft. An adjustment to the brake blocks relative to the brake wheel or an adjustment to the brake wheel relative to the brake is then necessary. This is usually a job for the millwright.

7.3.3 Inspecting the front hanger and the brake lever

7.3.3.a Front hanger

In a cap winder, the front hanger or brayer beam is attached to the sheer beam only at the top, usually supported by one or two braces. It is important to check every now and then whether this hanger is still properly secured. This is a two-person job: one releases the brake slightly, and the other shakes the front hanger in the cap. If the brake lever jams, it pushes the underside of the brayer beam in the direction of the weather beam. This can then become loose and be moved back and forth quite a bit. The brayer beam must then be rigidly secured with new braces and bolts. But the cause of the pinching of the brake lever must also be remedied.

jamming

7.3.3.b Brake lever

When the brake is applied, the brake lever should hang slightly above the horizontal position. The back end of the brake lever drops further the more sharply you brake. This is called tightening the brake. If the brake lever drops too far down, problems can occur:

tightening of the brake

- the braking force decreases;
- the rear end of the brake lever comes to rest on the floor or on the hanger guide, resulting in even more loss of braking force because the brake lever then no longer pulls on the brake blocks with its full weight.

These problems occur precisely when the brake must do its utmost to bring the mill to a halt.

- If the brake lever drops too far, the likelihood of it jamming increases.

7.3.4 Inspecting the brake catch and the first clamp strut

7.3.4.a The brake catch

Because the brake catch always falls onto the bed when the brake is released, the bed carries half the weight of the brake. The attachment of the brake catch to the brake blocks should therefore be checked regularly for loosening.

7.3.4.b First clamp strut

The first clamp strut should ensure that the space between the first brake block and the brake wheel is limited. The first brake block exerts lateral pressure on the first clamp strut. The attachment of the first clamp strut should therefore be checked regularly. It is then a good idea to immediately give the first clamp strut a lick of grease so that the first brake block can slide smoothly along it (see Fig. 6.6.4.2).

7.3.5 Inspecting the hook, thumb or clamp

It is extremely important for the hook, thumb or clamp to not slip off because, if that happens while the mill is turning, then the brake lever will drop down with its full weight and the mill will be braked so suddenly and forcefully that there is a chance of breaking the windshaft.
The point of the hook should be sharp so that the pin of the brake lever drops directly into the hook (see Fig. 7.3.5.1). Equally sharp should be the tip of the thumb so that the bracket of the brake lever drops down directly behind it.

On a point that is too flat, the pin or bracket can become dangerously stuck. Further, keep in mind that the pin or bracket on the brake lever may also wear out or become loose over time.

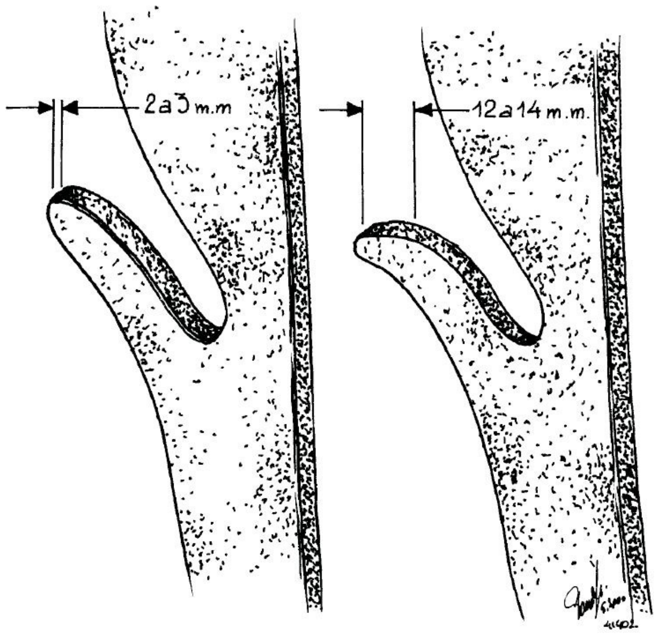


Fig. 7.3.5.1

Right and wrong shape of the hook or detent

7.3.6 Checking the fang staff and the brake chain or brake rope

The fang staff should be checked regularly for wood rot. Its suspension from the rear gable or cabin should also be checked regularly.
This is because the fang staff is in constant motion due to the wind, and in practice it has been found that the bolt or eye from which the fang staff hangs can wear surprisingly quickly.

As regards the brake chain, the attachment to the end of the fang staff is a particularly important item to check. The links may eventually wear out due to their constant movement in the wind.
One way to check this is to pull the release lever tight and then pull the brake rope in a controlled manner, several times with considerable force.

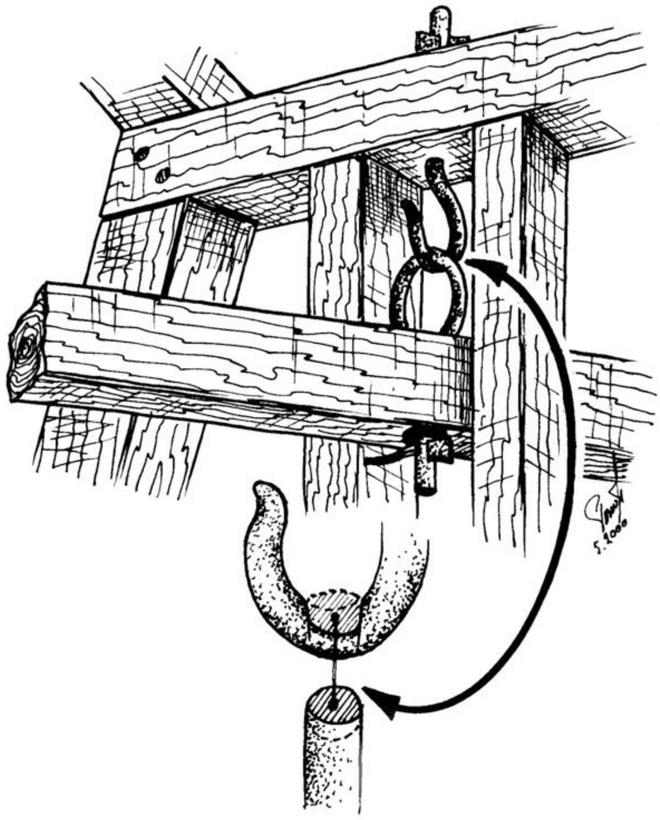


Fig. 7.3.6.1

Example of dangerous wear on the suspension of the fang staff

The use of a steel cable is not recommended because its condition cannot be checked. A steel cable may still look fine on the outside while on the inside many strands may have already snapped or rusted through.
Rope made from natural fibres perishes very quickly. Synthetic rope performs better.
The miller should further be aware that if the brake chain or brake rope is replaced with a heavier one, the braking force will be adversely affected.
He should also prevent a stainless-steel chain from coming into contact with ordinary or galvanized steel.

7.3.7 Adjusting the brake

Minor adjustment work on the brake should be done by the miller himself. If necessary, call in or ask an experienced miller for advice. If you do not manage to get the brake back in order in a simple way, leave this job to the millwright.
Always observe the following safety rule: never work on the brake of a

mill that is turning. That is extremely dangerous! The only thing you should check when the mill is turning is that the brake does not drag past the brake wheel anywhere.

The most common brake problems are:

7.3.7.a The bottom brake block drags along the brake wheel

shim

Every miller will get to experience the bottom brake block dragging along the brake wheel. This problem is easily solved by removing a shim, if present, between the bed and the brake catch. This allows the bottom brake block to drop down a little further and be released from the brake wheel. Removing a filler board can only be done when the brake is applied; in other words, when the mill is stationary. Then the brake catch is free of the bed!
The mill can turn again but the problem has only been temporarily solved!

dropped windshaft

More important, then, is recognizing the cause of a bottom brake block that drags: a dropped windshaft! The cause of this may be:

1. Wood (new wood) has settled and shrunk.
2. The sheers are bending or their heads have rotted.
3. The weather beam has rotted causing the neck brass to drop or tilt.
4. The stopping under the neck brass, the stone bed, is rotten.
5. The neck brass is too deeply worn or is broken.

Although the above causes are obvious ones, they are difficult to observe. More observable, however, are the phenomena associated with a sagging shaft:

1. The neck bearing carries the shaft over a smaller than original surface area; look out for streaks in the grease film on the neck bearing and possible overheating of the shaft.
2. The filling pieces around the windshaft are starting to rub against the sprattle beam and/or the long stretcher.
3. The cogs of the brake wheel engage too deeply with the cogs of the upper wallower or with the rods of the lantern wheel. Also, the cogs of the brake wheel can drop down onto the lower disc of the lantern wheel.

7.3.7.b The brake head drags across the brake wheel

Dragging of the head brake block along the brake wheel is caused either by insufficient space between the brake wheel and the head brake block when the brake is released or by uneven distribution of the available space. This problem does not occur that often but it can also be the result of moving the brake.lever.
This can be remedied in several ways:

1. Place an additional shim between the brake catch and bed. This better distributes the space available at the top between the brake wheel and the brake, provided there is sufficient space between the bottom brake block and the brake wheel.
2. If the first clamp strut is loose, the brake blocks are pushed away sideways rather than upwards when the brake is released. Tightening the first clamp strut is then sufficient in most cases to free the brake head from the brake wheel again. On mills with an adjustable first clamp strut, you can move the first clamp strut slightly in the direction of the brake wheel.
3. If solutions 1 and 2 do not yield results, then the space between the brake

and the brake wheel must simply be made larger, which means the brake must be released further. This can be achieved by hanging the hook higher. If the mill has a clamp brake then apply a thicker hardwood wear piece to the cclamp. As a final possibility, consider inserting the sword iron one hole lower in the brake lever.

7.3.7.c A brake lever that is hanging too low

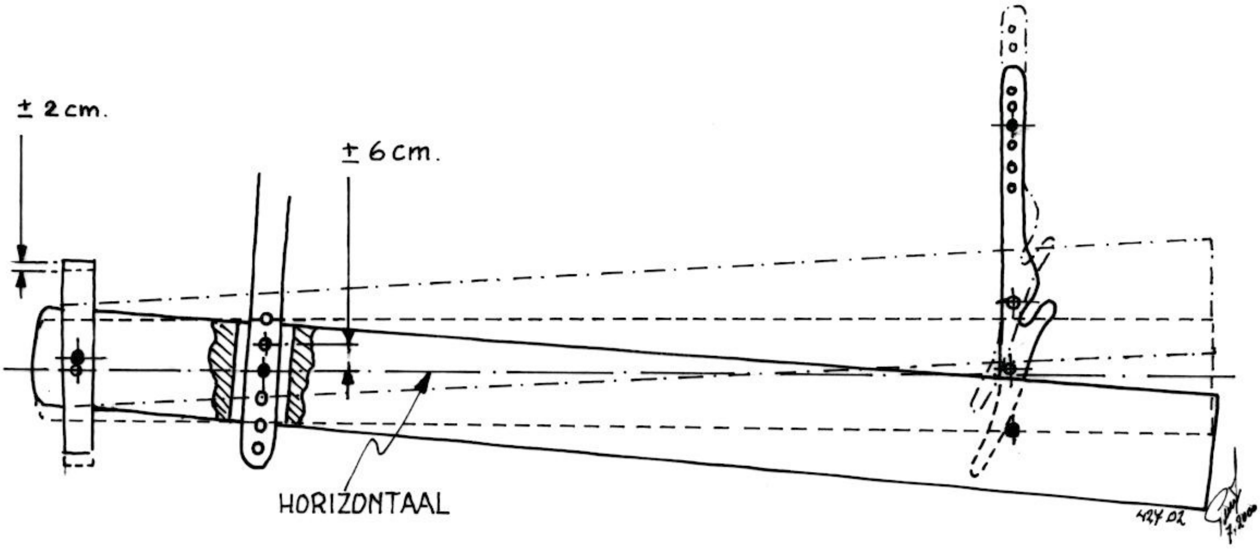
Wear on the brake blocks creates more space between the brake wheel and the brake. Thus, when the brake is applied, the sword iron along with it the brake lever end up hanging lower and lower. As a result, braking force is lost (see Section 7.3.3.b).
Wear of the bolts and eyes of the iron strap-work reinforces this process.

moving the brake lever

Moving the brake lever is done on a day with little wind. You clamp the sails and secure the mill tightly on the stock chains.
There are now two options: 1. Adjust the sword iron; and 2. Adjust the slider.
1. Adjusting the sword iron can be done by one person if they have access to a car jack or some other jacking device. Beforehand, mark with a chalk the current position of the brake lever relative to the sword iron. The jack is used to release the brake lever slightly so that the bolt can be pulled out through the brake lever and the sword iron (at this point, the brake no longer functions because the brake lever no longer pulls on the sword iron!). If there is a brake barrel, equalizer or interior fang staff, then a second person can use this to lift the brake lever slightly. Then the brake lever is raised a little further until the bolt can be inserted through a higher hole in the sword iron. This raises the rear end of the brake lever significantly.

Fig. 7.3.7.1

The advantage of a slider or frame in the brayer beam: By lowering the slider only 2 cm, the brake lever hangs exactly correctly. If you move the pin in the sword iron one hole, the brake lever will be much too high.



2. If there is a sliding gate in the front hanger (see Fig. 6.6.3.3), adjust the brake lever by releasing the bottom wedge of the slider and hitting the upper wedge. This lowers the slider and raises the rear end of the brake lever. The slider allows for more precise adjustment.

If there is no slider then the sword iron or the front hanger usually has a double row of holes staggered at an angle to each other, or there are filler boards on and under the gudgeon of the brake lever. This also achieves a reasonably accurate adjustment. After raising the brake lever, the brake generally needs to be readjusted because there is now less space between the brake wheel and the brake blocks, so there is a chance that the head brake block, in particular, will catch. By adding an extra filler board to the bed, this catching is usually resolved. This does indeed reduce the space at the bottom brake block, but since the bottom brake block receives the most wear, this is where the most space was created.
If an extra filler board is not sufficient, the first clamp strut may have to be adjusted or the brake lever catch hung higher (raising the clamp or the hook, respectively).

7.3.7.d   A bumping or humming brake

bumping or humming brake

A brake bumps or hums for several reasons:

1. The metal lining is rusty and therefore rough. The miller can usually solve this problem himself by sanding the lining several times. The mill is chained and the brake is released. Then fine, sifted sand is thrown between the bottom brake block and the brake wheel. The miller then lets the mill turn and then brakes it slowly with a dragging brake. This procedure is repeated several times.
2. The so-called rising sides on the brake blocks are missing or they are too small. As a result, the wood grain at the ends of the curved brake block is cross cut (against the grain, or end-grained) rather than with the grain. That catches considerably rougher. Most of the end-grained wood is removed by the use of rising sides. Adjusting this is a job for the millwright.

rising sides

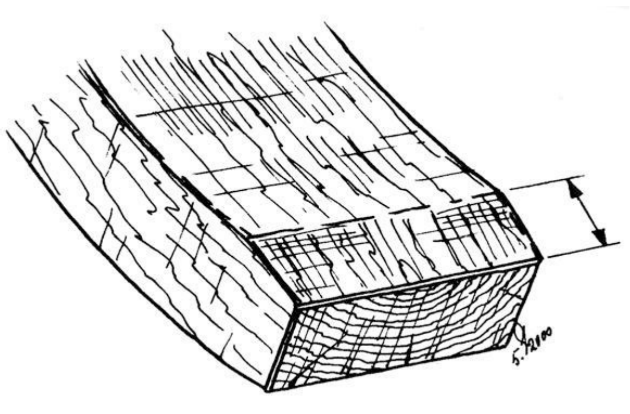


Fig. 7.3.7.2

Example of a rising side at the ends of the brake shoes

3. The brake does not close properly around the brake wheel. This results in the brake not touching the brake wheel everywhere. The remedy is to plane the brake blocks to fit again and/or to skim (true up) the brake wheel so that it becomes perfectly round again. This is millwright work, as it also requires the removal of the brake.
4. The windshaft is too light or it has filling pieces that are too short. The only remedy is to install heavier and longer filling pieces (millwright's work). This increases the mass of the shaft and makes it less prone to vibration.

7.3.8 Releasing the brake

releasing the brake

The actions for releasing the brake depend on the method of hanging the brake lever: in a brake lever catch, at a thumb (hook and eye) or on a clamp.
If the mill is equipped with a catch, the miller pulls the brake lever up far enough so that he can then, by slowly lowering the brake rope or brake chain slightly, lower the pin of the brake lever into the bfrake lever catch.
If the mill is equipped with a hook and eye brake, the miller pulls up the brake lever and then walks (facing the mill!) one step to the left, placing the brake lever against the rear hanger above the hook. He then lowers the brake lever so that the eyefalls behind the hook. The same order of action applies to mills fitted with a clamp.
As the miller walks to the left with the brake rope, he must be careful not to trip over a winding bollard or chain.
After releasing the brake, the miller should check whether the brake lever is hanging properly in the catch or at the hook or on the clamp, as the case may be. To check this, he very slowly raises the brake lever a little and then very slowly lowers it again. If this is done quietly, one go is enough to make sure that the brake lever does not rest on the tip of the catch or hook or on the edge of the clamp, as the case may be (see Section 7.3.5).
After this check, the miller places the brake rope around the appropriate clamp or single cleat, in such a way that it can be quickly released if needed to make an emergency stop. In so doing, the brake rope should not be completely tightened. It is a good idea to ensure that the brake rope does not end up hanging in the wet grass or dragging along an oily winding chain or steel cable.
It is not advisable to leave the brake rope hanging loose. In the unlikely event that something does happen to the hanging of the brake lever, a secured brake rope can prevent breakage of the windshaft. Also, a dangling brake rope can be an invitation for visitors to start pulling on it. If the brake lever comes out of its suspension point as a result, the mill will almost certainly be braked too suddenly, with potentially disastrous consequences.

7.3.9 Applying the brake

The method of action when applying the brake also depends on the method of hanging the brake lever but, in all cases, the brake lever must first be released from its suspension point.
If the mill is fitted with a catch, the miller first gives a short tug on the brake rope. As a result of this tug, the pin in the brake lever swings the catch forwards (in some cases, backwards). This gives the miller the opportunity to quickly lower the brake lever a little past the notch in the catch.
After releasing the brake lever from the suspension point, the miller eases the brake rope to the point where he can feel and see that the brake is catching and the speed of the sail cross is decreasing. He carries out this easing not by slipping the brake rope through his hands but by passing it hand over hand. Depending on the wind force, sail setting, turning speed and load, the mill will now come to a standstill in a shorter or longer period of time. Braking occurs differently at each mill. This does not depend on the type of brake, although steel band brakes are known to often brake sharply and strongly. The miller must not brake too quickly or too abruptly because then there is a risk of the windshaft breaking.

However, if the miller brakes for too long, the brake will become too hot, which can cause a fire. A rule of thumb is that another 1/6 of the number of whips that the mill is running may pass until the mill is stopped. If the mill turns 60 whips, then 10 more whips are allowed to pass before the mill is at a standstill.
At higher speeds, the brake may go all the way up right away. At low speed, you should be more careful.
Just before the sail cross actually comes to a halt, you must release the brake very briefly and then apply it permanently. This prevents the rebound of the sail cross, which causes great stresses in the canister (see Fig. 7.3.9.1).

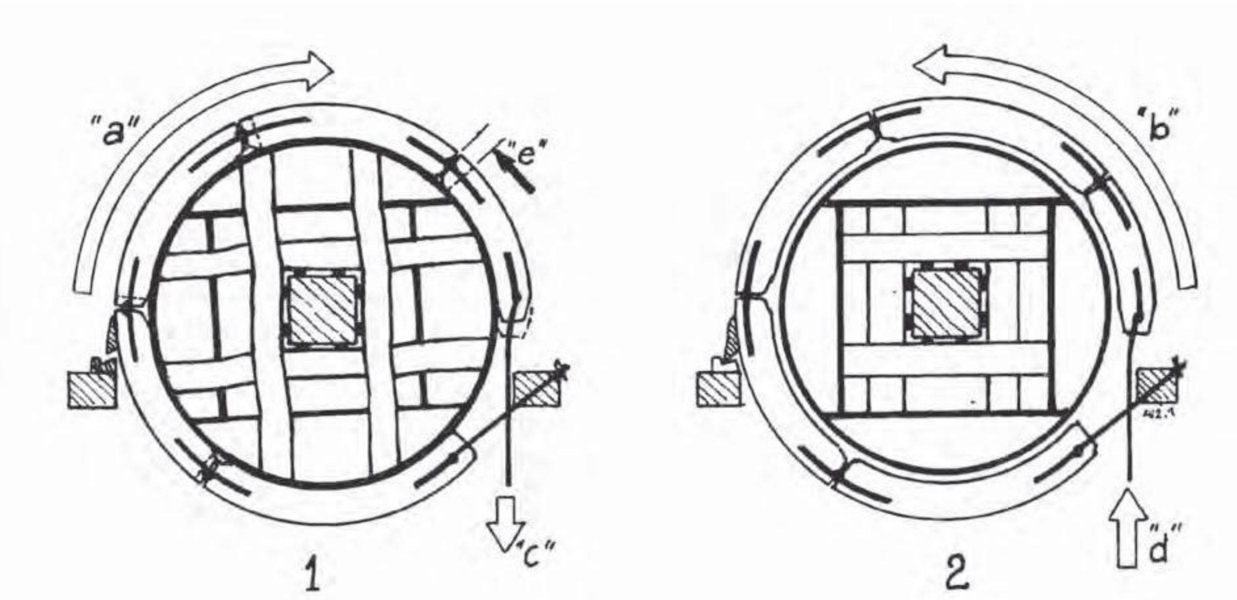


Fig. 7.3.9.1
Braking

1. *Situation during braking*
   a. *The tractive force of the brake blocks on thebrake wheel causes some deformation in its cross arms.*
   c. *Tractive force on the sword iron*
   e. *Tightening of the brake*
2. *The brake at the moment the brake wheel comes to a standstill*
   b. The tractive force on the brake blocks is briefly released by momentarily releasing the brake (d); the brake blocks then spring back to their rest position.

sail improvements

Sail improvements that increase tractive force require a more powerful means of braking than sail systems without these improvements.

control flaps

If the mill is equipped with automatic control flaps that operate under the influence of centrifugal force and cannot be operated at the tail, then braking requires extra attention. If the miller starts braking while the mill is turning at such a high speed that the flaps are open, then he must take into account that the flaps will slowly close due to the reduction in speed of the sail cross. This closure gives the sail cross more tractive force again and demands more braking power.

air brakes

In contrast, mills with air brakes that can be operated via a bored-through shaft or friction ring are very easy to brake. To do this, prior to braking, you open and secure the air brakes with the weight chain. The speed and tractive force of the sail cross then decrease significantly before braking begins.
If the miller underestimated a squall or acted too late, the mill can start turning so fast that it cannot be braked. Then, to prevent fire caused by prolonged braking, the miller must release the brake again. It is better to just let the mill rage on and wait for a wind lull; this is a temporary decrease in wind. During such a wind lull that is mainly audible by the sound of the sails, the miller must immediately fully apply the brake.

wind lull

In case of emergency only the miller can pull the release lever too, but there are great risks involved: it puts a lot of extra force on the sword iron and thus indirectly on the windshaft. Shaft breakage cannot be ruled out!
As soon as the speed of the mill decreases, the release lever must be released again: the brake should do the proper braking then.
If the braking fails you must wait until the squall has passed. This is not pleasant but it usually does not last that long.

cap wants to turn clockwise

We very strongly caution against winding the mill out of the wind in a squall when it is running through the brake. There is then a good chance that, when the chains on the tail are loosened, the cap will suddenly veer over. The miller can be hit by the sail cross and the cap can slide off the body.
Only in exceptional weather conditions, such as when the mill has run away in a storm, can the so-called 'brake-with-the-tail' action be considered, and then only with great caution and preferably with the help of several people. See Section 7.3.10 for how to proceed in this case.

check after emergency stop

If braking the mill has taken a lot of effort and time (for example, during an emergency stop), the miller should then first chain the sail cross and thoroughly inspect the cap. Take a fire extinguisher, a bucket of water and/or wet rags with you. Sparks and burning wood residue should be extinguished as soon as possible. The brake blocks should be checked for scorch marks. They may have become so hot under these conditions that they have begun to smoulder. If the brake is then released, due to the oxygen present, the smouldering can easily turn into fire. If no check is made for scorch marks, a fire can start even an hour and a half to two hours after the emergency stop. This check should therefore be repeated after a couple of hours. In the past, many mills used to have a bucket of water or sand ready on the cap floor.
Scorch marks have another annoying side effect; the resulting charcoal forms a kind of lubrication on the brake which makes it function worse.

7.3.10 What to do in case of brake failure

braking with the tail

Brake failure occurs when a part of the brake system breaks while you are in the process of braking. Braking is then no longer possible. The brake should therefore be thoroughly checked on a regular basis to reduce the chance of brake failure, although this may not always detect an impending material breakage. If something does break while the mill is being braked then the first action is to bring the mill to a standstill by winding it out of the wind. This is called 'braking with the tail'.

The following is important here:
- If possible, release the brake again. Depending on the cause of the brake failure, you may thereby reduce dragging when the brake rests on the brake catch.
- If you have manual air brakes, open them fully.
- For self-reefing, Ten Have and Van Riet systems, set the flaps/shutters fully open.
- The winding must be done quickly, even when the mill is turning only moderately, as brake blocks may drag against the brake wheel, quickly increasing the risk of fire.
- How the mill reacts when you loosen the anchor chain and/or start winding depends on several factors; is it turning loaded or unloaded, what type of mill is it, and what type of winding gear is involved? Therefore, practice tail-braking in calm weather to experience how the mill responds to braking with the tail.

Also keep in mind that the forces on the mill will be much greater in strong winds.

In the event of brake failure, it is preferable to wind the mill clockwise out of the wind. To wind quickly, you can take advantage of the phenomenon that a loaded mill (the post mill and paltrok mill excepted) wants to go round clockwise. This is because the brake wheel settles against the resistance of the grinding gear. Because the winding chain is usually laid out over as large a length as possible to the left and the anchor chain is secured as short as possible to the right (as seen from behind the tail), the miller can immediately begin winding clockwise. Loosening and gently slipping the anchor chain may be enough to get the clockwise turning going, especially with lightly running winding gear or a considerable speed of the sail cross. Under no circumstances should the miller completely loosen the anchor chain, because it may be under significant forces. If the chain is pulled out of your hands, the cap or cabin can shift once it is in motion, possibly causing damage.
If the mill is still running while the anchor chain is fully fastened, then the anchor chain must be shortened again before continuing to wind. If the stock chain is accessible, it can be used as a second anchor chain. If not, the winding chain should be laid to the other side and secured. The winding chain then temporarily takes over the job of the anchor chain. Then shorten the anchor chain, secure it, and place the winding chain to the left again.
A second reason for winding clockwise in the event of brake failure is that, from the bottom whip, the luff of the sail with the single cleat loops is now facing the wind. If you then loosen the pointing lines, the wind will not blow the sail out from behind the single cleats.
With an internal winder, additional risks are posed by winding in the cap while turning, with a faulty brake hanging against the brake wheel. Still, winding must be done but you should be very careful when doing it.
Working on a defective brake while the mill is turning is very dangerous and is therefore not recommended.

However, if the mill is already going anti-clockwise when the brake fails — for example, to turn it a little slower (winding with the tail) — then anti-clockwise winding is to be considered because the mill will then stop faster. Other issues for consideration as to whether you should wind clockwise or anticlockwise are: How is the winding chain lying? Is the mill turning under load? Does the mill have the (strong) tendency to want to go clockwise or not? If no sail is set, then the risk of the sails blowing off is not present either.
A grain mill can be further slowed down by completely filling the eye with

grain and setting the stone completely out of action. However, this does take extra time.

Through the winding, the mill comes to a standstill by itself. With a mill that is in operation, this is often before it is completely transverse to the wind. Do not wind any further then, because in this position there is still some wind pressure on the sail and then removing sail is a little easier than when it is completely transverse. The hook is used to set the bottom whip down or a whip on which there is sail. The miller now secures the sail cross with the stock chain. Then he first checks the brake for hot running.

If no sails are set, he further secures the mill. The brake is not working so he takes all the usual measures for safely putting the mill out of operation. He also puts the mill in gear to create additional resistance.
If there is sail set, it should be rolled up and clamped if possible.

If the problem with the brake is such that the miller can repair it provisionally or the millwright can come by quickly, the miller can then wind the mill facing the wind and take down the sails.
If repair is not immediately successful, then he should try to roll up the sails. Removing sail during what is roughly a crosswind can be done basically the same way as removing sails when facing the wind, but it has to be done with greater care. It often takes more force, especially in somewhat stronger wind. There is certainly a chance of blowing away. Consider in advance whether you, as a miller, agree with this! And call for assistance!

Some attention points:
- Preferably try to enlist the help of others.
- Do not loosen the pointing lines and tie ropes all at once. This keeps the sail under better control.
- If necessary, loosen the pointing lines one at a time when rolling up the sail.
- For a partially clothed sail, loosen the pointing line(s) and roll them along into the existing roll. Do not first unroll the sail again.
- When rolling up, keep the sail as flat as possible on the sail frame.
- After loosening the lower right tie rope, continue to roll as much as possible; take a step to the right and back, which releases a number of single cleat loops; and immediately start to hang from the sail with considerable weight. Due to the tension in the sail, it will largely roll up on its own. After this, roll a few more turns, take another step to the right and, in one fluid motion, pull off the remaining single cleat loops and once again hang heavily on the sail.

When stepping to the side, make sure that the upper left tie rope is in line with the rolled-up sail before firmly pulling on it; otherwise it will have less effect.

- If the sail cannot be held then let it go so as not to go up with it yourself (see also Section 7.2.5 and Section 7.2.6).

If the sail is rolled away, then clamp it. If this does not work against the wind, walk around the leading hemlath and fasten it.

After this, the next whip should present itself. To prevent possible reverse turning, insert the pawl.

7.3.11 What to do when the mill turns backwards

turning backwards

To stop a mill turning backwards, the miller will first try to brake in the usual way. If that fails, he can increase the braking force by tightening the release lever. This must be done expertly, as it exerts huge force on the brake and windshaft. If the mill does not have a release lever and someone else is present, then they can go and sit on the brake lever.
What is important here is that the miller can keep in touch with the person in the cap to give directions.

If you do not manage to stop the reverse rotation then the mill should be winded as soon as possible. Whether this is clockwise or anticlockwise depends on the weather situation that is causing the reverse rotation as well as the location of the winding chain.
The most likely causes are:
- a heavy squall veering past;
- a depression passing directly over the mill.

If a heavy squall veers past, the wind can veer so widely with the squall that the mill starts to turn backwards. If it cannot be braked in the normal way, the miller winds clockwise until the reverse rotation stops. Then he applies the brake. The miller who has then followed the golden rule by laying the winding chain long and ready for clockwise winding now saves himself a lot of time: he can start winding immediately. Loosening the anchor chain is not a problem in this situation because the mill rotates backwards and therefore will not turn clockwise. After the squall has moved on, you wind back to the original position because the wind returns there.
Although it is less common, even a backing, passing shower can sometimes lead to backward turning.

If the backward turning is caused by a passing depression where the wind is rapidly veering from approximately south-east to west to north-west, the miller should wind the mill transversely to the wind as quickly as possible so that the backward turning stops. Speed is advised because the expected increase in wind could cause the sails to pull the sail frame apart. Whether clockwise or anticlockwise winding is the fastest depends on how far the wind has already veered and what position the winding chain is in. If the winding chain has to be diverted first, it may take more time than an extra few metres of winding. The miller must then quickly weigh up the situation.
Once the mill stops, the brake is applied. The miller then continues to wind until the mill is facing the wind in order to be able to furl.
Compare this to the situation of brake failure described in Section 7.3.10 where the miller must also wind the mill transversely to the wind. In that situation, however, he will preferably wind clockwise and, standing transversely to the wind, carefully roll up the sails. Fast winding is important in that situation, as well, but fast sail removal is a bit less urgent.

7.4 PUTTING AWAY OR SECURING THE MILL

7.4.0 Introduction

It is very important that the mill is well protected against extreme weather situations, such as severe storms and lightning strikes. The miller bears primary responsibility for this, even during the days he is not present at the mill.
Several measures must be taken before leaving the mill. The following resources may be present at the mill for this purpose:

stock chains

- One long (about 10 metre) or two short (about 6 metre each) stock chains or ropes of sufficient thickness, fitted at one end with a loop, ring or hook, according to the type of mill;

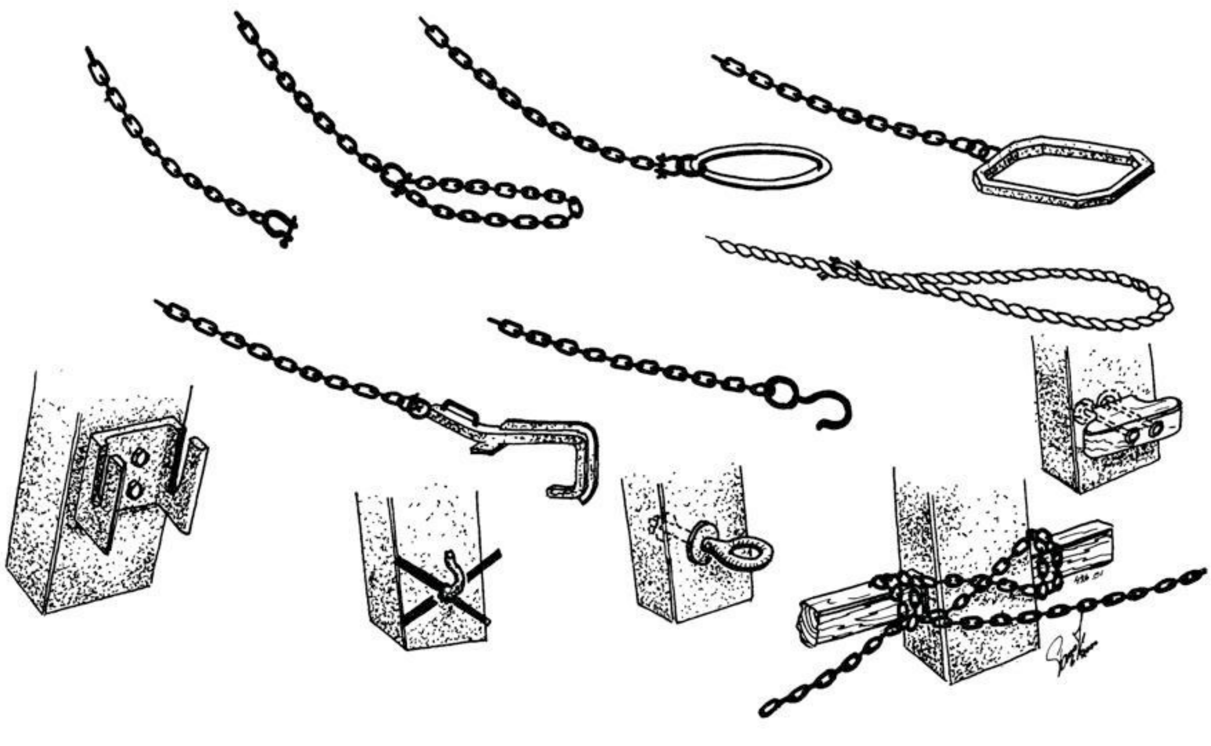
spare chain

- A spare chain of approx. 6 metre as a replacement for the stock chain, anchor chain or winding chain. This chain is also needed to set the mill in the long rest position;
- A lightning conductor cable of about 6 metre in length for connection to the sail cross and, if necessary, a cable for connection to an iron tail. Also recommended to have on hand is a spare cable, which can also be used when setting the mill in the long rest position.
- At least one heavy stud to block the brake wheel, even if the mill is equipped with a release lever.

It is important for the miller to realise that a stock chain or stock rope, which is located a long way away from the shaft, is much more effective than a stud close to the shaft. The latter must be able to withstand forces which are comparatively much greater.

Fig. 7.4.0.1

Examples of stock chain ends and rope ends and attachment points on the stock.



7.4.1 Securing the mill

7.4.1.a Securing the stock chain

chain clamp

The method of securing the sail cross must be 100% reliable. It is therefore safest to put the stock chain around the stock with at least one but preferably two full turns, whether or not in combination with a so-called chain clamp. In any case, in such a way that the stock cannot slip. Securing the stock only to the chain clamp risks having it bend open in heavy storms.
It is best to wrap the chain around the stock above the second sail bar. If the storm tears this bar apart, the bottom sail bar can catch the chain. The sail bars must be 100% reliable where they are located. The loose end of the chain is first wrapped a few times around a winding bollard and then a few turns around the chain part between the pawl and the stock.
Tying knots in chains is not to be recommended. This is because the wind pulls them so tight that they can hardly be loosened. If necessary, use a harp shackle if you want to secure the chain.
The stock chain for countering the forward movement of the sail cross should not be set completely taut in order to first give the brake some room to tighten. The stock chain for countering backward movement can be tighter because the brake does not work in the case of backward turning. This is especially true if the mill has no pawl.

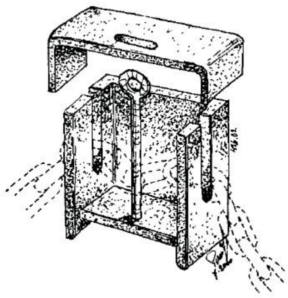


Fig.7.4.1.1
Chain clamp

7.4.1.b Securing the lightning conductor cable

It is prudent and especially safe to first secure the lightning conductor cable to the ring main. In fact, an approaching thunderstorm can develop a static charge in the sail cross. Such a static charge in the sail cross can also occur when the mill runs for an entire day in warm, dry weather.
Hold the lightning conductor cable by the rubber sheath and tap the bronze clamp against the grounding bracket on the stock. This dissipates any static charge that has built up.

7.4.1.c Using the pawl

The pawl serves to prevent a stationary mill from turning backwards. The pawl should be inserted only when the mill is stationary and never when the mill is already running in reverse, because that is sure to be at the cost of cogs from the brake wheel and/or pawl. To stop a backward turning mill, the miller can try to increase the braking force by pulling on the release lever. If that fails, he must set the mill to face the wind as soon as possible.
The proper use of the pawl is as follows: At the beginning of the day's operation, after the mill has been winded facing the wind, the miller pulls the pawl out of the brake wheel using the pawl rope, which is then secured. Usually the pawl rope runs down to the tail but sometimes the operation must be done in the cap.
At the end of the day's operation, the miller inserts the pawl by loosening and releasing the pawl rope. The counterweight will automatically move the pawl toward the brake wheel. From the yard or the stage, the miller cannot tell whether the cogs of the pawl are engaged with those of the brake wheel. They can also be butted against them but that is no problem. When the pawl is fitted with a good counterweight and the pawl rope is secured with some slack,

the cogs of the pawl will still naturally fall between those of the brake wheel as soon as the brake wheel turns slightly backwards.
If the pawl is inserted and the brake wheel rotates back slightly then the pawl may become stuck. The miller must then release the brake slightly and lower it again immediately afterwards. The brake wheel will then rotate slightly forward due to the tightening action of the brake so that the miller can pull out the pawl.

rotatable stud

Instead of a pawl, some North Holland internal winders have a rotatable, horizontal stud under the right-hand sheer beam. This can be placed against a cross arm of the brake wheel to prevent backward movement. By the way, this only works if the sail cross is put away upright.

7.4.1.d Using the release lever

If the wind is coming from behind, the brake will not work properly because when the mill turns backwards, the brake wheel raises the brake lever. Tightening the release lever prevents this. When the mill is stopped, the stock chain or stock rope prevents backward turning but they are loosened during winding. Therefore, the release lever and pawl are only loosened after the mill is set to face the wind.
So, the release lever and the pawl have the same function, which is why many mills only have a release lever. The release lever has the added advantage over the pawl that you can use it even when the mill is already turning backwards.

Furthermore, you can use the release lever to increase the braking force when the mill is running through the brake. By the way, this must be done very carefully because there is definitely a chance of shaft breakage. Using the release lever only briefly in such a situation can remove the greatest speed from the sail cross, thus preventing prolonged braking and the development of a lot of heat. This use of the release lever, by the way, is best left to the experienced miller.
A normal, properly functioning brake prevents the mill from running forward during storms. The prerequisite for this is that the brake lever is heavy enough or it is provided with sufficient additional weight.
The release lever rope should be tightened when taking the mill out of operation. Only after tightening the release lever do you secure the brake rope, but in such a way that it still has some play. If the brake still wants to tighten itself under the influence of a (heavy) storm, this must not be prevented by a brake rope that is too taut. (For the same reason, nor should the stock chain be set too tight to stop it moving forward!)
Using the pawl pin or weighted pawl rope (see Fig. 6.6.3.4), you can easily prevent the unauthorised release of the brake.

7.4.1.e Using the pull brake

The pull brake found on mills in the Zaan region of the Netherlands has the same function as the release lever. At the end of the day's operation, you pull the rope of the pull brake as taut as possible, thus additionally tightening the brake (see Fig. 6.6.8.1). Spider mills are also usually equipped with a pull brake. The fang staff is then absent, as is also the weight box on the brake lever. With a pull brake, you can still give the brake enough braking power. Two ropes emerge from the bottom of the cabin: the brake rope and the pull brake rope. When releasing the brake, the miller pulls the lighter rope and secures it to a cross cleat because there is no hook, thumb or cleat. The pull brake rope is then slackened.

brake rope, pull brake rope

When braking, the miller pulls the brake lever down using the pull brake rope. He holds the lighter rope with his other hand so he can release the brake lever if the braking is too severe or to get the sail cross into the desired position. Once the spider mill is stationary, the miller tightens the pull brake rope considerably and pulls it behind a notched wedge (see Fig. 6.6.7.1).

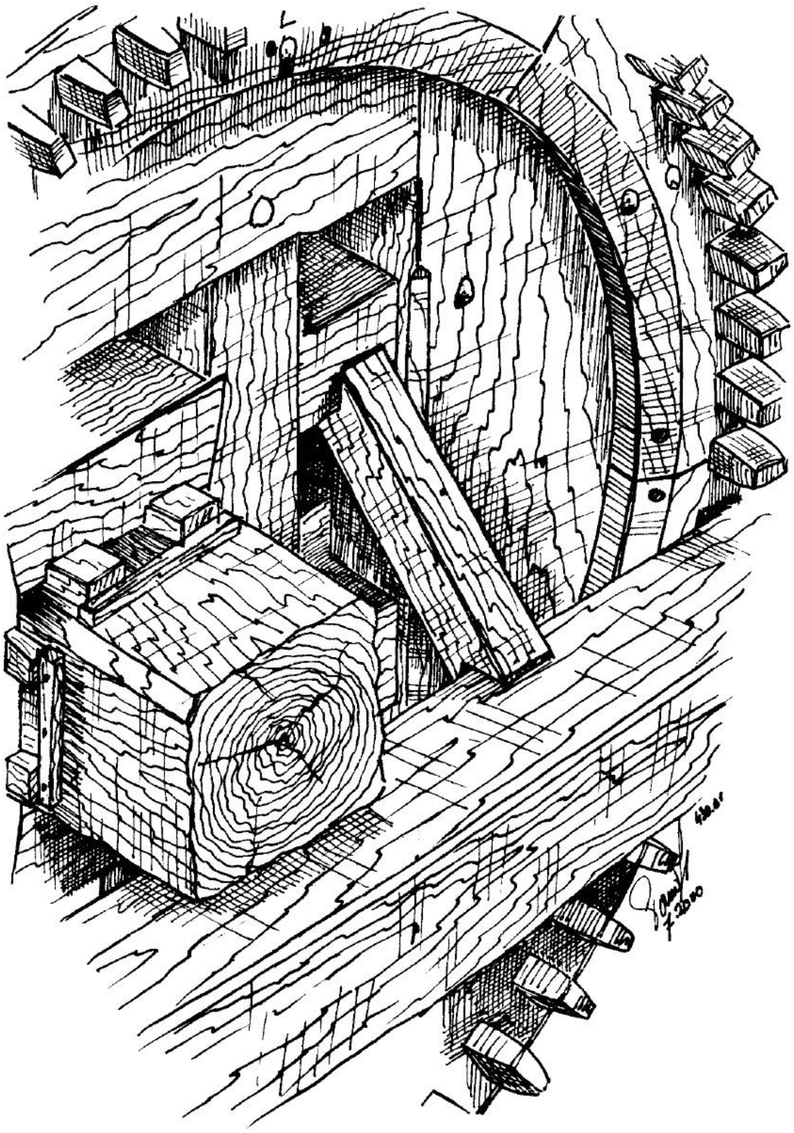


Fig. 7.4.1.2
Brake wheel stud

Placed between the sprattle beam and a cross arm of the brake wheel, to the right of the windshaft

7.4.1.f Using the studs in the brake wheel

brake wheel studs

As a final measure, the brake wheel can be blocked using brake wheel studs. These studs are placed between a cross arm and the sprattle beam or the long stretcher, but never under one of the cogs of the brake wheel. They are not designed for that. Be aware that the struts can work their way out through the movement of the brake wheel.

Together, the brake, pawl, release lever, studs and stock chain(s) should ensure that the mill will not turn, even in the heaviest storm.
Struts undergo enormous forces. If chains, ropes, eyes and winding bollards are in good order, they should provide adequate safety. When in doubt about this, struts can provide additional security.
At a grain mill, you have an additional option for securing the mill: setting the stones in operation and tentering them.

7.4.2 Securing the tail

The anchor chain, winding chain and spoke chain are already firmly fixed. But it is a good practice to reduce the tension put on the winding chain to prevent the cap from rocking to such an extent that the tail and long stretcher have an opportunity to spring back. In this way, you prevent the ends of the long stretcher from bending further and further upward and even staying like that in the long run. A strut against the tail beam can also cause this undesirable effect.

Moreover, for a stage mill, lessening the tension on the tail (and the long stretcher) also relieves the stage.

If the mill has a steel tail beam, it is a good idea to ground it. If the gudgeon end of the windshaft is also connected to the steel tail, then the mill is protected during grinding and there are several ways to deflect lightning when at a standstill. Although there is always a chance that lightning will strike, the presence of metal parts does not increase that chance.

7.4.3 Additional measures during severe storms

When a severe storm is expected, properly trained millers ask themselves whether the mill will withstand the impending bad weather. When in doubt, go to the mill to verify on site that the normal storm protection measures are in place.
In addition, special measures can also be taken:

- Remove all inner boards or storm boards if not already done.
- Before the storm begins, wind the mill facing the wind. This is even more true for mills with self-reefing.
- Use an additional stock chain if it is too dangerous to release the mill to start winding. Place this chain counter to the direction in which the sails want to rotate and around a subsequent winding bollard post or stage platform so that the force is distributed over two points.

7.4.4 Special positions of the sail cross

language of the sails

In the past, millers used their mill's sails to make various announcements, the so-called language of the sails. As volunteers, we have adopted these customs and thus are keeping them alive. If we want to do it well, then we must be aware of the regional traditions and honour them.
Inquire about these traditions with former and current millers in your area.

7.4.4.a Long rest position

setting in a long rest position

Setting a polder mill in the long rest position during the summer months used to be common. The sails were removed and stored, or taken away for repair.
By setting in the long rest position, the life of the (wooden) shaft and rods was extended. Rainwater ran off better and the rods bent less. For better run-off of rainwater, many millers nowadays also set the sail cross a little in the 'coming' position.

lightning strike

It was also hoped that this long rest position would reduce the chance of lightning strikes. This hope proved vain in practice: the difference in height compared to a sail cross in the short rest position is only slight.
Nowadays, mills are also set in the long rest position for nostalgic reasons, so they look good, or to prevent someone from climbing into the sail cross. Other reasons may be that birds do not like to sit on sloping slats or because this position helps keep the yard a little more clear.

7.4.4.b Celebration position

setting in the celebration position

There are two ways of setting the mill in the celebration position, specifically with or without flags.
If you set the mill in the celebration position without flags, then you should set the whip that is above such that it is well over a sail bar's length in front of the highest point of the turning radius of the sail cross.
If you use flags when setting in the celebration mode then you set the mill in the long rest position. The method of setting in the celebration position is also highly regional.
Therefore, for example, outside the Zaan region we should not dress a mill with

Zaan beauty

Zaans beauty despite the fact that it is a beautiful sight.
To honour the regional customs, here are some mills with decorations as were usual in the past (see Fig. 7.4.4.1). In Friesland, mills were set in the short rest position and with three flags; in Rijnland they were set in the celebration position with one flag on a vertical flagpole at the top whip.

flag lines

Finally, we would like to point out that for the flag lines from whip to whip, people usually use flags that are too small. For an attractive appearance, you should use flags that have a size of at least 45 x 30 cm or 55 x 35 cm, so with a length/width ratio of about 3:2. That size, by the way, again depends on the size and height of the mill.

Another way to celebrate a joyful occasion is to attach, at each end, a flag to the hemlath at the level of the bottom sail bars or a flag line along the entire hemlath of the sail frame.

In this last case, it is inevitable that there will always be some flags that are upside down. According to protocol, that should not be done with the Dutch flag.
Therefore, when the mill is turning there should be no Dutch flags in the sail cross, only on a flagpole.
When stationary, at least the red stripe of the Dutch tricolour must be at the top. If the mill is in the celebration position, the flagpole should still be vertical.

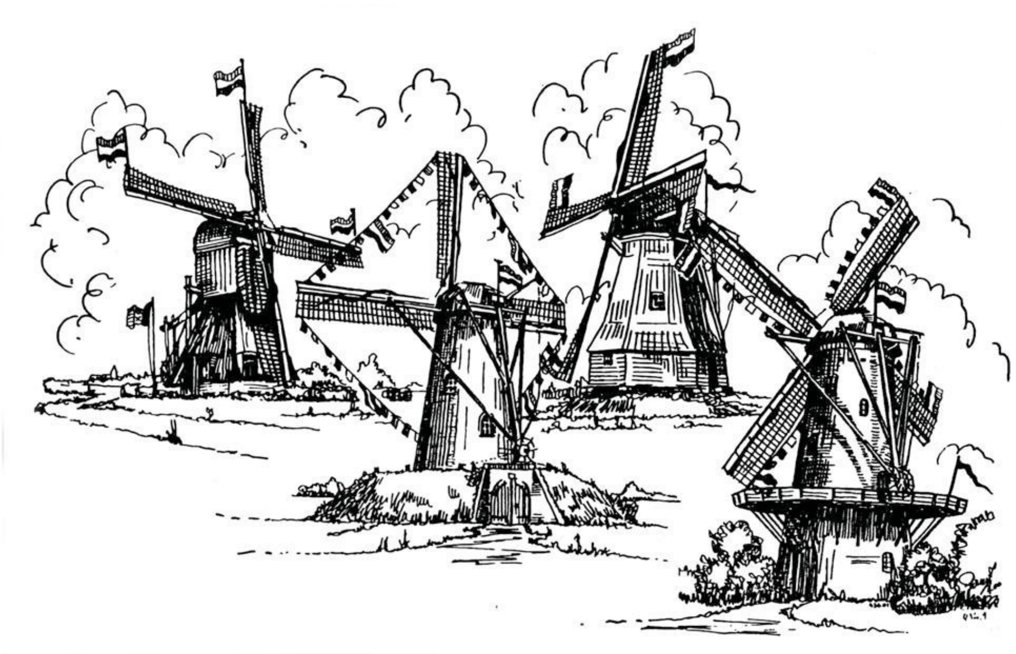


Fig. 7.4.4.1

Some examples of beautifully set mills.

A Dutch flag carried on a flagpole at the back of the cap or on the upper whip should be brought in one hour after sunset.

orange pennant

The orange pennant may be displayed only on holidays of the Royal House and only attached above the national tricolour on a flagpole at the back of the cap or next to the mill. Indeed, this is the official method of flying a flag with pennant on a mill.
Flag etiquette also prohibits the Dutch flag from being raised together with another flag on the same flagpole. The blue pennant, as well, is not allowed with the Dutch flag on the same flagpole.
If several flags are displayed, they can be different ones, such as provincial or village flags, with the Dutch flag above them.

7.4.4.c Mourning position

setting for mourning

Since this is a custom associated with grief, we must take care to set for mourning in accordance with the regional custom. In most parts of the Netherlands, this position is the mirror image of the celebration position. In some regions, however, the mill stands as coming into the mourning. The upper whip should now be about a sail bar's length past the highest point of the turning radius of the sail cross.

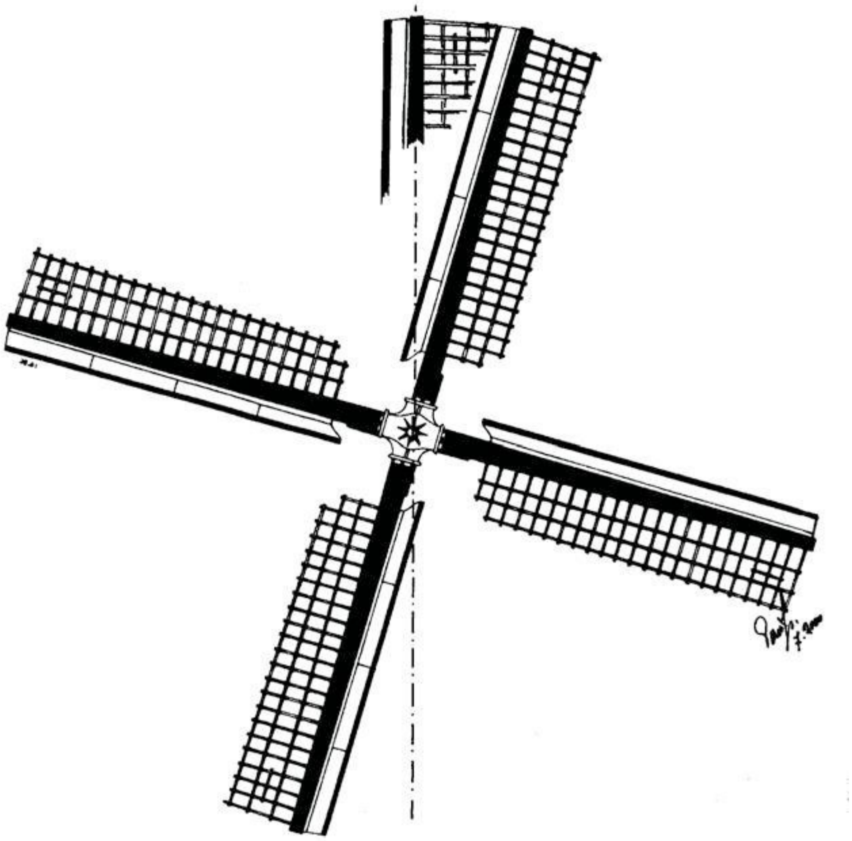


Fig. 7.4.4.2
Celebration position

The top of the upper whip is more than a full sail frame's width (including the wind-board) before the highest point.
The sail cross stands 'coming'.

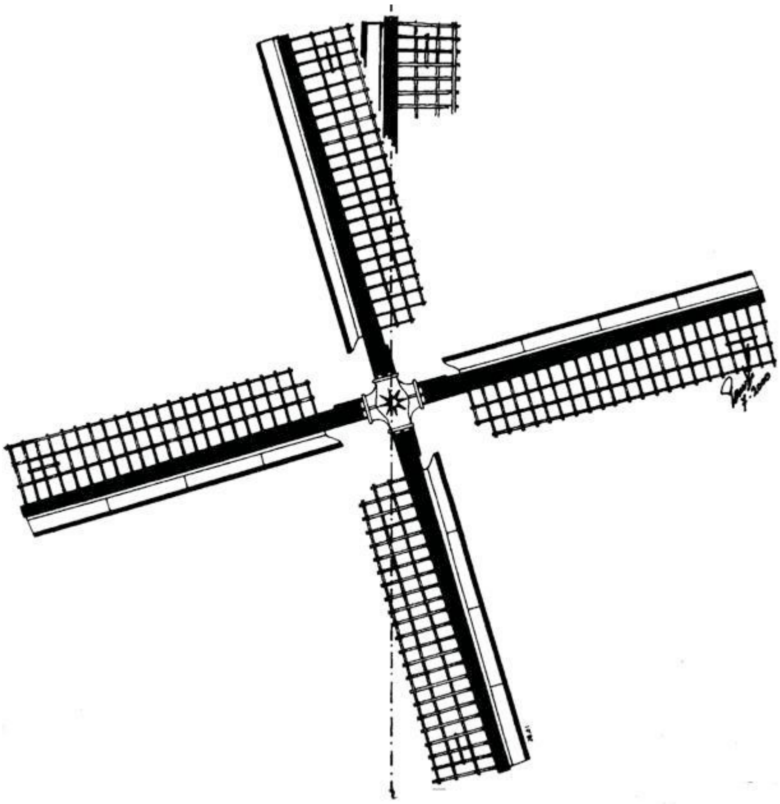


Fig. 7.4.4.3
Mourning position

Under these conditions, the top of the upper whip is well beyond the highest point.
The sail cross stands 'going'.

7.5 LUBRICATING THE MILL

7.5.0 Introduction

lubricating

Lubricating the entire mill involves checking all lubrication points inside and outside the mill and providing them with a proper dosage of the correct lubricant. The places and parts eligible for lubrication are:

- All moving parts of the sail cross and its operating system.
- The operating systems of the winding gear.
- Dead curb (including collars) and live curb winding gear.
- Bearings and friction surfaces of the running gear.

contaminated grease

Lubricating too little is not good but neither is lubricating too much. Excess grease is pushed away, falls down and attracts new dirt. Scrape away old grease and dirt from time to time. Contaminated grease or oil can cause a bearing to run warm or hot.

7.5.1 Lubricants

7.5.1.a Traditional lubricants

Traditional lubricants were used in mills long before the appearance of lubricants produced from mineral oils. They are:

pig fat, lard

- Pig fat, better known as lard. This is the belly fat from pigs. It must cure for at least six months before it is a suitable lubricant for the mill. It is often hung up in the mill to cure. When the white fat turns yellow, it can be used for lubrication. At low temperatures, it works well when ground in an old mincer or meat grinder or when chopped into small pieces. Melting lard is not recommended. Melted lard has a changed structure, which causes it to partially lose its lubricating properties. Melted lard can also cause problems in the summer because it runs off easily at high temperatures. In winter, however, melted lard has an immediate lubricating effect because ordinary lard is too hard then.
  Lard is also very suitable for lubricating dead curb winding gear, although it wears off faster.

horse fat

- Horse fat is similar in properties to lard but less hard. It is difficult to obtain though.

tallow

- Tallow (not to be confused with a fat which is a mineral product) comes from animal fats. It is mainly extracted from sheep fat and offal and is available in blocks of about 1 kg. Tallow can be used for lubrication of the windshaft.

rapeseed oil

- Rapeseed oil is extracted from rapeseed. It — like the fats described above — has extremely good lubricating capability in bearings that rotate slowly or on surfaces subject to light friction. It is therefore a good lubricant for pivot bearings.

'wonder oil' or castor oil

- Wonder oil or castor oil is a greasy oil and is very suitable for use in bearing pots.

green or yellow soap

- Green or yellow soap is used to lubricate dead curb winding gear and the collars of post mills and hollow post mills. However, the soap becomes sticky over time due to its drying out, which makes winding very difficult. Sprinkling with some water cancels out this disadvantage.

beeswax

- Beeswax is used for lubricating cogs and rods.

7.5.1.b Modern lubricants

transmission oil

Modern lubricants are produced by the distillation of crude oil and other chemical products. For application in mills, transmission oil is the most suitable of these machine oils. It is specially designed for bearings or friction surfaces that are under high pressure, such as pivot bearings.
Use the thickest type of transmission oil, indicated by the code SAE 250.

7.5.1.c Lubricating greases

lubricating greases, multi-purpose grease

graphite grease

- Multi-purpose grease, a soap-based bearing grease, is the most suitable of the greases. It is waterproof and resistant to high temperatures.
- Graphite grease is a normal type of lubricating grease which has been given more stability by adding graphite powder. Because the graphite powder adheres to the surface to be lubricated, the grease does not run off. This property makes it suitable for the lubrication of dead curb with cap sliding on sheers, live curb winding gear and collars the lubrication surfaces of which are difficult to reach. Graphite grease, however, softens wood, and this is a disadvantage when used on dead curb winding system.

7.5.2 Lubrication of the winding gear

In principle, the winding gear should be lubricated as often as necessary. For a live curb winding gear, that is about twice a year; dead curbs must be lubricated weekly or monthly.
Heavy winding can be due to lubricating the friction surfaces inexpertly, too sparingly, too infrequently or
not at all.

7.5.2.a Capstan wheel, winding wheel or geared hand winch

geared hand winch

If it is difficult or impossible to run out the winding chain, the barrel turns too heavily. It is then best to lubricate it with a water-resistant multi-purpose grease. You can also use graphite grease or lard.
The tail gudgeons of the geared hand winch must be regularly supplied with thick oil. The gears must be lightly greased with one of the two greases mentioned above. Greasing the barrel is also recommended. This makes it less likely that the chain or steel cable will double up and there is less chance that their wound-up parts will damage each other. Protect the steel cable from rust with the waterproof multi-purpose grease.

7.5.2.b Winding gear of the cap winder

A review of the various winding gears follows:

- Dead curb winding system

dead curb winding system
skid plate, curb carters,
friction surfaces

In a dead curb winding system, the cap circle slides over the skid plates during winding, and the outside of the cap circle glides along the curb carters (see Section 5.9.2.f). The skid plates are not lubricated but the friction surfaces are. That means the underside and outside of the cap circle. If the lubrication has been done with lard, horse fat or green soap since time immemorial, then leave it that way.

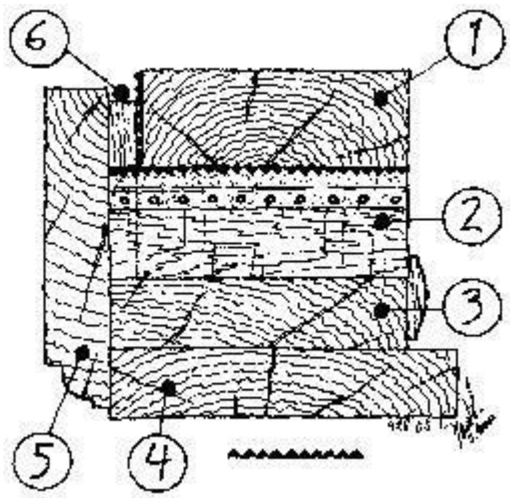


Fig. 7.5.2.1
Dead curb winding system

The surfaces to be lubricated are the outside and underside of the curb. The jagged edges indicate the areas to be lubricated.

1. *cap circle*
2. *skid plate*
3. *curb ring*
4. *uppersill*
5. *curb railing*
6. *curb carter*

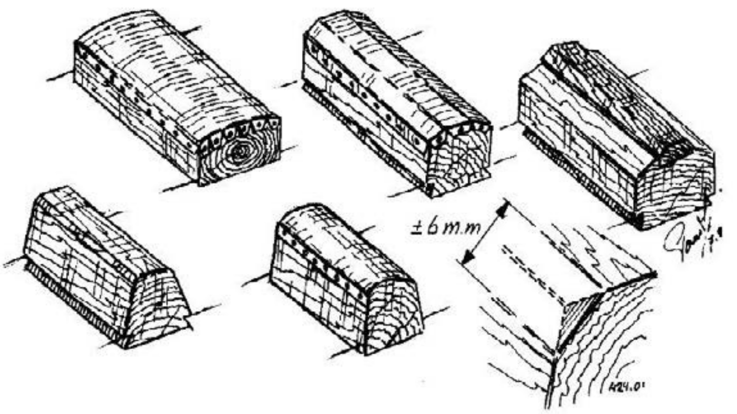


Fig. 7.5.2.2
Various skid plates

pits or hollows

Graphite grease has the disadvantage of softening wood so that, due to the pressure from the cap, the heads of the winding blocks press pits or hollows into the curb.
Oil or grease of mineral origin also compresses wood cells. The lubrication is then counterproductive and makes the cap even more difficult to wind.

Skid plates must be chamfered at a slight angle or be convex to allow the grease to get between them properly. If these rising sides have disappeared due to wear, they must be reapplied; otherwise, the blocks will scrape the applied grease off the cap circle again and the lubrication work will have been in vain (see Fig. 7.5.2.2). Skid plates are covered with tin to counter wear and tear, but wood on wood winds more easily.

- Dead curb with cap sliding on sheers gear

dead curb with cap sliding on sheers

In the case of a dead curb with cap sliding on sheers, the support and the puncheons slide directly over the top of the curb track. The poll wedges slide along the inside of them (see Section 5.9.2.g). Therefore, lubricate the top and inside of the winding ring with lard.

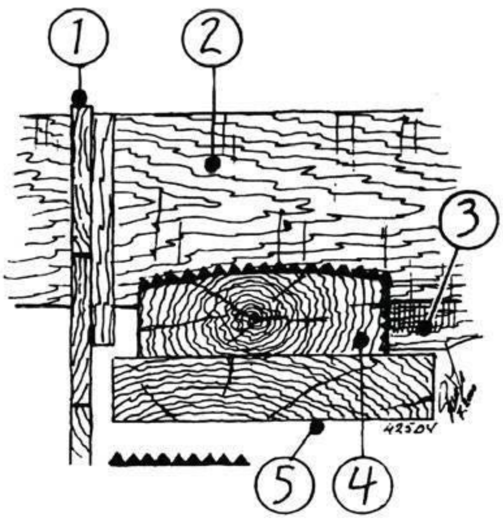


Fig. 7.5.2.3
Dead curb with cap sliding on shears

The surfaces to be lubricated are the top and inside of the winding ring.
The jagged edges indicate the areas to be lubricated.

1. *beard*
2. *sheer*
3. *poll wedge*
4. *curb track*
5. *uppersill*

Before lubrication, remove dirt from the curb track and remove the accumulated and hardened old grease on either side of the sheer beams and the support. At the same time as carrying out this cleaning, check that the sheer beams and sail clamps still have rising sides. If not, then the sheer beams and poll wegdes will scrape the applied grease off the winding ring again (see 'dead curb winding system').

- Live curb winding gear

live curb winding gear

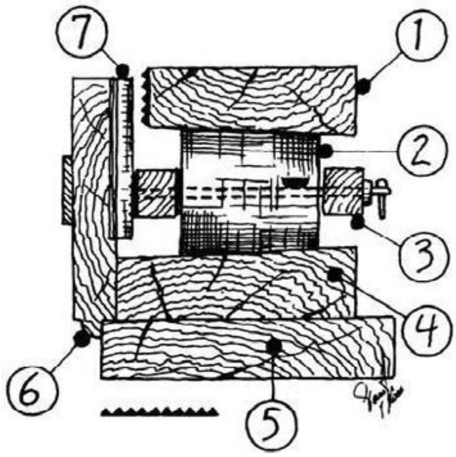
If the mill has a live curb winding gear, the following are lubricated:

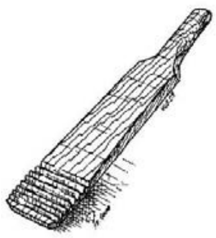
- Lubricate the outside of the cap circle with graphite grease.
- When doing this, pay particular attention to back of the cap, as it usually presses against the curb carters.
- Lubricate the outside of the roller wagon with graphite grease.
- Lubricate the top ends of the rollers with graphite grease. If the outside of the roller is (still) convex, lubricate only the centre.
- Lightly grease the shafts of the rollers once every two years with graphite grease.

Fig. 7.5.2.4
Live curb winding gear

The surfaces to be lubricated are:
- The outside of the curb
- The outside of the roller wagons and back of the rollers
The jagged edges indicate the areas to be lubricated.

1. *cap circle*
2. *winding roller*
3. *roller ring*
4. *curb track*
5. *uppersill*
6. *curb railing*
7. *curb carter*



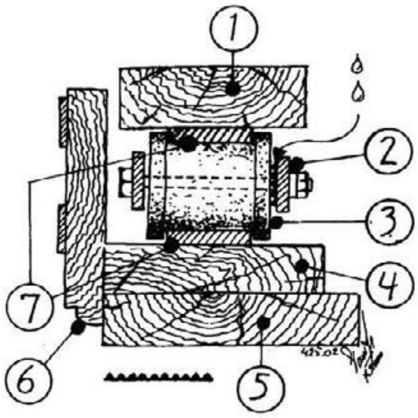


At some mills, the skid plates are on the outside of the cap circle and rollers are on the inside of the curb railing instead. In those cases, the inside of the curb railing is lubricated.
For lubrication, use a grease spatula, optionally grooved (see Fig. 7.5.2.5), that prevents the blob of grease slipping off the spatula and falling onto the winding track.

Fig. 7.5.2.5
A grease spatula

Fig. 7.5.2.6
Shot curb-English winding gear
The jagged edges indicate the areas to be lubricated.

1. *cap circle*
2. *roller-ring*
3. *winding roller*
4. *curb track*
5. *uppersill*
6. *curb railing*
7. *lower and upper rail*



- English winding gear – shot curb

English winding gear

From time to time, the shafts of the rollers can be lubricated with a few drops of oil.

7.5.2.c Winding gear of the post mill

pivot, lubricating hole

The pivot is lubricated through a lubricating hole through which grease can be pressed. Regular lubrication is necessary.
As soon as you hear grating or creaking of the pivot in the bearing during winding, immediate lubrication with lard or horse fat is a must.

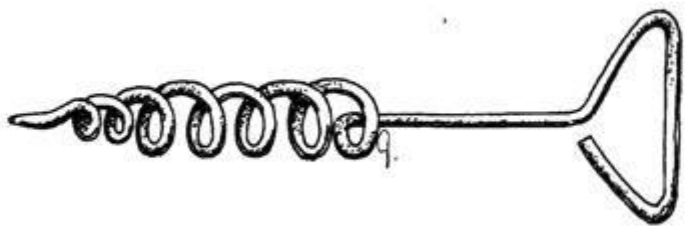


Fig. 7.5.2.7
The grease drill

Although the collar may only carry a small portion of the mill body, you must still lubricate the friction surfaces well. To do this, you apply graphite grease between the sheer trees and the trimmers around the main post. The lubricating hole for that is in one of those trimmers. Completely fill the hole, then wind the body 180° and repeat the operation.

grease stick

grease drill

To fill the grease hole properly, use a grease stick that fits precisely into the hole so that you can apply some pressure when pressing the grease in. If this is being done for the first time, it is recommended that both lubricating holes be cleaned of old grease using a grease drill. This useful tool has disappeared at many post mills, or people are not familiar with the function of this oversized corkscrew (see Fig. 7.5.2.7).
After filling the grease holes, also lubricate the contact surfaces of the spacers, the trimmers and the main post itself, which has been rounded in place.

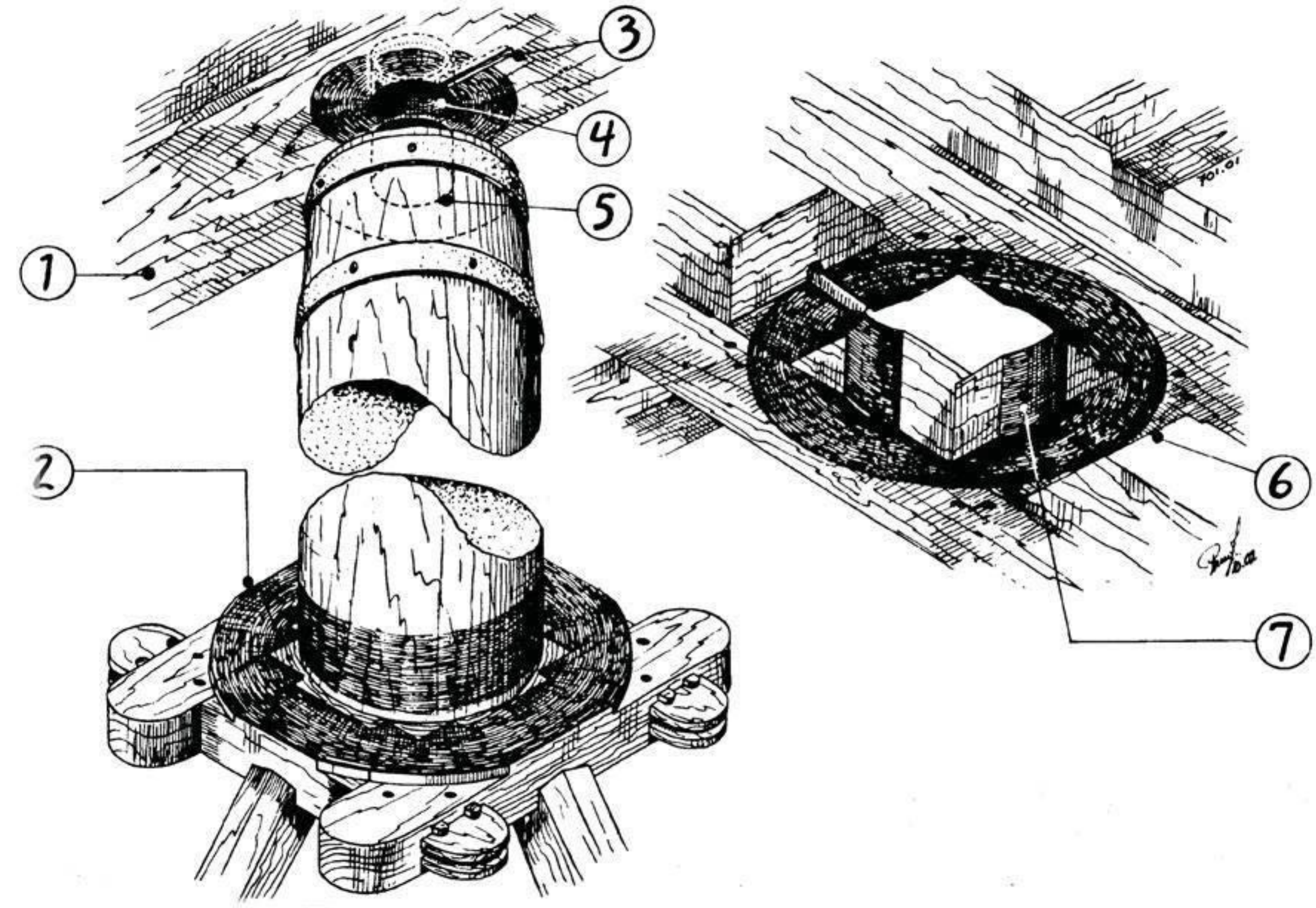


Fig. 7.5.2.8
Lubrication points of the winding gear of a post mill

1. *crown tree*
2. *bearing surface of the collar*
3. *lubricating hole in the crown tree*
4. *mortise*
5. *pivot*
6. *bearing surface of the sheer tree*

7.5.2.d Winding gear of the hollow post mill

upper collar
lubricating hole in the lower collar

The upper collar is constructed either with or without blocks on the collar. For an upper collar without blocks, fill the lubricating hole in the upper girdle completely with graphite grease and push it with the grease stick mentioned above for the post mill. Here too, wind the cabin 180° and then add more grease. For an upper collar with blocks, simply lubricate the underside of the upper girdle between the blocks with graphite grease.
In some cases, the blocks are attached to the underside of the upper girdle. In that case, of course, lubricate the top of the upper collar.
You must also lubricate the upper girdle's contact surfaces with the hollow post.

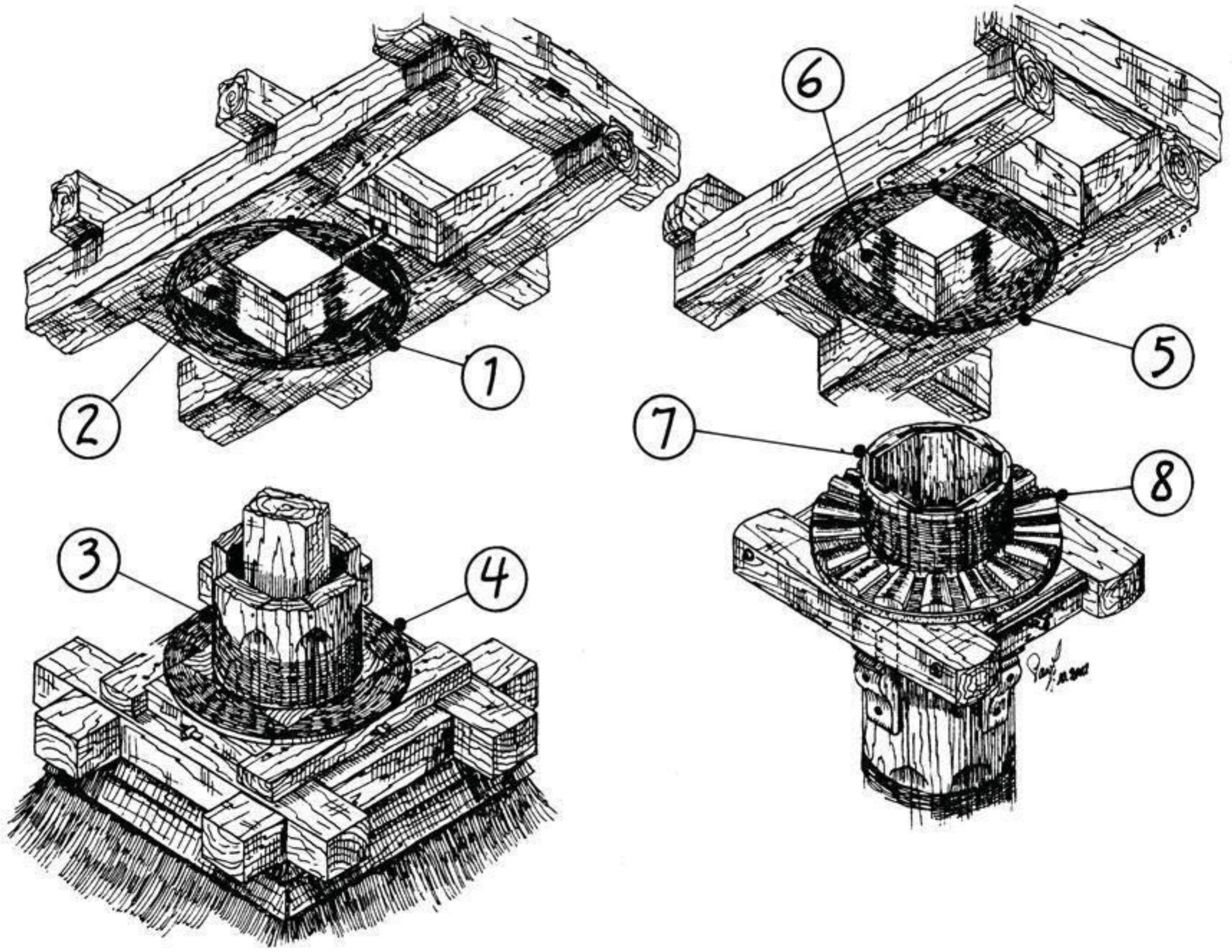


Fig. 7.5.2.9
Lubrication points of the collars of a hollow post mill

Lower collar
1. *bearing surface of the shear tree*
2. *friction surfaces of the shear tree*
3. *friction surface around the hollow post*
4. *bearing surface of the lower collar*

Upper collar
5. *bearing surface of the upper girdle*
6. *friction surfaces of the upper girdle*
7. *friction surface around the hollow post*
8. *bearing surface of the upper collar, if fitted with blocks*

The top of the lower collar can be reached from under the loose floorboards of the cabin. This is lubricated where not covered by the sheer tree, using a long grease spatula or tar brush.
When doing this, you also lubricate the outside of the hollow post, along which the lower girdle rubs.

In the case of a spider mill, you lubricate the top of the uppersill or the winding disk. As regards the lower collar, only the sides facing the hollow post are lubricated.

7.5.2.e Winding gear of the paltrok

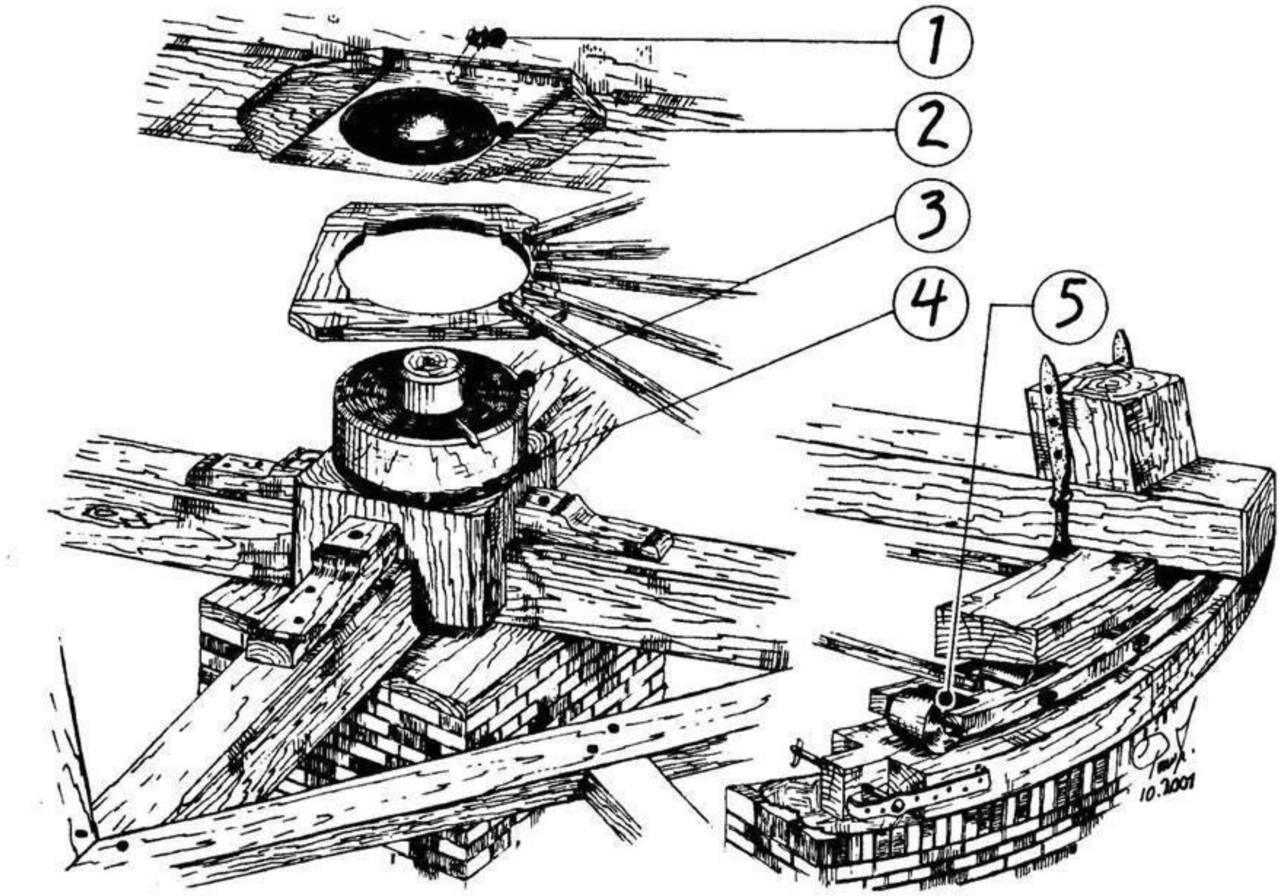


Fig. 7.5.2.10
Lubrication points of the winding gear of a paltrok

1. *lubricating hole in the tail pole*
2. *bearing surface of the tail pole*
3. *bearing surface of the king*
4. *friction surface around the central spindle for the collar*
5. *outer side of the winding rollers*

The roller-ring of the paltrok requires little attention. You can occasionally lubricate the axles of the rollers and the outside of the rollers.

bearing surface of the king
grease duct

Lubricate the pin and the round bearing surface of the king in the tail pole or tail beam using graphite grease. A grease duct is sometimes installed for this purpose. Do this regularly, as some 90% of the total weight of the mill turns and rests on the pin during winding (see Fig. 5.9.4.1).

7.5.3 Lubricating the driving gear

7.5.3.a Sail cross

pivot points of the flaps, grease nipples,

If the mill is equipped with an automatic reefing system, lubricate the pivot points of the flaps regularly with some thick oil. Lubrication nipples are pumped through with the grease gun.

tie rods, elbow levers
guide rollers

If the flaps present are joined together with tie rods and elbow levers, then the guide and pivot points of these must be greased. Guide rollers for any connecting wires used must be lubricated.
The striking rod is quite light and does not experience much friction. The front with the spider is the heaviest. Moving the striking rod outwards enables you to grease it there. All other pivot points should also be lubricated from time to time.

7.5.3.b Windshaft

neck bearing

The neck bearing is the most heavily loaded part of the windshaft and therefore warrants the most attention. In old miller contracts we find clear references about this: 'The miller should check the bearing on the weather beam every two hours for lubrication and hot running.'
This is not an excessive instruction because the shaft can run hot due to multiple causes:

broken bearing stone

- A broken bearing stone

The fractured edge of the crack can sometimes scrape all the fat from the neck.
The bearing then receives insufficient lubrication and becomes increasingly hot due to friction. The grease melts and disappears between the stone and the neck bearing board.
However, if the two parts are nicely wedged together and the shaft does not run hot, then no action needs to be taken.

inclusion

- An inclusion

Sometimes the bearing stone has an inclusion in the form of a piece of quartz that may come to the surface through the wear and tear of the stone. Quartz has a strong abrasive action that is accompanied by considerable heat generation.

deeply worn bearing stone

- A deeply worn bearing stone

This increases the friction surface but proportionally decreases the bearing pressure. Problems can arise mainly from reduced grease presence.
Bronze bearings can become too thin in the middle and start to bend, causing the ends to press heavily against the neck.

tilted bearing stone

- A tilted bearing stone

If the bearing stone is tilted inwards or outwards, it no longer carries the full width, which can cause the shaft to run hot. A small rise in temperature already makes the lard slightly liquid, causing the lubricating film to thin and the shaft to rapidly heat up. So there are plenty of reasons to check the bearing for lubrication and temperature regularly throughout the day.
If the tilting goes no further, this problem may disappear again after some time due to wear of the stone. Incidentally, this takes a little longer if the neck brass is deeply worn.
The neck of the windshaft should never be hotter than lukewarm. In general, it is fair to say that as long as the shaft remains cool, nothing is wrong.

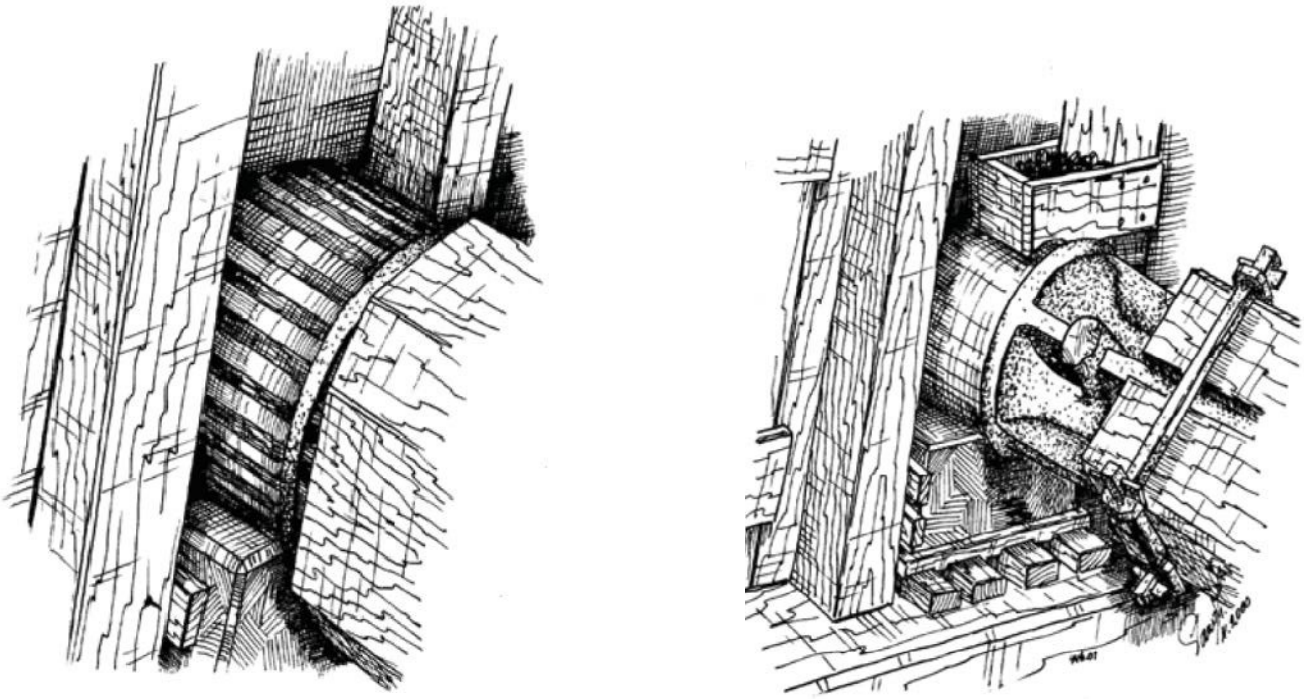


Fig. 7.5.3.2
Two different neck bearings: on the left, a wooden shaft and on the right, a cast-iron shaft

dollop of grease
grease spatula

We already mentioned lard as the most suitable lubricant but tallow in block form is a good substitute. The dollop of grease between the neck and the cheek and/or neck stud is pressed with a grease spatula.
Over time, the grease dollop may have become very hard and lack any lubricating power. In this case, too, things can run hot. The shaft then takes too little lard with it so that a thin crack soon forms and there is no more lubrication. Replace old and hard lard with fresh.

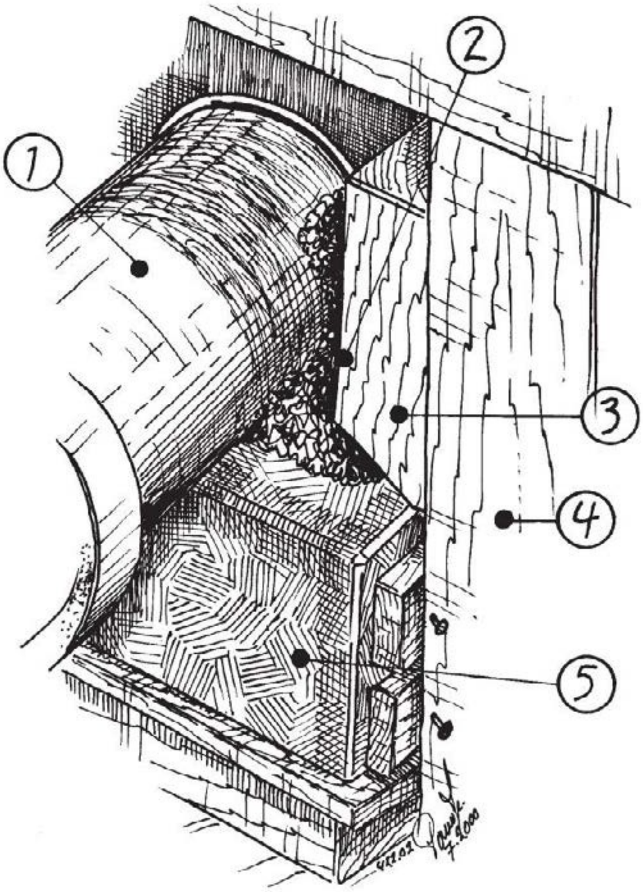


Fig. 7.5.3.3
The dollop of grease between the neck and the cheek or neck stud

1. *neck*
2. *dollop of grease*
3. *cheek*
4. *neck stud*
5. *bearing stone*

From a safety standpoint, the windshaft is lubricated only when the mill is at a standstill!
When lubricating, stand on the side of the weather stud next to the shaft.

tail bearing

The tail bearing is loaded in multiple directions:
- downward pressure due to the weight of the shaft;
- backward pressure by the wind on the sail cross;
- lateral pressure when loaded.

The tail bearing has three different versions:

tile stone or bronze plate

a. The tail bearing with tail brass and tile stone or bronze plate.
This is greased with lard. Lubrication is improved greatly if the tile or plate has a lubrication slot tapered towards the centre.

bridge brass

b. The tail bearing with a bridge brass.
This is also greased with lard. Lubrication can be improved by adding an inlet edge at the tail.

pivot and bulb plate

c. The pin bearing with pivot and bulb plate.
The tail is greased with lard. The pivot and the bulb plate lubricate themselves with thick transmission or rapeseed oil by means of a simultaneously revolving chain that descends into the oil-box with each revolution, thus delivering oil to the pivot (see Section 6.1.1.f).

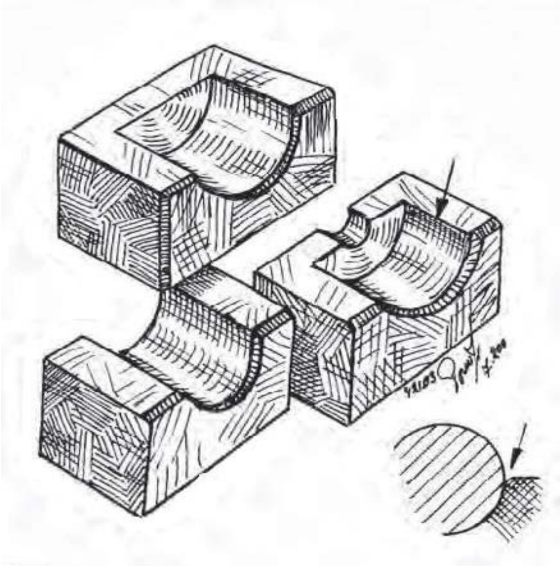


Fig. 7.5.3.4
A trio of tail stones: a bridge brass, a tail brass and a bridge brass with recess for a striking rod

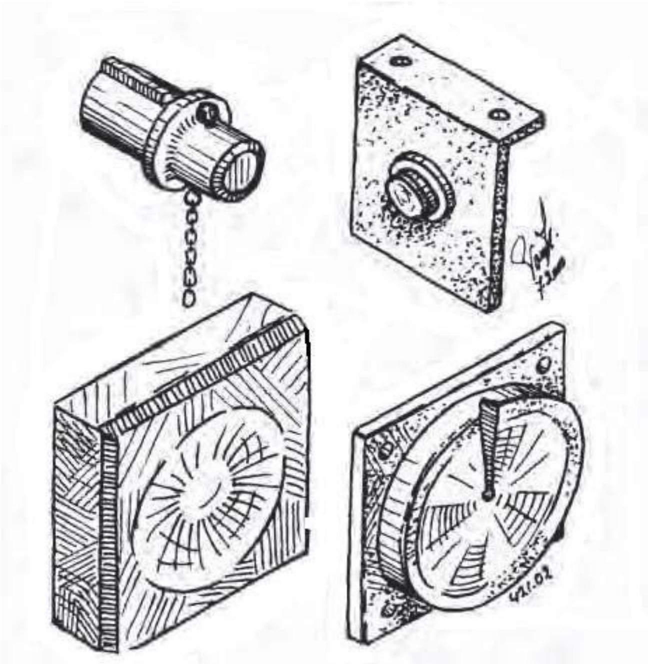


Fig. 7.5.3.5
Some versions of tiles behind the tail bearing and a pivot with a grease chain

7.5.3.c The main upright shaft (see also Section 6.1.2)

The top trunnion usually does not require much grease but should be lubricated regularly. The trunnion must be prevented from running hot. Each time before turning, press the lard a little with a spatula or stick.

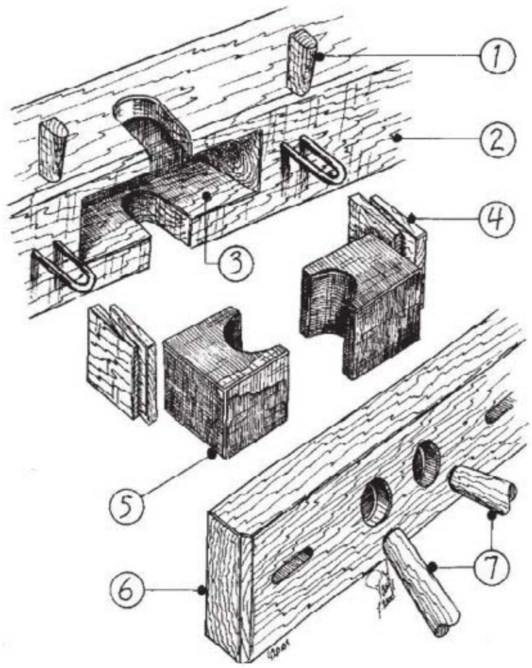


Fig. 7.5.3.6
The top bearing in the sprattle beam or spindle beam

1. *retaining wedge*
2. *sprattle beam or spindle beam*
3. *bearing cover*
4. *fillings*
5. *trunnion bearings*
6. *bearing cover*
7. *bearing cover poles*

It is a good idea to check every now and then if this bearing is running hot, as well as for play. To do this, move the crown wheel back and forth briskly. If there is too much space or the upper pivot is loose, the bearing must be removed. Start by securing the main upright shaft with a rope that you wrap around it. Then pass the ends of the rope through the brake wheel and secure them. Then remove the tightening rope from the bearing cover pole(s) and remove the bearing cover pole(s) themselves. Do not immediately release the small tightening rope because it may fly around rapidly and deliver heavy blows. Next, remove the securing wedges or nuts from the bearing plate or lock plate so that you can remove it. Also remove any filling shims that may have been used. Be sure to remember the placement of these shims, because they were used to plumb the spindle. Now gently slacken the rope slightly so that the main upright shaft can be pushed out of the bearing. In the process, the bearing gudgeons come out on their own. These can now be checked. They should not be too dry and must have an evenly worn surface. The trunnion must be shiny along the full length by which it runs in the blocks. A black to blue worn surface indicates hot running of the gudgeon, which means insufficient lubrication has been done. The remedy is to remove the thin black carbon layer and restore a good helping of grease to the trunnion. After lubrication, put everything back in place. If the bearing is very worn and the blocks are identical, you can also swap them.

bearing cover pole

tightening rope

filling shims

trunnion

If one of the blocks is made of bronze then return it to the left side of the bearing cover. This bronze block is the bearing: it captures the lateral pressure exerted by the brake wheel on the main upright shaft.
By gently tightening the rope, you pull the main upright shaft with the blocks back into the bearing cover. Now put the shims and bearing plate back in place. Check that the shaft does not rattle in the bearing. If it does, then the blocks have too much space. This must be corrected with filling shims. Also make sure the main upright shaft remains plumb.
Finally, during the next few days of operation, check that the bearing does not run hot.

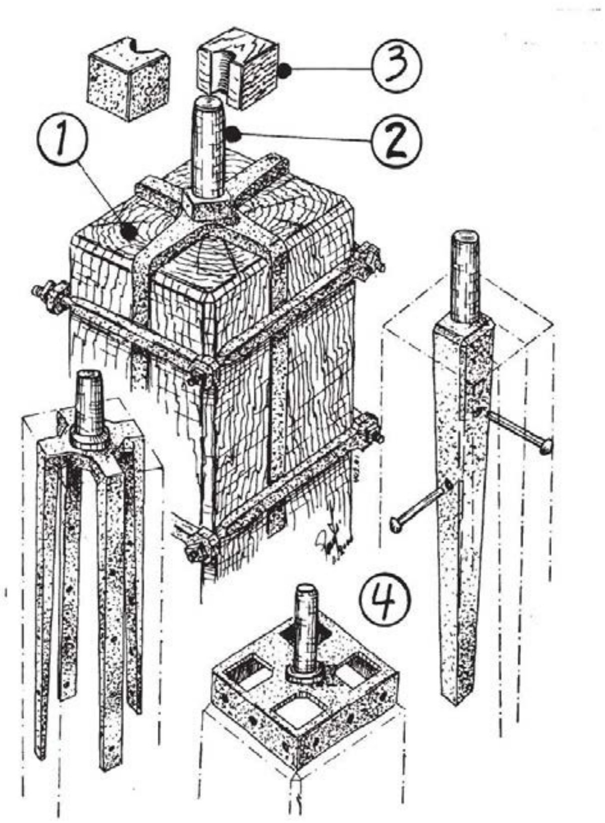


Fig. 7.5.3.7
Examples of various upper pivots of the central spindle

1. *head of the main upright shaft*
2. *gudgeon pin*
3. *trunnion bearings*
4. *two models of upper pivots, to the left a crown iron, to the right an insert iron, and in the centre a cap over an insert iron*

pivot bearing

The pivot bearing at the bottom of the main upright shaft should be checked regularly for heat; warm to the touch is good. If it gets hotter, then the bearing must be checked.
How often you must change the oil in the bearing pot depends on the function of the mill. For a polder mill this may be once a year, but in dusty mills you should check more often. Before refilling oil, clean the bearing pot completely with petroleum.

In the past, rapeseed oil was used but that is no longer easy to come by these days. For this purpose, nowadays it is best to use transmission oil of the thickest type.
In dusty mills, the life of the oil can be extended considerably by applying a close-fitting piece of leather around the pivot that covers the bearing pot. In recent years, more and more pivot bearings are being replaced by modern

thrust bearing

thrust bearings that can accommodate both lateral and downward pressure. You can also use transmission oil for these bearings. Because the spindle rotates only slowly, ball bearing grease is also suitable for these bearings.

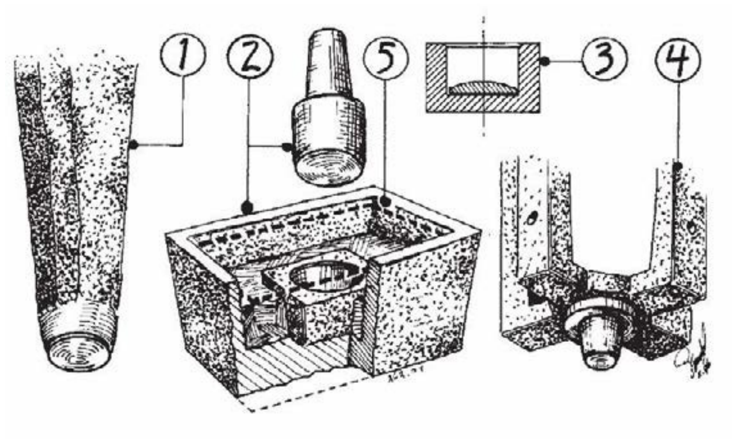


Fig. 7.5.3.8
Pivot bearings

1. *pivot*
2. *loose pivot with bearing pot*
3. *pivot bearing pot (cross section)*
4. *crown iron with fixed pivot*
5. *minimum oil level*

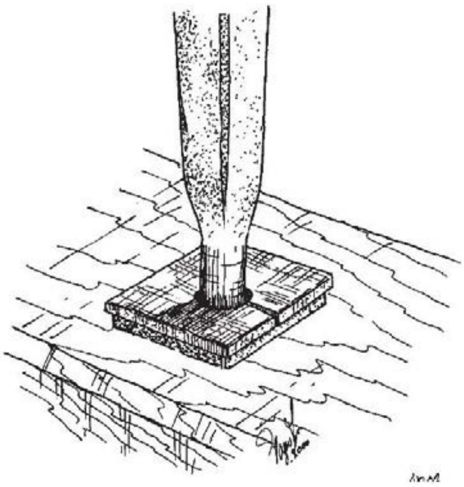


Fig. 7.5.3.9

Covering the pivot bearing with a piece of leather

7.5.3.d Cog, rods, lifters and spokes

washing the wear surface

The friction surface of cogs and rods, the wear surface, must be treated regularly. This smearing or washing is done only with pure beeswax.
Heat a cube of pure beeswax and smear it on the wear surface. It is sufficient to wax only the cogs of the larger of the two interacting wheels. As the larger wheel turns, the beeswax spreads naturally on the cogs or rods of the smaller wheel.
Be sparing with the beeswax: Do not apply wax to parts that do not touch each other.
How often you must wash cogs depends on the load on the driving gear and the number of operating hours. The cogs of a mill that runs only "for the prince" need to be washed less often than those of a heavily loaded industrial or polder mill.
Poorly maintained cogs make themselves known by a squeaking or whining sound when the mill is running slowly. Another consequence of poor maintenance is that the annual rings in the wood of the cogs and/or rods separate from each other under the heavy pressure, which is called

flesh on the cogs

"flesh on the cogs". This can also happen when two wheels are not in line; in that case, the cogs and/or rods are rubbing on each other.

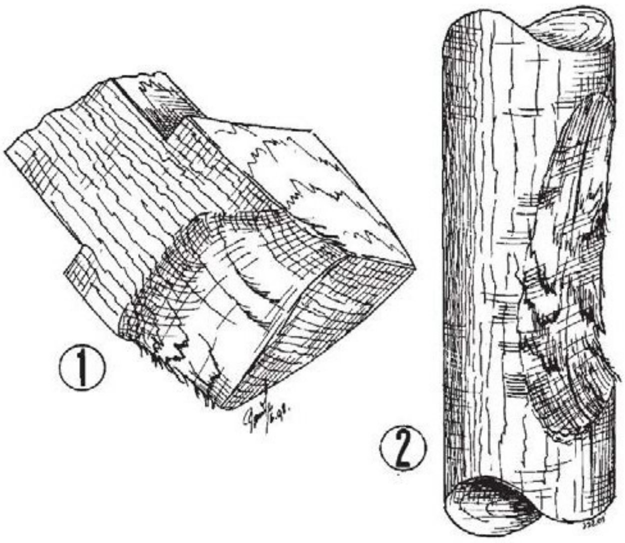


Fig. 7.5.3.10
Example of flesh on cogs and rods

1. *cog head that has been running too long without sufficient beeswax*
2. *a rod with flesh on the wear surface and the edges*

7.5.3.e Specific shafts of the polder mill

scoop wheel, scoop wheel shaft

Polder mills are equipped with a scoop wheel on a bottom shaft or scoop wheel shaft or with an Archimedean screw. The scoop wheel shaft almost always lies in two bluestone bearings lubricated with lard. Wooden Archimedean screws often rest on top of such a stone as well.
These bearing stones are similar to the stone bearing of the windshaft: semi-cylindrically executed and sometimes with a slightly higher side on the pressure side. They are lubricated with lard or tallow. The fat is of interest not just to the miller alone; rats and mice also like it. For that reason, the grease must be stored in a case that fits on the gudgeon of the scoop wheel shaft. This is especially true for the outer bearing of the scoop wheel.

outer bearing

interior stool rubbing plates, exterior stool rubbing plates, plate beam

The interior stool rubbing plate and the exterior stool rubbing plate (plate beam) at the ends of the waterwheel shaft are fitted with a small tile stone or thrust flange or bulb. These are also lubricated from time to time with lard to prevent excessive wear. This is especially true for the exterior stool rubbing plate that must absorb the outward pressure of the waterwheel shaft.

Archimedean screw

In a mill with a wooden Archimedean screw, the upper bearing is usually located directly behind the crown wheel. The bearing stone is set up on the neck beam that lies between the walls of the watercourse (see Fig. 7.5.3.12, drawing C). The upper bearing is almost identical to that of the neck of the windshaft. The angle of inclination is approximately 30°. The upper bearing is lubricated with lard.
Sometimes Archimedean screws are fitted with a pin at the bottom and top for the bearing.
The upper bearings of modern metal Archimedean screws must be occasionally lubricated with ball bearing grease. A Stauffer pot or grease nipple is provided for this purpose

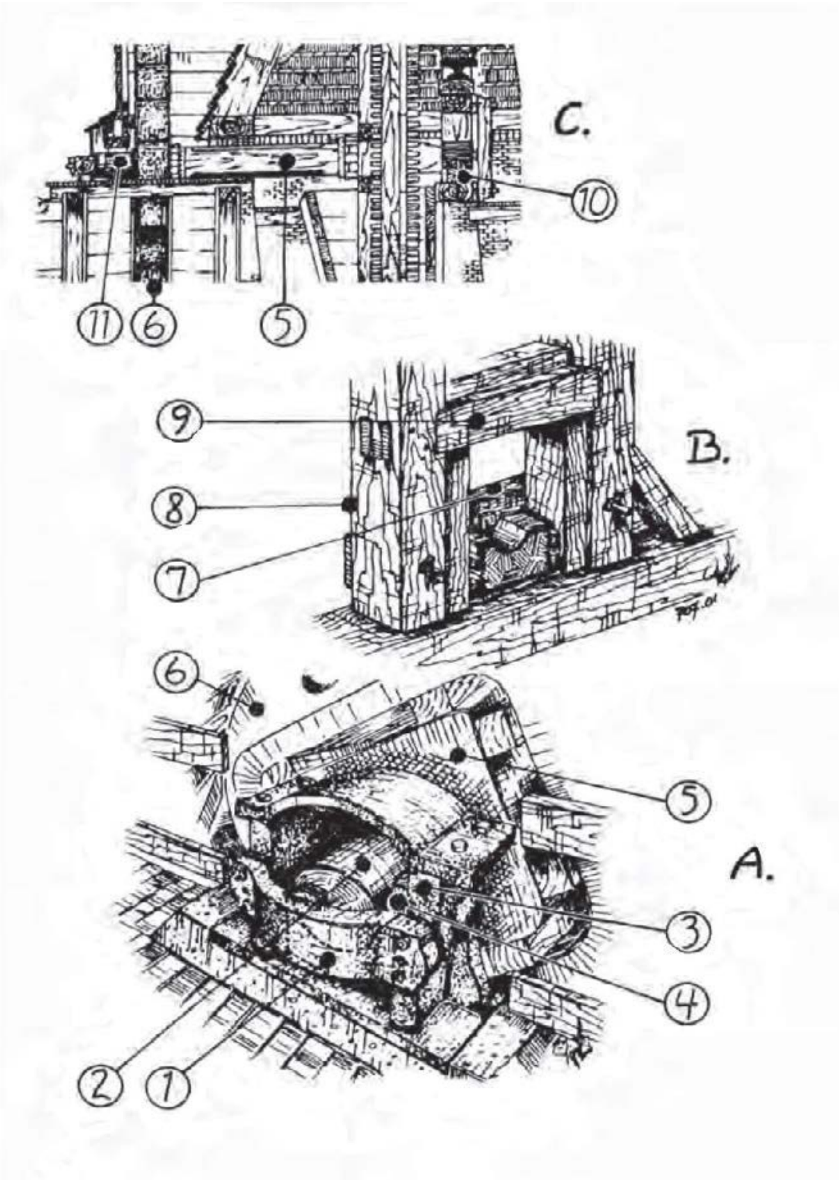


Fig. 7.5.3.11
Outer and inner bearings of the scoop wheel shaft

A. outer bearing frame
B. inner bearing frame
C. location in the mill

1. *exterior stool rubbing plate*
2. *pin of the waterwheel shaft*
3. *frame*
4. *cheek*
5. *scoop wheel shaft*
6. *scoop wheel*
7. *interior stool rubbing plate*
8. *vertical struts*
9. *transom*
10. *inner bearing*
11. *outer bearing*

water beam
tail beam

The lower bearing of the Archimedean screw is, of course, underwater. Historically, it was applied to a horizontal water beam. This was completely submerged, making it difficult to adjust the bearing when the Archimedean screw was running. Today, the lower bearing often sits on a vertical tail beam and is then adjustable with wedges (see Fig. 7.5.3.13).

Stauffer pot

Older Archimedean screws turn with a heavy pin in a hard stone or bronze bearing and are lubricated by water. Sometimes a Stauffer pot that enables pressure lubrication with ball bearing grease was added later.

automatic lubricator

Motor-driven metal Archimedean screws often have an automatic lubricator that may or may not be manually operable. Special environmentally friendly grease is available for this purpose, which is also suitable for Stauffer pots and grease guns.

Fig. 7.5.3.12
Examples of an upper bearing of an Archimedean screw as shown in the detail drawing

A. Location in the mill
B. The bearing for an Archimedean screw fitted with pins
C. The bearing for a wooden Archimedean screw with neck

1. transom
2. bearing block
3. pin bearing
4. pivot of the main upright shaft
5. bearing seat
6. bluestone bearing
7. crown wheel
8. centre line of the screw beam
9. neck beam

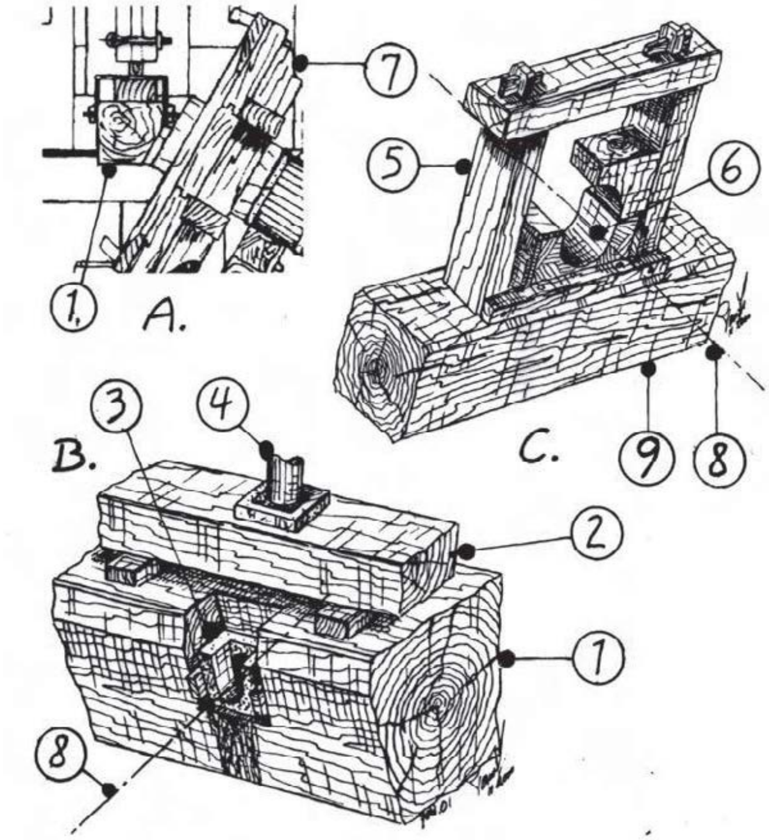
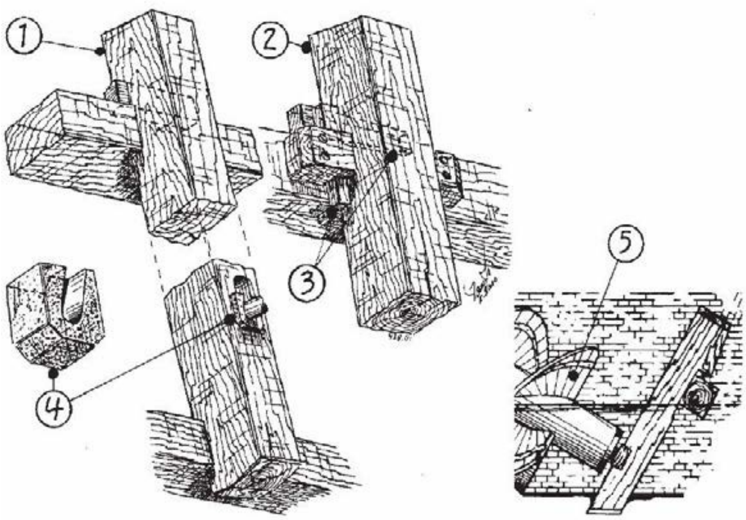


Fig. 7.5.3.13
The lower bearing of the Archimedean screw

1. tail beam
2. adjustable tail beam
3. adjusting wedges
4. loose bronze bearing
5. lower end of the Archimedean screw



7.5.3.f Specific shafts and spindles of the grain mill

Passing through the grain mill from top to bottom, you pass the sack hoist floor, the stone floor and the meal floor. Only the shafts and spindles which are part of the original equipment of the grain mill are treated. Mixers, crushers, elevators and the like are not included.

sack hoist spindle,

The sack hoist spindle usually has two wooden shaft trunnions that are normally supported in hardwood blocks. Lubricate them from time to time with some lard.

stone spindle

The stone spindle is bearing only at the top where the shaft trunnion can run quite hot. It therefore needs close attention, especially since it is difficult to reach it with lubricating grease. It is best to give the shaft trunnion a lick of lard or lubricating grease every time it is put into operation. It is therefore useful to have a jar of lubricating grease close at hand.

iron spindle

The neck of the iron spindle in the neck bearing can only be lubricated when the pair of stones is opened. Metal neck bearings and also wooden neck bearings can be lubricated with a Stauffer pot that can be twisted and filled from the meal floor.
The underside of the iron spindle is usually implemented as a pivot bearing on (the pillow of) the pass beam. The same rules apply here as for the pivot bearing of the main upright shaft. Given the dusty environment, covering with a piece of drive belt or leather is a necessity here.

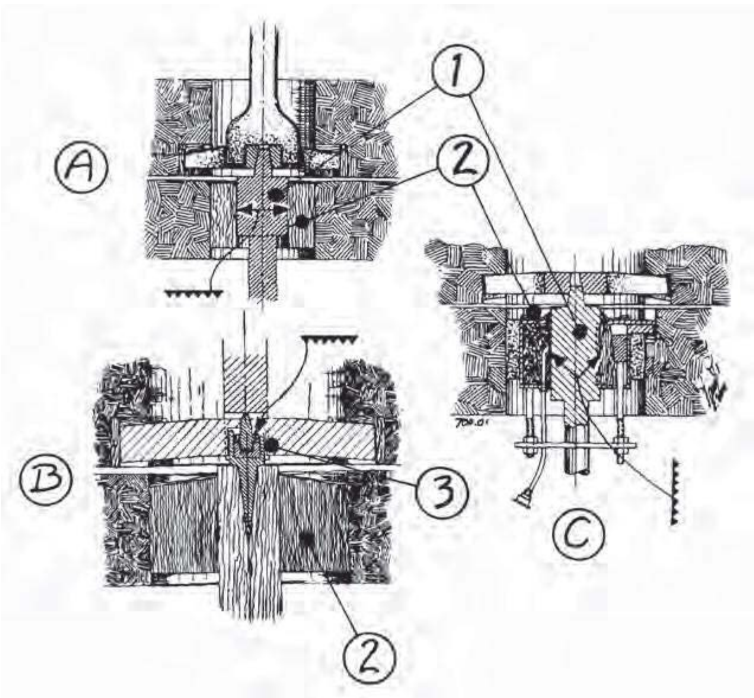


Fig. 7.5.3.14
Lubrication of the iron spindle bearing

A. wooden neck bearing
B. neck bearing with runner stone suspension
C. metal neck bearing

1. neck of the iron spindle
2. neck bearing
3. pintle bearing with quill

The jagged edges indicate the areas to be lubricated.

In recent years, restoration of grinding assemblies has increasingly turned to a combination of thrust and roller bearings housed in a bearing bush. These
must be provided with heavy transmission oil. Lubricating with ball bearing grease has the advantage that dust and dirt are better kept out of the bearing by squeezing the grease out a little bit.

governor

sliding bracket

The two bearings of the governor must be regularly given a few drops of transmission oil. The governor shaft is lubricated with some bearing grease at the location of the sliding bracket.

Other equipment and machinery are usually younger than the mill itself. These almost always have more modern bearings, such as ball or roller bearings in sealed bearing housings with pressure lubrication or with Stauffer pots. Such equipment has its own specific types of greases for lubrication.

7.6 MINOR MAINTENANCE

7.6.0 Introduction

7.6.0.a Duties of the miller

identifying defects

Besides operating the mill, the timely identification of defects or required maintenance are important tasks of the miller. The miller can prevent things from getting worse by taking action and fixing the problem quickly (or arranging for it to be fixed). Therefore, the miller must keep in touch with the owner about maintenance and repairs and make arrangements about doing the work themselves, etc.

maintenance, repairs

This section is a listing of simple maintenance work that most millers can do themselves. Some millers go so far in this regard that they also take on extensive jobs such as the complete paintwork, for example. Others have progressed over the years to practically become 'volunteer millwrights' or have even made it their profession.

Everyone is free to choose how much he or she will do with respect to performing maintenance work. However, the miller must keep a few important things in mind:

doing the work yourself

- Doing the work yourself may come at the expense of professional millwrights. Working as a millwright is an exceptional industry where continuity is very important. Experienced millwrights must be able to pass on their expertise to the younger generation.
- If you want to do a job yourself, it should not cause the mill to cease operation for a long time.
- For work done by the miller, use appropriate materials and take into account historic building values and regional details. The finish work should not be inferior to that done by a millwright.
- Perform the work safely. With respect to working at height, millers are subject to the regulations of the Dutch Occupational Health and Safety Act.
- When painting, use only paints which craftsmen and/or millwrights would also use. Take account of using the correct colours.

Occupational Health and Safety Act

7.6.0.b Specific millwright's work

Adjusting the running gear such as two interacting wheels and the bearings of the neck and tail is a job for a millwright. Cogs and rods must engage accurately to prevent wear and tear. Poorly aligned or misaligned bearings will run hot quickly. Inexpert knocking in of wedges which secure the wheels to the shafts or spindles can cause major damage to cogs and rods or to the wheels themselves.

knocking in wedges

Loose fixing wedges require quick action as the stock will slide back and forth between the sail clamps. Every time the loose stock is vertical, a loud thump is heard. Knocking in fixing wedges is a job for a millwright. It involves risk and it requires the requisite experience. If you knock in the wedges too tightly or hit the poll end, it can crack, although this is not immediately apparent. But when you brake heavily later in freezing weather, the invisible cracks will continue to grow and the sail cross may come down.

knocking in stock wedges

Adjusting bearings and hanging wheels is also a job for a millwright.

7.6.1 Loose cogs and rods

loose cogs

Loose cogs and rods rattle or bump with each revolution of the wheels, which does not promote longevity.

wooden hammer

Loose cogs are easily reattached. By tapping the cog heads with a wooden hammer, you can hear which one is loose. Once the loose cog is found, hit it first with a few vigorous taps but keep a block of hardwood between the cog and the hammer. Then hammer down the wedge or locking pin that protrudes through the cog tail. Sometimes hitting does not help and the cog remains loose. Then tap the wedge or locking pin out of the tail and knock the cog out of the wheel.

canvas on the working face

pressure face

To avoid disturbing the correct centre-to-centre distances of the cogs, place a strip of canvas in the cog hole on the working face — in other words, the side with which the cog pushes or by which it is pushed. Then reinsert the cog. Let the canvas protrude slightly to prevent it from disappearing into the hole with the cog. This keeps the pressure face of the cog in place.

If the cog is still loose, use thicker material or put the canvas around both sides of the cog tail (see Fig. 7.6.1.1).

loose rods
tie-rods
working face

Loose rods are a little more difficult to secure. Sometimes it is enough to tighten the tie-rods slightly. The tapered part of the rods is then pressed slightly deeper into the lower and upper vanes. If this fails, try securing the rod with guiding wooden or iron wedges along the working face of the square tenon.

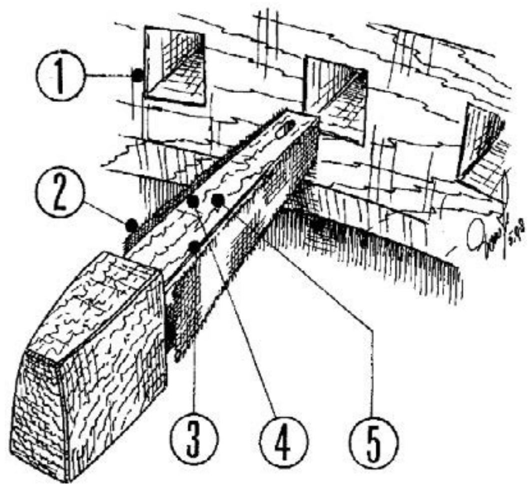


Fig. 7.6.1.1
How to attach a strip of canvas

1. *cog hole in the front rim*
2. *strip of canvas*
3. *pressure face of the cog*
4. *working face of the cog*
5. *cog tail*

7.6.2 The interlocking of cogs and rods

too deep in the gears

If two wheels are located too deep in the gears, the cogs can become caught between the cogs or rods of the other wheel. Besides extra wear, this also puts extra stress on the bearings. If there is a lot of space, sometimes the cogs of one wheel push splinters of wood off the back of the other cogs or rods.

out of alignment When the centre lines of two wheels do not coincide, they are not in alignment. This causes more friction and wear.
Furthermore, cogs can touch the plates of a crown wheel. This can be seen by evidence of wear and tear on the cog heads and on the blades.
Also, the rods of a crown wheel can touch the front rim of a brake wheel, *mirrors* which can be seen by the so-called mirrors on the rim. This will be millwright work.

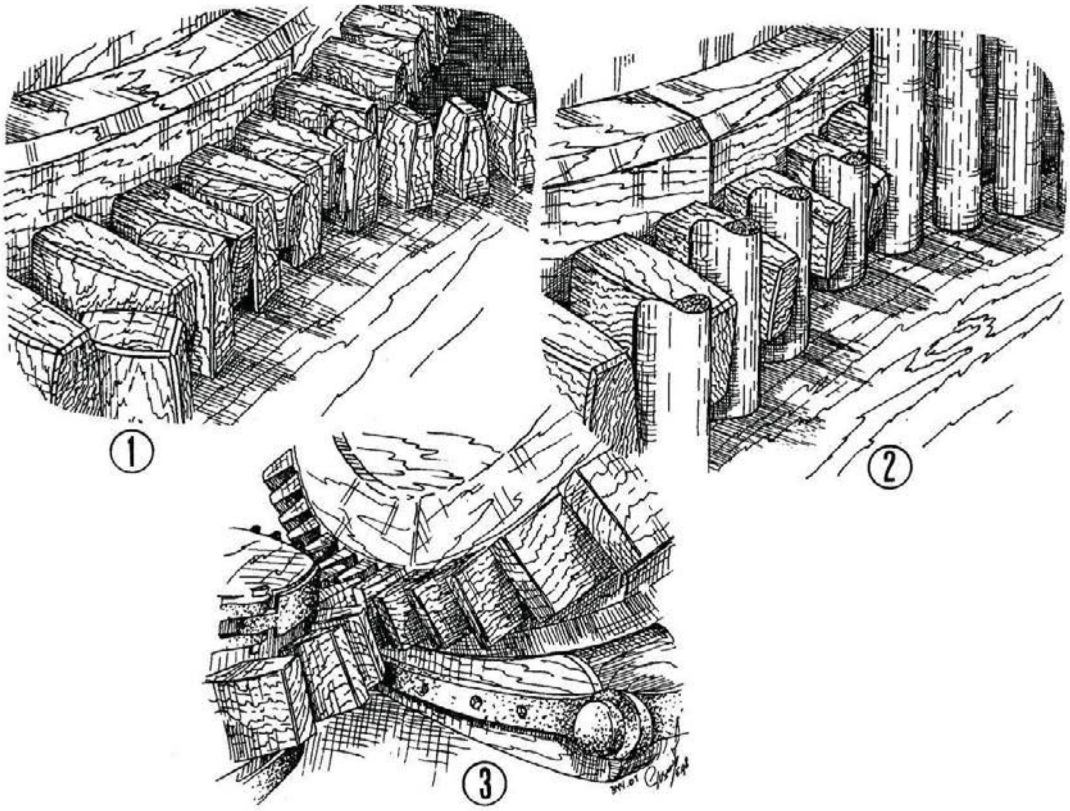


Fig. 7.6.2.1
Examples of proper engagement of cogs and bars with each other

1. *the top of the cog heads are flush with the back of the driven cog*
2. *the cogs here extend a few millimetres beyond or are flush with the back of the rods*
3. *the cogs here engage with each other for more than three-quarters of the head length*

7.6.3 Checking wedges, slings and bolts

loose wedges If you can easily tap a wedge back and forth during a long dry period, in summer or when there is frost, then it is time to check all the wedges of the driving gear. This is especially true for parts that have been recently renewed or repaired and/or were loose. Loose wedges can cause a wheel to shift on the shaft, resulting in major damage in the worst case.

Although the knocking in of wedges is, in principle, a job for a millwright, the millwright
is not called for every loose wedge. You can knock in small wedges yourself. Knocking in wedges of wheels, beams, etc. should preferably be left to the millwright. Larger wedges should be knocked in by turns and evenly.

keeper slats

securing pegs

bridle irons

Afterwards, place the keeper slats and safety pegs back behind the wedges. It is also useful to check all the sail bar wedges on a windless day. Bring a bag of new wedges and securing pegs because you will need a quite a few new ones.
Especially with new wheels, the tie-rods must be checked regularly in the beginning and tightened if necessary. The same is true for retaining rings and bridle irons around stone spindles and heavier shafts that can come loose due to the shrinkage of the wood that is supposed to hold them together.

7.6.4 Painting and tar work

moisture-regulating

tar-substitute products

Stockholm tar

white lead paint

toxic

Good woodwork protection is offered by moisture-regulating paints which professionals also use.
Sealing cracks, chinks or splits with a filler or putty is not recommended. Over time, the working of the wood causes this material to loosen and allow moisture to penetrate, which promotes wood rot.
Metal mill parts are best treated with rust-resistant metal paint.
Coal tar and 'Black Varnish' used to be available but they are banned today,
and tar-substitute products do not have a long service life.
Old tarred wood is best treated with Stockholm tar to which black powder has been added because replacement materials are quickly degraded by the old tar layer.
Wear safety glasses when scraping off old layers of paint. Splinters hard as glass, which can damage your eyes, can jump off old paint.
In addition, you must wear a face mask when scraping off any white lead paint, which is highly toxic and now banned.
Safety glasses are also recommended for overhead painting work. After working, there will be lots of paint splatters on the glasses.
Carry as much paint on the ladder as you can handle in half an hour, for example. Having such a small tin of paint fall down is less of a problem than a 5-litre container.

7.6.5 Digging in winding bollards

wooden winding bollards

Wooden winding bollards are prone to rot where they come above the ground. They are often surrounded by tall grass which keeps the bollard damp for long periods of time. Keep the grass around the bollard short or remove it completely over a strip of ± 10 cm. Furthermore, you should excavate the soil around the bollards to spade-depth (every year, for example) to impregnate them with a water repellent.
Excavating a bollard that must be replaced is done in such a way that the firm soil around the old bollard is not overly disturbed:

a. Starting from the bollard to be replaced, dig a trench away from the mill (see Fig. 7.6.5.1). Once it is deep enough, pull the bollard backwards and remove it from the trench.
b. Place the new bollard in the vacated hole at the back of the trench at the correct depth.

c. Close up the trench with small amounts of soil, wet it and stamp it down, layer by layer.

This method will result in the ground offering good resistance in the winding directions.

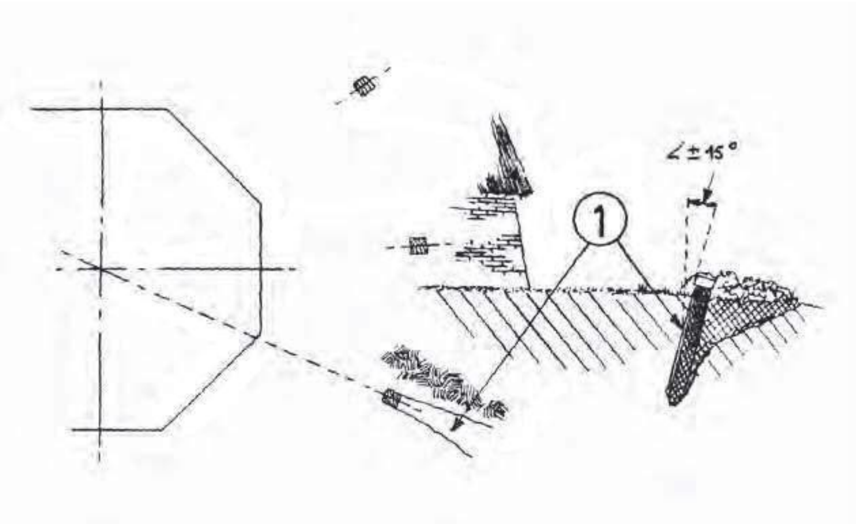


Fig. 7.6.5.1
The procedure to follow when replacing old winding bollards

1. *the trench to be dug*

7.6.6 Maintaining mill sails

cotton cloth

Mill sails made of cotton cloth, which were still used up until the 1980s, deteriorated rapidly in quality after seven or eight years.

half synthetic
Atlantex44

Twenty years before that, half cotton / half synthetic material began to be used. An example of such blended cloth is Atlantex44, available in white (ecru) and brown. The fabric is more fragile than 100% polyester because the cotton wears out faster. Its width of 205 cm makes it suitable for sail frames wider than 155 cm, as there is no need for a seam along the length of the sail. It also rolls up neatly.

sailcloth wax

The life of cotton or half synthetic cloth can be significantly extended by impregnating the sails every few years with sailcloth wax (Hydrolin), which makes them water-repellent to a certain extent. Spread the sails out on the ground, clean them first with water and (green) soap, allow them to dry thoroughly and coat them using a hoisting wagon, stiff brush or large tar brush. Dilute the Hydrolin with white spirit, if necessary. After the treatment, the sails will have a beautifully even colour. Hydrolin is available in a variety of colours.

WK77

In 1977, a sailcloth appeared on the market under the trade name WK77, a traditional-looking cloth made entirely of synthetic fibres. It is available in white, brown and brick red. WK77 is currently the strongest and most durable cloth on the market; lifespan 15-25 years. Unlike cotton cloth, it is impervious to moisture and mildew and is much less heavy, and therefore ideally suited for mill sails.
Impregnating polyester sails with Hydrolin makes no sense for durability, but you can impregnate the sail with highly diluted Hydrolin to freshen the colour.
It is further sensible to clean sails every two years with water, soap, a brush and a scouring pad, and to remove green deposits.

eye splice

whipping

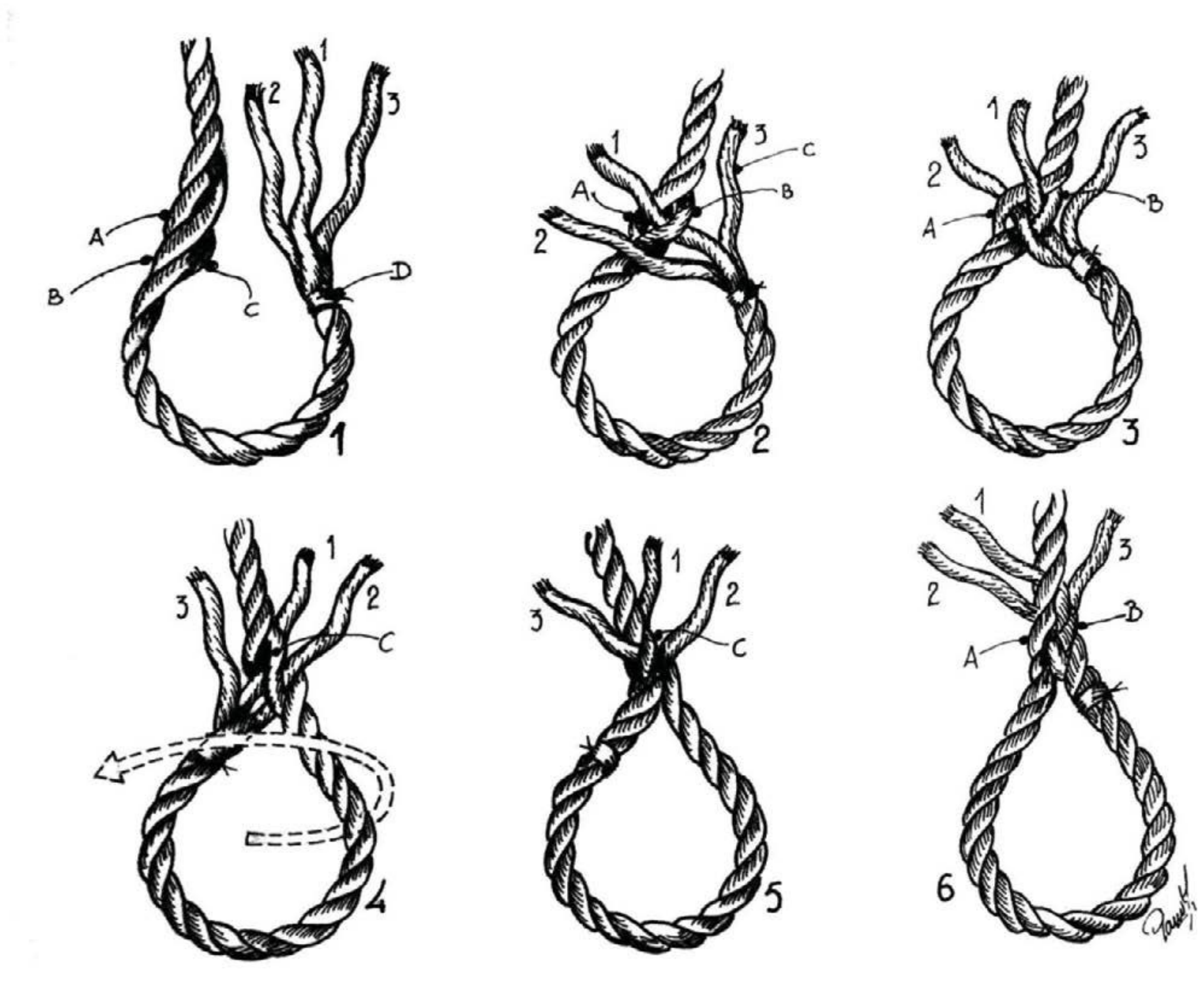
Worn ropes, such as pointing lines and tie ropes, are cut loose and replaced. Attach the new rope with an eye splice (see Fig. 7.6.6.1 & Fig. 7.6.6.2).
Ropes are prevented from fraying with a whipping (see Fig. 7.6.6.3). Knotting or re-splicing instead of a whipping makes the end of the rope thicker and less easy to loosen.
Natural rope has also been replaced by synthetic these days. For bolt rope, use 'Grypolen' and for rope that you grasp hold of, 'Hempex'. The difference between natural and synthetic rope is virtually undetectable.
For other sail and rope work, you have to rely on the sail maker, although it is not difficult to learn how to make minor repairs neatly yourself.

Fig. 7.6.6.1

Making an eye splice in 6 steps

Making an eye splice

1. Unravel the ends of strands 1, 2 and 3 from each other. To prevent going too far with the unravelling, place a temporary whipping (D). Bend the loose end back over a length of ± 10 x the rope thickness. Determine where the splice will be closed and unravel the strands from each other there.



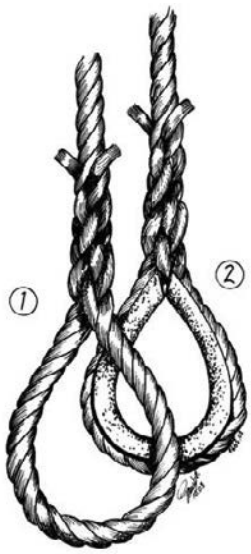


Fig. 7.6.6.2
Eye splices

1. normal eye splice
2. eye splice with rope thimble

2. Insert strand 1 under strand B of the fixed part and pull strand 1 against the whipping. To make an eye splice with a rope thimble, pull the splice to be made tightly around the rope thimble.
3. Insert strand 2 under strand A in the same way.
4. Turn the rope over, place strand 3 over strand C and then tuck it in underneath.
5. Strands 1, 2 and 3 now protrude from the rope in three directions.
6. Repeat operations 2, 3 and 4 at least two more times, always passing the loose strand over a fixed one and under the next fixed one.

Making a whipping (see Fig. 7.6.6.3)

4. Lay 8 to 9 cm of whipping yarn along the rope to be finished, measured from the end. Wrap the yarn tightly around the rope and over the loose end of the yarn at least 5 times. Place the loose end with a wide loop back along the rope, over the turns.
5. Place another 5 turns tightly around the rope and the laid-back loose end of the yarn. Cut off the long working end and insert it through the loop.
6. Pull the loop closed by tightening the end sticking out until the loop has disappeared under the whipping. Cut off the two ends.

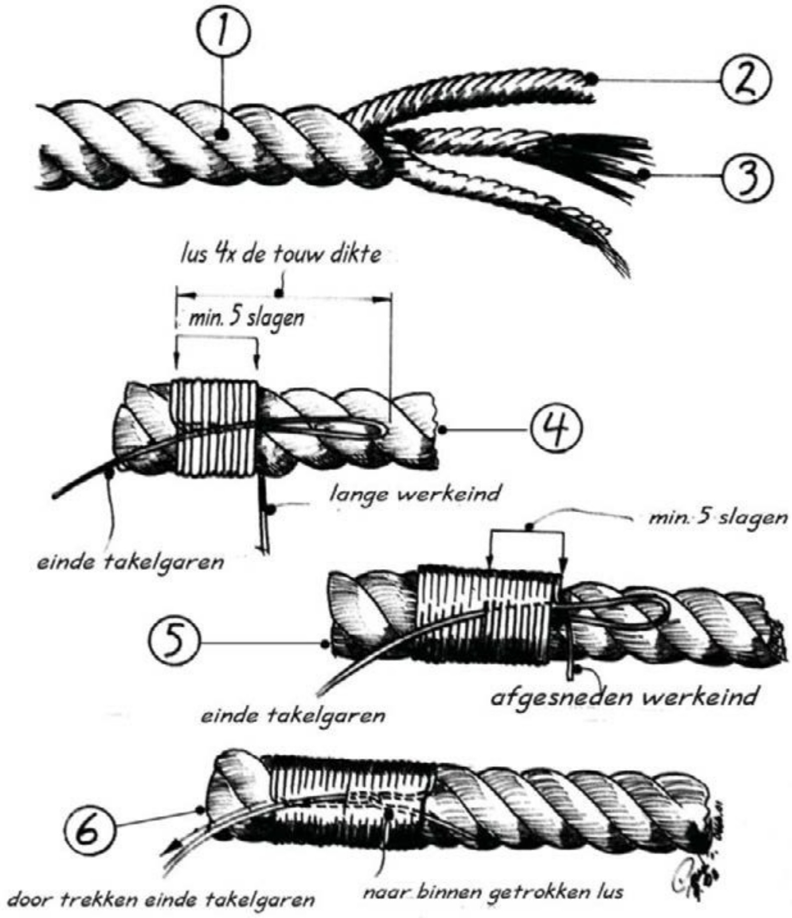


Fig. 7.6.6.3
Making a whipping

1. rope end
2. strand
3. cable yarn
4. first phase
5. second phase
6. third stage and finishing

7.6.7 Measures in the event of damage to the thatching

thatched mill

After any heavy storm, a thatched mill may have damage to its thatching. Usually a hole occurs near a roof casing, under a thatch plank or near the ridge poles on the cap. In these places the thatch is shorter, less easily bound and the above-mentioned wood must hold the thatch together. In earlier times, this short thatch was reinforced with fresh cow dung.

thatcher

To prevent a hole in the thatch from becoming larger, stuff a burlap sack or some rags into it. This pushes the surrounding thatch back in to an extent. However, you must have the thatcher seal up the hole as soon as possible.
When a larger hole is created or part of a side has blown away, you can fix the thatch around the hole from the inside. Take some laths that are longer than the hole and tie a piece of rope in the middle of each lath.
Insert each lath on the outside, lay it horizontally across the hole at the level of a thatch lath, and tie the lath tightly to the thatch lath in question. This emergency measure gives you time to wait for the thatcher to arrive.

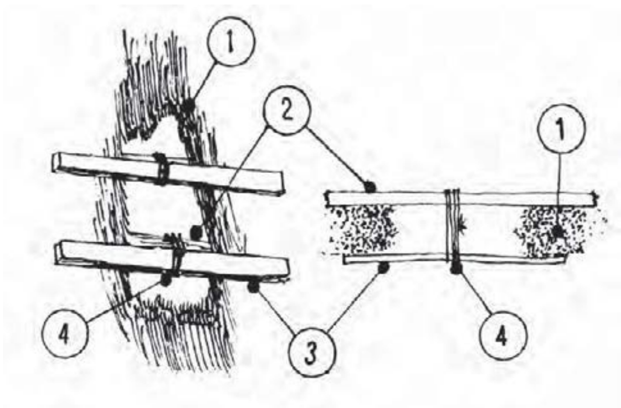


Fig. 7.6.7.1
Damage to the thatching

1. *hole in the thatch*
2. *thatch laths*
3. *emergency laths*
4. *string*

Incidentally, thatch damage can be prevented by applying wire gauze or netting in vulnerable areas. Use copper gauze or netting for this purpose that is highly durable. The slightly toxic copper oxide prevents moss and algae growth.
From the sail frame of the inner stock, wire gauze or netting can be installed along the underside of the thatch boards. If you set the inner stock transversely, you can place wire gauze or netting along the front gable from the poll end. Wire gauze or netting can also be applied along the ridge poles. Of course, you must wear fall protection when doing this work at a great height.
One side of the wire gauze or netting is nailed to the respective plank with staples or copper felt nails. The other side is secured in the thatch with thatch hooks. You can bend these hooks yourself from thick copper wire or galvanized iron wire. To prevent leakage, insert the hooks up into the thatch at an angle.

7.6.8 Combating birds

bird nuisance

There are several places at the mill where birds can cause a nuisance.

7.6.8.a The sail cross

starling plates

The ends of old (pot) stocks are often open; birds can then nest in them. New stocks are made inaccessible through the use of starling plates. So that rainwater can drain off, the starling plates have two holes and corners that are cut away at an angle. For stocks without plates, these can be made by a blacksmith. You can also make a wooden plug. Saw the corners off for water drainage. Secure the plates or plugs securely with tab bolts or screws, as the great centrifugal force is substantial.
Pigeons and starlings like to nest among the stock wedges and on the poll end. You can place wire gauze or netting between the fixing wedges but the only remedy against nests on the poll end is to operate the mill often.
Birds like to sit on the sail frame. In itself, this is not a problem but their droppings can contaminate the mill considerably. Sometimes a wire is stretched above the top sail bar or leading hemlath but this must be removed before milling. Putting the sail cross away in the long rest position also appears to be a good solution.

7.6.8.b The cap

bird baffles

Some mills lack bird baffles between the puncheons. Many birds like to be dry by sitting under the cap, on the keep flange. Sometimes they enter the cap through the winding gear. They also try to build a nest on the curb, between the winding gear, or behind the beard. Sealing the openings with wire gauze or netting or planks prevents unwanted guests and contamination.
When a kestrel is roosting at the mill, keep its flight opening open. It keeps all other birds out of the mill, leaving only some dry pellets.

7.6.8.c The thatch

Sometimes, while searching for insects, birds pull stems from the thatch, especially under the thatch boards, ridge poles or roof casings. Applying wire gauze or netting in the aforementioned places can prevent problems. See Section 7.6.7.

7.6.9 Keeping the winding gear clean and replacing winding rollers

The winding track must be kept nice and clean. Every twig or chip involves extra effort during winding. Moreover, a wooden roller is quite likely to snap when passing over it. While working in the cap, make sure that nothing falls between the rollers and onto the winding track. Even a cast-iron roller may not survive a stray nail.

scraper, small brush

With a scraper and a small brush of about 50 cm long, the winding track is easy to keep clean. The flat extension of a vacuum cleaner hose also works well.

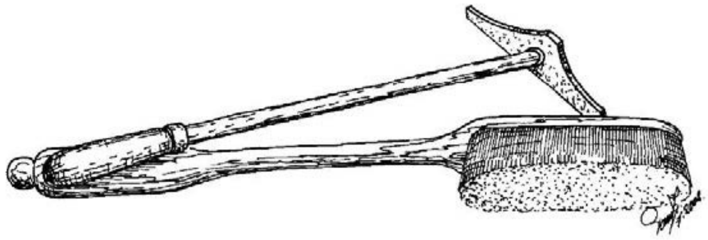


Fig. 7.6.9.1

Small brush and scraper for cleaning the winding track

Other winding gears should also be kept nice and clean. Dirt attracts dirt and, unnoticed, the winding becomes heavier and heavier. Remove old grease; often it has dried up, lost its efficacy and become hard. Moreover, the old grease immediately scrapes away the newly applied grease.

snapped wooden roller

When a wooden roller has snapped, you can no longer wind. First try turning the roller so that it does not touch the winding track and curb anywhere. Then secure it with a nail on the roller-ring. To prevent damage to other rollers, also remove all pieces that have broken off. Then you can resume winding. If it is not possible to have the broken roller hang freely by turning then you can try using a hammer and chisel to cut out a piece of the roller. When doing this the outside of the roller wagon should be supported against the curb railing to prevent it being damaged. Then try turning the roller again. When one roller is missing, there is no urgency in replacing it. The adjacent rolls have sufficient load-bearing capacity. At some point, the broken roller or empty place comes near to the roll sluice or roll compartment. This is the point at which to replace the roller.

roll sluice

cast-iron roller

If a cast-iron roller breaks, be extremely alert when continuing to wind after inspection. With this type of roller, small pieces of cast iron can sometimes jump out, causing the adjacent roller to snap as well. But such rollers do not break that easily, though. Investigate what could be the possible cause of this.

7.6.10 Species of wood in mill construction

species of wood

Mills are essentially machines made mostly of wood. Wooden parts, especially those for the running gear, are subjected to special loads. Therefore, the species of wood used are those that can handle this load without difficulty. Each species of wood has its specific properties that make it excellent for one application and less suitable for another.

There are many species of wood, and even within one species of wood there are differences in quality. The slower a tree grows, the better the wood will be. A tree grows more slowly on poorer soil and at lower temperatures, for example, but it yields heavier wood. It is often more sustainable, too.

The well-known saying 'you can't make a silk purse out of a sow's ear' certainly applies to mills. Besides suitability, however, availability and price have played an important role in the choice of certain species of wood used in mill construction in earlier times too.

Nowadays, people also use species of wood that were previously unknown in the Netherlands. Sustainability or price are important considerations in this.

Learning to recognize all kinds of wood species is not easy. It takes practice to learn this. Collecting sample pieces can greatly assist this process. However, a miller need not become an expert. However, he can be expected to have some knowledge of the species of wood used in his mill as well as the main properties of the wood.
The following is an overview of various species of wood and their possible applications in mill construction.
Coniferous wood comes from trees with needles that remain evergreen. Deciduous trees have leaves that usually fall off in the winter. In general, coniferous wood is softer than deciduous wood.

7.6.10 a Some species of woods used in mills and their applications

Species	Sustainability	Applications
SOFTWOOD:		
American Pine	moderate/low	Also: Pitch Pine. Especially suitable for wooden structures and indoor use.
European Pine	moderate/low	Formerly: octagons, stocks. Now for interior carpentry: floor timbers, window frames, cap boarding, leading boards. If creosoted, it can also be used outdoors: sail bars, stage parts.
Spruce	low	Suitable for underwater work: piles, mud sills, shoring, foundation boards.
Larch	moderate	Heavy long beams, floor joists, floor timbers, cap trusses, tail braces. If creosoted, it can also be used outdoors: sail bars.
Oregon Pine	moderate/low	Also: Douglas. Beams, spindles, window posts, framework, stone troughs, carts.
Parana Pine	low	Stone troughs, meal spouts.
Redwood	good	Jibs. Difficult to obtain.
Fir	low	'Scots pine'. Interior carpentry.
Red Cedar	moderate/good	Formerly: jibs. Of lesser quality now. Interior carpentry.
HARDWOOD:		
Afzelia	very good	Tropical hardwood. Pit wheels, waterwheels, wallowers, crown wheels, cross arms, cants. Large sizes hardly available any more.
Azobé	good / very good	Heavy tropical hardwood. Difficult to work by hand. Sinks in water. Main shores and struts, winding bollards, winding rollers, cogs and rods. Post and plank lumber for water work such as shoring.
Holm oak	moderate/good	Expensive. The wood of choice for cogs. Blocks.
Bankirai	good / very good	Heavy tropical hardwood. Hydraulic construction: shoring, sluice door, shot posts, spillway decks. Also for winding bollards, main shores and shore beams
Beech	very low	Winding bearings and carters, sometimes cogs. Highly susceptible to woodworm.
Bilinga	good / very good	Good substitute for oak. Weather beam, stretchers, tail beams, sill pieces,

		heavy wheels (excluding rims), filling pieces.
Balata	good / very good	Cogs and rods.
Box wood (Buxus)	good	Available in small sizes only. Rods (thin).
Demerara Ironwood	very good	No longer available. Cogs.
Oak	moderate/good	Heavy beams, sheer beams, weather beam, wheels (excluding rims), wooden wind shafts and other shafts, support beams.
Maple	very low	Winding rollers, rods.
Ash	very low	Cogs for lightly loaded wheels. Springs of leading boards. Roller wagons. Hammer handles.
Hornbeam	very low	Cogs, rods. Hard to obtain, little used.
Hickory	low	Stone troughs, hammer handles.
Elm	low	Difficult to split. Rims for wheels, crown wheels, pinion plates, winching wheels, roller wagons.
Meranti, red	good	Window frames, doors, windows, shutters, etc.
Merbau	very good	Sluice doors and frames, bridge decks, submerged beams in waterways, flaps, stop wood under bearing stones.
Lignum-vitae	very good	Rods, neck bearing blocks, blocks and winding rollers. Difficult to obtain.
Poplar	very low	Brake blocks.
Robinia, Acacia	good	Most durable native hardwood. Not from the Acacia! Stock wedges, sail clamps and other heavy wedges for use in the mill. Sometimes cogs for spur wheels, brake wheels, and crown wheels.
Willow	very low	Brake blocks. More wear-resistant than Poplar. Bent pieces are more often available than is the case with Poplar.
Yang (Keruing)	moderate/good	Winding bollards, spillway decks, watercourse screens and polder mill parts that are frequently wet.
Zapatero	good	Rods, cogs. Substitute for box wood.

NOTES

Chapter 8 The weather

Contents page:

This chapter was compiled by David Henneveld, who has been involved with weather since the 1970s, first as a hobby, later professionally including with the Department of Defence, where he dealt with weather and climate worldwide. Since 2000, he has worked at Weathernews in Soest as maritime meteorologist, providing weather information for the offshore industry.
He has also been involved in the world of milling as a meteorologist since 2008. He conducts weather courses for the Guild, writes articles in the Guild Letter and provides a weekly weekend weather report on the website for millers.
Members of the Guild of Millers may contact him for questions or weather information: d.henneveld@casema.nl

8.1 INTRODUCTION

Knowledge of the weather is vital for millers. And out of all the weather phenomena, this is certainly true for the wind. Without wind, windmills do not turn. But strong winds or gusts of wind can also be a threat to the mill. Equally, a settled, safe weather situation can sometimes turn into an unsafe situation in a short period of time.
Therefore, a miller should keep an eye on what is going on in the sky.

observing

A miller must be able to observe what is happening: the wind changing direction, blowing harder or easing off, the clouds changing, the temperature dropping, what kind of precipitation is falling, etc.
But observing change is of little use if you do not know the cause of that change. For then you do not know what is going on in the atmosphere. And consequently you do not know whether you should take action as a miller.

theoretical knowledge

We no longer have the practical weather knowledge that millers used to have. That is something with which a miller needs to refamiliarise themselves. This also requires some theoretical knowledge of weather in order to operate the mill in a variety of weather conditions.
And also to be able to decide whether, under the prevailing or expected conditions, it is safe to operate.

digital tools

Use "old-fashioned" tools such as the barometer and a wind vane for this. But also take advantage of contemporary resources, such as rainfall radar, the Windfinder app, online data from local weather stations, etc. They provide a good supplement to the information we need.
However, be aware that they have their limitations.
They can never replace your own observations, because the weather never exactly conforms to weather reports, forecasts, radar images, etc.

weather maps

Weather maps are also important tools. A weather map provides an overview of the state of the atmosphere at a given point in time. Using weather maps, you can also create your own approximate local weather forecast. This must then be supported by observation.
The reverse is also instructive: If you observe something in the sky, look at the weather map and try to explain the observed phenomenon.

This chapter discusses the main weather phenomena. You will learn to see connections between these phenomena. And their significance to the miller. You will also gain theoretical knowledge about weather phenomena. And you will learn to "read" weather maps.

Careful study of this chapter on weather on its own is not enough.
Observation of the weather and knowledge of the weather must go hand in hand. So that you, as a miller, become increasingly familiar with a variety of weather conditions.

As you involve yourself in the weather more and for longer, your understanding will develop.
However, the time required for this is longer than the duration of the training. But you can study the weather every day. Do not just limit it to the hours you spend at the mill.

8.2 THE BIG PICTURE

8.2.1 The atmosphere

There are several layers of air around the Earth as a transition to space. Together, these layers are more than 1,000 km thick. Of interest to us is the layer immediately around the Earth, because that is where all the weather phenomena occur.

troposphere, tropopause

This is the troposphere, with a transition to the next layer being the tropopause.

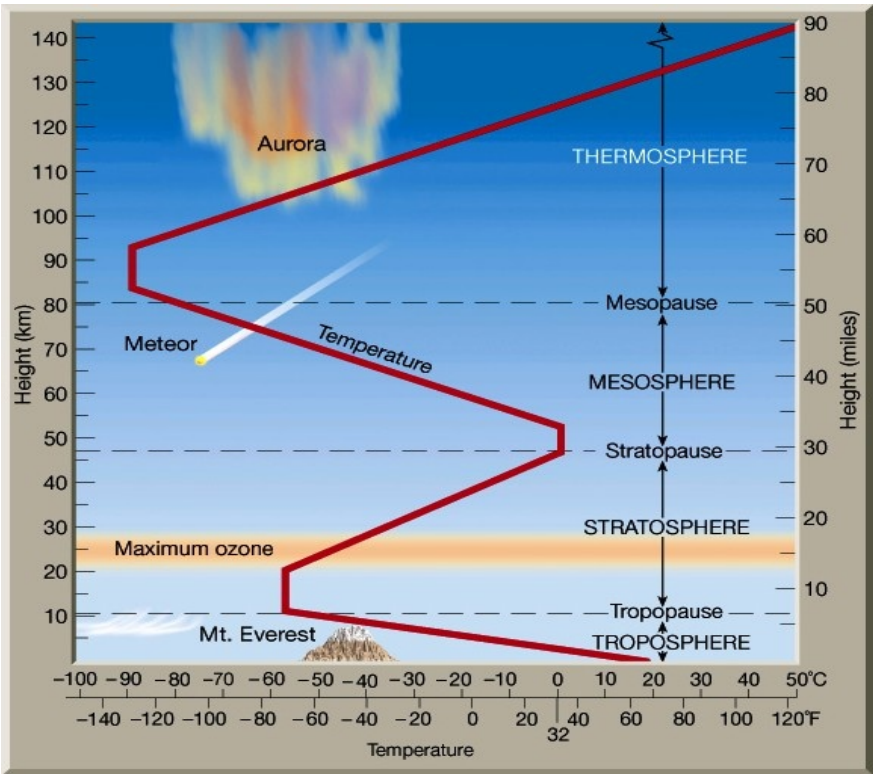


Fig. 8.2.1
The atmosphere around the Earth.

Within the different layers, the temperature decreases or increases as the altitude increases. (copyright KNMI)

8.2.2 Troposphere and tropopause

troposphere

The troposphere is the layer of air in which we find ourselves. It is 6-18 km thick on average, and its thickness varies day by day. Over the Netherlands it ranges from 6 to 16 km throughout the year, depending on season and temperature. This difference in thickness is caused by temperature differences.

** air contracts when cooled and expands when heated. Consequently, the troposphere is thickest around the equator and thinnest near the poles.*

The temperature of the Earth's surface only affects the temperature of the air just above the ground. With increasing altitude, that influence decreases rapidly. Hence the air gets colder and colder the higher you go.

The troposphere is characterised by a temperature decrease from an average of 16 °C at ground level to an average of -60 to -70 °C between 6-18 km altitude.

As a general rule, it maintains a temperature drop of about 0.5 °C per 100 m.

tropopause

The upper layer of the troposphere is called the tropopause.
Above the tropopause, the temperature does not drop further but slowly increases again in the layer above it.
Ascending – that is, cooling – air cannot rise further than up to the tropopause.
As a result, "weather" never happens above the tropopause.

** the tropopause acts as a lid on the troposphere, as it were, preventing rising air from escaping into space.*

8.2.3 Air pressure

air pressure

As a result of gravity, air presses on the Earth's surface with a certain weight, which we call atmospheric pressure or air pressure. Air pressure will be different each day and at each location because the air column above that location is different each day in terms of temperature and altitude.
These two factors determine the pressure we measure at the ground.

** as the thickness of the air layer changes due to temperature differences, the height of the air column above that location changes and thus the air pressure at the ground changes along with it.*

As altitude increases, air pressure also decreases. This is because the column of air above you then becomes smaller and smaller.

Therefore, the highest pressure is always measured at sea level. In the mountains, the pressure is already much lower; the air is thinner and there are fewer air particles per volume.

** the fact that air pressure decreases with increasing altitude is used in aircraft, for example, to measure altitude: so an altimeter is actually a barometer.*

barometer

millibar
hectopascal

An air pressure gauge – or barometer – measures the weight of the column of air above the measurement point. Measurement can be either analogue – with mercury or a liquid – or digital. The unit of measurement is the millibar or the hPa (hectopascal). Both units have the same value.

** all air pressure measurements are converted to sea level for comparison. Weather maps show these converted values.*

The mean atmospheric pressure at sea level is 1013 millibar. The pressure decreases about 1 millibar per 9 metres of height.

An example: if the air pressure in the Netherlands – that is approximately at sea level – is 1025 millibars, then in the mountains at for example 1800 metres altitude, it is only 825 millibars (1025 - 1800 / 9 = 825).

The highest atmospheric pressure measured in the Netherlands is around 1050 millibars, the lowest around 955 millibars. On a global scale, it can be even more extreme: between 1070 and 880 millibars at sea level.

Air pressure is not the same every day and can increase or decrease (rapidly). Changes in air pressure are an important forewarning that something is changing in the atmosphere. Therefore, a barometer is an important tool for a miller to get an idea of what is going on in the sky.

8.2.4 Seasons

We owe our four seasons (spring, summer, autumn and winter) to the fact that the North-South axis of the globe is at an angle to the plane in which the Earth revolves around the Sun. The angle of inclination is approximately 66°.

This tilt of the Earth's axis changes the Earth's position relative to the Sun as it rotates around the Sun. As a result, the Earth is not heated evenly. During the seasons, large differences in temperature of the Earth's air can arise.
The greater the distance from the equator, the greater the air temperature differences become in the seasons.

** we can observe the changing position of the Earth relative to the Sun through the path of the Sun above the horizon.*
In the northern hemisphere, it becomes higher in spring and summer, and lower in autumn and winter. In the summer, therefore, the days are longer and heating by the Sun is stronger.

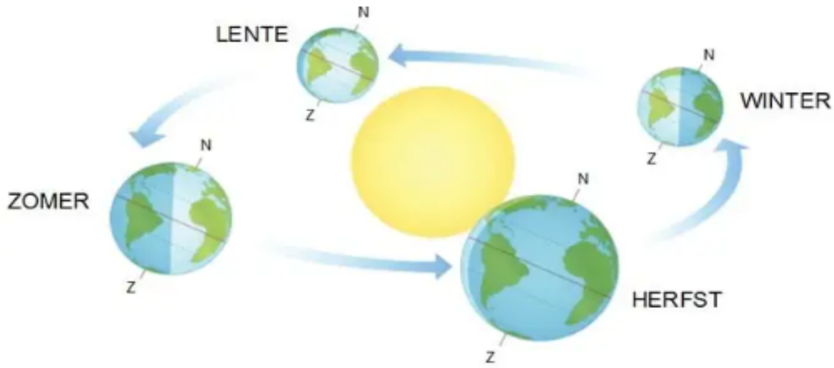


Fig. 8.2.4

The Earth revolves around the Sun. Because of the tilt of the Earth's axis, the Sun alternately heats the northern hemisphere or the southern hemisphere more.
(copyright PeriodeAardrijkskunde)

8.2.5 The jet stream

jet stream

Whirling around the Earth at considerable altitude (above 5 km) are broad bands of very high wind speeds, the jet streams. These are a kind of "wind rivers" or wind tunnels several hundred kilometres wide.
The jet stream is not a continuous flow but consists of sections and bends with higher or lower speeds. These are in a different place each day and have varying speeds.

** the jet stream can reach tremendously high speeds. From 118 km per hour upwards we speak of a jet stream; that is wind force 12.*
The wind speeds can reach up to 350-400 km per hour.

polar jet stream

The polar jet stream is of particular interest to our weather. This is the dividing line between fairly mild air on the Atlantic Ocean around the Azores and much cooler air around Iceland, Greenland and northern Scandinavia.
Around the Azores, the year-round temperature differences are quite small because of the relatively warm sea. At the North Pole, the differences are very great.

polar front

As a result, in the autumn and winter, the difference in temperature on either side of this dividing line (the polar front) is much greater than in summer, not only at ground level but especially at altitude (4 – 8 km).
As a result, the jet stream increases in speed and depressions become larger and more active, with more wind.

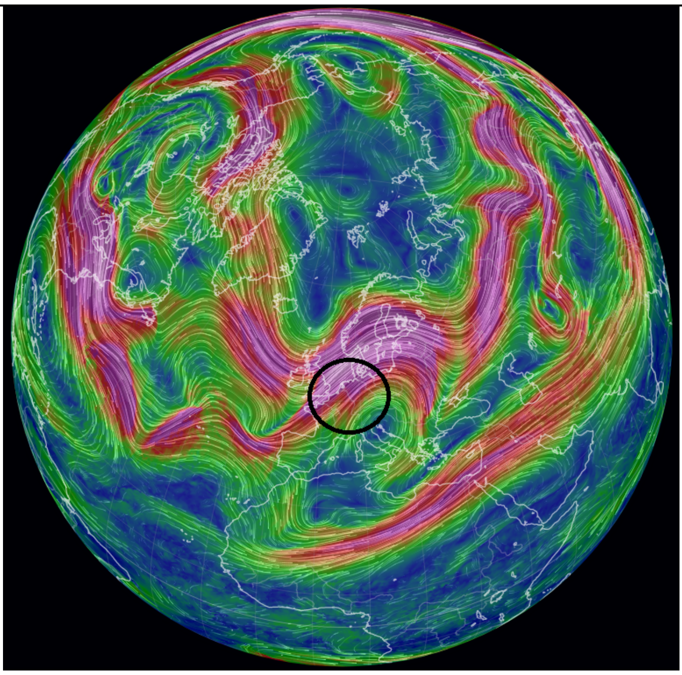


Fig. 8.2.5.1
Jet streams

The jet stream has many branches and bends.

Over the Netherlands (in the circle), the jet stream here runs from south-west to north-east.

Earth.nullschool.net, 13 Oct 2023

The jet stream generally blows from Canada and the East Coast of the US to Europe. And thus has great influence on our weather. It determines the trajectory and activity – including the amount of wind and rain – of depressions in our area.

The waves ("oscillations") in the jet stream bring in colder air at times, warmer air at other times.

Fig. 8.2.5
The polar jet stream

This oscillates generally from west to east across the northern hemisphere.

8.2.6 Air currents and air types

air types

The air in the troposphere is not the same everywhere. We distinguish different types of air. These are huge air masses, which have certain characteristics that distinguish them from other air masses.
In particular, it concerns differences in temperature and humidity. These are formed when the air mass is in a certain area for an extended period of time. For example, around the poles, the ocean or the mainland.

air current

There are also general air current patterns around the globe that set the air types in motion.

Moving air types will affect the type of weather we can expect in the Netherlands

We list the most common currents:

south-west circulation

The Netherlands mainly features "south-west circulation". There is a high-pressure area around the Azores, while depressions pass by to the north of us. Relatively warm and rather humid air is brought in from the Azores from the south-west. We call this air maritime-subtropical.

maritime-subtropical air

This is the air in the warm sectors: after passage of a cold front, another type of air moves in.

The south-west current causes rather variable weather in the Netherlands.
It carries lots of clouds with rain from time to time and showers of all types, with and without thunderstorms. However, no wintry showers.
In late spring, summer and early autumn, south and south-west currents often carry thunderstorms.

> ** the south-west circulation produces the classic weather pattern for Western Europe, with depressions moving from the Atlantic via Scotland to Scandinavia.*

polar air

With a "north-west current", fairly cold air is brought in from the Iceland/Greenland region and sometimes even from Canada. This is polar air.
As it flows over the increasingly less cold seawater, this air loses the worst of its coldness before it reaches the Netherlands.
We usually encounter this air behind a cold front.
North-west currents provide bright spells but also carry year-round polar showers with a local clap of thunder.
West currents also sometimes carry these types of showers. This is the most common type of shower in the Netherlands.

Eastern currents generally bring dry air to the Netherlands. In summer, that gives pleasant weather. In winter, it often freezes and sometimes snow falls.

continental-polar air

We call this air continental-polar air.

Currents from the south-east, east and north-east are often unable to produce showers because the air is usually too dry.

Southern winds, especially in summer, sometimes bring very hot air to the Netherlands, with maximum temperatures above 35 degrees. Often this type of air is also rather humid, becoming oppressive and muggy. This is continental-tropical air.

continental-tropical air

8.3 PRESSURE AREAS

** the weather is determined by high-pressure and low-pressure areas*

8.3.1 High-pressure area

High-pressure areas are areas where the highest air pressure is measured at ground level. On the weather map, they are represented by a (blue) **H**. They can be relatively small or they may cover thousands of kilometres. High-pressure areas usually move slowly, strengthening or weakening as they do.
The centre is often large. That is where the pressure is highest; it is usually between 1020 and 1050 millibars. From the centre outwards, the pressure diminishes.

8.3.1.1 Vertical current in high-pressure areas

descending air

High-pressure areas are "fed" by air that is brought in from higher altitudes – from 1 to 10 km – and then descends. So in the centre there is a current from top to bottom. The descending air collides with the ground and then flows away in all directions.
Because this descent happens gently, the air also flows gently away over the Earth's surface. Therefore, around a high-pressure area, there is usually little wind.

** On weather maps, around a high-pressure area, the isobars are often far apart. (see 8.6)*

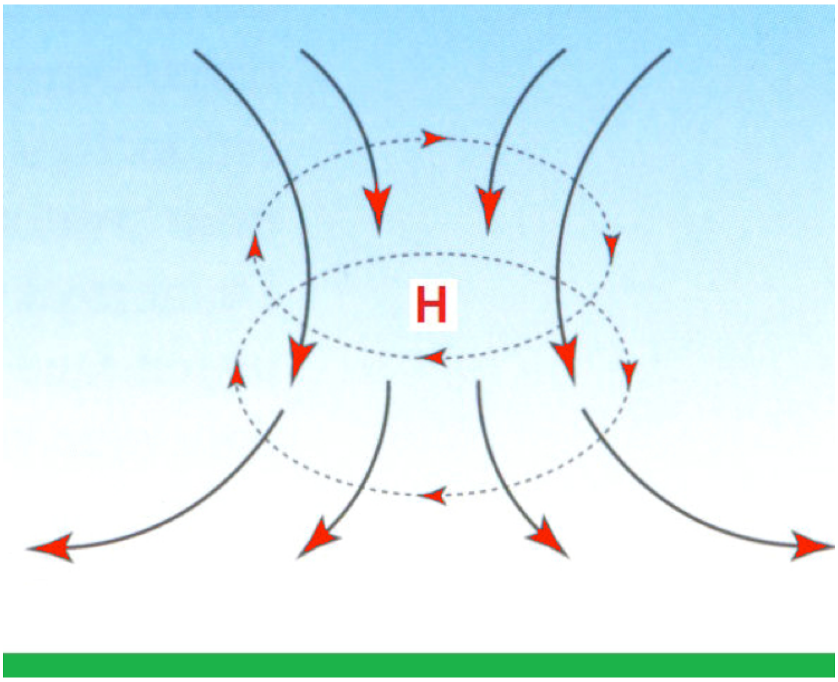


Fig. 8.3.1
Vertical current in a high-pressure area.

The air gradually warms as it descends, which is why the arrows are red.

air surplus

As long as the inflow of air from above is greater than the outflow of air at the ground, an air surplus is created. The air pressure continues to rise. There will literally be a "bulge" of air in the troposphere pressing down on the earth's surface. The barometer rises.

When the supply of air at altitude decreases or stops, the downward air current also decreases or stops completely. Air pressure in the centre will then decrease and the high-pressure area will weaken or disappear.

The descending air in a high-pressure area becomes more and more compressed and therefore warmer. This rise in pressure causes an increase in temperature.

** compressing air causes an increase in temperature.*
After using a bicycle pump, just feel the barrel!

stable weather

This warming also makes the air drier, often causing clouds to disappear. Consequently, high pressure is often accompanied by fairly sunny weather in spring, summer and autumn. We call this stable air or stable weather.

** in high-pressure areas we generally get calm weather with little wind and few clouds.*

8.3.1.2 Horizontal current around high-pressure areas

Coriolis effect

The descending air always flows outwards from the high-pressure centre over the Earth's surface.
Because the Earth is a rotating sphere, air currents do not move in a straight line but are deflected to the right (Coriolis effect).

** high-pressure area: air flows away from the centre – since there is surplus air – and deflects in a clockwise direction.*

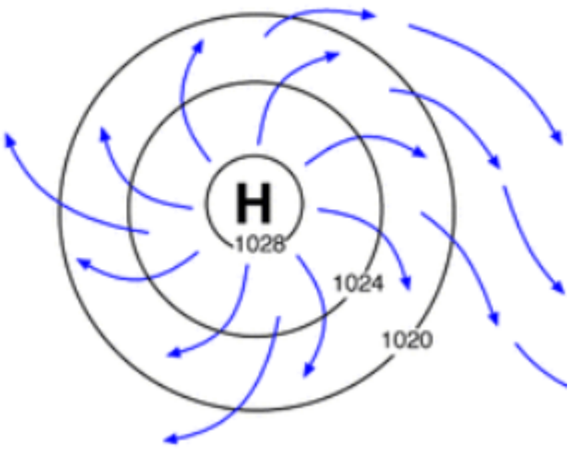


Fig. 8.3.1.1
Horizontal current from a high-pressure area.

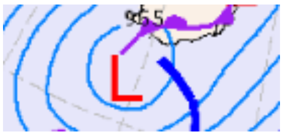
A top view of the air current at ground level.
The air flows outwards in a clockwise direction.

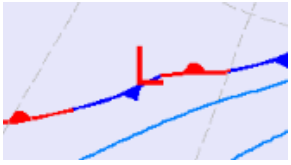
8.3.2 Low-pressure area or depression

depression

Low-pressure areas – also referred to as depressions – are areas where the lowest air pressure is measured at ground level. On the weather map, they are represented by a (red) **L.**

The centre is often small but can sometimes span thousands of kilometres. Low-pressure areas sometimes move slowly but often at brisk





speed as they strengthen ("deepen") or weaken ("fill up")
In the centre, the pressure is lowest; it is usually between 940 and 1010 millibars.
From the centre outwards, air pressure increases.

A characteristic of a low-pressure area is that the centre is enclosed by a single isobar. If this is not the case, we do not call it a depression.
But since low pressure does prevail at that location, a depression could still develop there. By looking at successive weather maps, this will become clear.
An "isolated" **L** however, can also indicate a remnant of a depression at altitude.

8.3.2.1 Vertical current in low-pressure areas

Low-pressure areas are "fed" by air brought in from the ground and then sucked upwards.
The engine behind this suction is the jet stream.

rising air

So in the centre there is an airflow from below upwards. Because this vertical air current – under the influence of the jet stream – often occurs at great speed, air over the Earth's surface also flows at great speed. The pressure in the centre can then drop rapidly from, say, 1000 to 970 millibars. Because of the greater pressure differences in low-pressure areas, the wind often blows much harder than around high-pressure areas.
This is especially true in the autumn, winter and spring, when the jet stream can be at its strongest and discharge a lot of air.

** on weather maps, around a low-pressure area, the isobars are often tightly together (see 8.6)*

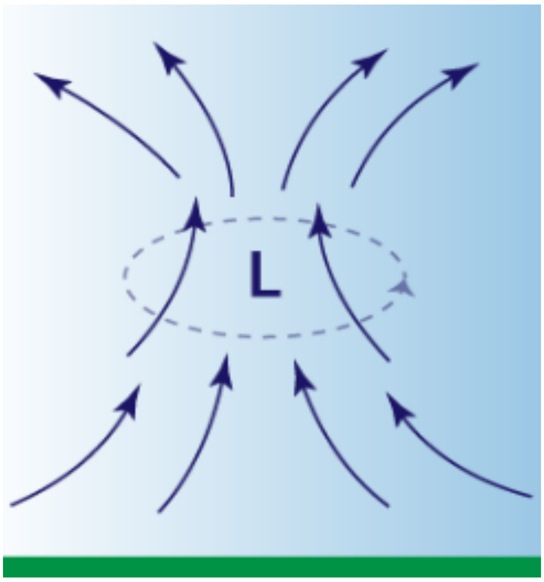


Fig. 8.3.2
Vertical current in a low-pressure area.

The air cools gradually as it rises, which is why the arrows are blue.

As long as the discharge of air at altitude is greater than the influx of air over the Earth's surface, there will remain an air deficit and the air pressure will fall. There will literally be a "hole" in the tropopause. The column of air pressing on the Earth at that location is smaller and the air pressure lower. The barometer drops.

When the discharge of air at altitude decreases or ceases, the upward airflow also decreases or stops completely. The air pressure in the centre will then rise again and the low-pressure area weakens ("fills up") or disappears.

The rising air in a low-pressure area will expand and cool. As a result, clouds often form and precipitation also falls. This happens throughout the year. We call this unstable weather; unsettled weather with clouds and showers. Because the jet stream is at its strongest in autumn, winter and spring, pressure differences can also be large during those periods, which means there will be more wind.

unstable weather

** in low-pressure areas, there is generally more wind and lots of clouds.*

8.3.2.2 Horizontal current around low-pressure areas

The air always flows over the Earth's surface towards the low-pressure centre: after all, there is an air deficit there. Because of the Earth's rotation, even with a low-pressure area, this does not happen along straight lines, but curved ones.

** low-pressure area: air flows towards the centre – since there is a deficit of air – and deflects in a counterclockwise direction.*

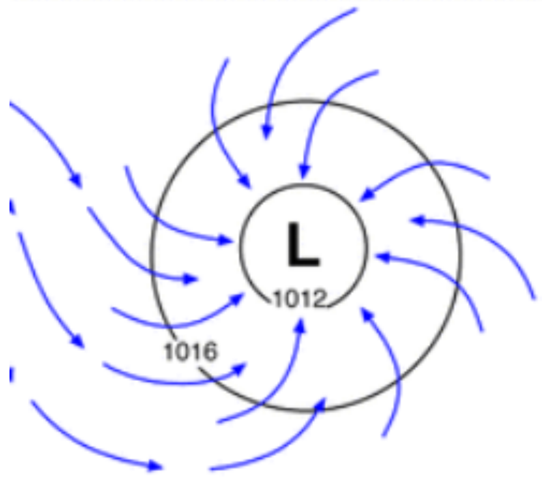


Fig. 8.3.2.1
Horizontal current towards a low-pressure area.

A top view of the air current at ground level.
Air flows towards the centre in a counterclockwise direction.

8.3.2.3 Emergence and disappearance of low-pressure areas

polar front

Depressions form along the polar front, the dividing line between warmer air over the Atlantic and cold air from the Arctic.
As these air masses brush past each other, a wave form is created in the front which, under the influence of the jet stream, continues to turn inwards into the familiar "curl".

fronts

This also creates the fronts, the dividing planes between these air masses.
Depressions undergo an evolution from their onset to their disappearance.
In young depressions, air pressure sometimes drops significantly and the wind can be strong. This is also where most precipitation falls.
With older depressions, air pressure increases again and winds die down. The fronts also become less active as far as precipitation is concerned.
At some point, the depression disappears again.

N.B. Because of the important significance of fronts for weather, the formation of depressions and fronts is discussed in more detail in the section 8.5

8.3.3 Current between pressure areas

High-pressure areas have a surplus of air – brought in from higher up in the atmosphere.
Low-pressure areas have a deficit of air – which is discharged from below into the upper atmosphere.

** because nature strives for equilibrium – that is, equal pressure everywhere – air always flows from high-pressure (areas) to low-pressure (areas)*

In this regard, the shortest path would be directly from high pressure to low pressure.

However, due to the Earth's rotation, this current bends away, from the high-pressure area clockwise and towards a low-pressure area then counterclockwise. The force that causes this deviation is called the Coriolis force.

** Coriolis force: Because of the Earth's rotation, the air does not flow in a straight line but will bend away.*

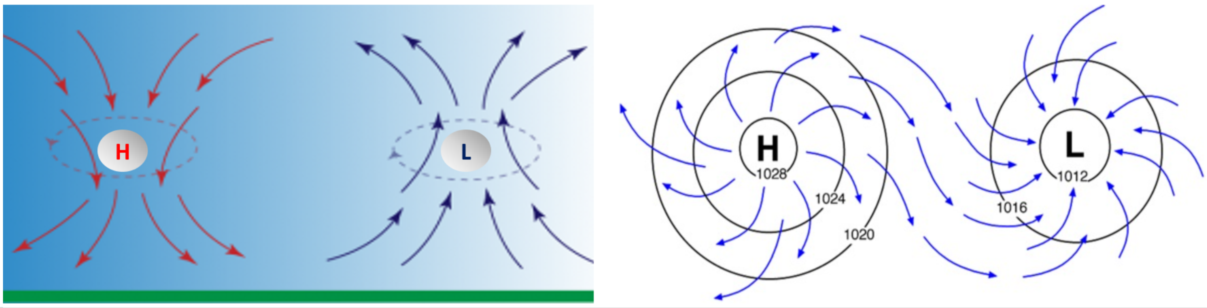


Fig. 8.3.3
Vertical current in pressure areas (left) and horizontal current between pressure areas (right).

High-pressure areas and depressions work together perfectly:
- from a high-pressure area, air flows along the ground towards a depression.
- the depression "sucks up" this air (that is what the jet stream does) and carries it away at altitude.
- Elsewhere, the air accumulates again and starts descending. A high-pressure area then forms there or an already present high-pressure area is strengthened.

Thus the circulation loops around so that after some time both high- and low-pressure areas disappear again.

** the (horizontal) current of air is what we call wind.*

How strong the current between high- and low-pressure areas is – or: how hard the wind blows – depends on the distance as well as the pressure difference between those areas.

Low- and high-pressure areas are each other's opposites in many ways

Feature	High pressure	Low pressure
Pressure	High in centre	Low in the centre
Vertical current	From higher air layers downwards	From the ground to higher air layers
Horizontal current	From the centre outwards	From outside to the centre
Current direction	Clockwise	Counterclockwise
Size of the centre	Relatively large	Small and compact

Depressions and high-pressure areas alternate and as a result we get variable weather. Sometimes depressions influence our weather for weeks on end, with wind and rain, sometimes it is high-pressure areas that give us sunshine and dry weather for longer periods of time.

8.3.4 Isobars.

isobars

To provide insight into air pressure distribution on Earth, we use isobars. Air pressure is measured in a large number of locations. Based on these observations and model data, isobars are drawn.

** connecting all points with equal air pressure creates uninterrupted flowing lines: the isobars, "lines of equal atmospheric pressure".*

Patterns then emerge that show exactly where the high- and low-pressure areas are located. The isobars here often have a circular shape.
Isobars can also be quite straight or (strongly) curved. Even a kink may occur.

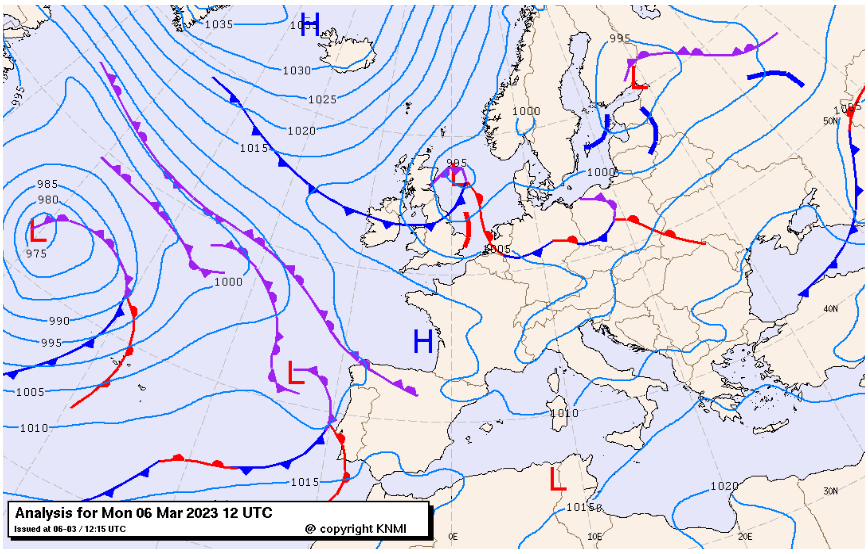


Fig. 8.3.4.1
Isobars on a weather map.

Isobars are depicted as thin blue lines.
They belong to a high- or low-pressure area. An isobar signals the pressure value.
Where an isobar cuts a front, it often has a kink.

** isobars show the position of pressure areas. Because the wind follows the isobars – albeit at a small angle – they also provide information about wind direction (see Fig. 8.4.2).*

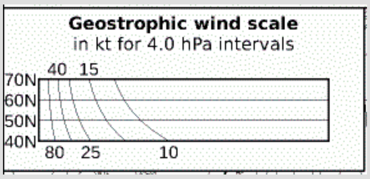
In general, the following applies:
The greater the air pressure difference between two locations, the stronger the current will be. In other words, the harder the wind will blow.
In that situation, the isobars are close (or closer) together.

And: the smaller the air pressure difference between two locations is, the weaker the current will be. In other words, the more gently the wind blows.
The isobars are then further apart from each other.

Right in the centre of a high- or low-pressure area, there is hardly any wind. The pressure differences there are very small so little or no current is created.
Around the centres, we then find the wind fields.
The strongest wind fields are usually found on the SW/W side of a depression.

> ** Isobars on a KNMI (Royal Netherlands Meteorological Institute) weather map do not indicate how strong the wind is;*

Fig. 8.3.4.2



Using the isobar pattern to estimate how hard the wind is blowing is difficult for non-meteorologists. However, the isobar pattern does give us an indication of whether increasing or decreasing winds are to be expected.

Note: On Bracknell weather maps there is a wind scale, which can be used to read the wind strength at a given position. (See fig. 8.6.1)
At that position, take the distance between two isobars using a pair of compasses and plot it – at the correct width – on the wind scale in the upper left corner of the map. You can then read the wind speed in knots (kt).

Example: if the distance between the legs of the compasses at 40° NL (40th parallel north) gives a wind strength of about 25 kt., at 70° NL (70th parallel north) it is only about 15 kt.

Thus, the same distance between two isobars means harder winds at lower latitudes than at higher latitudes.

8.4 WIND

**wind: current (displacement) of air*

The wind always blows from high to low pressure. In the process, the wind direction makes a small angle with the isobars.

Buys Ballot's Law

** when your back is to the wind, the low-pressure area is on the left and the high-pressure area on the right (Buys Ballot's Law)*

So the "engine" driving the wind is pressure differential. But the condition of the Earth's surface also affects the wind. Irregularity of the ground, buildings, forests and cities have a strong inhibiting effect on the wind and can make it blustery.

That explains why weather reports often mention that the wind speed over the sea and the IJsselmeer is somewhat higher than over land.
For example, if the mill is on the edge of a large lake, the wind there is much more constant when it blows from the water than from the land.

Between 1200 and 1500 metres altitude, these inhibitory ground influences have all but disappeared. Therefore, the wind speed will often increase with altitude, where it can be very fast at times.
Those higher wind speeds at altitude sometimes cause wind gusts or blustery winds (see 8.4.4)

For the miller, both wind direction and wind strength are important.

8.4.1 The wind direction;

Air flows from an area of high pressure (air surplus) to an area of low pressure (air deficit). The wind follows – at a small angle of about 10 to 20° – the isobars, as we saw above (see 8.3.4).
Over the sea, this angle is smaller than over land because of lower resistance.

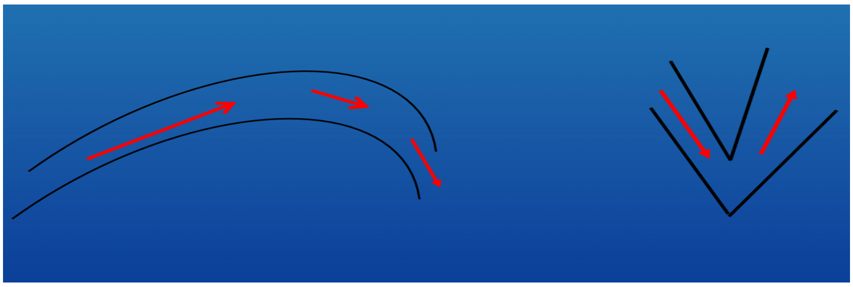


Fig. 8.4.1
The wind roughly follows the direction of the isobars.

At a bend or kink in the isobar, the wind will gradually or even suddenly change direction.

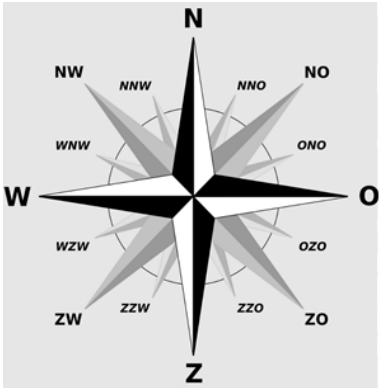
veering wind

** if the wind direction changes with the direction of the Sun, we call it "veering".*

backing wind

If the wind direction changes against the direction of the Sun, we call it "backing".

The direction in which the wind follows an isobar depends on whether the wind flows towards a low-pressure area – counterclockwise – or towards a high-pressure area – clockwise.



** if you expect a bend or a kink in an isobar to pass over the mill, be prepared for the wind direction to change quickly.*

The direction of the wind is named according to where the wind comes from. A southwesterly wind always blows from the south-west, a westerly wind from the west, and so on.

We name wind direction in accordance with the points on the compass. We primarily use the main compass points (North, East, South and West) and the main intermediate points (NE, SE, SW and NW) for this purpose.
A more exact subdivision (into NNE, ENE, ESE, etc.). is not that worthwhile for a miller. A general indication such as: "The wind is southerly/southeasterly" is sufficiently clear

8.4.2 Determining the wind direction from a weather map

If we know where the pressure areas are and how the wind rotates around them, we can determine the wind direction at a particular location.

The general rules in this regard are:
- *air flows away from a high-pressure area in a clockwise direction.*
- *air flows towards a low-pressure area in a counterclockwise direction.*
- *the air current follows the isobars at an angle of 10 to 20°.*

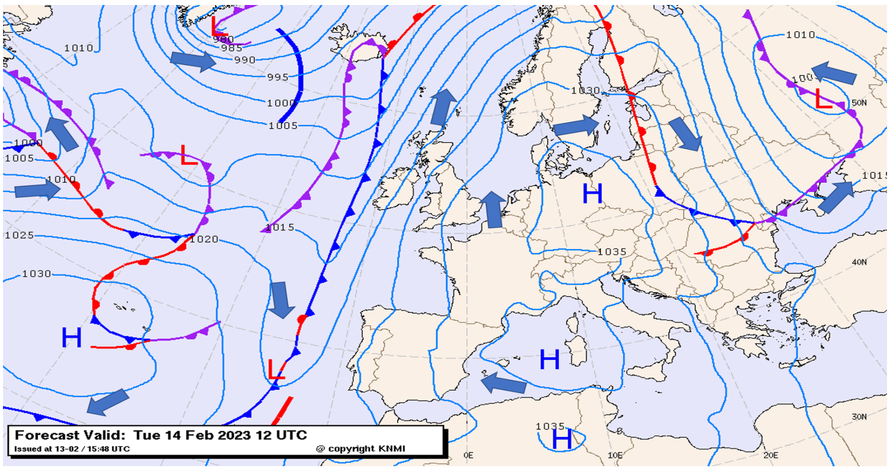


Fig. 8.4.2
The wind direction at a given location is determined by its position relative to the pressure areas.

If the high-pressure area is located:
- to the west of the Netherlands -> a current from the north-west to north.
- to the south of the Netherlands -> southwesterly to westerly winds
- to the north of the Netherlands -> winds from the north-east to south-east.
- to the east of the Netherlands -> southerly winds.

If the low-pressure area is located:
- to the west of the Netherlands -> southerly winds
- to the south of the Netherlands -> easterly winds
- to the north of the Netherlands -> westerly to northwesterly winds
- to the east of the Netherlands -> northerly winds

** our position relative to the pressure area determines the wind direction at that location. The wind direction will therefore change as the pressure area moves.*

8.4.3 Wind speed and wind strength/force

The wind strength at ground level is important to a miller. With too little wind, the mill does not turn; too much wind can pose risks.

wind speed

Wind speed is measured at a height of 10 metres. Due to variations in speed, the average speed is measured over 10 minutes.

Wind speed can be displayed in several ways. In the Netherlands, we do it in metres per second or in kilometres per hour. Bracknell charts use knots (knot, kt): miles per hour.

Beaufort scale

Also often used is the Beaufort Scale, a 13-point scale (from 0 to 12 Bft).
The Beaufort scale indicates wind force – not speed – and is based on the effect of wind on people and the environment.

wind force

To indicate wind force, use is made of descriptions such as: gentle breeze, moderate breeze, strong breeze, gale, strong gale, etc.
Each Beaufort scale covers a range of multiple wind speeds.
Thus, Wind Force 6 – 6 Bft – represents wind speeds between 39 and 49 km/h.

** weather reports usually report regular winds in descriptions: "The wind is weak to moderate from an easterly direction."*

Kracht*	Benaming	Windgemiddelde snelheid over 10 minuten (km/u)	Windgemiddelde snelheid over 10 minuten (m/sec)	Uitwerking boven land en bij mens
0	stil	0-1	0-0,2	rook stijgt recht of bijna recht omhoog
1	zwak	1-5	0,3-1,5	windrichting goed af te leiden uit rookpluimen
2	zwak	6-11	1,6-3,3	wind merkbaar in gezicht
3	matig	12-19	3,4-5,4	stof waait op
4	matig	20-28	5,5-7,9	haar in de war, kleding flappert
5	vrij krachtig	29-38	8,0-10,7	opwaaiend stof hinderlijk voor de ogen, gekuifde golven op meren en kanalen en vuilcontainers waaien om
6	krachtig	39-49	10,8-13,8	paraplu's met moeite vast te houden
7	hard	50-61	13,9-17,1	lastig tegen de wind in te lopen of fietsen
8	stormachtig	62-74	17,2-20,7	voortbewegen zeer moeilijk
9	storm	75-88	20,8-24,4	schoorsteenkappen en dakpannen waaien weg, kinderen waaien om
10	zware storm	89-102	24,5-28,4	grote schade aan gebouwen, volwassenen waaien om
11	zeer zware storm	103-117	28,5-32,6	enorme schade aan bossen
12	orkaan	>117	>32,6	verwoestingen

Fig. 8.4.3
Table of different representations of wind speed/strength and descriptions according to Beaufort.

wind gust

Wind gusts are short-lived squalls or blustery winds of at least 50 mph. They are measured over 3 seconds and are always higher than the average wind speed.

** weather reports always report wind gusts in km/h*

8.4.3.a Wind pressure

wind pressure

The temperature of the air also affects the pressure of the wind on the sail cross. At an equal wind speed, this wind pressure will be greater in winter than in summer. This is because cold air is heavier than warm air. Cold air contains more air particles per m^3 – these are more tightly packed – and is therefore heavier ("denser"). The wind then provides more energy.

Therefore, an easterly wind of 25 km/h at +2°C in the winter season will cause the mill to turn faster than an easterly wind of 25 km/h at 30°C in the summer season.

**at equal wind speed, the mill turns faster in winter than in summer*.

8.4.3.1 Wind speed and isobars

As previously described, wind speed is determined by the distance between the isobars.

As long as the spacing remains the same, the wind speed does not change.
But isobars do not always run parallel to each other. As they get closer together, the wind increases. This is because the pressure differences over smaller distances are then greater. When they are further apart, the wind eases.

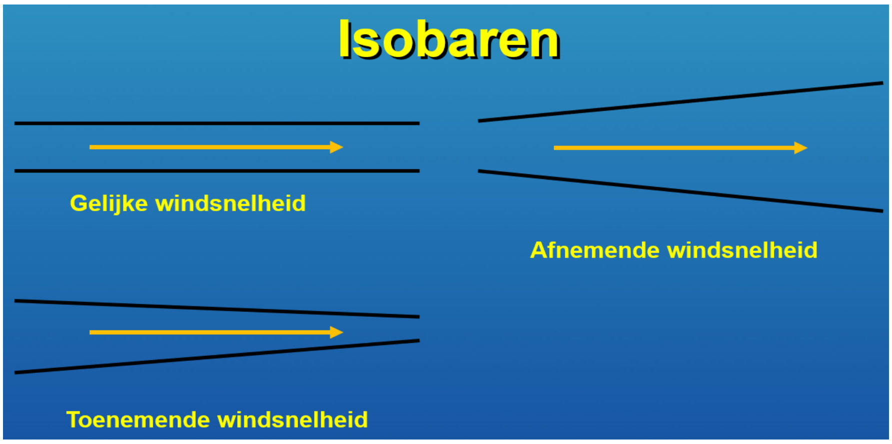
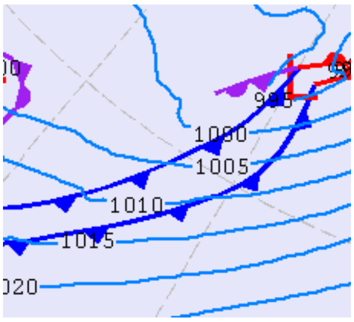


Fig. 8.4.3.1.1
As the distance between isobars changes, so does the wind speed.

Changes in the distance between isobars are seen quite frequently when they are intersected by a front.



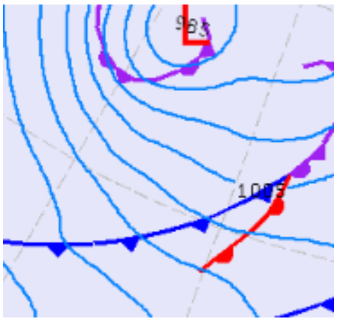


Fig. 8.4.3.1.2

Left: Behind the second cold front, the wind eases.
Right: behind the cold front, the wind gathers strength.

8.4.4 Wind gusts

Wind gusts are short spikes in wind speed; they are always above normal wind speed and last only a few seconds. They often occur during showers, but even without showers, strong wind gusts sometimes occur.

Wind gusts are measured in km/h, m/sec. or knots. They are usually between 60 and 120 km/h, but in extreme cases may reach 150 km/h.
This depends on the heaviness of the shower, the type of shower (rain, hail, snow or thunder) and how strong the wind is at altitude.

(severe) wind gusts

We speak of wind gusts (50-74 km/h), strong gusts (75-100 km/h) and severe gusts (101 km/h and above)
Wind gusts are most dangerous when they come on suddenly during a period of low wind.

wind gusts accompanying showers

One cause of wind gusts during heavy showers or thunderstorms is the precipitation.
The huge mass of falling water – many hundreds of thousands of litres – pushes a lot of air ahead of it, which starts to flow away over the Earth's surface.

A second cause is that large showers disrupt wind bands at about 1 to 2 km altitude – where the wind is almost always stronger than at the ground – and deflect some of it to the ground.
These effects suddenly amplify the wind at the ground: a gust.

> ** Wind gusts are most common at the front of a shower, near the first precipitation.*
> *Important: wind gusts only occur when the cloud has reached the shower stage and rainfall occurs. Not before!* (see 8.8.2)

Outside of showers, (lighter) wind gusts can also occur when thermals form due to heating. (see 8.4.5.1)

8.4.4.1 Wind gusts during storm depressions

Another danger arises with storm depressions. On the ground, the wind over land may soon reach 6-9 Bft, on the coast perhaps 9-10 Bft. At 300 to 500 m. altitude, it can then blow as hard as 11 to 12 Bft: violent storm to hurricane!
As winds begin to ease behind the storm depression, this easing often happens earlier at ground level than at altitude. Winds on the ground may ease to, say, 6 to 7 Bft, while there is still a wind force 10 to 11 Bft at 500 metres altitude.

You do not notice much from that wind at altitude – except that the clouds pass by at great speed – so the miller might consider turning for a while longer. However, any shower, no matter how small, can then bend down under the effect of wind at altitude and cause strong gusts. Much stronger than you might expect!

8.4.5 Daily cycle of the wind

In addition to air pressure, temperature (solar heat) also affects wind speed. We notice this during periods of calm weather when there are few isobars, or: slight pressure differences.

Overnight cooling will make the air heavier and settle down especially at ground level; the wind drops away by evening and into the night.
At some altitude (about 100 to 1500 metres), however, the wind just keeps blowing, although you do not notice it on the ground.

When the Sun rises in the morning, it also heats the air above it via the ground. As a result, the air becomes lighter and starts moving again; it starts blowing (gently). At the end of the day, the Sun's influence diminishes, causing the air to cool, become heavier and settle down again.

daily cycle

This daily cycle of the wind – calm in the morning, moderate wind in the afternoon, calm again in the evening – is a phenomenon just above the Earth's surface.

In these weather conditions, it makes little sense to set the mill's sails too early. For example, even though the weather forecast for the day indicates weak to moderate winds, it is only during the morning that this wind strength is reached.

The day does not always begin calm: If it is already windy around sunrise, then it will be due to a depression nearby which makes the isobars closer together. Even then there may still be a daily movement, but it will be less noticeable than in calm weather.

8.4.5.1 Blustery wind

thermals

The solar heat also gradually creates bubbles of warm air – thermals – which start to rise "like a hot air balloon".
As solar heat increases during the day, thermals become more powerful, reaching heights of between 100 and 1,500 metres. As a result, they disturb the wind at this altitude – which blows harder than at ground level. The disturbed wind bands are then deflected, partly towards the Earth's surface. This may increase the average winds on the ground, often to 3 or 4 Bft and also make them blustery. This blustery wind usually does not reach the speed of wind gusts, namely above 50 km/h.

Towards sunset, the temperature drops and the thermals collapse, eliminating the disturbance of the atmospheric bands at altitude. Ground winds and the blusteriness ease off again.

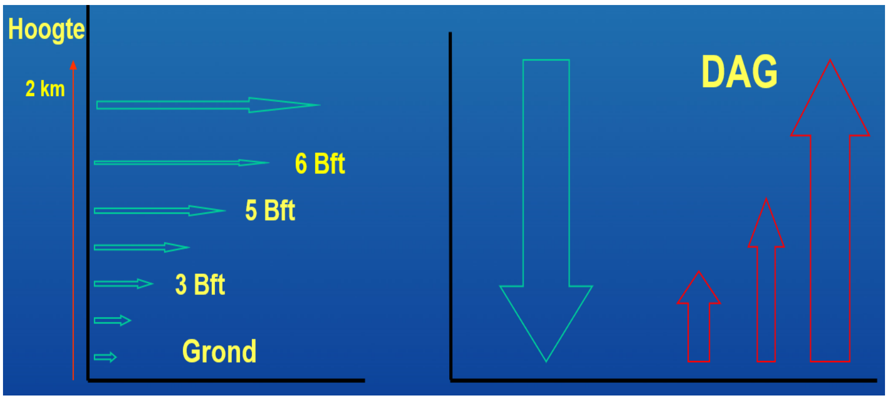


Fig. 8.4.5.1
Rising thermals (red arrows) cause air at altitude – that blows harder – to be partially carried downwards (blue arrow). The wind at ground level increases as a result.

8.4.5.2 Wind increase after front moves away during daytime

We saw above that the warming of air can lead to the formation of thermals, causing winds to increase and become blustery.
A blustery wind occurs not only in calm summer weather, but also, for example, when a front passes during the day with a lot of cloudiness, precipitation and southwesterly winds of about 3 Bft. This means that there is more wind at altitude!
As the front moves away in the morning and the weather clears up quickly, the Sun can warm the air considerably and thermals can form at a rapid rate. Once these reach some altitude they start disturbing the wind there, deflecting some of it towards the ground. As a result, prevailing winds may increase somewhat – by as much as one Bft extra – to 4 or 5 Bft, becoming blustery. With decreasing solar heat, the thermals collapse again and no longer reach the upper air layers; wind and gustiness decrease again.

**warming causes rising air and (to a certain extent) increasing winds and blustery wind.*

The reverse is also possible: warming air can lead to decreasing winds. Rising air can cause cumulus clouds to form. If a large part of the sky becomes covered by cumulus clouds, they limit heating by the Sun and weaken the thermals. The wind and blusteriness will then decrease somewhat.

8.4.6 Sea Wind

Sea wind is a wind that occurs mainly in spring and early summer, from late morning to late afternoon. The prevailing ground wind is almost always southerly to southeasterly and at most moderate, force 2 to 3 Bft.

** sea wind: the initially weak southerly/southeasterly wind flips to a westerly/northwesterly direction fairly quickly in the late morning and can then quickly increase to 3 or 4 Bft and become blustery.*
In the late afternoon, the wind returns to its original direction.

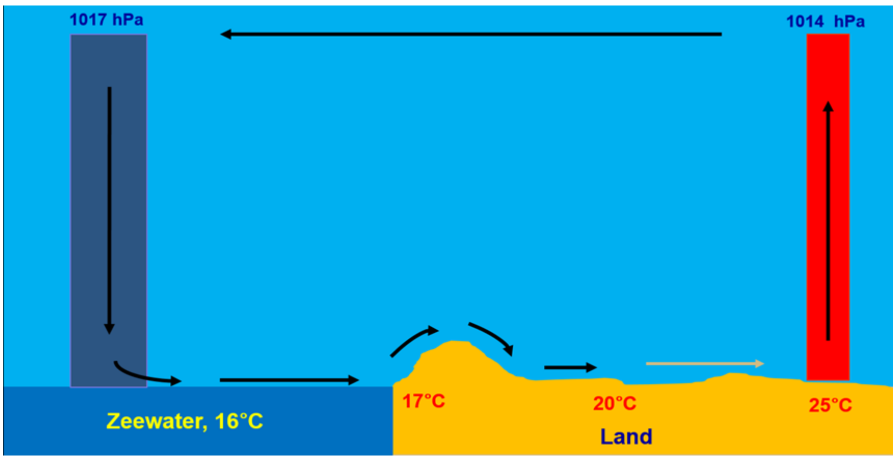


Fig. 8.4.5.1
Sea wind

Warming of the land creates an air deficit there, which is replenished by a current of air from the sea.

Four factors play a role in the generation of sea winds: cold seawater, warm land, moderate offshore winds and day length.

warm(er) land
cold(er) seawater

- The coastal zone is often 8-15 °C warmer than the sea water in spring and early summer. With strong warming of the land under the influence of the Sun, the air rises and a small low-pressure area is formed. To fill the resulting deficit of air, air is drawn in from the colder sea.

A small wind front then moves inland from the coast with a substantial wind shift.
On that wind front, the wind becomes quite blustery and "erratic" before it swings around and comes in from the sea.

sea wind

This is the sea wind and it will occur from about eleven in the morning until about five in the afternoon.

As the temperature again decreases in the coastal zone, the low-pressure area over land disappears and with it the suction effect.
The sea wind disappears.

- In spring, the temperature difference between seawater and land is at its greatest and sea winds will be able to form. Because the days are not so long yet and the warming by the Sun is not yet at its maximum, the sea wind will not be able to develop so strongly that it moves into the whole country.
Sea wind is a local phenomenon and is noticeable as far as central Netherlands – about 60 km inland. Occasionally, it gets as far as Nijmegen.
On a smaller scale, the phenomenon of "sea wind" can also occur along the coast of the IJsselmeer.

(moderate) offshore wind

- If the prevailing, offshore wind is too strong, e.g. more than 3 Bft, it provides too much counterpressure to the air current heading inland and no sea wind is created.

> ** a sea wind is not shown on a normal weather map with isobars, but it is shown on special wind maps.*
> *Weather reports sometimes mention the chance of sea winds.*

Sea wind and the miller
For a miller, sea wind can be a tricky phenomenon. It is a local and fluctuating wind front where the wind suddenly becomes blustery (2 to 4 Bft) and can take a totally different direction.
The wind front can pass the mill fairly quickly or linger for a while.
The front can often be seen coming as humidity suddenly increases and visibility decreases from the west, with some small cumulus clouds at times.

If the mill turns to the south-east because of the prevailing wind, then under the influence of sea winds it will have to turn to the west/north-west at some point.
Quick and timely action may be required to prevent the mill from turning backwards.
Since the wind will also increase, it may also be necessary to furl the sails.

8.5 FRONTS

8.5.1 What is a front?

At fronts, air types push against each other. This can be gradual or with some force. This forces air upwards, cooling it, forming clouds and often producing precipitation.
Fronts can reach the Netherlands all year round. Mostly from westerly directions, but all other directions also occur.

front

** A front is the dividing plane of two air types that differ in temperature and humidity.*
(Fronts on weather maps indicate the intersection of a front with the Earth)

There are great differences in air types over the Atlantic Ocean. Cold polar air of northern latitude lies against mild, subtropical air from more southern latitudes.

polar front

The dividing line between these two air types is the polar front and it is always present somewhere in the North Atlantic.

air type

** an air type is a huge air mass that differs from other air masses in terms of temperature and humidity.*

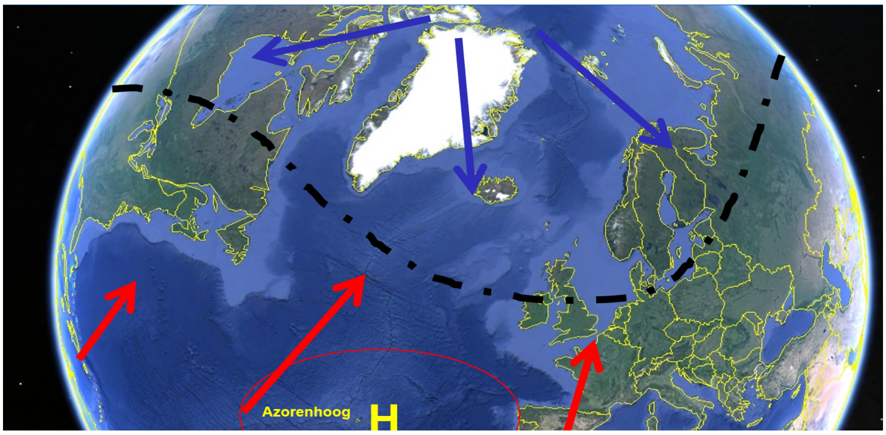


Fig. 8.5.1
The polar front (dotted line).

To the north of it, cold and relatively dry polar air, to the south warm, more humid, subtropical air.
Near the polar front, the jet stream blows.

In spring, the polar front moves northwards and warm air advances further from the south.

Depressions and high-pressure areas then cause the polar front to swing across the Atlantic Ocean and our region. This allows different air types to reach us in the Netherlands from the Atlantic Ocean.

8.5.2 The formation of depressions and fronts

Depressions are accompanied by fronts. They form along the polar front because a wave form is created when the air types pass each other in the polar front.

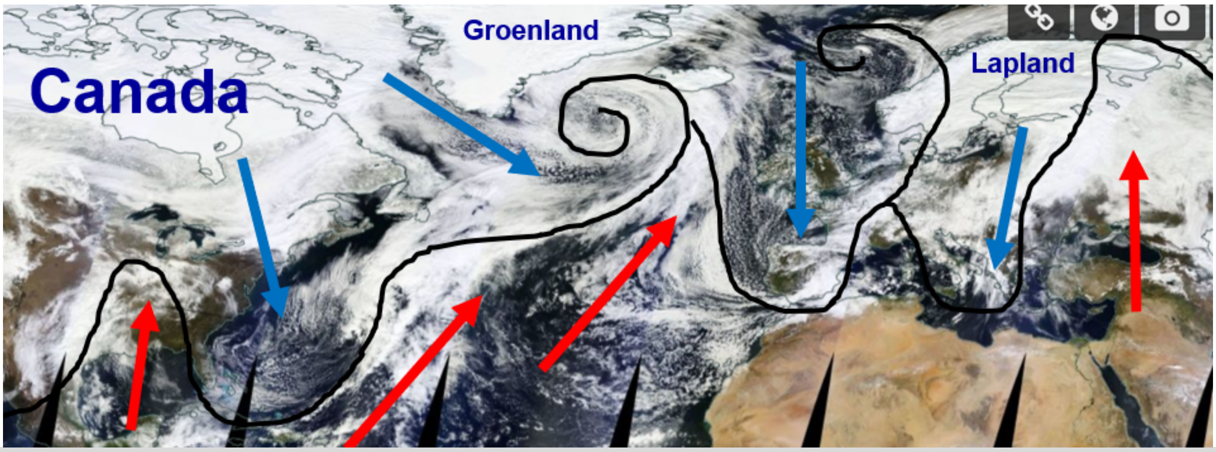


Fig. 8.5.2.1
The polar front swings back and forth from north to south. Movement is mostly from south-west to north-east with alternating warm and cold air blowing in.

Fig.8.5.2.2a: at the polar front, warmer air from the ocean collides with colder air from the poles.

Fig.8.5.2.2b: a frontal wave forms in the interface between the two air masses: the beginning of a depression with a warm front and cold front.

warm front The cold air on the right in the image is succeeded by the warmer air: a warm front

cold front The cold air on the left in the image pushes the warm air away: a cold front.

warm sector A depression in its early stages still has a very large warm sector. This is always on the south side of a depression, given the origin of this air.

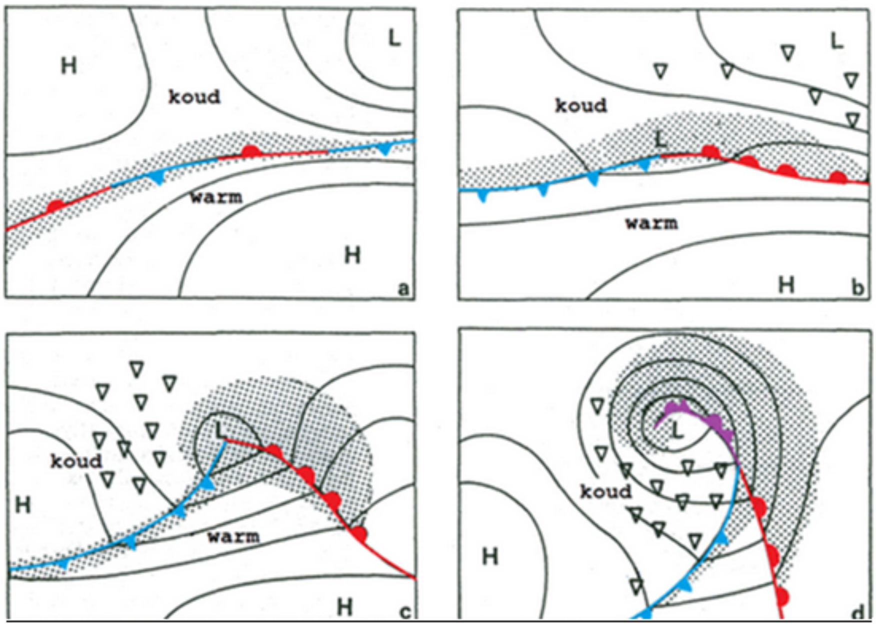


Fig. 8.5.2.2
The formation of a depression with associated fronts along the polar front.
The shading indicates the precipitation zone.

Fig. 8.5.2.2c: cold air is heavier and – once in motion – will move faster than warm air. As a result, the cold front catches up with the warm front, with the warm sector getting smaller and smaller in the process.

occlusion

Fig. 8.5.2.2d: where the cold front has overtaken the warm front, the air in the warm sector is completely pushed upwards; we call this an occlusion. The longer the occlusion gets and the further it turns in, the older the depression is.

Fronts are usually in motion. Cloud and precipitation often form on fronts. Wind direction and wind force may also change.
Consequently, passing fronts have great influence on weather in the Netherlands.

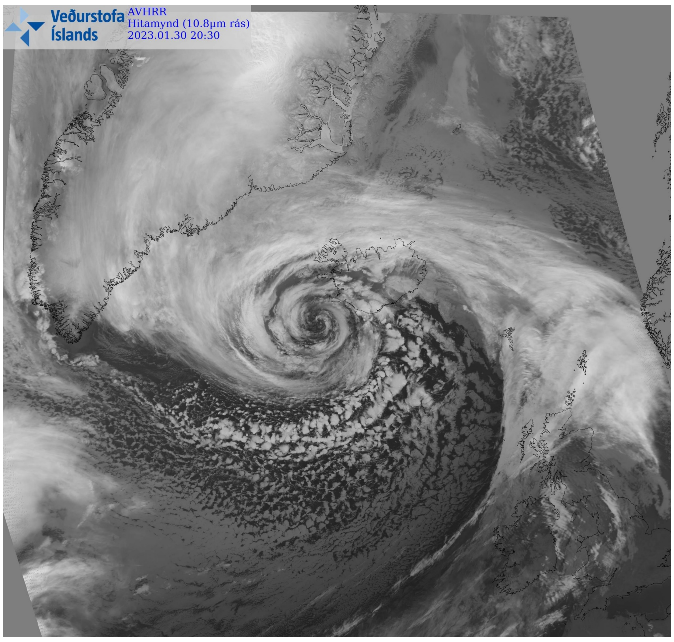


Fig. 8.5.2.3
A large, deep depression

The air flows in a large curl counterclockwise to the centre. The clouds have rotated around the centre several times: this indicates a mature, deep depression with high winds. The white and grey dots are showers behind the cold front.

8.5.3 The warm front

warm front

A warm front is the interface between colder air and warmer air in which the warmer air will drive out the colder air.
Warm fronts are the first to pass over in a depression.

> ** cold or warm is always relative: it says something about the difference in temperature of the two types of air, nothing about the actual temperature*.

Because warmer air is lighter than colder air, the warmer air will slide upwards along the colder air. This happens fairly quietly over a large area.

The angle of inclination of the frontal plane with the ground is quite small, about 30°.
Therefore, the frontal plane – with warmer air and increasing cloud above it – may already be above us while we are still in colder air and the ground warm front is still hundreds of kilometres away.

warm sector

The warmer air eventually pushes the colder air away, lastly on the ground. Behind the warm front is the warm sector.

A warm front is usually followed by a cold front. This cold air moves faster than the warm air, so the warm sector gets smaller and smaller and finally disappears. The warm air is pushed upwards in the process.

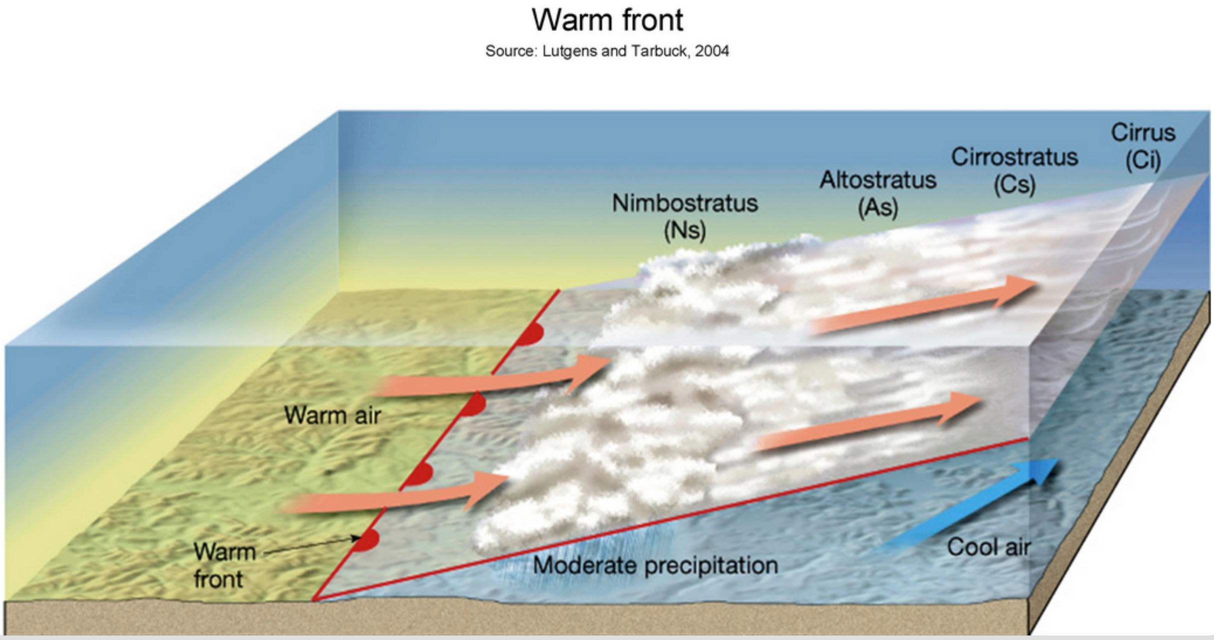


Fig. 8.5.3
A warm front.

The lighter warm air slides upwards against the heavier cold air. In the process, clouds form that thicken as the ground front approaches. Precipitation (drizzle or rain) often falls in front of the ground front.

8.5.3.1 Cloud cover and precipitation at a warm front

The warm air slides upwards from ground level to as high as 5 to 8 km altitude. In this process, the rising air cools and gradually creates a layered packet of clouds.
At the leading edge of the front, at kilometres' altitude, it freezes heavily and a thin layer of clouds (cirrus) forms. This consists entirely of ice crystals.

halo

The layer of cloud cover thickens (cirrostratus). Cirrostratus also consists of ice crystals. Initially, this allows the Sun to still be seen and sometimes a halo forms. A halo is a circle around the Sun that can be seen regularly in cirrus and cirrostratus when these are not yet too thick.

> ** a halo is often a harbinger of an approaching warm front, as is a beautiful red sunrise.*

Fig. 8.5.3.1.1
Left: a halo with left and right parhelion in high, increasing cirrus clouds.
Right:
There is a saying that goes: "Red sky in the morning, sailors take warning".

Red sky in the morning is caused by a lot of moisture in the atmosphere, which is characteristic of an approaching warm front with rainy weather. Incidentally, that front does not have to pass exactly over the Netherlands.

The thickness of the cloud cover increases even more: altostratus, nimbostratus and stratus clouds develop close to the ground. The sky is then completely grey. From this, a wide area of rain and drizzle often forms ahead of the ground front. (Fig. 8.5.3).
The slower the front moves, the longer the period of precipitation.

** as it starts to drizzle or rain, the ground warm front approaches.*

When the warm front has also passed at ground level, most precipitation ceases and temperatures (warm sector!) and humidity increase rapidly.
In the warm sector that follows, it is often cloudy with occasional rain or drizzle remaining, especially in the autumn, winter and spring seasons.

** note that a wind shift may follow during the passing of the ground front!*

Fig. 8.5.3.1.2
With an advancing warm front, clouds increase rapidly at altitude.
The Sun is still just visible "as if through frosted glass".
(The clouds move from lower right to upper left)

Points of interest in a warm front passage

- sometimes a quick wind shift (veering!) upon passage of the ground front.
- possible rapid wind increase (within 10 minutes) after passage of ground front, especially in winter. Check out the weather maps!
- especially in winter when there are large temperature differences before and after the warm front, the wind directions can be at right-angles to each other. (Fig. 8.5.3.1.3)
- in winter chance of freezing rain. (For occurrence of freezing rain, see 8.8.1)

8.5.4 The cold front

cold front

A cold front is the interface between warmer air and colder air in which the colder air will drive out the warmer air.
This expulsion is usually quite fast because the colder air is heavier than the lighter and softer air and it is moving faster.
The angle of inclination of a cold front is therefore greater, about 60°; the frontal plane tilts backwards. As a result, cold air enters first at ground level, then at altitude. (Fig. 8.5.4)

After passage of the cold front, we enter colder air; temperatures drop and humidity decreases. Bright spells often occur, possibly interspersed with showers.

** note that a wind shift may follow the passage of the ground cold front!*

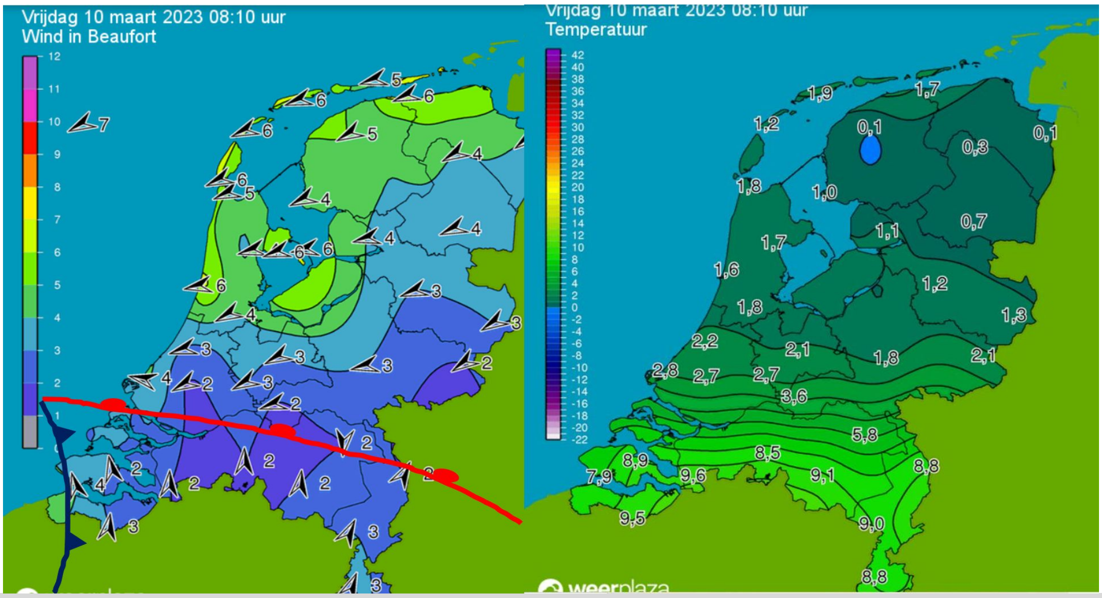


Fig. 8.5.3.1.3
Very large differences in wind direction and temperature can occur around a warm front. Ahead of the front, a moderate to strong northeasterly wind and 1-2 °C, behind it a weak southerly wind and 8-10 °C (maps Weerplaza.nl)

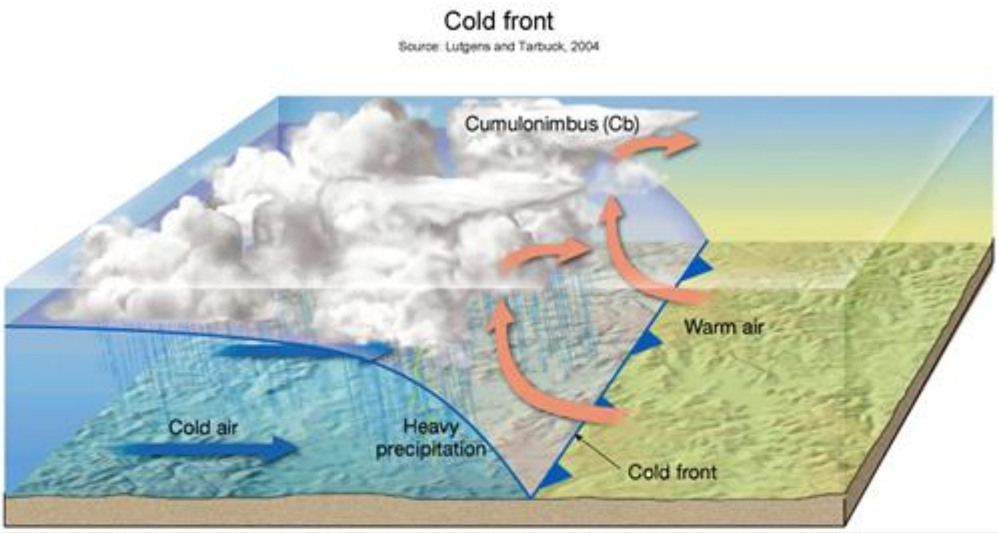


Fig. 8.5.4
A cold front
Due to the steepness of the cold front, warm air is quickly pushed upwards. This may give rise to rain and thunderstorms. Because the cold air enters first at ground level, most precipitation falls behind the front.

8.5.4.1 Cloud cover and precipitation at a cold front

Because of the steepness of the cold front as well as the greater speed of the approaching cold air, the warmer air is quickly pushed upwards. In the process, clouds form from which precipitation may fall. This is a very different type of cloud than that along a warm front. They include cumulonimbus, shower clouds.

The precipitation may consist of showers but light to heavy rain may also fall. It usually passes over quite quickly.

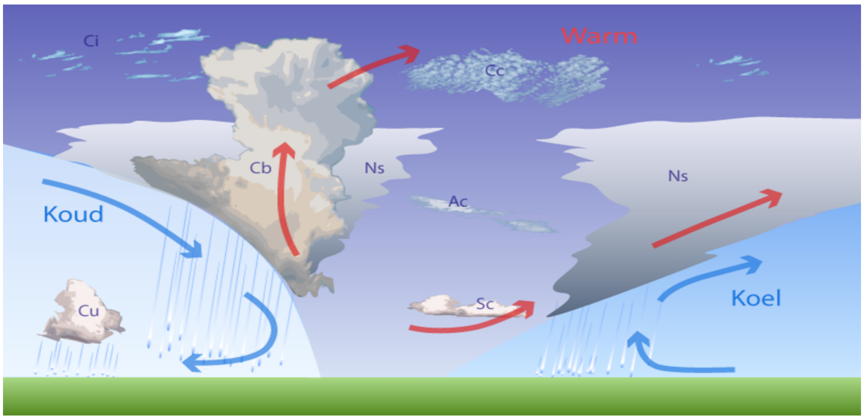


Fig. 8.5.4.1.1
Angle of inclination of fronts

Due to a different position of the front, a different type of cloud cover also develops.
In the middle, the warm sector.

Points of interest during a cold front passage: -.

- wind shifts during passage of ground front; always veering!
- a lot of wind around the cold front, often just before and on the front
- 'embedded' lines of showers on the front with wind gusts and possible thunderstorms.

Fig. 8.5.4.1.2
Back of cold front

The rain has passed. Colder and drier air usually streams in. The bright spells are already visible. (The clouds are moving towards us)

8.5.4.2 Cold fronts at storm depressions

We speak of “storm depressions” when the depression has a wind area with at least wind force 9 at the ground for some time: storm.
They occur mostly in the autumn, winter and spring.

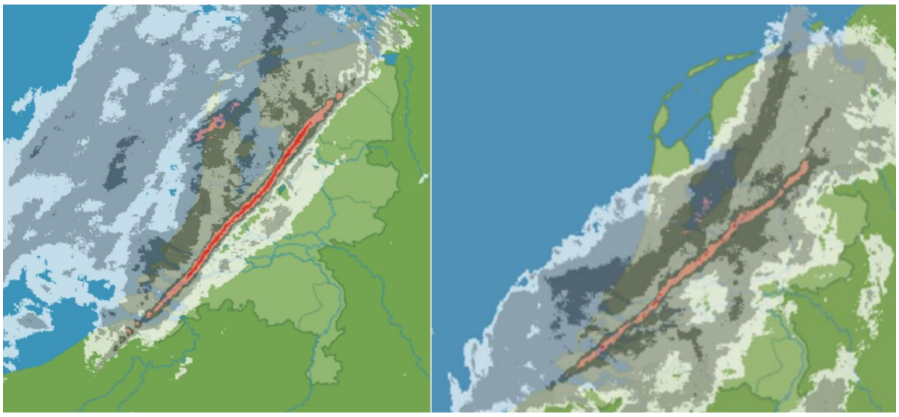


Fig. 8.5.4.2
Examples of very active, narrow lines of showers on a cold front. They can be located at the front or deeper in the precipitation area

With storm depressions, cold fronts can consist of a narrow line of showers with sharp wind gusts, hail and thunderstorms.
These fronts are embedded in a larger rainfall area. They are clearly visible on radar. They are fast-moving lines of showers that pass in about 5 to 10 minutes, with a rapid wind shift.
While they certainly carry danger, the winds will usually be too strong to allow turning. But properly secure a stationary mill in any case.

8.5.5 Occlusion

occlusion

Occlusions are fronts where the warm front has been overtaken by the cold front. Because a cold front moves faster than a warm front, the cold front catches up with the warm front.
The softer air on the ground in the warm sector disappears in the process and is pushed upwards and slowly starts to cool.
Towards the ground, the two cooler air types lie against each other. The dividing plane is called an occluded front or occlusion for short.

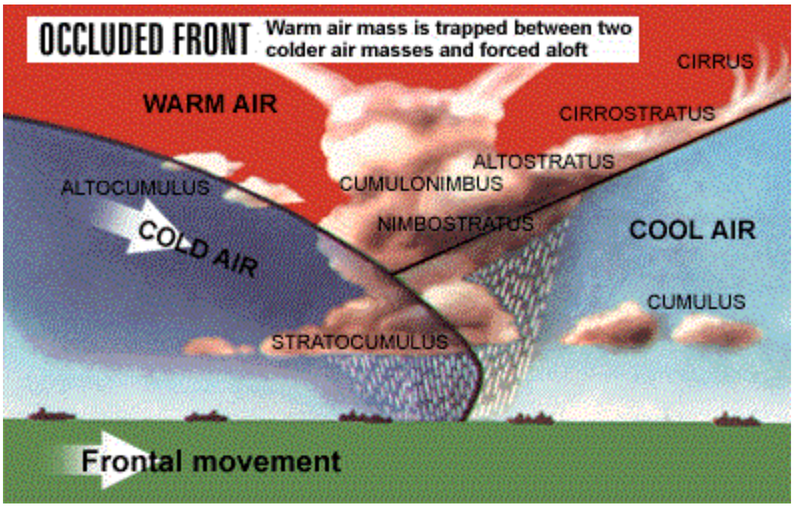
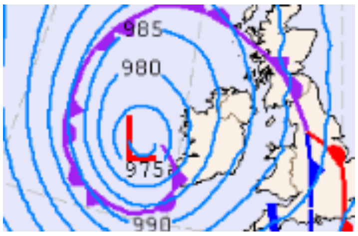


Fig. 8.5.5
An occlusion

The warm air is pushed upwards by the colder air.



Occlusions "curl" around the centre of a low-pressure area.
That can happen to such an extent as to come back east at the bottom of the centre ("back-bent").
Depending on the trajectory and your position, such an occlusion could then pass over the mill twice.
If the wind blows hard, they can "break off" and come through as an individual piece of front.
** when occlusions pass by, we can expect a wind shift.*

8.5.5.1 Cloud cover and precipitation at an occlusion

Cooler air lies on either side of an occlusion. Precipitation on an occlusion can therefore be any type whatsoever: heavy rain, light rain, drizzle or showers or even thunderstorms.
Precipitation can be expected anywhere around the occlusion front.
As far as clouds are concerned, everything that occurs with warm fronts and cold fronts can occur, which is not surprising as it is a "remnant" of these fronts.

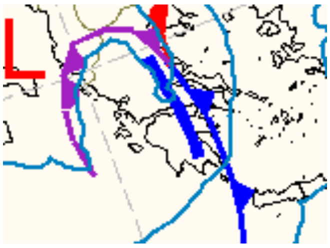
> ** around an occlusion, there is a chance of high winds, rain or thundery showers and substantial wind shifts (up to 180°)*

8.5.6. Troughs

trough

squall lines

A trough (also known as: upper-level trough) is a shower disturbance that occurs behind cold fronts. The showers will involve isolated or clustered showers, sometimes including squall lines that are a bit heavier with a chance of thunder, wind gusts and possibly hail.
Troughs emerge from south-west to north. They are common throughout the year in the Netherlands.
On weather maps, a trough is indicated by a thick **blue** (or black) line behind a cold front.
Note: Although a trough occurs at altitude, it is still drawn in the weather map – which otherwise represents the ground situation (see 8.6.1). This is because of the great influence a trough can have on the weather.



What is a trough?
A trough is a large bubble of extra-cold air at altitude, usually about 3 to 6 km. This cold air moves and forcibly pushes away the warmer air in front of it. The air becomes temporarily unstable and cloud formation occurs.

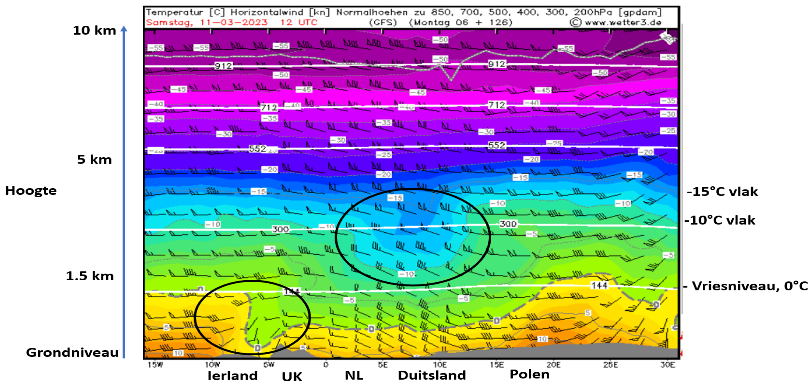


Fig. 8.5.6
Temperature build-up in the troposphere.

Big circle: a trough – a bubble of cold air – that descends. The -10 °C line drops about a kilometre.

Small circle: over Ireland, a warm front approaches with a wall of warm air.
The frost level (0 °C line) is lifted about 1 km.
Near Poland, a cold front with a wind shift from SW to NW.

rain cloud

This usually involves the formation of cumulus clouds, including cumulonimbus (Cb) or shower clouds. Thus, a trough often produces showers. Incidentally, these decrease again quickly once the trough passes over.

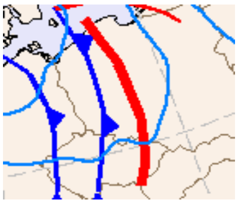
Around a trough, the isobars are often a bit closer together, which will increase

winds. Also, the wind usually turns more clockwise or veering
.

** a trough often produces (strong) showers and temporarily increasing, veering winds.*

On radar, an area of showers belonging to an upper-level trough can be identified by the somewhat heavier precipitation and sometimes by a line shape in the showers.
From the mill however, an upper-level trough is difficult to spot by eye.
These are showers that pass over, which are often scattered over the entire horizon. Troughs are usually embedded in an area where showers occur anyway.

8.5.7 Convergence lines



A convergence line is a disturbance in the warmer air. Large rainstorms or thunderstorms often form here, which can lead to severe weather. Convergence lines occur in south- to south-west currents, especially between May and September.
On weather maps, a convergence line is indicated with a thick **red** (sometimes black) line, always ahead of a cold front: that is where the warmer air is located.

What is a convergence line?
A convergence line is an area of lower pressure due to large land heat, which causes air to rise. This air collides with colder air over the Bay of Biscay and the British Isles. This always happens on the leading edge - warm side! – of a cold front. In the process, a considerable upward movement of warm air occurs and huge cumulus clouds and large rainstorm and thunderstorm complexes often form.
Sometimes several convergence lines form in succession, each with its own area of showers.

Convergence lines gather with showers or cause them to form at a rapid rate. During the showers there is a wind shift and the wind turns to south-west to west and cools. However, the cold front does not follow for some time!

Fig. 8.5.7
Altocumulus floccus and castellanus.

This type of cloud is often a harbinger of approaching thunderstorms.
The upper air has already thickened due to large anvil clouds.

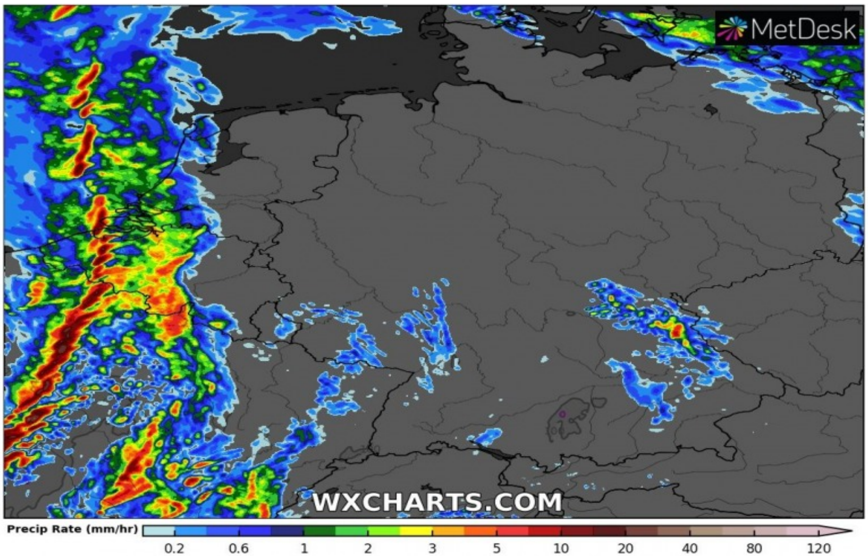
The showers are sometimes preceded 6 to 8 hours earlier by indicators of unstable weather, such as Altocumulus floccus or Altocumulus castellanus ("tower clouds")

Points of interest for passage of a convergence line:

- rapidly developing heavy rainstorms and/or thunderstorms, (large) hailstones
- strong or severe gusts of wind
- rapid passage
- wind shift

Fig. 8.5.7.1
Wind shift on a convergence line

A heavy shower line – dark yellow and black spots – is over Zeeland, among other places, and is moving NE.
Precipitation amounts of 10-20 mm/h are possible.



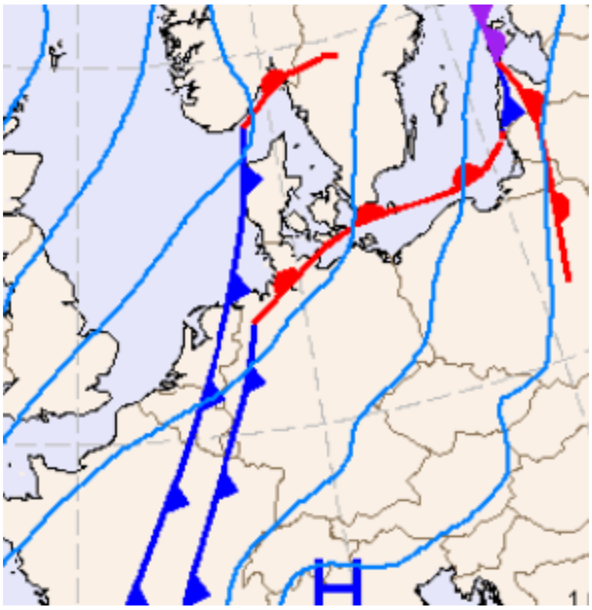
8.5.8 Frontal waves

frontal wave

It is common for a jet stream to attempt to form a depression but fail. Everything then is not neatly "in phase". The front will kink with formation of a warm front and cold front but no low-pressure area will form. We call that a frontal wave. Only a warm sector then forms, often without an occlusion.

Fig. 8.5.8
Frontal waves

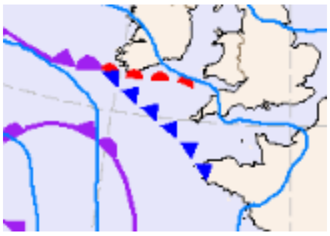
Two frontal waves move across the Netherlands into southern Sweden with little wind.
From the isobar pattern, something can be deduced about the amount of wind and wind shifts.



With frontal waves it is important to pay attention to the isobars. On the south side of such a wave there can be a lot of wind, while "at the top" there is little wind.
A frontal wave generally has no counterclockwise wind rotation "at the top" as

no depression centre will form. However, considerable wind shifts may occur. If such a wave passes exactly over the central Netherlands to the east, it can be almost windless in the north and wind force 7-8 Bft from the south-west in Brabant and Limburg.

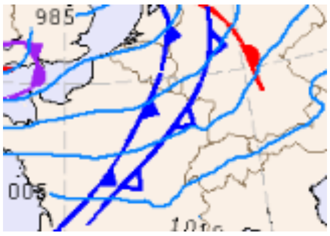
8.5.9 Dissolving fronts



Fronts can dissipate as the air type differences (temperature and humidity) become smaller or as higher pressure begins to build up over part of the front, which will reduce the shifting of air types.

Dissolving fronts are represented on a weather map by unconnected circles or triangles.
They no longer have a great deal of influence over the weather.

8.5.10 Upper-level fronts



Fronts can split in two and then pass over separately. This can be the case with warm fronts or cold fronts, as well as occlusions.

For example, due to extreme winds higher in the air, the original fronts are torn apart into two sections at a certain altitude and the upper part of the front becomes detached from the lower part. Both then take on a life of their own.

On a weather map, upper-level fronts are represented by open triangles or open circles

8.5.11 Young and old depressions

Above we saw the formation of pressure areas and fronts (8.5.2) and the close relationship between the two.
Both are experiencing development: they emerge but also disappear again after some time as the air pressure differences decrease.
Whether a depression is young or already disappearing affects the weather around such a depression.

young depression

Young depressions are developing with fronts. There is clearly a large warm sector with warm and cold fronts but troughs are not actually occurring yet. Also, the occlusion has not formed yet.
A lot of time may elapse between the passage of the warm front and the cold front following behind it.

Young depressions are important because it is precisely at these low-pressure areas that there can be a lot of wind with large drops in air pressure.
Most precipitation around fronts also falls from young depressions.

older depressions

In older depressions, the occlusion gets longer and longer and can curl back up to below the centre. Also, a long occlusion often breaks into pieces.
With the formation of the occlusion, the warm sector disappears.
Upper-level troughs also usually form. There may be wind, but the distance between the isobars increases and the wind decreases. The fronts become less active in terms of precipitation.

Where the fronts are not yet occluded, the cold front may follow soon after the warm front.

8.6 WEATHER MAPS

8.6.1 What is a weather map?

A weather map is a simplified graphic representation of the air pressure pattern on the ground, usually in combination with fronts, viewed from above and represented as a flat surface.

analysis map, forecast map

Weather maps come in two types: analysis maps and forecast maps.
The analysis map is drawn based on current conditions, such as measured air pressure and radar images of precipitation. The forecast map shows what the computer expects ("calculates") for the next few hours.
By placing some maps from different points in time next to each other, changes become visible.

UTC time

Weather maps always show the date and time. When UTC time is mentioned, for the Netherlands it is UTC+1 hour (standard time, 1 hour later) or UTC+2 (DST, 2 hours later)

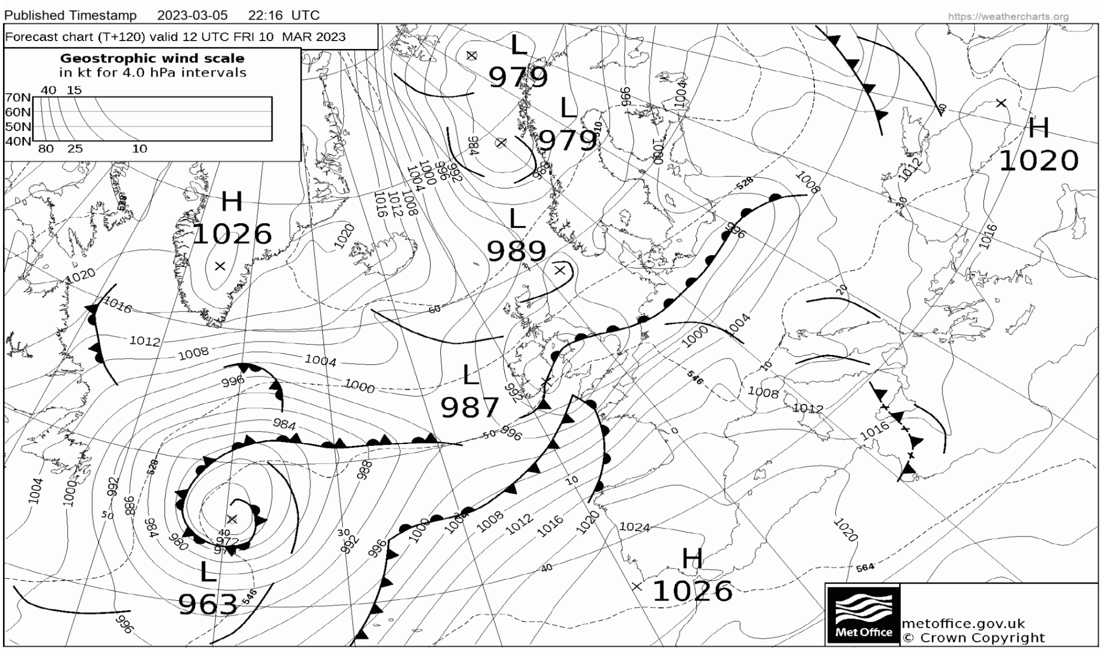


Fig. 8.6.1
A Bracknell weather map from the UK Met Office. These maps are always displayed in black and white.
The isobars are drawn every 4 hPa (millibars); at KNMI it is every 5 hPa.
Forecasts are given from 12-120 hours ahead. The issue date of this forecast is 5 March 2023, the forecast (Forecast, T+120) is 120 hours ahead, that is, for 10 March at 12 UTC.
Note that due to the type of map projection the meridians do not run parallel to each other or straight up to the North.

8.6.2 What do we see on a weather map?

8.6.2.a Pressure areas and isobars

isobars
pressure areas

A weather map shows isobars: lines of equal air pressure.
These lines form patterns that show where areas of high and low pressure are located

** on KNMI maps isobars are drawn as blue lines* *high-pressure area*

At the centre of a high-pressure area is an **H**(High) along with the highest pressure in millibars or hPa (hectopascal).
Around this are the isobars that represent decreasing pressure, often by 4 or 5 millibars or hPa.

low-pressure area

At the centre of a low-pressure area is an **L**(Low) or a T (German Tief). The centre is enclosed by isobars, with pressure rising outwards.

Earlier we saw how the current is around a high-pressure and a low-pressure area:
- at high pressure: clockwise from the centre.
- at low pressure: counterclockwise towards the centre.

wind direction

The wind direction is not shown on the map, but can be easily inferred from the isobar patterns (see 8.4.2).
When isobars start to bend it indicates a change in wind direction.

wind increase

If isobars draw closer together then we can expect an increase in wind.

wind decrease

As isobars draw further apart, the wind starts to decrease.

8.6.2.b Fronts

warm front, cold front:

A weather map also shows warm and cold fronts, either in colour or black and white. In a black and white representation, look out for circles or triangles. Circles and triangles indicate the trajectory of the front.

angle of inclination of fronts

The positions of fronts are shown at about 1.5 metres above the ground.
Keep in mind that frontal planes have an angle of inclination: as a result, the front in the upper air layers is located somewhere other than near the ground.

> ** a warm front can already extend over our heads – with the upper air already changing – while the front line drawn on the map is still hundreds of kilometres away.*

The representation of fronts:

warm front

– Warm front: red line with red semicircle or a black line with black semicircles. The semicircles are on the side towards which the front is moving.

cold front

– Cold front: blue line with blue triangles or black line with black triangles. The triangles are on the side towards which the front is moving.

occlusion

– Occlusion: purple line with alternating purple triangle and purple circle. The triangles and circles are on the side towards which the front is moving.

upper-level front

– Upper-level fronts: these fronts are represented in blue, red or black with open semicircles or open triangles.

dissipating front

– Dissipating cold fronts or warm fronts. Here only the circles or triangles are displayed - that is, without a line - in red, blue or black.

stationary front

– Stationary front; this is a front at rest, often in a high-pressure area. The air type separation is present but the air types are "at rest" next to each other and the front is stationary. Circles and triangles alternate *trough*

– Trough (or squall line): blue line behind a cold front (shower disturbance,)

convergence line

– Convergence line: red line ahead of a cold front. Sometimes still represented in herringbone.

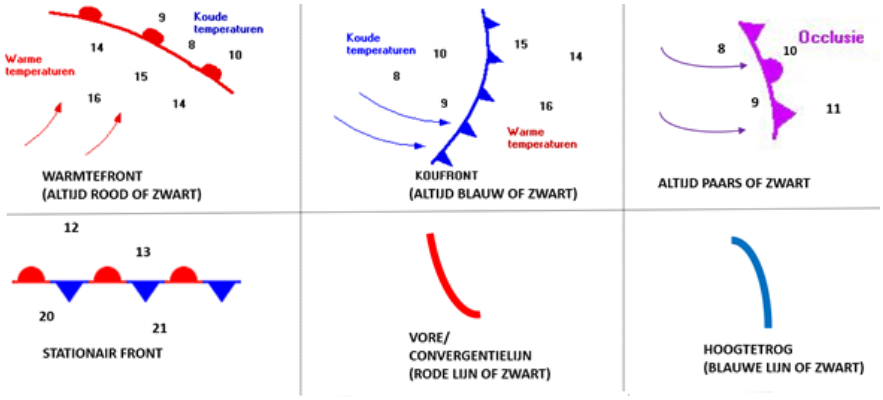
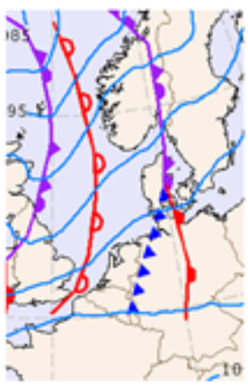


Fig. 8.6.2.1
The representation of fronts, occlusions, convergence lines and troughs on weather maps.



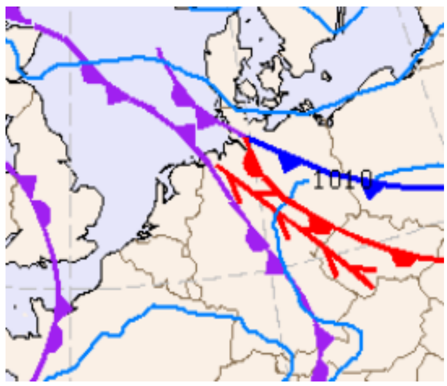


Fig. 8.6.2.2
Left:
Open circles or triangles: an upper-level front.
Separate triangles or circles: a dissipating front.

Right:
A convergence line is still sometimes shown as herringbone.

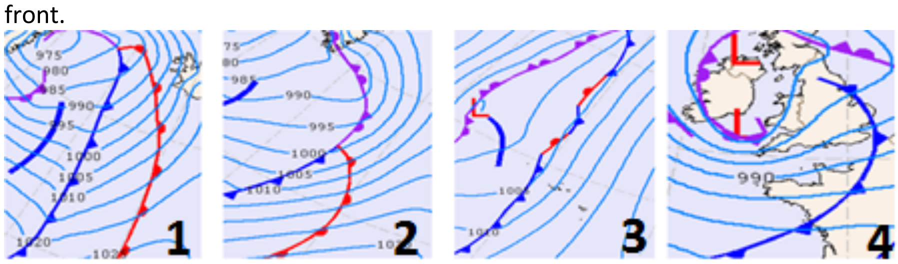
8.6.2.c. Wind shifts

wind shifts

Bends and kinks in isobars are important. These indicate that the wind will change direction. This can be gradual (for a bend) or very fast (for a kink).
Wind shifts occur mostly around fronts – but certainly not only there.
They are usually easy to see on a weather map, although in reality wind shifts can be larger than the weather map suggests.

A wind shift can be small – the wind then turns from south-west to west-south-west, for example, i.e. about 22 degrees – to as much as 180 degrees in extreme cases, with the wind suddenly turning from south to north.

In addition to wind direction, wind strength can also change with a wind shift on a front.



1. Wind shift on coldfront, wind strength does not change. 2. Wind shift on coldfront, strength declines. 3. Wind shift on coldfront, wind strength declines 4. Wind strength rises.

Fig. 8.6.2.3
Wind shifts on cold fronts.

When wind shifts occur, the wind direction changes. Sometimes the wind strength changes as well.

8.6.2.d A ridge of high pressure

ridge of high pressure

A bulge of a high-pressure area is called a ridge of high pressure.
It makes no difference whether a high-pressure area is to the north or south of us. A ridge of high pressure always lies between two depressions.

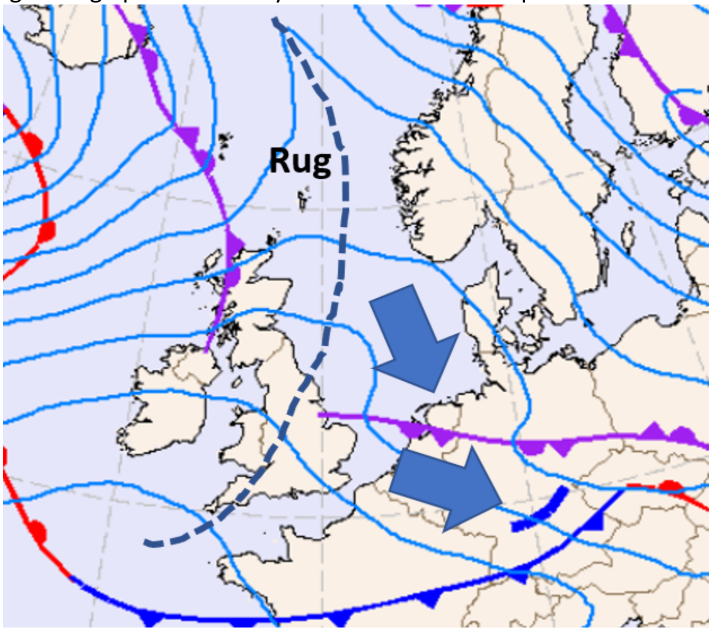


Fig. 8.6.2.4
A ridge of high pressure and a wind shift at an occlusion.

The occlusion moves in southwesterly direction over the Netherlands.
In the process, the wind turns from west-northwest to north-northwest. The moderate wind is relatively unchanging.
Dotted line: a ridge of high pressure with a large wind shift in the tail end.

The ridge always has bent isobars, from the high-pressure centre outwards. The bend may be weak or quite sharp. The sharper the bend, the greater the wind shift.
A characteristic of a ridge of high pressure is that it brings a weather improvement but also often causes winds to drop and shift.
Decreasing winds mean that the effect on a mill is usually not all that great.

8.6.3 Reading a series of weather maps.

By reading several weather maps in succession, for example the 06.00, 12.00 and 18.00 maps, you can see how quickly and in what direction pressure areas are moving and whether the air pressure will change.

change of atmospheric pressure

This allows you to estimate roughly how quickly to expect changes.
We can see how isobars will move over our region and whether there are kinks in them. This allows an estimate to be made of wind increase or decrease and (change of) wind direction.

change of wind strength
change of wind direction

passage of fronts

We can also see which fronts may be moving over our region. That may be an indication of forthcoming precipitation.

If we want to know more details, other information will be needed.

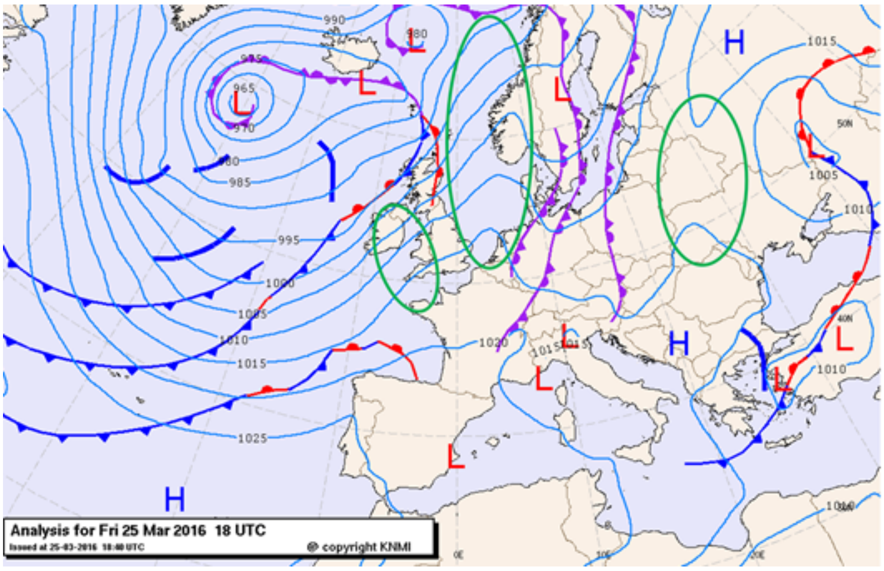


Fig. 8.6.2.5
Some ridges of high pressure. (outlined in green)
These are bulges of a high-pressure area located between two low-pressure areas. They point to a weather improvement.

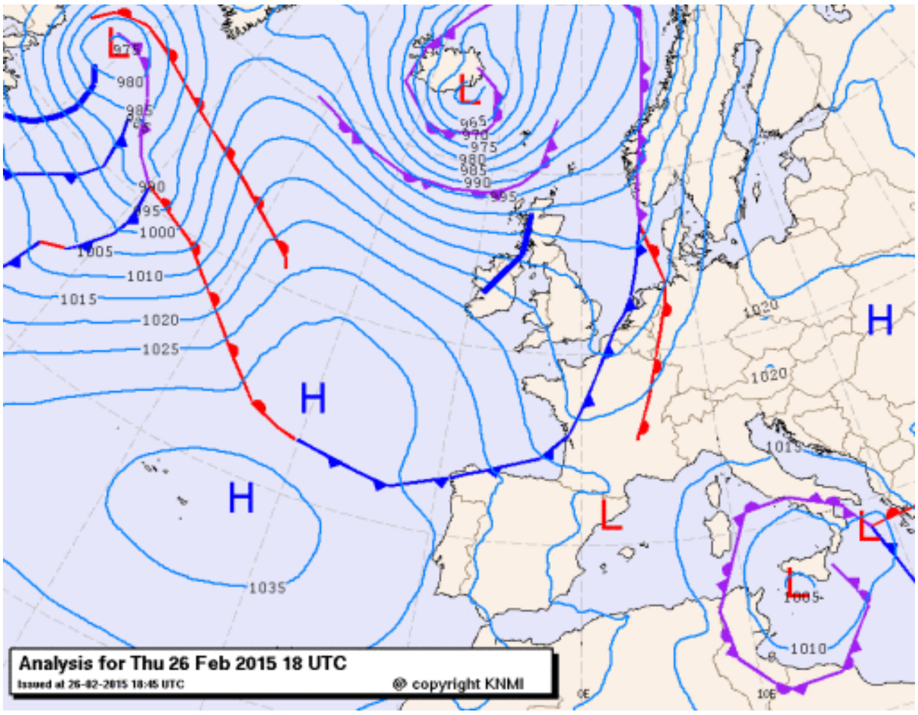


Fig. 8.6.2.6
A ridge of high pressure and wind shifts.

A cold front passes over the Netherlands. The substantial bend in the isobars will give a significant change in wind direction.
To the west of Iceland is a ridge of high pressure with a significant wind shift.
At the southern warm front and cold front SW of Greenland, also substantial wind shifts.

* *around fronts you can almost always expect a change in the weather.*

Note: not displayed on weather maps: wind strength and wind direction, cloud cover, precipitation, temperature and humidity.

8.7 CLOUDS

Clouds are visible fields of moisture that float in the air and have no contact with the ground. They come in many types and sizes.
They occur between 10 metres high (very low stratus - St) and nearly 18 km high anvils of showers (cumulonimbus - Cb).

(supercooled) water droplets
ice crystals

Clouds consist of water droplets, supercooled water droplets and/or ice crystals, depending on the type of cloud, how high in the sky they occur, the temperature there and the season.
Fog looks like a cloud on the ground but is not a cloud.

As an aside: the formation and dissipation of clouds – a physical phenomenon.

Emergence of clouds.

humidity

Although it is invisible, air always contains water vapour. It has a certain level of humidity. In moist air the humidity is high, in dry air it is low.

saturated air/ unsaturated air

This is indicated in percentages, for example 53% or 87%. If the humidity is 100%, then we refer to it as saturated air, otherwise it is unsaturated air.
However, the amount of water vapour the air can contain is not always the same: warm air can hold more than cold air.
Important: unsaturated air becomes increasingly saturated as it cools.

condensing

As air rises it cools – for example, at fronts or in a low-pressure area or because of heating by the Sun. The colder air can hold less water vapour and becomes increasingly saturated. Once the saturation point (100%) is reached and the air cools even further, the water vapour condenses: it turns into droplets. These are visible: a cloud.
This is a familiar phenomenon: during cold weather, our breath forms miniature clouds!

As the air rises even further – and becomes even colder – the water droplets first become supercooled, i.e. colder than 0 °C, but they still remain liquid. When it cools further to about -8 °C to -12 °C, they turn into ice crystals.
High clouds such as cirrus and cirrostratus therefore consist of ice crystals. Cumulonimbus does too, especially in the tops (the anvil).
Clouds are thus composed of water droplets or a mixture of supercooled water droplets and ice crystals.

Cloud dissipation.

evaporating

The reverse also happens: cold air becomes warmer as it descends. For example, at the end of a summer day, when the Sun's heat begins to wane. But also in the centre of a high-pressure area. As it descends, the temperature of the air increases. At some point, the water droplets in the cloud start to evaporate again: they turn into water vapour. This is invisible: the cloud dissipates.

dew point

The term "dew point" sometimes appears in weather reports, particularly for aviation. This is the altitude at which air temperature is such that water vapour will condense and the cloud begins to form.

Therefore, on such a day, the bases of clouds are usually at the same altitude. This is especially evident with cumulus clouds.
Incidentally, depending on humidity and temperature, the height of the cloud base will often vary from day to day.

With equal humidity and in cold rising air, cloud formation is more likely to occur than in warmer rising air.
However, cloud formation may also fail to occur in very dry air. This is because the rising air does not become saturated so condensation does not occur.

8.7.1 The classification of clouds

high, middle, low and vertically developed clouds

We broadly denote clouds as high, medium and low clouds and vertically developed clouds (Ns and Cb).
Vertically developed clouds can give (a lot of) precipitation.
Note: "nimbo" means rain, "stratus" means layered.

Clouds are classified by genus (e.g., Cumulus) and types (e.g., congestus, "saturated"). Example: Cumulus humilis, "small cumulus".
Sometimes they are given an additional designation (e.g., undulatus, "wavy")
Abbreviations are used for all these names, e.g. Ac, CS, St, etc. (Fig.8.7.1)

Not all of them need to be known by the miller. But knowing some names of common clouds, especially around fronts, is necessary.

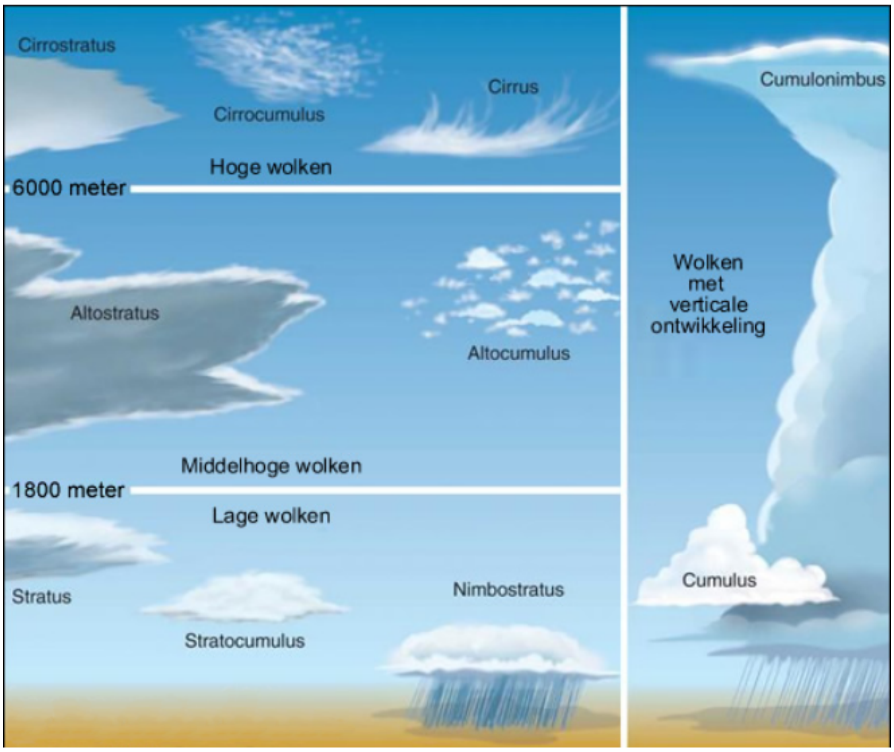


Fig. 8.7.1
An overview of cloud classes and the altitude at which they occur.

8.7.2 Frontal clouds

Frontal clouds are clouds that occur around a warm front or cold front, or an occlusion. They consist of layers of clouds resulting from the rising of air types or as fronts dissipate. These layers (cloud decks) can be thin, so that the Sun can still shine through them "as if through frosted glass" or so thick that the Sun is completely shielded.

condensation

As air slides up near fronts, air is pushed upwards. In the process, it cools and condensation occurs: clouds form. These can be thick, or thin

and may or may not give precipitation. They can cover the entire sky or parts of it. Importantly, these are layered clouds that occur in horizontal layers. Because a warm front makes a smaller angle with the Earth's surface than a cold front, it also creates a different type of cloud cover.
As a result, very different weather conditions can be expected.

8.7.2.1 Cloud cover at a warm front

During a warm front, warm air gradually moves upwards past the colder air. This process proceeds quietly, with the layer of clouds gradually becoming thicker. (cirrus, cirrostratus, altostratus and nimbostratus)

The heavy rain clouds (Ns) are located slightly ahead of the ground front; that is where most of the rain falls. Once the ground front passes, precipitation decreases.

Fig. 8.7.2.1
Cloud cover near a warm front, as seen by an observer on the ground (yellow arrow). The front moves from left to right.

- cloud cover is increasing, but the Sun is still visible. A halo appears.
- the Sun is on the point of disappearing behind increasingly thickening clouds.
- The whole sky is grey and enclosed.
- rain falls from the nimbostratus: the ground warm front approaches.

8.7.2.2 Cloud cover at a cold front

Due to the steeper position of the cold front, the air in the warm sector is pushed up quickly and with great force.
This gives rise mainly to stratocumulus and cumulonimbus, from which a lot of rain may fall.
Behind the cold front is cold air, in which clouds dissipate quickly, clearing the air. However, there are often still isolated showers.

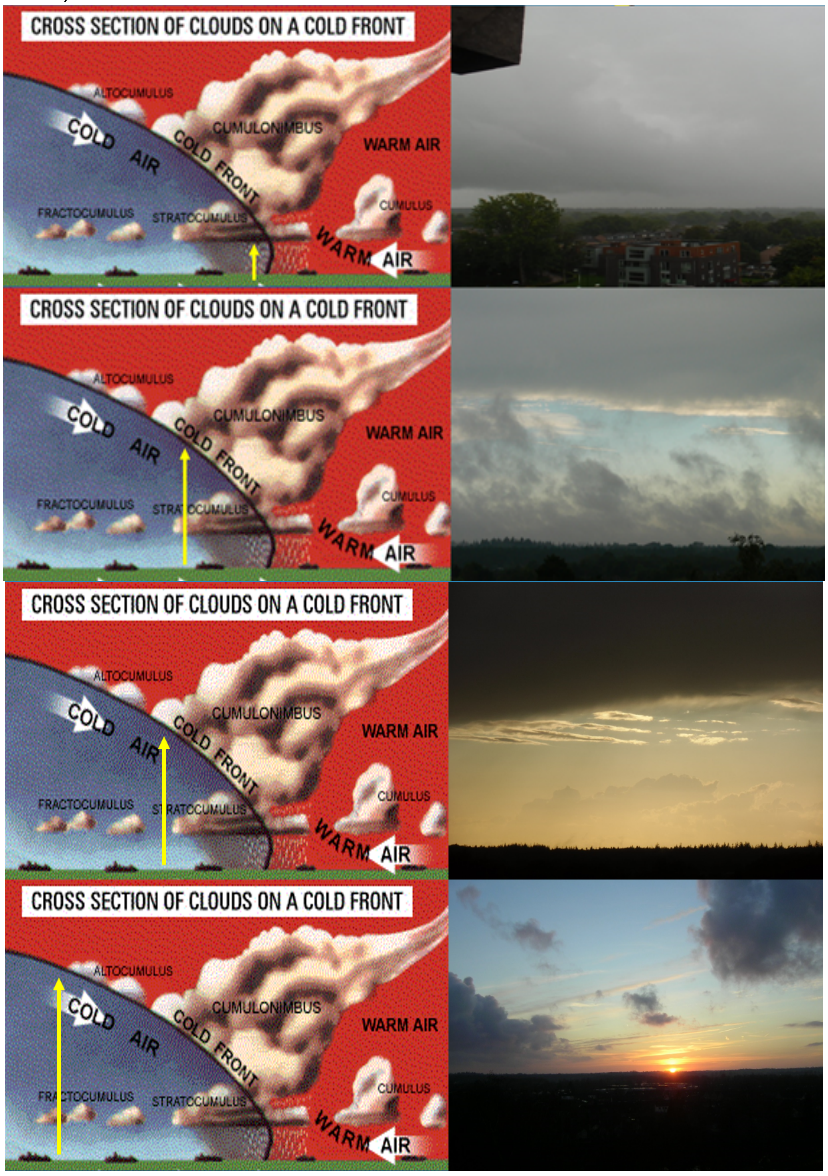


Fig. 8.7.2.2
Clouds at a cold front, as seen by an observer on the ground (yellow arrow). The cold front moves from left to right.
(Note: in the photos, the cold front moves from right to left)

- thick cumulonimbus clouds from which precipitation falls.
- the back of the cold front is coming into view.
- the back of the clouds is a fairly straight line.
- After passage it brightens quickly, but isolated showers may still occur.

8.7.3 Cumulus clouds

cumulus clouds

Cumulus clouds develop vertically. This distinguishes them from other – horizontally developed – cloud types.
A cumulus cloud is always a massive, separate cloud with no breaks. It has a sharp, clear outline and a flat base.

Cumulus clouds can be small, about 50 metres thick, or large, up to 18 km thick.
They can develop anywhere there is unstable, rising moist air. For example, at and behind a cold front or an occlusion.
Or at a convergence line. There, in fact, two different layers of air provide additional upward-pushing air, creating cumulus clouds.
Also at an upper-level trough, the cold upper air provides additional impetus for the formation of cumulus clouds.

However, most cumulus clouds form as a result of heating of the land by the Sun or by relatively warm sea water, combined with unstable air.

thermal

Large, invisible bubbles of warm air then rise (thermals). In higher air layers, they cool and the water vapour starts to condense.
Note: Hot air balloons use thermals for taking off. Glider pilots look for thermals so they can gain altitude.

If the instability of the air is great enough, the air continues to rise and cumulus clouds can grow into heavy shower clouds.

unstable air

** unstable air: if the air at the Earth's surface is warmer than the upper air, air will rise easily.*

stable air

** stable air if the air at the Earth's surface is colder than the upper air, air will not rise much, if at all.*

Fig. 8.7.3
Heavy cumulus clouds and dark undersides.

In the middle a high cumulus cloud, which will soon develop into a shower.
To its left and right, the ragged upper edges of the cloud indicate that it is spreading out into an anvil: precipitation is already falling there.

According to their size, we divide cumulus clouds (cauliflower-shaped clouds) into four types:
- a small, friendly cumulus cloud (Cumulus humilis) "Fair-weather cloud"
- a billowing cumulus cloud. (Cumulus mediocris)
- a high billowing cloud (Cumulus congestus). Look out!
- a mature cumulus cloud, which will bring showers (cumulonimbus)

A Cumulus congestus is the preliminary stage of the cumulonimbus: monitor such a cloud to see if it continues to grow into the cumulonimbus stage. In that case, you can expect showers with precipitation and possibly wind gusts. (see 8.8.2 and 3)

8.7.4 Daily cycle of cloud cover

Cumulus clouds – like wind and temperature – often have a daily cycle.
After sunrise – in calm and clear weather – the Sun begins heating the Earth.
Around 10 o'clock or so, the solar heat will have warmed the ground to the point where thermals begin to form. The first cumulus clouds appear.
As the Sun rises higher, the temperature increases and with it the rising power of the air; the clouds get bigger and grow higher and higher. In the process, showers may form at times, depending on the instability of the air.

In the afternoon the Sun gets lower and the temperature drops correspondingly.
As a result, the energy behind the thermals decreases; the air no longer rises.
Cooling causes them to sink again and the clouds to dissipate.
Around sunset, the clouds have disappeared again and only blue sky remains.

Note: Over the sea, this daily cycle is absent. The sea water temperature changes only very slowly under the influence of the Sun, so thermals do not form.
For this reason, glider pilots avoid (prolonged) flying over open water.

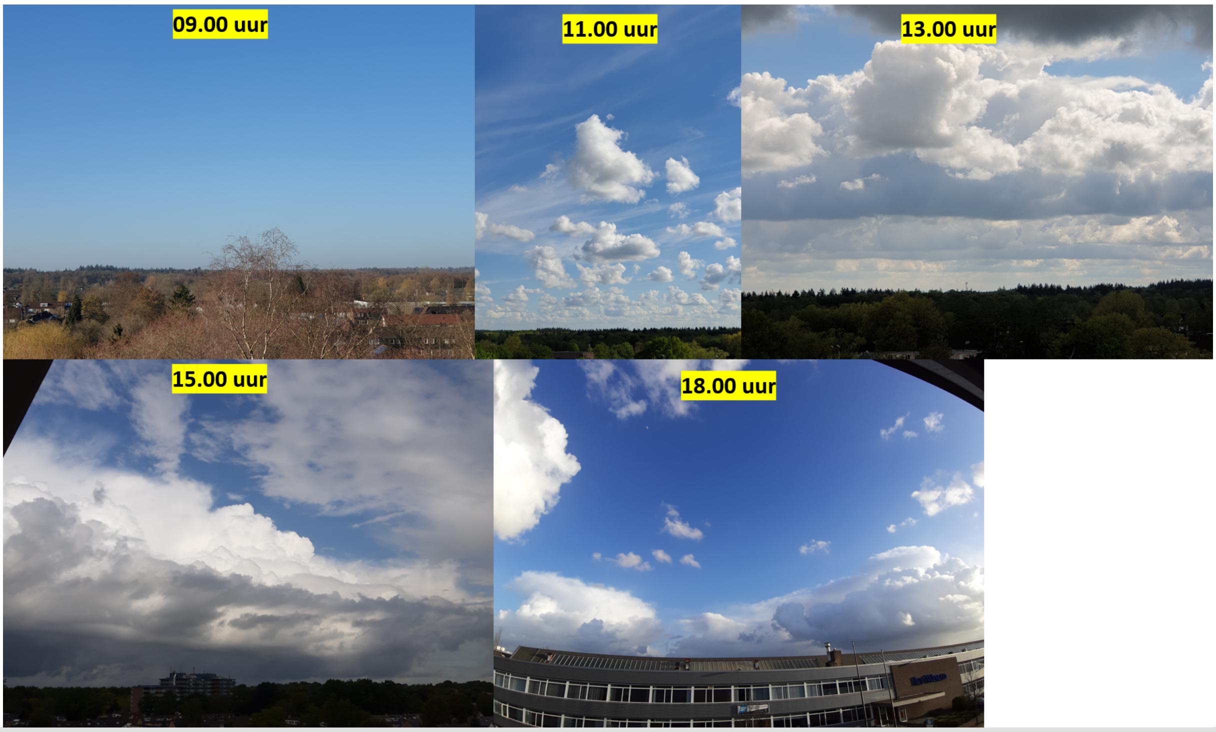


Fig. 8.7.4
The daily cycle of cumulus clouds

As the Sun gains strength, the air gets warmer and starts to rise. Cumulus clouds form in the process. When the Sun goes down, the air cools and starts to descend. The clouds dissolve again.

8.8 PRECIPITATION

Precipitation – both around fronts and from showers – occurs most often in the area where clouds have a temperature between -8 °C and -20 °C.
This creates snow in both summer and winter. This snow falls down and melts into rain before reaching the Earth's surface. Only if it is cold enough under the cloud – less than about +3 °C – will the snow or wet snow reach the Earth's surface.

> ** Between -8 °C and -20 °C, supercooled raindrops turn into ice crystals. The presence of ice crystals is an absolute prerequisite for the formation of precipitation.*

At higher temperatures and with moderate precipitation, the precipitation sometimes does not reach the ground, but evaporates as it falls; then only short rain curtains can be seen just below the cloud.

Precipitation can fall in small amounts or in huge masses. In summer, precipitation amounts are greater because the air is warmer. Warmer air can hold more moisture and therefore will give more rain.

8.8.1 Forms of precipitation

8.8.1.a Rain

When the snow formed in the cloud turns into drops due to the excessive temperature, the precipitation falls in the form of rain. Over 90% of precipitation is formed in this way. This happens in both summer and winter.

Rain may fall from layered cloud, as occurs with all fronts. This can be either light rain or heavy rain. Rain can also fall from banks of cloud or from cumulus clouds/showers.

> ** we distinguish between rain and showers: rain is – often prolonged – calm precipitation; showers are short-lived and sometimes intense. They arise from different types of clouds.*

Banks of cloud that give rain are often remnants of old occlusion fronts. This is often a mixed cloud form with light to moderate or sometimes still heavy rainfall

Clouds such as stratocumulus occur mainly with a northerly air current from the North Sea due to a high-pressure area above Scotland.
Descending air movements at this high-pressure area almost always create an

inversion

inversion. This is a layer of warmer air at altitude.
The cloud layers are sometimes thick enough for light rain but the inversion above them prevents them from fully developing and giving a lot of rain. Therefore, a characteristic of these cloud layers is that they are very flat at the top and are often only 1000-2000 metres thick.

drizzle

Drizzle is often caused by small cloud droplets colliding, growing larger and then becoming too heavy and falling. It differs from other forms of precipitation because drizzle is not preceded by the snow stage.

Drizzle falls only from layered frontal cloud.

A distinct form of drizzle can occur in dense fog, where small fog droplets coalesce into larger droplets and then fall.
However, this is not normal precipitation. If it is cold enough, this can also be freezing fog.

8.8.1.b (Wet) snow

Snow is formed in clouds at temperatures between -8 °C and -20 °C. These flakes then fall down and if it is cold enough they reach the ground.
Wet snow occurs at air temperatures between +3 °C and 0 °C. At 0 °C or colder, it falls as dry snow.

8.8.1.c Freezing rain and sleet

Freezing rain and sleet form in the area below the warm front – where it freezes – and the warm air above the warm front, where it thaws.
Snow falls first through the warm, or warmer, air behind the warm front. The snow then melts into raindrops. These raindrops then fall again through a layer with frost.

sleet If the layer with frost is thick enough the droplets may freeze: sleet.

freezing rain If the layer is thinner, the droplets only become supercooled: freezing rain.

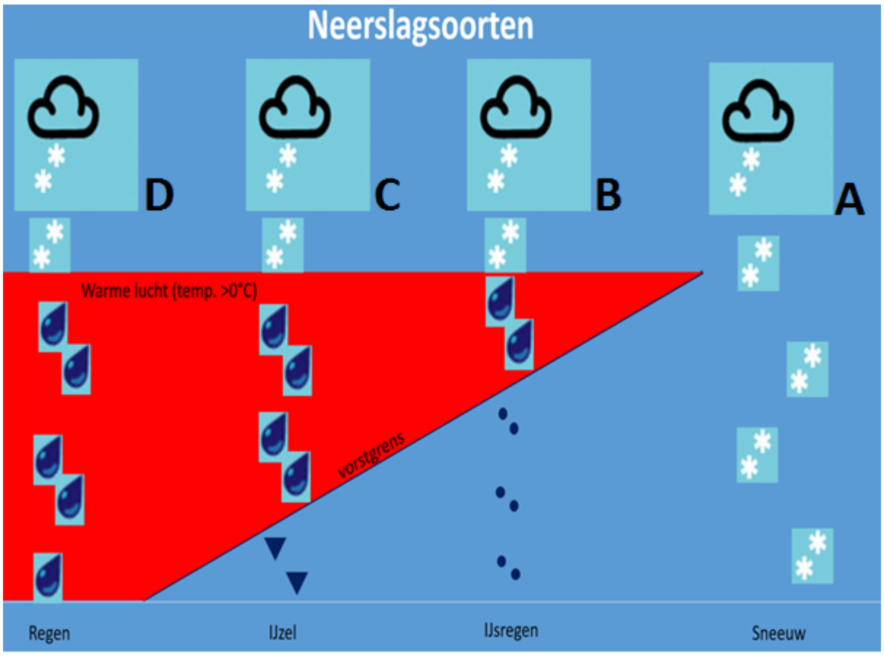


Fig. 8.8.1
Types of precipitation

Four forms in which winter precipitation can reach the Earth's surface: as snow, sleet, freezing rain or rain.
Red shows the approaching warmer air behind the warm front. The warm front plane here is the frost boundary.

freezing rain Freezing rain has the property of immediately turning into ice on its first contact with an object or the ground.
Black ice settles on everything and immediately forms a layer of ice.

** Black ice is different from rain that freezes on a frozen surface.*
Which makes no difference: both are as slippery as glass!

The chance of freezing rain or sleet occurs in winter when a warm front approaches after a cold period.
For example, after a period with a high-pressure area over Scandinavia, cold easterly winds and clear skies; the ground and the air above it are very cold.
There are four possibilities (Fig. 8.8.1):

snow

A: precipitation passes through the cold layer of air and reaches the Earth's surface as snow. Depending on the temperature of that air, it may be wet snow or dry snow.

On the approach of a warm front, warmer air reaches us in the Netherlands, above 0 °C.

sleet

B: the snow turns into droplets in the warmer air but they freeze again when falling through the dense cold layer below them: sleet.

C: same as B, but due to the shorter journey through the cold air, the droplets only become supercooled (< 0 °C). On contact with the ground or an object, they become ice: black ice.

rain

D: the ground warm front has reached us: the precipitation falls as rain.

What to do with iced-up sails?
In situation C, the miller will have to deal with ice on the mill yard, stage and other mill parts: beware of slipperiness!
Presented sails can also become covered with black ice.
Removing sails is then dangerous or even impossible. And going home with sails left presented is not an option!

drying

The solution then is: keep on turning! The passing air causes the ice on the sails to evaporate and the sails dry while turning.
That may take some time though.

And remember: in this situation, the ground warm front is nearby, with the warm sector following behind it and rising temperatures.

8.8.1.d Hail

Hail occurs through coalesced snowflakes in a cloud falling down and partially melting. Due to the intense turbulence in the cloud, they are then carried back up where the layer of melt water refreezes. The hailstone falls down again, whereupon it melts slightly again, etc. Each time the hailstone grows a bit in size. This process continues until the stone becomes too heavy and falls to Earth.
The diameter of a hailstone may reach some 6 to 8 cm. The speed of fall is between 50 to 120 km/h.
Large hail in heavy summer thunderstorms often falls down at the front from the anvil, just before the rain begins.
Weather reports do usually warn of the chance of hail. But it always falls very locally. Where that may be cannot be accurately indicated.

There is a difference between summer hail and winter hail.
Summer hail is formed in heavy showers and is extremely hard. Winter hail is quite soft. This is due to the lack of a melting layer during winter periods.
The shape also varies somewhat: summer hail is rounder, winter hail more triangular.

Hoar frost

hoar frost

Hoar frost is not precipitation but a moisture deposit that freezes during frost. This can be a small layer, or in fog a thick layer of more than a centimetre. Hoar frost consists of tiny ice needles that hardly have any weight, even in large numbers.
Hoar frost melts quickly due to radiation from the Sun.

Points for attention during (winter) cold and precipitation

- icing-up of mill components due to black ice
- falling lumps of ice or frozen snow
- slippery stage and sail bars due to hoar frost, black ice, snow, freezing conditions
- wet sails can freeze due to dry, cold air behind a cold front
- loose wedges due to drying out in prolonged frost period
- cast-iron (windshaft) becomes more brittle at low temperatures; brake gently!

8.8.2 Showers

Any cumulus cloud that gives precipitation we call a shower (Cb, Cumulonimbus). Looking at precipitation, there are different types of showers: rain, hail, snow and wintry showers. The latter have a mix of everything.

In terms of precipitation amount and intensity, showers can be light (just some precipitation) or heavy. They can originate over land or be brought in from the sea.

Fig. 8.8.2.1
A substantial shower.

The spreading anvil is clearly visible and betrays that the shower is mature and rainfall is occurring.

thunderstorm

A distinct type of shower is the thunderstorm, mainly because it is dangerous on account of all the peripheral phenomena such as thunder, hail, heavy rainfall and a chance of strong wind gusts (see 8.8.4)

Incidentally, a heavy shower does not necessarily have to produce a thunderstorm. Particular atmospheric conditions are required for that to happen. Cloudburst showers may well occur without thunder and/or wind gusts.

anvil
tropopause

Showers are characterised by the formation of an anvil at the top of the cloud. It will then spread out against the tropopause.
In the process of spreading out from the top of the cloud – along with the prevailing wind there! – the characteristic anvil shape emerges.

The anvil always consists entirely of ice crystals and therefore looks ragged. In fact, the temperature in the anvil is between -15 °C and -70 °C, depending on how high the cloud has risen. Because the tropopause is at a different altitude each day, the height of the anvil also varies.

> ** the higher the shower cloud grows, the heavier the showers can become*.

For meteorologists, the anvil height is important for estimating the probability of thunderstorms, hail and cloudbursts.

Fig. 8.8.2.2
An isolated, rainfall shower.

The shower has matured and is giving rainfall.
Below the shower, the precipitation is easy to see.
The oblique position of the precipitation indicates wind gusts.
(the shower is moving to the right)

Cumulus clouds that grow rapidly to the "congestus" stage should be monitored in particular: Is the top still smooth or is it already becoming ragged?
A general rule also is: the more easily and faster cumulus clouds form during the day, the greater the chance of showers.

duration of a shower.

Isolated showers have an average lifespan of about 30 minutes. This is the time between the onset of precipitation to dissipation after rainfall.

> ** if a shower passes over the mill, it will be hanging over the mill for at most 5-10 minutes on average.*

8.8.3 The trajectory of showers

It is very important for the miller to know whether a shower is passing (at a distance) or going to reach the mill. That determines whether or not they will have to deal with the weather phenomena surrounding a shower: wind gusts, precipitation, thunder and lightning, hail.

trajectory

The miller must, therefore, determine the trajectory of a shower.
Often the ground wind is a good gauge of this. On average, the governing wind behind the showers – the wind at about 3 to 5 km altitude – is almost the same as the direction that the wind on the ground has.
Also, the anvil will usually spread out to the side where the shower is moving toward.

> ** the miller should always monitor an observed shower and determine its trajectory in order to take timely measures.*

8.8.3.1 Deviating trajectory during severe thunderstorms

However, ground and altitude winds may differ in direction. This often occurs in the case of approaching convergence lines.

Then a southeasterly wind is blowing on the ground yet a southwesterly wind is blowing at some altitude. Showers will then move in from the south-west, despite southeasterly ground winds. At the showers themselves, the wind then turns.
You can often see then from thunderstorm predictors (Altocumulus castellanus and Altocumulus floccus) that they are drifting over from a different direction than the ground wind, a good indication a few hours before the showers appear.

8.8.3.2 Showers around the mill and wind direction

When showers pass a mill, they can affect the wind for a short time. Both in terms of wind direction and wind strength.
Wind gusts may also occur.

veering past
backing past

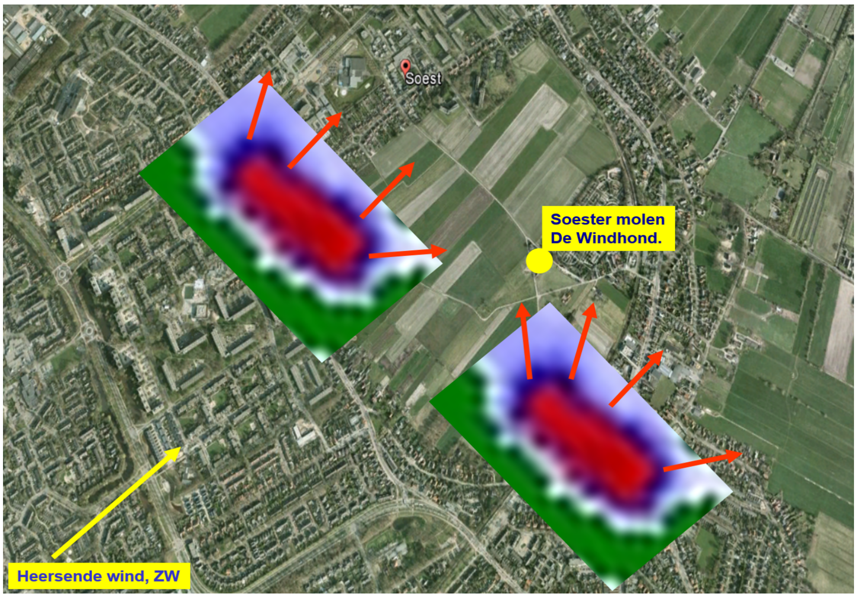
> ** for a shower we refer to "veering" or "backing" along the mill or "straight across the mill".*

The prevailing wind as it travels along is influenced by the wind flowing away from the shower.

In fact, the precipitation is accompanied by a huge amount of air that also comes down from the shower. This flows away in a fan-shape over the Earth's surface, partly also towards the mill. Sometimes people say, "The shower pulls the wind towards it".
What in fact happens is that the wind comes away from the shower.

As the shower veers past, the wind blowing from the shower will come in as increasingly veering. When backing past, the wind will back more and more.

Fig. 8.8.3.2
The effect of a shower on the wind at the mill.
Due to the wind flowing from the shower, it temporarily deviates from the prevailing wind (SW, yellow arrow).
Showers are moving from south-west to north-east here.



Once the shower has passed the mill, the wind returns to its original direction. Passing usually takes only a few minutes.

> ** because of the temporary nature of the veering or backing wind, we do not wind the mill in response. If necessary, we stop the mill to prevent reverse rotation.*

With passing showers, you can expect most of the wind at the front of the shower. After all, there the prevailing winds and the wind flowing out from the shower reinforce each other. At the back of the shower, they work against each other.

Fig. 8.8.3.3
A roll cloud

A roll cloud is often a sharply defined band of clouds. It forms at the front of the shower at the boundary of the air flowing out of the shower and the warmer air at some altitude. It slowly turns on its axis and stands apart from the shower. It is often a forewarning of a lot of wind.
The roll cloud is moving towards us.

Wind gusts during a passing shower

With all showers, there is a chance of blustery winds or gusts. Above we mentioned wind gusts due to the descending mass of water and air from the shower.

wind gusts

Other wind gusts do not originate from the shower but they are wind bands deflected by the shower at altitude, where the wind blows harder (see 8.4.4).

**wind gusts can only be expected when a shower starts to produce rainfall.*

Note that passing showers and passing depressions both affect winds around the mill. But don't confuse them!

passing shower

During a passing shower, the wind direction changes briefly – for a few minutes – and then returns to its original direction.

passing depression

With a passing depression, the wind direction and often the wind strength changes for an extended period of time. The weather also changes (see 8.9).

**for depressions we say: "passing to the north" or "passing to the south".*

8.8.4 Thunderstorms

lightning
thunder

Thunderstorms are characterised by the occurrence of lightning resulting in thunder. In this they differ from other showers.
These are the most severe showers that occur in the Netherlands.
However, there are different types of thunderstorms, all with accompanying weather phenomena.
Stroboscopic thunderstorms (30-60 lightning flashes per minute), severe wind gusts, cloudbursts and hail, all are possible.
However, even a shower that gives only one lightning flash is already a thunderstorm.
With thunderstorms, everything proceeds in a very intense way; the formation, growth, the height of the anvil, the wind speeds. In thunderstorms there is intense turbulence with warm air moving up and colder air moving down, with a lot of precipitation. The temperature in the anvil is often between -50 °C and -70 °C, with the anvil most often occurring at an altitude of between 9 and 14 km.

Very heavy thunderstorms can grow so hard and explosive that they become air-deficient and start sucking in air before the storm from some altitude (100-500 metres) Then air from behind the mill also flows towards the storm. People then sometimes say that "the shower gathers against the wind" but that is incorrect.

wind from behind
flapping sails top end

That wind from behind does cause the mill to turn more slowly or irregularly though. There may also be slightly flapping sails on the top end (!) in the process. This only lasts a short time; watch out, because the wind from the shower is on its way!

8.8.4.1 Types of thunderstorms

We distinguish different types of thunderstorms. They differ in how they are formed, the conditions under which they occur and what we can observe of them.

8.8.4.1.aThermal thunderstorms

These are often independent (isolated) but large and heavy thunderstorms that develop in warm and unstable air.
They form in the warm months when an old low-pressure area passes over the

Netherlands, sometimes from the east. On the ground, this low-pressure area has completely disappeared but at altitude the cold air is still present; this causes unstable air.

This unstable air, combined with solar heat during the day, can cause some very strong rain showers and thunderstorms to develop.
These showers usually develop just after the highest temperature in the afternoon, reaching their peak by evening and dying out again in the evening and night.

They usually move quite slowly but they can have quite large wind areas around them (gusts!), sometimes miles ahead of the shower. Thermal thunderstorms are known for their substantial precipitation and wind gusts. They are also often accompanied by hail.
Thermal thunderstorms are usually easily recognisable because there are bright spells around the showers; the shower is well defined.

Fig. 8.8.4.1.a
Thermal thunderstorm

In the afternoon, at 28 °C, a substantial thermal thunderstorm developed with a large and ragged anvil composed entirely of ice crystals.
Large cumulus clouds around it grew rapidly and almost merged into the thunderstorm.
(we are looking at the back of the shower)

Thermal thunderstorms are a land phenomenon: they develop from the east or south-east (referred to as "Ostgewitter", or "storm from the east"). They reach their greatest intensity over the Netherlands. As they move up the North Sea, they dissolve again.
Thermal thunderstorms do not usually result in a change of weather.

8.8.4.1.b Convergence line thunderstorm / cold-frontal thunderstorm

convergence line

Around cold fronts and convergence lines, you can expect severe thunderstorms and a strong wind shift. In the summer months thunderstorms are usually located on the convergence line, in the winter months on the cold front.

Convergence lines lie ahead of cold fronts. They have a wind shift combined with often extremely hot and very unstable air. Showers can develop very quickly in them. They usually move quickly and often bring severe weather with lots of thunderstorms and strong wind gusts.

convergence-line thunderstorm

Convergence-line thunderstorms move in from the south to south-west, bringing cooler air with them. They can occur as isolated cells or as a line of showers. They then cover the entire sky in the direction they come from.

In the summer months, convergence lines clear a lot of heat. As a result, the energy is already gone from the atmosphere, so the cold front behind it often gives no more than a bit of rain or a few showers, but no thunderstorms. (Although that cannot be ruled out!)

Fig. 8.8.4.1.b1
Altocumulus castellanus

This type of cloud cover is a true thunderstorm predictor. Incidentally, that thunderstorm does not have to pass over this region, but may occur close to the Netherlands.
They are often seen in the morning, 6 to 8 hours before the thunderstorm

thunderstorm predictors

Convergence lines are often preceded by thunderstorm predictors such as Altocumulus floccus and Altocumulus castellanus. These often move across the region 6-8 hours before the thunderstorms.

Fig. 8.8.4.1.b2
Instability clouds

Altocumulus floccus and castellanus. Above these, cirrus from an approaching frontal zone. If these types of clouds occur during the day, there is a high probability of rain and thunderstorms 6 to 8 hours later in the day.

cold-frontal thunderstorm

Cold-frontal thunderstorm is a somewhat misleading term because cold-frontal thunderstorms actually only occur between October and April. And mainly with storm depressions, especially if there is a lot of wind across the cold front.
Then the cold fronts often consist of sharp shower lines in which thunderstorms may occur. The thunderstorm is then not on a convergence line but on the cold front.
Cold-frontal thunderstorms move in from the south-west, west and north-west.

8.8.4.1.c Polar thunderstorms

Polar thunderstorms are showers brought to the Netherlands with a northwesterly (sometimes westerly) current behind a cold front.
These showers move across the country with rain, hail and sometimes locally a clap of thunder.
Between the showers, the Sun then shines beautifully in deep blue sky. They tend to develop properly in the afternoon in particular.
(Polar showers are also called air mass showers)

Fig. 8.8.4.1.c
Polar showers

Polar air is often easily recognised by its deep blue colour and white clouds.
Some mammatus (pouch) clouds can be vaguely seen in the anvil on the left. This is a sign of sharper showers.

Polar showers are easy to recognise. But whether they will be accompanied by a clap of thunder is not predictable. Because of the possibility of wind gusts, caution is advised.

Fig. 8.8.4.2
A severe thunderstorm

We see a clear collar of clouds with even skies behind them; a sign of heavy rainfall and possibly strong wind gusts.
The first lightning can often be seen around the collar of clouds.
The shower is moving toward us.

Points for attention during (summer) thunderstorms

- note convergence lines plotted on a weather map; chance of thunderstorms in summer.

- watch for tell-tale signs of thunderstorms in the morning: Altocumulus floccus and castellanus.
- watch out for Cumulus congestus; it may develop into a shower.
- the formation of anvils that will pass over. Rainfall, wind gusts.
- dark clouds are gathering / heavy skies approaching.
- greenish sky coming? High probability of cloudburst with hail.
- very sharply defined cloud collars with lightning on them or behind them.
- afternoon and evening showers are usually the heaviest.
- Mammatus ("pouch") clouds at the front of the anvil: heavy shower.
- roll clouds are often a harbinger of heavy wind gusts.
- showers can move extremely fast: up to 100 km/h.

8.8.5 What to do in case of an approaching shower?

Showers always present risks to the mill. The greatest threat is from wind gusts and lightning; not from precipitation.

Recognition of a shower.
First, determine whether it is a shower. A large cloud with dark underside does not have to be a shower.
- In broken cloud cover, a growing cumulus cloud can be readily observed.

sharp edges
As long as the top of the cumulus cloud is still sharply defined (the well-known "cauliflower cloud"), the cloud is not yet mature: it is not yet a shower.

anvil
If the top of the cloud becomes ragged and the cloud spreads out and an anvil forms: it is a shower.

dark underside
- When cloud cover is closed, the top of a cloud cannot be seen: but a very dark underside indicates a high rising cloud above it.

rain curtains
- Note the underside of the cloud: If you can see under it, it is not a shower (yet). If you see rain curtains or a dense sky that obscure the horizon, then it is a shower.
- try to estimate whether it is a light or heavy shower. Other sources, such as rainfall radar and the weather forecast can help.

> ** Only when a cumulus cloud produces rainfall do we call it a shower. Only then can we expect wind gusts.*

Monitoring a shower.
A shower can become threatening if it comes near the mill. Monitor the shower to determine its trajectory.
- the shower cloud is propelled by winds at about 3 km altitude. Often the direction of the wind at altitude is the same as the ground wind, but not always.
- the direction of the spreading anvil - especially of the long tip - says something about the wind at altitude. The anvil blows along with that wind. If the shower is coming towards the mill, you will not see a point but the anvil will spread over the mill like a "canopy" with a ragged front.
- determine whether the shower will pass by or over the mill.
- determine if the shower is moving fast or slower.

If it is a shower and coming towards the mill, take action in time. (braking, furling, attaching stock chain, lightning conductor in case of thunderstorms, etc.). Thunderstorms can certainly move very quickly!

8.9 A DEPRESSION IS MOVING TOWARDS THE NETHERLANDS

The Netherlands often experiences passing depressions. These are usually accompanied by fronts, and with fronts we can expect certain characteristic weather phenomena. It can be very calm, but it can also be very intense.
As we saw in earlier sections, "Fronts are almost always accompanied by weather phenomena!"

Most depressions pass over the Netherlands from south-west to north-east, but there are occasional exceptions to this!
As a depression approaches, its trajectory and our position relative to its centre will have a major impact on the weather.

Laying a number of weather maps back to back gives us a picture of the trajectory across the Netherlands and relative to the mill (see 8.6.3).

Three situations arise most frequently in this regard:
- the depression passes north of the Netherlands
- the depression passes through the centre of the Netherlands
- the depression passes south of the Netherlands.

8.9.1 The depression passes to the north

This is the most common situation. We are then on the south side of the depression with successive passage of the warm front and the cold front, or the occlusion.

As the depression approaches us from the (south) west, there is a southerly current at first (see 8.4.2).

approaching warm front
drizzle/rain

On the approach of the warm front, the clouds continue to increase (see 8.7.2.1) and – as the ground front approaches – it starts to drizzle or rain (see 8.5.3).

wind veers
warm sector

After passage of the ground warm front, the wind veers to south-west to west. The precipitation stops. The temperature and humidity are rising as we are now coming into the warm sector. In summer, it often clears up a bit; in winter, clouds often remain.
There can be strong winds in the warm sector, especially in winter.

approaching cold front
convergence line

Behind the warm front, the cold front approaches. This may follow quickly, or it may take quite a while, depending on the size of the warm sector.
Note: In summer, the cold front may be preceded by a convergence line with possible heavy (thunder) showers (see 8.5.7).

On the approaching cold front we can expect strong vertical cloud formation (cumulonimbus) (see 8.5.4 and 8.7.2.2) This is predominantly located just behind the cold front. This may include heavy showers.
If the warm sector is completely cloudy, these clouds turn into cold-front clouds and the approaching cold front is difficult to recognise.
Then watch out for a dark band of clouds to the west/north-west.

wind veers

On the cold front, the wind makes another shift and veers to west to north-west. This is often an excellent wind for milling!

bright spells

Behind the cold front is cold air, so the temperature drops. That cold air is often clear: after a cold front passage, we can expect bright spells, in which many showers may occur, but are easily observable.

trough, shower line

On the weather map we can see whether to expect another trough (or shower line) among the isolated showers behind the cold front (see 8.5.6).

> ** during passage of both the warm front and cold front we can expect a wind shift. The wind veers both times.*
>
> ** whether the wind will increase or decrease after passage of a front can be read from the isobar pattern on the weather map (see 8.4.3.1)*

occlusion

If the fronts are already partially occluded, the occlusion may pass us. And with a strongly turned-in occlusion, sometimes twice!
Consider the associated weather phenomena as those associated with a cold front. (see 8.5.5).

air pressure

The barometer: whether and to what extent air pressure changes when a depression passes is determined by our distance from the centre.
- if the trajectory of the depression is such that distance is reduced, the air pressure drops.
- if that distance increases, the air pressure rises again. This happens, among other things, after passage of the cold front.

8.9.2 The depression passes over the centre of the Netherlands

If a depression passes straight over the Netherlands, there will be large differences between the north and south of the Netherlands.

As the low-pressure area approaches, the wind will start to back.
In the north to the south-east, in the centre to the south, and in the south to the west. In the centre, the wind drops completely.

Fig. 8.9.2 *A small depression passes over the centre of the Netherlands.*
The wind in the north backs from south-east via north-east to north-west. The wind in the south veers from south-west to north-west. In the Hook of Holland, the wind decreases from 34 to 21 kt (from 8 to 5 Bft).

During passage, winds to the north will continue to back to the east to north-east. The wind in the south veers to west.
Where the centre passes, southerly winds will suddenly drop completely and

return from the north-west just behind the heart of the depression – and often increase sharply. Note the isobar pattern!
After passage, the wind becomes north-west everywhere.

In the northern part of the country, we will face an occlusion or area of rain at the head of the depression in this situation.
In the central part of the country, the cold front will quickly follow the warm front and in the south we will temporarily enter the warm sector.

** a depression over the mill announces itself by a rapid drop in atmospheric pressure.*

Note: The danger of a depression passing directly over is that the mill usually mills with plenty of sail on a moderate south/southeast wind, but - as the centre of the depression passes over - it may suddenly fall away and return more forcefully from the northwest.
Keep in mind that this shift can sometimes happen in a very short time!
Timely - i.e. before the wind changes! - braking, furling and turning to the west is important then!

8.9.3 Depression passes to the south

As the depression approaches, the wind backs, from south-east to east, north-east and via north to north-west.
Rain falls from the occlusion at the head of the low-pressure area or the area of rain only reaches the area of the big rivers.
In winter, it may snow or freeze. The wind that backs east to north then pulls cold air into the Netherlands.

** because of the constantly backing wind, the winding chain can be left lying for counterclockwise winding ("to the right").*

8.9.4 Depression moves north along the coast

In that situation, the Netherlands is east of the depression, that is, in a southerly current. In the process, fronts pass over the Netherlands. Often first the warm front, followed by the cold front and then possibly another occlusion curled around the low.
Immediately south of the centre, winds will veer to south-west to west and expand rapidly over the rest of the country.

8.9.5 Depression moves over eastern areas towards the north

With a low-pressure area moving along our eastern border to Denmark, winds will blow from the north-west to north over the Netherlands. At times, this will be accompanied by rain.
The above situations give a rough indication of what to expect. Weather maps show more information about the size and trajectory of depressions, the location of fronts and the isobar pattern.

8.10 SOURCES OF INFORMATION

In addition to weather reports on radio and TV, there is also a lot of information available online about the weather.
Incidentally, most (brief) weather reports on the Internet are compiled using computer models: they are not reviewed or corrected by a meteorologist!

The well-known KNMI weather maps are primarily based on air-pressure measurements and air-pressure variations. But there are also sources that give other information, such as precipitation, wind direction and strength, cloudiness, temperatures and the like.

8.10.1 Radar

Radar is a widely used source, especially since the images are easily viewed on mobile phones using weather apps.
Some rainfall radars indicate very accurately whether a shower will hit you or not. It is a useful tool for observing showers.
Understand, though, that showers are constantly changing. They can develop but also unload their precipitation and dissipate.

How does rainfall radar work?

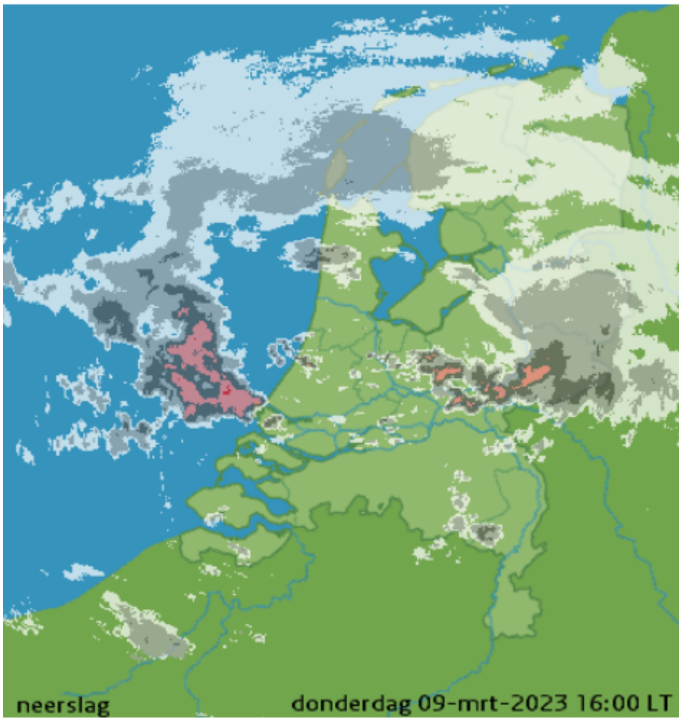


Fig. 8.10.1
A picture of a rainfall radar

Frontal rain over the north of the country and showers over the west and east of the country.
The brighter the colour, the heavier the precipitation.

Radar emits a signal that raindrops reflect. The reflected signals are processed into a radar image. One picture every five minutes.
Drizzle droplets, however, are too small to detect. So drizzle is usually not displayed by radar. The reflection of snowflakes is also not as good and snow showers often prove heavier than expected.

Weather radar has a range of about 300 km. Radar waves move exclusively in a straight line. So radar cannot see "beyond the horizon" because of the Earth's spherical shape.
At first, radar sees only the top of emerging showers. Once the shower gets closer, it can suddenly appear to be heavier. That is not the case: the radar detects the shower better as it approaches and makes it more visible.

All of our radar data comes from KNMI. It has two radar towers that cover the entire Netherlands. Each provider receives the raw data and then processes it with its own software.
Radar always provides a snapshot in real time: it reflects the current situation.

forecast

The animations of the further course of precipitation are thus forecasts and consequently less reliable.

Sites and apps that give forecasts from the radar for the next two hours should always be viewed with some suspicion.

8.10.2 KNMI

KNMI also maintains a weather site. Weather maps are displayed there – both analyses and forecast maps.

https://www.knmi.nl/nederland-nu/weer/waarschuwingen-en-verwachtingen/weerkaarten

Every 6 hours, a meteorologist prepares the so-called "guidance" model assessment. This is a comprehensive story about the weather for the next 48 hours for the Netherlands. A rather technical story, but there is enough that can be understood about various parts, such as wind.

https://www.knmi.nl/nederland-nu/weer/waarschuwingen-en-verwachtingen/extra/guidance-modelbeoordeling

KNMI also issues weather warnings, always in consultation with other agencies.

https://www.knmi.nl/nederland-nu/weer/waarschuwingen

8.10.3 Other websites

WXCHARTS https://wxcharts.com
This website shows not only ground pressure but also precipitation on fronts, isolated showers and cloud cover. This information can be found at the map "overview". By looking at these maps regularly, you will learn to recognise precipitation patterns from fronts and isolated showers.
Note that these maps do not include the drawn fronts.

Weerplaza https://www.weerplaza.nl/
Under the heading 'Expert-Weerkaarten' you will find the Harmonie model used by KNMI. At "Element" you can select 'Luchtdruk en wind' and you will even see the isobars per 1 millibar.

Under "EXPERT", Weerplaza gives the wind observations per 10 minutes such as wind force and wind direction as well as wind gusts.

Windy.com https://www.windy.com/

At Windy.com, you can combine ground air pressure with wind, precipitation and thunderstorms. This website offers a lot of information, including clear satellite images.

Wetterzentrale https://www.wetterzentrale.de

This German site lists all the weather models important for Europe, including ECMWF and CFS high-resolution images for the Netherlands.
The advantage of these maps is that the Netherlands is fairly centrally located.

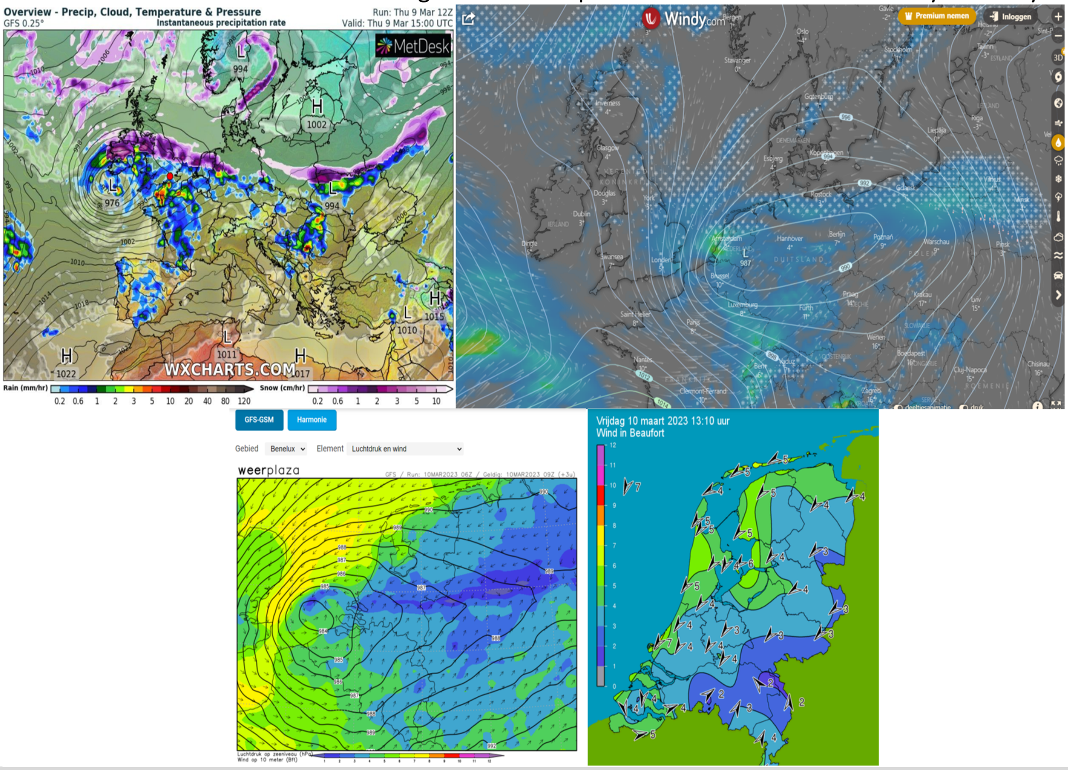


Fig. 8.10.3 Some weather maps from websites.

Putting these map types next to weather maps with fronts creates a good overview of what is going to take place.

Wetter3 https://www.wetter3.de
The most important map for us on this site is the one from 'Modell-Wetter'. This shows in what form precipitation falls: hail, snow, thunderstorm or rain.
On the main page, select Hoch aufgelöst (GFS ....)

Guild of Millers website
On the Guild of Millers website, David Henneveld provides a weather report for each Saturday, sometimes with additional explanations for special situations.

Chapter 9 The mill biotope

Contents page:

Foreword

The mill biotope is the entire area surrounding the mill, insofar as it affects the operation of the mill. Conversely, it is also the area within which the mill makes an important contribution to scenic quality and to the quality of the living environment.
The design of this environment is of great importance to the miller and to the operation and thus preservation of the mill. That is why this chapter has been added to the Handbook.

In its current form, this chapter deals only with windmills. Of course, water mills have a biotope as well. However, the biotope of a water mill differs so significantly from that of windmills that a separate description is needed for each water-powered mill. Proper consultation with the water authorities is a prerequisite to arrive at an acceptable water/reservoir level. However, a good deal of this chapter is of a more general nature and thus also applicable to water mills.

Evert Smit †

This chapter of the Handbook is dedicated to Evert Smit, the great promoter of work on behalf of the mill biotope.

9.1 INTRODUCTION

The time that every mill was in use as a machine lies far in the past. Polder mills drained water from deeper areas and, if the miller was too late in presenting his sails and removing the brake to set the mill in motion, angry farmers soon turned up on his doorstep. The grain miller was also often on duty day and night to produce flour for the baker or feed for the farmer. No day could be missed and every wind had to be used to its advantage.
Obviously, the source of energy — wind — was not to be put at risk. Because even then, people knew how quickly a mill's power declines when the wind decreases in strength. Wind rights at grain mills, often enshrined in wind privileges and the by-laws for polder mills, guaranteed free wind access. Standards of practice, with which you had to comply, were developed.
Now wind privileges no longer exist. The water authority by-laws are still in effect and are also regularly revised. Nowadays these are sometimes challenged, as polder mills no longer have a function.
We must therefore look for other instruments with which to secure wind capture. Water authority by-laws are still a good instrument for protecting wind capture, especially now that there is a move towards "green" by-laws. Examples include those at De Sluismolen (The Sluice Mill) in Koedijk and *De Dog* in Uitgeest. Even as auxiliary or emergency drainage, the mill can still be assigned an important role.
Moreover, a second aspect of the mill biotope has become important: how the mill blends into the surrounding landscape and urban planning. Previously, this was taken for granted. When the wind capture was good, you could see the mill and it played its role in the landscape and the village scene. The mill often dominated the scene. That is no longer the case now; we must fight to keep the mills in sight or to get them back in view.
From the mill's point of view, of course, wind capture is the most important thing. But for those living in a village or town, the mill is first and foremost a characteristic element of their living environment; they do not appreciate the importance of wind capture for the mill. The actual requirements of wind capture come into conflict with other, also very real, interests and desires. On the other hand, an environment appropriate to the demands of a mill is a prerequisite if a mill is to truly manifest itself as a monument of industry and technology. We will have to emphasize that side of things more strongly.

Since the founding of the Association *De Hollandsche Molen* in 1923, attention to mills has grown, both among the public and in the government. As a result, the mills — with only a few exceptions — were designated as historic buildings. They are monuments that have great cultural-historical, educational and tourist value because they are machines.
Historic building preservationists and mill organisations still lament that the surroundings of mills were not legally protected. Unfortunately, this is not to be expected in the future, either. Therefore, we must look for other ways. A great deal of money is spent by the Dutch government on the maintenance and restoration of mills. It takes a huge effort on the part of mill owners to keep the mill in good condition on a limited budget. In addition, the dedication of volunteer millers determines the future of the mill as a machine.
These millers get the mills turning and milling and this ensures the best maintenance for mills. A mill can only continue to do its job if enough wind flows to the mill.

We can thus see that meaningful mill conservation has at least three requirements:

- the mill must be in structurally sound condition;
- the mill must have a miller;
- there should be a good wind supply to the mill, as well as a good wind discharge
from it.

From a cultural history and landscape perspective, we must add a requirement:
- the mill should have a prominent place in its surroundings.

And if our actions are to be successful then a final requirement should be fulfilled:
- the mill should be considered by the population as an extremely important part of its
living environment; in other words, it should be seen as "our" mill.

The following chapter takes a closer look at the various aspects of the mill biotope.

A mill biotope that every mill owner hopes to have.
The Hiemertermolen (Hiemerter Mill), Burgwerd.

9.2 THE MILL BIOTOPE

9.2.1 The two sides of the mill biotope

The mill biotope can be literally viewed from two sides: from the mill and towards the mill — in other words, from the surrounding area. The former is addressed in the 'wind capture' section, the latter in the 'perception of the mill' section.

9.2.1.a Wind capture

H.A. Visser's 1946 book called "*Zwaaiende Wieken*" ("Waiving Sails") established the standards of practice for wind capture in a simple rule, the so-called 1:100 rule. This rule says that, for every 100 metres further from the mill, an obstacle may be 1 metre higher. A farm in the open landscape with a ridge height of, say, 10 metres thus had to be built at least one kilometre away from the mill and not closer. What is true for buildings also applies to trees. Trees and groups of trees present an additional disadvantage to a mill's wind capture. They hold the wind with their crown of leaves for some time, resulting in heavy turbulence and causing the wind to come at the mill with widely varying force. The phenomenon of a mill's racing and standing still is the under-appreciated consequence.
Highly fluctuating forces give the sail cross too much acceleration, which overloads the running gear. Especially in showery weather, this increases the risks to the grinding mill. Obstacles located too close to a mill keep the wind away from the lower half of the sail cross while the upper half experiences the full load. Not surprisingly, the forces that then occur in the poll end and in the cap of the mill are very unevenly distributed. As a result, in the worst case scenario, shaft breakage could result and cause the miller to lose his sail cross.
A mill in which grain is ground into meal should have a regular running speed. This is a requirement to produce a uniform product. Thus, we can see that the mill's environment determines whether or not this mill functions properly.

Visser's standard is still a handy rule of thumb. It has subsequently been better substantiated and further refined. In 1982, *De Hollandsche Molen* published its report entitled "*De inrichting van de omgeving van molens*" ("The design of the mill environment").
The calculation method shown in Section 9.5.2 is derived from this report.
The method factors in the height of the poll end above ground level as well as the type of environment in which the mill is located: open, rough/half-open and closed.

- Open: flat land with only superficial vegetation (grass) and sometimes minor obstacles. Examples are runways, pastures without windbreaks, fallow arable land.
- Rough/half-open: arable land with alternating tall and low crops. Large obstacles (rows of leafy trees, low orchards and so on) are at intervals of about ten to fifteen times their height. Examples are vineyards, corn fields and the like.
- Closed: ground regularly and completely covered with fairly large obstacles, with intervals no greater than several times the height of the obstacles. Examples are forests and low buildings.

Although this calculation is fairly widely accepted as a starting point, it is not universal.
The last word has not been said about this calculation.
The latter point requires an explanation.
The formula indicates how an obstruction affects the inflow of the wind from the direction in which the obstruction is located. But when the wind is stopped in a circle segment of, say, 10⁰ it does not mean of course that it reduces the wind capture of the mill by a total of 10/360. After all, the wind does not always blow from the same angle. On the other hand, you also have to deal with the effect of an obstruction on wind run-off, but there the distance factor works differently again. How important an obstruction is also depends on the wind capture still present at a mill. If it is already poor then further hindrance should certainly not be added.

In all calculations, it must always be remembered that the power of a mill decreases much more sharply than the wind capture. If the wind capture drops to 90%, the mill power drops by the third power of that factor: specifically, to 73%. Hardly anyone is aware of that.
Therefore, assessing what is acceptable is not a simple matter. The formula is a very important starting point, by which it should be noted that it already contains a compromise because it assumes a wind capture of 95%, so it already takes into account a loss of mill power of 14%.

Speed	Wind Table Mill Power
100%	100%
95%	86%
90%	73%
80%	51%
70%	34%
60%	22%
50%	13%

The need for a method of calculating obstruction from an individual object is always increasing but that, too, is proving to be a complicated matter. Wind tunnel tests can be a good but very expensive tool in this regard. In practice though, the results from a wind tunnel study have been shown to always paint far too positive a picture. The possibility of calculating the effect through computer modelling is currently being investigated. If we can master that, we will be in a much better position. But even then, what you have calculated must be contrasted with the obstacles that already exist around the mill in question.
Irrespective of any result, keeping a radius free of buildings and plants of at least 100 metres around the mill remains of the utmost importance.

9.2.1.b Perception of the mill

The miller sees the mill primarily from within, as a machine which must be used for work and cared for very well.
Millers have always placed great emphasis on wind capture.
But almost everyone else experiences the mill from the outside, as part of the landscape and/or part of his or her living environment. And that, too, is an important aspect of the mill's significance — one to which we may have paid insufficient attention in the past. As a result, we have been rather too one-sided and that was not wise. Not only have we neglected a substantial part of the cultural-historical significance of the mill — its place in the landscape and how it has developed — but we also missed the connection with the way in which other people perceive the mill. This is unfortunate because good wind capture and good integration with the landscape largely go hand in hand.

Mills demand openness around them. This is not only good for wind capture but also for the unobstructed view of the mill in the landscape. Therefore, we should also use that argument to try to preserve or reclaim the openness around the mill. This will also appeal more strongly to local residents. In doing so, we can also hopefully make what is in the mill's interest a more widely supported interest.
Integration is not only about an open aspect but also, and sometimes more strongly, about lines of sight to the mill. This goes without saying in a built-up area. It was not for nothing that people built mound and stage mills, but because that was the only way to get enough wind. Even in rural areas, complete openness is rarely a feasible situation. We must aim for a situation where the mill is a main element in the landscape but without compromising other important landscape aspects too much. As it often does, it is a matter of finding an optimal solution while taking other interests into account — the acceptable compromise that is usually unavoidable in a crowded country like the Netherlands. If we succeed in this, we can gain many allies.

9.2.2 Opportunities to preserve and enhance the mill biotope

9.2.2.a Obtaining support

Those who want to preserve heritage buildings have the best chance of success if they succeed in convincing many people of the importance of preserving such heritage and thus manage to get them on their side. This is no different for mills. Perhaps it applies to the mill biotope even more so because the requirements of a good mill biotope soon come into conflict with other interests.
After all, the space occupied by the mill's biotope is large and there are many competing claims for that space.

How do you create support?
First, by making sure people are aware of the mill.
Make sure the local press regularly features something about the mill.
Participate in fairs. Set up the mill on special occasions. Attract

The ideal environment for a mill. Free of any obstacle that may prevent the proper attainment of the wind. Windmill "Het Noorden" (The North), Oosterend, Texel people to the mill when an opportunity arises. This requires more than just a passive opening one afternoon a month, for example. Naturally, you should pay special attention to persons who have many points of contact with the mill, such as neighbours. And, of course, also to those who determine what can and cannot be done around the mill, such as the municipal government and its administration. Being unknown is to be unloved. Providing knowledge is therefore very important.

The next step is to clarify the requirements of a good mill biotope. The target audience becomes a bit narrower in the process, although it never hurts to express your opinions more widely. But exercise care with the latter. Making demands in an arrogant tone produces few allies. Better to save that for real conflict situations. Do let the neighbours and local residents see in practice what, for example, planting too high does to the turning of the mill when the wind is on that side. In all of this, bear in mind that support is gained by positive action, cooperative thinking and making adjustments where possible, and by being reasonable.
Do not avoid conflict, of course, if there is no other way, but then you are in another chapter.

9.2.2.b Responding to developments around the mill

Not only do we have to put our own interests well to the fore, but of course we also have to keep an eye on what is going on around us. That means looking systematically at what presents itself. The local press is very important in this regard. This should go beyond observing; action must also be taken.
Do not wait until something is officially announced or final but respond to the first signal and seek further information and make use of being able to submit a "view". If plans have not yet taken firm shape, there is often a great deal still open for discussion. Aspects which may have been forgotten, such as the requirements for a good mill biotope, can be pointed out.

The sight lines seem to be well looked after at the "Doesburgermolen" (the Doesburg Mill) in Ede...

The earlier you step in, the easier it often goes and the less conflict
there will be. Consider not only building and zoning plans but also land development plans,
landscape development, outline structure plans and whatever else you can think of.
Good contacts at the Town Hall are extremely helpful. Therefore, try to establish some sort of bridgehead in the Town Hall, especially with the officials who deal with spatial planning and/or historic preservation. If successful, you will then have a channel through which the mill's interest can be conveyed within the municipal organisation. Moreover, you will then have someone who can show you how best to handle things. Do not expect things that cannot be realised. A public servant is ultimately there for the common good, and must balance various interests.

If the opportunity arises, also try to initiate action yourself. If the mill suffers from overgrown plants and shrubs in the area, sometimes the Landscape Management Foundation (*Stitchting Landschapsbeheer*) in the province can help resolve this. Sometimes it can be beneficial to solicit the preparation of a landscape plan by the municipality or the region to initiate purposeful development and prevent undesirable developments.
Sometimes local historical societies can prove to be allies, etc. There is no general recipe for this, nor is it always possible. If an opportunity arises, take active advantage of it.
In any case, make an "view" known to the municipal council. If you do not do this and the zoning plan is adopted, then no further appeal or application for provisional relief is possible.

9.2.2.c Participation and raising an objection

Protecting the mill biotope is first and foremost a matter of clarifying its importance. Ultimately, of course, we want to see that interest protected through official regulations.

...however, when we walk about 100 metres to the south, the reality turns out to be completely different.

The best instrument available for this purpose is the Spatial Planning Act (*Wet ruimtelijke ordening*, or Wro in Dutch) and the regulations and procedures based on it. The Wro has many options for public participation and a whole series of opportunities to oppose what a municipal government is proposing. That opposition is the
final stage and you must try to prevent matters from reaching that stage. After all, what is included in a plan out of conviction holds up much better than what is enforced by higher authorities in appeals proceedings. Unfortunately, the latter does not always prove to be avoidable.
Public participation opportunities must, of course, be utilised. Even if everything is well regulated, it can be very useful to say so explicitly (and express appreciation) and, moreover, to keep an eye on whether other commentators sometimes advocate developments that are detrimental to the mill. Again, anything that can be regulated before a plan becomes official is a gain. Once the Municipal Executive has formally expressed its views, it is often difficult to get it to change its mind.
Spatial planning procedures and options for raising objections — views, concerns, objections, appeals, request for provisional relief — are discussed further in Section 9.5.

9.3 INVENTORY OF THE EXISTING SITUATION

Targeted action to preserve or improve the mill biotope obviously requires a good knowledge of the existing situation. Consideration should be given to the following:

- topographic situation, elevation, soil type,
  water management, land division
- list of owners, users and administrators of the plots near the mills
- type of land use
- plants and shrubs present by species, actual height and potential height
- buildings present and their height
- zoning plan regulations
- water authority by-law

It is recommended that these matters be inventoried for each mill. Display these data on the land registry map (obtain from the municipality) and draw circles of 100, 200, 300 and 400 metres with the mill at the centre.
In general, this then gives you the area to be carefully watched for urban and landscape developments. The availability of an up-to-date inventory can make it much easier to take fast action. Moreover, this makes it easier to obtain an overview of the current state of affairs regarding the mill biotope in the Netherlands.

Mills and the right choice of trees can lead to a beautiful landscape view. The tower mill of Gronsveld

9.4 THE ORGANISATION OF BIOTOPE CONSERVATION

9.4.1 Organising the monitoring of the biotope

Mill biotope conservation was established by Evert Smit (†). He set up a network of biotope guardians (over 200!) and single-handedly maintained it for years. He gathered information from the Government Gazette and forwarded it to the appropriate biotope guardian, who could then take action. Smit did that under the umbrella of the Guild of Millers and the *De Hollandsche Molen* Association. This has laid a solid foundation for conserving the biotope.
After his death, the task was taken over for some time by the secretary of the mill biotope working group of *De Hollandsche Molen*. It was clear even then that the work organisation had to be further developed and also adapted based on the foundation laid.

All the more so because due to changes in procedures in the Spatial Planning Act (Wro), municipalities are no longer required to have the necessary information (for example, zoning plan changes) published in the Government Gazette. This also makes it impossible to monitor everything from a single central point.

The biotope guardians have done very important work but they are always short of eyes, ears and hands. Their ranks must be strengthened, and local, regional and provincial organisations must be involved much more intensively in the conservation of the biotope. This further development is still being worked on but the results are already visible in several places.
The basic idea is very simple: effective action to maintain and improve the mill biotope is best undertaken at its foundation, since:

- That is where there is knowledge of the concrete situation, the problems and the possibilities.
- There you can keep a close eye on developments, bring attention to mill interests from the beginning, and come up with solutions in proper consultation with those involved.

A mill hemmed in by offices. Jutphaas hollow post mill, municipality of Nieuwegein

- There, with targeted actions, you can recruit the necessary support among the local population.

At that foundational level, it is very important to connect and maintain contact with all those involved with the mill — whether millers, owners, biotope guardians or foundation board members. Together you stand strong and, if you have good consultations, you cannot be played off against each other.
The miller is a central figure in this effort because he notices immediately when the biotope is not good. A second central figure is the person who keeps track of all plans in the area around the mill. This can be the miller but it may also be someone else, such as a biotope guardian. This must be very clearly agreed upon for each municipality. If that monitoring is not properly organised, nothing will come of it and you will be constantly faced with issues that can hardly be changed any more.
The local press should therefore be carefully monitored. Do not expect a biotope guardian to be able to keep track of everything that happens in a sizeable number of municipalities. That is impossible.
At the beginning of the planning process, many things can be arranged in the municipality. But not everything can be done at that level. When legal proceedings need to be conducted, outside support is often desirable. In special cases, the *De Hollandsche Molen* Association can provide support in this regard, but not in all cases. It cannot properly supervise all proceedings remotely and, in addition, it lacks manpower.

9.4.2 The role of *De Hollandsche Molen* in biotope monitoring

De Hollandsche Molen provides the tools for working in a decentralised or local manner; in other words, to collect and disseminate knowledge. A second main task with regards to conserving the biotope is to work with the Guild to monitor whether

Beautiful trees and a mill go very badly together. The mill of Mierlo

there is a properly functioning decentralised organisation and, if necessary, to take action to get it (back) to that point.
Furthermore, everything at the national and supra-regional level belongs by definition to the field of activity of *De Hollandsche Molen*.
Support in specific cases should also remain possible but, in principle, they should be special problems. If that happens too often, *De Hollandsche Molen* will not be able to get on with its main task: looking after the machinery.
The general rule is: First try to solve matters yourself; if that is not possible, go to the provincial organisation. Only approach *De Hollandsche Molen* if you are not successful with the province. While engaged in this, do keep an close watch on the deadlines. Responding on time is more important than a very nicely worded point of view. You can always supplement that view later.

Tall trees do indeed belong on ramparts, as bullet catchers, but not so close to the mill because then they become wind catchers.
De Stadsmolen (The City Mill), Hulst

9.5 PROCEDURES IN SPATIAL PLANNING

9.5.1 Introduction

The Spatial Planning Act (Wro) is the most important law for the protection of the mill biotope. In that regard, the main instrument under that law is the zoning plan.
We therefore limit ourselves to the zoning plan and what is associated with it, although the regional plan and the structure plan should not be forgotten of course.

The regional plan always (or almost always) covers an area that is larger than a municipality, and it is obvious that regional organisations look primarily at that.

The structure plan and the outline structure plan are municipal instruments. It is very important to pay close attention to them and make known your views on them and of related types of plans. What is contained in an outline structure plan and the like adopted by the municipal authority is not legally binding on citizens but it does indicate the direction of thought. If that direction is not favourable to the mill, we should definitely speak up about that.

However, so many different forms are possible that it is not useful here to talk about the procedures surrounding this type of planning. Do pay attention and, if something comes up for discussion, seek advice from *De Hollandsche Molen* if necessary.
There are some other types of planning that deserve attention. They are mentioned here even though, strictly speaking, they are not covered by the Spatial Planning Act. At the municipal level, these are landscape plans and landscape development plans. It goes without saying that those plans are important for mills. Latch onto it immediately when something like this presents itself, and try to adjust it in a positive way: the mill as a very important landscape element in a good high-profile location!
The same is true for land consolidation plans that usually involve more than one municipality. These also document matters that may be of vital interest to mills.

The mill in Zoutelande is threatened, but the situation was still acceptable in 1985...

9.5.2. The zoning plan

9.5.2.a Introduction

A zoning plan establishes what may be built in an area (height, area, location) and what land and buildings may be used for. The latter is important in connection with possible vegetation schemes. It is therefore important to take care that the zoning plan for the area around a mill provides rules that limit the height of construction and plants — as much as is necessary and possible. As much as necessary for the mill's wind capture and an unobstructed view of the mill. As much as possible, taking other interests into account.
The balancing of interests does not have to be done by the mill organisations themselves; that is the job of the municipal authority. It is neither sensible nor reasonable to pretend that no other interests are involved. You cannot simply undo what is already there by implementing a new zoning regulation. Matters that already exist have acquired rights. It is true to say that whatever can be settled by mutual agreement is most likely to stay in place. Remember that formal arrangements do need to be made so matters can be enforced or stopped if there is no alternative, and also to record and make official what has been negotiated by mutual agreement.

9.5.2.b The mill protection zone

Mill protection zones are zones around a mill with a radius of up to 400 metres, in which restrictive provisions apply to the height of buildings and plants.
Mill organisations and/or owners should try to have these included in zoning plans so that they are thereby established and made official.

...unfortunately, other decisions were made based on the zoning plan: "houses for sale, overlooking the mill".

Provisions on construction and designated use are set out in the regulations associated with a zoning plan. Such a regulation also governs a mill protection zone, usually as an additional provision, and the zone must also be indicated on the zoning plan map. This last requirement is important because then the municipal official who deals with it can immediately see that additional provisions apply here.
For an example of laws and regulations as well as model texts, see: www.molenbiotoop.nl

9.5.2.c The height of the buildings

The plan regulations always regulate the height of permitted construction, referring to the designations on the zoning plan map where appropriate. A distinction is made between eave height and ridge height. The ridge height, also known as building height, is of course the most important factor in connection with the mill. We must check that height against what is permissible according to the standards of *De Hollandsche Molen*, taking into account the distance from the mill. See Section 9.5 for this.
If the eaves height is listed, the shape of the house above the eaves is extremely important. If a generous mansard roof is put on it, another storey has suddenly been added.

9.5.2.d The regulation of vegetation height

The height of vegetation is by no means always regulated in the zoning plan, and that is a major omission. In many situations, more obstruction is experienced from vegetation than from buildings. So we need to make sure this is regulated, either by including a building permit system or through usage rules. To avoid additional procedures, the latter is often (but not always) preferable.
Remember that this section is not just about trees along roads and in gardens or around traditional woodlands. Under agricultural zoning, for example, it is often possible to plant a commercial forest for forestry purposes. This must be ruled out close to the mill.

9.5.2.e Exemption and amendment powers

A final component that should be explicitly mentioned is the exemption and amendment provisions in the zoning plan. Each plan includes rules on how the Municipal Executive may grant an exemption from the zoning plan or amend the plan. We have to look at that critically because this is a means whereby something might be permitted unexpectedly. When such an issue arises within a mill protection zone, the Municipal Executive should be required to seek advice from a recognised mill organisation prior to applying those powers. This may be a local or regional mill organisation or, as an exception, *De Hollandsche Molen*.

9.5.3 Zoning plan revision

When a zoning plan is being drafted or revised — which in principle should be done once every 10 years — it is a good idea to think about including a mill protection zone in a timely manner.
We could be unaware of the fact that the revision of such a plan is under preparation. There is an opportunity to learn of such a revision via a mandatory public participation process. In any case, before the plan can be adopted by the municipal council, it must be submitted for public inspection. The duration of the public inspection period may vary but must be announced in the relevant publication. During this period, any citizen or legal entity may submit their reasoned views to the municipal council, even if they took no active part in the public participation whatsoever.

Please note that views can only be submitted within the time period specified in the publication. This is usually six weeks, unless otherwise announced. Those who fail to respond then additionally lose any opportunity to submit concerns or appeal the plan to higher authorities.

9.5.4 Raising an objection to a zoning plan

The zoning plan determines what can be done with space within a municipality. A zoning plan states whether construction is allowed and, if so, how that must be done. There is an established process for the creation of zoning plans. People can influence this in several ways. Those who disagree with a zoning plan can appeal to the Administrative Jurisdiction Division of the Council of State.

No comment!
Besthmener Mill, Ommen

The entire procedure is as follows:

Announcement of zoning plan
The municipality announces in advance a zoning plan containing spatial developments. This can be in a residents' letter, a door-to-door newspaper or on the municipality's website.

Draft zoning plan
The municipality prepares a draft zoning plan. This draft can be inspected for six (6) weeks. This can be seen, for example, at the town hall, on the municipal website or via the website ruimtelijkeplannen.nl.
During this period, people can submit their "views" to the municipal council. What if you don't do this and the zoning plan is adopted? Then you cannot file an appeal or make an application for provisional relief.

Adoption and publication of zoning plan
After the six-week period, the municipal council must adopt the zoning plan within 12 weeks. It then has two (2) weeks to publish the decision.
(The deadline for publication may be longer in certain cases, namely six or seven weeks.)

Filing an appeal
If you disagree with the municipal council's decision, you can appeal to the Administrative Jurisdiction Division of the Council of State. In its publication of the adoption decision, the municipality will indicate the period during which appeals can be filed. This period is always six (6) weeks. After that, the zoning plan will take effect. The municipality can begin implementing the plan or parts of it.
To file an appeal, people must have expressed their views during the draft phase of the zoning procedure. Those who did not do so can only appeal changes made by the municipal council to the draft zoning plan.

Request for provisional relief
What if you want to stop construction from going ahead? Then, if you have lodged an appeal, you can also make an "application for provisional relief". If this application is granted, the entry into force of the decision is suspended until a decision is made on the appeal.

Court fees
If you appeal a decision in court, you will pay a court fee. You also pay this if you make an application for provisional relief. You will be reimbursed for the court fee you paid if you win the case.

Note: The information mentioned in this section is from the Dutch government: https://www.rijksoverheid.nl/onderwerpen/ruimtelijke-ordening-en-gebiedsontwikkeling/vraag-en-antwoord/hoe-kan-ik-bezwaar-maken-tegen-een- bestemmingsplan.
Since laws and regulations may change over time, it is always recommended to verify that the above information is still current before making an objection.

It is important that we also build case law that we can use in the future for tackling similar cases. Make sure these matters are coordinated. In any case, always report rulings in proceedings to *De Hollandsche Molen* and in your own province. That information can then be disseminated more widely from there.

9.5.5 Requirements for views, concerns and appeals

Several publications listed in the bibliography provide examples of views, concerns and appeals. It does not seem sensible to include them all here, but some general requirements can be mentioned.

The advertisements and the like always state to whom and when documents can be sent. Follow those directions carefully:

- Address accurately.
- Always respond within the official deadline.
- Date the document and state exactly what procedure is involved.
- Clearly state the subject matter.
- Provide a clear rationale for the "objections".
- Always stay businesslike and keep it as short as possible.
- Do not claim things that cannot be substantiated.

No one expects citizens to write letters like a lawyer or a civil servant. It is the arguments that will be examined, in other words: the content and not the style of the letter. As long as it is clear.

A good example of consultation between the municipality and miller. Many trees were eventually removed from around the mill. Nooit Gedacht (Never Thought) Mill, Warnsveld

9.6 WIND OBSTRUCTION

9.6.1 The calculation of wind obstruction

These calculations are not part of the exam material. They are included for information purposes because they can provide some insight into the influence of construction on the mill.

To determine the permissible obstacle height in relation to the distance from the mill, the biotope report "The layout of the mill's surroundings" was taken as a starting point. This report was published by *De Hollandsche Molen* in 1982.

When applying the formula, as we find in the next section, it assumes a maximum allowable wind reduction of 5%. That leaves 95% of the original wind speed remaining, resulting in a power reduction of 14% (see Section 9.2.1.a).
The outcome of the calculation based on this formula is based on a compromise. If the formula is strictly applied, the outcome may be that, around a stage mill, even obstacles that remain below the stage height are unacceptable, even at a distance in excess of 100 metres. Theoretically this is correct but in practical terms it cannot be sold. In practice, therefore, it is usually just maintained that anything lower than the stage is acceptable.

In the calculation, we also include the environment of the mill that can be characterised as open, rough or closed. The biotope report shows that a 100-metre open area should be present around the mill. This open area is needed to offset some of the turbulence caused by the obstacles. It is obviously preferable to argue for a 200-metre open area. Outside this 100-metre circle, a line runs diagonally upwards indicating what is and what is no longer permissible in principle as an obstacle height. Anything above the line must be critically examined.

In an open area, the calculation comes out roughly to what we call the "1 to 100 rule". This means that, for every 100 metres further away from the mill, the obstacle is allowed to be 1 metre higher. We do in fact use a factor of 140 in the formula, but by incorporating the poll end height into the formula, that approximates to 1 to 100.
A farmhouse to be built with a ridge height of ten metres must, in an open area, be at a distance of about one kilometre from the mill, according to this calculation. In practice, this standard is hardly achievable. Only in an open polder landscape can we argue for this. Therefore, as a rule we will only raise an objection if such a farm is located 200 metres from the mill. As mentioned in Section 9.2.1, the calculation of the obstruction is a matter with many if's and but's. The application of the formula is an initial approach, to be followed by a more precise assessment when the standards are exceeded.

In an urban area, a closed area, we use a factor of 50 in the formula. A conversion to a simple rule of thumb is often not possible here because the influence of the poll end height at stage or mound mills leads to different results. The examples given below demonstrate this.

9.6.2 Some calculation examples

A simple formula is given below for calculating how high obstructions may be in relation to the distance from the mill. When using this formula, we always apply the what is called the 95% rule (see Section 9.6.1).

The formula is as follows: $H_x = X/n + c \cdot z$, where:

H_x = height of obstruction

X = distance of obstacle from mill

n = 140 for open, 75 for rough, 50 for closed area c= constant = 0.2

z = height of poll end

Ground-sail mill with a sail cross of 24 metres

Example 1:

Someone wants to build a bungalow 60 metres from a ground-sail mill. The ridge height will be 4½ metres.
Obstructions not only block the wind flowing into the mill but they also impede wind stream. In addition, obstacles cause turbulence, both in the vertical and horizontal planes.
To reasonably cancel out this turbulence, which creates gusty winds and flapping sails, the oncoming wind must be able to recover over a distance of at least 100 metres. Therefore, there should be an open space around the mill of at least 100 metres.
The proposed bungalow falls within this 100-metre circle and therefore should not be built on that site.
At what distance may this bungalow be located? We assume a closed area, so n = 50.
The poll end height z is half of the sail cross, therefore 12 metres.

Calculation:

$H_x = X/n + c \cdot z$. We first write this out as: $X = n(Hx - c.z)$

$X = 50 (4.5 - 0.2 \times 12) = 50 \times 2.1 = 105$ metres

If it is an intact rural environment, we are dealing with an open area. Then the distance becomes $X = 140 \times 2.1 = 294$ metres

Example 2

A zoning plan revision has been submitted for review. Examination of this shows that they want to build a new district of low-rise housing at a distance of 180 metres from the mill. The ridge heights are 8 metres. At what distance could houses with an 8-metre ridge height be allowed?

Calculation:

$$X = n (H_x - c \cdot z)$$

$$X = 50 (8 - 0.2 \times 12) = 50 \times 5.6 = 280 \text{ metres}$$

Thus, if the homes are built at a distance of 180 metres, they will be too close to the mill. We now calculate the upward sloping line under which obstacles are allowed. We will then see what is the allowable height for buildings located 180 metres from the mill.

$$H_{180} = 180/50 + 0.2 \times 12 = 3.6 + 2.4 = 6 \text{ metres}$$

So the houses could be 6 metres high at 180 metres. To determine the upward sloping line, we calculate a few more heights at varying distances.

$$H_{100} = 100/50 + 0.2 \times 12 = 2 + 2.4 = 4.4 \text{ metres}$$

At 200 metres this is 6.4 metres, at 300 metres 8.4 metres and so on; thus every 100 metres the obstacle can be 2 metres higher.

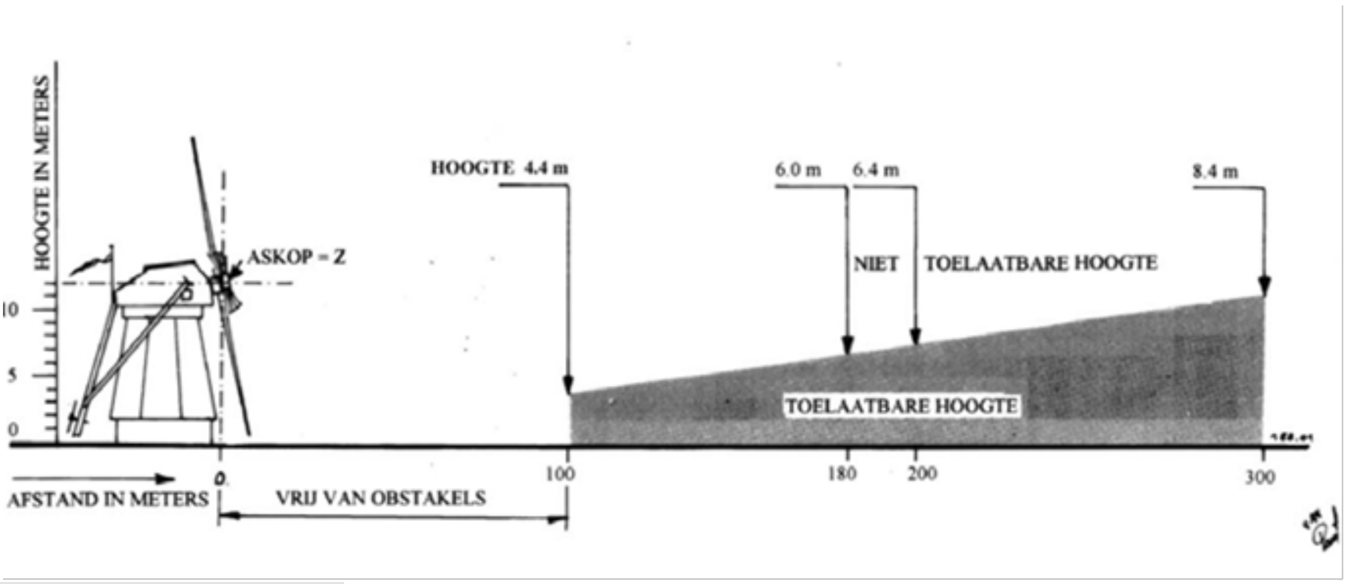


Fig.9.5.2.1
Permissible building distance and height to the ground-sail mill from Examples 1 and 2.

Example 3

A stage mill with a sail cross of 24 metres and a stage height of 10 metres

Here the poll end height is z = half the sail cross + stage height = 12 + 10 = 22. We need to remember that the higher the obstacle, the greater the impact on the oncoming wind and the more turbulence. The calculation using the formula gives the permissible obstacle height in relation to the distance from the mill.

We see how far from the mill a particular obstacle must be and how far it may exceed the height of the stage. Both theory and practice show that the higher the stage, the further away from the mill is the point where obstacles can be higher than the stage. Usually we are dealing with a closed area here, so we enter n = 50.
How far should a building with a ridge height of at least 12 metres be from the mill?

$X = 50\,(H_x - 0.2 \cdot z) = 50\,(12 - 4.4) = 50 \times 7.6 = 380$ metres

Example 4

A stage mill with a sail cross of 26 metres and a stage height of 6 metres.

Here the poll end height is z = half the sail cross + stage height = 13 + 6 = 19 metres. How far from the mill should obstacles remain below the stage height? The height of the obstacle is then 6 metres.

$H_x = X/n + c \cdot z$ or $X = n\,(H_x - c \cdot z)$
$X = 50\,(6 - 3.8) = 50 \times 2.2 = 110$ metres

Therefore, construction higher than the stage could be built beyond 110 metres. The calculated sloping line indicates how high the building can be.

$H_{100} = 100 / 50 + 0.2 \times 19 = 2 + 3.8 = 5.8$ metres
$H_{200} = 200 / 50 + 0.2 \times 19 = 4 + 3.8 = 7.8$ metres

Again, every 100 metres further away, construction can be 2 metres higher.

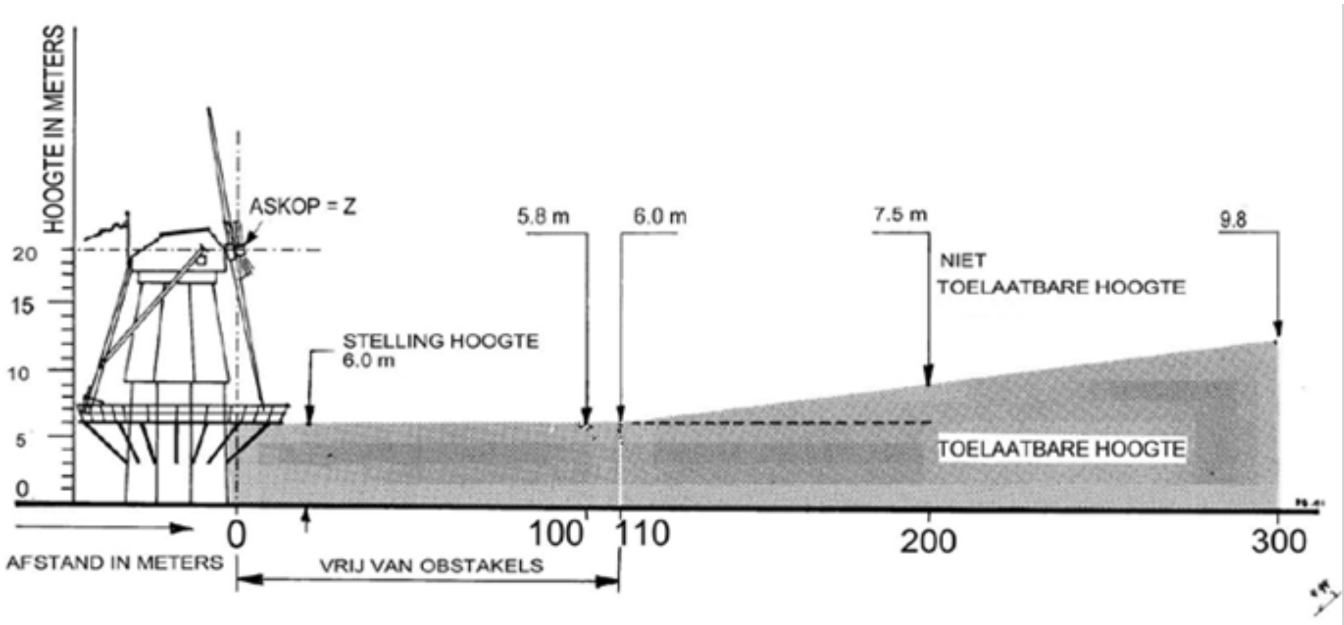


Fig. 9.5.2.2
Permissible building distance and height to the stage mill from Example 4.

9.7 IN CONCLUSION

The wind capture of our mills is significantly threatened. It is no exaggeration to say that building and vegetation growth present the greatest danger to mills. This course teaches how mills are built, operated and maintained. As a volunteer, it is also desirable to know some of the history of mills and to be able to distinguish the various types. Of course, working with a mill should result in the volunteer being able to operate the mill responsibly in all weather conditions.
This chapter indicates that it is additionally very important for every volunteer that mills be able to capture wind. Mills should be free standing all around and stand out from the sky. This enhances their functioning and increases their perceived value. Turning or milling with a mill is the best guarantee for maintaining it. Therefore, after obtaining the certificate, let the mills turn in an appropriate environment and commit to maintaining or improving the mill biotope. This is paramount for your own safety and for the mill.

It seems such fun, pushing a chestnut into the ground, but the consequences are incalculable later. The Slokop Mill (The Glutton Mill), Spaarndam

NOTES

Chapter 10 Safety

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NOTES

10.1 INTRODUCTION

Safety is of paramount importance for anyone who works at a mill or is there as a visitor. For this reason, attention to this topic is an essential part of the training. During the exam, therefore, you must show that you are aware of safety aspects and can work safely in all respects.

Between April 1980 and May 1984, the (volunteer) mill world was startled by three fatal accidents. Even after that, unfortunately, serious accidents again occurred at mills. This prompted a study of the safety features at mills, which resulted in the report "Safety at Windmills and Watermills".
During their training, millers-in-training become increasingly aware of the dangers they and others face at a mill, whether or not the mill is in operation, but the accidents mentioned above make it clear that you can never pay too much attention to safety.
Safety is first and foremost a matter of your mindset. You must be prepared to work according to basic safety principles; otherwise accidents are bound to happen in the long run.
Secondly, safety is based on knowledge, because ignorance can lead to dangerous situations.
Safety is everyone's responsibility: everyone who works at a mill must help ensure that work is done safely — by setting a good example, but also by discussing unsafe situations.

There are two categories of people who are at risk at a mill.
The first category consists of (volunteer) millers, millers-in-training, youth members and mill guides; that is, the people who work with or at the mill.
For this category, the greatest danger is becoming accustomed to constantly being near the moving mill parts. This familiarisation sometimes leads to operational blindness.
Youth members (<16 years old) and members-in-training 16-18 years old require special attention because they are subject to the rules of the Ministry of Social Affairs and Employment on employment for those aged under 18. It is recommended that their parents be made aware of this as well.

The second category is visitors who come to see the mill. However, mills are neither built nor generally set up for visiting. They were intended exclusively as business premises to which only the miller and his staff had access. Therefore, absent special safety measures, many mills are not suitable for visits.
Visitors are usually totally ignorant of the dangers they face during a mill visit. Through visitor rules, warnings and signs, they should therefore be made aware of these dangers. If the mill will be visited by a large group of visitors, the best measure to avoid accidents is to shut down the mill.

Millers, mill owners and visitors each have their own responsibility when it comes to promoting safety and preventing accidents. And the degree of responsibility is also the starting point for the degree of liability for accidents (see Section 10.2.2)

10.2 SAFETY IN PRACTICE

10.2.1 Safety in general

Remember that when working with a mill you are always at risk. Safety is the conscious taking of acceptable risks.
Taking proper precautions yourself can minimize the chances of an accident.
A well-maintained mill is a first step toward safe operation. Even a mill that is not running can pose a danger to the miller or to visitors. Mills are old machines. This means that certain parts may have deteriorated or worn out without anyone noticing this. In the Netherlands, most mills are fortunately in a reasonable to good state of repair. However, it is dangerous to rely completely on this.
Some points for attention:

- Stairs can be worn to the point where you can slip off or fall through them.
- Stair railings should be secure.
- Loose floorboards must be fixed immediately.

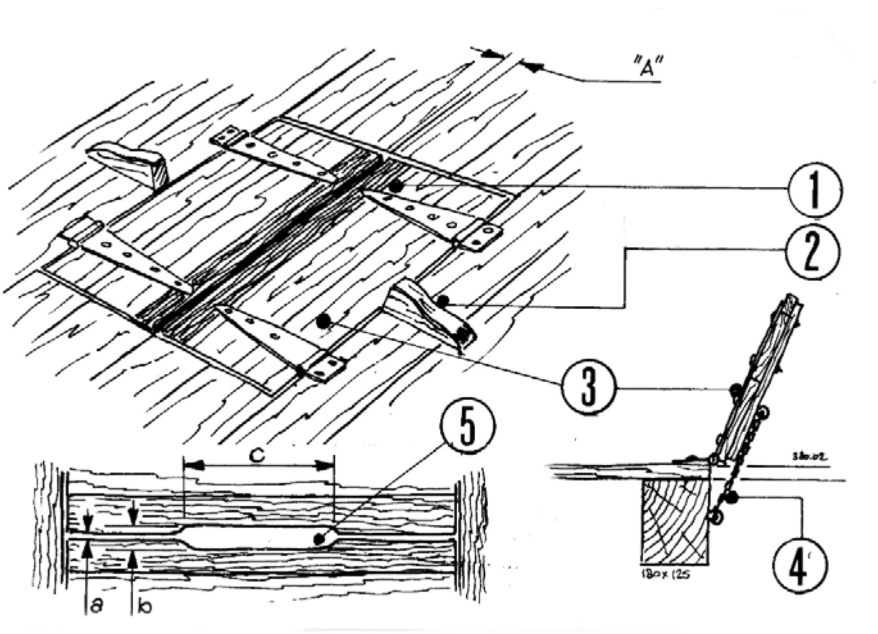


Fig. 10.2.1.1
The trap-doors

1. *hardwood edge*
2. *sill clamp*
3. *trap-door*
4. *chain*
5. *opening for hoisting rope*
   a. width max. 2 cm
   b. width max. 4 cm
   c. length max. 15 cm

- The condition of trap-doors and spindle hatches should be checked regularly (see Fig. 10.2.1.1).
- The stage must be reliable, with the condition of the shoring and joists being especially important. The condition of the stage railing is also important. You must be able to enter the stage without danger. However, the stage is not designed for large groups of visitors.
- Wood tracks may be slippery due to moisture or algae and should be provided with non-slip facilities.

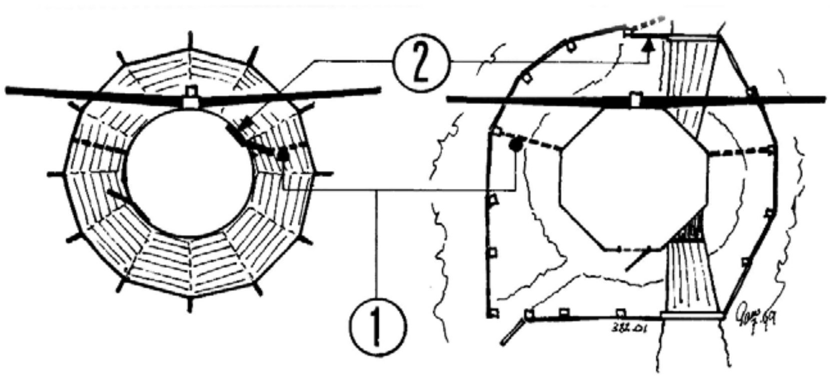


Fig. 10.2.1.2
Fencing off the rotational plane of the sail cross:

1. *fencing off using fences, nets, chains, etc.*
2. *passages to be closed*

A turning sail cross must be shielded even when no visitors are present because this shielding is also for the miller.

- Using proper demarcation materials, mark off that portion of the mill yard or the stage over which the windmill's sail cross turns (see Fig. 10.2.1.2).
- Make sure visitors do not open gates around the mill.
- From the inside, lock the door past which the sail cross turns.
- The mill may only be operated by authorised persons.

Make sure that, in case of an emergency, help can be provided quickly.

- A first aid kit should be available in each mill. This must be prominently displayed where everyone can see it.
- In an emergency, use the local emergency number.
- Outside help can be provided more quickly if the fire service and ambulance personnel know the way to the mill. Arrange for the local fire service to hold a drill at the mill.
- Think carefully in advance about what to do in case of any accidents and discuss it with all volunteers.

Smoking is absolutely prohibited in all mills. Care should be taken when stoking stoves and using other heating equipment. Switch off the electrical system before doing any work on it, as well as when you leave the mill after a milling or turning day.

10.2.2 Safe clothing

Loose clothing can easily get caught in a rotating component. For that reason you should wear clothing that meets the following requirements:

- Close-fitting clothing: However, do not leave clothing hanging open. Loose clothing or parts of clothing are dangerous: they can get stuck behind something and pull you into the running gear. Tuck the loose ends of a scarf inside the over-garment.
- Footwear: Clogs can be worn provided they are not worn out. If you have to perform work in the sail cross other than setting sails, do not wear clogs. In that case, it is even better to work without footwear because in socks you have a better grip on the prop. Clogs on slippery surfaces are also dangerous.
  Safety shoes are essential for work during which heavy objects

could fall, such as at sawmills or when hoisting pairs of stones at grain mills. Also when using heavy tools.
- Gloves: Wearing sturdy gloves is sometimes advisable. There must be at least a few pairs in a mill.
- Safety glasses, which fit the face (see Fig. 10.2.2.1): Wearing them is strongly recommended when doing jobs such as dressing stones and grinding metal, even if you already wear regular glasses. Indeed, a flying part could still accidentally end up behind the lenses and injure an eye.

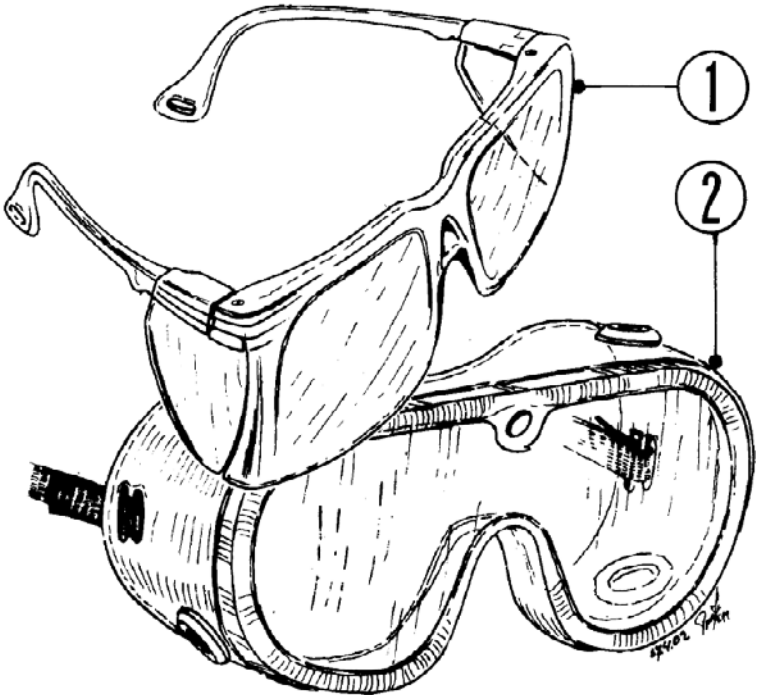


Fig. 10.2.2.1
Safety glasses
1. *for non-wearers of glasses*
2. *for wearers of glasses*

10.2.3 Working safely in and around the mill

Unlike heritage buildings such as churches and castles, a mill is not a static but a dynamic artefact. Because it is a machine, it needs more and regular maintenance. Both normal work at a mill and maintenance work require special measures for everyone's safety, including that of the mill.

- When working at height, use proper climbing and fall protection equipment. The Occupational Health and Safety Act sets very strict requirements for millers-in-training in this regard!
- Use good tools.
- Maintenance work close to the running gear must be performed when the mill is stationary. When doing this, make sure that everyone at the mill knows that maintenance work is under way. This prevents anyone from releasing the brake. Even better: make it impossible to release the brake.

- Work that carries more risk should preferably be done with a second person present so that, if necessary, they can come to the rescue or take appropriate action.
- Close cans of paint, thinners, fuel, etc. after use and make sure they cannot fall over or become trapped. Store them in a lockable cabinet or chest.
- Use extension cords of sound quality and make sure that they cannot become trapped between rotating parts. If a cable reel is used, it should be uncoiled completely when more or less heavily loaded to prevent heat build-up in the uncoiled section.
- Due to fire danger, smoking is not allowed in a mill under any circumstances, including on the stage! Working with open flames must also be kept to a minimum. If it nevertheless becomes necessary, have fire extinguishers and/or water for putting out a fire on hand. And an extra round of fire inspection must be done afterwards. When doing this, you should be especially mindful of smouldering items that are usually characterised by very little smoke.

10.2.4 Safe winding

Large forces occur when winding a mill, especially on the entire tail structure. Therefore, all parts of it should be in good condition. Especially important are the attachment points of the braces to the tail beam and to both stretchers. Via the winding chain or winding cable, those forces also act on the winding bollards or the stage structure. Place the winding chain in the winding direction as much as possible.
The condition of (wooden) winding bollards usually looks better than it actually is. Digging away the soil around it several decimetres deep soon reveals the condition of that winding bollard. Its condition is poorest where soil meets air. The quality of the shore beams in a stage mill is very important, because the hook at the end of the winding chain or winding cable is attached to them.

Of perhaps even greater importance is the condition of the anchoring of the main shores to the shore beams and to the masonry base or the consoles. When winding, make sure that the winding chain or cable is not wound around the barrel to the point that the chain or cable reaches a vertical position such that the hook pulls the shore beam up slightly. This could result in the braces being lifted from their support.
In addition, winding the winding chain too much takes a lot of force and produces little displacement of the tail.

The hooks or rings on the winding and anchor chains must be sufficiently strong so that they do not bend open during use or in storms.
Using a steel wire for winding requires extra attention. The cable remains constantly wet or damp, and it can rust away from the inside. Chains do not have that problem. Incidentally, these have to be good quality and the larger the mill, the heavier the chain.

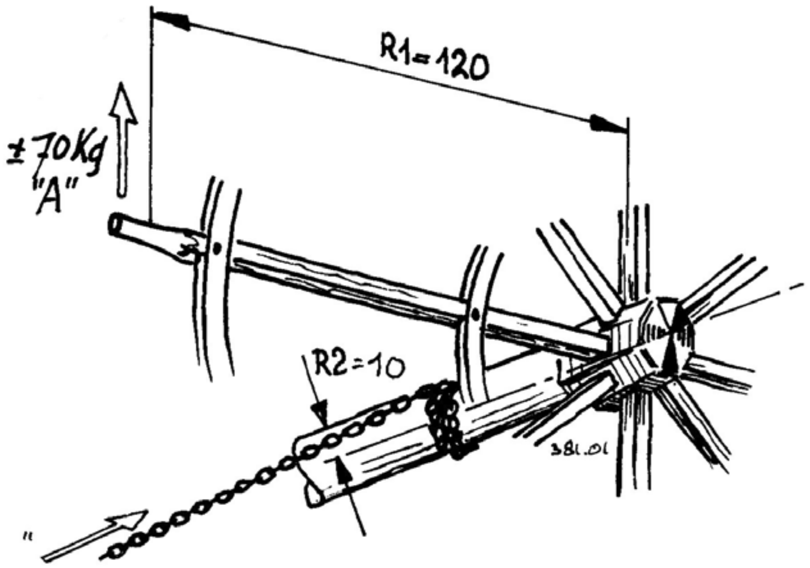


Fig. 10.2.4.1
Winding forces

The tensile force on the winding chain is determined by the following formula:
R1 x A = R2 x B
1.2 x 70 = 0.1 x B
B = 840 kg.

Fig. 10.2.4.2

Rotted winding bollard just below the ground level

The quality of a much smaller chain, the so-called spoke chain, is also important. Specifically, inspect how it is secured. After all, if this chain is missing or broken, the mill will be standing free. Also check the robustness of the anchor chain attachment point.

The capstan wheel also needs regular attention. Moisture and rainwater degrade its condition over time. Weak points are the places where the spokes are inserted into the barrel. People tend to forget to lubricate the barrel. If you do lubricate regularly, the winding will go easier and rainwater will be kept away.
If the mill has a geared hand winch, then there are other points for attention. The pawl return is of great importance but so is the shaft around which this pawl rotates. If the pawl return locks while in the process of running out the winding wire, damage may occur.
The various gears should engage properly with each other. Make sure that they are not worn to the point where they can slip over each other. Something like that will of course happen just when the greatest forces are applied to the winch. The crank(s) must be properly secured to the shaft. If the crank is detachable, never unwind the winch while the crank is still resting on the shaft. A flyaway crank is a dangerous projectile, especially if the mill is a stage mill.

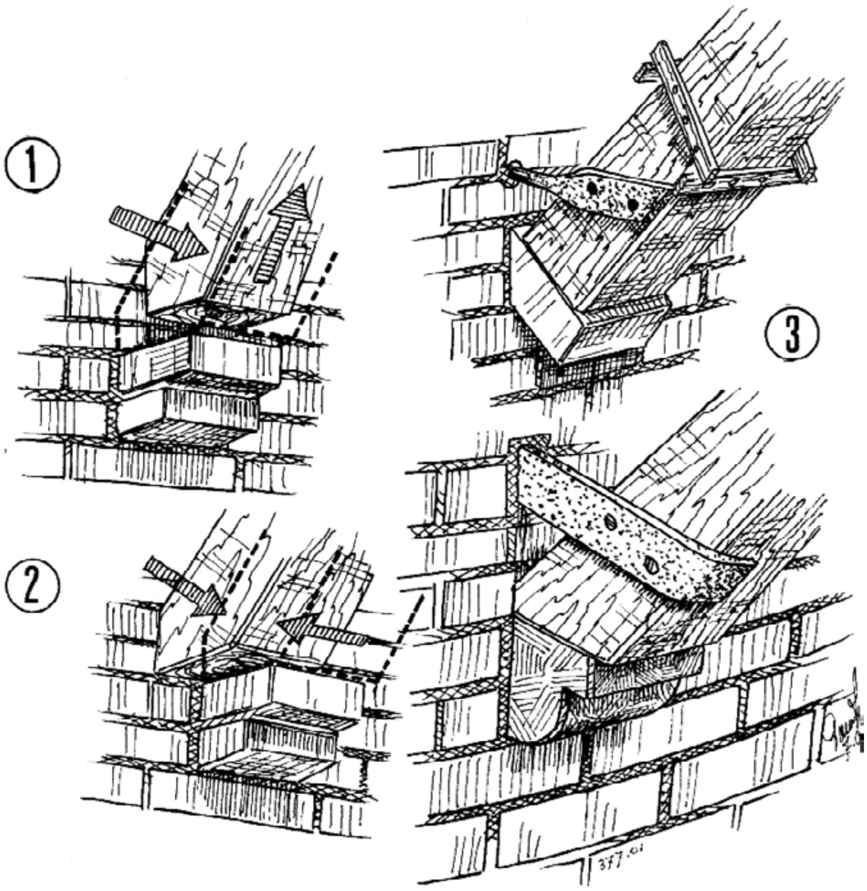
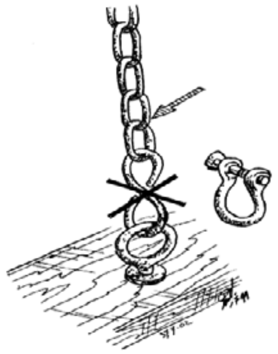


Fig. 10.2.4.3
The main shores:
1. *the shore is pulled up if too much winding is done*
2. *the shore slides sideways from the console*
3. *examples of pawls*



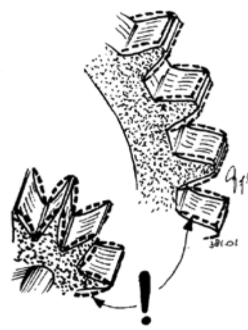


Fig. 10.2.4.4 (left)

Ensure reliable attachment of the spoke chain.

Fig. 10.2.4.5 (right)

The condition of the teeth of the geared hand winch determines the reliability of the pawl.

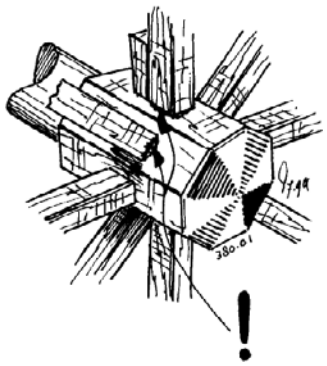


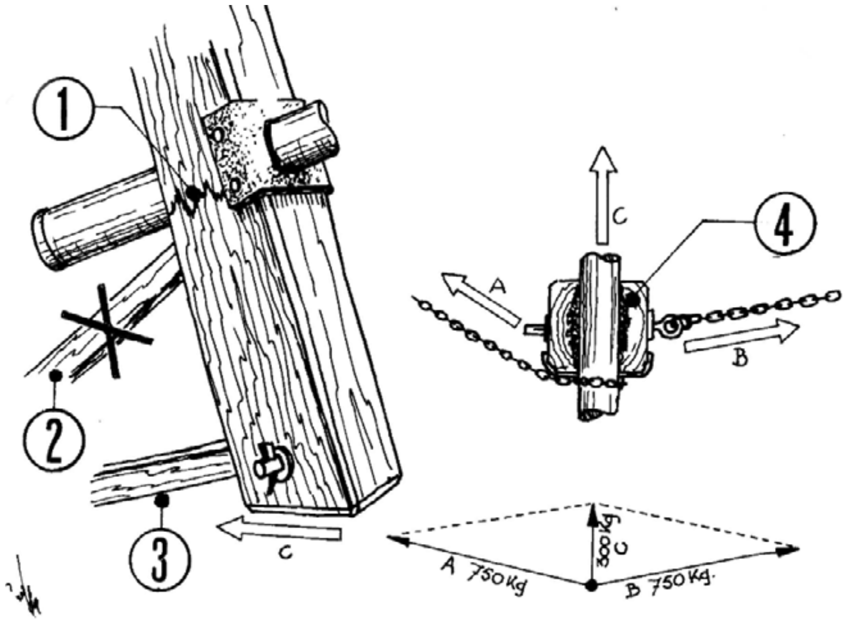
Fig.10.2.4..6
Rotting of the barrel

Rotting mainly takes place where the spokes insert into the barrel.

Fig. 10.2.4.7
Tension on the winding chains and tail beam:

1. *place where breakage may occur*
2. *misalignment of the tail strut*
3. *the correct alignment of the tail strut*
4. *place where wood rot often occurs*

With a capstan wheel or winding wheel, do not put too much tension on the winding chain and anchor chain. This pulls the tail toward the body of the mill. The tail beam has only two-thirds of its total wood thickness where the barrel protrudes through it. A tail beam buckled at the level of the hole for the barrel is no exception.
To prevent buckling, a tail strut is sometimes placed. This must be placed at the level of the winding chain and anchor chain.



10.2.5 Safety in the cap

When the mill is turning, the cap is not open to visitors. Always close the hatch and block the stairs with a board or lock the hatch. Just a "No Entry" sign will prove to be insufficient!
Work in the cap may be done only when the mill is stationary. Anyone who is going to perform work in the cap would do well to inform the other people present in the mill. If someone is working in the cap, only that person will put the mill back into operation.

Lubricating the upper shaft bearings or checking the temperature of the bearings is also done when the mill is stationary. It is good practice to do this once or twice a day. For safety reasons, the neck bearing should be greased while standing on the weather stud side. The grease must be carefully applied with a spatula (and not with bare hands!) and pressed in lightly. If a hen roost or peg ladder is missing at the front, move towards the neck bearing and back out across the left-hand sheer beam. When doing this, you should not look for support against the brake blocks.

The only work to be done when the mill is turning is to check the brake. If it is a case of listening to ascertain whether the brake is catching, you can do that just by sticking your head through the hatch and listen. Check this, as well, once or twice per milling day.

Anyone who, in very exceptional cases, enters the cap while the mill is turning must be very careful.
This is even more true when the brake lever is located above the hatch. In that case, do not step or climb over the brake lever but rather go around it or crawl under it as close to its rear end as possible.
The greatest danger in the cap is, of course, the rotating parts: the windshaft with the brake wheel and the main upright shaft with the crown wheel. The most dangerous place is the spot to the right of the crown wheel (as seen from the tail bearing) because the rotation there is in the direction of the windshaft. Anyone here who gets their clothes caught on a cog of the crown wheel runs a high risk of being crushed between the crown wheel and the brake wheel. Therefore, always pass the main upright shaft and brake wheel on the opposite side. A covering or shield over the space around the crown wheel and brake wheel must not be missing in any mill.
If there is someone in the cap by way of exception and the other people present have to stop the mill at that moment, warn whoever is in the cap — for example, with one or two short tugs on the brake rope. The alerted person can then move to a safe place in the cap.

When carrying out work on the brake, no matter how simple, the mill must definitely be stopped!
Also, always block the brake when working in the cap. This prevents unauthorised or unknowing people from releasing the brake and thereby endangering someone. This practice is especially true when the mill is ready to be put into operation with presented sails.
Protruding parts on wheels should be fitted in such a way as to minimize danger. All unnecessary protrusions must be removed or modified so that clothing does not catch on them.
Beware of electrical cords in the cap. Lay them rolled up on the side when the mill is running.
Any access to the cap must be lockable with a sturdy sliding hatch. Its strength must be equal to that of the rest of the floor so that an adult person can stand on it without danger. Always slide this hatch closed when in the cap, especially if you have visitors with you or are doing work! This prevents you or one of the visitors from stepping backwards into the stairwell — for example, when the hen roost is right above it. A sign must be posted at the entrance to the cap stating to whom access is reserved.
Never open shutters when the mill is turning. Make sure they are secured when you open them to prevent them from falling.

10.2.6 Safety around the sail cross

A turning sail cross poses a great danger to anyone who comes near it. Visitors should not only be made aware of this by signs and the like, but the sail cross must also be cordoned off so that people cannot get too close to it. Extra attention should be paid to small children; parents sometimes let their attention to their children slip when visiting.

The part of the mill yard or the stage over which the windmill's sails turn must be properly cordoned off with the chains or, better still, nets or fences provided for that purpose by the mill owner. Additional warnings not to step over the fence also appear to be necessary, unfortunately!
The door on the side of the turning sail cross must be locked, even when you are alone at the mill. If the miller must necessarily enter the railed-off area, stop the mill. If the mill is still turning, however, always keep an eye on the oncoming whip!

By virtue of the job, a miller regularly performs work in and near the sail cross.
The guiding principle which applies to performing work in the sail cross is: use one hand for the work and the other hand for holding on. If it involves work that requires two hands, use a fall protection device. With one leg around and between two sail bars, you will stand a bit more firmly. If possible, wrap one arm around an uplong.

fall protection

Fig. 10.2.6.1

When working in the sail cross, insert one leg through the sail frame. Also use fall protection.

The most common work, of course, is the setting and removal of the sails. Millers-in-training will have to deal with this very quickly. Be careful that one student does not release the brake while another student is still working in the sail cross.

Therefore, maintain as a general practice at the mill that the person who sets the sails or removes them also releases the brake. Or that there is eye contact between the two students.
Never set sails if the brake is not applied to them.
When setting sails, the law does not require fall protection, even for students. This is in contrast to changing sails.

Make sure the sail frame is in good condition so it can support your weight. Small orange fungi on the woodwork are cause for suspicion! Slippery sail bars are also dangerous.
Danger may be lurking when setting new sails. Never hang the sail with ropes tied together around your upper body! If the sail gets caught behind something or if the wind strikes it, there is a strong chance of you being pulled out from the sail frame. At a stage mill, moreover, you still run the risk of falling over the gallery railing. It is recommended that fall protection be used when setting or changing sails. For students, it is even mandatory!
Be careful when removing and transporting leading boards when the wind is strong, especially on stage mills. Loose and flyaway inner boards or leading boards occur far too often. This is usually the result of poor maintenance or defective securing. Therefore, inspect these regularly. The same applies to control boards or air brakes.
To secure the mill, the attachments for the stock chains must be in good order. In the absence of the chain clamp (which, by the way, can bend open) commonly used today, the two lower sail bars must be reliable because in heavy weather the chain, which is wrapped around the stock several times, must definitely not slip off the stock; if it did, the mill could go through the brake.

Make sure no one can release the brake when you are working in the sail cross. In that case, put the stock chains on the stock and use the release lever and the rope attached to the pawl.
Cordon off the area around the sail cross so that no one will get struck on the head by falling tools.
Do not perform work on the sail cross or sails when there is a strong wind. One gust of wind can be enough to lose balance. If a gust of wind takes hold of a loose sail, there is generally no stopping it. Just let the sail fly. After that, it may well be possible to secure it again.

10.2.7 The lightning conductor system

10.2.7.a Introduction

In the Netherlands, the NEN 1014 standard sheet provides instructions and regulations for the design, construction and maintenance of lightning conductor systems. However, the latest version was replaced by standard NEN-EN-IEC 62305 as of 1 February 2009. Since then, NEN 1014 only applies to systems which were installed under this standard.
The 1 November 1972 publication also provided information on the phenomenon of lightning. For example, the general considerations state that 31 windmills were struck by lightning in the Netherlands over a 20-year period (1946-1965). So, on average, three mills were struck by lightning every two years at that time. The arrival of global warming and increased air pollution since then will undoubtedly increase this number.

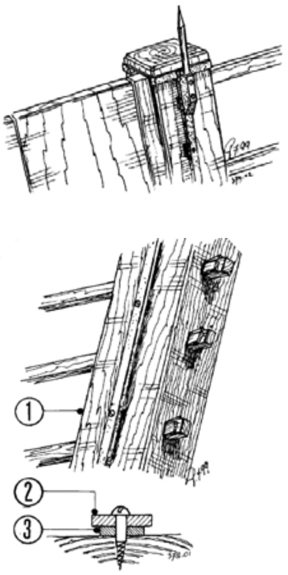


Fig. 10.2.7.1
Air terminal and conductor on a wooden stock:

1. *wooden stock*
2. *solid copper conductor*
3. *spacer*

In recent years, as attention to having a proper lightning conductor system at the mill has increased greatly, fortunately there are very few mills that are completely or partially destroyed as a result of lightning strikes.
According to standard 1014, a windmill belongs to those structures, for which a lightning conductor system is recommended because:
- A windmill has a great height and is often in a secluded location;
  A windmill is susceptible to lighting strikes;
- A windmill has a combustible roof covering;
- A windmill is of great or irreplaceable value.

The NEN 1014 standard has thus been replaced by the NEN-EN-IEC 62305 standard, which has been applicable worldwide since 2006. This standard takes a different approach to the probability of a lightning strike in general and roughly divides protection against a lightning strike into two methods:
- One method involves the load on the lightning conductor system due to the unimaginably high current intensity that can occur during lightning discharge. This current intensity, due to the very high electrical voltage, can reach up to 200,000 amps. It is very important that the system is able to discharge this high current intensity to the ground, even in the event of a multiple lightning discharge. By comparison, the electrical current intensity that a home can draw from the mains has a value of several dozen amperes.
- The second method involves the real possibility that other parts, such as the mill's cap, will be affected instead of the sails. Using the so-called "rolling ball method", an analysis is made of the probability that lightning may strike in undesirable locations by simply releasing the "rolling ball" from the highest point of the mill. This method can be used to determine which other places may be hit by lightning. The latter is the most important aspect in the design of the lightning protection.

Electric currents develop heat. It will be obvious that the very high current intensity which occurs when lightning strikes creates great heat with all its consequences.
Lightning conductors are installed to:
- control the effects of a lightning strike;
- hold the electric current within the conductors when struck;
- discharge the electrical current in almost all cases in a quick and harmless manner so that no fire occurs.

A lightning conductor system of a mill consists of:
- one or more air terminals;
- a number of downleads;
- at least two lightning conductor cables;
- an earthing system.

10.2.7.b The air terminals

It is the job of the air terminals to "attract" the lightning to themselves, after which the current is diverted to the earthing system via the downleads.

In windmills, the stocks act as air terminals.
Wooden stocks must be fitted with conductors and metal air terminals on the ends (see Fig. 10.2.7.1).
Metal stocks are good air terminals and good conductors. Proper electrical contact between both stocks and between the stocks and the poll end is a requirement.
For the purpose of connecting lightning conductor cables, copper earthing brackets must be provided at all stock ends (see Fig. 10.2.7.4).

10.2.7.c The downleads

Besides being air terminals, the stocks are also the downleads.
At stage mills, there is an induction loop at stage height. The lightning conductor cable can be connected to this from the stocks. The circular loop must be connected to the earthing system at a minimum of two locations via downleads.

Fig. 10.2.7.2
1. loop
1. connection point
2. manhole
3. manhole cover (old model)
4. idem (new model)

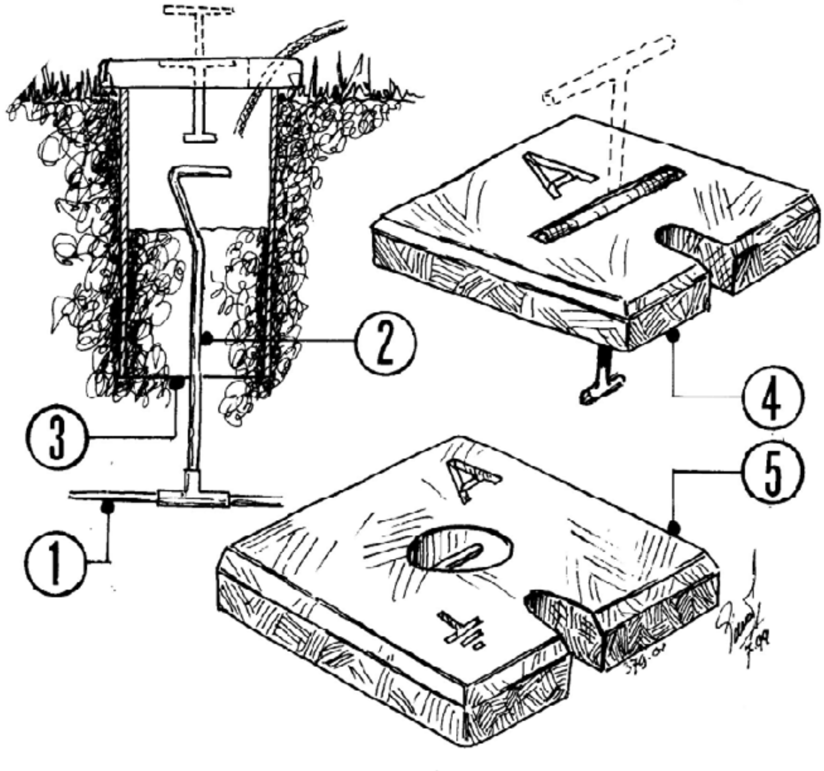
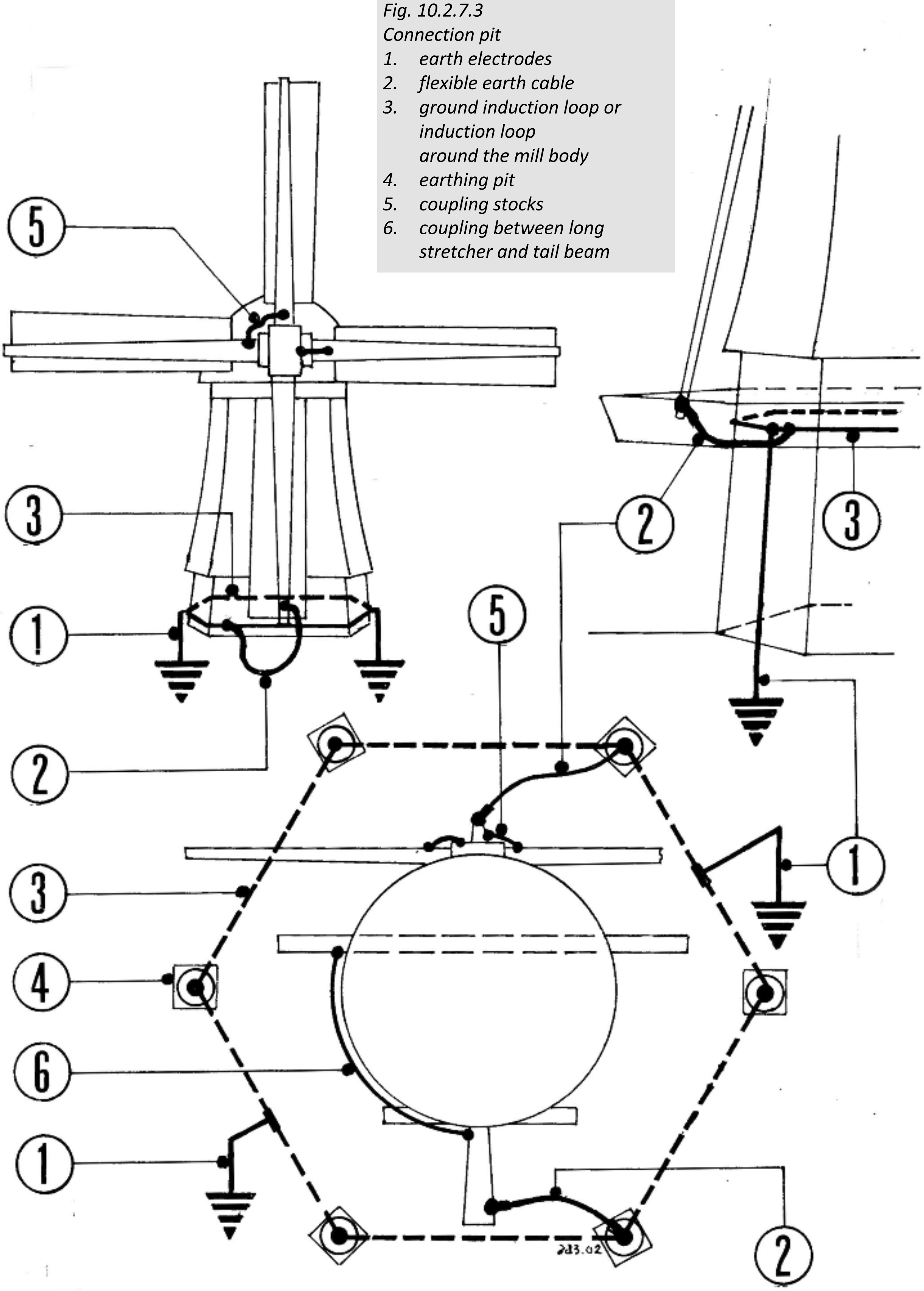


Fig. 10.2.7.3
Connection pit
1. *earth electrodes*
2. *flexible earth cable*
3. *ground induction loop or induction loop around the mill body*
4. *earthing pit*
5. *coupling stocks*
6. *coupling between long stretcher and tail beam*



Most of the remaining mills also have an induction loop that is earthed in at least two places. If there are practical objections to installing an induction loop around the mill body, then, if it is a ground-sail mill, earthing points can be installed around the mill at intervals not exceeding ten metres. These points must then be located in pits, which can be sealed with a special tile which has an opening for inserting the earth cable (see Fig. 10.2.7.2). The earthing points must be interconnected by means of a connecting conductor with at least two ground rods. The mill can then be grounded at one of the earthing points via the lightning conductor cable.
In the case of an entirely thatch-covered stage mill, the induction loop must be installed along the stage railing and the downleads must run down the shores. Metal parts which are longer than three metres (such as a metal tail beam, metal stretchers or metal shores) must be included in the lightning conductor system. Furthermore, it is very important that the electrical current to be discharged remains within the lines of the conductor system and does not skip to earthed metal parts or (electrical) systems.
If the mill has a metal tail beam then a copper earthing bracket should be present on it for the connection of a lightning conductor cable.

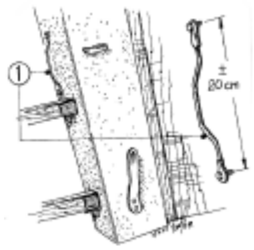


Fig. 10.2.7.4
Connection bracket:

1. *50 mm² copper grounding bracket with two stainless steel bolts*

10.2.7.d The lightning conductor cable

The lightning conductor cable is the flexible part of the system. After the mill is shut down (at the end of the milling day or during approaching thunderstorms), the cable should be installed between the lower connection point on the stock and the induction loop or in an earthing pit.

If the mill is stopped in the long rest position, both stock ends should be connected to the grounding system by a cable. Welding cables are often used as lightning conductor cables; the copper core of these must have a minimum cross-sectional area of 50 mm² (8 mm diameter). The advantages and disadvantages of these cables are:
- (+) a very low electrical resistance;
- (-) sensitivity to weather influences (weathering/disintegration of the copper core wires);
- (-) susceptibility to copper theft.

Nowadays, we increasingly see cables with a stainless steel core. The advantages and disadvantages of these cables are:
- (+) significantly less susceptible to theft;
- (+) significantly less susceptible to weathering;
- (-) a relatively high electrical resistance that may require a larger core diameter;
- (-) less flexible than copper cables.

These cables must be equipped at both ends with a metal corrosion-free clamp that maintains good contact even after repeated use. The connection must be capable of being easily applied without tools. It is advisable to always have a good cable ready in reserve.

Important: On mills whose sails are in the "long rest" or "St Andrews cross" position, the cap of the mill is NOT protected against lightning strikes. According to the analysis with the "rolling ball method", the cap and the windshaft can be struck by lightning. For proper lightning protection, an additional lightning conductor (air terminal) on the back of the body, cabin or cap is necessary.

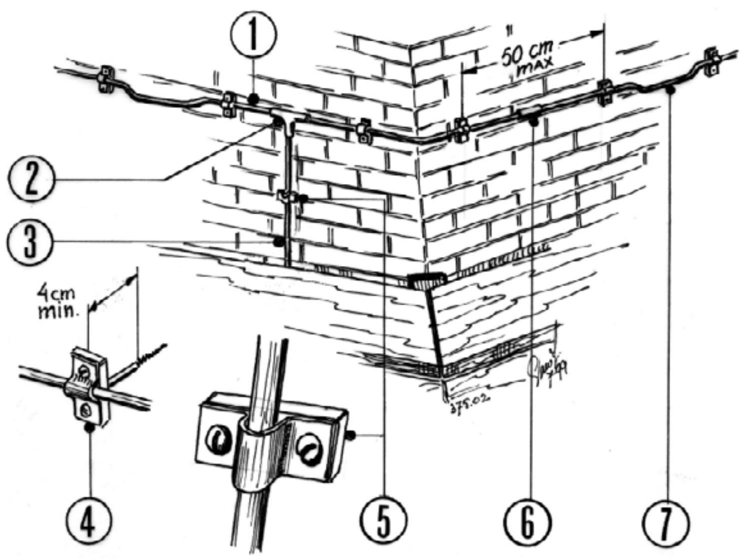


Fig. 10.2.7.5
Components of the induction loop:

1. *induction loop*
2. *T-piece*
3. *earth wire*
4. *cable strap for wooden walls*
5. *cable strap for masonry walls*
6. *straight coupling*
7. *earthing bracket*

10.2.7.e The earthing system

Lightning conductor systems must be equipped with their own earthing system, which remains functional without being connected to the water mains or to other existing earthings. The earthing system must have a low and, if possible, constant earth resistance. It is very important that the mill's electrical system is provided with potential equalization (voltage equalization).

10.2.7.f Potential equalization

Potential equalization, also called voltage equalization, is based on the fact that dangerous voltage differences are prevented by interconnecting conductive parts.

Potential equalization provides for the interconnection of earthing systems, such as lightning earthing and electrical earthing.

This not only distributes the discharge current but also achieves voltage equality among these parts and counteracts flash-over due to lightning strikes.

Also because of the pulse shape of a lightning discharge, such a connection must be repeated in special cases: for example, for mills with a body higher than about 20 metres. In practice, this often amounts to installing a potential equalization rail at a central location at the bottom of the mill and a second rail higher up in the mill. Via this rail, lightning protection earthing for metal gas, water and central heating pipes, etc. can then be connected to each other (see Fig. 10.2.7.6).

Until a few years ago, there was no official approval for connecting electrical earthing to this as well. The introduction of the NEN 1010 and 1014 standards have provided for this, though.
Especially in mills with extensive reinforced concrete construction, such a connection will already be present somewhere in that part of the mill. The NEN 1010, which differs from the old one in several respects, extensively covers potential equalization.

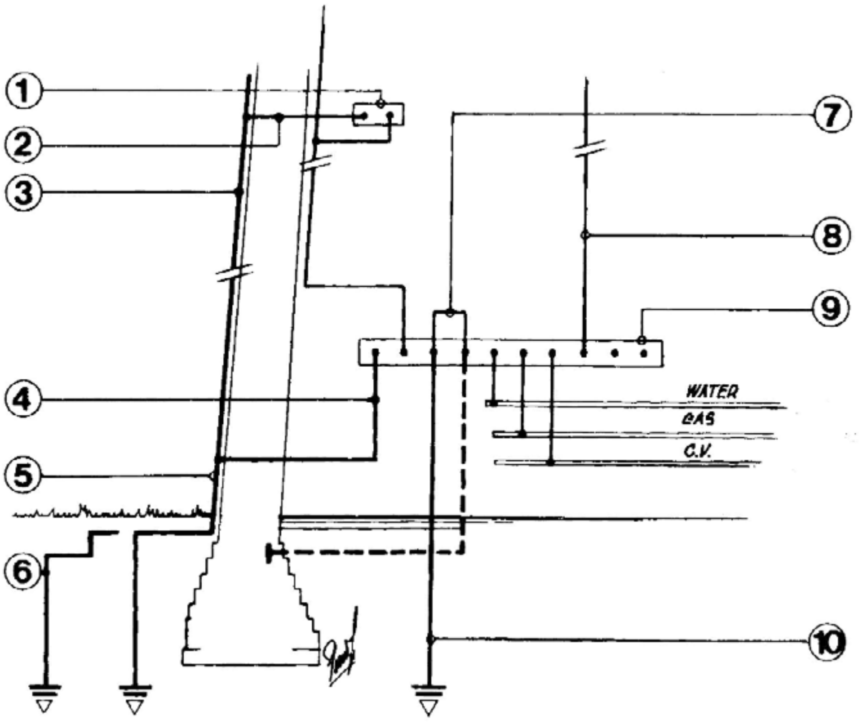


Fig. 10.2.7.6
Circuit diagram of potential equalization

1. *connection for repetition of potential equalization in mills higher than ± 20 metres*
2. *connection between 1 and 3*
3. *downlead of the lightning conductor system*
4. *connection between 3 and 9*
5. *earth electrode of the mill with an induction loop*
6. *ditto, with earthing pits*
7. *connection with steel reinforcement in the concrete foundation parts*
8. *grounding of the electrical system*
9. *grounding rail in the control cabinet*
10. *ground rod of the mill's electrical system*

10.2.7.g Using the system

Connecting the earth cable(s) puts the system "into service". It makes sense that this can only be done when the mill is stationary. The mill must also be stopped and the lightning conductor cable connected during approaching thunderstorms. This must always be done, even if the mill is only stopped for a short time.
The cable must be laid out in a smooth line with no kinks at the clamps. Sharp bends, loops or windings are absolutely not allowed, as they greatly impair the discharge of the lightning current. The very strong magnetic field that can occur in a winding pulls the cable toward the steel stock, which can cause cable breakage and damage to the induction loop.

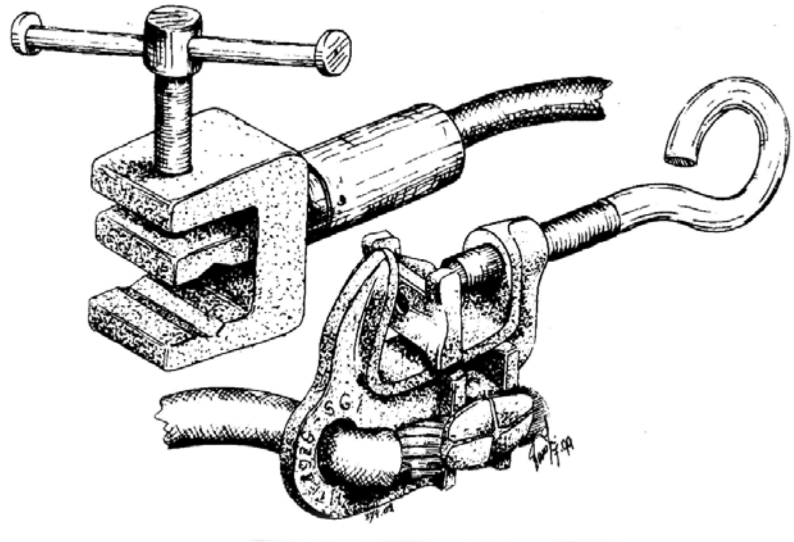


Fig. 10.2.7.7
A pair of connecting terminals for the earthing cable

10.2.7.h Inspection and maintenance of the lightning conductor system

On this subject, NEN 1014 says:
Inspection of the lightning conductor system should take place:
- upon delivery of the system;
- after repair or modification of the system;
- after extensive earthworks near the object to be secured have taken place;
- periodically: inspect at least once every two (2) years.

The lightning conductor cable is the most vulnerable part of the system but other parts can also suffer wear or damage that adversely affects the operation of the overall system. Make sure that a cable lying in the grass is not damaged by a lawn mower.
The lightning conductor cable must be checked regularly for the following points:
- Check for mechanical damage to the sheath or copper core.
- Check whether the clamps are still securely attached to the cable and, if necessary, tighten the clamp nuts or reapply the clamps.
- Check for broken cable core wires. If there are only a few, that is not problematic. If there are more than a few, then the cable must be reconnected. If the copper core is highly oxidized, the cable must be replaced.

A small amount of grease must occasionally be applied to the threads of the clamps. Several times a year, check the bolts used to attach the copper earthing brackets to the stocks to make sure they are still tight, there is no rust under the clamps, and the connection is well preserved against the effects of moisture.
This also applies to the interconnection of the stocks and the connection between the stocks and the windshaft.

The induction loop must be checked for wear or mechanical damage. The induction loop and connection points may not be painted; this would adversely affect the operation of the system or even render it completely useless.

Periodic inspections are very important for effective maintenance of a lightning conductor system and for adapting it to changed conditions. At windmills, such inspections should take place once every two years. The required inspections can be performed by your installer or by one of the members of the Guild's "Lightning Conductor Inspection" working group.

You can request an inspection via the Guild's website. After the inspection is performed, you will receive a report containing the findings and measured values and, if necessary, recommendations for adjustments or repair of the system.

10.2.7.i Some assessment standards

In general, the measured earth resistance of the earthing system should not exceed 2.5 ohms. In the northern, western and central parts of the Netherlands, this can still generally be achieved without high costs. In the other parts of the country, it is much more difficult due to the sandy soil which does not retain water well but also because the groundwater level is constantly being lowered. If achieving an earth resistance of 2.5 ohms is not economically justifiable, then potential equalization should be used.
The circuit resistance of the overhead conductor system should not exceed 0.5 Ohms. Therefore, this also means that the resistance in the stock from top to bottom must be 0.5 Ohms. The same applies to the resistance between the stocks.

The above is intended to give an impression of the regulations surrounding lightning conductor systems at windmills. Each mill has its own specific peculiarities, not only in terms of operation and construction, but also in terms of conditions regarding lightning protection. If you want further information on the latter, consult a professional lightning conductor installer or a member of the "Lightning Conductor Inspection" working group. They will no doubt be able to inform you of the specific lightning conductor issues for your mill.

10.2.7.j Copper theft

In 2008, the mill world was confronted by copper theft for the first time. It involved an induction loop which was completely cut away from a ground-sail mill. Thus, in addition to lightning conductor cables, induction loops also appear to be a part of the lightning conductor system that is susceptible to theft.

More drastic measures are needed to prevent theft of the induction loop. Consider versions made of aluminium (mechanically, slightly less strong) or burying the induction loop with four upright anchor points about 50 cm high, which offer the possibility of connecting the lightning conductor cable. The cost of burying the induction loop is high, especially if this requires mechanical excavation, but it is a one-off cost. General security measures such as lighting and/or a sound alarm may be useful but are of little use if the mill is remote.

10.2.8 Fire prevention and fire fighting

10.2.8.a Introduction

In recent years, several mills have been partially or completely lost to fire. Due to the construction using combustible materials and the chimney operation in the mill body, damage is usually extensive.
Causes of fire may include:
1. Arson.
2. Lightning strike.
3. Short circuit.
4. Chimney fire / stove.
5. Running through the brake / hot running of bearings, etc.
6. Flying sparks / fireworks.

These causes will be discussed in more detail later, but first some general fire prevention points:

smoking ban
- Introduce an absolute ban on smoking, in the mill as well as on the stage or in the mill yard. This also applies to the miller!

fire inspection round
- Use caution when using open flames, or perform the work differently if possible. The use of an angle grinder is also strongly discouraged. If you must perform risky work nevertheless, perform an extra fire inspection round afterwards. And repeat it one hour later. When doing this, you must be especially mindful of smouldering items, which are often characterised by very little smoke. Insist on a fire inspection round also from companies working at the mill doing maintenance work.

keep the mill dust-free
- Keep the mill tidy and as dust-free as possible. Dust is highly combustible, susceptible to smouldering, and highly flammable; in addition, dust spreads fire very quickly. Dispose of clutter and junk, so that less flammable material is then present.

fireproof cabinet
- Safely store flammable substances such as turpentine, paint, petrol for a motor mower, grease, etc. Special fire-resistant cabinets are available for this purpose. Ensure that containers holding flammable materials cannot tip over or open.

cut away reed plumes
- If your mill is thatched, inspect the inside of the thatch. Often the spreading layer, which is directly on the thatch laths, has been omitted. Many reed plumes then protrude inside from the thatch. These plumes are the most flammable part of the reed stems. Therefore, cut away any reed plumes.

Safety Working Group

Those interested in learning more about fire prevention and suppression are referred to the Safety Working Group. The addresses of Safety Coaches can be found on the Guild of Millers website.
www.gildevanmolenaars.nl

10.2.8.b Causes and prevention of arson

arson

1. Arson

Unfortunately, most mill fires in recent years have been caused by arson. Moreover, it is a cause against which preventive measures are difficult to take.

In any case, ensure that the mill is always properly locked so that it is difficult to enter. Try to make sure the mill yard has a neat and tidy appearance. If possible, ask if neighbours will keep an eye out. A good fence around the yard also helps, although it is often not pretty. A good deterrent is strong lights with a motion detector, possibly combined with sound.

lightning strike

2. Lightning strike

The effects of a lightning strike can be greatly reduced by a properly functioning lightning conductor system (see Section 10.2.7).

short circuit

3. Short circuit

After a milling or turning day, turn off the power if possible. If something does need to stay on, make sure you have a separate group for this device.
Use approved devices which carry the KEMA quality mark. Often second-hand stoves or refrigerators are used in mills. These are not always still safe due to their advanced age. In any case, have these devices checked regularly and repaired if necessary.
If you are installing or changing the electrical system in the mill yourself, have a licensed installer perform an inspection afterwards.

chimney fire

4. Chimney fire / stove

Various mills still use multi-burners. These require a certain degree of expertise to ignite. When doing so, do not use materials that cause flying sparks, such as newspapers, cardboard, plywood, etc. It is also important to sweep the chimney regularly to prevent chimney fires.

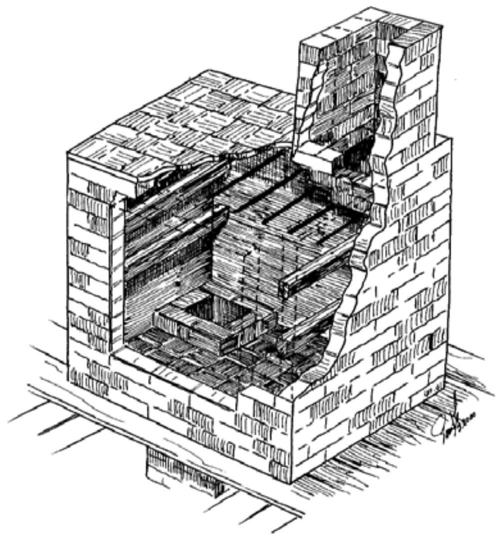


Fig. 10.2.8.1

An effective spark catcher is a so-called smoke box. For clarity,the door is omitted. This box was made of sheet iron or wood with tin fittings.

spark catcher, smoke box

In cap winders, where the chimney usually ends in the cap floor, the use of a spark catcher on the chimney is necessary. A so-called smoke box is very effective.
Open stoves, with gas cylinders or petroleum, are even more dangerous. Make sure they stand securely; falling over is certain to mean fire.

running through the brake

5. Running through the brake / hot running of bearings, etc.
When the mill runs through the brake during storms, the risk of fire is high. So much friction is created in the brake that fire eventually develops. It goes without saying that the miller should leave the mill in such a way as to minimize the likelihood of the mill breaking loose during storms.
If nonetheless you have managed to stop a mill that broke loose or the mill has been caught in a shower, cool the brake and brake wheel with as much water as possible. Secure the mill extra tightly to the chain, place braces in the brake wheel, and release the brake. You can then wet spray the friction surface of both the wheel and the brake thoroughly.
Keep a close eye on the brake for hours after hot running. At various times after hours, the brake began smouldering again nonetheless and the mill still burned down.

hot running of bearings

Hot running of windshaft bearings, pivots or slipping drive belts can also cause fire. So always be alert to this and regularly lubricate bearings properly.

fireworks / flying sparks

6. Fireworks / flying sparks
This is especially dangerous for mills with a covering of reeds on it's cap and/or body. One rocket can be enough to burn the mill to the ground. You can significantly increase fire resistance by using chemical liquids, so-called fire-retardant thatch coatings. Such a coating also makes setting the mill on fire more difficult. The disadvantages are the cost and the fact that the treatment must be repeated every three to five years. Other mills are equipped with a spray system on the outside of the cap or octagon, which can be used to soak the thatch shortly before New Year's Eve. If necessary, you can also have the fire service do this.

spark grinding

If a structure near the mill is on fire and sparks are blowing toward the mill, "spark milling" can be used to try to minimize the chance of the fire spreading. In spark milling, the sails are set loosely, with the pointing lines as loose as possible. Then the mill is allowed to turn as quickly as possible; the spinning sails keep the sparks away from the thatch, as it were.

10.2.8.c Reporting and fighting the fire

The sooner a fire is discovered, the more likely it is that the mill will be completely or partially preserved.
If a fire breaks out while someone is at the mill, the fire service can be alerted by (mobile) phone. Clearly indicate the address and, if necessary, the route to the mill.
Smoke or fire detectors can detect and report a fire when no one is present. The disadvantage is the high cost of purchase and maintenance. Also, such equipment is often not resistant to lightning strikes at the mill.

approved fire extinguishers
fire hose reel
incipient fire

If a fire breaks out while turning, the miller can begin extinguishing immediately after alerting the fire service. There should be approved fire extinguishers (type A, for solids) or a fire hose reel at every mill for this purpose. Keep yourself and others informed about the location and operation of fire extinguishers present. Practice their use, possibly together with the fire service. Be aware that the extinguishers mentioned are only suitable for extinguishing an incipient fire. If a fire has been able to develop even slightly, especially if it concerns a thatched mill, leave the mill immediately while observing your

own and others' safety. Once the thatch catches fire, the fire will spread extremely quickly. Keep in mind that burning thatch detaches from the mill body very quickly, falls and can end up in front of the mill doors. Before that happens, you must have left the mill.
The chances of success in fighting the fire are greatly increased when the fire service is very familiar with the situation in and around the mill. Make an attack plan with the fire service. Such a plan describes how to reach the mill, where the fire water supplies are, what is the construction and layout of the mill, etc. Floor plans and cross-sections can show where stairwells, silos, hatches, machinery, the main switch, etc. are located. The plan should also indicate who must be alerted in case of fire.

attack plan

If possible, practice annually with the fire service at the mill. Giving a tour in advance can remove some of the lack of knowledge and unfamiliarity. But also indicate what the main structure of the mill is that should be preserved in the first instance in case of fire.
The best way to effectively fight a fire is to install an automatic extinguishing system. This allows the fire to be fought directly from the inside. Very often, the high installation costs form an objection.

If, despite all the precautions, the mill does fall prey to fire, always consult a mill expert or millwright after extinguishing the fire and never allow the fire service to simply pull the mill down. Because the mill is built of heavy wood, the structure is usually still very sturdy. Unnecessarily pulling the mill down will only increase the damage and thus reduce the chances of repair or rebuilding.

10.2.9 Safety at the polder mill

10.2.9.a Around the mill

In addition to the general safety issues already mentioned, such as cordoning off the sail cross, several specific safety requirements apply to polder mills.
If the (hollow post) mill has an open scoop wheel, then it must have protective shielding. If the stairs to the cabin are above an open scoop wheel, a fall could cost you your life.
While turning, the hatches of the scoop wheel housing and those in the spillway deck must be closed.
The condition of watercourse screens must be such that a person can lean against them without any danger.
The weed screen must be sturdy and not give way under the weight of weeds, debris and floating plant material pressing against it (especially in late summer). This must always be removed with the pick hook. When doing so, make sure that the pick hook does not come into contact with the turning sail cross. Even better: stop the mill first.
No turning should ever be done with the weed screen raised. Milling floating debris into the storage basin is not only prohibited by the rules of the polder by-laws, it is also dangerous; a piece of wood floating in the water can become trapped and cause damage to the water-raising apparatus or any other part of the running gear.

The bridge above the weed screen must be strong enough to support several people and to absorb the pressure exerted on the weed screen. If there is an uncovered portion of the watercourse between the weed screen and the water-raising apparatus, then an additional safety measure is required to prevent anyone who enters this section of the watercourse from being caught by the water-lifting apparatus. The safest solution is positioning a second "weed screen" in the water in front of the water-raising apparatus. Another, less safe, solution is a boom anchored to the walls of the watercourse well before the water-raising apparatus.

10.2.9 b Inside the mill

The various wheels, shafts and spindles inside the mill must have proper protective shielding, especially near the steps leading past spindles and wheels.
The running gear of polder mills usually turns much faster than that of other mills — after all, the water must leave the polder as quickly as possible! — and it is heavier duty. This means the miller has to apply lubrication more often.
Polder mills whose water-lifting apparatus can be set in motion by both wind and electric power should be constructed in such a way that activation of the electrical part is not possible if the protective shielding around the installation is open for any reason. Equally, this should not be possible when the mill is actively milling or is ready for milling on wind power, nor when it is in the process of switching from electric to wind power or vice versa.

10.2.10 Safety at the grain mill

Of all mills, the grain mill is by far the most common type. Although its layout can vary from simple (one pair of stones and hoisting system) to elaborate (three or even more stone pairs, grain transport and a variety of machinery), the safety aspects are largely universally applicable.

If mill stones are used, the entire grinding works must be in good condition: strong stone spindles, sound bearings, safe stone troughs. The stones should not be damaged and there should be strong metal bands around the runner.

10.2.10.a The hoisting and storage of grain

The hoisting system warrants special attention. It is better not to operate this when there are visitors at the mill. After all, people are inclined to watch a sack as it goes up and to go and stand under it. Nor, for that matter, should the miller do that, even to pass on an instruction to a colleague above. The sack could shoot out of the clamp irons. The hoisting system should be operated by a single person.
Let only the person who attaches the hoisting rope to the sack give the signal for hoisting. Use sill clamps or chains to make sure that hatches cannot be left open, or put barriers around them.
The string of the sack hook should be fitted with a cross-piece. This prevents the hook from injuring the miller or a visitor, especially in the face. Remember that paper sacks tear easily. This can be avoided when hoisting by using a canvas mat in which the bags can be safely hoisted.

hoisting mat

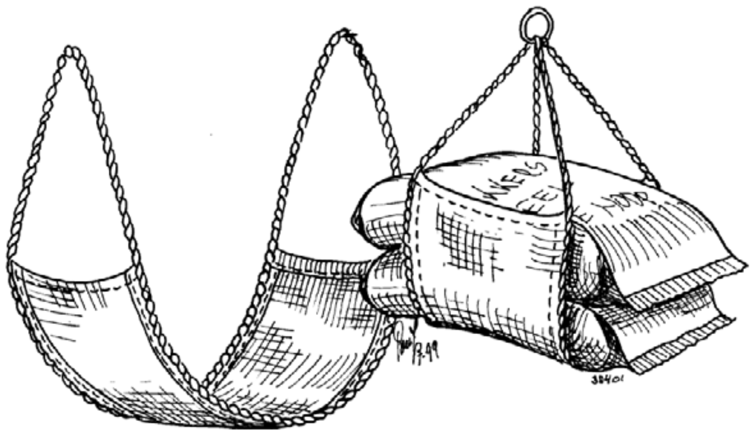


Fig. 10.2.10.1

The hoisting mat for safely hoisting grain packed in (paper) sacks

Stacking paper sacks requires extra care; they can slip off each other more easily than cotton or burlap sacks. Also check that the floor is sturdy enough in the area where you are going to stack them.

At a grain mill you are working with goods for consumption — either human or animal — so you must be very careful and cautious in handling pesticides. Opened containers should be stored tightly closed and in a safe place.

10.2.10.b Working on the millstones

Hoisting a pair of millstones before dressing the stones is one of the grain miller's most dangerous jobs. The stone crane must be 200% reliable, as it were. By this we mean that it must be so strong that it could support the weight of two stones. Do not assume without question that a crane present in the mill is indeed reliable. Inspect it before working with it. When doing so, pay attention to the following:

- Check that the stone clips and their pins are sufficiently heavy and sturdy to be able to support the stone. For example, the pins must not be so weak that they can sag under the weight of the stone hanging from them, because then the stone is guaranteed to fall out. Nor should the pins fit so spaciously in the holes that they angle downwards; they could shoot out in that case.
- Check that the clips have the correct curvature. The stone must be able to tilt under it when it hangs in the crane. The pins must be inserted sufficiently far into the stone. If the clips are positioned too wide, the stone can also easily fall out between them.
- Check in advance that the nut is properly seated on the hoisting screw and that there is a friction plate around the hoisting screw above the crane arm.
- Check both pivot points at the top and underside of the crane.
  Is the lower pin deep enough in the floor or chock? Grain kernels and/or meal dust that have got in can make that difficult.

hoisting the millstones

When hoisting the pair of millstones, observe the following safety precautions:

- Clear a space for putting down the lifted (and turned) stone. If possible, choose a location for this where a binder or another heavy beam runs or where two beams intersect.
- Never stand in such a position that the crane arm is pointing in your direction. If the crane fails, the stone will fall towards you.
- For "easy" turning of the stone in the stone clips, slide rings over the pins between the clips and the stone.
- Turn the stone upwards slowly because if the screw becomes stuck, the mass of the stone will cause it to turn some more and slip, which can have serious consequences.
- Perform the turning of the stone with a lifting motion, away from you, not by pushing one side of it downwards. Indeed, even during this operation, the crane could fail and then the entire hazard will come in your direction.
- While turning the stone, do not put your hands on the outer circumference of the stone that must pass under the clips. This could cost you your fingers because the space between the clips and the stone is usually very small.
- Turn the beam away from the runner with a pushing, not a pulling, motion.
- When replacing the stone, observe the same safety precautions.
- Do not allow visitors during this work.

For safety at other industrial mills, please refer to the "Report on Safety at Windmills and Watermills" by *De Hollandsche Molen*.

10.2.11 Safety for visitors

The phenomenon of "visitors at the mill" is from the last few decades. This is something that we ourselves wanted because we want to win the public over to support mill preservation. As normal as this appears to us today, it was formerly not the case at all. In the past it used to be as difficult to get into a mill as it is to get into a factory today.
If we allow visitors then we must also establish rules that visitors must observe, and we must inform them about those rules (through verbal instructions, signs, etc.). In addition, we must take the necessary safety measures.
Furthermore, the miller must supervise (or arrange for the supervision of) visitors, remembering: out of sight is unsupervised!

An emphatic warning is in order for those visitors with children. Children do not see danger and their actions are unpredictable. We cannot emphasize enough: Before the visit, make parents aware of the dangers children face and ask them to pay more than their usual attention to their children. Point out to them that they remain responsible for their own children during the visit.

10.2.11.a General regulations

The following is a list of some basic matters that must be properly organised at a mill which is open for visitors:

- The mill must be suitable for visits to take place.
- The section of the mill yard, mound or stage over which the sail cross turns should be properly shielded.
- Doors giving access to the above-mentioned places must be locked.
- Point out to visitors that they could easily trip over the winding chain or anchor chain.
- At the start of the tour, point out to visitors the danger formed by turning parts.
- Do not allow visitors to sit on the stage railing. It is not intended or suitable for that purpose and it is dangerous.
- Visitors may not enter the cap or other areas of limited size containing hazardous items or at best only with a guide. Access to the cap is only possible when the mill is at a standstill.
- It should be clearly stated that smoking inside and outside the mill is not permitted.
- When weather conditions or operations are such that they demand the full attention of the miller, receiving visitors at the mill must be discouraged unless the mill is stopped.
- Visitors must be reminded that it is safer to descend the stairs backwards.

It is better and safer to give a good tour in a mill running "for the prince" (for show) than in a turning mill because in the latter case the miller must divide his attention between his work and his visitors. If a mill guide is available, it is preferable that they provide the tour and supervise or assist in the supervision. But even during a tour of a mill running "for the prince" it may be sensible to stop the mill for some time.
There are additional points for attention when hosting groups and/or conducting tours:
- Set a maximum group size depending on the space in the mill and available supervision.
- Establish the number of people who may be permitted on the stage at the same time. The same applies to access to the cap or cabin.
- Agree on how to adequately supervise visitors when everyone is walking through the mill.
- When groups of children visit, agree beforehand on the group size, number of guides, supervision, etc.

10.2.11.b Specific safety requirements for receiving visitors at a grain and/or hulling mill

There are specific safety requirements when receiving visitors at a grain mill or hulling mill:

- Do not allow visitors to enter floors higher than the stone floor unless these are properly accessible and supervision is present there.
- Do not use the hoisting system during visits because then the hatches will be open or could open.
- Do not allow children to sit on the trough covers of the millstones. They will then quickly be tempted to touch the rotating stone spindle or push grain from the feed-shoe into the eye hole.

- Do not allow people to put children on their shoulders. The (limited) space under beams and rotating parts does not allow for this.
- A hulling mill in operation is, in fact, not suitable for visits. This is due to the nature of the hulling process, with the hulling spindles and other rotating parts which rotate very quickly. Visitors are only welcome if there are additional persons present to give visitors a tour.

10.1.11.c *Specific safety requirements for receiving visitors at a polder mill*

- Never open the scoop wheel housing or the hatches above the Archimedean screw for demonstration to visitors.
- Point out to visitors that it is dangerous to sit on the watercourse screens, especially the one above the weed screen.
- Do not allow anyone unaccompanied on the weed bridge.
- Ensure that there is proper protective shielding of the scoop wheel and the wallower, and of the screw wheel and the lower wallower.

10.3 THE LEGAL SIDE OF SAFETY

10.3.1 Safety legislation

Legally, mill owners are the ones primarily responsible for safety in and around their mills. But what standards must mill safety satisfy?
Because mills were originally set up as machines, safety regulations at the time were governed by the Safety Act of 1934 and its accompanying "Safety in Factories and at Workplaces Decree" of 1938 (V.B.F. 38). Many of its provisions were and still are applicable to mills. Specific to mills, for example, is Section 98a of V.B.F. 38. It states that mill sails, to the extent that they are hazardous, must be functionally shielded.
V.B.F. 38 has been succeeded in the Netherlands by the Working Conditions Decree in 1997 and the Working Conditions Act in 1999 (*Arbowet* in Dutch). The Working Conditions Act aims to protect workers/employees. Volunteers are not employees and are therefore only covered by this law since 2007 if they work either in a relationship of authority, at heights or with hazardous materials. (Note: The relationship of instructor - student miller is considered by the legislature to be a relationship of authority). Of course, many of the protective measures devised for employees can also benefit the volunteer. This is especially true of the Risk Evaluation and Inventory (RI&E). An RI&E is a systematic method of identifying problem areas with respect to safety, health and welfare. Conducting an RI&E and preparing a Plan of Action are the foundations for safety policy at a mill.

10.3.2 Liability

A basic rule of Dutch liability law is that everyone bears their own loss or damage unless:

- The loss results from the acts or omissions of another person;
- AND there is a causal relationship between that action/omission and the damage;
- AND that act or omission is culpable.

So, it is not true that someone is always liable. Instead, there is room for an unfortunate set of circumstances. If that is the case, each person bears their own loss or damage.

If liability does exist, the degree of liability is determined on a case-by-case basis according to the following criteria:

- How likely is the chance of risky behaviour?
- How likely is the chance of loss or damage as a result?
- What is the extent of the damage?
- How onerous are the measures to prevent damage?

In short, the greater the probability of damage and the more extensive the damage, the more measures must be taken to prevent damage.

The mill owner bears the greatest liability for safety at the mill. The owner has a duty of care and must ensure a safe environment for volunteers and visitors by informing visitors in writing of the risks and setting rules and by shielding the sail cross, parts where there is a danger of getting caught and the stage. The owner must therefore take safety measures unless they are too onerous. If someone organises something at the mill then the same applies to that organiser.
In addition to safety measures, supervision is also needed. Both are necessary! Omitting safety measures and replacing them with supervision is not an option.

Visitors should follow the safety rules and pay particular attention to their children. A mill is not a children's playground. The miller is not a babysitter. Signs pointing out the dangers of the mill do not relieve the owner of his duty to take safety measures. Those signs are there so that the visitor is aware of the danger into which he/she is entering.

The miller is an independent working volunteer and must perform his duties properly. The owner is entitled to assume that the miller has professional competence. The miller must follow safety rules and supervise compliance with visitor rules.
The instructor has a duty of care for students, particularly when instructing them to do things that involve risk. These include working at height (fall protection is mandatory for students!), as well as working with hazardous materials or working in situations where there is a risk of being crushed.
Prevent students having accidents. Accidents involving students are personal tragedies for the student as well as the instructor. If a relationship of authority was involved then liability raises its head. If insufficient measures were taken, there may also be criminal consequences.

10.3.3 Youth Members and Members-in-Training under 18 years of age

Young people under 16 can become members of the Guild. And from the age of 16, a young person can begin training as a miller.
However, any young person under 18 is subject to the rules of the Ministry of Social Affairs and Employment regarding employment for those under the age of 18. These rules also apply to the volunteer activities that we allow them to carry out at the mill.
In the case of youth members, it is advisable that parents are also well informed of the applicable rules and involved in what their child is doing at the mill.

10.3.4 Miller contract

The Guild of Voluntary Millers and *De Hollandsche Molen* have jointly prepared a "Model Contract for Millers".
Agreements about opening, maintenance, supervision, and the like can be incorporated in this contract. This contract contains, among other things, an article on safety in which the obligations of mill owner and miller with respect to promoting safety are recorded. It is important to note, for example, that while concern for the safety of persons present rests first and foremost with the mill owner, supervision of compliance with the rules is usually delegated to the miller(s).
Furthermore, this contract has an article on insurance that also includes something about the miller's liability. Among other things, this can be important for indemnifying claims if the damage from an accident exceeds the insured amount and the miller has acted competently and professionally.
It is recommended that each miller agree a mill contract with the mill owner. The model contract can be found at www.gildevanmolenaars.nl under verenigingsdocumenten.

10.3.5 Guild insurance

Unfortunately, when working with heritage machinery, mishaps and even accidents can never be completely ruled out, even if all safety procedures have been properly followed and the miller has acted professionally.
If such happens, the mill owner or miller may be held liable for the damage suffered. Or the miller himself may suffer permanent physical damage due to an accident.
For that reason, the Guild of Millers offers its members several supplementary insurance policies.
These are:
- Third-party insurance, against damage to third parties;
- Third-party Plus (fire and theft) insurance, against damage to the mill;
- Accident insurance, in case of death or permanent disability of the miller.

All the information about these policies and their terms and conditions can be found on the website www.gildevanmolenaars.nl.
In case of damage, mill owners can contact the Association *De Hollandsche Molen* for advice at www.molens.nl

NOTES

Chapter 11 The Polder Mill

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NOTES

11.1 INTRODUCTION

Even before the year 1000, mankind began clearing and cultivating unusable marshlands in northern and southern Holland. At that time, these fertile peat lands were still up to more than two metres above sea level. Ditches were dug to drain the wet marshlands. These drainage channels could naturally discharge their excess water into lower lying rivers.

settling

But when water is extracted from low moor peat, it starts to settle, which then causes the soil to sink. As early as the Middle Ages, residents had to lower the water level of the reclaimed areas from time to time to keep their land dry.

level reduction

These level reductions accelerated settlement, a process that continues to this day. During the 14th century, the soil in places had already sunk so far that the rivers, under the influence of the tides, often and for long periods of time burst their banks. To preserve the cultivated land, dykes and quays were constructed.

polders

culverts or drainage channels

This is how polders were created. The water was initially discharged via closable culverts or drainage channels that were opened during low tide.

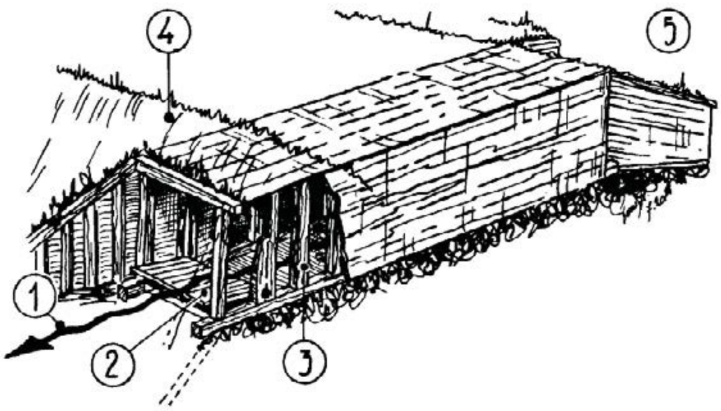


Fig. 11.1.1
A culvert

1. *storage basin side*
2. *shut-off flap*
3. *culvert or discharge duct*
4. *dyke body*
5. *polder side*

Due to the constant settling, the periods when draining was possible became shorter and shorter, and some lands were in danger of drowning permanently. Small polders were still kept dry with swing scoops and horse-driven watermills.

polder mill

By the early 15th century, the polder mill had been invented. Scoop wheel mills appeared in the landscape. The Netherlands is a windy country, and for the next four centuries, thousands of polder mills would make and keep large parts of the country dry. A scoop wheel mill can raise the water about 1.5 metres.

land reclamation

Besides keeping polders dry, the mill was also used in land reclamation projects. From the beginning of the 17th century, deep lakes and peat bogs were pumped dry using mills.

pumping head

gang of mills

Because the pumping head in this process often exceeded 1.5 metres, gangs of mills were created.

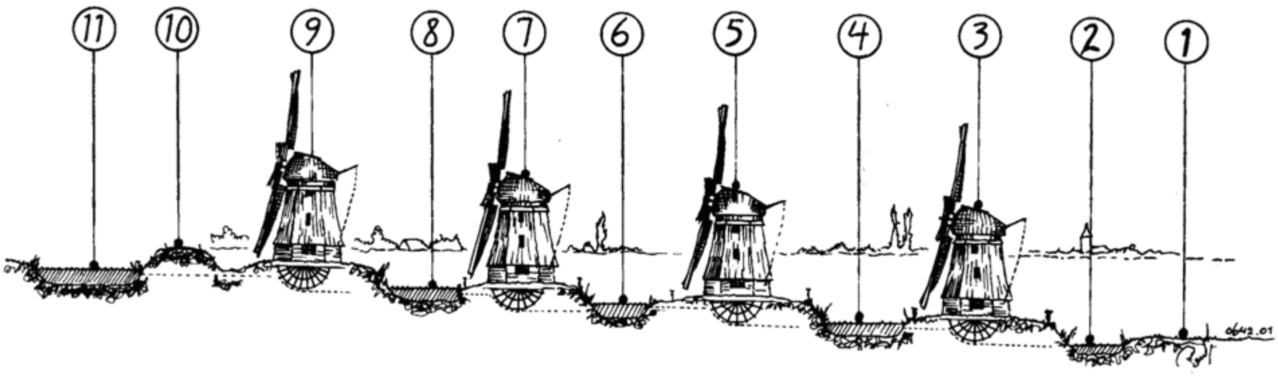


Fig. 11.1.2
Gang of four mills

1. *land reclamation*
2. *polder ditch*
3. *polder mill*
4. *lower pond*
5. *lower mill*
6. *middle pond*
7. *middle mill*
8. *upper pond*
9. *upper mill*
10. *ring dyke*
11. *storage basin or ring canal*

screw
enclosed Archimedean screw

Gangs of mills were series of two, three or four scoop wheel mills that pumped the polder water to one other. In this way they bridged the required pumping head from polder to storage basin level that sometimes exceeded four metres. From Archimedean screw, Symon Hulsbos in 1634 developed the screw that is used in tjaskers: the enclosed Archimedean screw. An enclosed Archimedean screw turns and carries the water upwards.

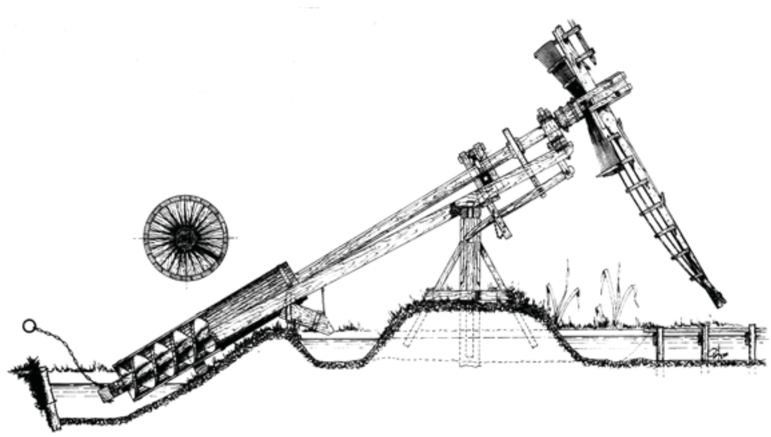


Fig. 11.1.3
Post tjasker with enclosed Archimedean screw

If you arbitrarily enlarge an enclosed Archimedean screw, it can no longer handle the weight of the water and will sag and stop.
Hulsbos devised a semicircular bowl in which the screw merely screwed the water upwards and no longer had to carry it.
In 1642, Lake Starnmeer was one of the first lakes in North Holland to be drained partly using screws. A screw raises the water in the same mill much higher than a scoop wheel does. But the use of screws did not become widespread yet because at that time most lakes and ponds were already being

drained with scoop wheels. It was not until the mid-18th century that scoop wheel mills which could no longer maintain the desired polder level due to a series of water level reductions began to be outfitted with screws. In addition, gangs of scoop wheel mills were replaced by a smaller number of Archimedean screw drainage mills.
In the late 19th century the steam engine made its appearance, and electricity arrived in the early 20th century. Pumping stations, independent of wind, eventually took over drainage from almost all mills. As a result, a great number of polder mills disappeared during the first half of the 20th century. They could not compete with the new energy sources, and ensuring a desired polder level was more difficult with them.
The fact that about 400 of the thousands of polder mills that once existed are still around is partly thanks to the efforts of the *De Hollandsche Molen* association, which was established in 1923. A considerable number of these 400 are still capable of pumping. During wet periods and during major flooding, the volunteer millers of these mills lend their help along with the modern pumping stations.

11.2 DESIGNATIONS

polder mill, catch-water mill, "iron" mill

lower, middle and upper mill

All mills that raise water using wind power are in fact watermills in terms of their function. However, to better distinguish them from water-powered mills, wind watermills are commonly called polder mills. A polder mill can also be used in other ways, for example as a catch-water mill, which is called an iron or scraper mill (strijkmolen) in North Holland. Catch-water mills pump water from a basin to open surface water or from a lower storage basin to a higher one. (Kinderdijk) And gangs of mills are divided into lower, middle (especially in North Holland) and upper mills.

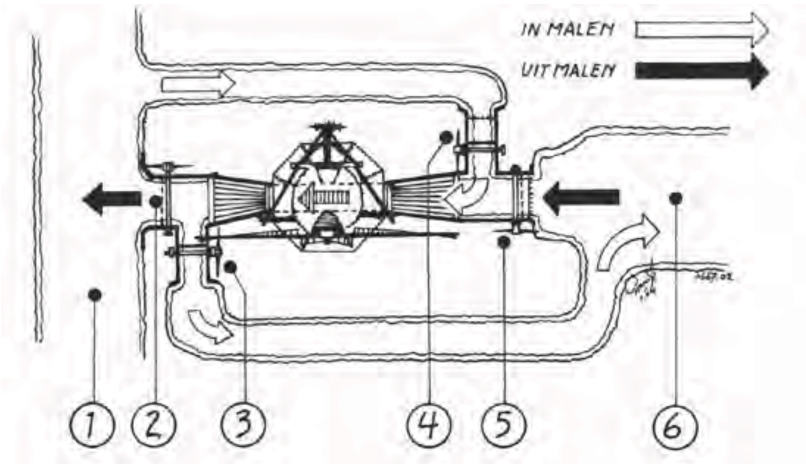


Fig. 11.1.2.1
Mill with a circuit system for pumping water in and out

1. *storage basin*
2. *storage basin sluice*
3. *pumping-in sluice*
4. *inlet sluice*
5. *pumping-out sluice*
6. *main drainage channel*

pumping-in circuit system

The vast majority of polder mills are used for pumping out excess water. A few may also pump in, such as in case of severe drought. Therefore, for this function, such a mill has a pumping-in circuit system.
Sometimes a second scoop wheel was present for pumping in (as seen at Overwaard 4, Kinderdijk).

11.3 SUB-CLASSES AND TYPES

water-lifting apparatus

screw pump, centrifugal pump, Dekker pump

Polder mills are equipped with a water-lifting apparatus. This leads to a few sub-classes. There are polder mills with a scoop wheel, called scoop wheel mills, and polder mills with a screw, called Archimedean screw drainage mills. There is also a small number of polder mills with a screw pump or centrifugal pump, or a Dekker pump. These were introduced around 1930, with varying degrees of success.
There are now more Archimedean screw drainage mills in the Netherlands than there are scoop wheel mills. Most scoop wheel mills are found in South Holland. Archimedean screw drainage mills are common in Groningen, Friesland, and in North Holland.

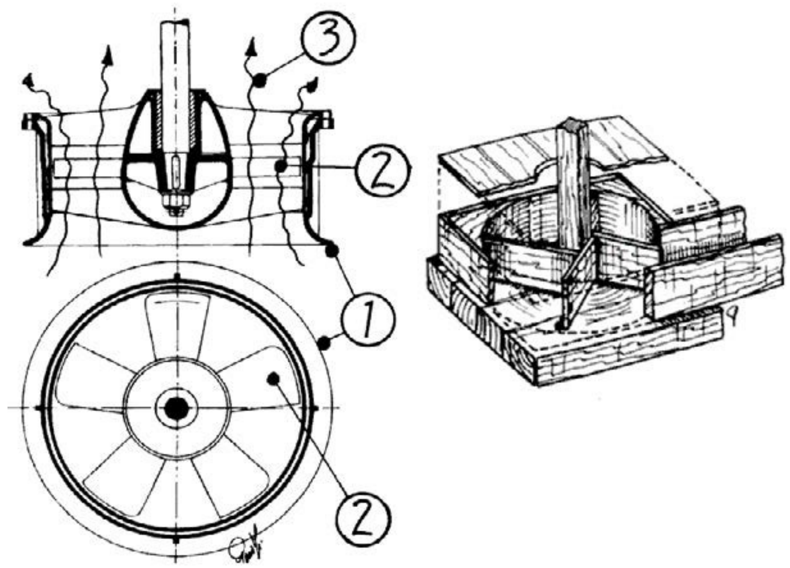


Fig. 11.3.1
The Dekker pump (left) and a vane pump of a meadow mill (right)

1. *pump housing*
2. *rotor*
3. *direction of the current*

Mill types such as octagonal and stone ground sail-mills, hollow post mills and spider mills can all be designed as scoop wheel mills or Archimedean screw drainage mills.
Two exceptional polder mills can be found in Haastrecht and in Hook of Holland. These mills have a stage.
The tjasker and the meadow mill that can pump plots of land several acres in size also belong to the polder mills. Both types are described in Chapter 5.

11.4 THE SCOOP WHEEL MILL

11.4.1 The watercourse

spillway
inner spillway wall, outer spillway wall
open scoop wheel
enclosed scoop wheel
scoop wheel housing

In relatively small polder mills and in all hollow post mills, the spillway, consisting of an inner spillway wall and an outer spillway wall, lies outside the mill. These mills have an external scoop wheel. If the scoop wheel is visible, it is called an open scoop wheel. This is usually shielded by a wooden fence and provided with splash or spray baffles at the sluice door. An enclosed scoop wheel has a scoop wheel housing around the entire wheel.

For mills with an external scoop wheel, the inner spillway wall is part of the foundation of the mill.
Large polder mills usually have an interior scoop wheel. In that case, the scoop wheel is set up inside the mill. The spillway is then also inside the mill and the outer spillway wall is then part of the mill foundation.

Fig. 11.4.1.1
The pot house (semi-underground cellar extension) above the tail race

The advantage of interior scoop wheels and enclosed exterior scoop wheels is that they are less likely to freeze in winter.

pot house

Often the interior scoop wheel is so large that it does not fit inside the mill. In these cases, a semi-underground cellar extension, called the pot house, is made above the tail race and contains a door leading to the sluice door. On the other side of the scoop wheel, part of the octagonal wall is omitted and closed off with a hatch.

head race, back end

debris grille, debris bridge

The beginning of the head race is the back end, where the debris grille is often hung. There are also mills with a debris bridge some distance from the mill; here, the debris grille is incorporated into the debris bridge. The function of the debris grille is to keep out floating debris.

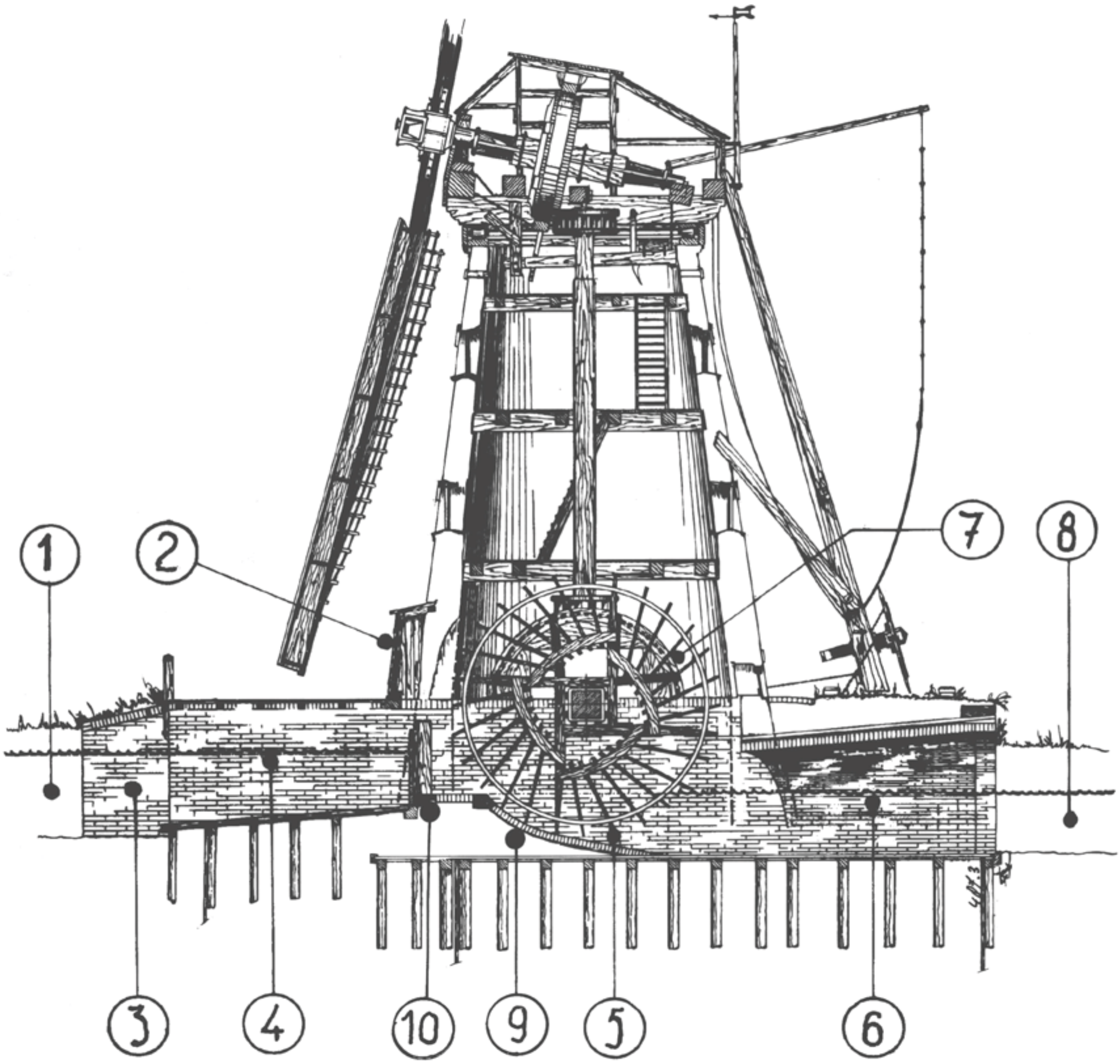
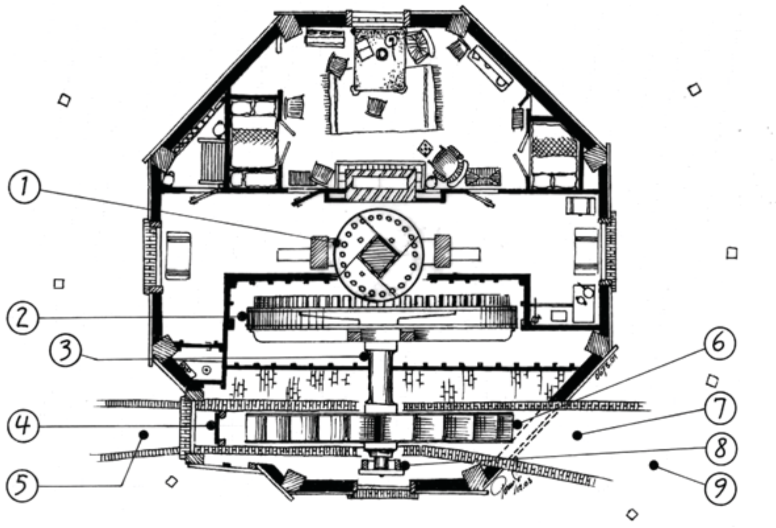


Fig. 11.4.1.2
Cross section of a round stone polder mill with an interior scoop wheel

1. *storage basin side*
2. *pot house*
3. *tail race*
4. *storage basin level*
5. *wooden scoop wheel*
6. *head race*
7. *pit wheel or waterwheel*
8. *main collection ditch*
9. *water guide*
10. *sluice door*

Fig. 11.4.1.3
Plan of a
scoop wheel mill

1. *lower pinion*
2. *pit wheel or waterwheel*
3. *waterwheel shaft*
4. *sluice door*
5. *tail race*
6. *scoop wheel*
7. *spillway*
8. *outer bearing*
9. *head race*



To direct the water faster to a rotating scoop wheel, the spillway of the head race gradually narrows from the back end to about 40 cm in front of the waterwheel shaft. There, the outer spillway wall does a dog-leg and then runs parallel to the inner spillway wall. Due to this additional constriction, the incoming water is forced into the scoop wheel from the side. The constriction thus provides for greater filling than what would occur with normal inflow.

head race deck — The head race is either bricked as a funnel-shaped vault under the mill yard or has a head race deck over the spillway walls. Spillway walls are sometimes made of wood. At the back end there is a watercourse gate.

water guide — Under the scoop wheel is the water guide, which is shaped to the outer circumference of the paddles that rotate just past it. Behind the water guide are

gate sill, gate posts, sluice door — the gate sill and the gate posts. Hanging on this is the sluice door, which is

tail race — pressed shut by the high level of storage basin water (see Fig. 11.4.4.2). The tail

front end — race ends at the front end and is constructed in the same manner as the head

tail race deck, — race, and it is covered with a tail race deck that may or may not have one or more hatches.

watercourse gate — Sometimes a watercourse gate is also placed on the front end but often not.

11.4.2 The scoop wheel

scoop wheel, paddle wheel — Until about 1850, there were only wooden scoop wheels (paddle wheels).

cross arms — Now almost all of them are metal. A wooden scoop wheel consists of four

main paddles, cross bar — cross arms that also act as main paddles. They are reinforced with four

intermediate paddles — curved cross bars. Five or six intermediate paddles are inserted into each diagonal bar. All the paddles are connected to each other with iron

shroud — (formerly wooden) shrouds.

metal scoop wheel, central iron frame — A metal scoop wheel consists of a central iron frame, one or two shrouds and a number of paddles.

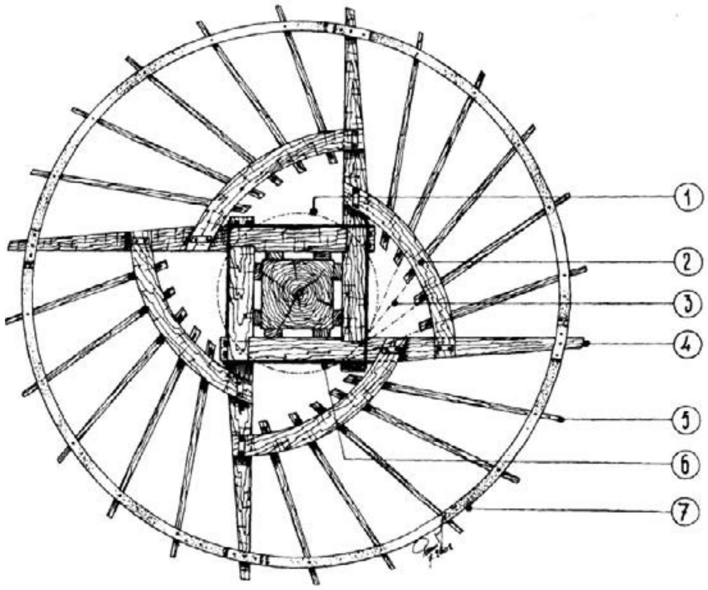


Fig. 11.4.2.1
Wooden scoop wheel

1. *draft circle*
2. *cross bar*
3. *draft circle of the paddles*
4. *cross arm or main paddle*
5. *intermediate paddles*
6. *clamp irons*
7. *metal shroud*

shaft hole
scoop wheel shaft
scoop
wheel feathers

The central iron frame is composed of two parts mounted together that form a square hole, the shaft hole, in the middle. Through this shaft hole protrudes the scoop wheel shaft, on which the iron frame is secured with oak wedges.
The paddles, straight or curved, are reinforced with corner irons, called scoop wheel feathers. They are attached to the central iron frame with nuts and bolts and are joined together with one or two shrouds.

draft circle

The paddles are mounted tangentially on the central iron frame: in other words, the centre lines of the paddles do not pass through the centre of the scoop wheel, but as tangents to an imaginary draft circle. The slope or tangent thus created promotes efficiency, allowing the pumped water to flow more easily off the blades.

draft

angle of exit, angle of entry

With a larger draft, the water would run off the blades even better because then the angle of exit would be large. But the angle of entry would then become so small that the paddles would hit too flat in the water, which would create great resistance. The size of the draft circle is approximately 1/7 to 1/9 of the diameter of the scoop wheel. The angles of entry and exit are then about the same. The angle at which the paddles enter the water should be around 30° (see Fig. 11.4.4.1).

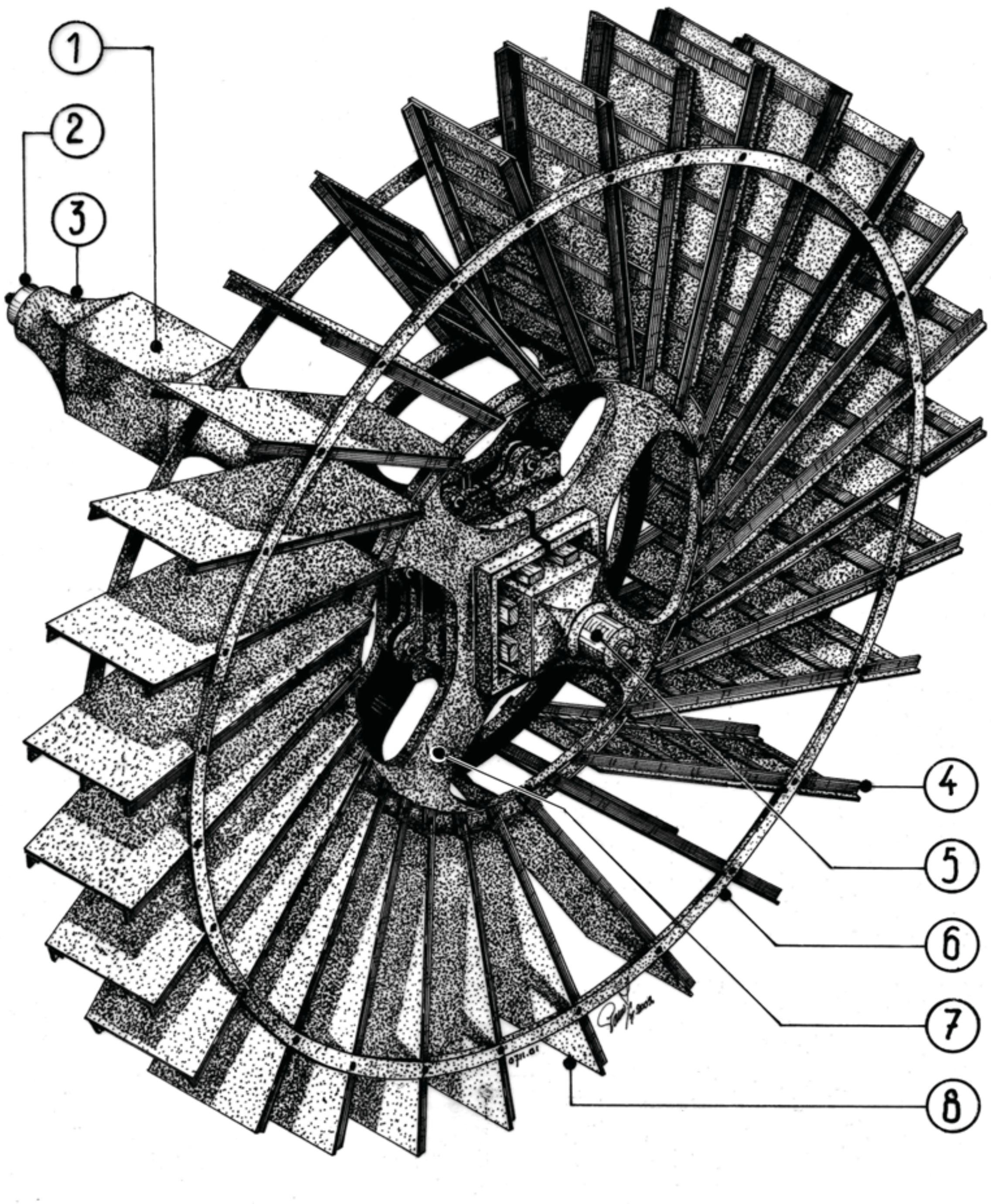


Fig. 11.4.2.2
A metal scoop wheel as manufactured by engineering works De Wed. Sterkman "De Prins van Oranje"

1. *place for the pit wheel*
2. *inner bearing pin*
3. *waterwheel shaft*
4. *paddle feather*
5. *outer bearing pin*
6. *shroud*
7. *central iron frame*
8. *paddle*

11.4.3 The driving gear

The driving gear of the polder mill, from the windshaft to the main upright shaft, is described in Chapter 6.

vertical strut, pivot bearing
bearing block, transom

The main upright shaft rotates between two vertical struts in a pivot bearing that rests in a bearing block. It is adjustable and rests on an oak transom firmly placed between the sheer posts.

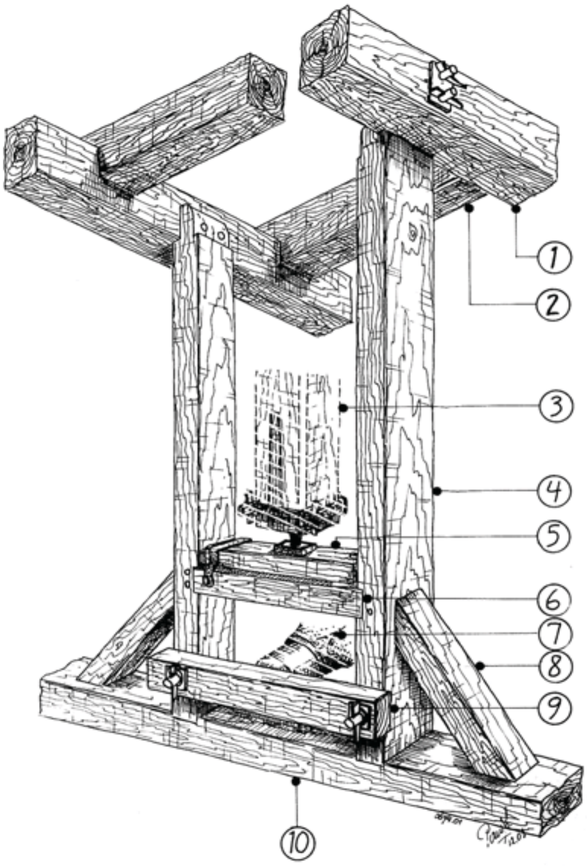


Fig. 11.4.3.1
The vertical strut framing in an octagonal mill

1. *fixed binder*
2. *loose binder*
3. *main upright shaft*
4. *vertical strut*
5. *bearing block*
6. *transom*
7. *scoop wheel shaft*
8. *brace*
9. *inner crossbeam*
10. *summer*

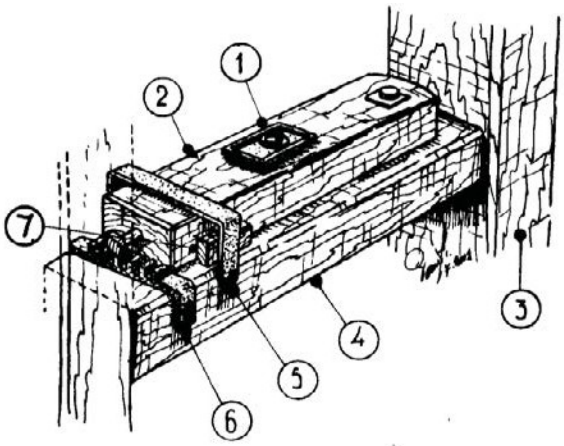


Fig. 11.4.3.2
Transom and bearing block

1. *pintle*
2. *bearing block*
3. *vertical strut*
4. *transom*
5. *locking bracket*
6. *lever cog*
7. *retaining wedge*

lower lantern pinion

To take the waterwheel out of operation, the bearing block can be shifted to disconnect the main upright shaft and the lower lanters pinion attached to it from the waterwheel.

waterwheel, pit wheel
scoop wheel shaft

The lower lantern pinion drives the waterwheel or pit wheel. The waterwheel is secured with wedges to the scoop wheel shaft, the other side of which carries the scoop wheel. The gear ratio of the sail cross to the scoop wheel is roughly 2:1; in other words, with two revolutions of the sail cross, the scoop wheel turns once. Like the windshaft, the waterwheel shaft rotates in two bluestone bearings. Previously, all waterwheel shafts were wooden and both ends had iron fillets.

inner bearing,
outer bearing,
water stool

The inner bearing rests on the summer under the transom. It is locked between the vertical struts with wedges, counter wedges and shims. The outer bearing lies in the water stool on the scoop wheel side and is also locked in with wedges. By loosening or knocking these wedges, the waterwheel shaft bearings can be moved back and forth a few centimetres.

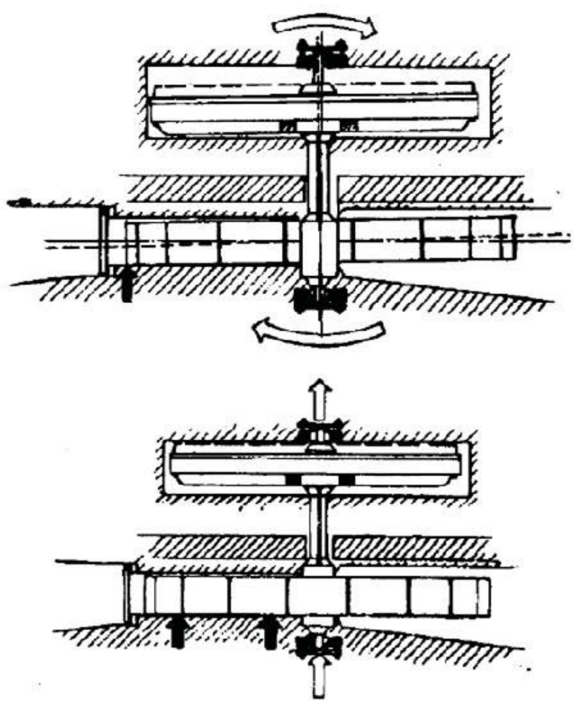


Fig. 11.4.3.3
Example of adjustment options for the waterwheel shaft and the scoop wheel

A. Straightening the waterwheel shaft using the wedges in the floor stand
B. Moving the scoop wheel slightly in the longitudinal direction of the shaft using the crossbeams

inner crossbeam, outer crossbeam

The ends of the waterwheel shaft are fitted with a steel pivot journal. Heavy pieces of oak, called the inner crossbeam and the outer crossbeam, respectively, are placed behind these pivots and against the vertical struts and the water stool. On the inside of both crossbeams is a steel plate with a bulb against which the pivots of the waterwheel shaft lean. The crossbeams, which are also adjustable, prevent the waterwheel shaft from shifting longitudinally. Using the aforementioned wedges and adjustable plates, the scoop wheel can be accurately adjusted between the spillway walls.

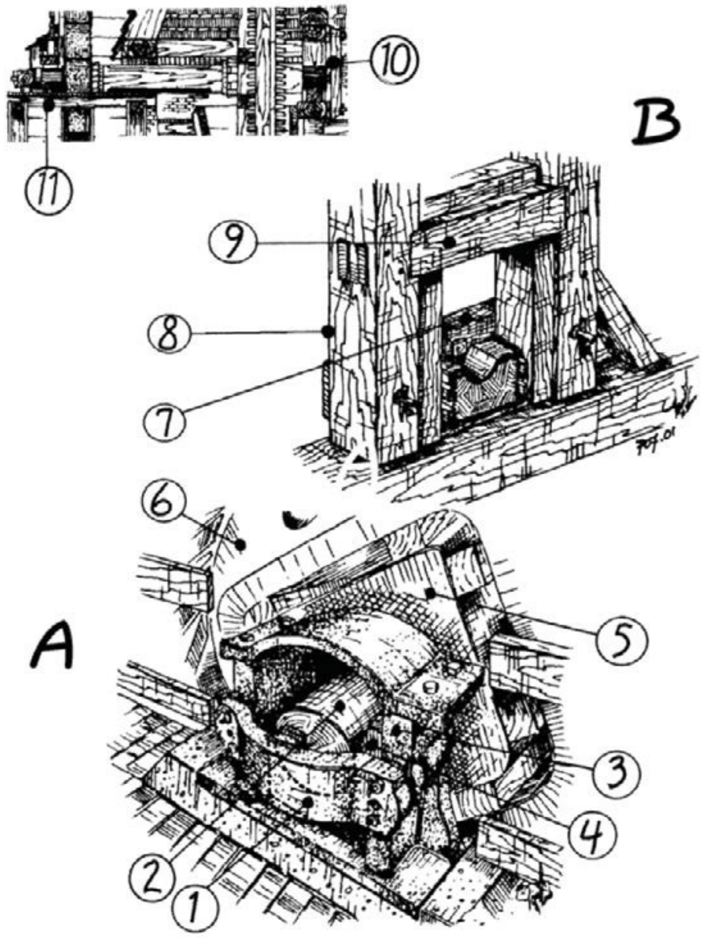


Fig. 11.4.3.4
Scoop wheel shaft bearings

A. outer bearing
B. inner bearing

1. *outer crossbeam*
2. *Waterwheel shaft pintle*
3. *bearing frame*
4. *grease box*
5. *scoop wheel shaft*
6. *central iron frame*
7. *inner crossbeam*
8. *vertical strut*
9. *transom*
10. *inner bearing*
11. *outer bearing*

11.4.4 Operation of the scoop wheel

pumping head

The scoop wheel pumps water from the head race up through the water guide into the tail race and the storage basin. The difference between the polder and basin levels is the pumping head. That is the number of centimetres that the water has to go up.

summer level, winter level

depth of immersion

Many polders work with summer and winter levels. The summer level is 10 to 20 cm higher than the winter level. The number of centimetres that the scoop wheel protrudes into the water, the depth of immersion, used to be between 50 and 90 cm. But the series of level reductions in recent centuries have gradually reduced the depth of immersion of many scoop wheel mills to a few decimetres or even zero. As a result, these mills have to raise the water too high. Sometimes they are completely incapable of doing this. Today, therefore, many scoop wheel mills cannot keep their polder dry without the help of a pumping station.
In some cases, this was improved by adding a larger (and sometimes narrower) scoop wheel.

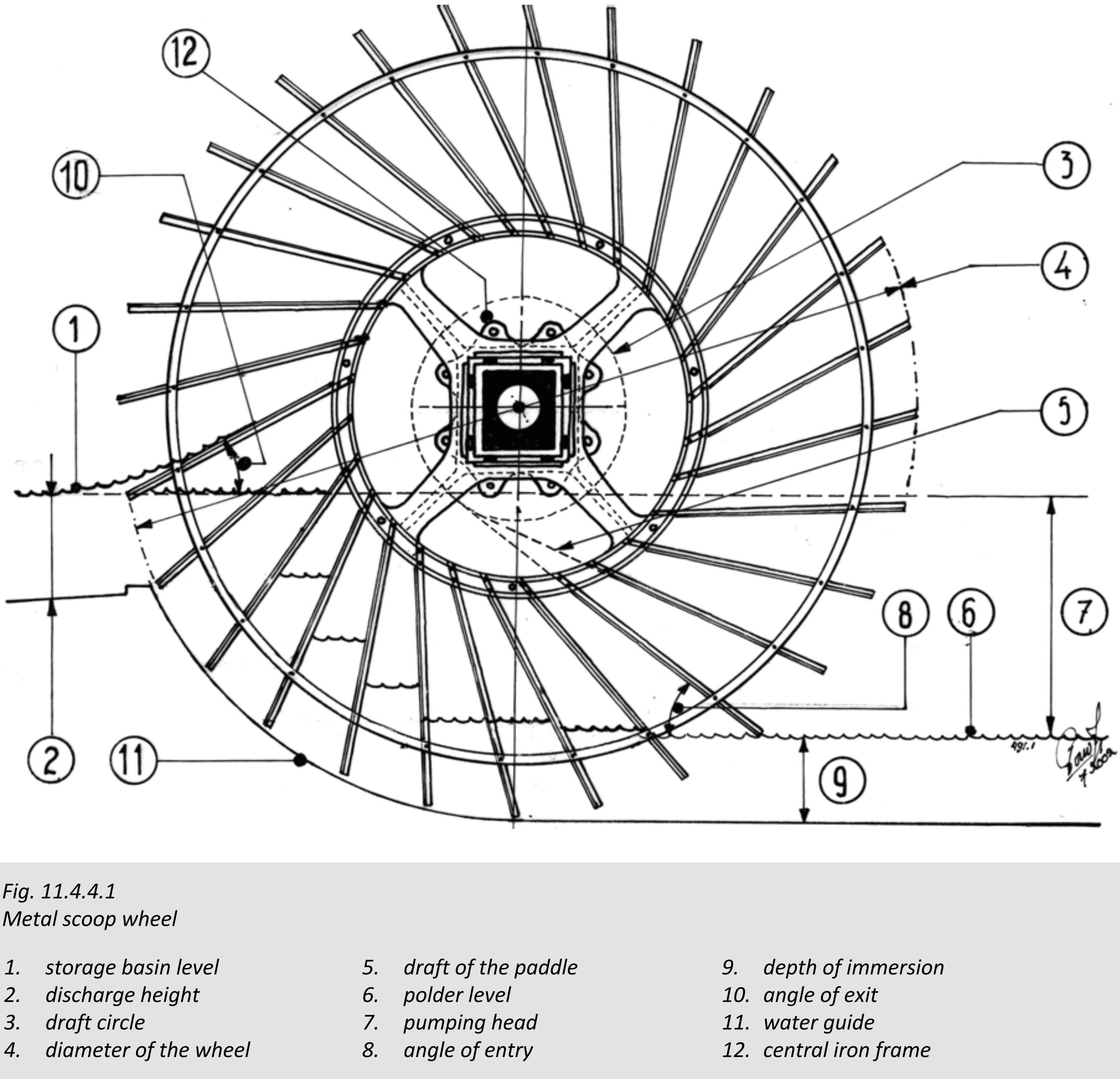


Fig. 11.4.4.1
Metal scoop wheel

1. *storage basin level*
2. *discharge height*
3. *draft circle*
4. *diameter of the wheel*
5. *draft of the paddle*
6. *polder level*
7. *pumping head*
8. *angle of entry*
9. *depth of immersion*
10. *angle of exit*
11. *water guide*
12. *central iron frame*

sluice door frame
gate sill, gate posts

At the end of the water guide, the water passes the sluice door frame, which consists of the gate sill and both gate posts from which the sluice door is hung. The pumped-up water pushes the sluice door open and flows into the tail race and the storage basin. When the scoop wheel slows down and/or stops, the higher storage basin water pushes the sluice door shut, preventing water from flowing back into the polder.

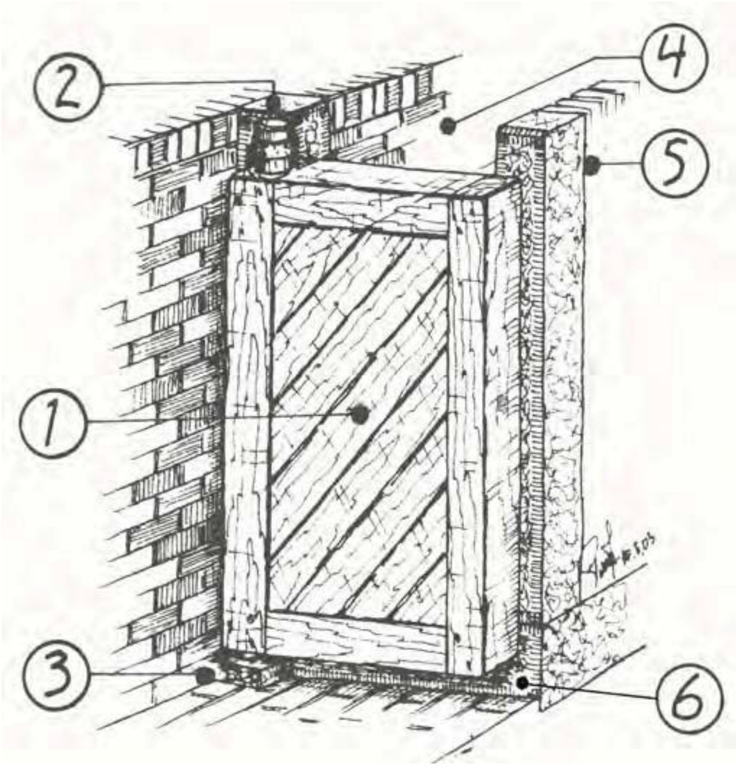


Fig. 11.4.4.2
The sluice door

1. *sluice door*
2. *cam*
3. *trough piece*
4. *spillway*
5. *gate post*
6. *gate sill*

clamp

To prevent the scoop wheel from completely opening the sluice door, a clamp is attached against the spillway wall or on the door so that back-flowing water can get past the wall behind the door and close it.

spray baffle,
splash wall, splash floor

Mills with an exterior scoop wheel are protected from splashing water by a spray baffle. Interior scoop wheels are separated from the other spaces in the mill by a splash wall and a splash floor.

11.5 THE ARCHIMEDEAN SCREW DRAINAGE MILL

11.5.1 The watercourse

Archimedean screw,

water trough

In Archimedean screw drainage mills, the spillway passes straight through the centre of the mill. The spillway walls are not part of the foundation here. The distance between the spillway walls, which is greater than that of scoop wheel mills, is determined by the diameter of the screw. Between the spillway walls lies the water trough, usually at an angle of 25° to 30° to the horizon. Water troughs used to be made of wood, but today they are often made of masonry or concrete. The pond is slightly more than semi-cylindrical and is only a few millimetres wider than the screw itself.

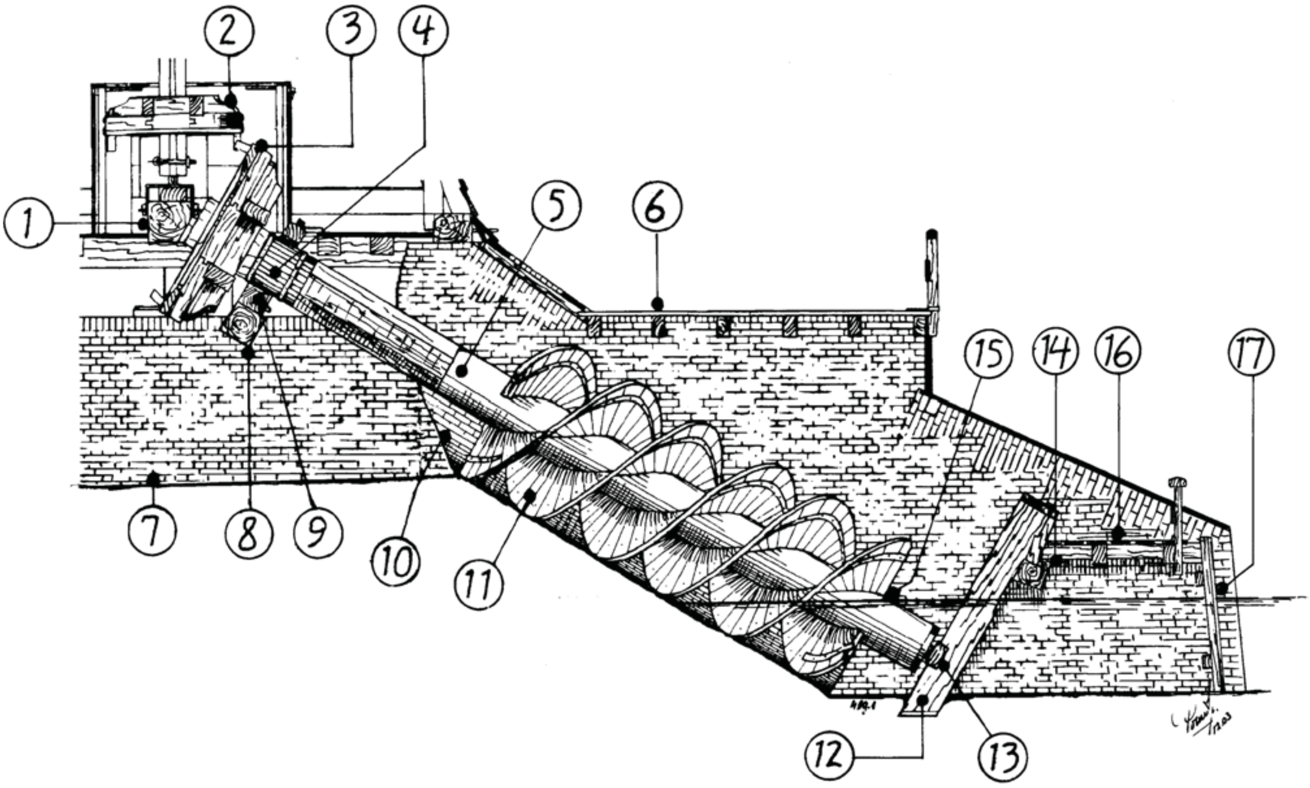
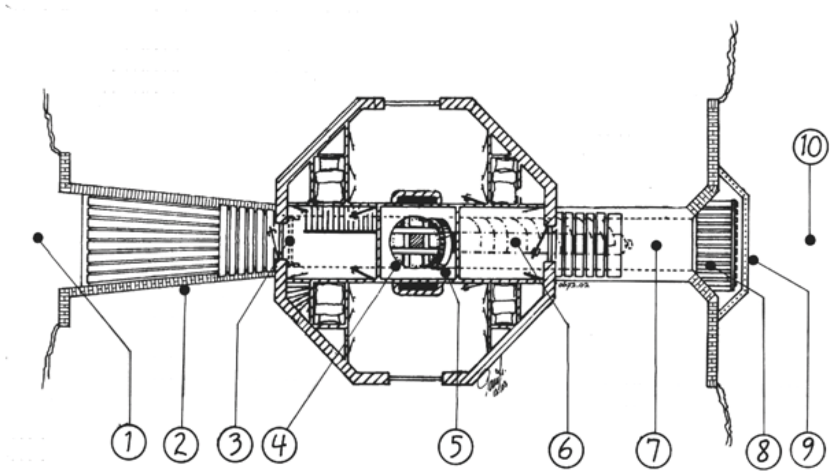


Fig. 11.5.1.1
Cross-section of the base of an Archimedean screw drainage mill

1. *transom or sumer*
2. *lower wallower*
3. *screw wheel*
4. *neck*
5. *screw beam*
6. *watercourse deck*
7. *apron*
8. *cross beam*
9. *neck bearing*
10. *water trough or housing*
11. *screw*
12. *water bolster or submerged tail beam*
13. *water bearing*
14. *lower spacer*
15. *filling point*
16. *debris bridge*
17. *debris screen*

Fig. 11.5.1.2
Plan of an Archimedean screw drainage mill

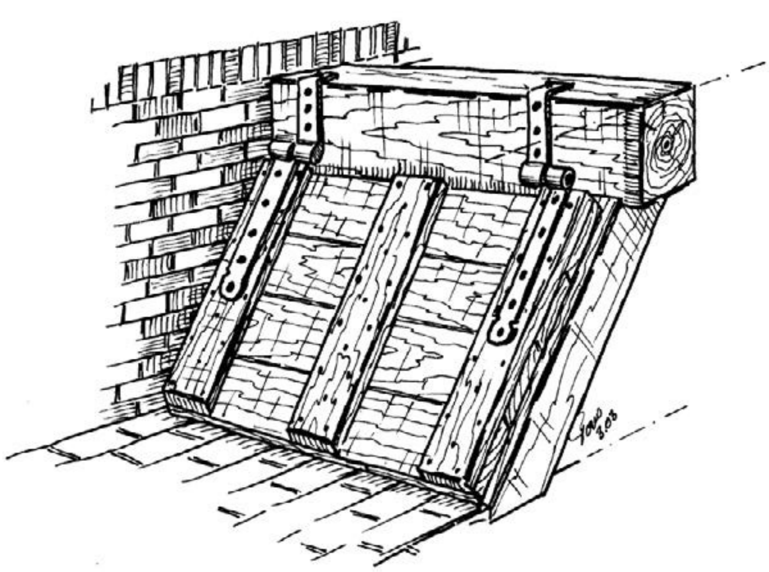
1. *storage basin*
2. *tail race*
3. *sluice door*
4. *lower wallower*
5. *screw wheel*
6. *screw*
7. *head race*
8. *debris bridge*
9. *debris screen*
10. *main collection ditch*



The supply of polder water is through the head race, which runs almost straight to the water trough.

apron

Immediately behind the highest point of the water trough is the apron, a section of tail race that slopes slightly towards the storage basin. At the end of the apron is the sluice door frame, consisting of two gate posts and a gate sill on which the sluice door is hung.
Behind the sluice door is the tail race, ending in the front end and the storage basin. As done with the scoop wheel mills, watercourse gates were installed on the front and back ends.
The water that passes the sluice door flows through the tail race into the storage basin.



free drainage

suspended sluice door

Frisian mounts sometimes have no sluice door and therefore have free drainage. The threshold of the water trough is 50 to 80 cm above the basin level. Many Archimedean screw drainage mills have a suspended sluice door, which is hinged at the top.

11.5.2 The Archimedean screw

screw beam
screw threads
sectors

A screw consists of a thick round shaft, the screw beam, on which two or three screw threads are attached. The screw is made of wood or steel. The screw threads of a wooden screw are composed of narrow thick planks, called sectors, which are nailed into the screw beam like a spiral. A wooden screw has the disadvantage that it can sag and catch in the basin.

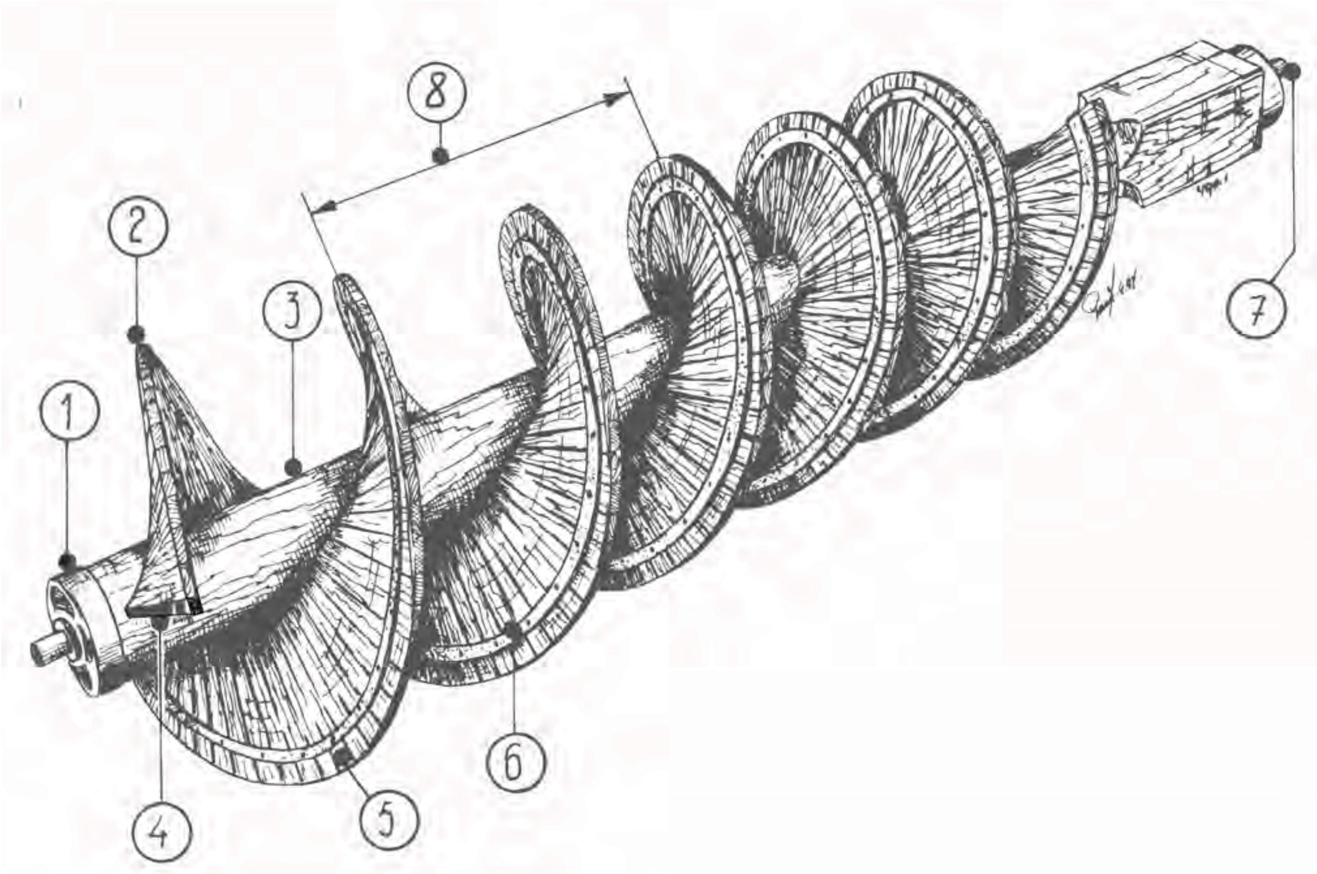


Fig. 11.5.2.1
Wooden screw with two threads

1. *lower crown gudgeon with pivot journal*
2. *screw beam*
3. *screw thread*
4. *striking iron*
5. *sector*
6. *nail band*
7. *upper crown gudgeon with journal*
8. *pitch*

In a steel screw, the screw threads are spirally riveted or welded around a steel screw beam. A steel screw does not bend, it lasts much longer and it can be adjusted with less play in the water trough. As a result, less loss through leakage occurs, resulting in higher efficiency.
Some screws have a wooden screw beam and steel screw threads.

11.5.3 The driving gear

lower wallower
summer or transom

The main upright shaft rotates in a pivot bearing on a sliding bearing block that allows the lower wallower, which is wedged to the main upright shaft, to be moved in and out of the machinery. The bearing block rests on a summer or transom anchored across the top of the water trough between the spillway walls. The lower wallower drives the screw wheel. Some wallowers are equipped with a double row of conical cogs (see Section 6.5.2 and Fig. 11.5.3.1)).

heavy work
light work
screw wheel

Depending on wind strength, the screw can be driven fast (for heavy work, the outer row of cogs) or slow (for light work, the inner row of cogs).
The screw wheel is secured to the top of the screw beam by means of wedges. The gear ratio from the sail cross to the screw is roughly 1:2; in other words, for one revolution of the sail cross, the screw turns twice.

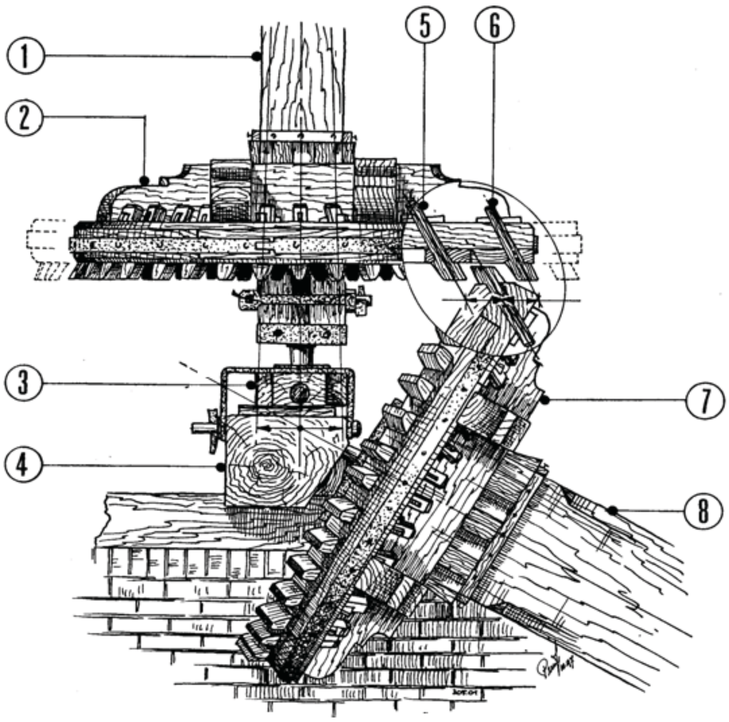


Fig. 11.5.3.1
Light and heavy work
1. *main upright shaft*
2. *lower wallower with a double row of cogs*
3. *bearing block to switch from light to heavy work*
4. *transom or summer*
5. *cog for light work*
6. *cog for heavy work*
7. *screw wheel*
8. *screw beam*

The top of the screw can be bearing-mounted in two ways (see Fig. 11.5.3.2):
– An iron trunnion in the screw beam rotates in a bronze bearing attached to the transom of the main upright shaft.
– The screw beam rotates by its neck in a bluestone bearing. This bearing is anchored with wedges in a frame, the stool, and rests on the upper spacer that is laid to the slope of the screw between the spillway walls.

stool, upper spacer

Behind the bearing, the screw beam extends 80 to 100 cm. The screw wheel is installed on that section.
At the bottom of the screw beam is a trunnion or pivot journal which rotates in a bronze bearing pot that is enclosed in the water pillow or submerged tail beam. This water pillow (horizontal) or submerged tail beam (inclined upright) is anchored in the water trough and between the spillway walls.

water pillow, submerged tail beam

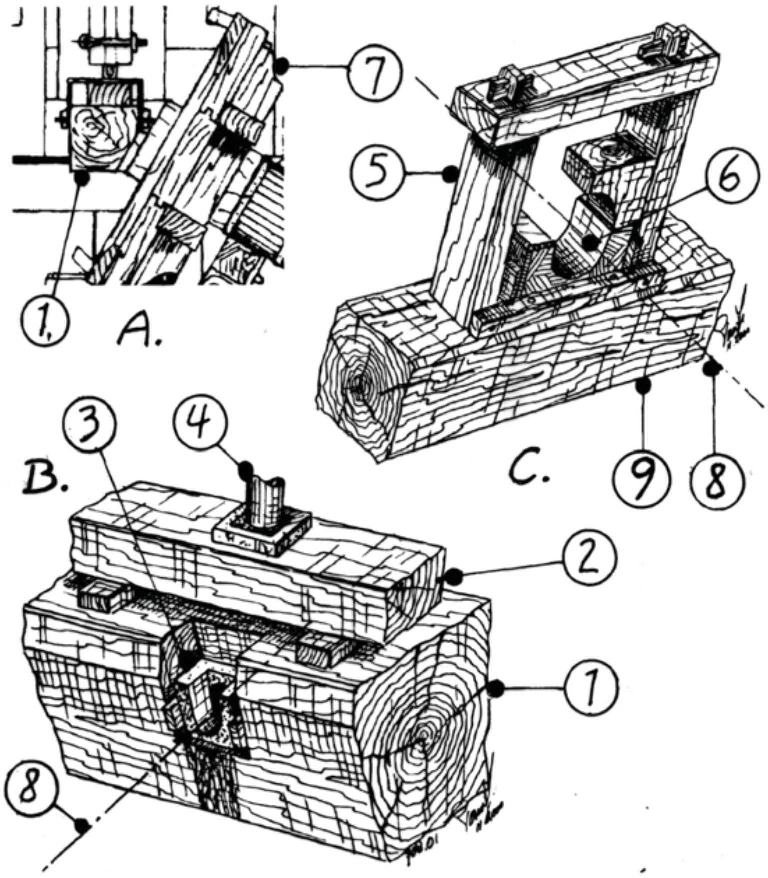


Fig. 11.5.3.2
Upper bearing of the screw

A and B Bearing of main upright shaft and screw with pivot journal
C Bearing frame for wooden screw beam

1. *transom or summer*
2. *bearing block*
3. *upper bearing for the screw*
4. *pivot journal of the main upright shaft*
5. *bearing frame*
6. *neck bearing for the screw*
7. *screw wheel*
8. *centre line of the screw*
9. *upper spacer*

11.5.4 Operation of the Archimedean screw

filling point

spilling point

From the head race (polder level), the water screw screws the water through the water trough to the tail race (storage basin level). The difference between the two levels is, again, the pumping head. The screw produces the highest efficiency when the filling point is several centimetres below the polder level. The filling point is the top of the screw beam at the beginning of the screw threads. At the upper end of the water trough, the pumped-up water reaches the spilling point.
There the water flows over the apron and then reaches the sluice door. Once the screw has pumped enough water, this pushes the sluice door open and the water flows away through the tail race. Archimedean screw drainage mills can raise water up to 4 to 5 metres without losing much efficiency. Pumping higher will cause the screw to become too long and too tight in its diameter, and the mill will underperform.

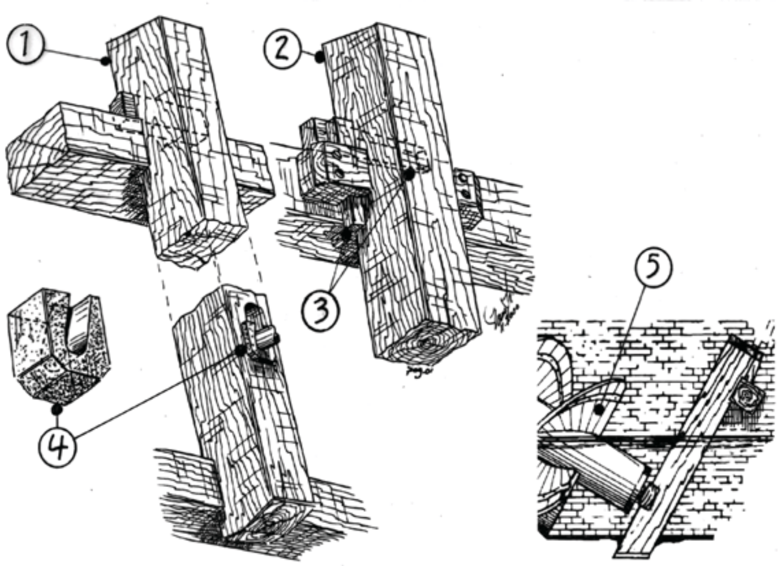


Fig. 11.5.3.3
Lower bearing for the screw

1. *Submerged tail beam*
2. *adjustable tail beam*
3. *adjusting wedges*
4. *loose bronze bearing*
5. *lower end of the screw*

11.6 POINTS OF ATTENTION FOR THE POLDER MILLER

11.6.1 Introduction

The material discussed in this section is not exam material. The Handbook teaches about turning with unloaded mills. However, during or after training, many millers will start working with a polder mill and, in many cases, pumping with it. It is important for them to take note of the following.

11.6.2 Winter and summer levels

winter and summer levels

All polders are subject to officially established winter and summer levels. This is the water level in the polder during the seasons. The winter level is about 10 to 15 cm below the summer level. It is recommended that the miller maintain contact with the water authority in connection with the aforementioned levels.

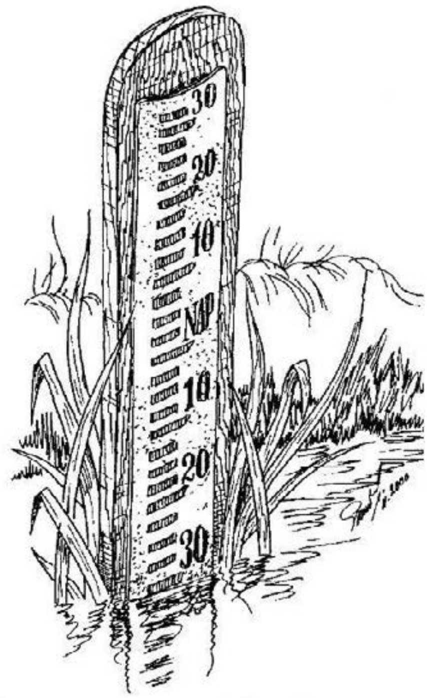


Fig. 11.6.2.1
Example of a free-standing depth gauge

AOD = Amsterdam Ordnance Datum

In autumn and winter, the miller had to maintain the low winter level to prevent prolonged autumn rains from making the land too swampy or even flooding it. In those days, polder millers often pumped day and night. That could continue into the spring.
In spring and summer, the atmosphere becomes drier and warmer. The water evaporates faster. In addition, plant growth gets underway. During the crop-growing period, there was much less to pump and the miller had to maintain the higher summer level to preserve the proper groundwater level.
If, during long dry summers, the summer level dropped too much, the

sluice door, admitting water

debris grille

miller opened the sluice door to admit water. The polder miller could accelerate this admission of water by putting the water-lifting apparatus out of operation, causing it to turn backwards. A debris grille in the tail race retained incoming floating debris that would otherwise accumulate in front of the scoop wheel or screw.

11.6.3 Pumping with a polder mill

gradient

under-pumping

Pumping a polder to level is a matter of experience. During pumping, the water level at the gauge directly behind the mill is lower than that at the back of the polder. We call this difference in level the gradient: the water surface in the polder is not absolutely level. The miller knows this and therefore pumps to a few centimetres below the level, which is referred to as under-pumping. When he stops the mill, water continues to flow to the mill until the gradient is levelled. The water surface is then absolutely level and the polder is (in the ideal case) at level.
For narrow, shallow or overgrown watercourses, the gradient can become large because the inflow of water is impeded. For wide, deep and clean watercourses, it amounts to only a few centimetres. In extensive polders, wind damming can also affect the gradient.
How much under-pumping is allowed depends on several factors. If the land is very wet or there is a lot of ice in the ditches, under-pumping too much can damage the embankments. If a lot of rain is expected or the drainage is running briskly, you can under-pump a bit more.

11.6.4 Efficiency

maximum efficiency

In general, polder mills can run at 100 ends with ease but it is not a case of: "The harder the mill runs, the higher the efficiency." The number of ends or bouts per minute at which a polder mill produces maximum efficiency depends on several factors, such as the diameter of the scoop wheel, the width of the blades, the depth of immersion and the gear ratio of the driving gear.
If the scoop wheel or the screw turns too fast, the mill pumps more water out of the head race than can flow in from the polder. The depth of immersion is then reduced, resulting in less water being pumped up and a decrease in efficiency. If the depth of immersion is always low, you should also turn less quickly.
Furthermore, if the mill runs too fast, the water-raising device will no longer be filled optimally. The inflowing water is then not given sufficient time to properly fill the water-raising device. Also, a fast turning water-raising device can cause so much churning in the inflowing water that filling is impeded.
For maximum efficiency, a large scooping device can run slower than a small scooping device. If it runs too fast, it still works fine but it takes more energy to pump out a litre of water.
Figure on about 5 revolutions per minute for a large scoop wheel to 8 for a small scoop wheel. The mill then runs at between 50 and 75 ends.
As the amount of water in the scoop wheel decreases, not only does the efficiency decrease but so does the load on the mill — so it will want to go even faster. The water can even be "pumped over the head" if it does not have enough time to run off from the scoops. As a result, efficiency continues to decline.

pumping over the head

For screws, you can figure on 30 to 50 revolutions per minute. The mill then turns between 60 and 90 ends or bouts. A screw inserted too deeply into the water scoops up more water than will fit in the screw. A lot of water then backs up, reducing the efficiency. This also causes the mill to turn more heavily. The numbers of revolutions mentioned do, of course, depend on the gear ratio of the driving gear.
Thus, a polder mill turning too hard does not always produce more yield. In that case, energy is wasted and there is unnecessary wear and tear.
However, if the scoop wheel or screw rotates too slowly, then less water is also pumped up per unit of time. Thus, the miller presents as much sail as is needed to achieve maximum efficiency.

11.6.5 Running out of control and jamming

pick hook

A pick hook is provided at each polder mill to keep the debris grille free of aquatic plants, wood and other floating debris. Small pieces of wood, slats, sturdy branches, etc., are removed from the water before they slip through the debris grille. A small batten can be enough to jam the scoop wheel or screw. Cogs or rods may then break. When cleaning the debris grille, make sure the rotating sail cross does not grab the long handle of the picking hook.
The following problems may occur:

too little water

- As already mentioned, a water-raising device that runs too fast collects too little water. This reduces the load on the mill, which causes it to turn even faster and may cause the mill to be uncontrollable.

debris grille full of debris

waterweed

- A debris grille may be full of debris and aquatic plants. This is enough to dry up the water supply and then the mill can run out of control. This happens especially early in autumn, when, for example, waterweed dies off and flows as a mass with the polder water to the mill.

debris grille gives way

- If the water-lifting apparatus pumps the water away faster than it can flow in, a level difference occurs in front of and behind the debris grille. This can cause the debris grille to give way. When combined with accumulated debris in front of the debris grille, this problem is exacerbated.

jamming

- The screw or scoop wheel becomes jammed, such as on a piece of wood. Then you can consider yourself very lucky if no cogs or rods are broken. If there is no way to unjam the scooping device, the first thing to do is to take the mill out of operation so you can approach the sails and clamp them if necessary. The sluice door should then be opened wide in the hope that the water pressure on the scoop wheel or screw will solve the problem. If this also fails, you can put the mill back into operation and carefully pull back the sail cross. It is wise not to start pumping again until the cause of the jam has been found and removed.

11.6.6 Frost and thaw

In the past, polder millers were usually instructed to keep their scooping device free from ice. To that end, they used a batten to set the sluice door ajar and thus keep the backwater moving. It then freezes up less quickly. But in harsh winters, everything freezes solid. Then you cannot pump or wind without risking damaging the driving gear because, during the winding process, the brake wheel takes the main upright shaft with it. If you still want to turn (for the Prince) then the scooping device must be taken out of operation. Do not try to pry it loose by pushing against the sail cross. This will come at the cost of cogs.

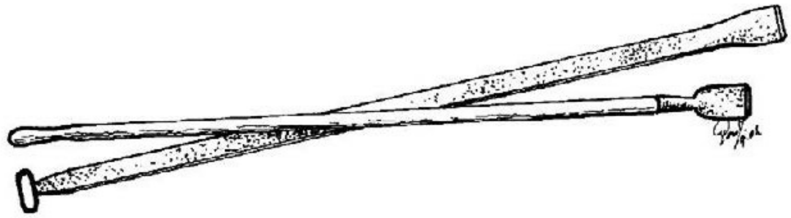


Fig. 11.6.6.1
Two examples of ice chisels

ice pick

If, for example, the miller wants to pump when the thaw sets in, he or she must chip loose both the scooping device and the sluice door. An ice pick consists of an iron rod approximately 2 metres in length with a flattened lower end and a handle at the upper end. This is used to knock the ice into small pieces. In doing so, you must spare the scooping device itself, as screws (especially wooden ones) are easily damaged. If you must stand on the screw when chipping loose, make sure it is properly blocked.
You can also use a bell pump to pump water into the screw: the water under the ice is slightly less cold and, after a night of pumping, much of the ice in the screw will be gone. The ice in the wide part of the head race can be left in place. Once the scoop wheel or screw is running, that ice will quickly become thinner and harmless.
The sluice door is then made ice-free to the point that it can be fully opened again. Only then can you pump.

floating ice

When a thaw sets in, a significant amount of floating ice may accompany the water. The debris grille can then be closed right to the bottom by floating ice and debris coming up against it!

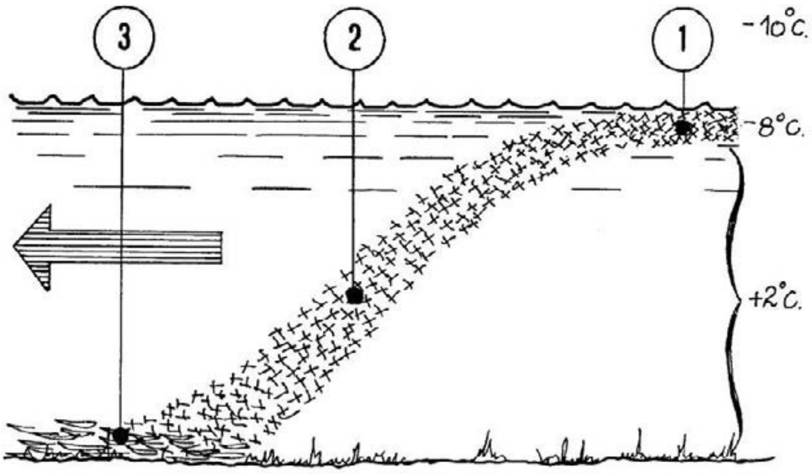


Fig. 11.6.6.2
The origin of ground ice

1. *the water on the surface is significantly supercooled*
2. *this supercooled water sinks to the bottom of the main collection ditch and forms ice crystals there*
3. *this ground ice is drawn to the mill by the flow of water*

If pumping is continued when frost sets in you should be aware that the screw or scoop wheel will freeze immediately after pumping ceases. To then clamp the sails, you have to take the mill out of operation.

ground ice

You also need to keep an eye on the debris grille when frost sets in. It can clog up from below because ground ice has formed that is drawn underwater to the mill. The supercooled water sinks and then ice crystals form at the bottom.

11.6.7 Wooden water-lifting apparatuses

Wooden scooping devices require more attention than metal ones. They are subject to shrinking, expanding and warping. Therefore, the miller must regularly rotate the wooden screw or scoop wheel half a turn to keep them evenly moist. This task used to be a standing condition in miller contracts.

NOTES

Chapter 12 The Grain Mill

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NOTES

12.1 INTRODUCTION

Grain kernels are too hard to be consumed unprocessed. They must be broken open and crushed to make their nutrients more digestible. Milling grain also allows the meal to be made into bread or cake.

mill stones

Mill stones have been used for the grinding process since prehistoric times. In the long history of grinding grain into meal, mill stones have developed from a hand-operated rubbing stone via the quern to the familiar mill stones of today.
The watermill was invented in the time of the Romans and pre-dates the modern era. Only in the 8th and 9th centuries was it was introduced into the Netherlands.
Wind-powered milling came to the Netherlands some four hundred years later in the 12th century, when the post mill made its appearance.
From the tower mills (circa 1400) and the hollow post mills — which were not only used to drain polders but were also equipped as grain mills — the cap winders developed (between 1550 and 1650). The demand for greater production and more space was key to this development.
The grinding mechanism itself has remained unchanged for the last two thousand years. It consists of two flat stones of which the lower one, the

bedstone, runner

bedstone, is stationary and the upper one, the runner.stone rotates.

12.2 THE FLOORS

floors

In grain mills, the various storeys, or floors, have specific designations.

cap floor, sack hoist floor

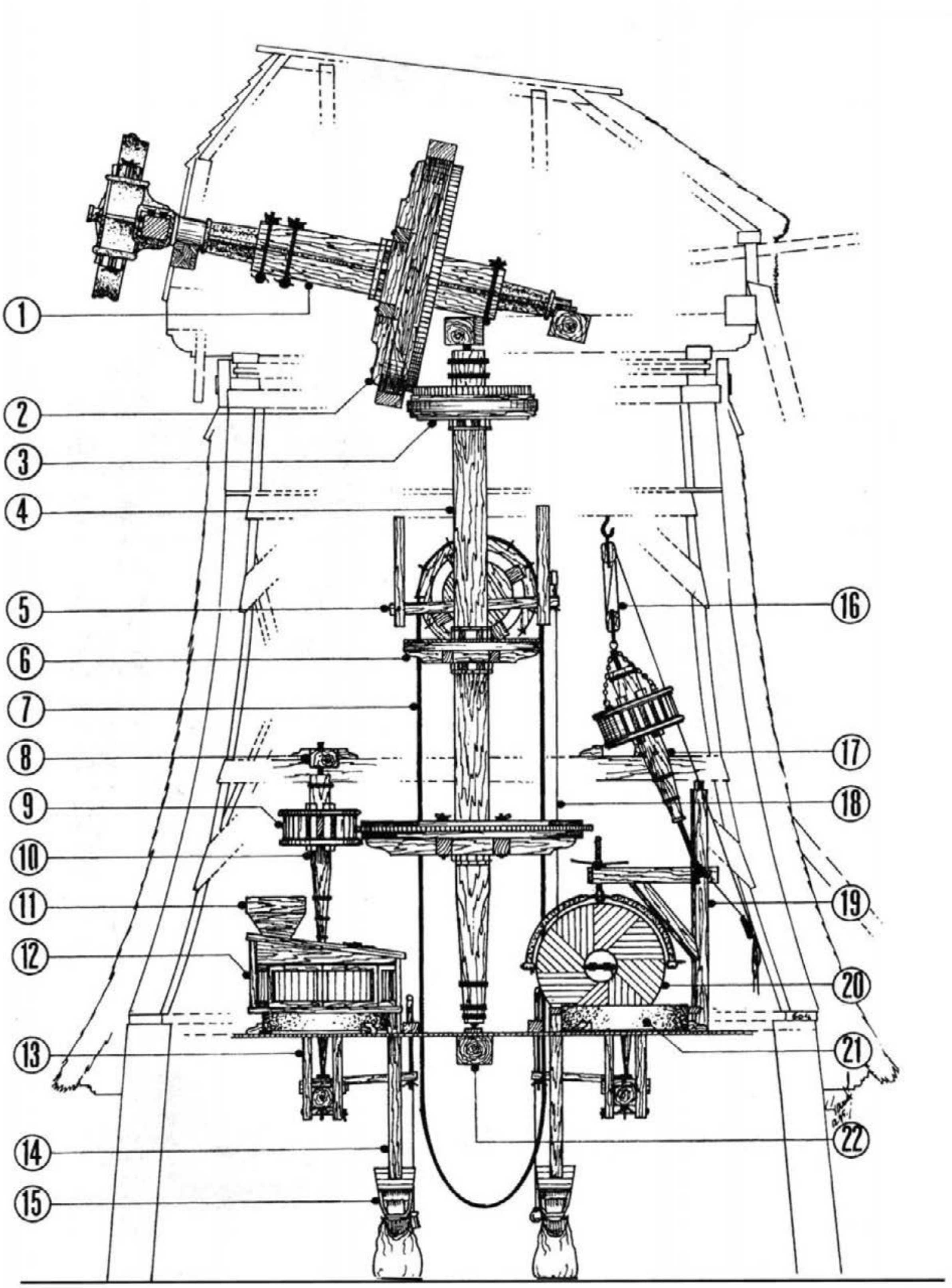
In the case of cap winders, the highest floor is directly under the cap and is therefore called the cap floor. Below that we see the sack hoist floor where the hoisting system is placed. The hoisting system is used to raise or lower mill stock (see section 12.8).

stone floor

Under the sack hoist floor is the stone floor, which houses the millstones.
The spur wheel and stone shafts with their pinions are also found in the stone floor (see sections 12.4 and 12.7.1).

meal floor

Below that lies the meal floor. This floor is the most important working area for the miller. From here, the miller operates the mill stones and processes the ground grain. The tentering mechanism of one or more pairs of stones hangs from the ceiling (see section 12.5).
In most mills, the stage or top of the mound is located at the level of the meal floor. From there, the miller can directly reach the brake rope. However, mills with the meal floor under the stage are by no means exceptions.
The body of the post mill usually has only two floors: the stone floor (above) and the meal floor (below).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12.3 THE DRIVING GEAR

stone set

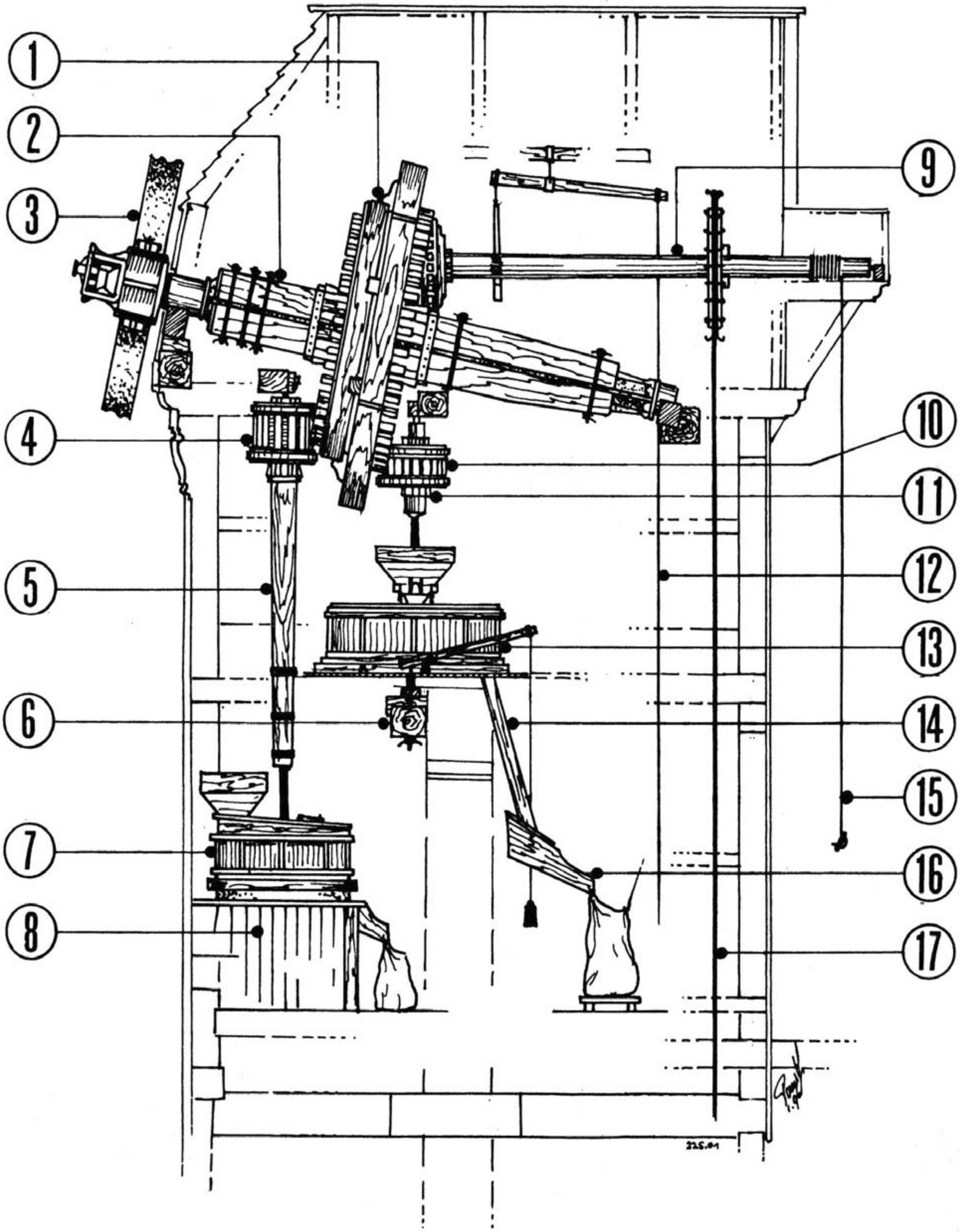
Post mills were equipped with only one pair of stones or stone set during the first centuries of their existence. It was not until the second half of the 17th century that a second pair were added. This pair of stones is driven directly by the brake wheel (with a few exceptions).
Thus the transmission from the brake wheel to the stone nut (see section 12.4.1) is single-geared and offers little opportunity to provide the runner substantial speed. Therefore, post mills have a relatively large brake wheel and a small stone nut. In this way, the runner develops a reasonable speed.
Post mills with two pairs of stones have either two brake wheels back to back on the windshaft or one brake wheel that has a row of cogs on both the front and back. Post mills with three pairs of stones in which two pairs are driven by means of a spur wheel on a short upright shaft are also seen but are rare.
At the time of the tower mills (during the 15th century), the drive of the post mill was initially continued; in other words, the pair of stones was located in the cap floor and driven directly by the brake wheel.
The advent of the upright shaft and spur wheel allowed the milling operation to be located a couple of floors below the cap floor. This enabled an expanded number of pairs of stones and it also enabled better

gear ratio

adjustment of the gear ratio. The gear ratio of the brake wheel to the waller or wallower above the upright shaft is about 1:2; that of the spur wheel, underneath the main upright shaft, to the stone pinions is 1:3 to 1:3½. The total acceleration from windshaft to runner usually ranges from 1:5½ to 1:7. This means that for one revolution of the windshaft, the runner goes around roughly six times! Post mills have a slower gearing, about 1:4½.

Fig. 12.3.1
The driving gear of an octagonal grain mill
(In principle, this classification applies to any cap winder grain mill.)

1. *windshaft*
2. *brake wheel*
3. *wallower*
4. *main upright shaft*
5. *hoisting system*
6. *friction ring*
7. *endless hand rope*
8. *spindle or stud beam*
9. *stone nut*
10. *stone shaft*
11. *hopper*
12. *stone trough*
13. *tentering mechanism*
14. *meal spout*
15. *bagging chute*
16. *stone shaft pulley*
17. *stone shaft*
18. *hoisting system control rope*
19. *stone crane*
20. *runner*
21. *bedstone*
22. *bridge tree or lower spindle beam*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12.4 THE DRIVE

12.4.1 The stone shaft and pinion

stone shaft, quant
journal, quant

The stone shaft occurs in two versions: as a continuous iron shaft, the quant with wooden cladding or as a wooden spindle with separate journal and iron quant.
The wooden covering is held in place with iron straps (see Fig. 12.4.1.1). The upper end is the trunnion, the lower end is the quant. The lower end of the quant is the clutch. This clutch engages the rynd (see section 12.4.3) and drives the runner.

clutch

spindle beam, stud beam
stone shaft top bearing part, glut

The stud of the stone shaft rotates in a wooden or bronze bearing which is enclosed in a chamber carved into the spindle or stud beam. This bearing usually consists of two parts, the stone shaft top bearing part and the glut. The latter is sometimes made from lignum-vitae wood, sometimes from bronze. If you remove the glut, the stone is taken out of operation. The journal is then shifted a good 10 centimetres from the point where the stone stands in its working position and is located in a separate wooden (gate) structure or a specially fitted stirrup iron. Placing the glut back afterwards prevents the spindle from falling back into its working position (see Fig. 12.4.1.3).

stirrup iron

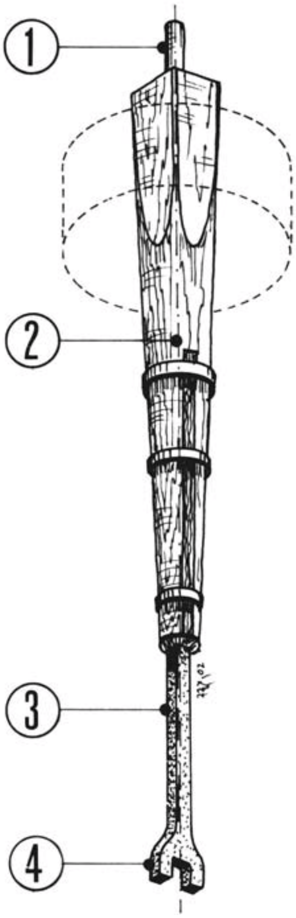
A second way to move the spindle out of its working position is to equip the spindle beam with a pivot point on one side and a lever on the other side (see Fig. 12.4.1.2).
This lever is used to swing the stone shaft away from the spur wheel. However, there are other bearing versions as well.

Fig. 12.3.2
The driving gear of a post mill

1. *brake wheel, pit wheel, large wheel*
2. *windshaft*
3. *stock*
4. *pinion of a tail mill*
5. *stone shaft*
6. *tentering mechanism of a head mill*
7. *tail mill*
8. *hurst frame*
9. *hoisting system*
10. *stone nut of a head mill*
11. *stone shaft*
12. *hoisting system control rope*
13. *head mill*
14. *meal spout*
15. *hoisting rope*
16. *bagging chute*
17. *endless hand rope*

pinion, stone lantern pinion

The pinion (or stone lantern pinion) is tightly wedged around the square wooden part of the stone shaft. The pinion consists of two elm sheaves, between which the rods are anchored. The choice of a pinion instead of a cog wheel has to do with the fact that the miller lighters or tenters the runner during the grinding process (see section 12.7). Therefore, a pinion as a drive for the stones is more suitable than a cog wheel. In addition, the stone shaft gradually descends over time as the stones are subject to wear and tear, causing the rynd and thus the stone shaft to slowly descend to an ever-lower level.
As this occurs, the cogs of the spur wheel always maintain a good grip between the staves of the pinion. With a cog wheel, this is not the case.



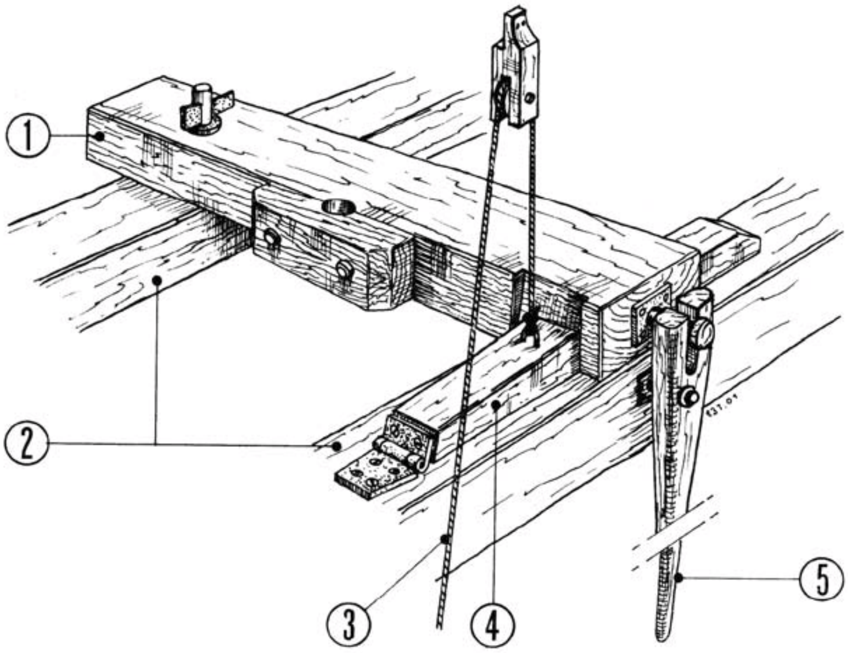


Fig. 12.4.1.2
The spindle beam

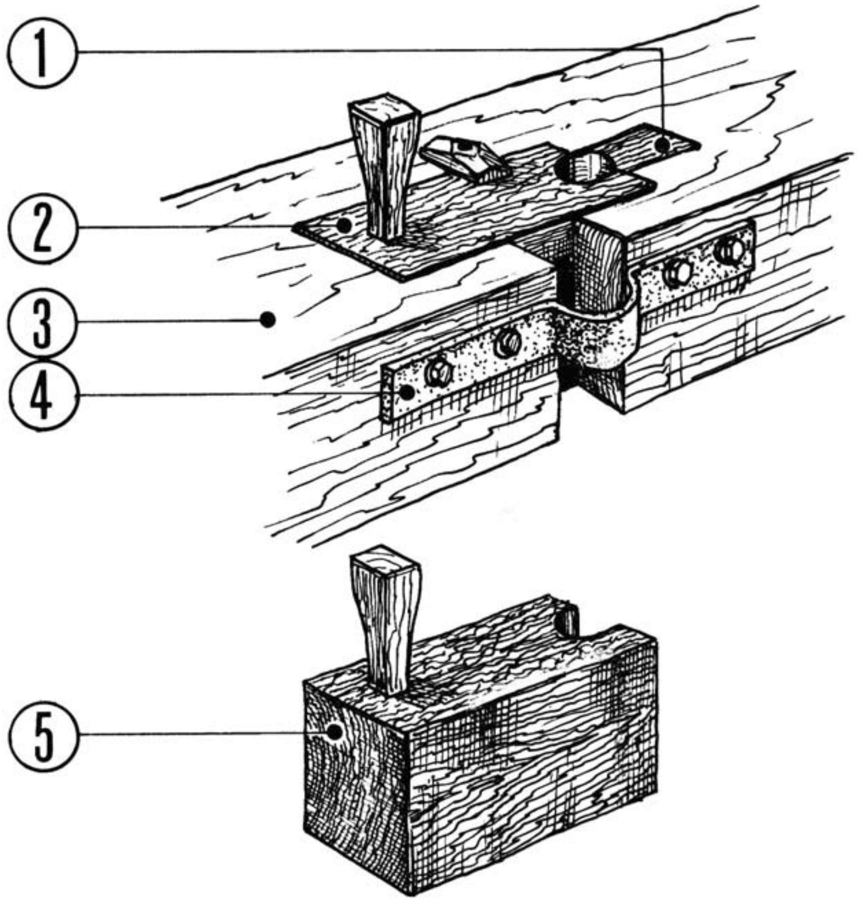
1. *spindle beam*
2. *tie beams or floor joists*
3. *steering rope of the spindle beam bolt*
4. *locking device*
5. *lever*

Fig. 12.4.1.1
The stone shaft

1. *trunnion end*
2. *wood packing*
3. *quant*
4. *clutch*

Fig. 12.4.1.3
The glut

1. *stone shaft top bearing part*
2. *glut*
3. *spindle beam*
4. *stirrup iron*
5. *removed glut*



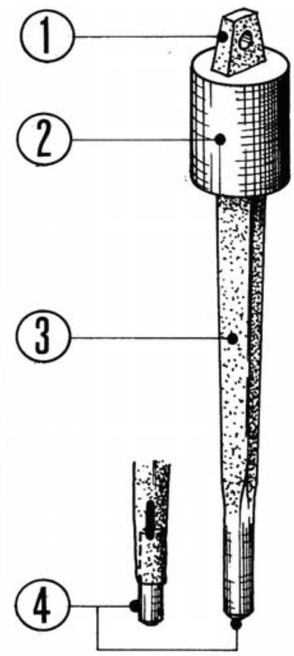


Fig. 12.4.2.1
The stone spindle

1. *cam for the rynd*
2. *neck*
3. *shank*
4. *loose or fixed pivot journal*

12.4.2 The stone spindle and accessories

stone spindle
pivot journal
pintle

The stone spindle (pear-shaped spindle) carries the runner via the rynd. At the bottom, the stone spindle (see Fig. 12.4.3.1) ends in a pivot journal that rests in a pintle. This pintle usually rests in the spacing block that lies on the bridge beam.

Bearings with a ball bearing are also possible.

spacing block
bridge beam, pull wedge,
push wedge

To accurately adjust the stone spindle in the vertical plane, the spacing block is adjustable in the horizontal plane on the bridge beam by means of pull and push wedges. The pivot journal is lubricated with castor oil or another oil that is not too thin. Over the pintle are two half covers to protect against dust getting into the bearing. On top of the stone spindle is a cam, and on this cam lies the rynd.

cam

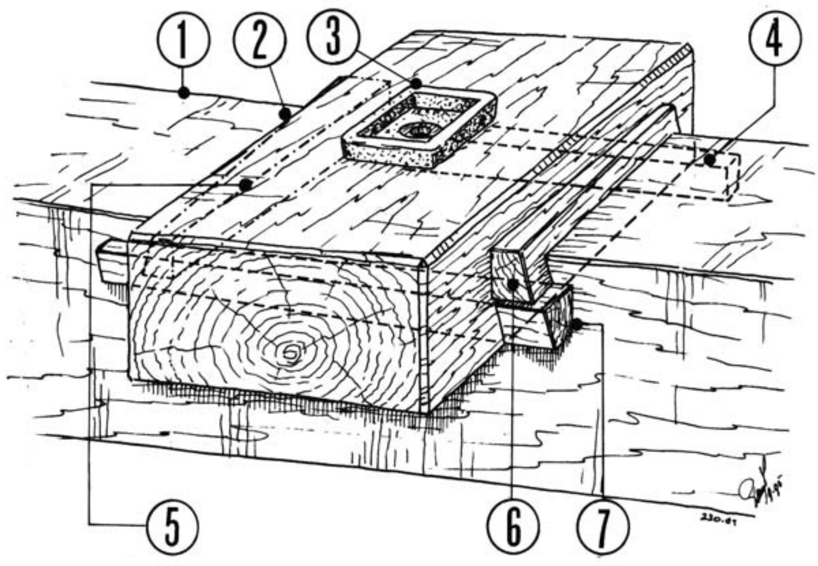


Fig. 12.4.2.2
Spacing block with pintle

1. *bridge beam*
2. *(and 6) push wedges*
3. *bearing pot*
4. *(and 7) pull wedges*
5. *centering block*

neck, neck bearing,

lignum-vitae bearings
wedges
grease chambers

Below the cam, the stone spindle has a bulge; this is the neck. This neck rotates in the neck bearing, the wooden or iron bearing in the eye of the bedstone (see section 12.7.2). The neck bearing holds the stone spindle in a purely vertical position by means of three lignum-vitae bearings that are adjustable with wedges placed behind them.
Between the bearings in the iron neck bearing are grease chambers for the neck of the stone spindle.

12.4.3 The rynd

rynd

The stone spindle carries the runner via the rynd, a strong iron structure. The quant of the stone shaft grips the top of the rynd. We distinguish between the fixed rynd, the balance rynd and the pin-and-socket rynd (see Fig. 12.4.3.1 and Fig. 12.4.3.2).

fixed rynd

The fixed rynd fits accurately and immovably on the cam of the stone spindle. The rynd has two, three or four ends, called the claws. These are moulded or wedged into the eye of the runner. Rynd and runner thus form a single unit. In order for the runner to run purely parallel across the bedstone, the fixed rynd must be mounted very precisely in the runner.

balance rynd
inner rynd, outer rynd

There are several versions of the balance rynd, with the most common being the English balance rynd. It consists of an inner and an outer rynd. The inner rynd rests on the cam of the stone spindle and is driven by the quant. The inner rynd has two round trunnions situated opposite each other. The outer rynd lies loosely on this so it can make a tilting motion.

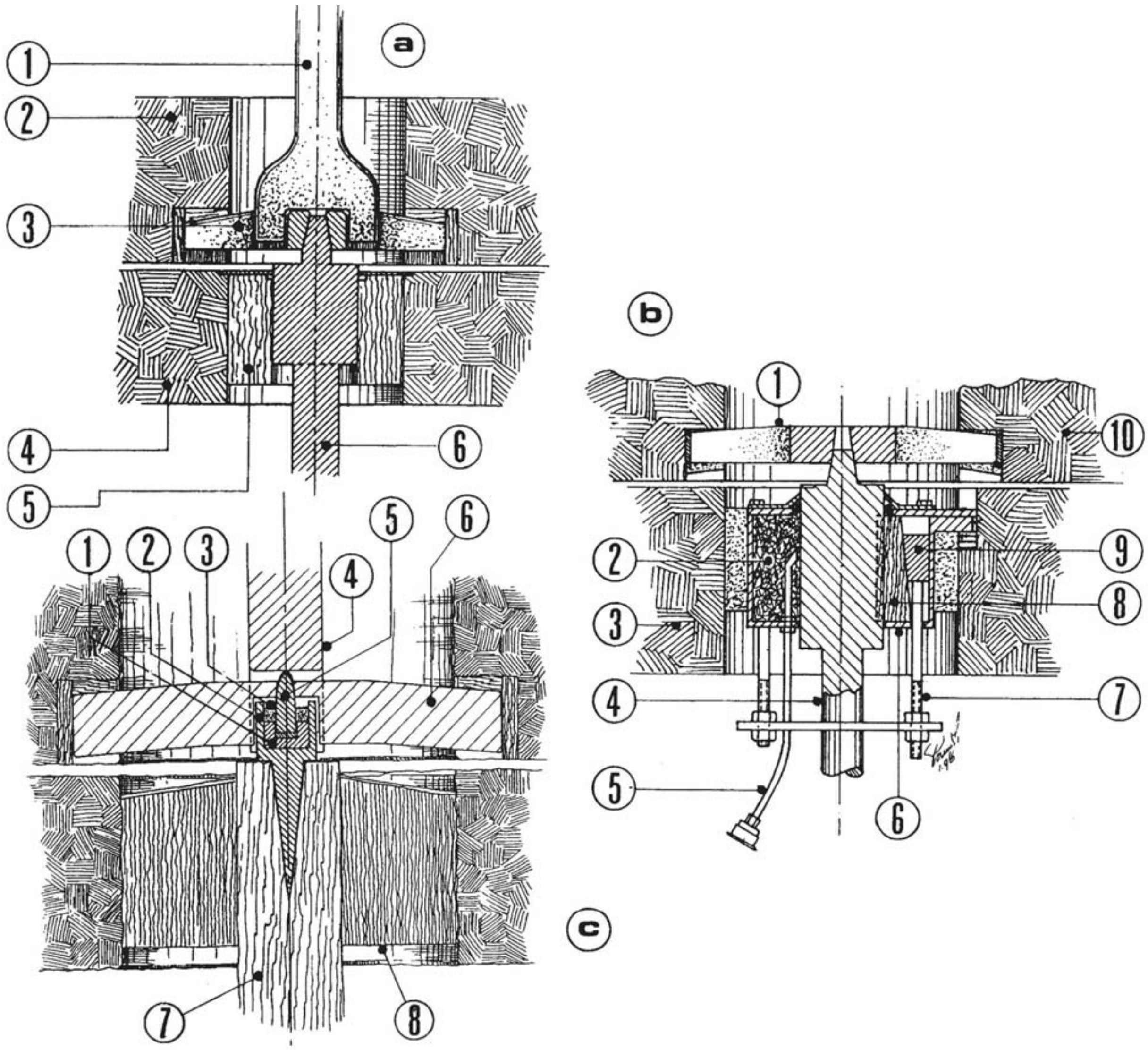


Fig. 12.4.2.3
Various versions of the neck bearing

a. wooden neck bearing

1. *quant*
2. *runner stone*
3. *rynd*
4. *bedstone*
5. *wooden neck bearing*
6. *stone spindle*

b. metal neck bearing

1. *rynd*
2. *grease chamber*
3. *bedstone*
4. *stone spindle*
5. *lubrication channel line*
6. *metal neck bearing*
7. *tie-rod*
8. *hardwood bearing*
9. *pull wedge*
10. *runner stone*

c. neck bearing for pin-and-socket rynd

1. *hardened steel pot*
2. *bearing pot*
3. *lubricating oil*
4. *quant*
5. *pivot journal*
6. *rynd*
7. *wooden stone spindle*
8. *wooden neck bearing*

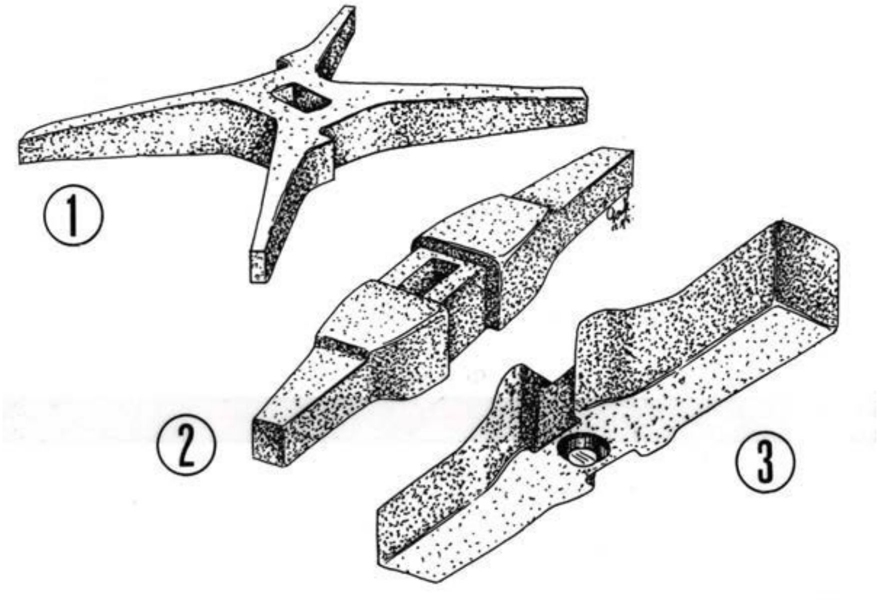


Fig. 12.4.3.1
Various rynds

1. *four-armed rynd*
2. *two-armed rynd*
3. *rynd for pin-and-socket rynd*

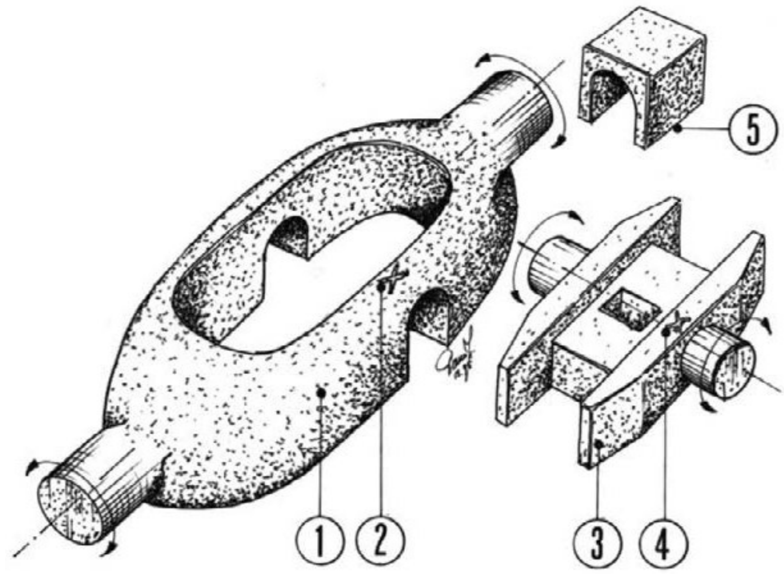


Fig. 12.4.3.2
Balance rynd

1. *outer rynd*
2. *fitting mark of outer rynd*
3. *inner rynd*
4. *fitting mark of inner rynd*
5. *liner*

The outer rynd has two trunnions perpendicular to the trunnions of the inner rynd as well.
These bear the runner via two liners.

pin-and-socket rynd

The pin-and-socket rynd can also balance. However, the stone spindle is stationary during this process.
Instead of a cam, the stone spindle here features a bearing pot. In this bearing pot there is a short pivot journal that can tilt slightly. The top end of the pivot journal is firmly held in the rynd.
This rynd has two arms, is fixed in the eye of the runner, and is driven by the quant in the usual way.

12.5 THE TENTERING MECHANISM

12.5.1 The hanger and accessories

hanger
bridge beam, brayer beam

The structure that carries the stone shaft, the rynd, the runner and the stone spindle is called the hanger. The adjustable centering block with the bearing pot in which the stone spindle is located is on the bridge beam or brayer beam.

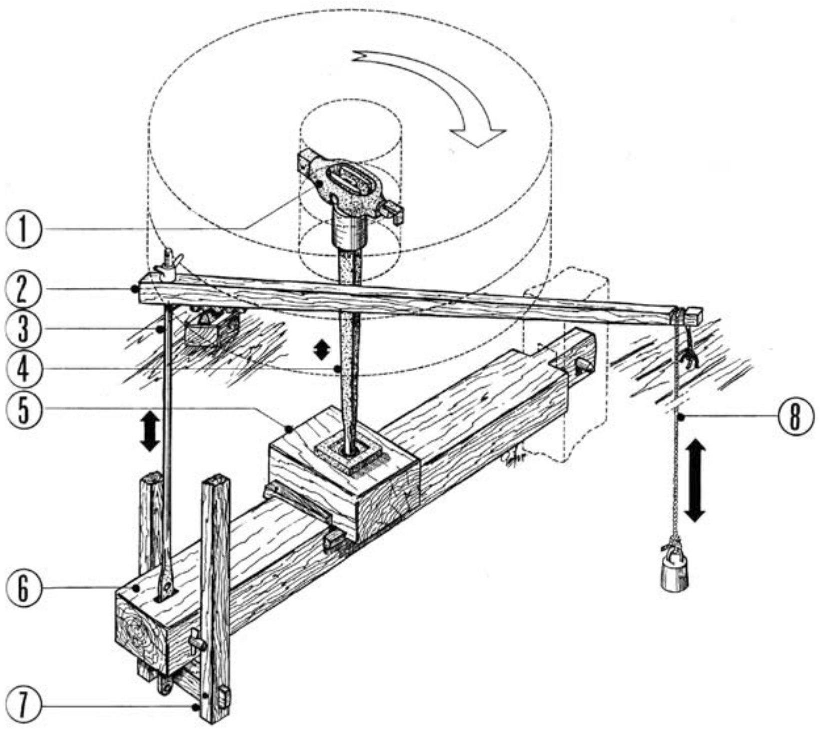


Fig. 12.5.1.1
The tentering mechanism with the tentering beam next to the pair of stones

1. *rynd*
2. *tentering beam*
3. *bray iron*
4. *stone spindle or pear-shaped spindle*
5. *centering block*
6. *bridge beam*
7. *hanger*
8. *lighter rope or belt*

hanger

bray iron,
tentering beam

This beam hangs with one end hinged in a hanger attached to the floor beams of the stone floor. The other end moves in the vertical plane within a wooden framework. This framework prevents lateral sway of the bridge beam. The bridge beam hangs by this same end via a tie-rod, the bray iron, on the short arm of a lever which is called the tentering beam.
Strung around the end of the long arm of the tentering beam is a rope or leather strap which is secured at one end to the floor or to a ceiling beam and equipped with a counterweight on the meal floor at the other end.

tentering
lightering

Pulling down the counterweight raises the bridge beam via the tentering beam and the runner is lightered. In other words, there is more space between the beam and the runner. However, if the counterweight is raised then the bridge beam descends via the tentering beam and the runner is tentered, meaning there is less space between the two stones (see section 12.7).

cross bridge tree

lighter staff

In another commonly used construction, there is also a cross bridge tree between the bridge beam and the tentering beam. This construction offers even finer adjustment of the space between the bedstone and the runner. However, sometimes a belt with a stick (the lighter staff) is used instead of a rope around the tentering beam.

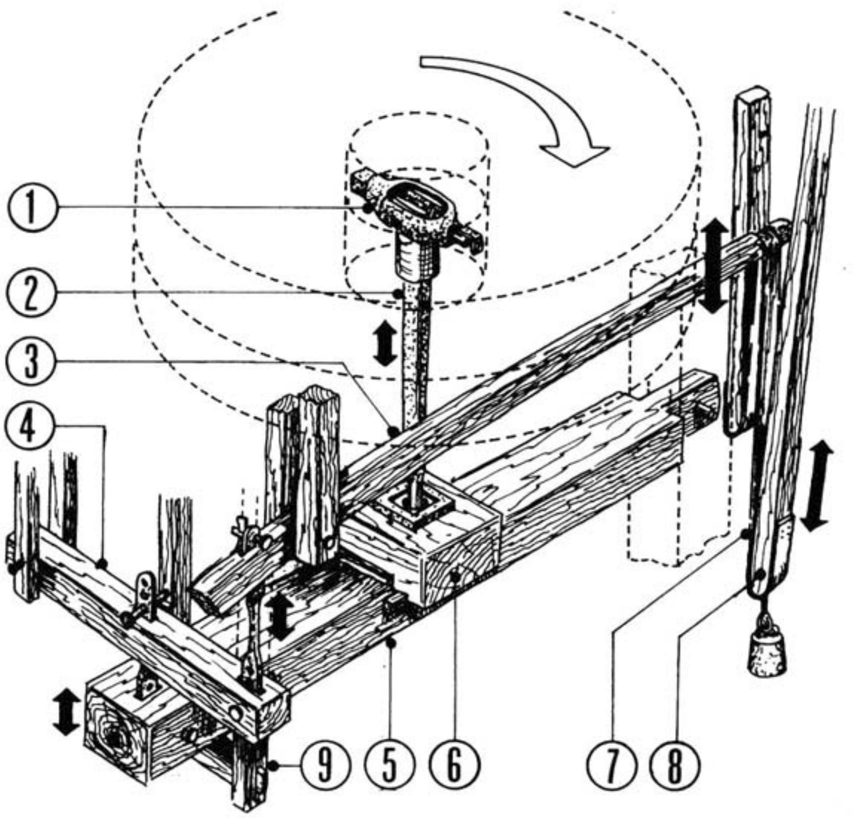


Fig. 12.5.1.2
Tentering mechanism with cross bridge tree

1. *rynd*
2. *stone spindle or pear-shaped spindle*
3. *tentering beam*
4. *cross bridge tree*
5. *bridge beam*
6. *centering block*
7. *belt*
8. *lighter staff*
9. *hanger*

12.5.2 The governor

Because the runner is constantly changing the number of revolutions it makes due to the varying wind speed on the sail cross, the miller must always use the tentering beam to adjust the distance between the stones accordingly to obtain an even product.

governor

A governor can assume some of this task.

A governor consists of a vertically standing shaft equipped with two arms that are hinged. A weight hangs from the end of each arm. When the shaft of the governor is set to turn via a drive belt from the stone spindle or from the upright shaft, the turning arms with their weights swing outwards and upwards due to centrifugal force. The faster the mill turns, the further out the weights go.

weights
centrifugal force

As the speed decreases, the weights drop back down.
These up and down movements are transmitted to the tentering beam via a rod-and-lever system. Lightering and tentering are now partially taken over by the governor.
When the governor is at maximum travel distance for a prolonged period of time, the sails turn too fast and the miller must furl; the proper travel distance is halfway. The governor can then both lighter and tenter.

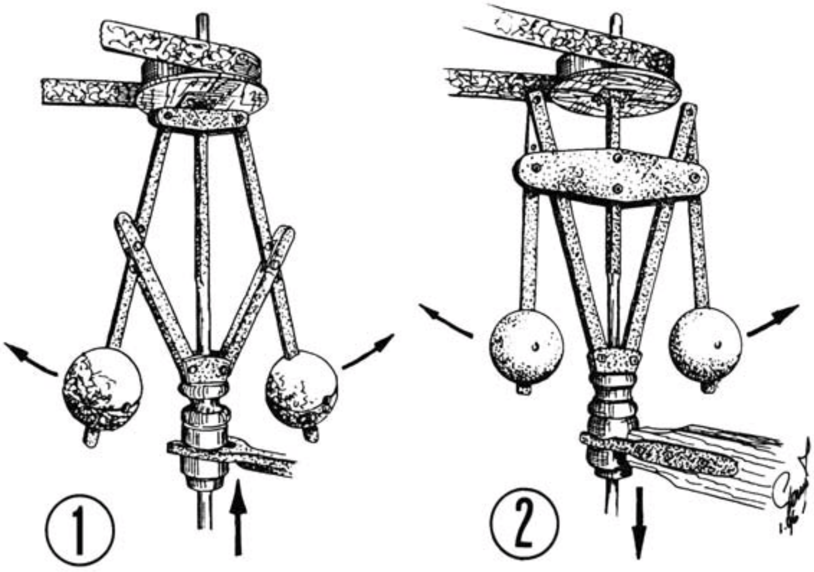


Fig. 12.5.2.1
The governors

1. *pull governor*
2. *push governor*

12.6 GRAIN SUPPLY AND MEAL REMOVAL

12.6.1 Grain supply

skirting board, millstone curbing

A few millimetres below the surface of the bedstone is a wooden ring, called a skirting board or millstone curbing, which has been fitted around the bedstone. On it is the (commonly) wooden trough which encloses the runner.

trough covers
hopper ladders
hopper
feed-shoe
shoe

The trough is covered with trough covers. Attached to the trough wall are the hopper ladders. They slope downward at an angle and taper towards each other. Resting on the highest part of the hopper ladders is the hopper, into which the grain is poured. Suspended below the hopper is the feed-shoe or shoe, a wooden chute tapering toward the centre of the trough that ends above the eye (see section 12.7.1) in the centre of the runner. Against one of the sides of the shoe is a bar, the shaker arm, which extends beyond the quant of the stone shaft.

shaker arm

slide

The grain flows into the feed-shoe via a slide in the hopper. By opening this slide to a greater or lesser degree, the grain supply to the feed-shoe is controlled.

The grain supply from the feed-shoe to the stones is also adjustable.

toothed rack
string

Firstly, the slope of the feed-shoe is adjustable using the toothed rack and the string.

Secondly, the supply is regulated by the shaking motion it makes. This shaking movement is caused by the shaker arm which is pulled against the quant by the angled position of the string. A square quant, when it starts rotating, will transmit a shaking motion to the feed-shoe. If the quant is round, the shaking movement is brought about by a number of hardwood slats or metal strips placed around the quant, the so-called shakers. The shaking causes the grain to fall from the feed-shoe into the eye of the runner. As the mill spins faster, the shaking will become faster and more violent and thus more grain will fall into the eye.

shakers

Fig. 12.6.1.1
A complete stone set with stone shaft and pinion

1. *hopper*
2. *hopper ladder*
3. *slide*
4. *dust board*
5. *feed-shoe or shoe*
6. *toothed rack*
7. *locking bolt on the casing around stones*
8. *runner*
9. *bedstone*
10. *stone nut*
11. *stone shaft*
12. *trough cover for the quant*
13. *hanger*
14. *string*
15. *trough*
16. *rynd*
17. *skirting board or millstone curbing*
18. *support of the millstone curbing*
19. *meal spout*
20. *spout*
21. *shakers*
22. *sweeper or paddle*

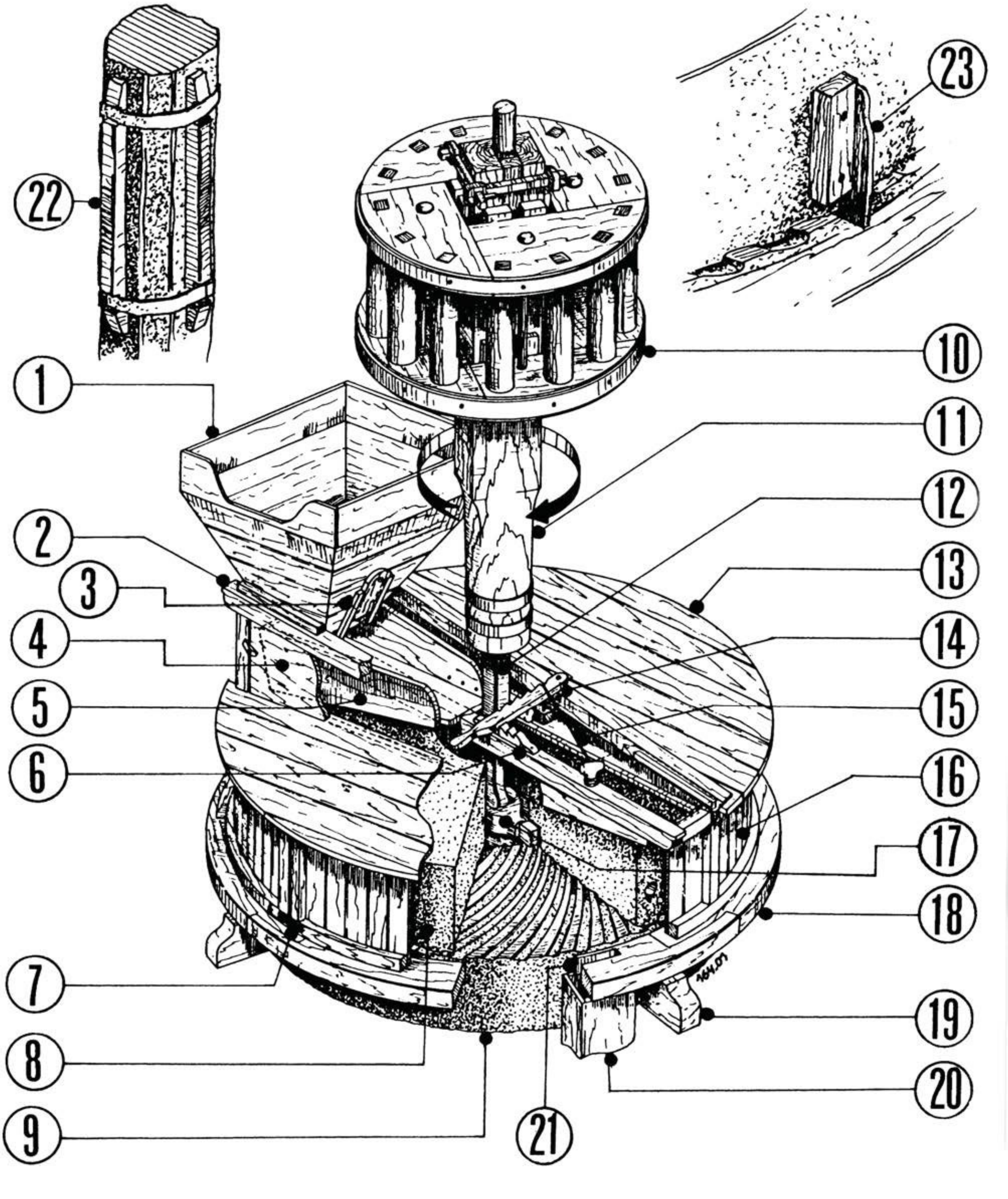


Fig. 12.6.1.1

draw-up

A third feature is that the feed-shoe is equipped with what is called a "draw-up": a cord (sometimes also iron wire) that goes from the feed-shoe via several small pulleys to a hinged batten on the bagging chute (or in its immediate vicinity). The more weights are hung on this batten, the less grain will fall into the stone. This is because it increases the distance from quant to shaker arm. There are regional differences in the implementation of the draw-up.

draw-on

Some mills are also equipped with a "draw-on": a wooden spring — or similar construction —that actually causes the shaker arm to be pulled against the quant with more force.

All in all, the grain supply is thus accurately controllable.

The trough usually consists of three or four parts so that it can be easily removed.

trestle, sack bench

Next to the hopper is often a trestle or sack bench set up, on which a sack of grain can be prepared for emptying into the hopper.

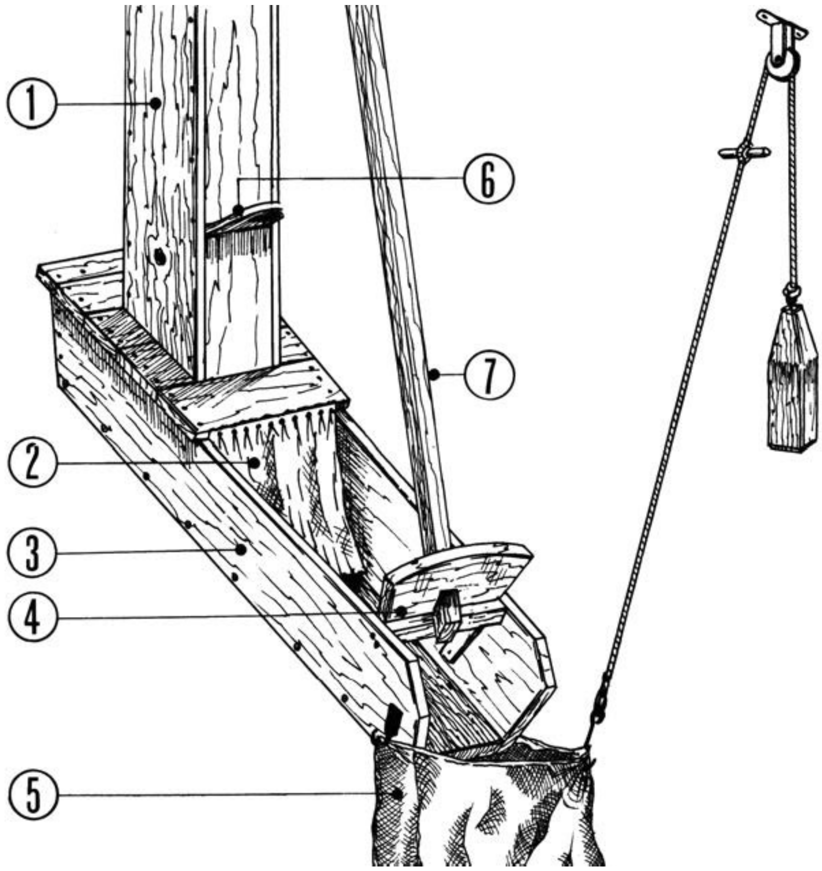


Fig. 12.6.2.1
The meal spout

1. *meal spout*
2. *dust cover*
3. *bagging chute*
4. *scoop board*
5. *meal sack*
6. *sliding plate*
7. *stick of the stopper*

12.6.2 Meal removal

spout
meal spout

Between the runner and the trough there remains a space that is approximately 5 cm wide. Into this space, whose bottom is formed by the skirting board, falls the flour when it emerges from between the stones. Inside the skirting board is the spout, a hole in the skirting board that provides access to the meal spout.

meal from the millstone curbing

paddle, sweeper

dust cover

bagging chute

scoop board

Airflow generated by the rotating runner drives the meal towards this hole. However, this airflow is not sufficient to feed all the meal into the meal spout. The meal left behind, the meal from the millstone curbing, would then lie there for a long time and, especially due to moisture from condensation, could form a cake on the skirting board. Such a cake is prone to rotting and, what's more, is a place in which some insects like to nest.

Therefore, attached to the runner is a paddle or sweeper that pushes the meal ahead of it over the skirting board in the direction of the spout so that no meal cake can form. However, the use of the sweeper does not obviate the need to regularly clean the space between the trough wall and the runner!

The meal falling into the meal spout then enters the bagging chute, an elongated (often tapered) wooden container that is partially covered with boards. A dust cover (a piece of linen or canvas) is hung in front of the discharge opening to limit dust formation.

The meal sack in which the meal is finally collected hangs from two hooks at the bottom of the bagging chute. The meal sack is held open by a third hook which is attached to a rope that runs over a pulley and to which a counterweight is attached at the other end. Nowadays, grinding is often done in paper bags for hygienic reasons; these are attached to the bagging chute with two simple metal clamps.

The drain opening of the bagging chute can be closed with the scoop board. The meal supply to the meal sack can thus be interrupted. This is necessary when the meal sack is full and the miller needs to unhook it and replace it with an empty one. Then the miller removes the scoop board again and the meal discharge resumes. The grinding process is not interrupted during sack changes.

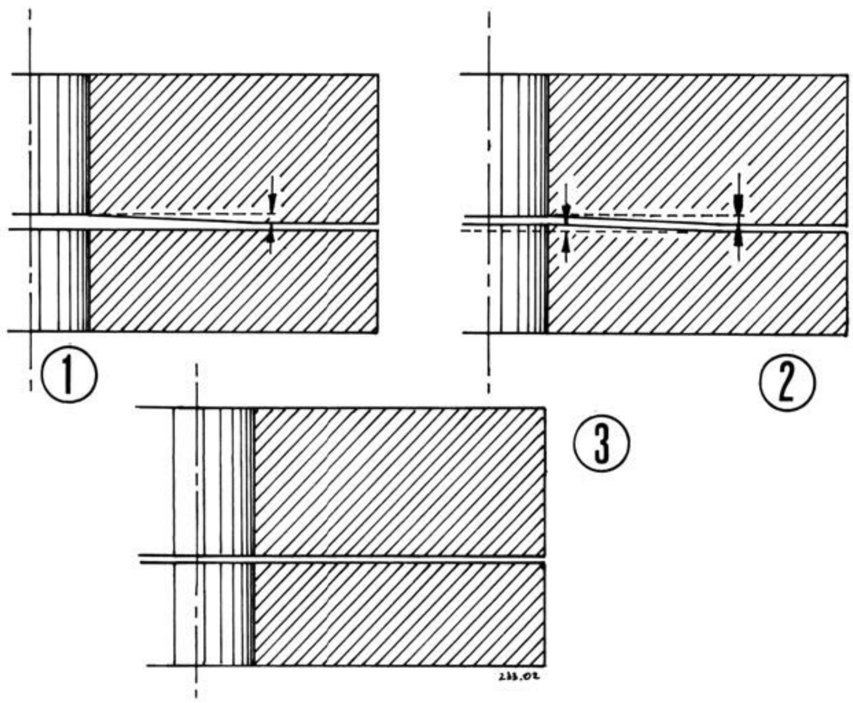


Fig. 12.7.1.1
Rich or poor stones

1. *example of a correctly dressed set of stones*
2. *a well-dressed, poor runner but the bedstone is too rich*
3. *the runner is too rich*

12.7 THE GRINDING PROCESS

12.7.1 Grinding

poor stone, rich stone

dressing pattern

Millstones work by means of pressure, cutting power and movement. The bedstone should be perfectly flat on the grinding surface while the runner should be slightly concave on the inner part of the grinding surface, which is termed a poor stone in technical jargon. A flat stone is called a rich stone.
The grinding surface of both the bedstone and the runner is dressed with a dressing pattern (see section 12.7.2). The purpose of this dressing pattern is threefold:
a. to increase cutting power;
b. to draw in cooling air for the meal between the stones;
c. to transport mill stock and meal.

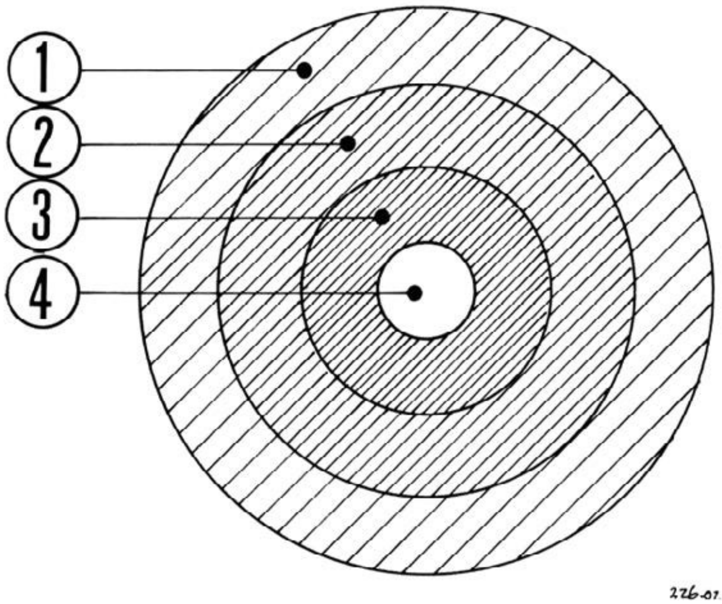


Fig. 12.7.1.2
Schematic layout of the grinding surface

1. *skirt*
2. *breast*
3. *waist*
4. *eye*

The inner part of the grinding surface, where the space between the stones is greatest, serves to distribute the mill stock. The middle section, where the space between the stones narrows, serves to crush the mill stock. The outer section, where the stones come closest together, serves to finely grind the mill stock.
When the mill rotates slowly, the shaking motion transmitted to the feed-shoe is slight; a small amount of grain gets between the stones and it is easily ground. If the mill is turning faster, this not only allows more grain to get between the stones, but the runner which is turning faster also feeds that grain outwards between the stones at a much faster pace.
This produces meal that is too coarse; the reason for this is that the larger amount of grain greatly reduces the pressure per grain.
To prevent that, the miller intervenes.

lighter staff, light

Using the lighter staff, called the light for short, the miller lowers the runner slightly, reducing the space between the two stones and increasing the pressure. The grain will now be ground again as desired. This action by the miller of bringing the stones closer together is called tentering.
When the speed of the runner decreases again, the miller increases the distance between the two stones slightly. This operation is called lightering. This enables the miller to ensure that the fineness of the meal remains as constant as possible because that is what the baker requires of him: a product of consistent quality.

tentering, lightering

Tentering and lightering the stones is the main task of the grain miller. When doing this, he constantly monitors the speed of the sail cross, mainly by listening. A miller therefore regularly checks the fineness and temperature of the meal by hand.
It goes without saying that the automation of tentering and lightering by the advent of the governor represented a major step forward in terms of consistent meal quality. It also provided the miller relief from this work, allowing him to devote more time and attention to other aspects of his job.

12.7.2 Mill stones

German stone
bluestone
French stone

Natural stone that is sufficiently rough and rigid and has an open structure (has a natural cutting ability) is suitable as a millstone. Such as the German stone or bluestone that comes from the Eifel region and is of volcanic origin.
Bluestone is fairly soft and good for grinding wheat. French stone is a second important type. This is composed of pieces of freshwater quartz, which is very hard and also suitable for grinding wheat.

composite stones
grinding layer, ballast layer
solid composite stone

Besides natural stones, composite stones are manufactured which consist of a grinding layer and a ballast layer (see Fig. 12.7.2.2). The grinding layer consists of pieces of natural stone that are cured together with a liquid binder in a trough and made suitable as a millstone. This is called solid composite stone because the surface is of uniform composition.

composite stone with a soft groove
groove, bottom
furrow

In addition to solid composite stone, there is also artificial stone with a soft bottom. This facilitates sharpening (dressing). The groove or bottom, the part to be dressed, is of a softer stone type than the furrow made of harder material that is to remain.

flintstone

Composite stones are generally well suited for grinding animal feed such as barley, oats and corn. In recent decades, however, artificial stones have also been made using the stone type of flint. In practice, these "flintstones" proved to be highly suitable for grinding wheat.

seventeeners, sixteeners

A new runner is about 40 cm thick, a new bedstone about 30 cm. The weight, of course, depends on the diameter and type of stone. There is a great variation in diameters. The most common are stones with a diameter of 1.50 m and 1.40 m, called seventeeners and sixteeners, respectively
Fifteeners, fourteeners and thirteeners, with diameters of 1.30 m, 1.20 m and 1.10 m, respectively, are less common. The designation "seventeener", "sixteener", etc. is said to be based on old girth measurements of Amsterdammers' feet, although there is still no certainty about this.
A new sixteener (so, 1.40 m in diameter) runner of bluestone weighs about 1200 kg and a new sixteener bedstone weighs about 900 kg.

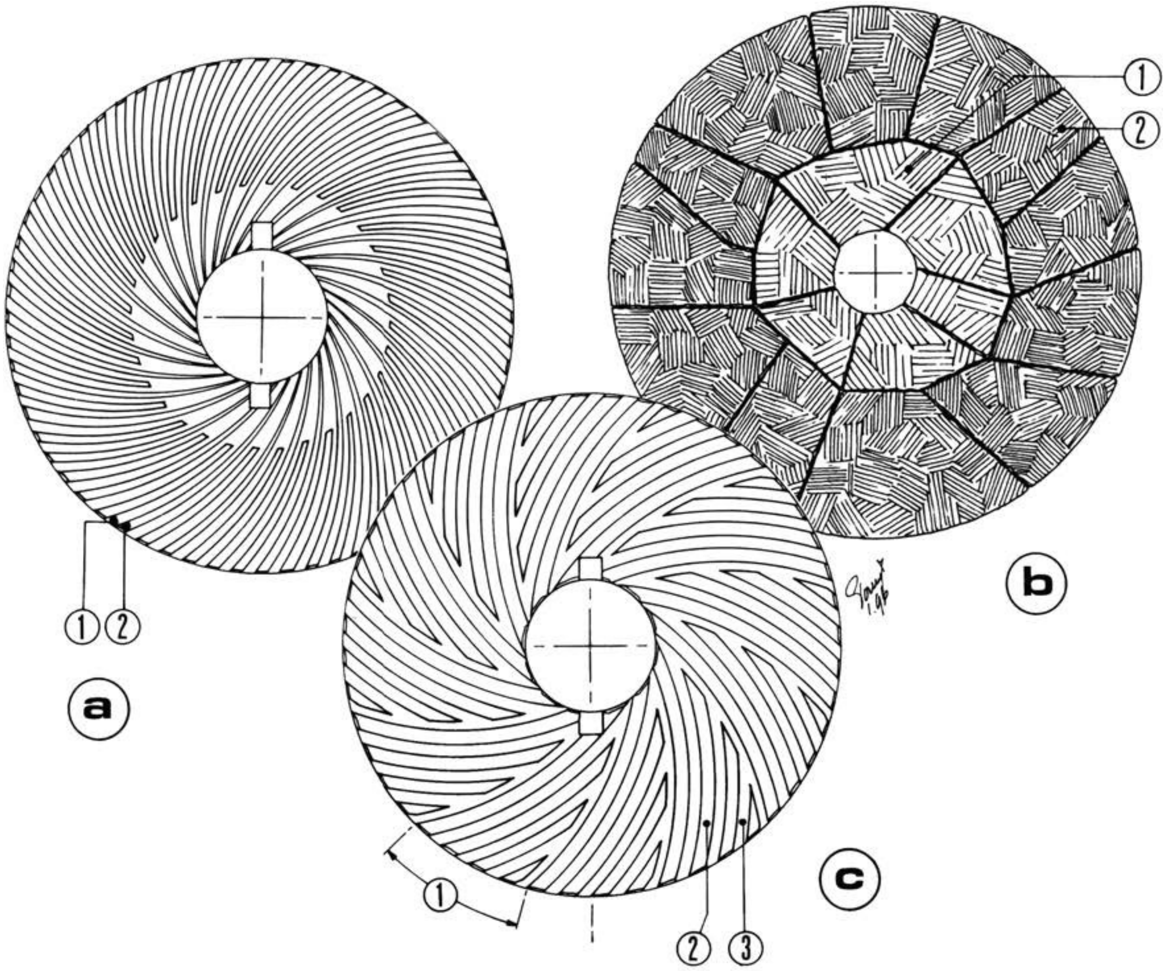


Fig. 12.7.2.1
The mill stones

a. German bluestone with an circular dressing pattern
1. groove or bottom
2. furrow

b. French stone
1. soft parts
2. hard parts

c. composite stone with a quarter dressing pattern
1. quarter
2. furrow
3. groove or bottom

The stones are subject to wear and tear during the grinding process and, partly due to the fact that they need constant re-sharpening, they will become thinner and less heavy over time. A runner which has been ground down ends up with a weight that is too low to still exert sufficient grinding pressure. However, it can then still be of use as a bedstone. There were also instances when worn-out runners had a ballast layer of concrete applied in order to restore sufficient grinding pressure.

eye, peg hole

Both runner and bedstone have a round hole in the centre. The hole in the runner is called the eye, the one in the bedstone is called the peg hole. The neck bearing is inserted in the peg hole of the bedstone (see section 12.4.2). The stone spindle is bearing-mounted in this neck bearing and can move up and down. To prevent dust and mill stock from getting in the

bearing, the peg hole is closed with a (zinc) cover.
The eye of the runner houses the rynd and the clutch. The grain introduced between the stones falls into this hole.

crane eyes

In their outer circumference, mill stones have what are called crane eyes. These are needed for hanging the stone in the stone crane.

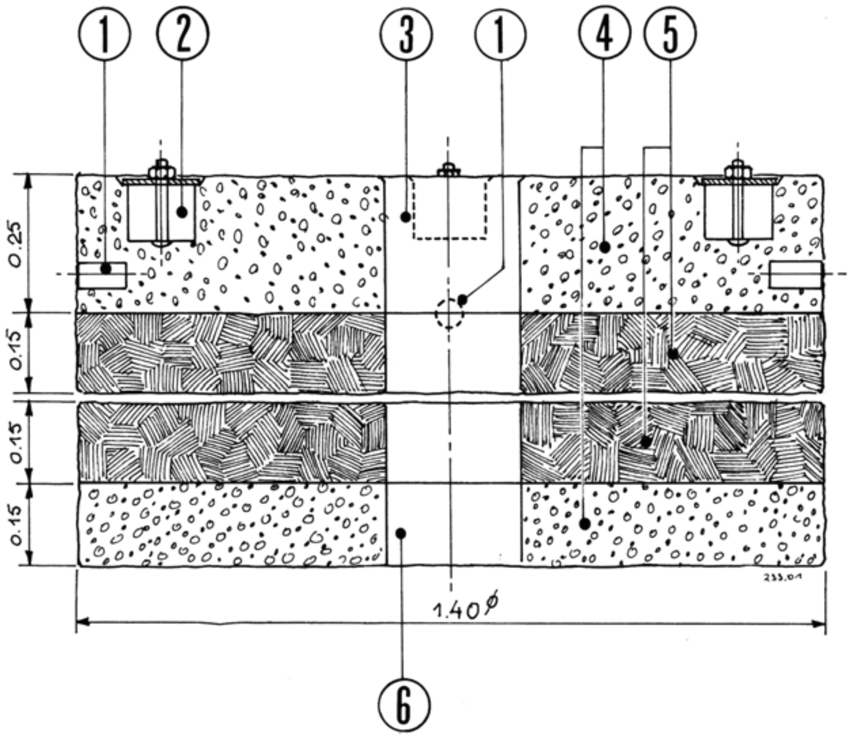


Fig. 12.7.2.2
Cross section of a composite stone

1. *crane eye*
2. *balancing box for weights on top of runner stone*
3. *eye*
4. *ballast layer*
5. *grinding layer*
6. *peg hole*

12.7.3 Dressing and the dressing pattern

The working surface of a runner and a bedstone is given a grooved pattern, called the dressing pattern. This process is called dressing or, simply, sharpening. The dressing pattern improves cutting performance, increases meal quality and speeds up the production process.

dressing pattern, dressing
grooves
furrows

A dressing pattern consists of alternating adjacent furrows (the ridges) and grooves (the grooves created by chipping away stone material).
Dressing patterns can vary greatly in form. Thus, they may have a lot of furrows or fewer furrows. Dressing patterns can be straight or curved. Furthermore, the distribution of the dressing over the grinding surface can vary greatly.

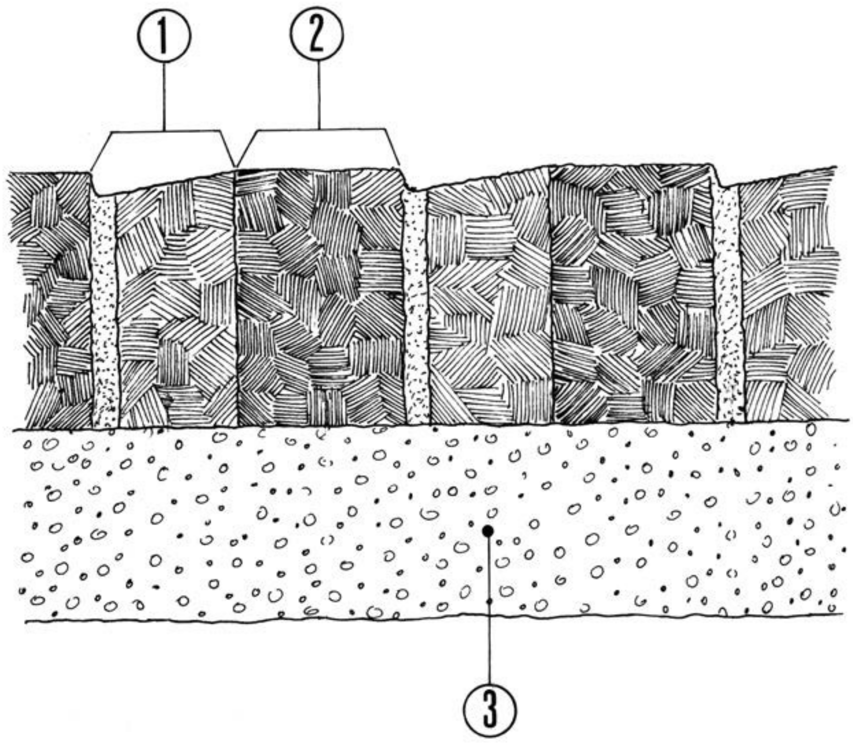


Fig. 12.7.3.1
Cross section of a stone with a soft groove

1. *groove or bottom*
2. *furrow*
3. *ballast layer*

Which dressing pattern is chosen depends on the structure of the stone, the product to be ground, the desired flour quality, and the desired production rate and quantity.

quarter dressing, circular dressing union dressing, central dressing

Examples of dressing patterns are the quarter dressing, the circular dressing and the central or union dressing. With the quarter dressing, the furrows are distributed in harps (or quarters) over the grinding surface. In these, each quarter consists of a master furrow and several journeyman furrows.

draft

In circular dressing patterns, the furrows running in curved courses may be directed toward the centre of the eye, but they may also run past that centre at equal distances. This is then referred to as draft.

The same applies to central dressings as for circular dressings: the furrows — which in this case proceed along straight lines — may also be directed toward the centre of the eye or pass by it at equal distances.

Note: a circular dressing and a union dressing can simultaneously be a quarter dressing!

sharpening

We have already mentioned that the stones wear out from the grinding process. The furrows become blunt. It is then time to re-sharpen (dress) the stones. The grooves' depth is restored and the cutting edge of the furrows is sharpened.

dressing pick

Dressing is a strenuous and time-consuming job that must also be done very precisely and requires great skill on the part of the miller.

Dressing or sharpening is done using the dressing pick. It weighs about 1½ kg and has a wide hardened steel jaw on both sides. In recent decades, virtually only picks equipped with so-called 'Widia' tips have been used. Widia is German and comes from "wie Diamant" (meaning "diamond-like"). These points are so hard that they almost never become blunt.

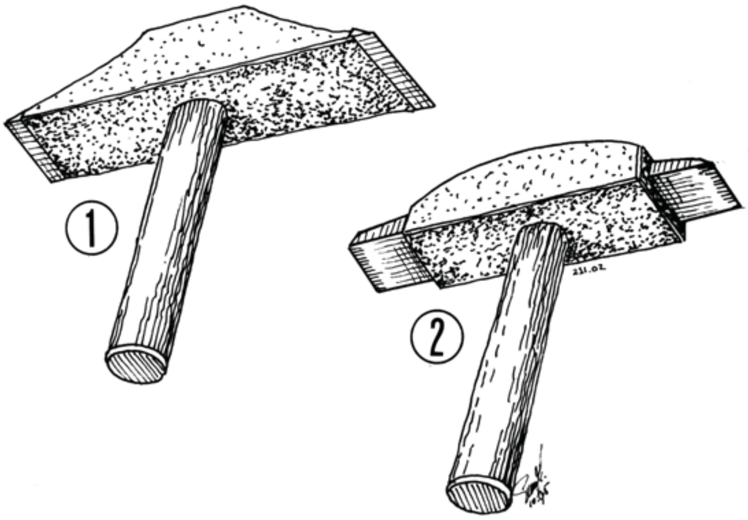


Fig. 12.7.3.2
Dressing picks

1. *dressing pick with hardened steel tips*
2. *dressing pick with interchangeable inserts*

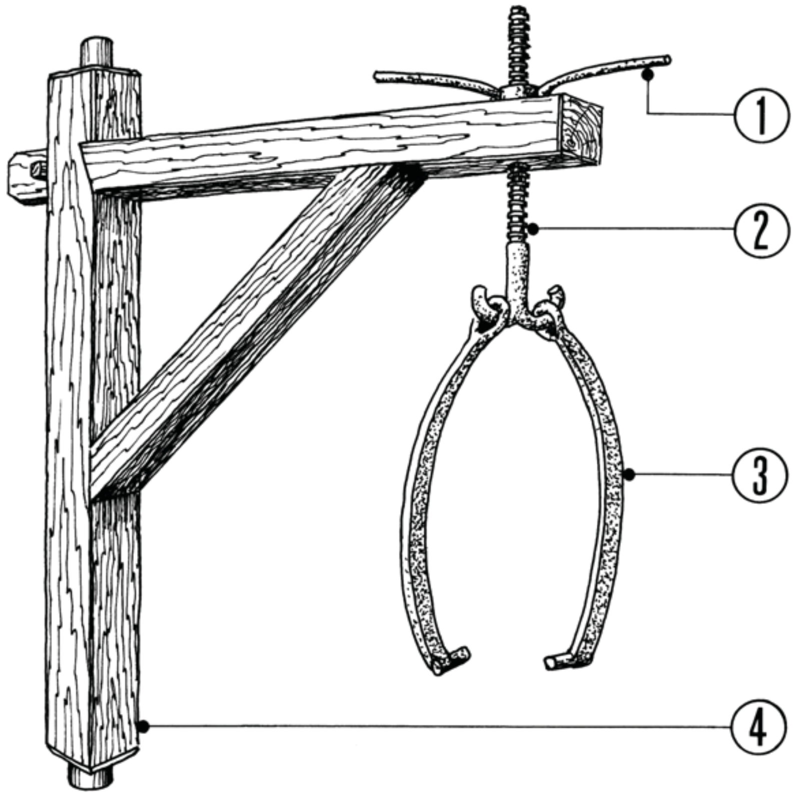


Fig. 12.7.3.3
Stone crane

1. *spindle nut*
2. *spindle*
3. *crane brackets*
4. *crane*

stone crane, crane brackets

In order to dress the stones, the pair of stones must be opened up. This is done using the stone crane. This is rotated above the runner, and the pins of the crane brackets are inserted into the crane eyes of the runner. Then, using the spindle nut which is located on the crossbeam of the

stone crane, the runner is turned upwards and the crane swings to the side and tilts the runner into the crane brackets.
If the runner needs to be dressed, then it is laid upside down on the bedstone.
If the bedstone needs to be dressed, usually the runner is put on its side next to the bedstone, above a heavy floor joist and well supported and secured (also see section 12.9.4).
The stone crane must be able to lift the runner, so it must be of solid construction. It is usually made of wood, consisting of a vertical fixed pressing plate and a supporting cross beam. A screw spindle that hangs from the spindle nut protrudes through this cross beam. At the bottom of the spindle hang two crane brackets, provided with thick tenons that fit into the crane eyes of the stone.

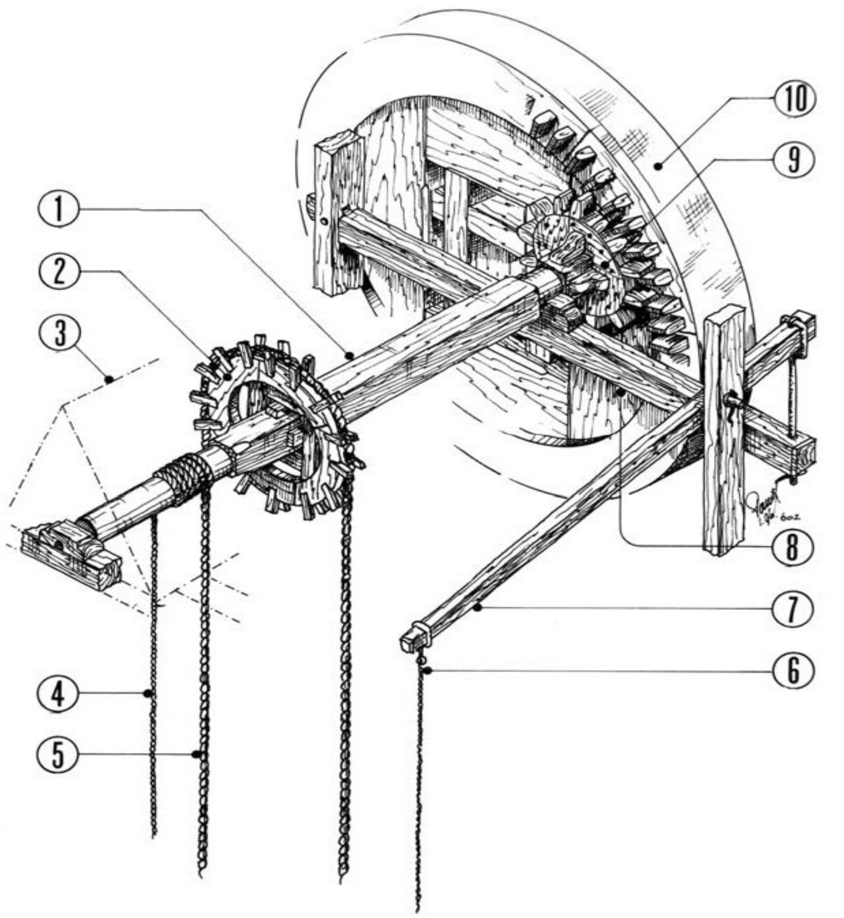


Fig. 12.8.1.1
Hoisting system of the post mill

1. *sack hoist spindle*
2. *Y wheel*
3. *lucam*
4. *hoisting rope*
5. *endless hand rope*
6. *control rope for the hoisting system*
7. *tentering beam*
8. *sole tree*
9. *spur pinion or sack hoist wheel*
10. *head wheel or brake wheel*

12.8 THE HOISTING SYSTEM AND FRICTION WINCH

12.8.1 Hoisting system

sack hoist spindle, hoisting rope

Mill stock needs to be lifted and/or hoisted. To do so, at the top of the mill there is a spindle (the sack hoist spindle) to which a rope (the hoisting rope) is attached. The miller can make the sack hoist spindle turn, winding the sack hoist rope around the sack hoist spindle and pulling up a bag of mill stock attached to the end.

hoisting system

If there is very little wind and the mill is hardly turning, the miller cannot use the hoisting system to raise a sack of mill stock because the weight of that mill stock is then already enough to bring the mill to a halt.

Y wheel

slipping-off

Cap winders, like post mills, are equipped in some regions with a Y wheel on the sack hoist spindle. This Y wheel is a wooden wheel with a number of forks on the outer circumference. Between these forks, the endless (continuous) rope runs through one or more floors. By pulling on this rope, the sack hoist spindle is set in motion and the miller can manually hoist or lower the mill stock. Lowering mill stock is called slipping-off.

lucam

sack hoist wheel

spur pinion

control rope

tentering beam

friction wheel

At a post mill, the hoisting is done outside. The sack hoist spindle of the post mill lies at the top of the body, more or less parallel to the windshaft. The back end is bearing mounted outside the body, under the lucam. The hoisting rope is attached to the sack hoist spindle under this lucam.

Attached to the other end of the sack hoist spindle is a sack hoist wheel or spur pinion, with cogs on the outer circumference, which can rotate along the inner circumference of the cogs of the brake wheel (pit wheel). The sack hoist spindle with the sack hoist wheel lies in the bearing on the bridge beam. With the control rope that hangs from the end of the tentering beam, the miller can raise the sack hoist spindle in such a way that the cogs of the sack hoist wheel are pulled between those of the rotating brake wheel, causing the sack hoist spindle to turn. It would be sensible for the miller to push the sack hoist spindle via the endless hand rope and Y wheel (manual operation!) in the right direction so that the shock of the sudden interlocking of the cogs of the sack hoist wheel and brake wheel is kept to a minimum. This prevents cog breakage.

Sometimes the sack hoist wheel is replaced by a friction wheel which is set in motion by the front rim or the inner side of the cogs of the brake wheel.

friction sack hoist, geared sack hoist

sack hoist floor

friction ring

In cap winders, there is the friction sack hoist and the geared sack hoist. The most common type of friction sack hoist operates as follows: On the sack hoist floor, a robust wheel is attached around the upright shaft on which the friction ring is mounted. Sometimes the friction ring is combined with the spur wheel.

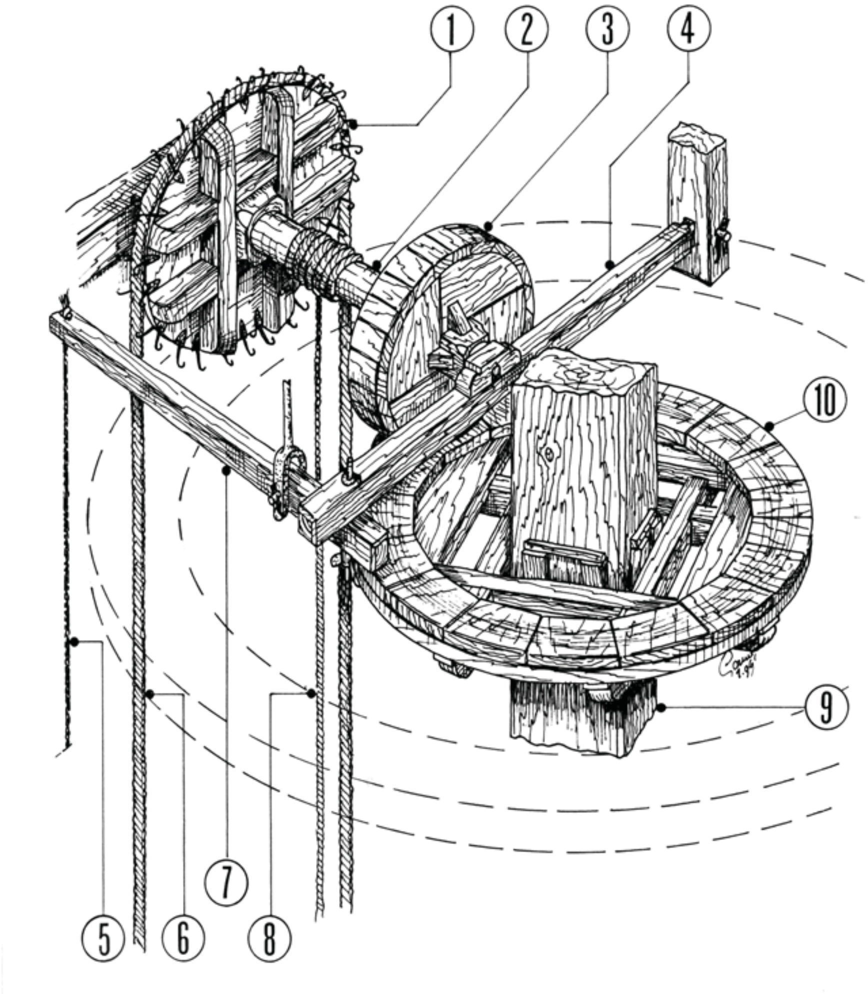


Fig. 12.8.1.2
Friction sack hoist

1. *Y wheel*
2. *sack hoist spindle*
3. *sack hoist wheel or friction wheel*
4. *sole tree*
5. *control rope*
6. *endless hand rope*
7. *tentering beam*
8. *hoisting rope*
9. *upright shaft*
10. *friction ring*

sack hoist wheel

Above the friction ring, at the end of the sack hoist spindle, is where the friction wheel (the sack hoist wheel) is located. This friction wheel can be lowered via the control rope from the tentering beam onto the rotating friction ring, causing the sack hoist spindle to move and start to wind.
Sometime an old car tyre is fitted around the sack hoist wheel to provide a better grip on the friction ring. Sometimes the friction sack hoist is tapered.

geared sack hoist

In a geared sack hoist, its friction ring and sack hoist wheel are executed as a cam shaft (or as cam shaft and pinion). Then it is sensible to manually give the sack hoist spindle a push in the right direction before pulling the hoisting system into its work. Of course, this is possible only if a Y wheel is present.
At many mills, the geared sack hoist is executed in such a way that the sack hoist wheel is not lowered from above on the sack hoist system cam wheel but is pulled into it from below. This is also known as "withdrawal hoisting system". There are also friction sack hoists in which the sack hoist wheel is drawn to the friction ring from below. Any breakage of the control rope will cause less damage in that case.

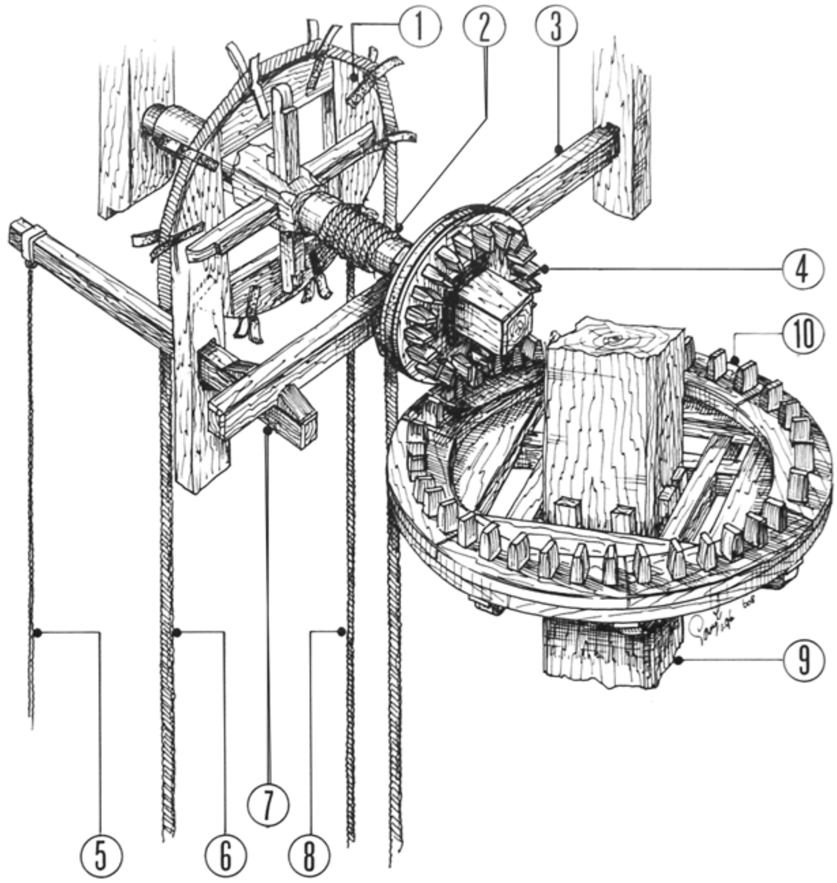


Fig. 12.8.1.3
Geared sack hoist

1. *Y wheel*
2. *sack hoist spindle*
3. *sole tree*
4. *sack hoist wheel*
5. *control rope*
6. *endless hand rope*
7. *tentering beam*
8. *hoisting rope*
9. *upright shaft*
10. *cam wheel for sack hoist system*

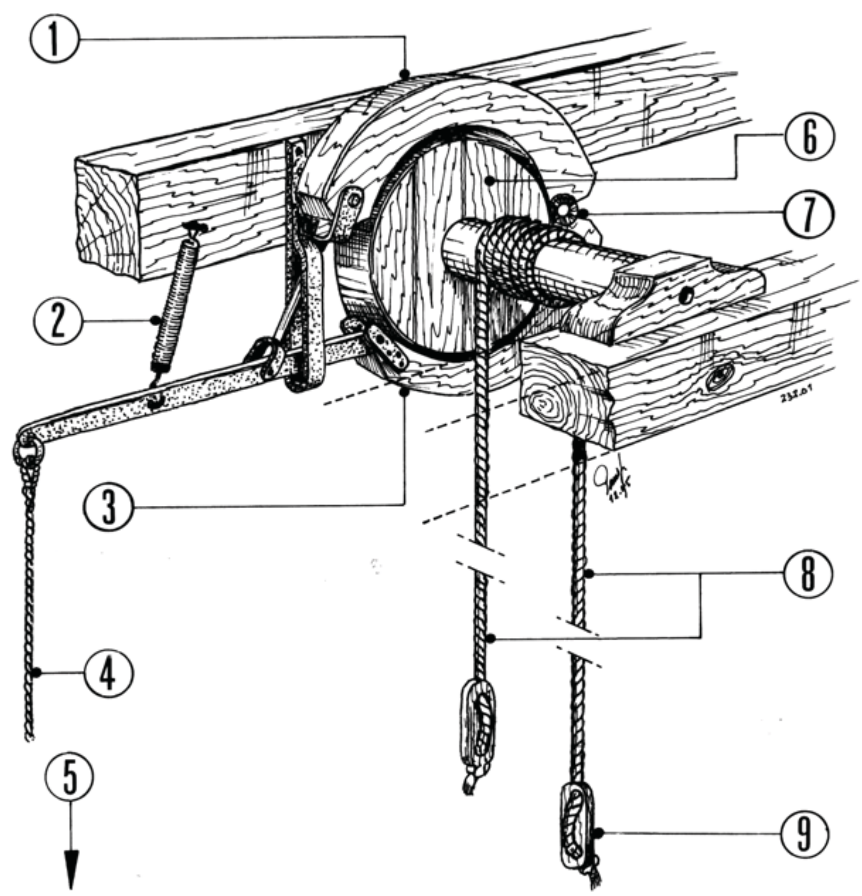


Fig. 12.8.2.1
The friction winch

1. *brake block*
2. *tension spring*
3. *brake block*
4. *control rope*
5. *pulling direction when braking*
6. *brake wheel*
7. *pivot*
8. *up-and-down rope*
9. *running noose*

12.8.2 The friction winch

friction winch

Slipping-off is the lowering of mill stock. A friction winch does not work via wind power but through gravity. For this purpose, several turns of a long rope are wrapped around the shaft. While one end of the rope carrying a sack of meal descends, the other end of the double sack hoisting rope rises (so that an object of lighter weight can possibly be lifted up with it at the same time). A brake wheel is attached around the sack hoist spindle with two brake blocks round the wheel for operation by a lever. This allows you to slow down the descending bag's speed of fall.

brake wheel, brake blocks

slipping-off

You can also slip off sacks of meal with a friction sack hoist but then, each time a sack of meal is lowered, you have to bring the sack hoisting rope back up before you can slip off the next sack.
The speed of fall can be controlled by letting the wooden pulley slip over the friction ring. You cannot slip off with a geared sack hoist!

12.9 SPECIFIC DUTIES OF THE GRAIN MILLER

12.9.1 Introduction

The Handbook for Millers trains you to operate an unloaded mill. Therefore, the reading material covered in this section is not part of the examination material. However, for millers or apprentice millers who are going to work on operational grain mills, it is important to know about the issues below relating to the driving gear.
(For directions about working safely, see also Chapter 10.)

12.9.2 Commissioning

Before the miller starts winding:

- The miller takes out of operation the grinding stone pairs that he or she is not going to use for grinding.
- The miller lighters the runner of the pair that he or she is going to use for grinding.

After all, upon leaving the mill last time the miller did put all the pairs into work as storm protection and he tentered the runners, meaning he or she laid them on the bedstones. (Also see section 7.1.1).
Before the miller starts grinding:

- The miller prepares the mill for use and sets sails (as applicable to all mills).
- The miller checks the lubrication of the bearings of the grinding stone pair he or she is going to use for grinding.
- The miller looks in the hopper to see if there is enough mill stock in it and he or she also looks in the eye hole to check that it is not full of grain for whatever reason.
- The miller checks the position of the feed-shoe. The final adjustment can only be determined during grinding.

12.9.3 Hoisting

The hoisting system is loadable up to about 70 kg. If there is a lot of lifting, it may be that the hoisting system no longer comes free of the friction ring (friction sack hoist) or the sack hoist system cam wheel (geared sack hoist). The sack can then catch on the sack hoist spindle and tear open. Also don't forget to lubricate the bearings of the sack hoist spindle from time to time.

12.9.4 Raising the stones

This is an extensive task for the grain miller that also involves some danger. Therefore, the equipment to be used, especially the stone crane, should be in good condition. Those assisting in this task must be well instructed beforehand. A pair of stones is opened for repair or for dressing the stones. The procedure is the same in both cases:

- Successively remove the hopper, feed-shoe, hopper ladders, dust boards, trough covers and trough parts. Put these parts far away from the pair of stones that is to be laid open so the parts do not get in the way.

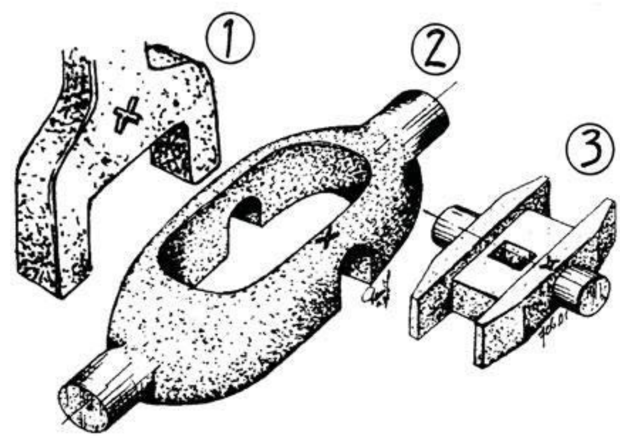


Fig. 12.9.4.1
The identifying marks on spindle and rynd

1. *clutch of the stone shaft*
2. *outer rynd*
3. *inner rynd*

- Make sure there are identifying marks on the stone, the spindle and the rynd; if not, then
  create them (see Fig. 12.9.4.1).
- Now carefully remove the stone shaft. When swinging it to the side, make sure that the clutch of the shaft does not damage the rynd (see Fig. 12.9.4.2). Raise the shaft to well above the runner, then put it away next to the bedstone and secure it from falling over.

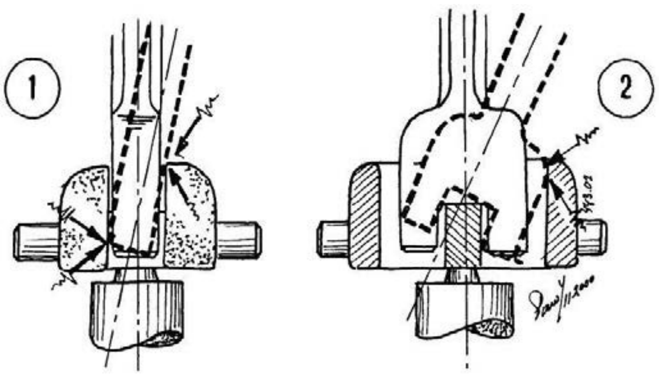


Fig. 12.9.4.2
What you should watch out for when
removing the stone shaft

1. *lack of space when lightering the spindle*
2. *safer position of the rynd when lightering*

- Now lighter and tilt the runner with the stone crane. Use the correct crane eyes: those that are most centred. In a properly functioning system, after first turning the runner upwards with the spindle nut free of the bedstone, you can simply turn the runner further upwards by turning the stone itself which does not affect the position of the spindle nut. This works easier and lighter than turning the runner upwards with the large nut. Place the runner where there is a beam present under the floor and secure it with two chocks to prevent it from rolling away.
  If you want to sharpen the runner, lay it upside down on the bedstone with a couple of beams in between.
- If you want to clean, lubricate or repair the neck bearing, the stone spindle must be taken out. Usually this can be pulled out upwards. Do not put the stone spindle with the pivot journal on the stone because it will damage the friction surface. This can cause lubrication problems later. Stone spindles are sometimes difficult to detach. In this case, lighter the stone spindle as far as possible and tuck the rynd under. The stone spindle will then come free when you gently tap the bearing.

- To close the pair of millstones again, perform the above tasks in reverse order. The identifying marks should again end up opposite each other.

12.9.5 Sharpening or dressing mill stones

The Handbook does not provide for learning how to dress mill stones. This can only be learnt under the guidance of an experienced professional. This is a painstaking task and definitely requires practice and the right tools.
A volunteer miller with no experience should not set about it on his own. A good millstone can be spoilt faster than it can be repaired.

12.9.6 Adjusting the stone spindle

The most important thing that you can adjust on the stone spindle is the location of the bearing pot that sits in the centering block on the bridge beam. Four wedges are there for its adjustment: two pull wedges and two push wedges. With the pull wedges, you move the centering block in a direction perpendicular to the bridge beam. Using the push wedges, you move the centering block in a direction longitudinal to the bridge beam. For this extremely important adjustment, we refer you to the book *Zingende Stenen* ("Singing Stones") by D.J. Abelskamp.

12.9.7 Adjusting the shoe or feed-shoe

For proper adjustment of the shoe or feed-shoe, use the string or lace and the hanger. This gives the shoe more or less slope and thus determines the amount of grain that falls into the eye hole per unit of time. Then, by moving the same string/lace further or nearer to the left or right across the hanger, you determine the force with which the corners or shakers of the stone shaft tap against the shaker arm.

12.9.8 Miscellaneous tasks

When you actually want to grind, there are many other aspects to consider in addition to the above matters. However, these fall outside the goal of the Guild of Millers (GVM), namely running mills "for the Prince". We would refer trainee grain millers to the grain milling course taught by the GVM in cooperation with *Ambachtelijk Korenmolenaarsgilde* (the Artisanal Grain Millers Guild, AKG).

cleanliness
hygiene code

One thing that we would like to bring strongly to your attention, though, is the matter of cleanliness. When grinding for human consumption, it is mandatory to work according to the Hygiene Code for windmills, water mills and artisanal grain mills.
Keeping clean the mill with which you are grinding is very important in this regard.

Chapter 13 The Hulling Mill

Contents page:

13.1 INTRODUCTION

hulling mill

Hulling mills originated in the Zaan region starting in 1639. More than 120 hulling mills have operated there. In those days, that was where the mill building technology, the entrepreneurs and the market were present. "Het Prinsenhof" in Westzaan is the only hulling mill still in existence. More hulling mills remain in the northern part of the Netherlands, particularly in Groningen. There, around 1900, most mills were fitted with elevators to facilitate the labour-intensive work. At *De Jonge Hendrik* (The Young Hendrik) in Den Andel, hulling was still done by wind power until about 1986. Therefore, we discuss in broad terms the Groningen hulling mill, where we will use as many Groninger names as possible, with other (mostly Zaan region) names in parentheses.

barley
rice
winter barley

Initially, the hulling mill was used for hulling barley. Only around 1830 did it begin to be used for hulling rice as well. Rice hulling mills have a slightly different design, which we will not take into consideration here. Hulled barley becomes groats. Winter barley is the most suitable type for hulling. Barley from the new sea polders of Groningen was especially widely used.
In the Zaan region, mainly barley of foreign origin was processed.
Well into the 19th century, groats were food for the working classes. There was also great demand for it in monasteries and boarding schools, and it was taken by ships as food for the crew because it kept for a reasonably long time. Groats were eaten as porridge, as mash and boiled dry, with the addition of fresh or dried fruits, syrup, brown sugar, butter, cinnamon and the like. In Groningen, it was (and is) also added to mashed kale with bacon and various types of sausage.

Hulling mills traditionally have a wide sail (up to 185 cm) and wide (up to 80 cm) leading boards that face forward. In addition, these mills have a deep camber or sail twist to develop the strength required for hulling. In the late 19th century, the advent of self-reefing made it somewhat easier to control the mill during hulling. But hulling remained hard and quite dangerous work because the force and speed with which it was done put the mill and particularly the miller to the test.
The Groningen hulling mill differs from that in the Zaan region. Almost all Zaan region hulling mills were built exclusively for hulling and usually equipped with two hulling stones. They were forced to sit idle for much of the year due to a lack of strong winds. Groningen hulling mills, however, almost always had mill stones in addition to two hulling stones. Grinding could then take the place of hulling when there was less wind. Water-powered hulling mills also had combined operations.
Another characteristic difference between the north-eastern Groningen and western Zaan region Dutch hulling mills is, for example, the possibility of lightering the stone on the latter; this is not possible at the Groningen hulling mills. The way the product is sieved also varies: in the Zaan region, this was done before hulling on the "cold harp" and then after hulling on the "hot harp". In Groningen and in the rest of the north-eastern Netherlands only one "sifter" is used to sift the product. Furthermore, there is a distinctive difference in the hulling stones themselves: the Zaan region hulling stone has six relatively narrow ventilation curves (wind grooves) while the Groningen hulling stone has four wide ventilation curves; these grooves taper off very gradually across the stone from the deepest point, at the striker at the end of the ventilation curves, to nothing. The transition area between the aforementioned parts of the country also shows a transition in some of these differences.

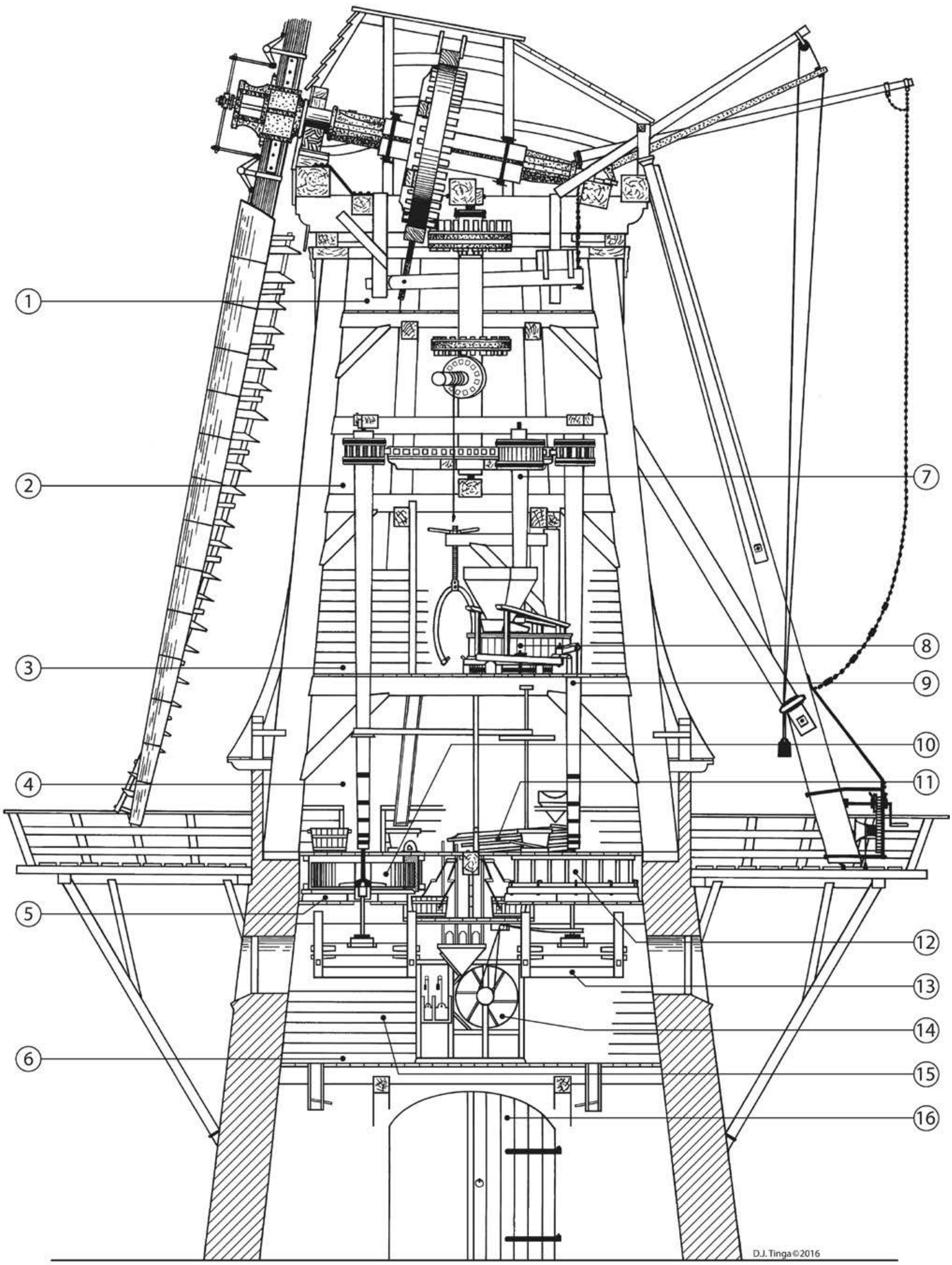

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Fig. 13.1.1
Cross section of a Groningen grain and hulling mill

1. *cap floor*
2. *sack hoist floor*
3. *stone floor*
4. *hulling or meal floor*
5. *dust group (group in the Zaan region)*
6. *winnowing floor*
7. *stone shaft*
8. *pair of stones*
9. *hulling spindle*
10. *forerunner*
11. *sifter (groats sieve)*
12. *follower*
13. *hanger with bridge tree*
14. *winnower*
15. *husk cupboard (husk house)*
16. *entrance*

13.2 LAYOUT

13.2.1 Partitioning

Going from top to bottom, the following is found in a Groningen hulling mill (see Fig. 13.1.1):

1. the cap floor
2. the sack hoist floor
3. the stone floor
4. the hulling floor
5. the dust group (Zaan: group)
6. the winnowing floor
16. the entrance

The stone floor houses the grinding section. See chapter 12, The Grain Mill, for more about this.

seed or barley house
spur wheel (raven wheel)
stone nut, hulling pinions

The stone floor usually holds one or two pairs of grinding stones. In addition, there is a storage area constructed for working barley, called the seed house or barley house. The spur wheel ('raven wheel' in the Zaan region) hangs below the sack hoist floor and this drives the stone nut (pinion of the millstone) and the hulling pinions (hulling stone pinions). The hulling pinions are noticeably smaller than the stone nut. The gearing to a millstone is about 1:6, that to a hulling stone is about 1:10. This is because, in connection with the hulling process, a hulling stone must turn much faster than a millstone.

hulling spindles

forerunner, follower, dust group beams

The stone shaft of the millstone ends in its normal place in the runner of the pair of millstones. The hulling spindles are more than twice as long, protruding through the stone floor and ending beneath the hulling floor. The hulling spindles are located between the two reefing stage doors. There, under the hulling floor, lie the two hulling stones: the forerunner and the follower. They are surrounded by the extra-heavy dust group beams (called "strike beams" in the Zaan region). Hulling stones, which are made of sandstone, rotate very quickly and they burst apart quite often. The strike beams under the floor then caught the debris. They are covered with thick rope.

The hulling stone husks with its side, which is why a hulling stone cannot be reinforced with iron bands, as is the case with mill stones.

shield covers

hoppers
sliding shutter

In the hulling floor (at stage height) are the shield covers (halfmoon-shaped segments) for reaching the hulling stones. These hatches have square holes on which the hoppers (small hoppers) are located for depositing the barley. These small hoppers are fitted with a sliding shutter, allowing the barley to be gradually introduced to the stone. The shield covers are a few centimetres above the runner and fit well on the trough edges.

sifter
half-hulling house (barley body), winnower
bridge beams (press beams)

husk cupboard

There is also a sifting device set up on the hulling floor: the sifter over which the groats can either run into the half-hulling house (barley body) or to the winnower. This is located one floor below, on the first floor under the stage. Here hang the bridge beams (press beams) with the stone spindles of the hulling stones. The winnower is a milling separator, which is used to clean the product. It blows the husks and dust into the husk cupboard.

13.2.2 The hulling stones

hulling stones
bedstone
Bentheimer sandstone,
ventilation curves

A pair of hulling stones consists of a 'nether stone' and a 'runner'. The nether stone is called the bedstone and is sometimes made from sandstone or from an old millstone, an iron plate or wood. The runner is a hard sandstone, usually Bentheimer sandstone, named after the location it comes from in Germany. The better hulling stones (from 'millstone grit') come from the north of the Peak District in Derbyshire, England. New hulling stones are 160-185 cm wide and 30-35 cm thick.
The hulling stones are flat and rough on the top. On the underside, the runner has four (in north-east Netherlands) or six (in western Netherlands) crescent-shaped ventilation curves

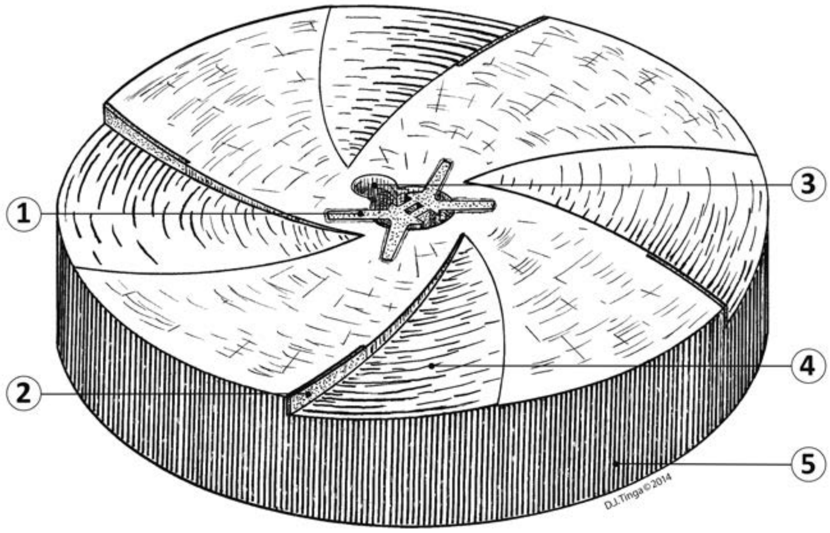

Fig. 13.2.2.1
The underside of a hulling stone in Groningen

1. *heavy four-armed rynd*
2. *striker*
3. *hand hole*
4. *ventilation curve*
5. *ribbed exterior*

(wind grooves)
strikers (groove irons)

(wind grooves). They blow air to the outside of the stone. These ventilation curves are covered on one side with wrought-iron strips — the strikers (groove irons) — which are designed to prevent the stone from wearing too quickly there.

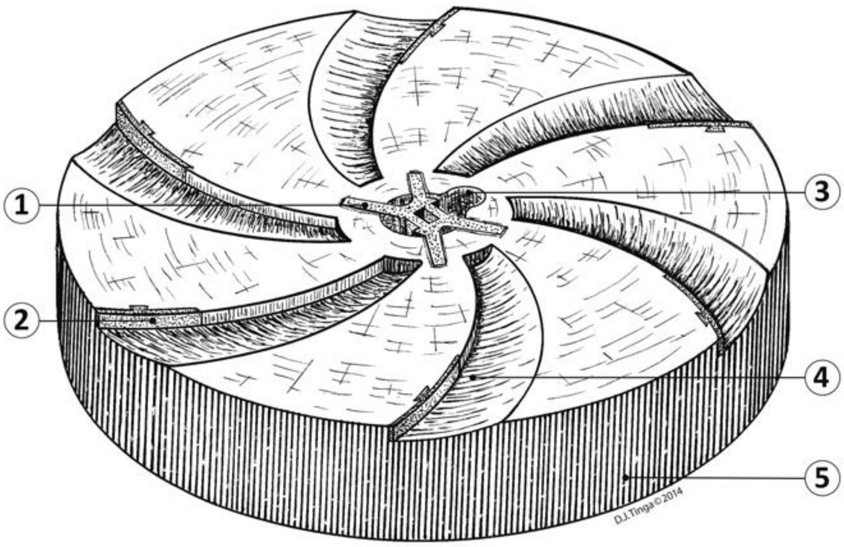

Fig. 13.2.2.2
The underside of a hulling stone in the Zaan region

1. *heavy four-armed rynd*
2. *groove iron*
3. *hand hole*
4. *wind groove (or wind furrow)*
5. *ribbed exterior*

hand hole,

bearing blade

The hand hole (a round hole in the hulling stone) is for lubricating the stone bushing and accessing the bearings around the stone spindle. To loosen the bearings or lubricate the stone bushing, the bearing blade — a long iron rod with a wide, flat and sharp bottom and a top ridge — is used. This is struck between the bearing and the feed plate present there. A tap against the underside of the ridge allows the jammed bearing blade to be released. Then some grease can be applied or, by putting a small piece of tin behind the bearing, the bearing can be adjusted a little tighter again.

Fig. 13.2.2.3
Bearing blade

rough chisel
scoop

On the outer circumference of the runner, many slightly sloping ridges were made with a rough chisel, which scoured the barley grains and also worked upward, preventing the scoop from sinking and jamming. The scoop is the amount of barley inserted (12-25 kg) depending, among other things, on the circumference of the stone, the strength of the wind and the condition of the trough.

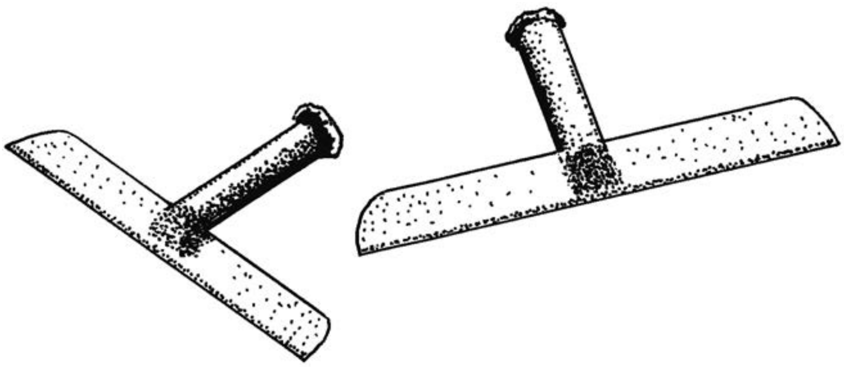

Fig. 13.2.2.4
Rough chisels

skirting board, trough casings (trough posts), trough frame
adjustment piece, closing piece

rasp
tin block
tin punch

millstone curbing
bedstone

baffle plate

The trough consists of two heavy wooden skirting boards, which are connected to each other with trough casings (trough posts). The trough frame usually consists of 4 to 5 segments, in which there is an adjustment piece or closing piece. This serves to reduce or increase the diameter of the trough according to the circumference of the stone. The trough frame is fitted with rasp. On the tin block (see Fig. 13.2.2.6), hundreds of holes were alternately punched in this with a punch, the tin punch, from outside to inside and vice versa (in the western Netherlands, only from outside to inside). Due to all the burrs around the holes, the rasp thus becomes a large grater. The bedstone (the 'nether stone') is surrounded by the millstone curbing, which is clamped with an iron tension band. The millstone curbing extends to just below the upper surface of the bedstone. The bedstone is completely flat and has a liner on the outside of the upper surface, made of round cast-iron plates (called a ring tin in the Zaan region). At the level of the spout, an adjustable rectangular iron plate, the baffle plate, is inserted herein. As the stone wears down, this baffle plate is pushed in slightly along with the hulling vat, keeping the spout free.

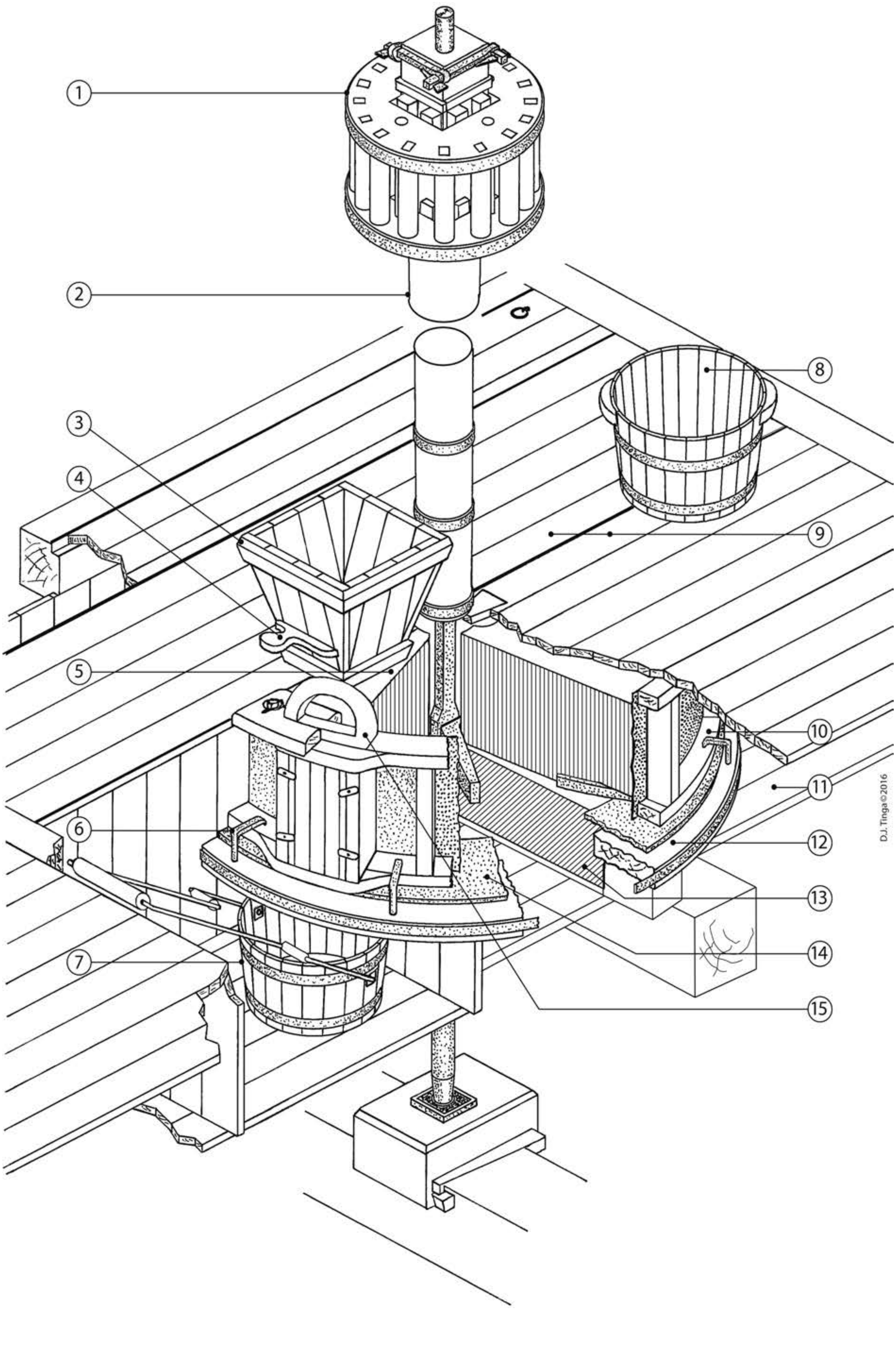
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Fig. 13.2.2.5
A complete pair of hulling stones

1. *hulling pinion*
2. *hulling spindle*
3. *hopper (barley hopper)*
4. *(inlet) slide*
5. *hulling stone*
6. *curb clamp*
7. *barley bucket*
8. *barley trough*
9. *shield covers (trough covers)*
10. *trough with rasp*
11. *dust group (Zaan: group)*
12. *millstone curbing*
13. *bedstone (nether stone)*
14. *cast-iron ring*
15. *(outlet) slide in the so-called "mouth"*

hulling vat
clamps
dust
(discharge) slide
barley bucket
hatch
trough battens

The hulling vat stands on the millstone curbing and is secured to this with heavy clamps. The space between the hulling stone and the trough is about 12 mm. The outwardly punched holes in the rasp promote drainage of waste dust and husks, which is referred to as dust. Casting the rasp double-sided also means it can be simply reversed when the inside is blunted by the husking. Inside the trough is the slide that the miller uses to have the groats run out from the trough into the barley bucket, which is made from chestnut wood and has a long iron handle. The slide is covered with a plate of iron that overlaps the rasp to counter wear. Outside the slide, the trough is sealed by a loose hatch which is covered on the inside with tin. This hatch leads the groats through an opening in the millstone curbing into
the barley bucket. To adjust the diameter of the trough, 11-mm-thick trough battens are used; these battens are placed between the hulling stone and the trough during adjustment and clamping. The trough is covered with two shield covers that are also lined with rasp at the bottom edge of the trough.

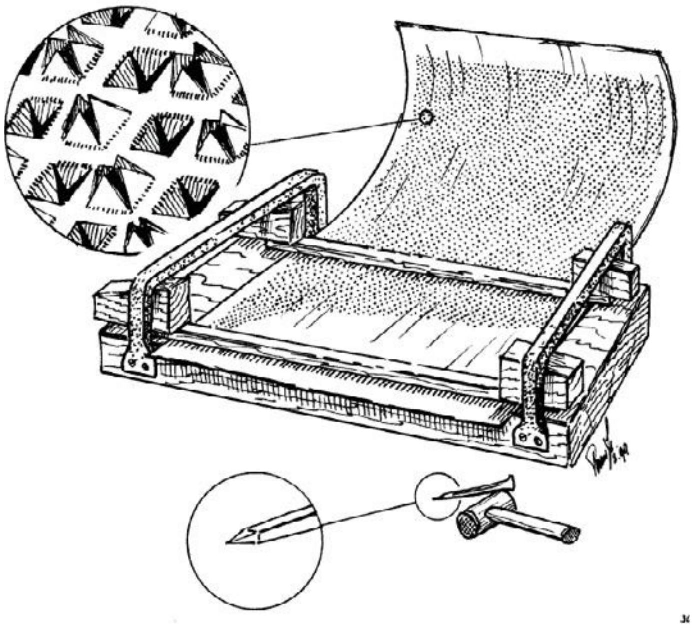

Fig. 13.2.2.6

The tin block, complete with tin, a tin punch and hammer

13.2.3 The sifter

sifter

The sifter is also set up on the hulling floor, namely in the recessed space between the outer wall and the attic floor, with the sieve hanging at floor level. In Groningen, the sifter has two functions. Before hulling, the barley is cleaned and sorted

cold harp, hot harp
pull block
flywheel crank
distribution board
groat pipes, winnower
half-hulling house
barley trough

and the hulled barley is then sorted by grain size. In the Zaan region, people used two sifters, the cold harp and the hot harp, for this purpose. They both have the same function. The sifter consists of three sieves stacked one above the other, covered with coarse to fine mesh. The sieve frame is suspended on ash wood springs and is restricted in its movement by two horizontal springs on either side on at the top end, which ensure that the sieve can shake only from left to right. The drive takes place from one of the hulling spindles via rope strings, or drive belts and sheaves. A pulling block (tensioner) with a pawl keeps the belt or string at the correct tension. The belt or string should be allowed to slip. A wooden flywheel provides a steady motion and a crank converts the rotary motion into a shaking movement. From the follower, the groats are poured into the body of the sifter and then fall onto a shaking distribution board before landing on the sieve. The sifted and sorted groats either fall through groat pipes (chutes) into a body above the winnower to be winnowed out or, after conversion of a batch, they end up in the half-hulling house where they are collected in the barley trough (a wooden trough with two handles) and transported to the hopper of the forerunner for further processing.

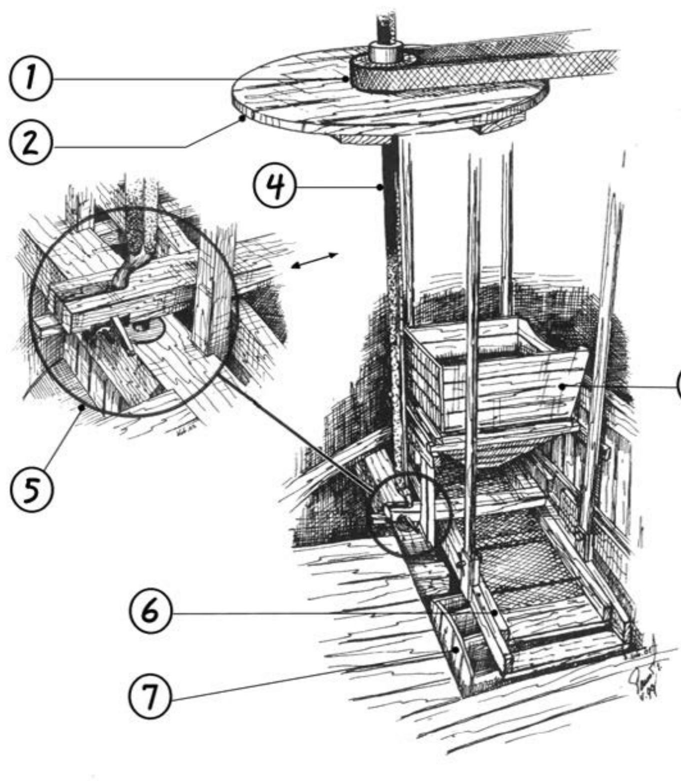

Fig. 13.2.3.1
The sifter, here with sealed half-hulling house

1. *drive belt*
2. *flywheel*
3. *body (hopper)*
4. *crankshaft*
5. *detail of the crank drive with the connecting rod (connecting rod)*
6. *triple sieve*
7. *groat pipes (chutes) to the winnower*

13.2.4 The winnower

husk cupboard
fan

The winnower, fan cabinet or milling separator, located on the floor below the hulling stones, cleans the groats of underweight grains, husks and dust. It is a large wooden body, set up in the husk cupboard which contains a fast-spinning paddle wheel as a fan, driven by a rope string or a drive belt from one of the stone spindles.

This usually has two pulleys to adjust the speed to match the speed of the hulling stones. The rope string or drive belt can be tightened using pulling blocks. The strength of the airflow is controlled by opening one or more sliders. The fan blows the residual dust and husks from the falling groat grains. At the same time, under the influence of the airflow, they sort themselves by size due to their weight. By stacking individual small laths or boards in front of the fan, the direction and force of the airflow is determined. The groats then fall into two or three spouts equipped with sliders to discharge the graded groats. Dust and husks are left in the husk cupboard.

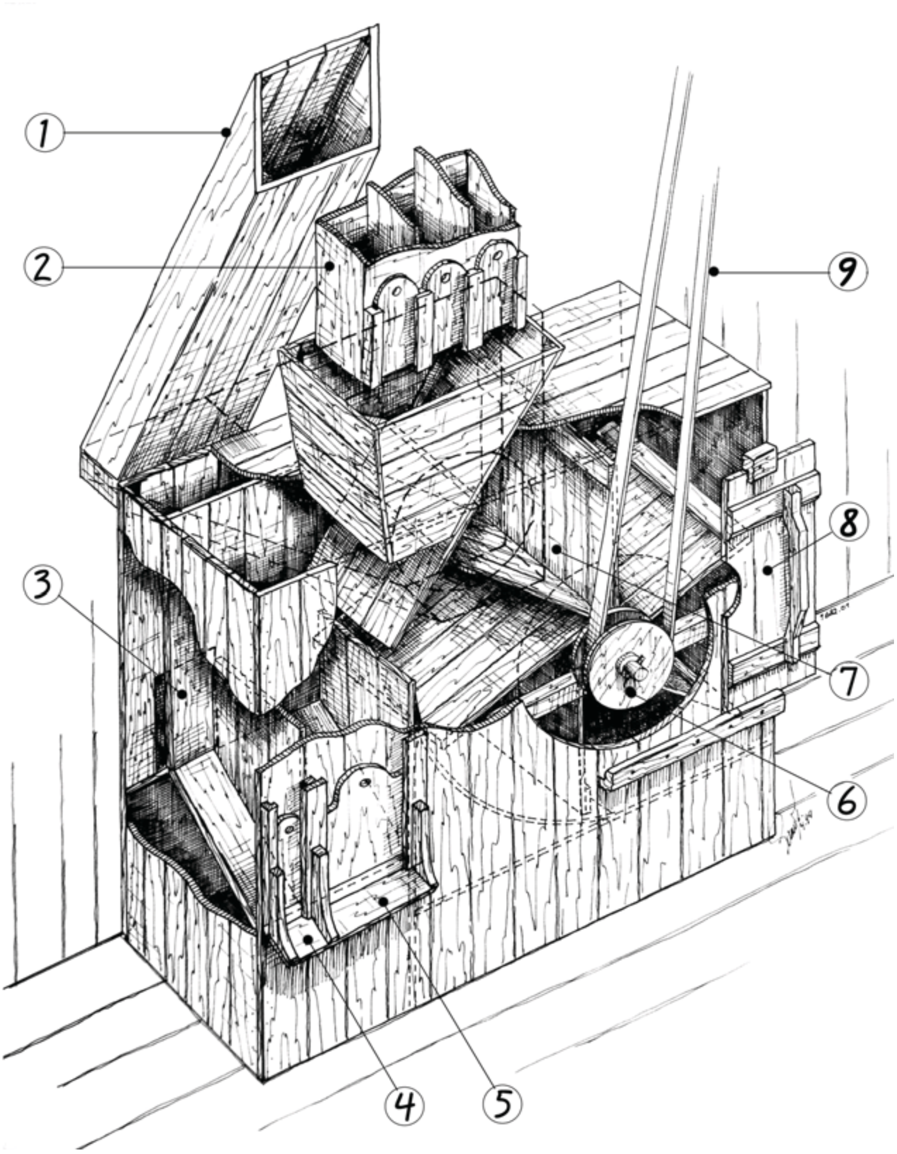

Fig. 13.2.4.1
The winnower

1. *dust pipe for removal of dust from the dust group (Zaan: group)*
2. *groat pipes (chutes), graded groats*
3. *grading chute, fine and coarse groats*
4. *spout for fine groats*
5. *spout for coarse groats*
6. *drive*
7. *fan*
8. *slide for air supply*
9. *drive belt*

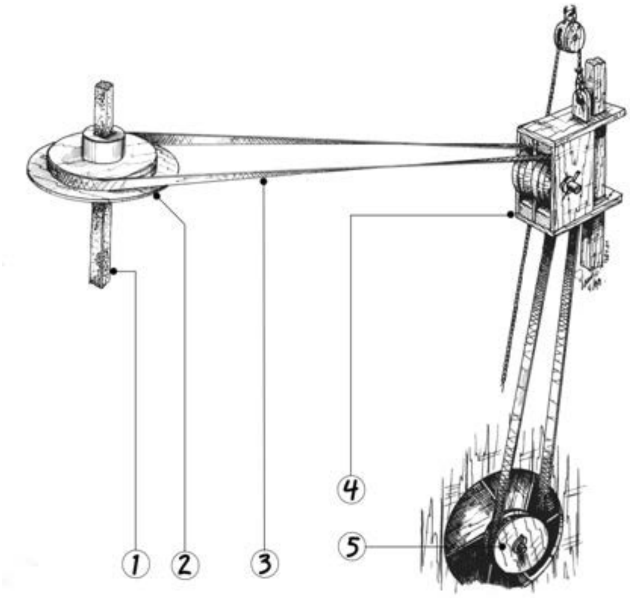

Fig. 13.2.4.2
Pulling block

1. *stone spindle of the follower*
2. *belt pulley*
3. *drive belt*
4. *pulling block*
5. *winnower drive*

13.2.5 Elevator

Jacob's ladder, elevator cups

In the mill, there is sometimes a double wooden transport chute running up to the sack hoist floor. This transport chute, called the Jacob's ladder or elevator, contains a circular conveyor which is equipped with metal cups. This is used to transport grain upwards. At the bottom of the elevator is an apron from which the cups bring up the mill stock and pour it into the barley houses. Propulsion is usually via a belted shaft from the upright shaft or it is electric.

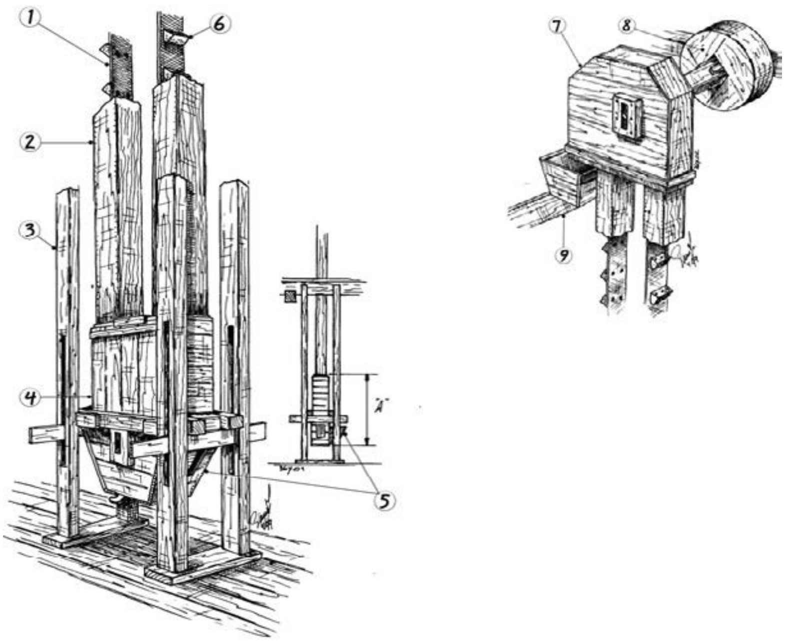

Fig. 13.2.5.1
Jacob's ladder / elevator (self-tensioning)

1. *transport belt*
2. *transport chute*
3. *conductor*
4. *foot of the elevator*
5. *apron*
6. *cup*
7. *top of the elevator*
8. *drive wheel*
9. *chute*

13.3 THE HULLING PROCESS

Two hullers usually worked at a hulling mill, the first working with the follower, the second operating the forerunner. They formed a team and had to be well attuned to each other. Specifically, both hulling stones may not be empty at the same time. Hulling mills are heavily loaded while hulling and operate only when the wind is quite strong (from wind force 5 to 6 and beyond) with a fair amount of sail or the flaps of the self-reefing system closed. Unloaded, the mill would run out of control. If someone allows the whole lot into one of the hulling stones while the other has not yet been discharged, then the opposite happens: the mill is overloaded and turns too slowly. When the mill runs unloaded, the hulling stones run as much as 180 rpm. With an amount of barley on the forerunner, the speed quickly drops to 140 to 130 rpm, only to increase again up to 160 revolutions. The runner rotates about 1.5 cm above the bedstone. At a Groningen hulling mill, the stone spindle stands on a fixed bridge tree, called the bridge beam. Therefore, the distance between the bedstone and the hulling stone can only be changed by striking or releasing wedges when the mill is idle. Hulling mills in the Zaan region have a movable bridge tree (press beam), just like the grain mill.

bridge beam

The day's job begins on the forerunner. The miller fills the hopper with barley. As the mill comes up to speed, the miller slowly pulls open the inlet slider, allowing the contents of the hopper to slowly flow onto the hulling stone. The barley grains fall onto the hulling stone, are immediately flung out at considerable speed and then fill the space between the outer circumference of the stone and the rasp. The airflow created by the ventilation curves (wind grooves) and the ridges on the perimeter of the stone works the grains back up and also around. Thus, for 2 to 3 minutes, the barley grains are rubbed around very quickly between the rough stone, the sharp rasp and also among themselves. During this time, the sharp points of the rasp and the rough outside of the stone serve to grate and grind the hard shell off the barley grains. Now the miller slowly pulls open the discharge slide and drops about half of the hulled barley into the barley bucket. The miller then closes the spout slide, retrieves the barley bucket and quickly releases the half scoop on the follower to keep the mill load balanced. He then places the barley bucket back and pours a new supply of barley into the body of the forerunner. The spout slide of the follower is pulled open, while the inlet slide of the forerunner is also slowly opened. From now on, the miller works with full scoops. The barley husked over two stones is now called half husk (half-peeled groats, called 'rel' in the Zaan region). The half-hulls are sifted out in the sifter and end up in the half-hull house. This operation is repeated twice more over the forerunner and follower until the desired product, such as pearl barley, is obtained. In between these operations, the groats are cleaned and sifted in the sifter and on the winnower. So the barley usually passes over the hulling stones six times before it becomes groats.

half husk

Finally, the groats go to the winnower for final cleaning and sorting. The product is now ready for sale and is bagged.

In Groningen, starting from the late 19th century, many mills were equipped with a double elevator for transporting the groats from the forerunner to the follower and then to the sifting mill, which lightened the miller's work. This often included a large Jacob's ladder for transport between the first floor and the barley houses on the stone floor.

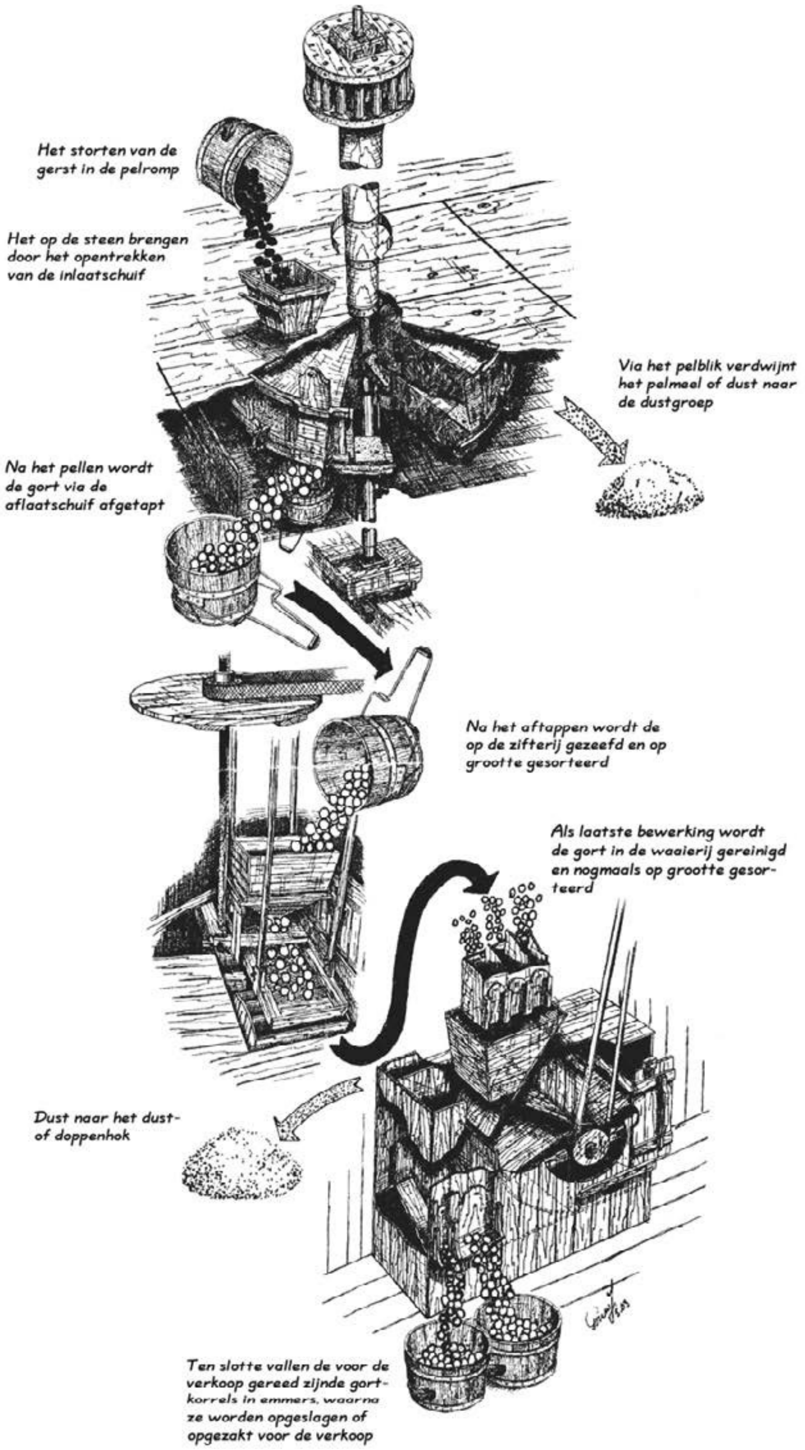

Fig. 13.3.1
The hulling process

NOTES

Chapter 14 The Oil Mill

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NOTES

14.1 INTRODUCTION

For centuries, oil has been pressed from seeds that contain oil. This was initially done by hand, but later horse mills were widely used for this purpose. Still later, watermills and windmills were used for this task. Wind-powered oil mills came to the Netherlands in the mid-16th century. Such wind-driven oil mills ("stamping-mills") existed even earlier than that in Flanders. These were post mills. Oil-pressing was done in the body where the stamps were lifted by spokes in the waterwheel shaft. Wind-driven oil mills in the Netherlands are mainly cap winders.

oil mill

An oil mill processes oil-bearing seeds, such as linseed, rapeseed and hemp seed. But nuts such as peanuts and cocoa waste were also sometimes processed, especially during the transition period to the steam era.
Linseed oil was and is used for making paint, soap, printing ink and linoleum, among other products. Rapeseed oil was used as lamp oil and cooking oil. Besides oil, an oil mill also produces cattle cakes. These were used in winter, when hay was scarce, to supplement cattle feed. Sometimes cattle cake production was a greater source of income for the miller than oil. A lot of oil was sold on the stock market in Amsterdam, allowing prices to fluctuate widely.

single-works oil mill,
double-works oil mill

There have been two developments at oil mills. The first was the single-works oil mill, followed later by the double-works oil mill.
Mills with a single oil works had a pair of edge runner stones, an oil seed heater and a stamper press. Initially these were horse-driven and water-driven oil mills, later also wind-driven oil mills. Many single-works oil mills sprang up in the northern, eastern and southern regions of the Netherlands. In addition, they were usually equipped with mill stones for grinding grain, as there was less demand for cattle cake in summer. Pressing oil was mostly seasonal work here. These mills were also called "farm oil mills" and they pressed mainly for their own inhabitants.
In the Zaan region in particular, the industrial wind-driven oil mill developed from the 17th century onwards. Initially work was done there with one oil press, mainly used for pressing hemp seeds. From the 18th century onwards came the double-works mills with two oil presses: in addition to a first pressing block, a second pressing block was present. Rapeseed and linseed were mainly pressed. Oil was pressed throughout the year. It was usually done in shifts, 6 days a week and 16 or 24 hours a day. At the peak of this branch of industry, there were about 140 oil mills in the Zaan region.

first pressing block
second pressing block

Again, however, the wind gradually had to give way to steam. In the Netherlands, pressing oil with wind, water and horse-driven mills was practically a thing of the past in the second half of the 20th century.

Fortunately, the situation now is that several oil mills have returned to small-scale operation after many years of inaction. Currently, we know of the following wind-driven oil mills that are capable of pressing:

- In Drenthe: *De Wachter* (The Watchman) in Zuidlaren and *Woldzicht* in Roderwolde.
- In Overijssel: *De Passiebloem* (The Passion Flower) in Zwolle and oil and hulling mill *Ter Horst* in Rijssen.
- In North Holland: *Het Pink* (The Little Finger) in Koog aan de Zaan; *De Bonte Hen* (The Colourful Hen), *De Zoeker* (The Seeker) and *De Ooievaar* (The Stork) in Zaandam.
- In North Brabant: Holten's Mill in Deurne.

Briefly, the process of oil-pressing is as follows:

first pressing meal

meal bin

second pressing meal

Seeds that contain oil are crushed under the edge runner stones and finely ground into what is known as first pressing meal. During this crushing, the meal is also moistened.
When this meal is fine enough, it is allowed to run off into the meal bin.
From here, a measured amount is consistently scooped onto the oil seed heater and heated. The hot meal is pushed into two cloth bags and placed in the wedge press where it is pressed. The oil is collected in a container and the meal is pressed into a cake. A second pressing follows in a double oil mill. The cakes are pounded fine in the stamper pots to make second pressing meal. This second pressing meal is heated again in the second pressing oil seed heater and pressed once more in the second pressing block.
In the first pressing, about 75% of the oil is pressed from the seed. After the second pressing, the cake contains only 8-12% of the oil originally present in the seed.

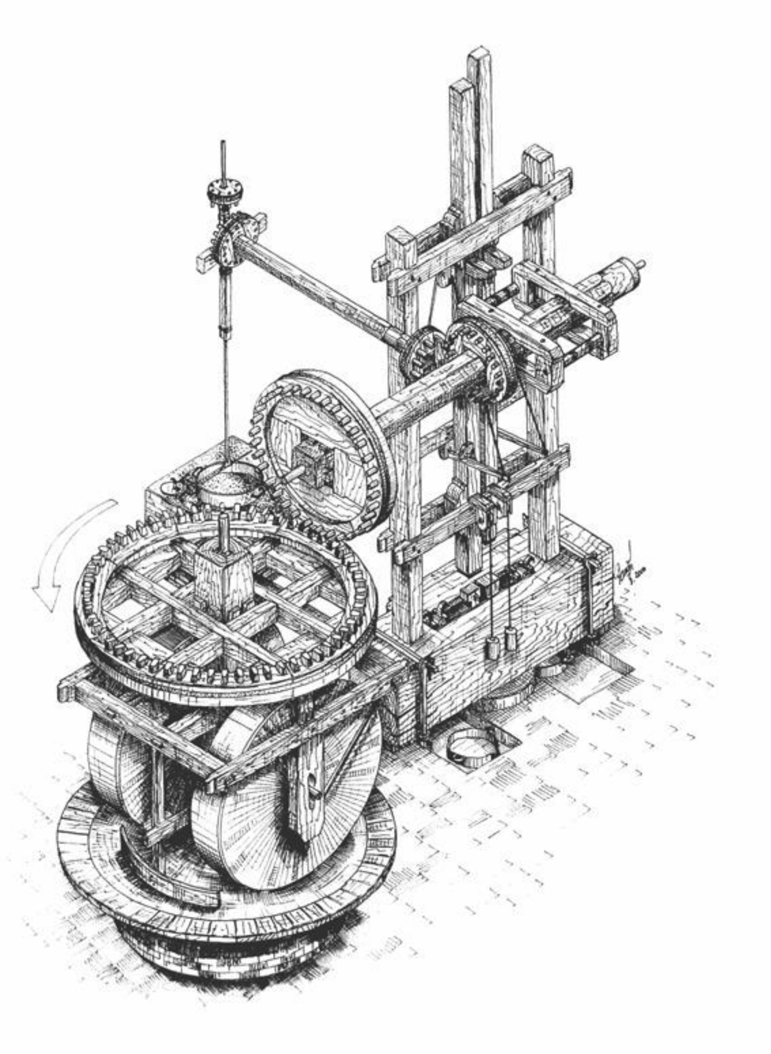


Fig. 14.1.1
An example of a single oil works for small-scale production, consisting of edge runner stones, an oil seed heater and a stamper press.

Based on a drawing by N. Jurgens
Manufactured for Holten's Mill at Deurne

14.2 LAYOUT

An oil mill contains several devices for pressing oil:

edge runner stones
- edge runner stones for crushing oil-bearing seeds;

oil seed heater, stirrer
- the oil seed heater with stirrer for preheating the crushed seeds;

pressing block or stamper press
- the pressing block (or stamper press) with rams for pressing the mill stock;

trough
- the trough with stampers for stamping the cakes;

plate mill
- a plate mill (not always present), which eased the task of the edge runner stones.

All these implements are located in the mill on the ground floor.

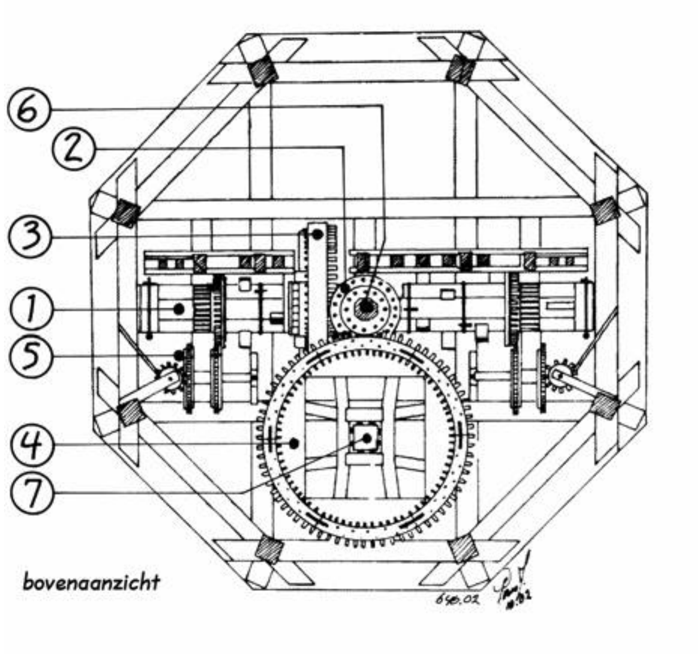


Fig. 14.2.1
The cam shaft floor

1. *cam shaft*
2. *stone wheel pinion and cam shaft wallower (installed above each other)*
3. *cam wheel*
4. *stone wheel*
5. *spur pinions*
6. *upright shaft*
7. *stone shaft*

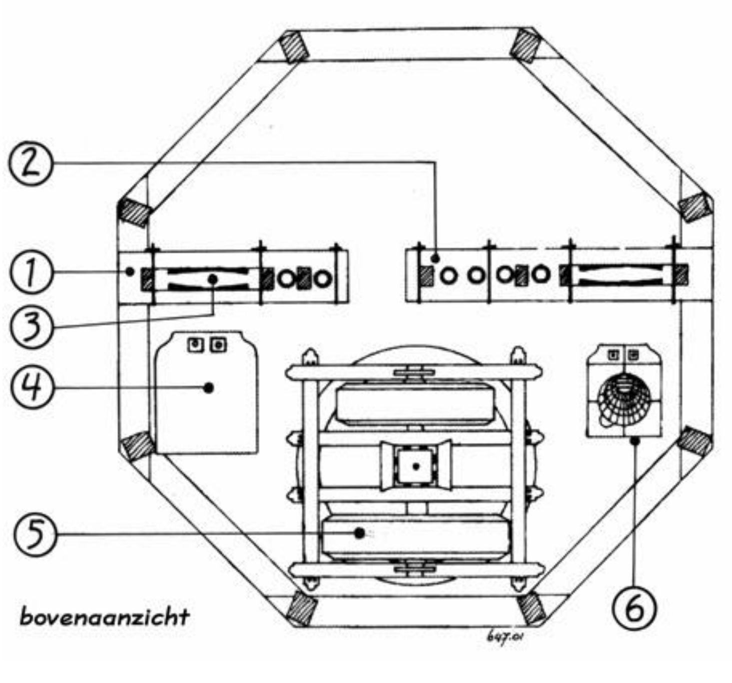


Fig. 14.2.2
The milling floor (based on Husslage)

1. *first pressing*
2. *second pressing*
3. *wedge press*
4. *first pressing oil seed heater*
5. *edge runner stones*
6. *second pressing oil seed heater*

A single-works oil mill is equipped with edge runner stones, an oil seed heater and a stamper press. A double-works oil mill also has one pair of edge runner stones but it has two oil seed heaters and two pressing blocks: the first pressing block and the second pressing block. There had even once been a double double-works oil mill!

wedge press, stamper pots

A pressing block is usually divided into a wedge press and stamper pots. As a rule, the first pressing block featured four stamper pots, the second pressing block had two of these. But other arrangements occurred as well.
Because single-works and double-works oil mills do not differ substantially from each other, this chapter discusses the double-works mill.

14.2.1 The driving gear

cam shaft

stone wheel, stone shaft

lower wallower

cam shaft wheel

The drive for the machinery is located on the cam shaft floor. The bottom of the upright shaft is bearing-mounted here on a trestle, which is placed over the cam shaft. The main upright shaft is equipped with two wheels at the bottom. The top one, a small stone gear with heavy rods, moves the edge runner stones via the large stone wheel and stone shaft. The bottom one, the lower wallower, drives the cam shaft via the cam shaft wheel.This cam shaft is a long heavy wooden shaft, which lies horizontally on the cam shaft floor. It rotates on two or three bluestone bearings with the sliding surfaces having steel fillets.

spokes, pressing ram

stampers, tappets

release lever

Spokes are inserted into the cam shaft: two spokes for the first pressing ram and three spokes for the second pressing ram and each stamper. Due to the rotation of the cam shaft, these spokes lift the rams and stampers via the tappets, after which they fall back. The rams are made of beech wood and are 5 to 6 metres in length. The weight is about 100 to 125 kg, which guarantees a considerable impact force. They move within sturdy frames placed on the first pressing block and on the second pressing block. With a release lever, the oil presser brings a ram or stamper beyond the reach of the spokes to stop the pressing or stamping.

spur pinion

Around each end of the cam shaft is a rim wheel that drives a small crown wheel via the spur pinion for the stirrer of the oil seed heater.

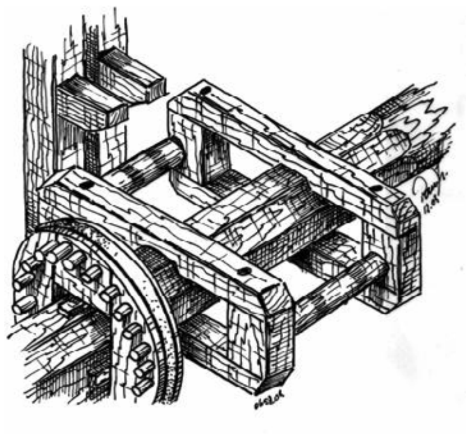


Fig. 14.2.1.1
The cam on the shaft in an oil mill

A double wooden framework with two rollers between it for lifting the rams.

oil mill shaft cam

In small single-works oil mills, the rams are sometimes lifted with a oil mill shaft cam.
This is a framework attached to the cam shaft with rollers that raise the rams.

14.2.2 The edge runner stones

edge runner stones
bedstone
closing plate / outlet spout
king

The edge runner stones, also roller strones, break up the seed. The stones have a diameter of 1.50 to 2.25 m, are about 40 to 60 cm wide and weigh between two and four thousand kilos. They roll and rub on their edge over an even larger stone, the bedstone. This causes the seed to break open. The pan lies on the bedstone, a round masonry stone table with a solid foundation. Around the bedstone is fitted a wide wooden rim, the parapet, which contains an opening that is closed by the closing plate / outlet spout. As the bedstone became worn down and chopped flat again, a raised part called a king gradually formed in the middle of the bedstone. Later, often a cast-iron bedstone that wore out less quickly and required little maintenance was used.

edge runner, yoke
stone shaft
ears

The edge runner stones run in the yoke, a heavy wooden framework that is wedged fast to the wooden stone shaft. The outer ends of the stone shafts turn in the ears. The holes in the ears for these trunnions are oblong. As a result, the trunnions have some play and can move up and down as the runners roll over the seed strewn on the bedstone.

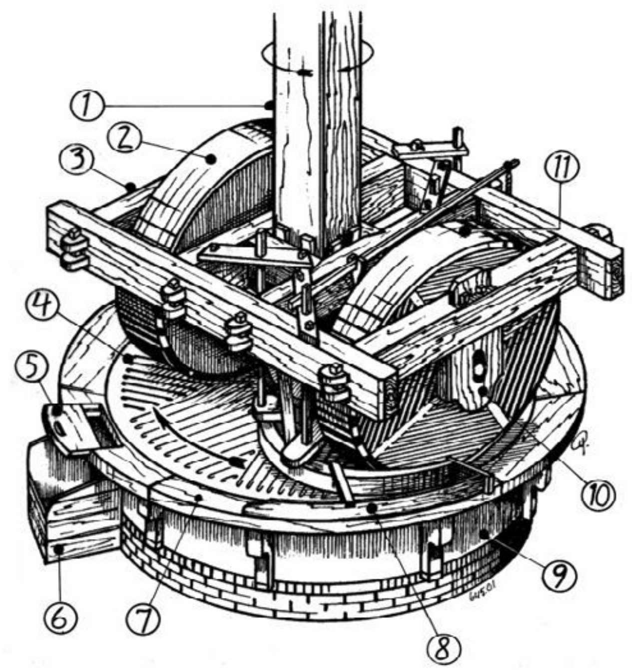


Fig. 14.2.2.1
The edge runner stones

1. *stone shaft*
2. *inner stone*
3. *yoke*
4. *bedstone*
5. *closing plate / outlet spout*
6. *meal bin*
7. *parapet*
8. *sweeper / drain bin*
9. *bedstone*
10. *stone ear*
11. *scraper*

stone wheel,
stone bearing block

The stone wheel is fitted to the stone shaft above the yoke.
The stone shaft rotates with its lower end on a hardened steel pivot journal in a bearing pot placed in the centre of the central post.
The upper end of the stone shaft is bearing-mounted in the stone bearing block. The miller can use control ropes to shift the stone bearing block and thus move the edge runner stones in and out of work. At a calmly turning mill, this can be done without braking first.

inner stone
outer stone
sweepers
sweeper
scraper

The edge runner stones usually do not run in the same track; there is an inner stone and an outer stone. The seed on the bedstone is alternately pushed in front of the inner and/or outer stone by rotating sweepers. The sweeper sweeps past the central post, pushing the seed to be crushed under the outer stone. After half a revolution, the scraper turns the seed and pushes it in front of the inner stone, etc.

the outward sweeper

The outermost or outward sweeper scrapes the parapet clean. It is usually fitted with an old cloth bag for this purpose. The parapet often slopes slightly to prevent seed from falling off and to make it easier to sweep it back in front of the stones.

drain bin
closing plate / outlet spout, meal bin
first pressing meal

When the seed is sufficiently crushed, the oil presser lowers the extended part of the sweeper, the drain bin. This moves the mill stock over the parapet, causing it to fall into the meal bin through the now-opened closing plate / outlet spout. This meal is called first pressing meal.

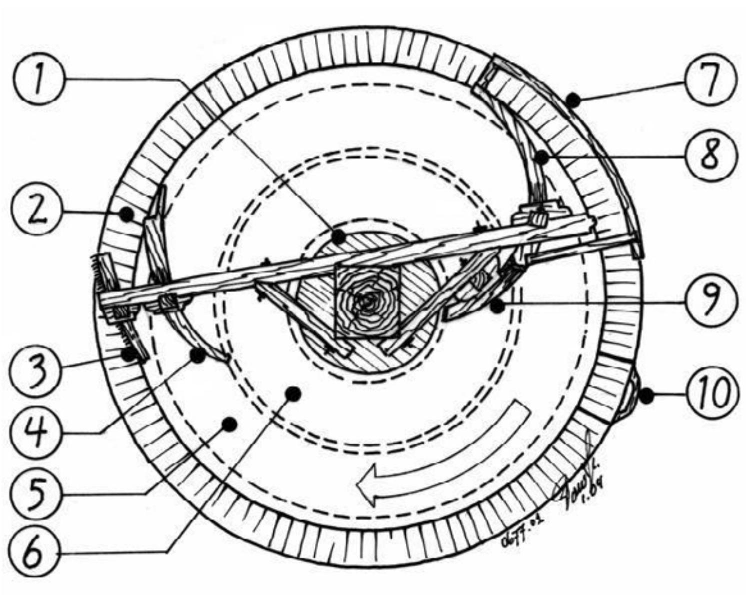


Fig. 14.2.2.2
The sweepers and the drain bin

1. *central post with bearing pot*
2. *parapet*
3. *outward sweeper*
4. *scraper*
5. *path of the outer stone*
6. *path of the inner stone 7*
and 8. drain bin
9. *sweeper*
10. *closing plate / outlet spout*

14.2.3 The oil seed heater

Before the first pressing meal is pressed, the oil presser heats it on the oil seed heater to make the oil more fluid, allowing more oil to be pressed out.

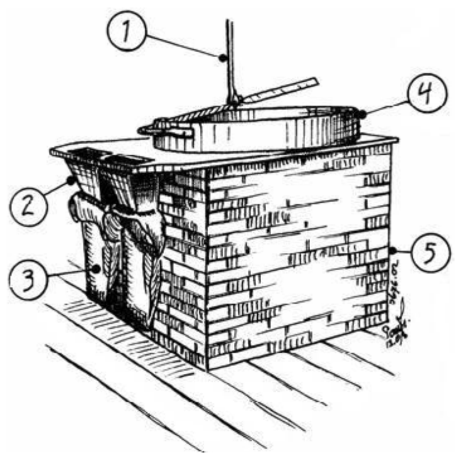


Fig. 14.2.3.1
The oil seed heater

1. *stirring rod*
2. *hopper*
3. *cloth bag*
4. *sliding ring or heating dish*
5. *oil seed heater*

The oil seed heater is a block-shaped masonry stove into which peat or wood is fed to obtain an even fire that is not too hot. The oil seed heater is covered with an iron heater plate that protrudes at the front about 20 cm. In this overhang are two rectangular holes under which small hoppers are inserted. Under each hopper, the oil presser can hang a cloth bag.

heater plate

hopper, cloth bag

sliding ring, stirrer

On the plate is the sliding ring, a pan without a bottom. The stirrer rotates in this ring. This keeps the meal moving, heating it evenly and preventing burning. When the meal is sufficiently preheated (lukewarm, about 35° to 40°), the oil presser raises the stirrer and pulls the sliding ring toward itself, causing the meal to fall through the hoppers into both cloth bags.

14.2.4 The first and second pressing block

wedge press, stamper potss

Opposite the oil seed heater is the first pressing block, which can be divided into the wedge press and stamper pots. The first pressing block (and the second pressing block, too) is a heavy oak beam reinforced with wrought iron bridle irons.

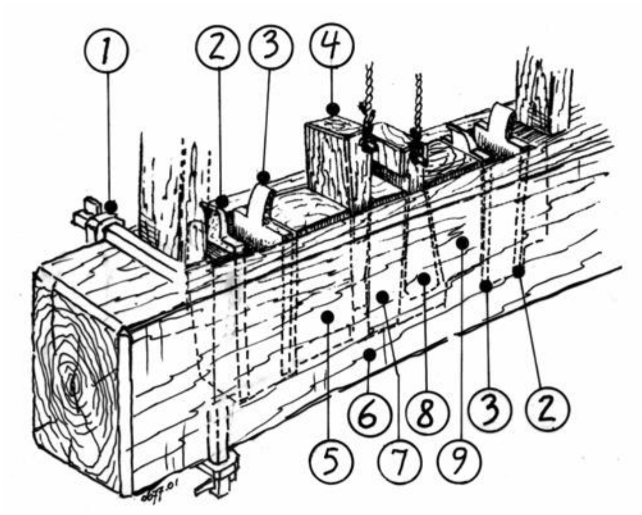


Fig. 14.2.4.1
The wedge press with all its parts

1. *bridle iron*
2. *fixed pressing plates*
3. *pressing plate or paddle*
4. *pressing wedge*
5. *spacing block*
6. *wedge press*
7. *filling piece*
8. *releasing wedge*
9. *spacing block*

sills

pressing set

paddles, fixed pressing plates

spacing blocks, filling pieces, pressing wedge, releasing wedge

hair

It rests on a heavy stone or wooden foundation, the sills. Carved into the pressing block is a space called the wedge press. The pressing set was placed in the wedge press, consisting of two sets of irons, called paddles and fixed pressing plates, two wooden spacing blocks, a scoop and the pressing and releasing wedges.
The oil presser now places each cloth bag with heated meal into a hair. This is a mat, braided from horsehair and fitted with a leather cover. Nowadays, people no longer use horsehair but other materials, such as nylon rope or boards.

Fig. 14.2.4.2
The hair

A braided horsehair sack covered with leather.

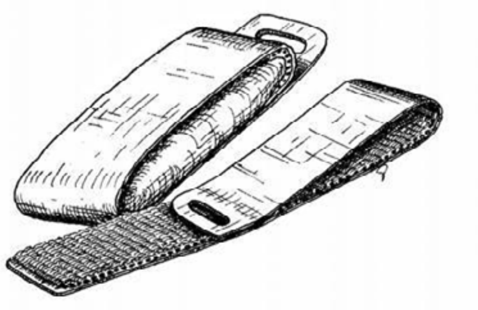
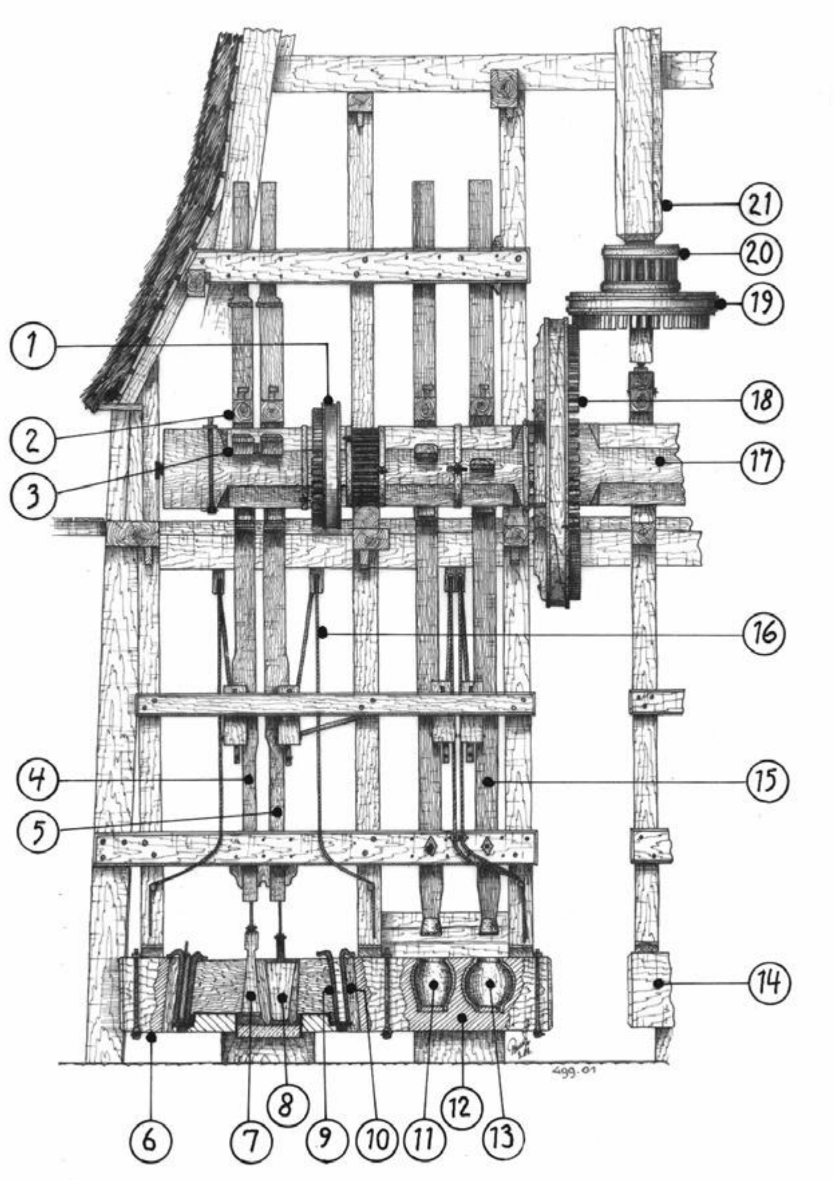


Fig. 14.2.4.3
The oil works (first pressing)
Based on Husslage

1. *rim wheel*
2. *tappet*
3. *spoke*
4. *releasing ram*
5. *pressing ram*
6. *pressing block*
7. *releasing wedge*
8. *pressing wedge*
9. *pressing plate or paddle*
10. *fixed pressing plates*
11. *stamper pot*
12. *trough*
13. *stamperpot*
14. *second pressing*
15. *stamper*
16. *release string*
17. *cam shaft*
18. *cam wheel*
19. *lower wallower*
20. *stone gear for stone wheel*
21. *upright shaft*



pressing ram
pressing wedge

Both of these hairs are placed between the pressing plates. Then the pressing ram is released. This drives down the wedge-shaped wooden pressing wedge with which, in the course of 40 to 50 strokes, the pressure between the pressing plates is raised to about 250 hPa, forcing the oil out of the cloth bags. Oil runs out of the wedge press through openings in the block and is collected in oil cans under the pressing block.

releasing ram, releasing wedge

After pressing, the oil presser suspends the pressing ram and releases the releasing ram. This presses down on the releasing wedge, a counter wedge, with a few strokes, which relieves the pressure in the wedge press and allows the hairs to be removed from the drawer.

trough

The pressing block is also usually equipped with several stamper pots, what is called the trough. On account of their shape, these pots are sometimes called apple pots.

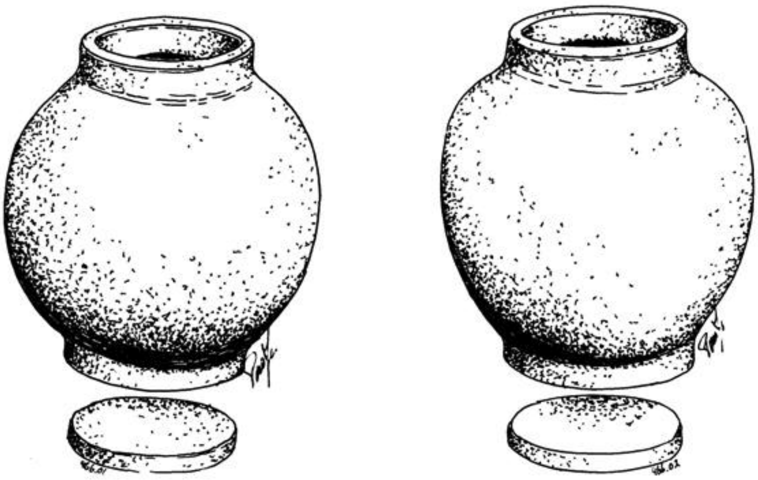


Fig. 14.2.4.4
Stamper pots, various forms

first pressing
frame for removing oil cake from cloth bag, cakes, stamper pot
second pressing meal

Due to the high pressure of pressing, the meal is turned into a hard cake.
The oil presser strips off the cloth bags from these first pressing cakes on the frame for removing oil cake from cloth bag and puts the cakes in the cast-iron stamper potsstamper. In there, they are finely stamped by the stampers into second pressing meal. This second pressing meal is heated again in the oil seed heater and pressed once more in the second pressing block.

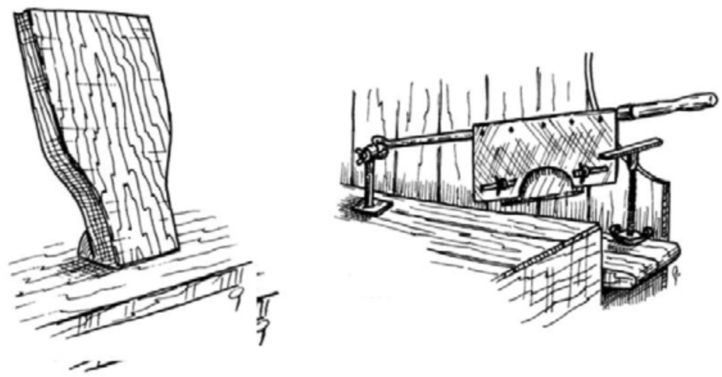


Fig. 14.2.4.5
The frame for removing oil cake from cloth bag and the knife to cut the oil cakes for processing the oil cakes

second pressing

The processing in the second pressing is virtually the same as that used in the first pressing. For each turn of the cam shaft, the second pressing gives three strokes, as opposed to two in the first pressing. However, the pressure in the second pressing becomes higher than in the first press because the second pressing tray is narrower, so the cloths bags are smaller and the pressing wedge is more pointed in shape. Due to this higher pressure of around 350 hPa, about 5% additional oil is squeezed out of the meal in the second pressing.
The cloth bags are stripped off from the second pressing cakes, after which they are cut into cattle cakes of a set size with the oil cake knife.
The sides of the oil cakes, the cut ends, then still contain some residual oil. This goes back into the stamper pots to be pressed once more.

oil cake knife

14.2.5 The stroke counter

The number of strokes during second pressing determines the percentage of oil left in the cake and thus the nutritional value of the cattle cake and the price. Thus, for consistent quality, a fixed number of strokes is required.
In order for the second pressing ram to make a set number of strokes, the oil mill is equipped with a mechanism, called the stroke counter, that counts the strokes. It has three wooden gears. One gearwheel, the bell wheel, provides the drive: it is connected to the pressing ram and acts as a kind of pawl feeder mechanism. A smaller gear wheel runs in conjunction and determines the number of strokes, usually 50, sometimes 70 or 80. After this number of strokes, the tumbler falls and the bell rings, after which the oil presser pauses the second pressing ram and the pressing stops. A third gear wheel, with only one or two teeth, is driven by the releasing ram. This puts the first gear wheel back into position for the next pressing.
(Note: In Fig. 14.2.5.1, the operation is not shown correctly; the stroke counter is in the starting position while the tumbler is already about to fall.)

stroke counter

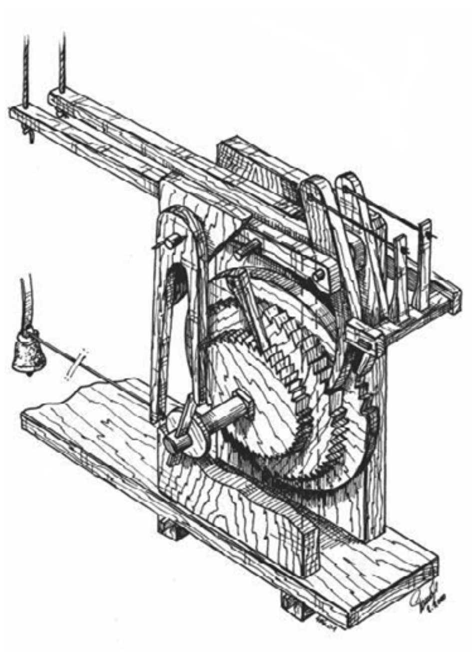


Fig. 14.2.5.1
The bell with the three wheels, the pawls, the tumbler and the bell

14.3 TRANSPORT AND STORAGE

To get an idea of the scale of transportation and storage: a large oil mill could process about 390 tonnes of seeds annually. That produced about 110,000 litres of oil and 270,000 kg of cattle cakes. All of that had to be transported by ship and loaded and unloaded by the oil pressers.

drip or drab bag

muck

The pressed oil was filtered into elongated tarpaulin bags called drip or drab bags. These allow the extracted oil to pass through extremely slowly to produce a high-quality, pure product. The dirt left in the drab bag is aptly called muck.

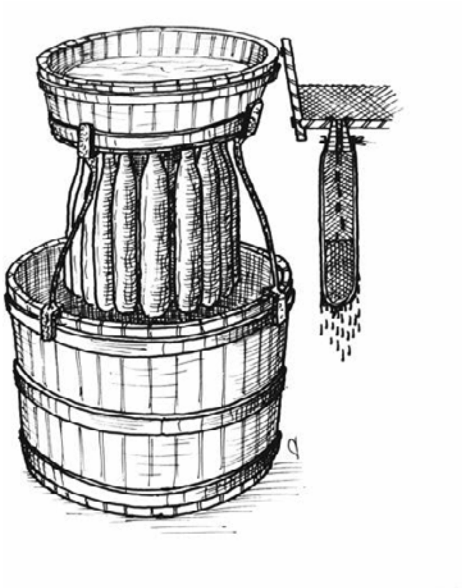


Fig. 14.3.1
Drip or drab bag for filtration of the oil obtained

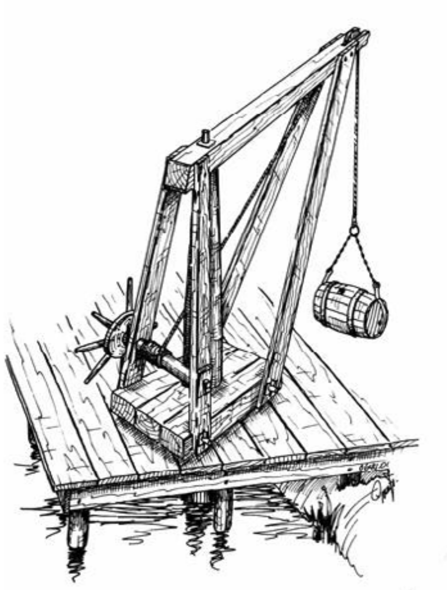


Fig. 14.3.2
The crane set-up: all-wood crane with a winch

oil cellars

The filtered oil was stored in large oil cellars. These were cellars of about 3 x 3 m and sometimes as deep as 3.5 m, divided into two or more compartments. Sometimes they are glazed on the inside.
They partly protruded above the floor, up to 80 cm. They usually lacked foundations and are thus "floating" and can move with the water at high tide.
The oil sank even further in the oil cellars, until the oil was completely clear.
Each compartment was equipped with a pump for pumping up the oil. When the oil was sold, it was pumped off and put into wooden barrels.

crane set-up

The transport of oil took place by ship. For loading and unloading the oil barrels, there was a crane set-up on the jetty along the waterfront, a typical feature for oil mills.
Cattle cakes were initially transported loose. They slid in stacks of 13 (a "throw") through a cake chute aboard the ship. Later, they were transported in wooden crates.

14.4 OTHER INFORMATION

It is important to note that during clockwise winding, the stampers and rams must be suspended. During clockwise winding, the cam shaft rotates counter to the normal direction of rotation, which can cause a spoke to end up on the top of a tappet. Because this can lead to damage, all rams must be suspended when the cam shaft is turning backwards.

An oil mill can turn too fast. This is the case when the cam shaft rotates so fast that a ram or a stamper does not have enough time to fall before the next spoke grips under the tappet. The stamper then falls with its full weight on the oncoming spoke. This so-called "spoking" can lead to damage.

A special feature for oil mills is that the brake wheel does not have a steel wear lining. A possible explanation for this is that the smoke that escapes freely from the oil seed heaters and enters the mill leaves a greasy soot deposit on this liner. This can cause the brake to slip.
This problem was also common in polder mills with external winders, where the chimney ended in the cap and soot and condensation settled on a steel lining.

Chapter 15 The Sawmill

Contents page:

NOTES

15.1 INTRODUCTION

Since time immemorial, humans have used wood to manufacture shelter, boats or household goods. Trees that provided the material were chopped and sawn into usable parts for this purpose. The oldest saw found is made of a hard stone and dates to about 5,500 years before our era. Metal saws came into use during the Bronze Age, about 2500 BC.

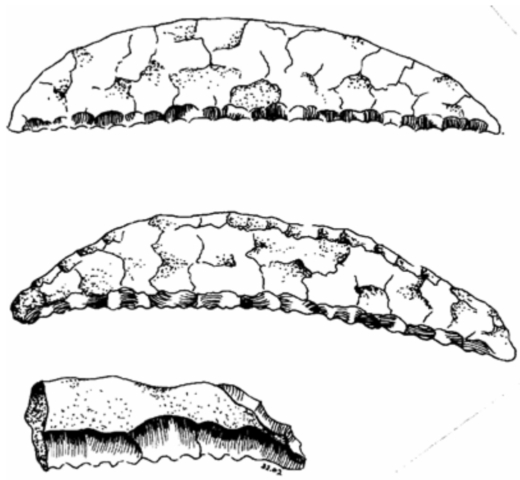


Fig. 15.1.1
Stone-made saws, 5500 BC

Sawing logs into planks was done by hand in the Netherlands until the late 16*th* century, and it was a heavy and time-consuming job. The work was done using handsaws that were operated by two men. As the population grew, the demand for wood for housing and shipbuilding increased, and this called for a solution.

Cornelis Corneliszoon van Uitgeest

Although we now know that Cornelis Corneliszoon van Uitgeest was the inventor of the sawmill, that is not entirely true. In the year 400 there was already talk of a water-powered sawmill. In the 16*th* century, drawings of complete sawmills powered by water or by muscle power appeared. Those drawings always featured a crankshaft with only one bend and thus one saw frame, so those mills must have been subjected to highly variable loads during sawing. The upswing of the crank with the saw frame, etc. cost more energy than the downswing. Cornelis Corneliszoon experimented with wind power on (small) mills with a single crank. In 1593, he received a patent for his invention of the wind-powered sawmill. He must have quickly encountered the problem of irregular loading. He devised the crankshaft with three 120° bends. Hung from this were three saw frames, which brought the crankshaft into balance. For that *Besondere Creckwerck* (Special Crankwork) — an improved crankshaft — he also received a patent in 1597.

paltrok, cap winder-sawmill

Two types of sawmills emerged, the paltrok and the cap winder-sawmill.

15.2 LAYOUT

beam sawmill, wainscot sawmill

There are two types of sawmills, the paltrok and the cap winder. Both types had sub-classes, namely the beam sawmill and the wainscot sawmill.
Cap winders sometimes combined both functions. There are no wainscot sawmills left in existence now.
The paltrok has always been set up exclusively for sawing wood and has never changed over the centuries. We know of two versions of the cap winder, the octagon and the hexagon.

The partitioning of the floors for cap winder sawmills comprises:
- the cap floor;
- the crank floor;
- the empty floor or connecting rod floor (only at large industrial sawmills);
- the saw jig floor;
- the sawing floor.

piers
frame saw pit
foundation columns

The sawing floor of cap winder-sawmills is on piers above the ground, because the space below the floor, the frame saw pit, is needed for the saw frames that move up and down and for storing the sawdust. The height of the foundation columns can range from 60 cm up to about 2.5 metres.

crane

In paltroks, the sawing floor is higher because the winding gear is under the mill. Because of this high elevation, paltroks have a crane at the beginning of the sawing floor to lift trees/logs from the water. The fixed parts of the paltrok and the cap winder are further described in Chapter 5.

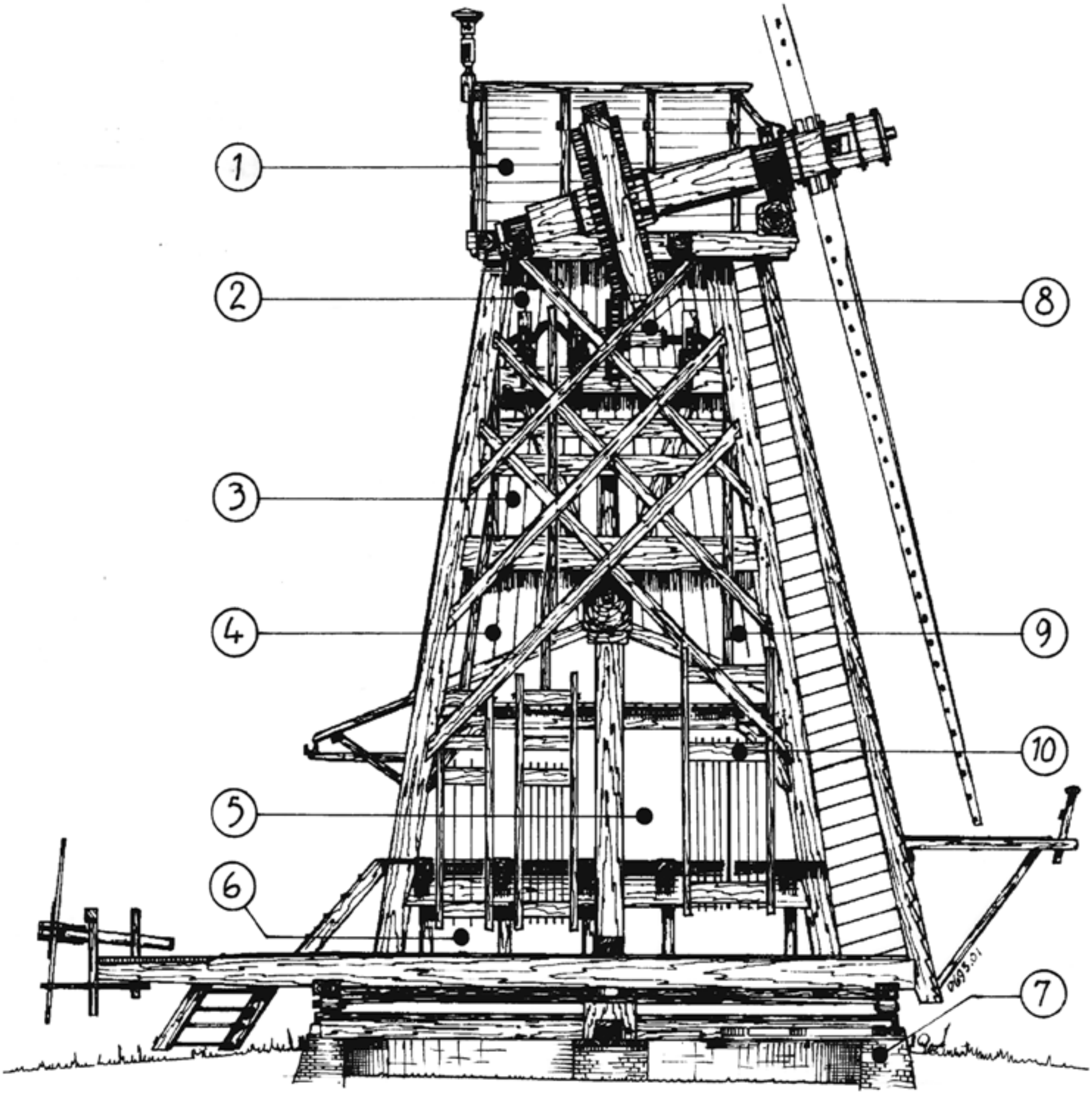


Fig. 15.2.1
Cross section of a paltrok beam sawmill

1. *cap*
2. *crank floor*
3. *weather boarding*
4. *saw jig floor*
5. *sawing floor*
6. *frame saw pit or bottom rig floor*
7. *masonry base*
8. *crankshaft*
9. *pitman or connecting rod*
10. *saw frame*

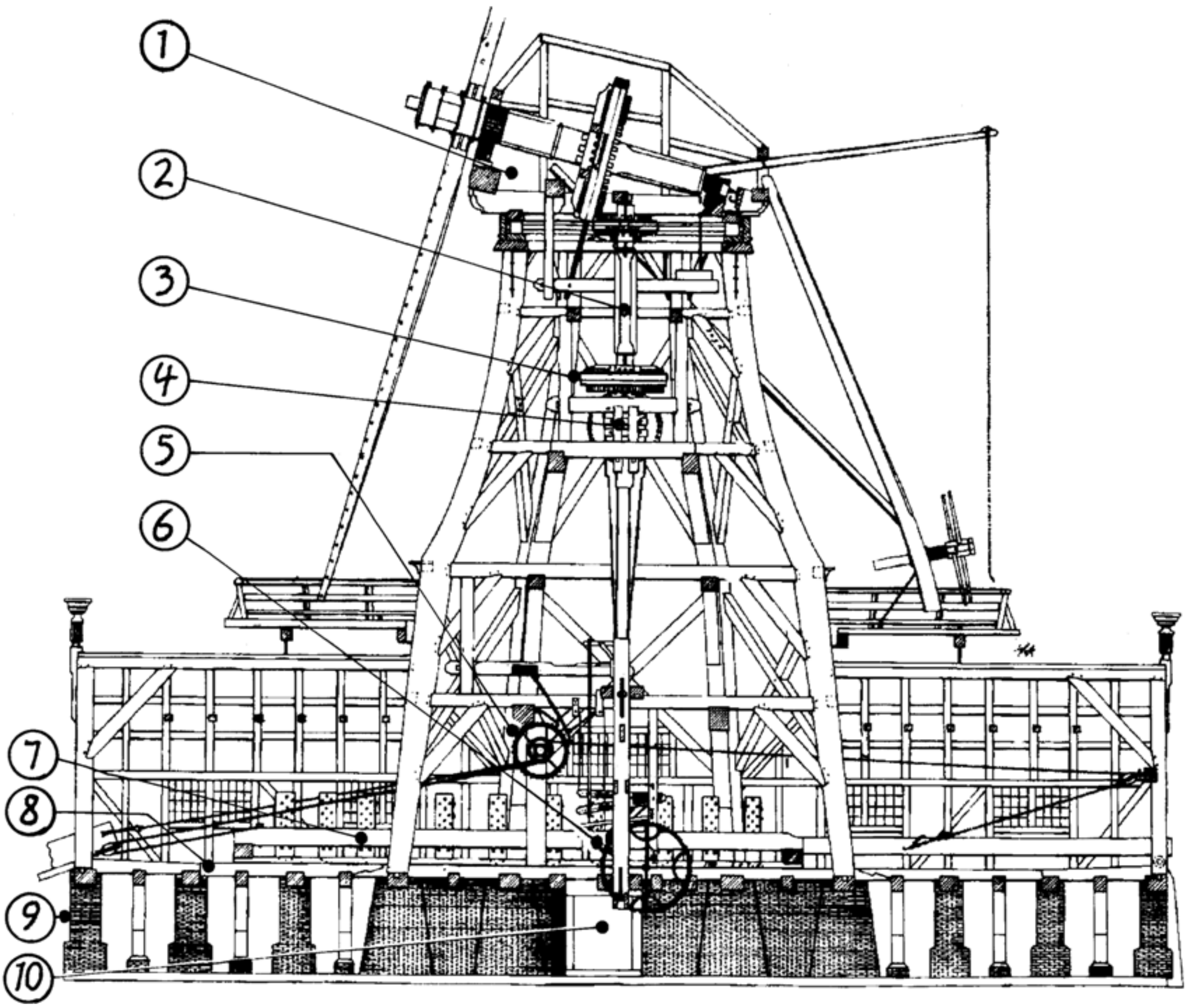


Fig. 15.2.2
Cross section of hexagonal sawmill
(based on an image in the Groot Volkoomen Moolenboek, "The Great Complete Mill Book")

1. *cap*
2. *upright shaft*
3. *lower wallower*
4. *crankshaft and crank wheel*
5. *retrieving device, carriage return winch*
6. *pawl feeder mechanism for saw carriage*
7. *saw carriage*
8. *saw floor*
9. *foundation columns, piers,*
10. *frame saw pit or bottom rig floor*

15.3 THE DRIVING GEAR

The driving gear of both types of sawmills is broadly similar but also has some distinctive differences.
The paltrok winds in its entirety and therefore does not require a main upright shaft. The brake wheel directly drives the crank wheel. Sometimes, for the drive mechanism, a second wheel is present on the windshaft. The crank wheel is implemented as a spur pinion or stone gear.
The cap winder-sawmill has a short main upright shaft. The lower wallower, at the bottom of the upright shaft, drives the crank wheel.
From the crank wheel attached to the square part of the crankshaft onwards, the driving gear of both types is the same.

crank wheel

15.3.1 The crankshaft and connecting rods

crankshaft
crank ends
crank beams

The crankshaft is located in the crank floor and has three cranks. It is thus referred to as a three-stroke crankshaft. As an exception, *De Eenhoorn* (The Unicorn) in Haarlem has four cranks and *De Salamander* (The Salamander) in Leidschendam has two. The crankshaft is supported between horizontal metal timbers recessed into vertically placed crank ends which are inserted into the crank beams or end beams. The lower oaken metal blocks usually contain a bronze bearing seat; the upper ones often do not. Wedges and metal blocks are used to adjust the crankshaft in accurate alignment. The crankshaft is forged from iron.

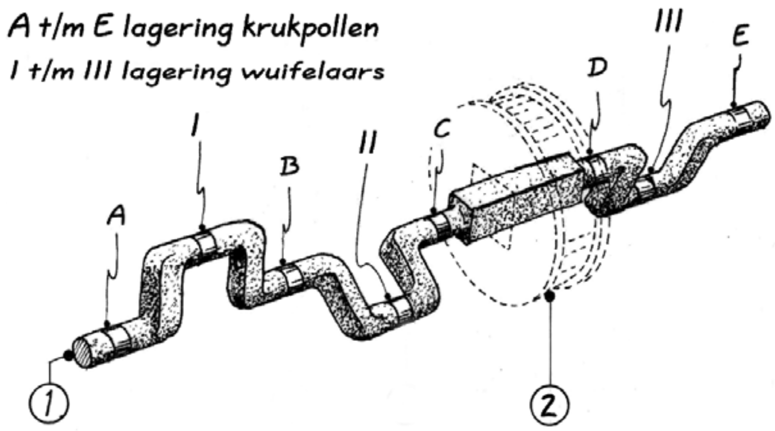


Fig. 15.3.1.1
Three-stroke crankshaft

1. *crankshaft*
2. *crank wheel*

pitmans or connecting rods
saw frames
pivoting crosshead

Between the crank ends are the three crank bends. The pitman bars or connecting rods are hung on the cranks and also bearing-mounted to them. They connect the crankshaft to the saw frames, converting the circular motion into an up-and-down motion. At the bottom, the connecting rods are connected to the saw frames by a transverse joint called the pivoting crosshead, which follows the back-and-forth motion of the connecting rods.

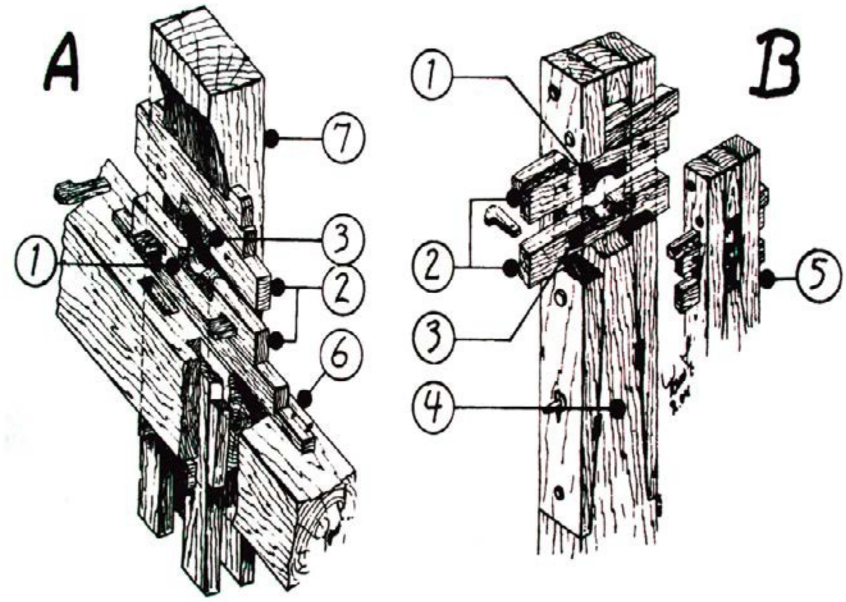


Fig. 15.3.1.2
Bearing of crankshaft and connecting rod

A. crank end
B. ear of the connecting rod

1. *bearing seat*
2. *metal blocks*
3. *bearing seat*
4. *top of the connecting rod*
5. *ear of the connecting rod*
6. *crank beam or end beam*
7. *crank end*

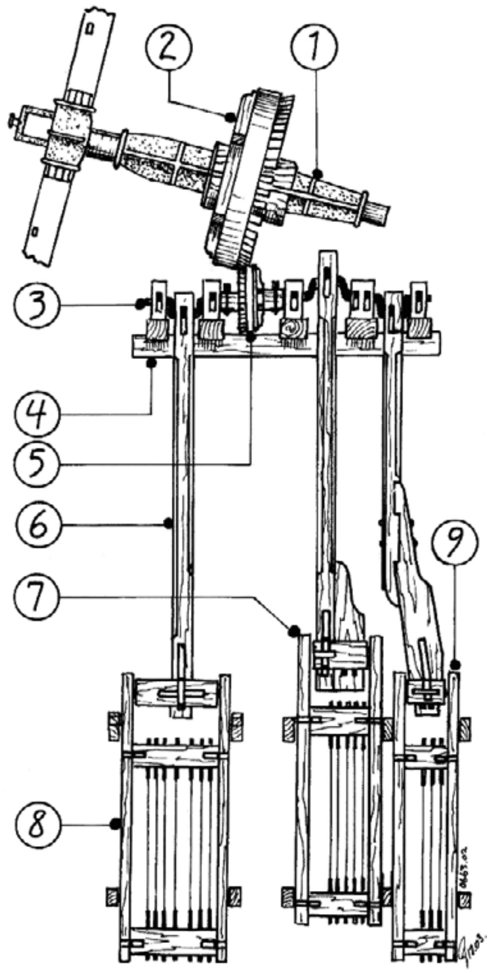


Fig. 15.3.1.3
Saws of a paltrok

1. *windshaft*
2. *brake wheel*
3. *crankshaft*
4. *crank binder*
5. *crank wheel*
6. *pitman bar or connecting rod*
7. *medium frame*
8. *large frame*
9. *rear or trimming saw*

15.3.2 The saw frames

large frame, medium frame, small frame

trimming saw

uprights, lower tensioning head, upper tensioning head, intermediate transom

Sawmills usually have three saw frames: a large, medium and small frame. These are used to cut logs into planks or beams. To square beams or planks, one frame is sometimes constructed as a trimming saw without a saw carriage.
A saw frame consists of two uprights with, from bottom to top, the lower tensioning head, upper tensioning head, intermediate transom and the pivoting crosshead. The lower and upper tensioning heads consist of two parts each, fixed with deep notches between the uprights.

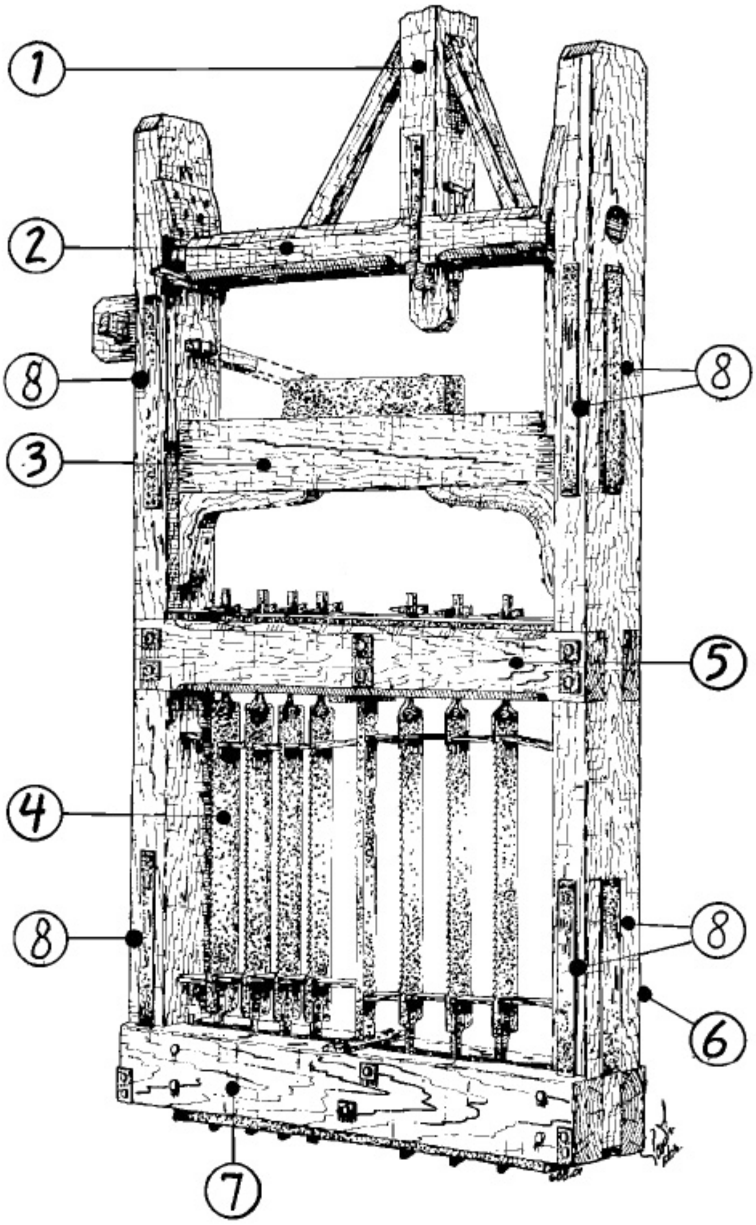


Fig. 15.3.2.1
The saw frame

1. *pitman or connecting rod*
2. *pivoting crosshead*
3. *intermediate transom*
4. *saws*
5. *upper tensioning head*
6. *upright*
7. *lower tensioning head*
8. *striking plate*

lower buckles
upper buckles
buckle eye

Between the two parts there is a cavity some 4 to 5 cm wide into which saw blade components are inserted. In the lower cavity are the buckles, fitted with a hook to attach under the lower tensioning head. In the upper cavity are the upper buckles with a buckle eye at the top which protrude above the tension head through which you insert a wedge. These hold each saw firmly in position and tension it. For that reason, the tension heads are made wide.
Saw frames weigh about 800-1,600 kg. The falling weight of the saw frame determines the sawing force that can be applied.

saw spacers, tensioning blocks

Between the saws you insert saw spacers or tensioning blocks. These chocks determine the distance between the saw blades and thus the thickness of the wood to be sawn. At every sawmill there is a large number of these chocks in the chock bin, sorted by commercial size.

chock bin
striking plates

There are a total of 12 striking plates at the top and bottom of the saw frame posts, on the front, back and sides. These striking plates guide the saw frames. They slide along adjustable lignum-vitae or bronze bearings recessed into the floor joists of the sawing floor and saw jig floor.

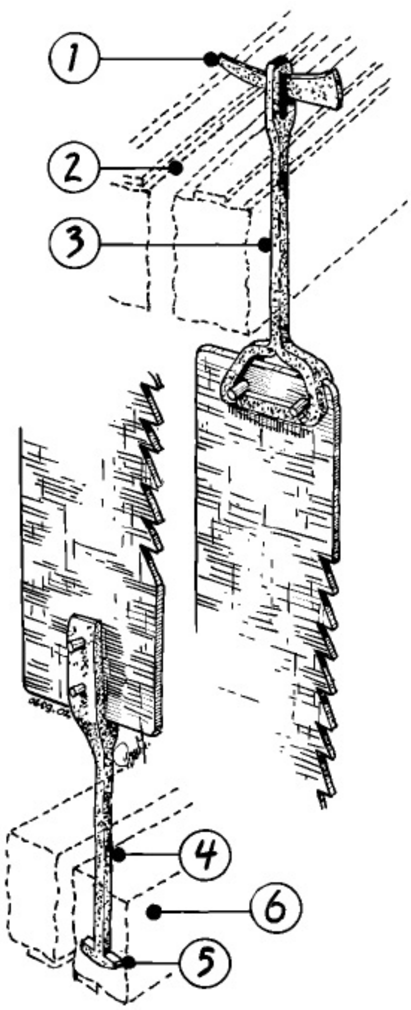


Fig. 15.3.2.2
Saw components

1. *tensioning wedge*
2. *upper tensioning head*
3. *upper buckle*
4. *lower buckle*
5. *hook*
6. *lower tensioning head*

15.3.3 The saw carriages

To feed a tree through the saw frames, you place it on a heavy framework, the *saw carriage*. It slides over hardwood bearings fixed in the sawing floor or is guided between two wooden carriage bearers. A saw carriage consists of two long beams, the loose and fixed *cheek* or girder, connected at the ends by the *cross-beams*. On the cross-beams, above the fixed cheek, there is a third beam: the side with *side rests (lit. 'tussock')*. Here are inserted the side rests that extend into the fixed cheek.
The carriages are interlaced with the saw frames, with usually the fixed cheek inside and the loose cheek outside the saw frame. (See Fig. 15.3.3.1: extended cross-beam belongs on the side of the loose cheek.)

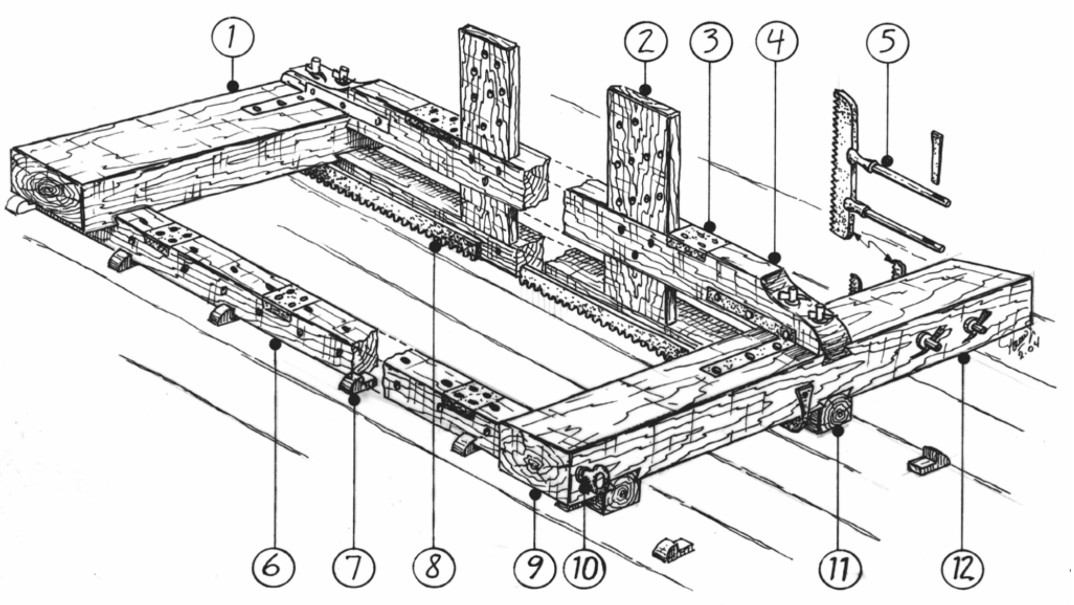


Fig. 15.3.3.1
The saw carriage

1. cross-beam
2. side rest
3. clamping piece
4. side, side member with side rests
5. header blade
6. loose cheek
7. carriage bearing
8. rack
9. cross-beam
10. pull eye
11. fixed cheek
12. extended cross-beam

Staggered dog holes were drilled in the side rests. The miller now lays loose cross beams, called *base plates*, on the cheeks, and on them he places the log or beam to be sawn. Then, above the log, he inserts *press jacks or press bars* into the dog holes of the side rests. He secures these irons with a rope and a *tensioning stick*. In this way he clamps the log in position. To prevent shifting or rolling, the miller hammers *dog irons* into the log and into the *clamping pieces* attached to the cheek and carriage.

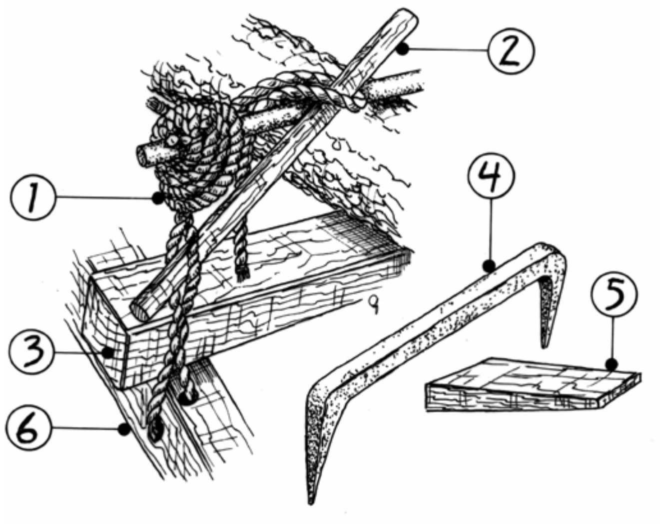


Fig. 15.3.3.2
Anchoring of the log or beam to be sawn

1. *press jack rope*
2. *tensioning stick*
3. *base plate*
4. *dog iron*
5. *wedge*
6. *loose cheek*

squaring floor
header blades, dogs
trimming saw

When trimming, the package of boards does not lie on a saw carriage but slides over bearings on the sawing floor, sometimes provided with guiding wedges: the squaring floor. The extended cross-beam fitted with 1 or 2 iron header blades or dogs (see Fig. 15.3.3.1) pushes the boards through the trimming saw. To guide the boards straight through the saws, they are secured to the loose cheek of the carriage with a dog iron.

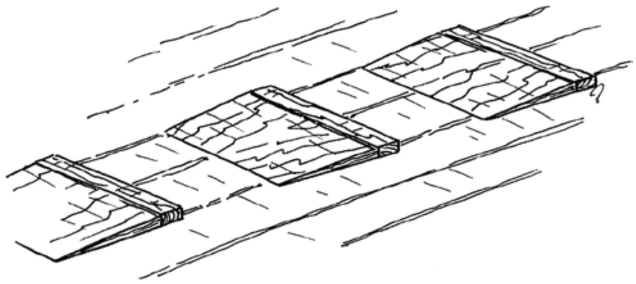


Fig. 15.3.3.3
The squaring floor is fitted with upward sloping floorboards

support board

To prevent the boards from hopping up, support boards — sturdy boards with a transverse timber at the bottom — are placed on top. The support board, located in front of and sometimes behind the saw frame, protrudes through a guide on a tie beam and is secured with a wedge (see Fig. 15.3.3.4). The support board slides in the direction of sawing and naturally jumps back on its own due to increasing bending stress. Sometimes struts are used instead of support boards.

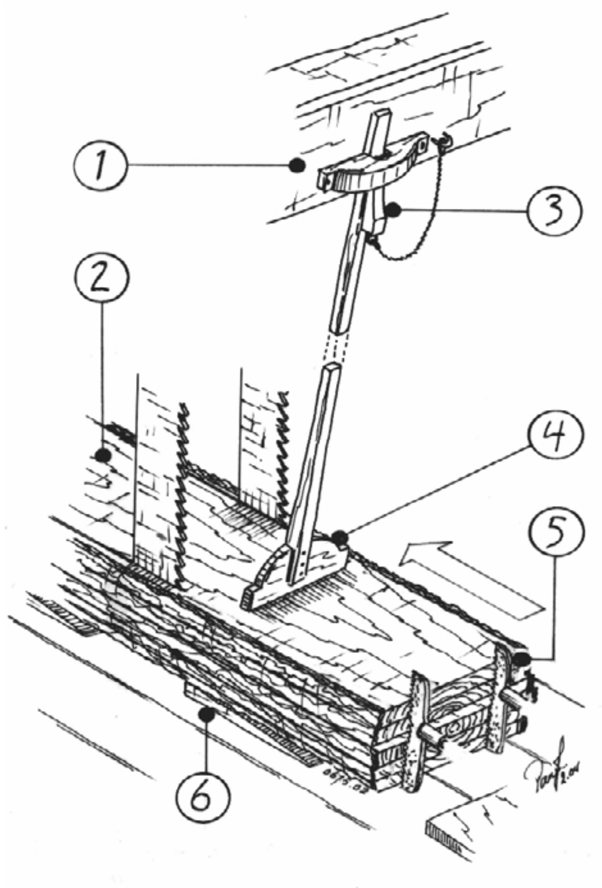


Fig. 15.3.3.4
The support board

1. *tie beam (at paltroks)*
2. *wood to be squared*
3. *wedge*
4. *support board*
5. *header blade of the saw carriage*
6. *squaring floor*

15.3.4 The pawl feeder mechanism

pawl feeder mechanism
feed bar, pawl stick or slotted lever
pawl feeder, pawl

The pawl feeder mechanism carries the saw carriage with the log to be sawn through the saw frame. Hanging from the saw frame that is moving up and down is the feed bar, whose lower end is connected to the pawl stick or slotted lever. This pawl stick hinges in a post next to the saw frame and it is fitted with a number of holes or notches at the top. In one of the holes or notches hangs a long iron hook, called the pawl feeder. A second iron hook, the pawl, is hinged at the same point as the pawl stick.

ratched wheel
feed shaft
metal pinion, rack

With each upward movement, the pawl feeder pulls one or more teeth of the iron ratched wheel past the pawl that, with each downward movement of the pawl feeder, prevents the ratched wheel from turning backwards. The ratched wheel is attached to the feed shaft that passes under the saw carriage. On the feed shaft there is a small metal pinion that drives the rack mounted under the saw carriage. As the pawl feeder pulls through one tooth of the ratched wheel, the saw carriage slides about 1 mm further.

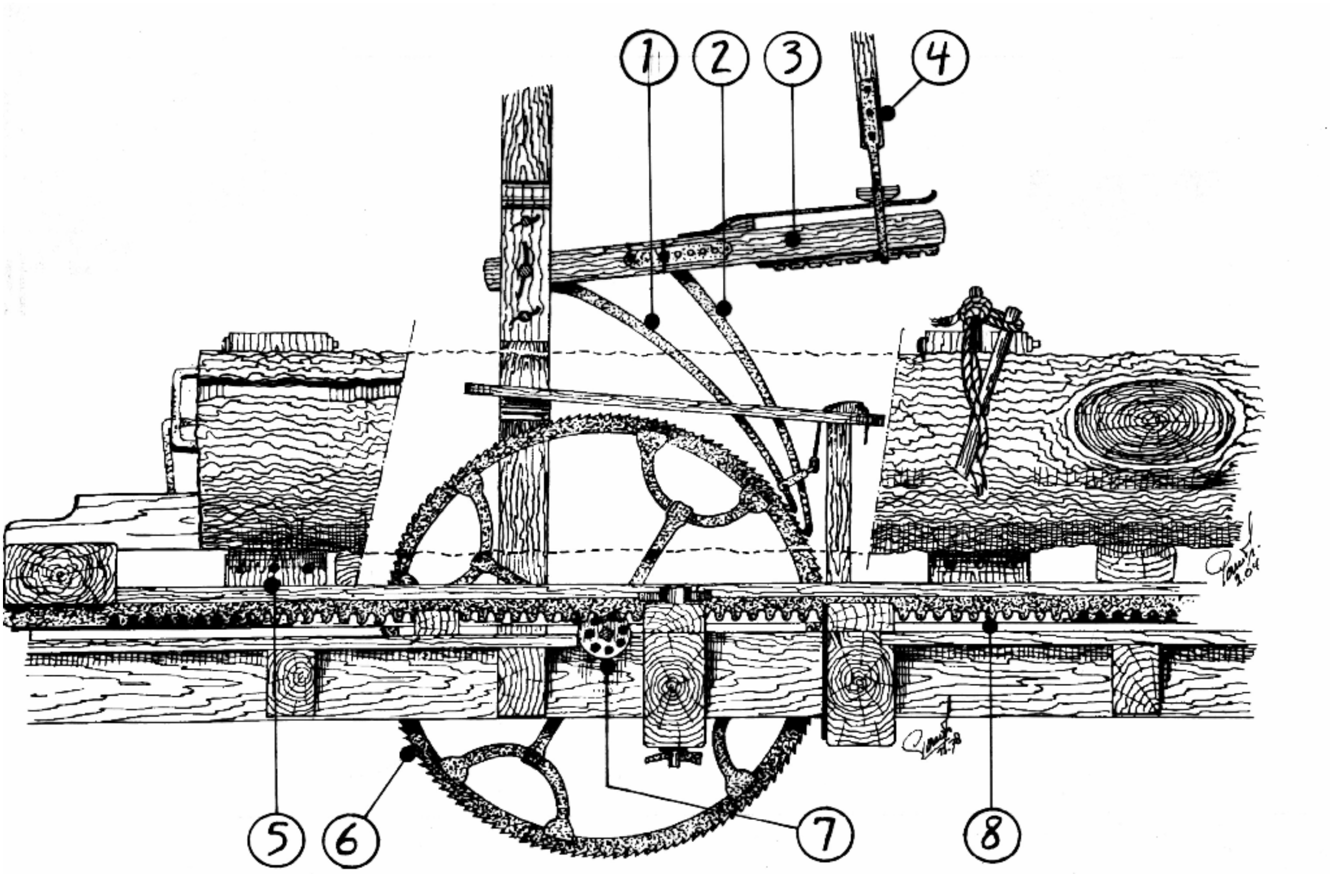


Fig. 15.3.4.1
The pawl feeder mechanism

1. *pawl*
2. *pawl feeder*
3. *pawl stick or slotted lever*
4. *feed bar*
5. *side rest*
6. *ratched wheel*
7. *ratched wheel with pinion*
8. *rack*

The number of teeth the pawl feeder engages on one upward movement depends on where it hangs on the pawl stick. The miller uses this to determine the feed of the saw carriage: in other words, how far the carriage moves per full stroke of the saw frame. The sawing speed is further affected by the speed of the up-and-down movement of the saw frame, which depends on the wind.
The miller can stop sawing without stopping the driving gear by pulling the pawl feeder away from the ratched wheel.

15.3.5 The carriage return winch

carriage return winches
retrieving devices
retriever pawl
brake rope

In order to retrieve the logs from the water, place them on the saw carriage and drag the saw carriage itself back, carriage return winches or retrieving devices were placed on or under the saw jig floor. The carriage return winch works in the same way as the pawl feeder mechanism and is also driven by the saw frames. Here, the pawl feeder is called a retriever, and the 'ratched wheel' is a smaller ring gear attached to a roller. The pawl prevents recoil. Heavy ropes, the ends of which are fitted with a sturdy hook, are wrapped around the rollers. At paltroks, around the crane carriage return winch roller there is another heavy rope with a full turn against the winding direction, the brake rope. This can be used to slow down the roller slightly when depositing the log on the saw carriage. At cap winder-sawmills, this is done by alternately lifting ("milking") the pawl and the retriever. The carriage return winch hangs under the saw jig floor at cap winder-sawmills; at paltroks, the carriage return winch is on the saw jig floor.

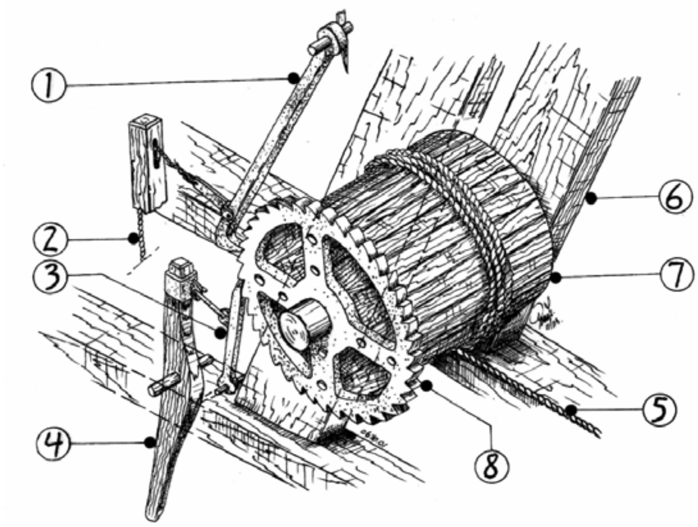


Fig. 15.3.5.1
The saw carriage return winch

1. *retriever*
2. *control rope*
3. *pawl*
4. *pawl stick*
5. *crane rope*
6. *roller post*
7. *roller*
8. *ring gear*

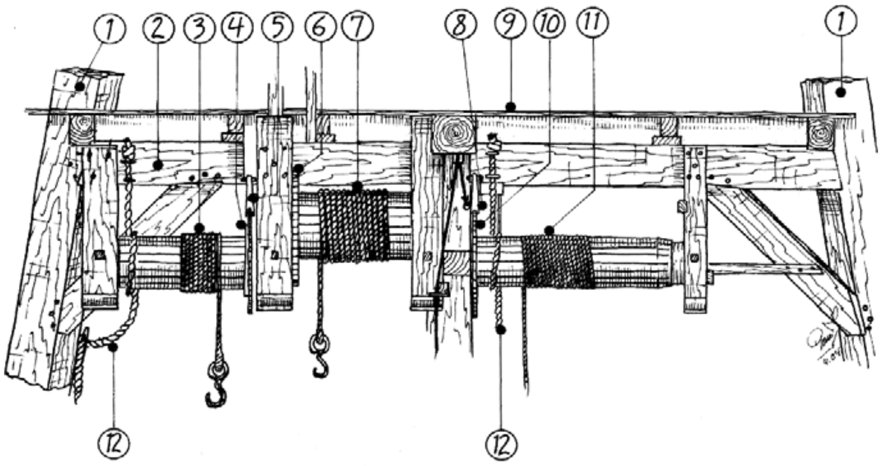


Fig. 15.3.5.2
Carriage return winches for a cap winder-sawmill with two carriages

1. *corner post*
2. *binder*
3. *carriage return winch, large frame*
4. *ring gear*
5. *pawl*
6. *ring gear*
7. *hoisting roller for the carriages*
8. *pawl*
9. *saw jig floor*
10. *ring gear*
11. *carriage return winch, small frame and trimming saw*
12. *brake rope*

15.3.6 The crane and crane tackle

crane

At the beginning of the sawing floor in a paltrok there is a crane. This is needed to hoist the logs out of the water. As seen from the tail pole, the crane can be either on the left or right side of the sawing floor. In a paltrok with the crane to the left, the sawing direction is opposite to that of one with a crane to the right.

crane tackle
crane rib

Paltroks are additionally equipped with two four-disc pulley blocks: the crane tackle that can be rolled back and forth over the crane rib, a heavy beam above the sawing floor. This is used to bring the log into the correct position on the saw carriage. Some cap winders also have such a hoisting device.

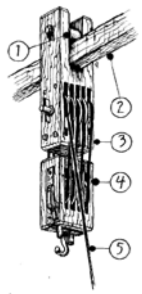


Fig. 15.3.6.1
The crane tackle

1. *roller*
2. *crane rib*
3. *upper block and tackle*
4. *lower block and tackle*
5. *line*

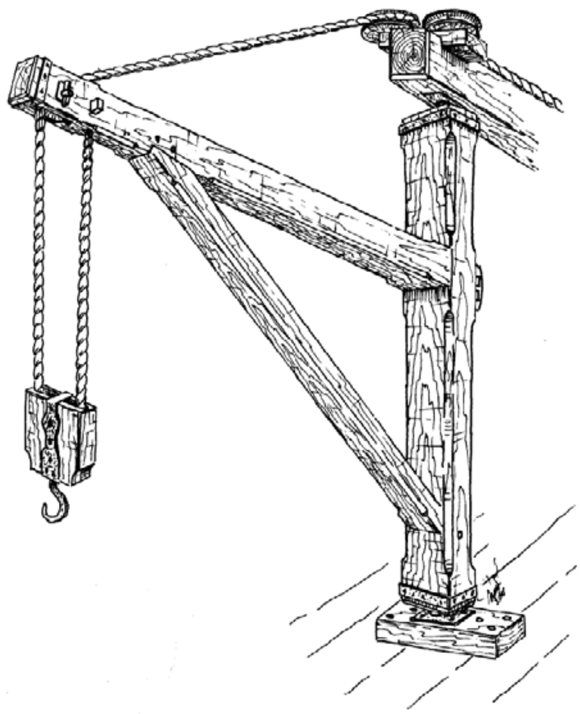


Fig. 15.3.6.2
The crane as applied to the paltrok with crane post, crane arm and strut

15.3.7 The log pond

log pond,
watering

In the canal next to which the mill stands, an inlet called the log pond is usually dug. This is used for storing the logs. The logs can also be watered here prior to processing. During watering, which can take several years, the water displaces the sap from the wood and this greatly improves durability.

ramp Cap winder-sawmills have a ramp at the beginning of the sawing floor up to the log pond to enable the carriage return winch to retrieve logs from the water.

hook boat A specific, rectangular vessel called the hook boat was used to retrieve logs from the log pond for dragging under the crane or to the ramp.

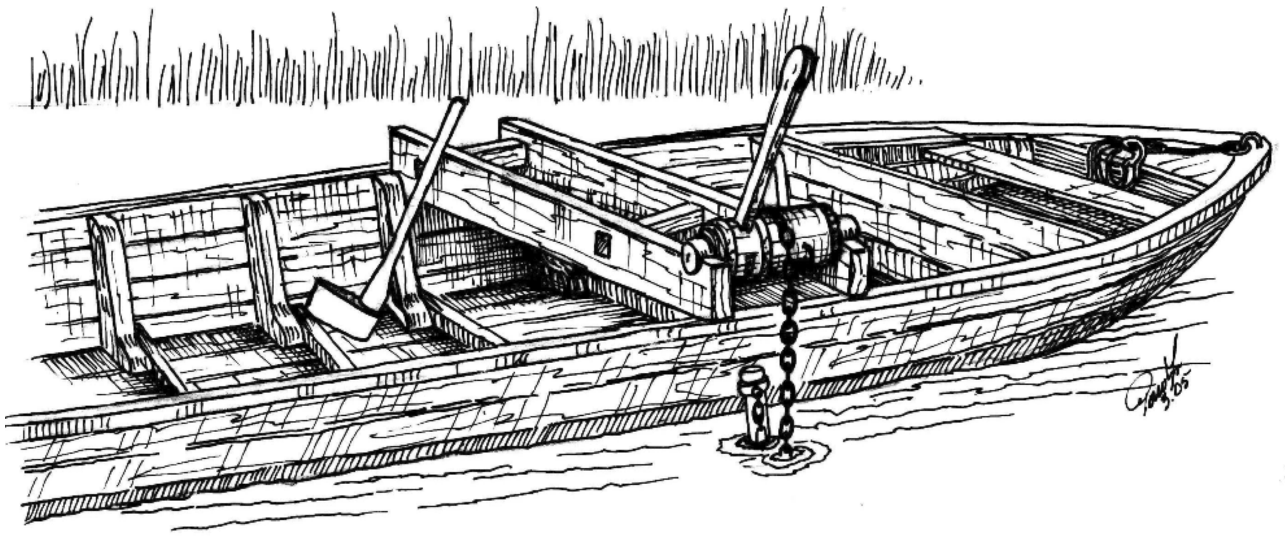


Fig. 15.3.7.1 & Fig. 15.3.7.2
Hook boat

Each saw mill had one of these vessels.
The hook is hammered into the log to be sawn.

15.3.8 Differences between the paltrok and the cap winder

- Paltroks wind in their entirety, cap winders only the cap.
- The sawing floor of paltroks is higher than that of cap winders.
- Paltroks have a crane to take the logs out of the log pond; cap winders have a carriage return winch or retrieving device and a ramp.
- Paltroks are half-open; you work outside but are sheltered from the wind. In cap winders, you work in the sawing shed although there the doors are always open and the wind penetrates.

- Paltroks have no upright shaft, while cap winders have a short one.
- Octagonal cap winder-sawmills stand on a square underbody (see Fig. 5.7.4.8), because otherwise four of the eight posts would interfere with the saw carriages. With a hexagon this is not necessary as it has two posts in the middle of the walkway between the saw frames.

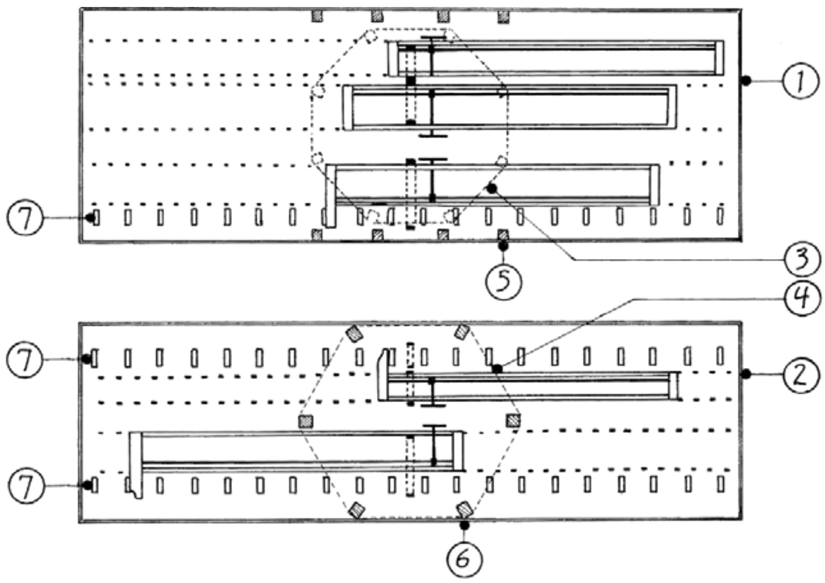


Fig. 15.3.8.1
Layout of the sawing floors of an eight-sided and a six-sided sawmill

1. *sawing floor of an octagon*
2. *sawing floor of a hexagon*
3. *perimeter of an octagon*
4. *perimeter of a hexagon*
5. *posts, square underbody*
6. *posts, hexagon*
7. *squaring floors*

Chapter 16 The Paper Mill

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NOTES

16.1 INTRODUCTION

The first properly writeable material, parchment, came from Pergamum, in western Turkey. Parchment supplanted papyrus, made from the papyrus plant, on which the ancient Egyptians were already writing.
Paper, as we know it, was invented in China around 105 AD. It reached Europe via Spain, where the first paper mill was established around 1100. Almost 500 years later, in 1586, Holland had its first paper mill. In that year one mill was constructed in Zwijndrecht, one in Dordrecht and the first wind-driven paper mill was set up in Alkmaar.

In the southern and eastern regions of the Netherlands, water-powered paper mills were built. There they had ample access to the clean, clear water needed to manufacture white paper.
In the western Netherlands, people built wind-driven paper mills. These were stage mills with long barns, because a lot of drying space was needed. To make white paper, they used well water which was pumped from great depths with a pumping mill. The only working wind-driven paper mill left in the Netherlands is *De Schoolmeester* (The Schoolmaster) in Westzaan.

16.2 LAYOUT OF A WIND-DRIVEN PAPER MILL

In the production of paper, the raw material must undergo several processes. This requires multiple facilities and spaces.
These various spaces are:

- the reservoir area
- the rag-house
- the mill
- the workhouse
- the hanging room
- the packing room

These will be discussed further in the following sections.

16.3 BRIEF DESCRIPTION OF THE PRODUCTION PROCESS

1. Sort rags by colour and type.
2. Tear the rags with the tearing knives into pieces, remove buttons, etc.
3. Finely chop the torn material in the chopping tub or chopper.
4. Wash and beat into fibres in the beater or hollander.
5. Let the ground material run off from the beater into a stuff-chest.
6. Dissolve the whole stuff in the mixing trough with water until it forms a uniform mass.
7. Transfer the whole stuff into the dipping-vat.
8. Form paper with the dipping mould. Stack with felt to create posts of 125 pieces.
9. The post goes under the wet press and then to the hanging room.
10. The paper is checked on the reading table.
11. Press paper flat in the dry press.
12. Calender the paper to make it smooth.
13. Press, sort by thickness and press again.
14. White paper goes to the sizing kettle.
15. Press and dry white paper in the hanging room.
16. Smooth out white paper with the calender rollers or plaster mill.
17. Press, sort by thickness, press again and pack.

16.4 THE RESERVOIR AREA

pumping mil,

In the beginning, people in the Zaan region used ordinary surface water. This was used to make grey paper. Making white paper required pure and clean groundwater to be pumped from great depths. The pumping mill was used for this purpose.

connecting rod
wells

This stood on an elevation under which was placed a sturdy lever that moved up and down via a connecting rod and a crank that was part of the wind shaft. Pumping mills pumped water from deep water wells, called 'petten' in the Zaan region. A well consisted of oak barrels placed on top of each other, down to a depth of about 10 metres. Through the lowest barrel, narrow wooden tubes were driven up to 25 to 30 m into the soft peat soil.

reservoir area

The pumped water was further deferrized in the reservoir area. This consisted of narrow channels dug in a zigzag with a total area of as much as one hectare. Eventually the water ran to a large tank under the mill where it was pumped to a filter tank that was filled with sand and shells and had a cloth over the bottom. The filtered water ran back under the mill and was pumped into the water tanks by the second pumping mill for use in the beaters. Making 1 kg of paper required 150 to 175 litres of water.

white paper mills
grey paper mills

All pipes were made of lead or copper to prevent the water from ever coming into contact with iron. This was especially true for white paper mills, to avoid rust stains in the paper. For grey paper mills, this was less important.

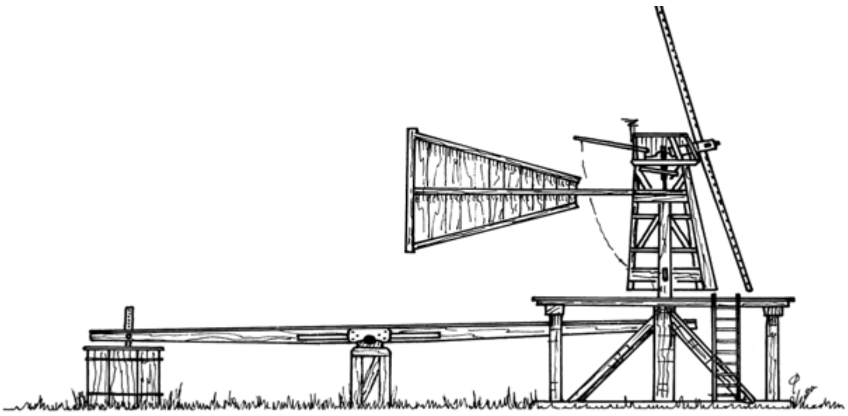

Fig. 16.4.1
The pumping mill stood on a stage, equipped with a long lever to the well

16.5 THE RAG-HOUSE

rag-house

The rag-house was where the rag pickers worked, processing the rags that came in.

low rag-sorting table

On the low rag-sorting table, a table with a slatted top, the rags were spread out and sorted by colour. White paper mills processed only white rags.

high rag-sorting table

Next to the low rag-sorting table was the high rag-sorting table, a table with a top made of copper mesh or fine wooden latticework. Dirt and dust was beaten out of the rags on this. Some mills had a pinion, a drum made of copper mesh in which the rags were spun around. The dust (dirt) from the pinion then fell into a wooden box below.

pinion

Fig. 16.5.1
The rag-house with the table on which the tearing knives stand

tearing bench

After sorting and cleaning, the material went to the tearing bench on which a fixed, wide and razor-sharp tearing knife was placed. Buttons, hooks, buckles, etc. were removed by this and people tore the rags into small pieces.
Raw material with long fibres such as hemp rope that was needed to give strength to packing paper was chopped into small pieces on a chopping block.

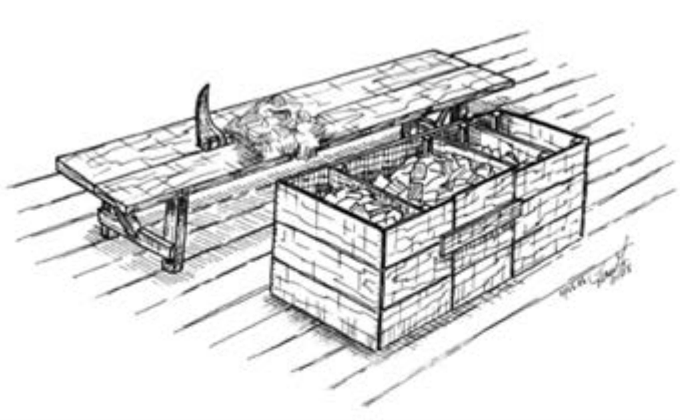

Fig. 16.5.2
The tearing bench with the tearing knife and, next to it, the sorting box

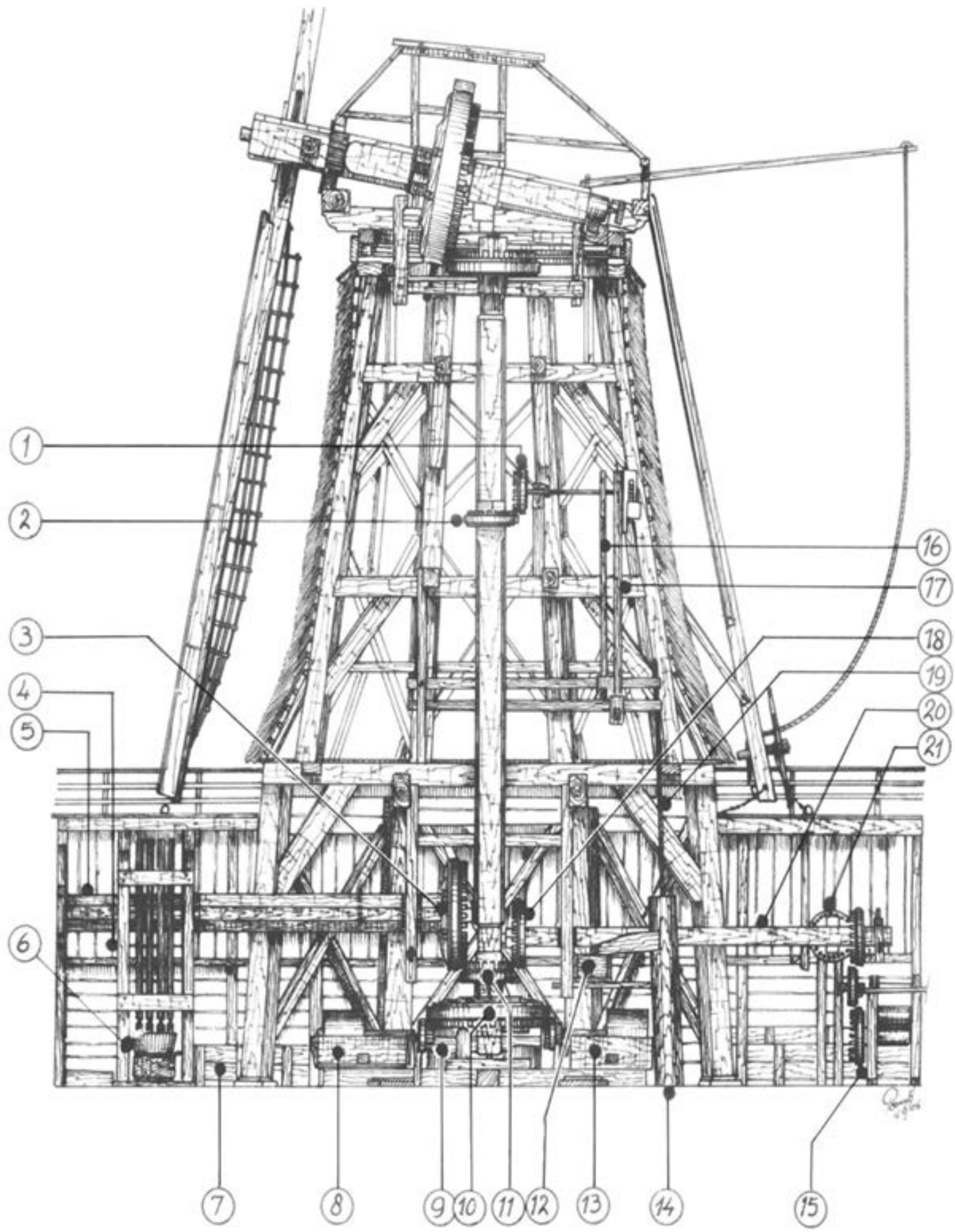
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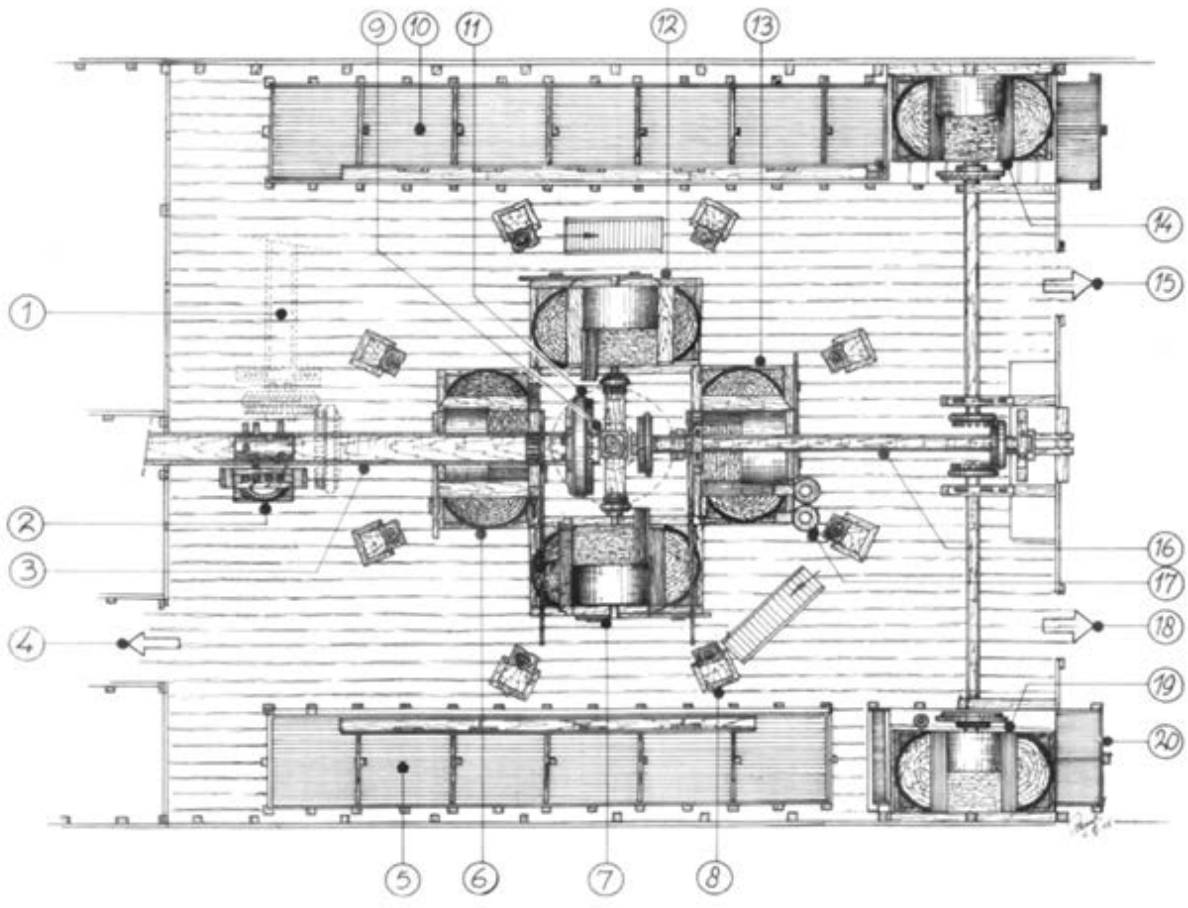
Fig. 16.6.1
The paper mill

1. *crank wheel*
2. *crown wheel for the pump*
3. *large cam wheel*
4. *chopping-tub*
5. *large cam shaft*
6. *trough*
7. *stuff-chests*
8. *beater*
9. *driving wheel*
10. *large pit wheel*
11. *crown wheel for the chopping-tub and calender*
12. *water tank*
13. *beater*
14. *water pumps*
15. *calender or plaster mill*
16. *connecting rod*
17. *connecting rod*
18. *small cam wheel*
19. *pump rods*
20. *small cam shaft*
21. *cogwheel for stirrer*

Fig. 16.6.2
The work floor

1. *cam shaft of edge runner stones*
2. *chopping-tub*
3. *large cam shaft*
4. *to rag-house*
5. *stuff-chests*
6. *beater*
7. *beater*
8. *octagonal post*
9. *upright shaft*
10. *stuff-chests*
11. *large cam wheel*
12. *beater*
13. *beater*
14. *stirrer*
15. *passage to workhouse*
16. *small cam shaft*
17. *water pumps*
18. *to workhouse*
19. *stirrer*
20. *stuff-chests for the dipper*



16.6 THE MILL

Paper mills drive quite a fair amount of machinery and turn heavily. For this reason, the sail cross is equipped with a deep camber, wide sail frames and additional forward-facing leading boards. This enables the mill to pull well in strong winds. Paper mills often had a flat roof instead of a stage.

flat roof
The flat roof is the roof of the barn in which the mill stands.

work floor
The upright shaft extends down to the work floor, is an extra heavy duty version, and is equipped with a number of crown wheels.

crank wheel, water pumps
The upper crown wheel in the middle floor in front of the pump drives the crank wheel with the water pumps for pumping up all the water needed.

chopping-tub
About three metres above the beating floor, two wheels are found on the main upright shaft. The upper crown wheel drives the chopping-tub and edge runner stones via the large cam wheel and the large cam shaft.

calender
hollander
Opposite it, the same wheel drives the small cam shaft for the stirrers and the calender via the small cam wheel. Below it is the large pit wheel that drives the four beaters or hollanders that stand on the beating floor.

16.6.1 The chopping-tub

sill
trough
stampers
rooter
sleeper tree
feed stick
ring gear
drive lever
It consists of a trough that rotates over a heavy iron-capped sill via a pin in the bottom. In the trough, the bottom of which is fitted with a metal plate, there are four heavy stampers equipped with chisels which chop the pre-processed material from the rag-house into tiny pieces. The fourth stamper is the rooter; it is somewhat twisted and slightly agitates the mass in the trough with each stroke. The sleeper tree receives the stampers so that the blades remain about half a centimetre above the bottom. The trough is pulled around by a feed stick that engages in a gear ring around the trough. In turn, the feed stick is moved back and forth by the drive lever, a heavy wooden lever propelled by spokes on the large cam shaft.

shredded rag storage
When the material is sufficiently finely stamped, it is stored in the shredded rag storage for further processing.

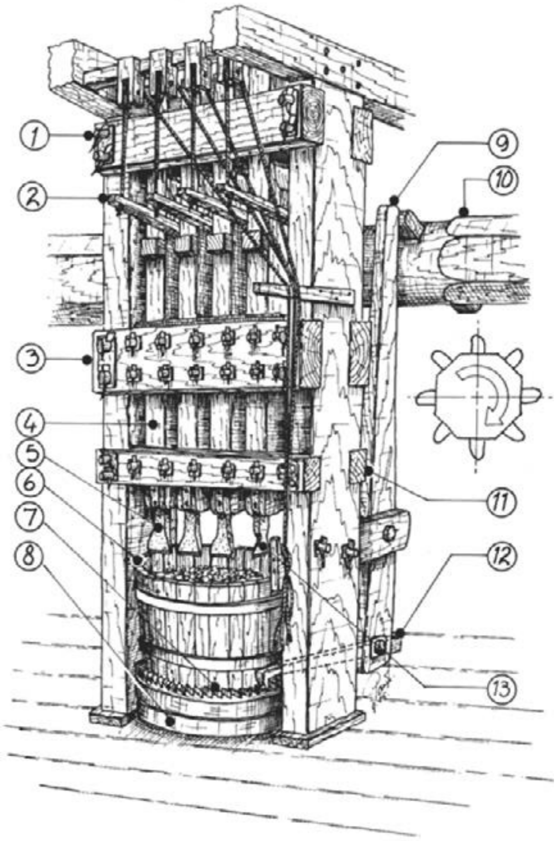


Fig. 16.6.1.1
The chopping-tub

1. *upper stamper spacer post*
2. *release lever*
3. *sleeper tree*
4. *stamper*
5. *stamping blades*
6. *trough*
7. *ring gear*
8. *sill*
9. *drive lever*
10. *large cam shaft*
11. *lower stamper spacer post*
12. *pawl feeder*
13. *rooter*

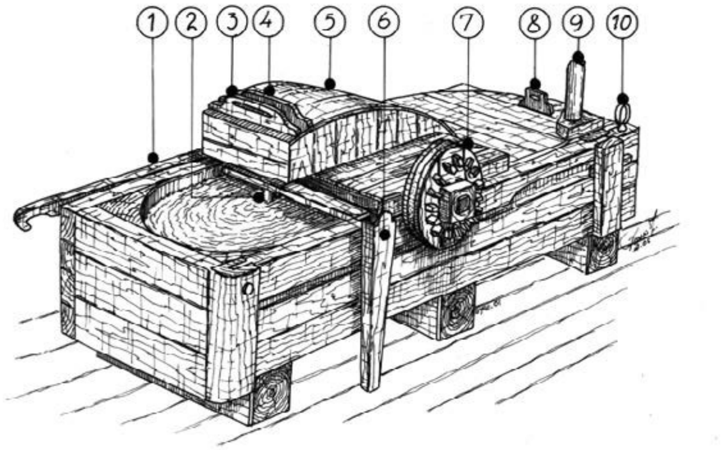
16.6.2 Beating

beater, Hollander
driving wheel
rise, bed-plate
beater roll
frayer
fillets

Beating is done in the beater or Hollander, which was invented in the Zaan region, perfected there in 1672 and made suitable for the production of white paper. It was a major technical improvement in paper-making. From the pit wheel, each beater is driven by a driving wheel of approximately 70 cm in size. The beater, filled with about 2 m^3 of water, is a heavy wooden container which measures about 3 m x 1.5 m and has rounded inside corners. A wooden partition wall about 6 cm thick, the ends of which extend to the beginning of the curve, divides the beater into two parts. In one run there is a raised part, called the rise, which contains the bed-plate: a heavy metal sill, the top of which has sawtooth-shaped furrows along its full length. Above this bed-plate rotates a 65 to 70 cm diameter hardwood roller, the beater roll. Protruding metal fillets, into which two furrows per fillet are cut, are inserted in the roller. The flat part, 8 to 10 mm wide, is the frayer. In white paper mills, the bed-plate and fillets were made of brass but in grey paper mills, cheaper soft iron was used.

Fig. 16.6.2.1
The beater or hollander

1. *outside gap of the beater roll*
2. *partition wall*
3. *washing sifter*
4. *dust slide*
5. *cover over the roller*
6. *waste water discharge*
7. *driving wheel*
8. *outlet slider*
9. *water supply*
10. *inside gap with eye*



jaw

inside gap, outside gap

Behind the bed-plate, the rise follows the beater roll to 5 cm below the top edge of the beater and then descends at an angle of about 40°. That last part is the jaw. The roller rotates on an iron shaft of about 10 x 10 cm, bearing-mounted on the inside gap and outside gap. The paper-maker uses this to set the distance between the beater roll and the bed-plate.
During the beating process, the beater roll pulls the material across the bed-plate via the rise, causing it to tear apart. Then it falls down over the jaw and floats back to the rise via the rounded inner sides in the beater, and so on. A hood is placed over the roller to prevent splashing.

hood
stuff-chest

When the fabric is completely ground into fibre, the mass is drained through a slide in the beater into a stuff-chest, a 5 m x 1.5 m container whose bottom is made up of closely spaced slats, so that the water can drain away and the paper dust remains. When there is sufficient wind, milling takes place and the chests are filled. The paper-makers can then make paper every day, even when there is no wind.

16.7 THE WORKHOUSE

16.7.1 The stirrers

stirrers

The drained whole stuff in the stuff-chest now goes to the stirrer. These stirrers look the same as the beaters except they don't have a bed-plate.

stirrer roller

Moreover, the stirrer roller here is made entirely of wood and has only a few narrow wooden teeth across its full width that brush closely across the rise in the wooden bottom. The stirrer roller mixes the thickened substance with water again.

cam shaft

The stirrers are driven by the small cam shaft mentioned above.

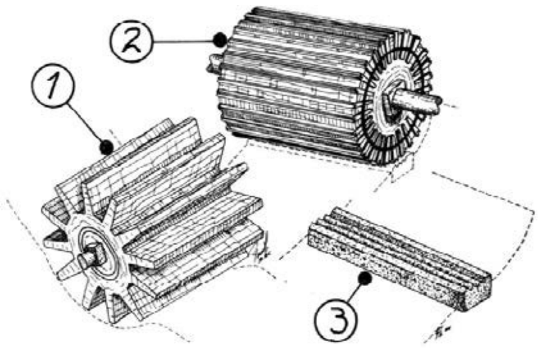


Fig. 16.7.1.1
The rollers

1. *stirrer roller*
2. *beater roller*
3. *bed-plate*

16.7.2 Forming the sheet

beater run-off reservoir
dipping-vat, dipper, coucher

The dissolved whole stuff is drained into a beater run-off reservoir. From there, it is added to the dipping-vat using a pail. Two men, the dipper and the coucher, worked at the dipping-vat.

dipping mould, cover

Together, they use two dipping moulds and one loose oak rim or cover. A dipping mould consists of a wooden rim with a number of narrow slats in between, over which a very fine grid of thin copper wire is stretched.

shuffling
plank

The dipper immerses a dipping mould into the trough, distributes the fibrous mass evenly over the entire surface (which is called shuffling), where the fibres are felted into a sheet and most of the water drains away, and slides the dipping mould over the plank to the coucher.
The dipper removes the loose lid and uses the second frame to dip the next sheet.

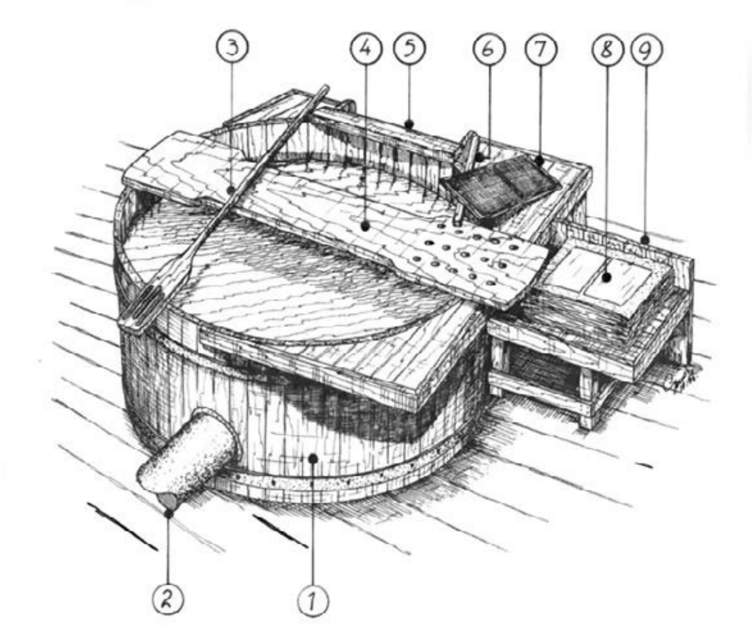


Fig. 16.7.2.1
The dipping-vat

1. *trough*
2. *blower*
3. *agitator or stuff pole*
4. *plank*
5. *place for the dipper*
6. *stay*
7. *dipping mould and frame*
8. *couching table*
9. *place for the coucher*

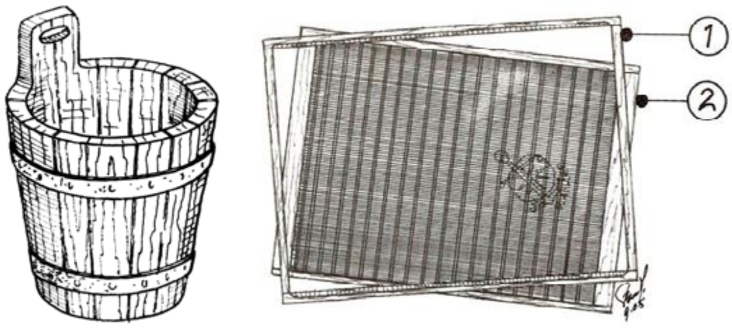


Fig. 16.7.2.2
A stuff cup and a mould frame

1. *edge or cover*
2. *dipping mould with watermark*

coucher

In a fluid motion, the coucher inverts the dipping mould onto the felt he has prepared so that the sheet remains on it. The empty dipping mould goes back to the dipper and the coucher covers the sheet with a felt. The two frames are used in rotation until a full stack of 125 sheets of paper has been repeatedly produced; this is called a post.

post, blower

The whole stuff in the dipping-vat is heated; for this purpose a copper bulb or pipe, the blower, is inserted into the trough. Burning peat is placed in the blower, so that the paper stuff in the dipping-vat is heated to about 30 degrees. The hot water runs through the sieve faster, increasing production.

watermark

It is possible to apply a watermark to the dipping frame by making a figure or name from a thin wire. This figure is then sewn onto the sieve.

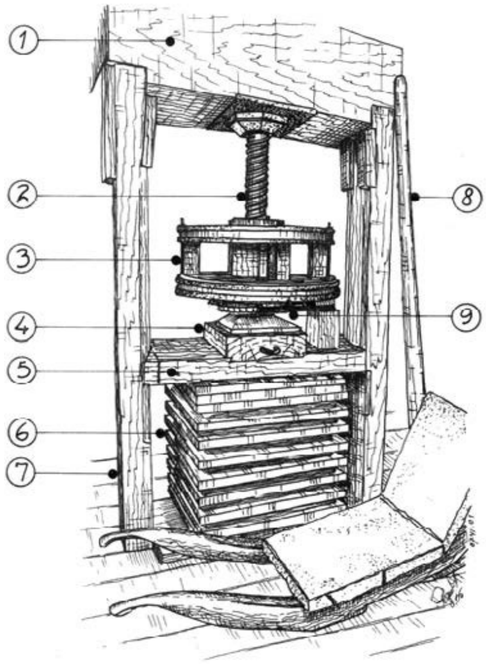


Fig. 16.7.3.1
The wet press

1. *cross beam*
2. *spindle or screw*
3. *stone gear with four supports*
4. *bearing*
5. *bridge*
6. *paper to be pressed*
7. *post*
8. *press pole*
9. *pawl for stone gear*

16.7.3 Pressing paper

wet press

The post of 125 sheets of wet paper, felt and couch boards then goes to the wet press. This consists of a heavy wooden structure and an approximately 10 cm-thick spindle that are used to force water out of the post under very high pressure.

press pole
press beam,
Sampson, layman
hanging room

Tightening the press is done first by inserting the press pole into the stone gear and tightening it by hand. Then the press beam is inserted into the stone gear, which is tightened with the Sampson. After the wet press, the layman separates the sheets of paper and felt and the paper is taken to the hanging room.

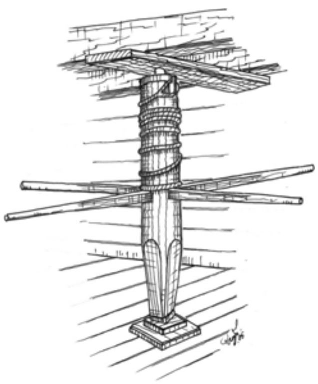


Fig. 16.7.3.2
Heavy-duty Sampson for pressing

16.8 THE HANGING ROOM

husks, treble-line

shutter opener

Paper mills had very long hanging rooms. Those of *De Schoolmeester* (The Schoolmaster) was once 88 metres long but is currently 60 metres.
The hanging room has loose beams, called the husks, which hang between the room trusses between which treble-lines are stretched.
The paper is hung sheet by sheet over the ropes by the drying worker to dry.
The side walls have shutters over their full length. Depending on the weather conditions, some of these on the sheltered side were opened using shutter openers. The drying time varies from 2 days to 2 weeks.

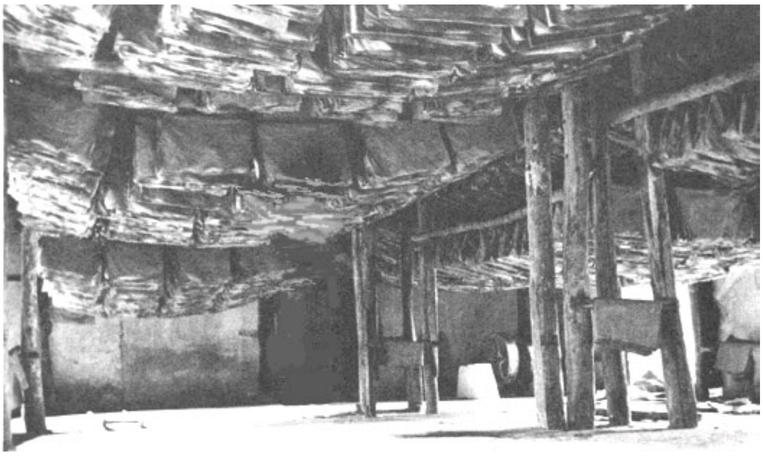


Fig. 16.8.1
Sheets of paper hang by the thousand on ropes to dry

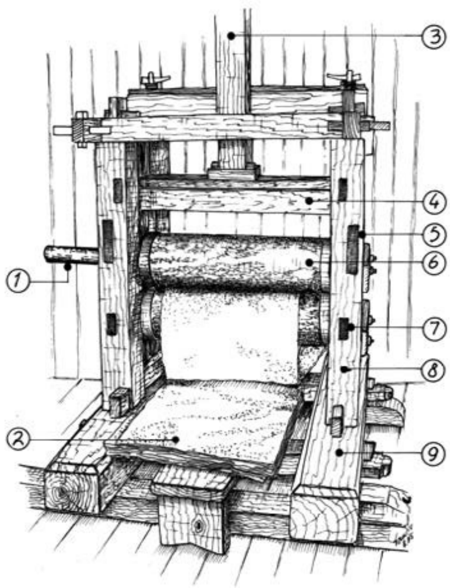


Fig. 16.8.2
The calender or plaster mill

1. *shaft for the rollers*
2. *paper to be processed*
3. *stamp*
4. *press or support beam*
5. *bearing blocks for press roller*
6. *press roller*
7. *bearing block for gloss roller*
8. *post*
9. *foot block*

16.9 THE PACKING ROOM

After drying, the sheets are screened to check for dirt and holes, pressed and then calendered. The calender consists of two rollers through which the paper is rolled under great pressure, sheet by sheet, making the surface smooth. It is then pressed, sorted by thickness, pressed again, and packaged for sale.

calender

White paper must be capable of being written on. To achieve this, the paper is sized in the sizing kettle with a warm mixture of water, animal glue and alum. After this sizing phase, the paper goes back to the hanging room.

sizing kettle

Finally, the product is smoothed in the plaster mill or calender.

plaster mill

packing room
reading table, books
ream

In the packing room, the paper was counted sheet by sheet and checked for quality on the reading table. The paper was then folded double into books of 24 sheets. Twenty books were packaged together into one ream on which was printed an image indicating what type of paper it contained and the name of the merchant.

NOTES

Chapter 17 The Watermill

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NOTES

17.1 DEVELOPMENT OF THE WATERMILL

17.1.1 Introduction

The water-powered mill, or watermill for short, is much older than the windmill. The reason for the development of the watermill was the total change in mankind's way of life, which involved a transition from a nomadic and hunting lifestyle to the life of an arable farming people. As long as people ate whatever was edible and whatever they happened to come across, there was no need for any tool to break down or crush all kinds of food.
Only after the transition to arable farming, whereby food began to consist largely of the seeds of a variety of grasses, did this change. These seeds which were mostly too hard for immediate consumption had to be first rubbed finely between rubbing stones or pounded finely in stamper pots or mortars.

rubbing stone, stamper pot, mortar

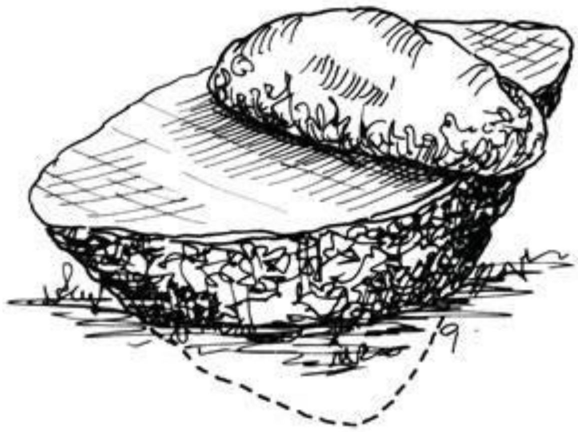

Fig. 17.1.1.1
Prehistoric rubbing stone, a so-called saddle stone

However, in the countries around the Mediterranean, working with rubbing stones was very quickly surpassed by the increasingly developed and useful millstones. Millstones remained in use throughout Europe until the 1st and 2nd centuries AD. Indeed, they were also found in the graves of the Germanic and Celtic people who lived in the lands that now fall under the province of Drenthe, among other locations.

17.1.2 Turning millstones

circular stone

A big step forward was made in the development of the fine rubbing of seeds when people switched from the rubbing stone to the circular stone. When this advance was made is not known.

quern

First there were small millstones turned by hand, the so-called querns, a pair of grinding stones made for household use. These were all fitted with small flat millstones.

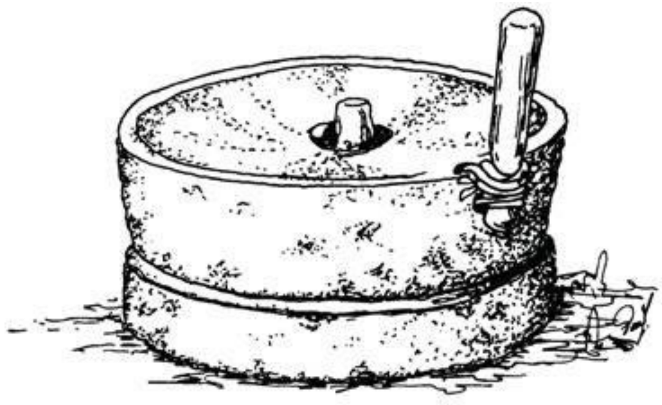

Fig. 17.1.2.1
A circular pair of millstones, the quern

diabolo-shaped mill stones

The oldest reliable information regarding large circular millstones in Europe comes from the finds discovered in Pompeii, Italy. This city was buried under a thick layer of ash in the year 79 AD due to an eruption of the Vesuvius volcano. During excavations over the last 100 years, a complete bakery was found there that had three diabolo-shaped millstones. These millstones were driven by animals or slaves. They were made of a kind of hard lava rock.

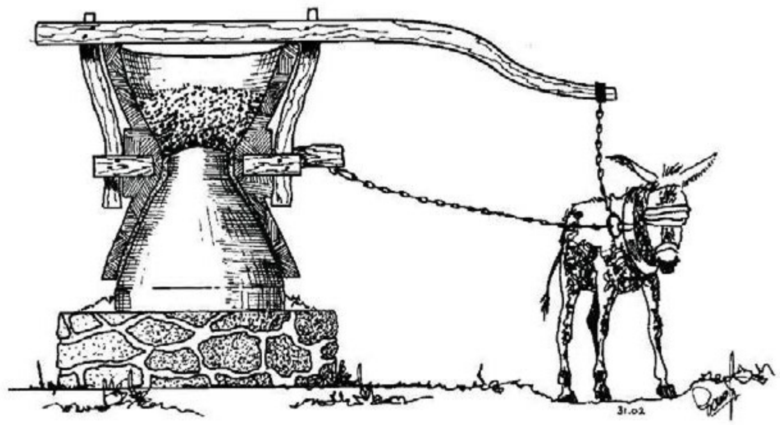

Fig. 17.1.2.2
Roman diabolo-shaped millstone

A diabolo-shaped runner stone turned over a conical bedstone.
In the centre and on the top of the cone was a cast-iron shaft trunnion on which rested a plate, also made of cast iron. This plate had the function of a rynd and was fitted with four holes. Through these holes, the grain ran between the stones.
Also found in Pompeii were several more of these millstones in which this rynd plate had been replaced by a wide cast-iron strip. So, a version strongly reminiscent of the bridge rynd already familiar to us.

conical millstone

In the Roman Empire, in addition to the aforementioned diabolo-shaped mill stones, pairs of stones with slightly conical-shaped millstones came into more frequent use. The large pairs of stones were intended for bakeries, the smaller ones for use on large estates and farms.

flat millstone

The development of millstones progressed from pointed conical through slightly conical to, finally, the flat millstone.

17.1.3 The water-powered mill

water power

water-powered mill

vertical and horizontal waterwheel

The date when people began to apply water power, in any form, is not known. Nor do we know when people started using water power to drive millstones. The oldest references date back to ancient Greece around the year 100 B.C. This reference is found in a document dating from the time around the beginning of our era. It lists notable buildings in the empire of Mithridates, including water-powered mills. This empire was located in the far north of what is now Turkey, so people there were already familiar with this type of mill.
The Romans had watermills with two completely different principles, namely mills with a vertically or horizontally placed waterwheel. Which of the two was the first to be developed will probably never be determined. Given the extremely simple design of the mills with a horizontally placed wheel, this is most likely to be the oldest type.

17.1.4 Watermills with a horizontally placed waterwheel

In countries with mountainous terrain, mills with horizontal paddle wheels were probably most common. This is also explainable given its construction, as this type of mill is highly dependent on very fast flowing water. The principle is that a powerful, guided jet of water is directed onto flat or spoon-shaped paddles.

Stockmühle

Known in mountainous regions as *Stockmühle* or stock mill, this mill is much simpler than the watermills with a vertically placed wheel due to its construction. This type of wheel is, in principle, the archetype of the turbine. Today such mills can still be found in Norway, with some of them still capable of milling.

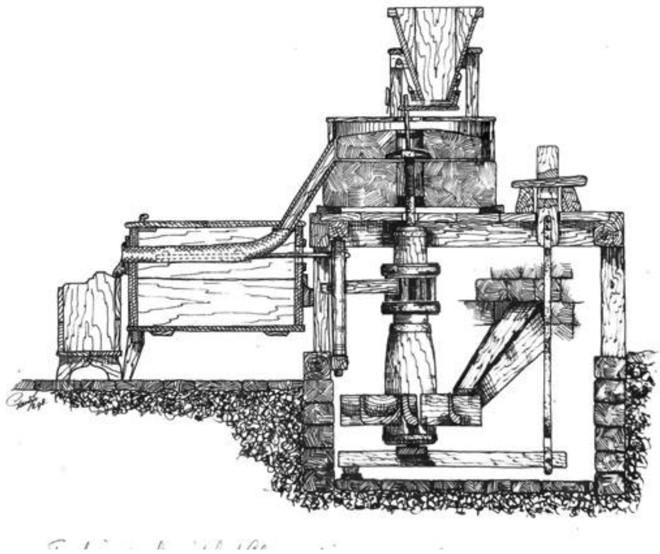

Fig. 17.1.4.1
An example of a complete "Stockmühle", or stock mill

The shaft on which the paddle wheel is placed has its bearing at the bottom on a type of bridge beam (see Fig. 17.1.4.1). The runner stone also rests on the top of the same shaft.
Depending on the amount of water available to drive the mill, the paddles are designed in various ways.
This type of mill has never been used in the Netherlands due to its lack of height differences. The distribution area of this type of mill is around the Mediterranean and in the Alpine region.
We will not consider it further within the scope of this basic course.

17.1.5 Watermills with a vertically placed waterwheel

Around 40 AD we encounter more and clearer mentions of watermills with a vertically placed waterwheel.
Based on these records, it has even been possible to reconstruct the probable design of such a wheel (see Fig. 17.1.5.1). The first tangible evidence for the existence of watermills at the beginning of the current era was found at Venafio, in the Italian province of Compobasso. The waterwheel found there dated to about 300 AD and had a diameter of 1.85 m. Further development of the watermill was generally completed around the year 1000.

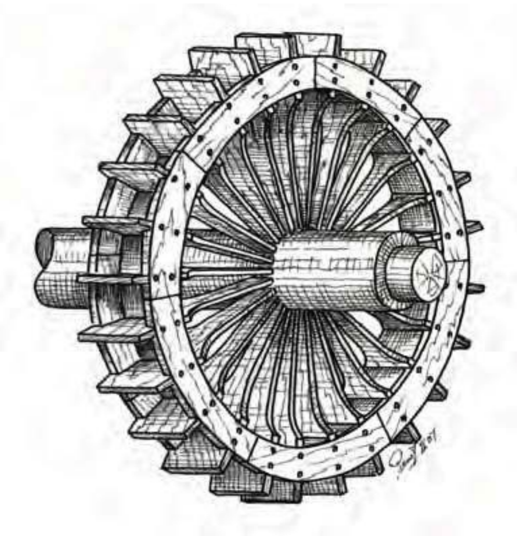

Fig. 17.1.5.1
Reconstruction of a watermill wheel from Roman times

17.2 WEIR RIGHTS

17.2.1 Introduction to wier rights

To operate a water-powered mill, you need the "weir right". In order to mill with a watermill for an extended period of time, not only do you need sufficient water but also sufficient fall to make the wheel go around with some force and speed.
Thus, the miller must have the right to store the inflowing water to a certain height by installing a weir.

weir

weir rights

The right to impound the water is associated with the weir right. Weir rights are inextricably linked to mill rights.

mill rights

The law essentially does not recognise mill rights and speaks only of weir rights, this to avoid confusion. The right to erect a mill does not yet automatically give the weir right, as the mill right can also relate to a windmill. Conversely, if you have the weir right, this also concerns the right to erect a watermill.
Nowadays, the rights apply only to non-navigable waters. Thus, only streams of relatively narrow width and shallow depth are concerned. These types of streams are found in the provinces of Limburg, North Brabant, Gelderland and Overijssel. As a result, the water miller therefore must deal with the Provincial Public Works and Water Management Department to which supervision has been delegated by the State. The miller must also deal with the water authorities under which the watercourse in question falls.

water miller,
Provincial Public Works and Water Management Department
water authorities

17.2.2 Retention of weir right, rules of evidence, and upkeep

If you want to find out more about these issues, you are referred to the scarce case law on this subject.
Despite this problem, the government definitely needs to take account of the weir rights granted. They cannot simply be disregarded. Evidence of a weir right can simply be provided by the fact that this right has been used for a long time without anyone ever challenging it.

proof of weir right

There are four reasons why a weir right may have lapsed or been declared as lapsed, specifically:

lapsed, declared as lapsed

- it has not been used in the course of thirty years.
- it has been formally renounced
- expropriation by means of the Expropriation Act
- bought out by the State or the water authorities

In the latter case, the government will have to adequately compensate the disadvantaged party, as stipulated in section 12a of the Public Works Act of 1900.

Public Works Act of 1900

17.3 WATERWHEELS AND TURBINES

17.3.1 Introduction

waterwheel
overshot, breastshot, undershot mill
turbine watermill

Watermills are characterized according to the design of the waterwheel, specifically: overshot, breastshot and undershot mills. If the watermill is powered by a turbine, then it is called a turbine watermill.

turning trunnion, shaft trunnion
battens
unsalted lard, iron trunnion
cast-iron bearing block
bronze bearing seat

Until the second half of the 19th century, all mill waterwheels were wooden and simple in construction. The shafts of the mills were also made of wood. Iron bands were fitted around the turning or shaft trunnions for reinforcement. The bearing parts, like the wooden windshafts of windmills, are fitted with strips called the battens. The trunnions also turn in open bluestone bearings and are lubricated with unsalted lard. Later, iron trunnions of significantly smaller diameter were inserted into the wooden shafts and secured with straps. The bearings then consist of a cast-iron bearing block containing a bronze bearing seat.

The service life of such wooden wheels that are in daily operation is relatively short and can be set at an average of 25 years.

pit wheel
shaft hole

In many mills, the wooden shaft was still used for a long time, even after the installation of cast-iron running gear or an iron waterwheel. The pit wheel and the waterwheel have a large opening in the centre, called the shaft hole, in which the wooden shaft is tightly wedged.

spoke, float
water turbine

Mixed constructions also appeared around 1900, consisting of a steel shaft with iron hubs for the wooden spokes, a wooden rim and sheet iron floats. At a number of grain mills, the wooden waterwheel was maintained until the 1930s or 1940s. Today, these wheels are still found at only a few mills. They were replaced at other mills, sometimes by an iron waterwheel but more often by a water turbine.

17.3.2 Undershot wheels

mill race
water channel

In undershot mills, water flows at great speed into and through the mill race or water channel in which the wheel rotates, colliding with the lower floats. These are pushed away, causing the wheel to turn. The straight floats are usually perpendicular (radial) or sometimes slightly oblique to the rim.

undershot wheels

A disadvantage with many Limburg waterwheels was their small width and height. Undershot wheels are used with a fall about 1 metre.

Most watermills with simple open bearings require a certain start-up time, during which more water is consumed than under normal operating conditions. Heavy initial running can be reduced by properly lubricating the bearings.

The diameter of undershot wheels is usually 4 to 8 metres and the number of floats is 24 to 48.

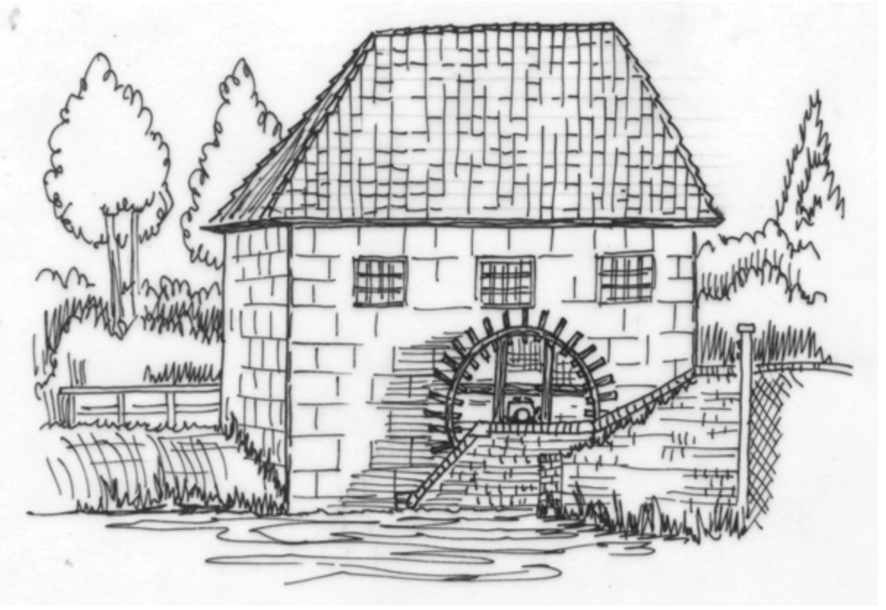

Fig. 17.3.2.1
Mill with undershot wheel

17.3.3 Breastshot wheels

breastshot wheel

In a breastshot wheel, the water arrives at the floats of the waterwheel approximately at shaft height. If the water flows in at a slightly lower or higher position, such as in the case of a small or large fall, then it is called a low breastshot wheel or a high breastshot wheel, respectively.

low breastshot wheel
high breastshot wheel

The flat floats are sometimes angled on the rim, with a large centre line they are directly on the rim. In the mid-19*th* century, undershot and breastshot wheels differed little in shape. Originally, water entered the wheel at a low height to prevent it from striking above the floats.

sheet-iron floats

On the later wooden wheels with sheet-iron floats, the floats on the inside of the wheel were turned around to reduce this over-strike of water.

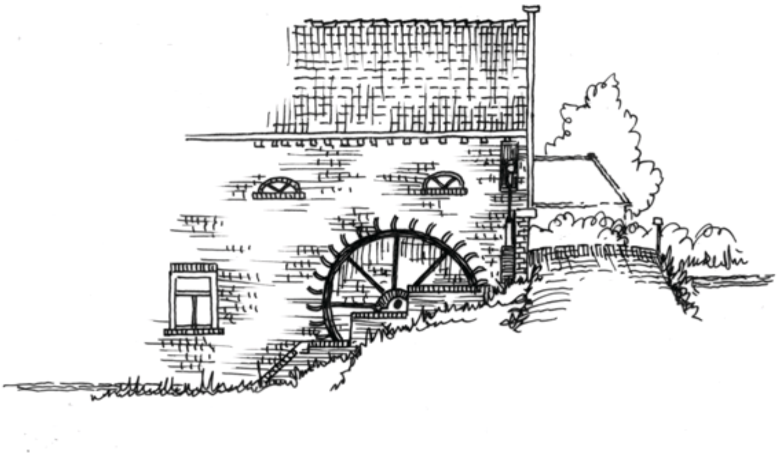

Fig. 17.3.3.1
Mill with breastshot wheel

A breastshot wheel rotates under the influence of the impact of the water on the floats as well as the weight of the water remaining in the buckets until they reach their lowest point.

curved floats

In the late 19th century and early 20th century, a number of mills replaced their wooden waterwheels with all-metal wheels, equipped with curved floats. Sometimes the sides of the buckets are enclosed by circular plates. Breastshot wheels are used at falls from 1 to around 3 metres.

17.3.4 Overshot wheels

trough, flume
buckets

In the case of overshot wheels, the water is raised with a trough or flume to above the wheel, after which it flows into the buckets through an opened hatch.
The sides of the floats are enclosed by two wooden rims or plating. The wheel starts to turn under the influence of the weight of the water in the buckets.
Overshot wheels are used for a fall of about 3.5 to 5.5 metres.
The wooden buckets are placed at a 30° angle to the circumference.

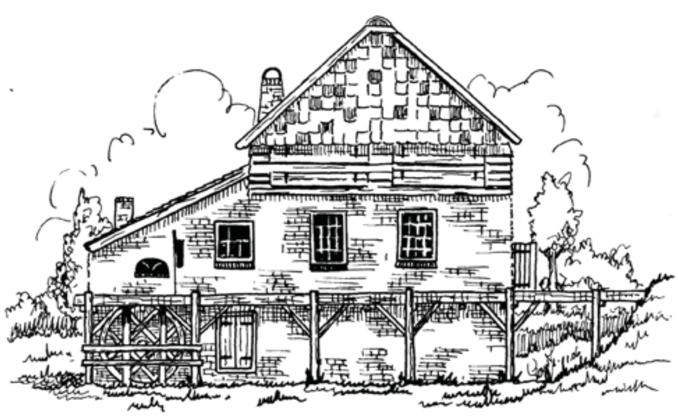

Fig. 17.3.4.1
Mill with overshot wheel and long flume

17.3.5 Wooden waterwheels

set of floats
waterwheel shaft

In its simplest form, a wooden waterwheel consisted of a rim with a set of floats and a double row of four spokes each, fastened radially to the waterwheel shaft with wedges and notches. The spokes were evenly distributed around the circumference. The Swalmen grain mill still had such an undershot wheel with radial spokes until late 1944.

radial spokes, cross arms

Most of the overshot wheels were constructed with heavy wooden cross arms attached to the sides of the set of floats. This construction was usually applied to small-diameter waterwheels, such as the aforementioned overshot wheels.

shaft hole
turning trunnions

At the location of the shaft hole of the waterwheel and the pit wheel, the waterwheel shaft was square and went circularly or polygonally to the turning trunnions.

Breastshot and undershot waterwheels were usually constructed with a row of eight spokes, which were inserted into the corresponding notches on the octagonal waterwheel shaft.

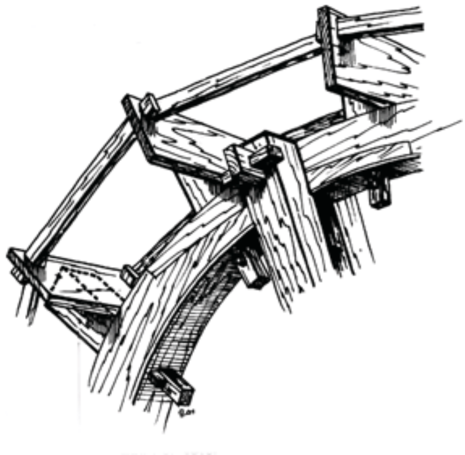

Fig. 17.3.5.1
Construction of a waterwheel with ring pieces and floats with tails

tails
ring pieces (extra ring for support of the floats)

Undershot and breastshot waterwheels feature a single heavy rim in which the tails of the floats are inserted.
The rim consisted of ring pieces joined together with lap joints.
Large-diameter overshot wheels were also constructed in the same way.
These wheels have one row of spokes on each side of the set of floats.

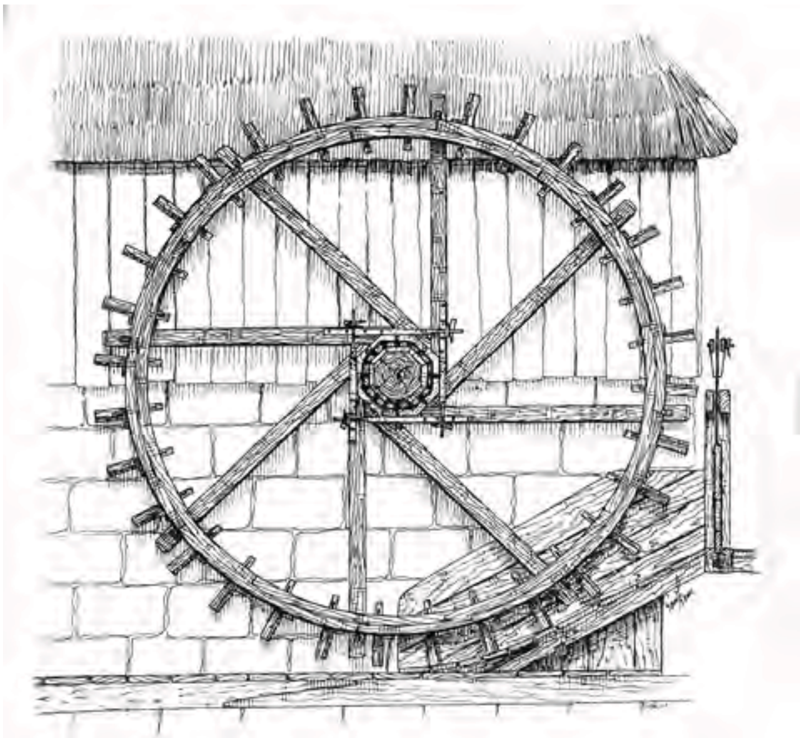

Fig. 17.3.5.2
All-wood low breastshot waterwheel, with radial spokes, for a breastshot watermill

17.3.6 Improved waterwheels

During the 19th century, research was conducted in several countries and theories were developed that led to a great improvement in the waterwheels of the time.

The Poncelet wheel

Poncelet wheel
curved floats
ground mill race

J.V. Poncelet, a Frenchman, developed an iron waterwheel, the so-called Poncelet wheel, in which water flows upward between the floats almost without colliding against the curved floats.
A ground mill race that followed the curve of the wheel was installed. Also, the slider was installed near the circumference of the waterwheel.
This significantly improved efficiency. Also, the buckets were sealed on the sides by a plating which trapped the water inside the buckets.
When executed correctly, this undershot waterwheel reached an efficiency of 65% to 70%.
The first Poncelet wheel in the Netherlands was attached to the *Slaanmolen* mill (Pressing Mill) in Eijsden in 1846. Other Poncelet wheels can be found in Limburg on the mills in St. Pieter and Oud Vroenhoven near Maastricht and in the mills of Petrus Regout in Maastricht and at the bark mill in Gulpen.

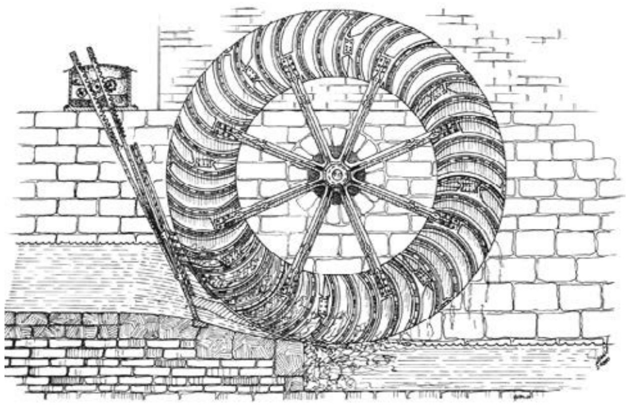

Fig. 17.3.6.1
All-metal Poncelet wheel. This type of wheel was used exclusively as an undershot wheel.

The Sagebien wheel

Sagebien wheel

Another Frenchman, Sagebien, developed the wheel named after him, which was an undershot wheel for large diameters which had very many floats. It was particularly suitable for large amounts of water and the development of great power. The water enters the waterwheel slowly in a dense, broad stream, so that collision losses are almost entirely avoided.
The fall is used almost exclusively as a pressure drop. Efficiency was high: 85% to 90%. Sagebien wheels were used in Nekum (Oud Vroenhoven) near Maastricht.
At the flour mills in Roermond, the original Poncelet wheels were replaced by one large Sagebien wheel.

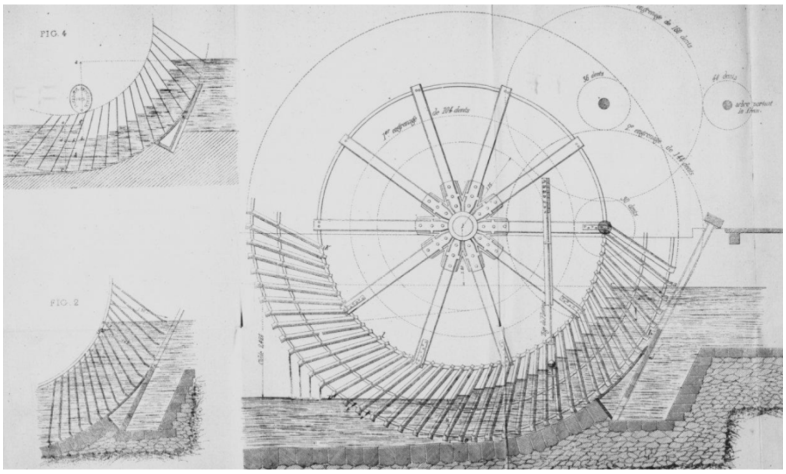

Fig. 17.3.6.2
Example of a Sagebien wheel with wooden floats, implemented as a breastshot wheel

The Zuppinger wheel

The Zuppinger wheel

In the second half of the 19th century, structural engineer W. Zuppinger developed the waterwheel named after him. These wheels found widespread use in Germany as undershot and breastshot wheels. With widely varying falls, a Zuppinger wheel still achieves an efficiency of 75%. The speed is about 5 revolutions per minute and the greatest power obtained is 60 kW (80 HP). Wheels up to 5 or 6 metres wide were no exception in Germany. Zuppinger used a lot of cast iron in his construction. The floats were composed of wooden parts.
Waterwheels built according to the Zuppinger principle can still be found in the *Kruitmolen* (Gunpowder Mill) in Valkenburg-Houtem and at the *Bovenste Molen* (Upper Mill) in Mechelen, where the wheel was only installed in 1978.

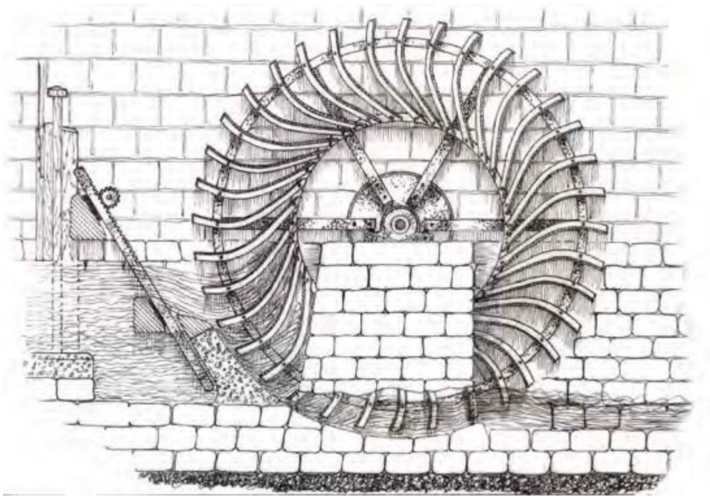

Fig. 17.3.6.3
All-metal Zuppinger wheel, designed as an undershot wheel.
Water flows through a double adjustable slider on the floats.

17.3.7 Special waterwheel arrangements

There were several places in Limburg where two waterwheels turned in the same water guideway, one after the other. The front wheel was usually a breastshot wheel or an undershot wheel with a large fall, and the rear wheel was then an undershot wheel. The rear waterwheel took advantage of the speed of the water after passing the front wheel.
An unusual arrangement of an undershot wheel and an overshot wheel side by side is found in the *Kasteelmolen* (Castle Mill) in Arcen. The two superimposed waterwheel shafts drive one upright shaft of the running gear.

17.3.8 Water turbines

Despite several more or less successful improvements to the waterwheels, in the long run they still proved unable to fully meet the desire to extract more power from the available flowing water.
This was not a new problem: A simple turbine watermill, made entirely of wood, was developed as early as the 4th to 5th centuries.

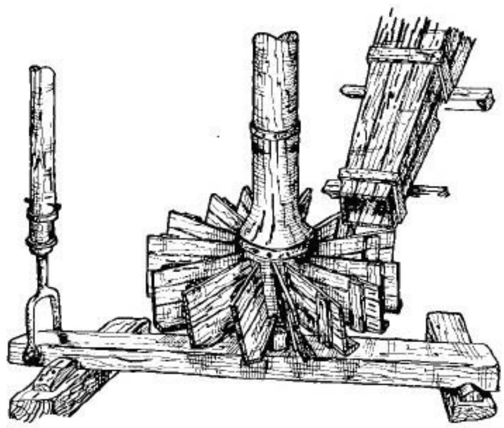

Fig. 17.8.3.1
Example of an all-wood turbine of a so-called Stockmühle

Development of the modern-day turbine

Various engineers therefore strove to make something that was better. The problem that called for a solution was the continued loss of excessive amounts of water at the various waterwheels.
The results of the studies eventually led to the turbine-driven mill.
It was also being considered in the Netherlands, as evidenced by the well-known book by Krook which was published in 1850. Drawings of a flour mill equipped with a turbine are depicted in this book. Whether the turbine shown therein ever found application anywhere is not known.

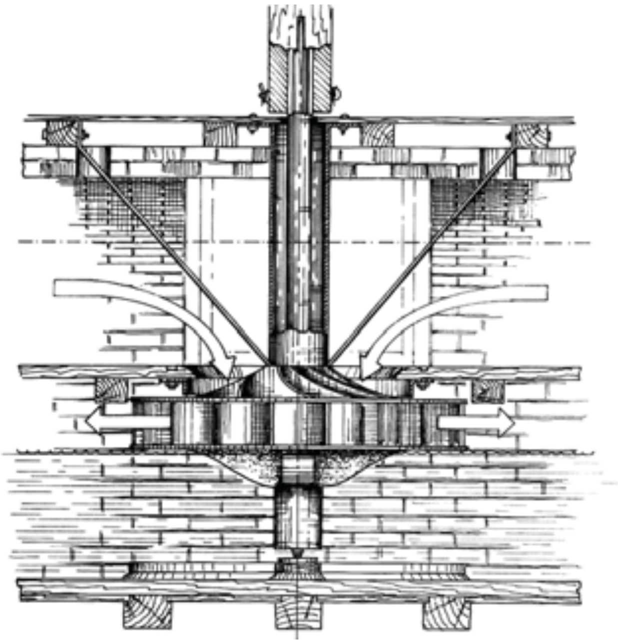

Fig. 17.3.8.2
The turbine designed by Krook

water turbine
shaft
turbine housing

A water turbine is basically a horizontally placed wheel with small blades that is completely submerged in a masonry or concrete tube, the shaft; only the turbine shaft and the controls for regulating the water flow in the turbine housing rise above the water level.

blade wheel, guide blades

The turbine itself consists of a circular cast-iron turbine housing in which the rotor, a blade wheel, turns. Adjustable blades, called guide blades, are attached to the perimeter or on the top of the housing. These blades direct the water, according to the most ideal streamlining possible, on the vanes of the impeller.

impeller

working blades

Water flows down through the shaft into the turbine housing, directed by the guide blades onto the working blades.

foot bearing

The turbine is induced into rotary motion by the weight and velocity of the oncoming water. The pressure is absorbed by the foot bearing.

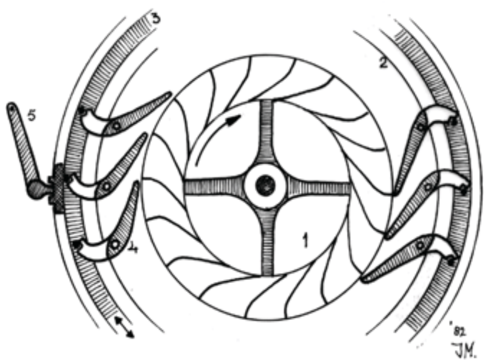

Fig. 17.3.8.3
Cross section of a turbine with guide and working blades

Girard turbine

The Girard turbine

In the mid-19*th* century, the small, simple and therefore inexpensive Girard turbine was very popular. This turbine was a greatly improved version of existing constructions, and several patents were granted for it around 1850.

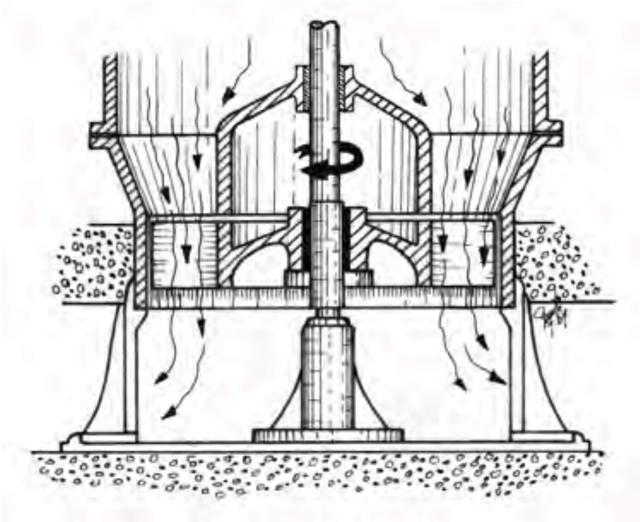

Fig. 17.8.3.4
Cross section of the turbine wheel as applied in a Girard turbine

axial or free-jet turbine
guide blades

The Girard turbine is an axial or free-jet turbine. The water flows through the turbine entirely in a vertical direction. The guide blades in the turbine housing are located above the impeller blades.

free-jet turbine

adjustable valves

As a free-jet turbine, the impeller should always be above the water level of the head race. The water supply to the impeller is adjustable with removable or adjustable valves or with adjustable guide blades.

The Francis turbine

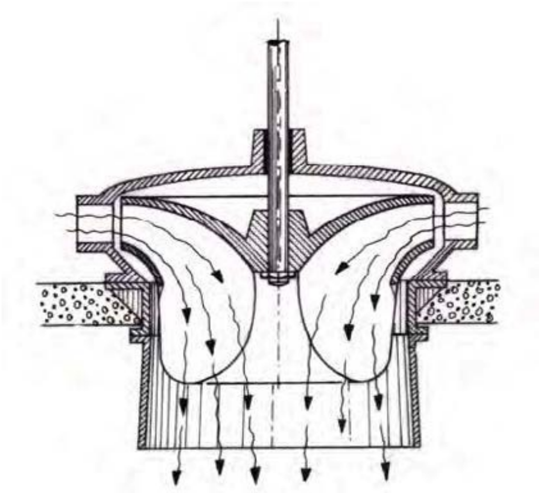

Fig. 17.3.8.5
Cross section of a Francis turbine. The direction of water flow is indicated

An American, J.B. Francis, developed another type of turbine in 1840. A number of changes were made later but the main features remained virtually the same.

Francis turbine

radial turbine

In the vertical Francis turbine, water on the outer perimeter flows through the guide blades in the turbine housing into the impeller. Therefore, the turbine is also called a radial turbine. The blades in the impeller have a rather complicated shape, especially in slow-running turbines with a speed of 60 to 80 rpm. For the incoming water-jets, the angularly placed blades have a straight shape, which turns into a curve at the bottom of the impeller.

draft tube

under-pressure

vertical and horizontal turbine

fir pole fence

After leaving the impeller, the water flows through a slightly conical draft tube which is fitted under the turbine housing. The continuous flow of water leaving the impeller generates a strong under-pressure under the influence of the weight of the out-flowing water column in the draft tube. The draft tube allows a Francis turbine to be run either vertically or horizontally. The speed of the vertical as well as the horizontal turbine can be increased by using the draft tube.
To prevent the inflow of coarser water contaminants, an iron grate (weed screen/debris grille) is placed at the entrance to the water supply channel. In front of it is usually a heavy iron gate or fir pole fence.
In Limburg, three single horizontal turbines were installed in addition to a large number of vertical Francis turbines. The only double horizontal Francis turbine operates in Meersen in the *Oude Molen* (Old Mill).

17.3.9 Mill water

mill water

blocking

In watermills with an undershot or breastshot wheel, the so-called mill water passing the mill must be free of entrained floating and/or suspended dirt or other coarse contaminants so that blocking of the waterwheel and destruction of the floats or buckets are prevented.
Blocking of the waterwheel may also cause damage to the drive mechanism due to blocking the upright shaft or waterwheel shaft.
Due to the narrow passageways in the turbine housing, water turbines have more stringent requirements for the removal of floating debris.
After all, small objects trapped between the turbine wheel and the guide blades or the turbine housing are difficult to remove. Often this is only managed after disassembly of the usually hard-to-reach turbine.

17.4 THE DRIVING GEAR

17.4.1 Introduction

In this chapter we will deal only briefly with the driving gear of the watermill because it is broadly similar to that of the windmill. Most watermills are grain mills or oil mills. Sometimes they are set up as hulling mills or sawmills. Because of the relatively small part of the Netherlands where watermills can be found, we will only discuss the two most common mills in terms of layout.
The similarity between a watermill and a windmill is that the waterwheel shaft located at the bottom of the watermill can, in essence, be compared to the windshaft of a windmill. Furthermore, in several cases the drive of the driving gear is similar to that in the post mill: in other words, a drive without the intermediary of a upright shaft. However, watermills with a upright shaft do exist. This has to do with the number of machines and whether or not they are equipped with under or upper drive.

under-drive, upper-drive (over-drive)

17.4.2 Grain mills

The driving gear of grain mills includes the following parts that are similar to those of the windmill:

a. the running gear or driving gear;
b. the stone shafts;
c. the stone table;
d. the pair of millstones;
e. the stone tenter or tentering mechanism.

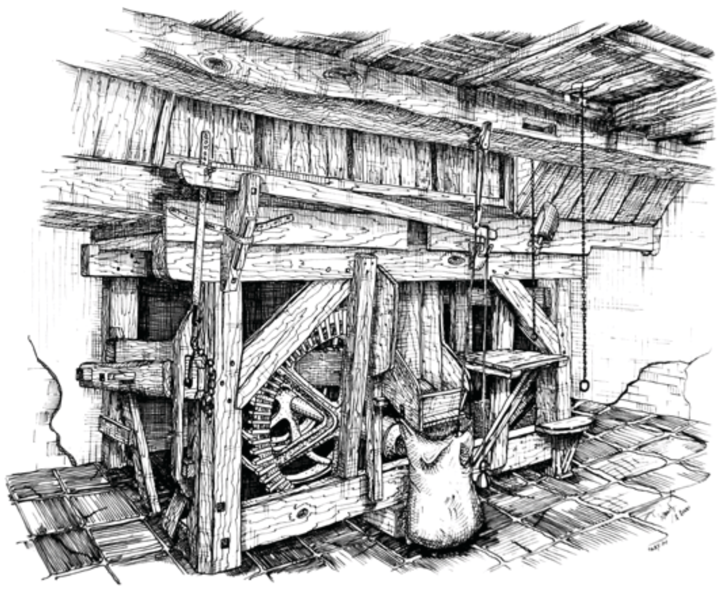

Fig. 17.2.4.1
An example of the interior of a watermill

So there is little difference between a watermill and a grain mill, only the arrangement within the mill is completely different.

stone table

This is because the milling mechanism is located at an elevation in the mill, called the stone table. This is a mezzanine floor similar to a hurst frame. The stone table is formed by a number of heavy main beams over which lie the floor joists or tertiary beams at one metre intervals, further covered with the milling floorboards. In some cases, such as in the smaller mills, only one or two pairs of millstones are set up here. However, in many cases there is also space here for storage of the grain, finished product and other items.

17.4.3 Running gear or driving gear

under-drive

waterwheel shaft

As examples, we provide two watermill layouts here. The first is that of the smaller mills with only one pair of stones. The drive in the mill shown is a so-called under-drive.
Both the millstones and the hoisting system are driven directly from the waterwheel shaft. This type of mill is a true village mill that primarily milled for the village's local baker. Not infrequently, that baker was also the miller.

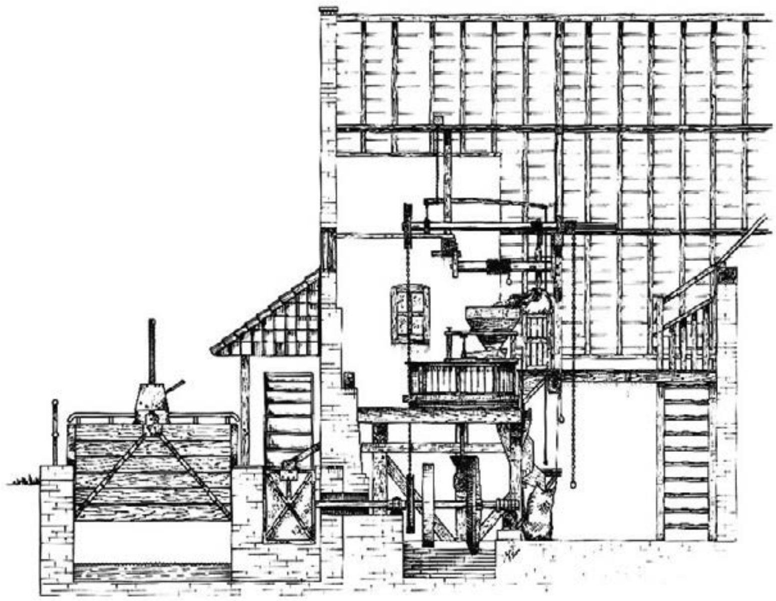

Fig. 17.4.3.1
A small type of village mill that milled primarily for the local baker and farmers

The larger and/or more elaborate watermill often has multiple functions in addition to several pairs of millstones, such as farm milling for cattle feed, hulling of barley, or sometimes a facility for oil-pressing from oil seeds.
In a large watermill with, for example, three pairs of millstones driven by one waterwheel, the driving gear is usually located under the hurst frame or stone table. Here, too, an under-drive is used.
The mill has a short upright shaft with a spur wheel / stone gear combination. Because of these multiple tasks, the driving gear is different from that used in the smaller mills.

Often the stone table is combined with the meal floor and/or grain floor. The entire construction is supported by heavy posts. Under the stone table is a more-or-less sunken basement room in which the running gear is set up. This *shaft wheel* running gear consists of the pit wheel, which is fixed to the waterwheel shaft, as well as the waterwheel attached to this shaft on the outside of the mill, an upright shaft with pinion and spur wheel, the stone nuts and stone shafts.

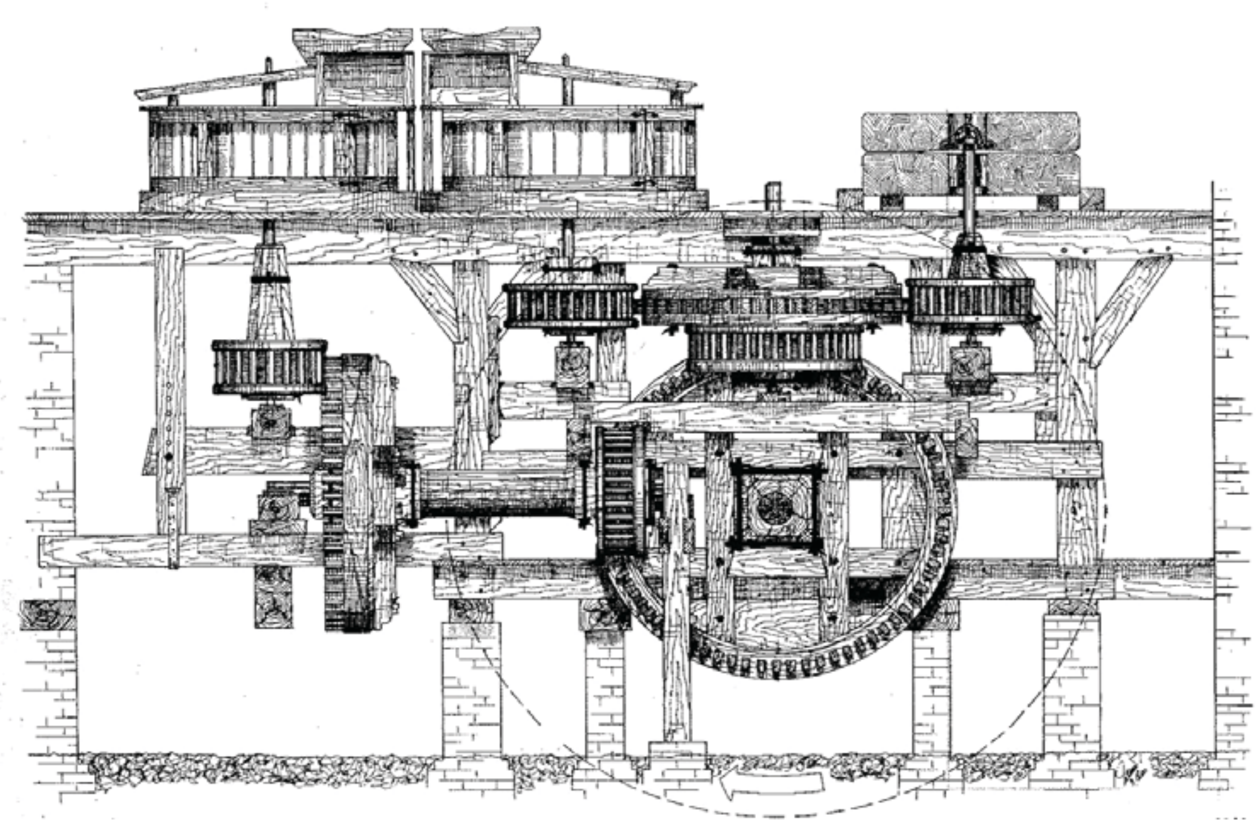

Fig. 17.4.3.2
Example of the layout of a large watermill with three pairs of millstones. They are lined up on the stone table.
Two pairs are driven by the face gear wheel (or pit wheel) via a spur wheel / stone nut combination. The third pair, on the left, called the lame mill, is driven via a horizontal shaft with a crown wheel and a stone nut.

17.4.4 Oil mills

After the grain mill, the oil mill was the most common type of mill. In addition to grain milled for consumption, oil was needed in large quantities for food preparation and for lighting.
In the Netherlands, only about six oil mills have been preserved more or less intact.

The layout of an oil mill differs from that of a grain mill due to the completely different production process as well as the
significantly different machinery required for production.
The parts that may be found then in an oil mill are:

a. the edge runner stones;
b. the oil works;
c. the running gear.

For a detailed description, see Chapter 14, 'The Oil Mill'.

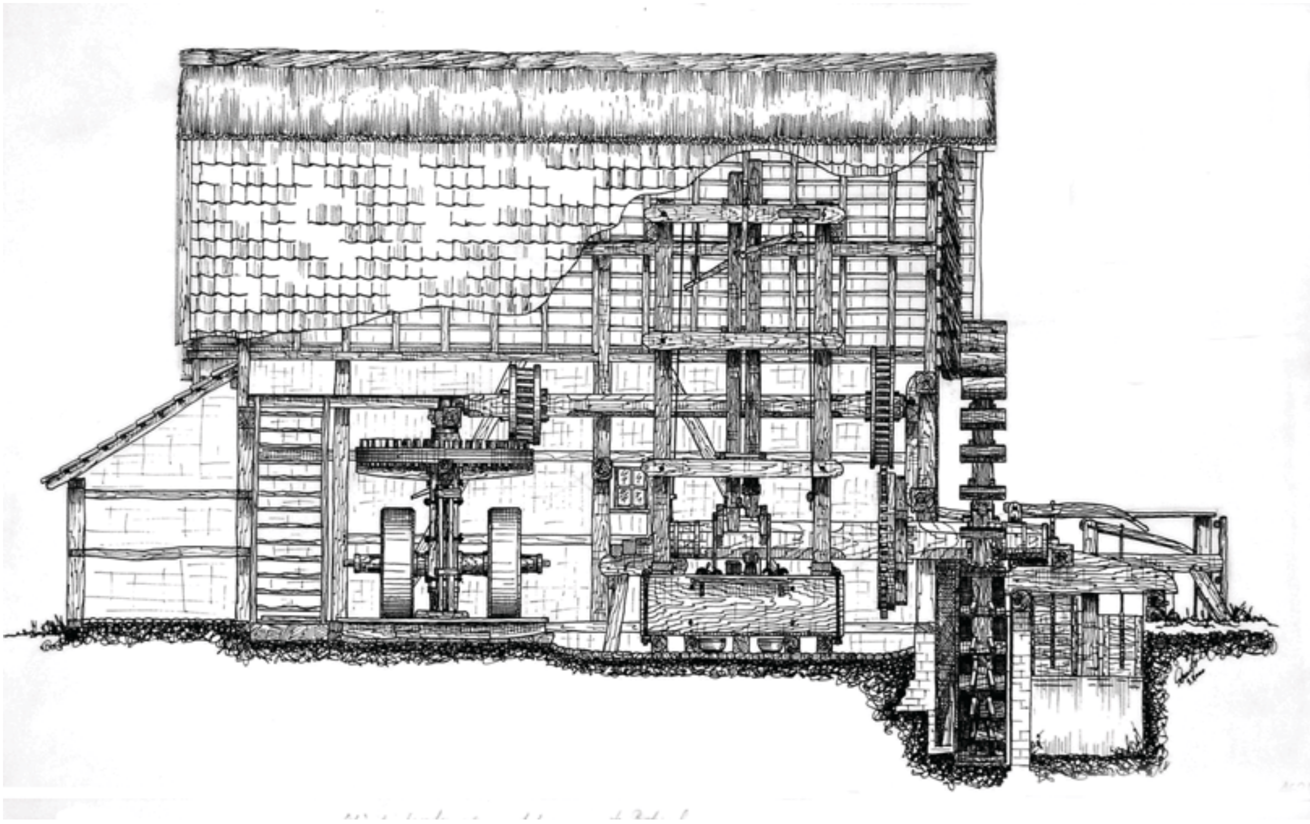

Fig. 17.4.4.1
Cross section of one of the few remaining all-wood, water-powered oil mills.

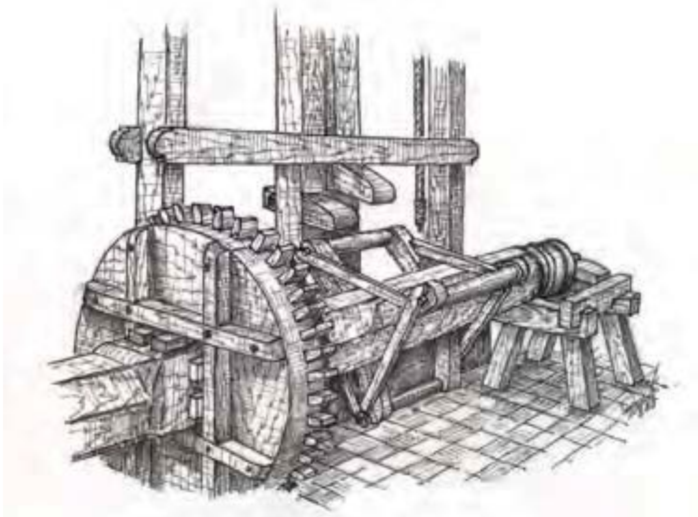

Fig. 17.4.4.2
A cam shaft in an oil mill with
a triple cam (lifting lever)

The cam shaft is equipped with a so-called lifting lever to lift the pressing rams , unlike, for example, oil mills in the northern provinces.

17.4.5 From wood to iron

cast-iron running gear

In the second half of the 19th century, cast-iron running gears made their appearance. This often occurred during repair or replacement; parts of the wooden running gear, worn or otherwise, were then replaced with parts made of cast or wrought iron.

cast-iron columns

The running gear is in a tall hurst frame that also supports the floor. This hurst frame is formed by a number of cast-iron columns, standing on stone base blocks of bluestone or masonry.

A good example of the development from wood to iron, among others, is the St. Ursula Mill at Nunhem. In this mill, the running gear for grain milling including the waterwheel section has been replaced by metal. The oil works have been maintained in wood, making this mill a good example of industrial progress.

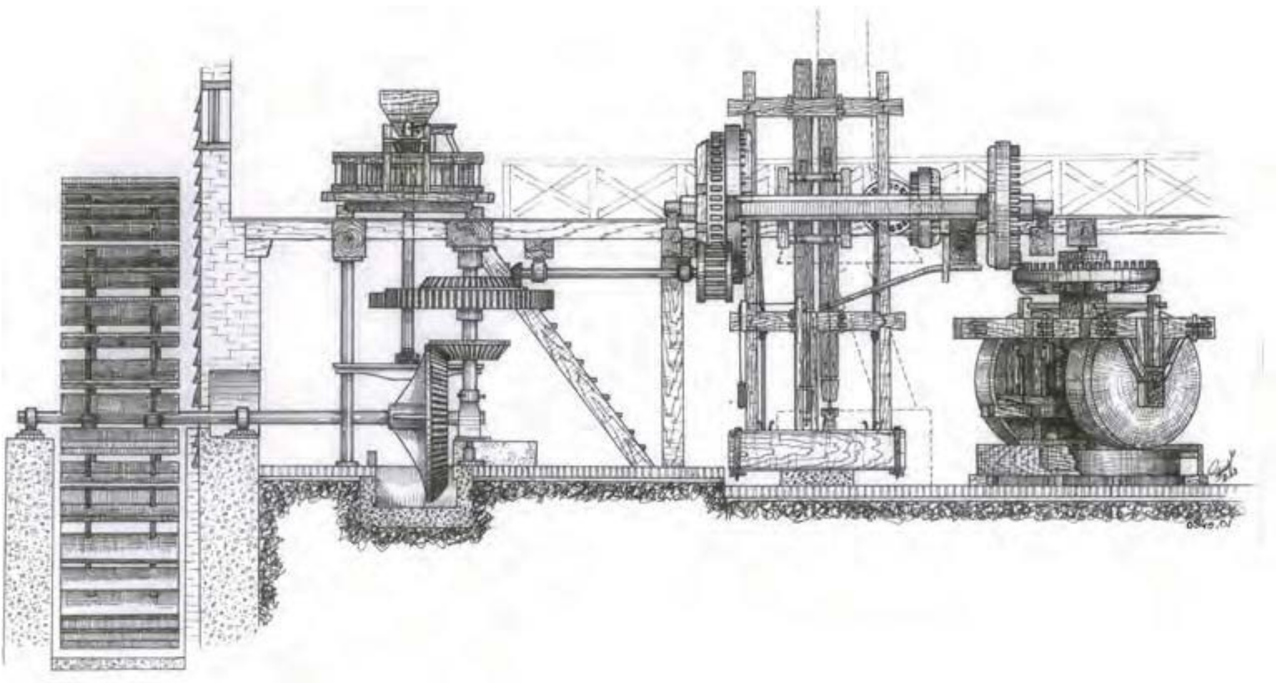

Fig. 17.4.5.1
Overview of the St. Ursula Mill in Nunhem.
The driving mechanism for the grain mill is made of ironwork while both the drive for the oil works and that for the edge runner stones are maintained in wood.

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