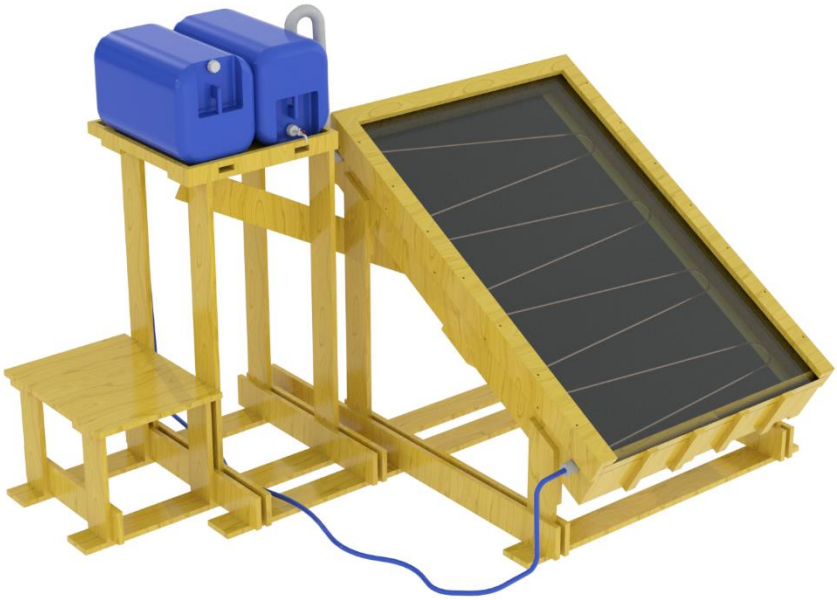
Construction Manual

SoWaDi – Solar thermal water disinfection system



INGENIEURE OHNE GRENZEN

Contents

Contact

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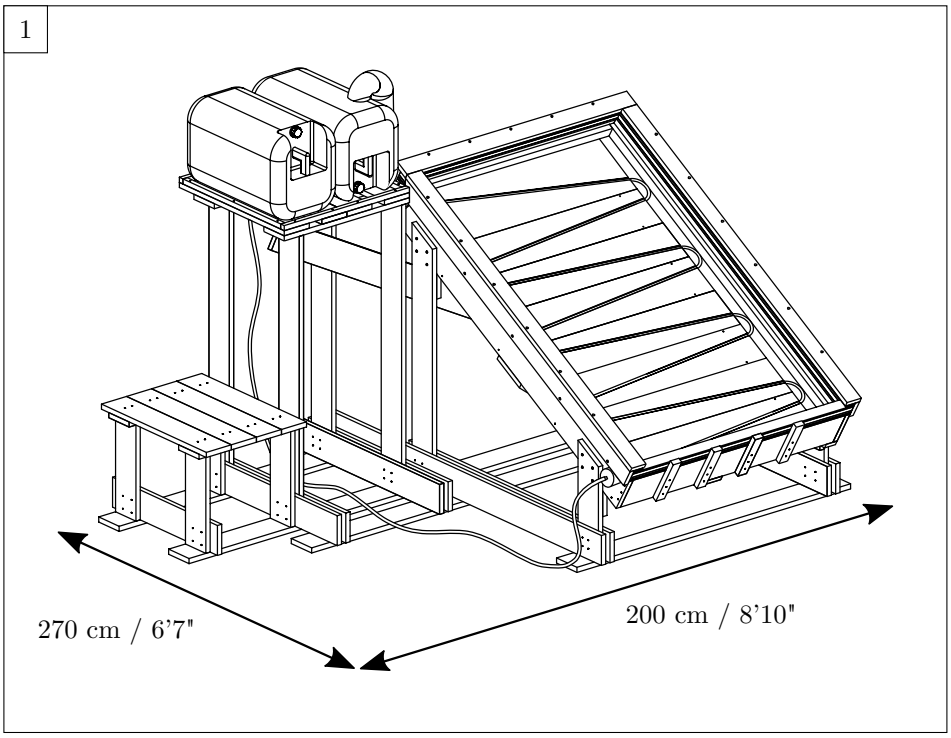
Any questions, feedback or suggestions? Contact us!

1 Introduction

This is the construction manual for a solar thermal water disinfection system. It is developed by Engineers Without Borders Germany (Ingenieure ohne Grenzen e.V.). The system heats water using solar energy. Thereby pathogens are killed, the microbiological quality is improved and water-borne diseases can be reduced.
All information in the manual are important for building the system, so read them carefully and plan the construction. For operating the system properly there is an user manual.

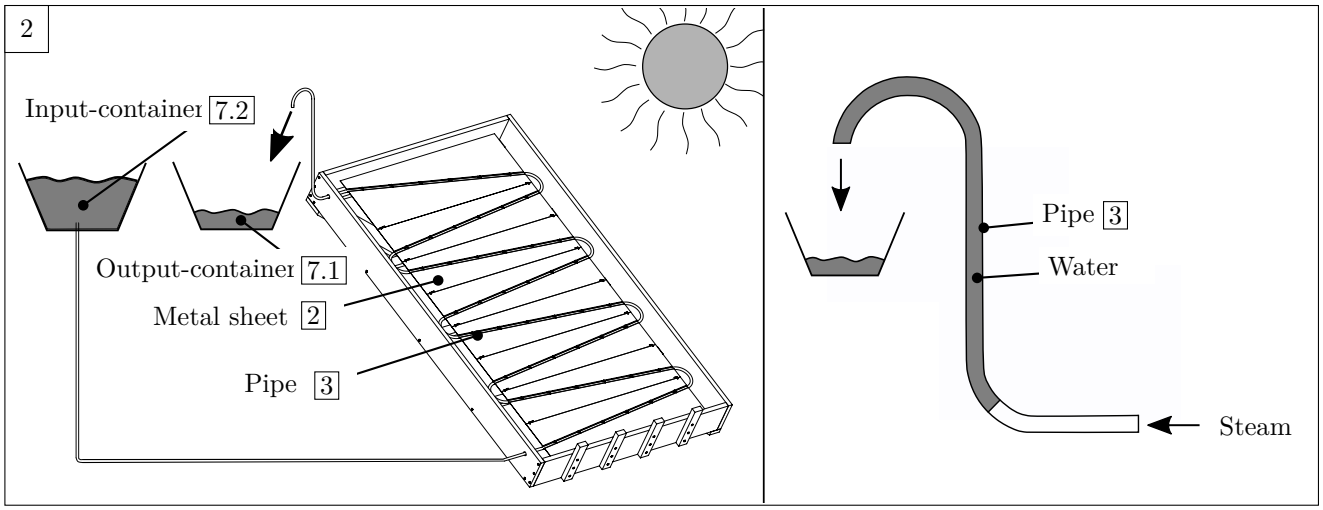
1.1 Size, characteristics and performance

1



- For setting up the system you need a flat area with the size of 270 cm / 6'7" x 200 cm / 8'10". Sun must shine on the area.
- The system has to be oriented in a certain direction with its sloped surface:
  - Face the system south, if you are nothern of the equator (northern hemisphere).
  - Face the system north, if you are southern of the equator (southern hemisphere).
- The system weighs around 95 kg or 210 lbs (without rack and water).
- To build the system you need at least three persons who are experienced in working with tools.
- The output of the system is 20 liters of water a day on average. On very sunny days it may increase up to 40 liters a day.
- To work properly, the system needs enough sun. This is particularly given at locations near the equator (approximately between 40° north and 40° south).
- The sun must shine on the area. Make sure it is never in the shadow.

1.2 How the system works



- The water flows from the input-container 7.2 into the pipe 3 . The sun heats up the metal sheets 2 and the water in the pipe. When the water is hot enough, it starts boiling and pathogens are killed.
  To isolate the front-side, two glass panes are placed on top of the pipe (this is not shown in the picture).
- When water boils, steam is produced. The steam needs much more room than the liquid water. Thus, the steam pushes some of the heated water out of the pipe into the output-container. Afterwards the boiled water flows out of the outlet and is collected in the output-container 7.1 .
- After enough water has flown out of the system cold, untreated water from inside of the input-container can pour in and the process restarts.
- For more information about the working principle, see the section "How it works" on our website (www.sowadi.de).

1.3 What you need to run the system

- To run the system you need water which meets the following criteria:
  1. No chemical contamination, e.g. fluroine from the ground water.
  2. No turbidity, e.g. dirt in the water.
  3. A low water hardness (low mineral content), otherwise the pipe will calcify.
  4. Preferably you should use harvested rainwater.

1.4 What you need to build the system

- At least three persons who are experienced in working with tools.
- Hint: If there are more than three persons, you can work parallel and save time!
- List of tools in chapter 4.2 (Page 21). You can build some tools on your own (see appendix).
- Hint: Rent tools or let materials be processed in stores (i.e. glass panes, metal sheets, wooden parts).

1.5 How the manual works

- Different parts put together build assemblies which all together build the system.
- The assembly number correlates with the chapter where it is described.
- Each part has a number, too. The first part of it shows you in which assembly it is used in. The second one refers to its position/number within the assembly. For example is the part 6.3 the third part in the assembly 6 . These numbers are always framed as well.
- For each part size, material and the quantity required are specified in the material list.
- Mark all parts right after buying in order to have a better overview. Write on each part the number of the material list.

1.6 What's particularly important

The following points must not be changed. You have to stick to them under all circumstances!

- Pipe:

  Outer diameter: 1/2" / 1.2 cm

  Thickness: 1 mm

- The pipe has to stick tight on the metal sheets.
- Glass panes on top of the absorber:

  There must be two glass panes.

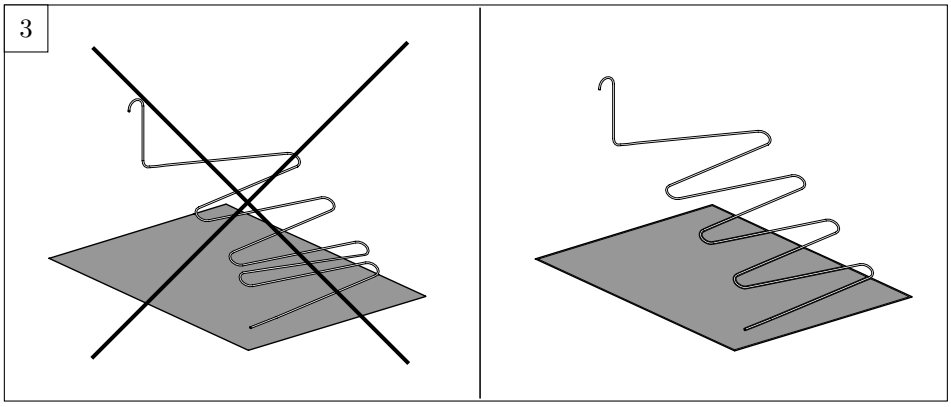
  Do not replace glass with foil or acrylic glass!

- Wooden box has to be well insulated.

  No water and only a bit of air should get inside.

- Pipe always has to go up (see the picture 3) so that the generated steam can ascend.

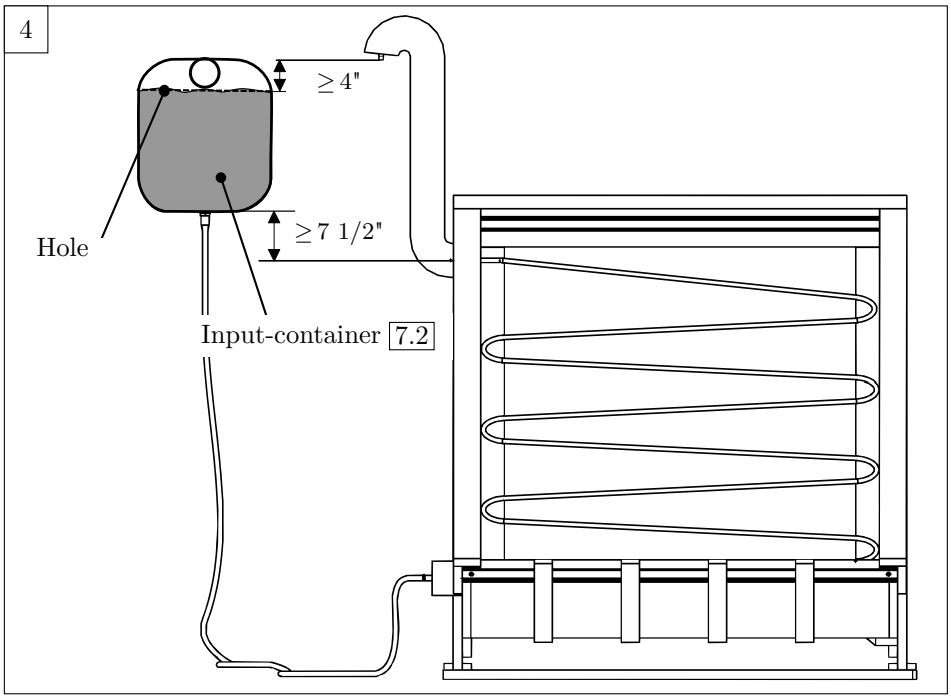
3



- The input-container [7.2] has to be on the correct height (see picture below).
- At least 4" between water-level (input-container) and the outlet

  < 4" : Untreated water will leave the system. **Make sure to drill a hole into the input-container at that height!**

  Much more than 4" : The system will produce less water.
- The difference in height of the bottom of the input-container and the point where the pipe leaves the wooden box has to be 7 1/2". This difference also may not be changed, otherwise the system will not work well either. Please note that the water-level in the input-container [7.2] will fall while the system is running. In order to keep this variation low, the input-container should have a large floor area.



1.7 Units used

The dimensions are all expressed in millimeters (mm), centimeters (cm) or meters (m) or alternatively in feet (') or inches ("). They can be converted as follows:
Meters, centimeters and millimeters:

- One meter equals 100 centimeters: 1 m = 100 cm
- One centimeter equals ten millimeters: 1 cm = 10 mm

Feet and inches:

- One foot equals 12 inches: 1 ' = 12 "
- The notation 1 '10 " equals 22": 1 '10 " = 12 " + 10 " = 22 "

Conversion between meters, centimeters, millimeters, feet and inches:

- One foot equals 0.3048 meters: 1 ' = 0.3048 m = 30.48 cm
- One inch equals 2.54 centimeters: 1 " = 2.54 cm = 25.4 mm
- One meter equals 3 feet 3.37 inches: 1 m = 3 '3.37 " = 39.37 "
- One centimeter equals 0.39 inches: 1 cm = 0.39 "
- One millimeter equals 0.039 inches: 1 mm = 0.039 "

1.8 Glossary / Definitions

- Symbols $<$ / $>$ and $=$ show if dimensions are smaller/larger or equal to one another.

  e.g. $<$ 10 cm means that the dimension should be smaller than 10 cm

- $\leq$ / $\geq$ show that dimensions can be smaller/larger but also equal

  e.g. $\geq$ 10 cm means that the dimension should be at least 10 cm

-  shows a right angle, (90°-angle, perpendicular)

1.9 Further information

You can find further information about the system and the project online: www.sowadi.de
There you can find the user manual, product-datasheet, explanation on functionality, information about the history of the project and our contact.

Explanations on a scientific level can be found in the following publication:
J. Dietl, H. Engelbart, A. Sielaff: *A Novel Type of Thermal Solar Water Disinfection Unit*, 2015.
You can download it from: http://tuprints.ulb.tu-darmstadt.de/4460

1.10 Disclaimer

This is a construction manual for a system, which heats water through solar radiation and thus kills pathogens. We point out that water also can be contaminated by other factors and a complete disinfection cannot be guaranteed. Thus, it is not guaranteed, that each water is drinkable after the treatment.
We point out that the solar disinfection system does not ensure the production of drinking-water (referred to WHO Guidelines for drinking-water quality), but significantly improves the microbiological quality. Nevertheless it still can contain harmful substances, such as heavy metals or fluoride.
Engineers Without Borders Germany does not guarantee the functionality of the system and is not liable for defects on any property or persons which happens through the operation of the system or the described construction processes.

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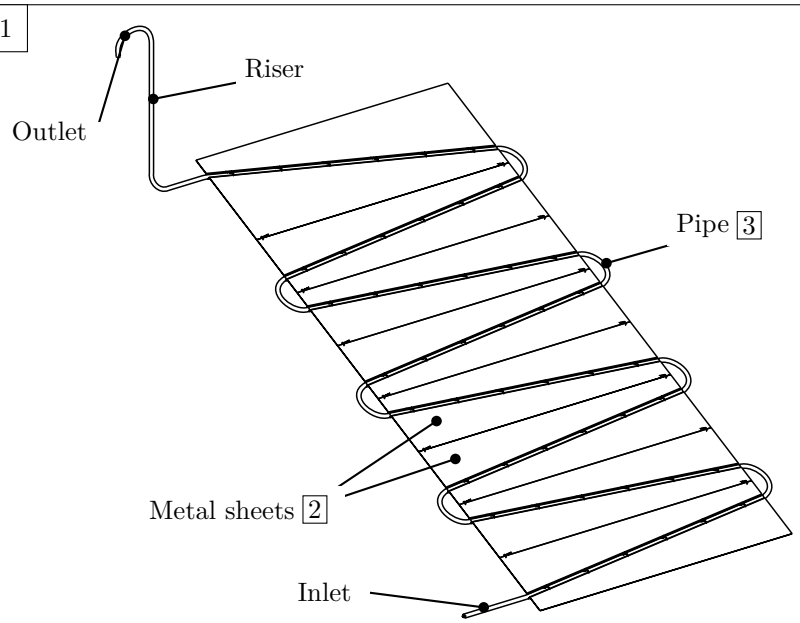
2 Overview of Modules

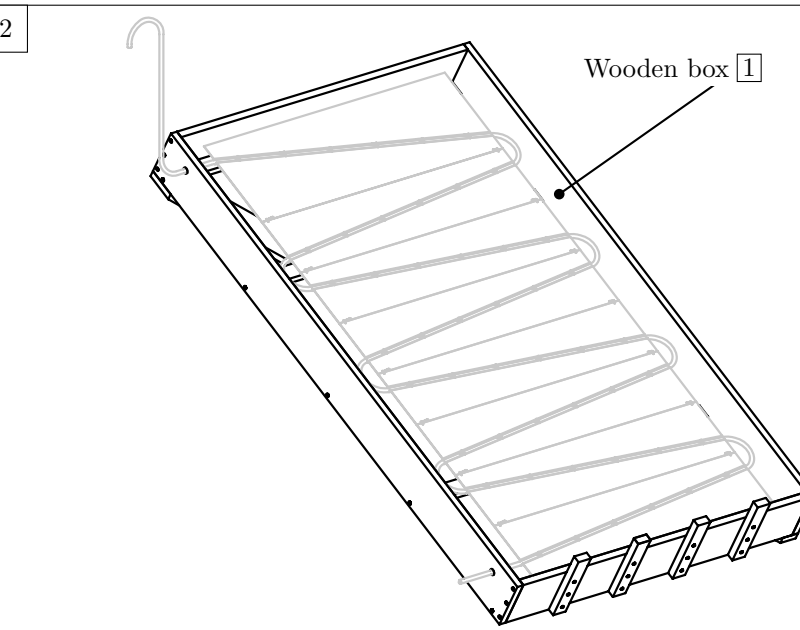
This chapter gives you an overview of the different modules of the system. The instructions on how to build these modules will be given later on.

1



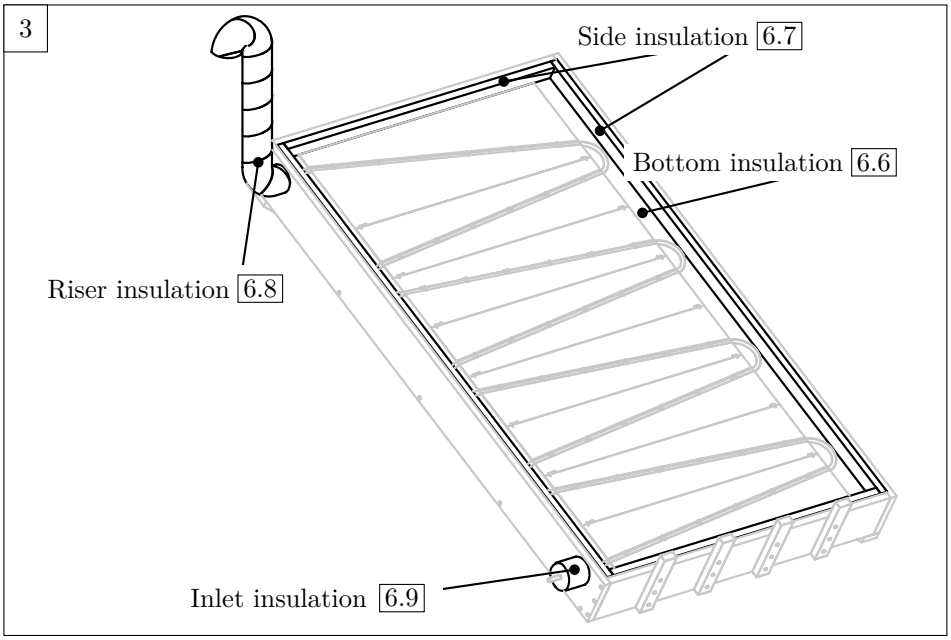
This is the absorber. It is made out of black painted metal sheets 2 and the pipe 3. The metal sheets absorb sunlight and conduct the heat to the pipe. Cold water flows in the inlet, heats up until it reaches 100°C and flows out through the riser.

2



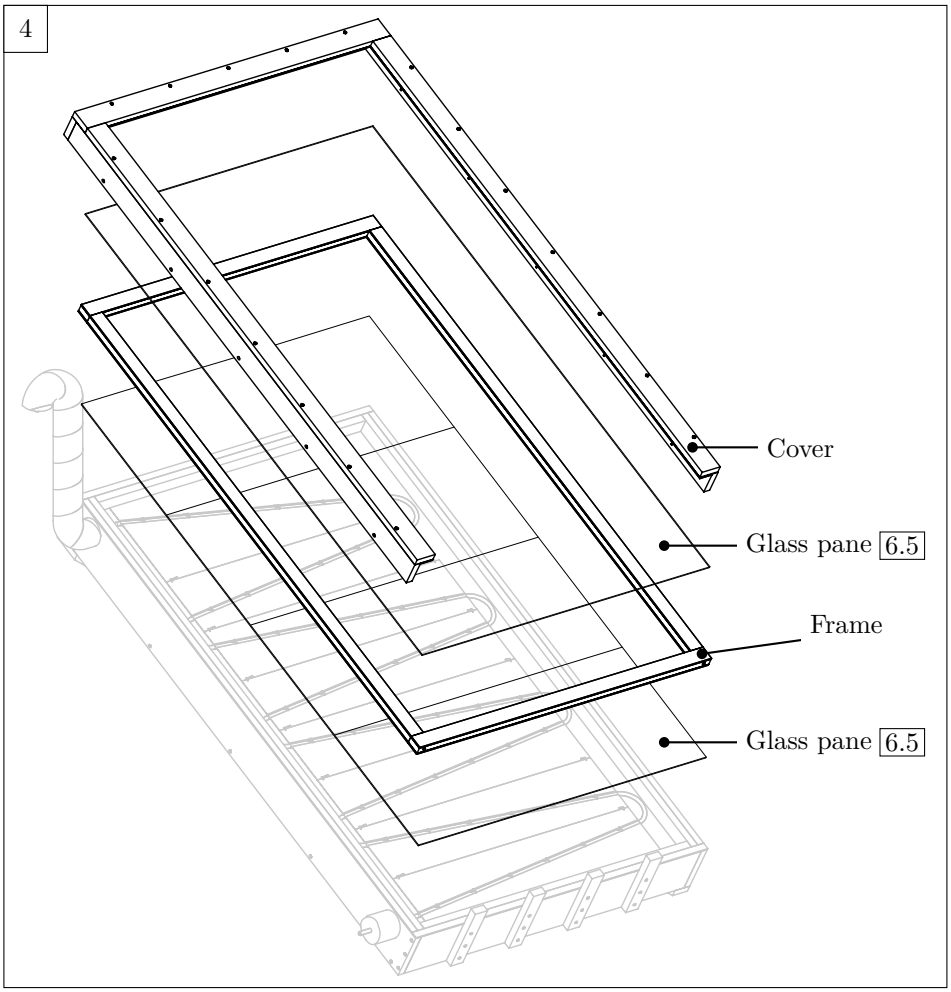
This is the wooden box 1. It contains the absorber and the insulation.

3



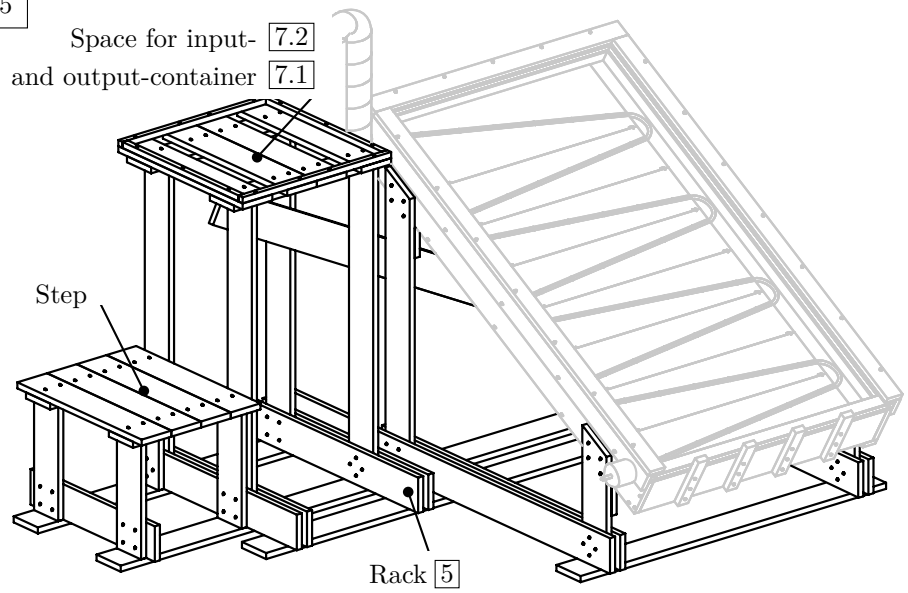
In order to heat up properly, the absorber must be well insulated. This is why the box, inlet, riser and outlet are all insulated with the same material.

4



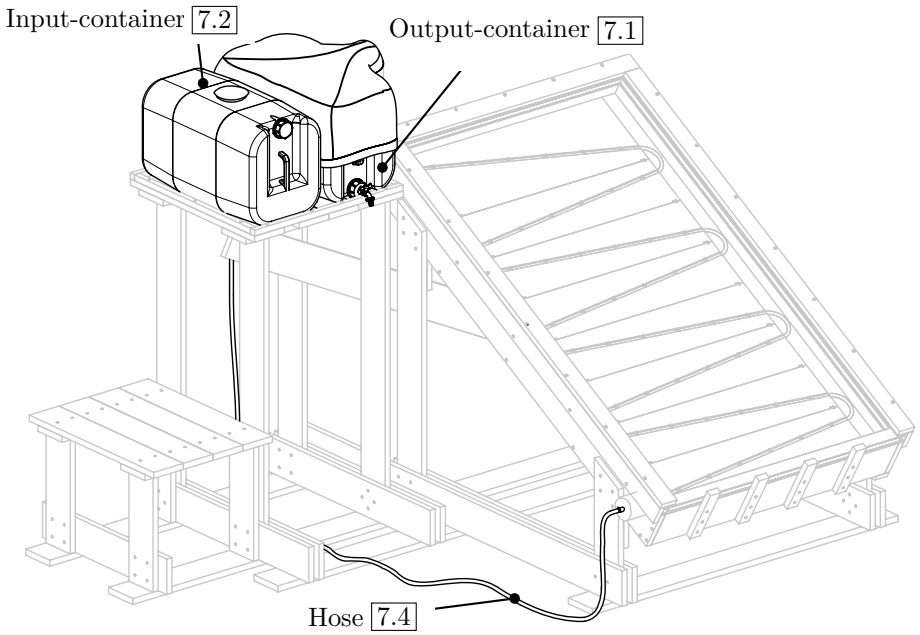
For insulating the top of the box but still letting sunlight reach the absorber, two glass panes 6.5 are used. A wooden frame keeps them apart from one another and the cover prevents the construction from slipping out of position. To avoid breaking the glass, there is soft damping above and below the pane. It can be made out of the insulation material, if this is soft.

5



The rack 5 is used to tilt the absorber in the direction of the sunlight. Additionally it is used to hold the input- 7.2 and output-container 7.1 at the correct heights.

6



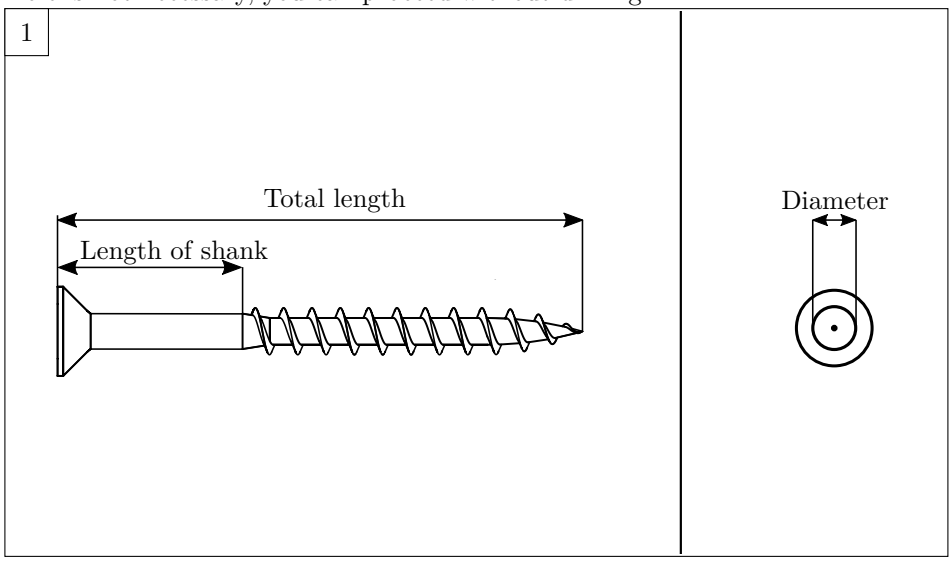
The input-container 7.2 stores the cold water, which has to be treated. The container has to be mounted in the correct height for the system to work. It needs a hole for refilling and for cleaning (which needs to be closed with a lid) and is connected to the inlet using a hose 7.4 . The output-container 7.1 stores the treated water.

3 Notes on the Construction

This chapter gives some notes on the construction.

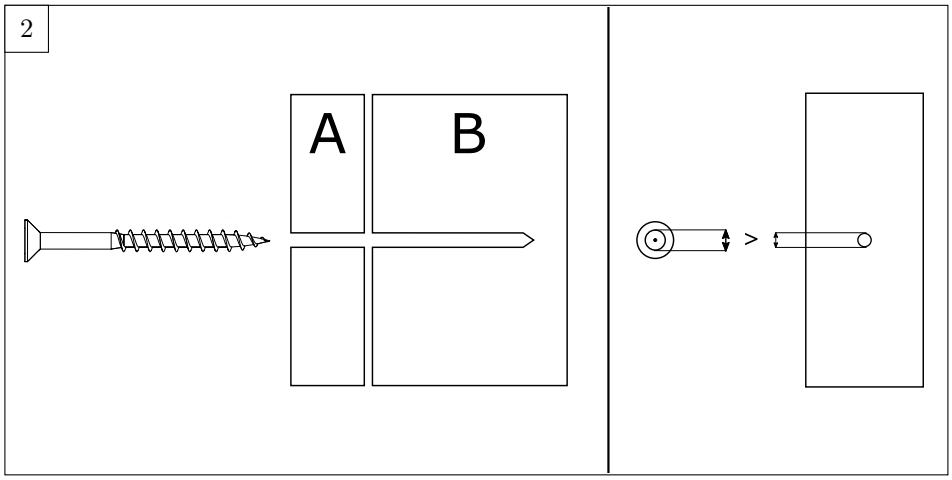
Pre-Drilling

The following chapter will give you advice when and how to drill a hole prior to screwing the screw in it. Pre-drilling is essential if you use very hard wood or if your screws are thick or very close to an edge. If you are sure that drilling a hole is not necessary, you can proceed without drilling.

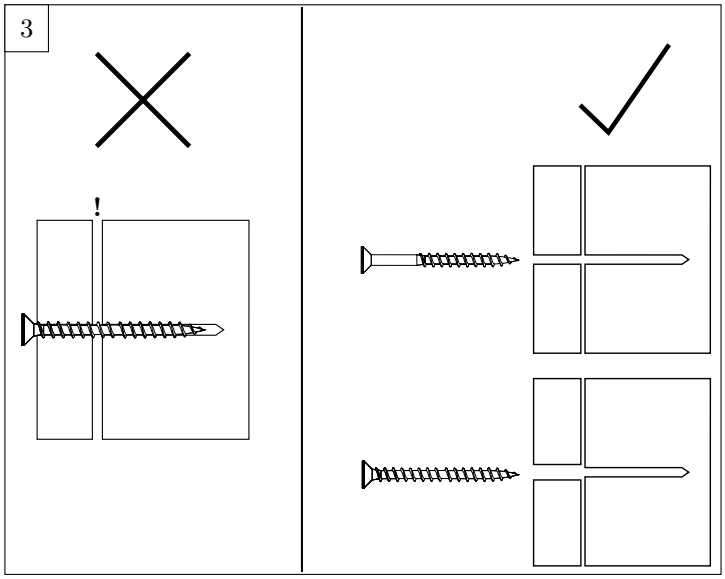


Screw to use:

- A diameter of approximately 3 mm
- Length: The thread should reach at least 1.5 cm into board B
- Screws with a shank are best to use



The screw is jamming board A to board B. The size of the hole should be slightly smaller than the diameter of the screw (and not too big). You have to drill completely through board A. The hole in the second board B has to be roughly as deep as you expect the screw to reach. The total length of the screw has to be shorter than the thickness of board A and B together.



The thread has to be only in board B and the shank has to fill board A. If screws only with a thread are used, you have to drill a bigger hole in board A (not too big so the head of the screw does not go through). If you use neither of the above techniques, the screws will not fixate the board properly and there will be a gap between the boards.

4 List of Tools and Materials

4.1 List of Materials

This is the list of all the material you will need to build the system.

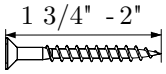
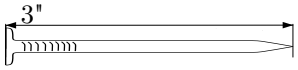
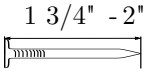
- If you do not have tools for deep-drawing the metal sheets or for bending the pipe, you can use the instructions in appendix A.1 (Page 76) and A.3 (Page 100) to build these tools. Also you can check there for the needed materials, too.
- Before buying the material, check out chapter 5 (Page 23) to see, where it is needed and what it is used for. The number of the part shows you the sub chapter it is used in. The first number corresponds to the number of the sub chapter.
  E.g. board [1.1] can be found in chapter 5.1 and rail [6.3] can be found in chapter 5.6.
- The materials are listed according to their type.
- For a better overview mark all parts right after buying. Write the number of the material list on each part.

Boards and Rails:

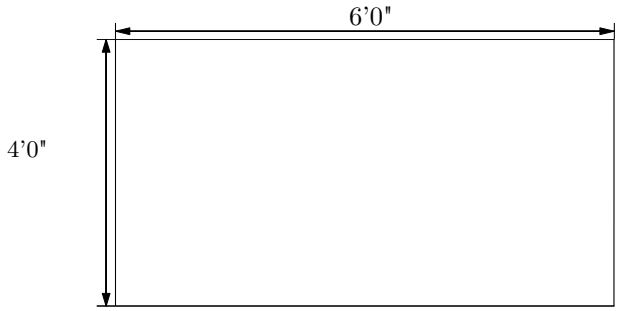
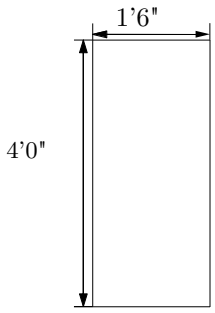
- All boards and rails are made of wood. They can be rough sawn and do not necessarily need to be planed or sanded.

Number	Figure	Title		Other
2 x	7" × 6'1/2" or 189 cm	Board	[1.1]	Material: Timber Thickness: 1"
2 x	7" × 3'11"	Board	[1.2]	Material: Timber Thickness: 1"
2 x	4" × 4'0"	Board	[1.3]	Material: Timber Thickness: 1"
1 x	4" × 7'4"	Board	[1.4]	Material: Timber Thickness: 1"
1 x	4" × 4'3"	Rail	[6.3]	Material: Timber Thickness: 1"
2 x	4" × 6'1/2"	Rail	[6.4]	Material: Timber Thickness: 1"
2 x	2" × 5'11 1/2"	Rail	[6.19]	Material: Timber Thickness: 1"
1 x	2" × 4'3"	Rail	[6.2]	Material: Timber Thickness: 1"
4 x	2" × 10"	Rail	[1.5]	Material: Timber Thickness: 1"
2 x	1" × 5'10 1/2"	Rail	[6.18]	Material: Timber Thickness: 1"
2 x	2" × 4'1"	Rail	[6.1]	Material: Timber Thickness: 1"

Screws and Nails:

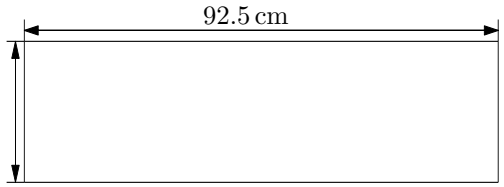
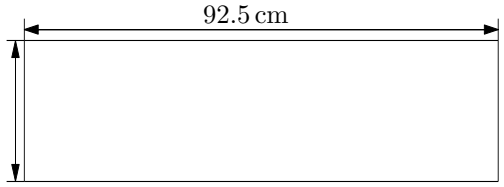
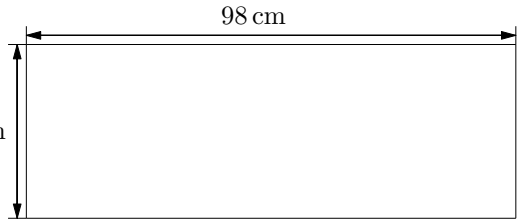
Number	Figure	Title		Other
14 x		Wood screw	S1	Length: 1 3/4" - 2"
40 x		Nail long	N1	Length: 3"
35 x		Nail short	N2	Length: 1 3/4" - 2"

Glass:

Number	Figure	Title		Other
1 x		Glass pane	6.5	Thickness: 5 mm Material: Glass
4 x		Glass pane	6.5	Thickness: 5 mm Material: Glass

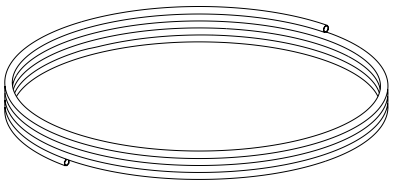
Metal sheets:

- Thermoconductive
- **Easy to bend**
- Thickness: 0.6 - 1 mm, **thinner is easier to bend**
- When buying the metal sheets: **Check with hand if metal sheets are easy to bend**

Number	Figure	Title		Other
4 x	23 cm 	Metal sheet	2.1	Thickness: 0.6 - 1 mm Material: Aluminum/Copper Identical to sheet 2.2
3 x	23 cm 	Metal sheet	2.2	Thickness: 0.6 - 1 mm Material: Aluminum/Copper Identical to sheet 2.1
1 x	33.5 cm 	Metal sheet	2.3	Thickness: 0.6 - 1 mm Material: Aluminum/Copper

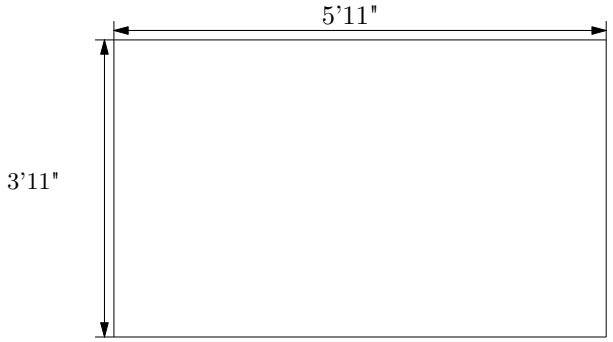
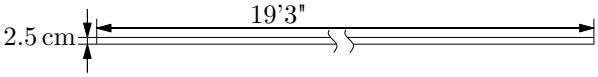
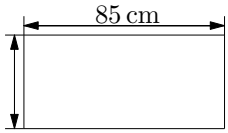
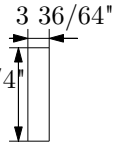
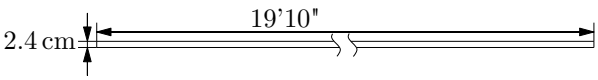
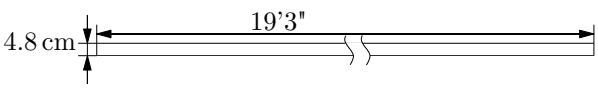
Pipe:

- You need 10.5 m of easily bendable pipe. The pipe needs to be made out of soft copper so it can be easily bent. You can buy it on rolls. Hard copper, which you can normally buy in bars, is not bendable and therefore not suited.

Number	Figure	Title		Other
1 x		Pipe	3	Length: minimum 10.5 m Outer diameter: 1/2" / 1.2 cm Wall thickness: ca. 1 mm Material: soft, bendable copper

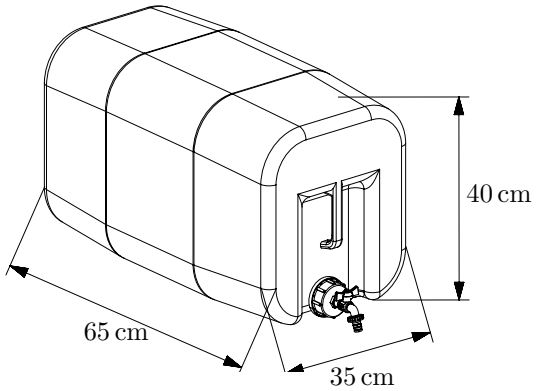
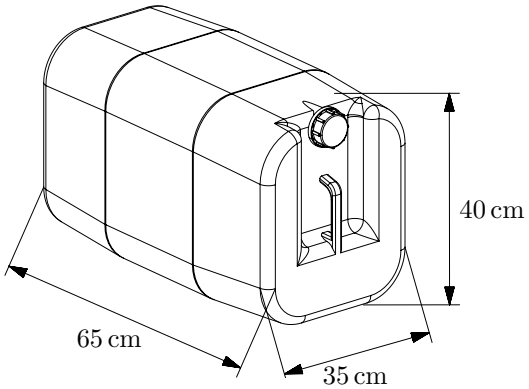
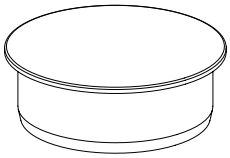
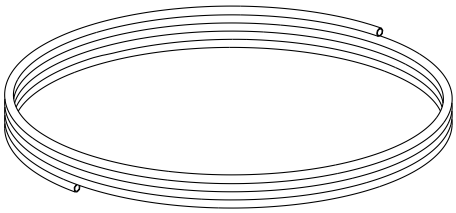
Insulation:

- Insulation material which is resistant up to at least 140°C. For example glass wool or hemp mat.
- In total 4.8 m^2 with a thickness of 5 cm each.
- Each part can be made out of several smaller parts. The parts 6.7 , 6.10 and 6.11 have to be cut in several smaller parts again later.
- The dampings 6.10 and 6.11 are embedding the glass in order to absorb shocks and to prevent it from breaking. The material needs to be very soft. If it is soft enough, you can use the insulation material.

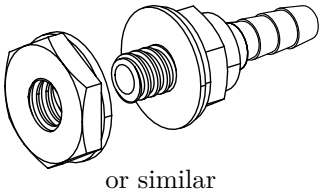
Number	Figure	Title		Other
1 x		Insulation bottom	6.6	Thickness: 10 cm Or two layers with 5 cm thickness.
1 x		Insulation side	6.7	Thickness: 5 cm
1 x		Insulation rising tube	6.8	Thickness: 5 cm
1 x		Insulation Inlet	6.9	Thickness: 5 cm
1 x		Damping Glass	6.10	Thickness: ca. 1 cm
1 x		Damping Glass	6.11	Thickness: ca. 1 cm

Container and connections:

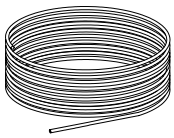
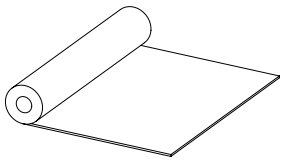
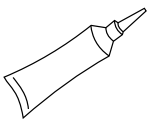
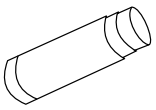
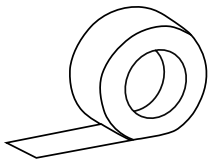
- See comments in chapter 5.7

Number	Figure	Title		Other
1 x	 or similar	Output-container	7.1	Dimensions correspond to standard rack (see appendix A.5 (Page 115)). Identical to input-container 7.2 , but with a tap. If you build your own rack you may use other dimensions but the volume should be at least as big as the input-container.
1 x	 or similar	Input-container	7.2	Dimensions correspond to standard rack (see appendix A.5 (Page 115)). Identical to output-container 7.1 , but without tap. If you build your own rack you may use other dimensions but the volume should be at least 60 liters and the floor area at least 0.25 m^2.
1 x	 or similar	Lid	7.3	Input-container lid 7.2 . You are going to drill a hole (ca. 4") in order to fill the container easily. Therefore you need a lid to close it.
1 x		Hose	7.4	Suitable for drinking water. Length: ca. 9'10 1/8" - 13'1 1/2" Inner Diameter: ca. 1/2" / 1.2 cm
2 x		Hose clamp	7.5	Size corresponding to hose 7.4

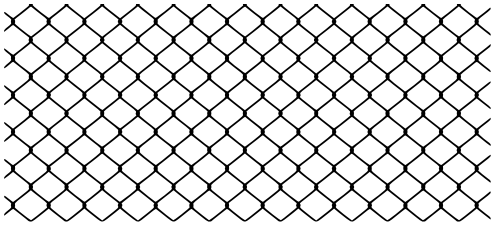
Container and connections (continued):

Number	Figure	Title		Other
1 x	 or similar	Hose connection	7.6	To connect the hose 7.4 to the container 7.2 . Depending on the container used, this part may look different.

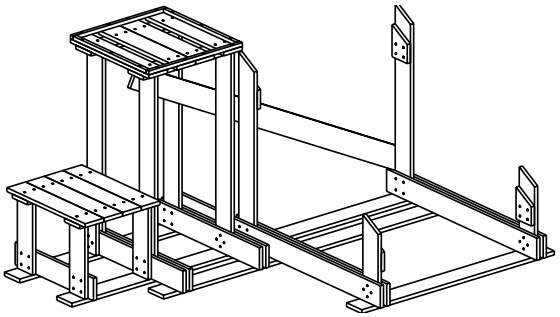
Other:

Number	Figure	Title		Other
1 x		Wire	4.1	Length: at least 23' or 7 m Diameter: 1 mm The wire has to be sufficiently strong. For example wire used for concrete building is well suited.
1 x		Paint	4.2	Black, heat resistant paint. Apply thinly. Enough for at least 20 ft^2. Must be heat resistant up to 140°C.
1 x		Foil	6.12	Flexible, water resistant foil. • It is used to fix the insulation to the rising tube. • You also need foil to cover the back of the box. This foil must cover more than 4x6 ft.
1 x	 or  or similar	Glue	6.13	Glue to fix damping and insulation
1 x	 or similar	Duct tape	6.14	Duct tape

Other (continued):

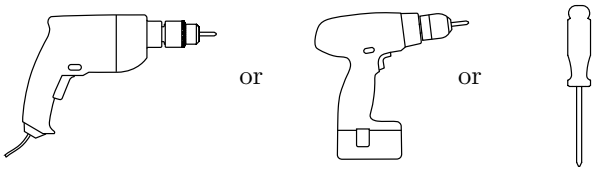
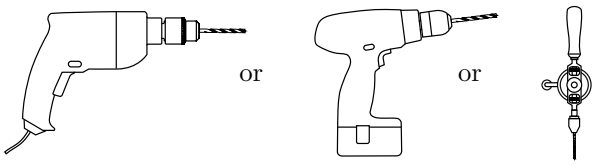
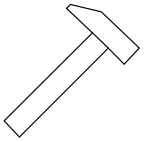
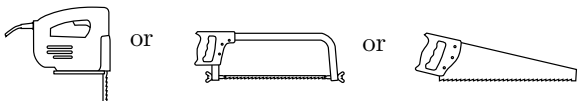
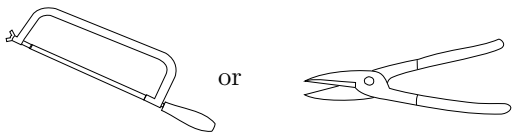
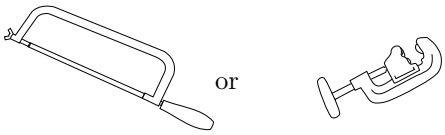
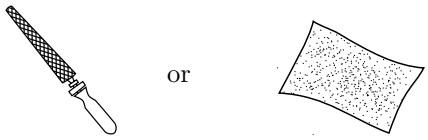
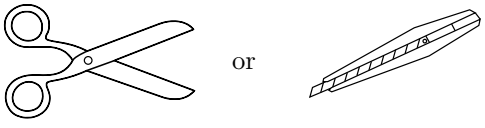
Number	Figure	Title	Other
1 x		Chicken Wire	Surface: 24 ft^2 Use this to protect your plant against vermins if they are a problem.

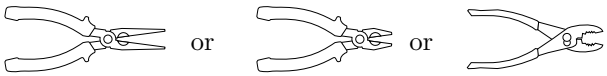
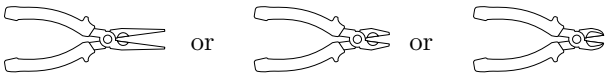
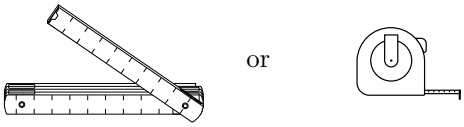
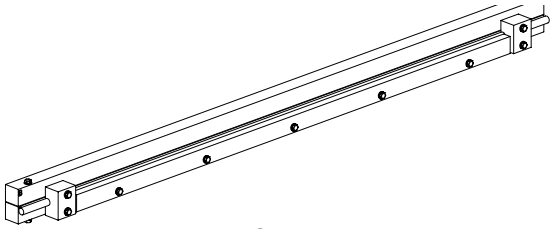
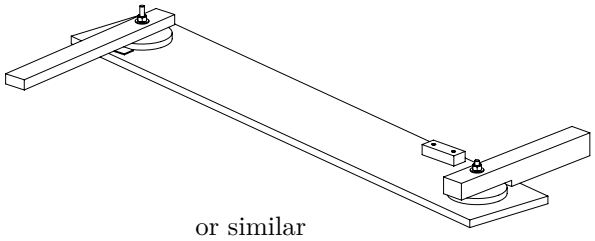
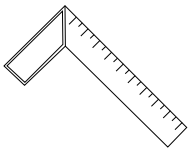
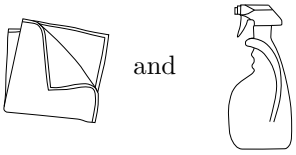
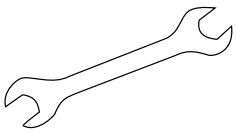
Rack:

Number	Figure	Title	Other
1 x		Rack [5]	See chapter 5.5 (Page 49). Either use the design in appendix A.5 (Page 115) or use your own design based on the required dimensions listed in chapter 5.5 (Page 49).

4.2 List of Tools

This is a list of all the tools you will need for the construction.
If you have other tools which do the same job, you may use them.

Number	Figure	Title	Other
1 x		Screwdriver	Suitable for the screws
1 x		Drill	• Wood drill for pre-drilling • Wood drill for drilling the tube connection (ø 18 mm) • Metal drill for wire 4.1 • Drill for hole in output-container 7.1 (ca. 1.4 - 2 cm)
1 x		Hammer	For driving in the nails.
1 x		Wood saw	For preparing the wood.
1 x		Metal saw or sheet shears	For cutting the metal sheets.
1 x		Metal saw or pipe cutter	For cutting the copper pipe 3 .
1 x		File or sandpaper	For deburring the copper pipe 3 an the holes in the containers 7.1 and 7.2 .
1 x		Scissors or knife	For cutting the damping and insulation of the wooden box and the holes into the containers 7.1 and 7.2 .

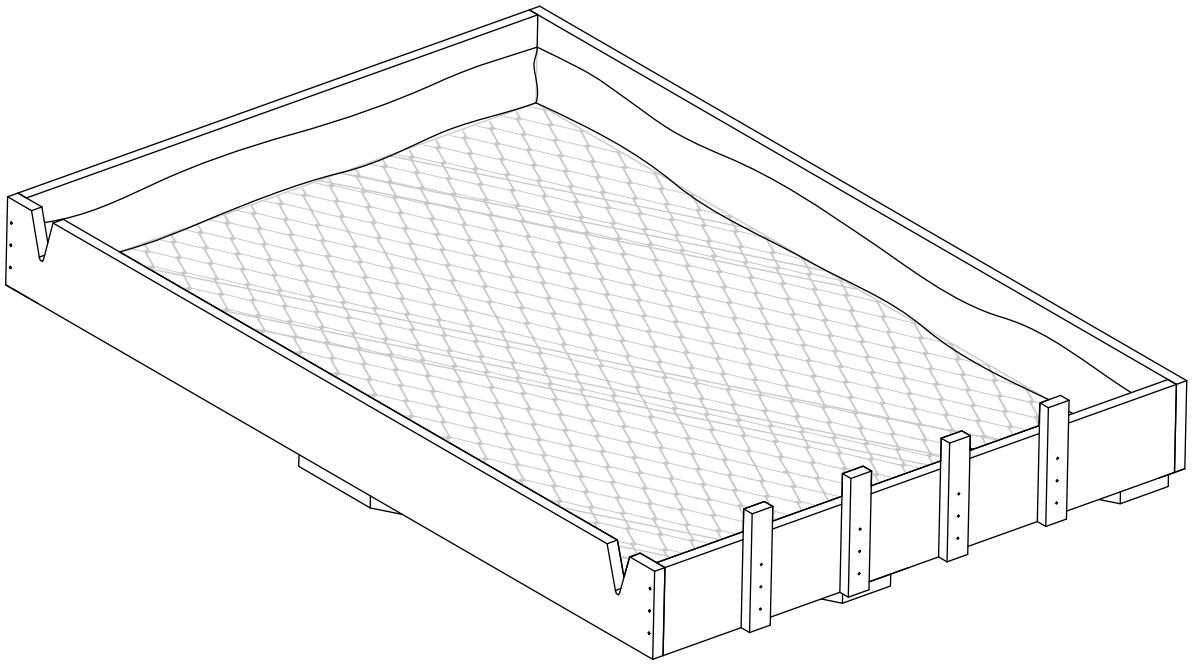
Number	Figure	Title	Other
1 x		Pliers	For twisting the wire 4.1 .
1 x		Side cutter	For cutting the wire 4.1 .
1 x		Measuring tape	Measuring tape or ruler. This will not be explicitly mentioned in each chapter, even if it is required.
1 x	 or similar	Metal-Sheet-Bending-Tool A.1	Tool to produce a round nut in the metal sheet (dimensions in chapter 5.2 (Page 29) step 4). If you do not have a tool like this, you can build one using the instructions in appendix A.1 (Page 76).
1 x	 or similar	Pipe-bending tool A.3	Tool for bending a 1/2" / 1.2 cm pipe (dimensions see chapter 5.3 (Page 35) step 5). If you do not have a suitable tool, you can build one with the instructions in A.3 (Page 100).
1 x		Angle meter	An angle meter with an angle of 90°.
1 x		Cleaning material	A cleaning cloth and some cleaner.
1 x		Screw wrench	A screw wrench.

5 Construction

This chapter describes the construction of the system. The process is divided into single steps (Chapter 5.1 (Page 23) to 5.7 (Page 68)).

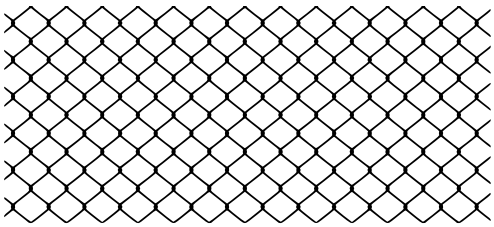
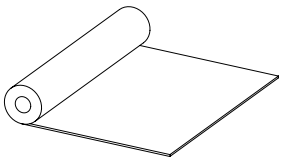
5.1 Wooden Box

The wooden box is the main module of the system. Absorber, glass pane and insulation will be built in later.

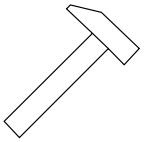
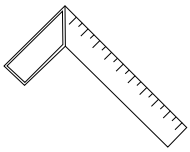
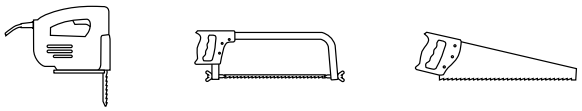


Required materials:

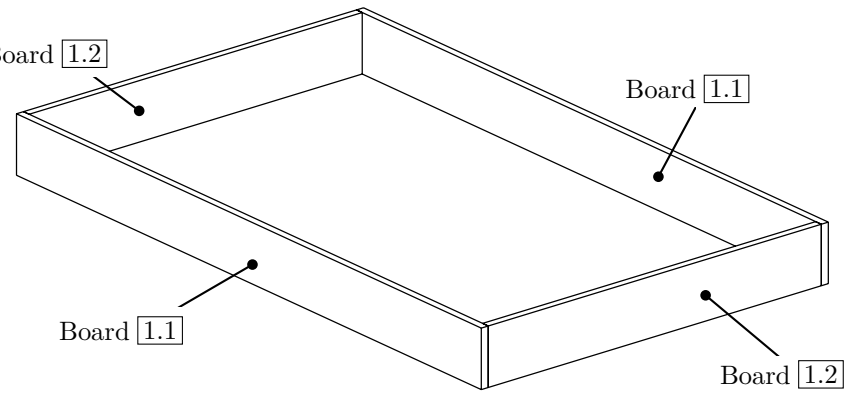
Quantity	Figure	Title		Other
2 x	7" 6'1/2" or 189 cm	Board	1.1	Material: Timber Thickness: 1"
2 x	7" 3'11"	Board	1.2	Material: Timber Thickness: 1"
2 x	4" 4'0"	Board	1.3	Material: Timber Thickness: 1"
1 x	4" 7'4"	Board	1.4	Material: Timber Thickness: 1"
4 x	2" 10"	Rail	1.5	Material: Timber Thickness: 1"
36 x	3"	Nail long	N1	Length: 3"

Number	Figure	Title	Other
1 x		Chicken Wire	Surface: 24 ft^2 Use this to protect your plant against vermins if they are a problem.
1 x		Foil 6.12	You need the foil to cover the back of the box. This foil must cover more than 4x6 ft.

Required tools:

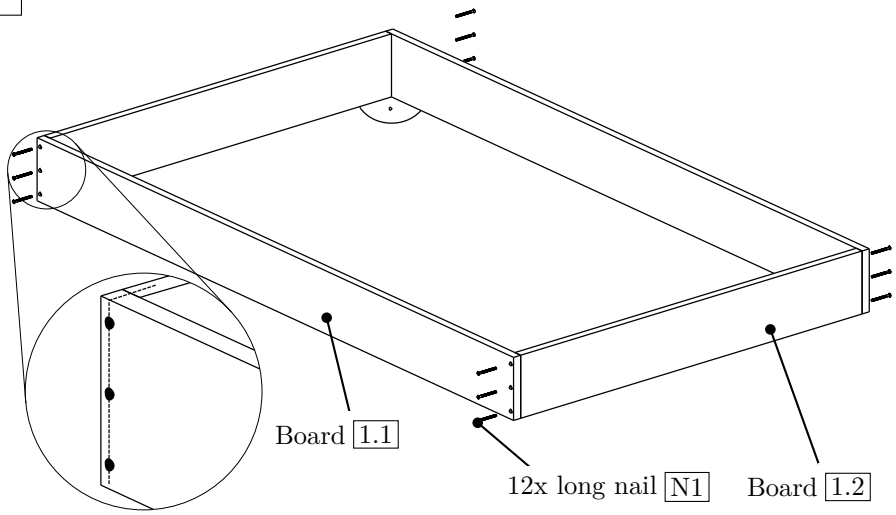
Quantity	Figure	Title	Other
1 x		Hammer	For driving in the nails.
1 x		Square	For the right orientation of the boards.
1 x		Saw	For sawing off unused parts of the boards.

1



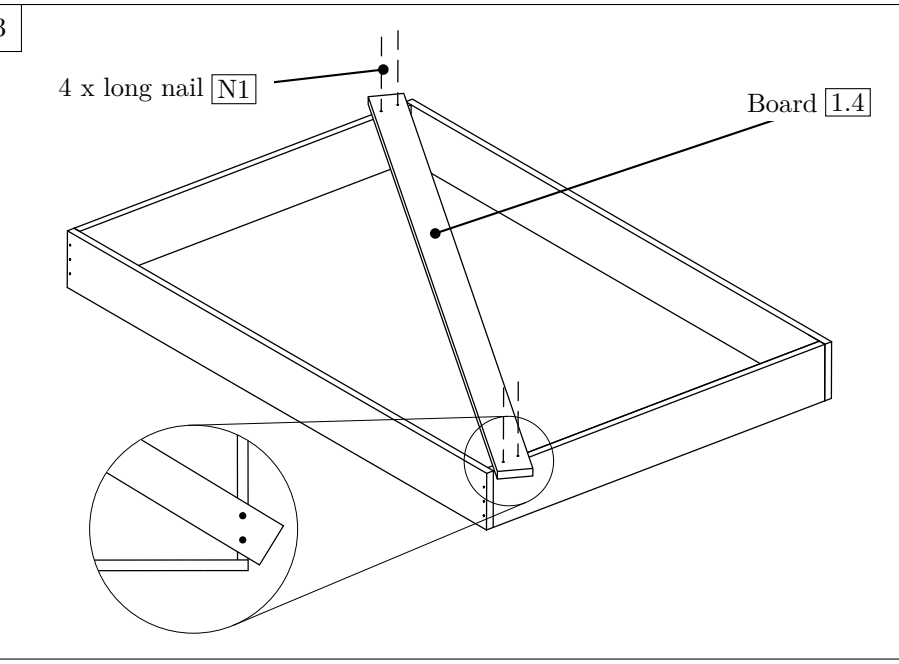
Place the boards 1.1 and 1.2 like shown in the picture. Make sure to place the short boards 1.2 between the longer boards 1.1 .

2



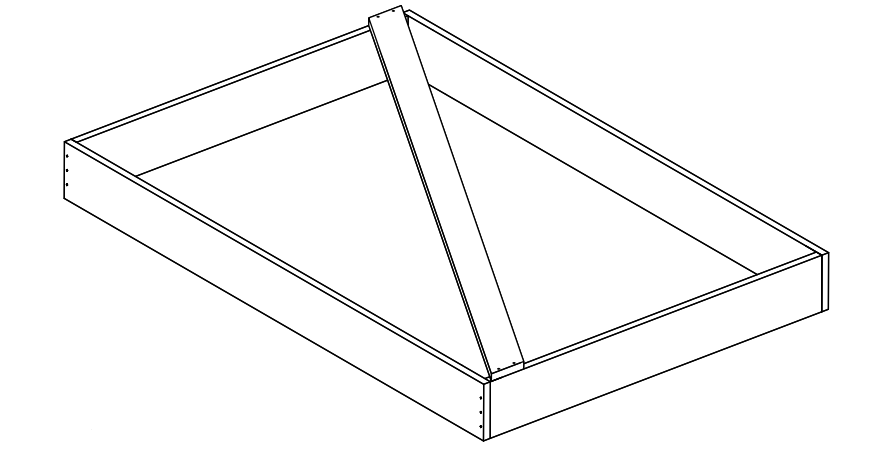
Put the boards together at all four edges. Use three long nails N1 per edge. The nails need to be placed in the center of the face-side of the board 1.2 (see dotted line). Distribute them evenly over the height of the board. Use a square to make sure that all boards are connected in a 90° angle.

3



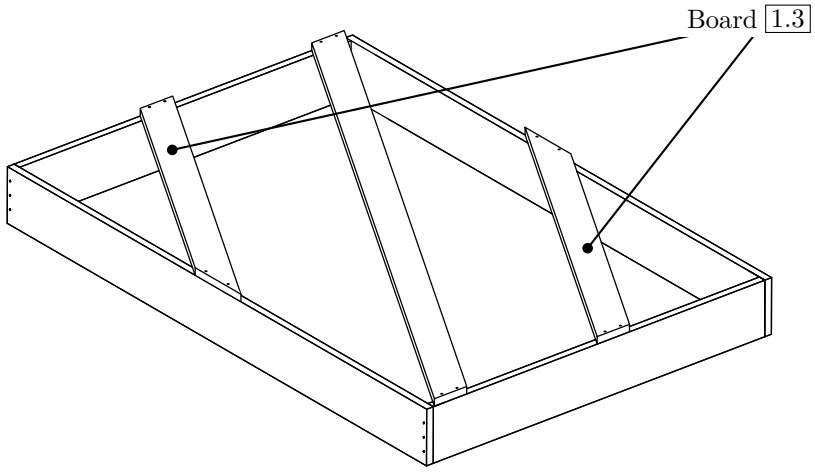
Now attach three diagonal boards to stabilize the box. Begin with the larger board 1.4 in the center. First fixate the board with one long nail N1 on each end. After ensuring that all edges of the box are in a 90 degrees angle, use another long nail on each end to finally fix the board. Make sure to only fix the board 1.4 onto the boards 1.2 . Be careful with the nails used in step 2.

4



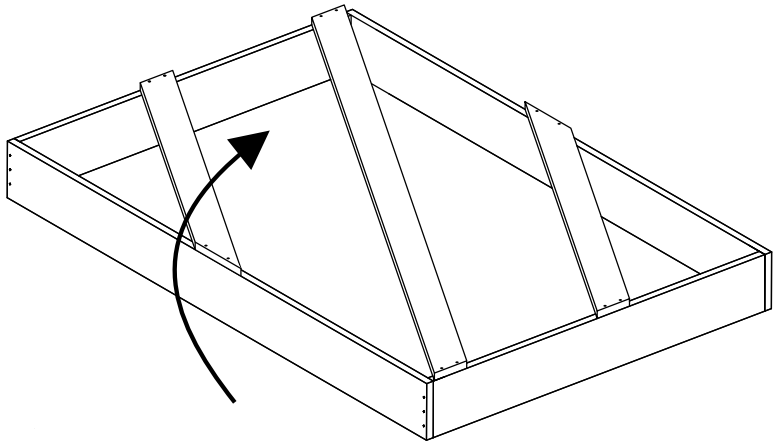
Saw off the protruding edges.

5



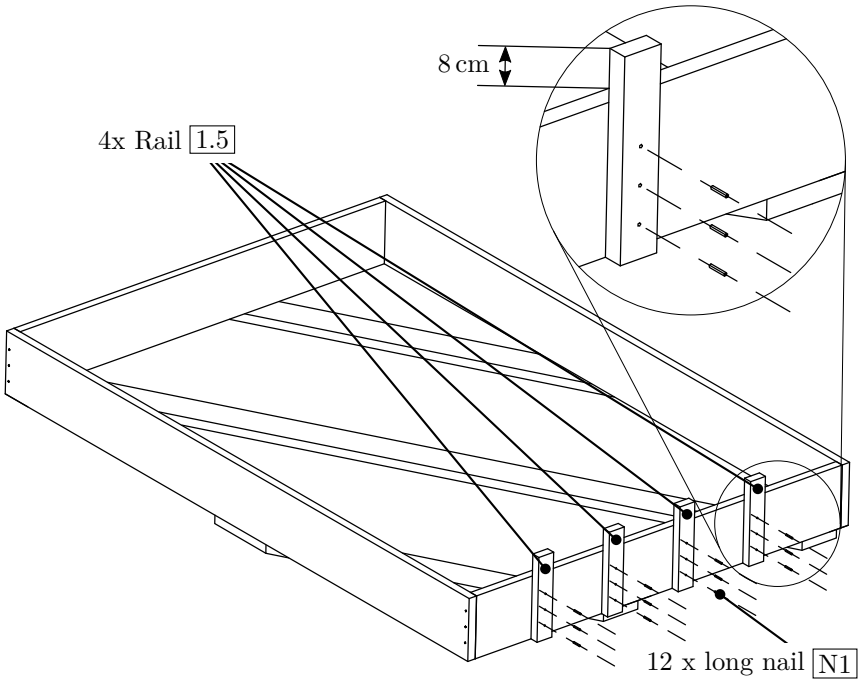
Follow the same procidure described in steps 3 and 4 for the smaller boards 1.3 . After that the box should look like the one in the picture.

6



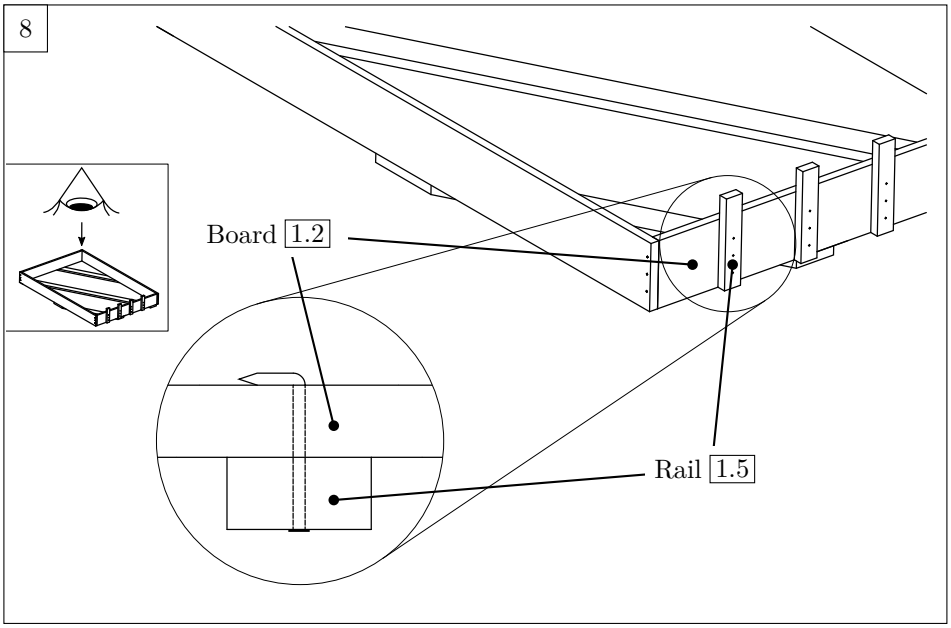
Turn the box around, so that the diagonal boards are facing down.

7



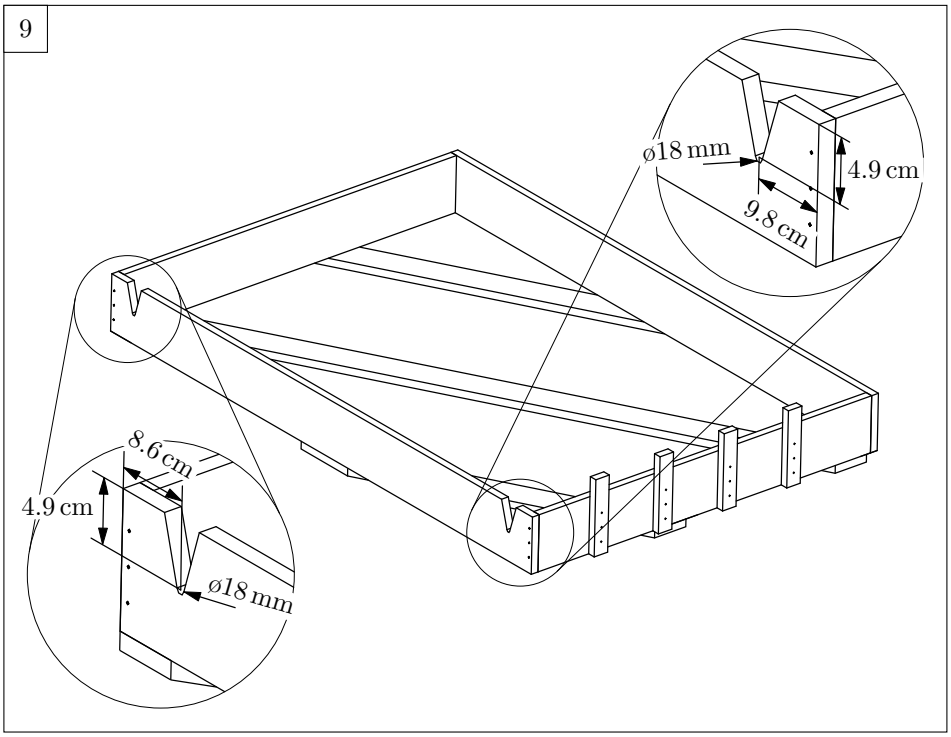
In order to support the glass later on, short rails are mounted to the box. These rails have to jut out at least 8 cm (see detail). Jam the rails 1.5 onto the board 1.2 . Use three long nails N1 per rail.

8



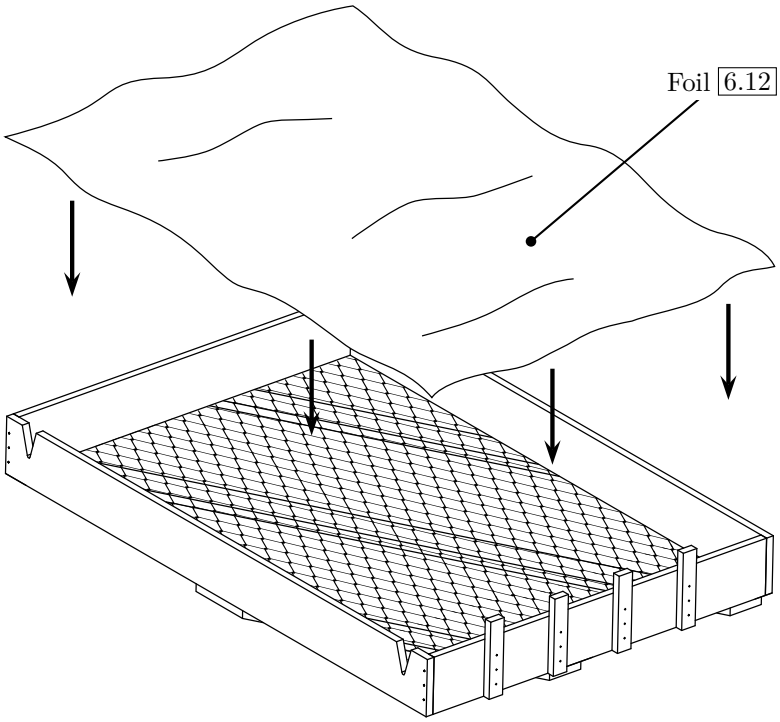
Since the nails are a little longer than the thickness of rail 1.5 and board 1.2 combined, the end of the nails needs to be bend in a 90 degrees angle as shown in the detail view.

9



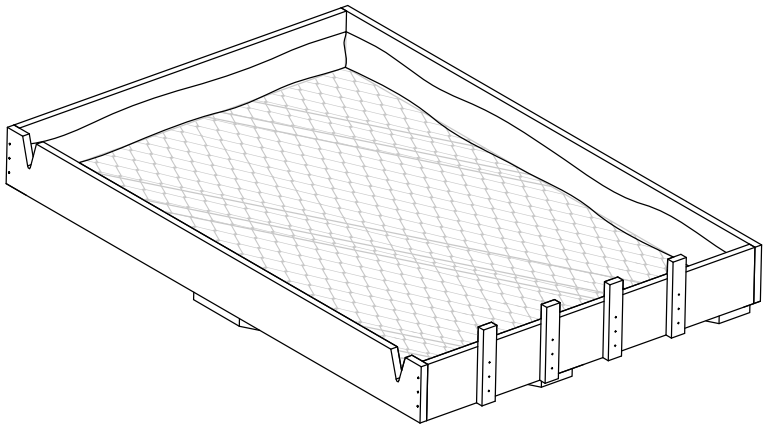
The box needs two gaps in order to install the pipe. Saw two slots at the positions shown in the picture. Important: The lower end of the slots needs a width of 18 mm, they can be wider at the opening.
First drill the holes at the point specified in the graphic with a diameter of 18 mm and then use a saw to cut the edges.

10



If vermins are a problem near your plant, you can protect the absorber's insulation by using some chicken wire. Lay it flat against the diagonal boards in the back of the wooden box. To protect the insulation from moisture, use the foil 6.12 and attach it accordingly.

Wooden box



The wooden box is finished.

5.2 Absorber Metal Sheets

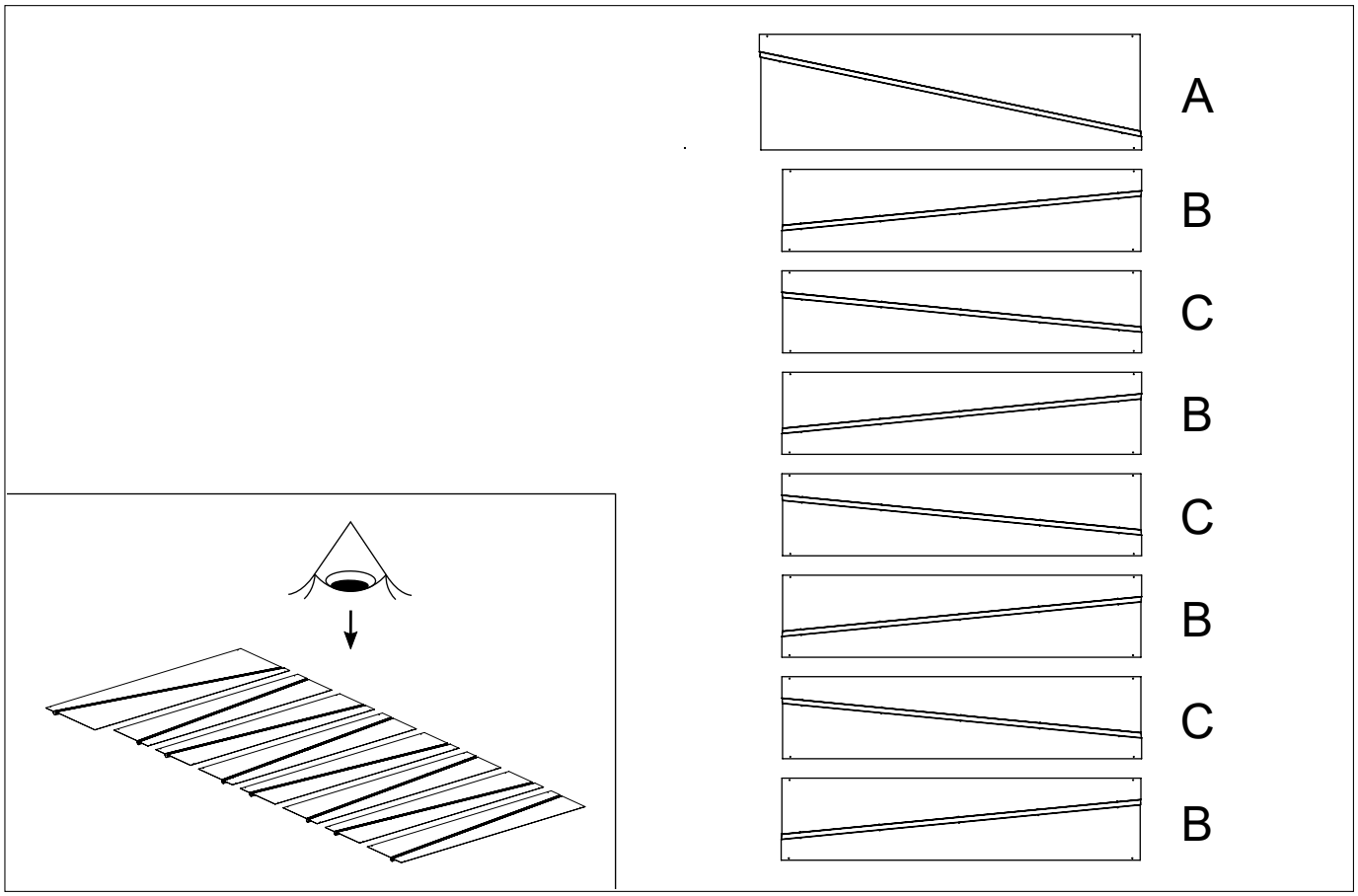
The metal sheets absorb sunlight and transfer the heat to the metal pipe. The pipe sits in the grooves of the metal sheets. You have to bend the metal sheets to get the grooves.
This chapter shows the dimensions of the final sheets. It does not show how to bend the sheets.
If you don't have a tool to bend the metal sheets, build the "Metal Sheet Bending Tool" (see Appendix A.1 (Page 76)) and use it (see Appendix A.2 (Page 93)).

Metal sheets:

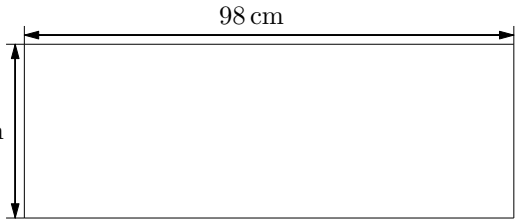
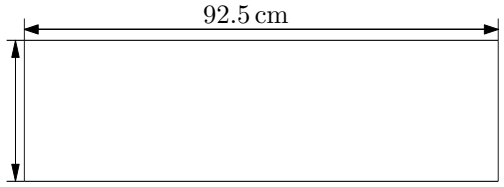
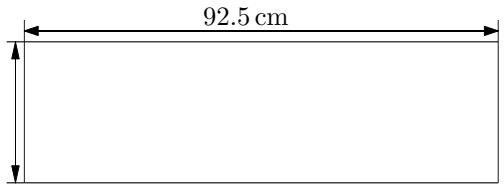
- Thermoconductive
- **Easy to bend**
- Aluminum or copper are good
- Thickness: 0.6 - 1 mm, **thinner is easier to bend**
- When buying the metal sheets: **Check with hand if metal sheets are easy to bend**

Arrangement:

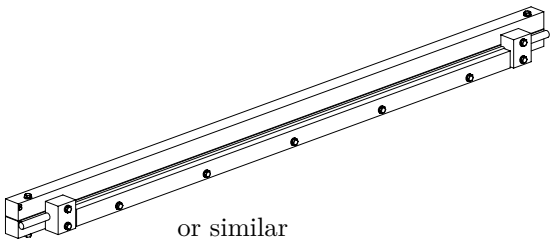
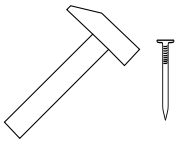
- Three different types of metal sheets (A, B, C)
- A is bigger
- B and C have the same size but are mirrored
- See arrangement in the picture



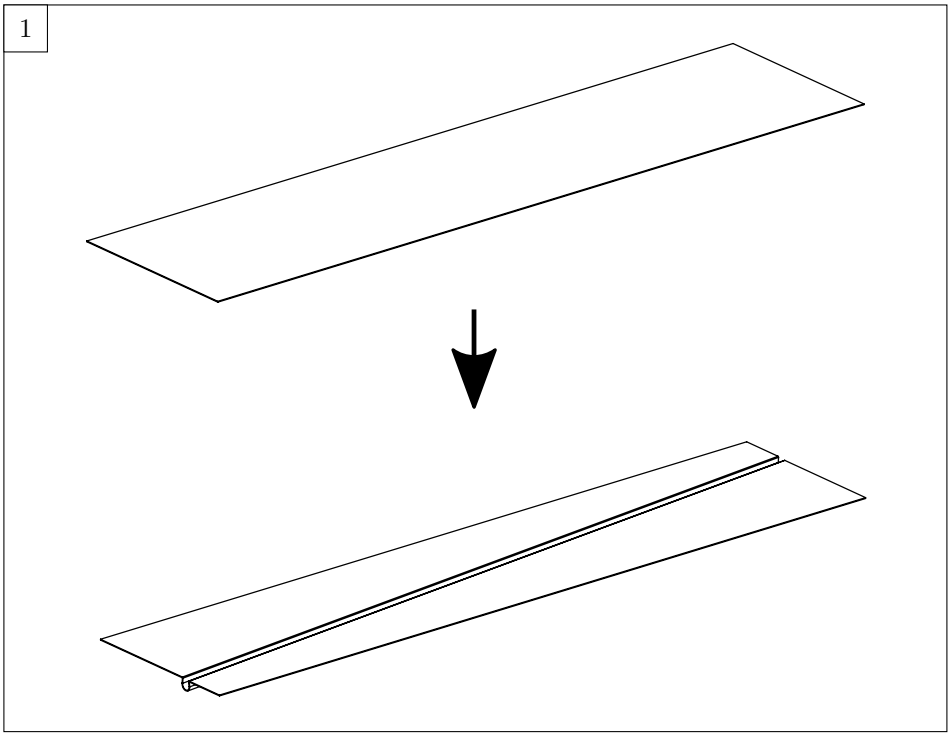
Required materials:

Quantity	Figure	Title		Other
1 x		Metal sheet A	2.1	Thickness: 0.6 - 1 mm Material: Aluminum/Copper
4 x		Metal sheet B	2.2	Thickness: 0.6 - 1 mm Material: Aluminum/Copper Same as metal sheet 2.2
3 x		Metal sheet C	2.3	Thickness: 0.6 - 1 mm Material: Aluminum/Copper Same as metal sheet 2.1

Required tools:

Number	Figure	Title		Other
1 x	 or similar	Metal-Sheet-Bending-Tool	A.1	Tool to produce a round groove in the metal sheet (dimensions see step 7). If you do not have a suitable tool, you can build one using the instructions in chapter A.1 (Page 76).
1 x		Hammer and nail		Diameter of nail: Corresponding to wire 4.1

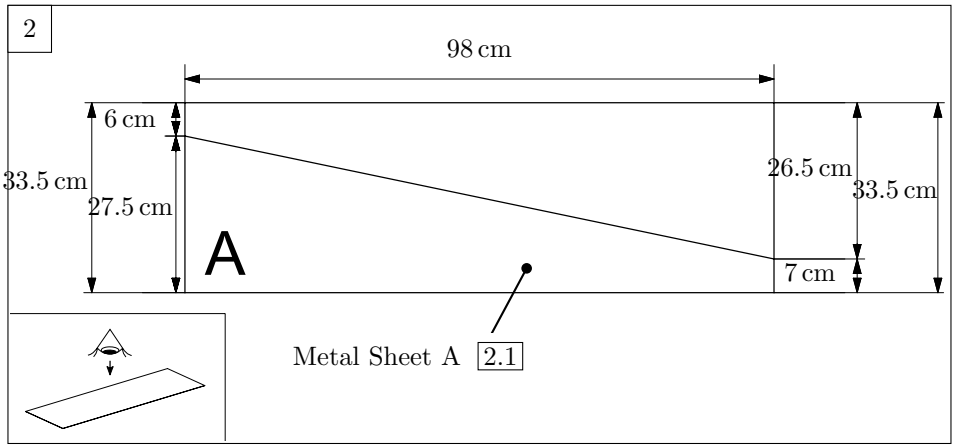
1



Bend the metal sheets to get the grooves

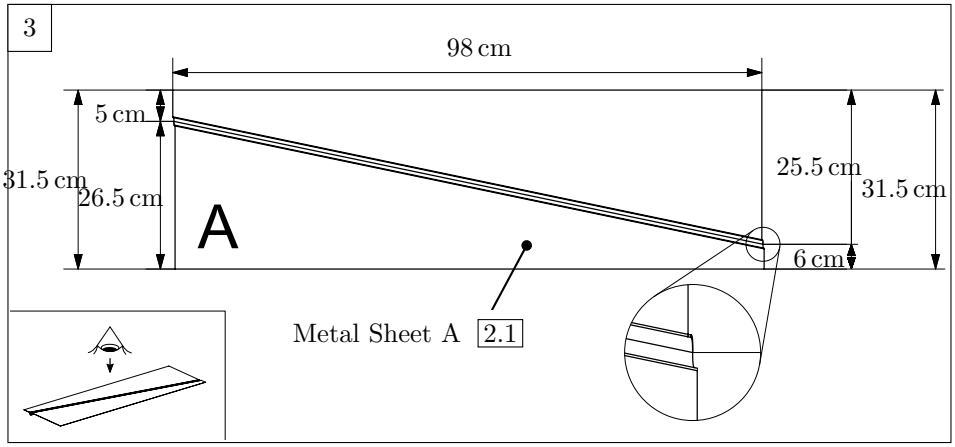
The following pictures show the dimensions for metal sheet A, B and C. Use them to bend the metal sheets.

2

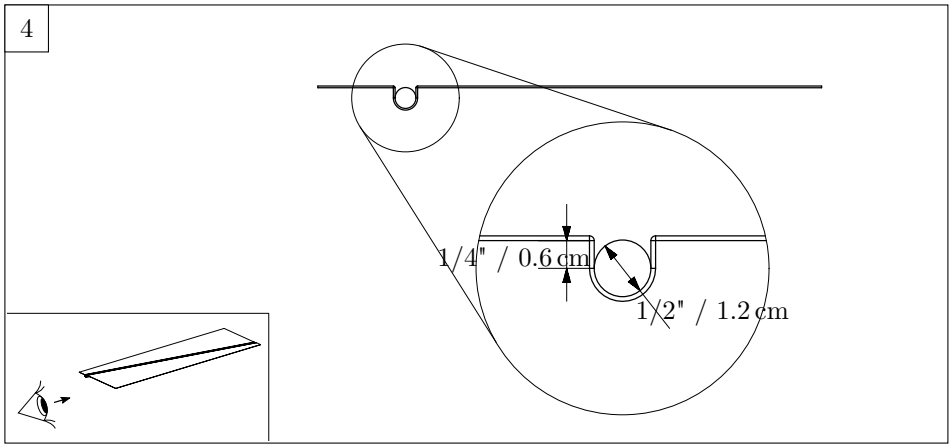


This shows the dimensions of the straight metal sheet A (before bending). The line will be the middle of the groove.

3

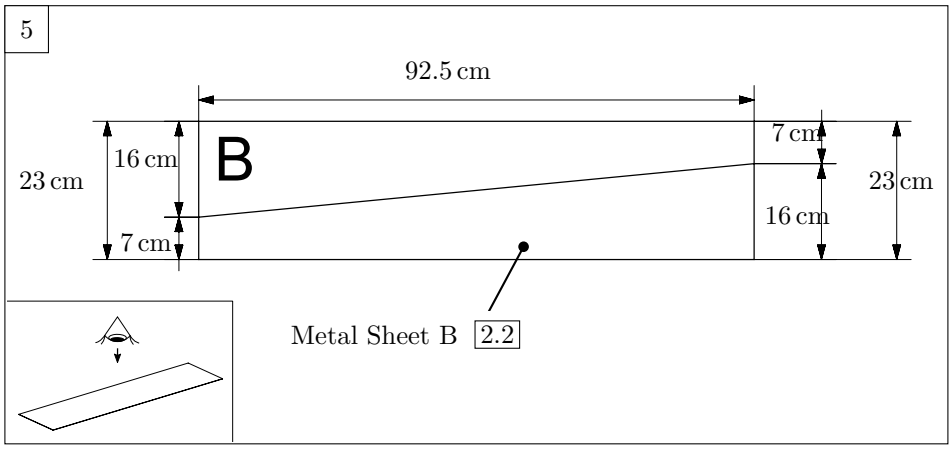


This shows the dimensions of the metal sheet A with groove (after bending).

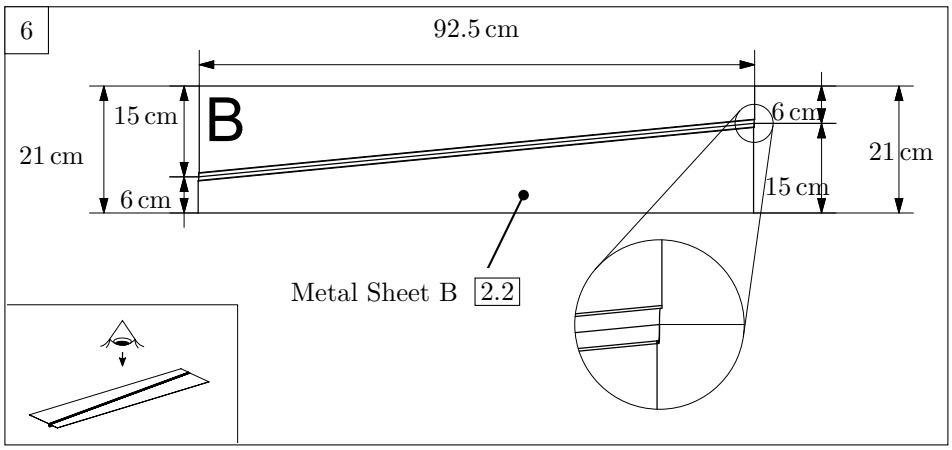


This shows the dimensions of the groove. It is the same as metal sheet B and C.

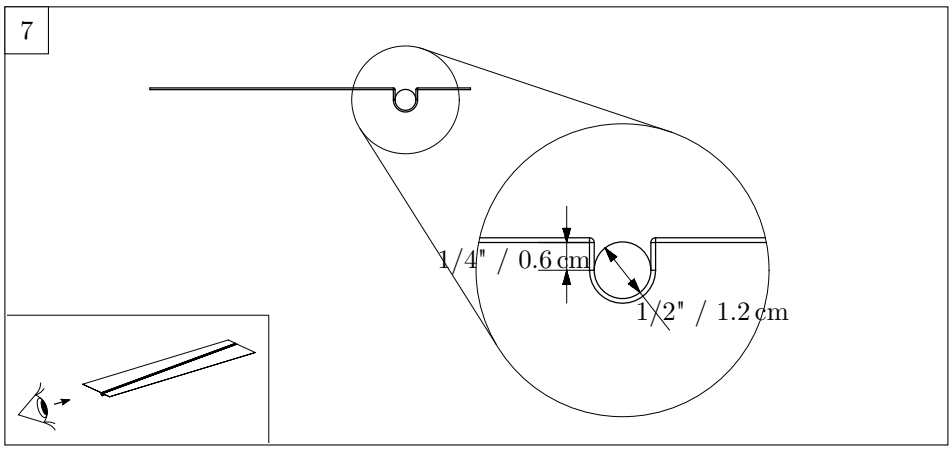
You need 1x metal sheet A.



This shows the dimensions of the straight metal sheet B (before bending). The line will be the middle of the groove.



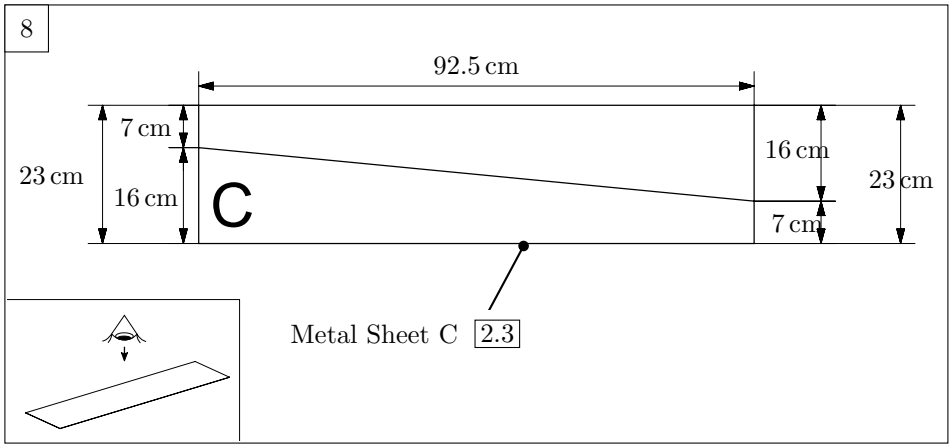
This shows the dimensions of the metal sheet B with groove (after bending).



This shows the dimensions of the groove. It is the same as metal sheet A and C.

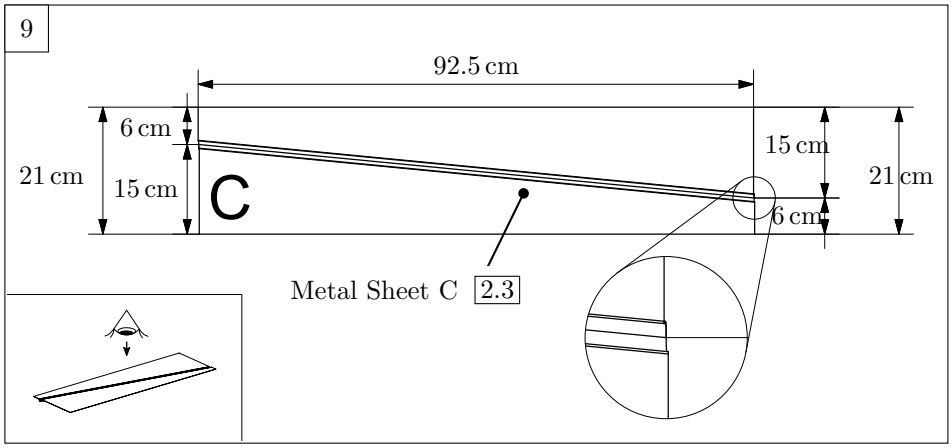
You need 4x metal sheet B.

8



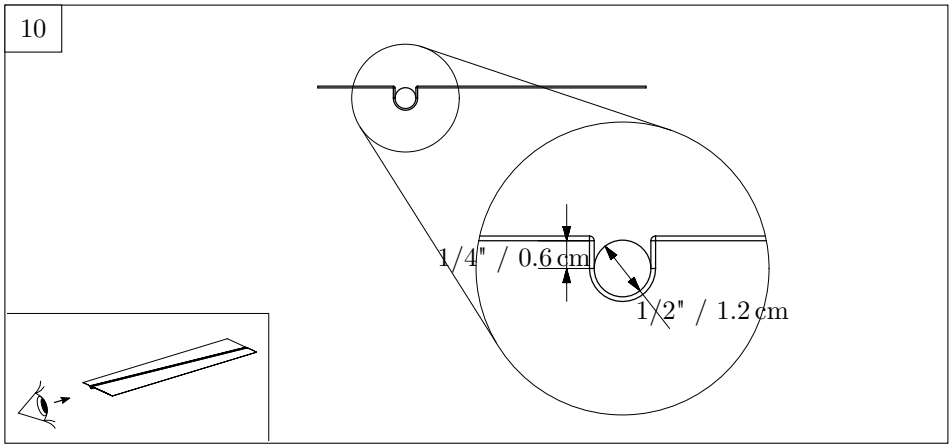
This shows the dimensions of the straight metal sheet C (before bending). The line will be the middle of the groove.

9



This shows the dimensions of the metal sheet C with groove (after bending).

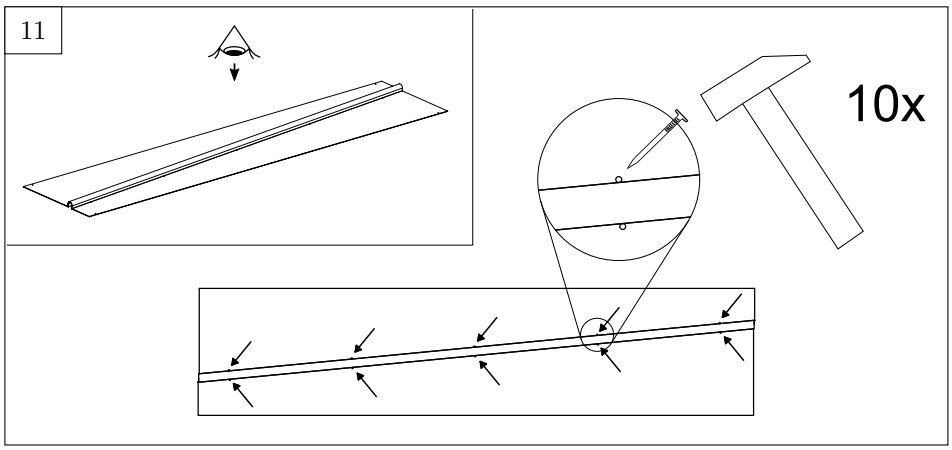
10



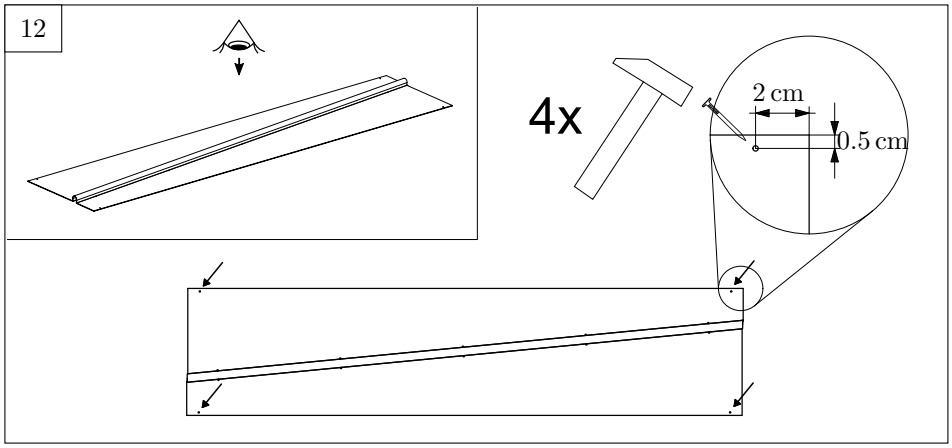
This shows the dimensions of the groove. It is the same as metal sheet A and B.

You need 3x metal sheet C.

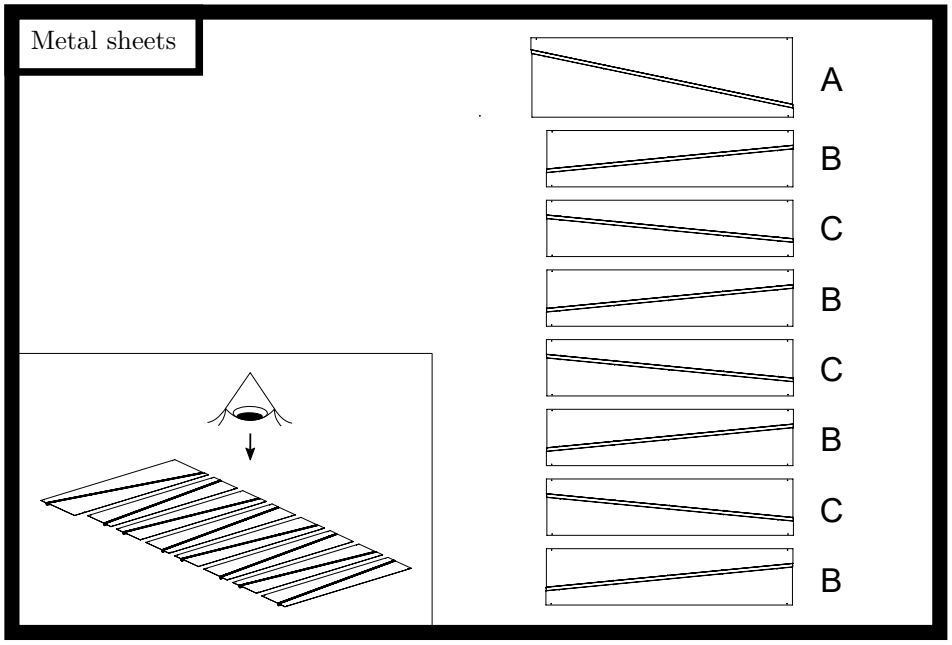
11



Poke holes in all metal sheets along the groove. Use hammer and nail. The holes have to be big enough for the wire 4.1 . The pipe will be fixed with the wire.



Poke holes in the corners of all metal sheets. Use the hammer and a nail. The sheets will be fixed to each other with wire.

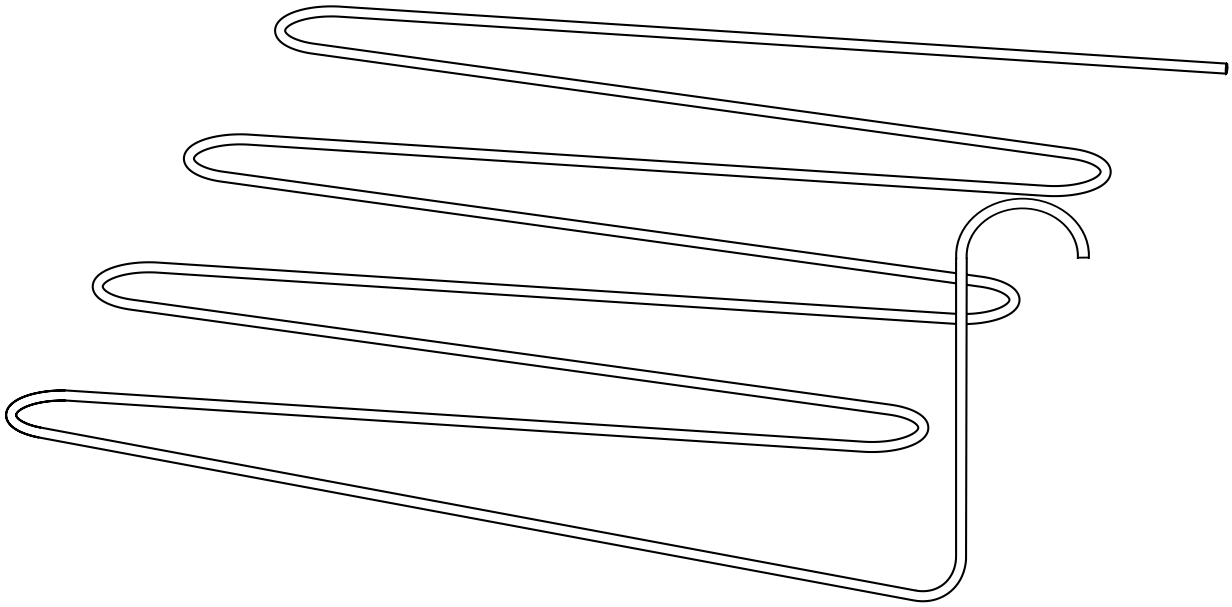


Finish all metal sheets and arrange them according to the picture.

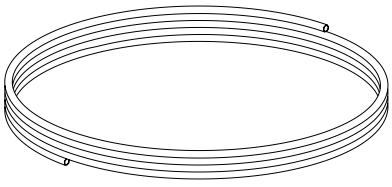
5.3 Pipe

The water is flowing through the pipe and is heated until it reaches 100 °C.
If you do not have a suitable tool to bend the pipe, skip this chapter. Instead go to chapter A.3 (Page 100) and build the described pipe-bending tool. Afterwards bend the pipe as described in chapter A.4 (Page 104).

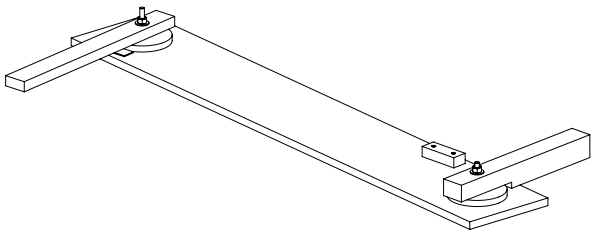
- You need a 10.5 m long pipe of easily bendable material with an outer diameter of 1/2" / 1.2 cm. The pipe has to be made out of soft copper as this makes it easy to bend. You can buy it in large coils. Hard copper pipes, which are sold as rods, are not suitable for bending.
- The pipe will always stay quite flexible. As long as it has roughly the right shape you can force it into the right positions after mounting it.
- You must not bend the pipe too often at the same position. This will make the copper hard and unsuitable for further bending.
- If you have your own tool for pipe bending, only use it if you are absolutely sure how it works. In any other case use the tool you can build with the instructions in appendix A.3 (Page 100).



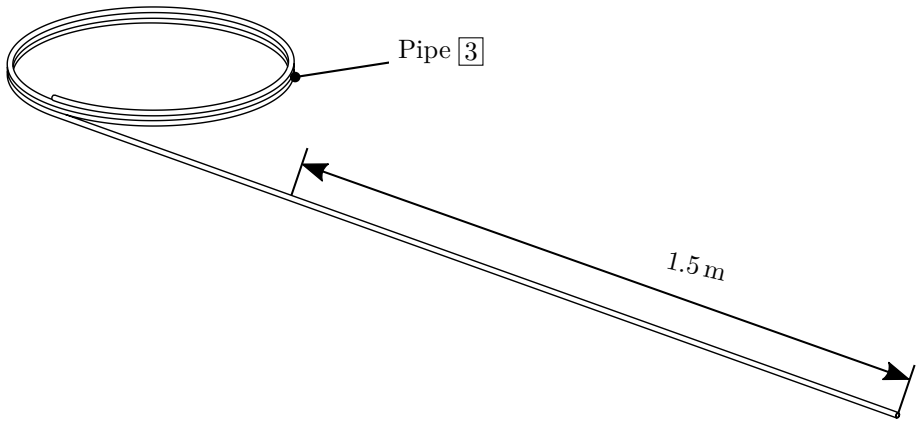
Required materials:

Quantity	Figure	Title		Other
1 x		Pipe	3	Length: at least 10.5 m Outer diameter: 1/2" / 1.2 cm Wall thickness: ca. 1 mm Material: soft copper

Required tools:

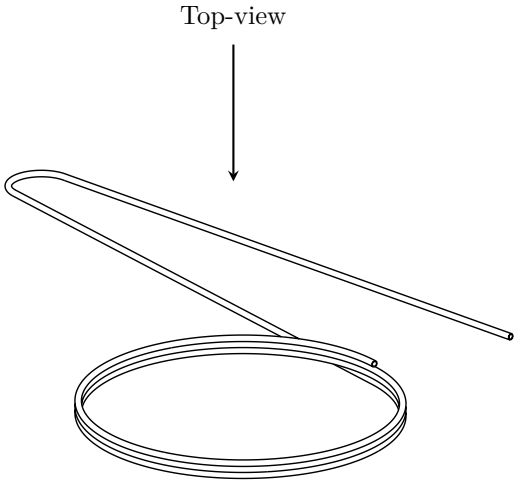
Number	Figure	Title	Other
1 x		Pipe-bending-tool A.3	Tool for bending a 1/2" / 1.2 cm pipe. If you don't have a suitable tool, you can build one with the instructions in appendix A.3 (Page 100).

1



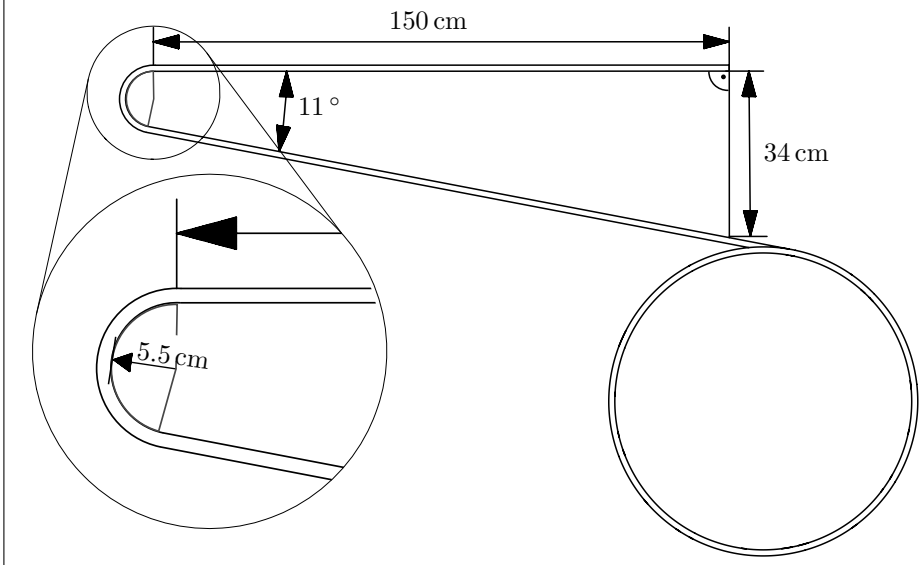
Unwind at least 1.5 m of the pipe and straighten it.

2



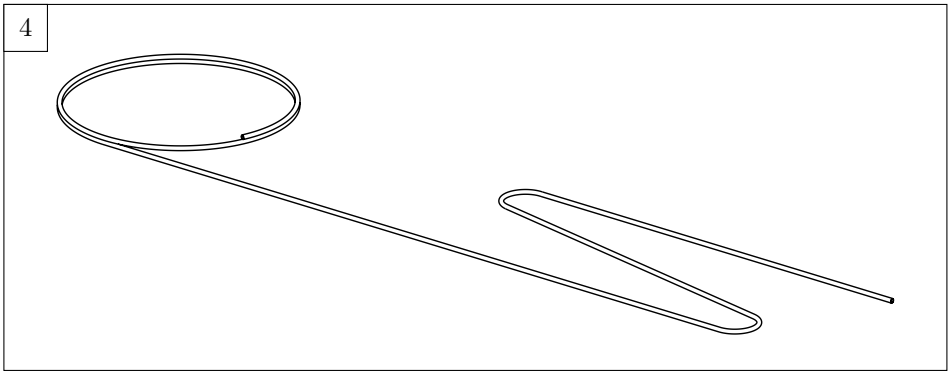
Bend the first part. The dimensions are always shown in top-view.

3 - Top-view



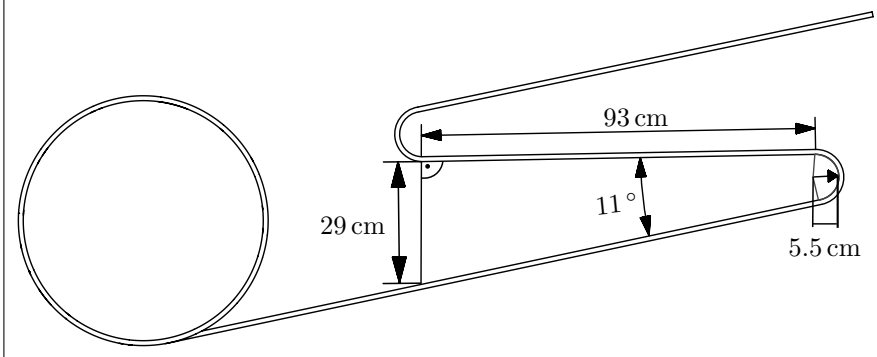
Here you can see the dimensions. The distance between the end of the pipe and the first bend has to be 150 cm. The radius of the bend is 5.5 cm, measured from the center point to the inner side of the pipe (see detail picture). By ensuring a distance of 34 cm between the straight parts at the position shown in the picture, you will get an angle of 11 °.

4



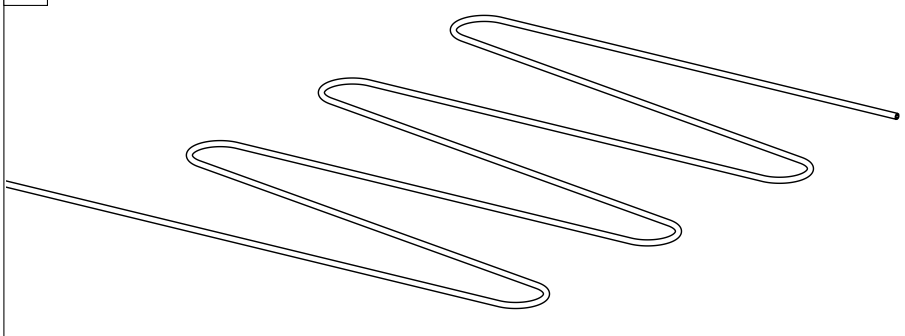
Now do the second bend. Use the dimensions shown in the next picture.

5 - Top-view



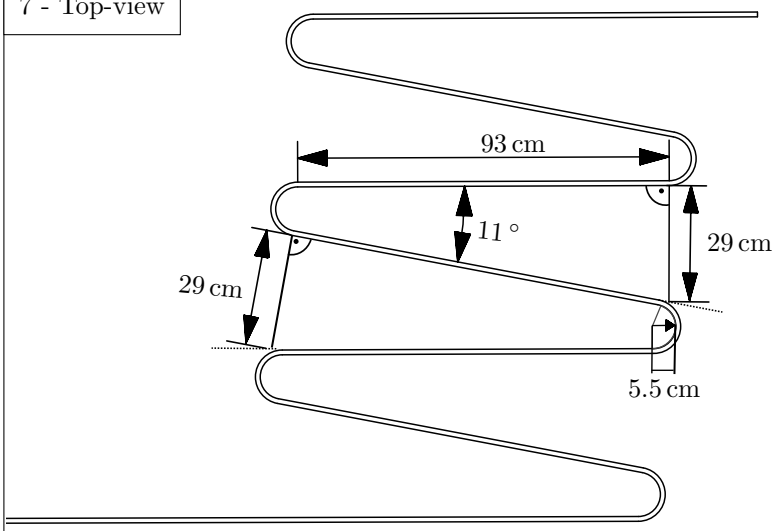
Bend the pipe as shown in the picture. The distance in between bends is 93 cm. The radius is 5.5 cm. The angle of 11 ° can be achieved by maintaining a 29 cm distance between the straight parts at the position as shown in the picture.

6



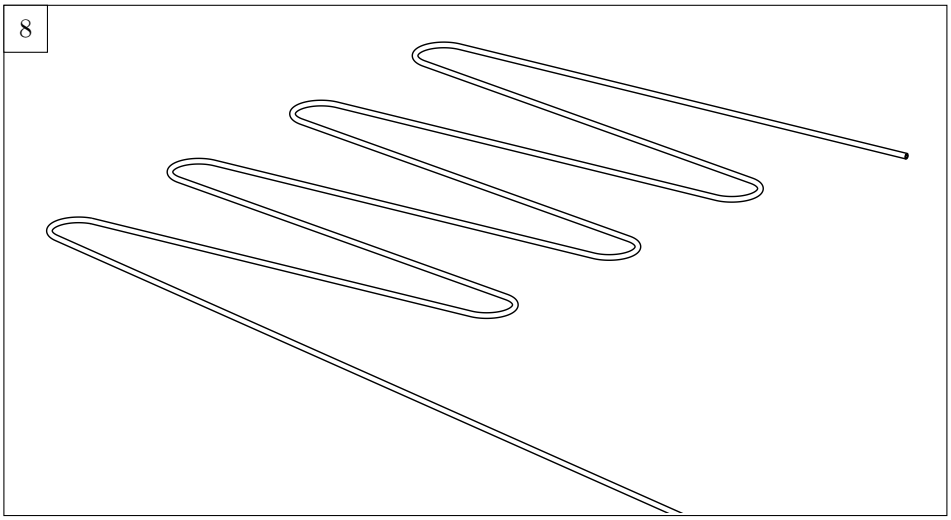
Repeat the last step until there are 6 bends. The dimensions are shown in the next picture.

7 - Top-view



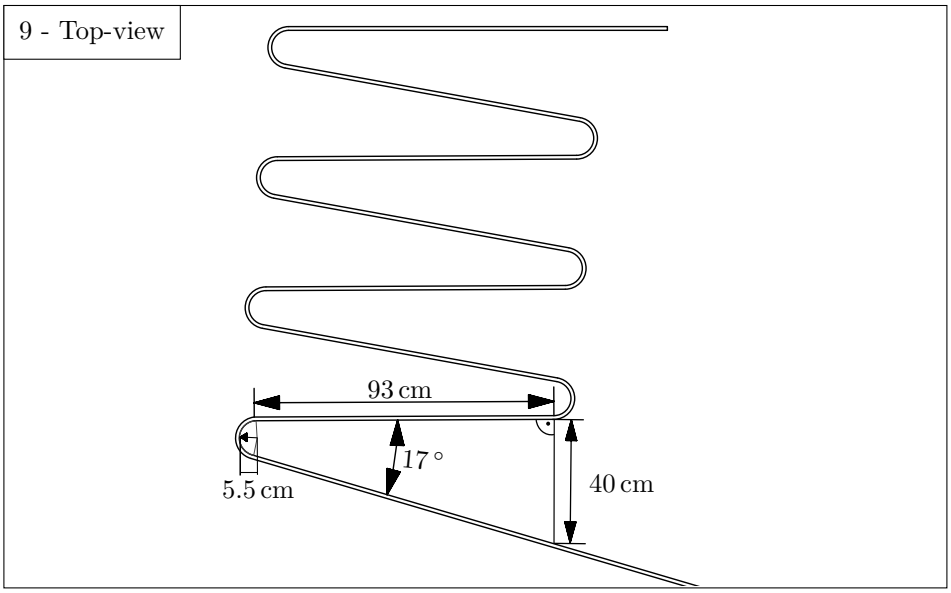
The dimensions are the same for all bends. Continue until you have 6 bends.

8



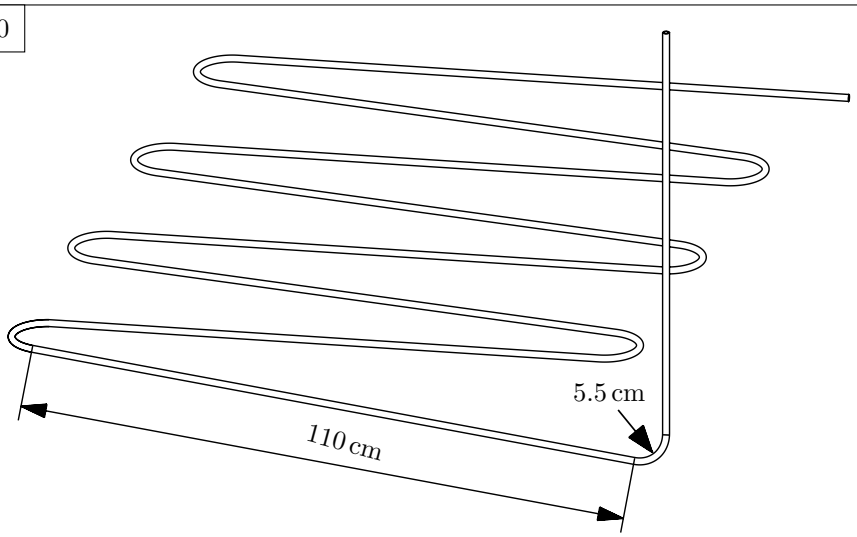
The 7th bend is a little different. The angle is a bit larger than before, see next picture.

9 - Top-view



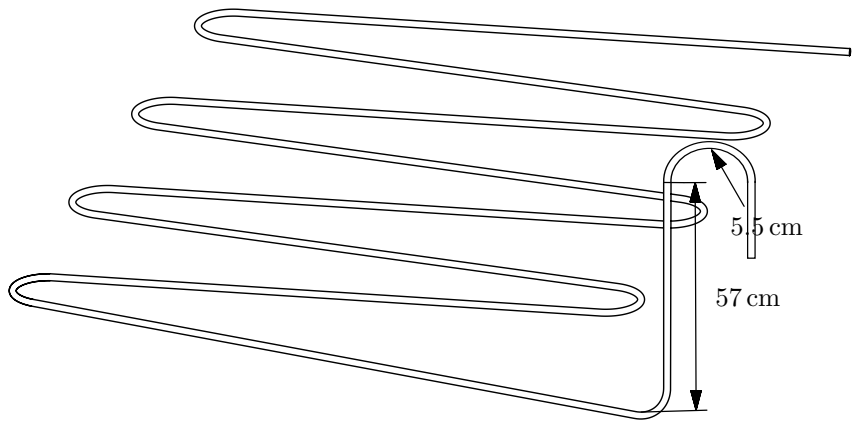
The radius is still 5.5 cm. If there is a distance of 40 cm between the straight parts at the position shown in the picture, you will get an angle of 17 °.

10



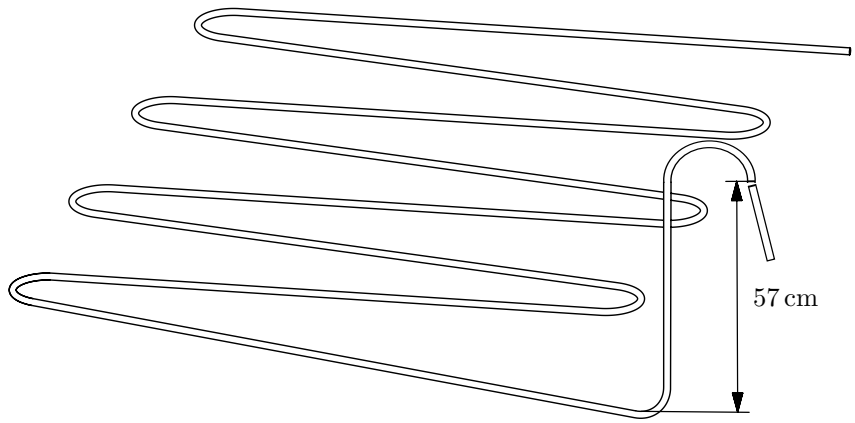
Bend the remaining pipe perpendicularly upwards at a distance of 110 cm from the last bend. Again the radius should be 5.5 cm.

11

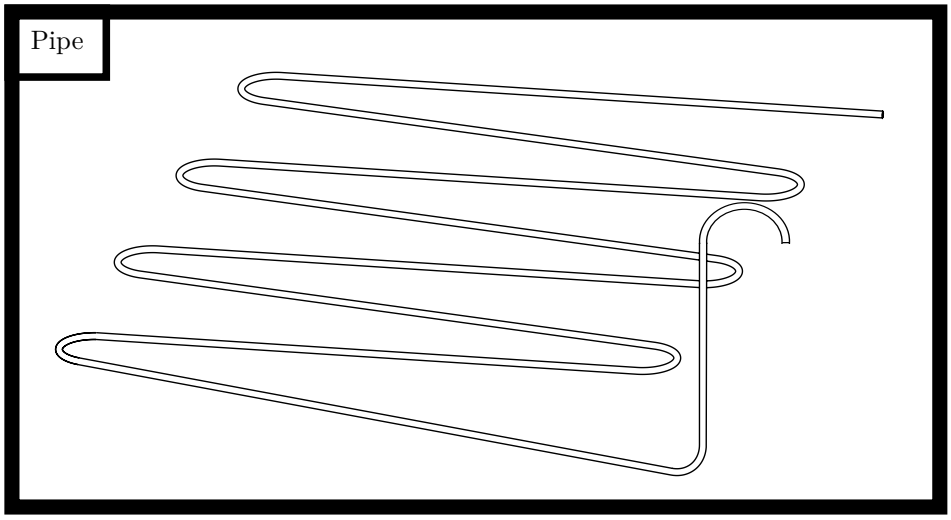


Bend the pipe as shown in the picture. The distance between the new bend and the straight pipe of before the last bend is 57 cm. The radius is 5.5 cm again. Make a bend of 180° this time.

12



At last cut the pipe at the end you just bent. The outlet must have a distance of 57 cm to the last bend.

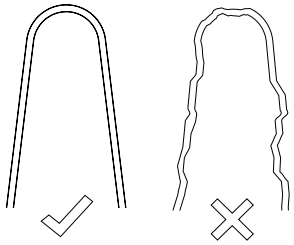


The pipe is finished.

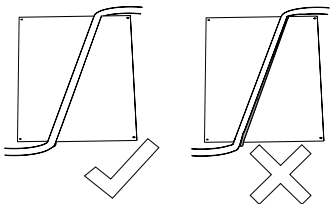
5.4 Assembly of the Absorber

Now we connect the sheets to the pipe. As a result, they conduct the heat over the pipe into the water. We call this part the absorber because it absorbs the solar energy.
We insert the pipe into the grooves of the metal sheet and fix them with pieces of wire. Finally, we will paint the absorber black to improve the heat transmission.
Some important points are:

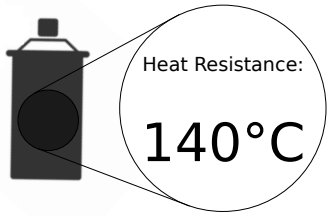
- Check that the straight segments of the pipes are really straight.

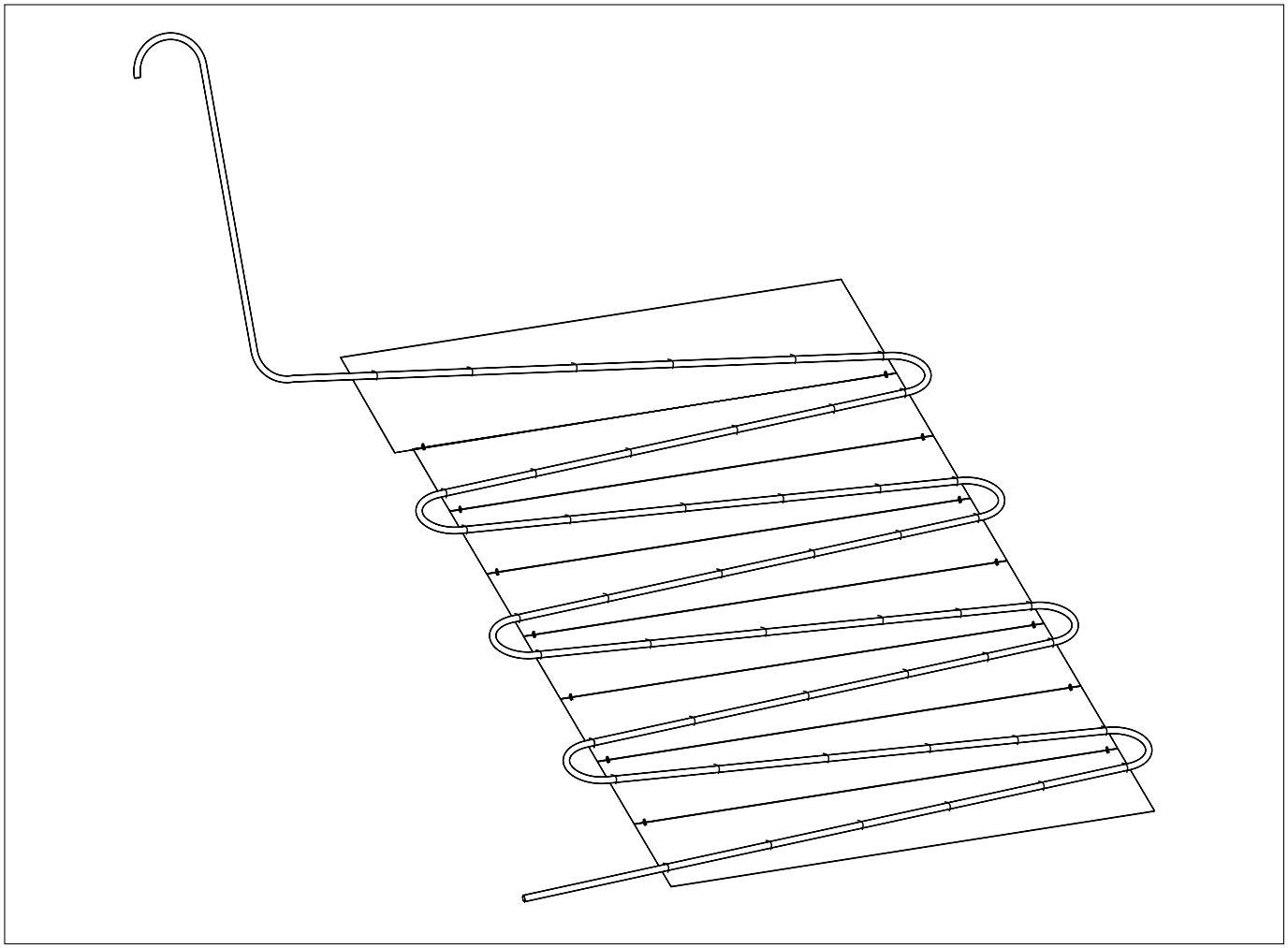


- The pipe has to fit neatly into the grooves.

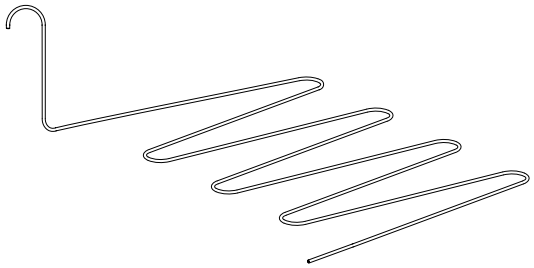
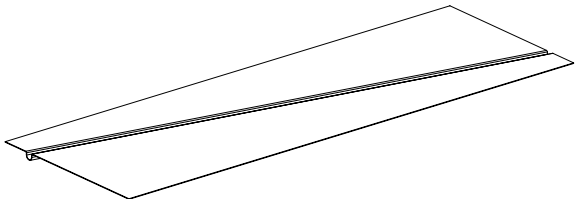
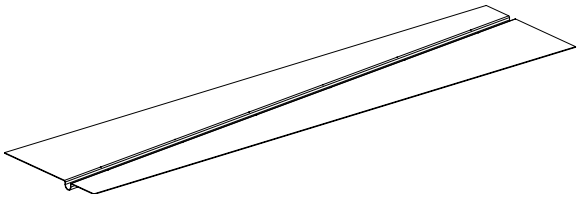
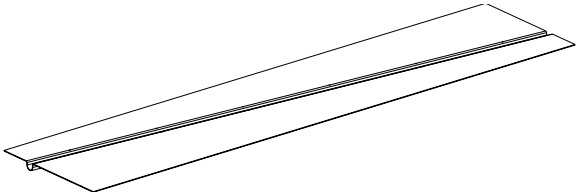
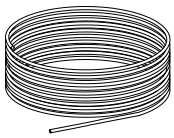


- The paint has to be heat resistant up to 140°C.

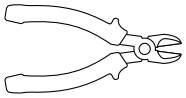
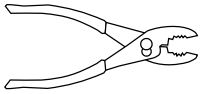




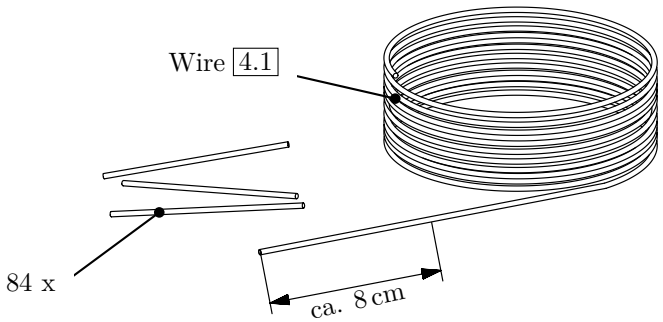
Required material:

Number	Figure	Title		Other
1 x		Pipe	3	See chapter 5.3 (Page 35)
1 x		Metal Sheet A	2.3	See chapter 5.2 (Page 29)
4 x		Metal Sheet B	2.1	See chapter 5.2 (Page 29)
3 x		Metal Sheet C	2.2	See chapter 5.2 (Page 29)
1 x		Wire	4.1	Length: at least 23' or 7 m Diameter: 1 mm The wire has to be sufficiently solid. For example, wire from concrete building is suitable.
1 x		Spray Paint	4.2	Black paint, has to be heat resistant up to 140°C. Apply a thin layer. Sufficient for at least 20 ft^2.

Required tools:

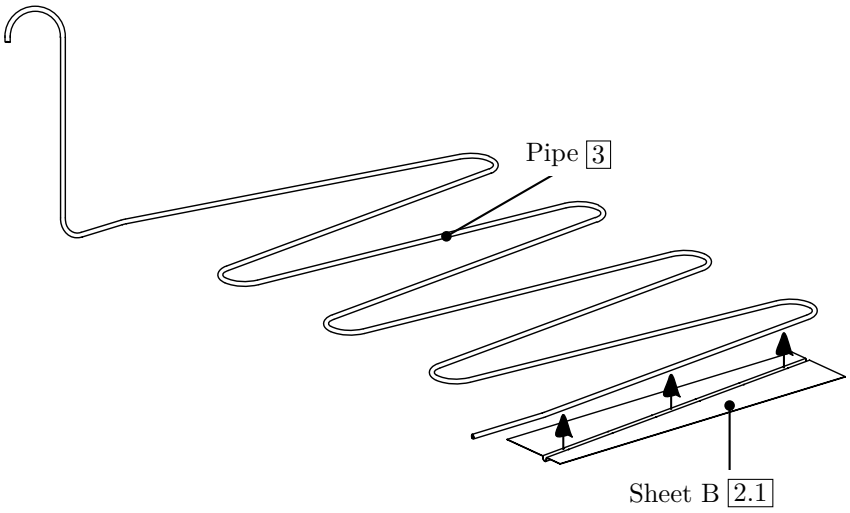
Number	Figure	Title	Other
1 x	 or similar	Side cutter	For cutting the wire.
1 x	 or similar	Plier	For twisting the wire.

1

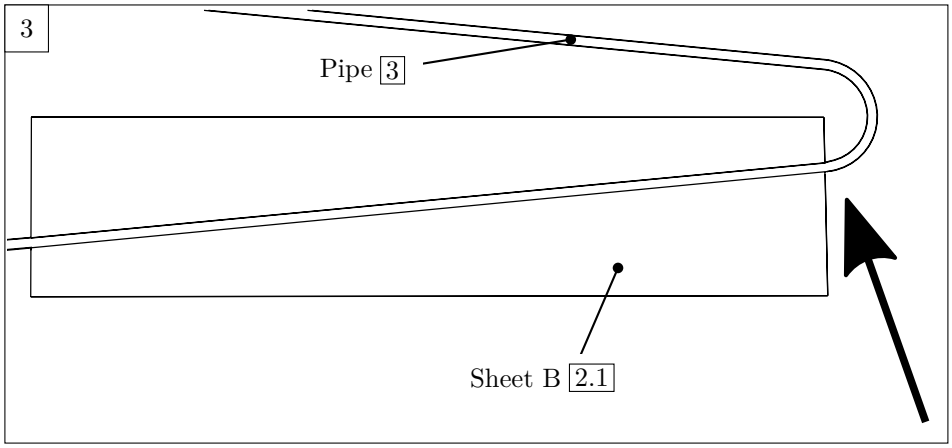


Cut off about 8 cm long pieces from the wire 4.1 . In total, you need 84 pieces.

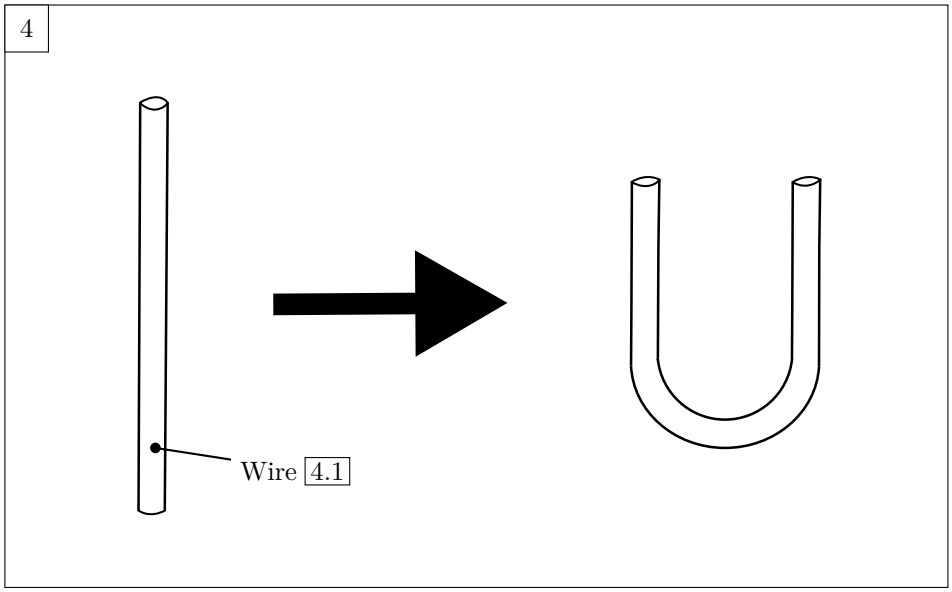
2



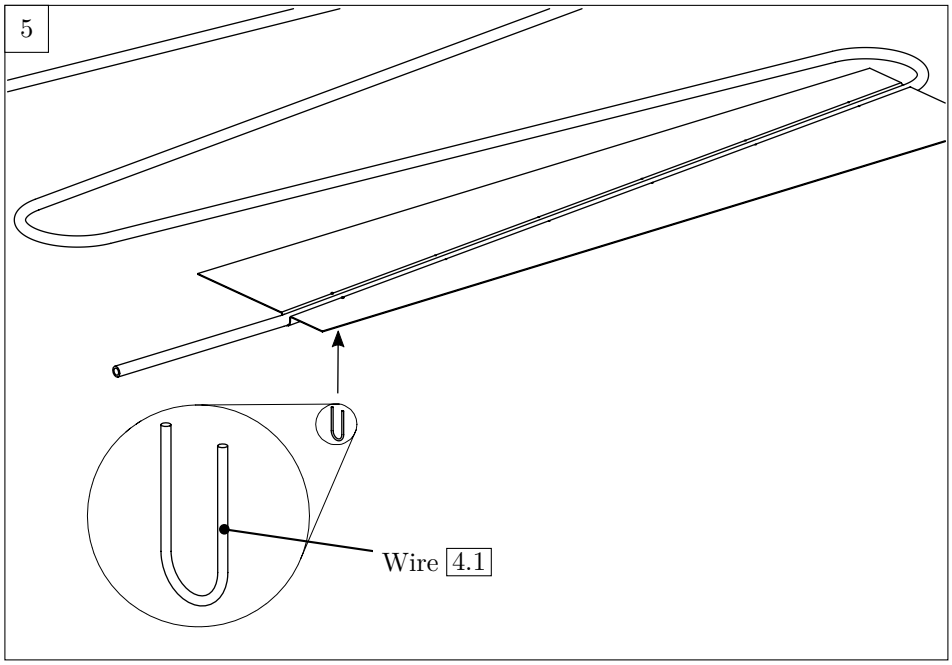
Clamp the sheet B 2.1 to the beginning of the pipe from below. On the next picture you can see more precisely where to put the sheet.



Make sure sheet B 2.1 ends where the curve of the pipe 3 begins.

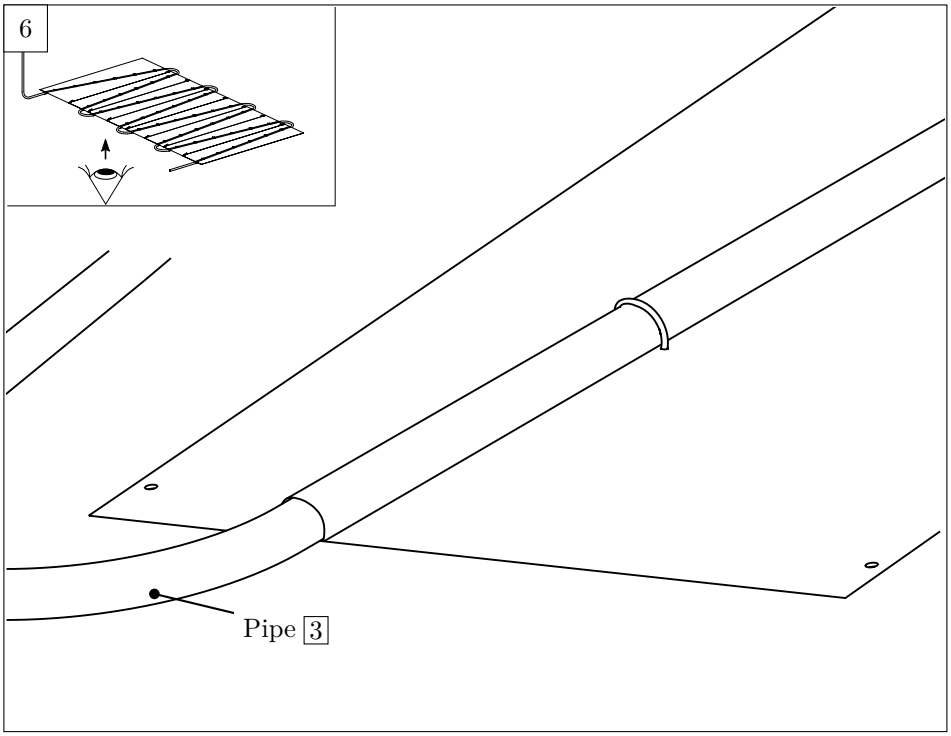


Bend a piece of wire 4.1 to a U shape.



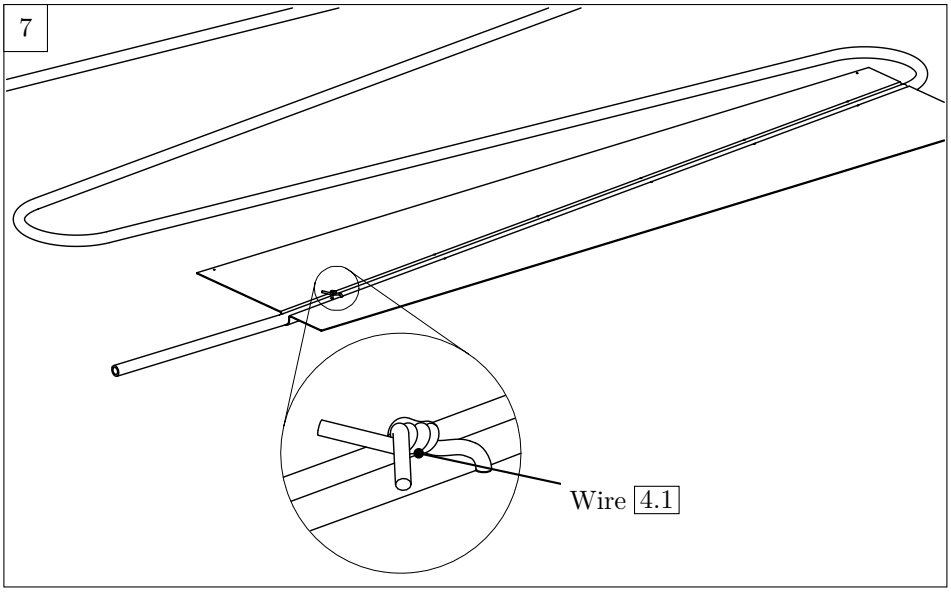
Stick the wire 4.1 through the holes to fix the pipe.

6



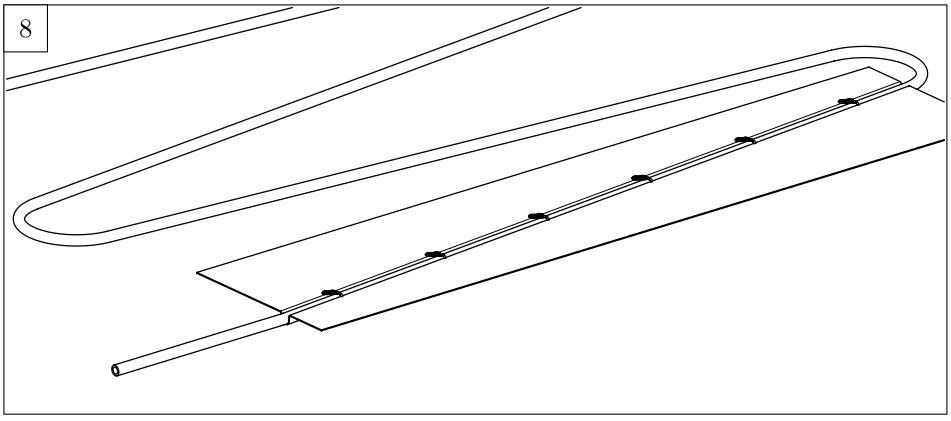
From below it should look like this.

7



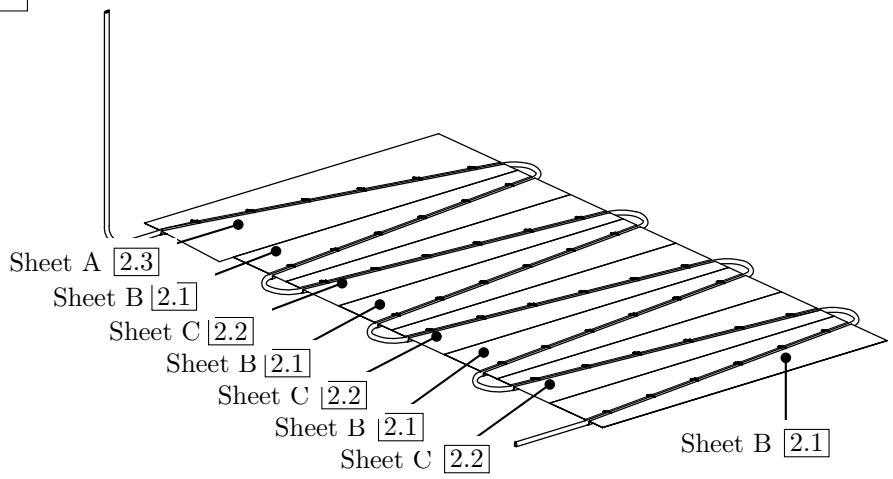
Twist the wire 4.1 using the plier and fold the ends down. Make sure the pipe is tight and does not shake any more.

8



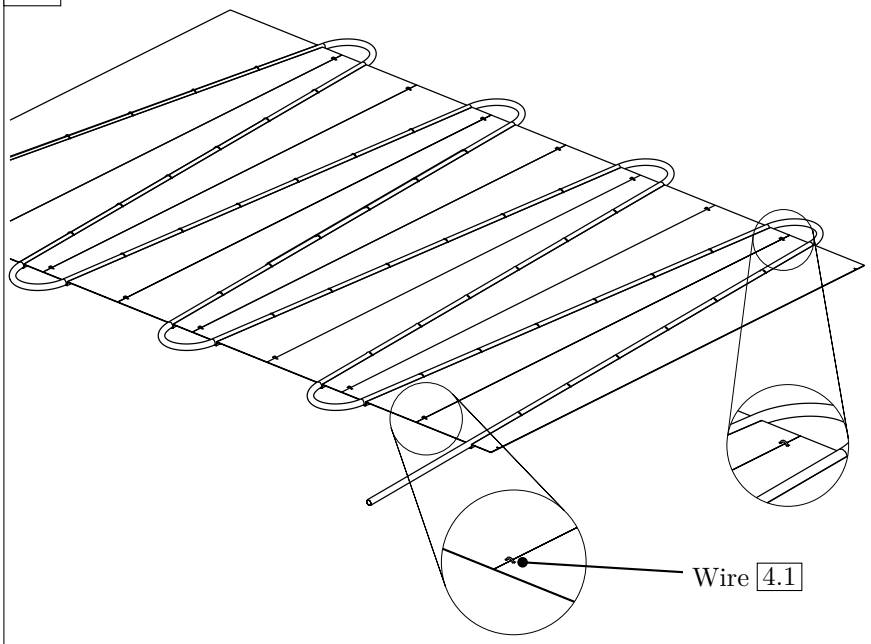
Install the other pieces of wire for that sheet in the same way.

9



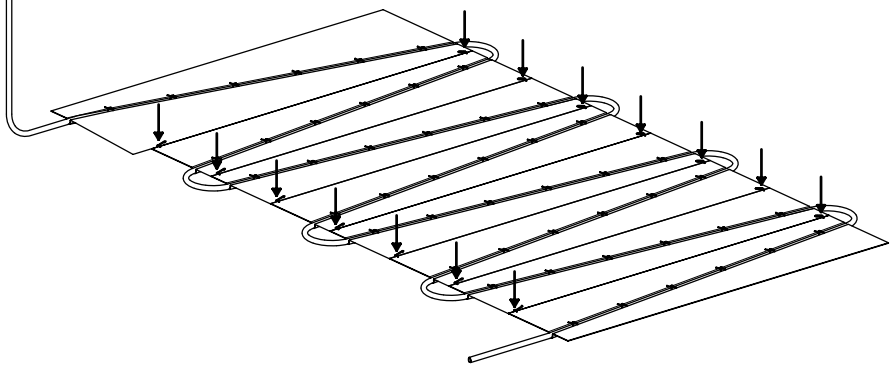
Add the other sheets and other pieces of wire to attach them to the pipe. Use a sheet C 2.2 and a sheet B 2.1 alternately. Finally, you have to install the sheet A 2.3 , which is slightly larger.

10



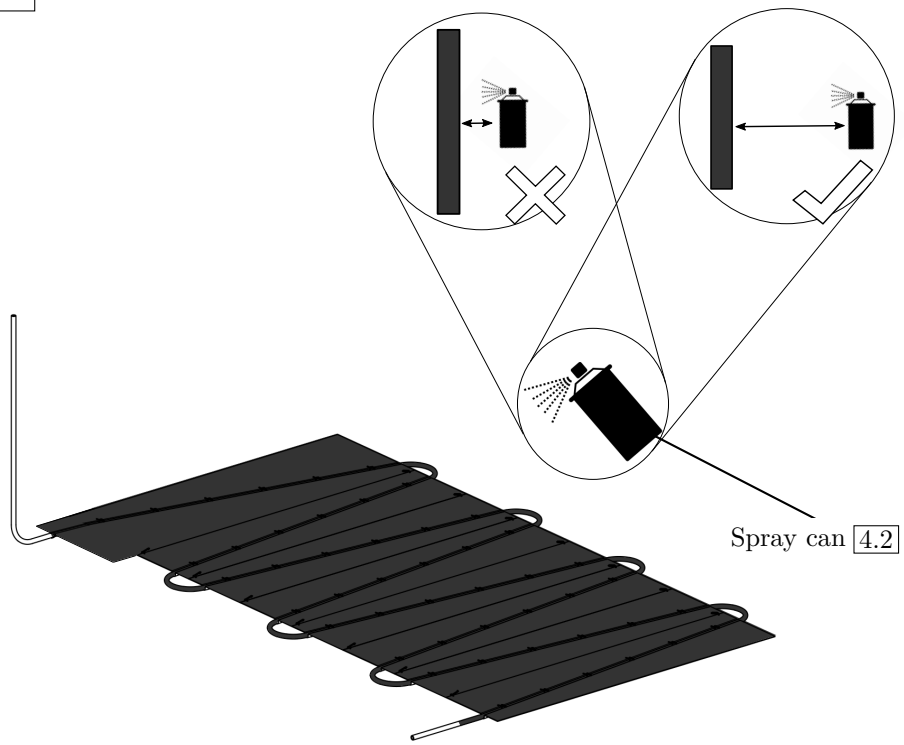
Connect the two lower sheets 2.1 and 2.2 with two pieces of wire 4.1 . Use the holes along the sides of the sheets, twist the wires and fold the ends towards the center of the sheets, similarly to the previous steps.

11



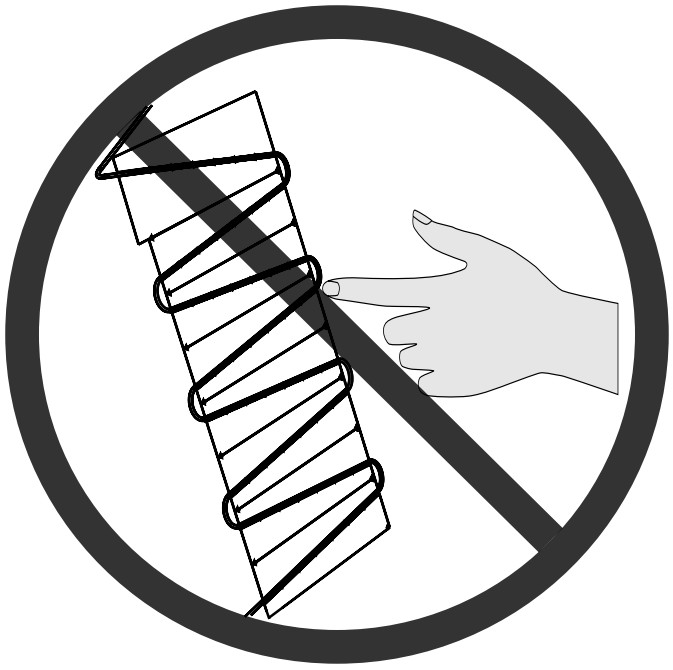
Connect the other sheets in the same way. Always connect two sheets with two pieces of wire 4.1 . The arrows in the image show the position of the wires.

12



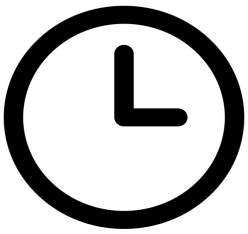
Now paint the absorber as shown in the picture. The dark parts in the picture represent the areas to be painted. However, the absorber is still displayed unpainted in the remaining pictures. Hold the spray can 4.2 an arm's length away from the metal sheets.

13



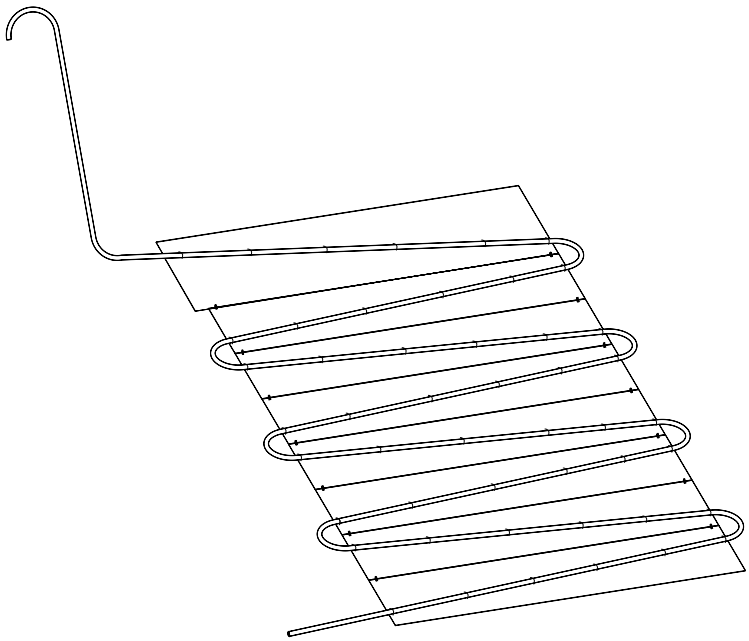
WARNING: The painted metal heats up in the sun very fast. Do not touch it with any more without gloves!

14



Let the surface of the absorber dry. You can already start with the next chapter.

Absorber

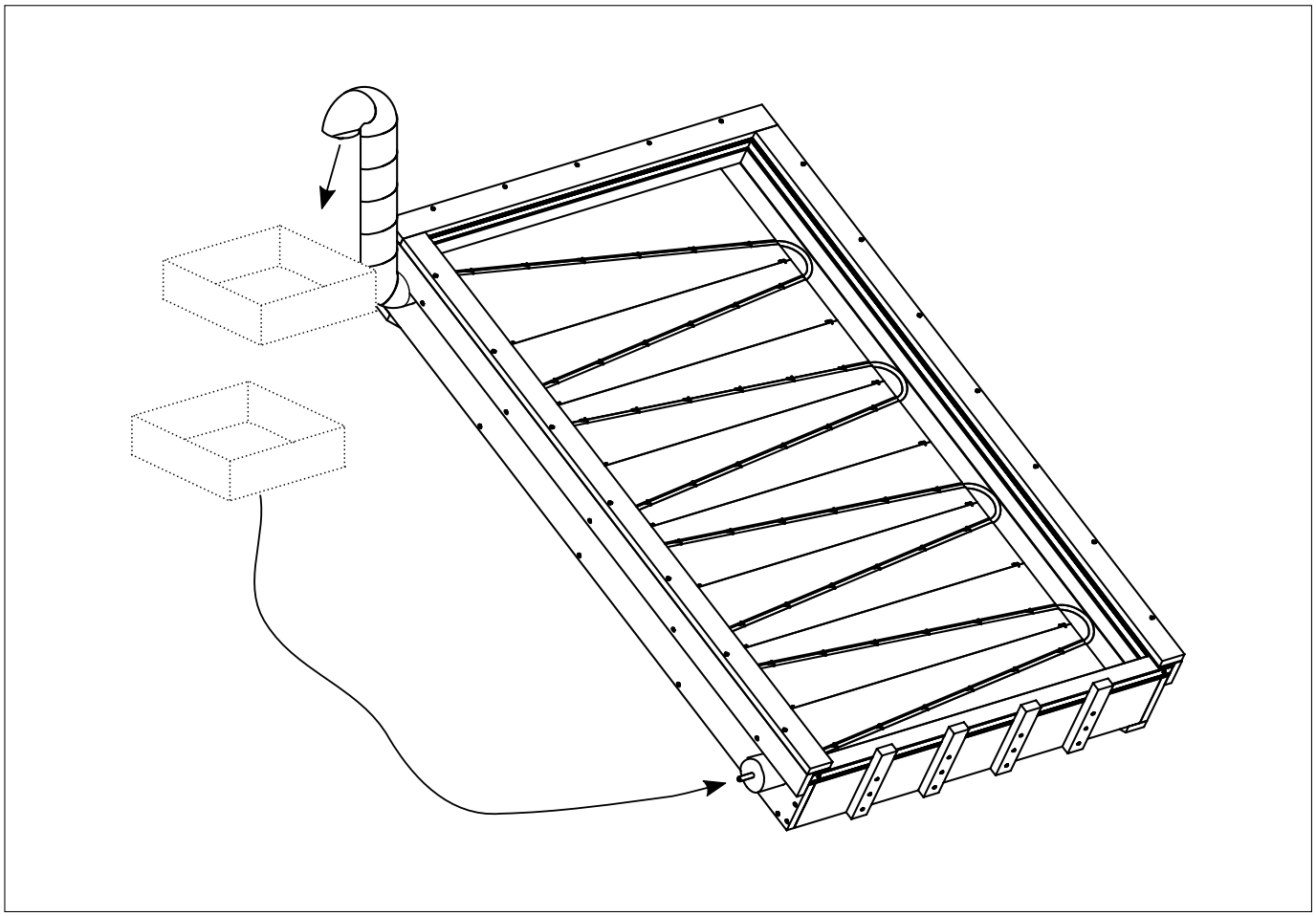


The absorber is now finished.

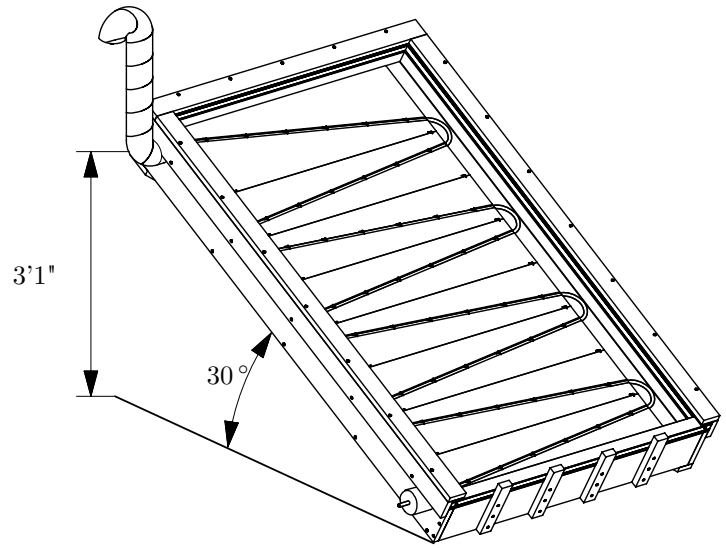
5.5 Planning the Rack

You need a rack in order to set up the box. You can find detailed instructions for building a suitable rack for a flat area in the appendix A.5 (Page 115). Skip this chapter when building that particular rack. If you want to create your own rack, you will find the most important measures in this chapter. They have to be followed.

- For illustration the following pictures show the box in its final state, although the assembly will not be described before the next chapter. So you understand more easily what is important about the rack.
- Most important are the angle between rack and ground and the input-container's height relative to the outlet of the riser of the box. The output-container has to be placed underneath the outlet at the riser.
- The input-container requires a floor area of at least $0.25\,\mathrm{m}^2$ and a volume of at least 60 liters. The floor area of the output-container is not that important. Nevertheless, its volume has to be at least as big as the one of the input-container.

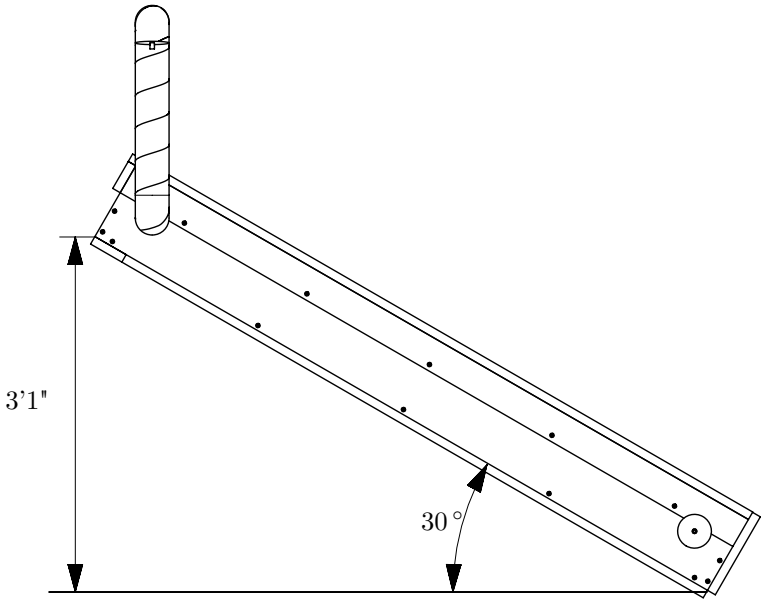


1



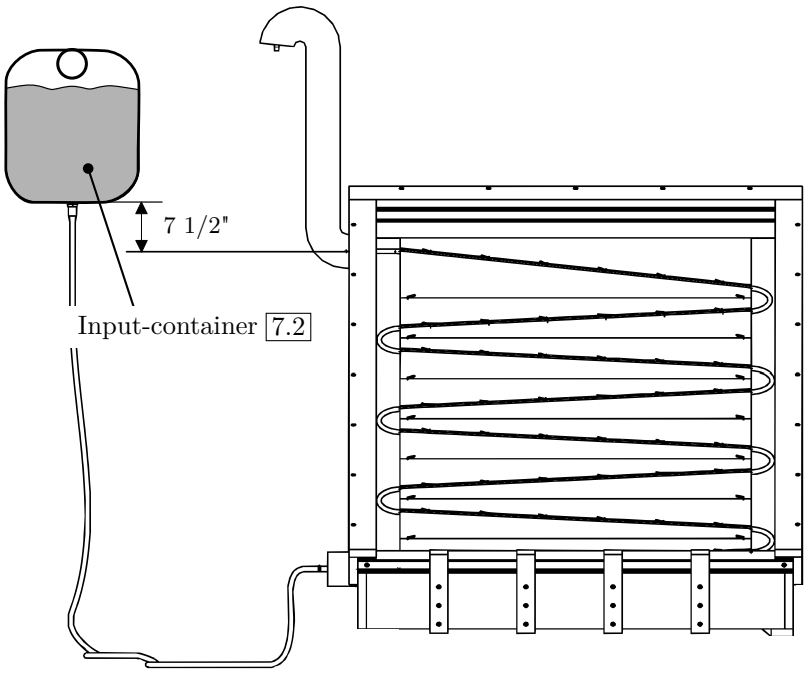
The rack has to be set up at an angle of 30 °. The difference in height between the front and the back edge is then 3'1".

2 - Side View



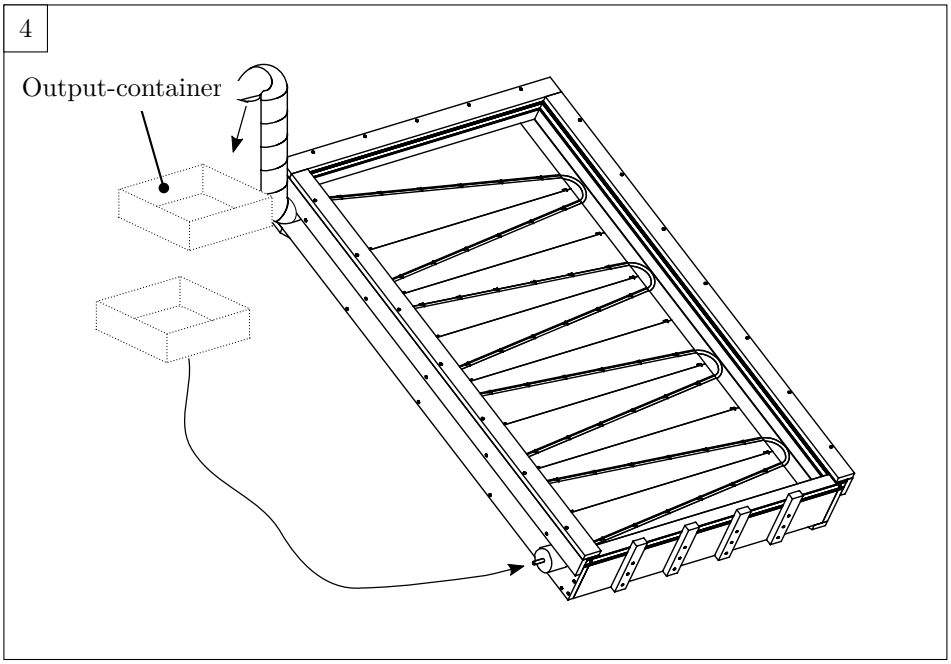
The pictures shows the exact measures again.

3



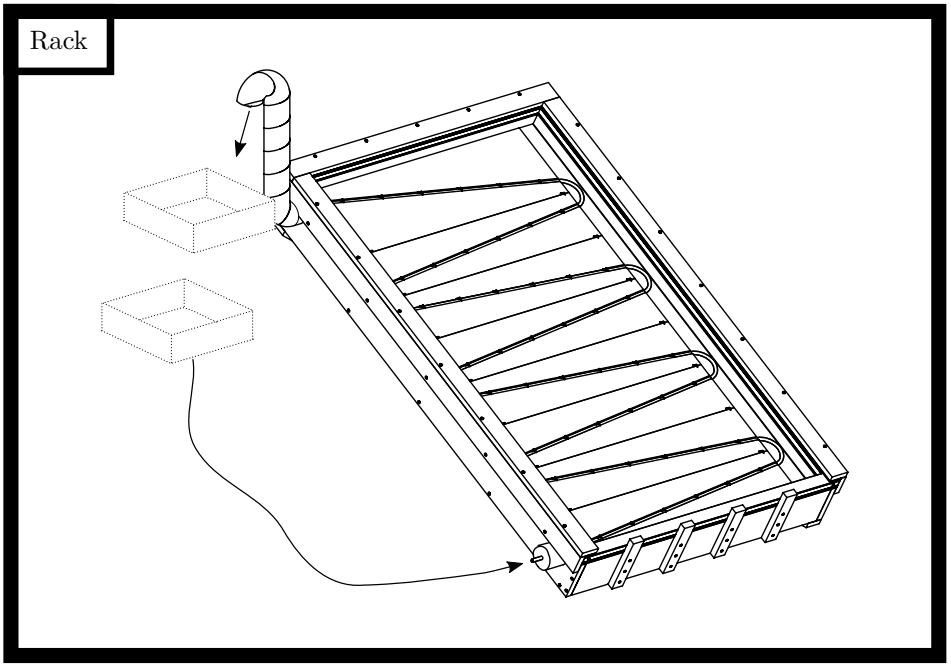
You need a place for putting down the input-container. The difference in height between the outlet of the riser and the bottom of the input-container has to be 7 1/2". As long as the height is correct, the position does not matter, but it should not cast a shadow on the device. A possible way of avoiding this is to place the input-container behind the box. Later on it will be connected to the inlet with a hose or a pipe.

4



In addition, you will need a place for putting down the output-container later. The output-container has to be located underneath the outlet. The height is not that important.

Rack

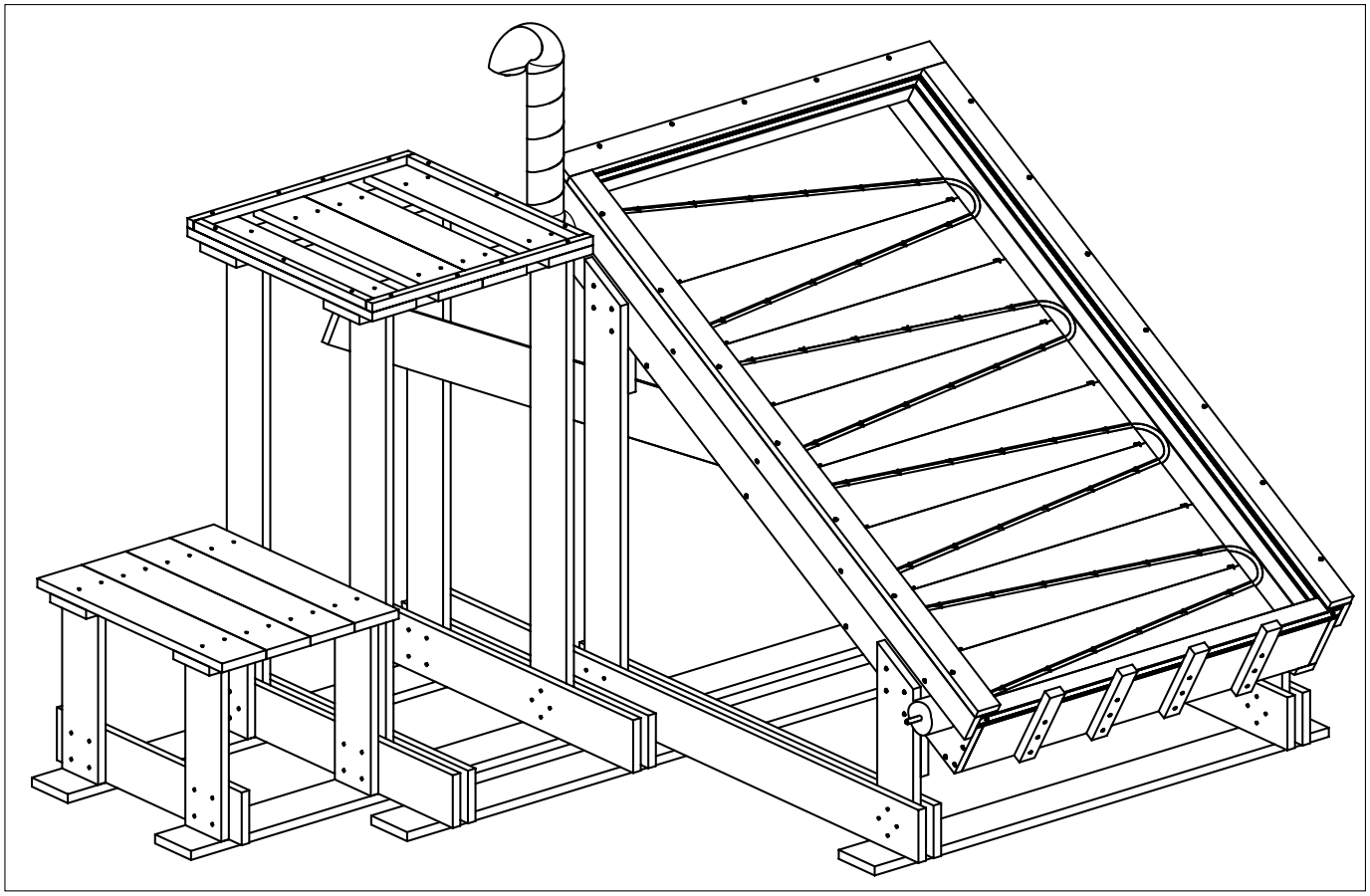


You are done as soon as there is a place for the input- and the output-container and the angle between box and floor is 30 °.

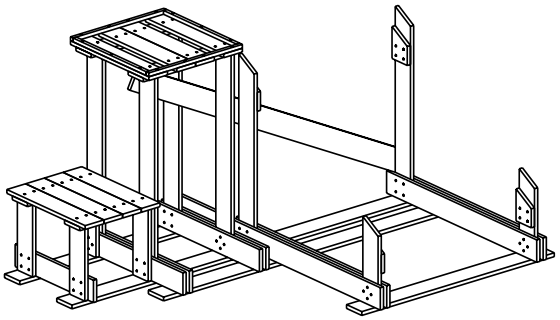
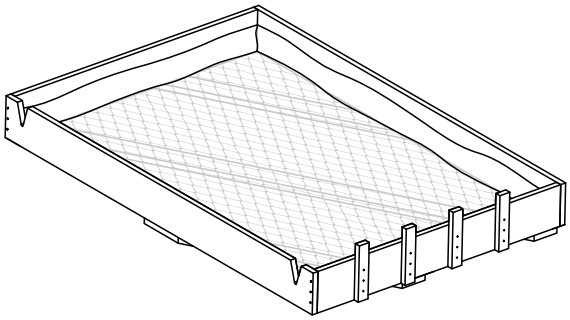
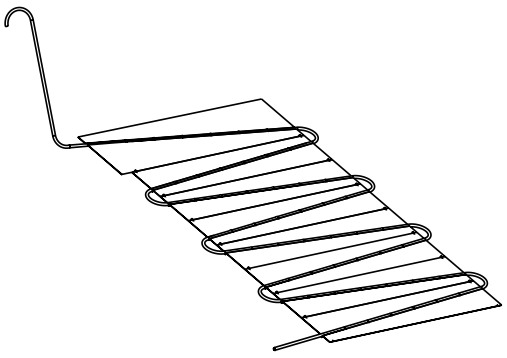
5.6 Installation and Assembly

First of all, install the box [1] into the rack [5] . Next the insulation [6.6] and the absorber [4] are installed. Then you have to arrange the riser and insulate the riser and inlet. After that, install the glass pane [6.5] , the frame and the cover.

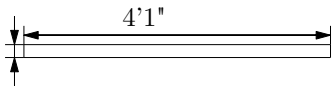
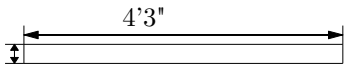
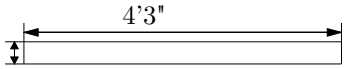
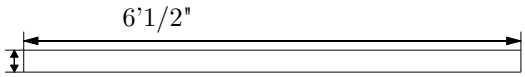
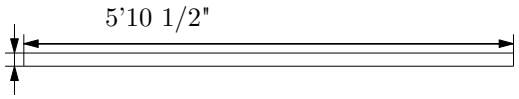
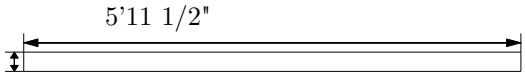
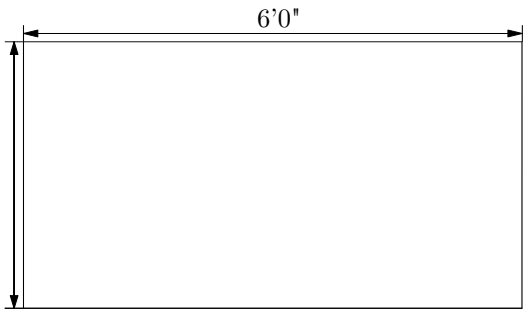
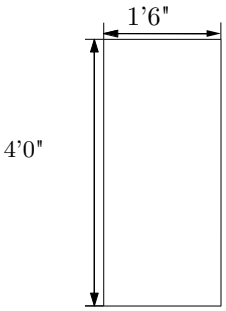
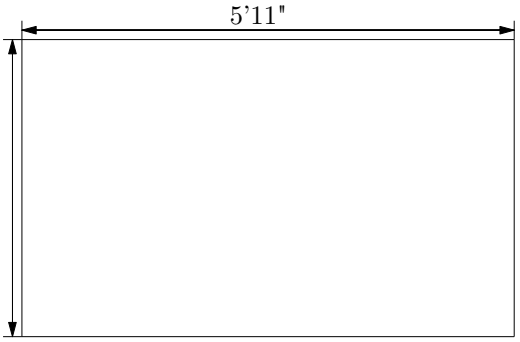
- First of all, the wooden box is fitted into the rack. This is shown in the example of the rack in the appendix A.5 (Page 115) . Alternatively the wooden box can also be installed in a different rack.
- A part of the rack is hidden in some pictures in order to make them clearer.
- You need insulation material that is heat resistant up to 140 °C (e.g. glass wool or hemp mats). In total you need 4.8 m^2 with a strength (also called thickness) of 5 cm. In this chapter you will also see the amount of insulation material required for each part. Each of the following pieces can also be composed of smaller pieces. The pieces [6.7] , [6.10] and [6.11] have to be divided into smaller pieces later.
- The damping [6.10] and [6.11] shall store the glass softly to prevent it from breaking. Therefore, the damping should be soft. If the insulation material is soft, you can use it therefore.
- As soon as you have mounted the glass pane, the device gets very hot. For that reason, it is better to assemble it in the shadow or underneath a lightproof cloth, as soon as the glass panes are installed.



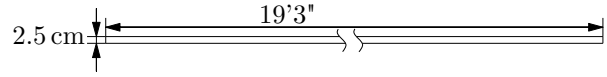
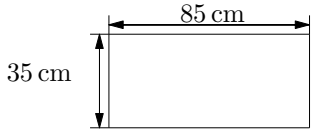
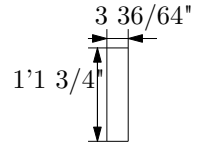
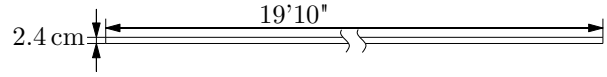
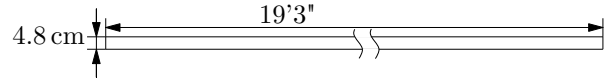
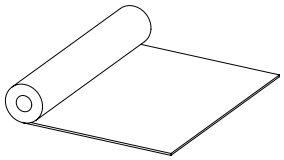
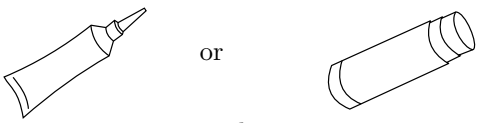
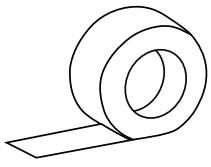
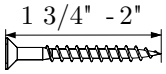
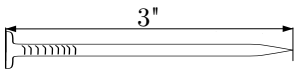
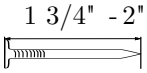
Required Material:

Number	Figure	Title		Other
1 x		Rack	5	See chapter 5.5 (Page 49). Use either the construction from the appendix A.5 (Page 115) or an own construction with the measures from chapter 5.5 (Page 49).
1 x		Wooden box	1	See chapter 5.1 (Page 23).
1 x		Absorber	4	See chapter 5.4 (Page 41). After the installation, the stabilizing rails are required for the frame and the cover as well.

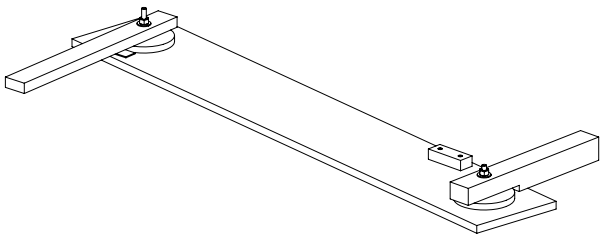
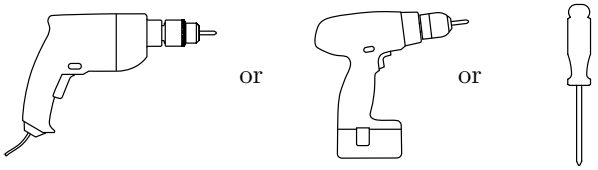
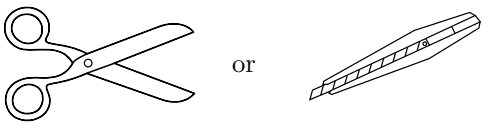
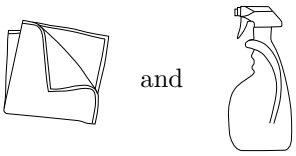
Required Material (continued):

Number		Figure	Title		Other
2 x	2"		Rail	6.1	Material: Timber Thickness: 1"
1 x	2"		Rail	6.2	Material: Timber Thickness: 1"
1 x	4"		Rail	6.3	Material: Timber Thickness: 1"
2 x	4"		Rail	6.4	Material: Timber Thickness: 1"
2 x	1"		Rail	6.18	Material: Timber Thickness: 1"
2 x	2"		Rail	6.19	Material: Timber Thickness: 1"
1 x	4'0"		Glass pane	6.5	Material: Window glass Thickness: 5 mm
4 x	4'0"		Glass pane	6.5b	Material: Window glass Thickness: 5 mm
1 x	3'11"		Insulation bottom	6.6	Thickness: 10 cm You can also use 2 layers with a thickness of 5 cm each (or several thinner layers).

Required Material (continued):

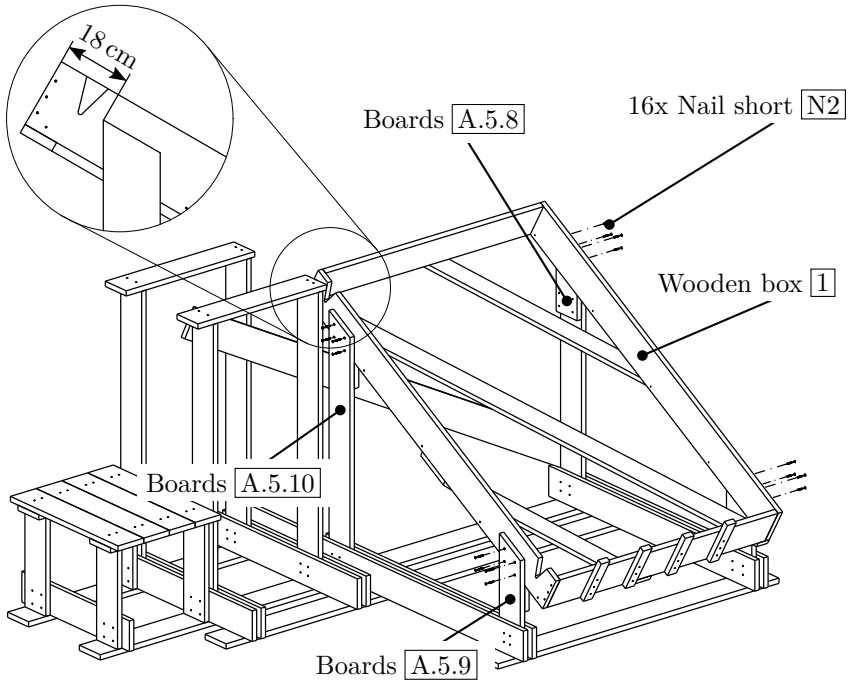
Number	Figure	Title		Other
1 x		Insulation side	6.7	Thickness: 5 cm
1 x		Insulation riser	6.8	Thickness: 5 cm
1 x		Insulation inlet	6.9	Thickness: 5 cm
1 x		Damping material	6.10	Some thin soft material to place the glass on. This layer is to protect the glass from direct contact with hard wood. Good expamples: textiles, felt Thickness: 1 cm
1 x		Damping material	6.11	Some thin soft material to place the glass on. This layer is to protect the glass from direct contact with hard wood. Good expamples: textiles, felt Thickness: 1 cm
1 x		Foil	6.12	Flexible, water resistant foil for fixing the insulation at the pipe.
1 x		Glue	6.13	Glue for fixing the damping and the insulation
1 x		Duct tape	6.14	Duct tape Alternatively, you can use a cord.
14 x		Wood screw	S1	Length: 1 3/4" - 2"
4 x		Nail long	N1	Length: 3"
35 x		Nail short	N2	Length: 1 3/4" - 2"

Required Tools:

Number	Figure	Title	Other
1 x	 or similar	Pipe bending tool A.3	Tool for bending a 1/2" / 1.2 cm pipe (dimensions see chapter 5.3 (Page 35) step 3). If you do not have a suitable tool, you can build one with the instructions in A.3 (Page 100).
1 x	 or or	Screwdriver	Fitting to the screws.
1 x	 or similar	Scissors or knife	For cutting the damping and the insulation.
1 x		Cleaning rag and glass cleaner	For cleaning the glass panes.

In the following pictures the rack is only partly shown in order to bring out the important parts more clearly.

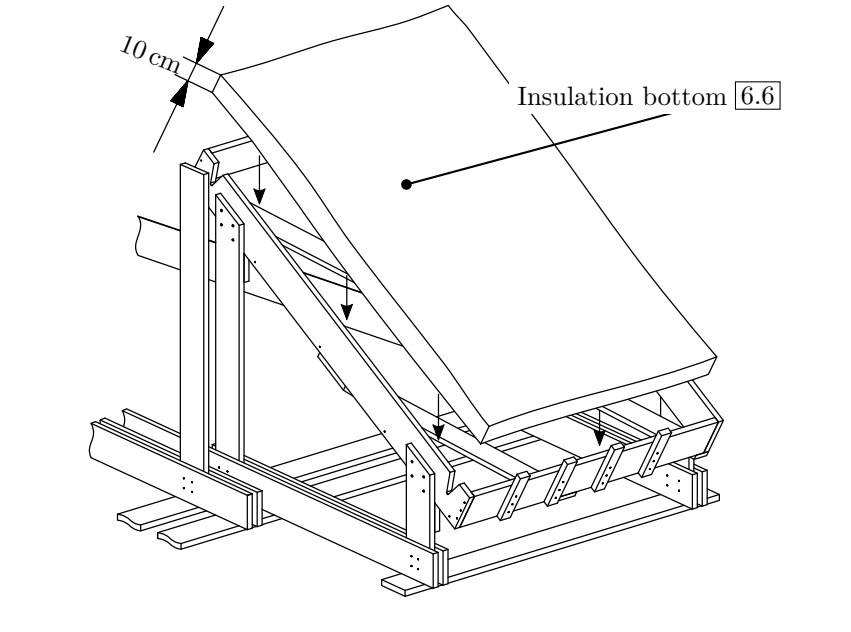
1



In order to install the wooden box 1 , you clamp it between the boards A.5.9 and A.5.10 , so that the box is lying on top of the boards A.5.8 .
On the upper side, the box should stick out by 18 cm.
Now fix the box by driving short nails N2 through the boards A.5.9 and A.5.10 into the box from both sides.

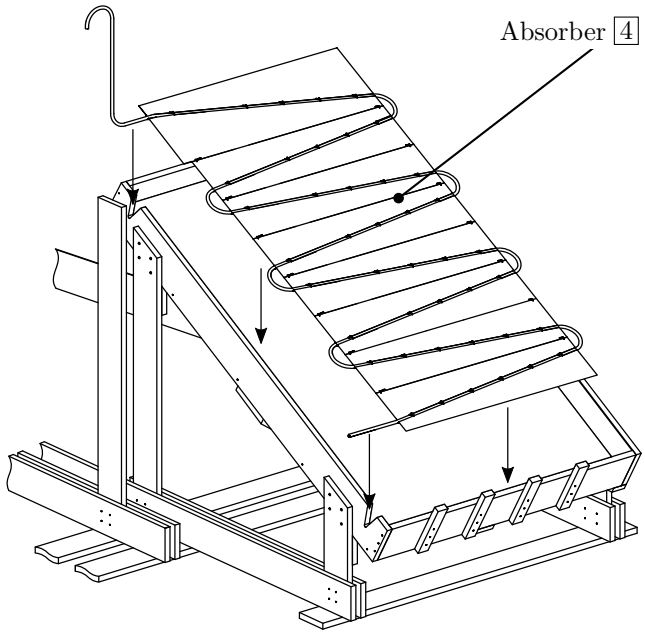
If you are using a different rack:
Think of a way to fix the box safely. Be sure to place the box so the upper hole for the pipe is 7 1/2" under the input-container (compare to page 8).

2



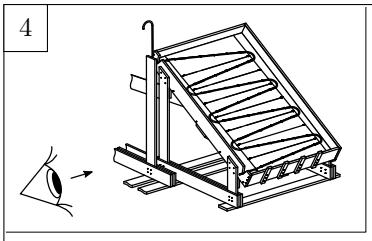
Put the insulation 6.6 into the box. It should be about 10 cm thick and a bit larger than the inner space of the box. In this case the insulation fits tightly to the edges.

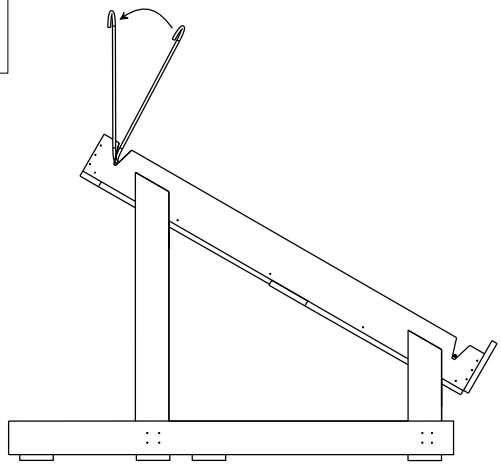
3



The next step is to install the absorber 4 . Place the pipe and the metal sheets into the wooden box. Put the pipe inside the box carefully to make sure it does not bend. In case it does bend slightly, you can simply bend it back into the right shape.
The pipe should fit into the two holes you cut out of the box.

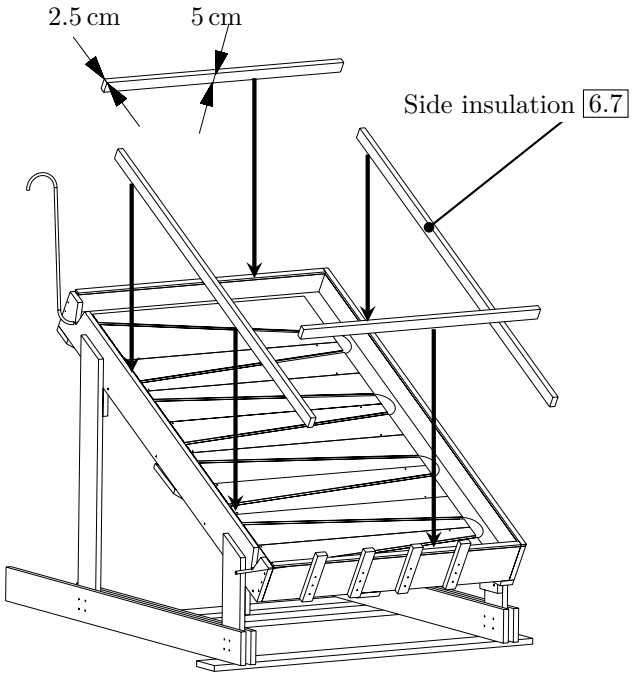
4





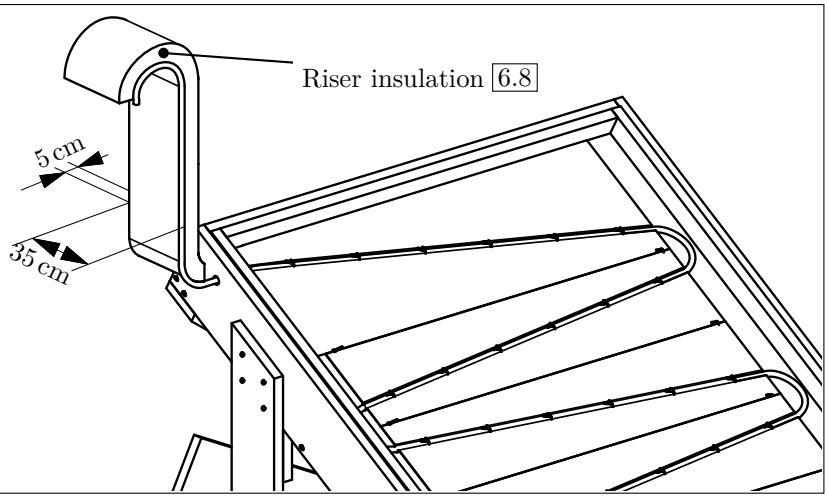
Arrange the end of the pipe. It has to point upwards vertically. Bend the pipe into the right shape with your hands carefully. Make sure that the rest of the absorber does not bend too much.

5



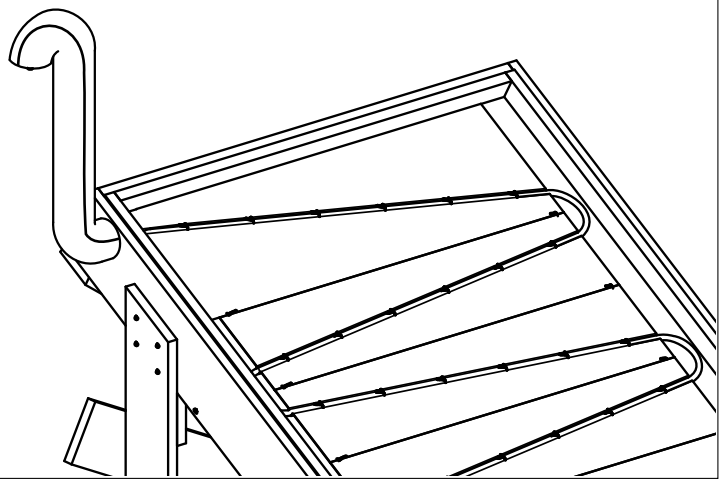
Bring on the side insulation 6.7 . For that purpose, put a 2.5 cm wide and 5 cm high strip along the interior side of the box. You can use multiple small pieces of insulation for this.

6



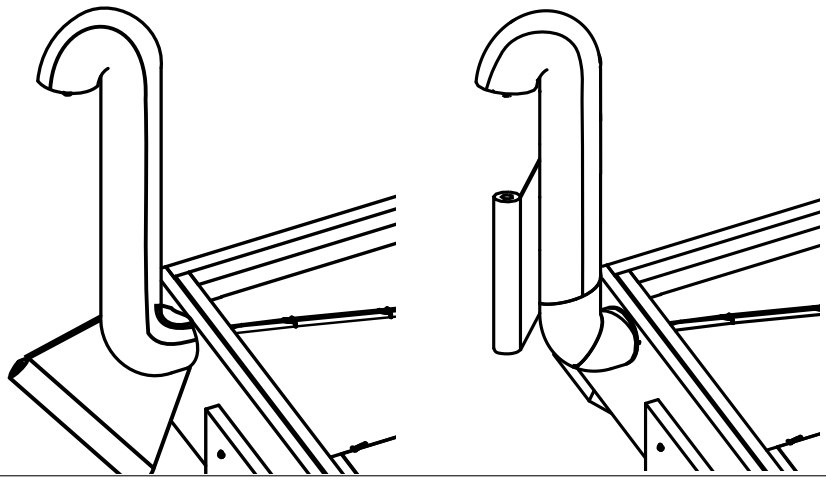
Now insulate the riser. Use the insulation 6.8 . The insulation 6.8 has to be ca. 5 cm thick, 35 cm wide and 85 cm long. You can also use several smaller parts for that purpose.

7



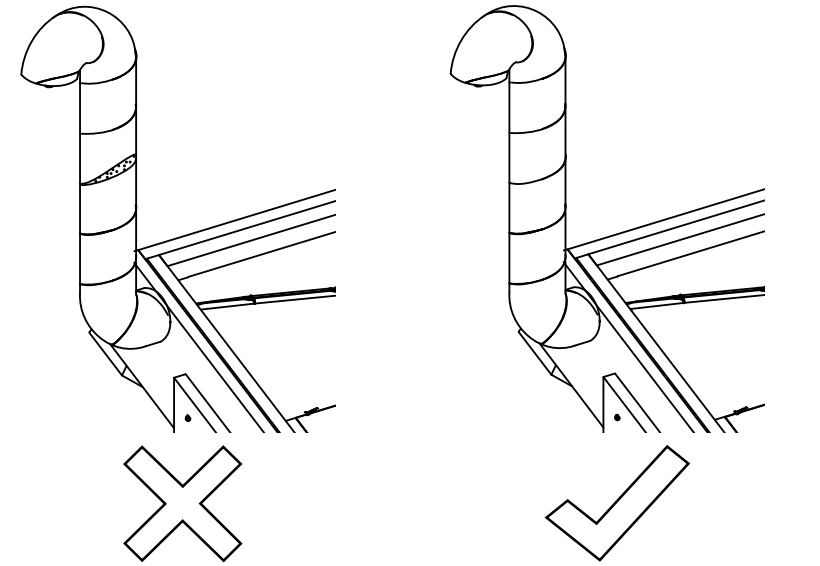
Wrap the insulation around the pipe similar to the picture.
Pay attention that you leave no gap between the insulation and the wooden box.
You can then fix it provisionally with a cord or with some tape.

8



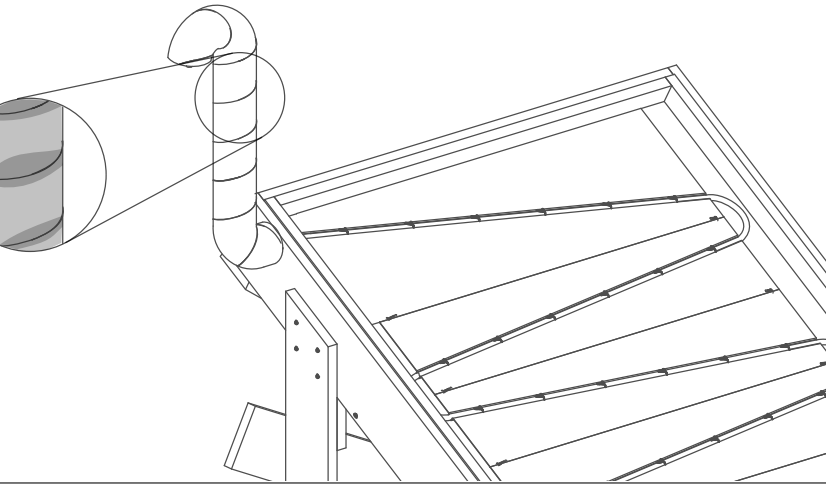
Use foil 6.12 and wrap it around the insulation to fix it and to protect it from water.
Wrap the foil around the insulation from the bottom up, ideally in several layers. Be careful not to wrap it too tight.

9



Check whether the foil is wrapped around the insulation as shown. If there are still gaps in the wrapping, use additional foil to wrap it. Also check whether there is no gap between the insulation and the box.

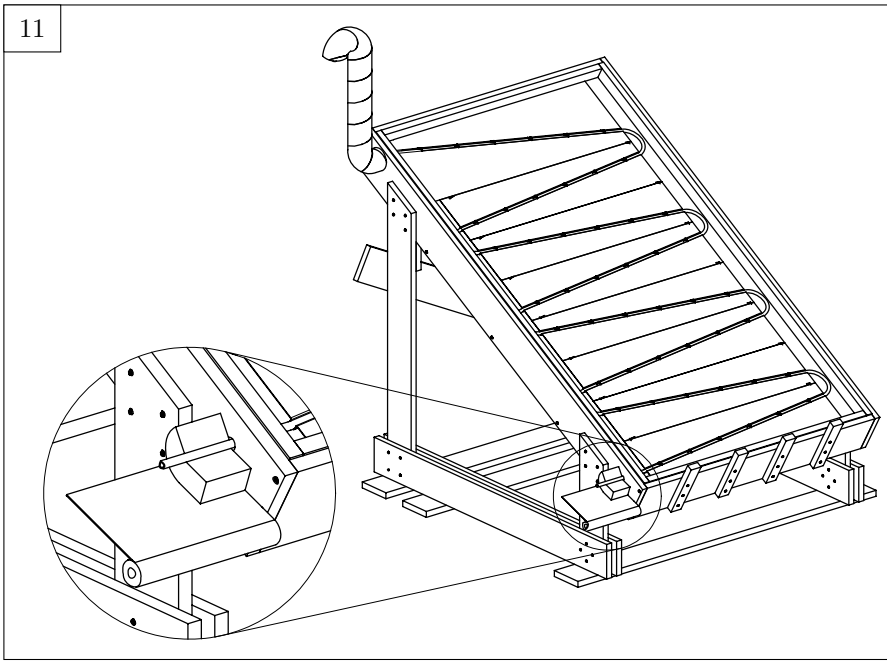
10



The foil has to overlap a bit, so that the device cannot get wet from rain.

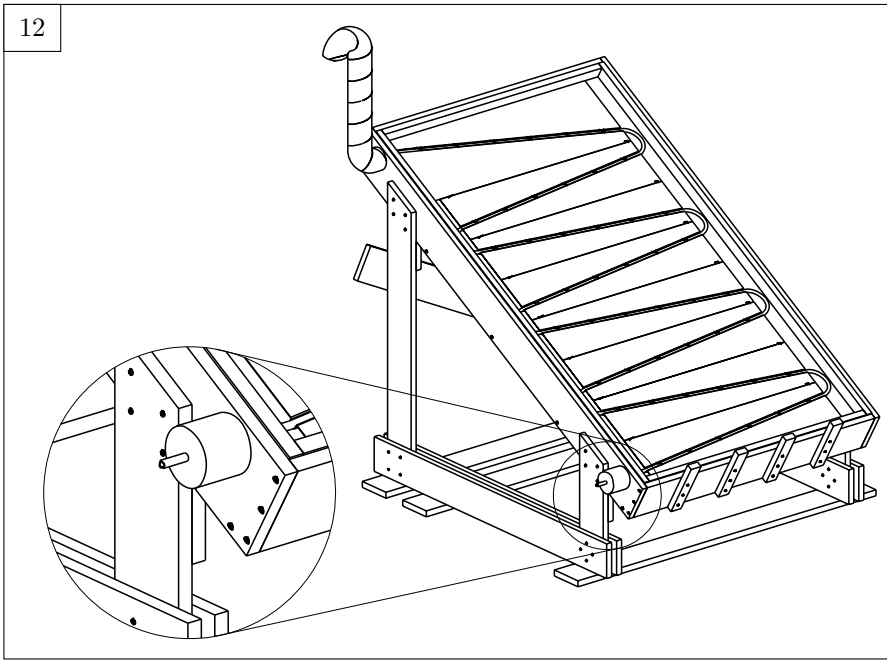
If the foil is not resistant to sunlight, you have to change the foil regularly or protect it from the sun (e.g. by covering it with a plastic bag).

11



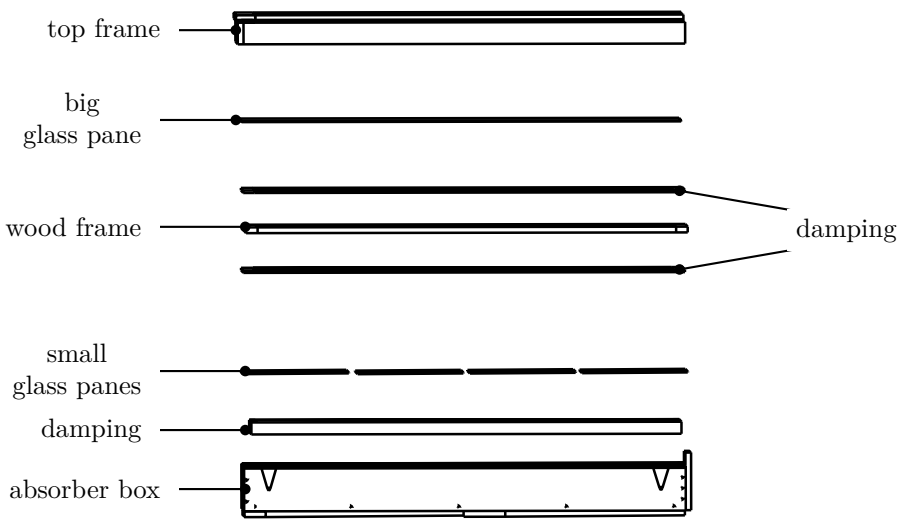
The next step is to insulate the inlet. Wrap the insulation 6.9 around that part of the pipe and fix it with foil, as you did with the riser. Again, make sure there is no gap between the insulation at the inlet and the box.

12



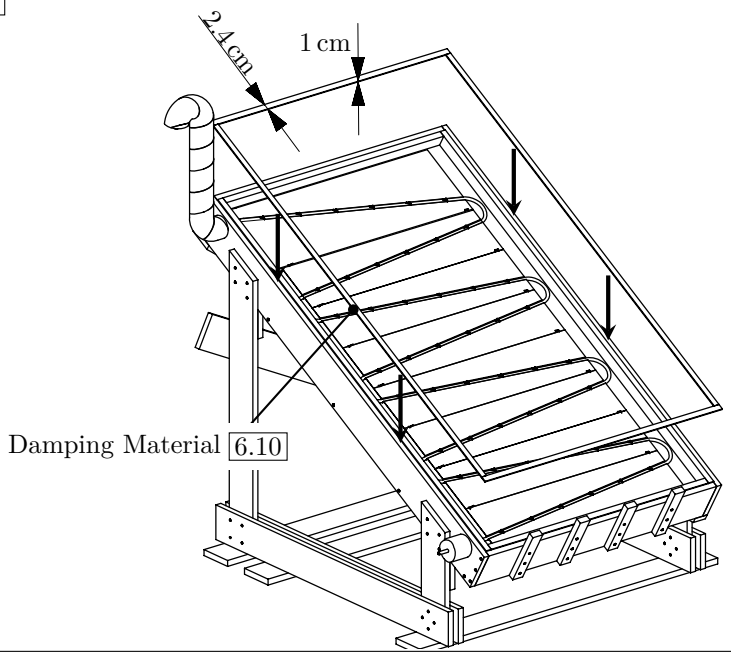
Check whether the inlet is insulated as shown.

13



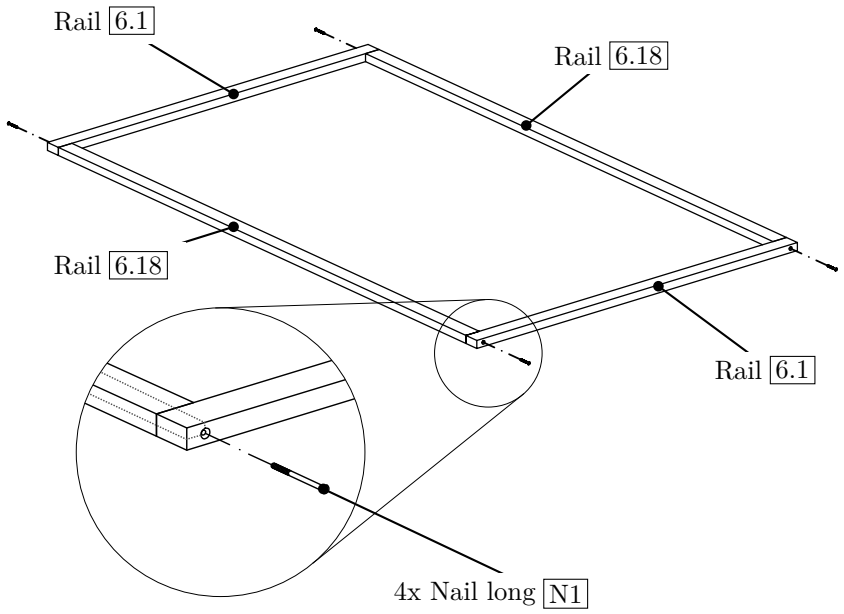
In this picture you can see a side view of all the layers you are going to install in the next steps. If you are not sure what to do next, go back to this point and check the order with this picture.

14



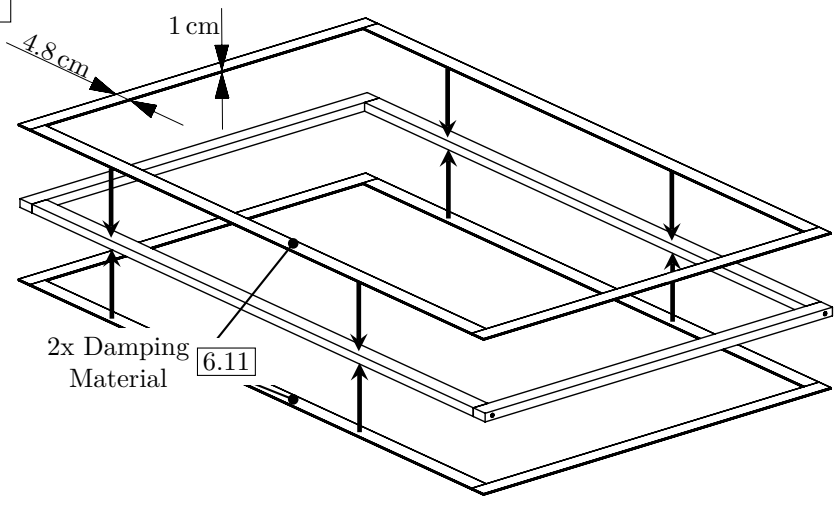
Now place the damping for the glass 6.10 , a ca. 1 cm thick strip of the insulation, on top of the outer boards of the box.
The strip should be about as wide as the board, which is 2.4 cm. On top of that, you will later put the glass, so that it is stored softly. Fix the damping with glue, so that it does not slip so easily.
The strip can also consist of several pieces.

15



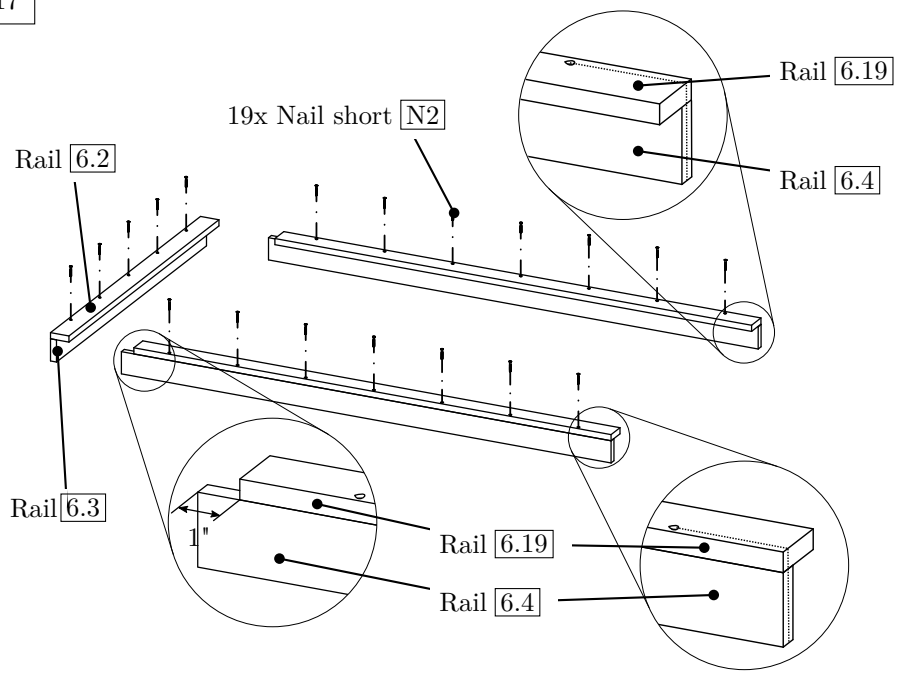
Now assemble the frame. Lay together the rails 6.18 (the small stabilizing rails of the absorber) and rails 6.1 as shown. Make sure the long rails 6.18 are between the short rails 6.1 . Nail the rails together with four long nails N1 . The nails should be placed in a way, so that they stick exactly in the middle of the front sides of the long rails.

16



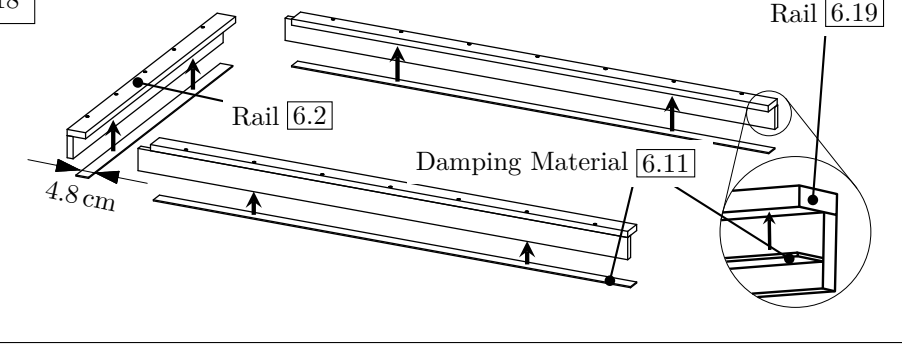
Stick one strip of the damping 6.11 on the frame from above and one from below. It should be 1 cm thick and about 4.8 cm wide. These stripes can also consist of several pieces. Put the frame with the damping aside.

17



Nail together the rails for the cover. These rails are to be screwed to the box later and avoid the glass to slip. First take the long rails 6.4 (bottom) and 6.19 (top). Put them down as shown, making sure they end flush on one side (see the right detailed picture). On the other side, the top rail 6.19 is about 1" shorter than the bottom rail 6.4 (see the left detailed picture). Nail them together with 7 short nails N2 each. They should be evenly distributed over the length of the rail and nailed in the middle of the rail 6.4 (see the dashed line in the detailed picture). Now nail together the short rails 6.3 (bottom) and 6.2 (top) with 5 short nails N2. Here the two sides end flush.

18

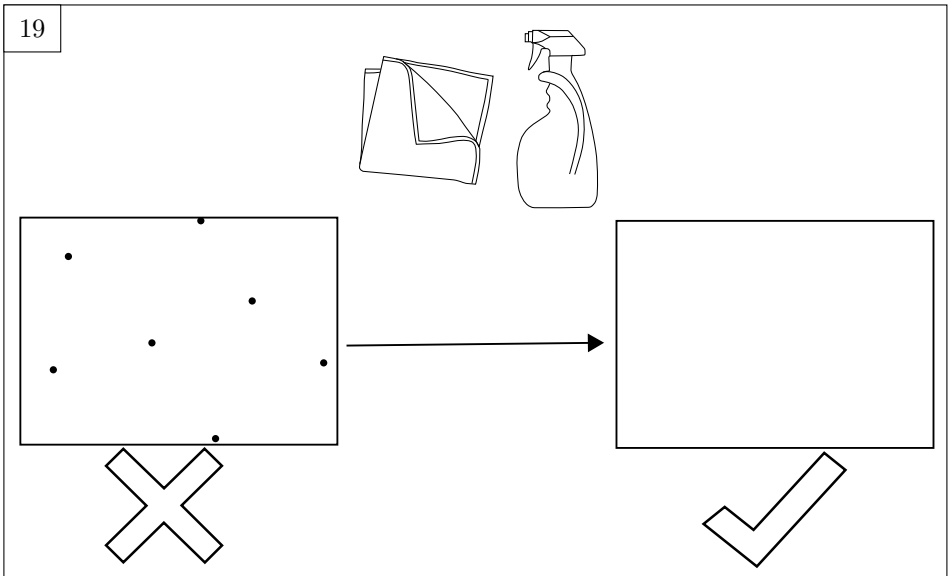


Bring on the damping 6.11. Stick a ca. 4.8 cm wide and 1 cm thick strip to the upper rails 6.2 and 6.19. Put the rails aside. (See step 20)

In the following steps you will work with the glass panes. They can break easily. Let other people help you and be very careful!

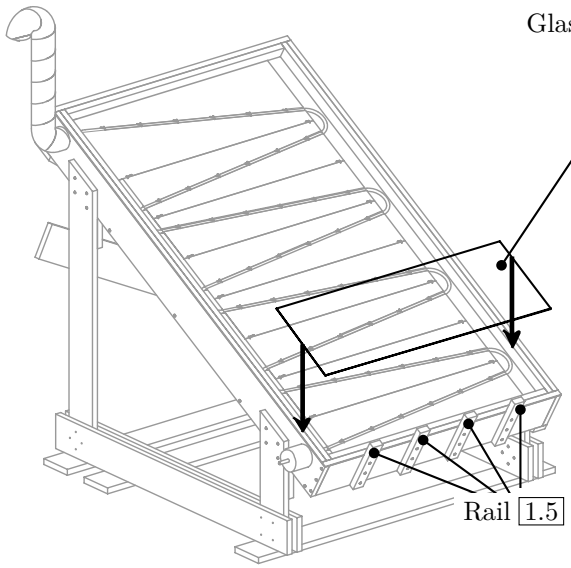
The glass panes may have sharp edges, better work with gloves so you don't hurt yourself.

19



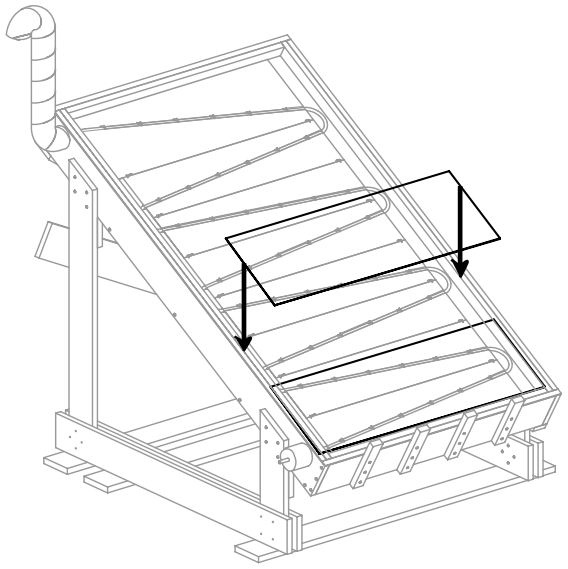
Clean the small panes 6.5b . Make sure there is no more dust or dirt left.

20



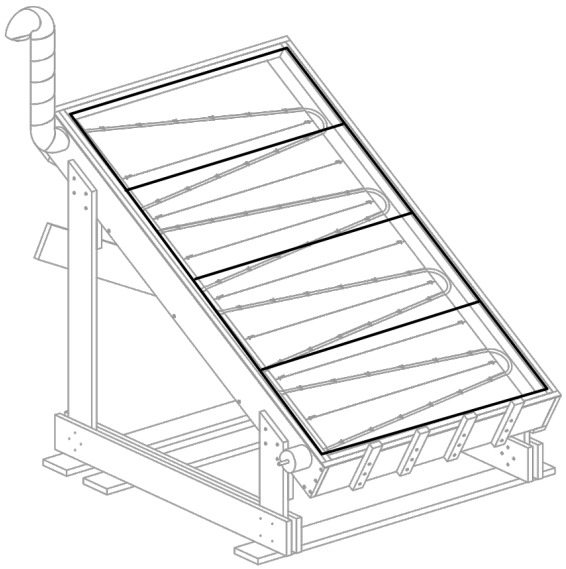
Carefully place the first pane on the damping on the bottom part of the box.
Make sure it touches the wooden rails 1.5 on the bottom, so that its weight is supported by them.

21



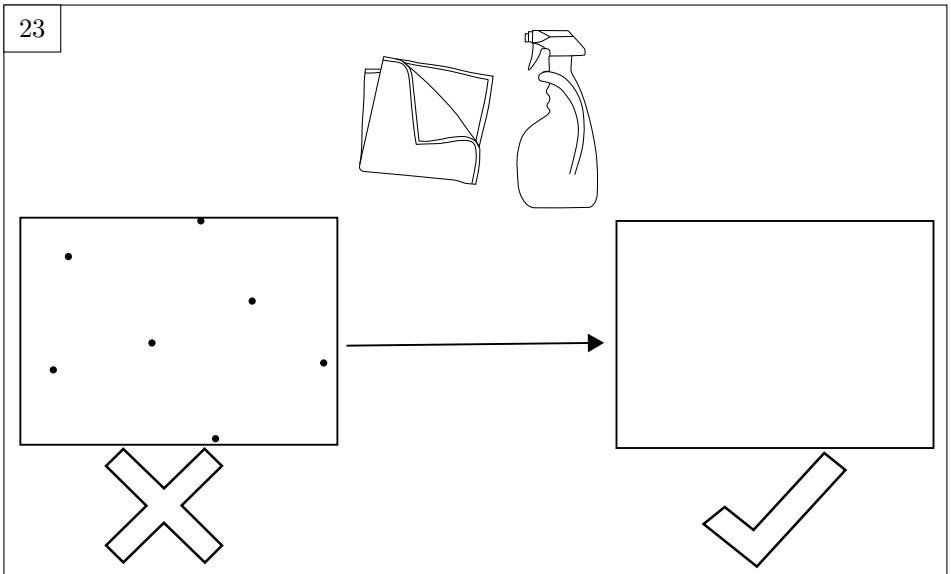
Now take the second glass pane 6.5b and place it on the box. Place it directly above the first pane, so that the edges touch.

22



Repeat the previous step until all four glass panes are placed on the absorber box.

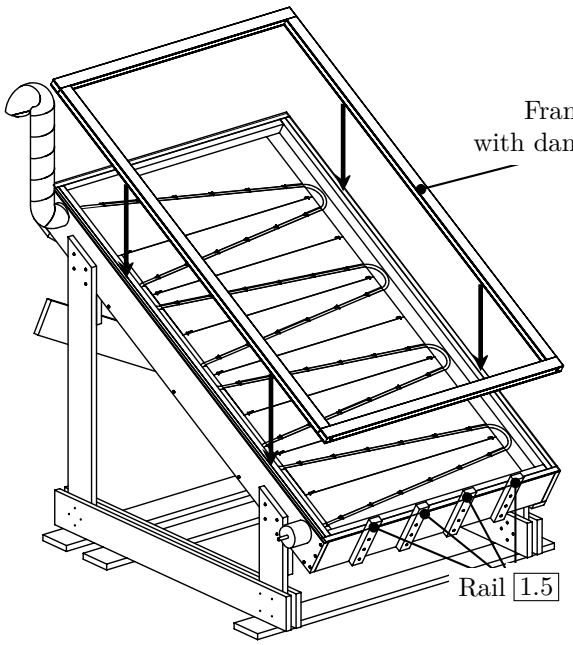
23



Clean the big glass pane 6.5 . Also clean again the small panes if necessary.

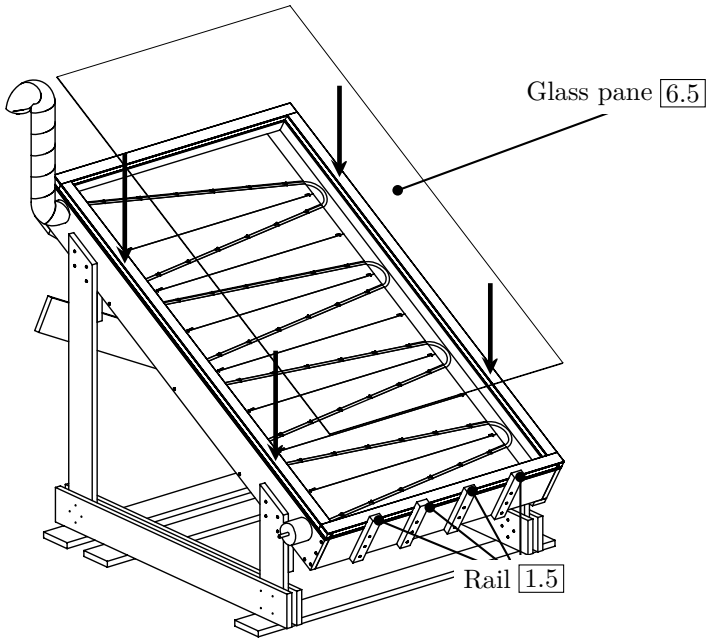
From now on the device can get very hot. Pay attention when you are working on it. To protect yourself and the device put it in the shadow or cover it with a light-proof sheet while not working with it. Otherwise the device can be damaged!

24



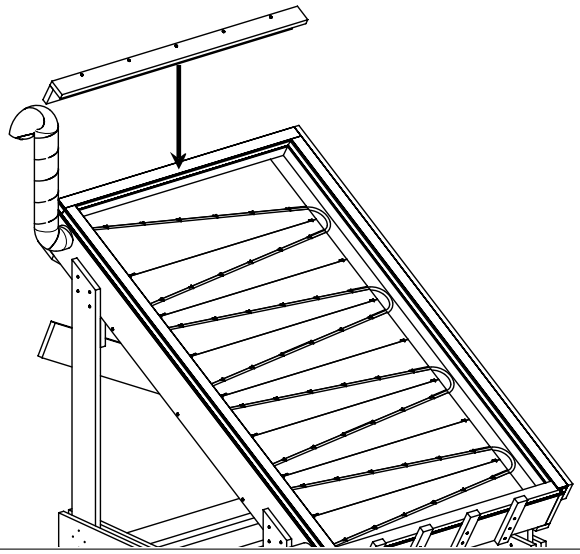
Take the frame you have built in step 15 and put it on the glass panes. The frame also has to touch the wooden rails 1.5 .

25



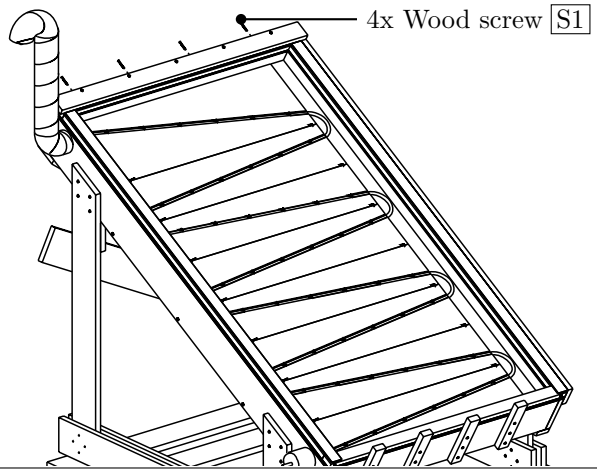
Carefully put the big glass pane 6.5 on top of the frame. It too should touch the rails 1.5 .

26



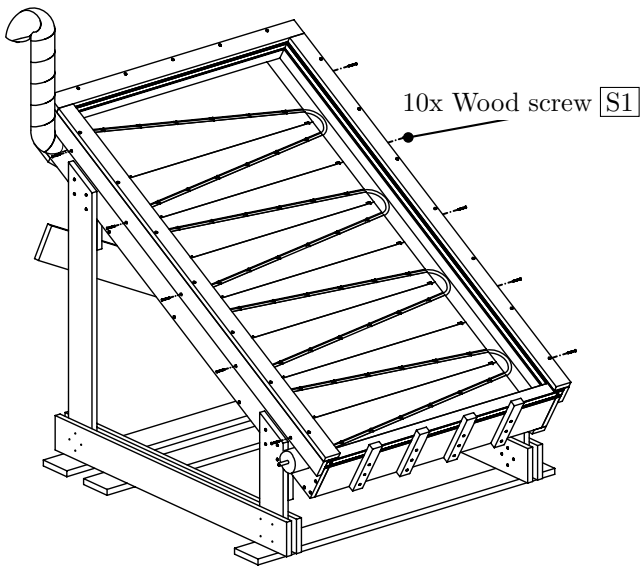
Place the upper part of the cover on the upper part of the pane, so that the damping lies on top of the glass pane. It has to be installed centrally. The glass needs some space to expand otherwise it will break. It needs at least 0.2" distance to the cover.

27



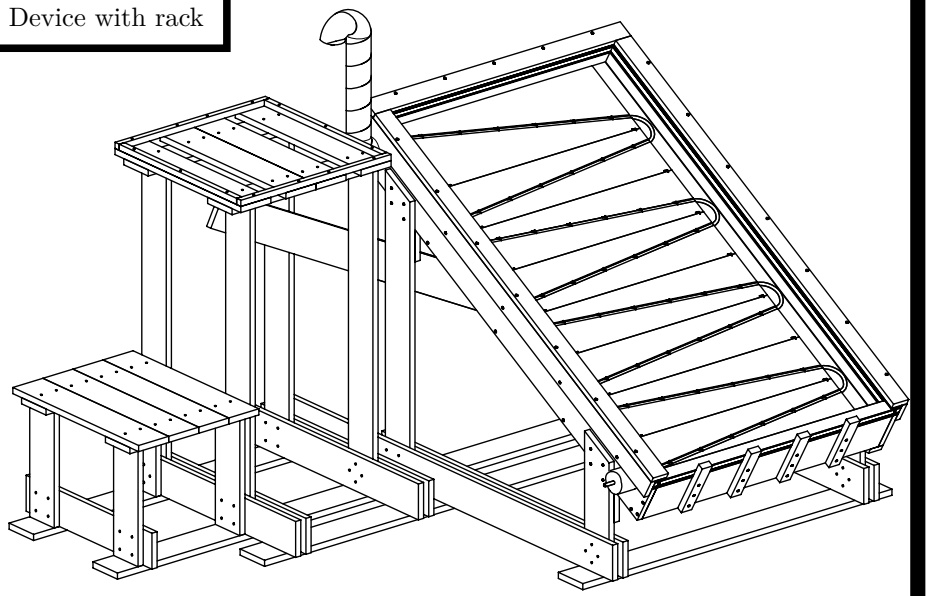
Push the upper part of the cover slightly on the glass pane and screw it together with the wall of the box from outside, using 4 wood screws S1 .

28



Put the two lateral parts on the glass pane as shown. Push them on slightly and screw them together with the box with 5 wood screws S1 each. There should be no gap between the upper part and the lateral parts.

Device with rack

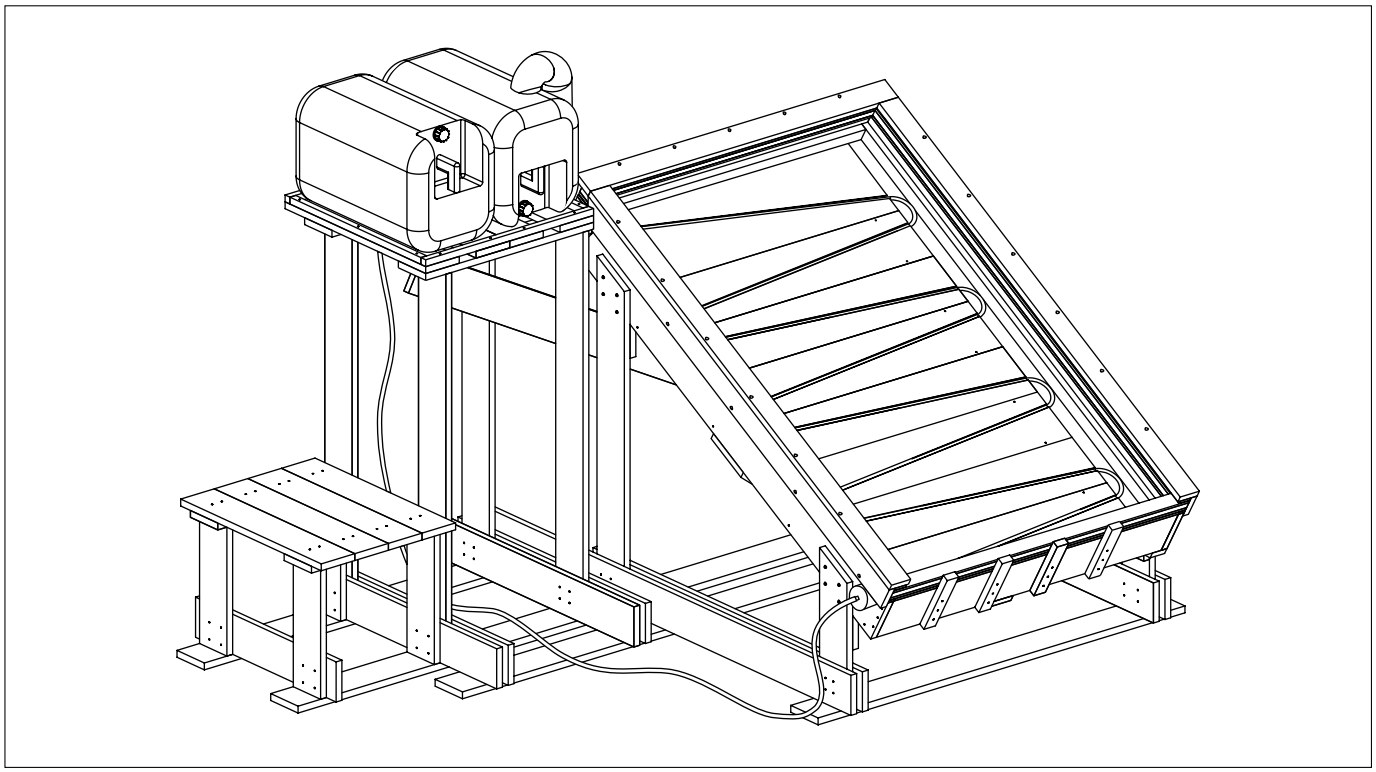


Now the device is finished. You only have to connect the input- and output-containers. Since the system can become very hot without water, make sure it is standing in the shadow or covered.

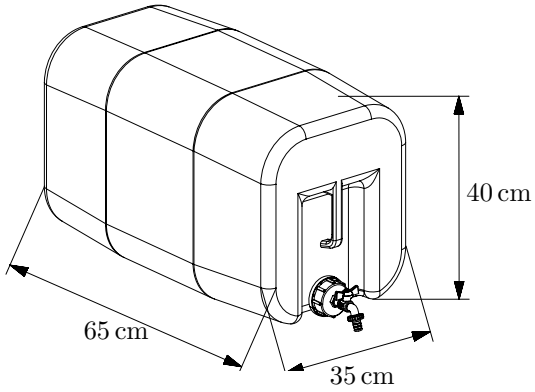
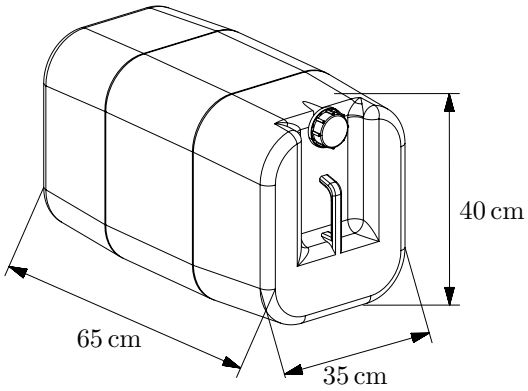
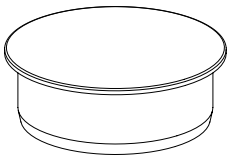
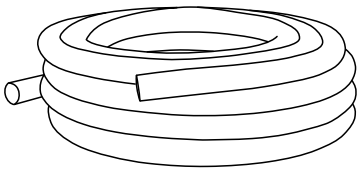
5.7 Connecting the Containers and the Periphery

Finally, connect the input- and output-containers.

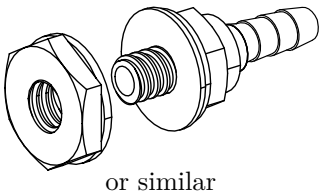
- The picture shows the assembly with the rack described in the appendix A.5 (Page 115). If you have chosen an own rack, make sure the input-container is installed on the right height. You can therefore take a look at chapter 5.5 (Page 49).
- If you do not find any containers looking like the ones on the pictures, you can take a different one as well. Only make sure the ground area of the input-container is not too small and that the capacity is sufficient.
- The input-container has to be easy to fill (large, closeable opening on top) and you have to be able to connect a hose on the bottom side. The measures here refer to the installation into the rack from the appendix A.5 (Page 115). If your rack differs from that one, make sure that your ground area is at least $0.25\,\mathrm{m}^2$ and the volume has to be at least 60 liters.
- The output-container needs an opening that allows water from the riser to flow in. Besides it needs a water tap or something similar to release the water. The measures here refer to the installation into the rack from the appendix A.5 (Page 115). Be aware that the volume has to be at least as big as the volume of the input-container. The ground area is not that important. The water has to be able to flow into the output-container freely.
- The input- and output-container must not be entirely airtight. They should also be suitable for drinking water and UV-resistant.
- Use a hose, that is suitable for drinking water, for the connection. In case you cannot find any, you can use a suitable pipe. Think of a good way to connect it to the input-container and the copper pipe of the absorber.



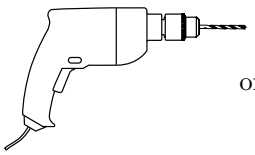
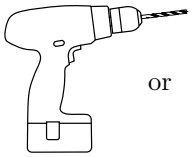
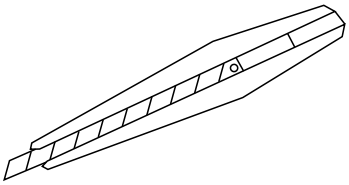
Required material:

Number	Figure	Title		Other
1 x	 or similar	Output-container	7.1	Dimensions correspond to standard rack (see appendix A.5 (Page 115)). Identical to input-container 7.2 , but with a tap. If you build your own rack you may use other dimensions, but the volume should be at least as big as the input-container.
1 x	 or similar	Input-container	7.2	Dimensions correspond to standard rack (see appendix A.5 (Page 115)). Identical to output-container 7.1 , but without tap. If you build your own rack you may use other dimensions, but the volume should be at least 60 liters and the floor area at least 0.25 m^2.
1 x	 or similar	Lid	7.3	Input-container lid 7.2 . You are going to drill a hole (ca. 4") in order to fill up the container easily. Therefore you need a lid to close it. Further information regarding the lid can be found in step 2.
1 x		Hose	7.4	Suitable for drinking water. Length: ca. 9'10 1/8" - 13'1 1/2" Inner Diameter: ca. 1/2" / 1.2 cm
2 x		Hose clamp	7.5	Size corresponding to hose 7.4

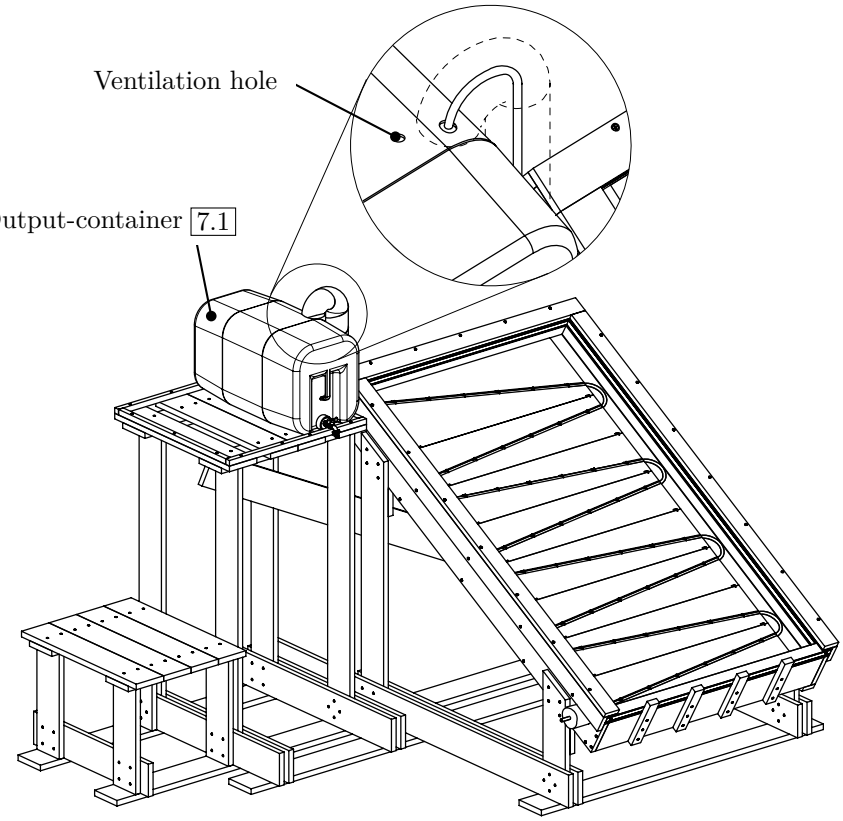
Required material (continued):

Number	Figure	Title	Other
1 x	 or similar	Hose connection 7.6	To connect the hose 7.4 to the container 7.2 . Depending on the container used, this part may look different.

Required Tools:

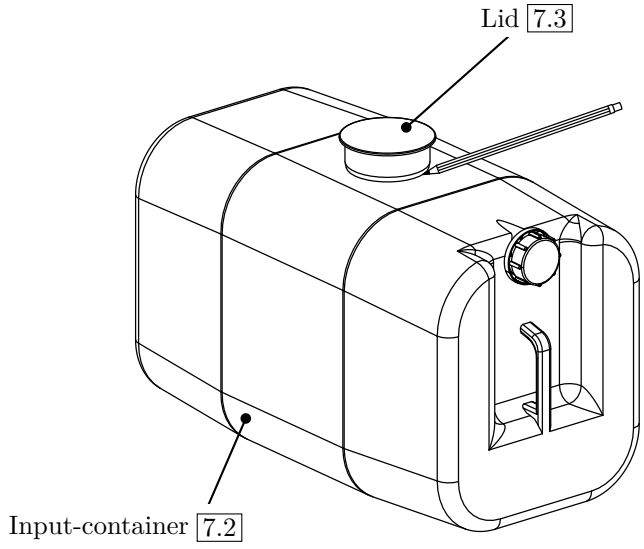
Number	Figure	Title	Other
1 x		Screwdriver	Suitable for the hose clamp 7.5 .
1 x	 or  or 	Drilling machine	Use the drilling machine to drill holes into the containers.
1 x		Knife	Use the knife to enlarge the hole of the input-container.
1 x		Pencil	To mark the outer diameter of the lid on the input-container.

1



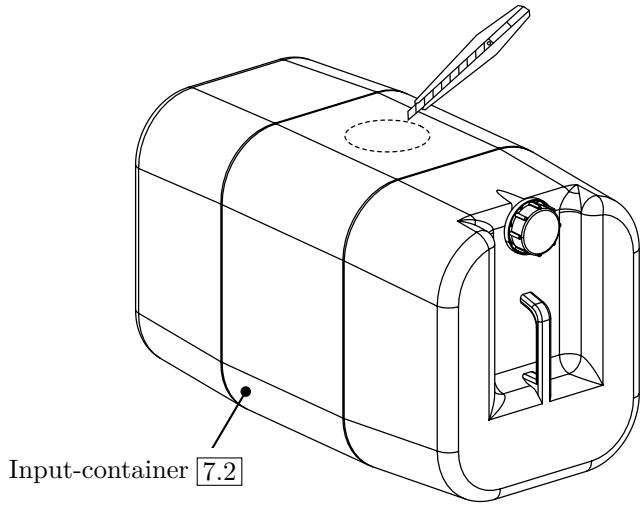
Put the output-container 7.1 underneath the outlet. The water has to be able to flow into the container freely and the pipe should extend into the container. Drill or cut a hole into the container so that the pipe fits nicely. (ca. 1.4 - 2 cm). Drill a ventilation hole into the container because it is important that the container is not entirely airtight. Besides the container needs a water tap or something similar for releasing the water.

2



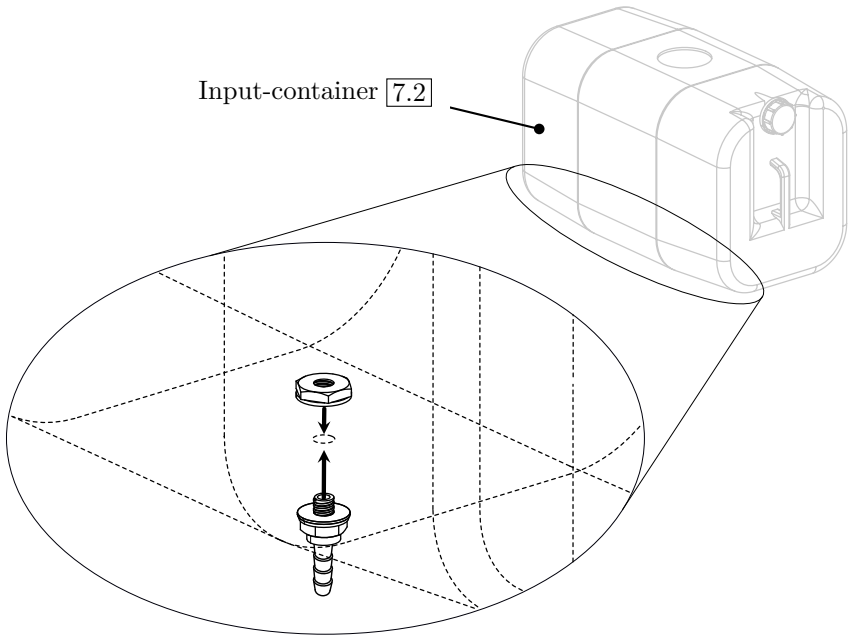
The input-container 7.2 needs a hole on the top, so that you can fill it and clean it. The hole should be large enough for taking your hand inside and pouring water into the container. You need a lid 7.3 to avoid dirt from getting in. It is better to use a real lid, but you can also use a plastic bag or something similar. To make a hole for the lid, first use a pencil to mark the outer diameter of the lid on top of the input container.

3



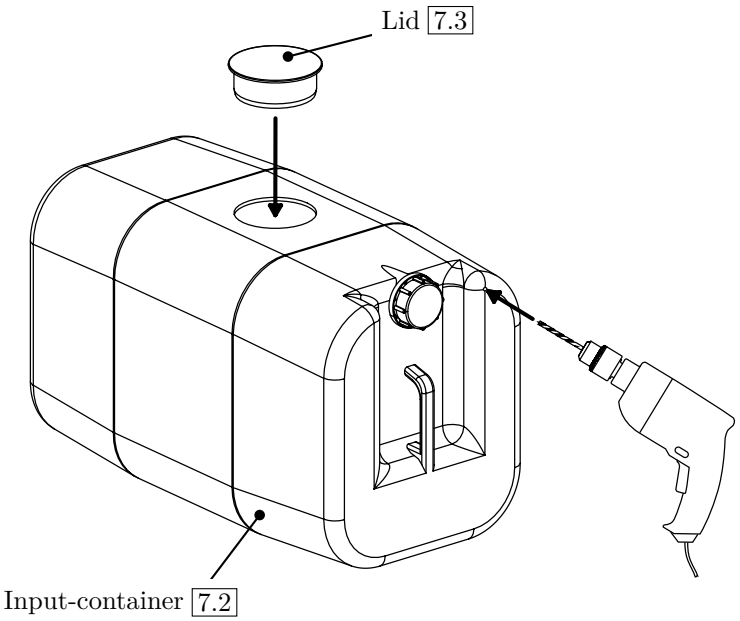
Cut a hole using a knife. To make things easier, you can drill a small hole first.

4



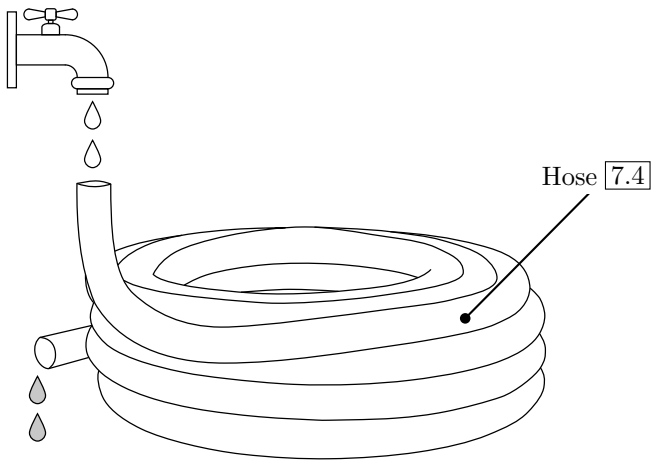
Now install the connection for the hose 7.6 at the input-container 7.2 (the dashed lines). It should be installed on the bottom of the container. If you are using a different connection than the one in the list of materials, you have to find an own way to connect it. To fix the connection, screw it apart first. Measure the diameter of the piece with the thread and drill a hole with that diameter centrally into the bottom side of the container (compare to the picture). Stick the piece with the thread and perhaps the sealing rings through the hole. You can also put on a sealing ring from the inside. Screw it down with a screw nut.

5



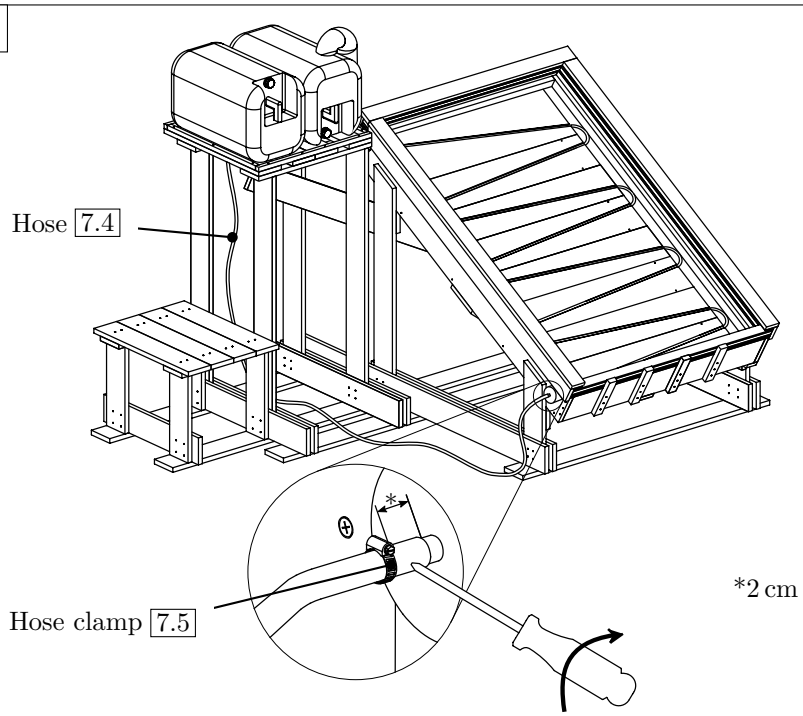
Now drill a little hole in the container for regulating the maximum water level. It should be at least 4" underneath the outlet (for further instructions, see chapter 1.6). It also functions as a ventilation hole, so if the lid is very tight (e.g. like a plug), the container is not entirely airtight.

6



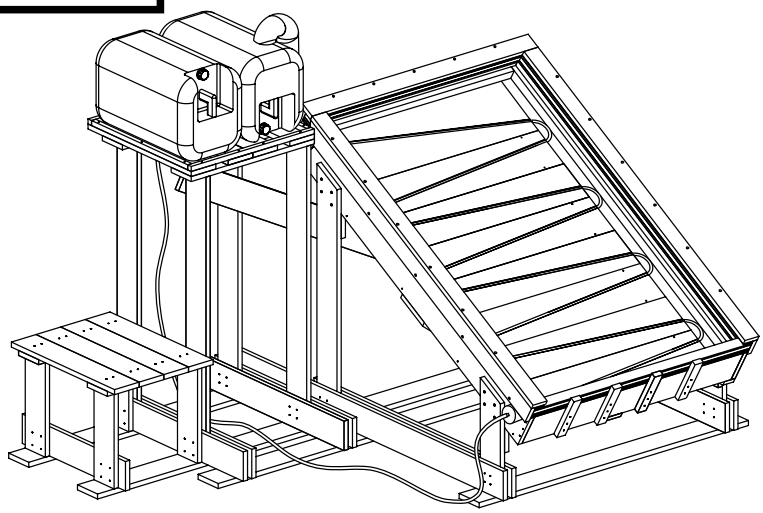
To ensure that the used hose 7.4 is clean, rinse it with water.

7



Now put the input-container 7.2 on the podest. It is important that it has the right height. Then connect the hose to the input-container. Push the hose and a hose clamp 7.5 over the connection 7.6 . Then turn the hose clamp tight. Also push the other end of the hose with a hose clamp 7.5 at least 2 cm over the copper pipe at the inlet and turn the hose clamp tight (see detailed picture). If you do not have a hose suitable for drinking water, use a pipe that is suitable for drinking water. In that case you have to think of a way of connecting it by yourself. Secure the containers, so that they cannot fall down any more. You can use e.g. a cord or a tension belt.

Complete system



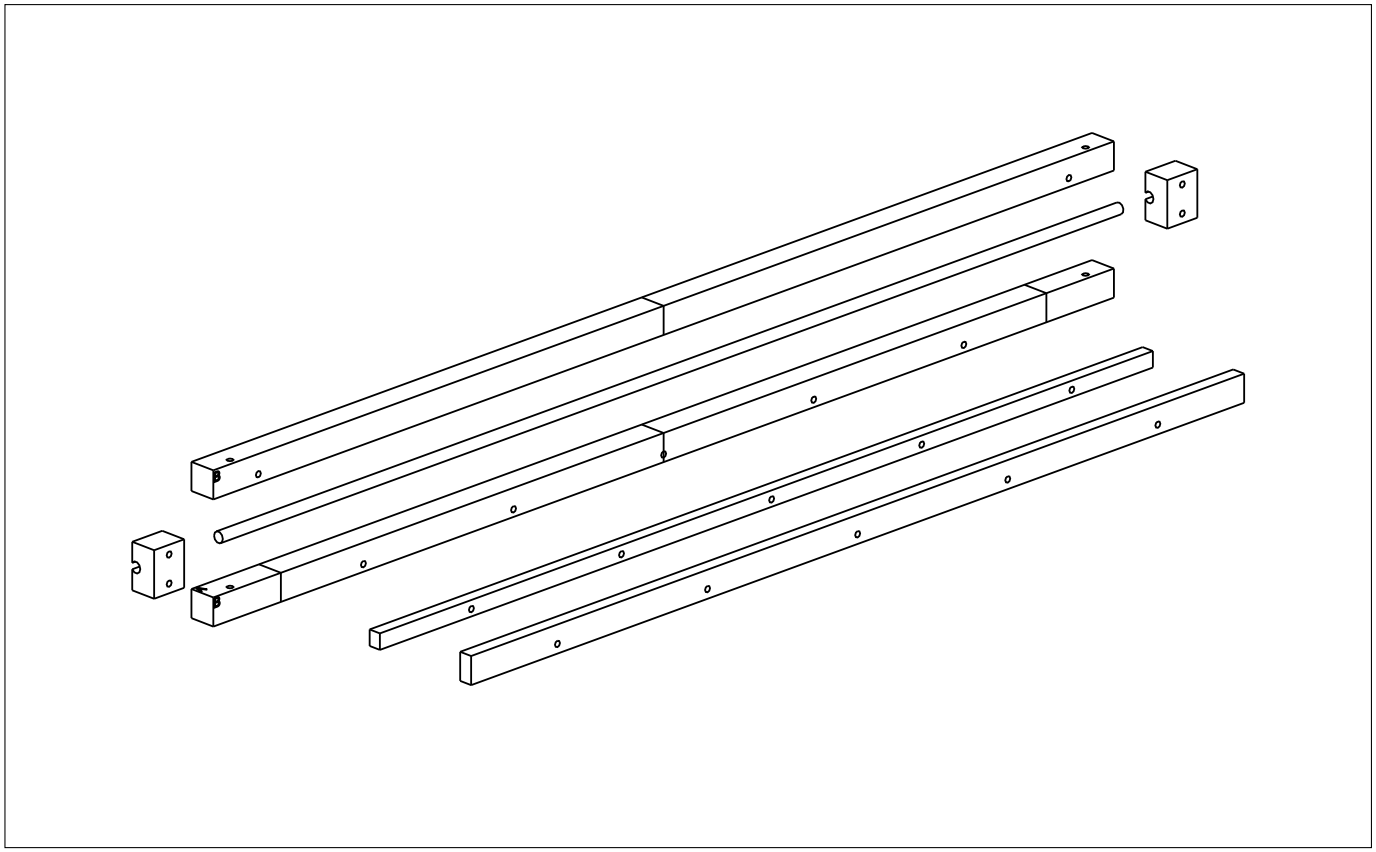
Congratulations, the entire system is finished now and can be used! Check the user manual for commissioning, operation and maintenance.

A Appendix

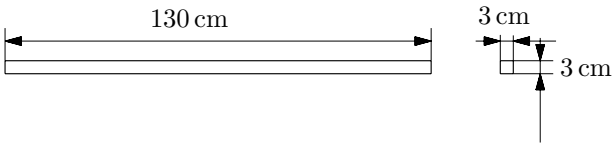
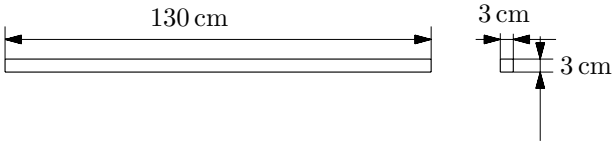
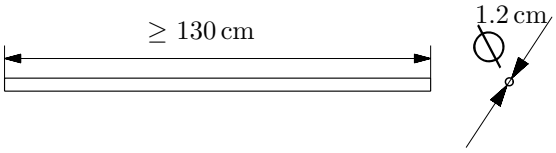
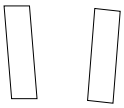
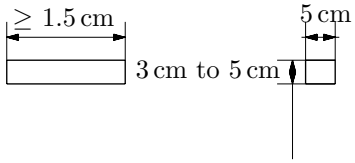
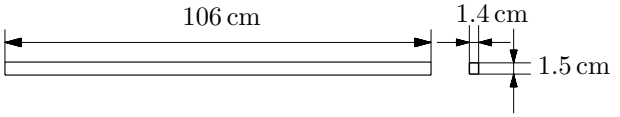
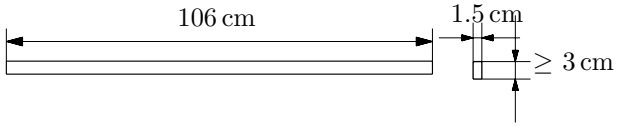
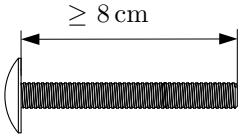
This is the Appendix. It contains instructions on building tools for pipe-bending and sheet-bending as well as their directions on use. The last chapter includes instructions on building a frame that is suitable for placing the system on a levelled ground.

A.1 Building the Metal Sheet Bending Tool

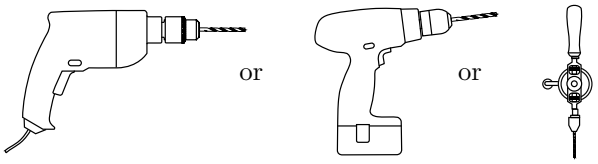
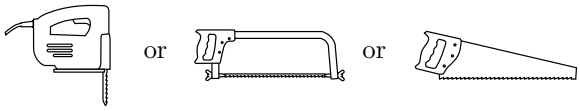
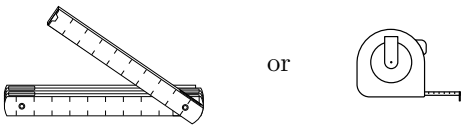
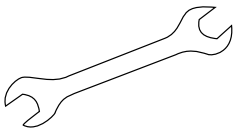
These are the instructions on building a Metal Sheet Bending Tool. If you do not have a tool to build the metal sheets, you can build this tool. See chapter A.2 (Page 93) on how to use it.



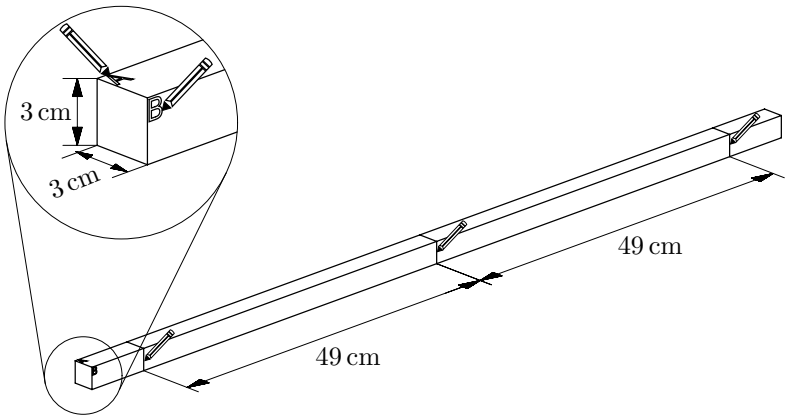
Required materials:

Number	Figure	Title	Other
1 x		Clamping piece A.1.1	Material: Wood bar Width: 3 cm Height: 3 cm Length: 130 cm
1 x		Clamping piece A.1.2	Material: Wood bar Width: 3 cm Height: 3 cm Length: 130 cm
1 x		Metal bar A.1.3	Metal bar Diameter: 1.2 cm Length: ≥ 130 cm
2 x		Scrap metal A.1.4	Use small pieces of the metal sheet you wand to bend with the tool
1 x		Block A.1.5	Material: Wood block Width: 5 cm Height: 3 cm to 5 cm Length: ≥ 1.5 cm
1 x		Clamping piece A.1.6	Material: Wood bar Width: 1.4 cm Height: 1.5 cm Length: 106 cm
1 x		Clamping piece A.1.7	Material: Wood bar Width: 1.5 cm to 2.5 cm Height: ≥ 3 cm Length: 106 cm
6 x		Carriage bolt A.1.8	Type: M6
6 x		Nut A.1.9	Type: M6 Nut with washer fitting the screw A.1.7 . Butterfly nut or normal nut.

Required tools:

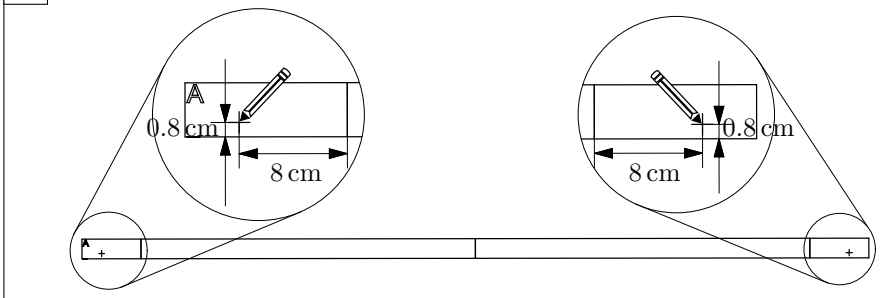
Number	Figure	Title	Other
1 x		Pen	A pen to mark the wood.
1 x		Drill	Wood drill • 6.6 mm • 12 mm
1 x		Saw	To cut the wood bars.
1 x		Measuring tape	To measure distances from 8 mm to 50 cm.
1 x		Wrench	Fitting to the screw you are using.

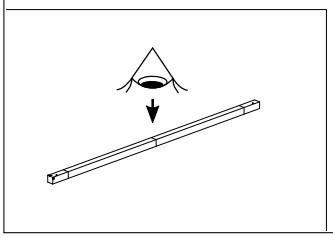
1



Take wood bar A.1.1 . Mark the middle. Mark surface of first clamping (A). Mark surface of second clamping (B). Mark the location 49 cm from the middle in both directions (Later the metal sheet will be in between these marks).

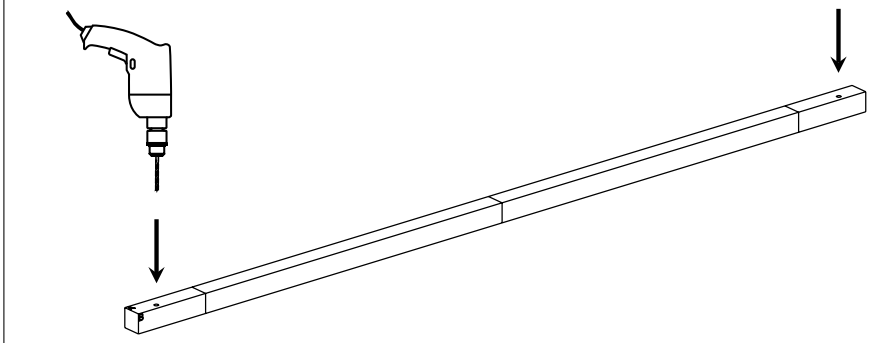
2





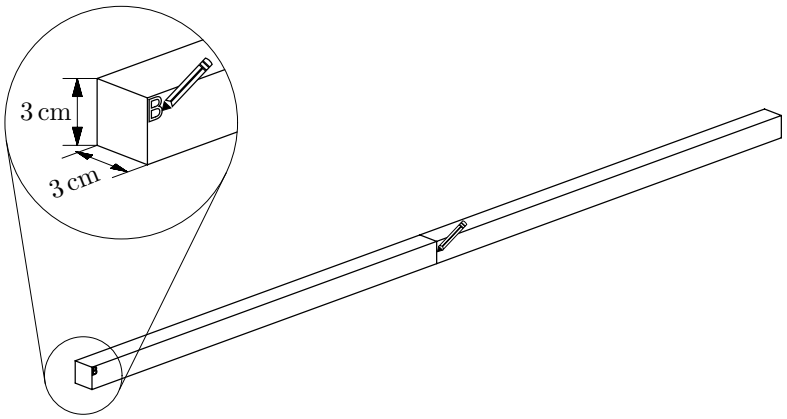
Mark the location of the two holes.

3



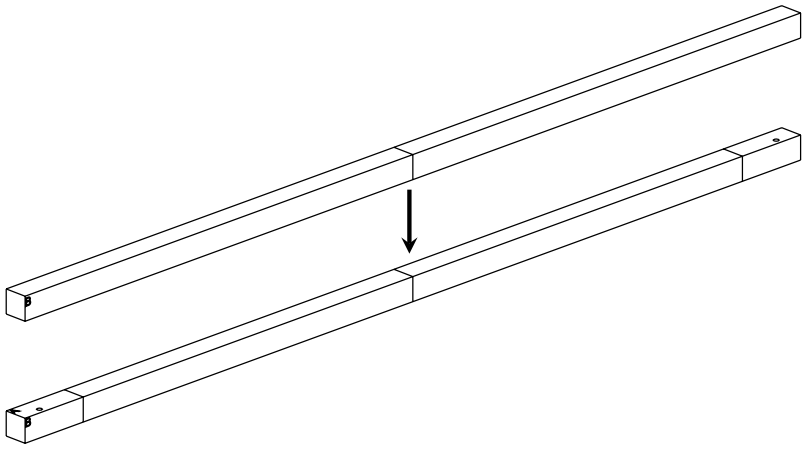
Drill the holes (diameter 6.6 mm).

4



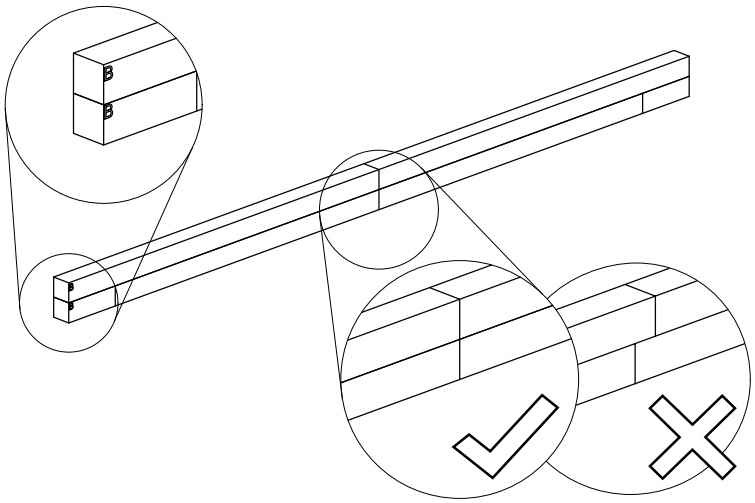
Take wood bar A.1.2 . Mark the middle. Mark surface of first clamping (A). Mark surface of second clamping (B).

5



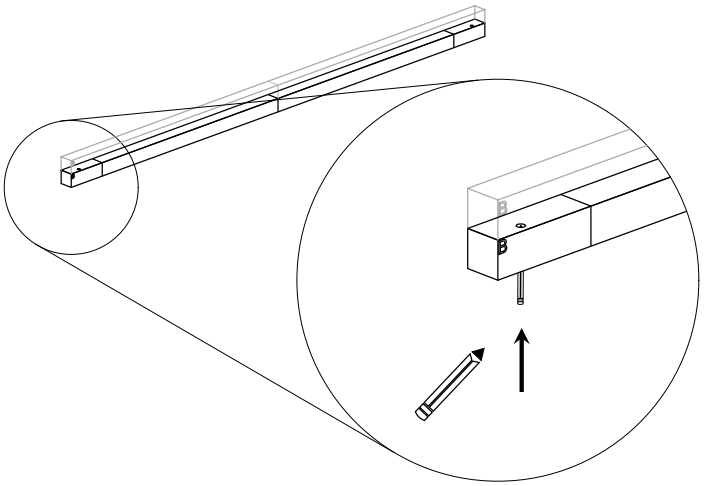
Place wood bar A.1.2 on top of wood bar A.1.1 .

6



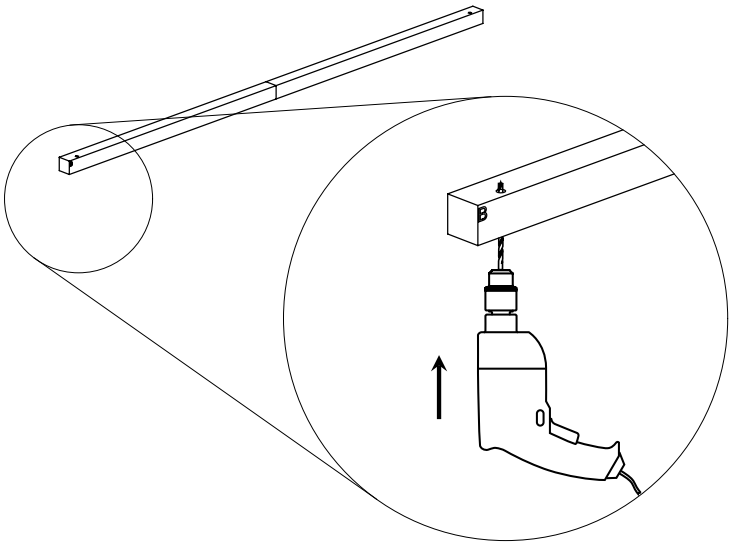
Marks for the middle must match. Surfaces (A) are on top of each other (not visible anymore). Surfaces (B) build one surface (visible).

7



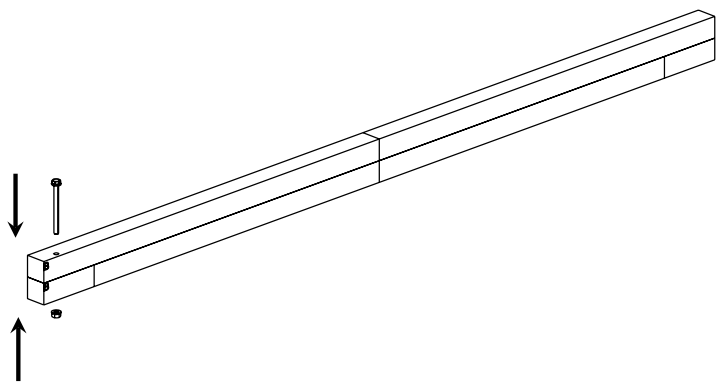
Mark the position for one hole on wood bar A.1.2 through existing hole in wood bar A.1.1 .

8



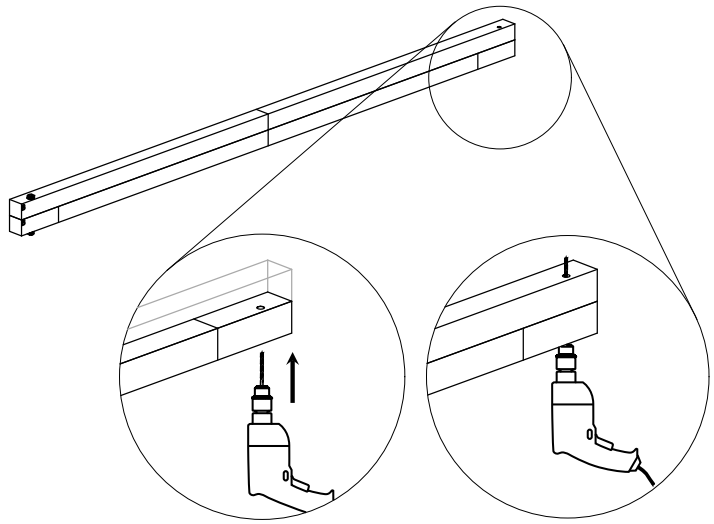
Drill the hole in wood bar A.1.2 (diameter: 6.6 mm).

9



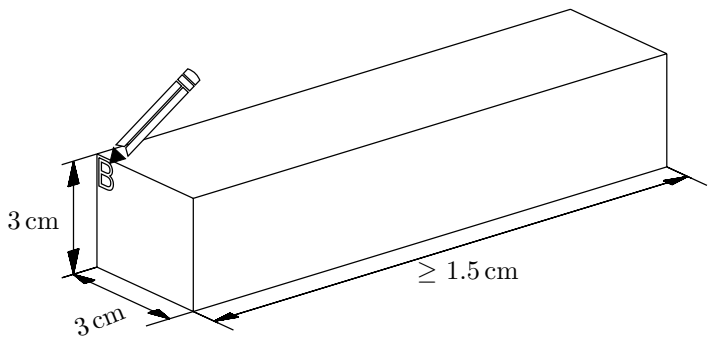
Fix wood bar A.1.1 and wood bar A.1.2 with a screw and a nut.

10



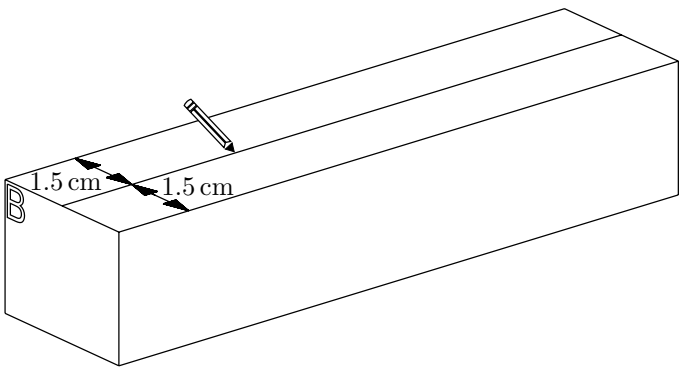
Drill through the second hole of wood bar A.1.1 to get the second hole in wood bar A.1.2 (this makes sure the holes match).

11



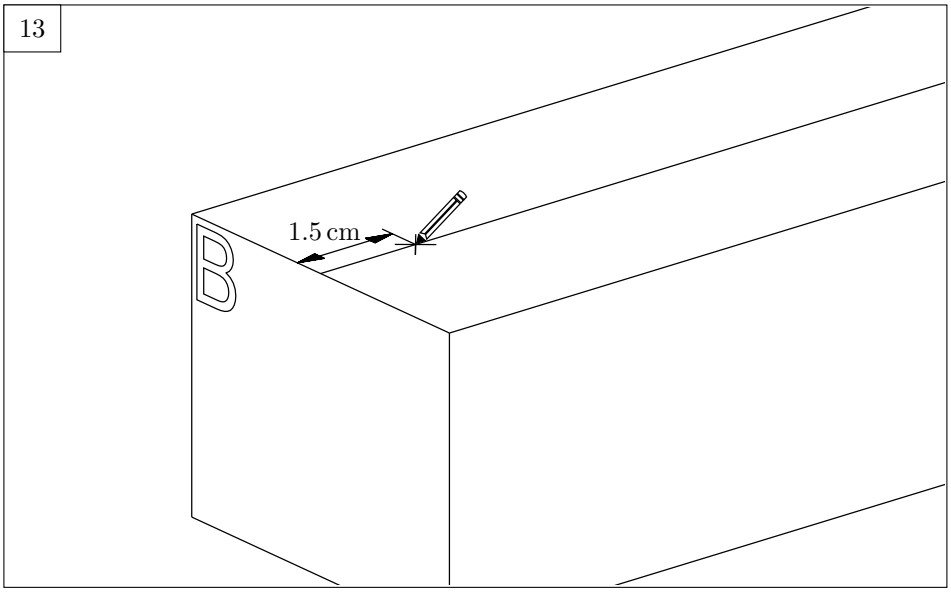
Mark wood piece A.1.5 . Mark the surface of second clamping (B).

12



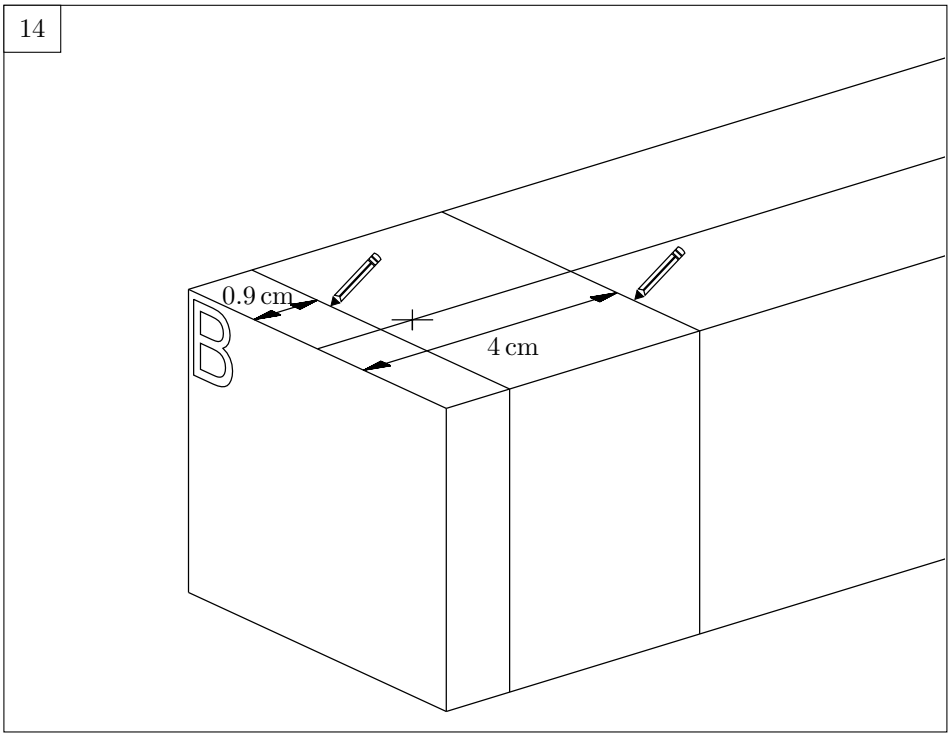
Mark the middle on the long surface.

13



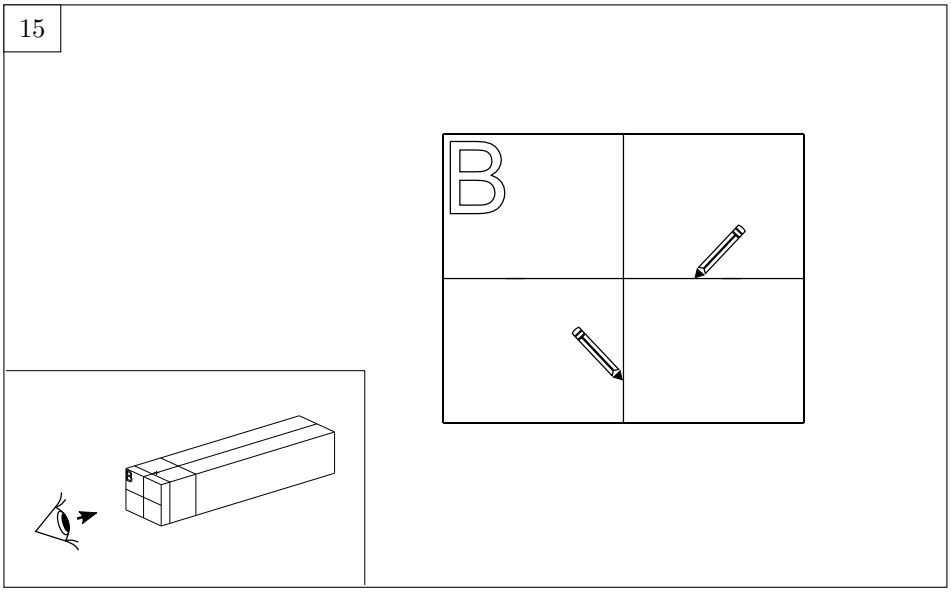
Mark the first hole on the long surface.

14



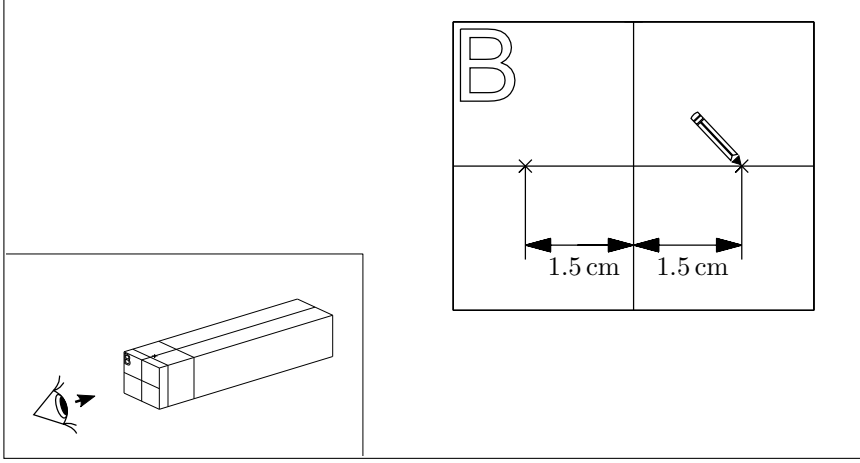
Mark a line 0.9 cm from surface (B). Mark a second line 4 cm from surface (B).

15



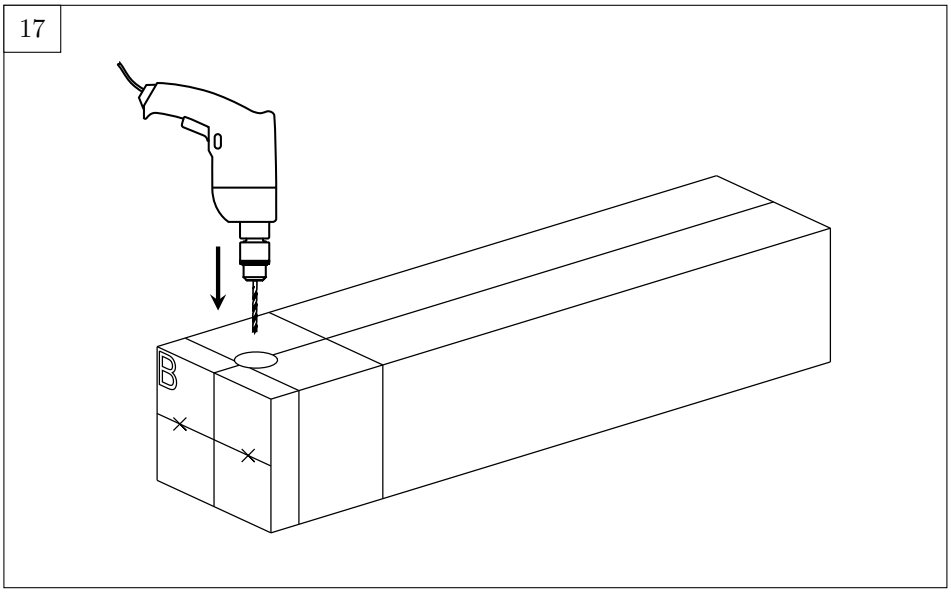
Mark both middle lines on the small surface.

16



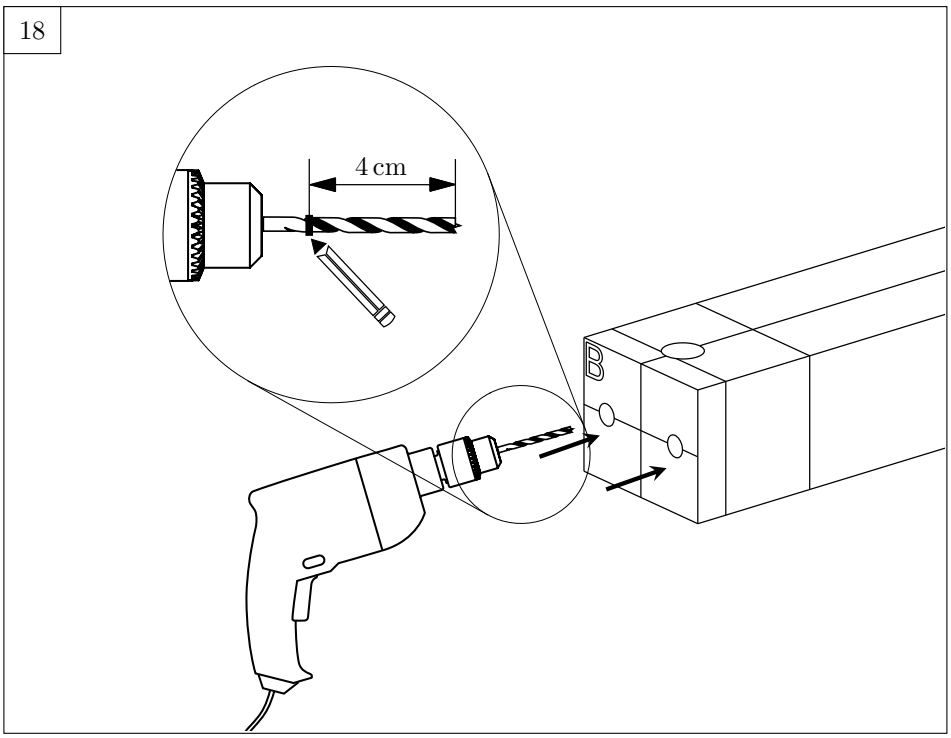
Mark the positions of the next two holes on the small surface.

17



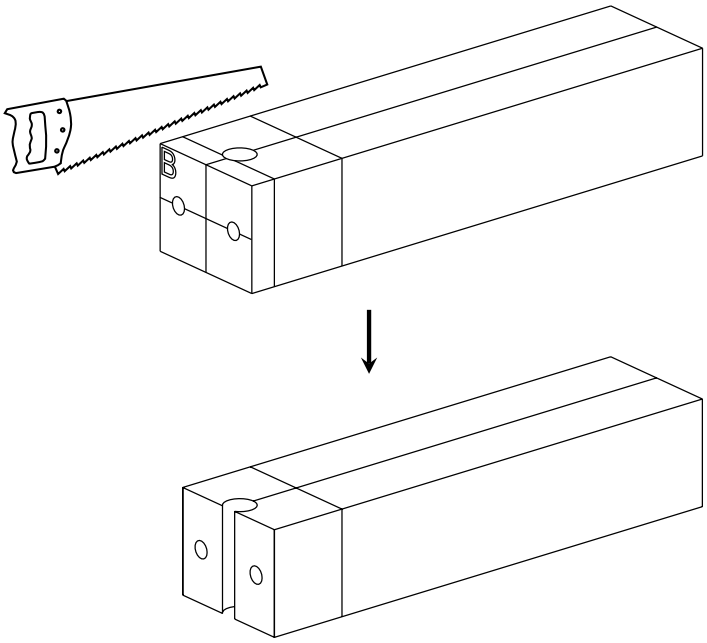
Drill the first hole (diameter: 12 mm).

18



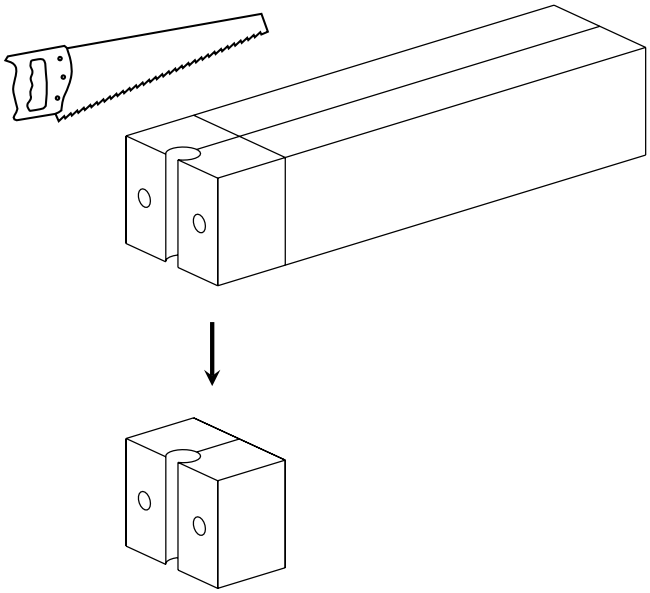
Drill the other two holes on the small surface 4 cm deep (mark the drill). Diameter: 6.6 mm
The holes must be straight.
the holes must not be less than 4 cm deep.
The hole must cut the big hole.

19



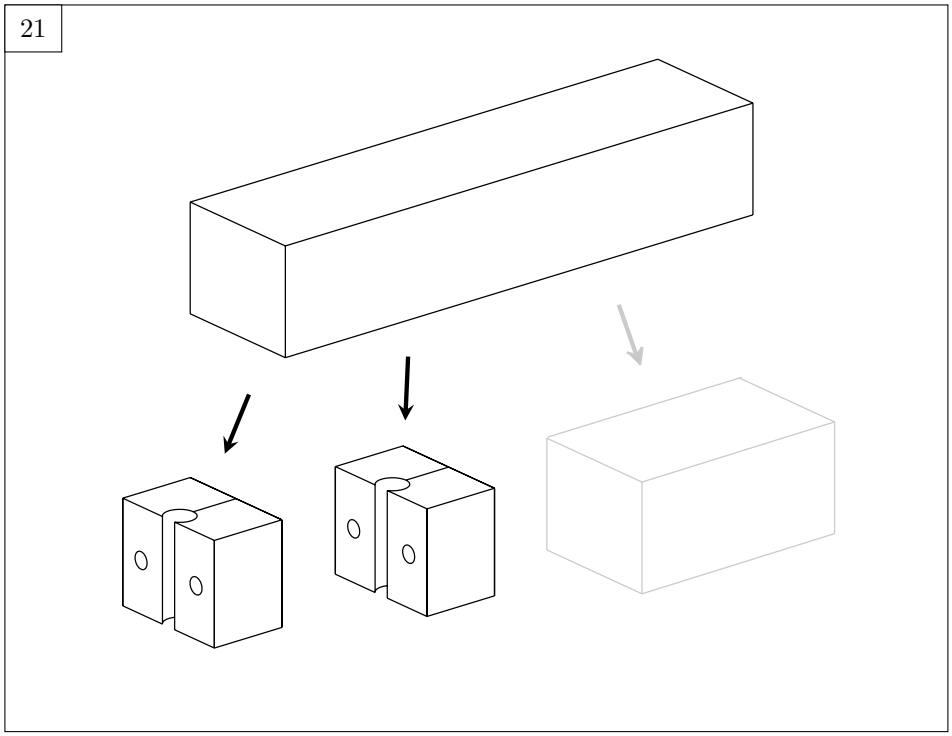
Cut the first line. The big hole is cut.

20



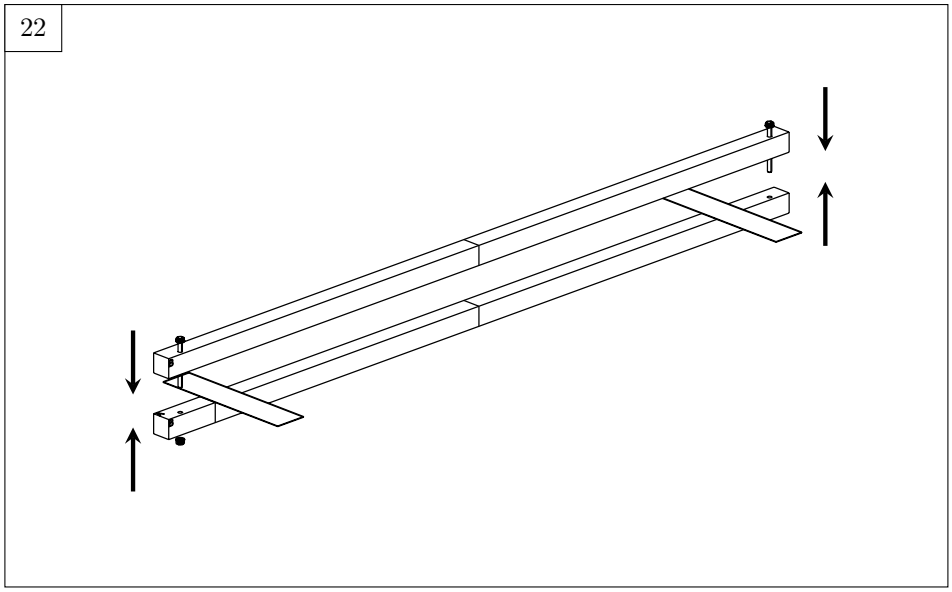
Cut the second line.
The small holes now go through the block.

21



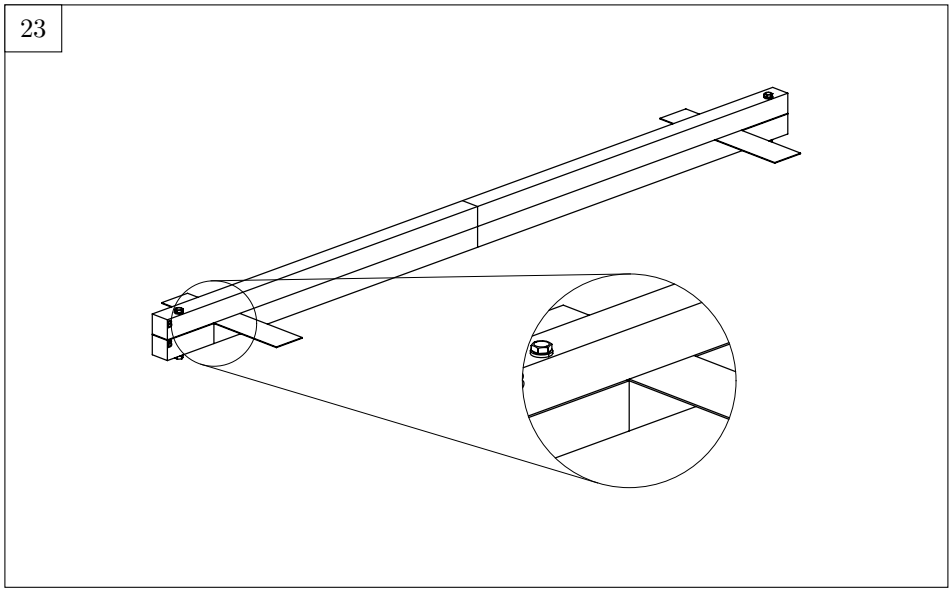
Repeat the previous steps beginning from step 11. At the end you have two pieces to use and a leftover.

22



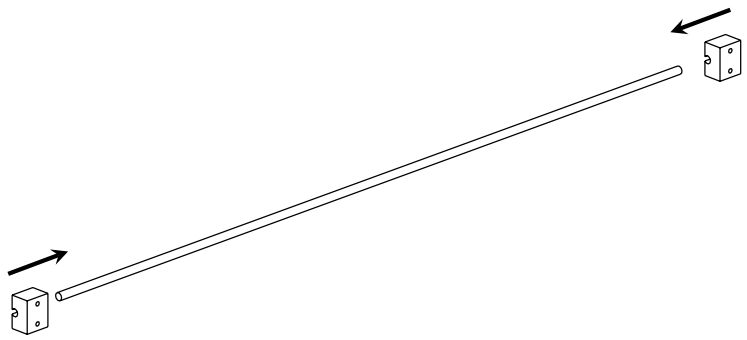
Clamp two scrap metals A.1.4 between wood bar A.1.1 and wood bar A.1.2 .
Fix screws A.1.8 with nuts A.1.9 .

23



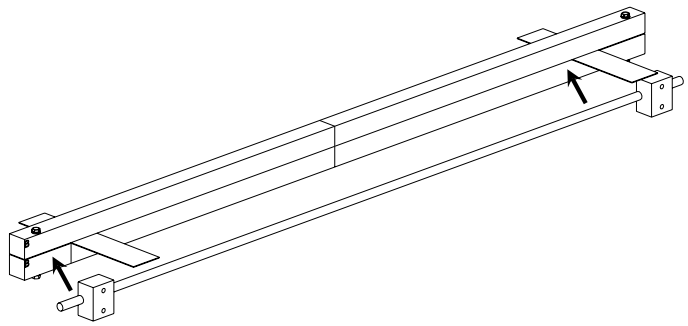
The metals must be between the marks.

24



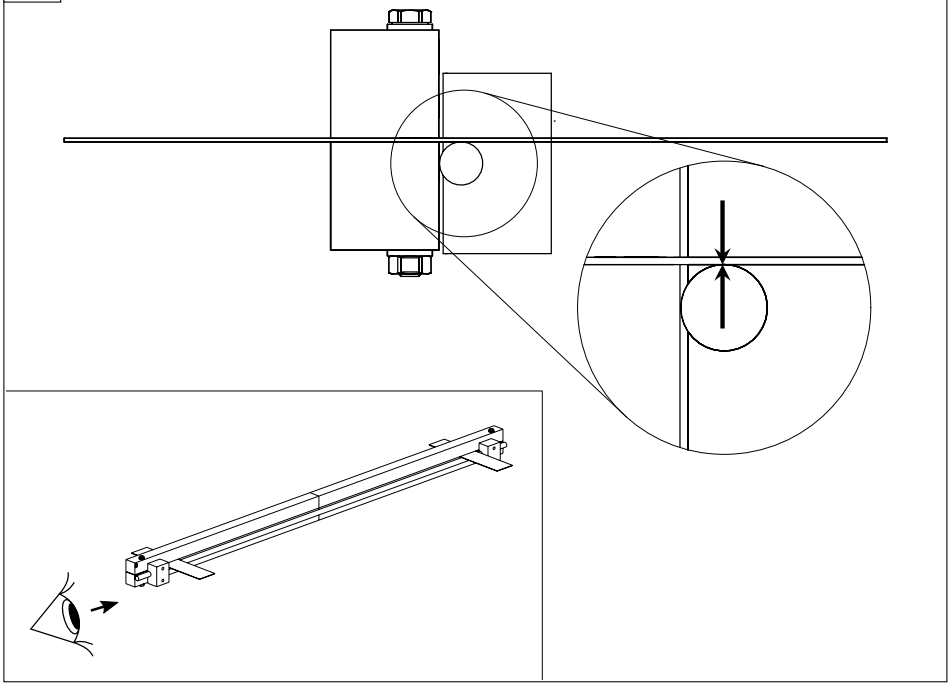
Slide wood pieces A.1.5 on the metal bar.

25



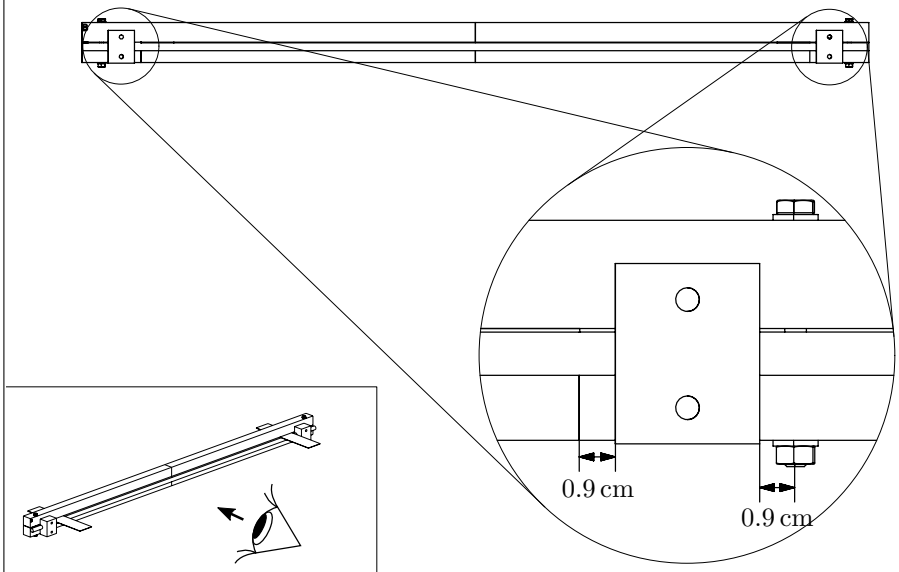
Mark wood piece A.1.5 . Mark the surface of second clamping (B).

26



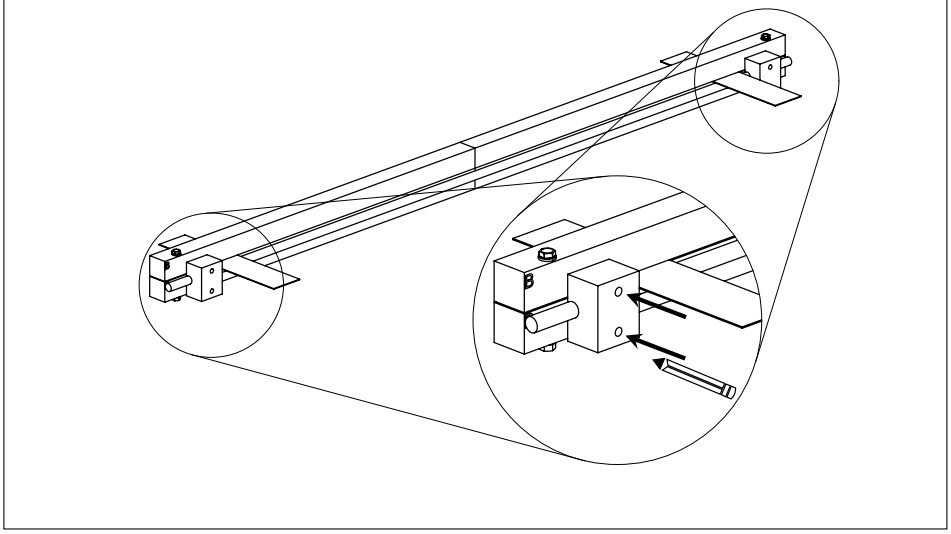
The top of the metal bar must touch the scrap metal.
The cut side of the wood pieces A.1.5 shows toward wood bar A.1.1 .
The metal bar touches wood bar A.1.1 .
There is a small gap between wood bar A.1.1 and wood piece A.1.5 .

27



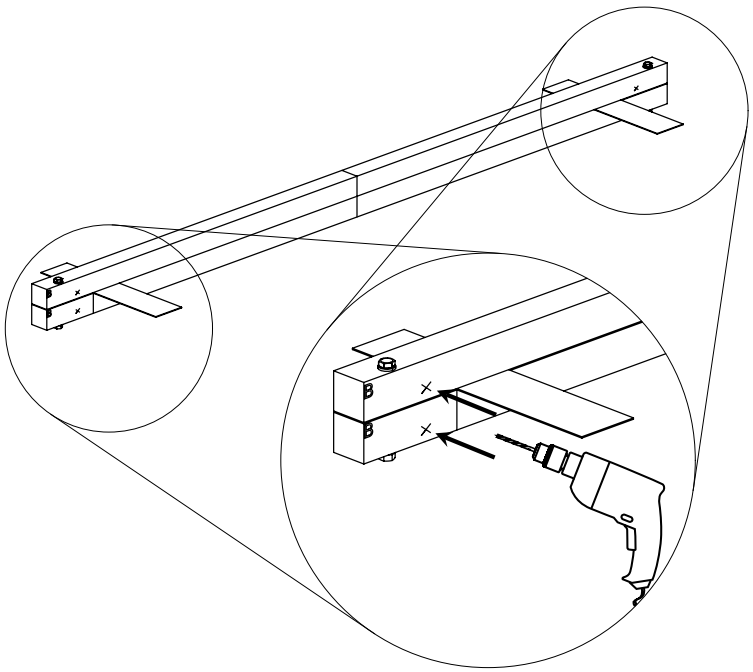
Position wood pieces A.1.5 so that there is a distance between the screw and the mark (at least 0.9 cm).

28



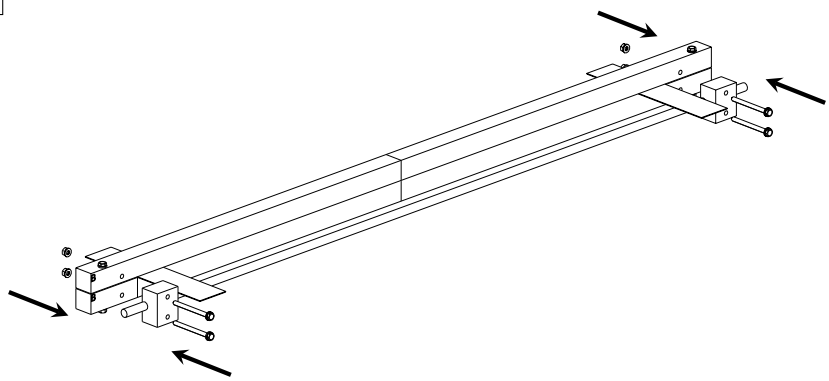
Mark the positions of holes on wood bar A.1.1 and wood bar A.1.2 through the holes of wood pieces A.1.5 (this makes the holes match).

29



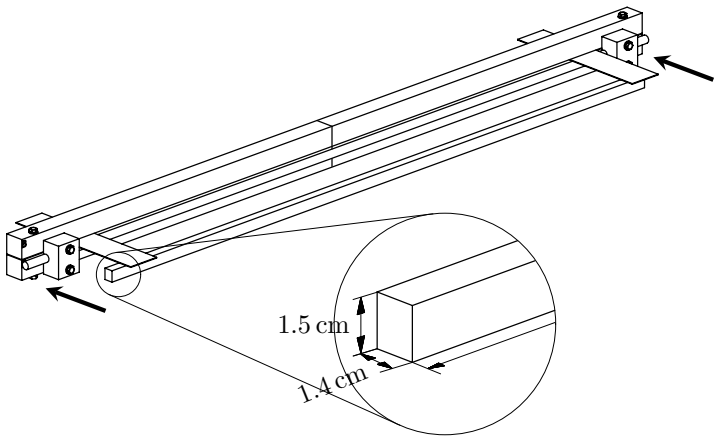
Drill the holes (diameter: 6.6 mm).

30



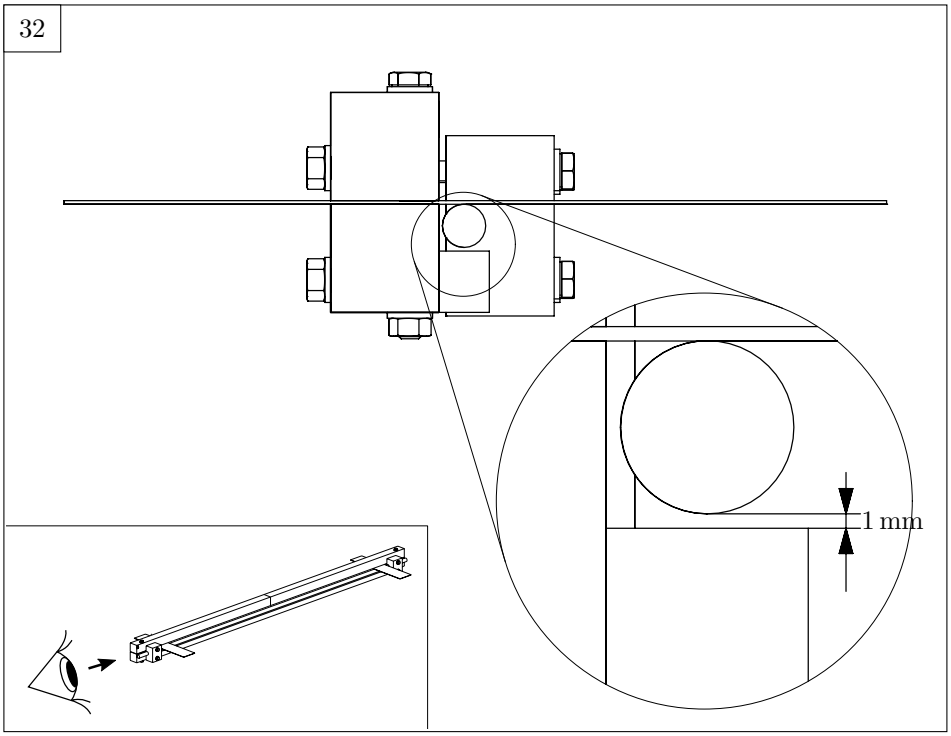
Fix wood pieces A.1.5 and the metal to wood bar A.1.1 and wood bar A.1.2 with screws and nuts.

31



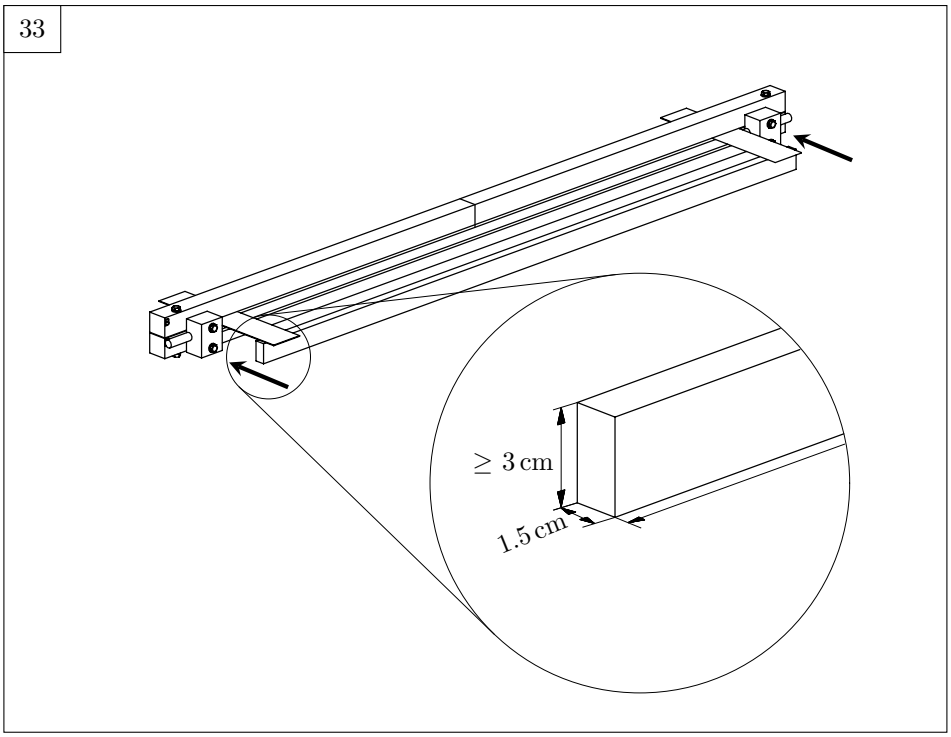
Move the wood bar A.1.6 to the other pieces.

32



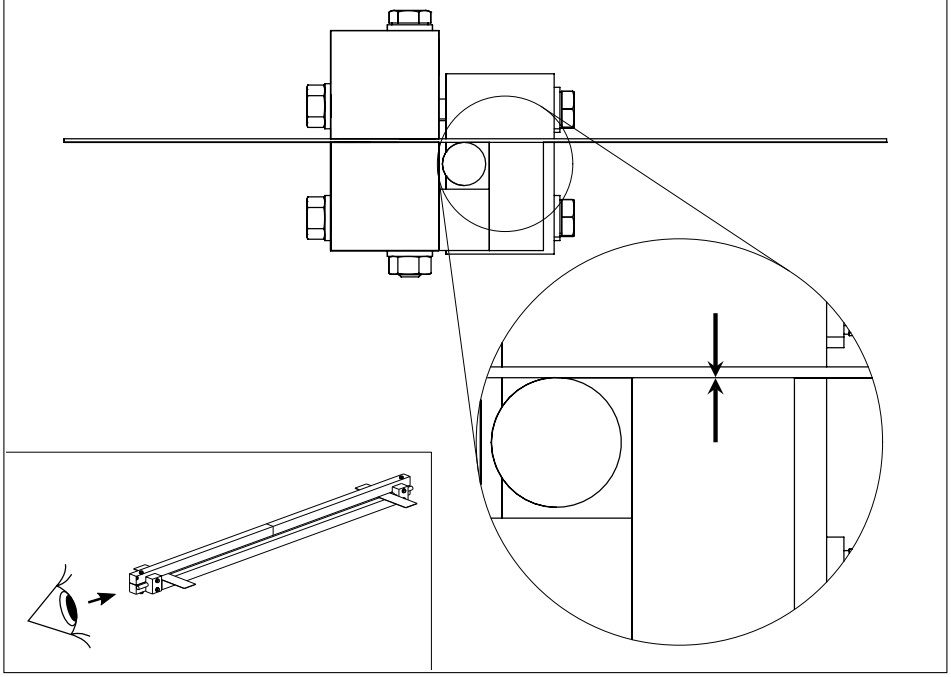
There must be a distance of at least 1 mm between wood bar A.1.6 and the metal bar A.1.3 .

33



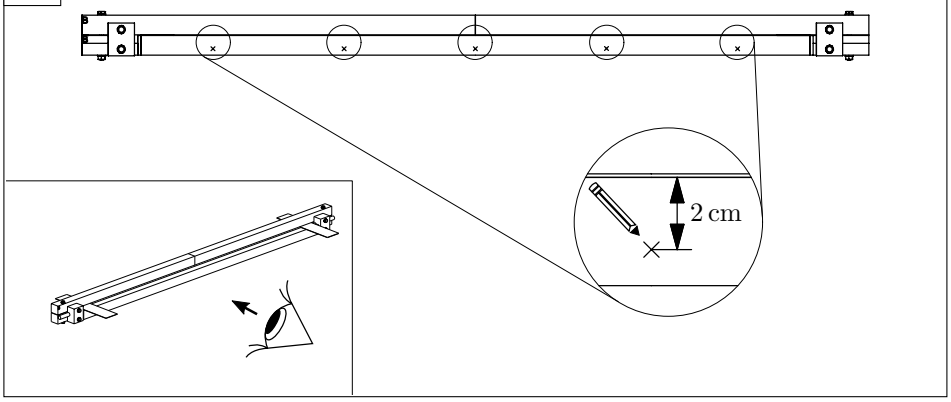
Move wood bar A.1.7 to the other pieces. The position of wood bar A.1.6 must not be changed.

34



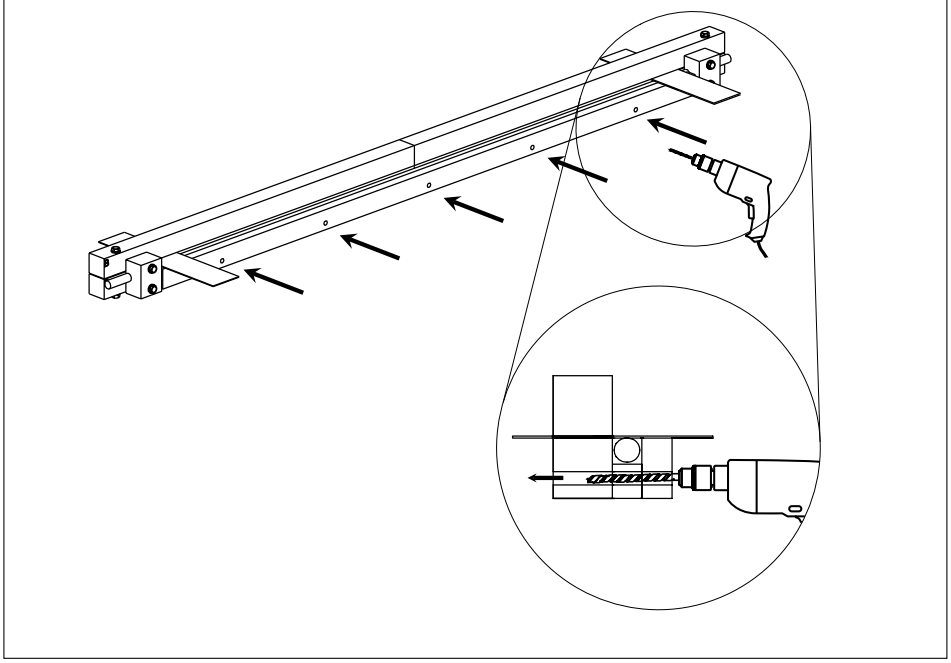
Wood bar A.1.7 must touch the scrap metal.

35

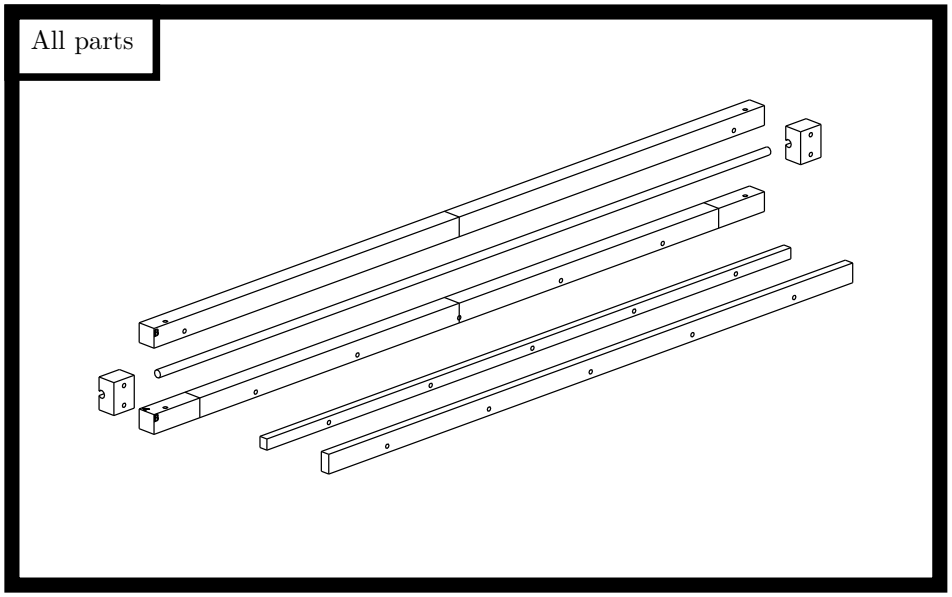


Mark the positions of at least 5 holes on the wood bar A.1.7 . The distance to the scrap metal is 2 cm.

36



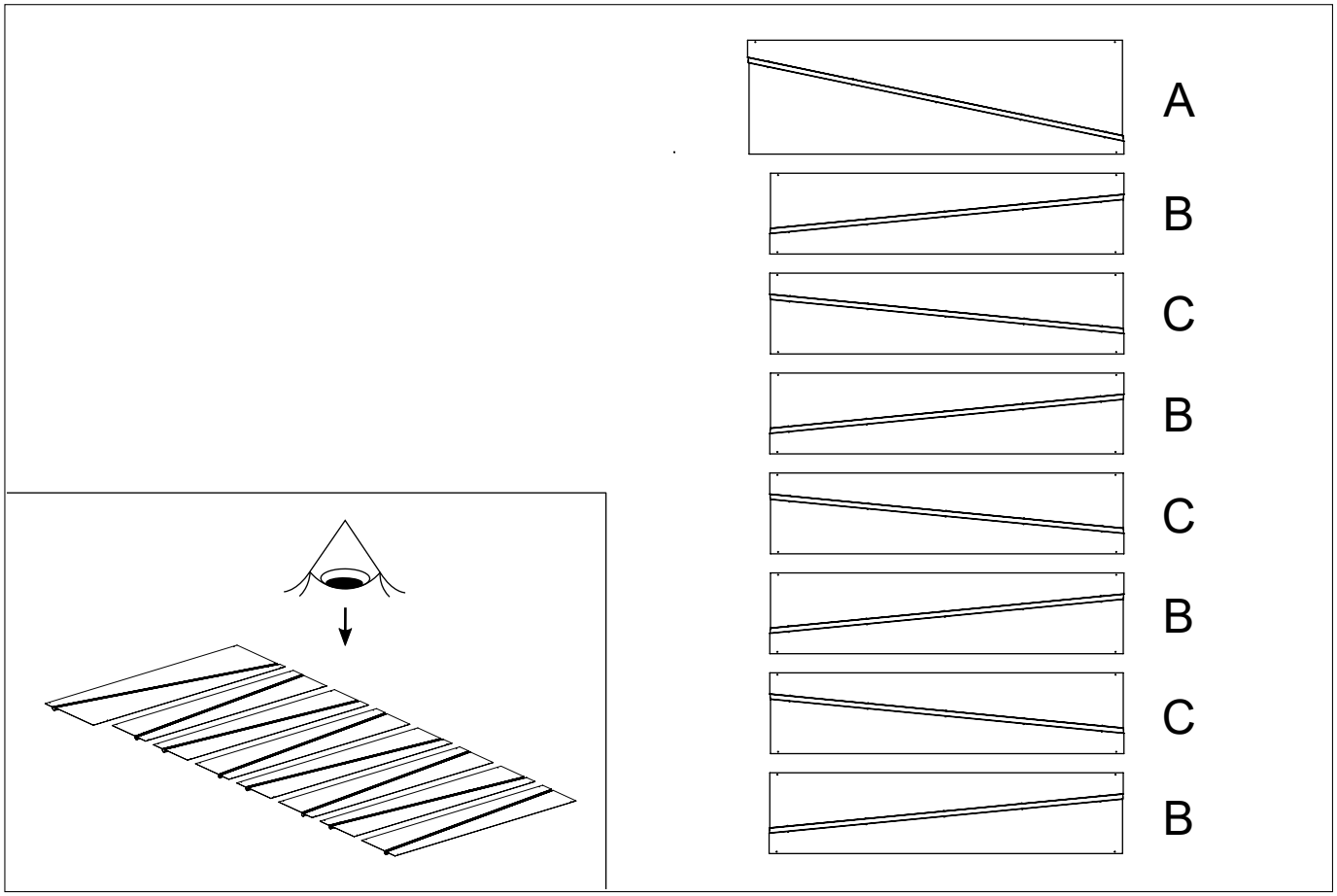
Drill the holes (diameter: 6.6 mm through all wood bars.)



The parts for the Metal Sheet Bending Tool are finished. Disassemble all parts.

A.2 Using the Metal Sheet Bending Tool

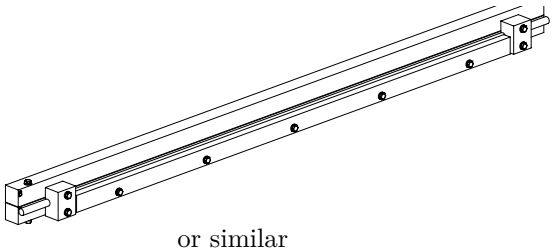
After you built the Metal Sheet Bending Tool (chapter A.1 (Page 76)) you can now use it.

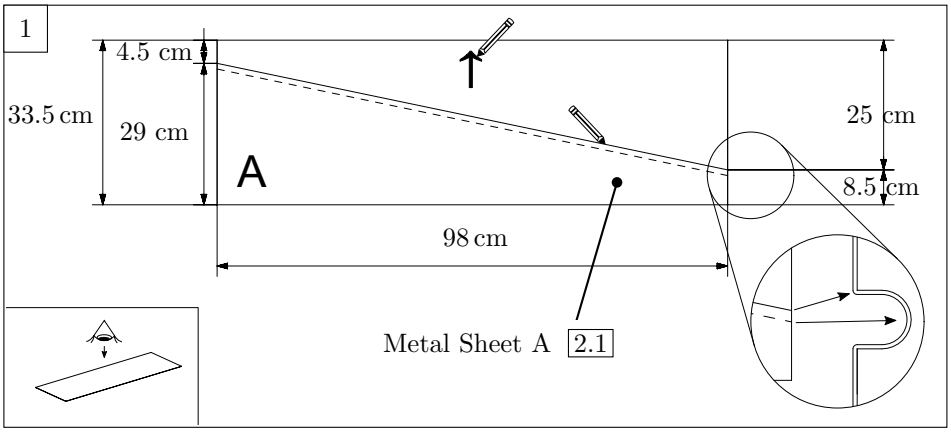


Required materials:

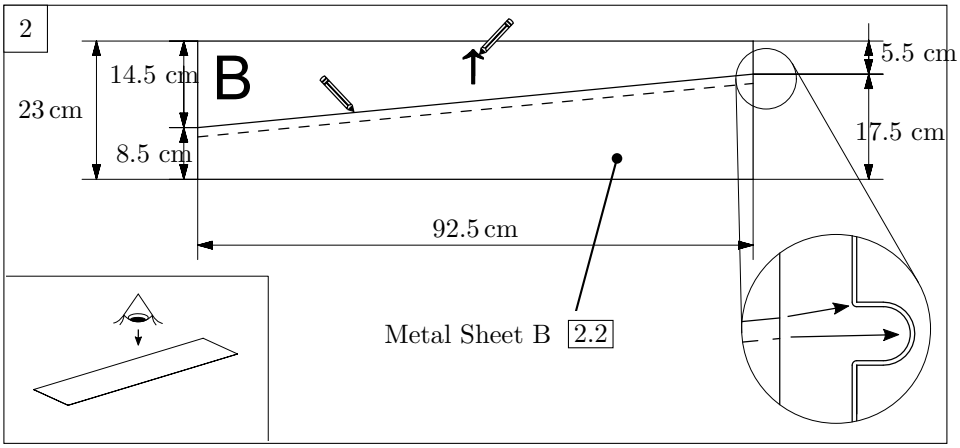
Quantity	Figure	Title		Other
1 x	98 cm, 33.5 cm	Metal sheet A	2.1	Thickness: 0.6 - 1 mm Material: Aluminum/Copper
4 x	92.5 cm, 23 cm	Metal sheet B	2.2	Thickness: 0.6 - 1 mm Material: Aluminum/Copper Same as metal sheet 2.1
3 x	92.5 cm, 23 cm	Metal sheet C	2.3	Thickness: 0.6 - 1 mm Material: Aluminum/Copper Same as metal sheet 2.1

Required tools:

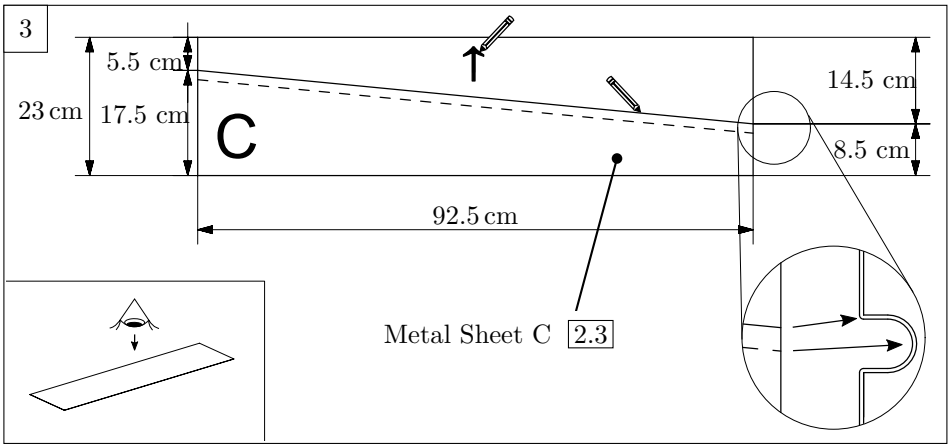
Number	Figure	Title	Other
1 x	 or similar	Deep-drawing-tool A.1	Sheet-bending tool from chapter A.1 (Page 76).



Mark the first bending edge on metal sheet A.
Mark the orientation with an arrow pointing to the top.
The dotted line will be the middle of the groove.



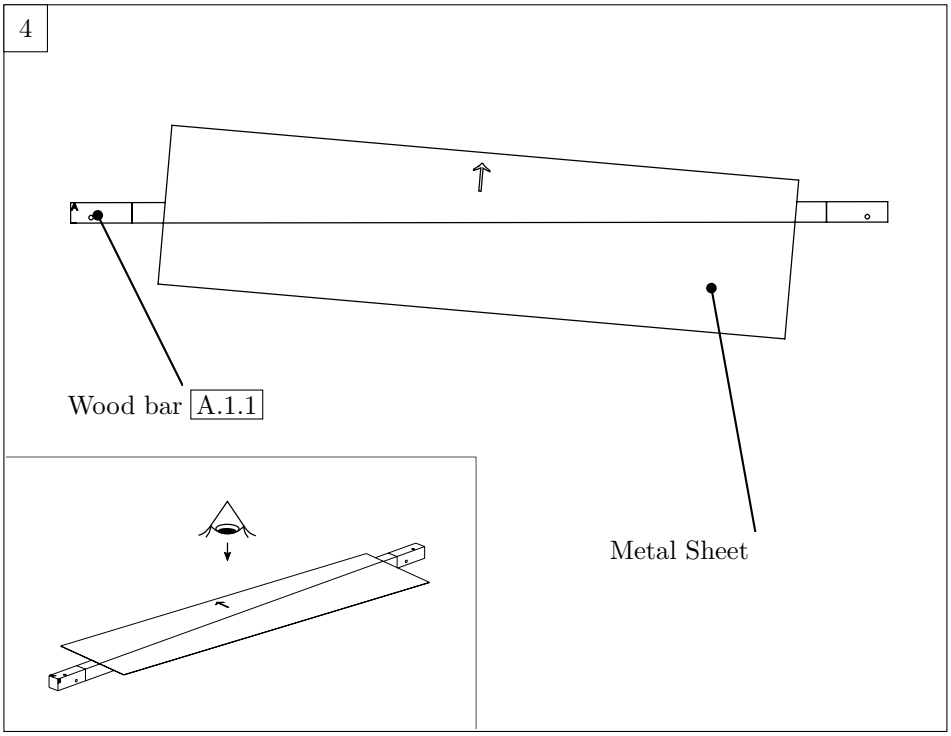
Mark the first bending edge on metal sheet B.
Mark the orientation with an arrow pointing to the top.
The dotted line will be the middle of the groove.



Mark the first bending edge on metal sheet C.
Mark the orientation with an arrow pointing to the top.
The dotted line will be the middle of the groove.

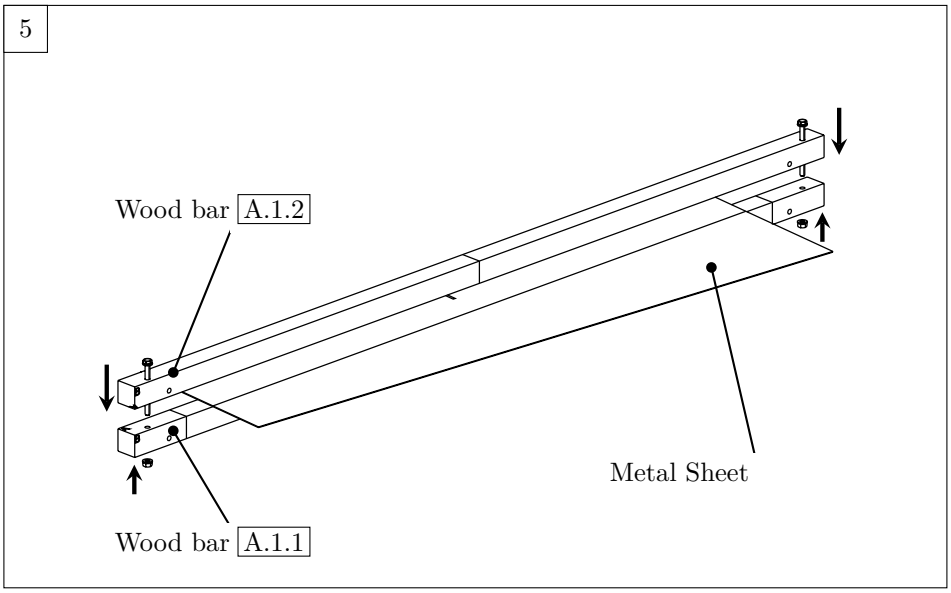
The following steps show how to bend the metal sheets. Repeat the steps for every metal sheet.

4



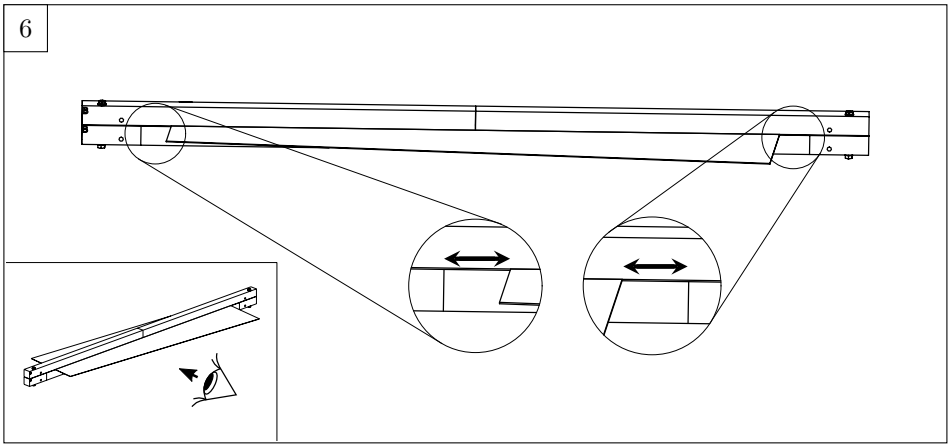
Clamp the metal sheet on wood bar A.1.1 .
The arrow has to point in the correct direction (see picture).
The marked bending edge must be on the edge of wood bar A.1.1 and wood bar A.1.2 .
Fix with screws and nuts.

5



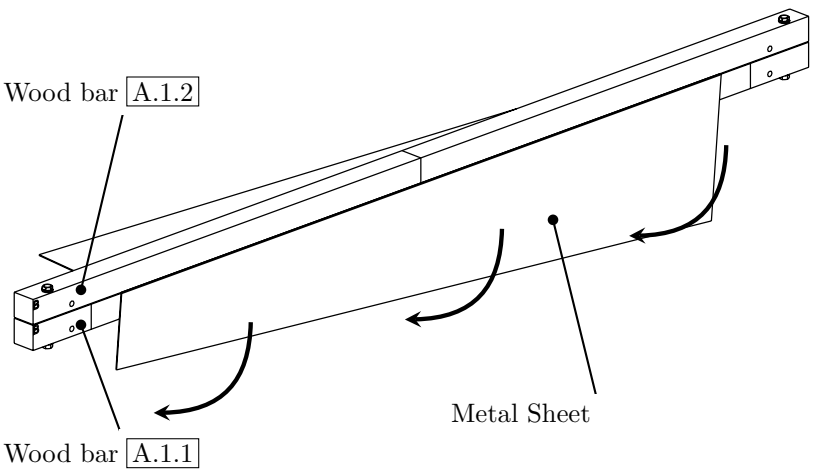
Clamp the metal sheet between wood bar A.1.1 and wood bar A.1.2 .

6



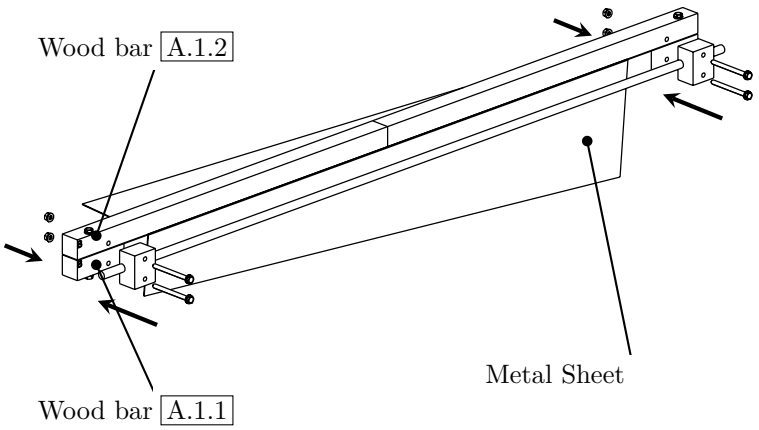
The metal sheet must be between the marks on wood bar A.1.1 .

7



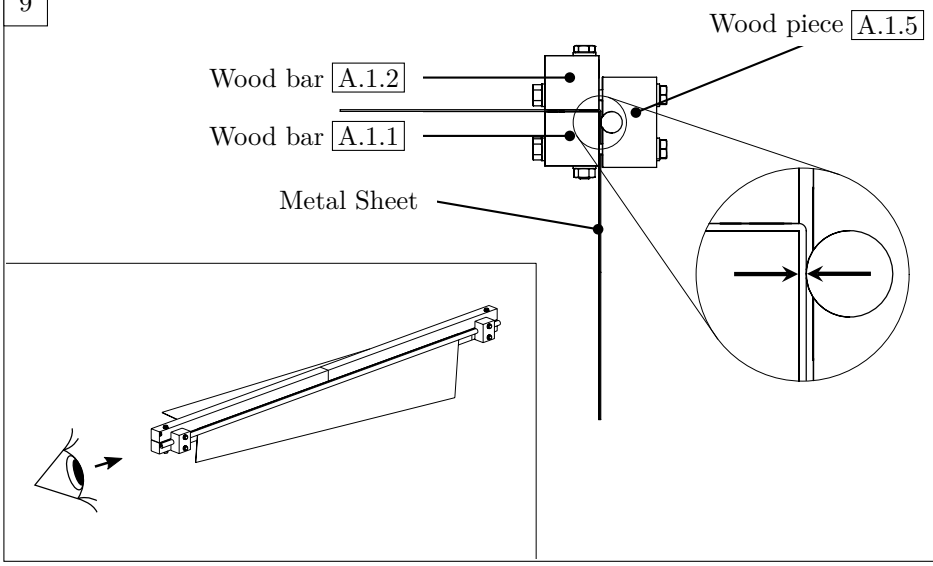
Carefully bend the metal sheet 90° to the bottom.

8



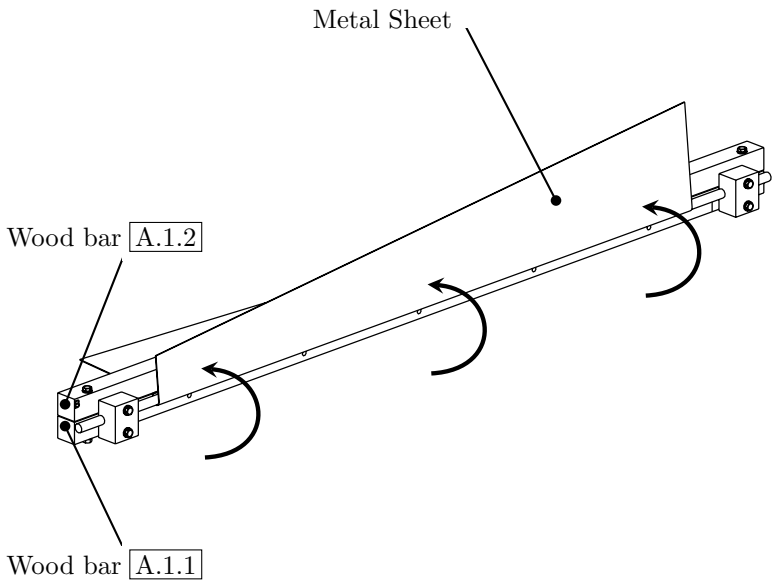
Assemble the metal bar with the 2 wood pieces A.1.5 .

9



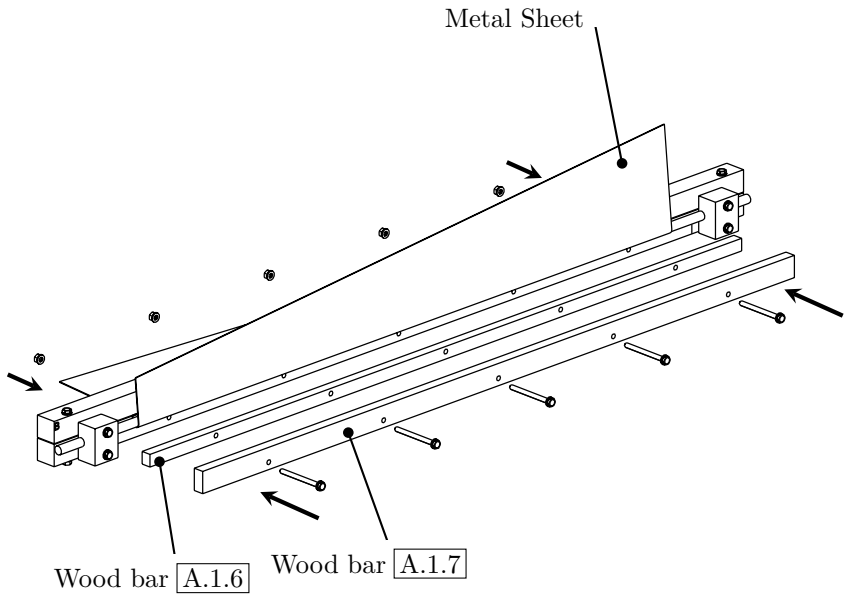
Clamp the metal sheet between the metal bar and wood bar A.1.1 . Fix with screws and nuts.

10



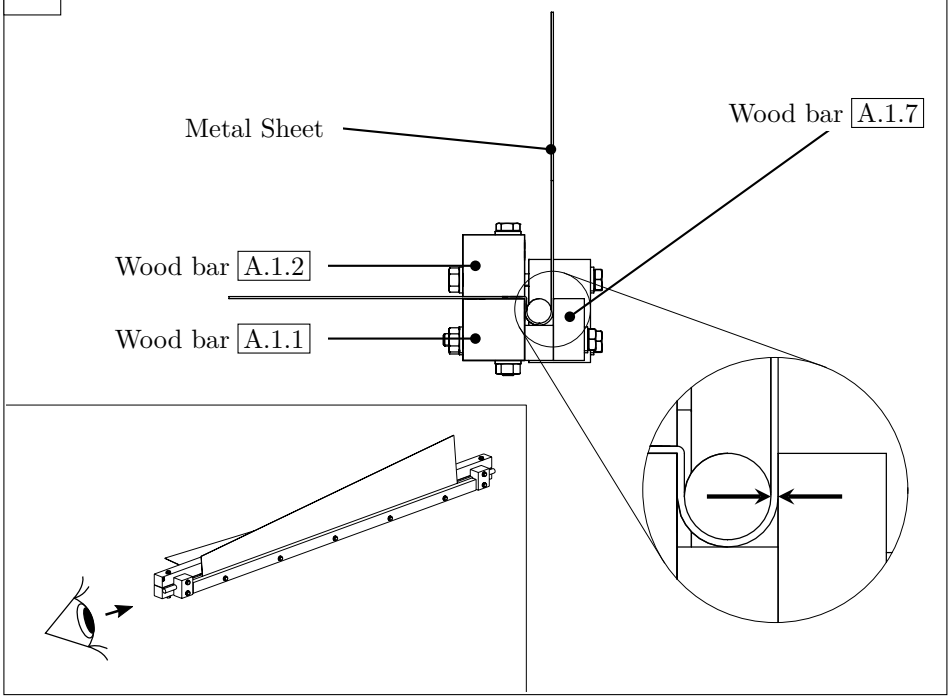
Carefully bend the metal sheet 180° to the top.

11



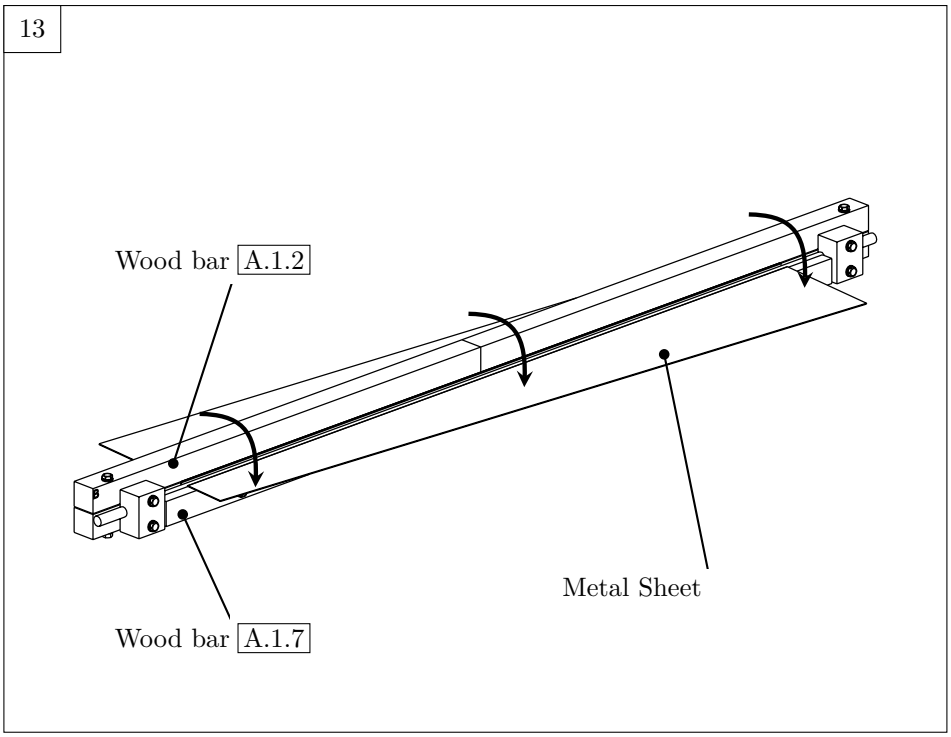
Assemble wood bar A.1.6 and wood bar A.1.7 .

12

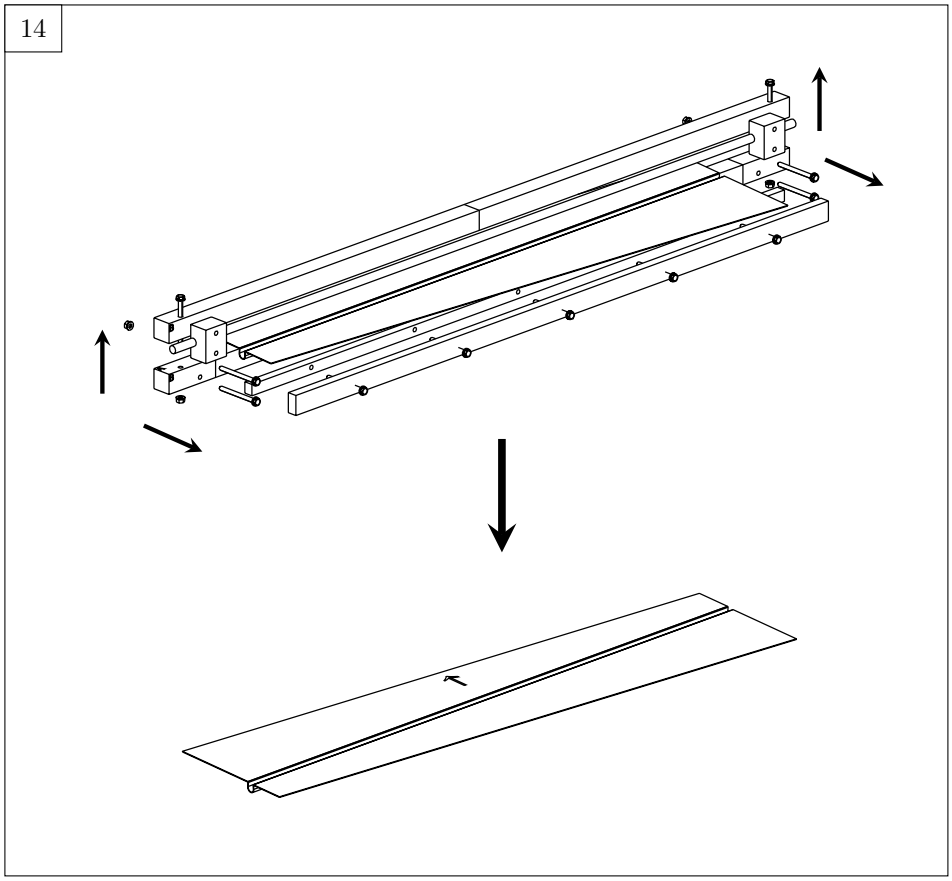


Clamp the metal sheet between the metal bar and wood bar A.1.7 . Fix with screws and nuts.

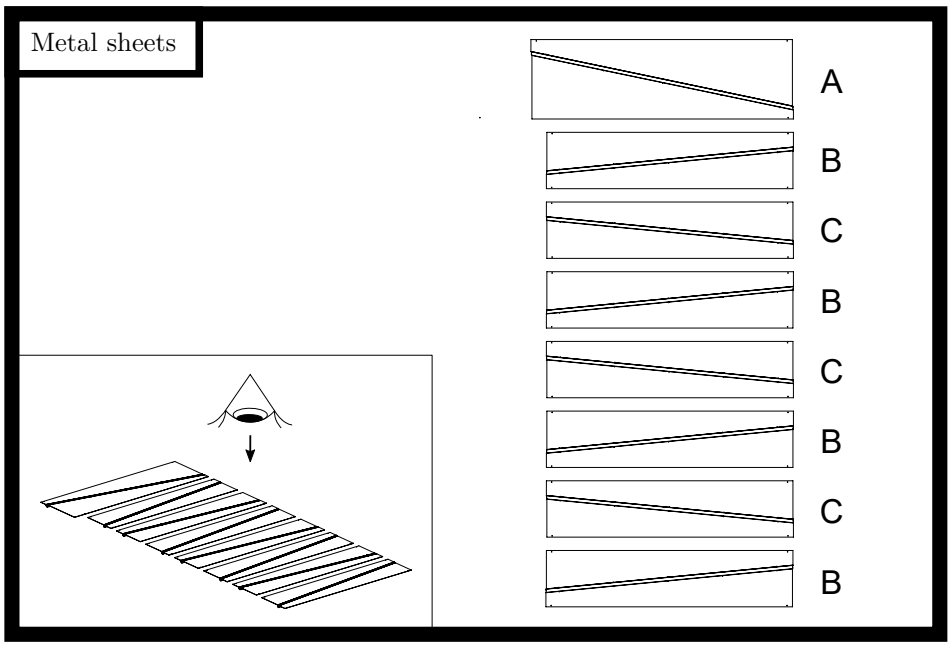
13



Carefully bend the metal sheet 90° down.



Now disassemble all parts of the sheet bending tool.

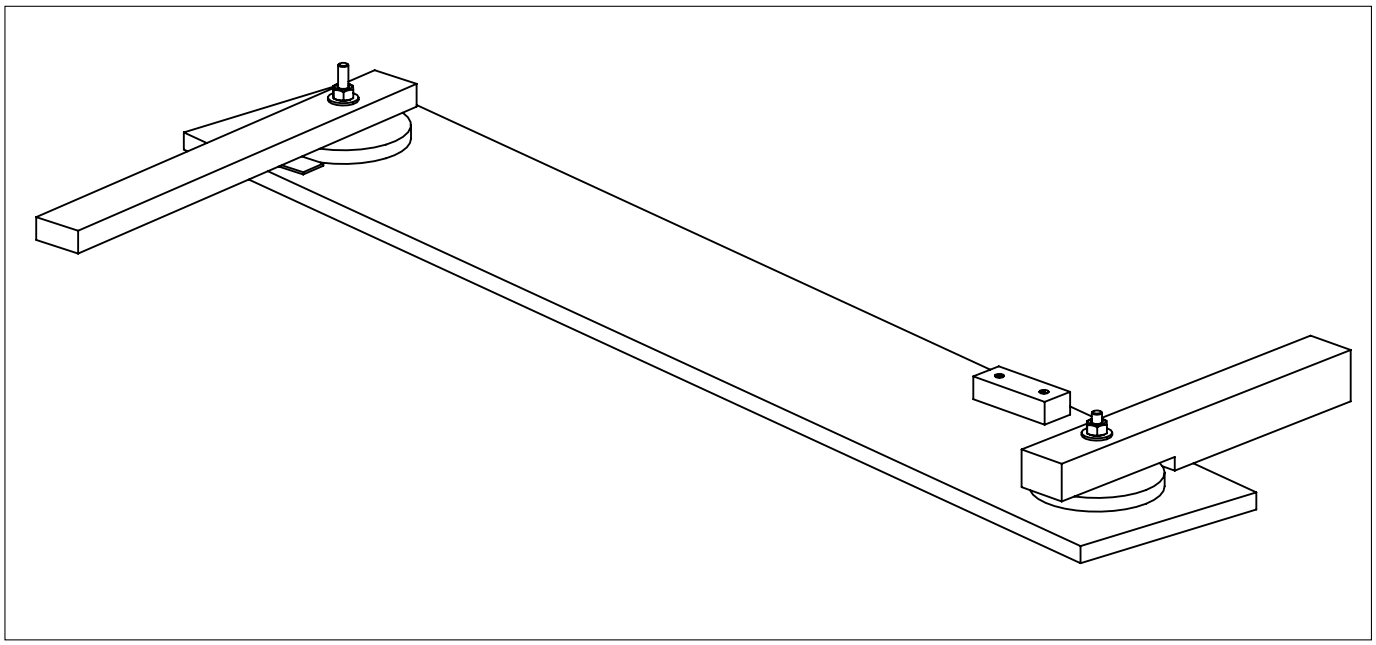


Now the metal sheet has its finished form. Repeat the process with all other metal sheets.

A.3 Building the Pipe-Bending Tool

These are the instructions on building the pipe-bending tool.

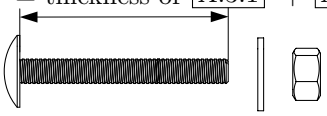
- If you do not have a tool for bending pipes, you can build one yourself. This tool is called pipe-bending tool. It can be used several times.
- It is important to precisely follow the given dimensions, otherwise the pipe will not fit. If no dimensions are given, they are not so important and you can make a rough estimate.
- Directions for use are given in chapter A.4 (Page 104).



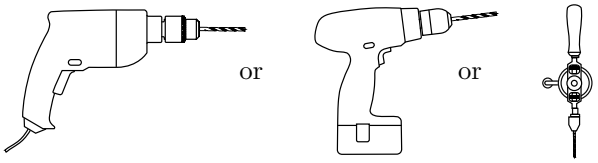
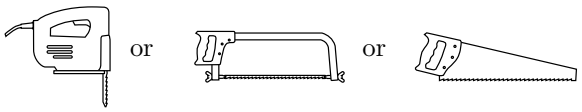
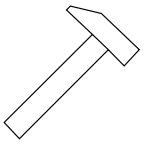
Materials needed:

Number	Figure	Title		Other
1 x	≥ 110 cm; ≥ 14.6 cm	Board	A.3.1	Material: Timber Thickness: at least 0.9 cm
2 x	11 cm	Disc	A.3.2	Material: Timber Thickness: 1.2 cm
1 x	≥ 33.4 cm; ≥ 4.5 cm	Square timber	A.3.3	Material: Timber Thickness: at least 3.2 cm
1 x	≥ 41 cm; ≥ 2 cm	Square timber	A.3.4	Material: Timber Thickness: at least 1.5 cm
1 x	≥ 0.9 cm; ≥ 0.9 cm	Sheet	A.3.5	Material: Timber / Metal Thickness: very thin (1 mm-2 mm)

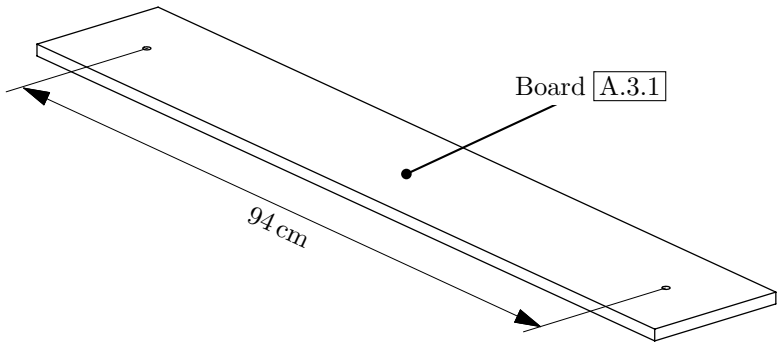
Materials needed (continued):

Number	Figure	Title	Other
2 x	= thickness of A.3.1 + A.3.3 + at least 0.9 cm 	Carriage bolt, washer, nut A.3.7	To screw together board A.3.1 and square timber A.3.3

Tools needed:

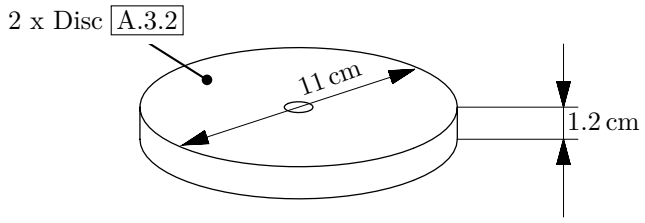
Number	Figure	Title	Other
1 x		Wood drill	Wood drill for pre-drilling the holes for the carriage bolt A.3.7
1 x		Wood saw	For step 4
1 x		Hammer	To drive in the carriage bolt A.3.7

1



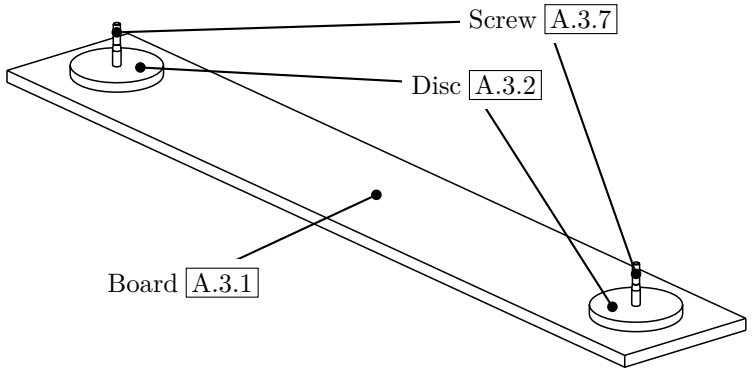
Drill holes for the screws that are 94 cm apart and 8 cm into the board A.3.1 .

2



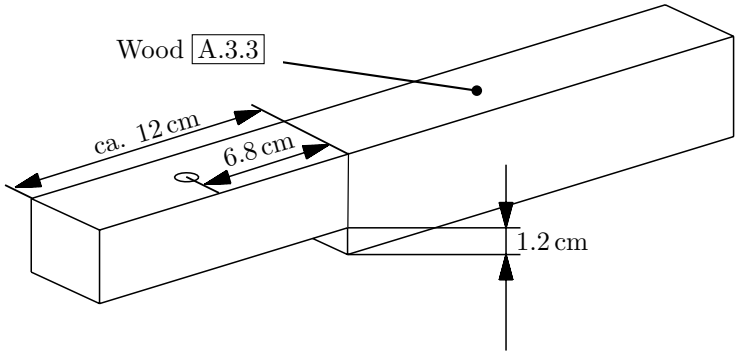
Drill a hole for the screws A.3.7 into the middle of the round discs A.3.2 . You need two of them.

3



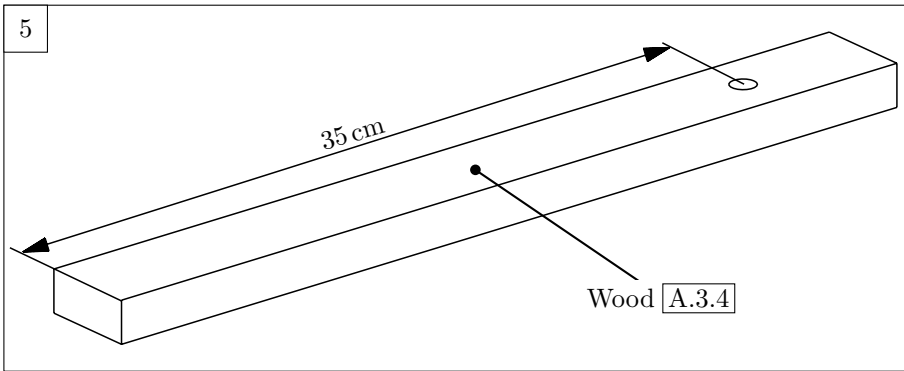
Stick the screws A.3.7 through the board A.3.1 from below. Hammer them into the board, until they do not stick out any more. Put the discs A.3.2 on top of the screws.

4

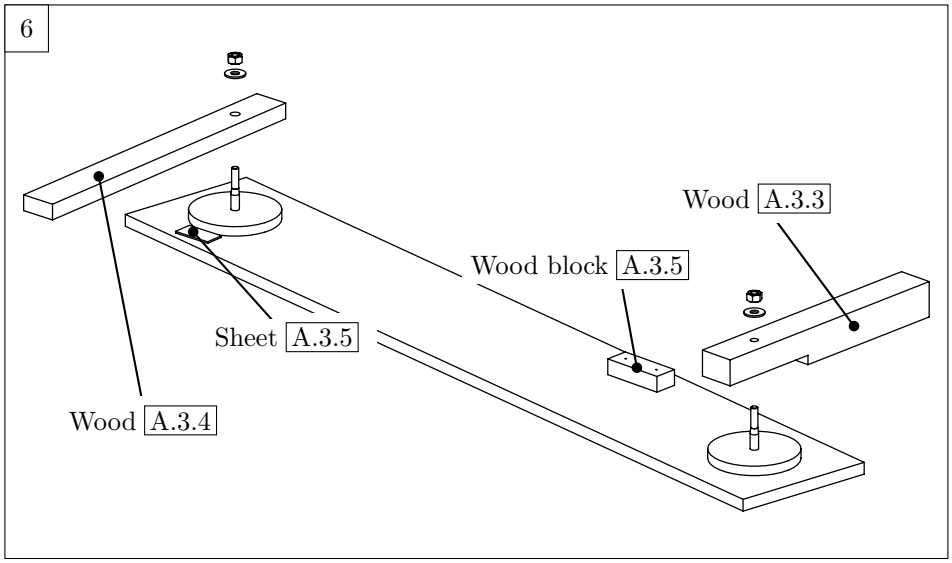


Make a cut-out into the wood A.3.3 , as shown in picture 4. Drill a hole into the wood for the screw. The distance between the middle of the drilling and the edge has to be exactly 6.8 cm.

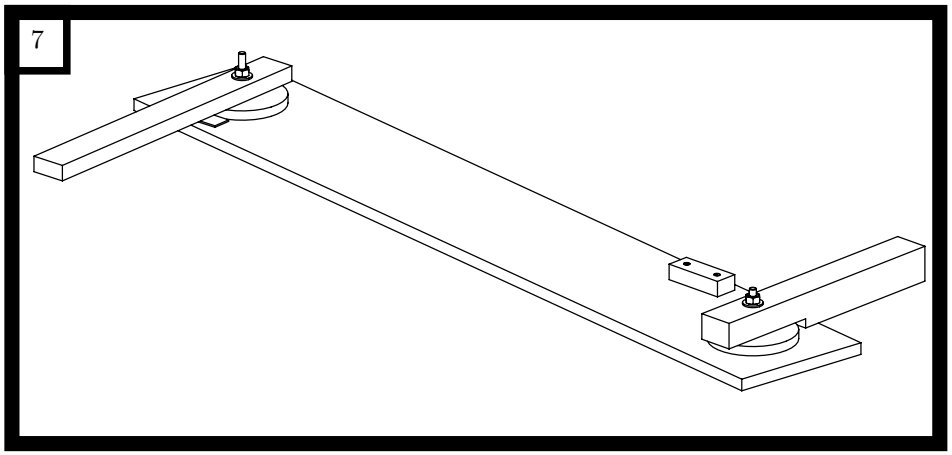
5



Drill a hole for the screw through the wood A.3.4 . The distance to one end has to be 35 cm.



Plug the two wooden parts A.3.3 and A.3.4 onto the screws as shown. Screw both of them with each a washer and a nut. The piece of sheet A.3.5 will be trapped between the wood A.3.4 and the pipe. The exact shape of the piece of sheet A.3.5 is not that important, but it should be ca. 1 mm-2 mm thick.

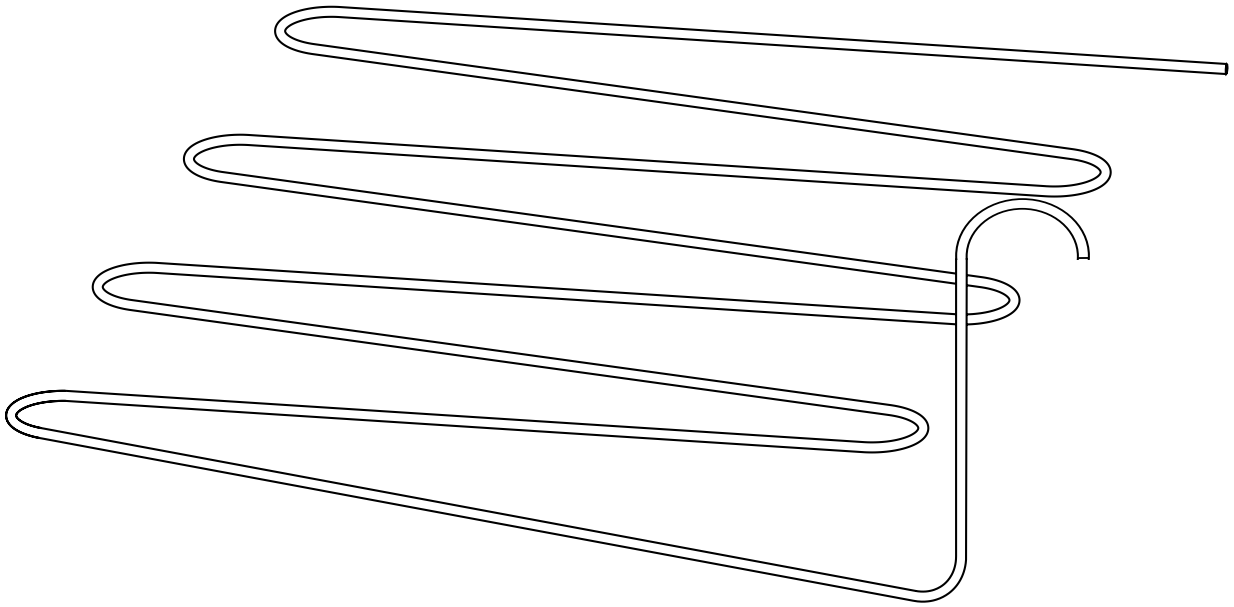


The pipe-bending tool is now finished.

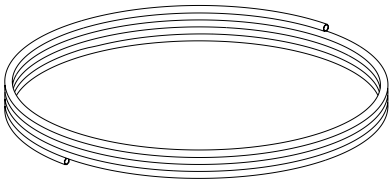
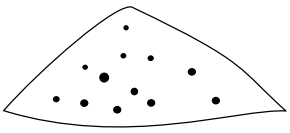
A.4 Bending the Pipe

These are the instructions for bending a pipe using the bending device A.3

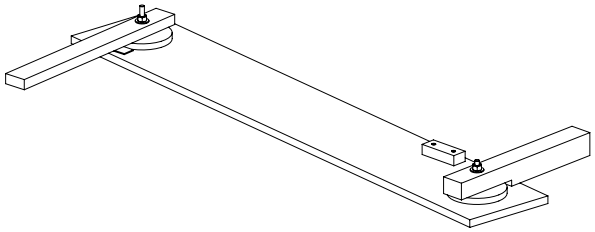
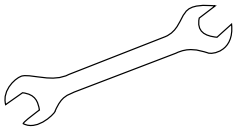
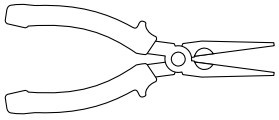
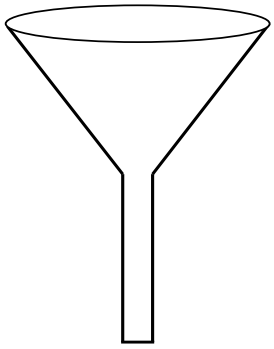
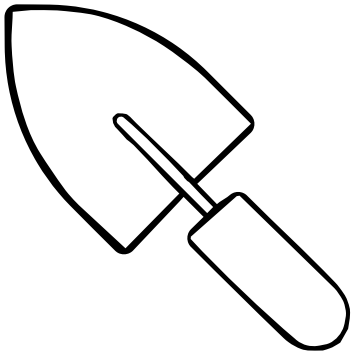
- You need a 10.5 m long pipe of easily bendable material with an outer diameter of 1/2" / 1.2 cm. The pipe has to be made out of soft copper as this makes it easy to bend. You can buy it in large coils. Hard copper pipes, which are sold as rods, are not suitable for bending.
- The pipe will always stay quite flexible. As long as it has roughly the right shape you can force it into the right positions after mounting it.
- You must not bend the pipe too often at the same position. This will make the copper hard and unsuitable for further bending.
- Look for a big, even, solid surface of about 4 x 4 m.



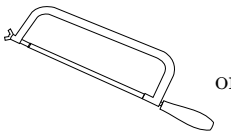
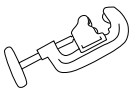
Required Material:

Number	Figure	Title		Other
1 x		Pipe	3	Length: at least 10.5 m Outer diameter: 1/2" / 1.2 cm Wall thickness: ca. 1 mm Material: soft copper
1 x		Sand		Material: Sand Quantity: 2 kg or 4.5 lbs

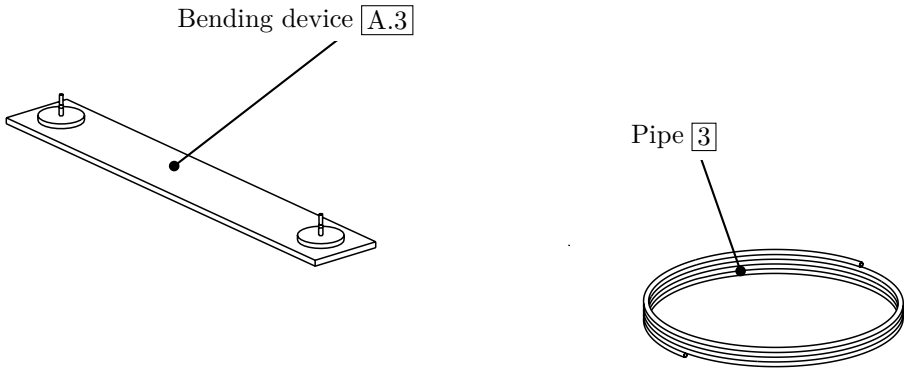
Required tools:

Number	Figure	Title	Other
1 x		Pipe-bending-tool A.3	Assembly: See chapter A.3 (Page 100)
1 x		Wrench	Suitable for screw A.3.7
1 x		Flat pliers	For folding over the pipe 3
1 x		Funnel	For filling the pipe 3 with sand
1 x		Shovel	For filling the pipe 3 with sand

Required tools (continued):

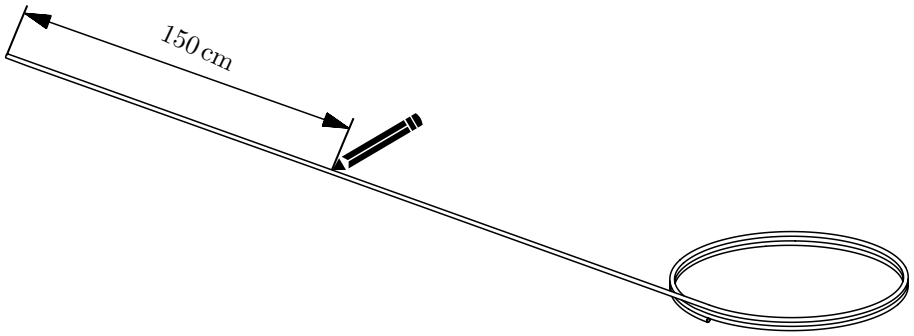
1 x	 or		Metal saw or pipe cutter	For cutting the copper pipe 3 .

1



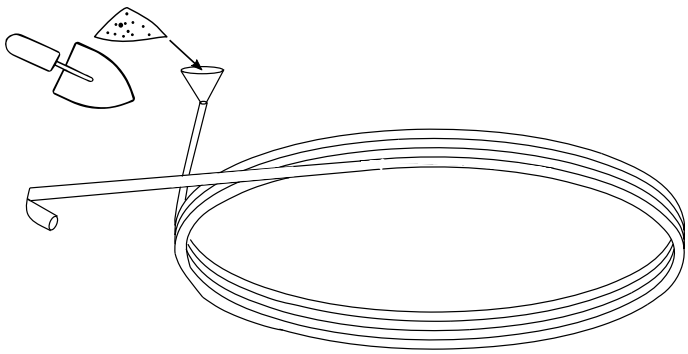
Look for a big, even, solid surface of about 4 m x 4 m. Keep the bending device A.3 and the pipe 3 ready. Take the timbers A.3.3 and A.3.4 off the bending device.

2



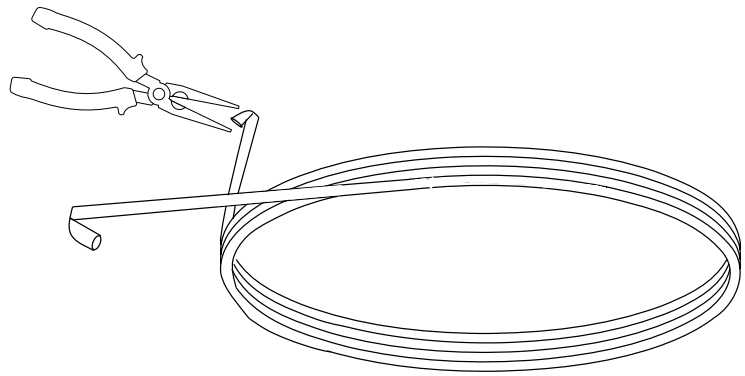
Roll out approx. 250 cm of the pipe and bend it straight. Mark the pipe at 150 cm.

3



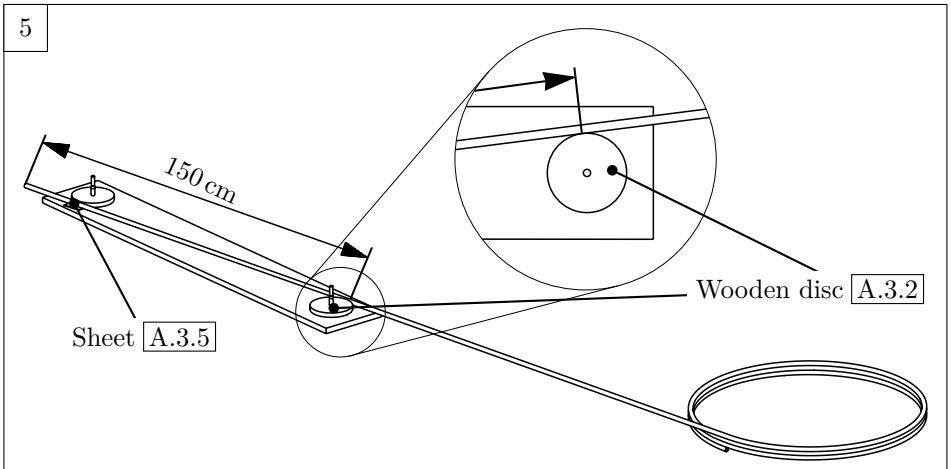
Fill the pipe with dry sand until it comes out of the other end. Ensure that the sand is really dry and contains no gravel! Both could plug the pipe irreparably! Then bend the end over to seal it. Proceed with filling in the sand until it is full. Hint: Pull the pipe apart like a coil spring and shake it during filling. It could be helpful for the filling person to stand on a ladder or wall.

4



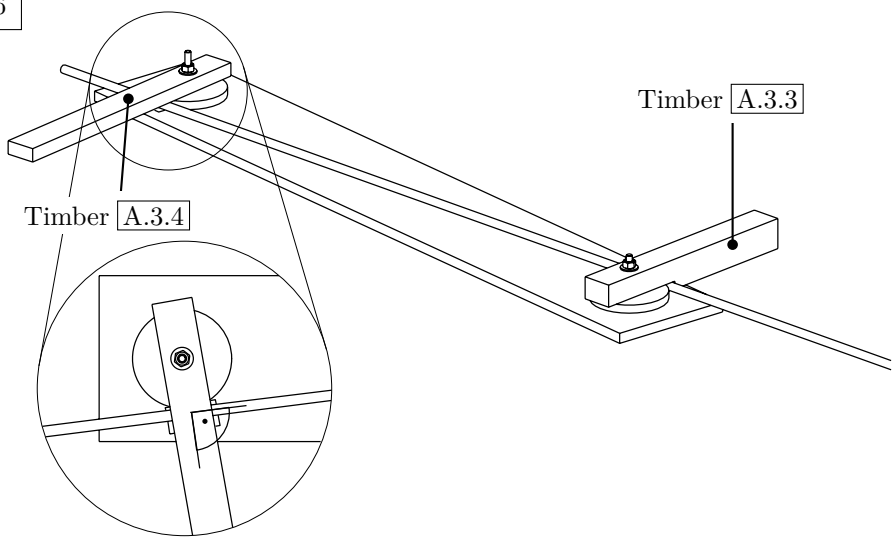
Close the second end with flat pliers.

5



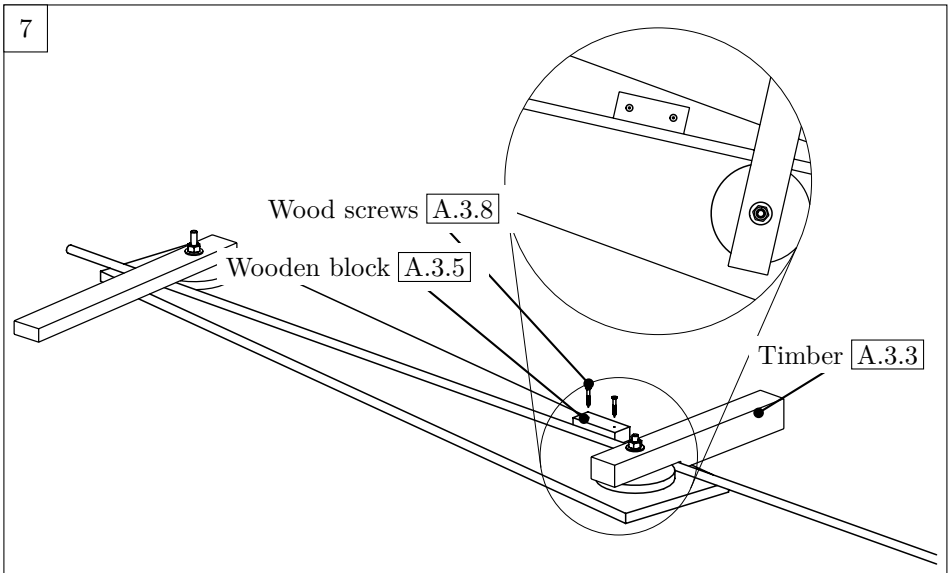
Now put the pipe diagonally into the bending tool as shown. The marking has to touch the wooden disc A.3.2 exactly. Then place the piece of sheet A.3.5 below the pipe at the other end of the pipe.

6



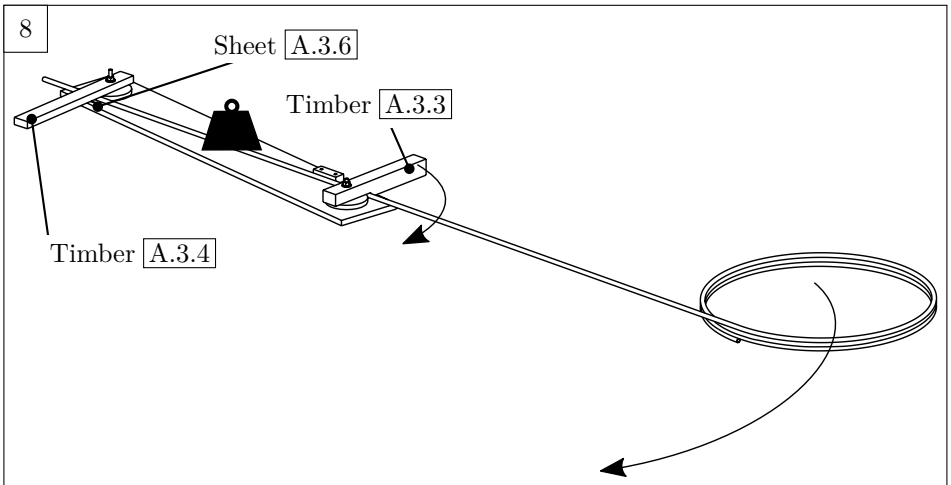
Screw on the timber A.3.4 very tightly. There must be a right angle between the pipe and the timber (see detailed picture). It is important that the piece of sheet A.3.6 lies underneath. That way, the pipe is fixed in the right position and cannot move any more. Make sure that the marking on the pipe is at the other wooden disc. Screw the timber A.3.3 a little bit tighter. You should still be able to move it slightly.

7



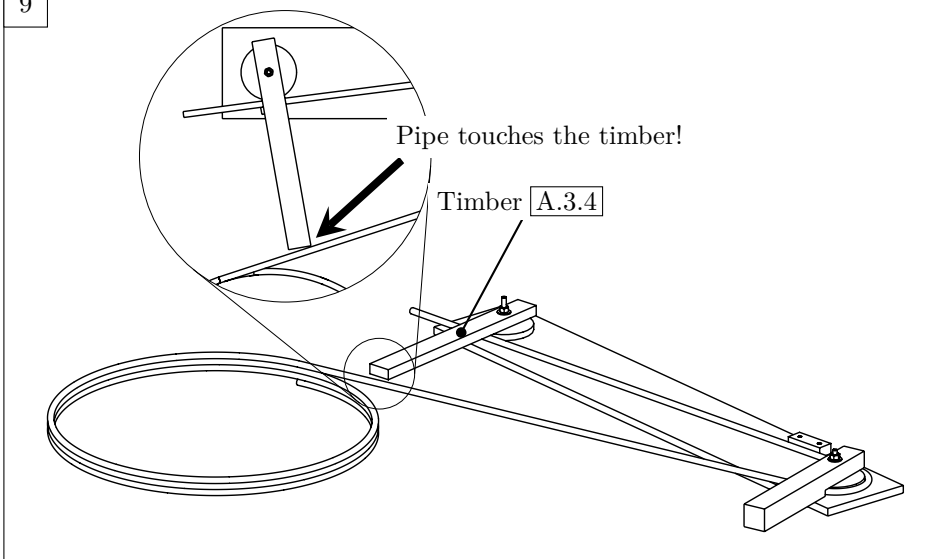
Put the wooden block A.3.5 close to the pipe, several centimeters in front of the timber A.3.3 . Screw the wooden block A.3.5 with the wood screws A.3.8 . That way, the pipe is fixed in its position during the bending process. Check again that the marking on the pipe is at the wooden disc and everything looks like in the picture.

8



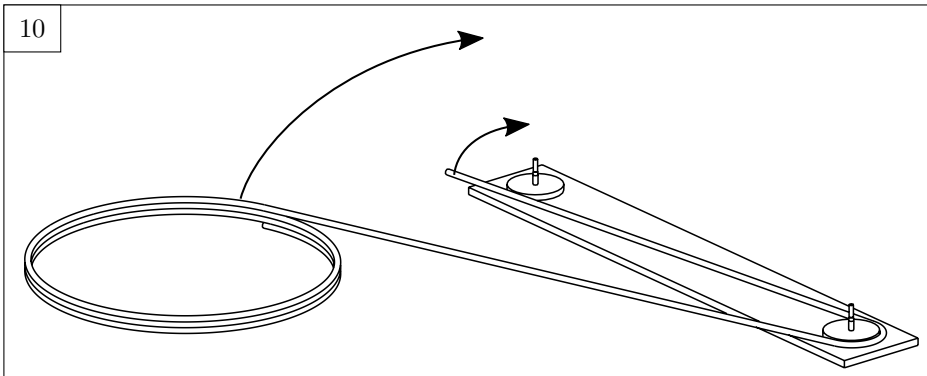
The pipe has to be held with the downforce of a foot so that it cannot slip or move. For bending grab the timber A.3.3 with one hand and the pipe with the other hand. Try to bend the pipe with both your right hand and timber A.3.3 . Someone else has to carry the remaining coil. Bend the pipe slightly further than the other lever (A.3.4), so it touches the lever after you let it go.

9



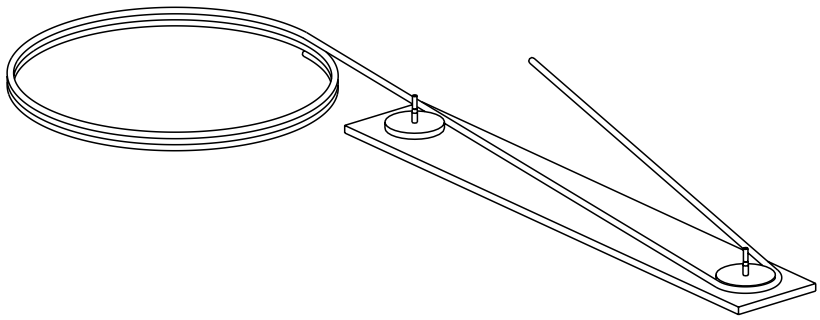
The pipe has to touch the timber A.3.4 as shown in the picture. If the pipe bounces a bit, bend it further.

10



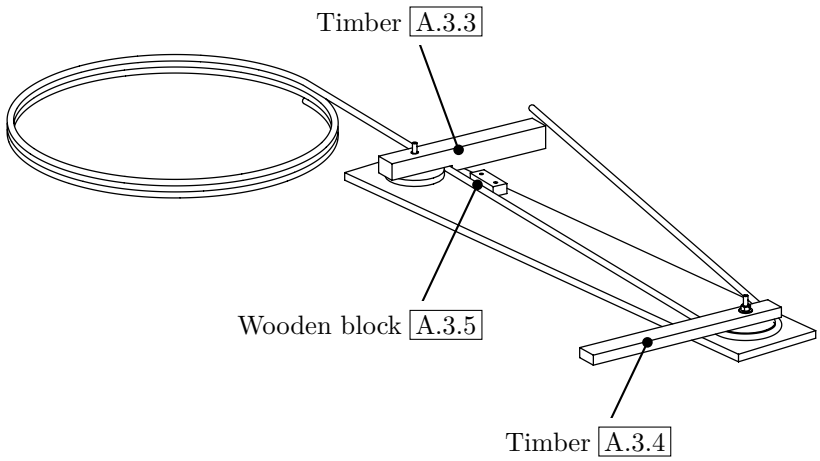
Screw off the timbers A.3.3 and A.3.4 and the wooden block A.3.5 . Turn the whole pipe around the bent spot and lift it above the wooden disc A.3.2 .

11



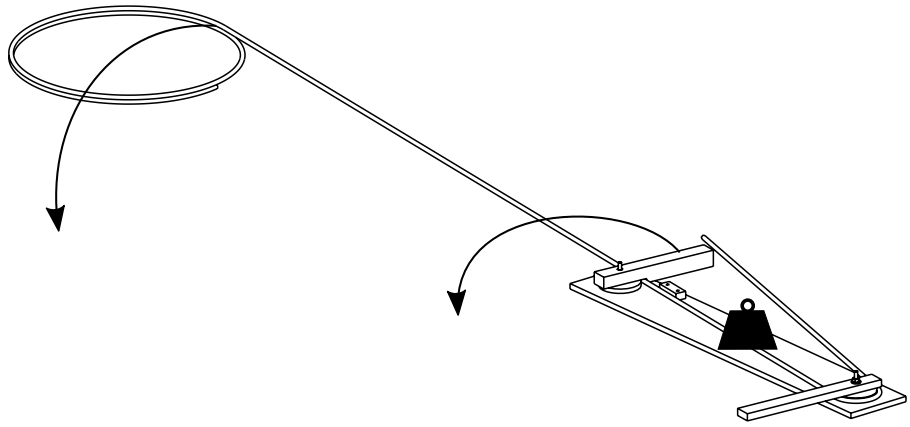
After the turning, the pipe has to look as shown in the picture.

12



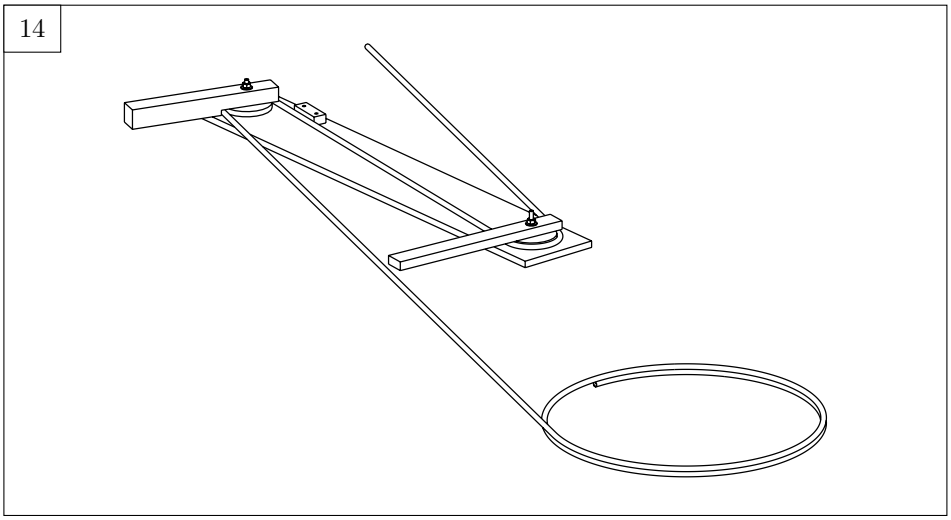
Screw on the timbers A.3.3 and A.3.4 like in step 6, but in a reversed position. Screw on the wooden block A.3.5 as shown in the picture. This time, you do not have to put the piece of sheet A.3.6 underneath. There has to be a right angle between timber A.3.4 and the pipe again.

13



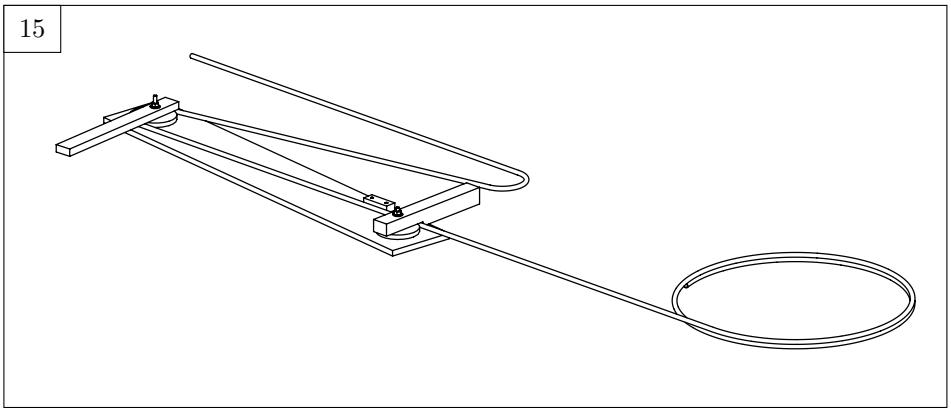
Roll out another segment of the pipe with a length of 1.5 m and bend it straight. Fix the bending tool again. Then grab the timber A.3.3 with one hand and the pipe with the other. Someone else has to take the rest of the pipe and guide it during the bending. Bend the pipe around the disc until it touches the timber A.3.4 . Make sure that the rest of the pipe remains straight.

14



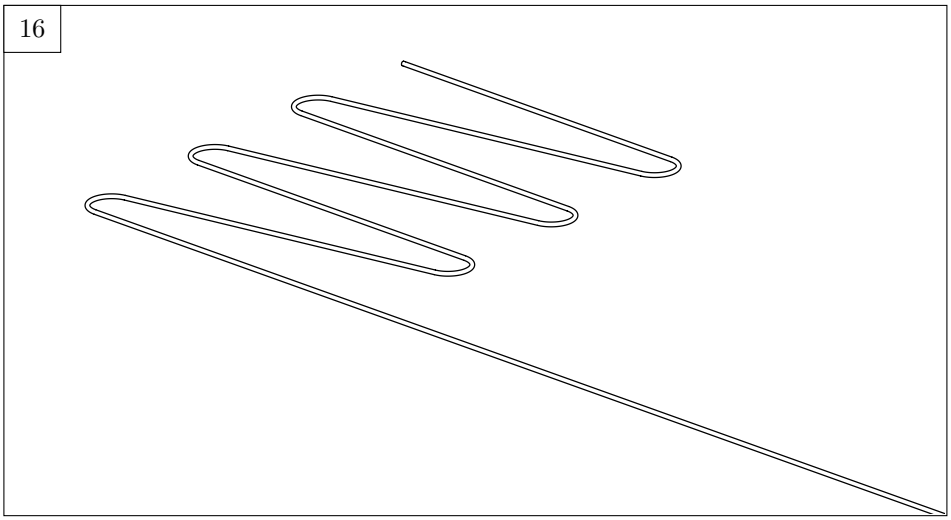
The pipe has to touch the timber A.3.4 as shown in the picture. If the pipe bounces a bit, bend it further.

15



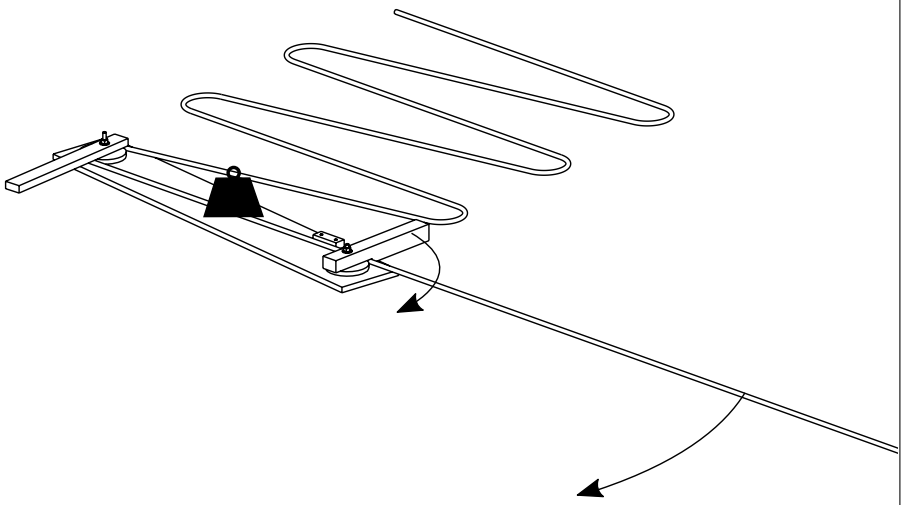
Screw off the timbers A.3.3 and A.3.4 . Turn the pipe around the most recently bent spot and lift it above the other disc. Now screw on the timbers A.3.3 and A.3.4 again in a reversed order as shown in the picture. Then bend the pipe the same way as you did before.

16



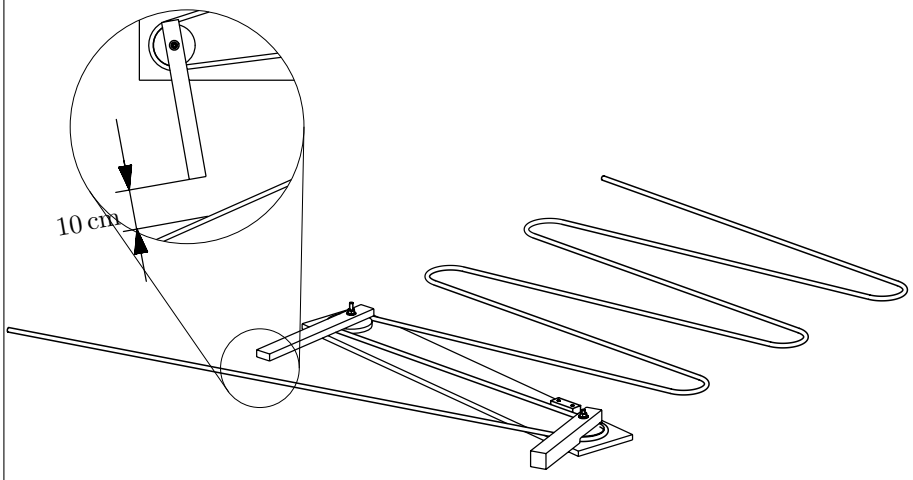
Repeat the bending procedure until you have a total of 6 bendings and the pipe looks like in the picture.

17



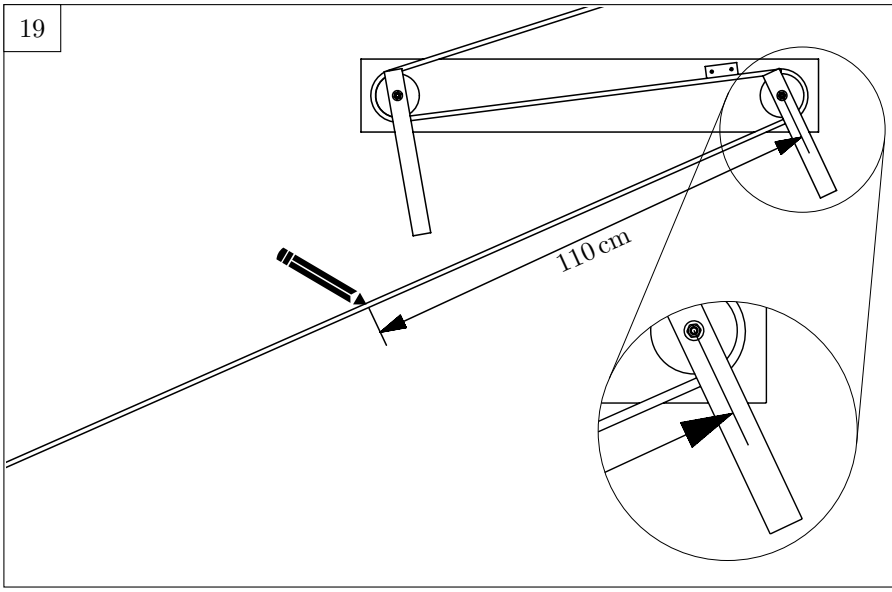
The last bending has to be a little bit larger. Fix the pipe in the bending tool again. Bend it again, but this time not quite until it touches the other timber.

18



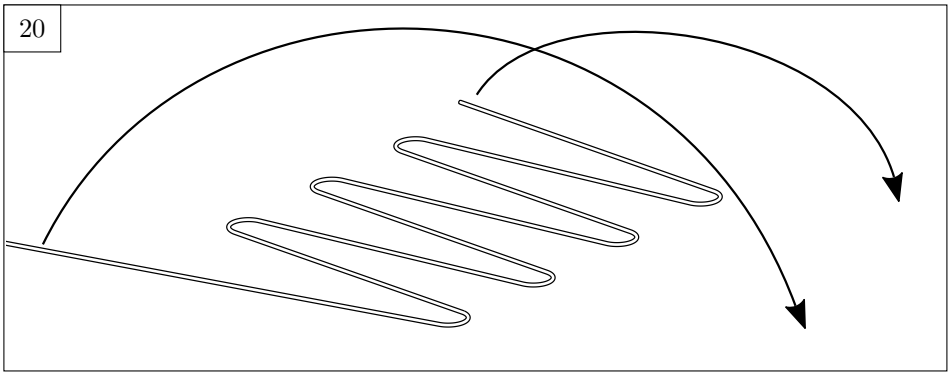
This time, bend the pipe only until it is approx. 10 cm away from the timber A.3.4 as you can see in the picture.

19



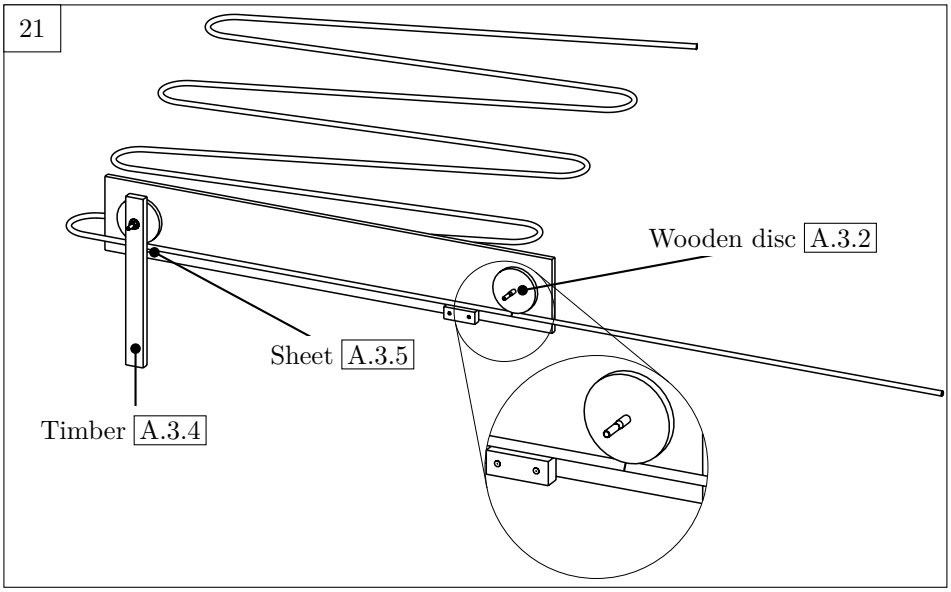
The next step is to bend the last part of the pipe upwards vertically. Bend the rest of the pipe straight and mark the pipe 110 cm behind the point, where the pipe is touching the disc.

20



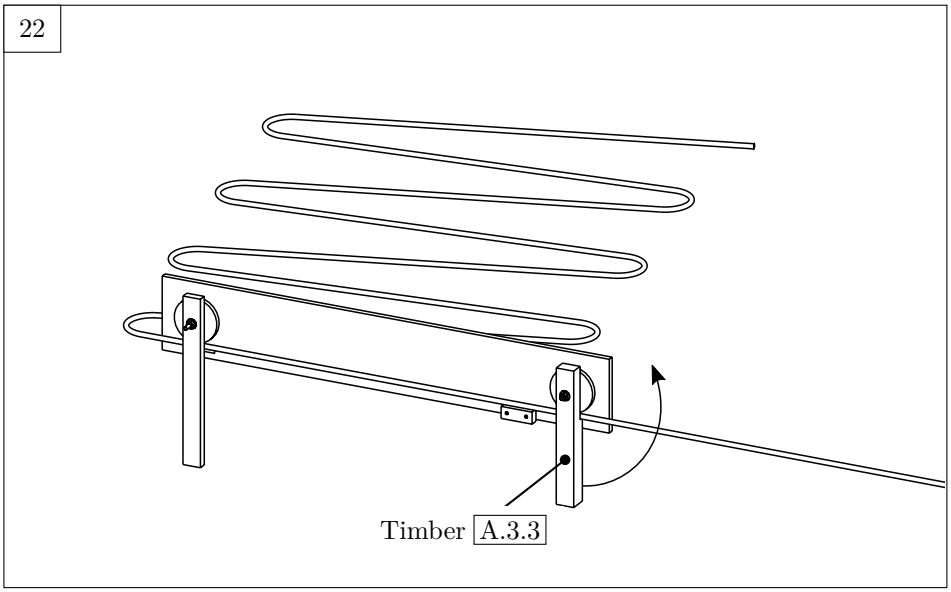
Take the pipe out of the bending tool and turn it around as shown in the picture.

21



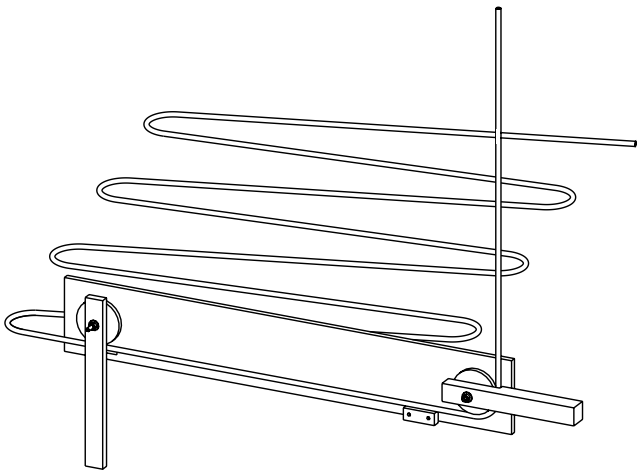
Install the turned bending tool at the pipe. The wooden disc A.3.2 has to touch the mark from step 19. You have to put the piece of sheet A.3.5 underneath like the first time you bent the pipe. Then the pipe should be fixed. The timber A.3.4 has to push down the pipe. For that reason, you should lay the pipe on an elevation.

22



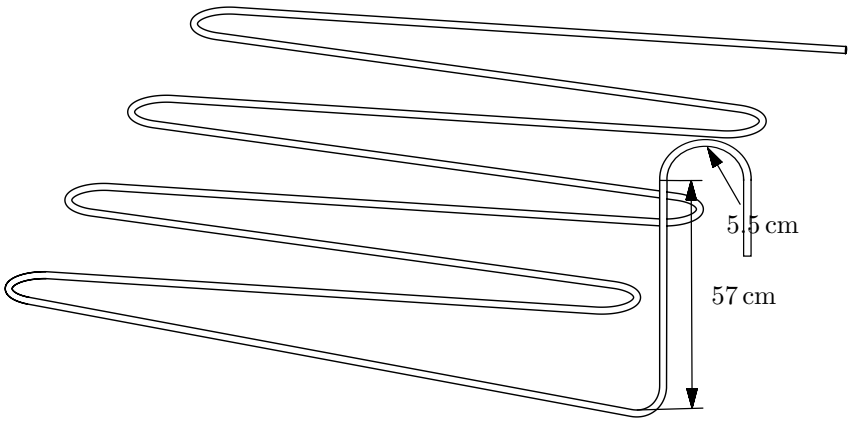
Now install the other timber A.3.3. Make sure that the mark of the pipe is at the bending disc. Someone else has to hold the bending tool. Grab the timber A.3.3 with one hand and the end of the pipe with the other and bend it upwards carefully.

23



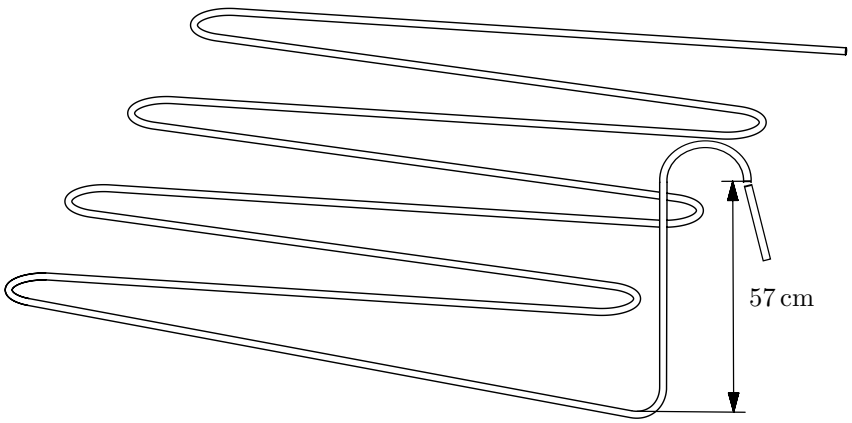
The pipe has to point upwards vertically. If that is the case, remove the bending tool.

24

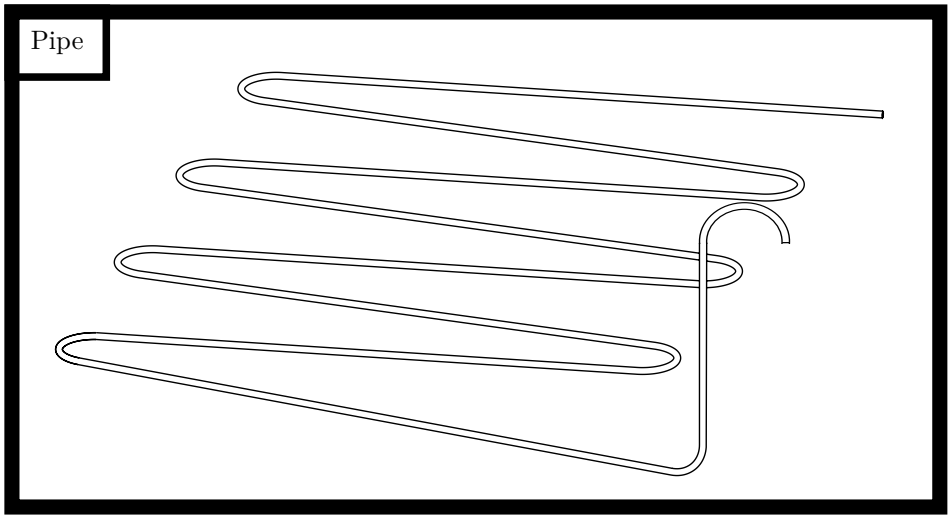


Bend the pipe as shown in the picture. The distance between the new bend an the straight pipe of before the last bend is 57 cm. The radius is 5.5 cm again. Make a bend of 180° this time.

25



At last cut the pipe at the end you just bent. The outlet must have a distance of 57 cm to the last bend.

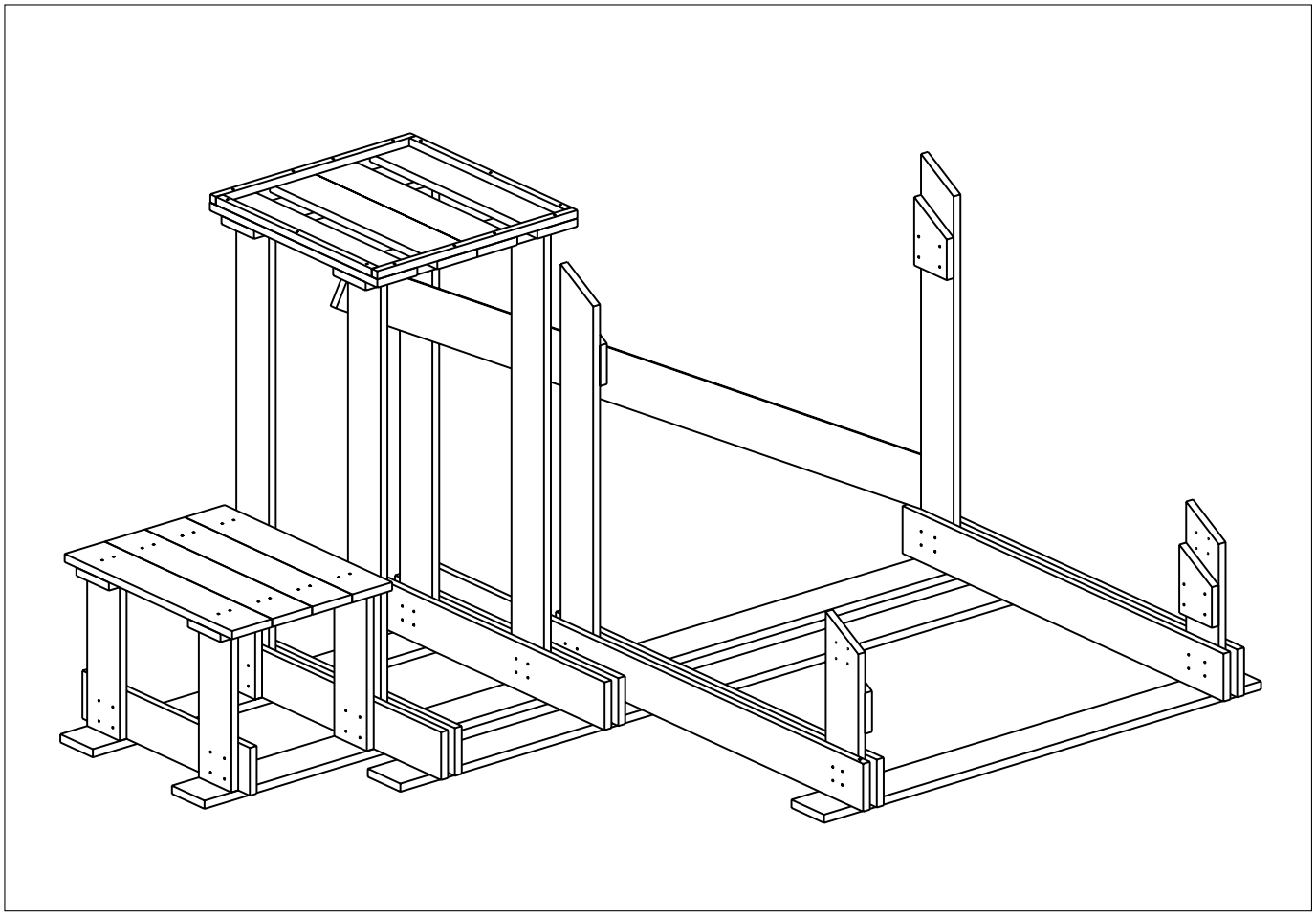


The pipe is finished.

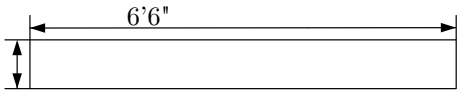
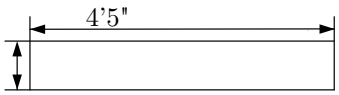
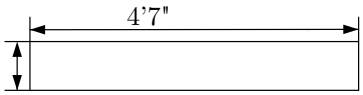
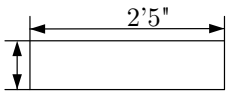
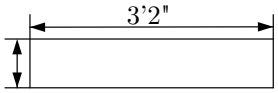
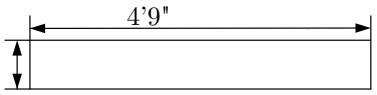
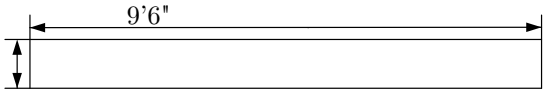
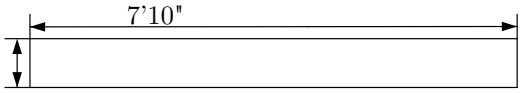
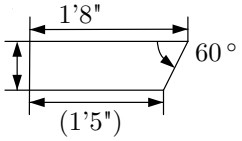
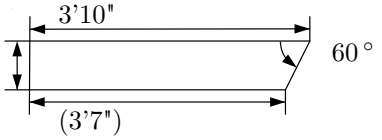
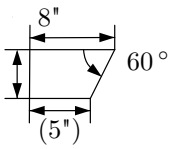
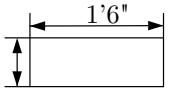
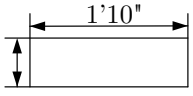
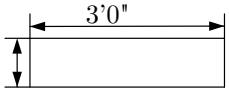
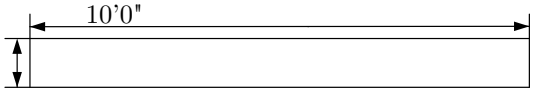
A.5 Building the Rack

This chapter is about building a rack for the whole system.
Some important points are:

- The rack has to hold the wooden box at an angle of 30 degrees to the ground.
- The correct height of the containers is also very important.
- You will need at least two people and an area of at least 53.82 ft^2.
- The rack has to stand on even ground. If you do not have even ground, use bricks or wood to level the rack.
- The rack is designed for two 60 liter containers with the dimensions 65 cm x 35 cm x 40 cm. If you use other containers, you might need to change the design.
- All boards and rails are made of wood. You do not have to smooth or sand it.
- After **every** step, check that the angles and distances of the boards have not changed.
- In this chapter, you will only need nails. Screws are not necessary. The nails have to be three times as long as the thickness of the material to be nailed down.



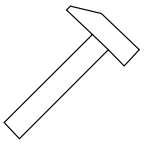
Required materials:

Number	Figure	Title		Other
1 x 6"		Board A1	A.5.2	Thickness: 1"
4 x 6"		Board A2	A.5.11	Thickness: 1"
3 x 6"		Board A3	A.5.1	Thickness: 1"
9 x 6"		Board A4	A.5.6	Thickness: 1"
4 x 6"		Board A5	A.5.5	Thickness: 1"
2 x 6"		Board B1	A.5.3	Thickness: 1"
1 x 6"		Board B2	A.5.4	Thickness: 1"
1 x 6"		Board B3	A.5.7	Thickness: 1"
2 x 6"		Board C1	A.5.9	Thickness: 1"
2 x 6"		Board C2	A.5.10	Thickness: 1"
4 x 6"		Board C3	A.5.8	Thickness: 1"
4 x 6"		Board D1	A.5.12	Thickness: 1"
2 x 6"		Board D2	A.5.13	Thickness: 1"
2 x 6"		Board D3	A.5.14	Thickness: 1"
1 x 6"		Board E	A.5.17	Thickness: 1"

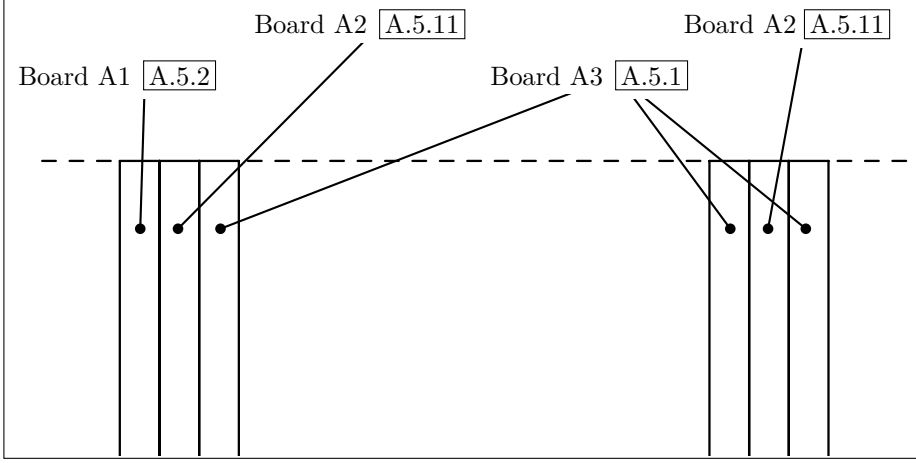
Required materials (continued):

Number	Figure	Title		Other
2 x	0.94" 3'0"	Rail F1	A.5.15	Thickness: 1"
2 x	0.94" 2'3"	Rail F2	A.5.16	Thickness: 1"
160 x	ca. 2"	Wood nail	A.5.19	Length: ca. 2"
52 x	ca. 3"	Wood nail long		Length: ca. 3"

Required tools:

Number	Figure	Title	Other
1 x		Hammer	For nailing the parts together

1

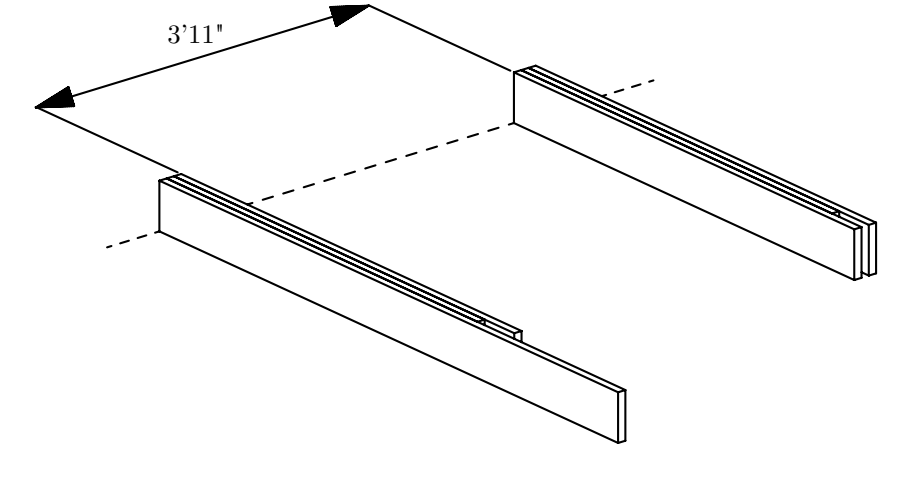


Form two piles of boards in the following order:

Left pile: A1 A.5.2 , A2 A.5.11 , A3 A.5.1

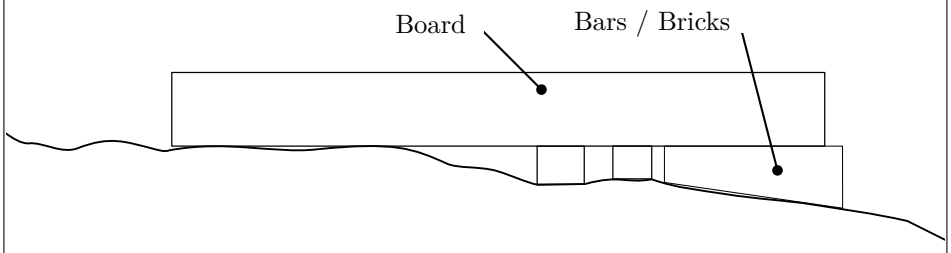
Right pile: A3 A.5.1 , A2 A.5.11 , A3 A.5.1

2



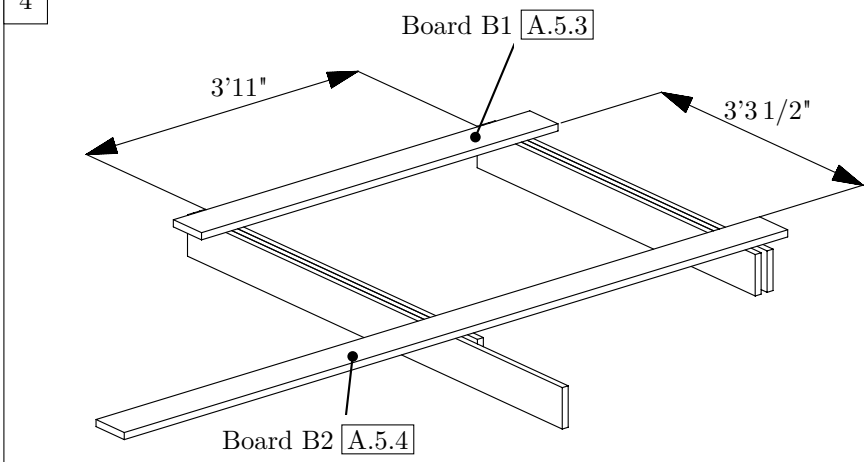
Set up these piles parallel with the inner boards facing each other. The boards should end evenly at one side (dashed line in the picture) and the distance between them has to be 3'11".

3



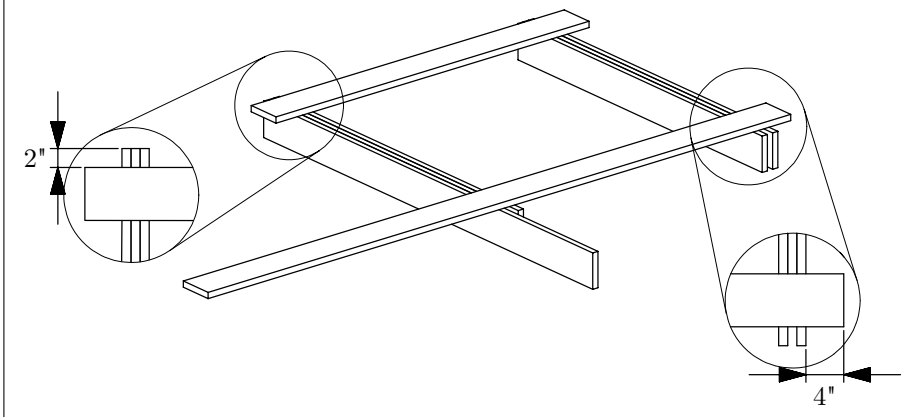
If your ground is not even you can use bars or bricks to put underneath.

4



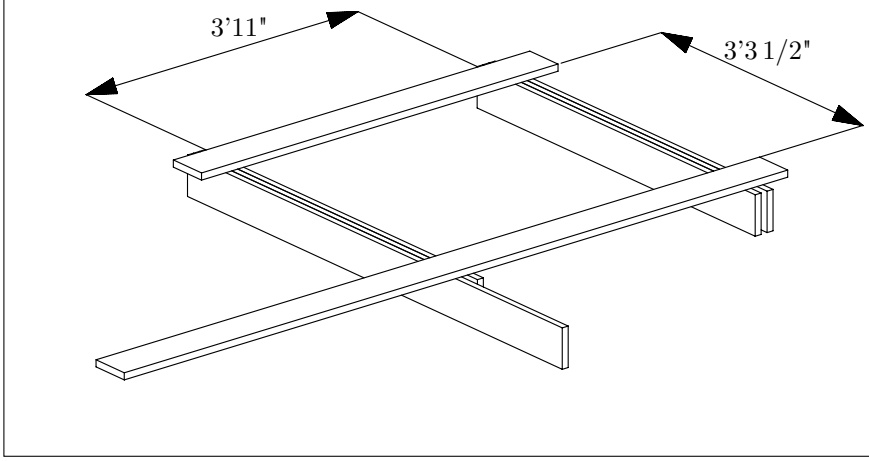
Lay the boards B1 A.5.3 and B2 A.5.4 above the piles forming a right angle. They should have a distance of 3'3 1/2" to each other.

5



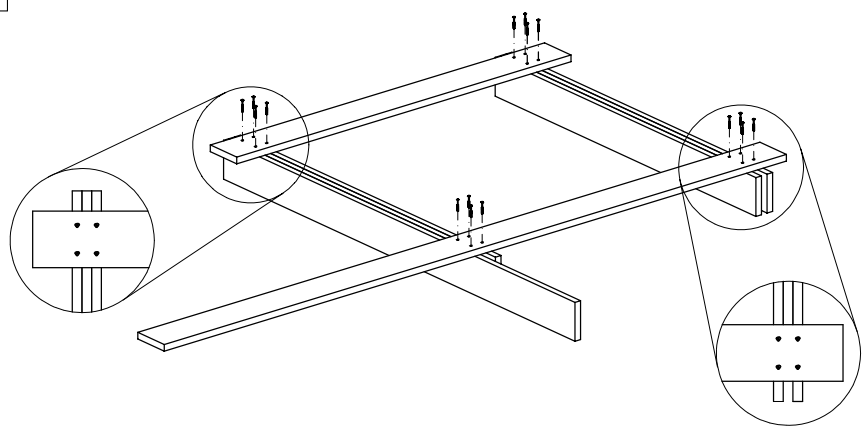
As shown in the picture, the boards on top should stick out on the right side by ca. 4". Board B2 A.5.4 should be placed 2" from the common end of the piles.

6



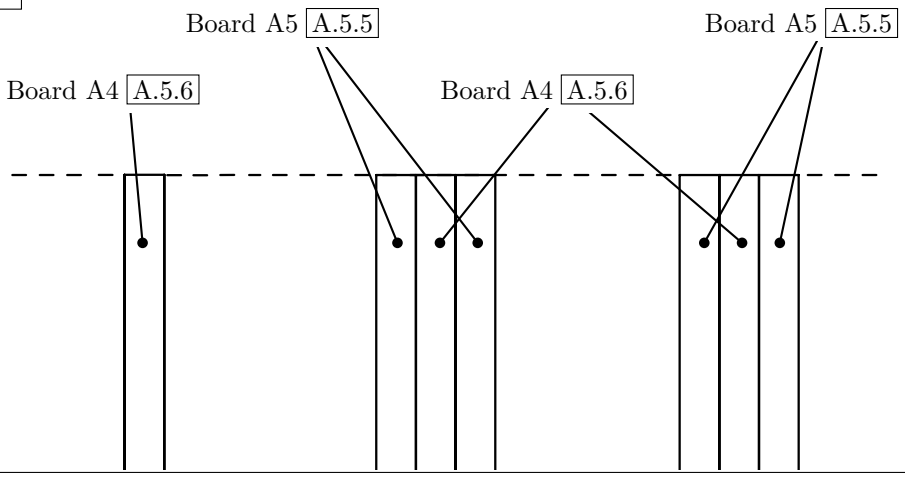
Make sure that the piles still have a distance of 3'11" on both sides and that the boards B1 and B2 still have a distance of 3'3 1/2" to each other.

7



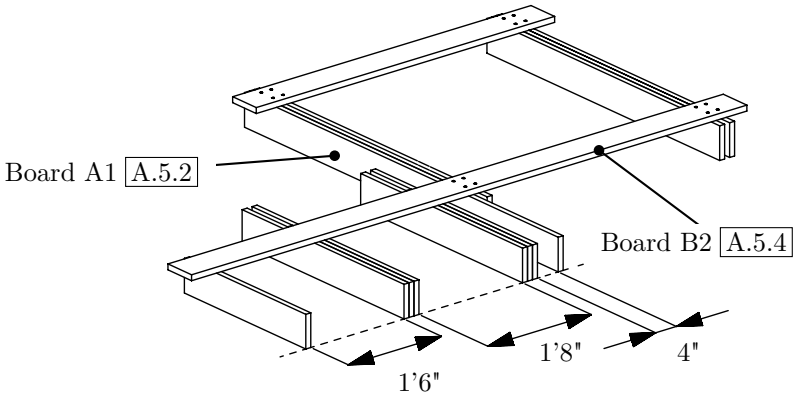
Nail the boards lying on top to the two outer boards of the piles. **Do not nail the boards in the middle!**

8



Form three piles of boards in the following order:
Left pile: Only A4 A.5.6
Middle pile: A5 A.5.5 , A4 A.5.6 , A5 A.5.5
Right pile: A5 A.5.5 , A4 A.5.6 , A5 A.5.5

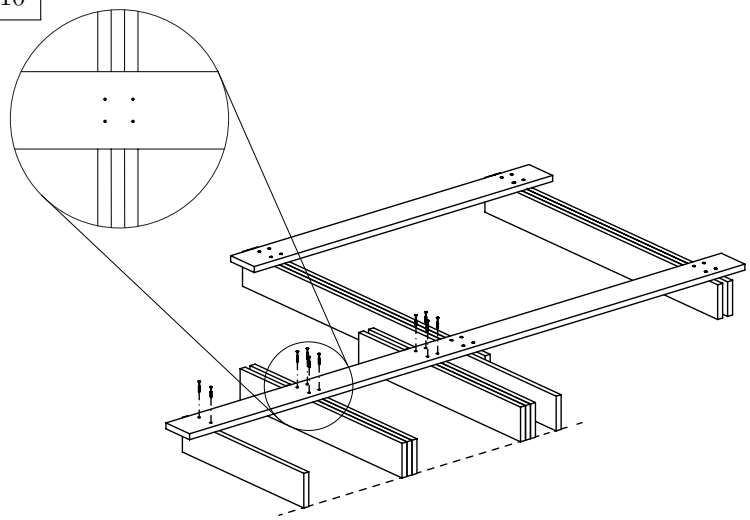
9



Set up the new piles parallel to the other piles underneath the longer board B2 A.5.4 with the inner boards facing each other. They should all end evenly with Board A1 A.5.2 (dashed line in the picture).
The distances should be:

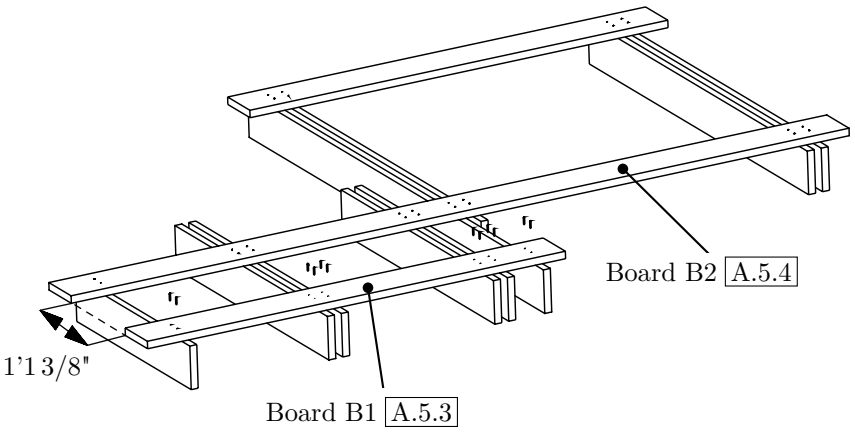
- Right pile to A1: 4"
- Middle to right pile: 1'8"
- Left to middle pile: 1'6"

10



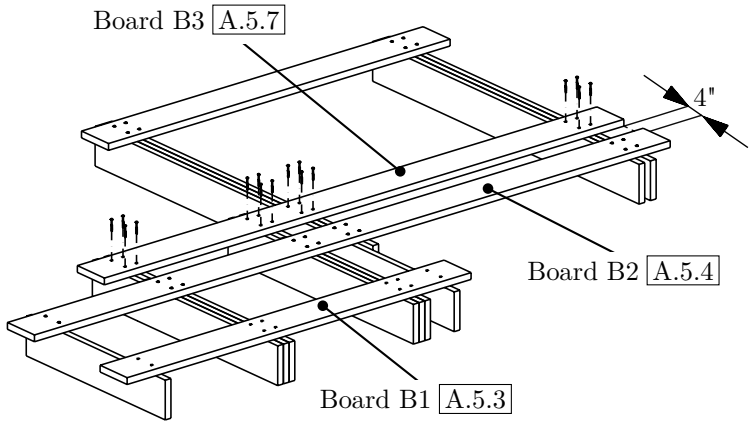
Nail the board B2 A.5.4 to the outer boards of the piles. **Do not nail the boards in the middle!** It is very important to check the right angles.

11



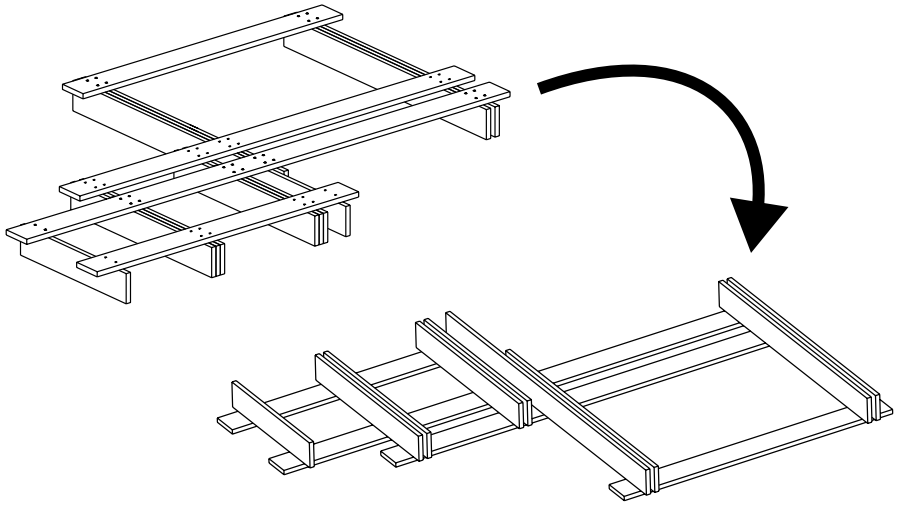
Lay the board B1 A.5.3 parallel to the board B2 A.5.4 with a distance of 1'1 3/8" to it. Nail together the intersection points of B3 A.5.3 and the outer boards of the piles with 2 nails per board (as shown in the picture).
Do not nail the boards in the middle!

12



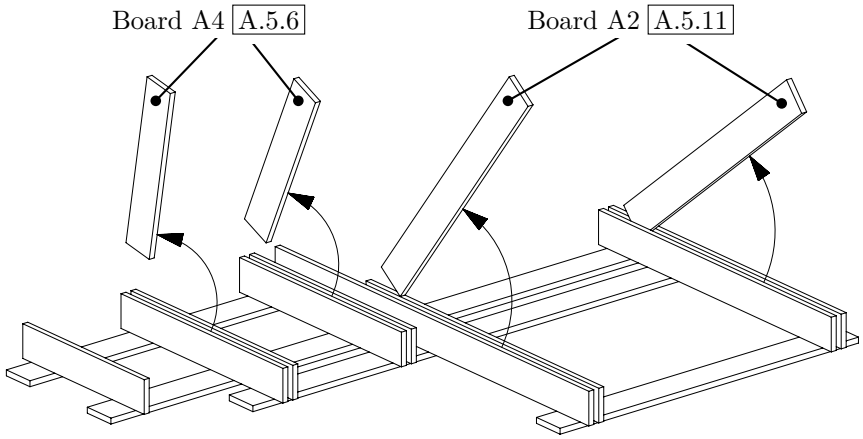
On the other side of the board B2 A.5.4 , set up the board B3 A.5.7 in parallel with a distance 4" to it. Nail together the intersection points of B3 A.5.7 and the outer boards of the piles with 2 nails per board (as shown on the picture). **Do not nail the boards in the middle!**

13



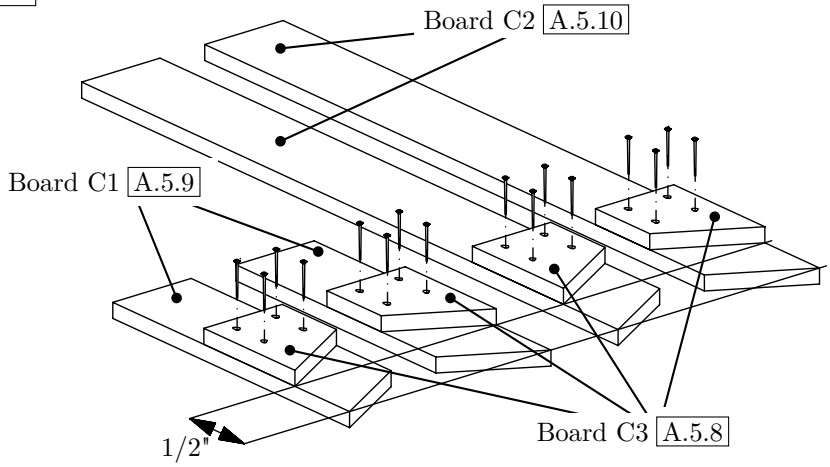
Lay down the whole wooden equipment upside down.

14



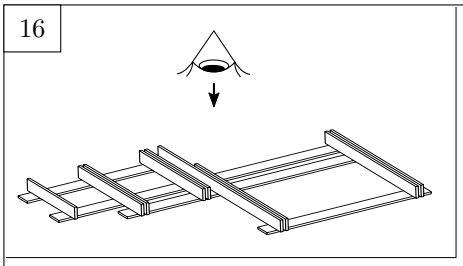
Remove the four middle boards A4 A.5.6 and A2 A.5.11 .

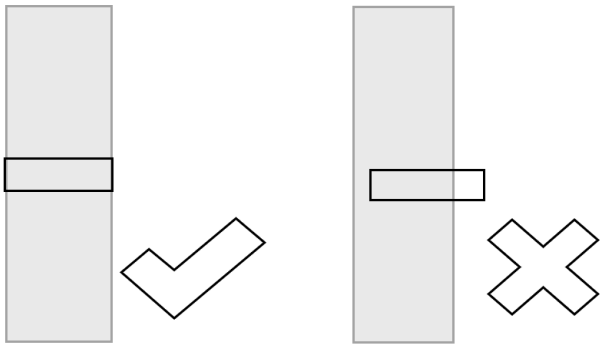
15



Nail one of the small boards C3 A.5.8 to each of the boards C1 A.5.9 and C2 A.5.10 , so that the diagonal ends point in the same direction and the peaks should have a distance of 1/2".

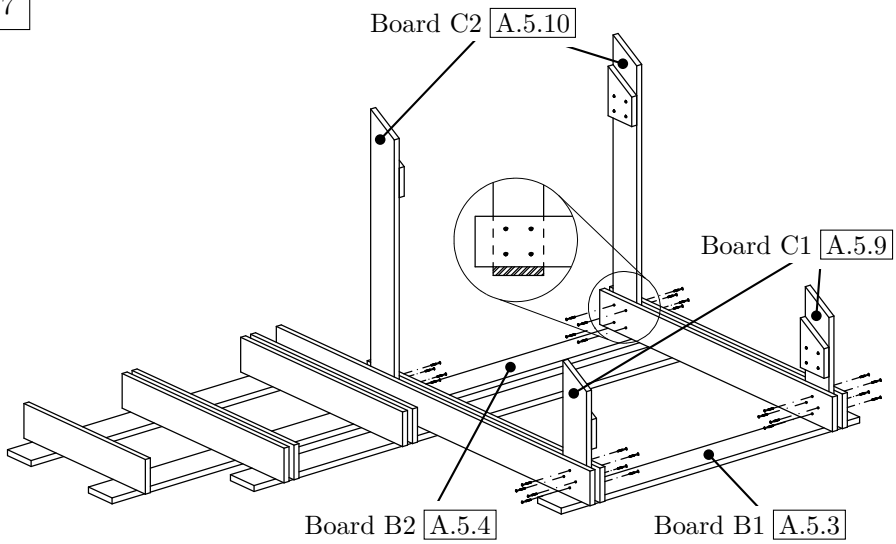
16





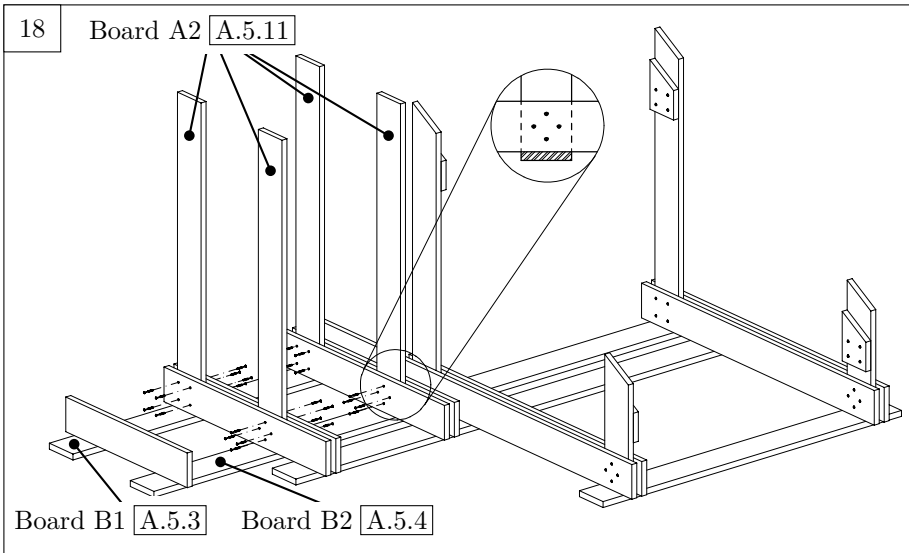
In the following steps make sure that the upright boards are standing entirely on the boards on the ground.

17



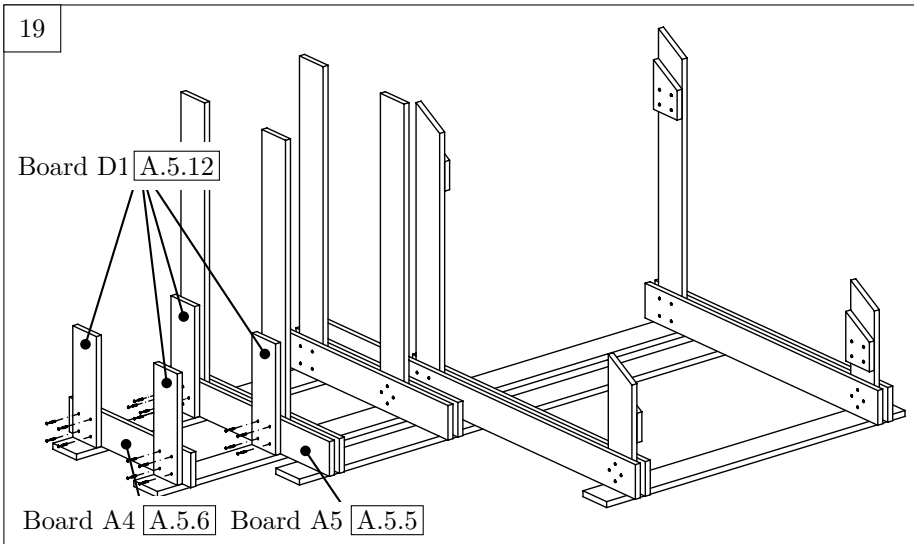
Stick the boards C1 A.5.9 and C2 A.5.10 into the gaps of the longer piles as shown in the picture, so that the attached small boards are facing each other. Make sure that the boards are located directly above the boards on the ground B1 A.5.3 and B2 A.5.4 . Then nail the boards C1 A.5.9 and C2 A.5.10 into the gaps from both sides using the long nails.

18



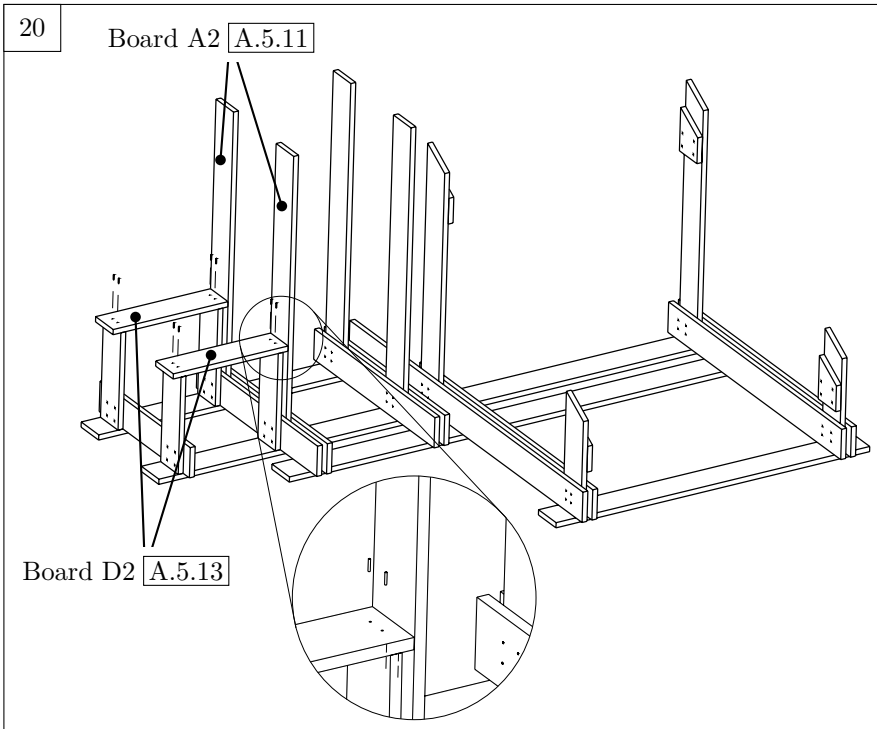
Stick the boards A2 A.5.11 into the gaps of the two shorter piles as shown in the picture. Make sure that they are positioned directly above the boards B1 A.5.3 and B2 A.5.4 . Then nail them into the gaps from both sides using the long nails.

19



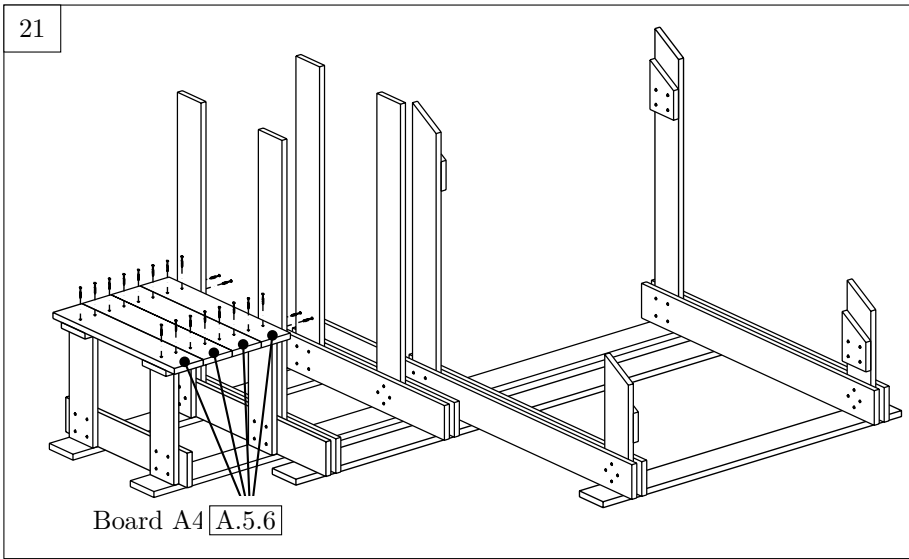
For building the step, place the four boards D1 A.5.12 next to the boards A5 A.5.5 and A4 A.5.6 from the outside. They should be located above the boards on the ground. Nail them on from both sides.

20



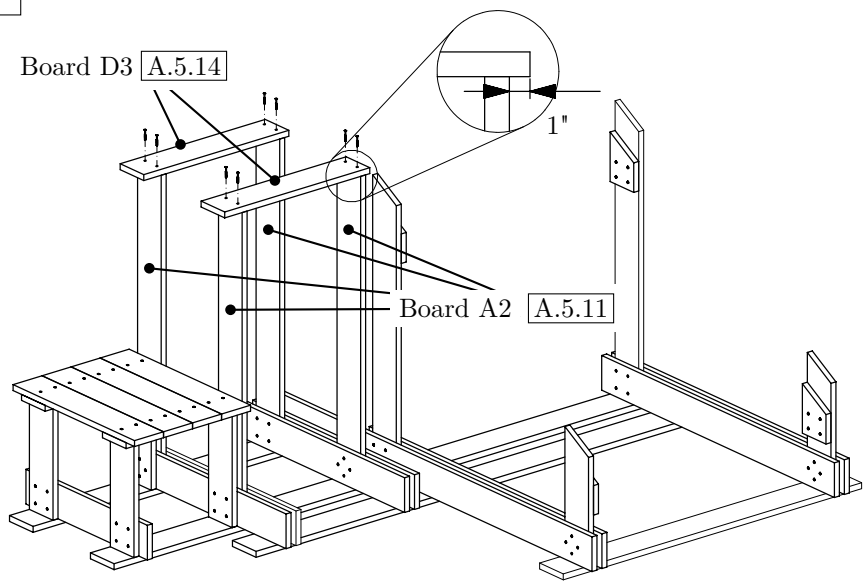
Put the boards D2 A.5.13 on the ends of the boards D1 A.5.12 , so that they touch the boards A2 A.5.11 . Nail the boards together.

21



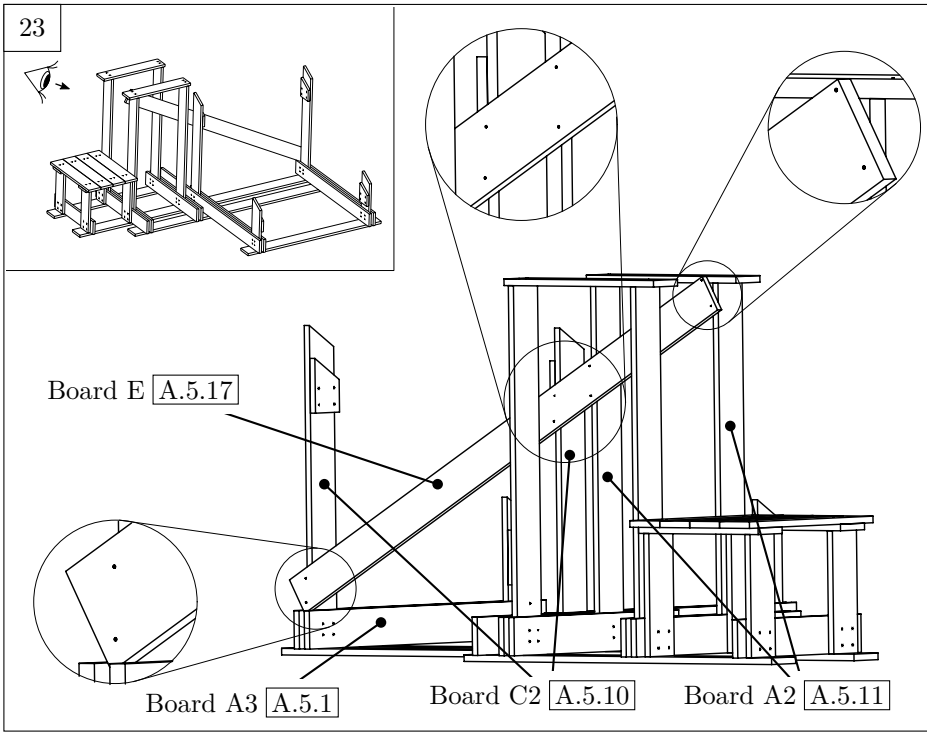
Now cover the step with the boards A4 A.5.6 and nail them on. The step is now finished.

22



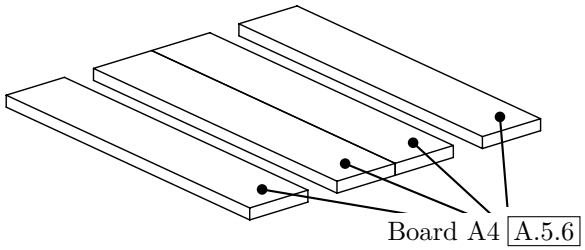
For building the container storage, place the boards D3 A.5.14 on top of the ends of the boards A2 A.5.11 . They should stick out in the direction of the diagonally sawed boards by ca. 1". Nail on the two boards.

23



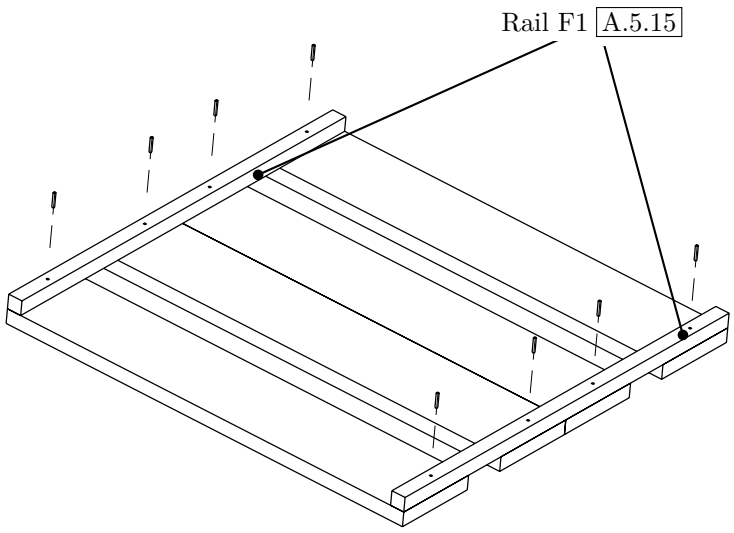
Put the board E A.5.17 diagonally across the boards C2 A.5.10 and A2 A.5.11 . On one side, the corner should lie in the gap between the boards A3 A.5.1 (left detailed picture). On the other side, the board must not stick out over the device (right detailed picture). Make sure that everything is straight and nail the board E A.5.17 to all the crossing boards.

24



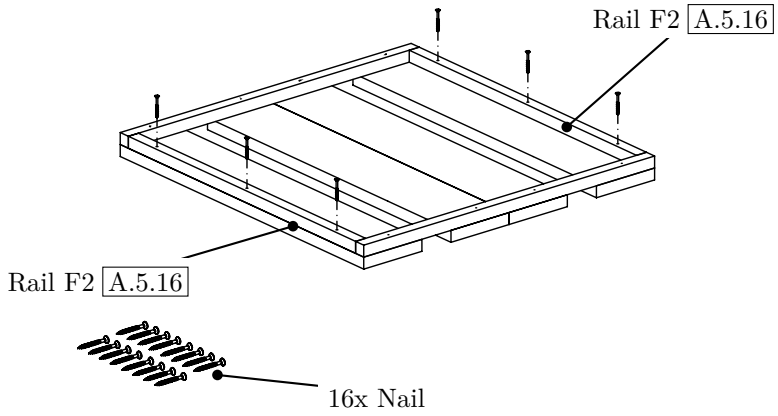
Now build the storage surface for the containers. Lay the boards A4 A.5.6 next to each other. Only the boards in the middle should touch.

25



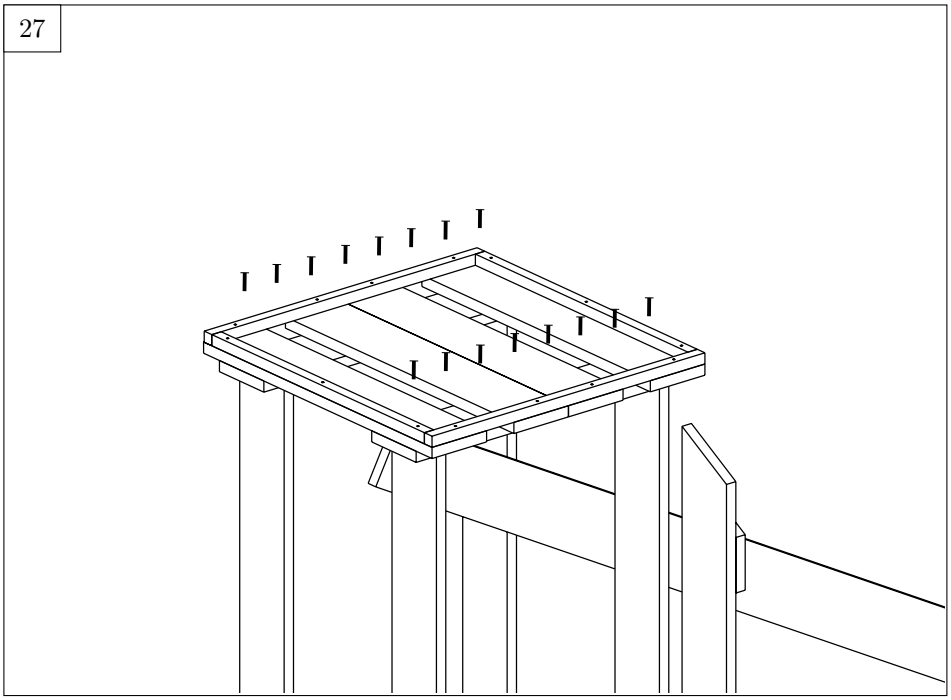
Place the two longer rails F1 A.5.15 on the shorter ends of the four boards A4 A.5.6 . Nail everything together. Make sure that the boards in the middle touch each other and that the sides are even.

26



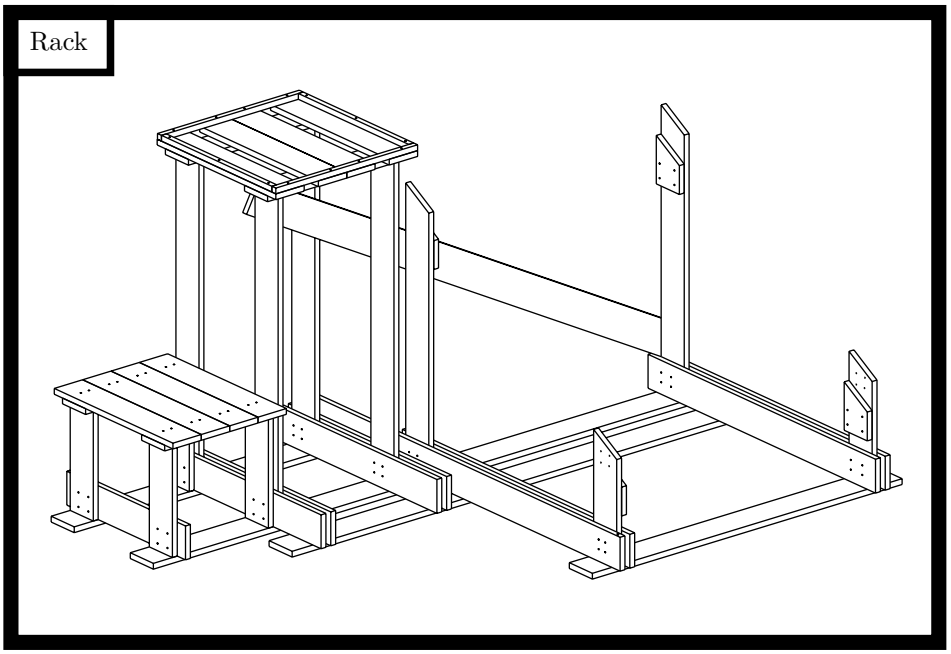
Now put the rails F2 A.5.16 on the two free edges of the boards A4 A.5.6 and nail them on.

27



Nail the storage surface to the underlying boards D3 A.5.14 with 16 wood nails.

Rack



The rack is now finished.

Contact

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Any questions, feedback or suggestions? Contact us!