Construction Manual

2.7m² Scheffler Reflector Solar Cooker

Written by:
Manu Gomez
Maren Kern

Practical help of:
Andreas Egli

Technical support by:
Adrian Konrad
Wolfgang Scheffler
Heike Hoedt

revised in July 2010 by Heike Hoedt

1 Table of contents

2 Introduction

You are about to build a Scheffler Solar Cooker. First you have to consider, that there are two different models as shown below:

Fig. 1: Standing Reflector

Fig. 2: Lying Reflector

The advantages and disadvantages of each model depend on the latitude of your place:

	Lying Reflector:	**Standing Reflector:**
Advantages:	generally easier to construct	cooking area is at a comfortable height when standing freely
	more power in summer than winter (bigger aperture)	more power in winter than in summer
	cooking area can be integrated into a house or balcony	
Disadvantages:	cooking area is, depending on latitude, very high above ground (about 2.5 m in Zürich 47.5°N)	construction of cooking area and stand is tricky. Cooking area needs a bigger secondary reflector → less efficient.

The orientation of the cooker depends on the model and whether you are on the Northern or Southern Hemisphere.

Cooking area positioned in the North: **Lying Model in the Northern Hemisphere and Standing Model in the Southern Hemisphere**

Cooking area positioned in the South : **Standing Model in the Northern Hemisphere and Lying Model in the Southern Hemisphere.**

This has consequences for the construction. The positions of some pieces differ.

In this manual we're usually referring to a Lying Reflector built for the Northern Hemisphere (Cooking area in the North) at 47.5° latitude.

We tried to make notes if the standing model (or the use for the Southern Hemisphere) requires changes or additional pieces. At the end of chapter "6. Stand" you can find a picture of the construction for the Standing Reflector. A separate manual for the cooking area for the Standing Reflector will be soon available at www.solare-bruecke.org.

The lengths of some pieces depend on latitude of your place.

For comfortable cooking you'll need a tracking system that guarantees that the focus is always stable at one point during the day.

There are two tracking systems for either model in use:

Mechanical tracking system:	**Photovoltaic tracking system with 4 solar cells:**
Option 1: The clock is built from bicycle pieces; see "Mechanical tracking system for 8m² or 10m² Scheffler Reflector" on www.solare-bruecke.org	See "2m² Scheffler Reflector from Aluminium" on www.solare-bruecke.org pp.44 You don't need to follow chapter 6.4 of this manual
Option 2: The clock is built from pre-manufactured pieces that can be purchased at Solare Bruecke e.V. Wolfgang Scheffler und Heike Hoedt Graf von Werdenberstr.6 D-89344 Aislingen Manual for this option is under construction	

3 Material

3.1 Tools

- Drill press or Chinese drill (with full set of drill bits)
- Metal cutting, straightening, untwisting, and bending tools (including anvils)
- Hacksaw and blades
- Files, grinder
- Glass Cutting Tool
- Pliers (with wire-cutter), for twisting and cutting wires
- Wrenches, according to bolt size
- Screwdrivers, according to screw size
- Vernier callipers
- Clamps and vise-grips
- Work table
- Welding equipment
- Ruler/Scale
- Measuring tape (3m)
- Protractor
- String
- Permanent Marker
- Water level (Spirit level)
- Brush for painting
- Steel brush

3.2 List for purchasing materials

Material	Type	Dimension [mm]	Length [mm]
steel	square bar	12x12	11090
		10x10	3612
		16X16	1200
	square tube	20x20x1.5	2600
		15x15x1.5	1100
		50x50x2	10320
	flat iron	40x2	160
		25x6	2330
		40x3	520
		50x6	1515
		25x3	100
	round bar	6	5880
		8	4722
		10	4120
		4	400
	Bolt	M8x40	7x
		M8x70	9x

		M6x20	4x
		M8x25	3x
		M6x25	5x
		M10x70	3x
	nut	M8	20x
		M6	9x
		M12	2x
		M10	9x
	sheet	10x1	280
		230x2-3	230
	Template sheet!	1800x2	2300
	u-profile	40x15x1.5	1360
	angle iron	15x15x2	480*
		40x40x3	736
		40x40x6*	150
	round tube	inner Ø 12	1800
	flat iron/sheet	15x1	490
	washer	M10	1x
		M8	2x
	Cable*	Ø6	1000
Aluminium	sheet	600x2	610
	flat/sheet	15x2-3	~34 m
Reflective aluminium	sheet	730x1	Depending on latitude
other	hacksaw blade		1x
	pulley wheel*		1x
	cable clamp*		4x
	tension spring*	Ø bar 2-3	2x320
	mirror, clear glass	Favoured 2mm thick	$2.5m^2$
	wire	~1	13200
	redoxide paint		~1L
	acrylic paint		~1L
	Counterweight 5kg*		1x

* only for mechanical tracking system.

3.3 List for cutting material

Material	Type	Dimension [mm]	Length [mm]	Part of	Position	Pieces
steel	square bar	12x12	600	bending tool		2
			40	bending tool		2
			50	reflector	FC2	1
			500	reflector	CB7	1
			650	reflector	F1	2
			1240	reflector	F2	2
			1200	reflector	F3	1
			2340	reflector	FC 1	1
			1030	cooking area	C 1	1
			910	cooking area	C 2	1
		10x10	40	bending tool		6
			400	bending tool		4
			251	reflector	CB7	2
			1200	reflector	F4	1
			70	cooking area	C 3	1
		16X16	600	bending tool		2
	square tube	20x20x1.5	600	compass		1
			1900	compass		1
			100	compass		1
		15x15x1.5	1100	compass		1
		50x50x2	100	rotating support jig	RI 4	2
			681	rotating support	R 1	1
			1588	rotating support	R 2	1
			1680	rotating support jig	RI 2	1
			920	rotating support jig	RI 1	1
			120	rotating support jig	RI 3	2
			See page 16, chapter 6.Stand	stand	S 1	1
				stand	S 2	1
				stand	S 3	1
				stand	S 4	1
				stand	S 5	1
				stand	S 6	1
	flat iron	40x2	80	compass		2
		25x6	40	rotating support	R 13	2
			50	rotating support	R 9	1

				rotating support jig	RI 11	1
			25	rotating support	R 10	1
			65	reflector	FC 3	2
			150	stand	S18*	1
			75	rotating support jig	RI 12	1
				stand	S 8	4
			490	rotating support	R 11	1
			550	rotating support	R 12	1
			70	stand	S19*	1
			90	stand	S20*	2
		40x3	150	reflector	F5	2
			60	cooking area	C 9	1
			Depending on lat.**	cooking area	C10	1
		50x3	50	stand	S 9	5
			65	rotating support	R 5	1
		50x6	100	rotating support jig	RI 10	1
			50	stand	S 10	1
			180	rotating support	R 6	2
			265	rotating support	R 7	1
			75	rotating support	R 8	1
			200	rotating support jig	RI 9	2
			90	stand	S7	1
		25x3	25	cooking area	C 11	4
	round bar	6	100	rotating support jig	RI 15	2
				seasonal adjustment	A 5	2
				stand	S 13	1
			50	compass		3
			256	reflector	CB1	2
			325	reflector	CB2	2
			392	reflector	CB3	2
			406	reflector	CB4	2
			390	reflector	CB5	2
			346	reflector	CB6	2
			150	rotating support jig	RI 14	2
			520	rotating support	R 15	1
			60	stand		3
		8	400	cooking area	C 6	1
			100	cooking area	C 7	1

			514	reflector	CB1	1
			639	reflector	CB2	1
			785	reflector	CB3	1
			811	reflector	CB4	1
			781	reflector	CB5	1
			692	reflector	CB6	1
		10	600	rotating support	R 17*	1
			500	seasonal adjustment	A 4	1
			340	rotating support	R 14	1
			550	rotating support	R 16*	2
			700	seasonal adjustment	A 3	1
			Depending on lat.**	stand	S 12	1
			20	cooking area	C 5	1
			Depending on lat.**	cooking area	C 4	1
		4	400	cooking area	C 8	1
	sheet	10x1	35	reflector	FCcb	8
		Ø 230x2-3		cooking area	C 15	1
	u-profile	40x15x1.5	1360	rotating support	R 3	1
	angle iron	15x15x2	480	rotating support	R 4*	1
		40x40x3	40	rotating support jig	RI 8*	1
			100	rotating support jig	RI 5	2
			150	rotating support jig	RI 6	1
			264	rotating support jig	RI 7*	1
			82	rotating support jig	RI 13*	1
		40x40x6	60	stand	S16*	1
			90	stand	S17*	1
	round tube	inner dia.12	600	stand	S 11	1
			500	seasonal adjustment	A 2	1
			700	seasonal adjustment	A 1	1
	flat iron/sheet	15x1	35	reflector	Fcb	14

* only for mechanical tracking system
** cut before welding

4 Rotating Support Jig

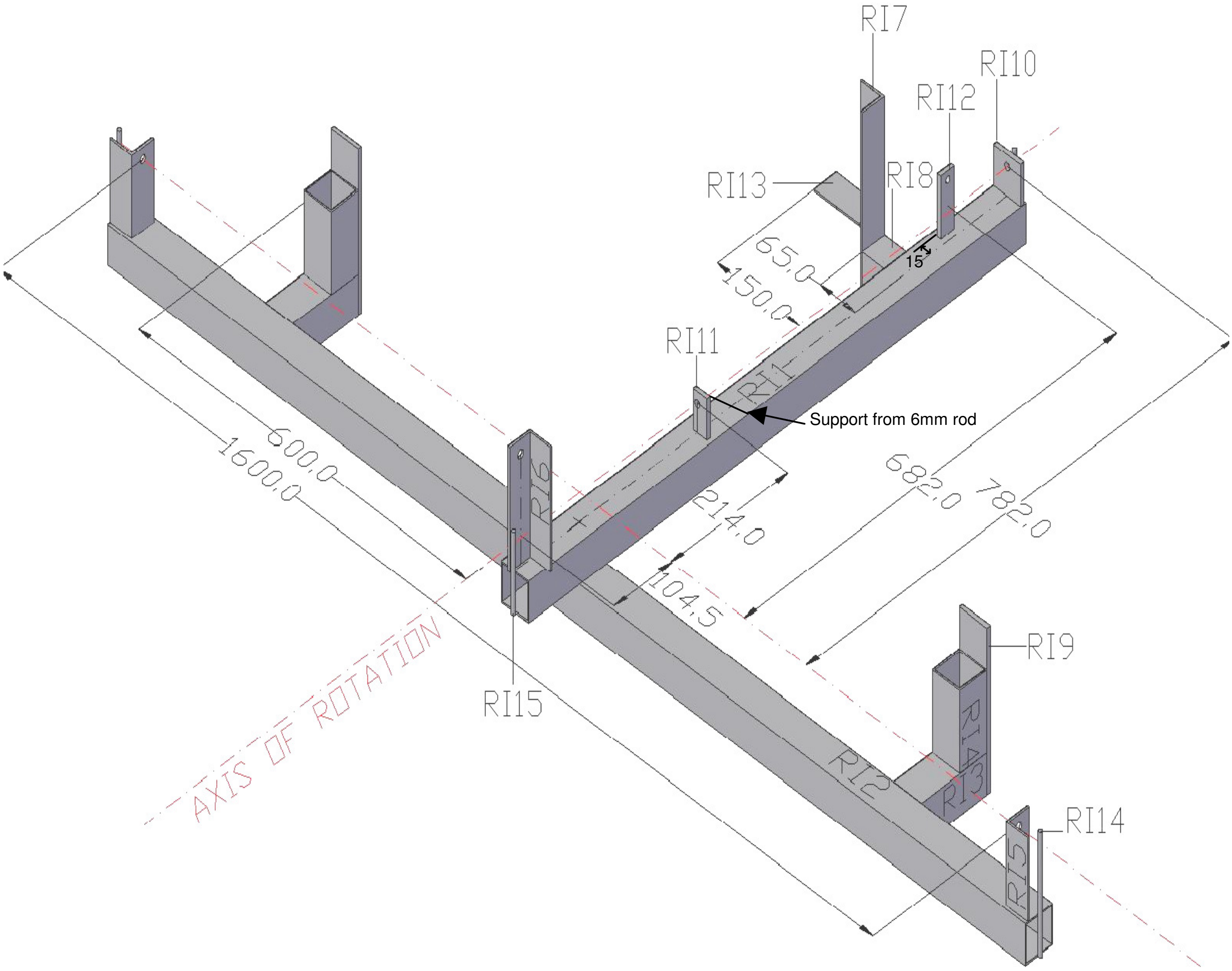


Fig. 3. Rotating Support Jig

See also plans in 10.4 Plan, Fig.90-91

Position	Pieces	Type	Dimension [mm]	Length [mm]
RI 1	1	square tube	50x50x2	920
RI 2	1	square tube	50x50x2	1680
RI 3	2	square tube	50x50x2	120
RI 4	2	square tube	50x50x2	100
RI 5	2	angle iron	40x40x3	100
RI 6	1	angle iron	40x40x3	150
RI 7*	1	angle iron	40x40x3	264
RI 8*	1	angle iron	40x40x3	40
RI 13*	1	angle iron	40x40x3	82
RI 9	2	flat iron	50x6	200
RI 10	1	flat iron	50x6	50

RI 11	1	flat iron	25x6	50
RI 12	1	flat iron	25x6	75
RI 14	2	round bar	6	150
RI 15	2	round bar	6	100

* only for mechanical tracking system

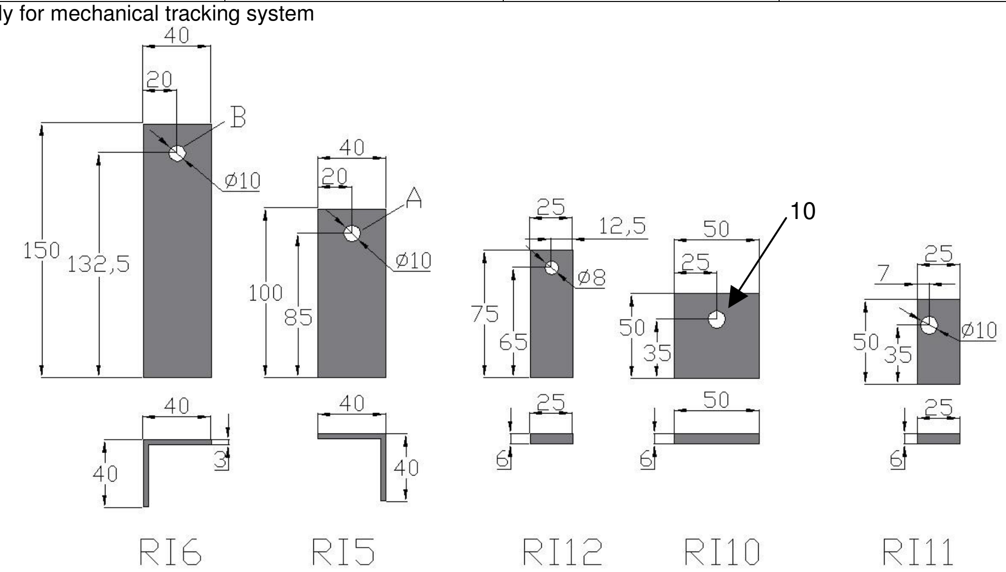


Fig. 4: RI6,RI5,RI12,RI10,RI11

4.1 Assembly of Rotating Support Jig

Step 1 Weld RI1 and RI2 together

Step 2 To guarantee an exact measurement of the jig weld RI15 to either end of RI 1 and RI 14 to either end of RI2.

Step 3 Form a string-cross by tying a string between the two RI15 and the two RI14. The string must be at height of axis of rotation (35 mm from RI1 and 85mm from RI2.)

Step 4 Weld all the pieces to RI1 and RI2 according to Fig.3. Use the string cross as measuring point.

If the cooking area is in the south weld RI7, RI8 and RI13 to the other side (east side) of RI1

Step 5 Check distances again.

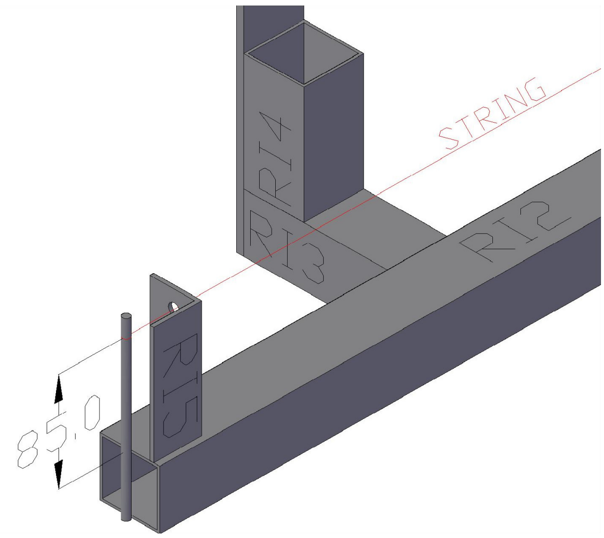


Fig. 5: Detail string-tying for RI2

5 Rotating Support

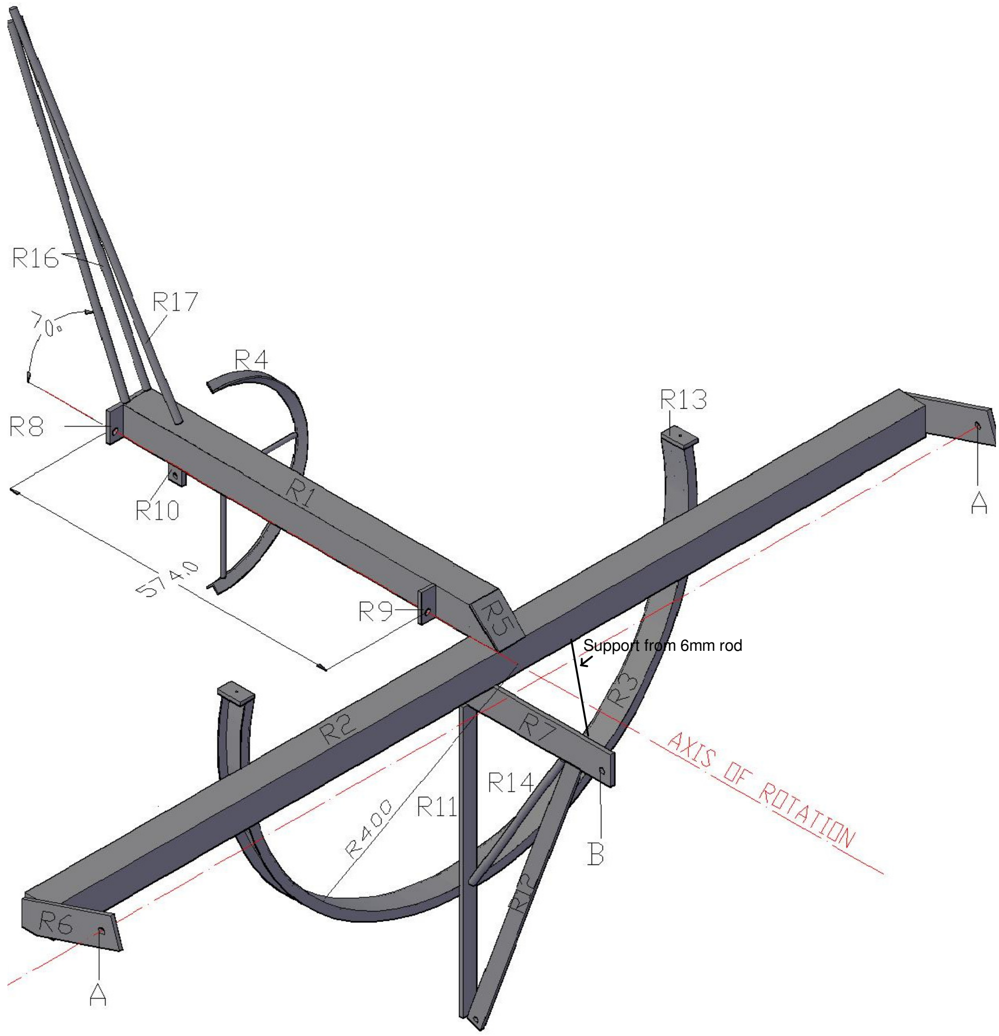


Fig. 6: Rotating Support

See also plans in 10.4 Plan, Fig.92-94

Position	Name	Pieces	Type	Dimension [mm]	Length [mm]
R 1	Rotating ~~short~~ square tube	1	square tube	50x50x2	681
R 2	Rotating long square tube	1	square tube	50x50x2	1588
R 3	Tracking channel	1	u-profile/sheet	40x15x1.5	1360
R 4*	Spring channel	1	angle iron	15x15x2	480
R 5	To close short square tube	1	flat iron	50x6 or 50x3	65
R 6	Outer frame support (A)	2	flat iron	50x6	180
R 7	Centre frame support (B)	1	flat iron	50x6	265
R 8	Back bearing	1	flat iron	50x6	75
R 9	Bearing	1	flat iron	25x6	50
R 10	Attachment southern seasonal adjustment	1	flat iron	25x6	25
R 11	Attachment northern seasonal adjustment	1	flat iron	25x6	490

R 12	Attachment northern seasonal adjustment	1	flat iron	25x6	550
R 13	To close tracking channel	2	flat iron	25x6	40
R 14	Tracking channel spoke	1	round bar	10	340
R 15*	Bracing pieces spring channel	~4	round bar	6	Total 520 (cut when needed)
R 16**	counterweight holder	2	round bar	10	550
R 17**	counterweight holder	1	round bar	10	600
	Counterweight 5kg	1			
	Bolt	3	bolt	M10	
	Bolt	1	bolt	M8	
	Nut	3	nut	M10	
	Nut	2	nut	M8	

* only for mechanical tracking system.
**only for lying reflector

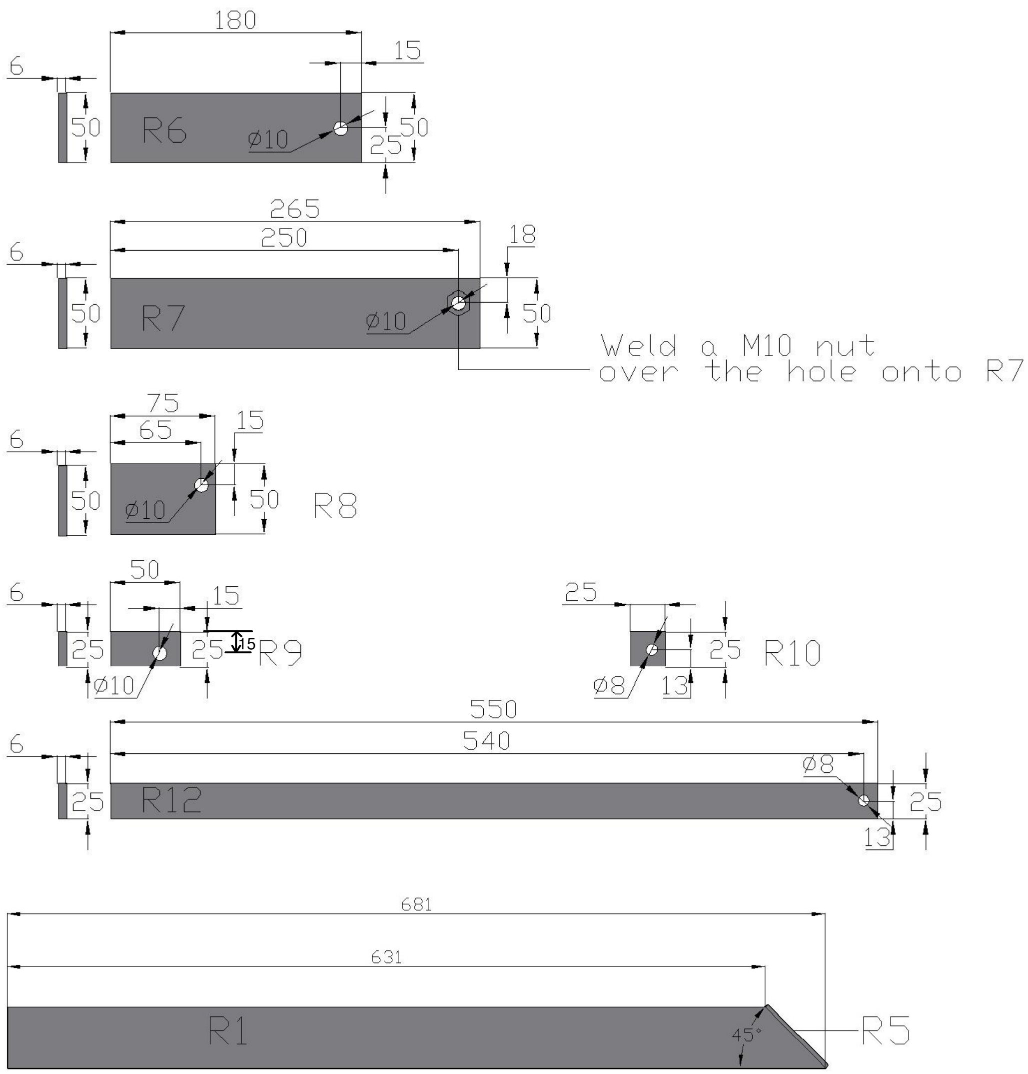
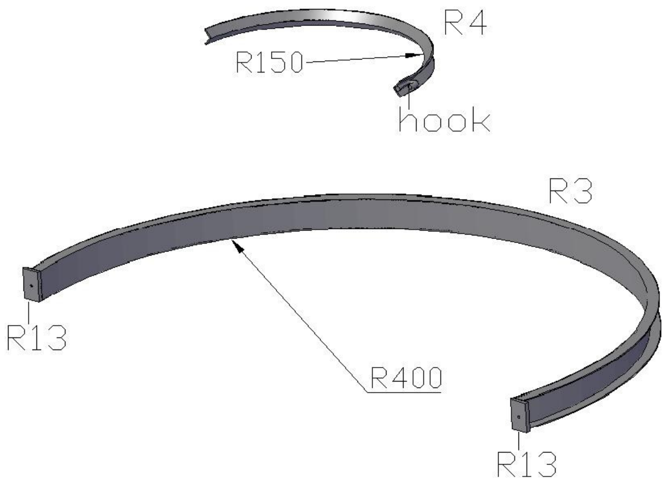


Fig. 7: R6,R7,R8,R9,R12,R1,R10



Drill a 6mm hole into R13 (will be used for attaching the chain of the tracking system)

Fig. 8: R4,R3

5.1 Assembly Rotating Support

Step 1 Remove RI14 and RI15 from RI1

Step 2 Place R8, R9, R10, R6s at their corresponding position on the jig (see Fig.9 and Fig.10) and fix them with M10 / M8 bolts and nuts. There is a 8 mm gap between R1 and RI11. This gap is the space for the weld!

Step 3 Weld R8, R9 and R10 to R1.

Remove R1 from the jig and remove distortion from welding (R1 has to be strait!).

Close R1 with R5, grid the top and bottom side of the weld so that R1 can sit flat on the jig and touch R2 without problems.

Place R1 back on the jig, tighten the bolts again.

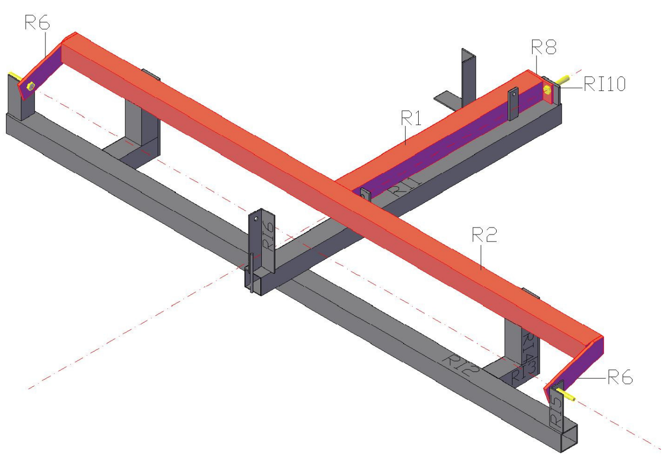


Fig. 9: Assembly of RS step 1-3

Step 4 Weld R4 with bracing pieces (R15) to R1.

Step 5 Weld R2 to R1 with for strong welding spots in the corners.

Weld R3 perpendicular to the axis of rotation to R2. The centre of R3 has to be on the axis of rotation. See Fig.10.

Step 6 Place R7 in position and tighten the bolt. (See Fig.11). Make sure R7 is parallel to R1 and weld it with 4 strong spots on the corners of R2.

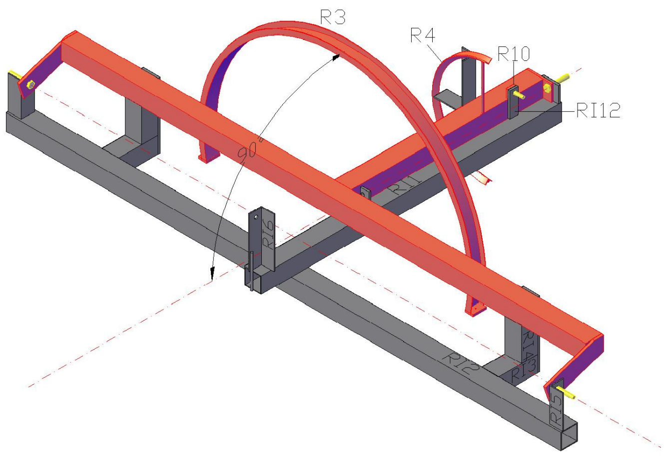


Fig. 10: Assembly of RS step 4-6

Step 7 Weld R11, R12 and finally R14 as shown in Fig.12. Make sure that the distance (605mm) from the axis of rotation to the hole on R12 is correct.

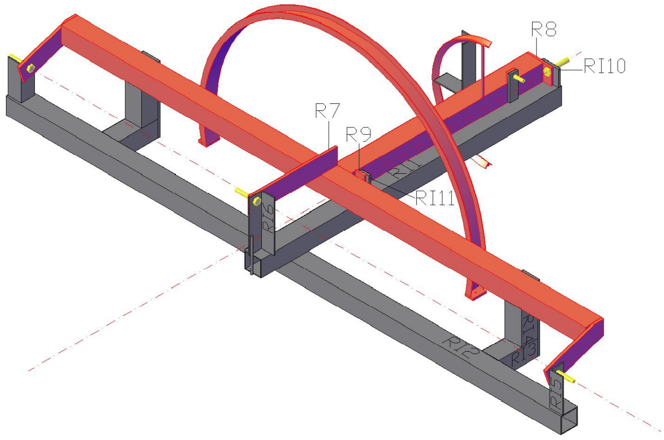


Fig. 11: Assembly of RS step 7

Step 8 Finish assembling the Rotating Support by welding both R6s to R2. This has to be last, in order to avoid strong distortions.

Step 9 Remove the completed Rotating Support from the Jig and check if some additional welding is necessary.

Step 10 **Try not to add any welding distortions with those final welds.**

Step 11 Weld R16 and R17 to R1 as shown in Fig.6.

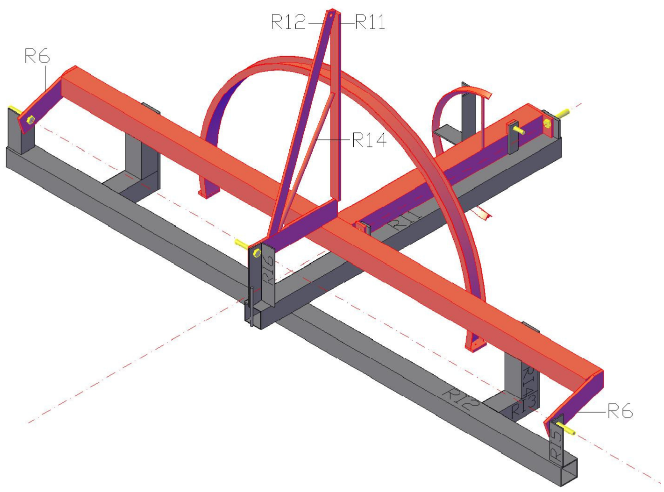


Fig. 12: Assembly of RS step 8-11

6 Stand

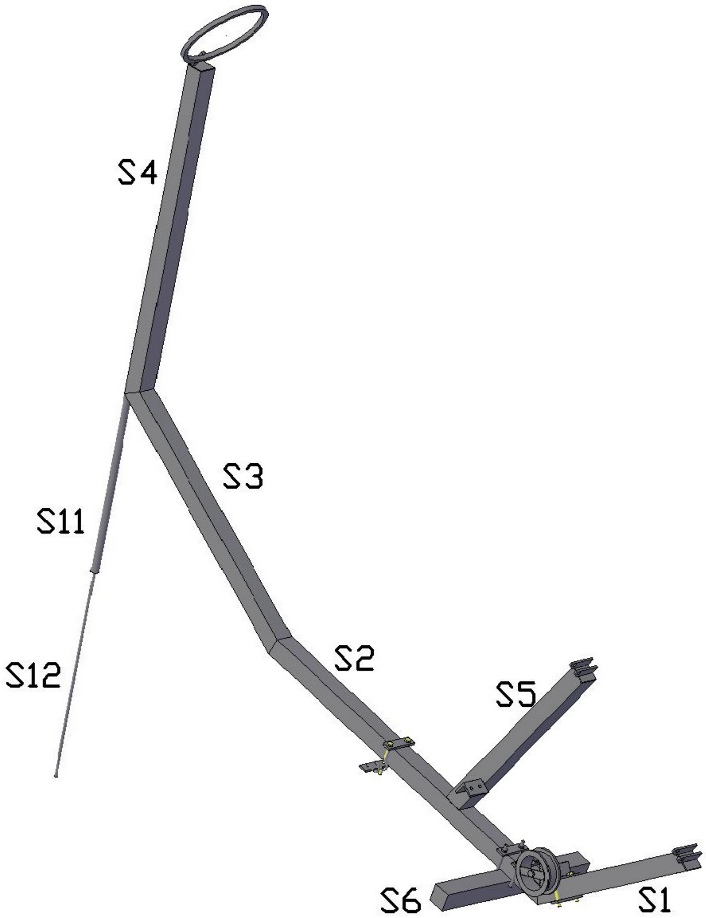


Fig. 13: Stand

Position	Pieces	Type	Dimension [mm]	Length of the longest edge [mm]	Angles [º] for cutting end 1/end 2
S 1	1	square tube	50x50x2	566	66.5/67.7
S 2	1	square tube	50x50x2	1083	67.7/79
S 3	1	square tube	50x50x2	778	79/61.8
S 4	1	square tube	50x50x2	915	61.8/90
S 5	1	square tube	50x50x2	619	90/68.3
S 6	1	square tube	50x50x2	1050	90/90
S 7	2	flat iron	25x6	90	-
S 8	4	flat iron	25x6	75	-
S 9	5	flat iron	50x6	50	-
S 10	1	Flat iron	50x6	50	-
S 11	1	round tube	Outer Ø variable, inner 12	600	-
S 12	1	round bar	10	700*	-
S 13	1	round bar	6	100	-
S 14	1	bolt	M8x40		-
S 15	1	nut	M8		-

	1	round bar	10	Min. 600	-
	4	bolt	M8x70		
	4	nut	M8		

*length depending on latitude

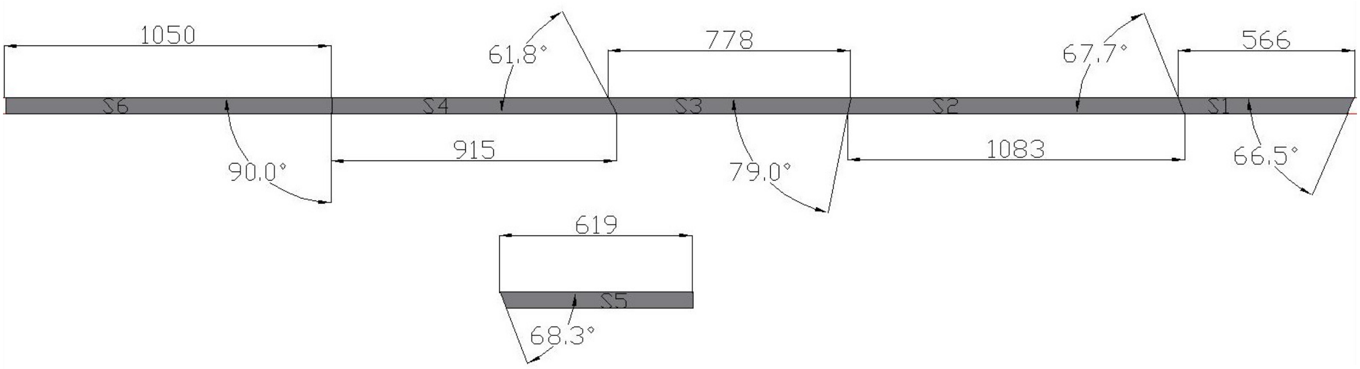


Fig. 14: Cutting order S1-S6

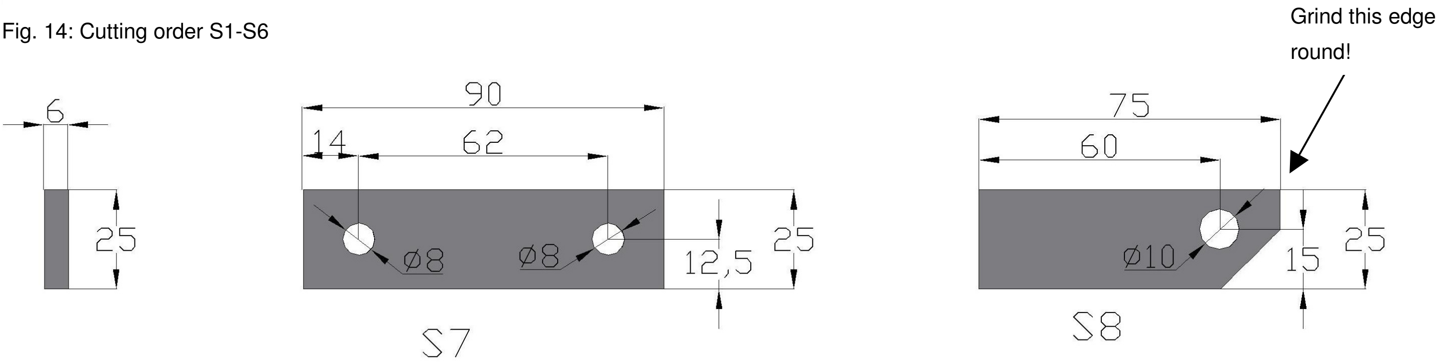


Fig. 15: S7 and S8

6.1 Stand template

Draw the following template on your template sheet, another flat sheet of wood or metal (size at least 2920x920), or on flat ground.

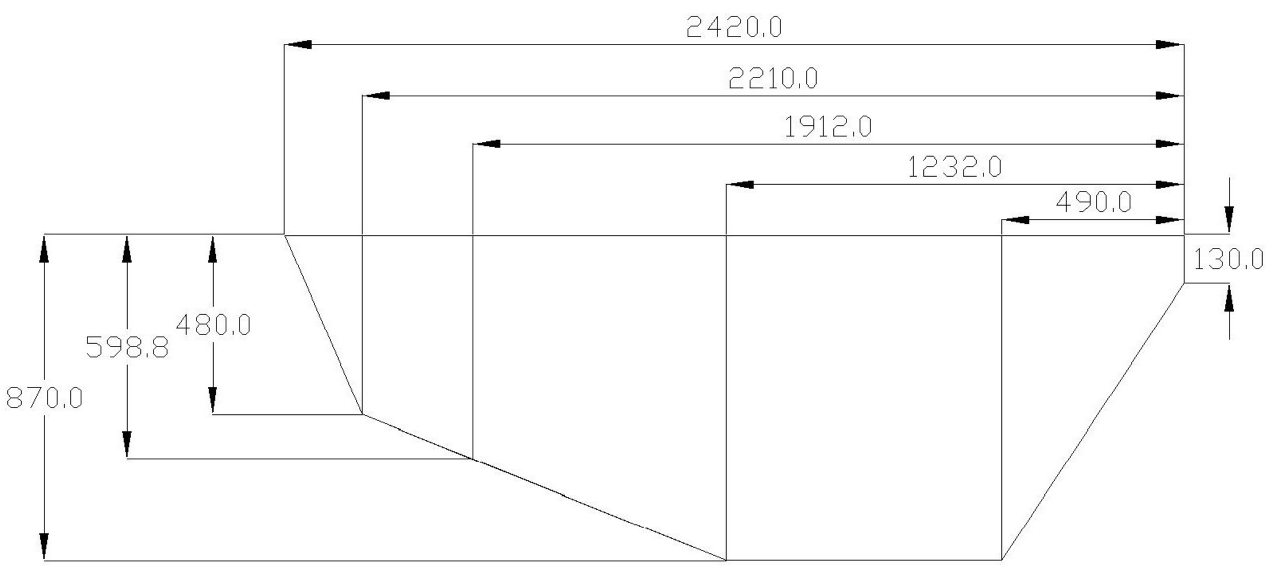


Fig. 16: Stand Template

6.2 Assembly of stand

Step 1 Position S2 and S5 on the template

Step 2 Spot weld the pieces together.

Step 3 Tack two cross braces on each side of piece S5 down to S2.

Step 4 Remove it from the template. Weld around the joint.

Step 5 Remove the cross braces.

Step 6 Put the welded piece on the template and set the other pieces. If it doesn't match, hammer till it does.

Step 7 Weld S1 to S2, S3 to S4 and then S2 to S3 always using cross braces.

Step 8 Check if the stand matches to the template.

Step 9 Close S1, S5, S4 and S6 with S9s.

Step 10 For the front adjustable support weld S15 to S11 and S14 to S13 to get a structure as described for the Seasonal Adjustments (Fig.58).

Step 11 Weld S11 to S4.

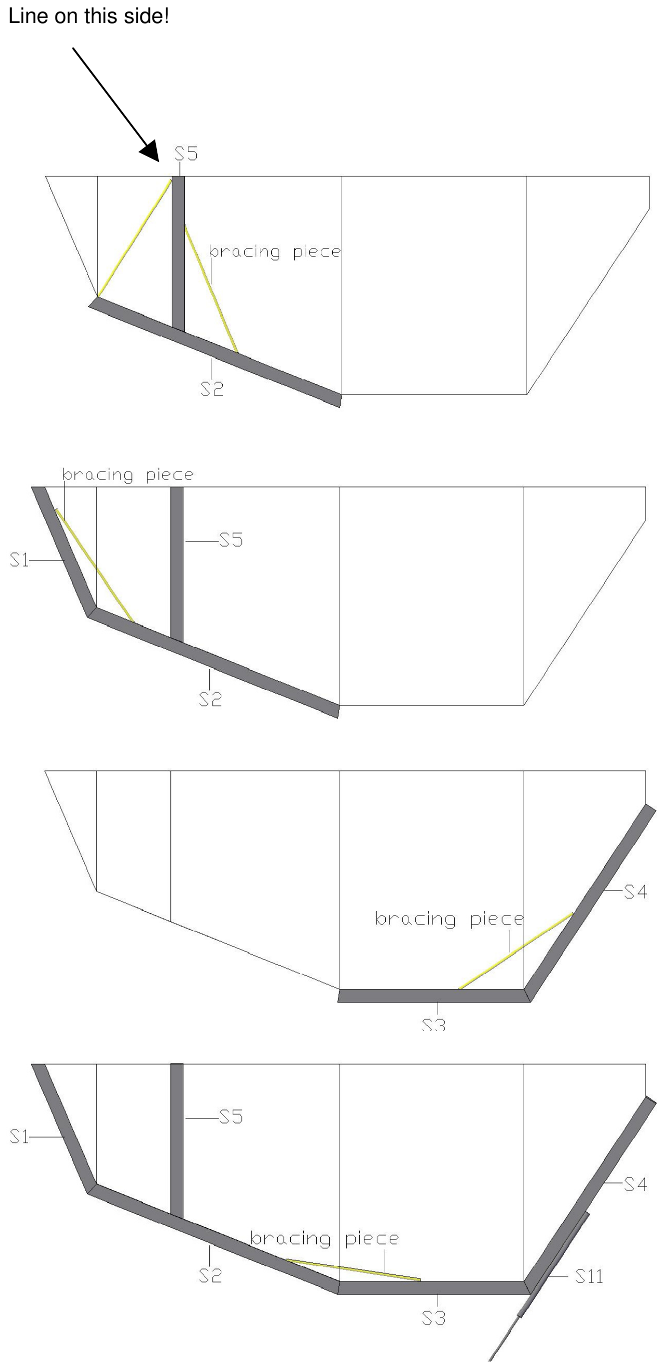


Fig. 17: Welding order

Step 12 Cut off the head of M8 bolts and weld them to S6.

Step 13 Clamp S6 to S1 or S2 (according to latitude. See Fig.69) using S7s as counterpart. Due to practical reasons of height, S6 can be clamped later before fixing the Cooking area

Step 14 Weld S10 to S12 in a way that S10 appears as a foot flat on the ground and stick S12 into S11.

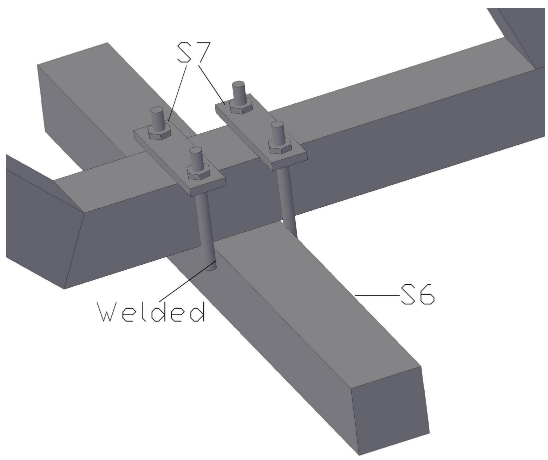


Fig. 18: Clamping S6

6.3 Assembly of main bearings

Step 1 Weld bearing 1 (S8) flush to the northern edge of S5 (use a flat iron as aligning support), the hole for the axis of rotation to the west. See Fig.19

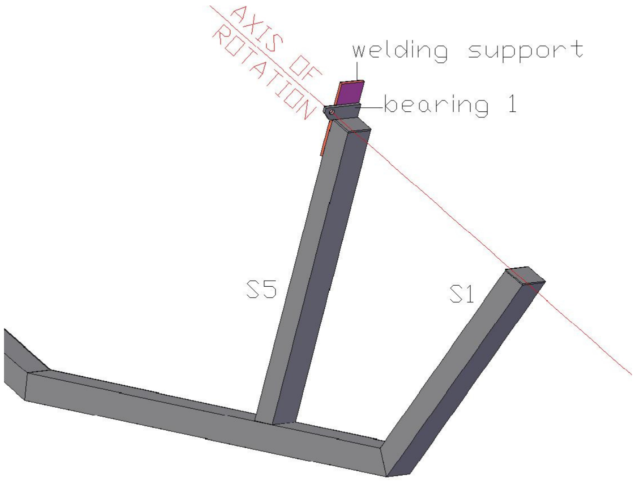


Fig. 19: Assembly of main bearings step1

Step 2 Push a 10mm rod trough bearing 1 and bearing 2. Place bearing 2 flush to the northern edge of S1. Weld it ensuring that the rod can be moved easily. See Fig.20.

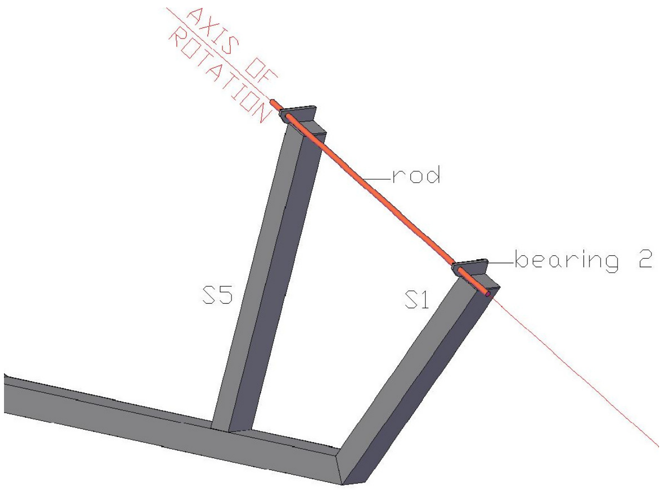


Fig. 20: Assembly of main bearings step2

Step 3 Weld bearing 3 and 4 with a distance of 24mm from the northern edge to S5 respectively S1, using the rod again to check the alignment. See Fig:21.

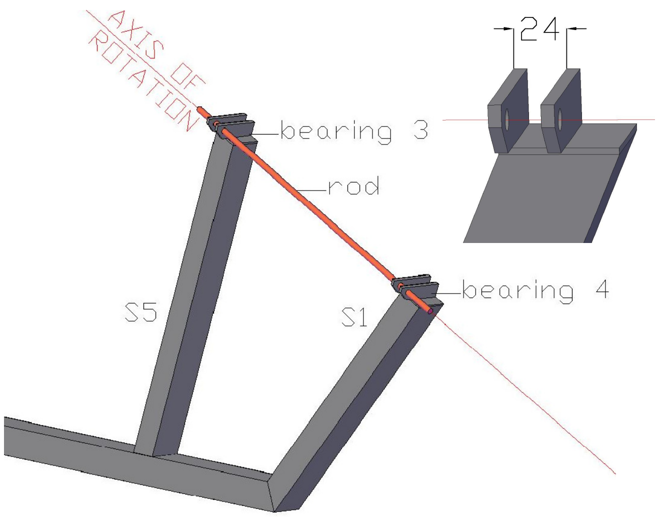


Fig. 21: Assembly of main bearings step3

6.4 Assembly of clock additives for mechanical tracking system

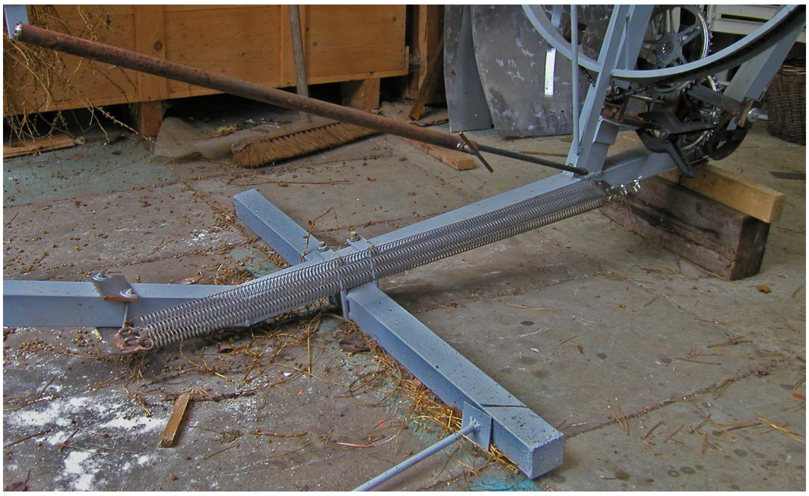


Fig. 22: Additives for mechanical tracking system

Position	Name	Pieces	Type	Dimension [mm]	Length [mm]
S16	Clock mount	1	angle iron	40x40x6	60
S17	Pulley wheel fixation	1	angle iron	40x40x6	90
S18	Fix spring holder	1	flat iron	25x6	150
S19	Loose spring holder	1	flat iron	25x6	70
S20	Counterpart for Fix spring holder , Pulley wheel	2	flat iron	25x6	90
	Pulley wheel (manufactured or bought)	1	as stiff material as possible	∅ 100	-
	Hook	3	round bar	∅ 6	60
	Steel cable	1	cable	∅ 6	approx. 1000
	Cable clamp	4			
	Tension spring	2	round bar	∅ bar 2-3 inner ø spring 24	320
		4	bolt	M8x70	
		4	nut	M8	

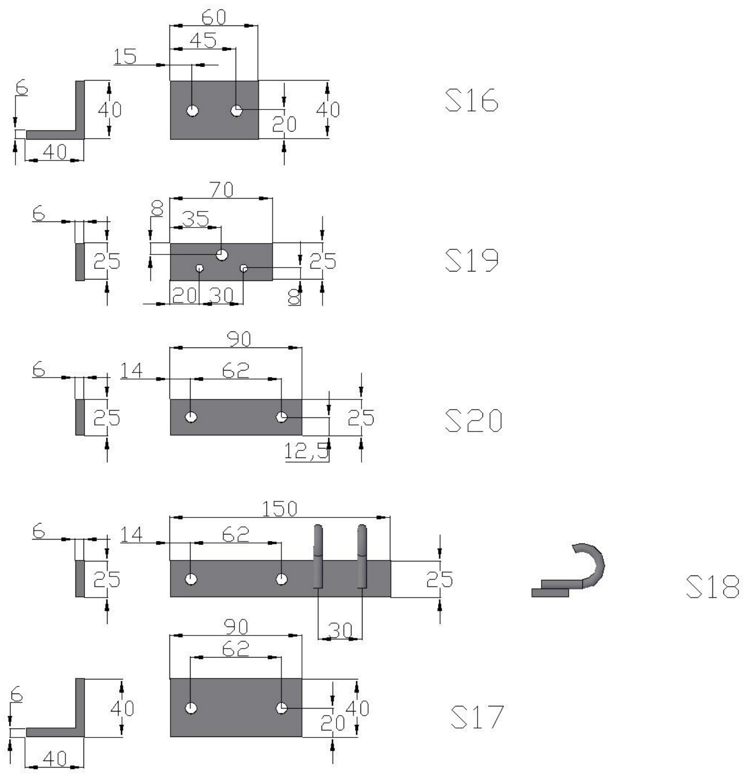


Fig. 23: S16, S17, S18, S19, S20

Step 1 Weld S16 (Clock mount) to the west of S5 (side of bearing; for standing reflector eastside). If you use the clockwork mechanism described here weld S16 495 mm from axis of rotation (See Fig.24). For different tracking systems choose the distance accordingly.

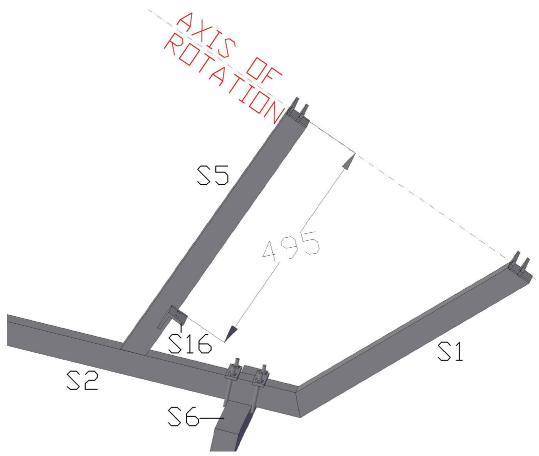


Fig. 24: Position of clock mount

Step 2 Mount Rotating Support on stand (Use M10 bolt). Weld pulley wheel to S17 and clamp it with S20 to S2 so that the cable comes perpendicular to the axis of rotation (parallel to S5) See Fig.25.

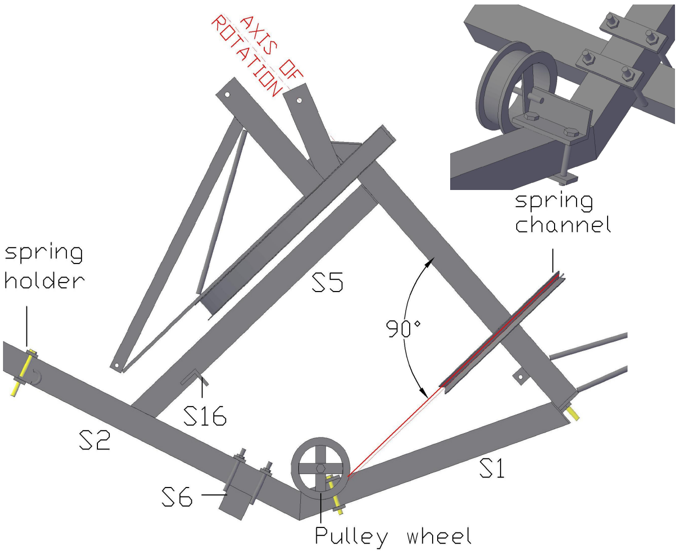


Fig. 25: Pulley wheel fixation

Step 3 Clamp the fix spring holder to S2 using the counterpart S20. See Fig. 26

Step 4 Fix the springs to the spring holder.

Step 5 Fix the cable with two clamps to the hook of the spring channel. The other end of the cable goes through the 8 mm hole in S19 (loose spring holder). See Fig. 27

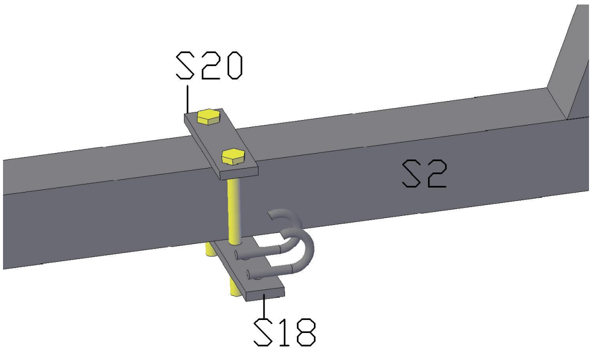


Fig. 26: Fix spring holder with counterparts

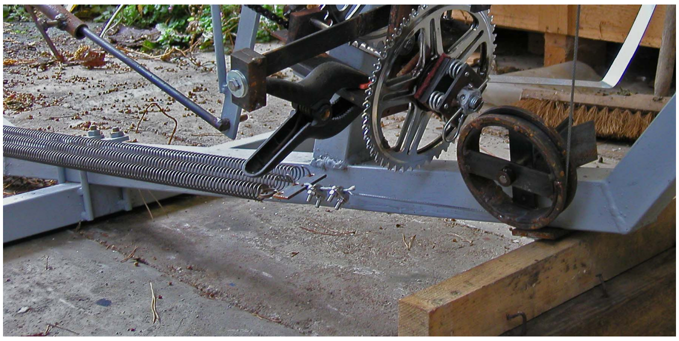


Fig. 27: Cable clamping and loose spring holder with additional spring

6.5 Stand plus additional pieces for the Standing Reflector

Fig. 28: Stand of Standing Reflector + Rotating Support

7 Reflector

The reflector is the most important part of the solar cooker. If the reflector is not made **EXACTLY**, the focus will not be correct and the cooker will not work properly, the food will take much longer to cook, and the cooker may even be unusable.

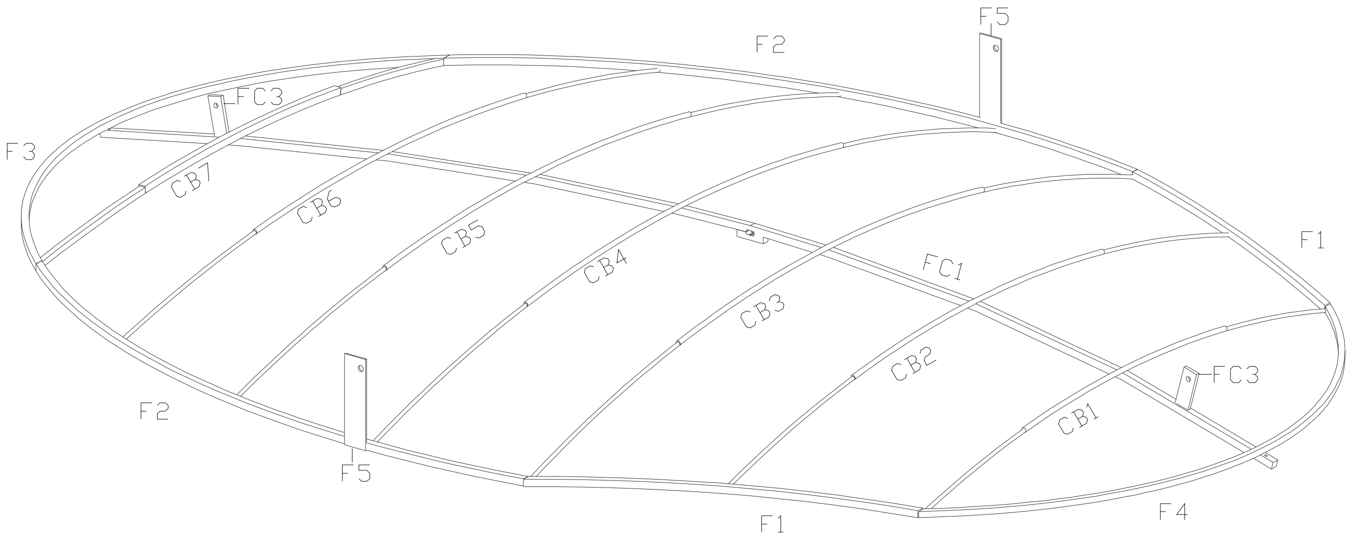


Fig. 29: Reflector

7.1 Crossbars

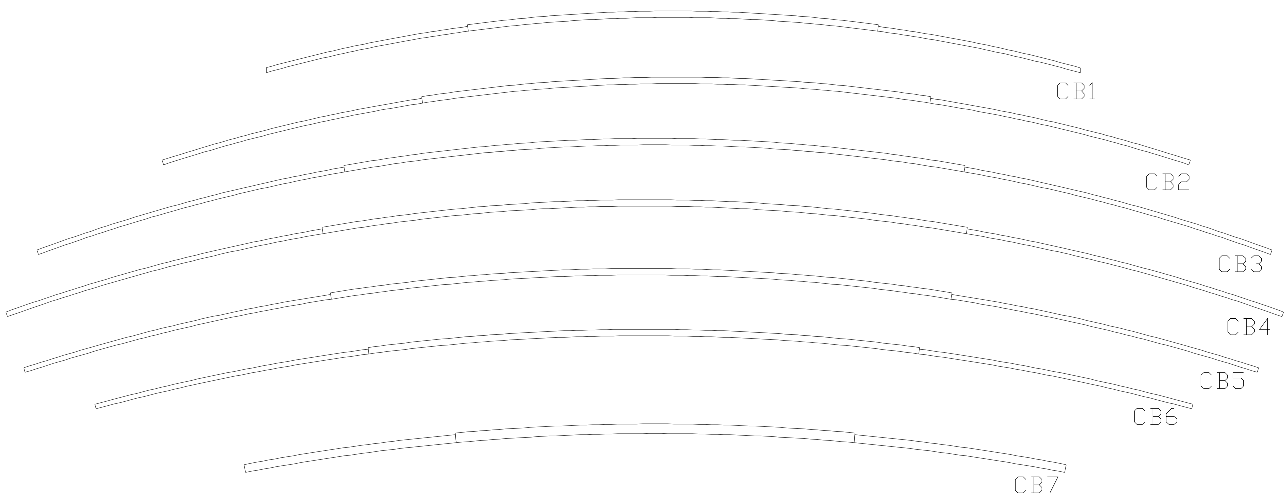


Fig. 30: Crossbar 1-7

Position	Pieces	Type	Dimension	Length [mm]	Total Length CB X [mm]	Radius for bending [mm]
CB1	2	round bar	6	256		1929
CB1	1	round bar	8	514	1026	1929
CB2	2	round bar	6	325		2102
CB2	1	round bar	8	639	1289	2102

CB3	2	round bar	6	392		2257
CB3	1	round bar	8	785	1569	2257
CB4	2	round bar	6	406		2398
CB4	1	round bar	8	811	1623	2398
CB5	2	round bar	6	390		2526
CB5	1	round bar	8	781	1561	2526
CB6	2	round bar	6	346		2644
CB6	1	round bar	8	692	1384	2644
CB7	2	square bar	10x10	251		2752
CB7	1	square bar	12x12	500	1002	2752

7.2 Crossbars template

Draw the radius of each Crossbar with the Compass (Appendix 9.1) on your template sheet

7.2.1 Assembly of crossbars

Step 1 Weld the three pieces for each Crossbar together, ensuring that **ONE EDGE IS FLUSH**. See Fig.31.

Step 2 Grind the weld at the flush edge carefully, because this will be the inner edge of the reflector surface where the mirrors are mounted. They must follow the curve exactly for the reflector to focus properly. Mark the centre of each crossbar

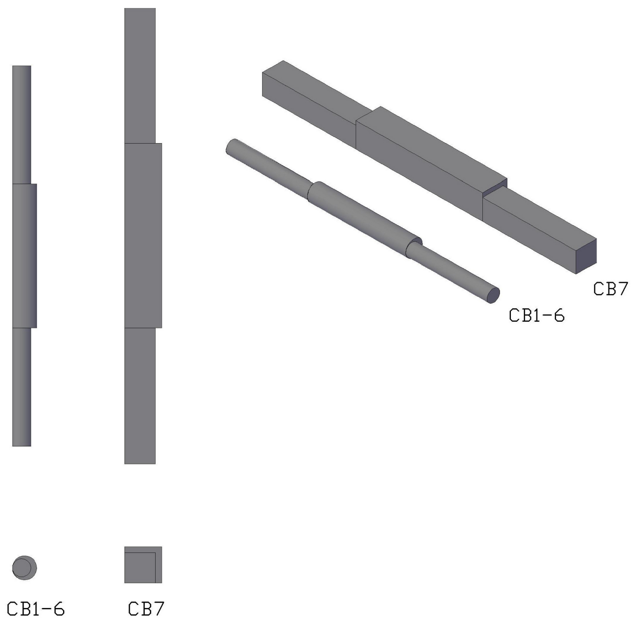


Fig. 31: CB welding

Step 3 Using the Crossbar-Template and the Bending tools (Appendix 10.2), bend each Crossbar to its proper radius ensuring that the **FLUSH EDGE FOLLOWS THE CURVE PRECISELY** (±0.5 mm tolerance) and the Crossbars lie flat on the template

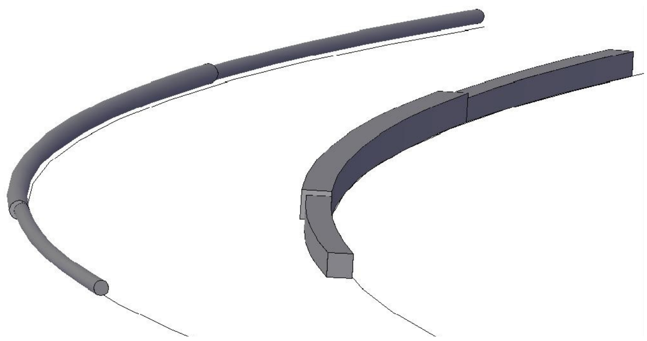


Fig. 32: CBs on template

7.3 Centrebar

Fig. 33: Centrebar

Position	Name	Pieces	Type	Dimension [mm]	Length [mm]
FC1	Centrebar	1	square bar	12x12	2340
FC2	Centrebar slot	1	square bar	12x12	50
FC3	Seasonal adjustment attachment	2	Flat iron	25x6	65
FCcb	Centrebar-Crossbar Connectors	8	sheet	10x1	35

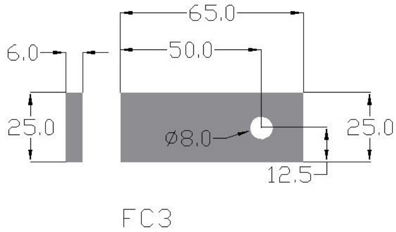


Fig. 34: FC3

7.3.1 Centrebar template

Draw the template as shown in Fig.35 by marking points 1-7 (Crossbar attachment points), and points 0 and 8 (frame connecting points) on your template sheet. Connect those points with a straight line.
Mark point S (Centrebar Slot) and points SA (Seasonal Adjustment Attachment).

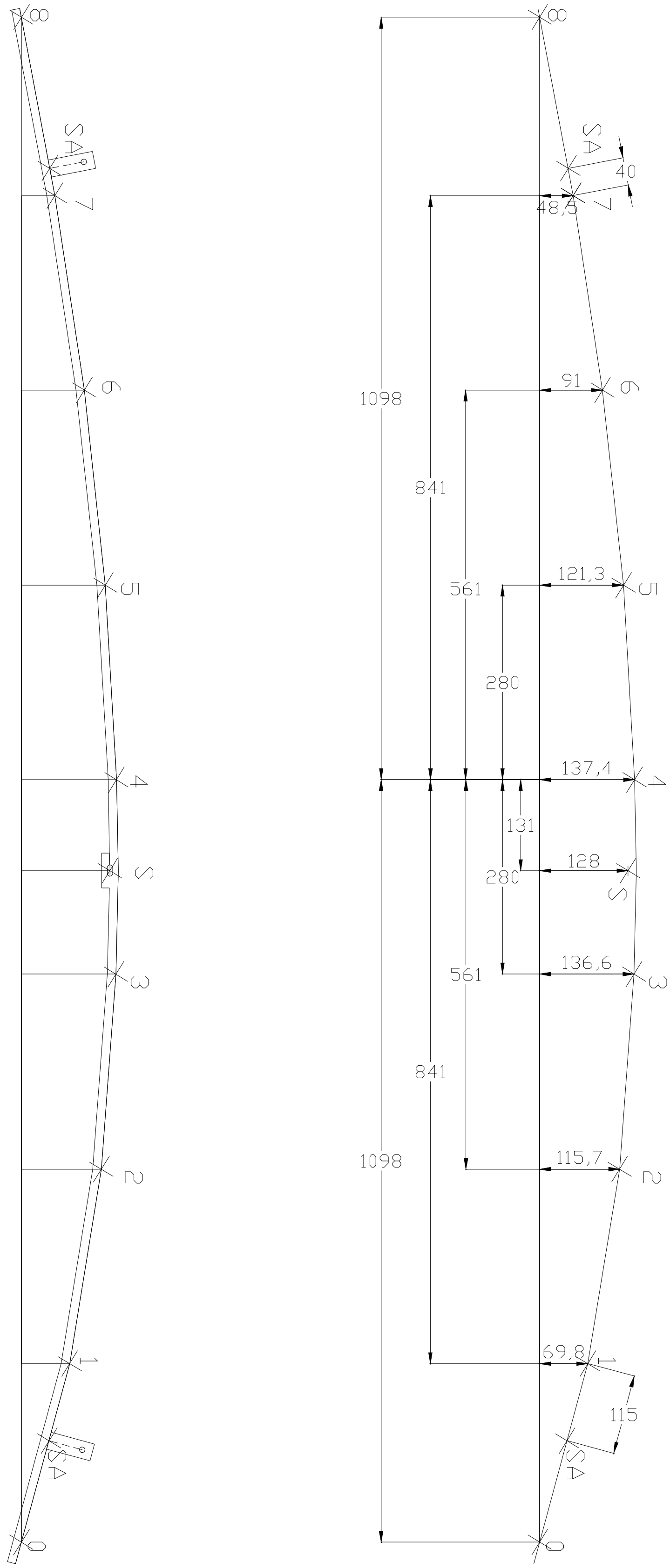


Fig. 35: Centrebar template

7.3.2 Assembly of Centrebar

Step 1 Take FC1, check its straightness and mark its centre(= point 4). Measure 131mm from the centre and mark point S. Remove one edge of FC2 (on both sides of the part) so that a groove is formed for the weld. Weld FC2 to FC1 so that it is centred at point S. See Fig.37

Step 2 Drill two 10 mm holes just beside each other on FC 2/ FC1, each one 5mm from S. Grind the spare material so you'll have a 10mm wide and 20mm long slot

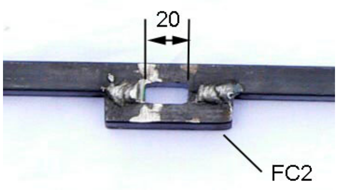


Fig. 36: Centrebar Slot

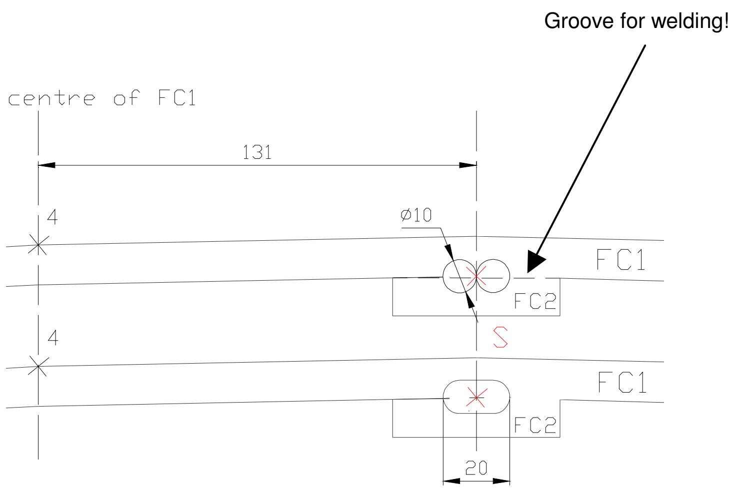


Fig. 37: Marking of Slot

Step 3 Bend FC1 to the template using the bending tools (Appendix 9.2) always ensuring that it lies flat on the template. **THE POINTS FOR THE CROSSBAR ATTACHMENT HAVE TO BE ALIGNED EXACTLY.**

Step 4 Mark the Crossbar attachment points 1-7 and points 8 and 0 on the Centrebar.

Step 5 Twist the FCcbs as shown in Fig.38.

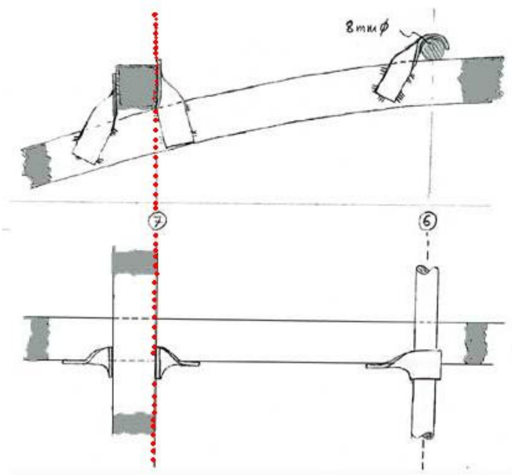


Fig. 38: Shape and position of FCcbs

Step 6 Use a piece of 8 mm rod centred about the CB1 attachment point and weld a FCcb in place to fit around this rod

Step 7 Move the rod to the CB2-CB6 locations and repeat.

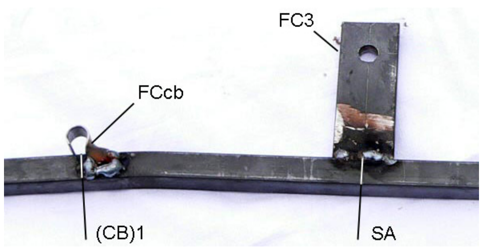


Fig. 39: Position of FCcb and FC3

Step 8 On the CB7 attachment point, use a 12x12 mm square rod and weld the two designed FCcbs to FC1 to fit to the sides of this bar as shown in Fig.38.

Step 9 Weld FC3s to FC1 centred at point SA. See Fig.39/40.

Step 10 Remove distortion and check the Centrebar's flatness.

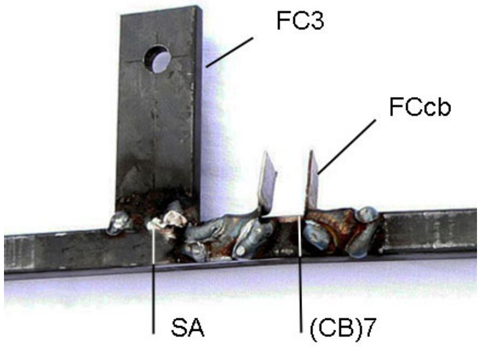


Fig. 40: FCcbs at CB7 attachment point

Step 11 Lay a piece of 12x12 mm square bar over Point 8 (perpendicular to FC1) and mark its sides on FC1

Step 12 Repeat with a 10x10mm square bar at Point 0. See Fig.41.

Step 13 Drill 3mm holes at these locations they will allow the Centrebar to be attached to the frame using pieces of wire

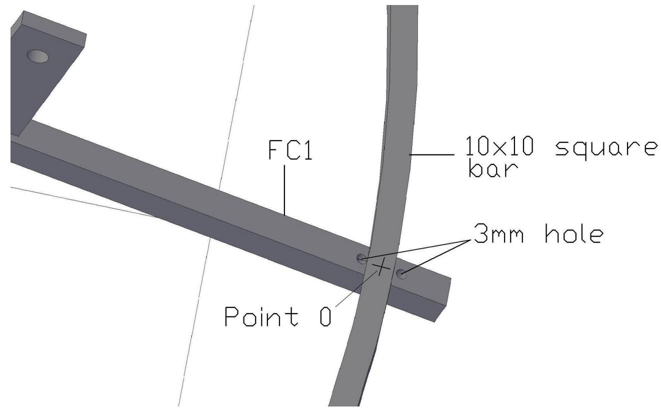


Fig. 41: centrebar attachment points

7.4 Frame

Position	Pieces	Type	Dimension [mm]	Length [mm]
F1	2	square bar	12x12	650
F2	2	square bar	12x12	1240
F3	1	square bar	12x12	1200
F4	1	square bar	10x10	1200
F5	2	flat iron	40x3	150
Fcb	14	flat iron/sheet	15x1	35

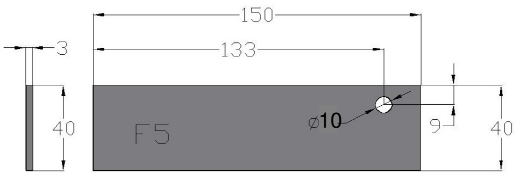


Fig. 42: F5

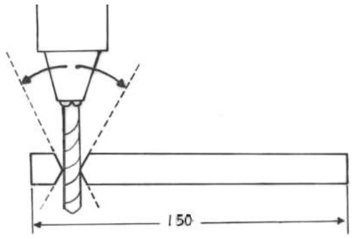


Fig. 43: Making of tapered hole

Tapered hole from both sides (F5 has to be able to incline on the bolds of the RS when the reflector's shape is changed due to seasonal adjusting

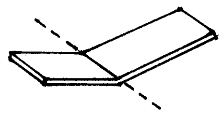


Fig. 44: Fcb bending

Pre-Bend the Fcbs (frame-crossbar connectors) as shown in Fig.41
A sharp bend for aligning them with the Crossbars.

7.4.1 Frame Template

Points 1-7 are the Crossbar (CB) attachment points. The lines connecting them give the CB positions.

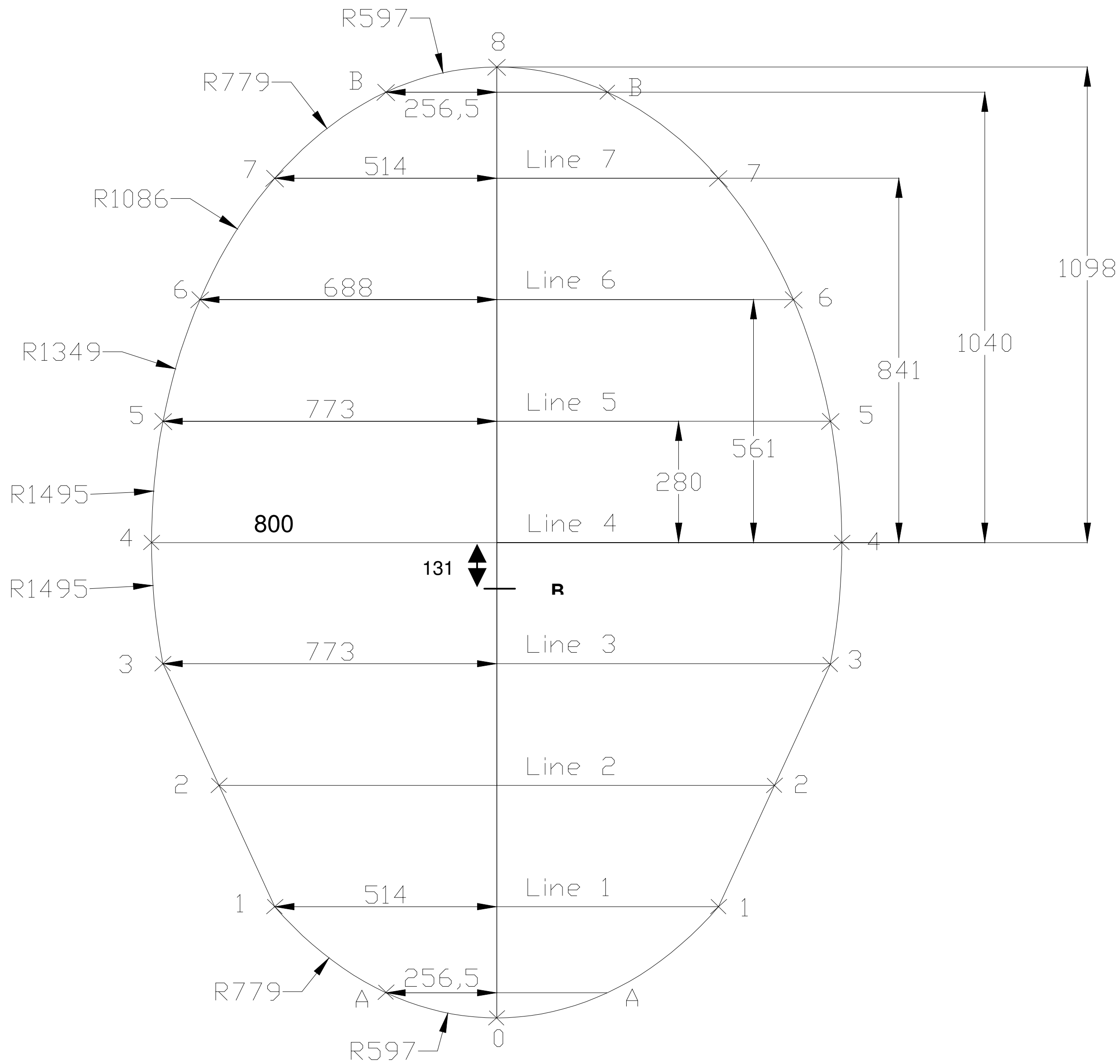


Fig. 45: Frame template

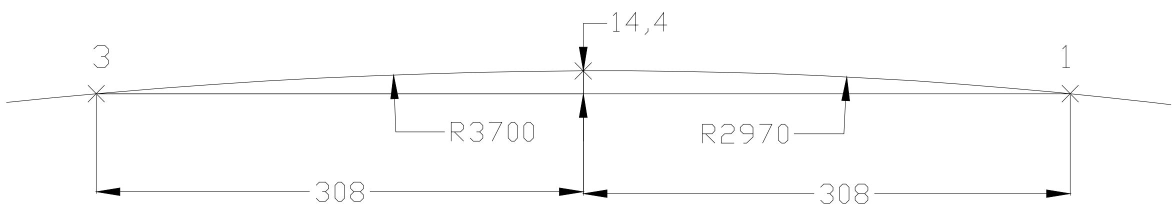


Fig. 46: F1 template

7.4.2 Assembly of frame

Step 1 Bend piece F1 to the according curve. Ensure that the **INNER EDGE FOLLOWS THE CURVE PRECISELY** (±0.5 mm tolerance). Always start bending from the centre of the frame piece. See Fig.47

Step 2 Bend F2, F3 and F4 to the elliptic shape (Positions compare Fig.29). Ensure that the **INNER EDGE FOLLOWS THE CURVE PRECISELY** (±0.5 mm tolerance) See Fig.48

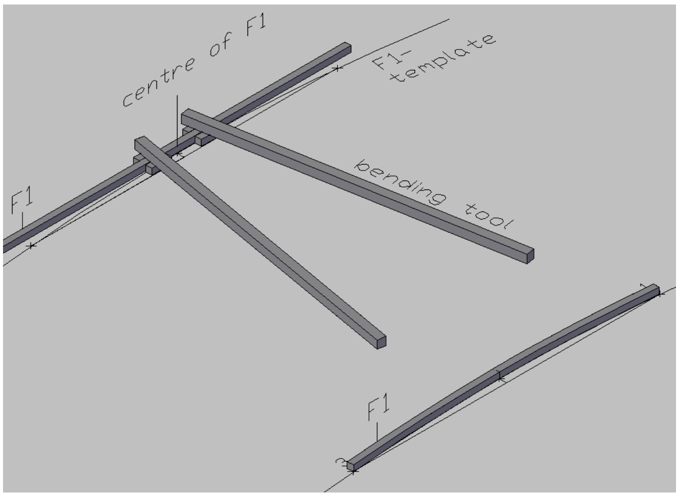


Fig. 47: Bending of F1

Step 3 Make sure that there's no gap between two neighbouring frame pieces by cutting them to the according length and angle. The centre of F3 and F4 has to be on the long axis of the ellipsis.

Step 4 Mark the positions of the Crossbars and Centrebar on the frame pieces

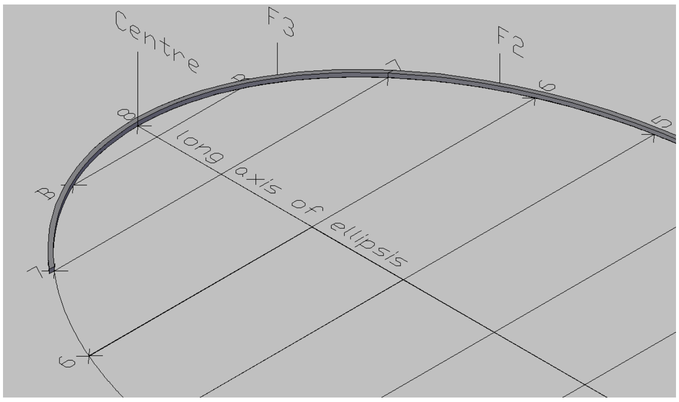


Fig. 48: F2, F3 on Template

Step 5 Weld the attachment pieces for points A (F5) perpendicular to F2 as shown in Fig.49

Step 6 Correct the welding-distortion and **RECHECK THE CURVATURE** of F2 with the template.

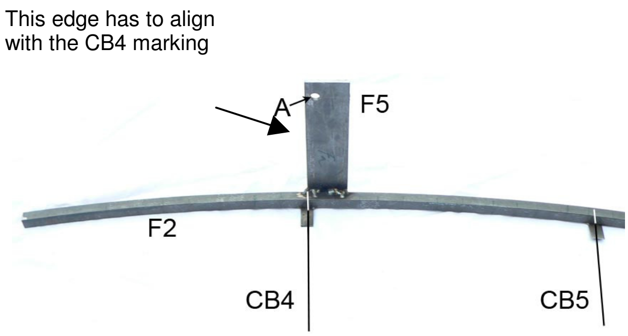


Fig. 48: Position of F5

Step 7 Weld the 14 Fcbs (frame crossbar connecters) to F1, F2, F3 and F4. See Fig.50

Step 8 **RECHECK THE CURVATURE AND FLATNESS** of the frame pieces!

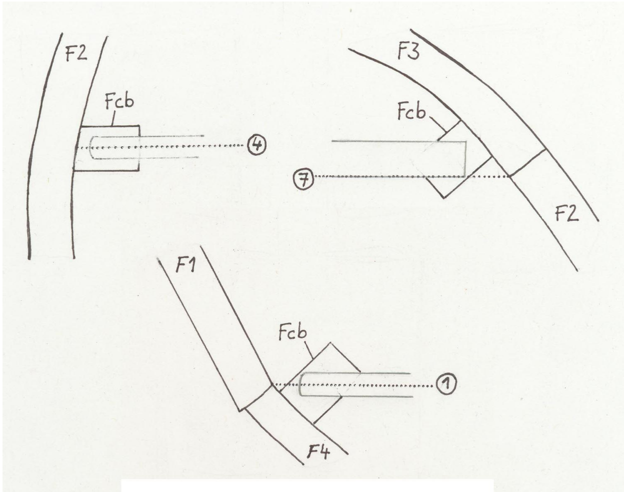


Fig. 49: Positioning Fcbs

Step 9 Lift the frame pieces with distance pieces of same thickness to keep the Fcbs from touching the template. See Fig.51

Step 10 Weld the frame pieces together in the following order by **CHECKING AND CORRECTING THEIR SHAPE AND FLATNESS AFTER EACH WELDING**

- F1s to F4
- F2s to F3
- F2 to F1

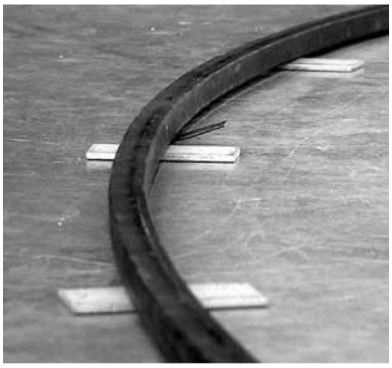


Fig. 50: Lifting the frame pieces before welding

7.5 Assembly of Reflector

Step 1 Lift the frame from the template with distance pieces of the same height (around 20mm high). See Fig.52

Step 2 Hold the Centrebar (FC1) in place (crossing beneath the frame at marks 0 and 8) and tie it with wires through the 3mm holes to the frame. See Fig.52

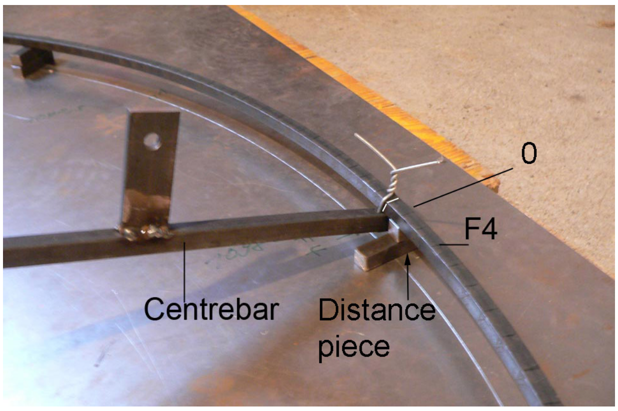


Fig. 51: Centrebar fixation

Step 3 Put a support beneath the Centrebar so that the upper edge of the Centrebar at the CB4 crossing is 137mm above the distance piece (same height as underneath the frame). See Fig.53.

Step 4 Push CB4 through the FCcb and centre it.

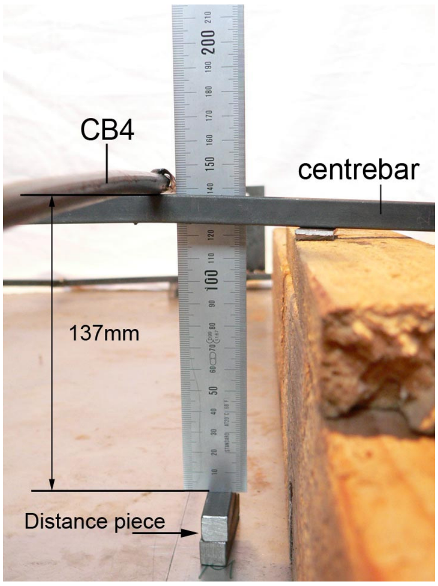


Fig. 52: CB fixation

Step 5 Align CB4 such that its centreline is **EXACTLY ALIGNED** with Line 4 on the template. The inner edge of CB4 is guiding to the inner edge of the frame (dashed line in Fig.54) For proper fitting, adjust the bends of Fcbs. See Fig.54. Do not force any of the CBs to fit, cut them to the correct length if necessary.

Step 6 Weld the CB4 to Fcb at both sides

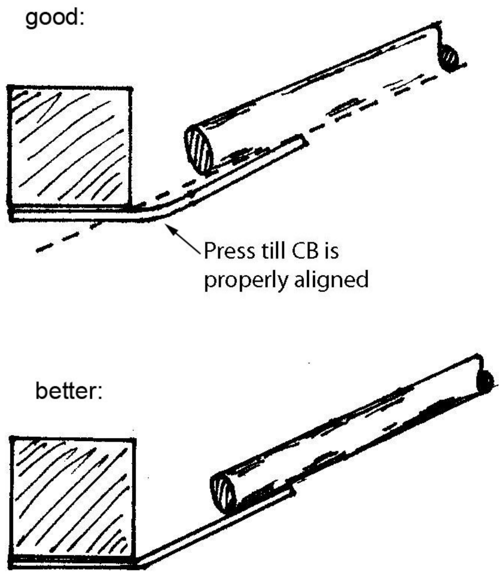


Fig. 53: Alining CBs

Step 7 Check if the Centrebar (FC1) is centred. Attach CB4 to FCcb by **SPOT WELDING** (Too much heat will distort the CB). See Fig.55.

Step 8 Repeat Step 4 to 7 for CB1, CB6, CB2, CB3 and CB5.

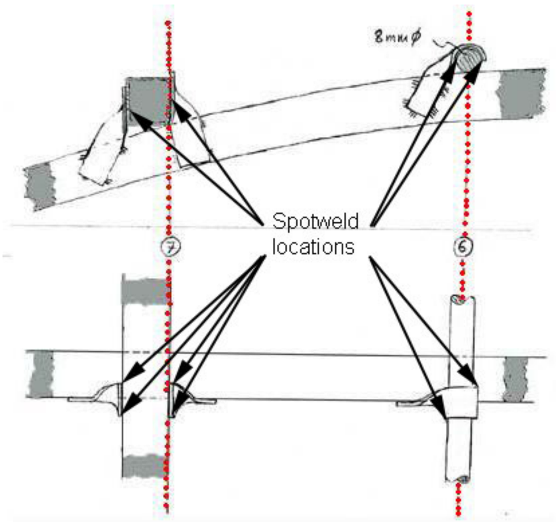


Fig. 54: Spot welding CBs

Step 9 Place CB7 on the Centrebar as shown in Fig.55. The flush edge of CB7 has to align with Line 7 on the template. See Fig.56. Continue in the same manner as for the previous CBs.

Step 10 Once all the CBs have been spot welded, turn over the whole Reflector and finish the all-round welds between CBs and Fcbs and FCcbs. **BEWARE OF DISTORTION!**

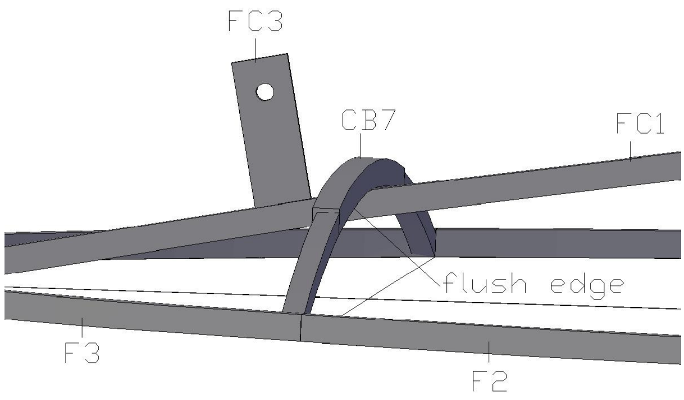


Fig. 55: CB7 aligning

7.6 Seasonal Adjustments

Two seasonal adjustment pieces are needed; the long one for adjusting the bottom half of the reflector surface, and the short one for adjusting the top half of the reflector surface.

Fig. 56: Seasonal Adjustment

Position	Pieces	Type	Dimension [mm]	Length [mm]
A1	1	round tube	outer ∅ variable, inner 12 mm	700
A2	1	round tube		500
A3	1	round bar	10	700
A4	1	round bar	10	500
A5	2	round bar	6	100
	6	bolt	M8x40	
	4	nut	M8	

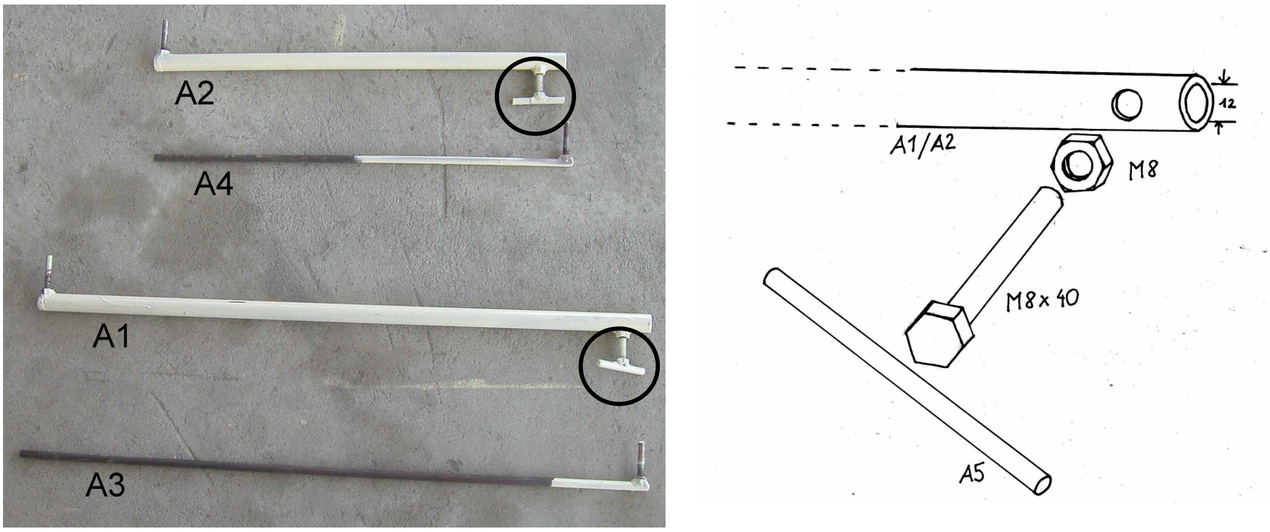


Fig. 57: Making of Seasonal Adjustments

7.7 Joining the Reflector

To attach the Reflector to the Rotating Support, follow the following steps:

Step 1 Attach F5 to R6 from the R6 side with a M10 bolt. Put a nut in between to tighten the bolt to R6. Use another nut and mount it to the bolt from outside. Note that a 10 mm clearance on either side of F5 is required for enabling the Reflector's seasonal distortion → 20mm thread. See Fig.59.

Step 2 Attach R7 (B) from western side to the slot in the Centrebar with a bolt and a nut. Use a washer in between

Step 3 Attach the Southern Seasonal Adjustment (shorter) to R10 and the southern FC3 and, the Northern Seasonal Adjustment to R12 and the northern FC3

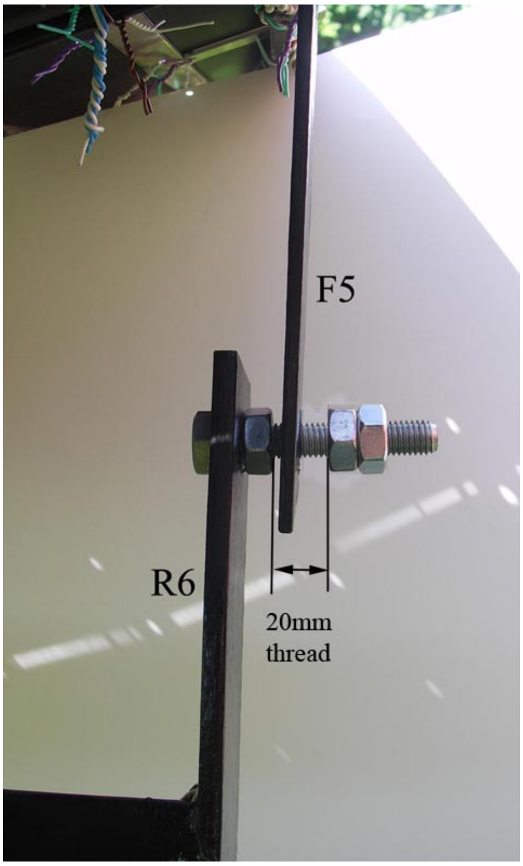


Fig. 58: Thread between R6 and F5

8 Cooking Area

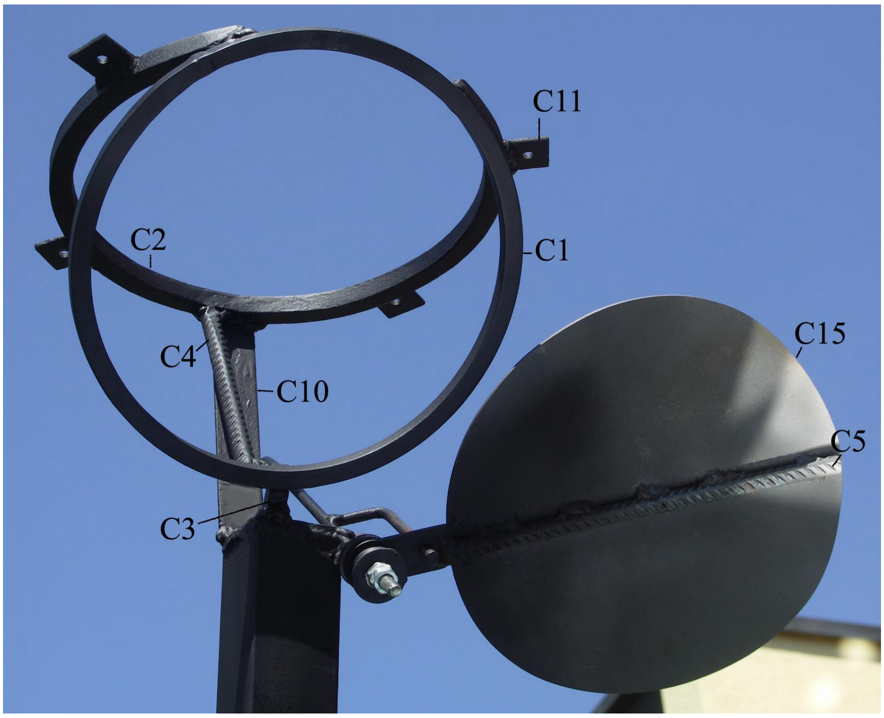


Fig. 59: Cooking Area

Position	Name	Pieces	Type	Dimension [mm]	Length [mm]
C1	focusing circle	1	square bar	12x12	1030
C2	cooking circle	1	square bar	12x12	910
C3	attachment focusing circle to S4	1	square bar	10x10	70
C4	bracing piece	1	round bar	10	Depending on latitude
C5	shutter support	1	round bar	10	200
C6	shutter handle	1	round bar	8	400
C7	shutter handle	1	round bar	8	100
C8	spring	1	round bar	4	400
C9	shutter handle	1	flat iron	40x3	60
C10	bracing piece	1	flat iron	40x3	Depending on latitude
C11	Cooking surface attachments	4	flat iron	25x3	25
C12	shutter handle	1	bolt	M8x70	
C13	shutter handle	2	nut	M8	
C14	shutter handle bearing	2	nut	M12	
C15	shutter	1	sheet	thickn. 2-3 Ø 230	
	Cooking surface fixation	4	bolt	M6x20	
	Cooking surface fixation	4	nut	M6	
	Shutter handle	2	washer	M8	

Cooking surface	1	aluminium sheet	600x610x2
Secondary reflector	1	reflective aluminium sheet/ aluminium sheet with aluminium foil	Depending on latitude x1

Focusing Circle:

Bend C1 to a circle with 220mm inner diameter.

Bend it around a round template, e.g. a pot and cut the spare material (circle will require 730 mm)

Cooking Circle:

Use the same template as for C1 to bend C2 (open circle will require 610 mm). Leave a gap of 120mm in the arc where it will be welded to the focusing circle.

Weld C11s after drilling the 6mm holes flush to the Cooking circle in one section

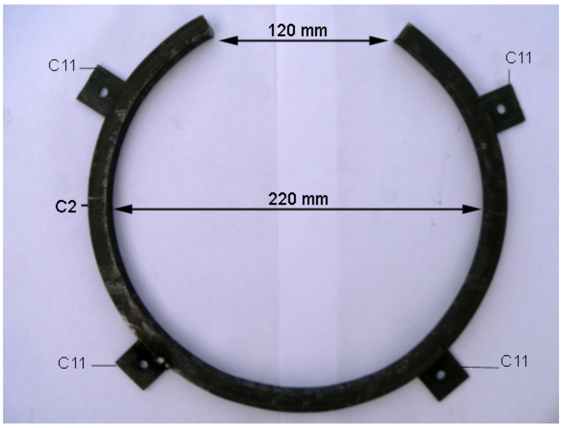


Fig. 60: Cooking Circle

Handle and Shutter:

Step 1 Bend C6 as you can see in Fig.62. and weld it to C12

Step 2 Weld the two C14s together, they will serve as bearing for the shutter.

Step 3 Weld C15 to C9

Step 4 Brace C15 by welding C5 on to it.

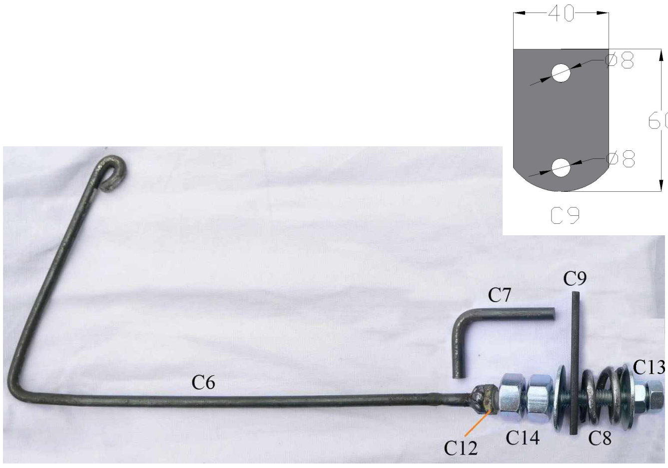


Fig. 61: Handle

Aluminium Cooking Surface:

Cut out the cooking surface as shown in Fig.63. Bend it along the dashed lines. See Fig.64.

Bend up the rim of the hole a bit with a pair of pliers. Then place it on the Cooking circle (C2) and drill the holes through the C11s. See Fig.65.

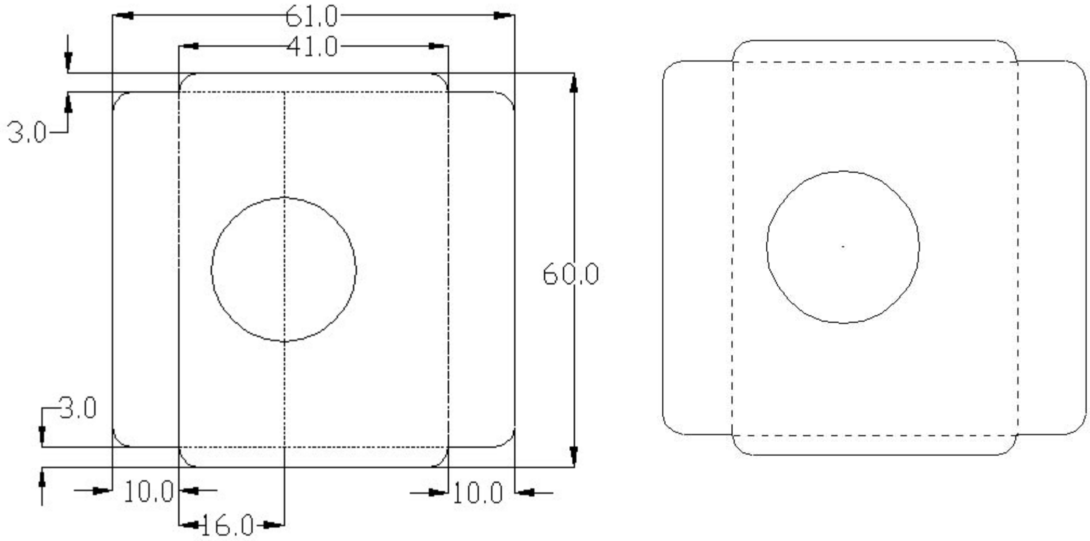


Fig. 62: Template of aluminium cooking surface

Fig. 63: Making of aluminium cooking surface

Fig. 64: Marking holes for C11

8.1 Assembly Cooking Area

Step 1 Weld the Focusing Circle (C1) to S4 using C3. It has to be

- with the **EXACT DISTANCE** from the back bearing to the centre 2459,5 mm
- with its centre in the axis of rotation (use a string through the main bearings to figure the axis of rotation and make a string cross in the Focusing circle)
- perpendicular to the axis of rotation

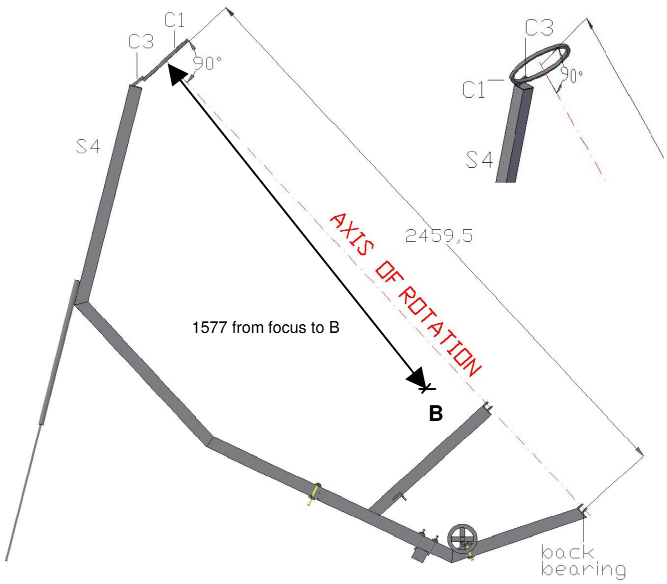


Fig. 65: Attaching Focusing Circle

Step 2 Weld the Shutter handle bearing (C14) to the east side of S1, make sure that

- C14 is parallel with the axis of rotation
- C15 is properly aligned with a clearance of about 1 cm to the Focusing circle

Step 3 Weld C7 to C6 in a way that

- it goes through the hole in C9
- the handle is pointing eastwards with closed shutter. See Fig.67

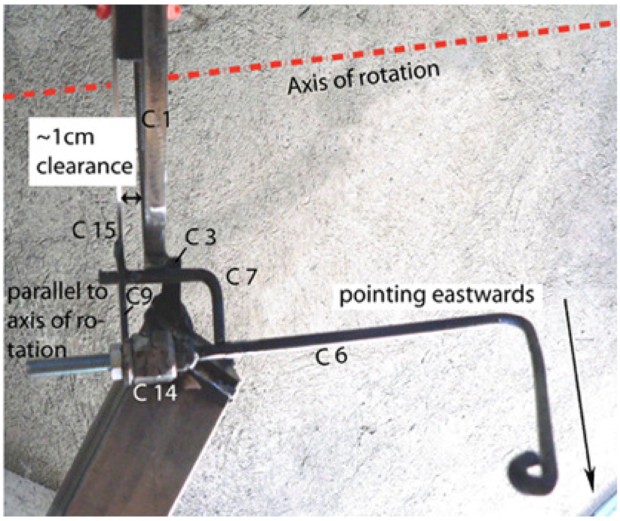


Fig. 66: Mounting shutter and handle

Step 4 Clamp S6 to S1 or S2 using S7s as counterpart. The Axis of rotation has to be parallel to the polar axis, according to the latitude of your place. See Fig.69.

You might have to use additional pieces of square tube for more stability as you can see in Fig.2.

Step 5 Weld C10 to S4.

Step 6 Weld the C2 to C10 and C1. It has to be horizontal. Use a spirit level. See Fig.68

Step 7 Stabilize C2 with C4. See Fig.60.

Fig. 67: C2 fixation with spirit level

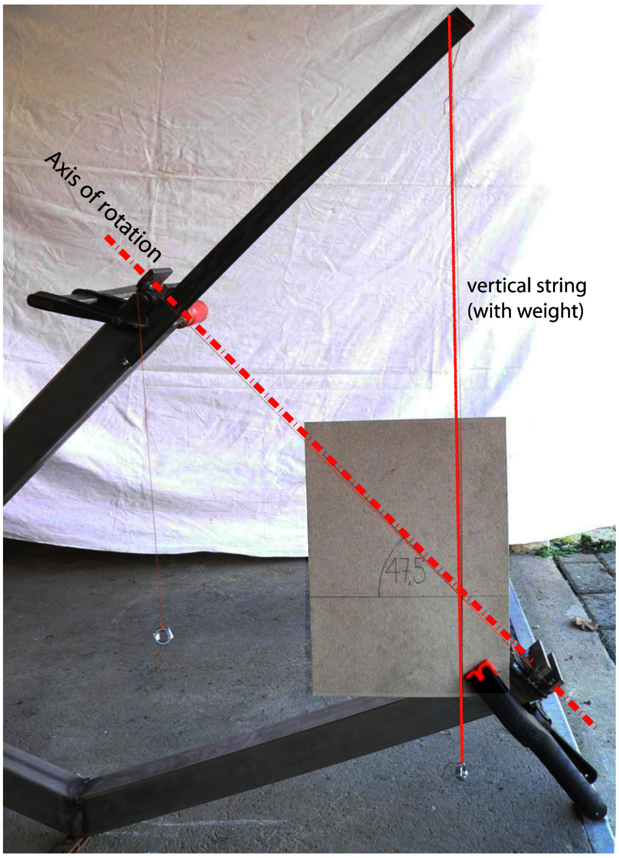


Fig. 68: Aligning of Axis of Rotation in Zürich, 47.5°N

Secondary Reflector:

Use a piece of strong paper to draw and cut out the shape between the southern edge of the Focusing circle and the border of the hole of the Cooking surface. Use it as template to cut out the secondary reflector of the reflective aluminium sheet. Drill small holes to fix it to the Focusing circle with wire. You can also use a normal aluminium sheet and cover it with aluminium foil.

Fig. 69: Shape Secondary Reflector, according to latitude.

Fig. 70: Secondary reflector fixation

9 Completing the cooker

9.1 Equinox setting and Frame flatness

Mount the Rotating Support to the stand, and the Reflector to the Rotating Support. Attach the Seasonal Adjustments.

Equinox setting:

The Equinox position is very important as it is used for checking frame flatness as well as for fixing mirrors.

Step 1 Open both Seasonal Adjustments fully so that they can move freely

Step 2 Attach a thin string to the bolts of the reflector attachment so that it is centred over CB4 and taut.

Step 3 Using a ruler, measure from the top of CB4 at the Centrebar to the string (depth of parabola at centre, compare Fig.52). Tilt the reflector back and forth until the distance is 137mm.Do not touch the Seasonal Adjustment during this step!

Step 4 Tighten the Northern Seasonal Adjustment, ensuring that the distance from CB4 to the string remains 137mm

Step 5 Tie a second string to the frame as close to the Centrebar as possible from North to South. This string must pass underneath the first string.

Step 6 Adjust the Southern Seasonal Adjustment until both strings touch

Step 7 Close the Southern seasonal Adjustment

Step 8 If the distance does not stay at 137 mm, continue to adjust using one Seasonal Adjustment at a time, until the strings touch and the distance is correct

Step 9 Leave the strings for checking **Frame flatness:**

Step 10 Hold a third thin string between the opposite ends of CB1 and CB7

Step 11 Move one end of the third string up and down until all three strings touch at the centre.

Step 12 Measure the distance you had to move away from the frame and write it at that point on the frame

Step 13 Repeat to check the frame joints at CB3 against the joints between CB5 and CB6

Step 14 Once all deviations are marked, look through the two first strings from all angles towards the frame to detect where the bumps or hollows are

Step 15 Correct these deviations by hammering **ON THE JOINTS IN THE FRAME ONLY!** Use a heavy counterpart for hammering.

9.2 Mirror surface

Name/Material	Pieces	Dimensions [mm]	Length [mm]
Mirror, clear glass	~ 240 or 330 + ~ 20 for reserves	90x120 or 80x100 favoured 2mm thick	-
Aluminium flats	-	15xXX 2-3mm thick	all together around 30000
Wire (weather resistent)	-	~ 1mm	~132000

For mirror-cutting jig: wood   For flat-bending jig. See Fig.76: steel angles, wood, bolts

Tools needed:

- File
- Hammer
- Ruler
- Glass-cutting tool
- Pliers .with wire cutter for twisting and cutting wires
- Permanent marker
- Drills, Drill machine

Cutting the mirrors:

Cut the mirror to your preferred size. Build a mirror cutting jig to get equal pieces.

Mounting the mirror surface:

We recommend marking the aluminium flats one by one, always after finishing one row of mirrors.

You can work simultaneous at either side of the Centrebar and stick together two flats of the same position mirror inverted for drilling

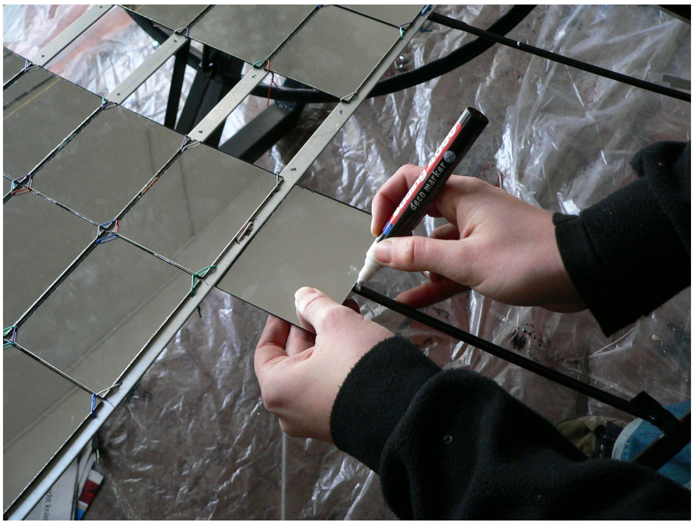


Fig. 71:

Mark the width of one mirror on the CBs. Try to use always the same mirror for the aluminium flat distances to keep constant.

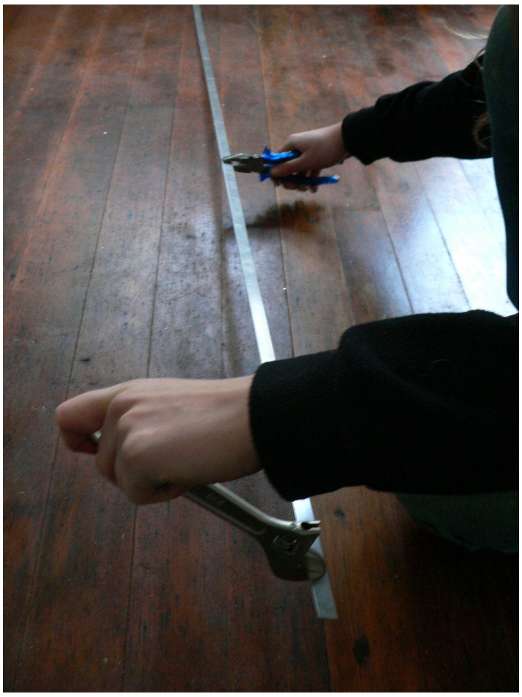


Fig. 72:

Bend out the twists of the aluminium flat

Fig. 73:

Place the flat parallel to the Centrebar.Mark where this flat crosses each Crossbar and the Frame. Cut the flat leaving it overhang 30mm from the frame

Fig. 74:

Because of the curvature of the ellipse, the flat will not go along your markings when posed flush on the CBs. The further away from the Centrebar, the stronger the deviation that has to be corrected

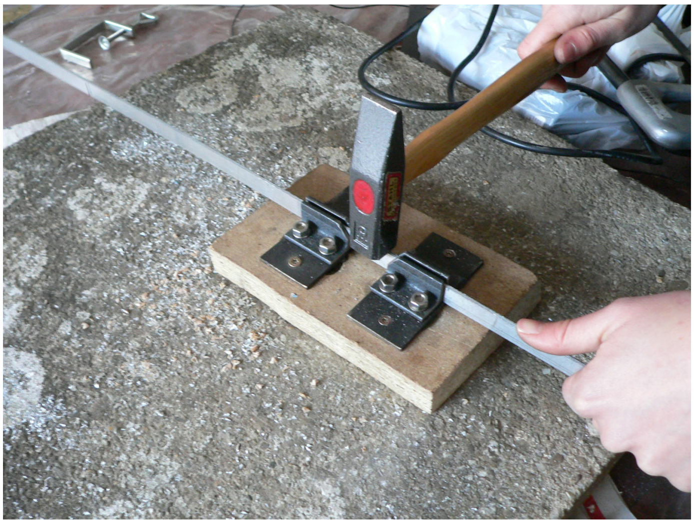


Fig. 75:

With jig: hammer the flat at the CB-cross-markings. Without jig: bend the flat till it lies flat on the CBs along your markings.

Fig. 76.

Fig. 77:

When you reach the outer parts of the frame, you will have to bend the flat around the Fcbs.

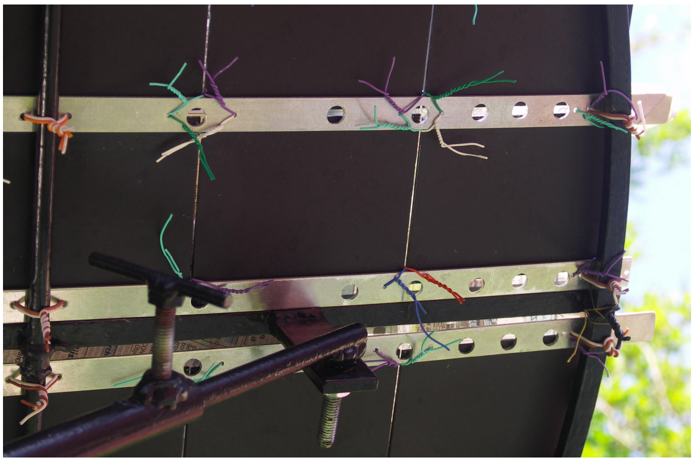


Fig. 79:

For a correct shape towards the outer part of the reflector, weaken the ends of the flats by drilling e.g. holes between the last CB and the Frame.

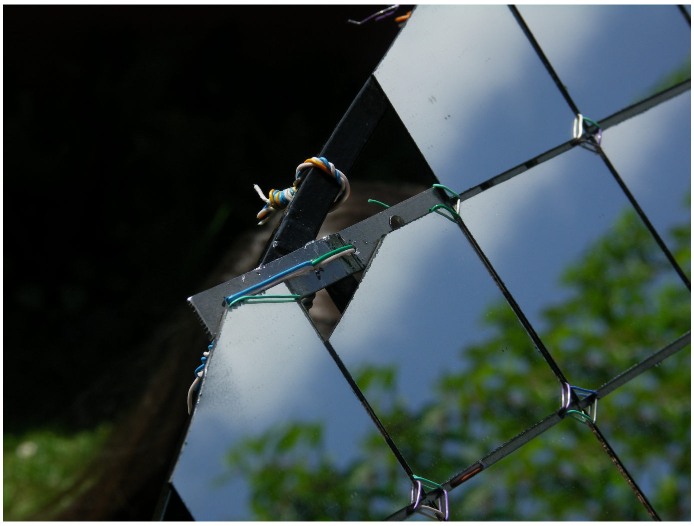


Fig. 81:

Attach the flat to the CBs and the Frame using wire. Bind the mirrors to the flat.
You will need special shaped mirrors at the edges of the frame.

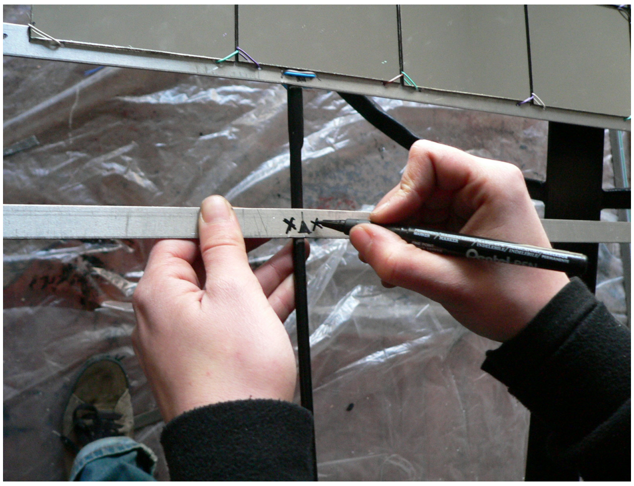


Fig. 78

Mark the places for the holes around the CBs and Frame.

Fig. 80:

Mark the places for mirrors. Then draw dots for holes about 20mm from the mirror-size markings in the middle of the flat.
Drill holes at your markings on the flat. Use diameters depending on the diameter of your wire

Fig. 82:

To attach the most outwards row of mirrors, use small pieces of alu perpendicular to the long Alu flats

10 Appendix

10.1 Compass

Fig. 83: Compass

Name	Pieces	Type	Dimension [mm]	Length [mm]
Tracing tool:	1	Square tube	15x15x1.5	1100
	2	Flat iron	40x2	80
	1	Hacksaw blade with sharpened point		50
3 Holders:	1	Square tube	20x20x1.5	1900
	1	Square tube	20x20x1.5	600
	1	Square tube	20x20x1.5	100
	3	Round bar	6	50
	5	Bolt	M6x25	
	3	bolt	M8x25	
	5	nut	M6	
	3	nut	M8	

Tracing tool:

Drill two holes at the same location into the flat irons. Weld one flat iron to the square tube and bolt the two flats together with the hacksaw in between using 2 M6x25 bolts.

Fig. 84: Tracing tool front view

Holder:

Step 1 Drill an 8mm hole centred into one square tube about 20mm from the end. Weld a M8 nut centred onto it.

Step 2 On the other end of the square tube, weld a M6 nut

Step 3 Sharpen a M6x25 bolt to a point and cut the bolt in a way that you get a 10mm piece with a sharp centred point. Screw it into the M6 nut.

Step 4 Use a M8 bolt and weld one piece of rod to it for better handling

Step 5 Insert the tracing tool into the holder and tighten with the M8 bolt.

Step 6 Repeat steps 2-5 for the other sizes of square tube

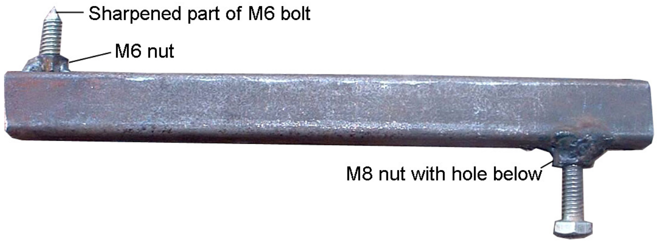


Fig. 85: Small holder

Fig. 86: Tracing tool with small holder

Now you've got a compass with different sizes of holders, each can be used for drawing a specific radius.

Instruction for use:

The compass is used by first setting the distance (measured from the edge of the hacksaw blade to the tip of the sharpened screw) and then placing the point of the sharpened screw in the centre of the circle or arc to be drawn, and holding it firmly while moving the end with the hacksaw blade to make a deep V-groove in the sheet.

10.2 Bending Tools

Name	Pieces	Type	Dimension [mm]	Length {mm]
Bender	2	Square bar	16x16	600
	2	Square bar	12x12	600
	4	Square bar	10x10	400
Parallel pieces	2	Square bar	12x12	40
	6	Square bar	10x10	40

You'll need 4 pairs of bending tools. Each bending tool goes for one material:

- Tool for bending 12x12 square bar: 16x16 bender + 12x12 parallel pieces.
- Tool for bending 10x10 square bar: 12x12 bender + 10x10 parallel pieces
- Tool for bending 6 mm and 8mm rod: 10x10 bender + 10x10 parallel pieces

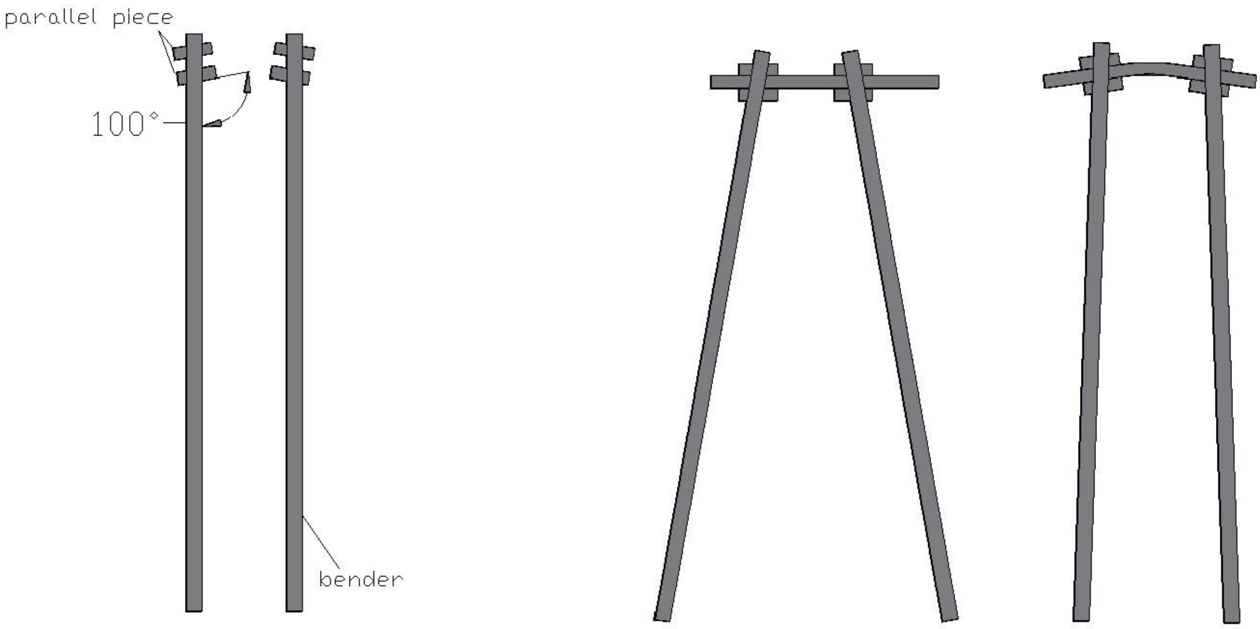


Fig. 87: Bending tools

Fig. 88: Using bending Tools

10.3 Plan

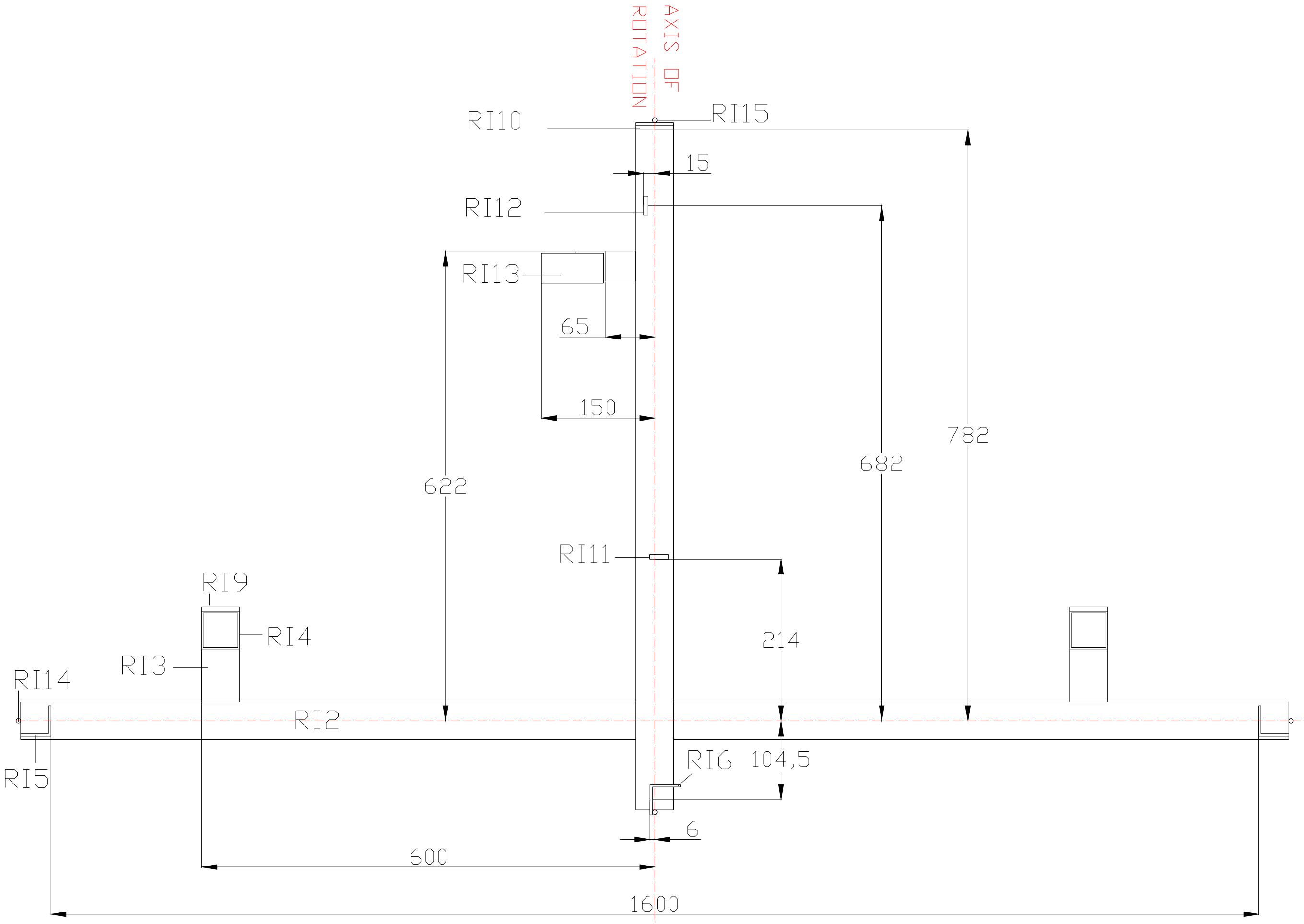


Fig. 89: Rotaiting Support Jig, top

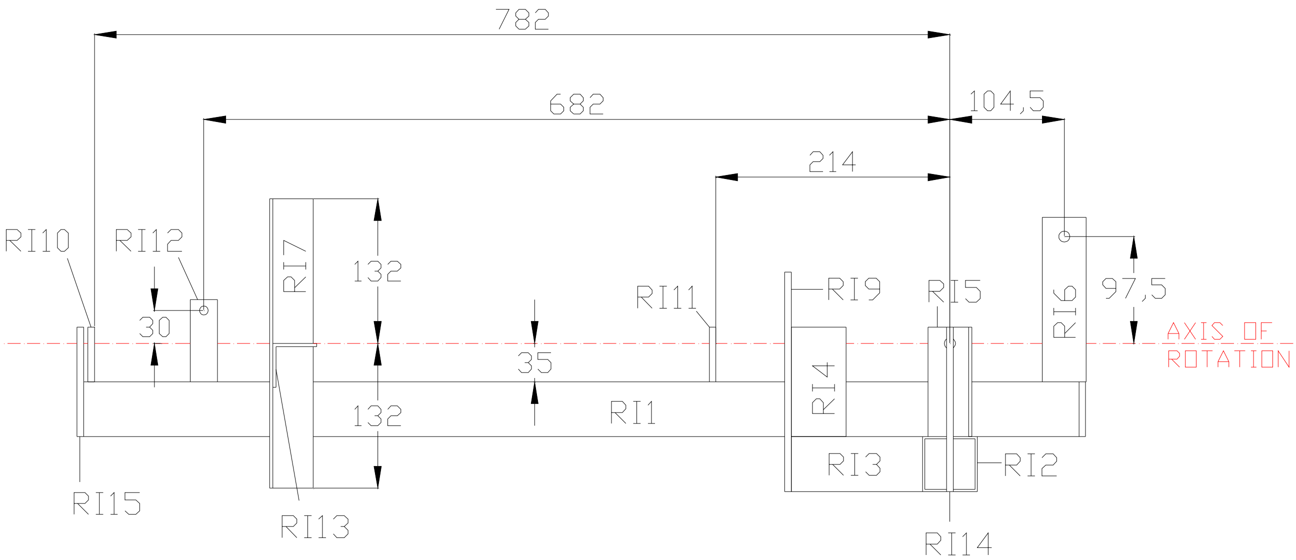


Fig. 90: Rotating Support Jig, left

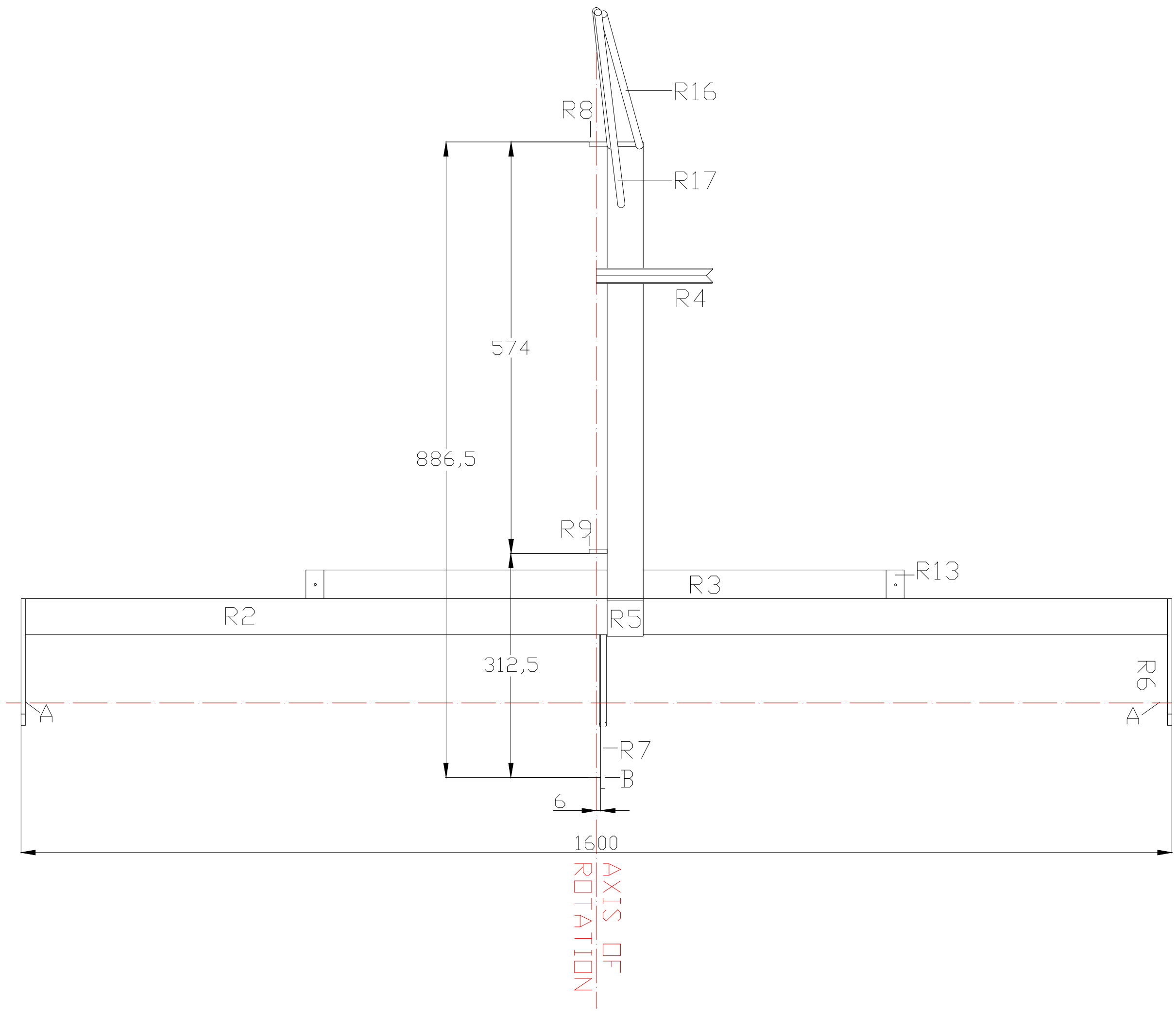


Fig. 91: Rotating Support, top

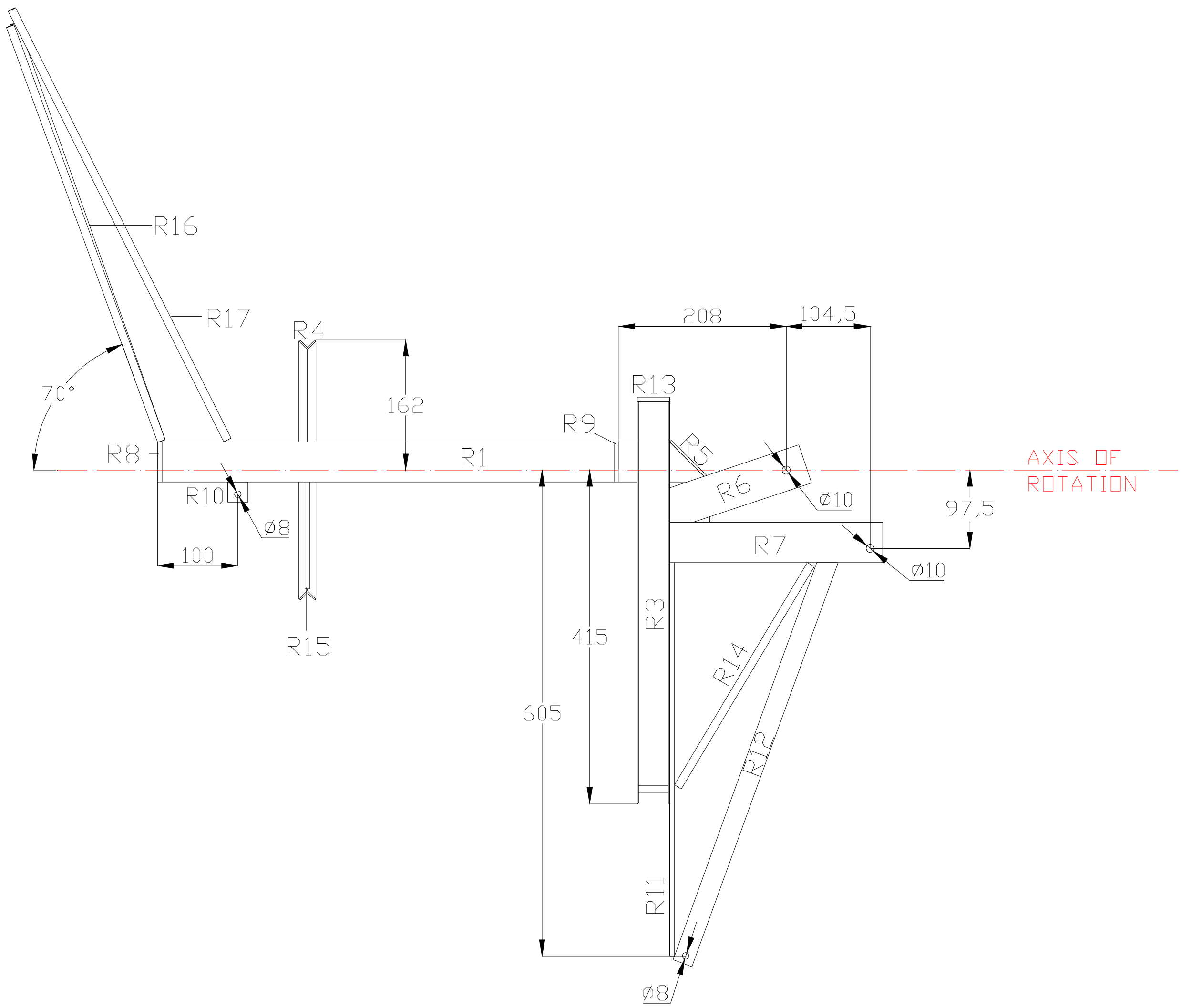


Fig. 92: Rotating Support, left

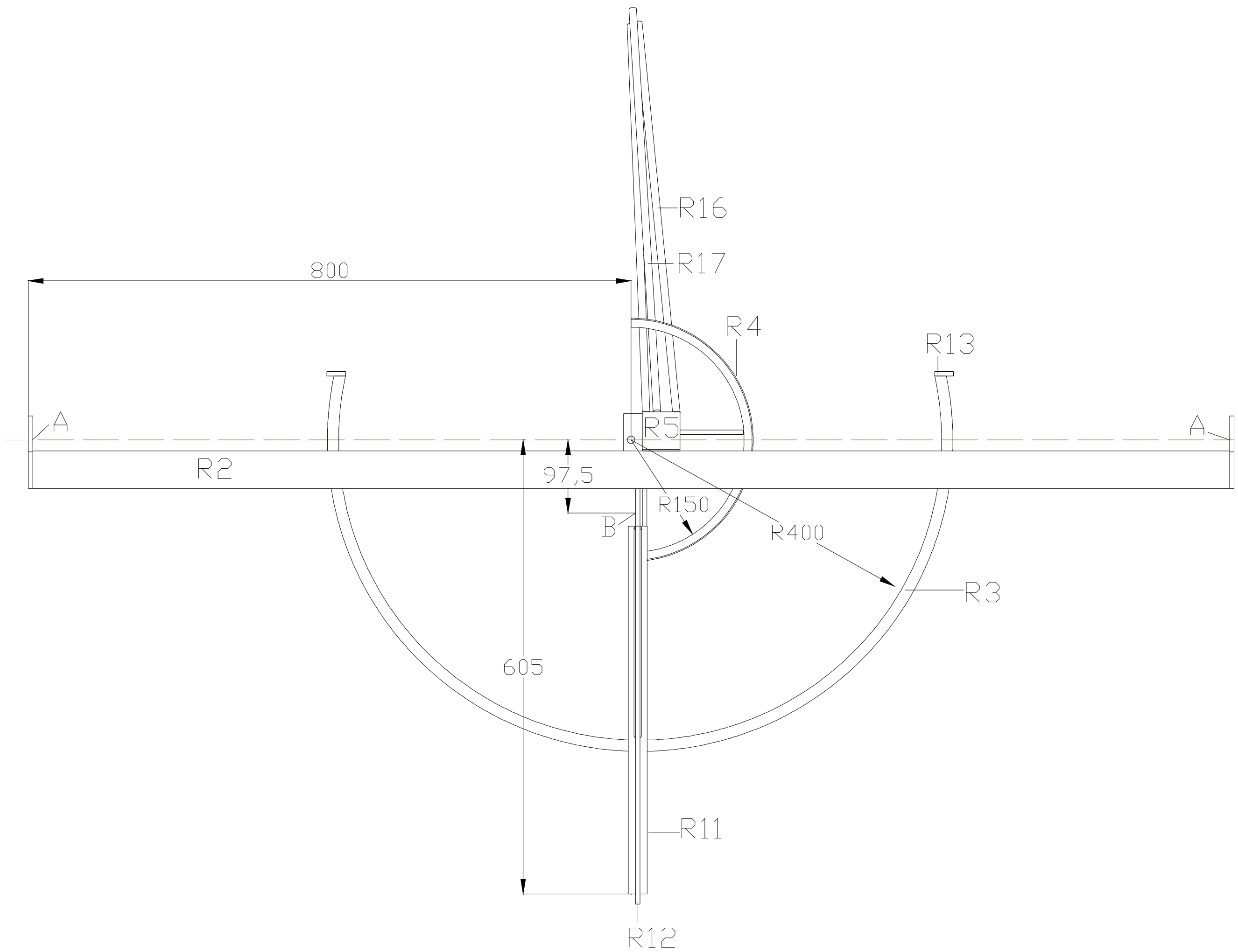


Fig. 93: Rotating Support, front

11 Instruction for use

Positioning:

- Choose a place where no shadows disturb your cooking over the day
- Position the cooker North-South with the help of a compass. For the Northern Hemisphere: The Cooking Place has to be in the North and the Reflector in the South. For the Southern Hemisphere: The Cooking Place has to be in the South and the Reflector in the North
- Check that there are no shadows disturbing over the day
- Put the solar cooker horizontally. If the ground isn't horizontal, level the cooker by adjusting the front adjustable support and the second foot (S6).
- If possible, fix the cooker to the ground, so it can not be thrown over by strong wind

Security:

- Check that your cooker is standing firmly on the ground
- There shouldn't be any inflammable material in a perimeter of about 1m around the Focusing Circle
- Do not look directly into concentrated light, e.g. the focus on the shutter; Use sunglasses!
- Close the shutter always before putting a pot on the cooking circle and before taking it away

Setting a good focus:

- Spin the reflector around the rotation axis towards the direction of the sunlight.
- Seasonal adjustment: loosen the two Seasonal Adjustments and change the inclination of the reflector around the lateral axis until the reflected light falls on the closed shutter. Now tighten one telescope pole to fix one end of the reflector.
    - i) Keep on moving the loose end of the reflector easily up and down until you reach the smallest light spot possible. Now tighten the second bolt.
    - ii) Then loosen the fixed bolt on the other side so you can move this side up and down until you reach the smallest light spot. Tighten the bolt again.
    - iii) Repeat step 1 and 2 until you can not see further improvement.

Cooking:

- It is best to use pans out of a material with high heat conductivity (e.g. aluminium) and with a thick base, to prevent burning the food in the centre, where the heat is strongest
- The base of the pan should be black on the outside to capture the maximum of heat. Use heat resistant black paint or blacken the bottom of the pot on fire.
- Heat regulation while cooking can be done by closing the focusing circle partially with the shutter

Maintenance:

- Clean the reflecting area with water, dish washing liquid and a sponge or a rag, flush it afterwards with water which contains one drop of dish washing liquid (so that all water runs off)
- See maintenance advices for the tracking (www.solare-bruecke.org)

12 Sources

The text is partly copied or very close to a former version of a construction manual for a 2.7 Scheffler Solar Cooker prepared by Jennifer and Robert McArthur and Wolfgang Scheffler at SWRC Tilonia (Rajastan, India, Version 1 – February 2005).

Chapter 10; Instruction for use, is related to descriptions of the Construction manual for the 2m² Scheffler Reflector by Daniel Philippen, Adrian Konrad, Benjamin Leimgruber (Jahr 2003).