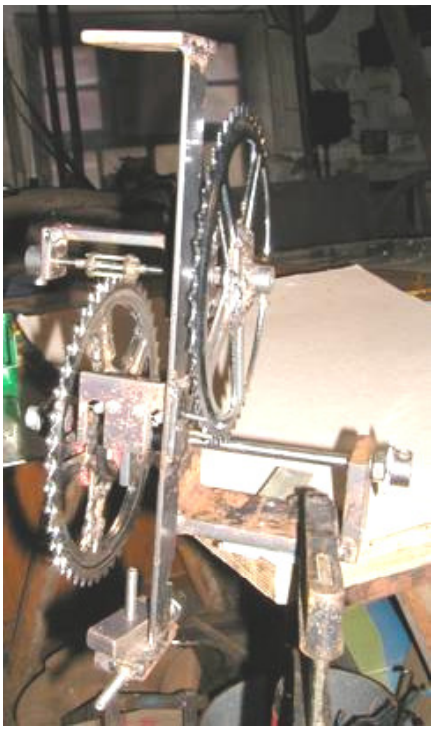
Tracking-System for Scheffler-Reflectors of 8 or 10 m²
Mechanical Clockwork

By
Matthias Leuenberger
Heike Hoedt

The force for rotating the reflector is given by a weight of ~50kg which is applied to the axis of rotation. The weight is pulled up manually when the reflector is rotated into its morning position. Now the weight wants to fall down – with the effect of rotating the reflector into its evening position very fast. In order to keep the focus in a fixed position the rotational movement of the reflector has to be slowed down → the weight has to fall with the same speed the sun travels across the sky. A mechanical clockwork can be used as a breaking system. The pendulum will give way to the fall of the weight at intervals (period of the pendulum) that allow the reflector to rotate simultaneously with the sun.



Great care has to be taken when manufacturing the clockwork, because it is very sensitive to friction. The gear ratio of the clockwork described here is calculated for a radius of the tracking channel of 800mm. The speed of the pendulum is adjusted to 2.35 sec per period by fixing weights (washers, nuts,..) at the three bolts of the pendulum. The pressure on the clutch has to be adjusted once manually: it shouldn't be to difficult to turn the reflector manually and on the other hand it must not slip and give way to the fall of the weight (even at higher wind speeds).

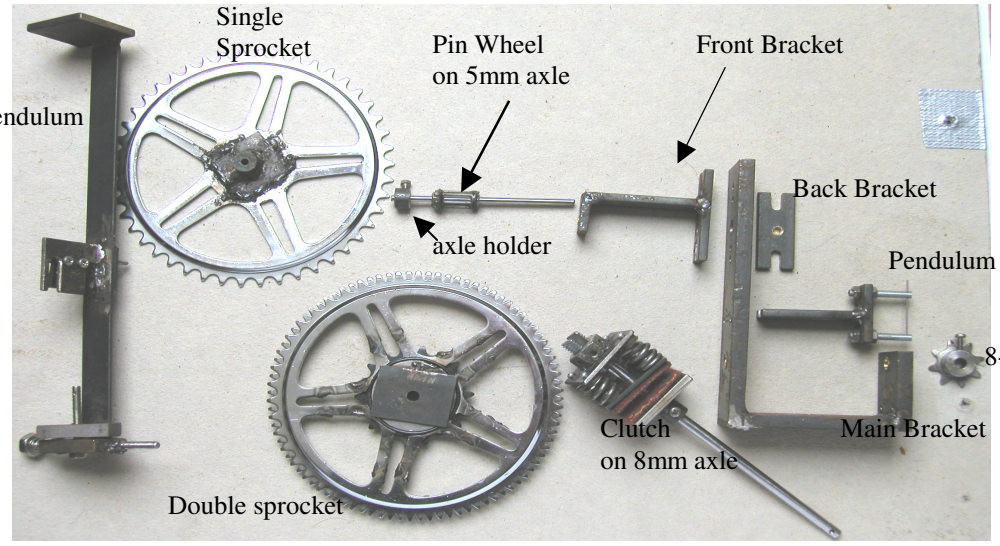
Reflector in evening-position
→ weight down on the ground

Cutting List:

Profile	Description	Dimension	Length	Name	Page
	Flat bar	50mm x 10mm	200mm	MB1	3
	Flat bar	50mm x 10mm	95mm	MB2	3
	Flat bar	50mm x 10mm	60mm	MB3	3
	Flat bar	50mm x 10mm	30mm	P3	7/8/9
	Flat bar	50mm x 10mm	20mm	P4	7/8/9
	Flat bar	50mm x 6mm	50mm	P1	7/8/9
	Flat bar	50mm x 6mm	50mm	C1	10/11
	Flat bar	50mm x 3mm	50mm	C3	10/11
	Flat bar	50mm x 3mm	50mm	C4	10/11
	Flat bar	40mm x 3mm	50mm	P5	7/8/9
	Flat bar	40mm x 3mm	40mm	(TS1)	12
	Flat bar	40mm x 3mm	40mm	SS1	13
	Flat bar	40mm x 3mm	50mm	DS1	14/15
	Flat bar	40mm x 3mm	50mm	DS2	14/15
	Flat bar	25mm x 6mm	70mm	FB2	5
	Flat bar	25mm x 6mm	70mm	FB3	5
	Flat bar	25mm x 6mm	65mm	PH1	6
	Flat bar	25mm x 6mm	60mm	BB	5
	Flat bar	25mm x 6mm	45mm	PH2	6
	Flat bar	25mm x 6mm	30mm	FB1	5
	Flat bar	25mmx 3mm	30mm	P6	7/8/9
	Flat bar	25mmx 3mm	315mm	P2	7/8/9
	Flat bar	25mmx 3mm	40mm	P7	7/8/9
	Round bar	16mm diameter	50mm	special punch	4
	Round bar	16mm diameter	18mm	C2	10/11
	Round bar	16mm diameter	10mm	(TS2)	12
	Round bar	16mm diameter	10mm	SS2	13
	Round bar	16mm diameter	10mm	AH	17
	Round bright bar	8mm diameter	215mm	8mm axle	10
	Round bright bar	5mm diameter	145mm	5mm axle	17
	Angle iron	40 x 40 x 3mm	80 mm	clock holder	
	Angle iron	40x40x3	50mm	Chain guard	

Two axles are required for the clock: one 5mm diameter (145mm long), and one 8mm diameter (215 cm long). Check that the iron rod (bright bar) is straight. If you can't insert the axles into their bushings easily: file the ends a bit round.

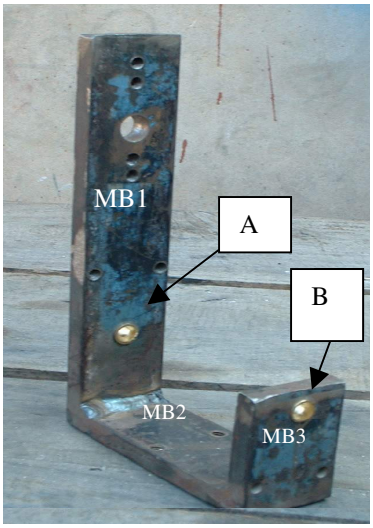
1. Components



Without photo:
Chain Guard

1.1. Main Bracket

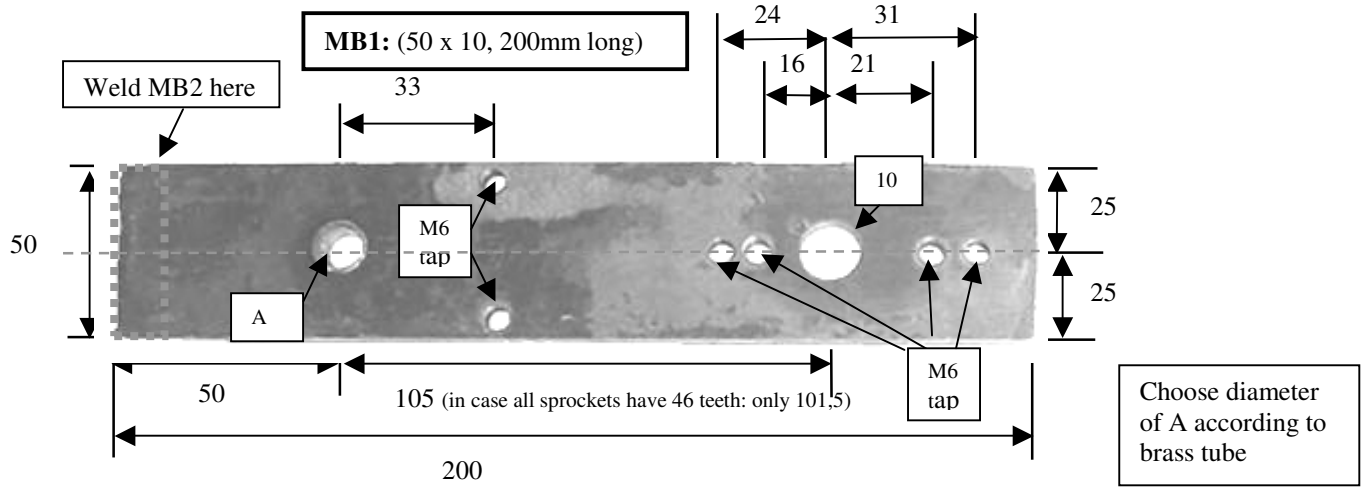
Completed main bracket:



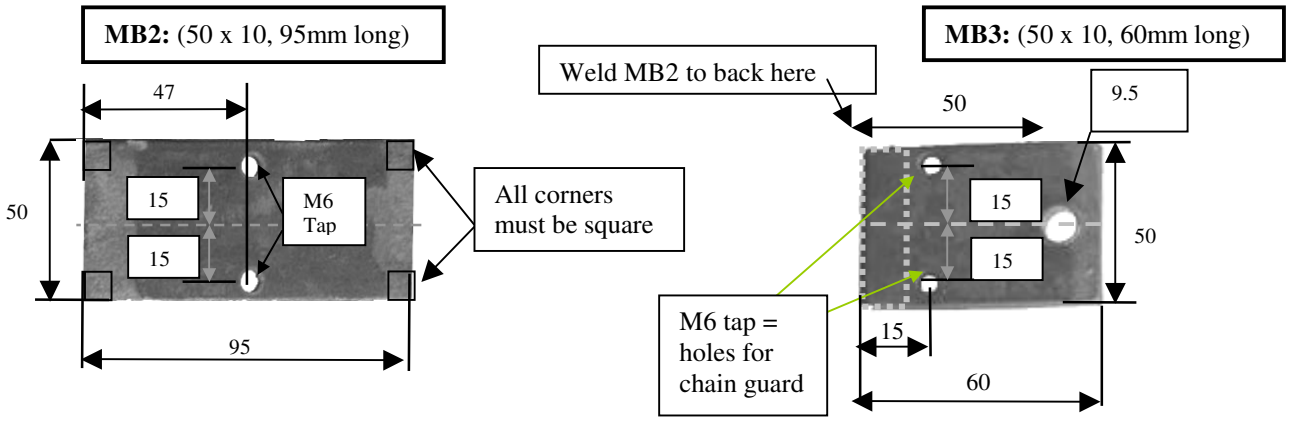
The main bracket consists of 3 parts made from 50x10mm flat iron (pieces MB1, MB2 and MB3) and two brass bushings (10mm outside diameter, 8mm inside diameter) that are inserted into the holes (A and B).

First cut the pieces and drill (thread) all the holes. Then insert the bushings into holes A and B (details on page 4). Then weld MB1, MB2 and MB3 together. For smooth functioning of the clockwork it is very important that the main bracket is square and the holes for the axle are well aligned. Please follow the process described on page 4.

MB1 (all dimensions are in mm)

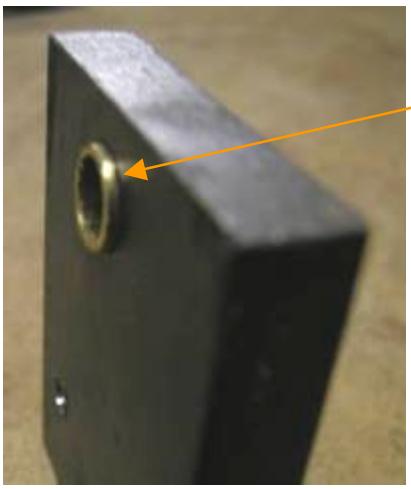


MB2 and **MB3** (all dimensions are in mm)

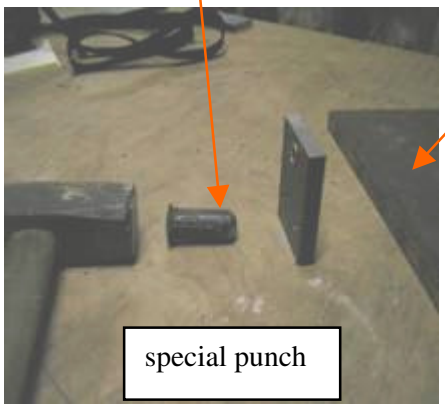


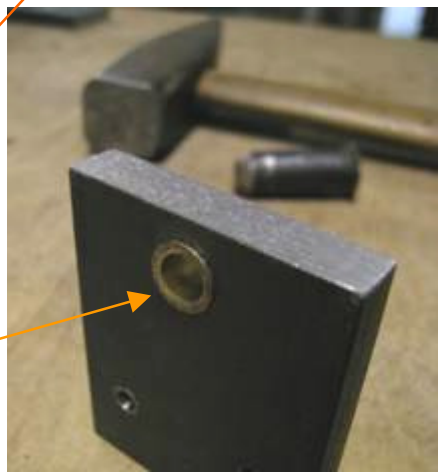
The Bushings

The brass bushings are mounted in the holes in the main, front and back brackets.
You need a special tool – a special punch, which you can make out of 16mm iron rod, ~50mm long. Grind one side completely round.



Insert the brass tube in the hole with the outer diameter of the brass tube (inner diameters of the brass tube has to be the same as the axle diameters, 8mm and 5mm) and cut it, so that the brass tube will stand out 1mm on each side.
Hit with the round side of the special tool from both sides, so that the tube widens up and forms a rim. Take a piece of iron as counterpart for hitting.





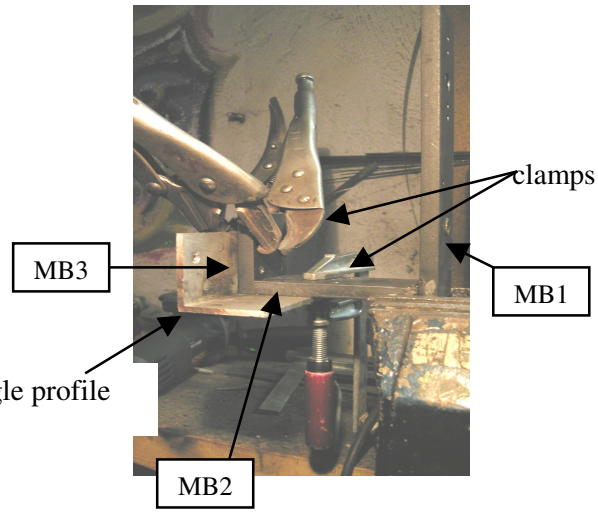
When the brass tube can't move anymore, hit it (relatively) flat on both sides. Pass the 8mm (or 5mm) drill through (very straight!). If necessary file a little until you can insert the axle and it runs smoothly.

Now weld the main bracket:

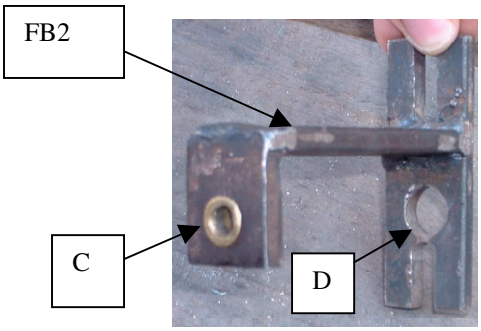
When the alignment is correct, weld one end of MB2 to MB3.
To join MB1 you can insert a piece of 8mm diameter steel rod (which will be the lower axle) through holes A and B (the bushings might need to be filed slightly so that the axle runs smoothly) as a guide. Use clamps and angle profile!

Ensure that the main bracket is exactly square. It helps to clamp the two parts (firmly) to a angle profile (check squareness of the angle profile beforehand).
After welding check for squareness and alignment.
(If not correct you will have to start again.)

MB3 will be welded to MB2:



1.2. Front Bracket

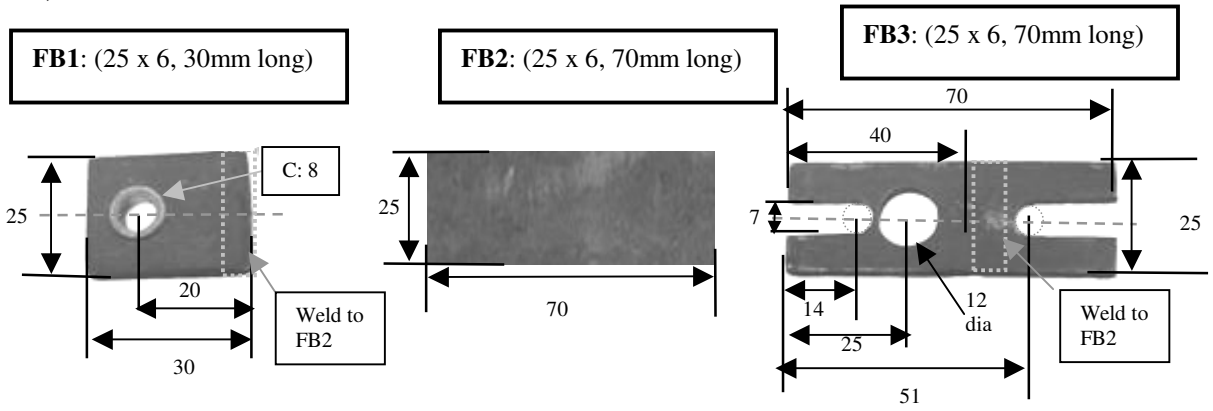


Material:

- 3 pieces of 25x6mm flat iron (FB1, FB2 and FB3)
- one brass bushing (8mm outside diameter, 5mm inside diameter) that is inserted into hole C.

The Front Bracket is attached to the Main Bracket with 2 M6 x 15mm bolts with washers.

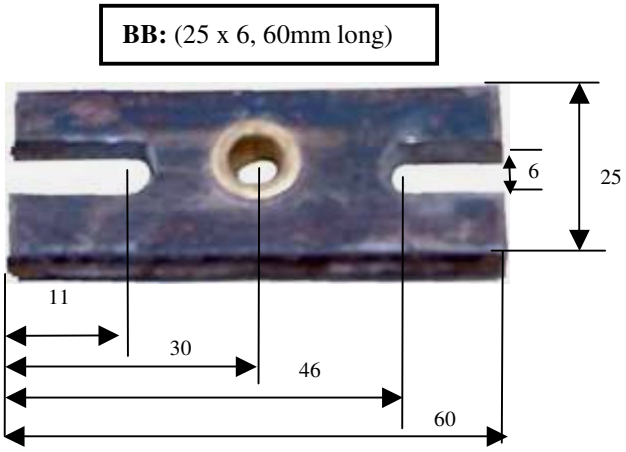
FB1, FB2 and FB3 :



Once the pieces have been cut and the holes are drilled, insert the bushing into hole C (view page 4). Then weld pieces FB1 and FB2 together. Check the angle between the pieces to make sure that it is 90° (squareness). Insert a piece of 5mm diameter steel rod (bright bar = 5mm axle) through holes C and D to get FB3 aligned properly (the bushing may need to be filed slightly so that the axle runs smoothly). When the alignment is correct, weld piece FB3 to piece FB2.

1.3. Back Bracket

Use bushing with 5mm inner diameter. For the slots drill a 6mm hole at 11mm and at 46mm, then cut the slot. File edges.
The back bracket is attached to the Main Bracket with 2 M6 x 15mm bolts with washers.



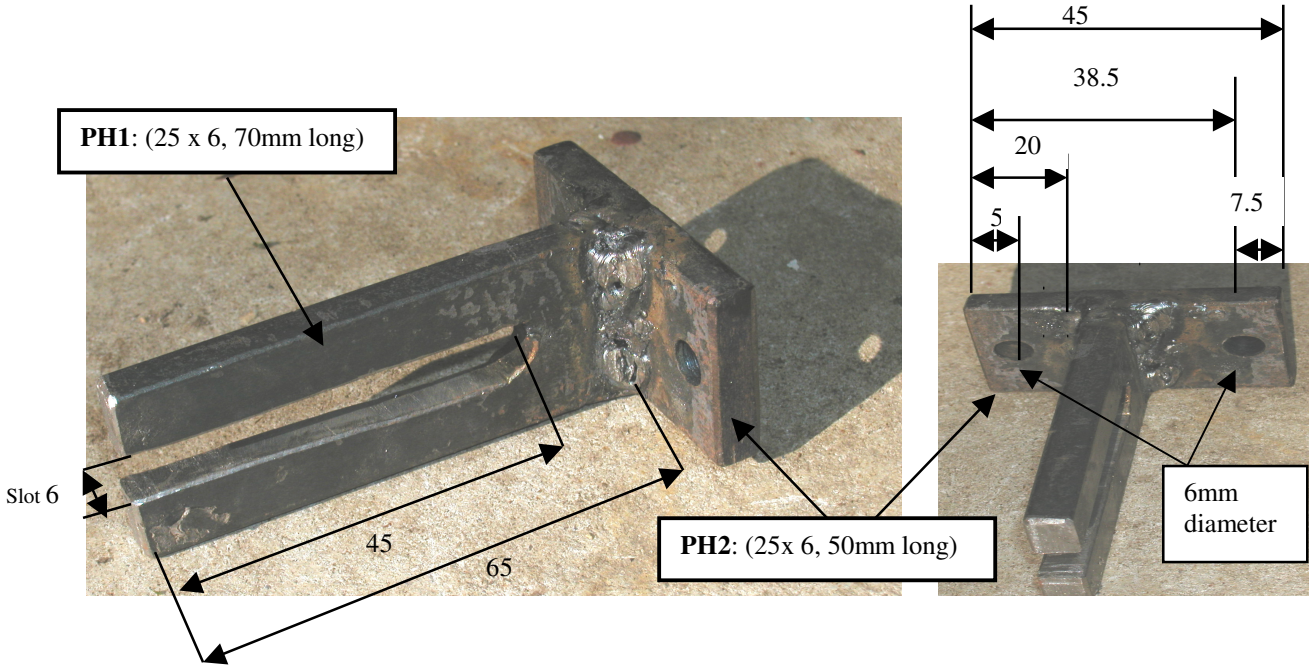
1.4. Pendulum Holder

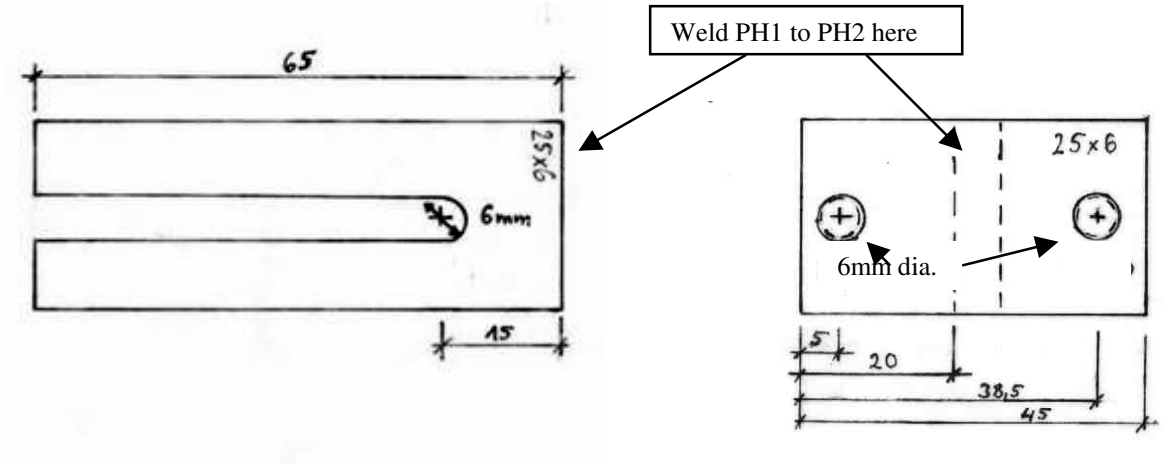
Material:

- two pieces of 25x6mm flat iron for PH1and PH2;
- two M6 x 55mm bolts (or longer bolts cut to length)
- four M6 Nuts
- one large best quality (hard) sewing needle (40mm long, 1mm diameter, eye cut off)
- or better: use 2mm hardened pin

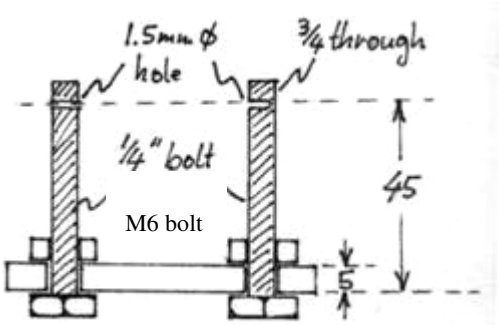
The Pendulum Holder is attached to the Main Bracket with 2 M6 x 15mm bolts with washers.

For the slot in PH1 first drill a hole at 45mm, then cut the slot and file the edges. Drill the holes in PH2. Clamp PH1 to PH2 in the correct position and weld them together. Check squareness.

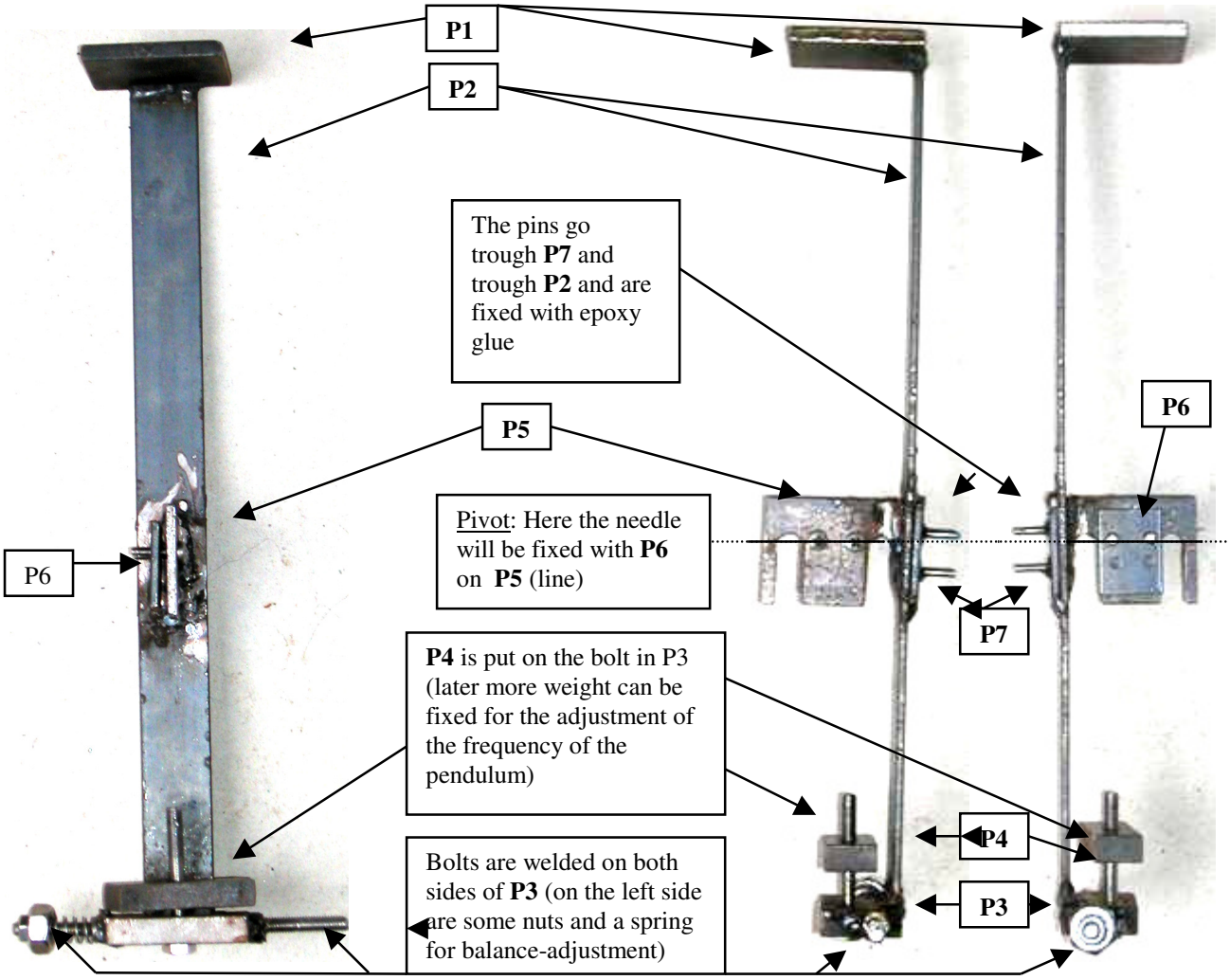




Cut the head of the M6x55 bolts (so that the rest is 55mm long).
Drill 1.5mm diameter holes (2,5mm for 2mm pin) into each bolt, 5mm from the end.
Attention: in one bolt the hole goes through all the way. In the other bolt it enters only ¾ into the bolt (dead end).
Put the bolts through PH2, the one with the 75%-hole on the shorter part of PH2 (witch measures only 20mm from PH1) and attach the nuts on both sides. The holes are about 40mm up the bolt (measured from the top of the plate), but they will be adjusted later.



1.5. Pendulum

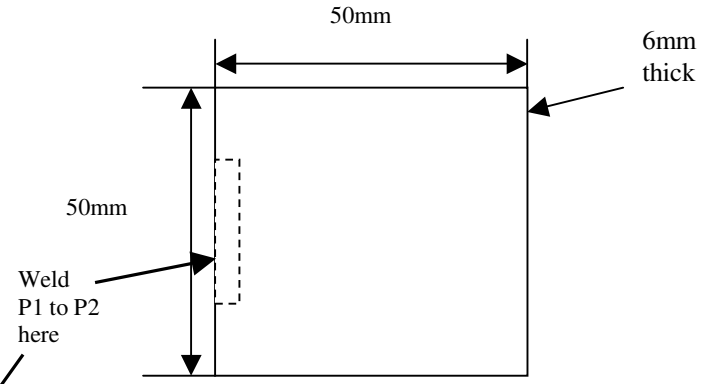


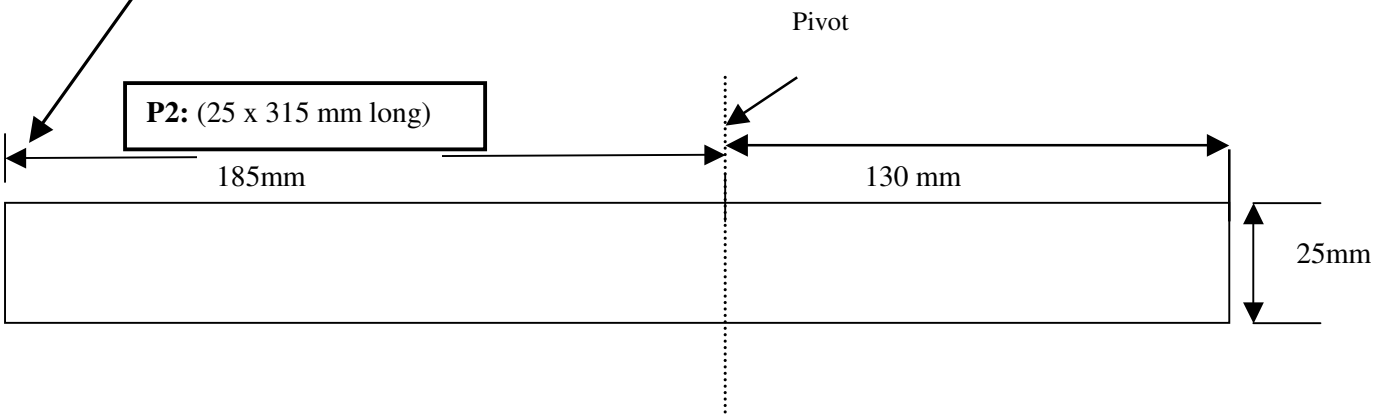
The pendulum consist of eight pieces (see drawings below for dimensions). When all pieces are prepared and the holes are drilled, weld P1, P3, P7 to P2 (take care, that the pivot is exactly between the two holes in P7).
Now drill the holes in P7 (for the pins) also through P2, using the P7-holes as guide-holes.
Then weld P5 to P2 so that the groove (axle line) on P5 is centred between the holes for the pins in P7.
After this, weld two M6 bolts (40mm long) to P3 (later you can put nuts as weight for adjustment of the balance on them. You can add a spring + washer to keep the weights in place and to keep the nuts from shaking loose).
Fix a M6 bolt to P3 (thread-hole) and put P4 on it (and later probably more weight for adjustment of the frequency of the pendulum).
P6 is the piece that holds the needle in place, you fix it with two M4 bolt to P5.

Insert two pins (3mm diameter, 20 mm long) through P2 and P7 and fixate with epoxy glue (but after all the welding!). The pins should be precisely placed so that they are perpendicular to P2, parallel to each other and in the same distance to the needle in the pivot. Ensure that the glue is mixed properly and allowed to harden long enough (at least 24 hours), before the pendulum is moved. The pendulum may need further adjustment and additional centre weight pieces when the clock is complete – this will be discussed later in the paragraph on adjustment.

The better solution instead of using a sewing needle can be to use a 2mm hardened pin . E.g. a piece of wire as used to make springs. It is cut to length and then hardened. Make sure you don't make it soft again by heating it up to much when you grind one side to have a point. You can first grind a point and then harden the wire.

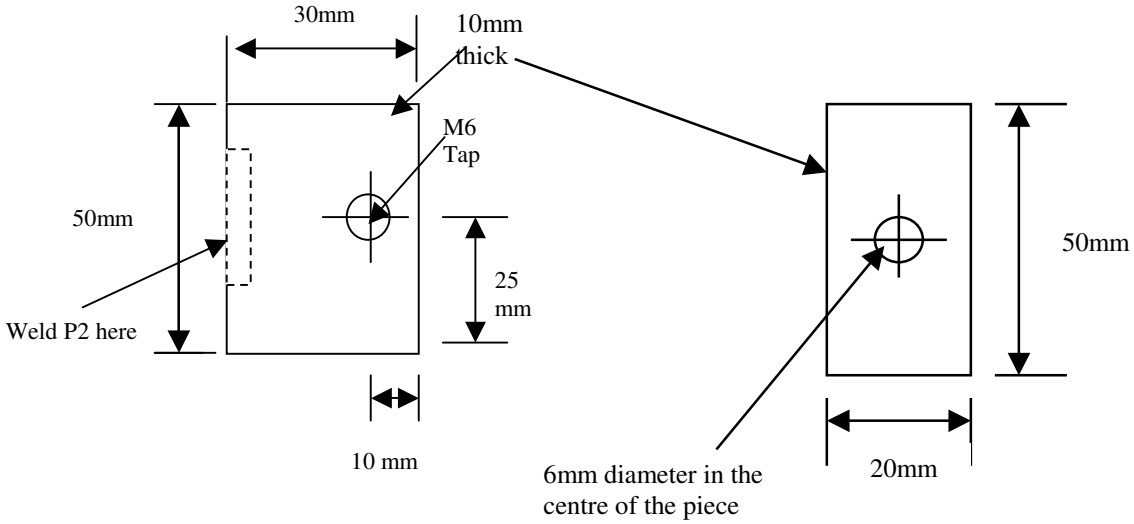
P1: (50 x 6, 50mm long)



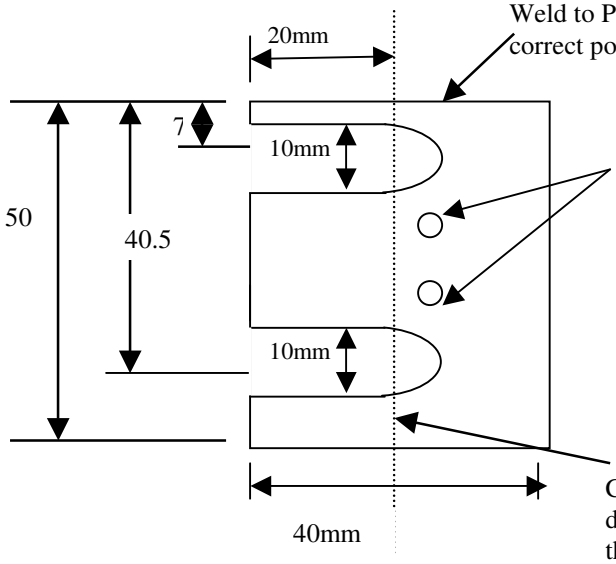


P3: (50 x 10, 30mm long)

P4: (50 x 10, 20mm long)



P5: (40 x 3, 50mm long)

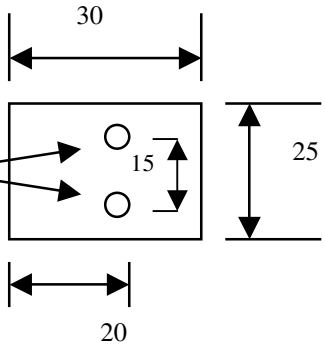


Weld to P2 to this side in the correct position to the pivot

4mm dia. Minimum 3 mm distance from slots and pivot. Center of these holes 15mm apart

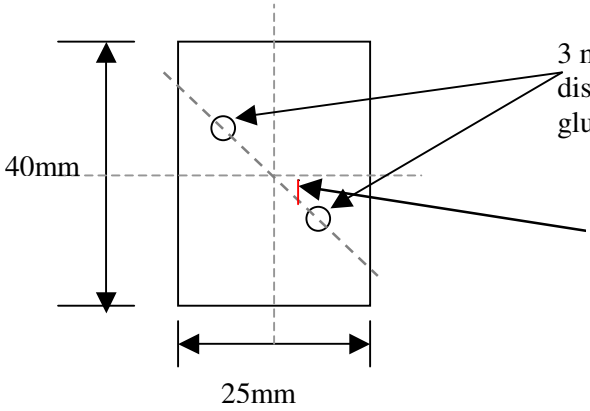
Cut a little groove (0.5mm deep) along the pivot (for the needle=axle)

P6: (25 x 3, 30mm long)



M4 Tap, the distance in-between is the same as between the 4mm holes in P5

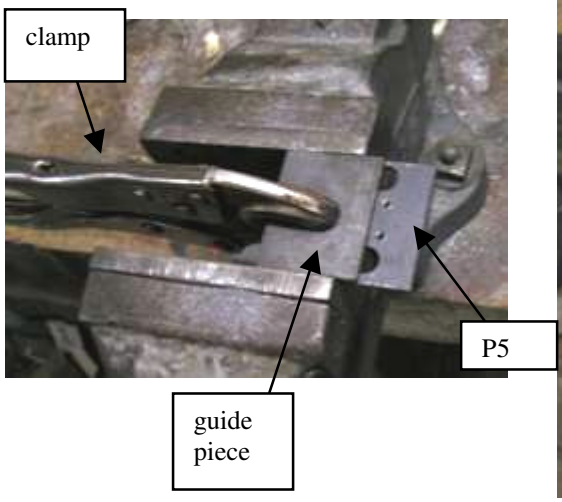
P7: (25 x 3, 40mm long)



3 mm diameter holes with exactly 19.5 mm distance between their centres. The pins are glued into these holes.

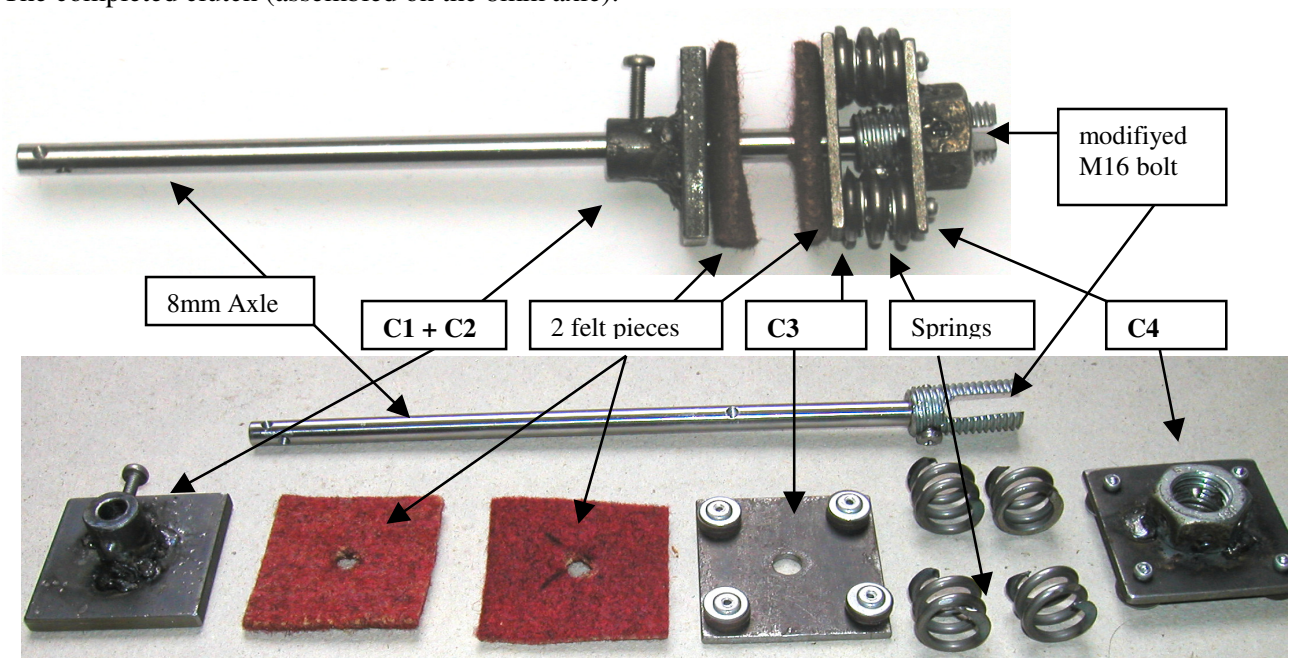
This angle is exactly 45°

To cut a straight groove in P5 : first clamp an other piece to P5, so that it guides you along the pivot line. Cut the groove with a hacksaw.



1.6. Clutch

The completed clutch (assembled on the 8mm axle):



The clutch assembly on the 8mm-axle consists of four parts (C1-C4) , two felts pieces, four springs, a modified M16 bolt, it's nut and two M4 x 20 bolts:

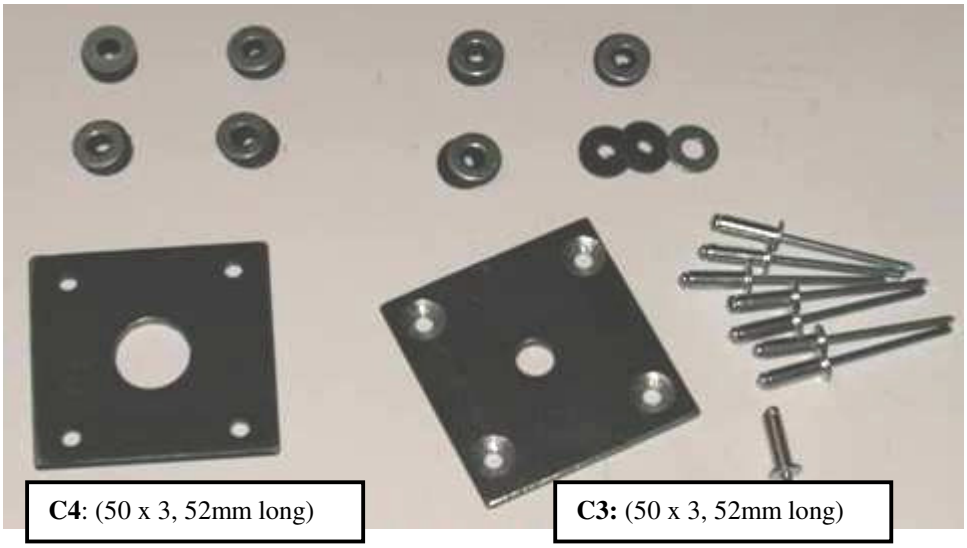
The **8mm axle** is 215mm long, hardened steel (bright bar).
There are three M4-taps through the 8mm-axle:

- For tapping use a 3.5mm drill bit (because the axle is hard).
- Mark the side from where you insert the bolt (on both parts the bolt and tap goes trough). The tap will be destroyed if you put the bolts in the wrong way round (specially if you force it).

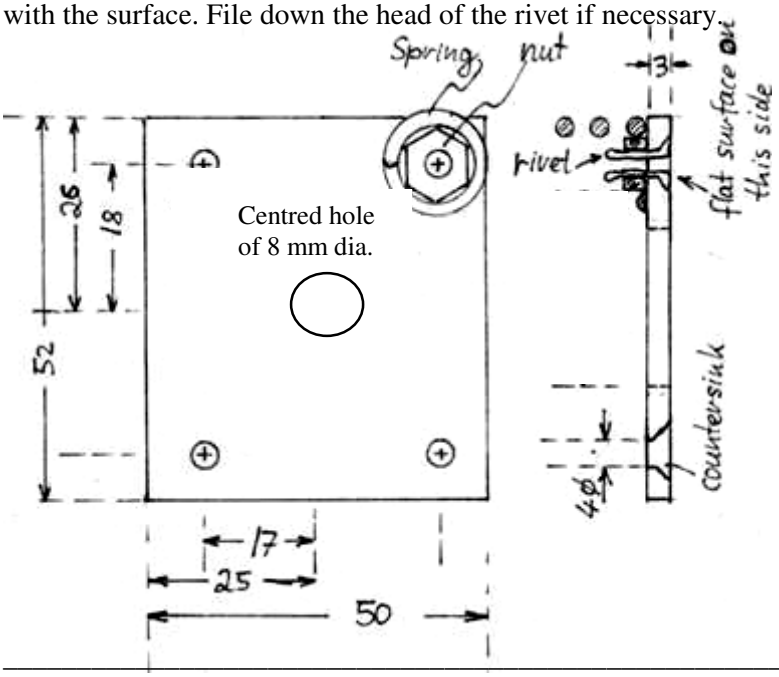
C1 is a 50 x 6mm flat iron, 50mm long.
C2 is an iron rod (16mm diameter x 18mm long) welded to the centre of C1. Prior to welding ensure that C2 is flat and square with C1. During welding, the metal square C1 must remain exactly square to the iron rod C2 (use a C-clamp). After welding drill an 8mm hole through the centre of both. Then put C1/2 on the axle 140 mm from the end without the clutch (so it will be placed between 140 and 164mm from this end). Drill a 4mm tap hole trough C2 and the axle (use drill bit of 3.5mm). Fix C1/C2 with a M4 bolt.

The two **felt pieces** are 50 x 50 x ~4mm (with an 8mm hole in the centre). Here they are made out of an old carpet.
The **springs** are ~15mm long sections of compression spring with 20mm inner diameter, 3mm thick. Grind the ends, so that they come more or less flat.

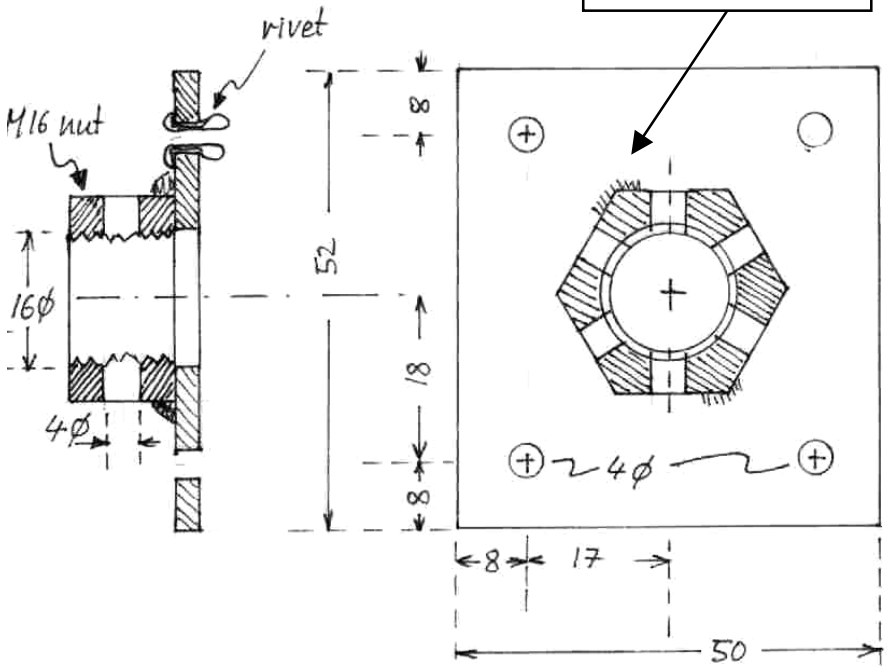
C3 and **C4** are 50 x 3mm, 52 mm long flat irons with four holes. For the fixation of the springs drill four holes of 4mm diameter in their corners (8mm from the edges). To prevent the springs from falling out fix three washers with a rivet (12mm length) in each corner. Alternatively you can use nuts which have more or less the same outer diameter like the inner diameter of the Springs.

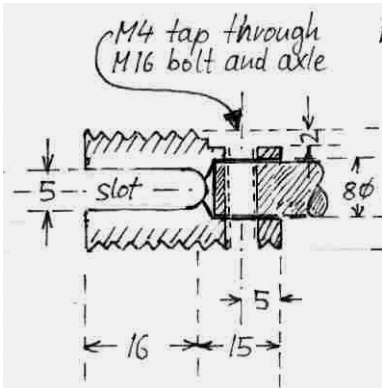


C3 has an 8mm hole in the centre. The four holes in the corners are counter sunk, so that the rivets are flush with the surface. File down the head of the rivet if necessary.



Drill a 16mm diameter hole in the centre of **C4**. Then take an M16 nut and drill 4mm dia. holes through the centre of each face (drill through opposite faces at the same time to ensure that holes line up). For welding fix the nut wit a M16 bolt to C4. Spot weld this nut to C4 before you fix the rivets.



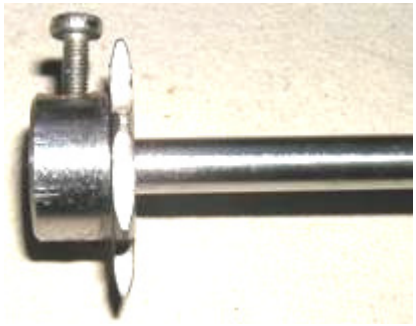


The **modified M16 bolt**: First drill an 8mm diameter hole through the whole bolt (at least 31mm). For this, fix the bolt (head under) with a M16 nut in the centred hole in the drilling table of the column type drilling machine. Make sure the hole is centred with the shaft of the bolt, not only with it's head.

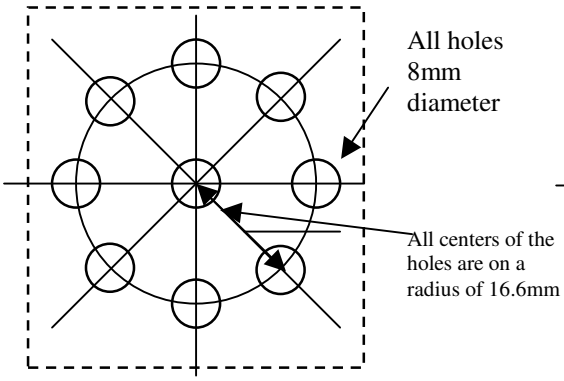
To make the slot, drill a 5mm hole through the centre of the bolt 16mm from the bolt end (end without head). Cut down to this hole from the bolt end and file so that the slot is straight and smooth.
Cut the bolt head away, so that the remaining shaft has at least 31mm.
Insert the 8mm-axle (15mm as indicated in the drawing) and drill a 4mm tap (3,5mm drill bit !) through bolt and axle.

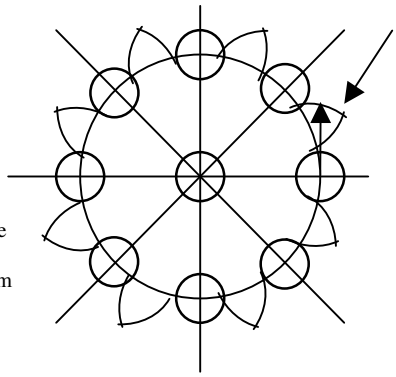
1.6. The 8-Teeth Sprocket

The sprocket will be fixed with a M4 x 20 mm bolt on the end of the 8mm-axle, (opposite to the clutch)
We need a M4 tap trough sprocket bushing and 8mm-axle (leave enough distance, so that the bolt head doesn't get in trouble with the chain later. Better you first check the distance with the chain).

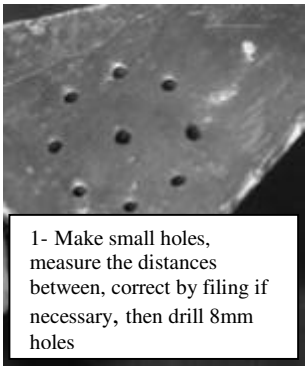


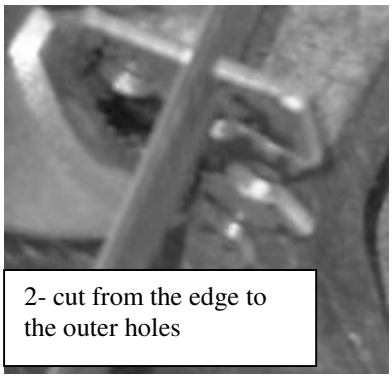
Often there is no 8-Teeth Sprocket available, but you can make one on your own. Use 40 x 3 flat iron, 40mm long (**TS1**).
First mark the centre on that plate, and then mark all positions for holes and then the eight teeth.

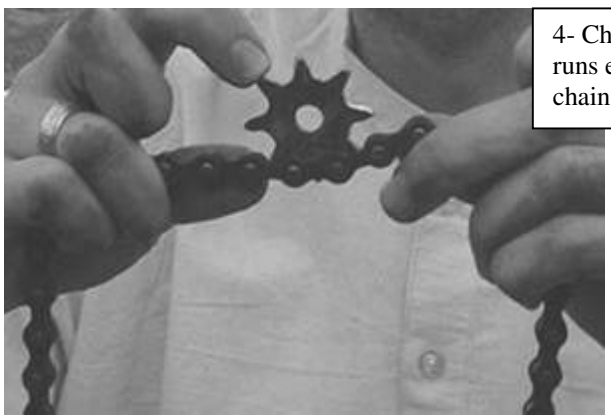




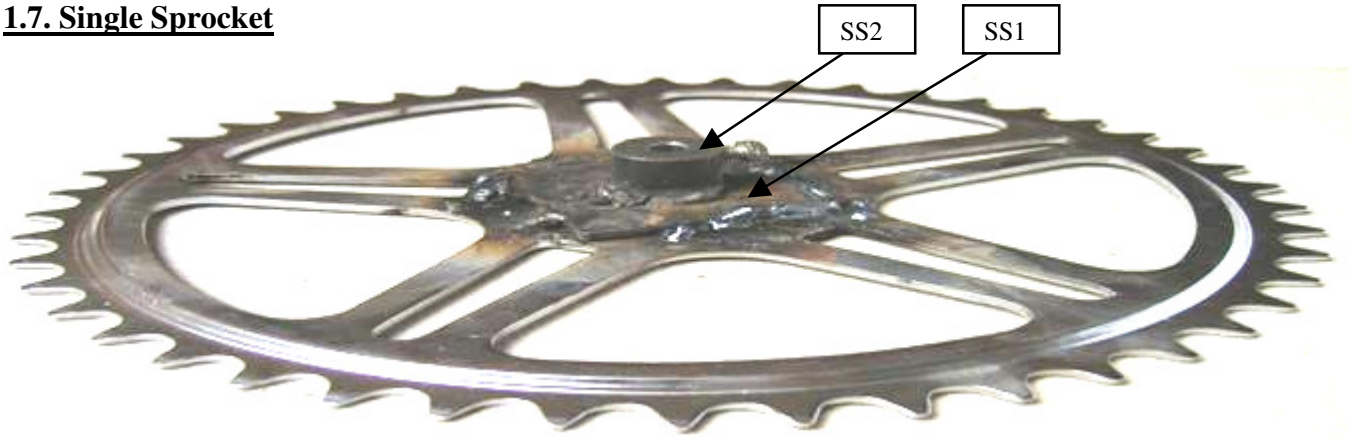
To make the 8-ToothSprocket, proceed step by step as indicated below. Then weld an iron rod (16mm outer diameter,10mm long (**TS2**)) with a 8mm hole in the centre to the sprocket. You can use the axle to align both.







1.7. Single Sprocket



The single sprocket is a 48-teeth bicycle pedal sprocket (if not available use 46 teeth, but then change the distance between the axles (see Main Bracket (1.1.page3)).

Remove the pedal, by grinding off the protruding ring on the back side with the angle grinder, so that the pedal falls out, when you hit it.

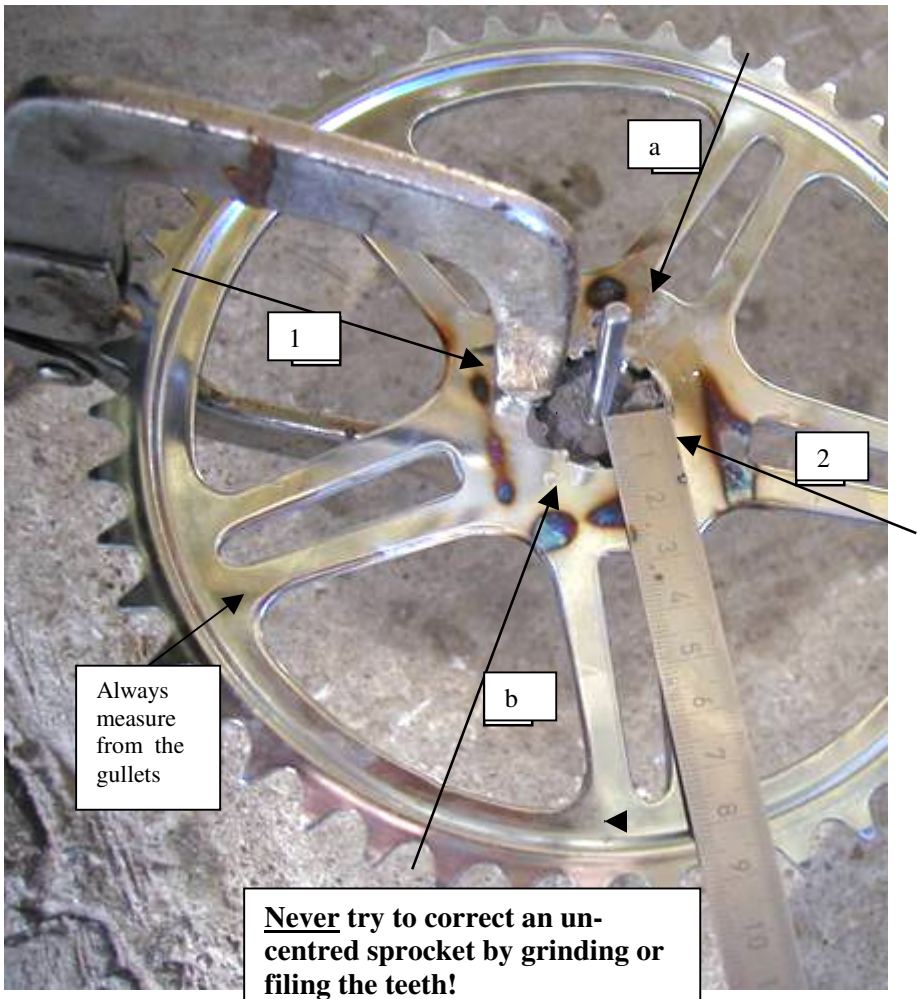
Prepare **SS1** (40 x 3, 40mm long) with **SS2**, an iron rod (16 dia. x 15 mm long) welded exactly to the centre of SS1. File the one side of the SS2 witch you weld on SS1 really flat and square. Use a C-clamp to fixate the welding position.
After welding drill a 5mm dia. hole for the axle through both (in the centre). Check squareness of the hole by putting the axle through.
Drill an 4 mm tap through SS2 to fix the sprocket later on the axle with a M4 bolt.

It is very important, that the axle is square with the sprocket and the sprocket is exactly centred and every tooth has exactly the same distance to the axle, so that it interacts later regularly with the pendulum.

The assembled SS1/SS2 must be welded perfectly centred to the sprocket, so the work is best be done on a lathe by an experienced machinist.

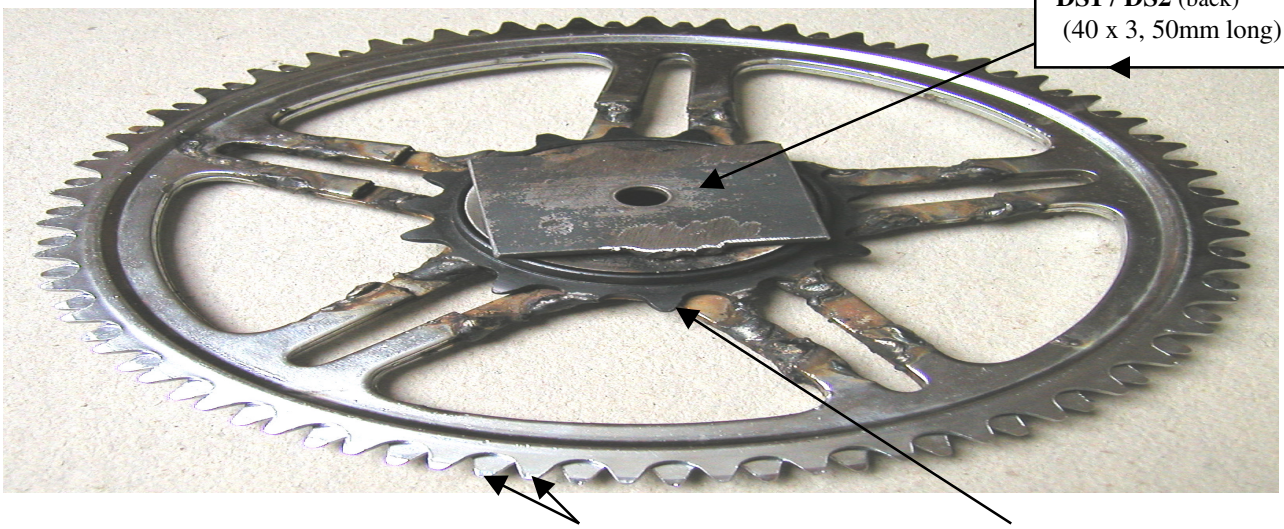
With patience, you can do it manually:
First fix SS1/SS2 with a C-clamp more or less in the centre of the sprocket, then measure and hit it slightly from the different directions until it is exactly in the centred.
You can correct first one direction:
Measure radius 1 between the deepest point between two teeth (gullet)and the axle, then the same with radius 2, correct by hitting from the side on SS1/SS2, measure 1 and 2, correct, ... and so on, until in this direction the two distances are exactly the same.
Then the same with direction a - b.
Then control also other directions.
When it fits, spot weld.

In my experience, it is best to correct first the direction, where clamp and axle are in one line (here radius 1 and 2).



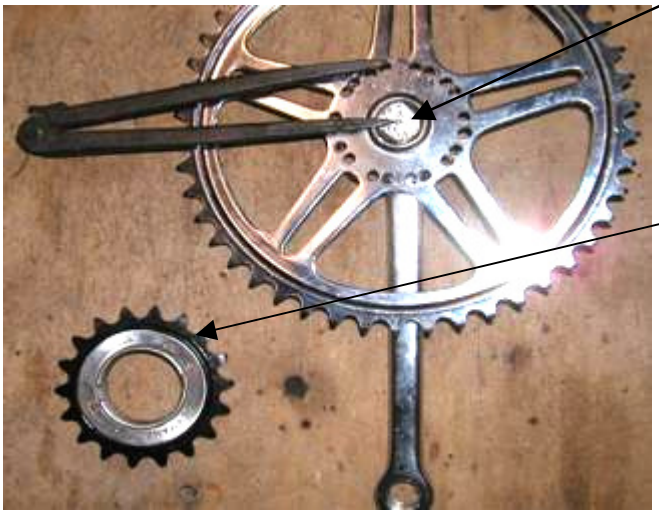
<u>Never</u> try to correct an un-centred sprocket by grinding or filing the teeth!
Instead: remove SS1/SS2 and centre them again with the sprocket.

1.8. The Double Sprocket



The Double Sprocket is made by welding two 48-teeth bicycle pedal sprockets together.
A 16-tooth bicycle freewheel in the centre, with a flat plate (DS1 + DS2) on each side (for the clutch).

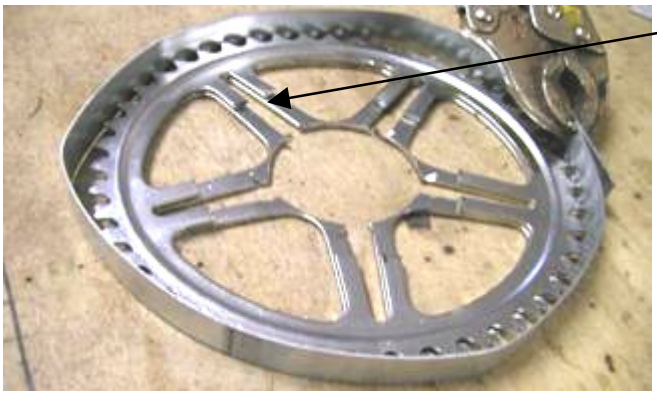
First, the pedal must be removed from one 48-teeth sprocket and the centre hole must be increased to the radius of the freewheel (minus the teeth). This must be perfectly centred so the work best is done on a lathe by an experienced machinist.
If there is no lathe, you can proceed like this:



1. Hit a little piece of aluminium into the hole in the centre of the sprocket. It doesn't have to fit exactly, but it shouldn't move.
2. Mark the exact centre of the sprocket (by two direction measuring, view single sprocket (1.7. page 13).
3. Measure the radius of the rim of the freewheel.
4. Mark a circle with this radius on the sprocket (with a compass).

5. Drill inside(!) this line lots of holes to cut the inner part away. (for having always the same distance to the line you can mark another circle with 3mm less radius and drill then with a 5,5mm drill bit along this line.)

6. Cut between the holes und file until the freewheel fits well and is completely centred.



Cut the inner part of the second sprocket away.
Align the two sprockets by placing them one on top of the other. Rotate until all of the teeth line up perfectly (if the sprockets were perfect, this would happen in all positions, but since there are imperfections there is only one position) – then shift the top sprocket by half a pitch.
Before clamping and welding in this position, you have to control, if all the tops of the teeth are in the same line (it can help to put a strip of metal sheet around like in the picture).

Then set in the freewheel, so that the inner part of the freewheel can turn free clock wise. Set it in from the same side as the second sprocket is put on (in the picture from top). Make sure that the teeth of the freewheel and of the two big sprockets are more or less in the same plain.

Take care whilst welding the teeth of the freewheel to the big sprocket. If you heat to much the little balls of the ball bearing in the freewheel will get stuck. For the same reason it is important to put the earth directly on the sprocket and not on the freewheel.

DS1 and **DS2** are 40 x 3, 50mm long flat plates with a 8mm diameter hole for the axle in the centre.
If you have a lathe spot weld the to plates on the centre of the freewheel and drill then a centred 8mm hole trough both.

If you have no lathe, drill first the holes in the centre of the plates.
Then clamp DS1 on one side to the inner part of the freewheel and centre it very exactly (like the Single Sprocket 1.7.) For welding you have to put the earth directly on the inner part of the freewheel (probably you can put it on the clamp), if not you will destroy the freewheel by welding the ball bearing together.
While spot welding take care, that it doesn't heat up to much (You can weld it from inside the opening of the freewheel, that's is easier).

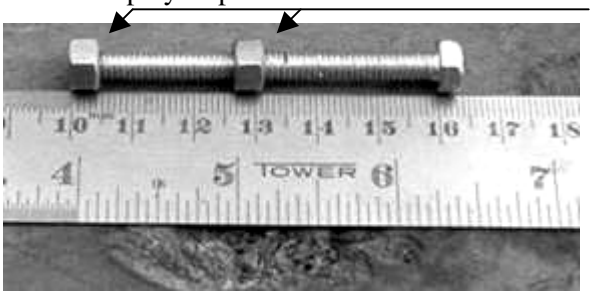
For welding DS2 you put the 8mm axle through DS1/freewheel and put DS2 on it, when the axle is rectangular to DS2 (in all directions!) clamp, control and spot weld.

1.9.a. "Pin-wheel"

The Pin Wheel consists of two M6 nuts, six pins, thin string or wire and epoxy glue. **You have to use M6 – the nuts measured in inches don't give the correct spacing for the pins**.

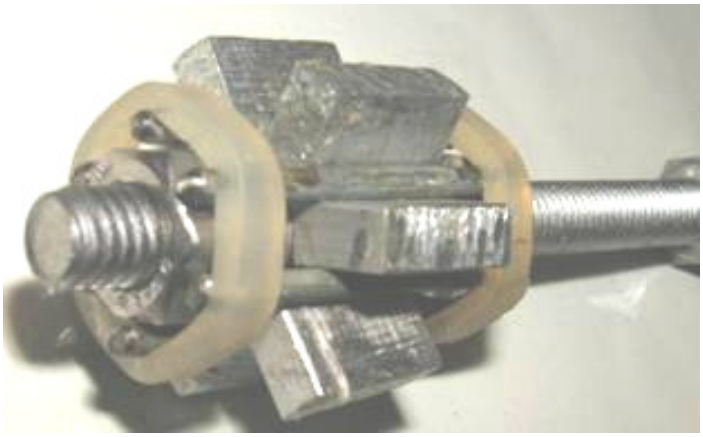
To make the Pin-wheel, you need some resources:
a M6 bolt (at least 40mm long), six distance pieces (exactly 4mm thick, ~10 x 18mm long), thread or thin wire and two slices of an silicon tube (14mm inner dia, ~2-3mm long) or two small rubber bands. Silicon is better, because it doesn't stick with epoxy glue. Ensure there's no grease on the parts, epoxy glue doesn't stick well on greasy materials. Clean all parts with alcohol or thinner.

Follow step by step:



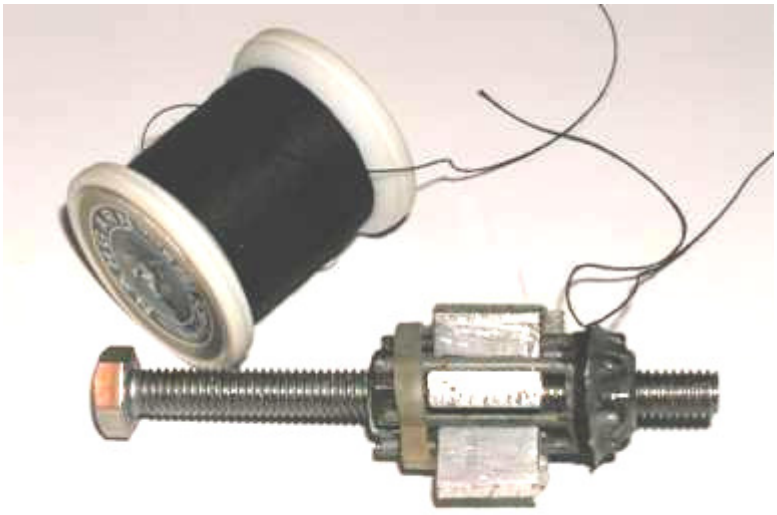
1. Put two M6 nuts on a M6 bolt with an outer distance of 30mm.

2. Cut 6 pins of 30mm length from an bicycle spoke (3mm dia. hardened steel) **. Use only spokes of 2mm diameter**.



3. Put he pins on the nuts (one on each face) , fix them with the silicon tubes (or rubber bands). Then insert the distance pieces (here: six aluminium pieces, 4mm thick).

4. When the pins are well placed on the nuts, in the middle of the faces and parallel to each other and the bolt, move the silicon tubes or rubber bands a bit back, so you can put some epoxy glue between nut and pins. Be careful that no epoxy glue gets between nut and bolt or pins and distance piece. For that, its probably better to glue first one side, so it can harden standing on the head of the bolt. Then insert the bolt from the other side and glue the other nut to the pins.
Ensure that the glue is mixed properly and allowed to harden long enough (at least 24 hours).

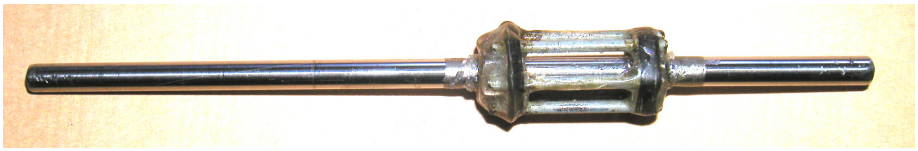


5. When the epoxy glue has hardened enough (on both nuts), take away the silicon tubes or rubber bands (cut away what possible) and bind the thin thread or wire around the nuts and pins (over the glue). Then put more epoxy glue over the binding.

Allow to harden long enough (at least 24 hours).

1.9.b. The 5mm-Axle

Fix the Pin Wheel to the 5mm axle.



Ensure that there is no grease on the axle, (clean probably with thinner). Make two marks 35mm and 65mm from one end. Then file around these marks so that the axle gets grip for the glue (take care that you don't hurt the rest of the axle, it needs to have a smooth surface to rotate without much friction). Then control the marks (or probably renew them, from the same end!), insert the axle into the Pin wheel and put some epoxy glue between and around the nuts and the axle. Let it harden long enough.

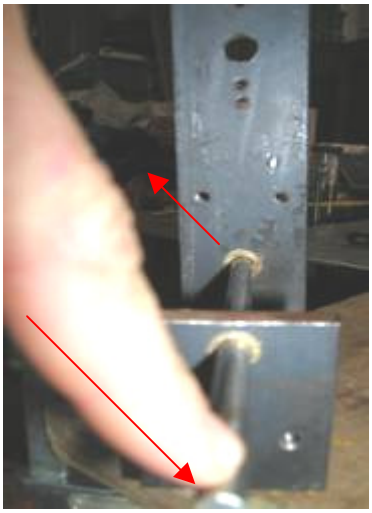
For assembling prepare the 5mm Axle Holder (**AH**), which is an iron rod (AH:16mm diameter, 10mm long) with a 5mm hole trough the centre and a 4mm tap in the side.

2. Assembly and Adjustment of the Clockwork

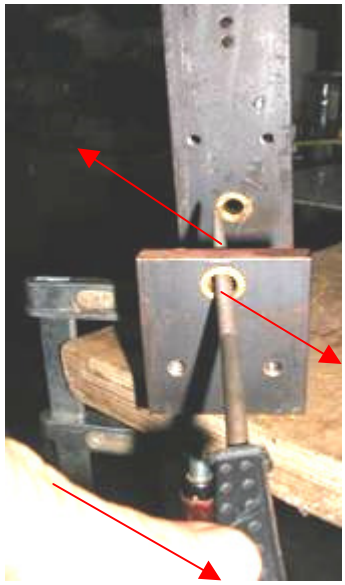
The process of assembly consists of a series of steps, trying to get the parts aligned as well as possible. Once all parts are in place, adjustment will be required to ensure that the gears mesh properly and that the pendulum interacts properly with the single sprocket.

2.1. Assembly of the Clockwork

The pictures below illustrate the order by which pieces must be attached to the main bracket.

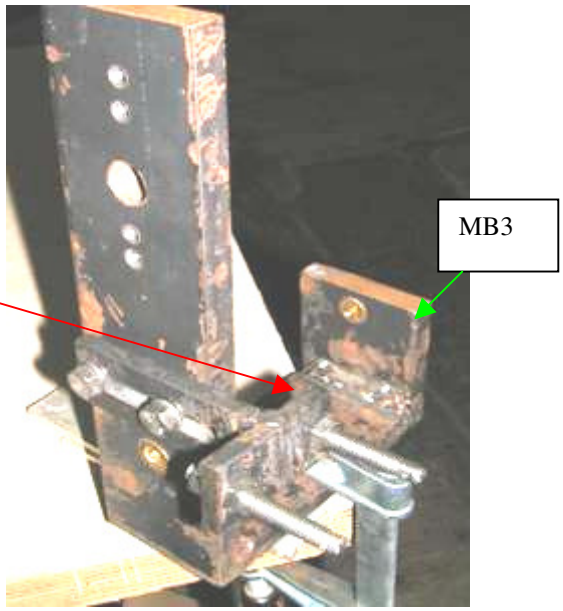


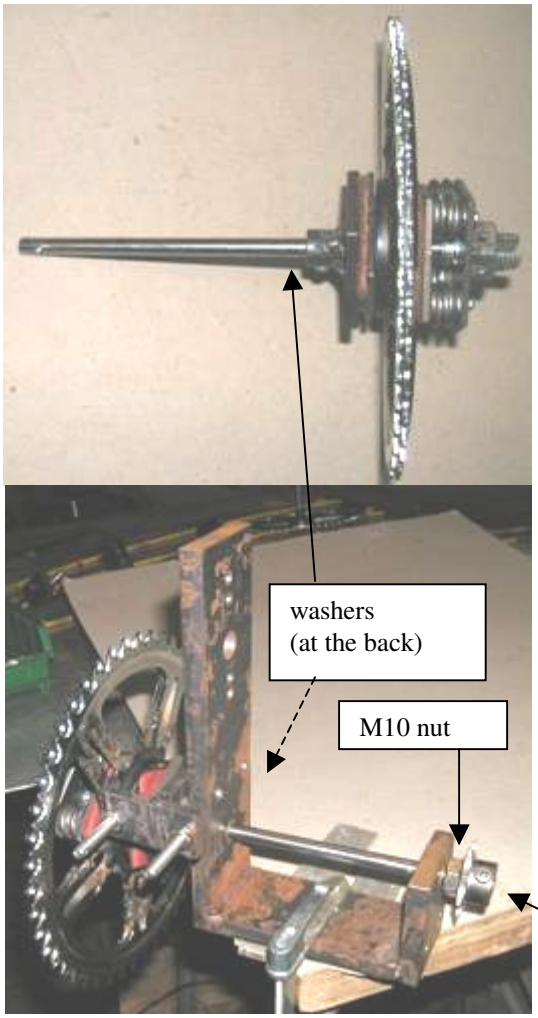
A1. Control and adjust the Bushings. Insert an 8mm-axle into one of the bushings, until just before the second bushing (don't enter into second). Then exert pressure from all sides (step by step) to find out on which side of the bushing you need to file in order to give room for a smooth movement of the axle. The end of the axle has to move over the rim of the second bushing about 1mm in all directions. In cases where it is less, insert the file and exert pressure during filing in the same directions (as you did with the axle) and file the front or the back edge of the bushing. Check which side of the bushing needs more filing (front or back).



If one 8mm bushing is fine, repeat the same process with the other one.
But be careful, don't file to much, the insides of the bushings mustn't be curved.

A2. Attach the pendulum holder to the main bracket using 2 M6 bolts. View the picture for the correct way round (there is one right way and seven wrong ones).
The short part (bolt with the hole that goes in by 3/4) looks towards MB3.

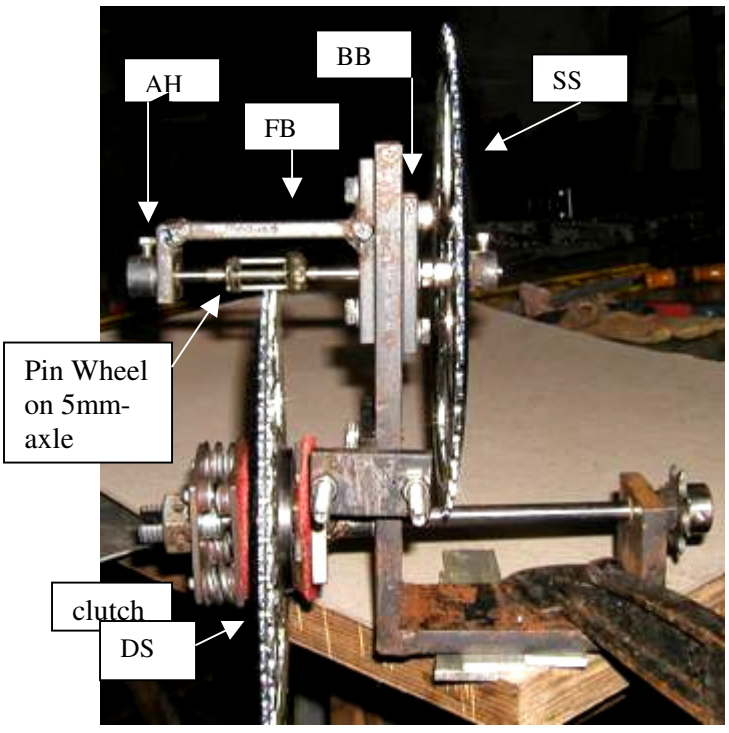




A3. **The 8mm-axle**:
A3.1. Put the Double Sprocket on the 8mm-Axle, between the two felt pieces (of the clutch), then fix the clutch. Ensure that the sprocket turns clockwise (whilst looking from the clutch side) without moving the axle, turning free because of the freewheel (and counter clockwise engaging the axle).

A3.2. Put some washers (1to 3) and insert the axle into Main Bracket (the washers are on the axle, between counterpart of the clutch and the Main Bracket part MB1).

Then put a M10 nut on the other end, behind MB3 and then bolt the 8-Teeth sprocket onto the axle.



A4. **The 5mm-axle**:

A4.1. Fix the Front Bracket (FB) to the Main Bracket in the highest possible position, with two M6 x 15mm bolts and washers.
If you use others bolts, they should be cut so that they don't protrude from the back of the Main Bracket (because there the Back Bracket (BB) will be fixed). For the Back Bracket (BB) two bolts of the same length are required.

A4.2. Insert the longer end of the 5mm-Axle (measured from the Pin Wheel to the end) through the big hole in the Front Bracket and the Main Bracket. Then move back and insert the shorter end through the bushing in the Front Bracket.
Then fix the Back Bracket (BB) to the Main Bracket, inserting the axle into the bushing (in the BB). Fix BB with two M6 Bolts (which are short enough) and washers.
Fix the Axle Holder (AH) on the axle - the Double Sprocket in the middle of the Pin Wheel. Maybe use a washer (between AH and FB).
Then place enough distance pieces (nuts, washers) on the axle and fix the Single Sprocket (SB).

A4.3. Adjust the correct position of the 5mm-axle:
The Pin Wheel should be mounted as low as possible without the axle touching the teeth of the Double Sprocket (DS).
Hold the Front Bracket and the Back Bracket in place with the bolts very loose. Align the Front and Back Brackets as low as possible so that the Pin Wheel interacts properly with the Double Sprocket and the teeth of the Single Sprocket don't touch the 8mm-axle.
If the 5mm axle doesn't run smoothly: Control the bushings, and check whether the axle is square to Front and Back Bracket.
If the Single Sprocket touches the 8mm axle, control if the Main Bracket is really square. If not, take all the components of the Main Bracket, correct it (hit it until it's square) and then re-assemble the components.

A5. **The pendulum**:
A5.1. Insert the needle into the pendulum holder and attach the pendulum. Fix it (with two M4 bolts and P6) so that the point of the needle can't spring out of the 75% hole (Hold P5 totally to the left and the needle totally to the right).

A5.2. Probably you have to cut away a bit of the Pendulum, where it touches the Main Bracket. Make a mark there and cut a triangle away.

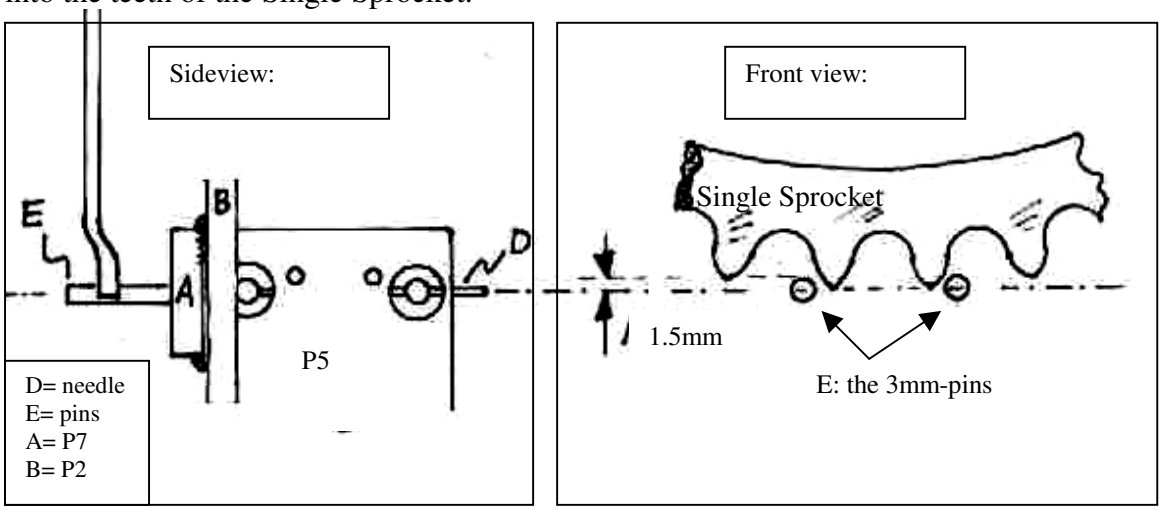
A5.3. Adjust the balance of the pendulum. When the pendulum is balanced both pins enter equally far into the teeth of the Single Sprocket. To balance the pendulum, adjust the location of the nuts on the bolts by moving them along the bolts (which are welded to P3). Move closer to the centre on the side that needs to be raised. Fix those adjustment-nuts well, so that they can't change their position once the clockwork is running (with a spring or against each other).

A5.4 **Chain Guard**
40x40x3 angle, 50mm long.
The Chain Guard prevents the chain from jumping of the 8 teeth sprocket. Find the correct position (distance to the sprocket) on **MB3** by placing the chain around the sprocket. The guard must not touch the chain! The two 6mm holes in the Chain Guard are 15mm to each side of the centre. They have to match the holes in **MB3** (see page 3).

2.2. Adjustments of the clockwork

Now adjust the clock properly. As the clockwork will be mounted on the reflector in an inclined position, you should mount it for adjustment also in a bit inclined position, with the 8-Teeth Sprocket downhill.
All pieces should be mounted such that the axles are parallel with each other and square with the main bracket.
Rotate the Sprockets several full turns, to ensure that they run smoothly and don't touch the other axle If they are not centred, you have to re-weld them centred.

Check that the pendulum holder is mounted correctly, by verifying that the pins enter deep enough into the teeth of the Single Sprocket.



Ensure that the pins (E) enter equally into the teeth of the Single Sprocket. The points of the teeth are in one line with the centre of the pins (see front view). If one pin enters more into the sprocket than the other, add or remove weights (or move them) on the bolts welded to P3.

Place a bicycle chain over the 8 teeth sprocket. Add a weight (~30 kg) on one side of that chain.
Now adjust the pressure of the clutch, it has to hold the weight (30kg), but not more, the clutch has to slip when you move it by hand. Then fix the position of the clutch (with a nail trough the modified nut).

Then adjust the pendulum period, the speed is set with the weight on the end of the pendulum. Adding weight increases speed (lowering the weight, too, which means putting it lower on the bolt).
With a stopwatch measure how long 21 clicks take (i.e. start the watch on the first click and end on the 21st) – this should be 25 seconds. If it takes longer, put more weight, or move the centre weights down on the bolt. If it takes less, remove weight or move the centre weights up.

When the clockwork runs well, you have to check if it runs without trouble over a long time (at least a hole day, better several days). It is important that the movement of the pendulum is very regular, you can judge by the rhythm of the sound.

An uneven rhythm means that the pendulum is not properly balanced.

If the clockwork stops (this can also happen after five hours well running), it is because of friction in some place (bushings, sprockets, pendulum).

Try to find out where the force is consumed:
Move the pendulum **very slightly**, to see if
the Single Sprocket starts running.

If so: The pendulum is the problem, because it stopped the movement.
Possibilities: - Pins are bent, not parallel or glue is on the pins.
- Needle is bent, or not properly mounted in its bearings.
- Pendulum itself rubs some where.

In case the Single Sprocket doesn't start running:
Possibilities: - Any of the sprockets hits an axle.
- Glue on the Pin Wheel
- Pins (Pin Wheel) are bent or not evenly spaced.
- Friction in the bushings.
- The self made 8-Teeth Sprocket doesn't run well.
- Axles are not straight.

If the clockwork doesn't run regularly, in a way that it is sometimes faster and sometimes slower (listen to the change between faster and slower rhythm) the reason is a un-centred Single Sprocket. You can solve this problem probably by adjusting the Pendulum Holder, so that the pins enter deeper in the Single Sprocket. If this doesn't solve the problem: Check if all teeth have the same length, if not replace the sprocket.

(2.3.) How to calculate the period of the pendulum (not necessary when you followed the descriptions, with the given dimensions and 46teeth sprockets):

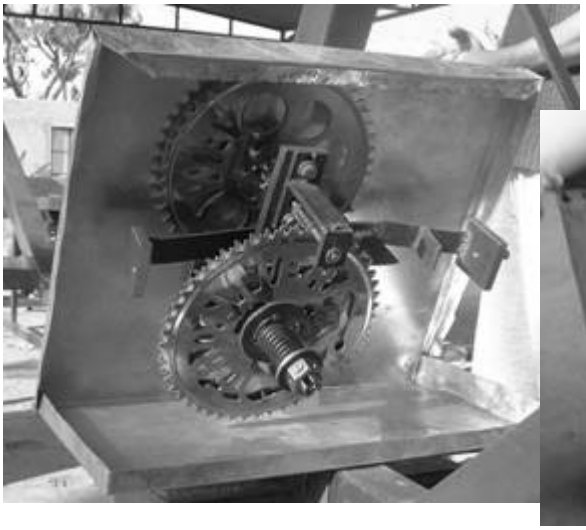
Radius tracking channel:		800mm
Length of one chain link:		12,7mm
Total of chain links (half circle):	(800 * π) ÷ 12,7	= 197
one turn in:	12h	= 43 200 sec.
one chain link needs to advance in:	43200 ÷ 197	= 218,2 sec.
one turn of the 8mm-axle:	218,2 * 8	= 1 754.3 sec.
one tooth of the DS needs:	1754,3 ÷ 92	= 18,5 sec.
one turn of the 5mm-axle:	18.5 * 6	= 114.6 sec.
one tooth of the SS		
= period of the pendulum:	**(114,6 ÷ 46)**	**= 2,5 sec.**

3. Clock Cover

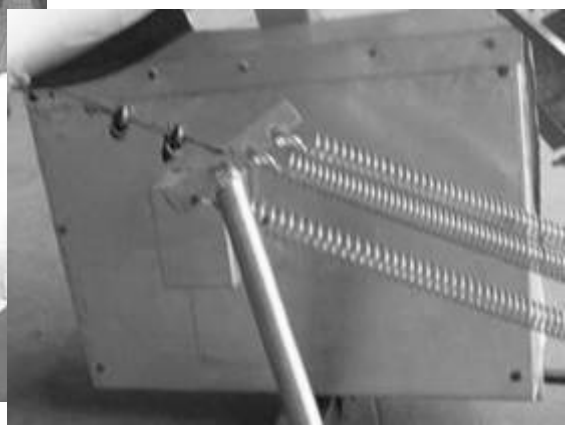
Once the clockwork is completed, tested and mounted on the stand, it should be enclosed in a box . This box should not interfere with the motion of the clock in any way, but should enclose it fully and protect from rain, dust or peoples manipulation. A few examples of clockwork boxes are shown here (only the photo in the centre is of a clockwork of the exact type described in this manual).

Hint: to find out the dimensions, first make a box from cardboard.

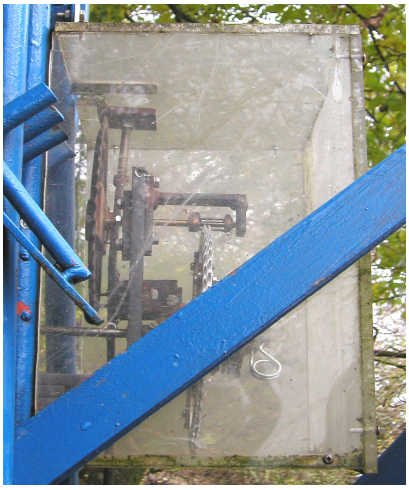
Made from galvanized metal sheet.



Clock fits inside. Closed – from back (left) and side (right)



Or acrylic glass:



Or iron sheet:

5. Material needed for the clockwork

List of steel:

Profile	Description	Dimensions	Length: (add for the cuttings)
	Flat bar	50mm x 10mm	> 405mm
	Flat bar	50mm x 6mm	> 100 mm
	Flat bar	50mm x 3mm	> 104 mm
	Flat bar	40mm x 3mm	> 230mm
	Flat bar	25mm x 6mm	> 340 mm
	Flat bar	25mm x 3mm	> 285 mm
	Round bar / Rod	16mm diameter	> 98mm
	Round bar / Rod for axle (bright bar)	8mm diameter	> 215mm
	Round bar / Rod for axle (bright bar)	5mm diameter	> 145mm
	Angle iron	40mm x 40mm, 3mm thick	130mm

List of other materials for the clockwork:

Picture	Description	Dimensions	Length / Number
	Brass tube	8mm inside diameter	> 24mm long
	Brass tube	5mm inside diameter	> 16mm long
	Bicycle freewheel	16 or 18 teeth	1
	Bicycle pedal sprocket	48 teeth (if not available: 46teeth)	3
	Springs (compression)	20mm diameter, 3mm thick	Four 15 mm (one >60mm)
	Bolts	M6 x 15	14
	Bolts	M6 x 50	3
	Bolts	M6 x 20	2
	Bolts	M16 x 30	1
	Bolts	M4 x 15	5
	Bolts	M4 x 10	2
	Nuts	M6	18
	Nut	M10	1
	Nut	M16	1
	washers	M6	15
	washers	M10	4
	Aluminium rivets	4mm diameter x 10 - 12 mm long	8
	Hardened steel rod (or Sewing needle)	1mm diameter or better 2mm	50mm long
	Hardened steel rod (Bike spoke)	2mm diameter	180mm long
	Hardened steel rod	3mm diameter	2 pieces of 20mm
	Bicycle chain		>2,5 meters
	thin string or wire		~1meter
	epoxy glue		

If no metric bolts and nuts are available:			
Metric	**M4**	**M6**	**M16**
Inches	**1/8**	**¼**	**5/8**

If steel is sold in inches:								
Metric	50x10	50x6	50x3	40x3	25x6	25x3	16round	40x40x3
Inches	2 " x 3/8"	2 " x ¼"	2"x1/8"	1 ½" x 1/8 "	1" x ¼"	1" x 1/8"	**5/8"**	1 ½ " x 1 ½ " x 1/8 "

Contact:

Solare Brücke e.V.
www.Solare-Bruecke.org
info@solare-bruecke.org