# Assembly of a **hhs/1** Recumbent Bike

# Content:

# 1 Introduction.

The following is an assembly description of what is called a **hhs/1** recumbent bike.

This design has been made after 4 years of practice with used bicycles which have been turned into recumbent bikes. I thought it was about time that I made a nice-looking bike, which was not made out of a square tube and an old bicycle.

The main idea is still that most of the assembly can be done at home. No need for special equipment. There is a small exception regarding this when it comes to the main tube. This has to be bent by someone who can bend a 50 mm tube. When this is done the rest should be easy for an experienced recumbent bike builder !

Since this document is made while building the recumbent bike, there may be changes to the final design, compared to what it looked like when I started. The drawings in the appendix should reflect the final design.

## *1.1 Abbreviations.*

| Abbreviation | Description |
|---|---|
| HPV | Human Powered Vehicle |
| Liggecykel | Recumbent bike |
| www.hpvklub.dk | Aalborg liggecykle klub (Aalborg recumbent bike club) |

## *1.2 History.*

| Date | Ver | Description |
|---|---|---|
| 2002-10-07 | 1 | Initial version |
| 2003-02-16 | 3 | New pictures and updated figures. |
| 2003-07-22 | 4 | Minor changes and some new pictures of the rear fork. |

## *1.3 References.*

| Reference | Description |
|---|---|
| 1 | Homebuilt Recumbent Bike Parts |
| 2 | |

## *1.4 Tooling assumptions.*

Except for some special parts (the main tube) it is the intention that the present recumbent bike can be built at home.

In order to do so you need to have the following tools at your disposal:

- A welding machine
- A drilling stand
- Some kind of grinding machine (to make life easier !)
- Ordinary toolbox with screwdriver, file, adjustable spanner.

# 2 Design and calculations.

## *2.1 Bike assumptions.*

I have been riding an “Evita” (Hurricane dublicate) for some time. I like the design and the way it performs. The only drawback, as I see it, is lack of suspension. So my intention was to design a low recumbent bike with suspension.

The design I came up with can be seen in the next figure.

**Figure 1: The hhs/1 recumbent bike with suspension.**

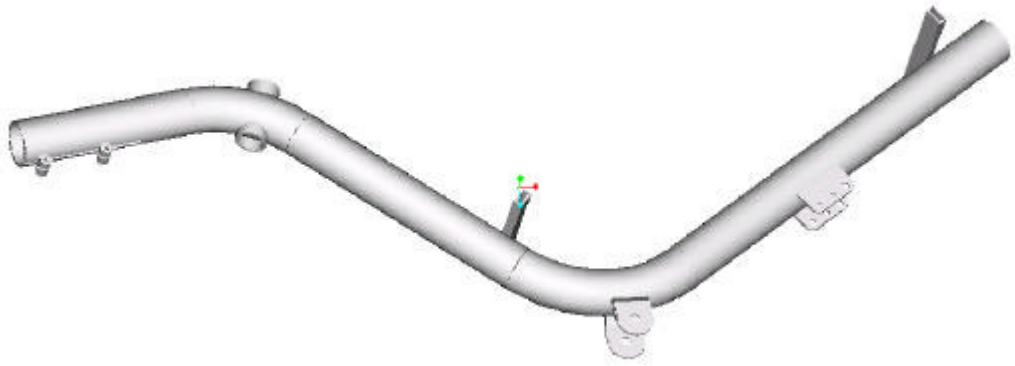
Dimensions:

| | |
|---|---|
| **Wheelbase** | 113 cm |
| **Front wheel size** | 20” ETRTO 406 |
| **Rear Wheel size** | 20” ETRTO 406 |
| **Rear suspension length.** | 150 mm |
| **Seat height** | 470 mm |
| **Seat angle** | $40^{o}$ |
| **Material frame** | Steel |
| **Material seat** | Wood |
| **Weight** | App 18 kg |

## *2.2 Main tube.*

Below the main tube (the bended 50 mm tube) can be seen.

**Figure 2:**
**The main tube.**



In “Appendix A1. Main tube.” the main tube is shown in detail with meassures. This chapter will describe the intention behind the design.

The tube is 50 mm in order to be able to have a secure attachment for the headset tube. The radius of the two bends is 150 mm. This is due to what I could get in the neigbourhood. Other dimensions can be used but try to keep the dimensions between the three straight lines of the tube.

The pedals (or the bottom bracket) are attached to another smaller tube which goes inside the 50 mm tube. The next figure shows how the front of the 50 mm tube is made in order to secure the inner tube with the pedals.

**Figure 3:**
**The front of the 50 mm tube.**

Through the two nuts a bolt will fit and keep it all together. The design is made with 8 mm bolts, but 6 mm will do as well.

## *2.3 Rear fork.*

Below the rear fork is shown.

In “Appendix A2. Rear Fork.” the rear fork is shown in detail with meassures on. This chapter will describe what it consists of.

**Figure 4:**
**The rear fork.**

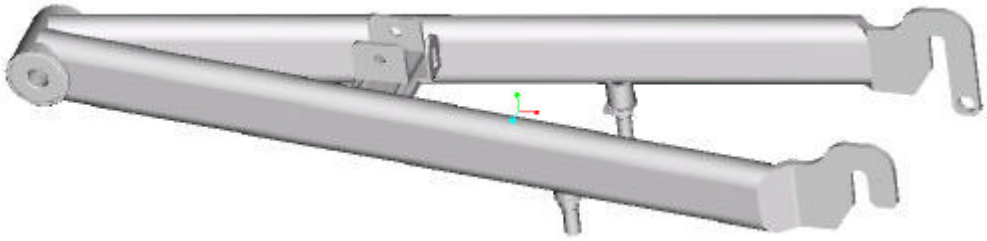
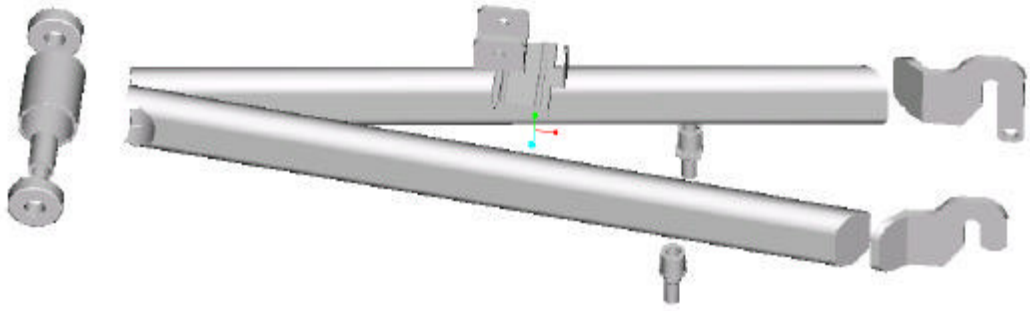


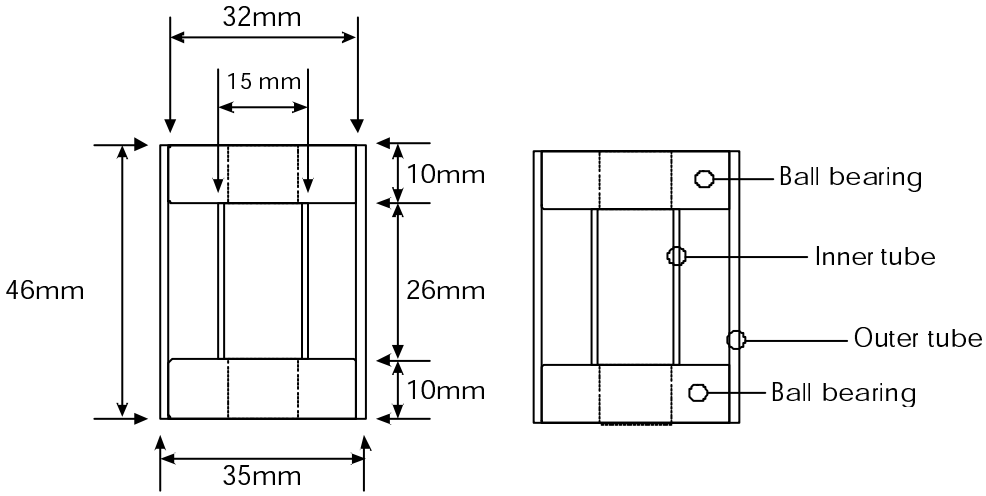
**Figure 5:**
**Exploded view of the rear fork.**



The idea is to make a fork which is as stiff as possible. This is done by making an “A”. The fork is welded together at the top and 1/3 down.

The fork is attached to the main tube by two ball bearings This may seem as an expensive solution, but compared to what a ball bearing costs and how much work needs to be done in order to make another nice looking solution, the ball bearings were chosen.

**Figure 6:**
**Detailed design of the ball bearing attachment.**




As can be seen in the above figure the solution consists of two ball bearings and an 35 mm outer tube and an inner 15 mm tube. If your ball bearings have other dimensions adjust accordingly. The inner tube is 15 mm, but other dimensions can be used. The inner tube keeps the ball bearings in position when tightened.

The two V Brake Pivots have been placed below the fork in order not to conflict with the chain.

The rear dropouts are made out of a piece of metal which is bent in the right angle.

**Figure 7:**
**Rear dropouts.**

Dimensions of the two dropouts can be seen in “Appendix A3: Rear dropouts.”

In the above figure the dropouts have been shaped to fit the oval tube. This can usually not be done before they have been welded to the oval tube.

I found a manufacturer who made the dropouts for me. They can be seen in the next figure.

**Figure 8:**
**Laser cut rear dropouts.**

The rear fork is made for a 406 20” wheel. In case you want a bigger wheel, the design can be extended, but I have no experience of how the recumbent bike will behave with a bigger wheel.

If you try to make a rear fork for a bigger wheel, you have to figure out the angle (138,6°) between the oval tube and the rear dropout. You still have to maintain the 130 mm distance between the two dropouts.

In case you cant make the above mentioned dropouts, you can use a small piece of metal bent in a 90 degree angle as shown in the next pictures.

**Figure 9: Alternative rear dropouts.**

# 3 Assembly guidelines.

The following describes how I assembled the **hhs/1**. There are probably other and better ways to do it, but it gives an idea about how to do it.

In order to have a bike which is not distorted, you will have to start making the rear fork. When that is done, you can start looking at the main tube. You need the rear fork in order to attach several of the mounts to the main tube.

## *3.1 The rear fork.*

The easiest way to make the oval tubes fit the small 35 mm tube, is to cut a piece of the oval tube at the double length and make a 35 mm hole in middle. This can be seen in the next figure.

**Figure 10: Before the oval tube is cut into two.**

Next you cut out the small 35 mm tube and the inner 15 mm tube.

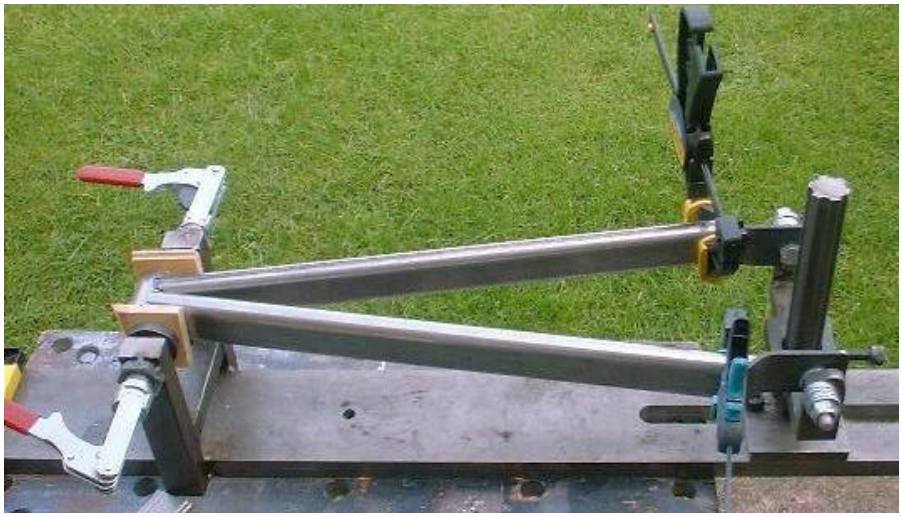
Then it is time for the two rear dropouts which hold the wheel. Here you need some kind of tool which can bend the dropout in the right angle. (or some heating device) When you cut out the metal piece which is going to make the dropout you need to know how you will bend the metal. Some times in order to fit the tool the initial metal piece need to be longer than the final one.

Now you have the main parts for the rear fork and can start planning to assemble the pieces.

Before you can assemble the rear fork you need to have some kind of jig.

At “Aalborg liggecykel klub” we have made a standard jig for making the ”Odense cykel”. This has been used for making the rear fork, but it may be simpler to put the pieces on a flat surface, instead of having it hang in the air. The jig can be seen in the next picture:

**Figure 11: The rear fork ready for welding.**



The next picture shows how the oval tube is connected to the bended metal piece which acts as a dropout.

**Figure 12: The oval tube attached to the reardropout.**

In order to seal the rear fork completely the two parts have to be welded together “inside” before the oval tube is welded to the small 35 mm tube. This is shown in the next figure.

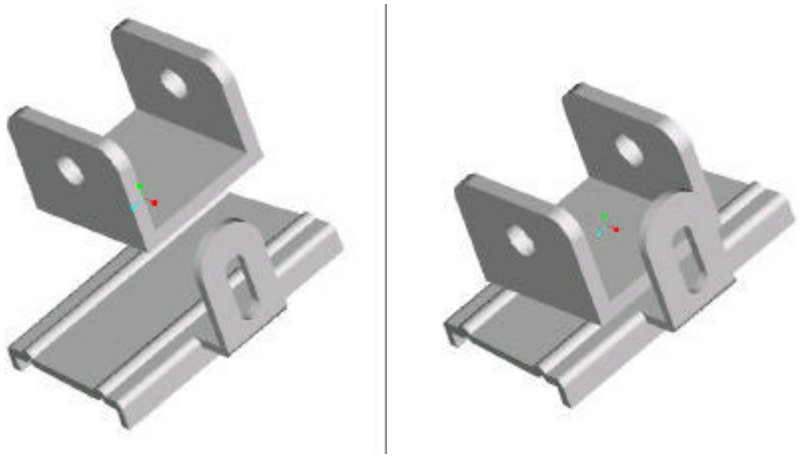
**Figure 13: The rear fork before and after being welded “inside”.**

The inside welding is done after the oval tubes have been partly welded to the rear dropouts. By doing this they stay in the jig.

### 3.1.1 Spring mount.

The spring mount at the rear fork is made out of a ready-made mount for an ordinary bicycle, with a u-shaped tube attached to it. The two pieces can be seen in the next figure.

**Figure 14: Rear fork spring mount.**

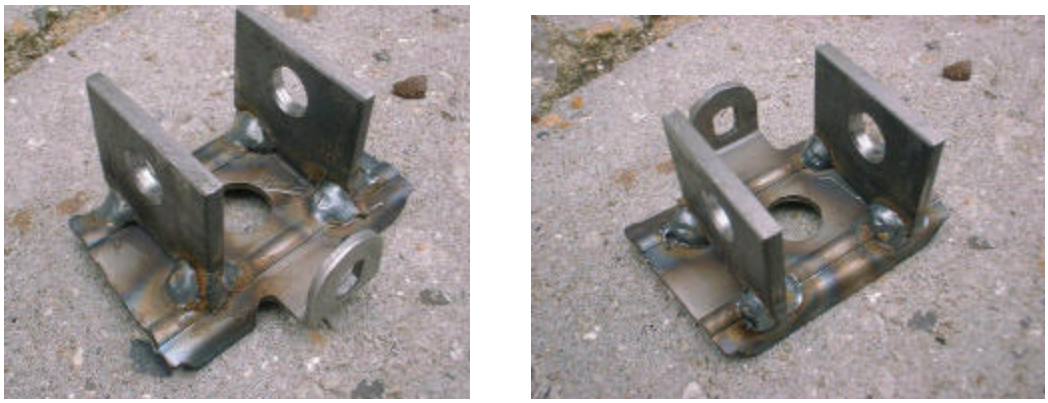


The spring mount can be seen in the next two pictures. Since there was no u-shaped tube available at the moment when the mount was made, two small pieces of metal were used instead.

The actual dimensions can be seen in Appendix A6: Rear fork spring mount.

The next pictures show how it looked when welded.

**Figure 15: Spring mount after welding.**



## *3.2 The main tube.*

This is how my 50 mm tube looked when I received it from the manufacturer:

**Figure 16: The 50 mm tube bend at the right dimensions.**

The main thing is to get a nice round bend which hasn't collapsed.

### 3.2.1 "Pedal" mount.

Below the front of the main tube is shown.

**Figure 17: Front of the main tube.**

In order to make the slit, the easiest way is to use a compass saw. Make a 5 mm wide mark and cut it with a special blade. I found it much easier than using a grinder. When this is done you can either weld small nuts on or make small tubes which are welded on. The next picture shows how the small tubes are welded on.

**Figure 18: Attaching the small tubes at the front of the main tube.**

As can be seen in the picture small spacers are used to position the small tubes.

The dimensions of the small tubes shown in the above picture can be seen in the next figure.

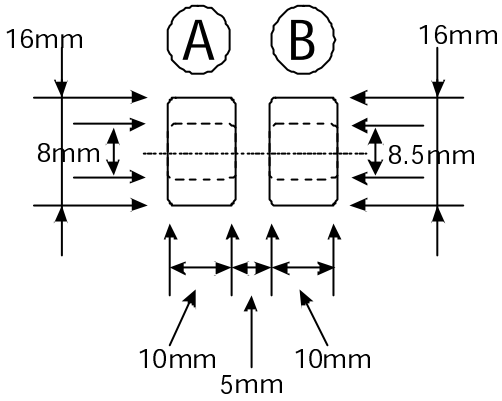



**Figure 19: The small tubes which are used to tighten the main tube.**

Please note that the two parts are different. (A) has a 8 mm thread while (B) only has 8.5 mm hole without a thread.

### 3.2.2 Head tube mount.

Mounting the head tube onto the main tube is somewhat difficult. You need to cut a hole in the main tube at the right angle. In order to do so you need to take the figure in Appendix A3: Head tube template" and enlarge it to a scale of 1:1.

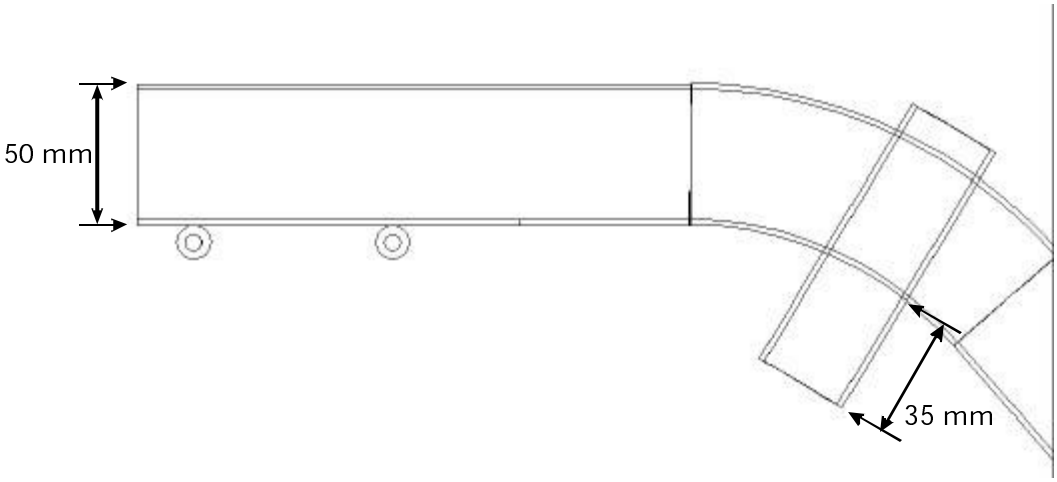
Then you place the main tube on top of it and mark the hole for the head tube. For details see next picture.

**Figure 20: Guidelines for placing the head tube.**

Next you need to cut the hole in the main tube. This can be somewhat difficult, so be sure to start with a hole which is too small and then enlarge it.

In order to have sufficient clearance for the chain, the head tube need at least 35 mm below the main tube as shown in the next figure.

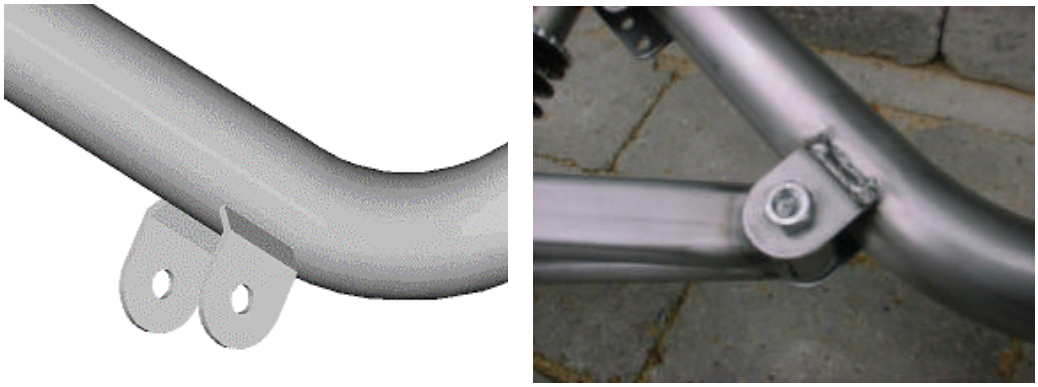
**Figure 21: Length of the head tube.**




### 3.2.3 Rear fork mount.

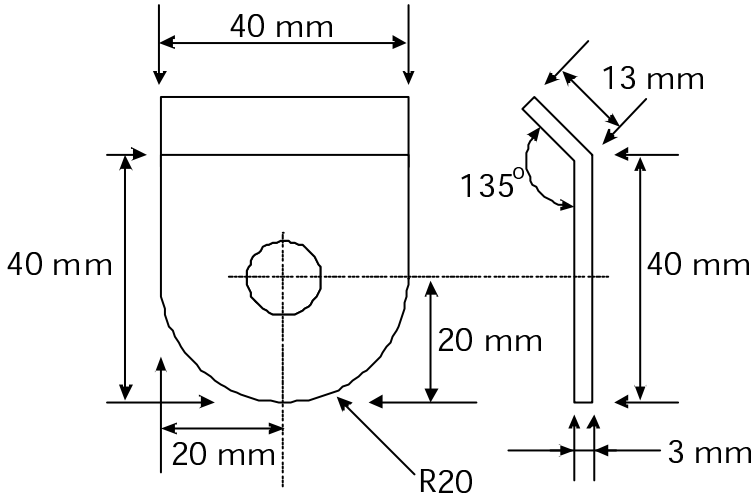
The rear fork is attached to the main tube by two mountings as shown in the next figure.

**Figure 22: The rear fork mount.**



The two mounts are something which I found readymade, but they can have any other shape. The dimensions of the mounts used here can be seen in the next figure.

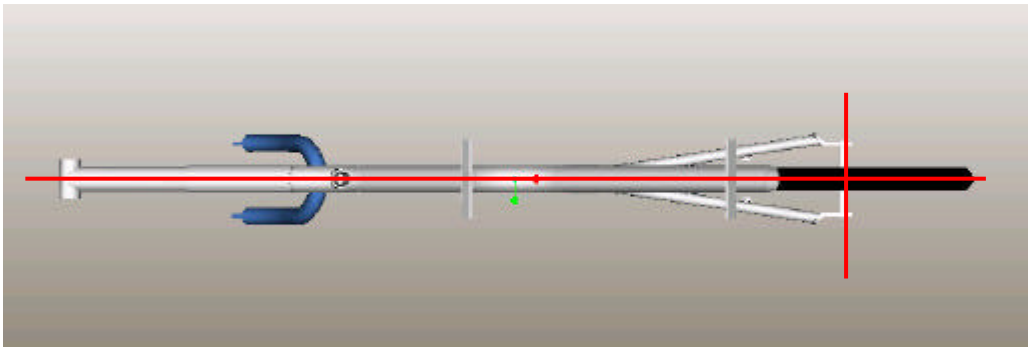
**Figure 23: Details of the rear fork mount at the main tube.**




The actual attachment of the mounts to the main tube was done by using the jig used in the rear fork section. The main concern is to have the headset of stear and the rear dropouts fully aligned.

The next figure tries to give an idea about this. The angle between the two read lines need to be 90° This is done by having a jig that fixes the headset and the reardropouts as shown in the next figure.

**Figure 24: How to align main tube and rear fork.**



The red line which goes straight through the length of the bike must not be bent. This may happen if the rear fork is not alignede parallel with the “red line”.

If you don’t get it right the first time, it is better to cut things appart and start over at this point. If you wait it will be more difficult later !

### 3.2.4 Seat mount.

The seat mount consists of two pieces of metal measuring 10x20x140 mm. The thicknes of the mounting is 2 mm. They can be seen in the next picture.

**Figure 25: Seat mount attached to the main tube.**

The position of the seat mounting can be seen in Appendix A1.

The chosen solution is simple, and any other solution can be used instead. The only requirement is that it stays in position !

The mounting of the seat is shown later.

### 3.2.5 Spring mount.

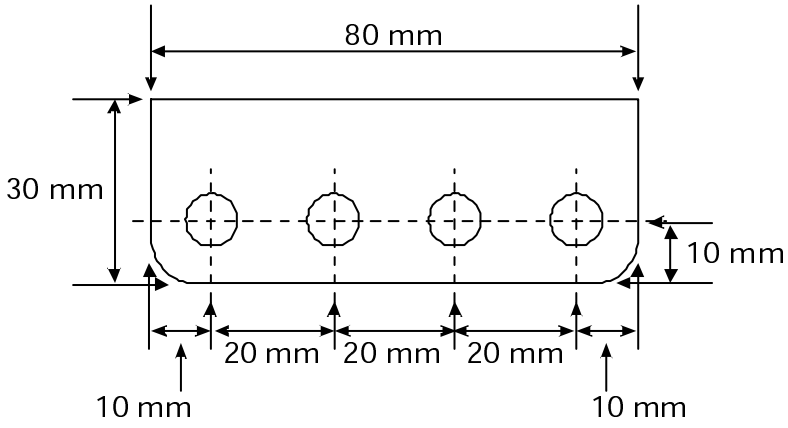
The mounting of the spring is made so that the spring can have several attachements. The next picture shows how.

**Figure 26: The spring mount at the main tube.**

The dimensions can be varied and so can the placement. If the mount is moved further up (to the left in the picture), the spring will seem soft while moved further down (to the right in the picture) the spring will seem harder.

The dimensions of the mount shown in the picture can be seen in the next figure.

**Figure 27: Spring mount at the main tube. Thicknes is 3 mm.**




The above-shown spring mount may have other dimensions which fit your needs.

## *3.3 The rear fork and main tube assembled.*

The next picture shows the rear fork with the spring attached to the main tube.

**Figure 28: The rear fork and the spring mountet at the main tube.**

The length of the spring I used is 150 mm. Please keep in mind that the springs available come in many different lengths.

## *3.4 The stear*

The chosen overseat steering solution can be adjusted during the ride. I myself prefer overseat stearing so this will be the only solution presented here. I don't know if I will make an underseat stear in the future.

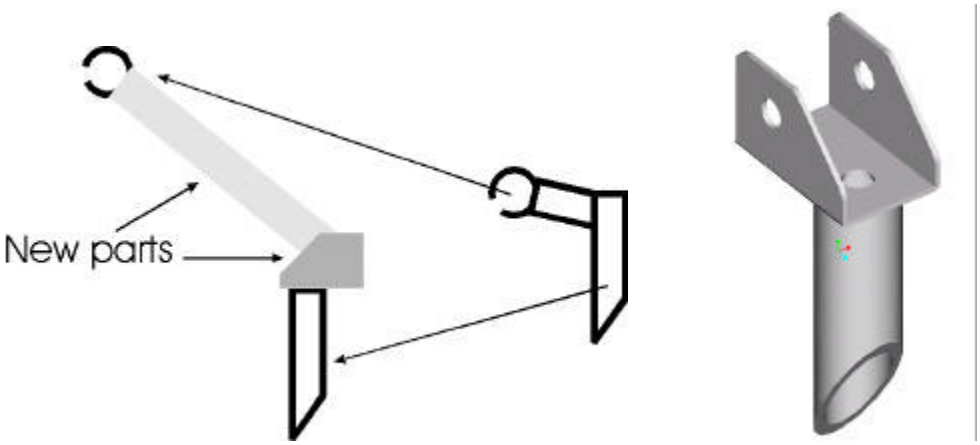
As can be seen in the pictures below, the stear consists of two parts:

- a long adjustable stem, and
- the stear itself.

**Figure 29: The complete stear after welding and the stem alone**

The adjustable stem is made out of an ordinary stem which is cut apart. The next figure shows how.

**Figure 30: "Where do the parts come from?" and the new mount .**




If you don't want an adjustable stear there is another design in Ref[1]

## *3.5 The seat*

The seat is a proven solution (to me and Aalborg liggecykel klub) and consists of 3 pieces of birch veneer (size 220 x 1000 x 4 mm) which are pressed into the right shape by the jig shown in the next picture.

**Figure 31: Seat jig.**

The final result can be seen in the next picture.

**Figure 32: The seat before it is painted.**

In Ref [1] you can se other types of seats and seat jigs.

Any other type of seat can be used. The main thing is that it fits your body and that you feel comfortable.

### 3.5.1 The mounting of the seat.

*Seat mount solution 1:*

The following was the original design.

It is made out of two pices of metal which are bent 90 degrees and one lager pice to connect them.

The three pices are welded together and grinded to give a smooth surface. The result can be seen in the next figure.

**Figure 33: Seat mount solution 1 after welding and painting.**

The actual design of the seat mount can be seen in appendix A5.

*Seat mount solution 2:*

In order to reduce the amount of work needed to make the seat mounts an alternative method was used. There is one drawback to this solution, you need some kind of tool which can bend a 3 mm metal piece.

**Figure 34: Seat mount solution 2 before paint.**

The additional two metal pieces have been added in order to be able to adjust the angle of the seat.

The actual design of the seat mount can be seen in Appendix A5: Seat mount.

## *3.6 The chain*

The chain consists of 2½ ordinary chains which have been assembled into one big chain.

In order to guide the chain a “chain wheel” and a “chain tube” have to be used.

### 3.6.1 Chain wheel.

The chain wheel can be seen in the next figure:

**Figure 35: Finished chain wheel with ball rollerblade bearing.**

The actual dimensions of the chain wheel used can be seen in appendix A4. The ball bearings used are taken from an old rollerblade.

In order to attach the chain wheel to the main tube a small mount has been made. The small mount can be seen in the next picture.

**Figure 36: Chain wheel mount. It measures 20x30x4mm**

### 3.6.2 Chain tube.

In order to protect the rider from getting greased by the chain some kind of protection is needed. This protection is done by a chain tube. For chain tubes a “plastic-garden-watering-system tube” or similar can be used.

The one used so far is 12 mm PVC. It come in a roll and will not lie straight. In order to get the tube straightened out hot water is poured into the tube.

First cut the right length and position the tube so it can hang at full length without touching the ground. Put a plug in the low end and pour hot (appr 100$^{o}$ C) water into the tube. **This has to be done very carefully** since the air in the tube will cause the hot water to splash while escaping the tube.

The next picture shows how the chain tube looks when straitend.

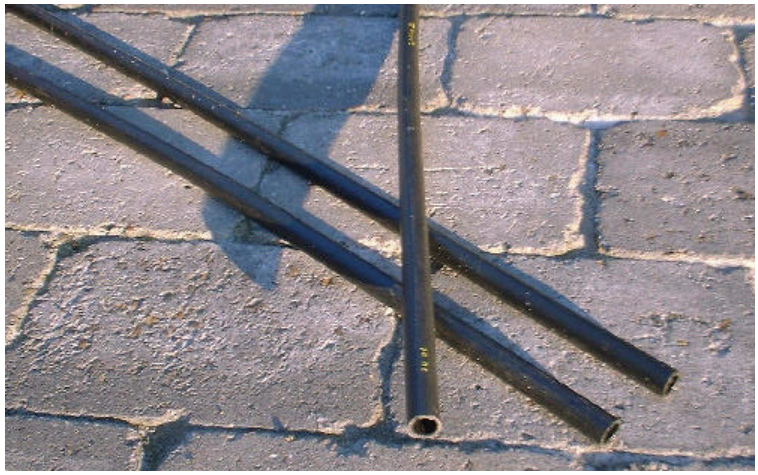


**Figure 37: Chain tube made out of 15 mm plastic tube.**

Other plastic chain tubes may be used, but some of the plastic materials are quite noisy.

## *3.7 The pedalmount or The bottom bracket tube*

The pedal mount consists of a bottom bracket mounted on a tube as shown in the next picture.

**Figure 38: The pedal mount after welding.**

The tube has to be smaller than the tube used for the rest of the recumbent bike. Since the main tube measures 50 mm with 2 mm thicknes the bottom bracket tube measures 45 mm. This leaves 0.5 mm for paint.

The next picture shows how the peadalmount is attached to the rest of the main tube.

**Figure 39: The pedal mount attached to the main tube.**

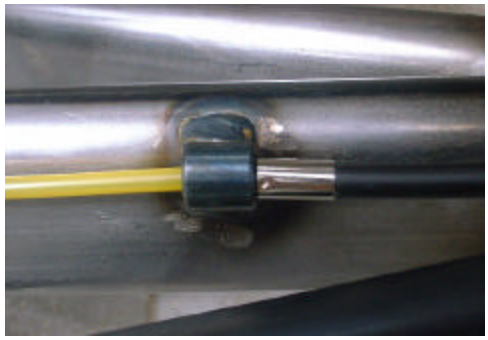
In case the pedal mount is too big to fit the main tube, it needs to be shortened. It is on the other hand advised not to shorten the pedalmount until you are absolutly sure of the length.

Please remember that if the tube is shortened too much, the chain, the pedals or your feet may hit the front wheel.

## *3.8 Cable guide*

In order to guide the cable for the rear derailleur I have made some small cablestops as shown in the next picture:

**Figure 40: Two cablestops at the rear fork.**



The welding of the cable stop can be done in the following way:

**Figure 41: Welding of the cablestops at the rear fork.**

# 4 The final bicycle

The picture below shows what the final recumbent bike looks like.

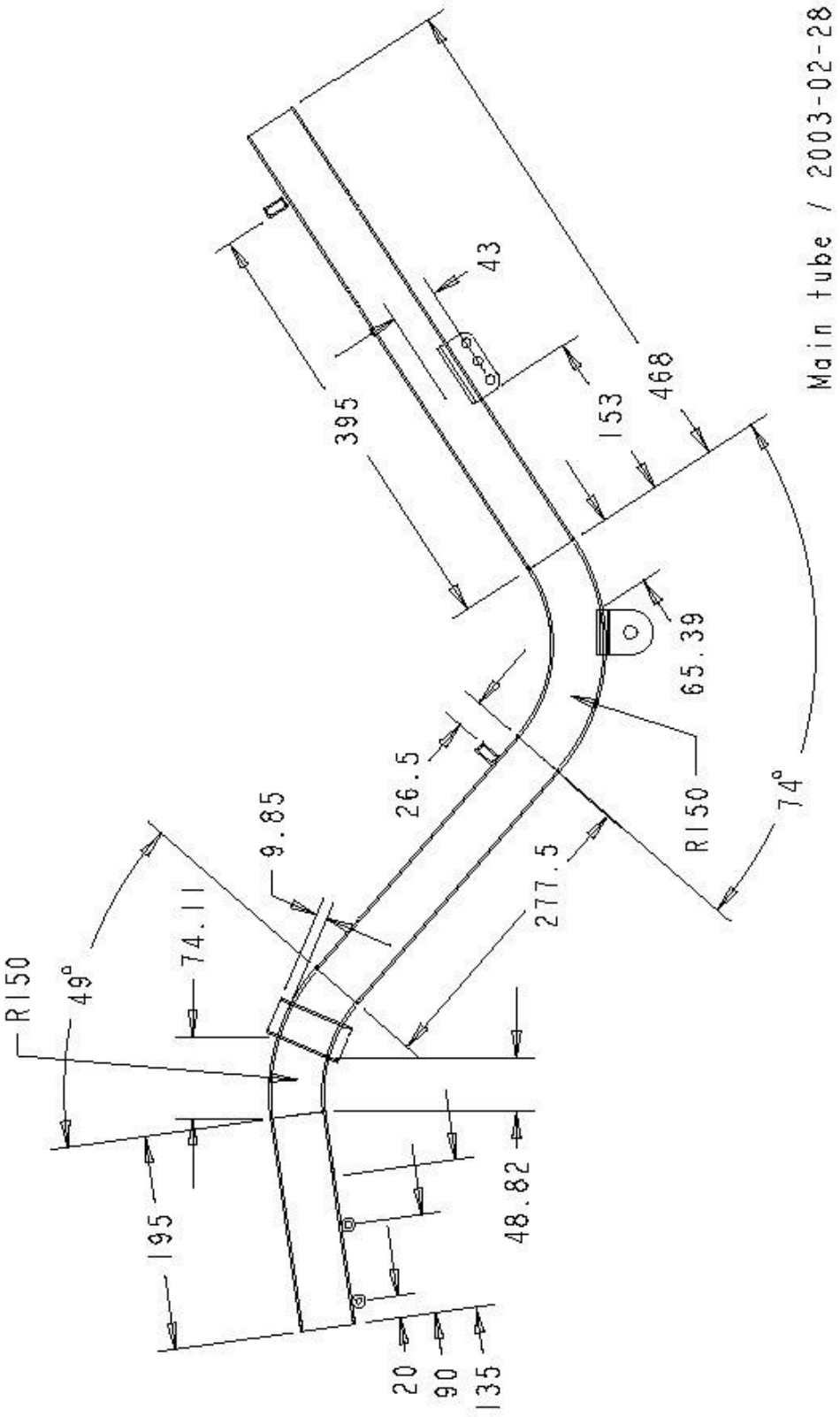

The front fork will not be the final one, but will be used until I have made one which fits the rest of the design.

As the picture also indicates, the seat has to be redesigned so the space between the main tube and the seat can be reduced.

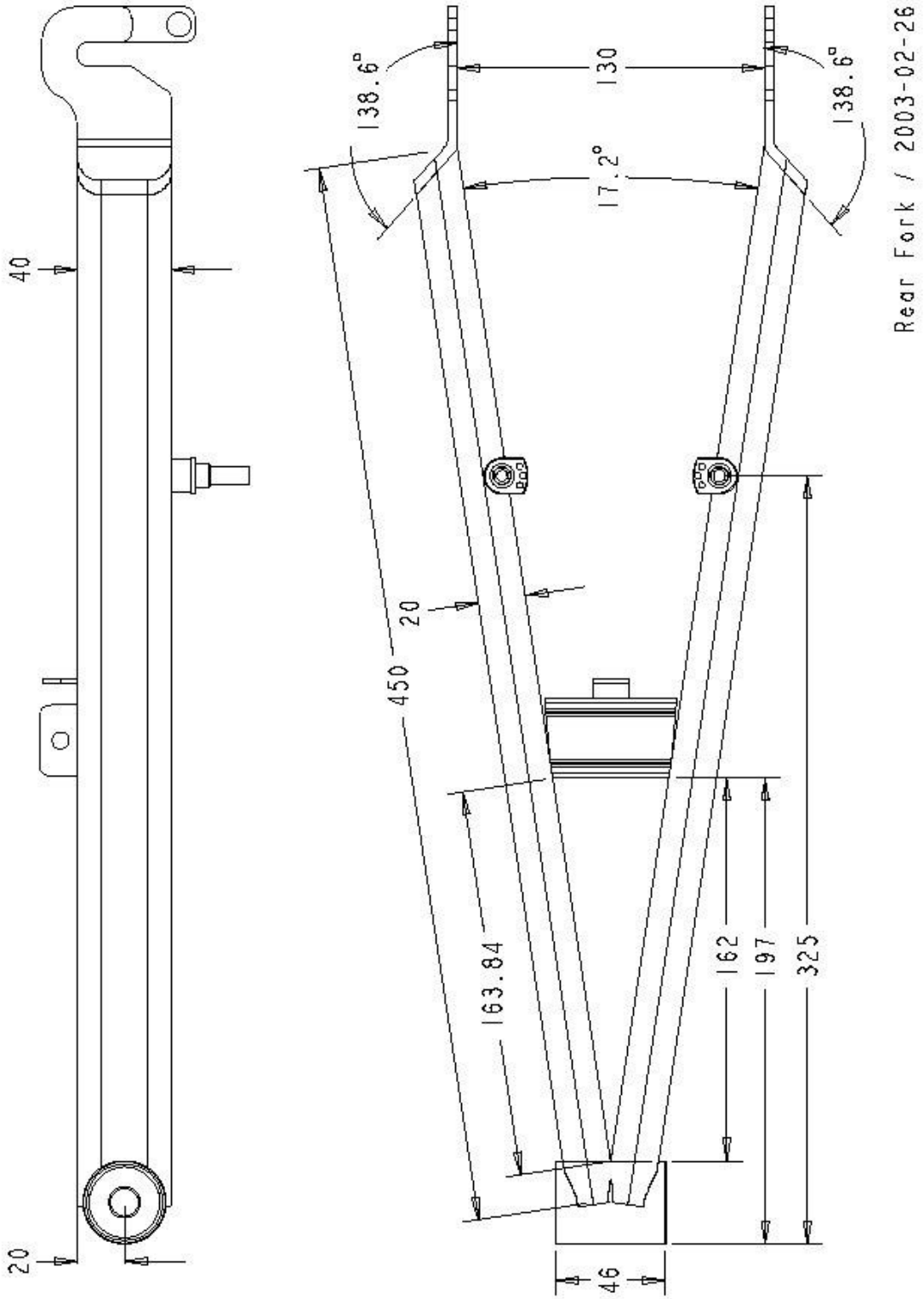
## *4.1 Later adjustments.*

In order to fit the chain tube I have made several small mounts.

# 5 Appendix A1. Main tube.

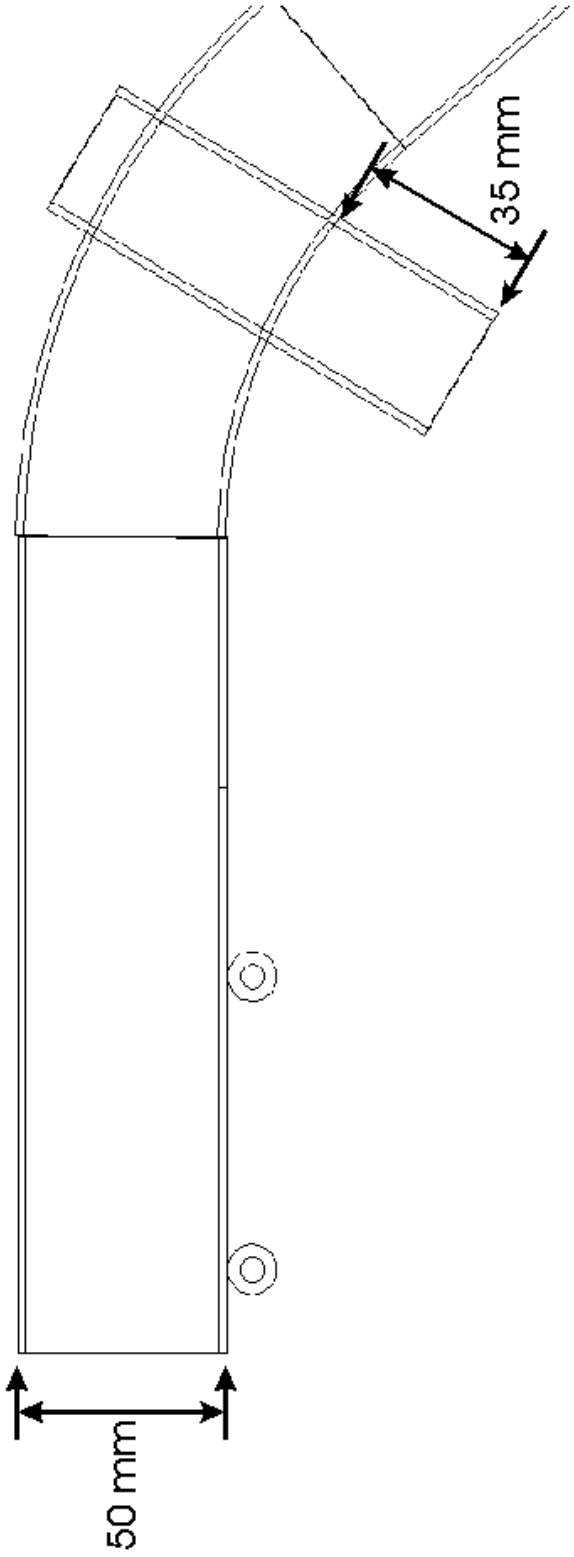


# 6 Appendix A2. Rear Fork.

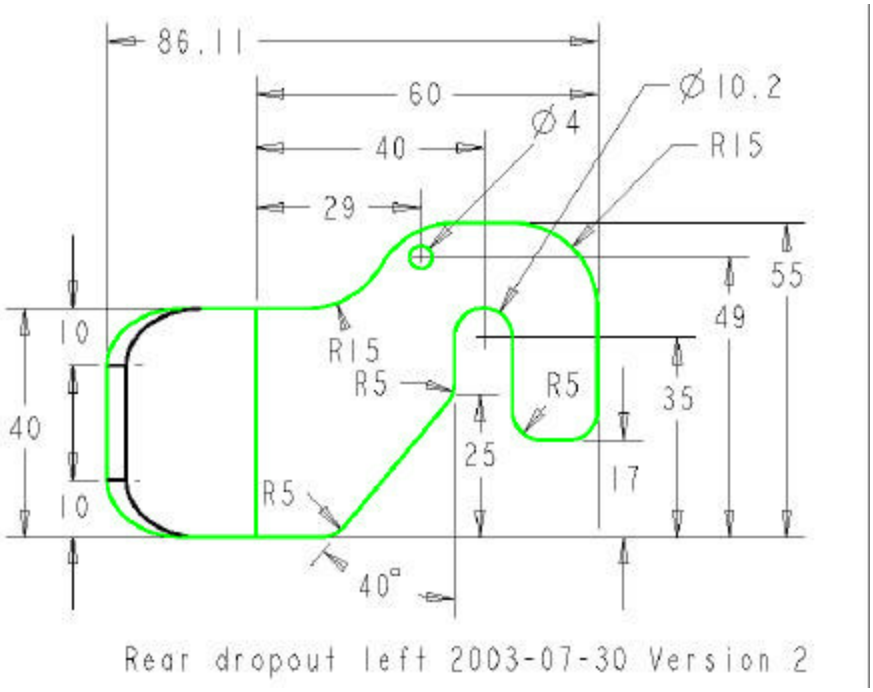


# 7 Appendix A3: Head tube template

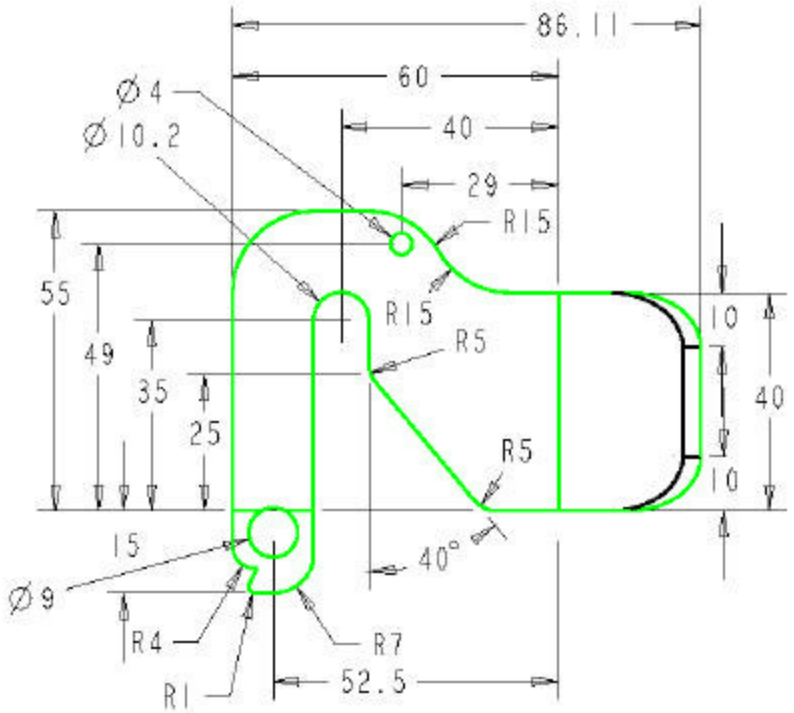
The following figure has to be enlarged so it is in a scale of 1:1.



# 8 Appendix A3: Rear dropouts.

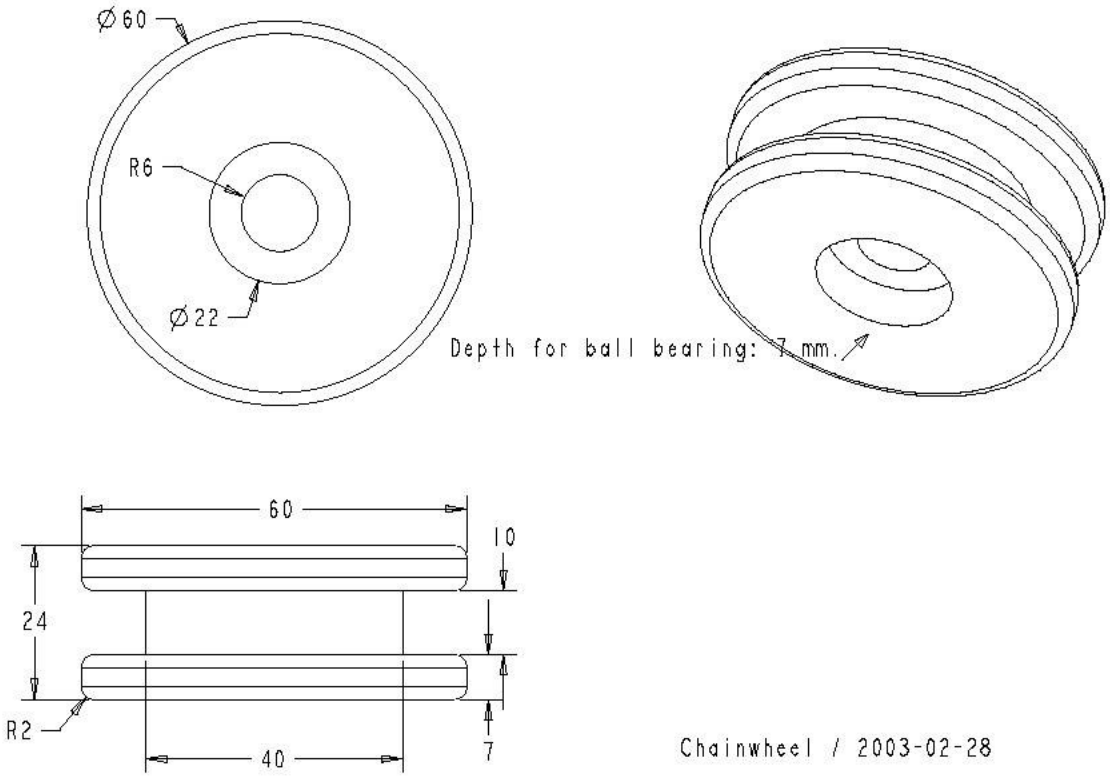



Rear dropout left 2003-07-30 Version 2



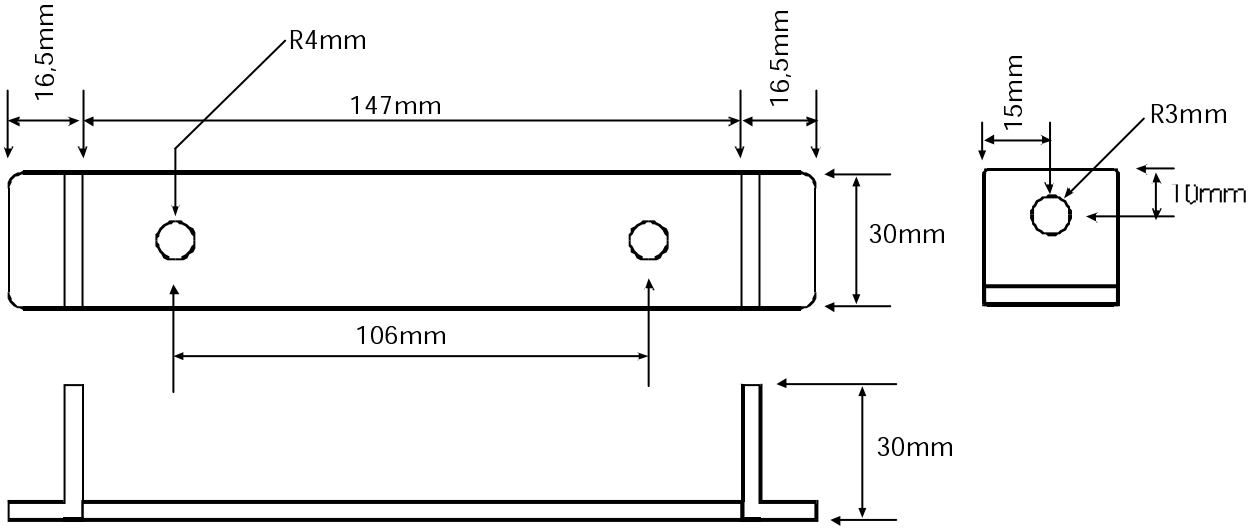

Rear dropout right 2003-07-30 Version 3

# 9 Appendix A4: Chain wheel.



# 10 Appendix A5: Seat mount.

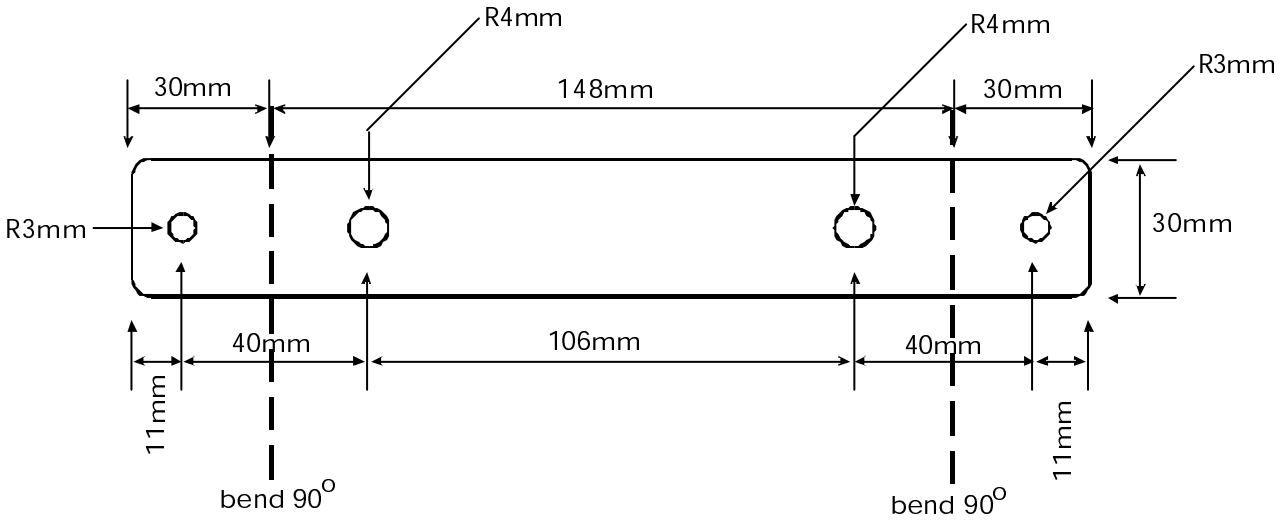
### Version 1:




The two holes with 106 mm in between have to match the holes in the seat.

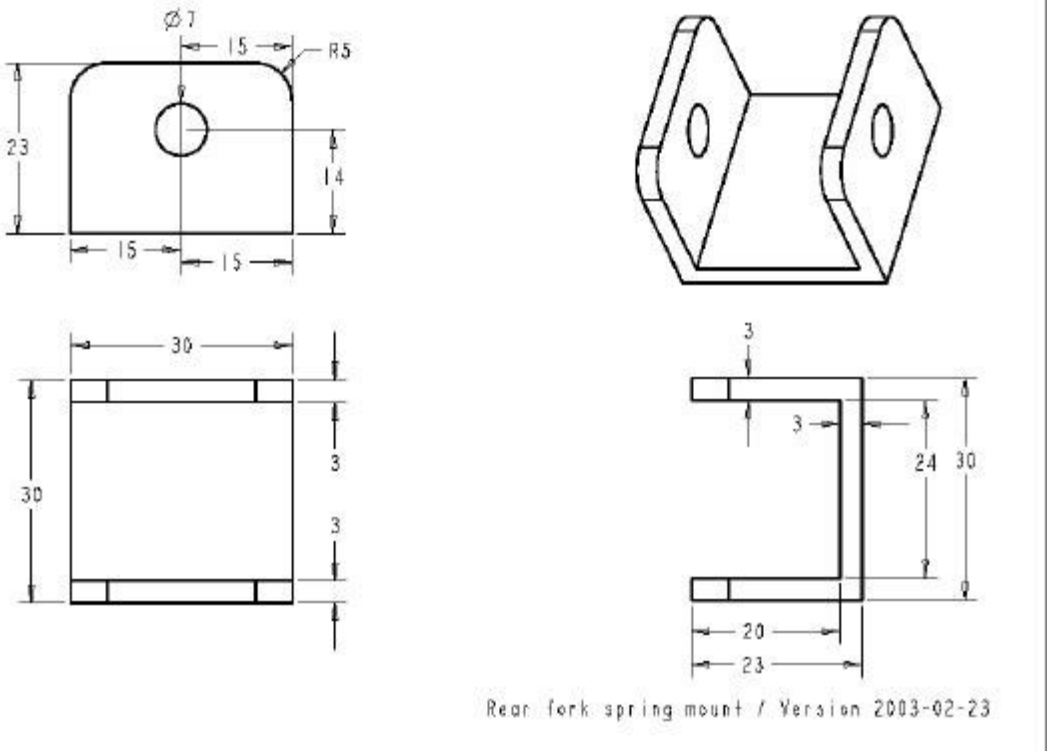
### Version 2:

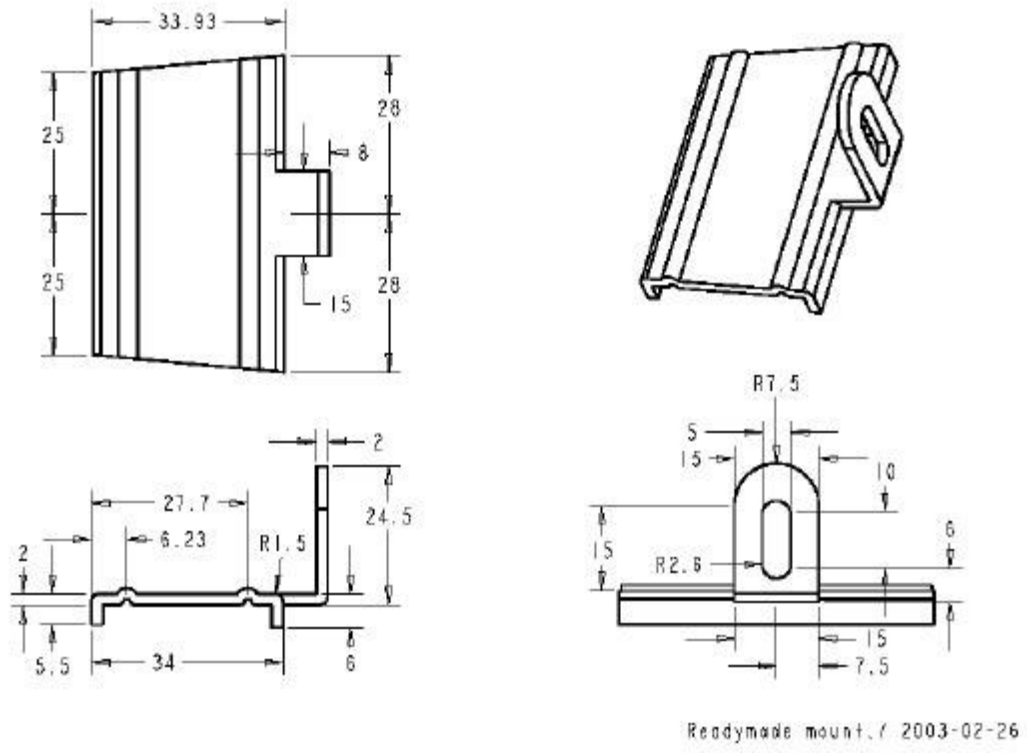
This seat mount is made out of a small piece of metal which is 3mm thick and bended 90 degreees in two places.This results in a very wide u-shape seat mount.




In case other screws are used change R3 and R4 accordingly.

# 11 Appendix A6: Rear fork spring mount.



# 12 Appendix A7: Additional drawings.

**Figure 42: Detailed design of the ball bearing attachment**

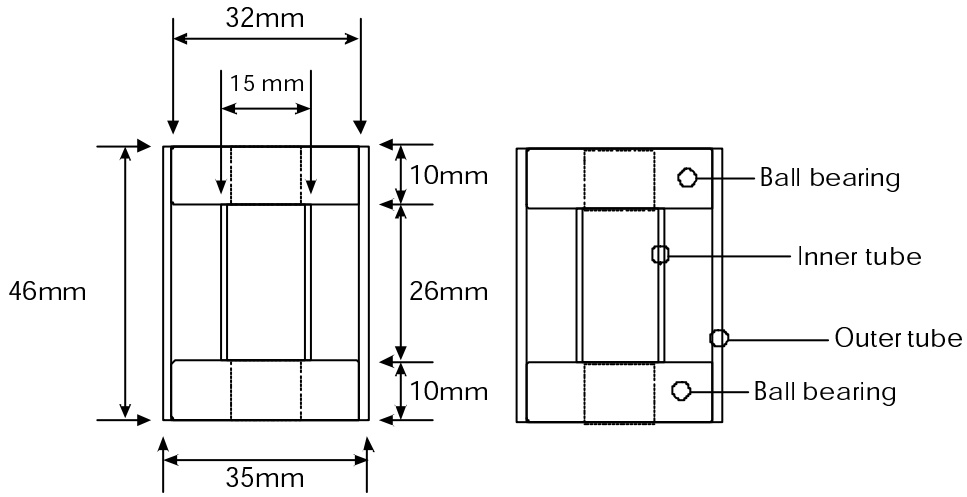



**Figure 43: Small tubes to tighten the main tube.**

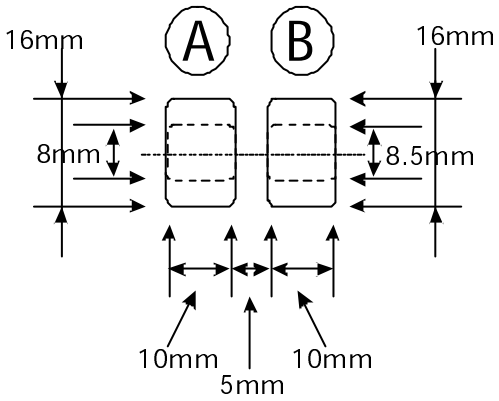



**Figure 44: Cross section of the rearfork tube.**

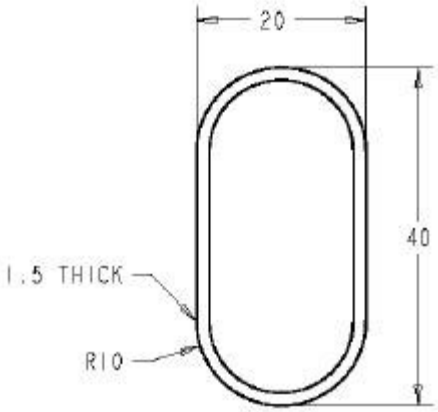


**Figure 45: Rear fork mount on the main tube.**

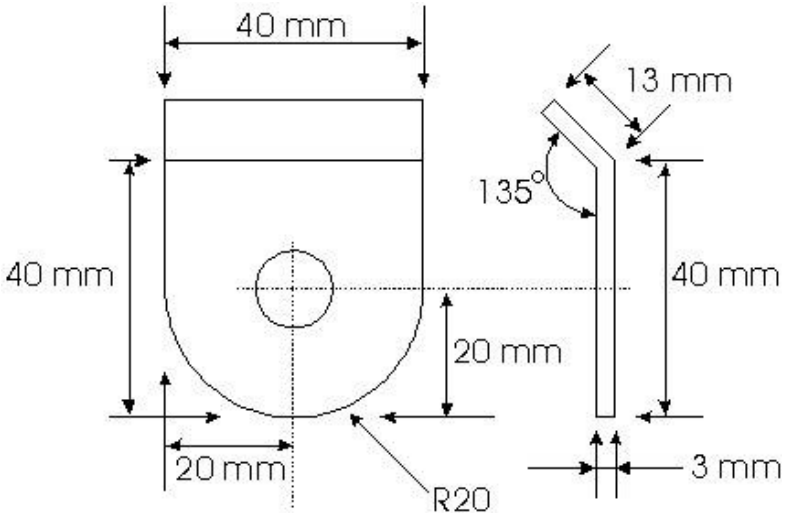
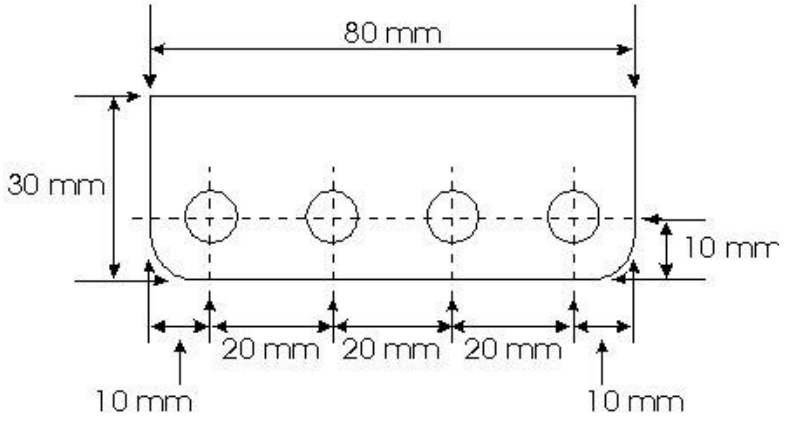



**Figure 46: Rear fork spring mount on the main tube.**



# 13 Appendix A8. Bikepart.

I have found the following picture somewhere at the Internet.

If you know who has designed the picture let me know.