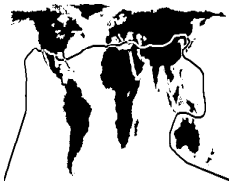
DTU

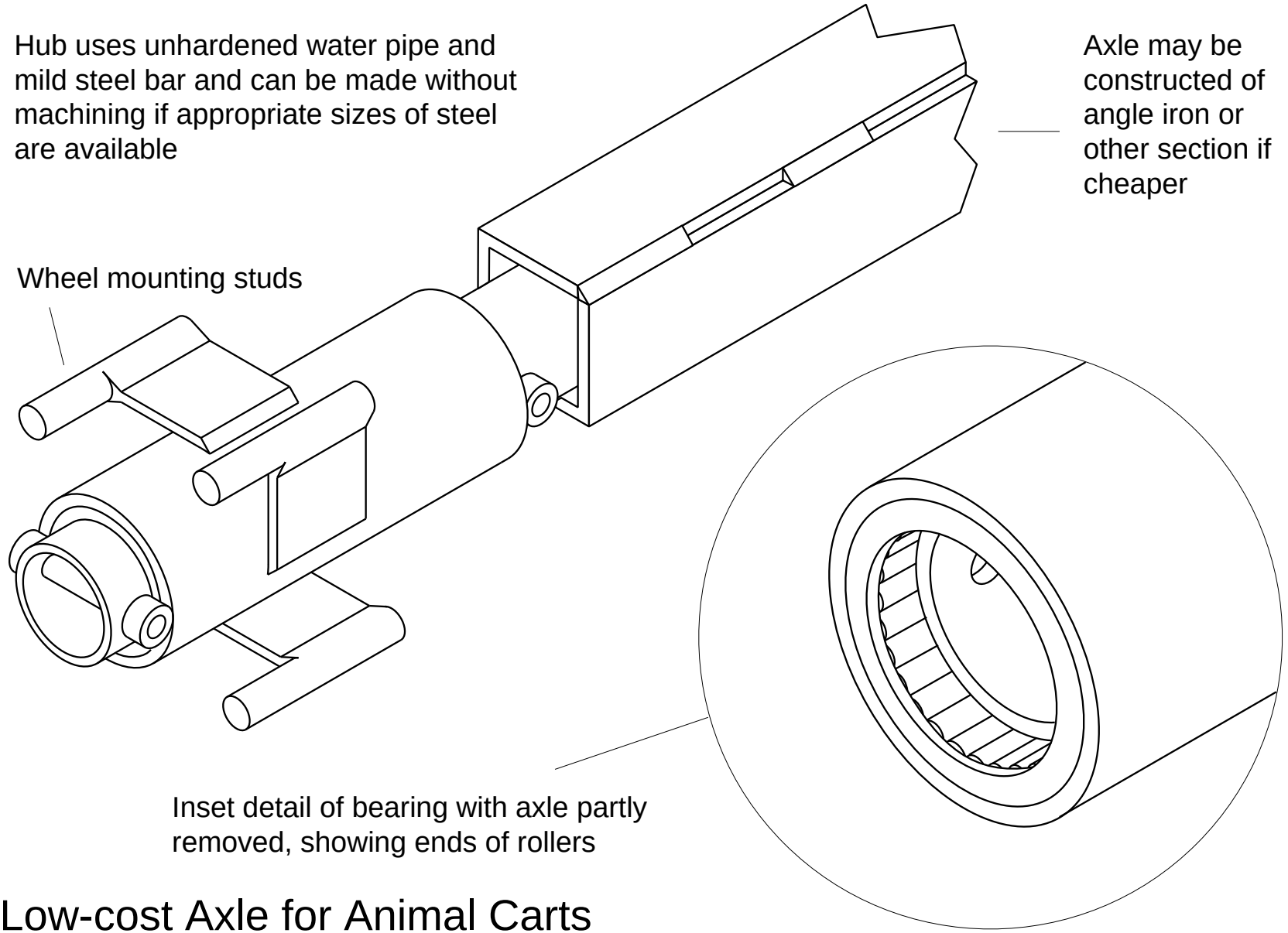


Animal Cart Programme

TECHNICAL
21
RELEASE

PIPE AND ROLLER DONKEY CART AXLES

Development Technology Unit, Department of Engineering, University of Warwick, Coventry, CV4 7AL UK, tel: +44 (0)1203 523523 extn 2339, fax: +44 (0)203 418922, email: esceo@uk.ac.warwick.eng



Low-cost Axle for Animal Carts

TR21: 1st August 1994

Pipe and Roller Donkey-Cart Axles

Introduction

Not enough farmers in Africa have animal carts. Those who have carts can take their produce to places where they can get the best prices. They can also get into town and buy fertilizer and better seeds and move stuff around their farm easier. The trouble is that carts are too expensive for many farmers. The question is what can be done about it?

Carts are made in many different places. Some carts are made in factories in industrial countries and some are made in factories in Africa, but most are made by local blacksmiths or carpenters using scrap car and Land-Rover axles. These people cannot get enough axles to meet the demand so the price is high. Another problem is that the axles are often so worn that they do not last long. Lots of farmers take the diff (differential) unit out of the axle too, which makes it break sooner and lets the dirt in.

What you need is an axle which blacksmiths and fabricators can make with fairly simple tools - without having to get parts machined. There are usually blacksmiths and fabricators in the small market towns used by the farmers. Experts think that having the cart maker close to the farmer is a good thing because they can talk to each other easily and sort out any problems. And of course if the cart is made locally, it can be repaired locally, so there will not be problems with spare parts.

Idea behind design

The idea behind the design of axle described in this technical release is to allow construction without the use of machine tools (lathes and milling machines), and using materials which should be readily available. The materials can be used 'as bought' - no hardening of any of the components is needed. The only tools which you must have are a hacksaw, a file and a drill able to drill a 13mm hole in steel. Having a vice is also very handy.

Of course if you do have power tools - especially a power hacksaw or cutoff wheel - things can be made much faster. This axle is suitable for a wide range of production methods.

The long thin needle rollers in this design have been used so that the hubs will usually fit scrap car wheels. Most wheels have a hole in the middle for the axle. This hole is usually

about 60mm diameter, or a bit bigger. Sometimes they are smaller and the wheel will not fit. You can sometimes saw or file the hole bigger. Putting the fixing studs on struts like you see in the drawings means that you might be able to bend the struts a bit to fit a different wheel. Or if that does not work you can even cut nearly through the welds and then weld them in the right place. You could even cut the struts right off and weld on a different number if your wheels have a different number of holes.

Performance

We have tested axles like these for more than 10 000km in the laboratory and some axles have been ok for 30 000km. Usually we set the load at 200kgf per wheel, but we have used them at 400kgf for thousands of km. Sometimes you need to clean them out and regrease them. Some of the axles we have tested have not been very round at all - one was more than 1mm out, but they have still worked. We have tried rollers made out of 6" nails with the heads cut off. They still worked even though they were slightly bent. (The symbol " means inches so 6" means about 150mm since there are 25mm in one inch.)

component	material	number & lenghth required [no.×mm]	total material in axle [mm]	materials cost in Nigeria [$us]
central axle	2" angle iron[1]	2×1200	2400	3.94
hub stub axles	1¼" BSP malleable iron pipe	2×350	700	4.71
hub tube	2" BSP malleable pipe	2×164	328	1.47
rollers	5 mm or 3/16" dia BMS[2]	60×152	9120	2.49
roller retaining rings	5mm or 3/16" dia BMS	4×167	668	0.20
axial thrust rollers	16 mm dia BMS[3]	4×8	32	not used
hub restraint bolts	M8 or M10 bolts ×70mm	70×4	280	1.28
wheel studs	12mm studding	8×70	560	2.55
wheel stud struts	6×40 black steel strip	4×37	148	0.68
stud washers	3×40 BMS strip 4	4×40	160	not used
TOTAL COST =				17.32

1 Axle could be one piece of pipe with the stub axles - see text.

2 BMS = bright mild steel round bar.

3 Thrust rollers can be made from a stack of washers. They are not essential but give better performance.

4 Backing washers, placed on the stud before the wheel, make the wheel more secure if it has large stud holes.

Cutting list and costs

The table shows a cutting list for a complete axle - two wheel hubs and stub axles joined by an angle iron section in the middle. We did this because angle iron was much cheaper than pipe. But if it is not where you are then make the whole axle out of one piece of pipe. Recent prices of materials in Nigeria are shown in $_{US}$. The 2" BSP (British Standard Pipe)

is about 60.8mm outside diameter, or a bit less, with a wall thickness of about 3.6mm. The 1¼" BSP is about 42.9mm outside diameter, with a wall thickness of about 3.2mm.

Construction step by step

These instructions deal with making an axle to the design shown in the drawings. If you find that you cannot get the right sizes you might still be able to make an axle with other sizes. See the **Modifications** section on page 6.

1. The first and probably most difficult job, is to get some suitable pipes and roller material. Obviously the axle has to be strong enough to carry the cart, so it should **not** be made from pipe smaller than about 40mm outside diameter. You must make sure that the pipe has a wall thickness of more than 2.5 mm.

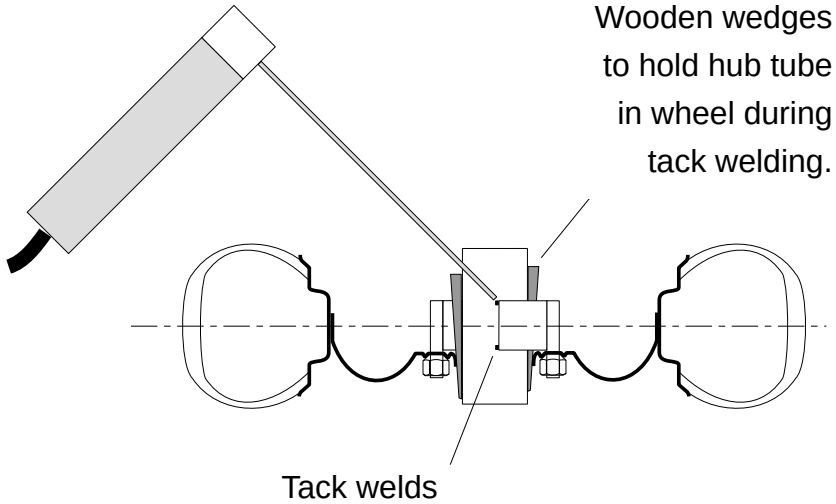
   The hub pipe must also have a wall thickness of 2.5mm or more. And it must have a bore (or inside diameter), which goes over the axle with enough room for rollers all the way around between it and the axle. Rollers must be 4.5mm, 3/16" or 5mm diameter (if they will go in). There can be quite a lot of play (slackness, looseness or clearance) between the rollers and the axle (say 1mm) - it does not have to be tight like an ordinary ball race.

2. When you have worked out how to get the right pipe and roller sizes, then you can cut the two hub pipes 164mm long and the two stub axles 300mm long. You also have to cut enough rollers to fill up between the stub axle and the hub pipes. You will probably need about 25 or 27 for each hub and the rollers must be about 152mm long. Do not try to squeeze the hub full of rollers - the best way to find out how many you need is to put as many in as you can and then take one or two out. You should clean up the ends of the rollers with a file after you have sawn them.

3. The next step is to weld the stud bolts or bits of threaded rod onto the struts. When you've done this you can put the studs into the wheels, put the nuts on, and get everything even and straight with the hub pipe in as well. You might find that holding the hub tube in with some wedges as shown in Figure 4 is a good way to do it. You also want to get the middle of hub pipe level with the middle of the tyre, as is shown in Figure 5. Most car wheels need the studs to be about 40mm offset and this is what is on the drawings. When you are happy, tack weld the struts to the hub pipe, remove the wheel and wedges so you've got room and weld the stud supports to the hub tube. Repeat this for the

other hub. If you are going to make several axles you can make up a simple jig, rather than the wedges, to hold everything for welding. We have used a piece of plywood with a central hole to fit snugly over the hub tube and four holes for the studs. In other words its a bit like a dummy wheel. Its best to check that the hubs, rollers and stub-axles still go together when you've finished welding - sometimes weld contraction can pull it all out of shape and make it all too tight. You might need to file off some high spots inside the hub. If you can get it together without a hammer you'll be ok because it will wear to the right shape.

Figure 5: CROSS SECTION OF TYRE WHEEL AND HUB TUBE DURING TACK WELDING OF STUD SUPPORT STRUTS



4. Now take the wheels off the hubs and make up four rings (called roller restraint rings on the drawing) from the same material as you used for the rollers. The rings have to be welded just inside the ends of hub pipes to stop the rollers falling out. When they're welded in you need to use a half round file to open the hole in the middle where the axle pipe will go so that it's got plenty of room - you do not want it rubbing on the axle.

5. Next drill the four holes for the cross bolts. Put the end ones about 15mm from the end of the axles. At the other end you need to make them just far enough away from the end of the hub so that you can turn the nuts to get them on. Again about 15mm seems to do the trick. It does not matter of they are a bit loose.

6. Nearly there! Now you need to cut two bits of angle iron and weld them together to make the center axle to join the stub axles. You must put the stub-axles in position when you weld - the contraction of the angle iron when the weld cools down clamps everything (if you are lucky). Otherwise

just put a few tack welds on to hold it in place.

7. Now put it together! Put some grease into the hub and put the right number of rollers in so that they are in place against the inside of the hub tube. You can hold them in with a bit of rag or a plastic bag if the grease does not stick them. Then just slide them onto the stub axles and fit the cross bolts. (If a plastic bag or rag was used to hold the rollers it should be pushed out by the axle.)

8. You've done it!

Modifications

If you cannot get suitable sizes of pipe and round bar, then pipes can be made slightly bigger (up to 1mm bigger) by forcing a short piece of round bar of the right diameter through them with a press. Another way to do it is to saw the pipe along its length and open to the right size and then weld it. You can also make it a bit smaller like this by cutting a wider slot and squashing the pipe down. Do not worry about the rollers rolling over the groove - as long as you clean the weld back flush with the tube it will be ok.

If you find that you cannot get anything like the materials talked about in the cutting list then maybe you can adapt the design a bit. If the hole in the middle of the wheels is big then you stand a better chance of finding a combination of pipes and rollers that will fit. You can often cut a bit out of the middle of the wheel to make the hole bigger. The hole in Land Rover wheels is big and you can get 4" pipe into them. You may find that you can use small pipe say 1/2" pipe to make the rollers for example. Of course the shaft does not have to be a pipe - it could be solid and then it could be a bit smaller, say 30mm diameter if the steel is high quality.

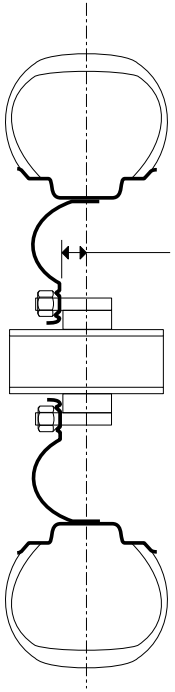


Figure 5: CROSS SECTION OF TYRE WHEEL AND HUB TUBE SHOWING CENTERING OF HUB TUBE IN WHEEL

This distance must be set to get the hub tube in the middle of the tyre.

Hub tube.

Getting the hub in the middle of the wheel and tyre means that the bearings in the hub are evenly loaded.

Another idea that we have tried is to use a hardwood as the hub and even the wheel. If you think about it, the wear on something which is rolling must be less than when something is sliding over it, so a wooden bearing should be better than a sliding one. Some bearings we have tried have had a steel ring fitted inside so that the rollers roll on this steel. We have also tried making these rings from round bar like wire so that it's like the rollers roll on the inside of a spring. This seemed to work quite well.

The main thing to remember with these bearings is that the rollers must be long compared to the diameter of the axle. In the axle and hub shown in this technical release the rollers are about four times as long (150mm) as the diameter of the axle (43mm). Also bigger rollers work better. In our design for Land-Rover wheels on bullock carts we use 3/8" or 10mm diameter rollers and we have successfully used rollers over 20mm diameter in some experiments.

Other ways of making the thrust bearings

We have tried some other ways of making the thrust rollers at the ends. You can have just one roller on each cross bolt and this one can have a countersunk hole in its end so that the

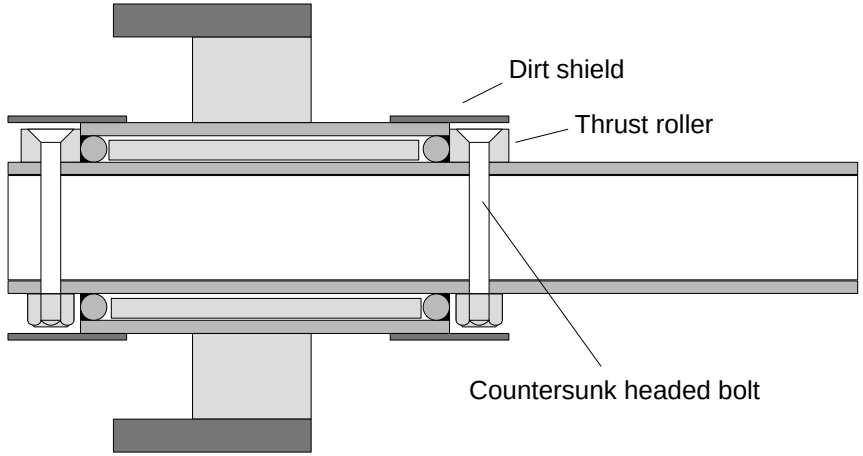


Figure 6: axial restraint rollers on countersunk head cross bolts.

cross bolt head (if its countersunk) can fit in and not stick out. This makes it easier to put dust shields on. You can see this arrangement in Figure 6.

Another way that we have used rollers is to put them inside the dirt shields without any bolts. You can see this in Figure 7. The rollers have no holes - they are just plain pieces of rod. You need to use big rod so that its diameter is a bit bigger than its length. If you do not do this the rollers can turn over and jam.

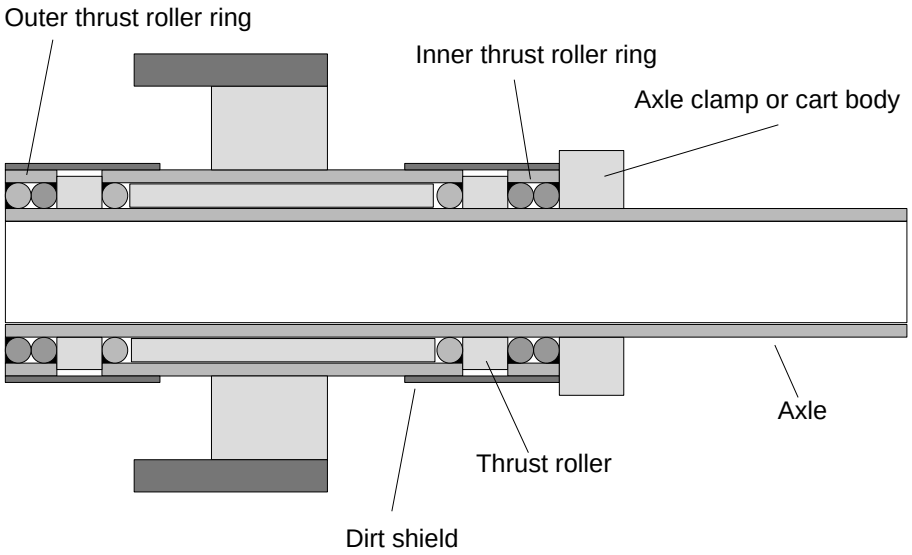


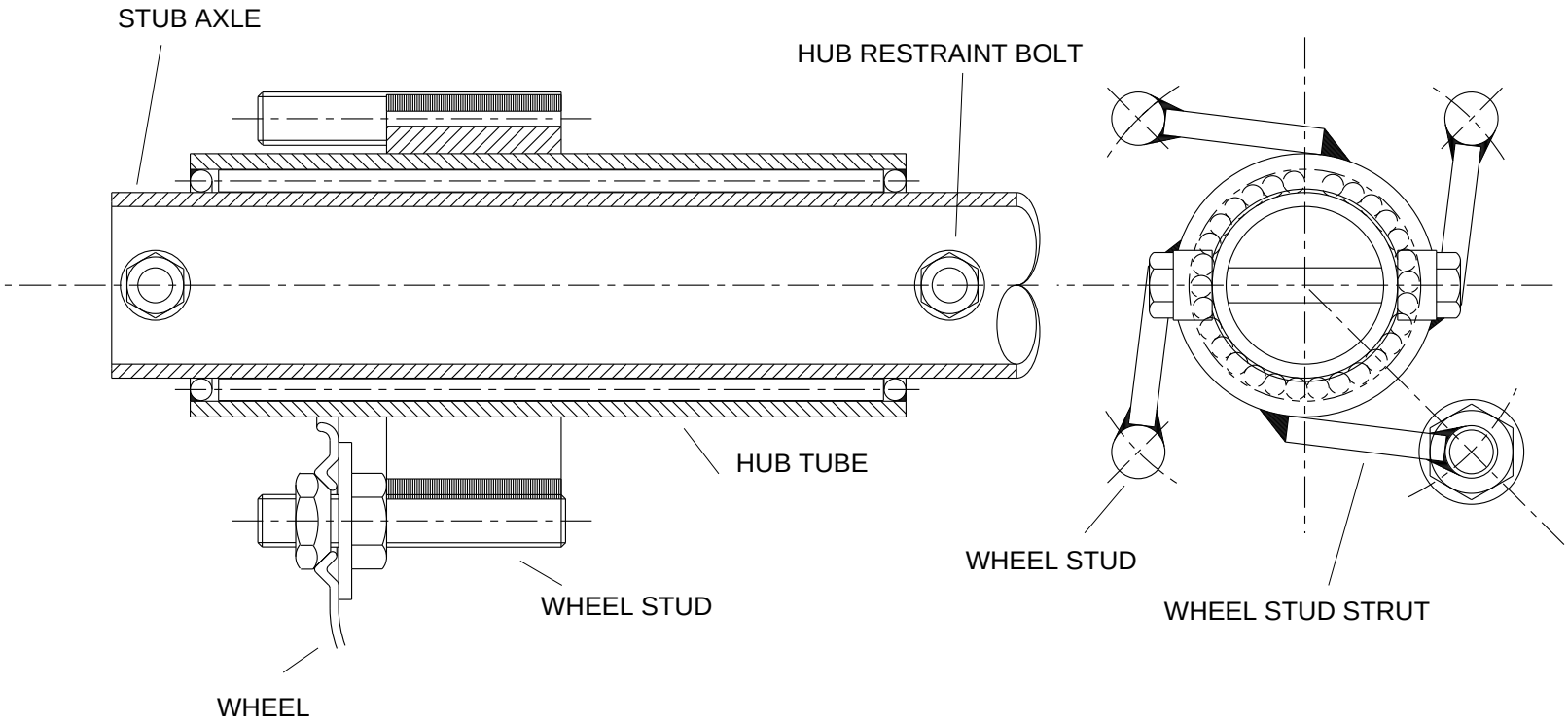
Figure 7: axial restraint rollers held inside dirt/ oil shields.

You must clean up the ends of the rollers with a file and round off the corners a bit so that they can slide inside the dirt shield and not catch on anything. The rollers roll against thrust roller rings made of the same pipe as the hub tube is made from and the same rod as the rollers. The outer thrust roller ring should be welded to the axle. The inner one is held on by the cart body or the clamps which hold the axle to the body. You can put one or more thrust rollers in.

One more advantage of this method of axle construction is that you do not need to drill any holes.

Other DTU cart developments

Other methods of hub design using aluminium castings, for example, which might need no machining, are under development at Warwick and wheel designs in steel sheet, cast aluminium and timber are also in manufacture or under development. A range of designs for donkey and ox carts made of steel and wood, is also available, some of which are in production in Nigeria.



	GENERAL ASSEMBY DRAWING	Scale	10mm	Title	Drawn by	CEO
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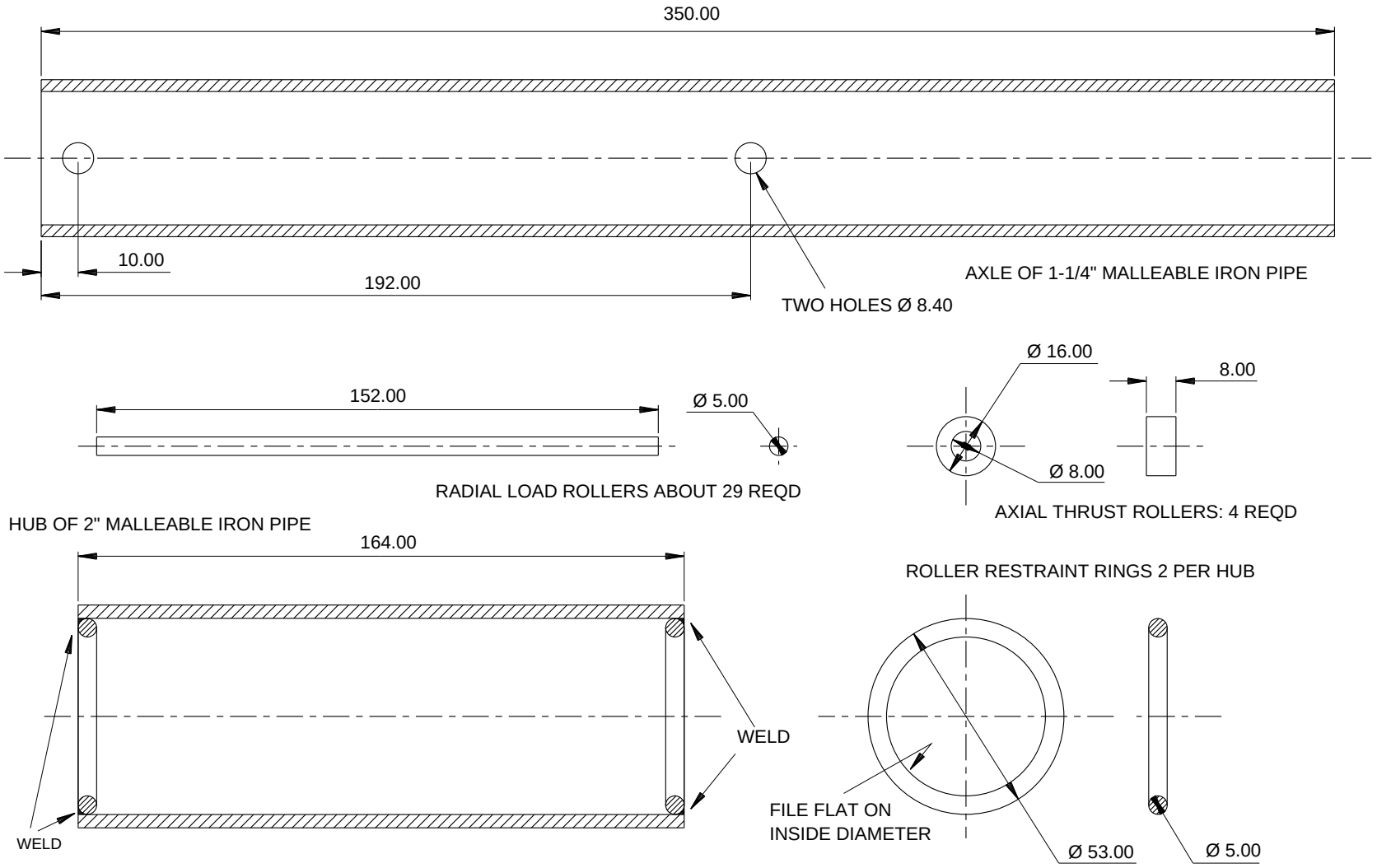

	HUB AND AXLE COMPONENTS	Scale	10mm	Title	Drawn by	CEO
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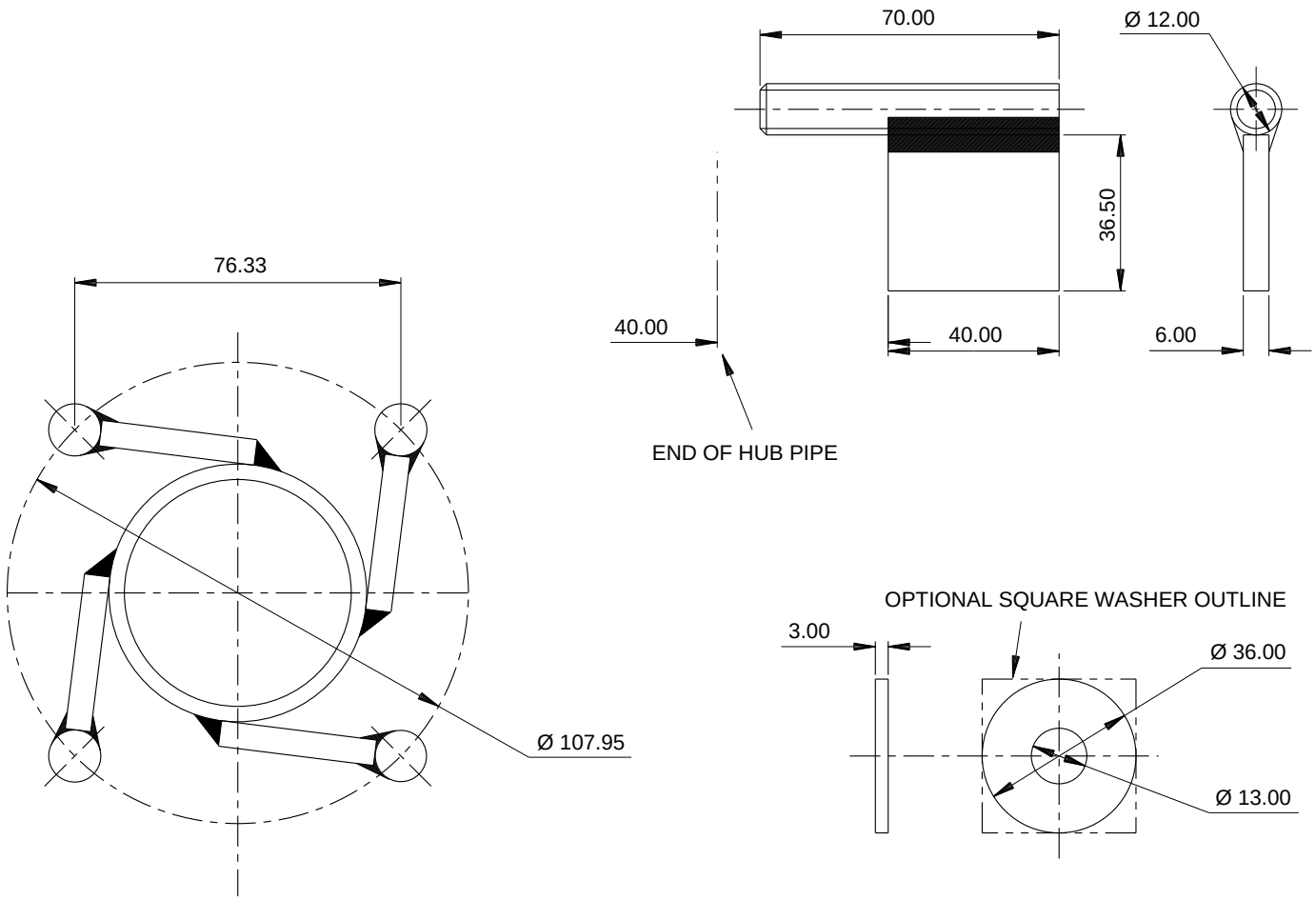

	WHEEL MOUNTING COMPONENTS	Scale	10mm	Title	Drawn by	CEO
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