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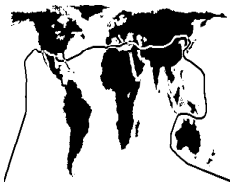

Animal Cart Programme

TECHNICAL
22
RELEASE

PIPE AND ROLLER AXLE FOR OX CARTS

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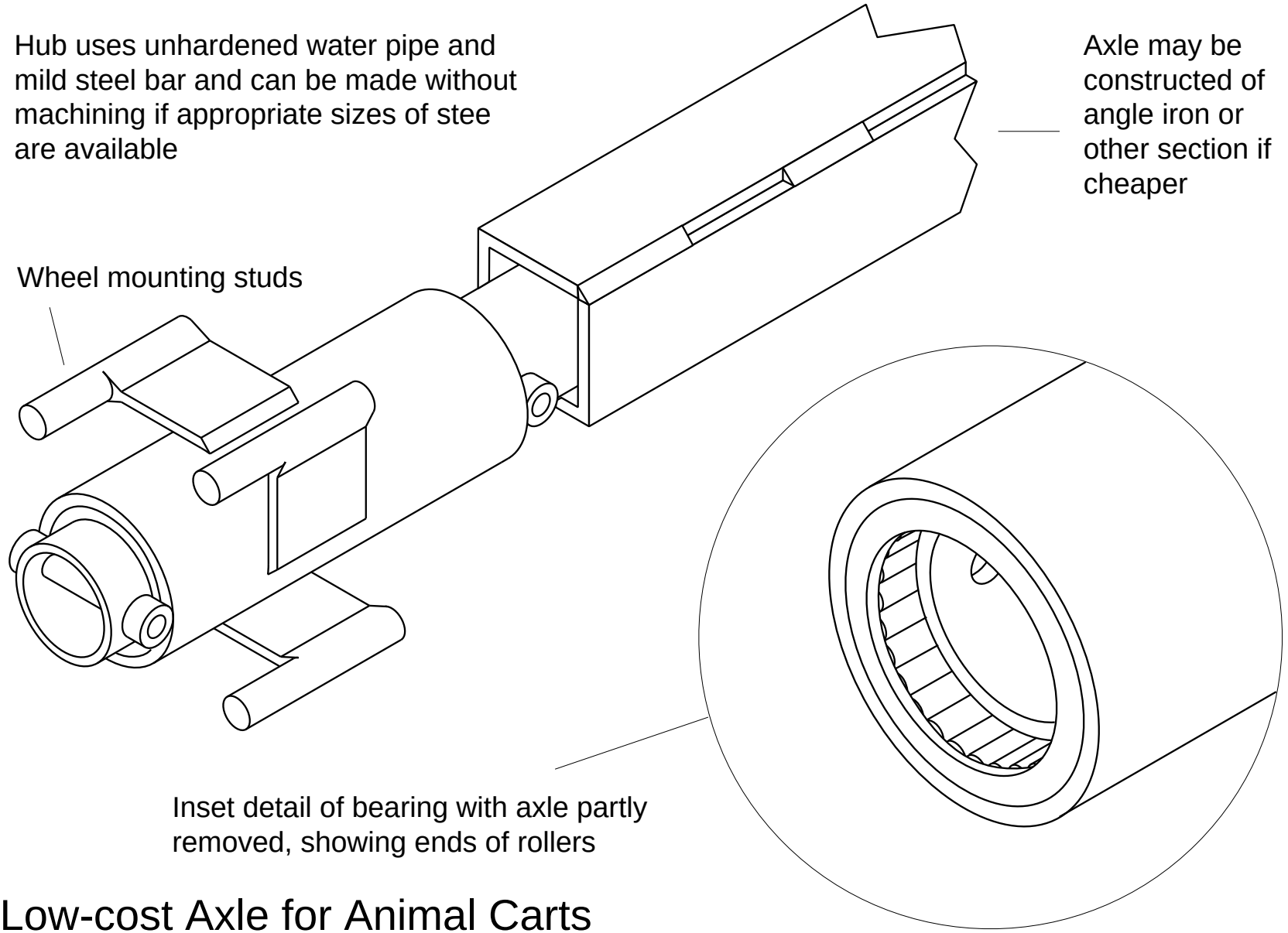


Low-cost Axle for Animal Carts

Pipe and Roller Ox-Cart Wheel Hubs

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 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 won't be problems with spare parts.

Idea behind design

The idea behind the design of axle described in this technical release is to allow axle 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, and you do not need to be super accurate - good hand working is good enough. 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 - you could even tool up for manufacture with some specially made tools!

The long thin needle rollers in this design have been used so that the hubs will usually fit scrap Land-Rover and Japanese four-wheel-drive vehicle wheels. These wheels have a hole in the middle for the axle which is 115mm diameter (ie 4½") on a

Land-Rover wheel, but is smaller on the Japanese vehicles. If the wheel won't 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 doesn't 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 smaller versions of axles like these for more than 10 000km in the laboratory and some axles have been ok for 30 000km. With the smaller axles we usually set the load at 200kg per wheel, but we have used them at 400kg for thousands of km. With these big axles we expect double the load capacity - say up to 800kg on each wheel. You will probably find that the axles need to be cleaned and regreased every six months or year depending on how much they are used. The materials that you use do not have to be perfect - 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 on the small version of the hub. They still worked even though they were slightly bent. Another material which might work for small rollers is welding electrode with the flux knocked off. Of course none of these axles are as good as axles with proper bearings in them, but they are a lot cheaper and easier to make and they should still last many years.

Cutting list and costs

Table 1 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 isn't where you are, then make the whole axle out of one piece of pipe. Recent prices of materials in Nigeria are shown converted to $\$_{US}$. The 3"BSP (British Standard Pipe) is about 89mm outside diameter with a wall thickness of up to 5mm. The 2"BSP is about 61mm outside diameter with a wall thickness of about 4.5mm.

Construction step by step

These instructions deal with making an axle to the design shown in the drawings. If you find that you can't 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

Table 1 Cutting list and costs for pipe and roller ox cart axle				
component	material	number & length required [no.×mm]	total material in axle [mm]	materials cost in Nigeria [$us]
central axle	75mm (3") angle iron[1]	2×1200	2400	2.98
hub stub axles	2" BSP malleable iron pipe	2×500	1000	5.67
hub outer race	3" BSP malleable pipe	2×250	500	1.24
rollers	10 mm or 3/8" dia BMS[2]	40×228	9576	26.49
roller retaining rings	10 mm or 3/8" dia BMS	4×219	880	2.43
axial thrust rollers	25 mm dia BMS[3]	4×12	48	0.41
hub restraint bolts	M12 bolts ×100mm	4×100	400	1.28
wheel studs	12mm studding	8×70	560	2.55
wheel stud struts	6×40 black steel strip	5×62	310	0.47
stud washers	3×40 BMS strip 4	5×40	200	0.14
TOTAL COST =				43.66
1 Axle could be one piece of pipe with the stub axles - see text.				
2 BMS = bright mild steel bar.				
3 Thrust rollers can be made from a stack of washers. They are not essential but give better performance in dusty environments.				
4 Backing washers, placed on the stud before the wheel, make the wheel more secure if it has large stud holes.				

suitable pipes and roller material. Obviously the axle has to be strong enough to carry the cart, so you must make sure that the pipe has a wall thickness of more than say 3.5 mm.

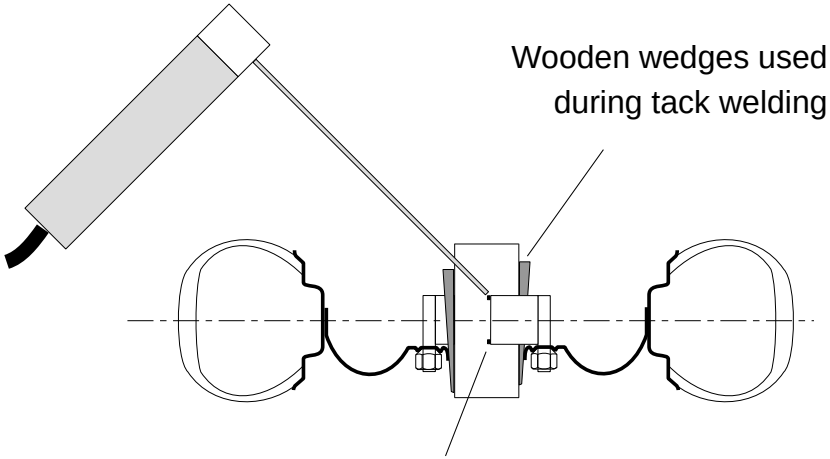
The hub pipe must also have a wall thickness of 3.5mm or more. It must also have a bore (or inside diameter), which goes over the axle with enough room for rollers all the way around between it and the axle. Rollers must be 9mm, 3/8" or 10mm diameter (if they will go in). There can be quite a lot of play (looseness, space 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 250mm long and the two stub axles 450mm or so long. You also have to cut enough rollers to fill up between the stub axle and the hub pipes. You will probably need about 20 or 21 for each hub and the rollers must be about 228mm 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 the wheel with some wedges, as shown in Figure 2 makes things easier. Also don't forget that you want to get the middle of hub pipe level with the middle of the tyre, as is shown in Figure 3. Most 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 tube, take the wheel off so you get at the tube easily and weld the stud support struts 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 to hold everything for welding. We have used a piece of 18mm plywood with a central hole that fits the hub tube tightly and has a hole for each of the studs. Really this is like a dummy wheel. After welding its best to check that the hubs, rollers and stub-axles still go together - 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 or you may even have to use smaller rollers. If you can get it together without a hammer you'll be ok because it will wear to the right shape.

Figure 2: CROSS SECTION OF TYRE WHEEL AND HUB TUBE DURING TACK WELDING OF STUD SUPPORTS



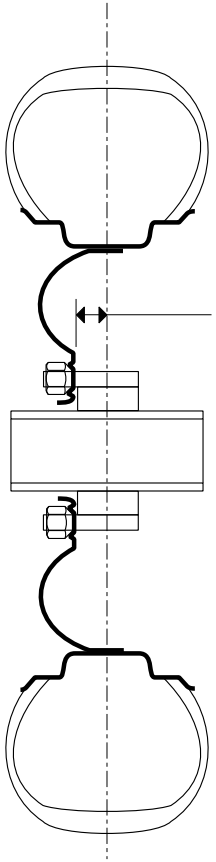


Figure 3: CROSS SECTION OF TYRE WHEEL AND HUB TUBE SHOWING CENTERING OF HUB TUBE

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.

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. Bend them in a vice if you have it, and cut the rod so that there is say a 4mm gap between the ends when they are the right diameter. Then you can push them into the end of the hub tube and weld the ends together. It's best to remove them then from the tube and clean up the weld with a file. The rings have to be welded just inside the ends of hub pipes to stop the rollers falling out so do this next. 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 don't want it rubbing on the axle.

5. Next drill the two holes in each stub axle for the cross bolts. Put the end ones about 20mm from the end of the stub axles. You need to make the holes for the other two bolts just far enough away from the end of the hub so that you can just get the thrust rollers on. Probably the best way to do it is to assemble the hubs on the axles after you've drilled the first holes, offer up the other roller and mark the position. It doesn't matter of the hubs are a bit loose on the axles.

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 all 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 place with a bit of rag or a plastic bag if the grease does not stick them. Alternatively you can put the hub a little way onto the shaft and then just ease the rollers into place one by one. Then just slide the whole thing 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. Don't worry too much about the rollers rolling over a groove, but you will need to clean any flash

or weld bead off from the bore.

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 just get 4" pipe into them. You may find that you can even use small pipe say 1/2" BSP pipe to make the rollers for example, but you must make sure that it has a thick wall. Of course the shaft does not have to be a pipe - it could be solid and then it could be a bit smaller, say 38mm diameter or bigger if the steel is high quality.

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 (228mm) as the diameter of the axle (about 60mm). Another rule is that bigger diameter rollers work better.

Other thrust bearing arrangements

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

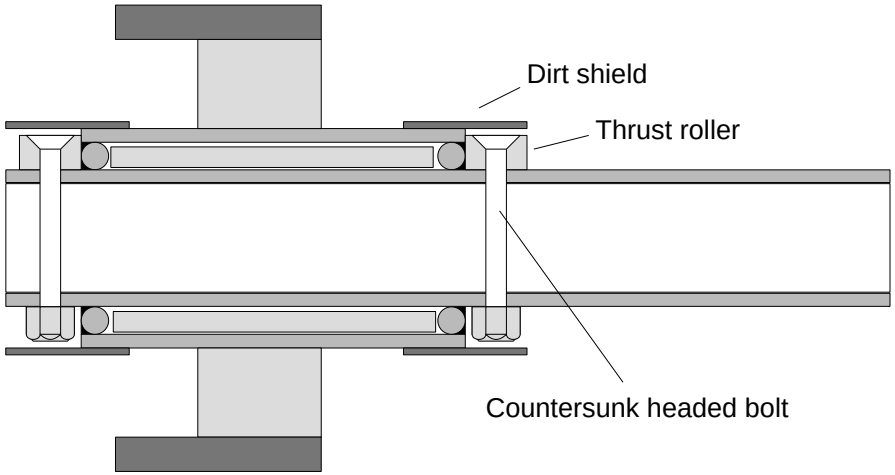


Figure 6: axial restraint rollers on countersunk head cross bolts.

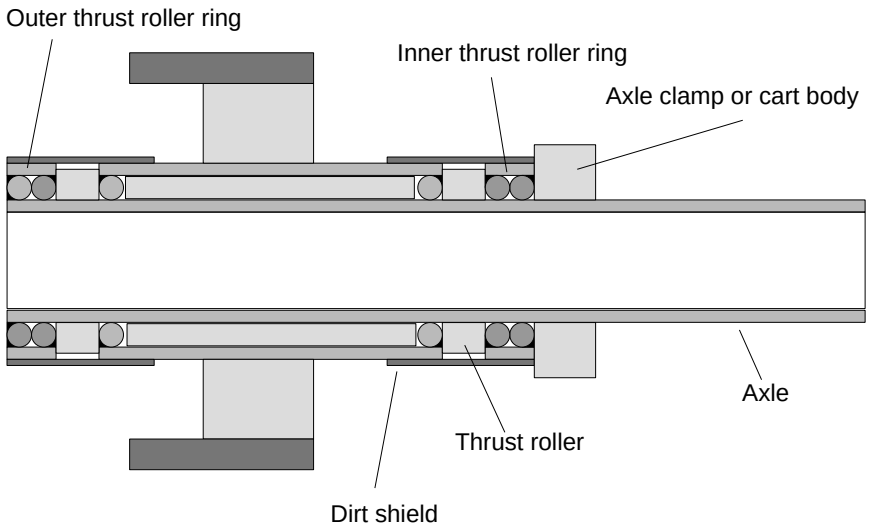


Figure 7: axial restraint rollers held inside dirt/ oil shields.

cross bolt head (if it is 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.

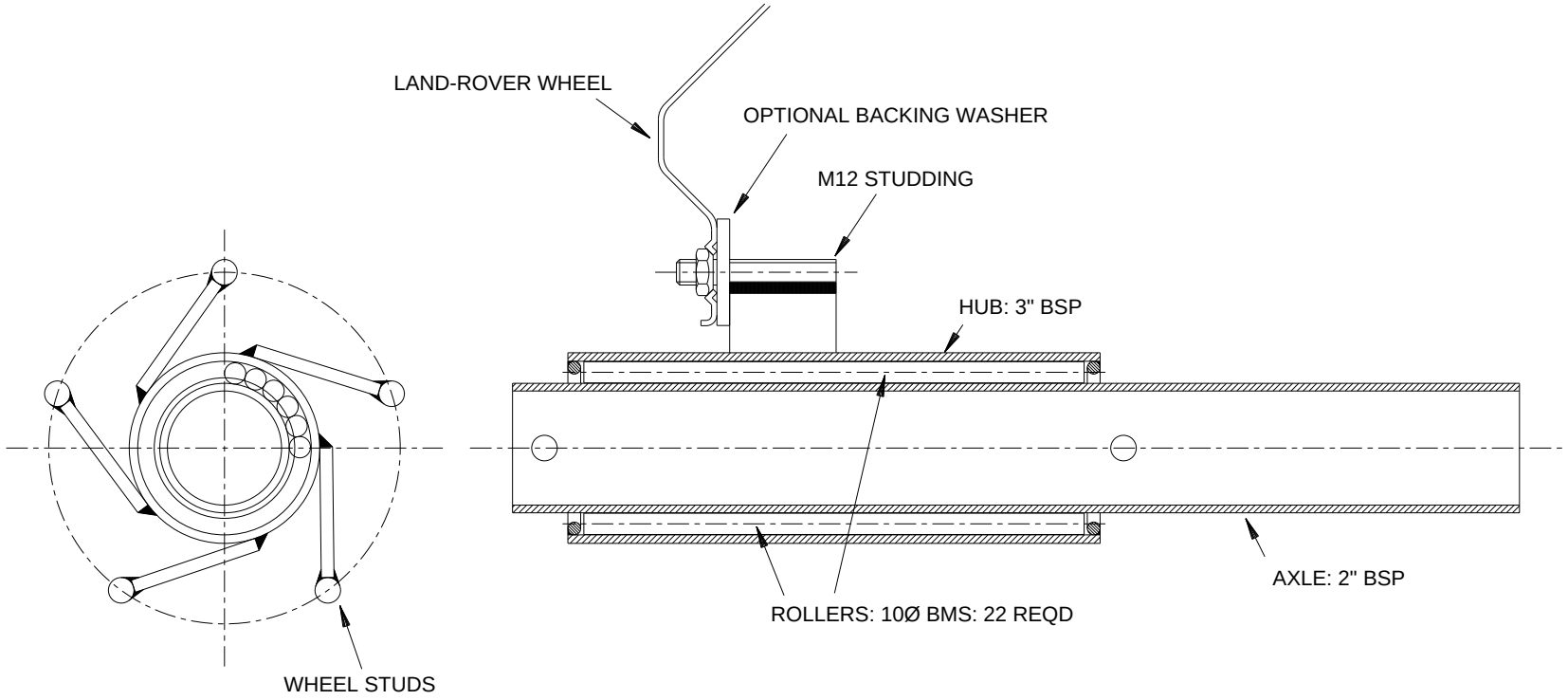
Another way that we have used rollers is to put them inside the dirt shields without any bolts. You can see this in Figure 7. The rollers have no holes - they are just plain pieces of rod. You need to use big rod so that its diameter is a bit bigger than its length. If you do not do this the rollers can turn over and jam. You should 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, and others which need only limited machining are under development at Warwick and wheel designs in steel sheet, cast aluminium and timber are also in manufacture or under development. We have also been working on a variety of other bearing types including pressed cup-and-cone ball bearings. 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.

If you are interested we can send you more information.



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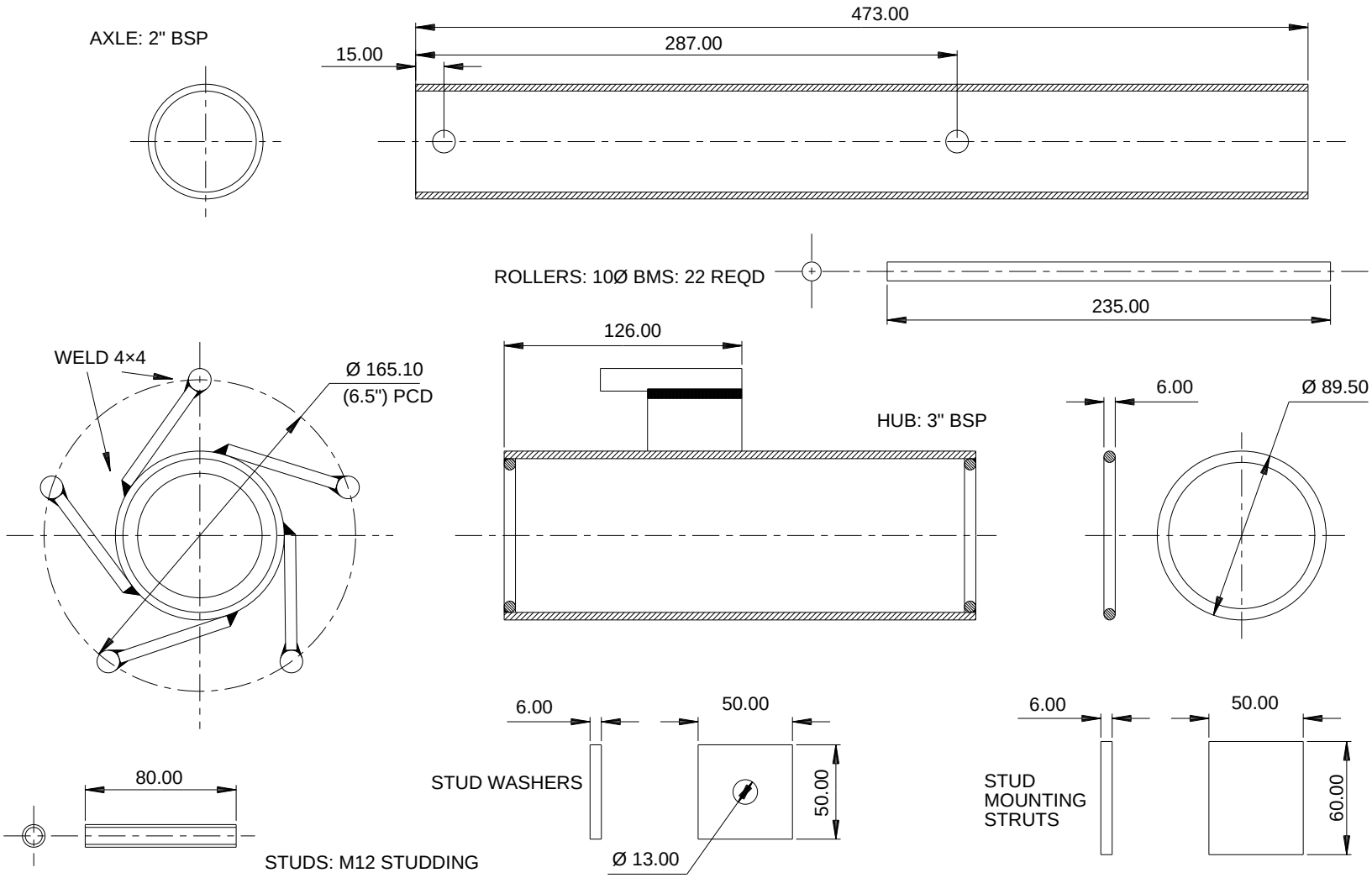

PIPE AND ROLLER AXLE FOR OX-CARTS

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