

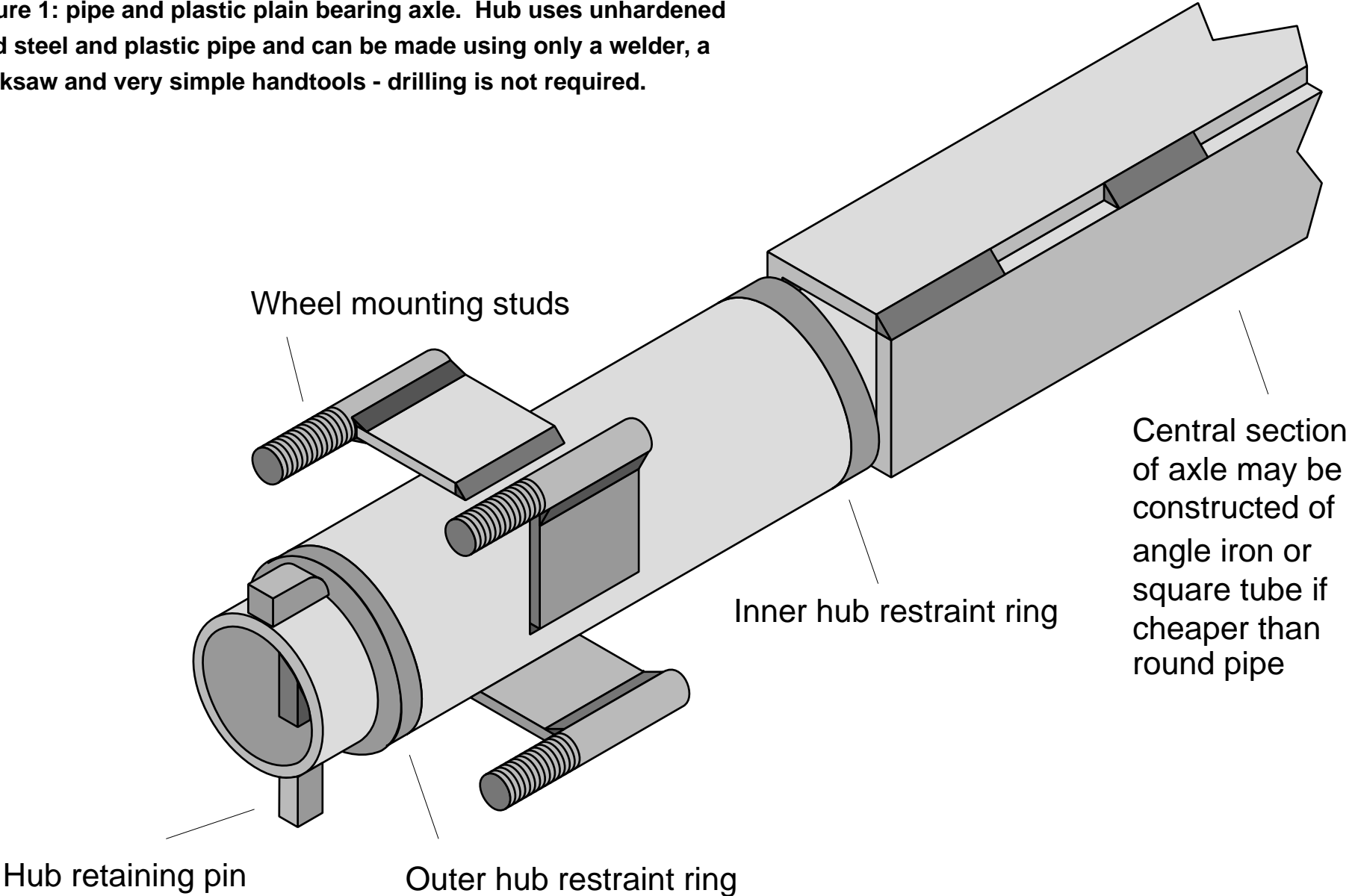


Animal Cart Programme

TECHNICAL
28
RELEASE

PIPE PLAIN BEARING DONKEY CART AXLE

Figure 1: pipe and plastic plain bearing axle. Hub uses unhardened mild steel and plastic pipe and can be made using only a welder, a hacksaw and very simple handtools - drilling is not required.



Pipe Plain Bearing Donkey-Cart Axle

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 things 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 4WD axles. In many countries 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 the axle 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 (drills, lathes and milling machines), and to use 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 welder and a hacksaw, but a file and a vice are also very handy. Of course if you do have power tools - especially a power hacksaw or anglegrinder with cutoff wheel - things can be made much faster. This axle is suitable for a wide range of production methods so that if you have to make many of them you can make special tools to make it quicker.

The hubs in this design use 2"BSP pipe on 1 $\frac{1}{2}$ " BSP axles so that they have a small diameter and will fit most 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, but you can sometimes saw or file the hole bigger if you have to. Another way of avoiding the hole in the wheel problem is to use live axles as described in Technical Release 29.

The best way to make these axles is to use a piece of plastic pipe between the axle and the hub tube to make a bearing. The best plastic is probably polythene, but this is hard to get in short lengths so we have used PVC in Kenya. Search around the stores in your area to see what is available. If the only steel pipes you can find for the axle and hub tube do not have enough gap between them for a plastic bearing then you can still get good performance without it, but the axle will wear a bit faster and the cart will be a little harder to pull. Alternatively you can enlarge the hub tube a little see the **modifications** section.

You will see from Figure 1 that the wheels are fixed to the axles by struts rather than by thick metal discs as on most axles. Putting the fixing studs on struts like this is much easier and cheaper. It also means that you might be able to fit a slightly different wheel by bending the struts a bit to fit. 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 not yet properly tested axles like these, but many farmers and water carriers in Kenya have used them on their carts for three years or more without even a plastic bearing. Of course you need to clean the axle and hubs out and regrease them every year at least and if you use them heavily you should grease them every day. Actually this is easy because all you need to do is remove the hub restraint pin through the end of the axle, take the wheel and hub off, put some grease on the axle and replace everything. It should only take a few seconds.

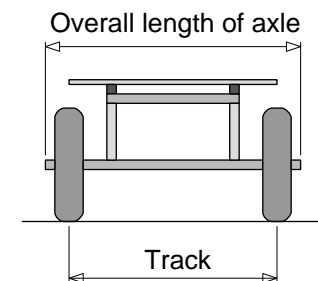


Figure 2: track width of cart.

Length of axle

You need to decide how long to make your axle. Of course you can make the axle any length you like to suit your cart, but most carts will need an overall axle length of between 1400 to 1600 mm. In the **cutting list and cost** section you will see that you can make the axle with a central section of some other material than the 1½" BSP if this is very expensive. We have assumed that you will use square box tubing but you could use angle iron. To calculate how long to make the axle decide how big you want the **track** to be (see Figure 2) and add 280 mm. This distance will now be the **overall length of the axle** (see Figure 2 for this also). If you are going to use square box tubing or angle iron for the central section of the axle then you should subtract 240 mm from the **track** and make the central section this long.

Cutting list and costs

The table shows a cutting list for a complete axle - two wheel hubs with stub axles joined by a square tube section in the middle. We have shown this way because round pipe is very expensive in some countries. But if pipe is reasonably cheap where you are then make the whole axle out of one piece of

pipe. Recent prices of materials in Kenya for the axle are shown in \$_{US}. The 2" BSP (British Standard Pipe) is about 61mm outside diameter, or a bit less, with a wall thickness of about 3.6mm. The 1½" BSP is about 49mm outside diameter, with a wall thickness of about 3.2mm.

component	material	number & length reqd [no.x mm]	total material in axle [mm]	materials cost in Kenya [\$US]
central axle	2" square box tubing	1x1200	1200	3.20
hub stub axles	1½" BSP malleable iron pipe	2x350	700	2.60
hub outer tube	2" BSP malleable iron pipe	2x200	400	1.80
optional plastic brg	1½" or 2" plastic pipe	2x200	400	0.47
hub retaining rings	6mm or 8mm square bar	4x154	616	0.12
hub restraint pegs	6mm or 8mm square bar	90x2	180	0.04
wheel studs	50 x 12mm bolts	8x50	na	2.40
wheel stud struts	6x40 black or bright steel strip	8x37	296	0.60
TOTAL COST =				11.23

Construction step by step

1. The first and probably most difficult job, is to get some suitable pipes. Obviously the axle has to be strong enough to carry the cart, so it should be made from pipe bigger than about 40mm outside diameter. You must also make sure that the pipe has a wall thickness of more than about 2.5 mm.

The hub pipe also must have a wall thickness of 2.5mm or more. And it must have a bore (or inside diameter), which goes easily over the axle with enough room for the plastic bearing and some grease. There can be quite a lot of clearance (slackness or looseness) between the hub and the axle (say up to 3mm) - it does not have to be tight. If you cannot get steel pipes with enough clearance for a plastic pipe bearing then the axle will work quite well without it, but you should grease it more often.

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

2. You will probably find that no plastic pipe fits properly between the axle pipe and the hub tube but all you need to do is slit a piece along its length and open it up a bit or close it down until it fits. A better way is to make a helical saw cut in the plastic pipe so it is like a spring. Then it will open up or close down to the size easily and it will not tend to wear the area around the slit.

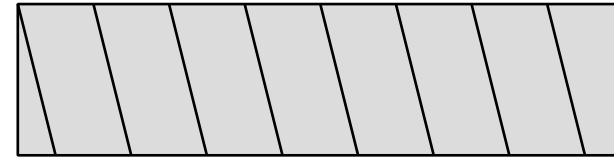


Figure 3: helical saw cut in plastic pipe bearing sleeve.

3. When you have got the right pipe sizes, you can cut the two hub pipes each 200 mm long and the axle pipe about 1500 mm or 1600 mm long or if you are going to do it with a central section in square pipe or angle iron you need to cut the central section about 1200 mm long plus the two stub axles each about 350mm long. If you need to support a simple one piece pipe axle an easy way is to weld short pieces of round bar onto it as shown in Figure 4. If you make these about 300 mm long they will strengthen the axle quite a lot as well.

Figure 5 shows how you can weld the stub axle tube into the square box tubing. You will need to cut slots in the sides of the square tube so that it can bend in or out to accept the stub-axles. When you are welding the stub axles in, make sure you tack weld them in first and check that they are straight before you do the final weld.

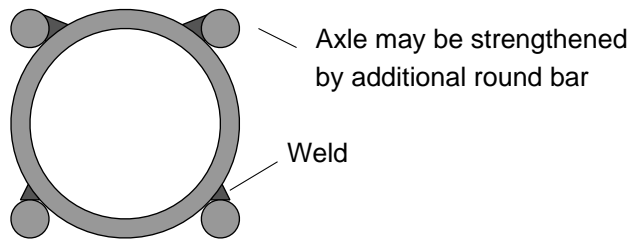


Figure 4: method of adding round bar to support pipe axle and strengthen it if needed.

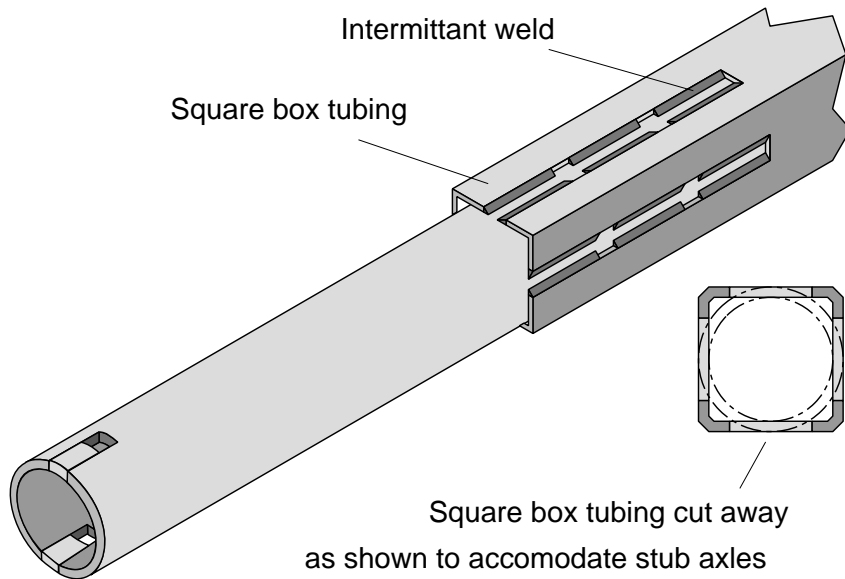


Figure 5: method of welding stub axles into square tube.

- Next you need to make a hole near each end of the axle pipe for the hub restraint pin. To do this without using a drill cut a slot in each side of each end of the axle. Make the slots about 30 mm long to start with and about 10 mm wide. You want the slots just the right length so that with the hub restraint pins in place the hub tubes are not pinched tight. It does not matter if they are a bit loose.

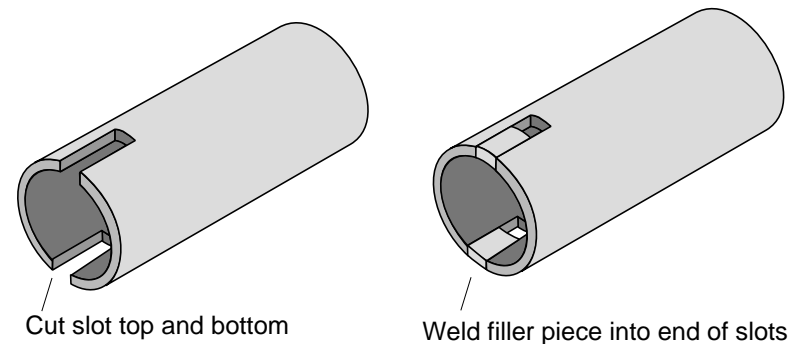


Figure 6: method of making hole for hub restraint pin without drilling.

- The next step is to weld the stud bolts or bits of threaded rod onto the struts. If you have a vice it makes welding the bits together easier because you can clamp the pieces together while you tack weld them. You need to make one strut for each wheel stud unless you are using five or six

stud wheels on a single donkey cart. If so you could use only three studs per wheel if the cart user wants only light use from the cart.

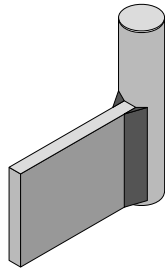


Figure 7: stud welded to the wheel struts.

We have used this method of fixing wheels successfully with the old VW wheels which have very large holes in the middle.

When you've made up the struts you can put a nut on each stud and then put the studs through the wheels, and put a second nut on each stud. Then get everything even and straight with the hub pipe in place as well in preparation for welding the struts to the hub tube. You want to get the middle of hub pipe level with the middle of the tyre, as is shown in Figure 7. Most car wheels need the studs to be about 40mm offset and this is what is on the drawings.

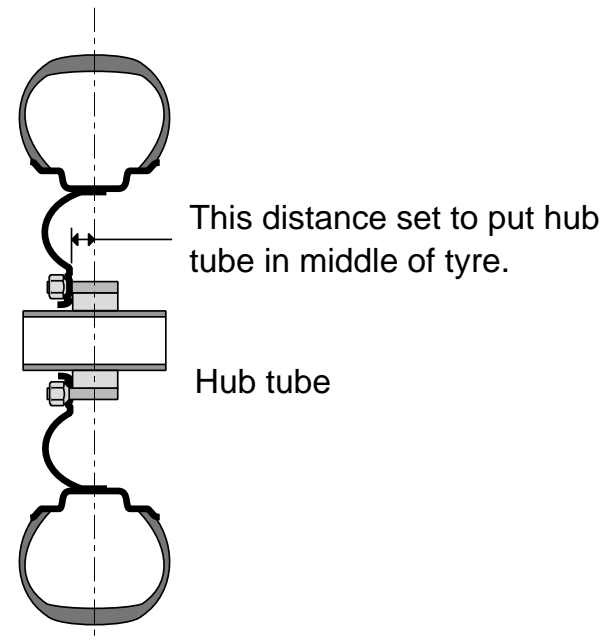


Figure 8: cross section of tyre wheel and hub tube showing centering of hub tube in wheel

Getting the hub in the middle of the wheel and tyre means that the bearings in the hub are evenly loaded. You might find that holding the hub tube in the wheel with some wedges as shown in Figure 8 is a good way to do it.

When you are happy, tack weld the struts to the hub pipe. Then remove the wheel and wedges so you've got room and finish the welding of the 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, 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.

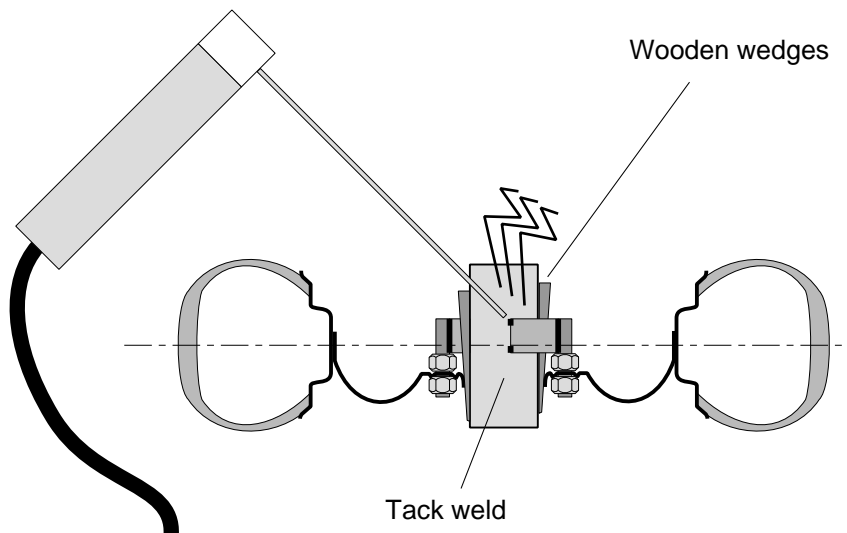


Figure 9: cross section of tyre wheel and hub tube during tack welding of stud support struts

It is best to check that the hubs, and stub-axles still go together when you've finished welding because 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.

6. Nearly there! Now take the wheels off the hubs and make up four rings (called hub restraint rings on the drawing) from 6 mm or 8 mm square steel bar (or round bar if you cannot find square). One ring must be welded about 230 mm from each end of the axle pipe or from the ends of the stub axles to stop the hubs going too near the centre of the axle.
7. Now put it together! Smear some grease onto the plastic bearing pipe (if you are using one) and onto the axle and put the hub tube and plastic bearing onto the axle. Then put the outer hub restraint ring on and secure it with the hub restraint pin. Do the same for the other hub.
8. Paint everything!
9. You've done it!

Modifications

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 it up 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. Try to clean the weld back flush with the tube using a file if you can as this will give longer life. It does not matter if

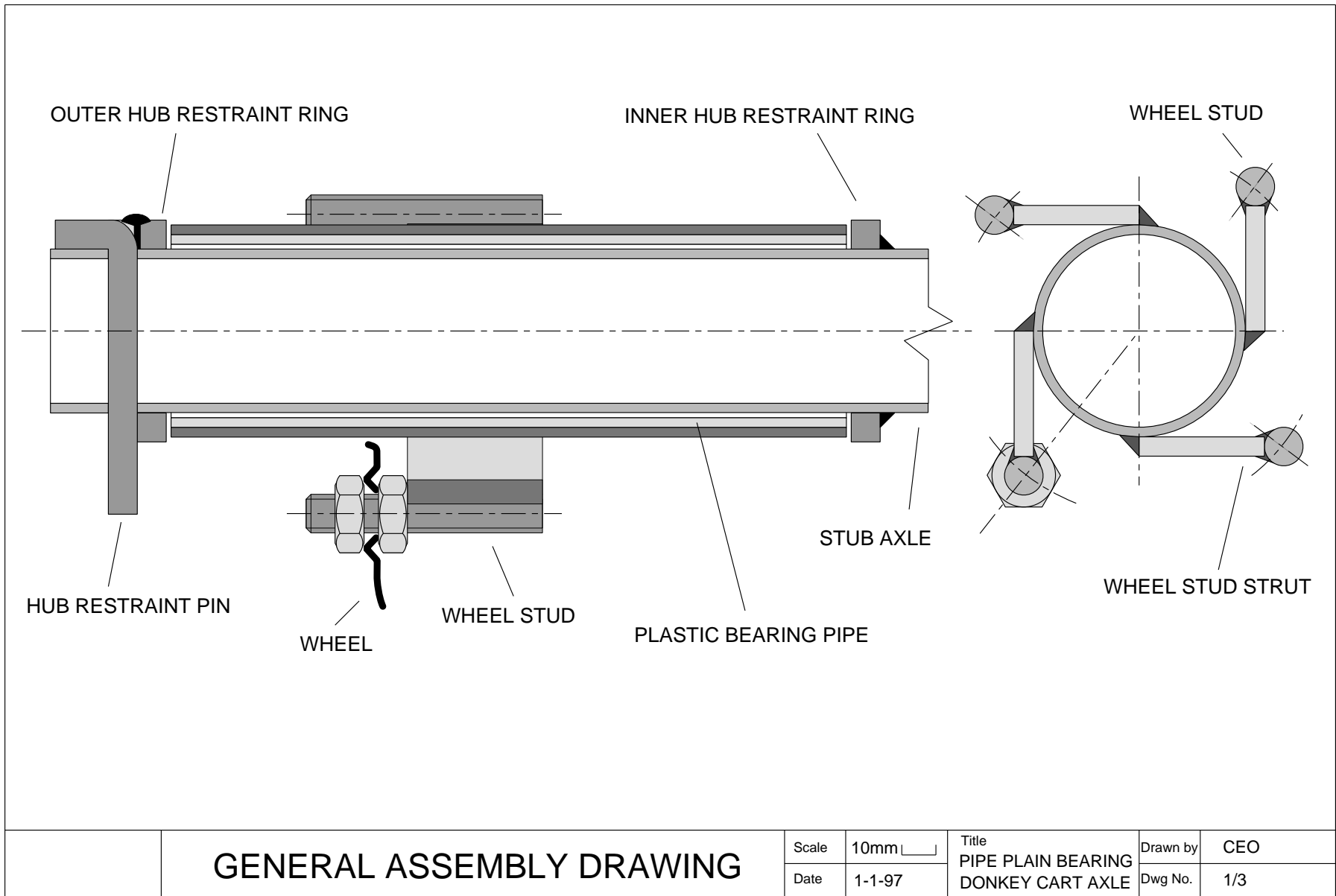
If you find that you cannot get anything like the materials talked about in the cutting list then maybe you can adapt the design a bit. If the hole in the middle of the wheels is big then you stand a better chance of finding a combination of pipes and rollers that will fit. You can often cut a bit out 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. 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.

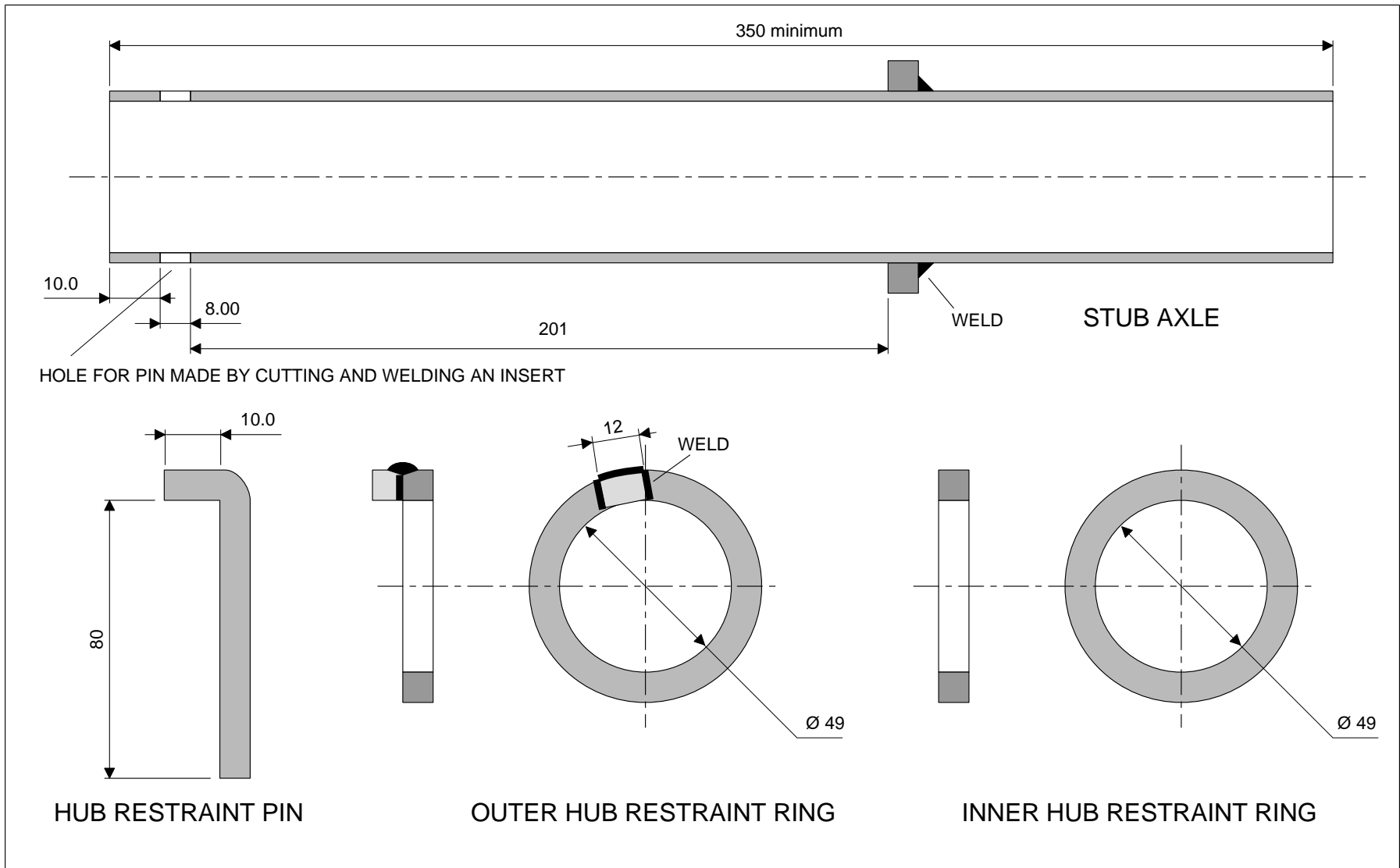
Another idea that we have tried is to use a hardwood as the hub and even the wheel. If you think about it, the wear on something which is rolling must be less than when something is sliding over it, so a wooden bearing should be better than a

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.

Other DTU cart developments

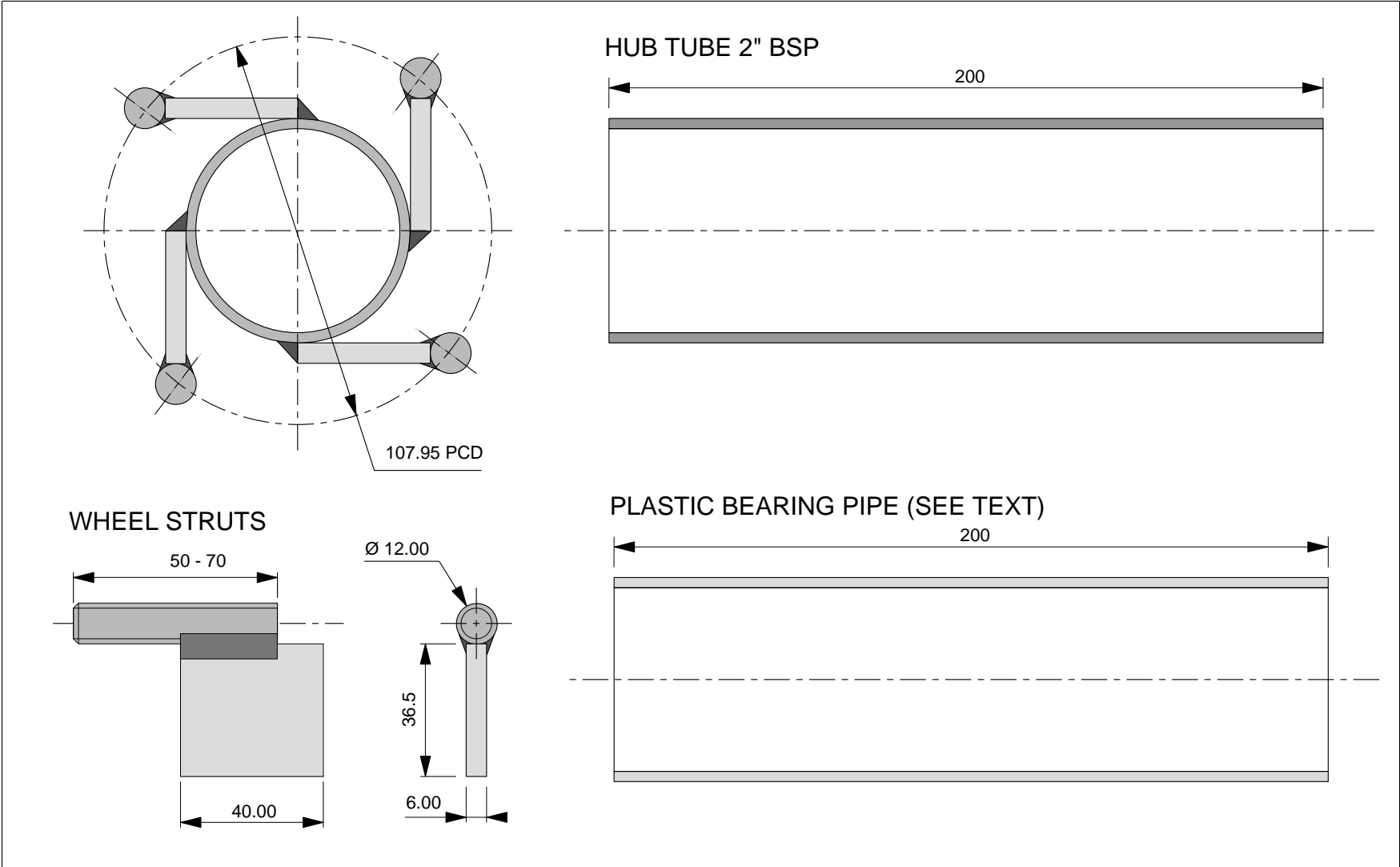
Other methods of hub design using aluminium castings, for example, which might need no machining, are under development at Warwick and wheel designs in steel sheet, cast aluminium and timber are also in manufacture or under development. A range of designs for donkey and ox carts made of steel and wood,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





HUB AND AXLE COMPONENTS

Scale	10mm []	Title	PIPE PLAIN BEARING	Drawn by	CEO
Date	29-12-96	Title	DONKEY CART AXLE	Dwg No.	2/3



HUB TUBE, PLASTIC BEARING & WHEEL STUDS	Scale	10mm <input type="checkbox"/>	Title PIPE AND PLAIN BEARING DONKEY CART AXLE	Drawn by	CEO
	Date	1-1-97		Dwg No.	3/3