KENDAT

DTU

Animal Cart Programme

TECHNICAL
41
RELEASE

Twin Ball Bearing Axle for Donkey Carts

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Novel bearing arrangement for animal carts using scrap (or new) ball-race, running on outside of full width axle. No machining or accurate work required. Bearing may be replaced with different size. Only one bearing per wheel required.

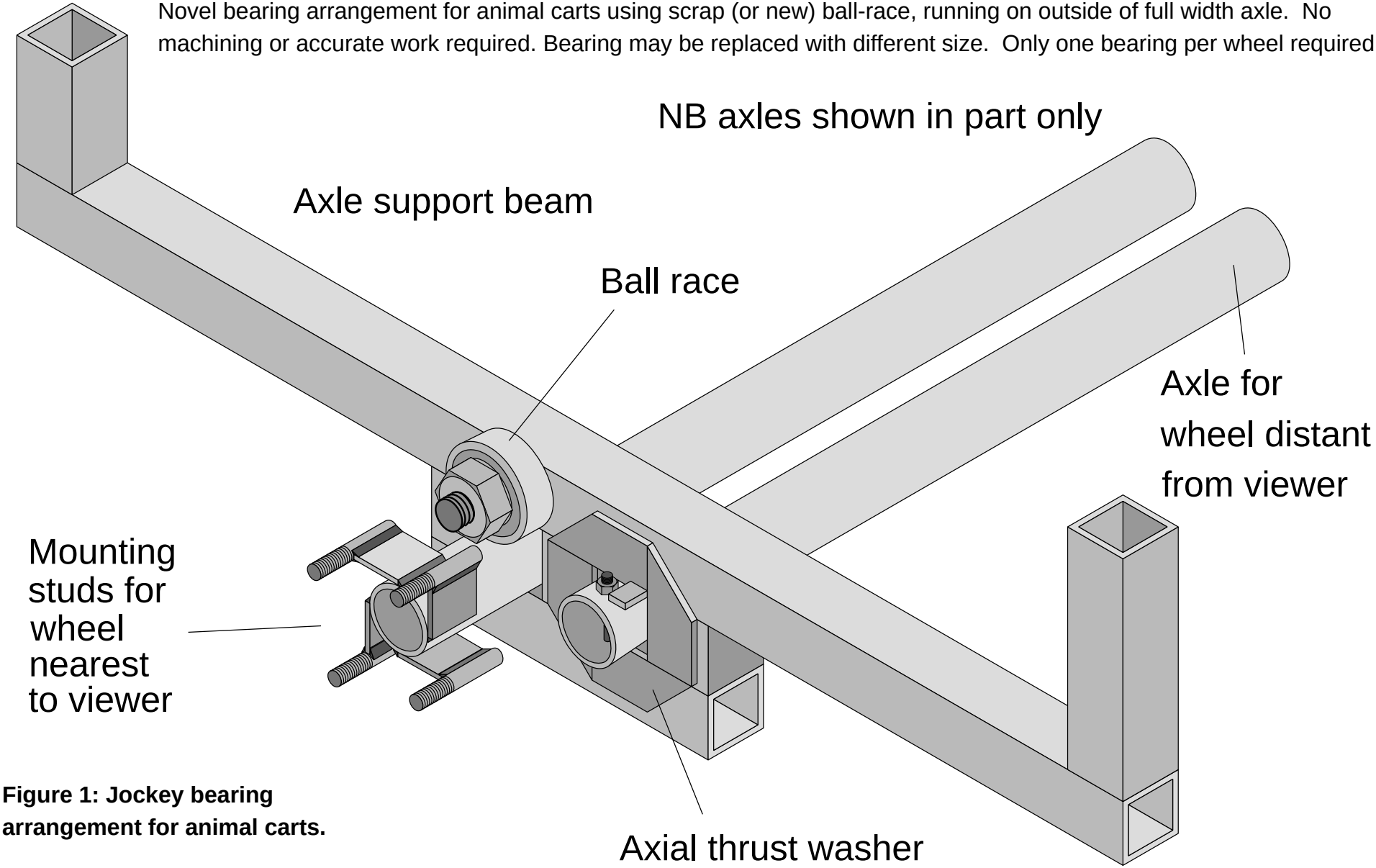


Figure 1: Jockey bearing arrangement for animal carts.

Twin axle system for donkey carts using scrap/ new ball bearings.

Introduction

In this booklet we tell you how to make an axle system for a simple donkey cart from round steel tube and ball bearings. The instructions do not cover how to make the cart itself - you will need to read other Technical Releases from us to find out how to make the carts.

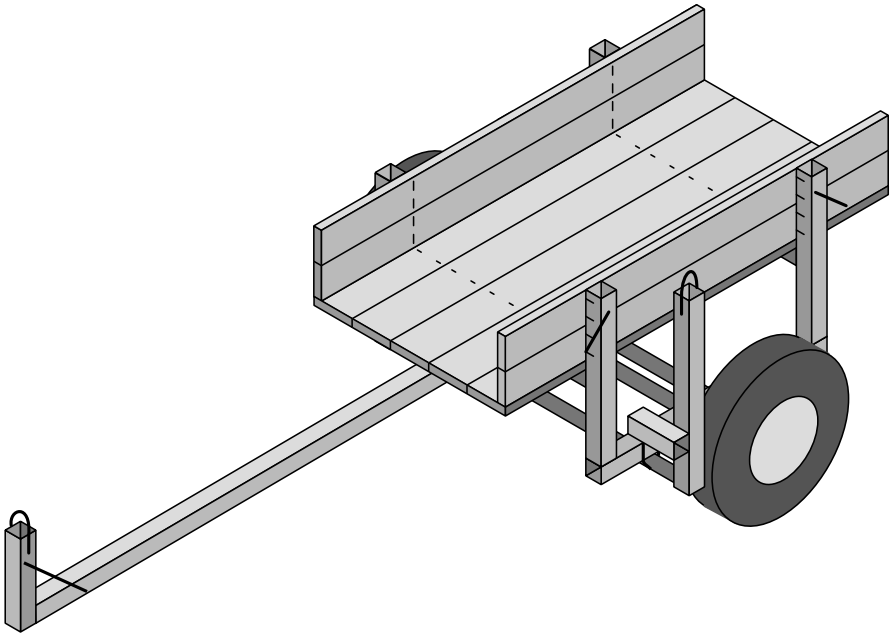


Figure 2: DTU donkey cart fitted with twin axles and PVC bearings.

You should find that you can make the axle system for about £40 including the wheels, tubes and tyres. This cost will depend on the cost of the materials and labour. Once you get organised, two men can probably make and fit one cart with axles in half a day. This is quite a lot faster than it takes to find and a scrap car axle and it will be much cheaper.

In other booklets in this series you can find out how to make other low-cost axle systems and carts.

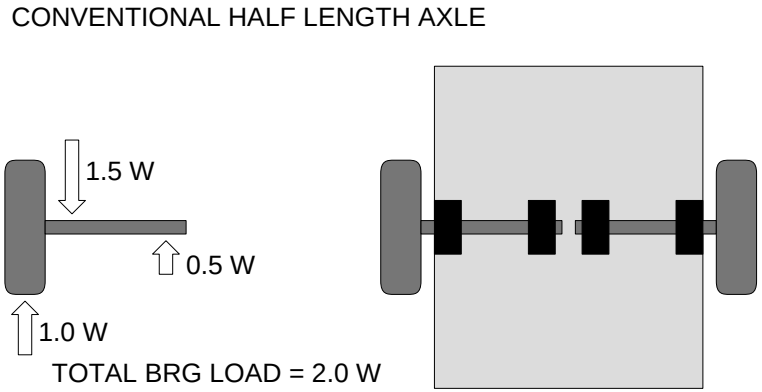


Figure 3: bearing loads in conventional half shaft axle.

Why have twin axles?

There are two types of axle: fixed axles and stub axles. In a stub axle the wheel-hub rotates on a stationary axle. In a live axle arrangement the axle revolves in stationary bearings.

With the stub axle types the bearings must be inside the wheel. This is easy with expensive ball bearings in a machined hub but more difficult to do in a simple workshop. Really you need two ball bearings per wheel as well. You also need to make things quite accurately or make the hubs quite long to stop wheel wobble. Another problem is that the hubs stick out of the wheel and catch on animal and human legs.

If you would really prefer to make a stub axle we have quite a good one using plain bearings made from PVC pipe. This axle also has the advantage that you can take the wheel off without a spanner. We also have a system of making your own roller bearings and we can send you Technical Releases on how to make these axles, but we think the twin axle system here is easier to make and a bit better.

Long twin axles reduce bearing loads and require less accurate manufacture. Figure 3 shows the bearing loads of short axles and Figure 4 shows the twin axle method. You will see that bearing loads are about 30% lower. Surprisingly there is no extra steel required either because there would have to be some steel to support the middle bearings anyway.

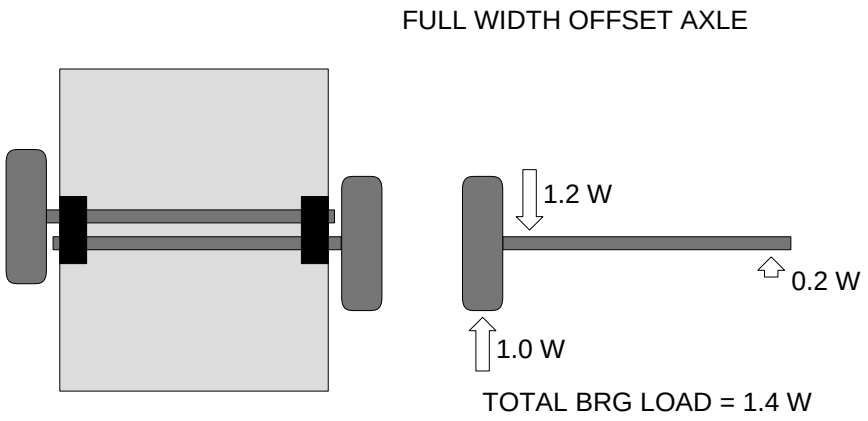


Figure 4: bearing loads in twin offset axles.

Easy to make design.

These axles are designed to be constructed without any special tools and jigs, and without any hard-to-get materials. The only tools which you must have are a simple welder, a hacksaw, and

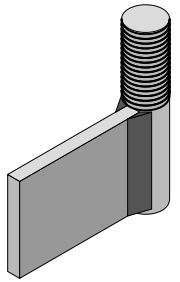


Figure 5: a welded wheel stud and strut fabrication.

a hammer. You might find that a couple of 4" or a 5" G clamps (or something like it) are useful too. We have deliberately designed the axle so that drilling is not required.

We have tested many of these axles in Kenya and Uganda and we have had only a few failures caused by poor welding or incorrect material. We think that they are strong enough, but you can always find someone to break anything. To get a reasonable cost you need to experiment a bit to see how the farmers treat their carts and what they expect them to stand.

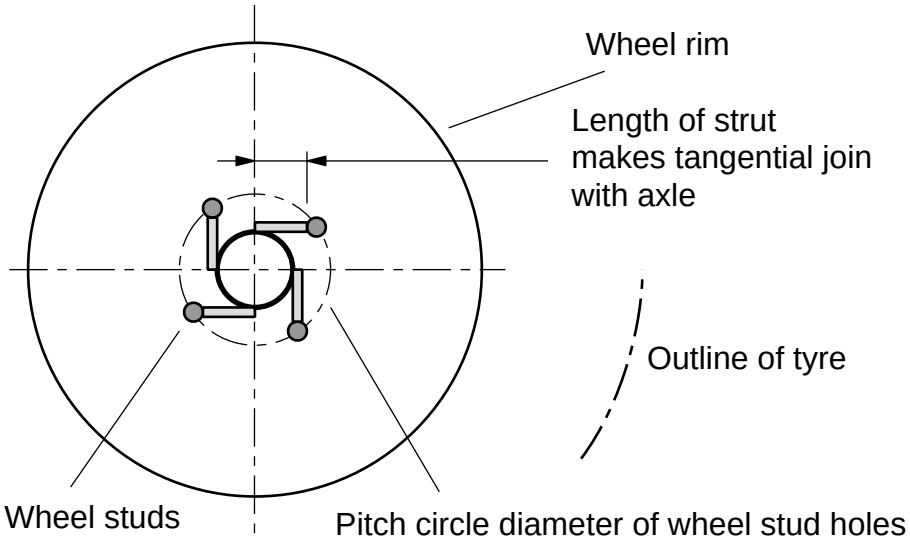


Figure 6: length of wheel strut.

Cutting list and costs

Table 1 shows a cutting list for a complete axle - Recent prices of materials in Kenya are shown converted into £UK.

Construction step by step

1) The first job, is to get all the material together and clear a space to work. Ideally you will be able to work on a flat area of concrete.

2) Start by getting the two ball bearings you want to use and cleaning them. If they have rubber or steel shields it is probably best to leave the shields in place, but if they are open clean the bearings in petrol or diesel fuel or kerosine. Then re-grease them.

TABLE 1: materials for ball bearing twin axle.

component	material	# lengths reqd [#*mm]	total material for one axle [mm]	cost [UK£]
wheel studs	50×M12 nuts and bolts	10	10	2.60
wheel stud struts	6×40 BMS strip	10 × 37	650	0.49
axial thrust washers	6×40 BMS strip	8 × 90	720	0.54
axle cross bolts	75×M12 nuts and bolts	4	4	1.04
axles	1-½" BSP malleable iron pipe	2 × 1500	3000	6.00
axle reinforcements	1-½" BSP malleable iron pipe	2 × 30	60	0.12
main bearing	scrap ball race eg 6205, 6206	2 off reqd	2	5.00
ball bearing mounting bolts	M24×50 or similar	2 off reqd	2	2.00
bearing box sides	50×50×3 mm square steel tube	6 × 53	318	0.73
bearing box top	50×50×3 mm square steel tube	2 × 252	504	1.16
wheel rims, tyres + tubes	na	2	2	25.00
			TOTAL	**44.69**

3) Now you need to get a large nut and bolt for each bearing. Ideally the bolt should just go through the middle of the bearing, but it can be quite loose as long as the bearing can be held very tightly when the nut is tightened.

   If you cannot get a nut and bolt you can use a piece of pipe and a welded ring.

4) Next make the wheel stud struts shown in Figure 5. You need to make one of these struts for every stud hole in the wheels you are going to use. Figure 6 shows how to measure the length of the struts. The struts are made from 6×40 flat bar or similar and M12 bolts 50mm or 60mm long. The flat bar should be long enough so that it meets the axle tube tangentially as shown in Figure 6.

5) Once you have made these struts, screw a nut onto each one until it touches the 40×6 metal. Then put the thread through the hole in the rim and screw another nut onto the thread. Tighten this nut lightly with a spanner. Repeat for all the struts so that they all point the same way round the axle, as in Figure 6, and leave a gap for the axle.

6) Now centre the axle in the rim and get it square using a tape measure, a trysquare and a plank or piece of steel resting on the tyre.

   Put the wheel rim on the floor and put the axle in place in the middle. You should put something under the end of the pipe to get it in the right position as shown in Figure 7. Get an assistant to hold the top end of the pipe and tell him to

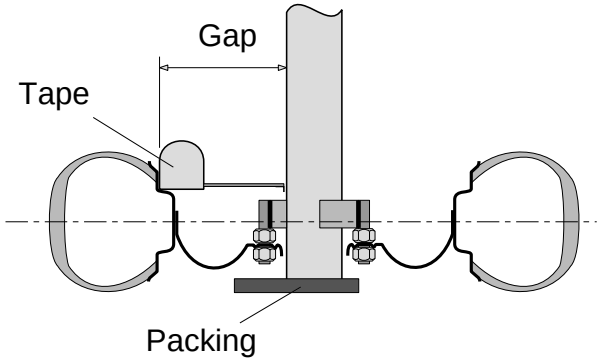


Figure 7: using tape measure to centre axle in wheel.

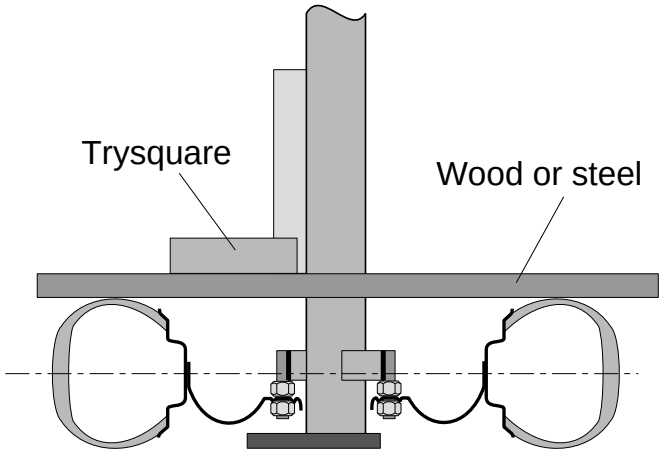


Figure 8: using trysquare to get axle square to wheel.

keep very still! Use your tape to measure from the outside of the pipe to the inside of the rim as Figure 7 shows. Measure in one place and then measure the gap opposite. Move the axle pipe over until it is central. Repeat this for the other direction at right angles. You could use wooden wedges as shown in Figure 9 to hold it.

Now use the trysquare and a piece of wood to get the axle square to the rim as shown in Figure 8. You put the wood on the tyre or rim so that it is flat and you put the trysquare on the wood. You have to move the axle until it is straight with the trysquare and your assistant must hold it without moving. Check it several times - its hard to correct afterwards!

7) Once you have it in position, tack weld the ends of the struts to the axle tube as shown in Figure 9. Then weld the struts on properly. Do as much welding as you can without taking the axle out of the wheel because the metal changes size as it heats and cools and it may move out of place.

8) Next cut six 53 mm pieces of square tubing for the bearing boxes. Mark the centre of the axle support beam of the cart and put marks on the beam 25 mm and 125 mm either side of this. You need to weld the 53 mm pieces on to the axle beams as shown in Figure 10. Weld a 252 mm piece of

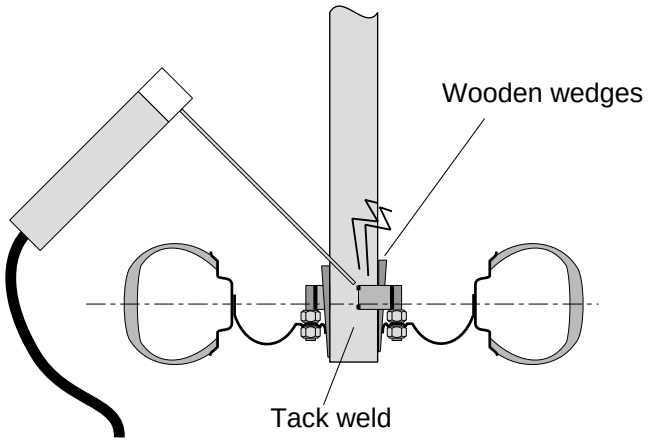


Figure 9: tyre, wheel and axle tube during tack welding stud support struts

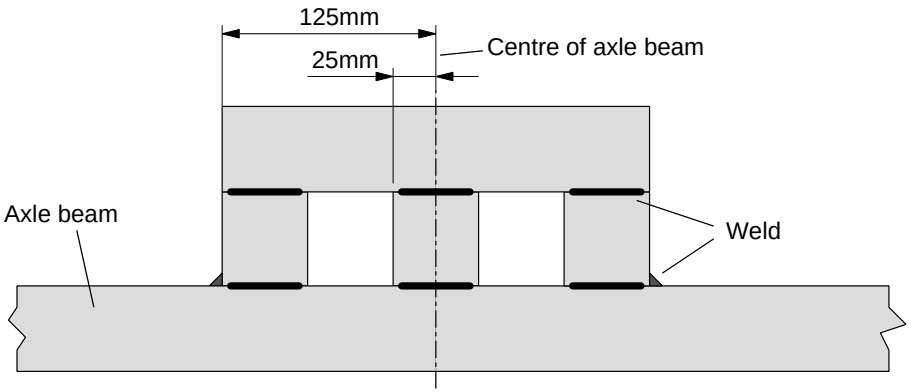


Figure 10: position of bearing support blocks - nb the cart is upside down here.

square tubing across the ends of the 53 mm pieces as shown in Figure 10.

9) Make four axial thrust washers from 40×6 or 40×3 or similar flat bar like those shown in Figure 12. You must remember to weld on a tag made of a 20 mm length of bar to each ring as shown in the drawings. This makes the washers go round with the axle and stops wear in the wrong places.

10) Assemble the axles and thrust washers as shown in Figure 13 but without the crossbolts. Put the wheels onto the axles, lightly tighten the nuts and position the axles so that there are 50 mm gaps between the tyres and the axle beams.

11) Now mark the position of the cross bolt holes. Remember that the nuts will have to be turned so do not make the holes too close to the thrust washers - centre about 15 mm away is fine. Use the welder to blow the holes.

12) Cut the excess axle off about 40 mm from the thrust washer. To mark a line around the pipe to cut it square, wrap a strong piece of paper or thin card around the pipe, get the edge in line and use the edge to guide the felt tip pen or scriber as you mark the line.

13) Mark the place on each axle where the bearing will roll. Cut 30 mm pieces of pipe, slit them so they can be opened and placed on the outside of the axles and weld them in place where you have marked.

14) Now assemble the ball bearings on their bolts and lightly tighten the nut. Position each bearing under the middle of the axle as shown in Figure 11 so that the axle is held 2 or 3 mm away from the axle beam as in General Assembly 1. Then tack or 'spot' weld the ball bearing bolt to the axle beam. Remove the bearings from their bolts and weld fully.

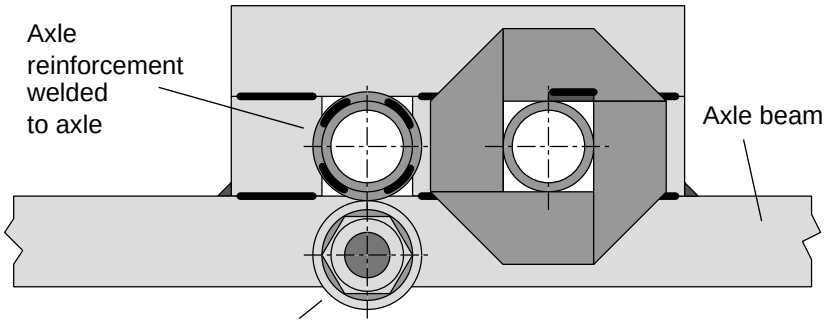


Figure 11: ball bearing mounting and axial bearing washer.

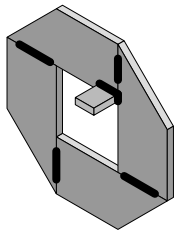


Figure 12: axial bearing washer.

15) Apply grease to the axles where they rub on the axle beams, replace the bearings on their bolts and tighten the nuts, fit the thrust washers and crossbolts and tighten.

16) You've finished it!

Other DTU cart developments

The DTU has been working on new designs of wheels, hubs and bearings to bring down their costs and make things more locally manufacturable. It has designs for twin axles with wooden bearings and twin axles with bearings made from PVC water pipe. And it has two systems of fixed axle: one with PVC bearings and another using needle roller bearings which you can make yourself. No machining is necessary for any of these axles.

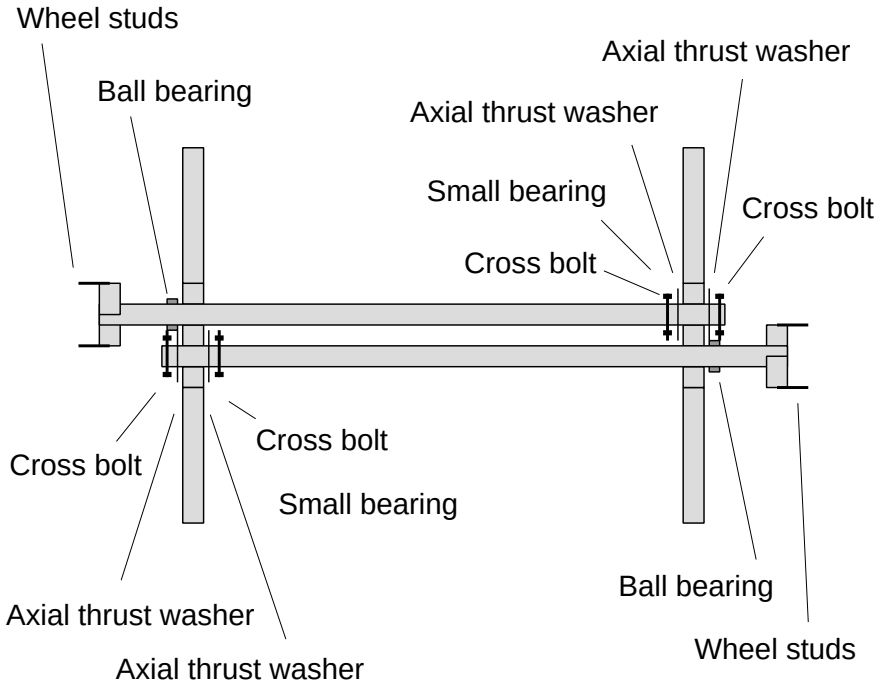


Figure 13: axle and bearing arrangement.

Other hub designs using, for example aluminium castings, have been in production in Nigeria and we are trying to reduce or eliminate the machining in these. Also wheel designs in steel sheet, cast aluminium and timber are under development. We have a design for solid steel rim wheels in which the rim is made from round bar and does not need any hammering.

The DTU has also been working on a range of cart body types for use with both donkeys and oxen. It has designs for wooden and steel framed types. The wooden types are cheaper in material terms, but the steel framed ones are easier to make because the joints are more straightforward - nevertheless you can make either type of cart in only one or two days, if you are reasonably set up with tools and materials.

Drawings

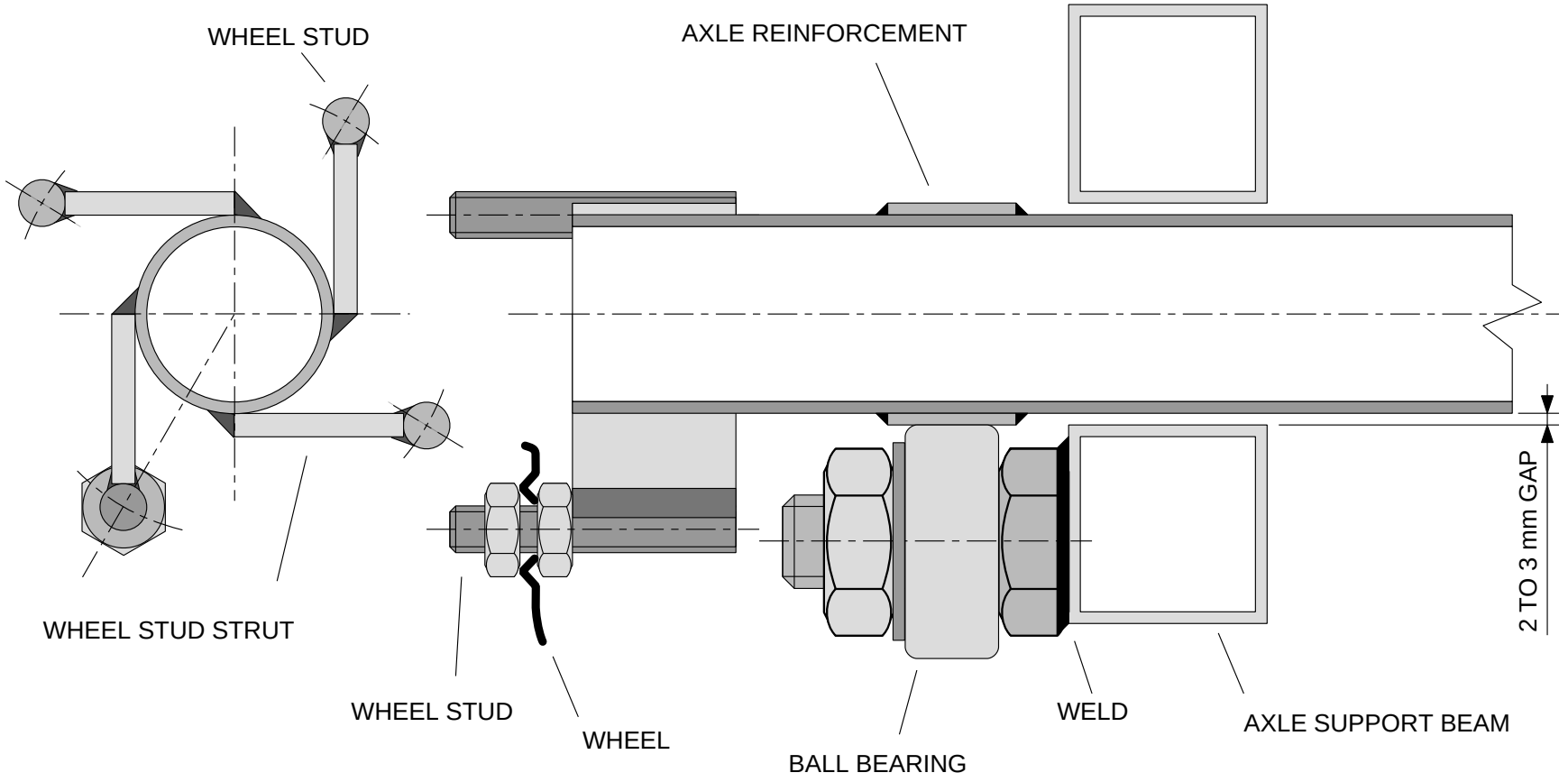
You will find four drawings on the next pages, the first two give a general section view of the axle. The third gives a view of the components of the axle itself and the fourth a drawing of the thrust washer.

Acknowledgements

The DTU is grateful to the DFID (British Government) for the financial support necessary to carry out the research and development project under which this product was developed.

The DTU would also like to thank Dr Pascal Kaumbutho of KENDAT in Kenya and Mr Joseph Mugaga of TOCIDA in Tororo, Uganda for their very considerable help with this project. A large number of other people and organisations have contributed to the success of the project, most notably Mr Anthony Ndungu in Kajiado Kenya, Mr JD Kimani in Kikuyu Kenya and Mr Joseph Gitari in Wanguru Kenya in whose workshops most of the development work of this project was performed. Thanks are due also to Mr Stanley Lameria in Kajaido, Mr Patrick Gitari in Wanguru and Mr Mathew Masai in Machakos for their assistance.

NB CART IS UPSIDE DOWN IN THIS VIEW



	GENERAL ASSEMBLY DRAWING 1	Scale	10mm	Title	BALL BEARING TWIN DONKEY CART AXLE	Drawn by	CEO
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AXIAL RESTRAINT WASHER TAG

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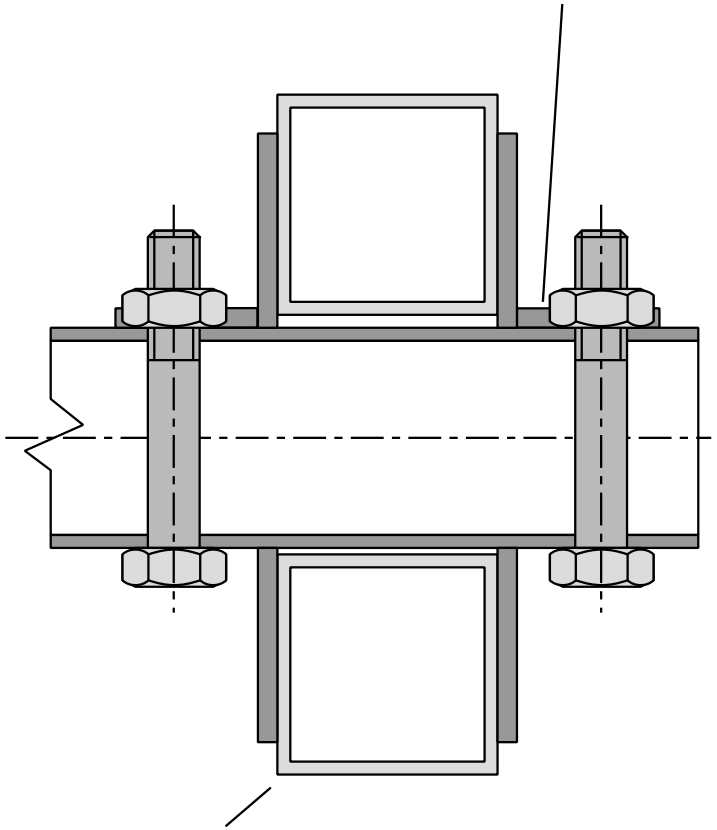
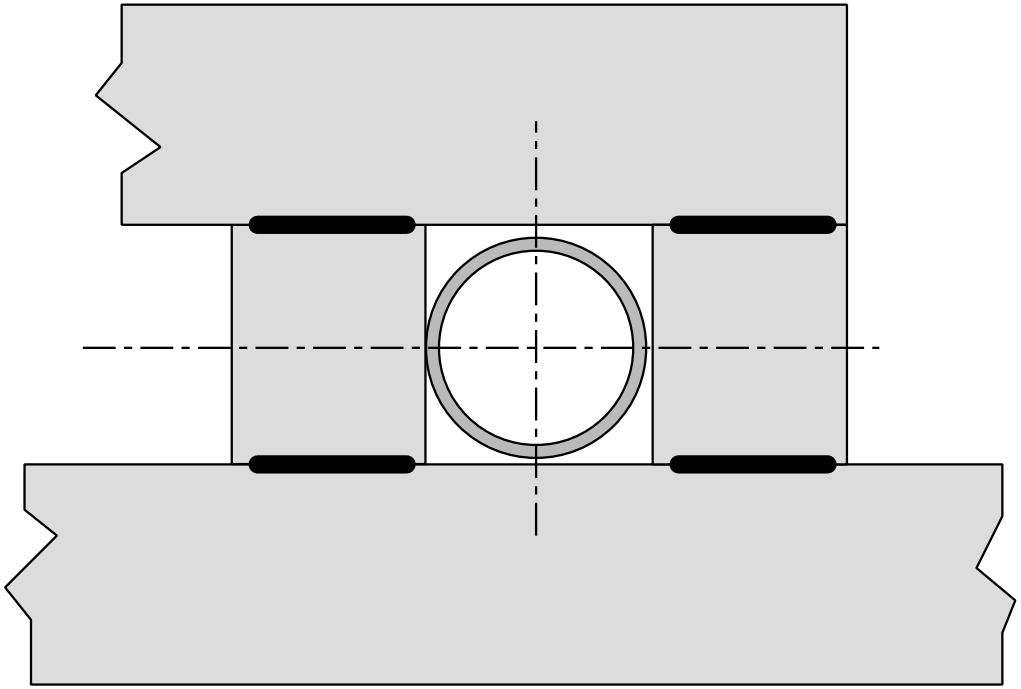


AXLE SUPPORT BEAM



END VIEW - THRUST WASHER AND BOLT REMOVED

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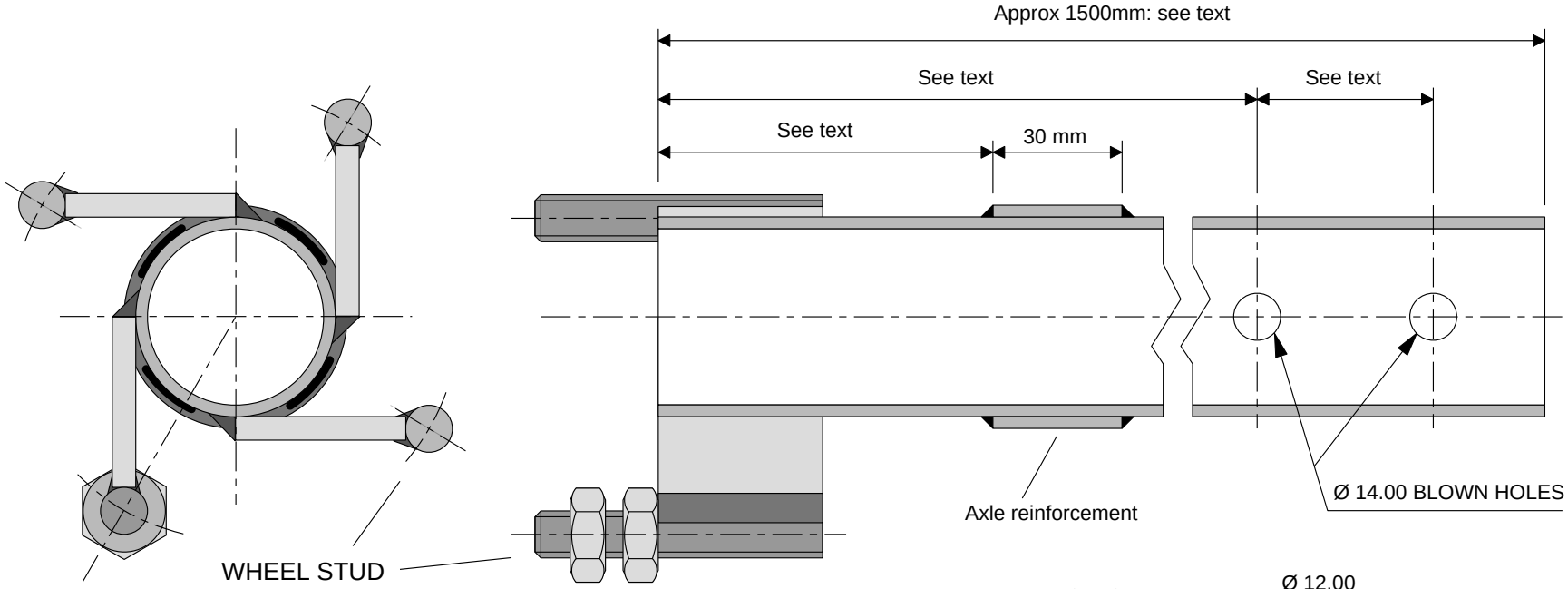
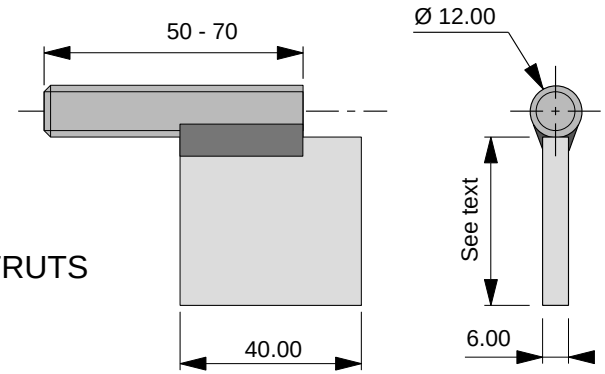


AXLE: 2 OFF REQD.



WHEEL STRUTS

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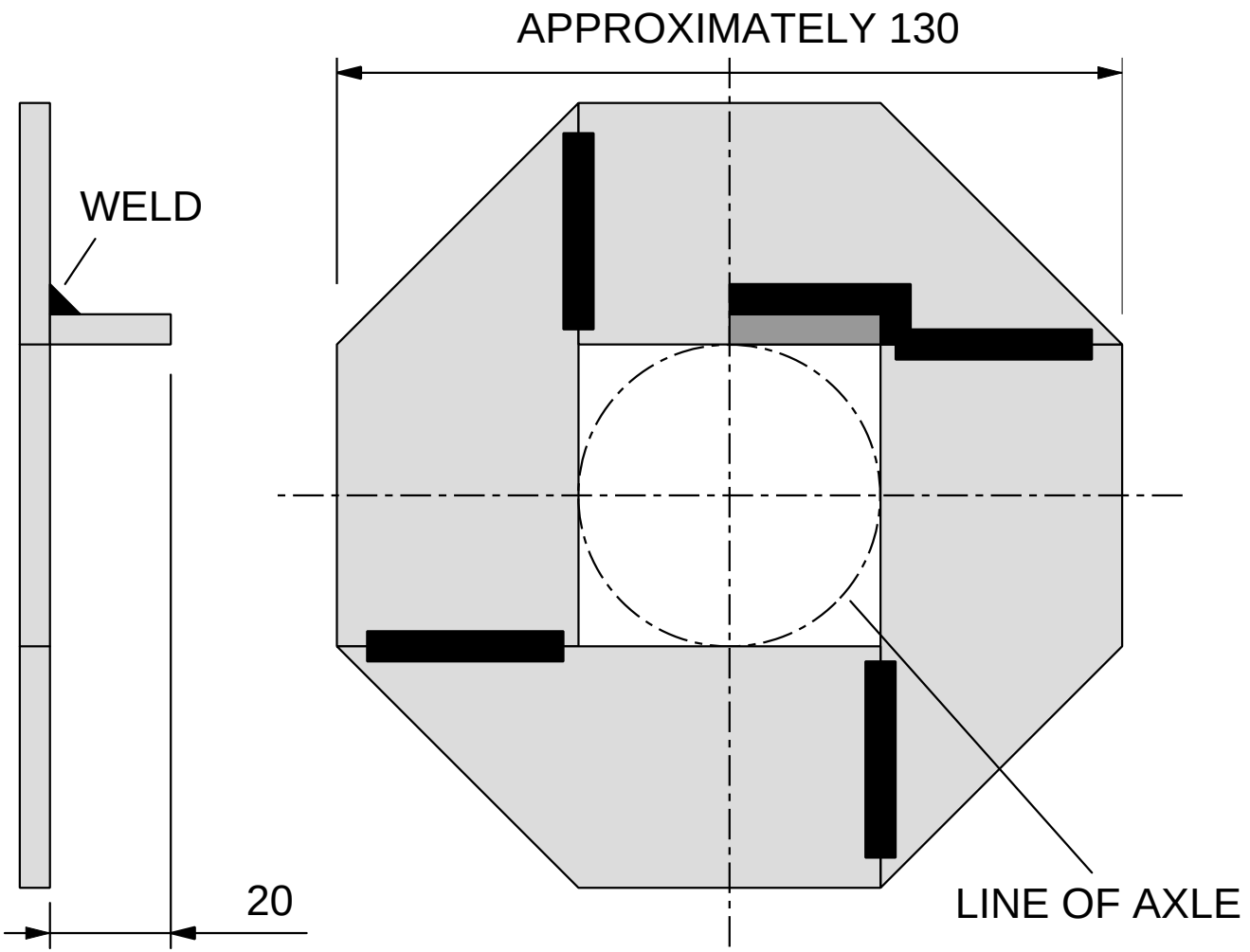

AXIAL THRUST WASHER: 4 REQD

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