



MANUFACTURING THE DONKEY CART AND AMBULANCE

1. Introduction

For poor people trying to escape poverty, lack of mobility can push them further into physical and economic isolation. Practical Action Sudan works to help poor communities in North Darfur State increase their access to the facilities and services including markets that are essential to improving their lives, opportunities and economic growth.



Picture 1: The water carrying donkey cart

Following the path forged in the Eastern Sudan Integrated Technology Programme, the development of intermediate means of transport (IMT) devices such as animal drawn carts has been promoted. Around 40 metal workers in North Darfur have been trained so far in the use of wheel-making sets and production of carts, trailers and wheelbarrows together with spare parts.

Practical Action Sudan has supported the creation of a manufacturer society for the production of these IMTs and maintained distribution channels for the finished products through village development committees. These committees have their own funds for purchasing IMTs and selling them on to local farmers through a credit system.

Practical Action has also been helping with the development of the donkey cart ambulance and has worked with



Picture 2: The Donkey Cart Ambulance

manufacturers in both North Darfur and Damazin. Many people living in rural areas find it very difficult to access health centers or hospitals when they are ill. It is hoped that the donkey cart ambulance can act as a means of safe transport to these facilities when no motorized vehicles are available.

This manual aims to give useful information to local fabricators and organizations that support them to help them make these intermediate means of transport. Although we have tried to give accurate information there is more than one way of making some of these components and their dimensions may need to change depending on what is available in the local markets.

2. The Wheel Jig

2.1 Background

Access to wheel manufacturing technology enables workshops to set up their own facilities to produce a range of good quality wheels from standard steel sections. Wheels can be made to take bicycle, motorcycle, car and solid rubber tires and to suit a range of low-speed vehicles such as handcarts, bicycle trailers, wheelbarrows and animal drawn carts.

An assembly jig technology has been introduced by Practical Action Technology to ensure that the wheels can be made to a consistent quality. The equipment can be made in a workshop that has competent metalworking skills and basic tools for cutting, welding, drilling and grinding steel. It can be readily adopted and used by other workshops with basic metal working facilities to produce good quality wheels at low cost and on reach a small to medium scale of production.



Picture 3: Manufacturing the wheel jig during a workshop in Damasene

2.2 Parts List

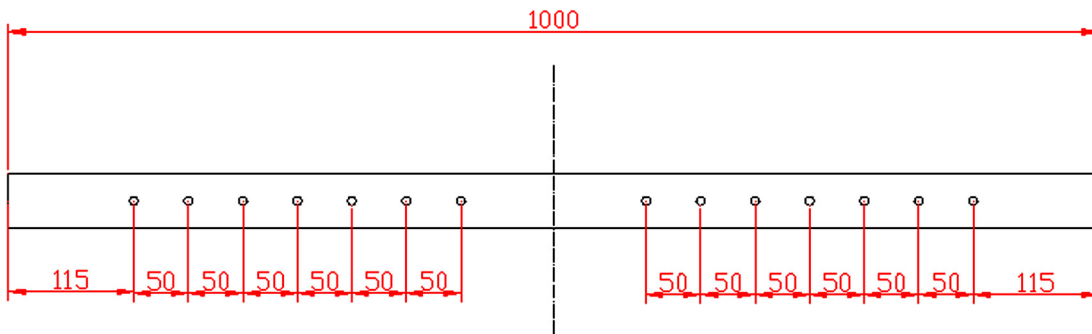
| Part | Material and Notes | No off | Length (mm) | Width or cross section (mm) | Depth / Wall Thickness (mm) | Diameter (mm) |
|------|--------------------------------|--------|-------------|-----------------------------|-----------------------------|---------------|
| A | Angle iron (jig base) | 1 | 1000 | 50 x 50 | 4 | |
| B | Angle iron (jig base) | 6 | 475 | 50 x 50 | 4 | |
| C | Flat Plate (rim clamp base) | 8 | 180 | 50 | 4 | |
| D | Flat Plate (rim clamp support) | 8 | 40 | 24 | 4 | |
| E | Flat plate (Backstop) | 8 | 50 | 30 | 4 | |
| F | Round bar (Backstop) | 8 | 90 | | | 20 |
| G | Round Bar (Handle) | 8 | 120 | | | 12 |
| H | Pipe (Screw support) | 8 | 60 | | 2 | OD 25 |
| I | M20 Bolt (and nuts) | 8 | 160 | | | M20 |

| | | | | | |
|---|---------------------------------|----|-----|--|-----|
| | (Vice screw) | | | | |
| J | M8 Bolts (and nuts) | 16 | 25 | | M8 |
| K | M30 Centre Screw (and 2 nuts) | 1 | 160 | | M30 |
| L | Round flat plate (Locking Disc) | 2 | | | |
| M | Hub Clamp Handles | 2 | 116 | | 16 |

2.3 Instructions

1. The purpose of the jig is to hold the wheel rim concentric to the wheel hub so that the wheel spokes can be welded in place. The first task is to cut the angle iron to the appropriate sizes shown in the material list (Parts A and B).
2. Once the material is cut a number of 8mm clearance holes need to be drilled in each piece of angle iron for the 8 wheel clamps (see diagram 3) which will allow for varied size wheels to be made. It is important that these holes are drilled accurately. The holes in Part A can be drilled first, with the first hole being 115mm from the end. After that there should be 6 more holes 50mm apart. This is also the case for part B where you should start at the end which has not been cut at 45 degrees when marking the holes.

Diagram 1. Hole positions for the jig base



The table below shows the position of the holes and the different size wheel rims which can be produced (ID) depending on their position (hence the holes in diagram 1 are 50mm apart).

| Wheel Rim (ID) | Hole position from end (for wheel clamp) | Hole position from end (for wheel clamp) |
|----------------|--|--|
| 150mm | 415mm | 265mm |
| 200mm | 365mm | 215mm |
| 250mm | 315mm | 165mm |
| 300mm | 265mm | 115mm |

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4. These parts now need to be arranged as in diagram 2 where they should be welded in position. As can be seen from this 4 pieces of Part B should be cut at 45 degree angles.

5. The next stage is the making of the 8 rim clamps which will hold the wheel rim. Firstly 8mm clearance holes need to be drilled and equal distance apart (150 mm).

These holes will allow the jig to make different size wheels.

6. The heads of eight 20mm bolts are cut off and the handles (Part G) are welded at one end.

6. A 20 mm nut is then welded to the end of the tube (Part H)

7. Following this, Parts E and F are welded together and then welded to Part C (see tech drawing WJ – 02 for positioning dimensions).

8. The rim clamps are now ready to be screwed in place on the frame.

Obviously in the same position on each leg although it will be quite apparent if one is in the wrong place.

9. The central locking bolt can now be put in the centre of the frame. First of all a hole is burned in the metal with the welder that allows the 30 mm threaded bar (Part K) to fit inside. The threaded bar is then welded in position (90 degrees to the base).

Diagram 2. Plan view of wheel jig base

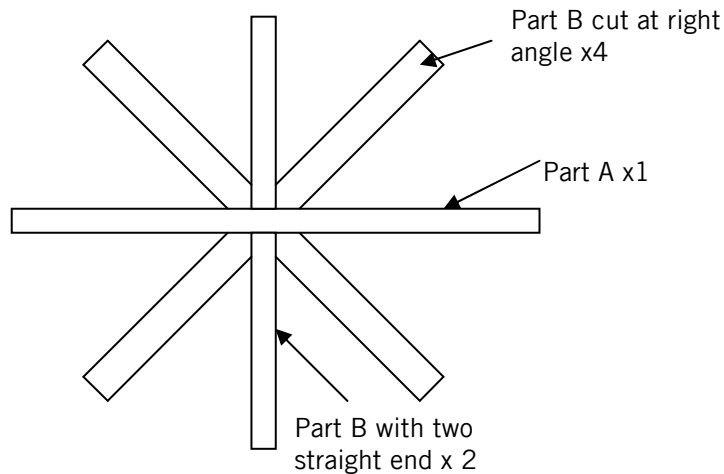


Diagram 3. A 3-D Model of one of the 8 wheel rim clamps

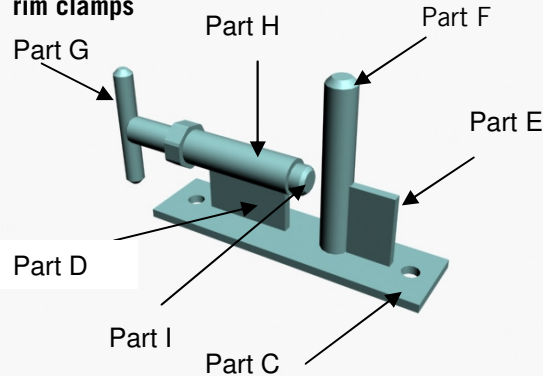
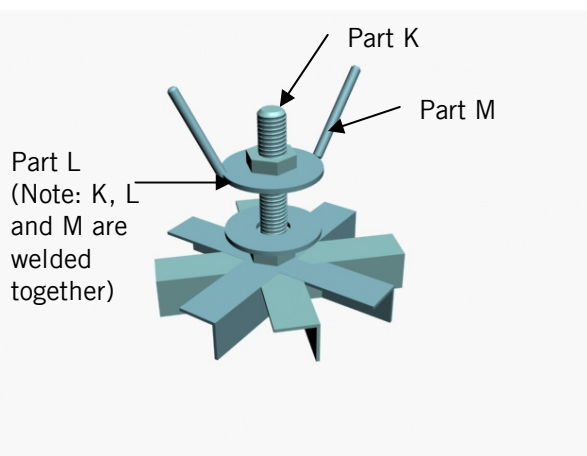


Diagram 4. A 3-D Model of the Hub Clamp



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Picture 4: A completed wheel jig

10. The final phase is the making of a small device capable of locking the wheel hub concentrically. This of course will depend on the size of the wheel hub you are using. In the cart outlined in this manual the OD of the bearing is 92 mm. Therefore a circular piece of material is required with an OD of 90 -91mm and a 20mm clearance hole in the middle for the locking thread.



Picture 5: A completed wheel jig from above (Note: The diagonal parts of the jig base should be at 45 degree angles as shown in the technical drawings).

This will probably need to be prepared on the lathe unless suitable size washers can be found. This disc is then welded concentrically to the nut. This needs to be made twice to lock the hub concentrically at the bottom and at the top. Finally the handles are welded to the top locking disk as shown in diagram 4. In pictures 4 and 5, instead of using M30 nuts, specially manufactured round bar material has been threaded; as stated in the introduction there is more than one way of making some of these components.

Note: Please see Technical Drawing Number WJ - 01 and 02 for more details.

3. Manufacturing the wheel

3.1 Parts List

| Part | Material and Notes | No off | Length (mm) | Width or cross section (mm) | Depth / Wall Thickness (mm) | Diameter (mm) |
|------|---|--------|-------------|-----------------------------|-----------------------------------|---------------|
| A | Mild Steel Round Section Bar | 2 | 1300 | N/A | N/A | 15 |
| B | Mild Steel Flat Plate (Rim) | 1 | 1240 | 100 | 3 | |
| C * | Mild Steel Tube – * see method NO 6 before starting | 1 | 100 | | 8mm (4mm for the bearing surface) | External 100 |
| D | Mild Steel Right angle section (spokes) | 5 | 150 | 50 x 50 | 4 | N/A |
| E | Mils Steel Flat Plate | 5 | 60 | 50 | 5 | N/A |

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3.2 Instructions

1. Using a hammer and a bend former, hammer the round section bar (Part A) until a circle is formed. The bend former (i) can be any steel object which has a hole in the middle. The bending of the plate takes place when the bar is hit over the hole. In this workshop the bend former was taken from an old diesel generator (see pic 6).

2. Once a complete circle has been formed it is hammered flat on a hard surface. It should have an internal diameter of 400 mm. Steps 1 and 2 are repeated again.

3. The flat plate (B) is now bent into a circle this time using a different type of bend former (ii). This piece of equipment has been fabricated ad hoc in the workshop. It is made of a steel pipe with a metal strap welded on top leaving a gap underneath to slide the metal plate under. This former is then held in a vice. The plate is then pushed by hand around the tube. (See picture 7, right).

4. The circular shape of B is perfected using bend former (i) as described in process 1.

5. The flat plate which is now circular is put on to the wheel jig. This piece of equipment has been made specifically for making donkey cart wheels of a certain size. Therefore part A is placed on the jig and the wheel clamps are tightened up to hold it in place. If the length of A is excessive it should be marked and cut off.

6. Before placing the steel pipe C onto the jig it should have two bearing surfaces cut into each end. They should be 20 mm in depth and have a recess of 4 mm (Half the material thickness).



Picture 6: A Fabricator bends the metal bar (Part A) using a hammer and a bend former (i)



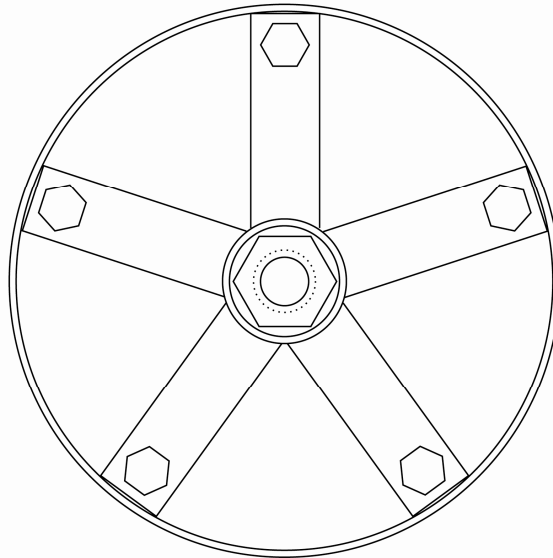
Picture 7: The fabricator bends the flat plate (Part B) using the bending tool



Picture 8: The wheel rim is placed in the jig and measured for accuracy

They will house the wheel bearings. Part C is then placed on the wheel jig centre threaded shaft and locked in place with a nut which locates on the pipe hole ensuring it is centralized. Part C is now concentric to part A, its bottom edge is flush with the bottom edge of part A but its top edge protrudes by 20mm.

Diagram 5: The 5 spoke wheel



7. Using suitable measuring and marking equipment, 5 marks are made at an equal distance apart to designate the position of the wheel spokes. See diagram 5 right. An equal measurement of 220mm should be between point.

8. Each of the 5 pieces of angle iron Part D are then spot welded between each of the marked points and a perpendicular point on part D. These are the wheel spokes. If the spokes are in an equal position apart then they are seem welded in place.

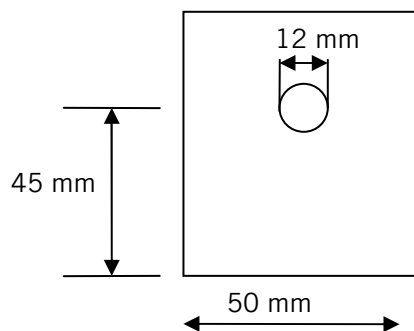


Picture 9: The wheel being welded showing the tire valve hole

9. The next stage is for part A to be spot and seem welded around the top and bottom outside edge of the wheel.

10. A clearance hole is made half way across the width of the wheel rim (part B) diameter approx 15mm for the tire valve hole (see pic 9). If you do not have an adequate size drill the welding torch can be used as the hole is not required to be accurate

Diagram 6: Part E made from flat plate steel



11. Part E (tab) requires a 12mm bolt clearance holes to be drilled in it as shown in diagram 6.

12. Following this the tabs (5 x Part E) are placed on top of the spokes (Part D) and welded at the 50 mm end to the rim (Part A).

13. Next the 12 mm clearance holes in part E need to be extended into the spokes. This can be done using a drill following the path of the holes in the tabs (see pic 10).

14. Following this all parts need to be deburred and left in a good condition ready to be painted. The 12 mm bolts are used to connect the spokes and the tabs for extra strength and support. The wheels can be painted and once dry the bearings can be fitted.

15. Finally suitable sized tires can be pressed onto the wheels.



Picture 10: A makeshift pillar drill used for drilling the holes in the spokes

4. Manufacturing the Frame

4.1. Parts List

| Part | Material and Notes | No off | Length (mm) | Width or cross section (mm) | Depth / Wall Thickness (mm) | Diameter (mm) |
|------|--|--------|-------------|-----------------------------|-----------------------------|--------------------|
| A | Mild Steel Tube (main frame) | 2 | 3000 | | 1.5 | External 50.8 (2') |
| B | Mild Steel Tube (main frame) | 2 | 550 | | 1.5 | External 50.8 (2') |
| C | Mild Steel Right Angle Section (sub frame) | 2 | 1350 | 50 x 50 | 3 | |
| D | Mild Steel Right angle section (sub frame support strap) | 4 | 700 | 25.4 x 25.4 (1') | 1.5 | |

4.2. Instructions

1. Hammer the ends of parts A and B so they are oval in shape and arrange them as in the diagram (right) and weld in place.

2. The next part to be made is the axle support frame (part 3). Using a hacksaw cut the angle iron along the 6 dotted lines shown in diagram 8 (Dimensions in mm).

Diagram 7. Plan view of frame

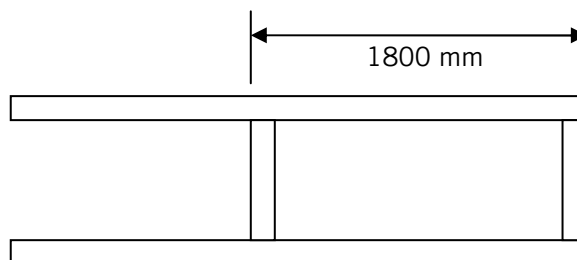
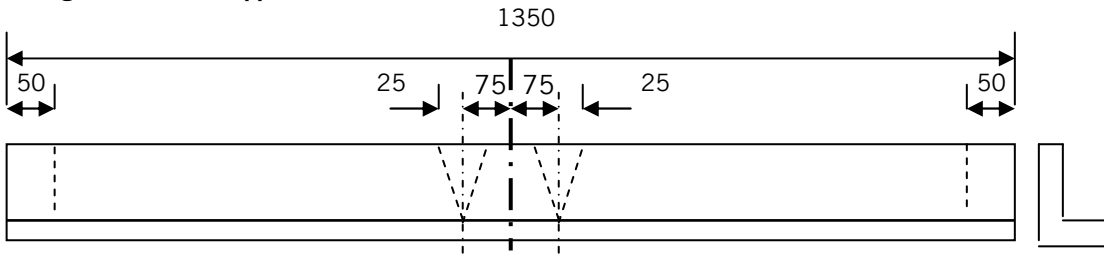


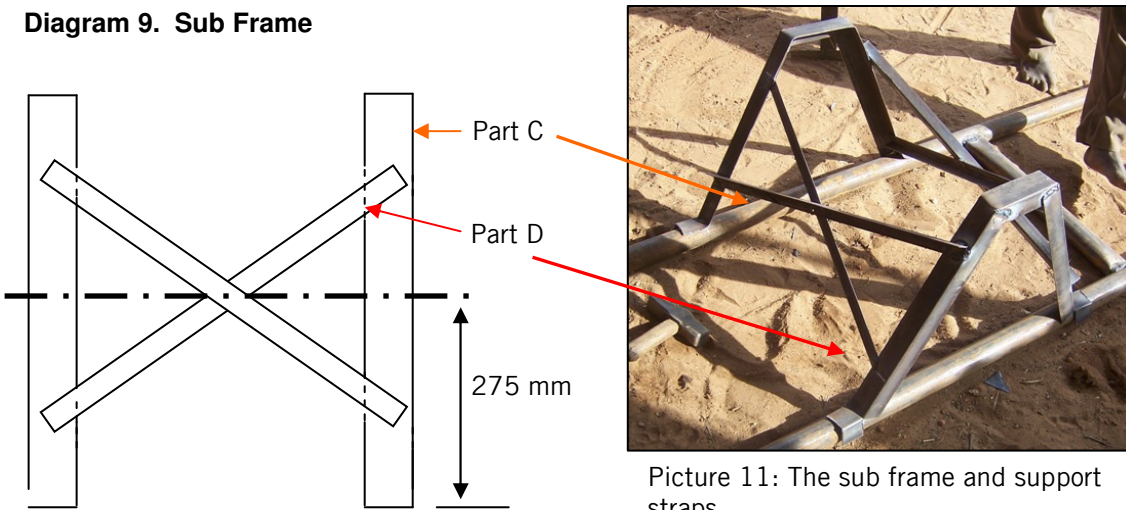
Diagram 8. Axle Support Frame



4. This allows you to bend the material into the shape shown in pic 11. The two bottom joints should be welded in position. The top cuts should be bent into the position shown in the diagram ready to be welded to the main frame

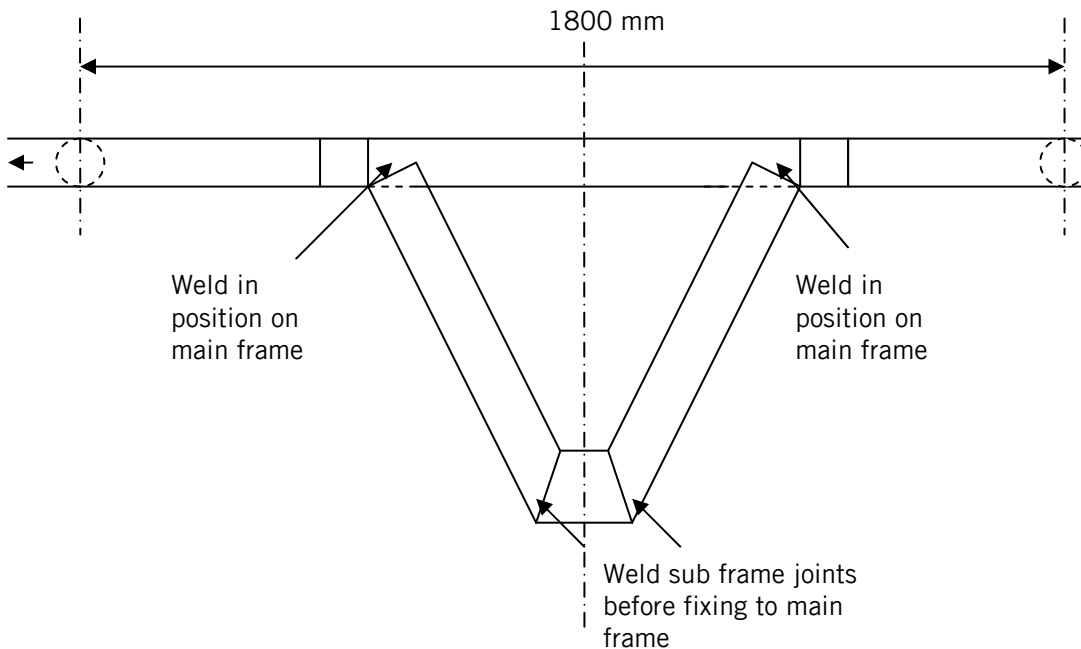
5. The next stage is for the sub frame support straps to be fitted which join the two sides of the sub frame. They should be welded in a cross formation in the middle of the sub frame. See diagram 9 and pic 11.

Diagram 9. Sub Frame



Picture 11: The sub frame and support straps

Diagram 10. Main frame and sub frame



6. Finally the complete sub frame can now be welded in position on the main frame. They are to be an equal distance between the two cross members of the main frame (see diagram 10 below).

5. Manufacturing the Axle

5.1. Parts List

| Part | Material and Notes | No off | Length (mm) | Width or cross section (mm) | Depth / Wall Thickness (mm) | Diameter (mm) |
|------|--|--------|-------------|-----------------------------|-----------------------------|---------------|
| A | Mild Steel Right Angle Section | 2 | 1000 | 50 x 50 | 3 | |
| B | Mild Steel Right Angle Section (Brackets) | 4 | 50 | 50 x 50 | 3 | |
| C | Mild Steel Round Section with 12 mm thread at one end 40mm in length | 2 | 240 | | | 50 |

5.2 Instructions

1. Firstly the two shafts (Part C) are placed at either end of one of the right angle sections (Part B). They should be positioned so that the shafts protrude by 140 mm (including the 40mm thread) and are then welded in place.

2. The second length of angle iron (Part A) is used to form a square cross – section (see diagram 11). This is then welded in position both to the axle shafts and the other piece of angle iron.

Diagram 11. Side view of one end of the axle

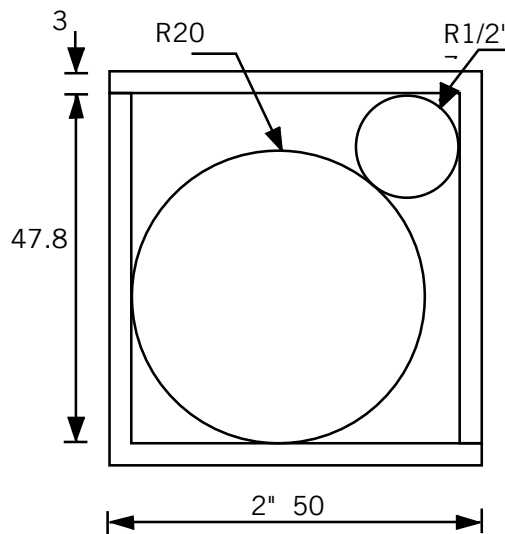
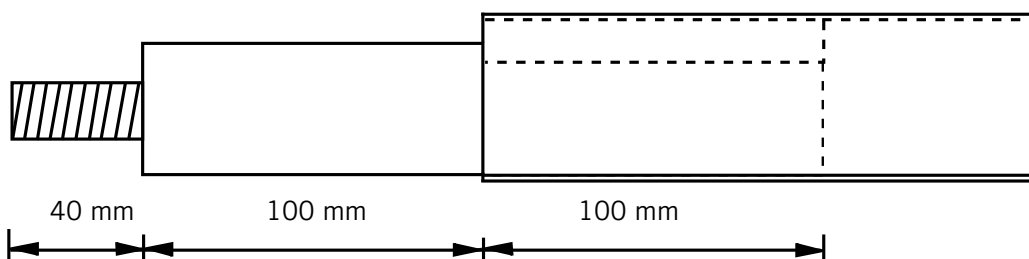


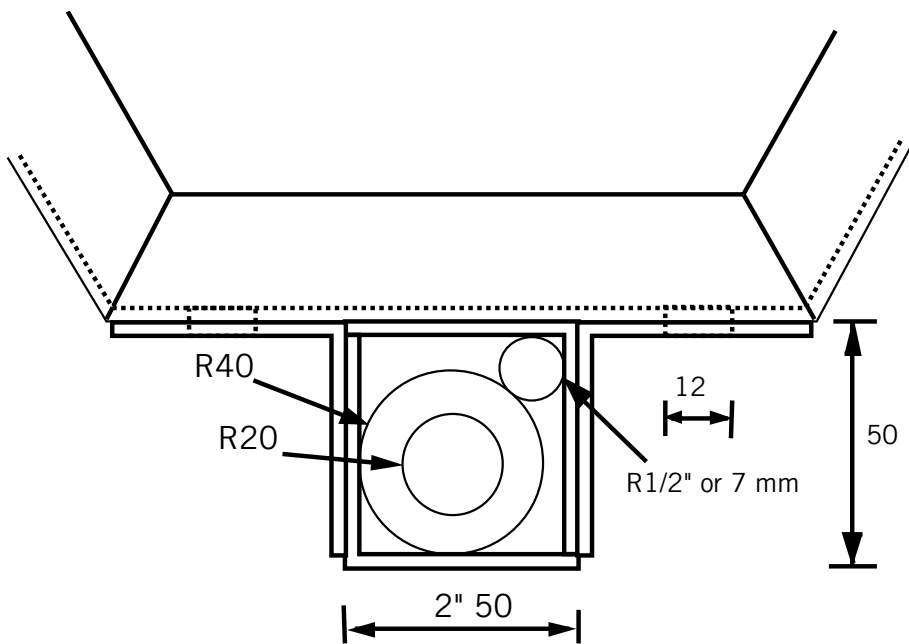
Diagram 12. End of Axle



3. The manufacturer of this cart has been suffering problems from the original design as the axle would break off from the frame due to a small contact surface area. The following modification is suggested to prevent the problem from continuing. Firstly, an angle iron brackets need to be made with 12mm clearance holes in the middle of one side.

4. Each bracket is welded either side of the axle angle iron frame (Part A) in line with the side frame (Frame – Part C, Sub frame), with the clearance hole facing up, see diagram 13.

Diagram 13. End view of axle and support bracket



5. Using 12 mm bolts secure the axle into position. Alternatively use the bolts for positioning and weld in place.

6. The wheels can now be put on to either end of the axle, this is easiest with the cart upside down. Tap the wheel gently with a soft hammer at all points on the wheel to ensure even distribution of force (ideally a press should be used).

7. With the wheel in place slide on a washer and lightly secure the 12 mm nut being careful not to over tighten them.

Note: Please see Technical Drawing Number DC- 01 and DC - 02 for more details

6. Ambulance conversion

6.1 Parts List

| Part | Material and Notes | No off | Length (mm) | Width or cross section (mm) | Depth / Wall Thickness (mm) | Ø(mm) |
|------|--|-------------------|-------------|-----------------------------|-----------------------------|-------|
| A | Mild Steel Flat Section (Ambulance Brackets) | 4 | 50 | 50 x 50 | 3 | |
| B | Mild Steel Right angle section (Ambulance frame) | 4 | 1800 | 25.4 x 25.4 (1') | 1.5 | |
| C | Mild Steel Right angle section (Ambulance frame) | 3 | 1510 | 25.4 x 25.4 (1') | 1.5 | |
| D | Mild Steel Right angle section (Ambulance frame) | 4 | 300 | 25.4 x 25.4 (1') | 1.5 | |
| E | Mild Steel Flat Section (Ambulance frame support strap) | 3 | 296 | 50 | 1.5 | |
| F | Wire Mesh | 2 | 1794 | 294 | 1 | |
| G | Wire Mesh | 1 | 1504 | 294 | 1 | |
| H | Planks of Wood (dimensions given are approx, wood must cover an area of 1500 mm x 1790 mm) | 8 + 1 cut to size | 1500 | 200 | 15 | |
| I | Mild Steel Flat Section (wood support) | 2 | 1796 | 20 | 2 | |
| J | Mild Steel Round Section (Roof support) | 2 | 260 | | | 10 |
| K | Material (Cotton Cloth) | Cut to fit | | | | |
| L | Mild Steel Right angle section (Seat Support) | 1 | 275 | 25.4 x 25.4 (1') | 3 | |
| M | Mild Steel Right angle section (Drivers Seat) | 2 | 300 | 25.4 x 25.4 (1') | 3 | |
| N | Mild Steel Right angle section (Drivers Seat) | 1 | 225 | 25.4 x 25.4 (1') | 3 | |

6.2 Instructions

1. Weld each of the four ambulance support brackets to the side of the cart program (Part A).
2. To make the driver seat support bracket (Part L) mark the shape of the curved surface of the main frame bar on to one end of Part L). Using the angle grinder grind part so that it has a clear curved surface which can be welded flush to the mainframe. See diagram 14 and 15. This

Diagram 14. Plan view of cart frame with brackets

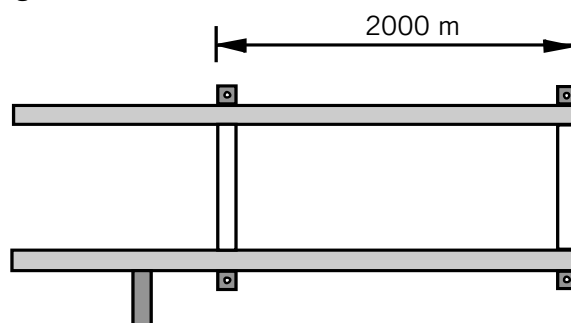
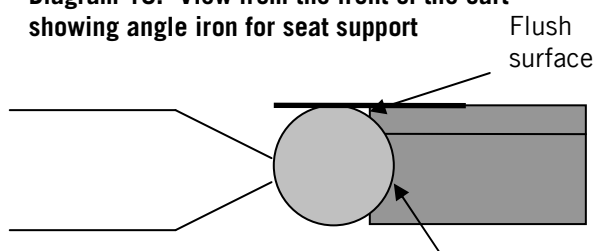


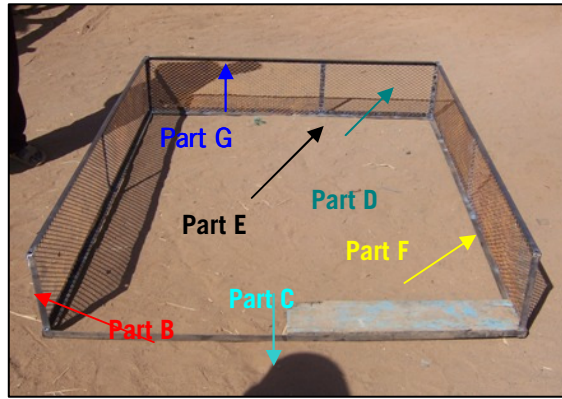
Diagram 15. View from the front of the cart showing angle iron for seat support



Part L with curved surface welded to the side of the cart mainframe

will support the seat for the driver of the ambulance. The seat can be seen more clearly in the 3D model drawing in diagram 18.

2. The next stage is the making of the ambulance frame (one is shown in picture 12).



Picture 12: The ambulance frame

a) The sides of the frame (Part B x 2 and Part D x 2) are welded together to form a rectangle. The wire mesh (Part F) is put inside and welded in place. Following this the frame support strap (Part E) is welded in the middle from the inside holding the wire mesh in place. This is done twice to form the sides of the frame.

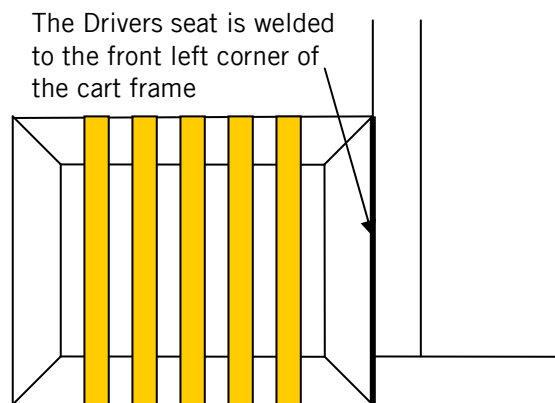


Picture 13: The wire mesh

b) The lower back (not the upper back) and front of the frame (Part D x 2) is then welded to the sides to form the full frame and wire mesh (Part G) is placed in the back section and welded in place and the support strap (Part E) is welded in place as in the previous instruction. The front remains open as this is the point of entry for the patient.

Diagram 16. The drivers seat

c) The drivers seat is formed by cutting 45 degree angles on parts M and N and welding them into a rectangle.

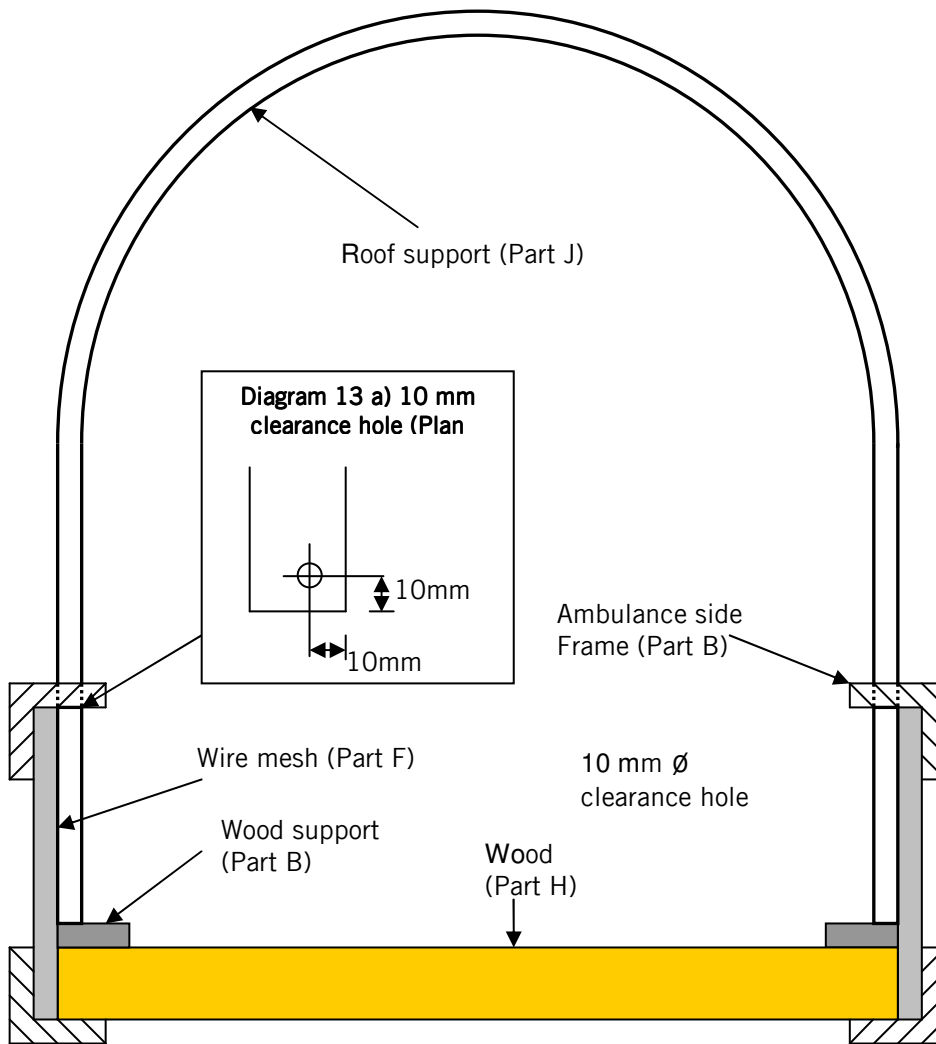


d) The drivers seat is then welded to the front left corner of the cart frame as shown in diagram 16.

c) Planks of wood (Part H) are then put on the frame to make a base. These are held in place by welding two metal strips (Part I) slightly above the wood on each side. See diagram 17.

3. In order to insert the round section bar that acts as a roof support, four 10 mm clearance holes need to be drilled at the ends of the upper ambulance sides (Part B). The position of one the holes is shown in diagram 13 a), the other 3 holes are in the same position at each end.

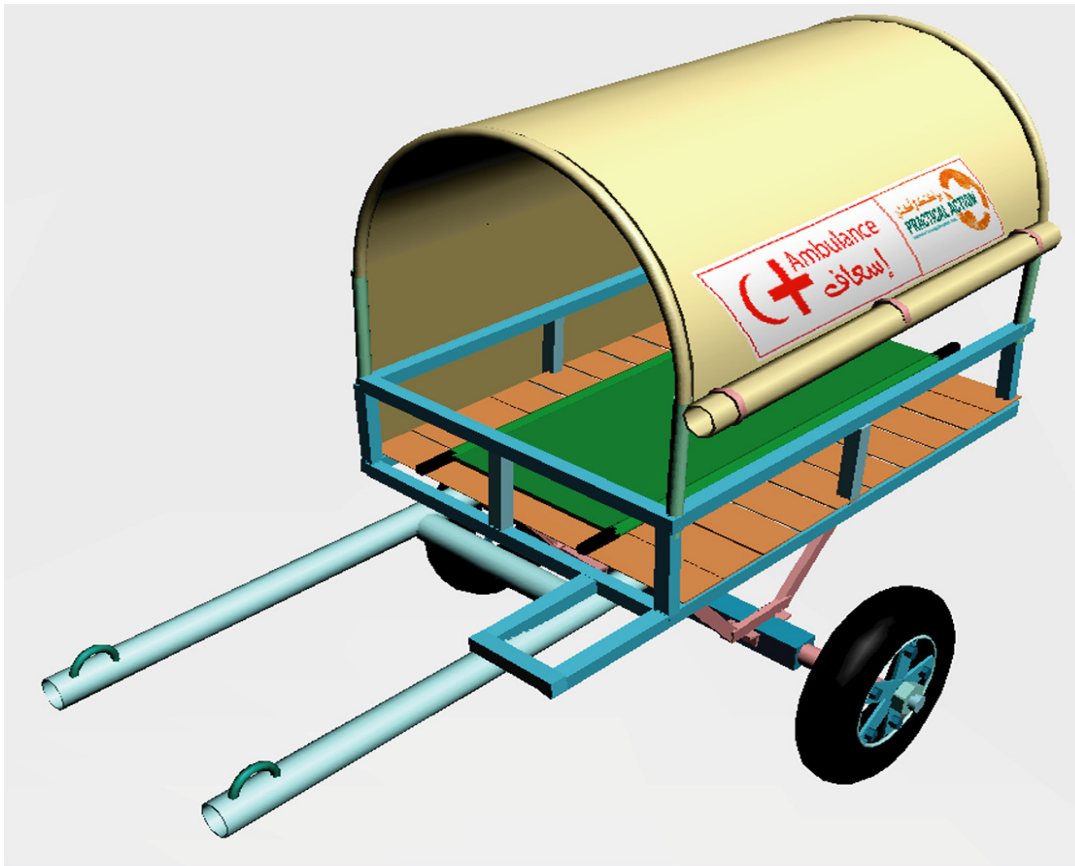
Diagram 17. Cross sectional view from the front of the cart



3. The two roof supports need to be hammered round to form the oval shape shown in the diagram. This is done using the same process as described in Part 1.1.
4. Insert the two roof supports into the holes made in the frame and weld in place.
5. The cotton material is then cut to size and is pulled over the roof supports and tied in place.
6. Following this the ambulance frame is lifted up on to the cart frame and with the 4 bolt holes lined up, insert the 12 mm bolts and tighten their respective nuts.
7. The ambulance is complete please see diagram 18.

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Diagram 18. 3D Model of the Cart



Note: Please see Technical Drawing Number DCA - 01 for more details

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