Design, adaptation and manufacture of animal-drawn carts

by

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Abstract

Animal-drawn carts can meet many of the transportation needs of a small farmer. This paper describes some designs and details of animal-drawn carts that have been promoted for more than 20 years. Information is based on the experiences of the author with appropriate technology organisations in Tanzania and Ghana. Drawings are provided of several designs of cart and bearings, some suitable for manufacture in local workshops. Production methods are also discussed.

Introduction

The most important implements for a farmer using draft animals are the plow, followed by the inter-row weeder. But the use of these implements is seasonal, and if a farmer wishes to make use of his draft animals all year round, the cart is the really important item. A cart owner can make considerable income from hiring out the cart for haulage of goods.

It is not easy to make a durable ox cart at a price that a small-scale farmer can afford. Carts can be made using wheels and axle assemblies from old cars, but the supply of these components is not nearly enough to meet the demand for ox carts. There is a need, therefore, to design bearings and axle–wheel assemblies that can be made by any local craftsmen with average skills.

The following analysis is based on the author's experience with carts while working at the Tanganyika Agricultural Machinery Testing Unit (TAMTU), Arusha, Tanzania (1968–76), the University of Science and Technology, Agriculture Engineering Department, Ghana (1976–85) and the Institute of Production Innovation (IPI), Dar es Salaam, Tanzania (1985–92).

*Josef Wirth was tragically killed in a car accident in Tanzania in 1992

Designs for ox carts suitable for manufacture by rural artisans

Design of a suitable bearing

The biggest problem encountered when designing a suitable axle–wheel assembly for an ox cart is finding a suitable bearing. Such a bearing should be:

- simple to manufacture
- extremely durable
- resistant to rough treatment
- easy to maintain, repair or replace
- reasonably priced.

Experience has shown that a very suitable combination of bearing materials is a mild steel shaft running in an oil-soaked hardwood bearing.

The hardwood bearing can be made as a prismatic wooden block or as a cylindrical wooden bush (Figure 1). The wooden block bearing is the easiest to manufacture; making the cylindrical wooden bush needs more skill or, preferably, a lathe.

African mahogany is a suitable wood for this purpose, as is wood from the trees known locally as *mvule, loliondo, panga panga* and *mtundu*. The wood must be well seasoned and dried. Artificial drying can be carried out in a solar drier, provided it can produce temperatures of around 60–80°C: this process takes about two weeks.

Photo 1: Wananchi ox cart, with steel wheels and block brakes

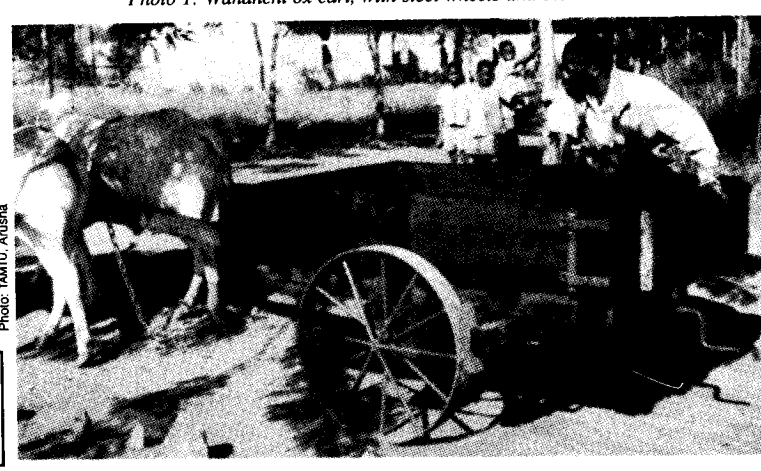


Photo: TAMTU, Arusha

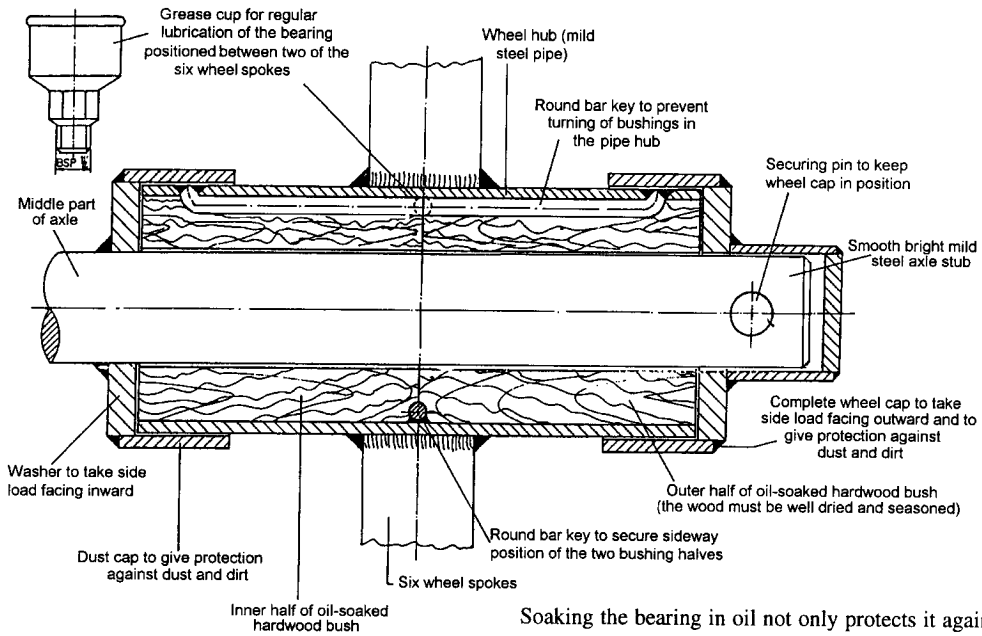


Figure 1: Standard cylindrical wooden bush bearing

Soaking the bearing in oil not only protects it against water, but also gives it some emergency lubrication, which is important if the farmer does not grease the bearing frequently.

Test of bearing performance

The two types of bearing mentioned were tested on a drum type test rig. This rig simulated an ox cart travelling on a rough road at a speed of 9.3 km/hour (slightly high due to the second-hand components available for manufacture of the rig) for a total travel distance of 4000 km, running over about 5 million obstacles. This test was made in 1973 by TAMTU in Arusha, Tanzania. (TAMTU has since become Camartec—Centre for Agricultural Mechanisation and Rural Technology—also based at Arusha.)

The measured wear was less than 1 mm of the bearing's diameter, despite the fact that lubrication

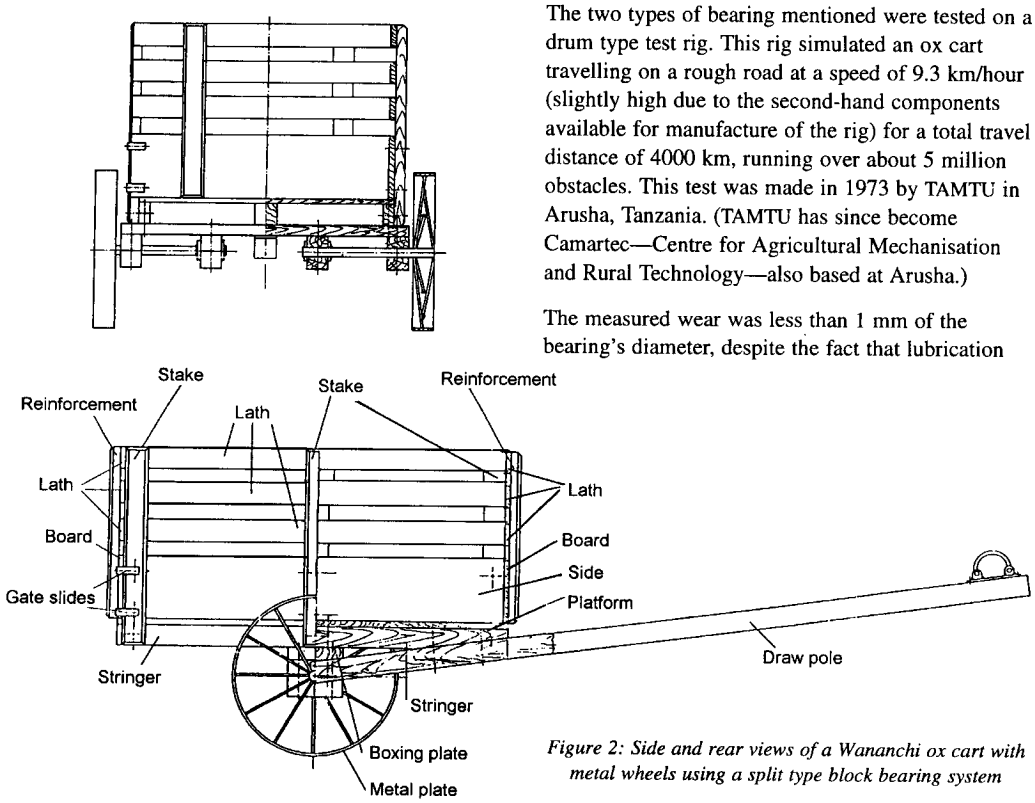
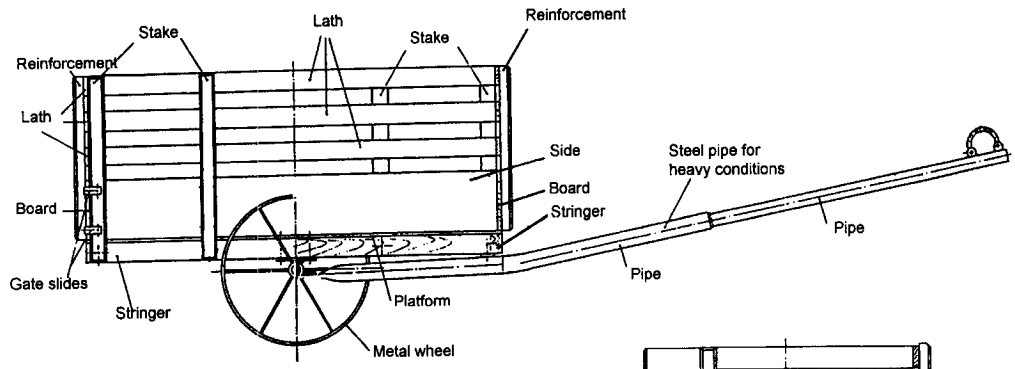


Figure 2: Side and rear views of a Wananchi ox cart with metal wheels using a split type block bearing system



was neglected during the last 1000 km of the test. The load on the bearing was 365 kg.

One cart made by TAMTU was called the "Wananchi" ox cart (see Photo 1 and Figure 2). One such cart made in 1969 was still in good condition in 1976. It was used on stony roads in the Lekuriki area in Arusha Region. A wooden bush rail axle cart (*Afromosi* bush bearings: Figure 3) showed very little wear after five years of use in a village in northern Ghana.

Over the years, field observations have shown that the bearings do wear considerably, especially if they are not well made or if unsuitable timber is used. Some carts seen during a tour of Iringa Region in 1986 showed serious damage or failure of the bearings due to poor manufacture and the wrong choice of material.

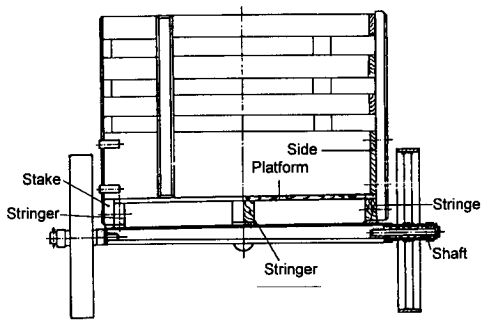
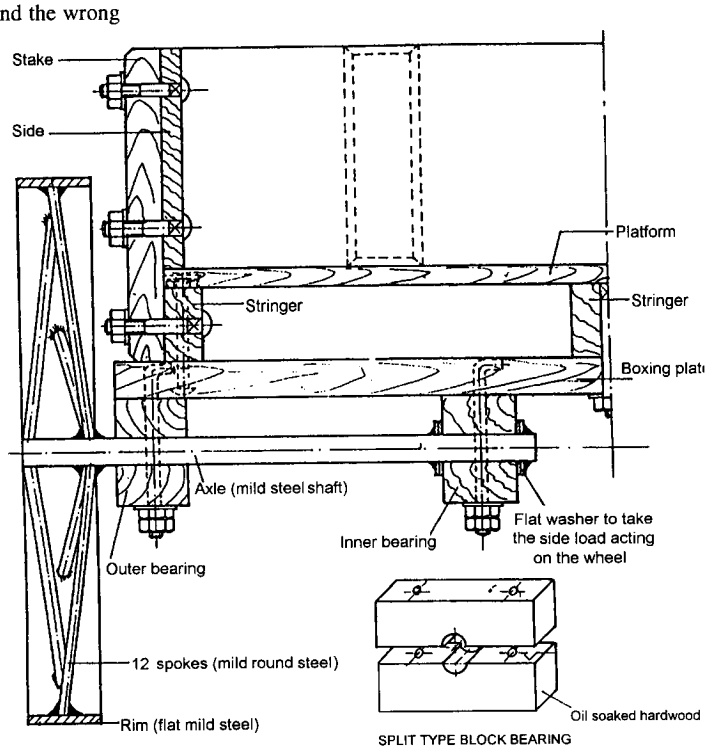


Figure 3: Rear and side views of an ox cart using a rail axle and wooden bush bearing system with metal wheels

Figure 4: Wananchi ox cart block bearing system



Design of axle–wheel arrangements

Based on the two types of bearings mentioned above, four different axle–wheel systems have been designed:

- Wananchi ox cart block bearing system
- symmetrical wheel block bearing system
- wooden bush stub axle system
- wooden bush rail axle system.

These four bearing systems, and ox carts built around them, are shown in Figures 2–8.

Each system has its advantages and disadvantages which make it more or less suitable for different applications.

Carts of various sizes can be made using any of the above four designs. The diameter of the wheels can also be varied; in particular, metal wheels can be manufactured in diameters ranging from 80 to 120 cm.

Design of wheels

In conjunction with each of the four axle arrangements, four different types of wheel may be used:

- metal wheel
- pneumatic wheel
- solid rubber wheel
- "mbaomatic" wheel.

The diameter and type of wheel will be a compromise of choices depending upon the requirements of the farmer and the materials available.

Metal wheel

The metal wheel (Figure 9) will be the choice if the cart is to be used in remote areas with no puncture repair facilities. Metal wheels for travel on sandy soil will have wider rims. The size of the flat bar that is bent to form the the rim will have to be 80 x 10 mm to 120 x 12 mm (to 150 x 16 mm at the most) depending on the size of the cart. Rims of 10 x 10 mm are good for small donkey carts. For normal ox carts flat bars of 100 x 12 mm are well suited. Recommended wheel diameter is 750 mm.

A simple wooden block brake can easily be incorporated into the construction of the cart (see Photo 1).

Pneumatic wheel

Pneumatic tyres will usually come from old cars. Tyres from a passenger car ("175 x 14" size) are suitable for donkey carts and small ox carts but for most carts the larger wheels used on a four-wheel drive vehicle such as a Land Rover or a Land Cruiser ("7.50 x 16" size) are preferred.

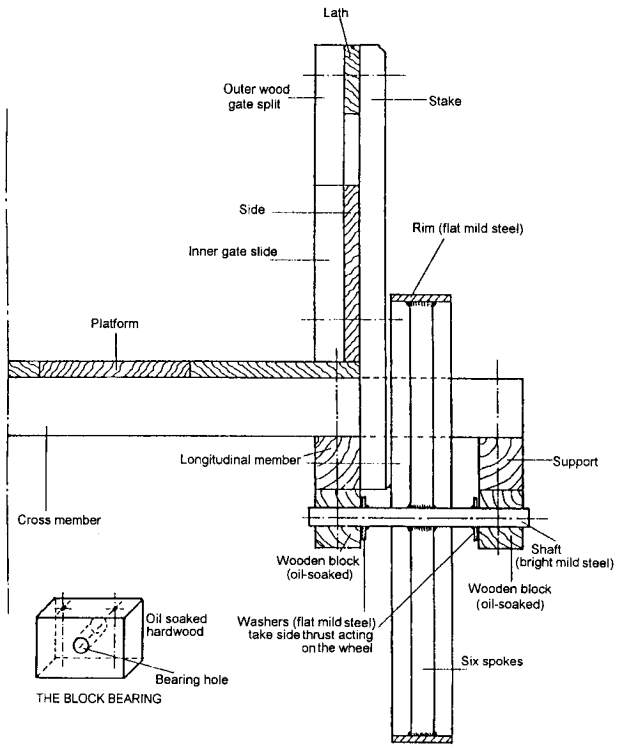
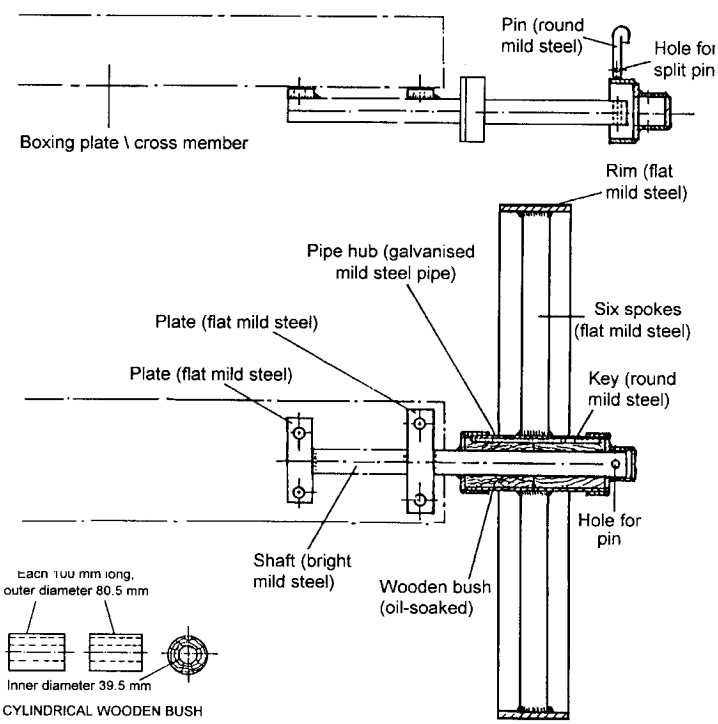


Figure 5: Symmetrical wheel block bearing system

Figure 6: Wooden bush stub axle bearing system



Usually, old tyres are more readily available than old rims. The design of a rim suitable for local manufacture is shown in Figures 10 and 11.

Solid rubber wheel

Solid rubber wheels seem to be the answer for ox carts. Only a few carts have been made with these wheels, but the experience so far is positive. On sandy soil, solid rubber wheels have no advantage over metal wheels. On stony roads, solid rubber wheels will not make the noise associated with metal wheels, but they also will not give the suspension effect of pneumatic tyres. Unfortunately, solid rubber wheels are quite expensive and are not available locally. A compromise wheel can be made by cutting out the middle part of an old car tyre and fixing it to the rim of a metal wheel.

One prototype ox cart with a solid rubber wheel is still in use at the Mbeya Rural Craft Workshop after about 12 years.

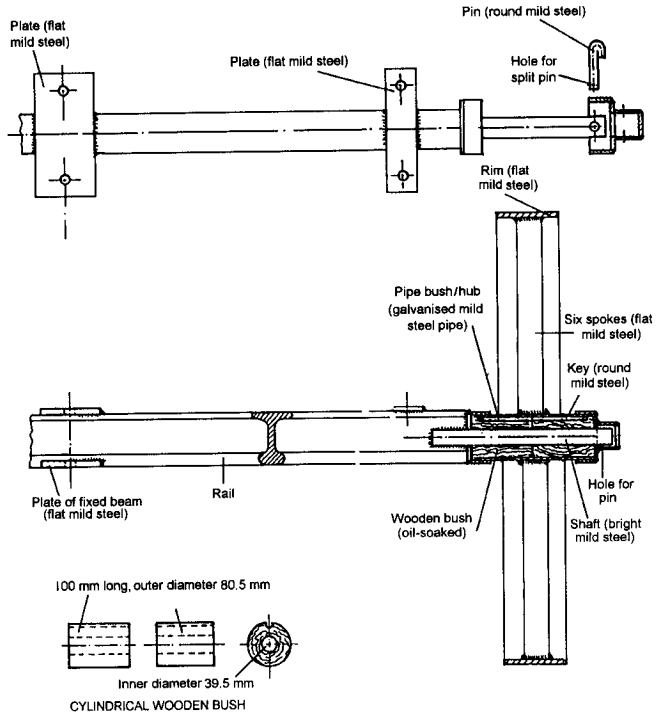
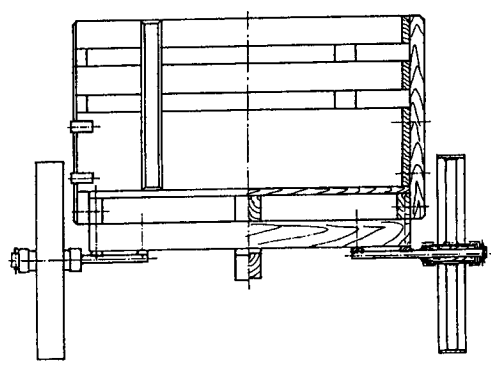


Figure 7: Wooden bush rail axle bearing system

"Mbaomatic" wheel

The name "mbaomatic" is derived from "mbao" (Kiswahili for timber) and "matic" (from pneumatic, as the tyre from a pneumatic wheel is used for the lining). This wheel (designed by George Macpherson) consists of a wooden disc made of three pairs of planks (2–3 cm thick) nailed together crosswise and cut into a circular shape (Figure 12). This wooden wheel disc is covered with an old car tyre of suitable size (eg, an old Land Rover tyre).



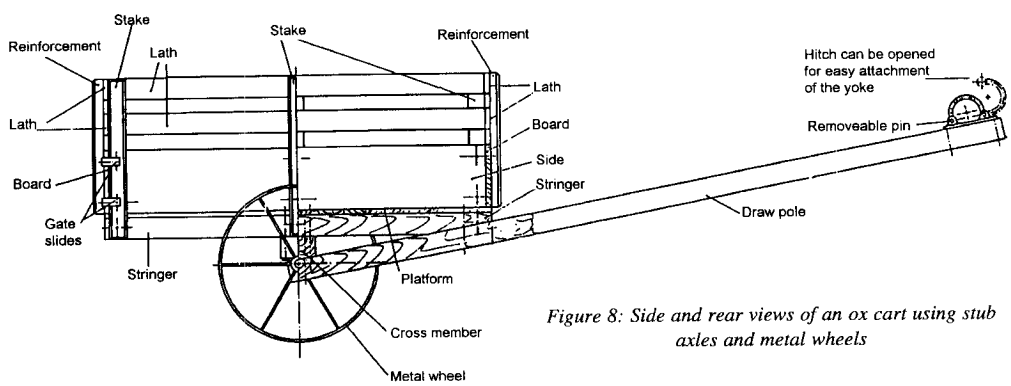


Figure 8: Side and rear views of an ox cart using stub axles and metal wheels

The wheel disc is bolted to a hub flange made of 6–8 mm thick mild steel plate.

Jigs for cart production

The manufacture of animal-drawn carts requires a fairly well-skilled metal craftsman and an average-skilled carpenter. Purpose-designed jigs can be of great help in the manufacturing process, especially if large numbers of carts are to be made. The following are the most important jigs developed for the purpose of making the metal parts of the carts:

- rim bending jig
- wheel assembly jig
- axle assembly jig
- pneumatic wheel rim assembly jig.

The rim bending and wheel assembly jigs can be combined into one (Figures 13 and 14) and will allow the manufacture of an accurate metal wheel.

The axle assembly jig is less important, but it is useful in the manufacture of a rail axle for ensuring that the two bright mild steel stubs are correctly aligned.

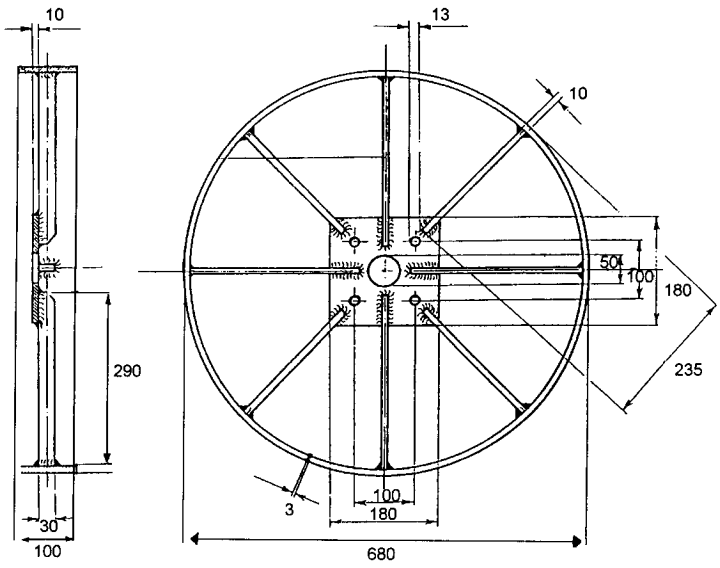


Figure 9: Replacement metal wheel designed for a pneumatic tyred cart of the Tanga Animal Draft Power Project (dimensions in mm)

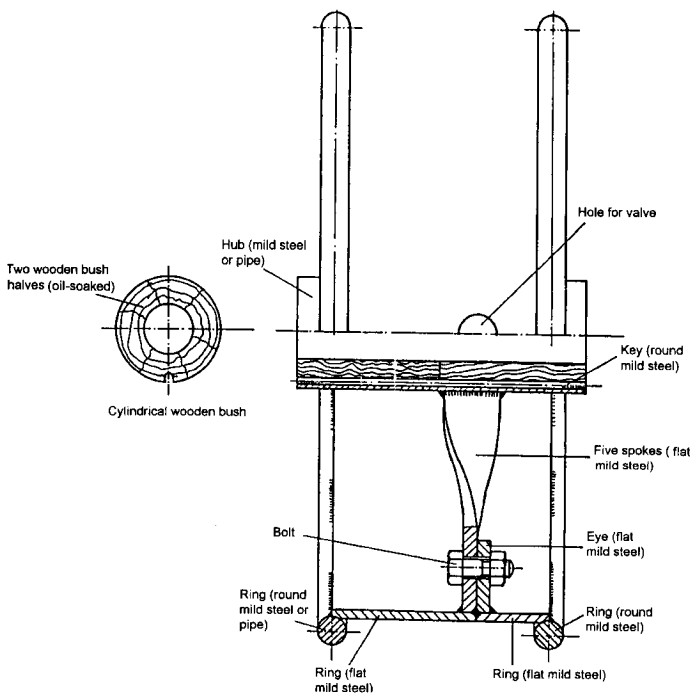


Figure 10: Rim for pneumatic tyre

Medium and large workshops

Experience gained from other projects aiming at the promotion of animal-drawn equipment has shown that it is quicker and cheaper to centralise the manufacture of ox carts or related items in one or a few workshops, depending on the size of the project area.

In West Africa, several countries have large workshops producing carts. The Arcoma production organisation in Burkina Faso has two main workshops, one in Ouagadougou and one in Bobo Dioulasso. These two workshops produce carts and plows for the whole country and even export some items to neighbouring countries. Similarly, a workshop in Tamale in northern Ghana produces equipment for the whole of the Savannah Region of Ghana. Senegal has the large Sismar factory. These workshops all produce carts with roller bearings and pneumatic tyres.

There are several advantages of such centralised production. Experience has shown that at least the manufacture and supply of equipment in sufficient

quantity and quality can be guaranteed with this arrangement.

For quick and measurable success it is better to go for centralised production. Attempts to achieve a widespread introduction of animal-drawn carts through decentralised production have had limited success.

However, given the necessary efforts, it is certainly possible to cover a demand by decentralised production. Local production has the advantage of encouraging local repair and maintenance services.

The Institute of Production Innovation (IPI) in Tanzania has designed two animal-drawn carts, one small and one large (Figures 15 and 16), for production in a central workshop. Both are equipped with pneumatic tyres. The wheel hubs run on roller bearings (Figure 17) and the basic frame of the cart is made of metal sections welded together. Timber is used for the draw poles and the platform.

Raw materials

Under the economic circumstances prevailing in Tanzania it is cheaper for an aid project to import raw materials than to depend on local supply. This is a very unusual situation. The main reason is that the unfavourable exchange rate makes local purchases from officially converted foreign currency very expensive.

For example, in the late 1980s, a piece of mild steel plate suitable for the floor of an ox cart cost 975 Tanzanian Shillings (Tsh) at the National Steel Corporation in Tanzania. The same sheet metal imported through aid channels would cost only about Tsh 650. Wooden planks of equivalent area cost Tsh 1152 at that time.

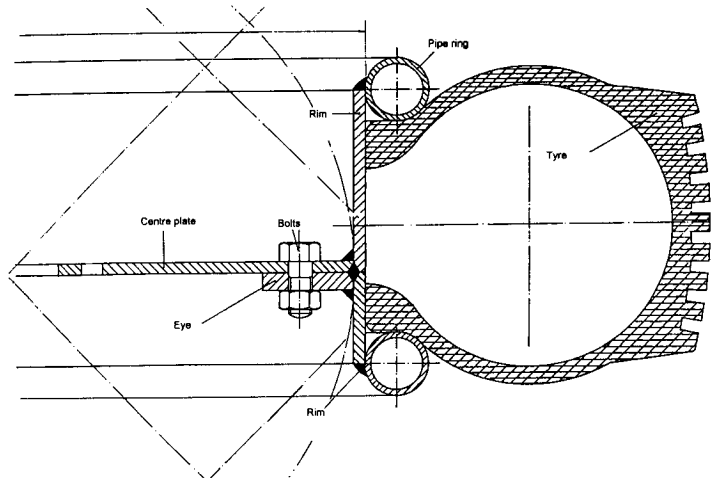


Figure 11: Detail of rim for pneumatic tyre

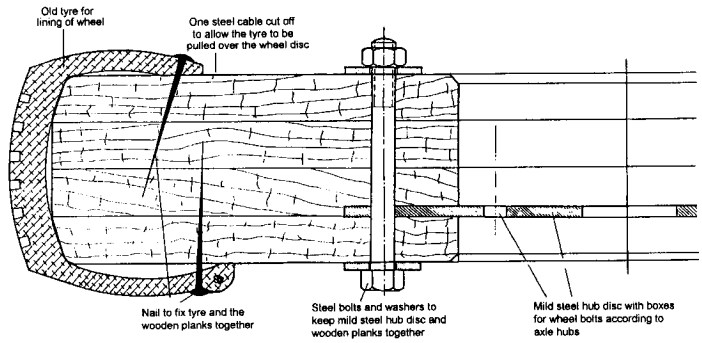


Figure 12: Replacement "mbaomatic" wheel designed for a pneumatic tyred cart of the Tanga Animal Draft Power Project

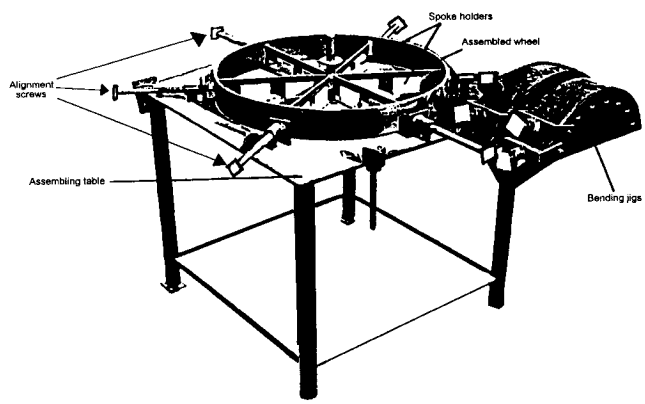


Figure 13: Combined wheel assembly and rim bending jig

So it was cheaper to make the platform of an ox cart with imported sheet metal than with locally available wood.

For development agencies wishing to get carts to farmers, it is often quickest and cheapest to import raw material and arrange the local manufacture and assembly of the carts. However, once that particular aid has dried up, the lack of suitable raw materials becomes a major problem. Realistically, there will always be some local supply problems when it comes to cart components and the desirable objective of strict reliance on local materials may prove very difficult to follow.

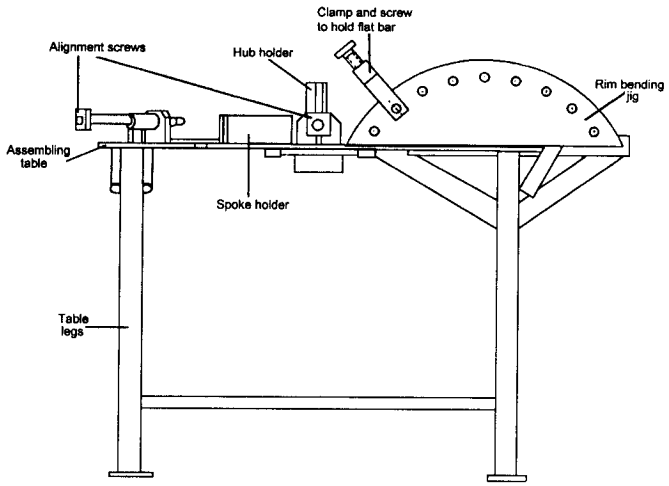


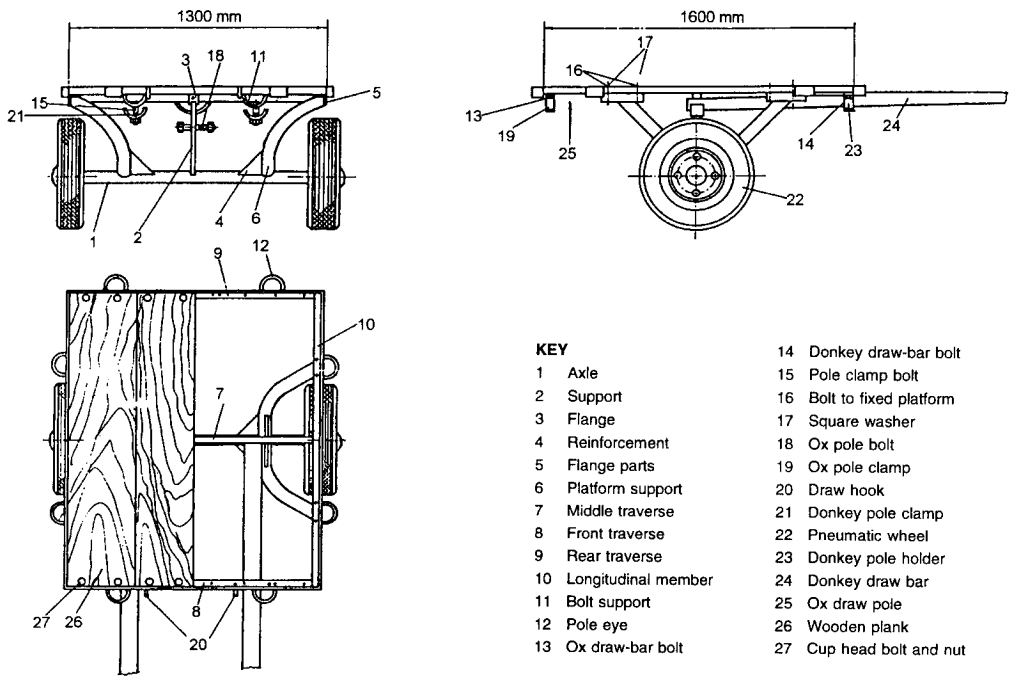
Figure 14: Side view of combined wheel assembly and rim bending jig

To reduce external supply problems, attempts have been made by some appropriate technology organisations in Africa to make ox carts entirely out of wood with a minimum of nails. None of these attempts have been successful. Either they have never got beyond the prototype stage or the number produced was so small that it is hardly worth mentioning.

Cart manufacturing enterprise that are not in a position to do their own importation have to rely on whatever current supplies are available. They must therefore be ready to adjust their designs frequently so they can make use of the materials, bearings and steel sections available.

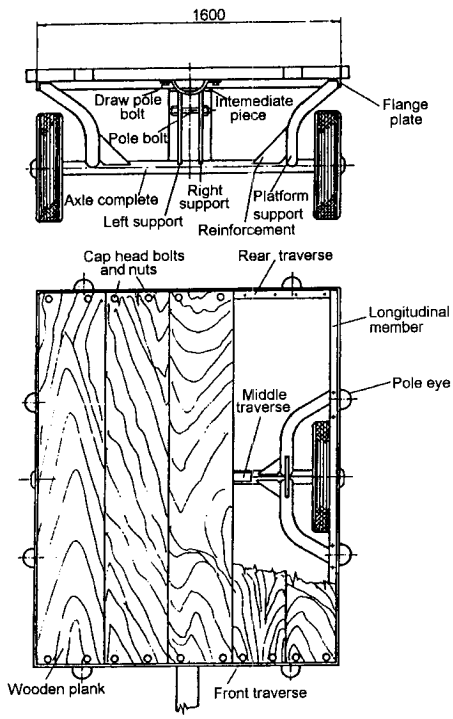
In the case of reliance on local material supplies, a constant adaptation to available supplies requires continuous design adaptation efforts. If a workshop

Figure 15: Animal-drawn cart designed by the Institute of Production Innovation



KEY

1	Axle	14	Donkey draw-bar bolt
2	Support	15	Pole clamp bolt
3	Flange	16	Bolt to fixed platform
4	Reinforcement	17	Square washer
5	Flange parts	18	Ox pole bolt
6	Platform support	19	Ox pole clamp
7	Middle traverse	20	Draw hook
8	Front traverse	21	Donkey pole clamp
9	Rear traverse	22	Pneumatic wheel
10	Longitudinal member	23	Donkey pole holder
11	Bolt support	24	Donkey draw bar
12	Pole eye	25	Ox draw pole
13	Ox draw-bar bolt	26	Wooden plank
		27	Cup head bolt and nut



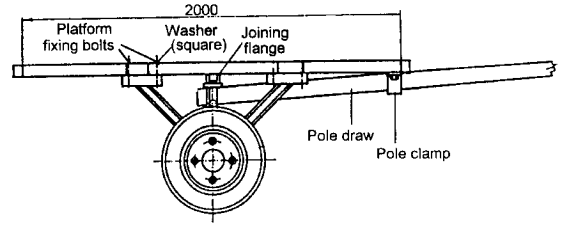


Figure 16: Three views of the Institute for Production Innovation's large animal cart

cannot do this, that would be one of the jobs to be done by a permanent consultant to the workshop.

Further information

Further information and technical drawings of many suitable cart designs are available from IPI (PO Box 35075, Dar es Salaam, Tanzania) and Camartec (PO Box 764, Arusha, Tanzania).

Figure 17: Standard conical roller bearing wheel hubs for IPI animal-drawn carts: without brake (top) and with shoe brake (bottom)