Tillers'

TechGuide

Improving Ox Yokes

With Limited Material, Tools, and Resources

By David Kramer

Introduction

Staff and volunteers of Tillers have had the opportunity to visit and work in many countries of Africa. We are always curious to see local ox yokes, and we have found a variety of designs being used in African countries. We cannot help but compare some of these designs to our own traditional yokes of North America. In pulling experiments with traditional African and North American yoke designs we have found that oxen often pull a greater load with the traditional North American neck yoke. This Tech Guide focuses on the basic differences between African and North American neck yoke designs, and gives some examples of how ox yokes might be improved with limited materials, tools, and resources.

Introducing change to a set tradition can be difficult, especially when the change is introduced by someone from outside the community. Outsiders often do not understand all the reasons for why a tradition exists, and want to introduce changes without understanding the full picture. I do not believe that the North American neck yoke design can or should be transferred directly for use on cattle in Africa. At Tillers we try to encourage experimentation and innovation. It is my hope that the readers of this Tech Guide, whether they are local farmers or development workers, would approach the subject of ox yokes with a sense of experimentation. Look at the design factors presented, study the local tradition, find out what local resources are available for yoke construction, and experiment to see what types of improvements might be introduced to local ox yokes. Farmers should be included in considering any design modifications, and they will be the final judges. If the new yoke is an improvement over the old and is an affordable alternative, then it will not be difficult for them to accept. At the present time most yokes are built in the village. Any changes introduced into a yoke design should be done at the local village technology level. This will keep the cost to a minimum, and will enable repairs or adjustments to be done locally and quickly when necessary.

A Look At Some African Yoke Designs

Neck yokes we have seen in Africa are usually made from a small round pole, about 4 inches (10 cm) in diameter. Steel bars or flat wooden staves (sometimes referred to as "skeis") are placed through holes in the beam to hold the animals in position. A rope connects the bottom of the staves. Sometimes even just a rope is tied through the holes to hold the animals in place. The plow or implement is tied with a rope or hitched with a clevis to the center of the beam. (Fig. 1)

The Traditional North American Neck Yoke

Tillers Tech Guide, *Neck Yoke Design and Fit*, covers in detail the traditional yoke style used in North America. Major points of that Tech Guide are reviewed here and below. The North American neck yoke design was inherited from neck yoke designs used in England. These yokes are made from a large beam of wood. Curved neck seats were carved into the beam. The oxen were held in

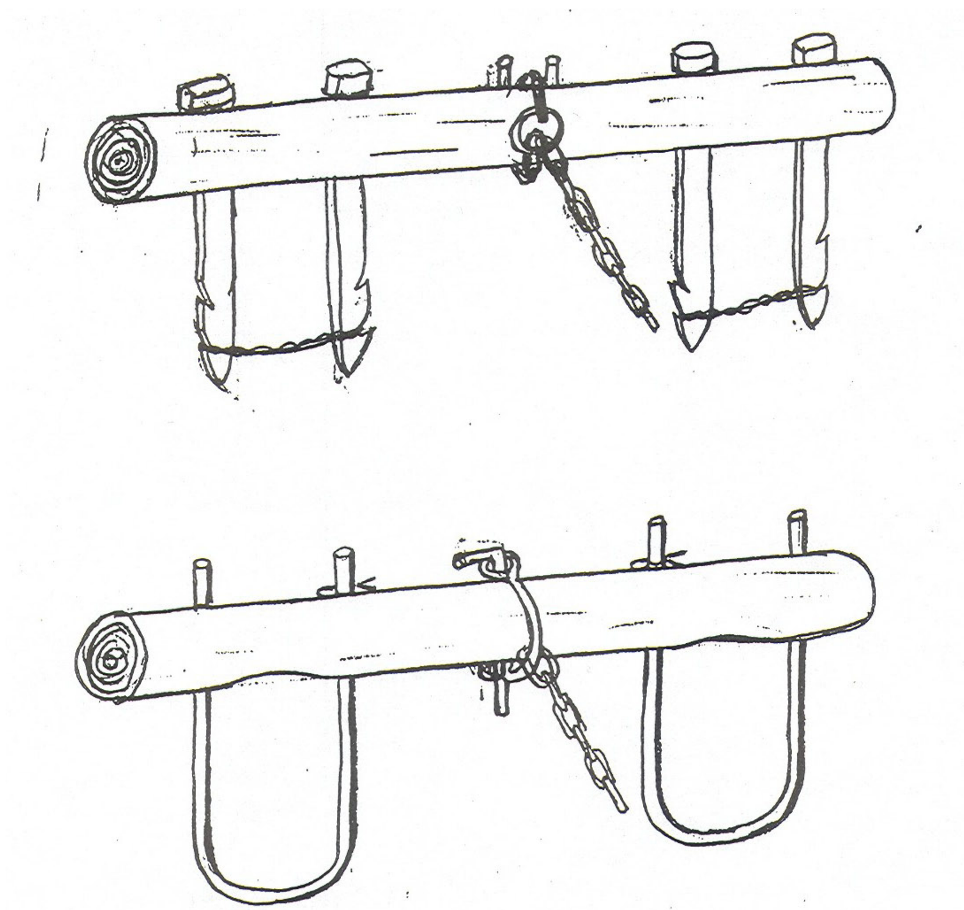


Fig. 1: Examples of some neck yokes we have seen made from small poles in Africa. The hitch point for the chain is behind the beam. There is little or no carving to fit the neck of the oxen. Rectangular paddles or thin steel bars are used to hold the animals in position.

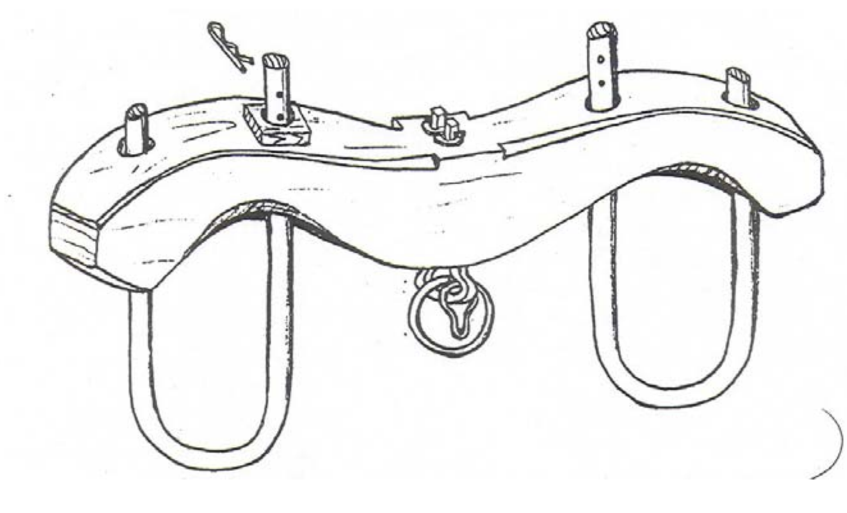


Fig. 2: Examples of a historical neck yoke used in North American. A large beam of wood is used to construct the yoke. The beam is carved to fit over the neck of the oxen. The hitching point is below the beam. Bent wooden bows keep the oxen in position and provide an additional area for the animals to push against.

place by bend wooden bows, and the hitching point was located below the beam. (Fig. 2)

Comparison of African and North American Yokes

The carved neck seat of historical American yokes provides a wide comfortable area for the oxen to push against. Small pole yokes have a very small contact area on the neck, causing all of the pressure to be carried in a small space. Spreading out the contact area allows oxen to work for longer periods and pull heavier loads without the danger of bruising or causing sores on the neck. At a workshop in Uganda, we asked farmers to compare the yoke styles by placing the yokes on their own necks and by lifting a heavy weight tied to the yoke beams. They were quickly convinced that the carved neck seat was more comfortable than a small round pole, even though the beam with the carved neck seats was much heavier than the small pole.

The wooden bows of historical yokes also provide a surface for the oxen to push against. The hitch point of a historical yoke is below the beam, and it causes the beam to rotate the bows back into the shoulders of the oxen when they are pulling a load. (Fig. 3) The steel rod bows or wooden staves of small pole yokes are only used to hold the oxen in position. Because the hitch point of a pole yoke is behind, rather than below the beam, the bows or staves tend to jut forward and away from the oxen when they pull a load. (Fig. 4) Because the oxen do not push against the bows or staves of a pole yoke, they can be made of small ½ inch (13 mm) diameter steel rod, or square shaped wooden staves. Bows on historical yokes were made of smooth round wooden sticks, at least 1 inch (25 mm) in diameter or larger, which provided a comfortable surface for the shoulder to push against. The spacing between bows, or what we call the **bow width**, becomes critical when hitch point is dropped and the oxen push against the bows. The bow width should be about one inch wider than the oxen's neck. When the bow is in place you should be able to slide just the flat side of your hand between the neck and bow on one side of the ox. (Fig. 5) When the oxen are taking a forward step

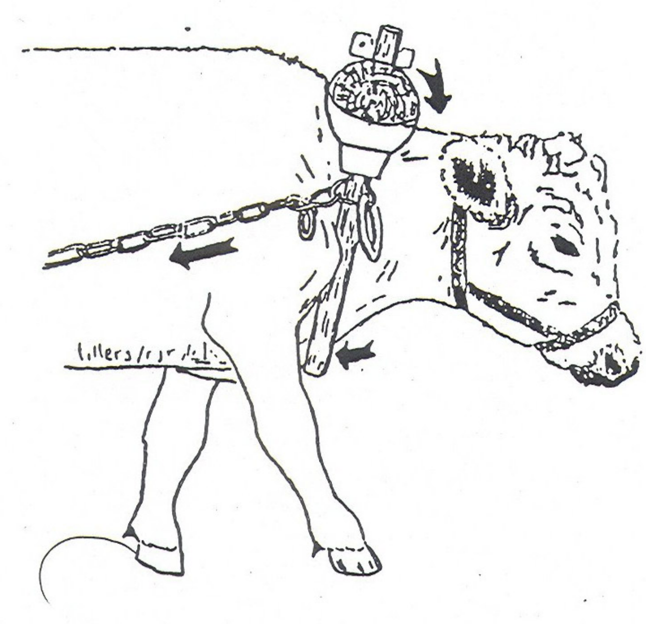


Fig. 3: Because of the lowered hitch point, the beam of a historical yoke rotates the bows back into the shoulders of the oxen, giving them an additional surface to push against.

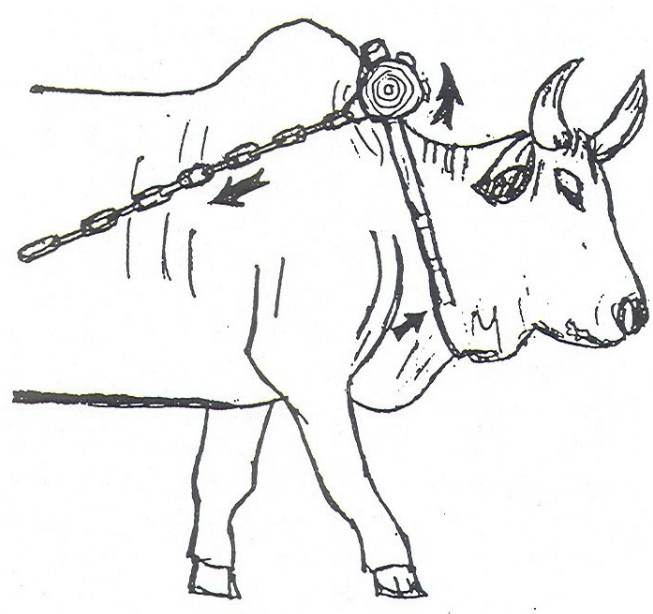


Fig. 4: Most African pole yokes have the hitch point behind the beam, which causes the bows to rotate slightly forward and away from the oxen's shoulders.

pulling a load, the bow should momentarily be obscured in the pocket between the neck and shoulder. (Fig. 6) If the bow is narrow the neck will be pinched. If the bow is wide the front edge of the shoulder will rub against it and become sore. Because the bow width is critical, a team of oxen will require several yokes as it grows in size. With the simple pole yoke the bow width is not critical and a team of oxen may require only one yoke. This is a cost factor which farmers will need to consider. If enough farmers in one area accept the new yoke design, then in time a variety of small yokes will become available for trading and loaning.

Comparison of African and North American Cattle

Many cattle which are used for oxen in Africa have large humps which provide a good spot for the animals to push against the yoke. (Fig. 7) Cattle used for oxen in North American do not have humps, which could be the reason that larger surfaces for pushing against were incorporated into the yokes here. It would seem that even cattle with humps could benefit from a yoke which spreads some of the load to a wider area of the neck and shoulders. I spent several years working in Uganda with Ankole cattle. No one thought that Ankole cattle could work as oxen. They are generally taller and thinner than the zebu breed, and they have no hump. (Fig. 8) I found that they could be trained to plow, but not with a small plow yoke. They would only plow when I made a yoke with a carved neck seat and dropped hitch point. I chose to train Ankole cattle because they were prevalent in the southern area of Uganda where I worked and they were more resistant to the tick born diseases of the wetter climate there. Shipping in cattle from the northern area of Uganda would have been very costly. In this case a yoke which was more comfortable allowed farmers to train and use a local breed of cattle which normally was not thought of as strong enough to work.

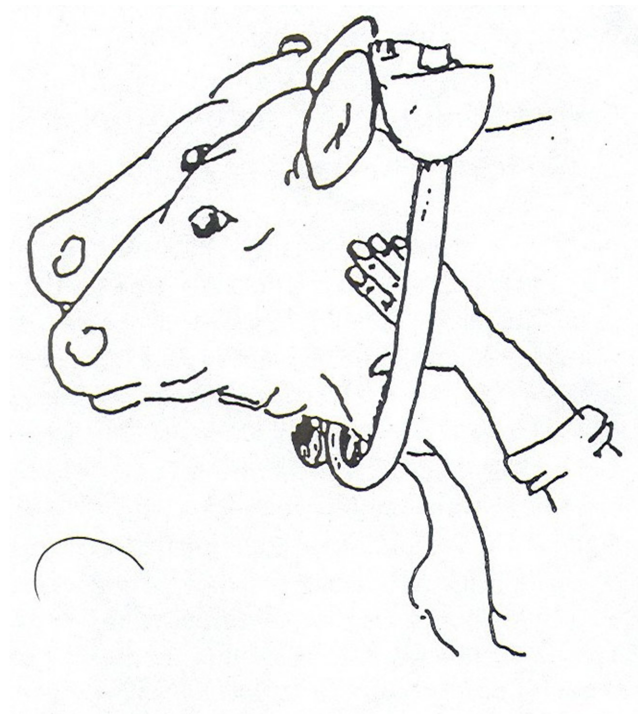


Fig. 5: A well fitting bow should leave just enough room to slide your hand between the neck and the bow when the oxen are not pulling a load. (Drawn by Marcia Keith)

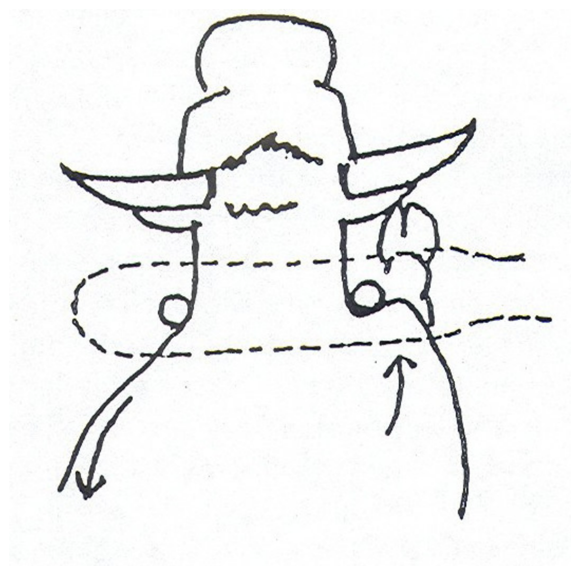


Fig. 6: As the oxen step forward the bows should fit back into the pocket between the neck and shoulder. (Drawn by Marcia Keith)

Fig. 7: Many African cattle have a hump on their necks which provides a spot for the yoke to rest.

Fig. 8: Some African breeds of cattle, such as the Ankole, do not have humps and can greatly benefit from a yoke which gives them a wider neck surface and bows to push against.

Construction Techniques

The traditional tools and methods of constructing a North American neck yoke are described in Tillers Tech Guide: *Building An Ox Yoke*. The techniques described here are adaptations for constructing a neck yoke with limited tools and resources.

Wood For The Yoke Beam

Yokes with carved neck seats and a dropped hitch point require a much larger piece of wood to build than a small pole yoke. The deeper belly, or curve down to the hitch point, and the wider surface for the neck seat require a beam with a cross section as large as 8 x 8 inches (200 x 200 mm) to make a yoke for a large team. In addition, the beam for a yoke is normally split from one section of a large tree. (Fig. 9) which helps to prevent splitting and checking as the wood dries. This means a tree twice the size of the yoke must be obtained.

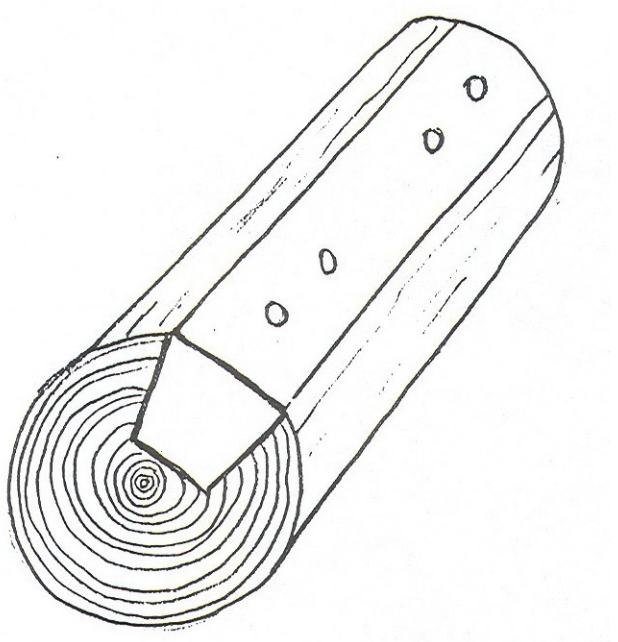


Fig. 9: Traditionally a large tree was split and one section was used to make the yoke beam. This eliminated the heartwood, and the tubular grain structure which often causes checks and splits when drying.

I found large beams of wood difficult to find and very costly in East Africa. The first yokes I made in Africa were from eucalyptus trees, which were grown in large plantations for firewood. All of the yokes I made from eucalyptus trees developed large checks and splits, and became useless as yokes because the splits would have caused sores on the oxen's necks had I continued using them. Finally I got smart and consulted the local carpenters. They showed me a tree called *musambia* in their language. It dried with very few splits or checks. I was able to carve a yoke from a small log, rather than splitting a large log. So my first advice in selecting wood for yoke beams is to consult the local woodworkers and find out which woods can be easily dried without checking. It is also important to dry to wood as slowly as possible. Coating the wood with oil or paint will help to slow down the drying. Keep the wood in a cool shady place. Covering the yoke beam with grass or leaves can also help to slow down the drying, but check it daily to make sure it is not getting moldy or rotten under the grass.

Fig. 10: Adding a block of wood to a small beam can give it a deeper belly and drop in the hitch point.

Another way to obtain a yoke with a deeper drop in the hitch point is to use a log just large enough to carve the neck seats, and add a section under the middle for the yoke belly. This extra piece can be secured in place with large nails or wooden pegs. (Fig. 10)

I also experimented with laminated yoke beams in Africa. Laminated beams are made by gluing together several boards to form a beam large enough for a yoke. I ran into several problems making laminated yokes in Africa. First, the lumber is usually still green or wet when purchased, and it must be carefully dried before assembling or the glue will not hold. Second, sawn lumber is more expensive than a log, and it must be planed smooth before gluing which also costs money. Third, it takes as many as 10 large clamps to glue up a big yoke beam, and these were not usually available. Holes can be drilled in the lumber, and bolts can be inserted to help pull the boards together when gluing the beam, but large bolts are also expensive. Finally, I found the local glue to be less than adequate. Both of the laminated yokes I made fell apart after several months. Perhaps it was a combination of wet wood and poor quality glue.

Shaping the Beam

Tillers yoke plan gives some general measurements for a historical yoke. All measurements on the plan are factors of the bow width (Bw) or bow depth (Bd). First determine the bow width for your oxen, and then plug that measurement into the equations given to find the other dimensions. (Fig. 11) Many farmers we have worked with feel the yoke design we show them is too heavy for their oxen to carry, yet we see some of these same farmers load several drums of water on the front of their cart, and ride down the road sitting on the cart pole. We feel that the added comfort a larger beam provides is worth the extra weight, and we have not found oxen that were not strong enough to carry a slightly heavier yoke beam.

The first step in making the yoke beam is to lay out and drill the bow holes. The bow holes should be spaced one inch wider than the neck of the oxen. The distance between bow holes should be 2.5 to 3 times the bow width. The largest auger I was able to purchase in Nairobi or Kampala was one inch in diameter. This was smaller than the finished hole I needed for my bows. After drilling a one-inch hole, I used a small chisel to enlarge the hole to the diameter I needed. I also made a tool for enlarging the bow holes. I found a piece of water pipe the size of the hole I wanted, and used a hacksaw to cut large teeth into the end of the pipe. I tapped the teeth outward to give them some set, and welded a steel rod on top for a handle. With much pushing and twisting I was able to enlarge and true up the holes in my yoke beams. Many carpenters in Africa are accustomed to chiseling deep square mortises. If a drill is not available, the hole for the bow can be made entirely with a chisel and mallet. Another option for making holes is to heat a piece of steel red hot and slowly burn through the wood. This is a slow method. If a small hole is drilled in the wood, it can be enlarged by forcing a red hot piece of steel into the hole. With a variety of different sized pieces of steel, the hole can gradually be enlarged to the desired size.

Most of the villagers I worked with were very handy with a machete. This seemed to be the preferred tool to use when shaping the yoke beam. It does not take long for a skilled worker to roughly carve the neck seat area with a sharp machete. (Fig. 12) The traditional tool used in North America to carve a yoke was the adze. Some carpenters in Uganda, especially those who worked on canoes or carved wooden tubs for mixing beer, had an adze in their toolbox. I made an adze by cutting the eye off an old hoe, and welding a short piece of leaf spring onto it for a blade. (Fig. 13) Spokeshaves are also commonly used by furniture carpenters in East Africa. They are very helpful in smoothing the neck seat of an ox yoke. (Fig. 12) Finally the neck seat can be scraped smooth with a sharp piece of broken glass.

Bows/Staves

In America bows were bent from hickory, oak, and ash wood. The trees in tropical countries are different. Many of the large furniture wood tropical trees such as mahogany, mvule, and musizi, do not bend well even when heated in steam. I did see chairs for sale in East Africa which were made from bent sticks lashed together. Some of the African students who have visited Tillers tell us the woods which are used for making spears can be

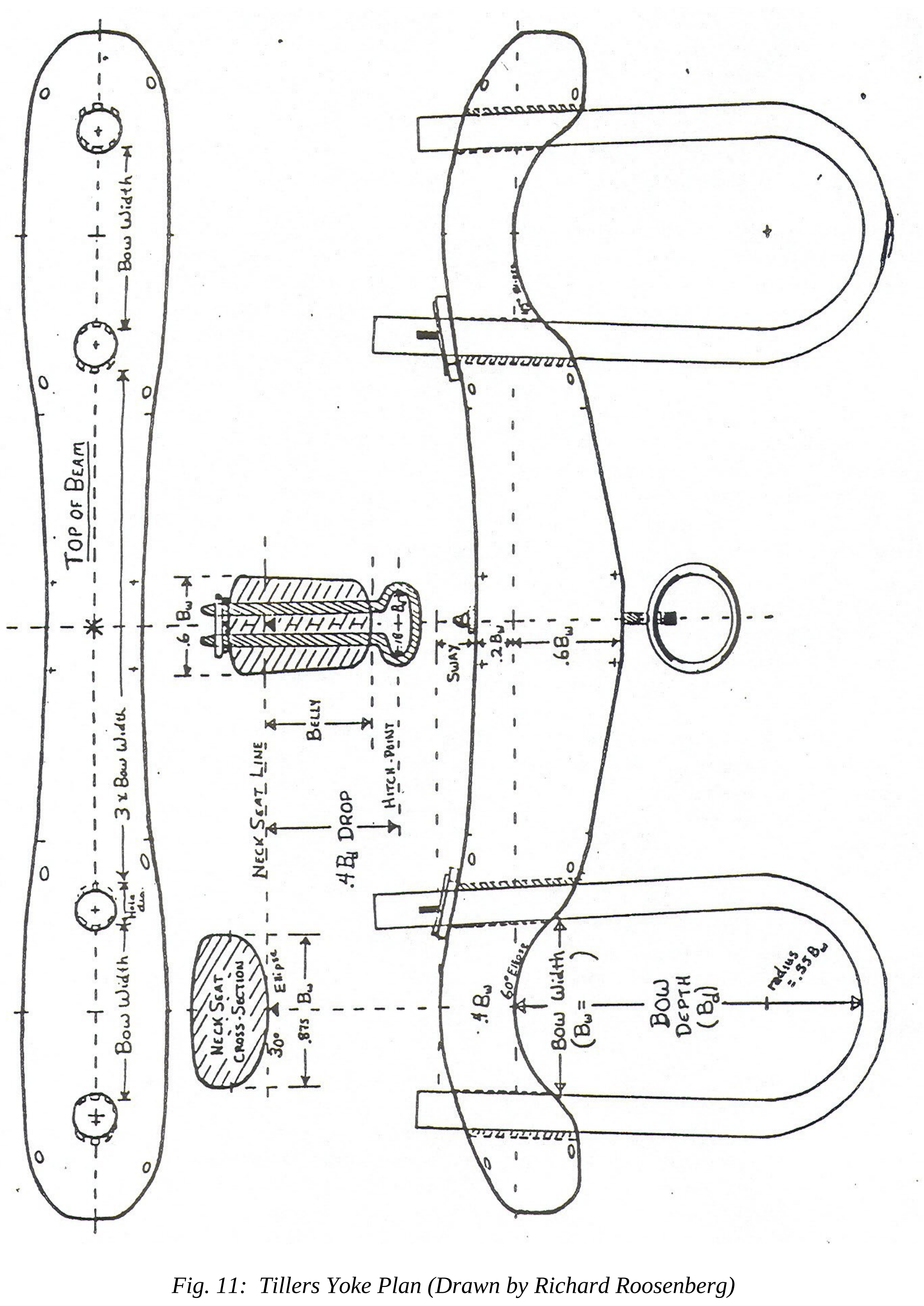


Fig. 11: Tillers Yoke Plan (Drawn by Richard Roosenberg)

Tools That Can Be Used to Construct An Ox Yoke

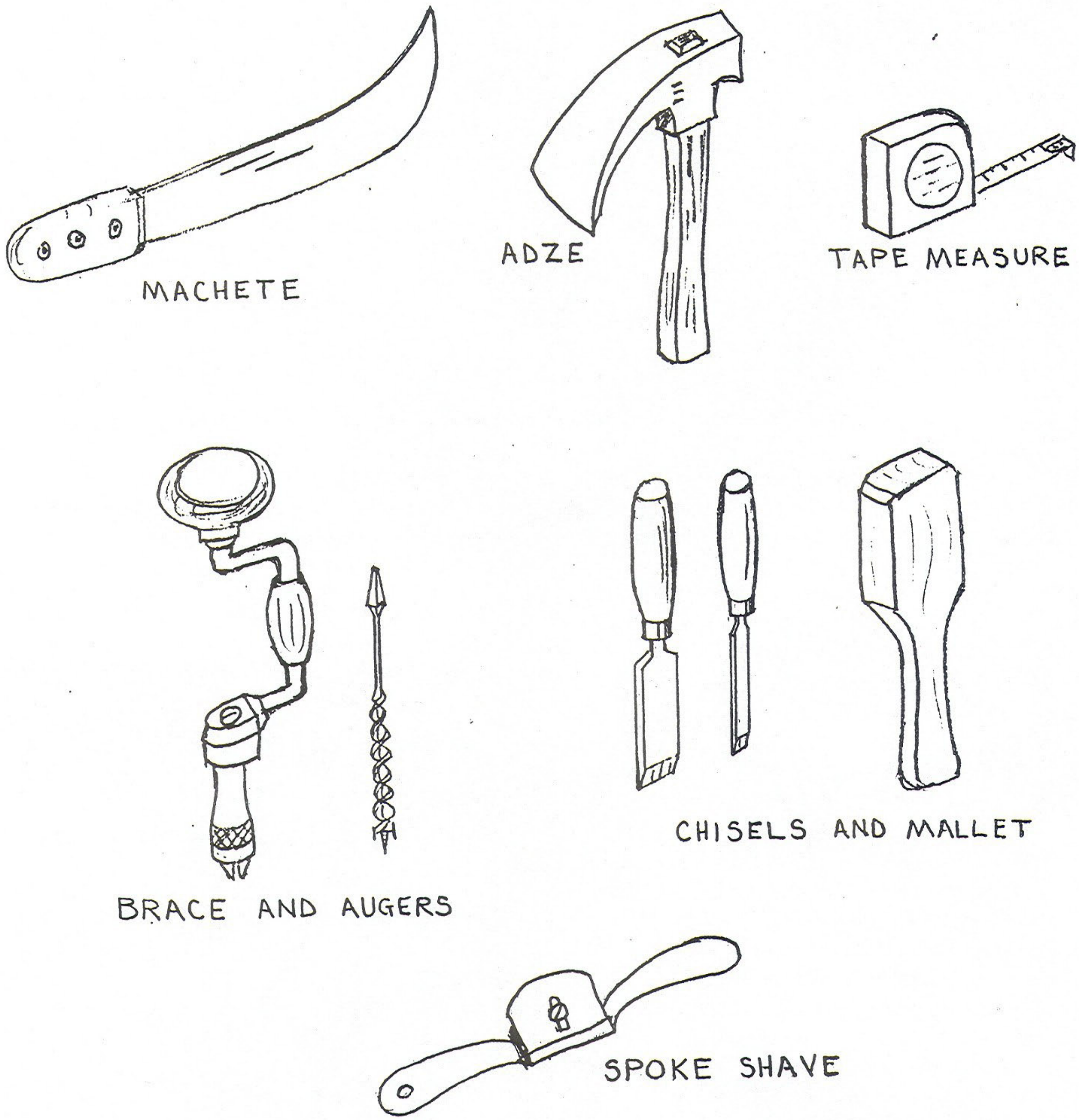


Fig. 12: The tools needed to make an ox yoke should be available in most villages.

Fig. 13: A blacksmith can make an adze from an old hoe and a spring from a truck.

heated and bent when green. I would again suggest asking advice from local craftsmen to find out what woods might be bent and how to bend them to make ox bows. We usually steam our wood in a steam box for at least one hour, then bend and clamp it around a wooden form. Having straight-grained wood without any knots or defects is important. After several days the bow can be removed and smoothed to a round shape with a spoke shave.

Tubing and pipes can also be bent to make ox bows. Thick walled plastic pipe can easily be bent and is suitable for small yokes. We recently used plastic bows at a women's co-operative where we trained young teams of oxen to pull small carts with a drum of water and loads of firewood. (Fig. 14) The plastic pipe held up for this purpose. The first step in bending plastic pipe is to fill it with dry sand and plug the ends with some wet soil or clay. Sand will keep the walls of the pipe from collapsing during the bending process. Have a form cut out of wood to bend the pipe around. Heat the area of the pipe to be bent over the fire. Keep it moving to prevent it from burning. Make sure this is done in a well-ventilated area. Hot plastic can give off poisonous fumes. When the plastic begins to feel soft, remove it from the fire and bend it around the form. Hold it around the form for a few minutes until it has had a chance to cool. Remove the sand and it is ready to use. To increase the strength of the plastic bow, insert wooden sticks into the straight sections of the bow.

Fig. 14: Bows made from plastic pipe being used in a small yoke to train young oxen.

Metal pipe can also be bent to form ox bows. It must be heated to a red hot temperature to bend. Look for pipe which does not have a shiny silver galvanized coating. Metal water pipes are usually galvanized. When this galvanized coating is heated, it gives off very poisonous fumes. Try to find black pipe, which is used for gas lines. Black pipe does not give off dangerous fumes when heated. I used ¾ inch inside diameter (1 inch outside diameter) pipe bows for many yokes in Uganda. I found that they held up well, even for plowing. Bending metal pipe is similar to bending plastic pipe, but more heat is needed. The pipes should first be filled with dry sand. Wet sand will create steam and the sand will shoot out the end of the pipe and burn you. We heated our pipes over a coal forge fire. We built a simple fan to blow under the fire and give us more heat. When the pipe begins to turn red, take it out and bend it around a brake drum, wheel rim, or some other metal object of appropriate diameter. The pipe will bend most quickly where it is hottest. If the pipe is bending too much on one side, put it back in the fire and try to heat the section which needs the most bending. (Fig. 15)

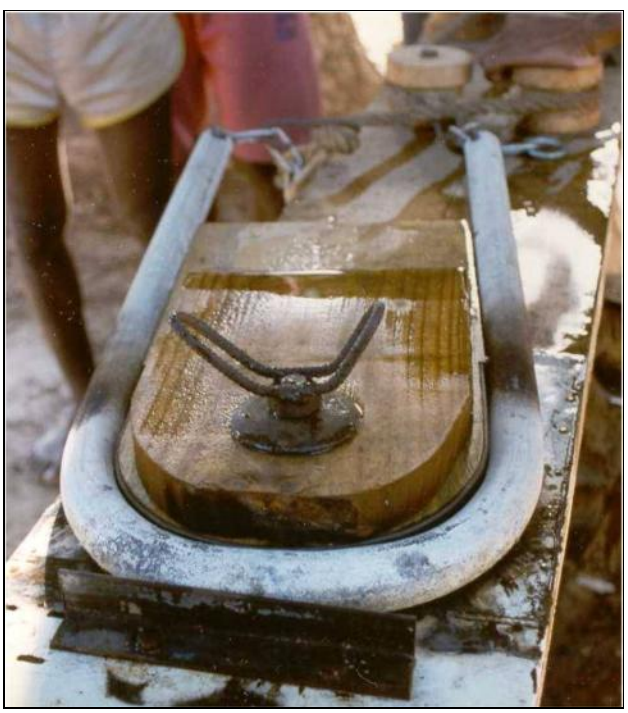


Fig. 15: Bending metal pipes to make ox bows.

If a bendable wood cannot be found and pipes are too expensive, straight wooden staves can be used. A yoke with a low hitch point will need staves that are smooth and round. Rectangular or paddle shaped staves would not be comfortable. Leave the staves long so that the end hangs below the shoulder and cannot poke the ox. (Fig. 16)

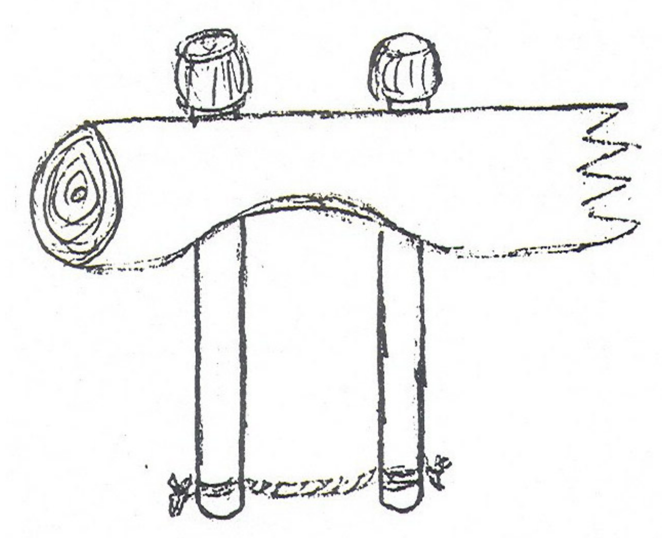


Fig. 16: Wooden staves are similar to the skeis used in many ox yokes, but with a dropped hitch point yoke, the wood must be round, not rectangular, so that it cannot injure the neck or shoulder.

Bow Pins

We made metal pins for holding the bows from small pieces of spring steel. The coil springs underneath bicycle seats are readily available in most towns. They can be heated and shaped to hold the bow in position. Several holes drilled through the bow can provide some depth adjustment. (Fig. 17)

Yoke Hardware

The hardware on a traditional North American yoke consists of a staple, pole ring (to hold the pole on a cart), and a chain grab link. These items need to be made by someone with some blacksmithing and welding skills. The staple is made from square or round mild steel stock, about 15 mm in diameter.

The staple can have two stems, or it can be welded shut at the bottom and have just one stem. I usually made single stemmed staples in Uganda because they were easier to shape and I had access to a welding machine. A hole can be drilled or punched in the top of the staple and a nail inserted to hold the staple in position, or threads can be cut on the end of the staple and a nut and washer used to hold it in position. I did not have a tap and die to cut threads in Uganda, so I usually cut the head off a small bolt and welded it to the top of the staple. The pole ring can be made from stock about 12 mm in diameter x 400 mm long. The grab link can be made from stock about 10 mm in diameter and 300 mm long. Most farmers are used to tying their cart or plow chain to the yoke. This is time consuming and eats up a lot of rope over time. The farmers who have tried the system with the grab link and pole ring are delighted with how quickly they can hitch their team to the cart or plow. (Fig. 18)

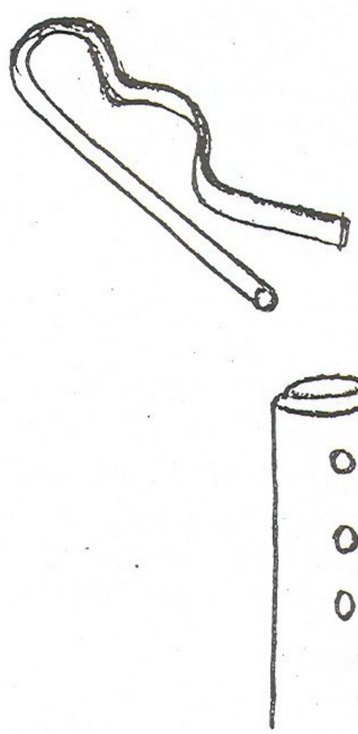


Fig 17: A pin to hold the bow can be made from the spring of a broken bicycle seat.

What an Improved Yoke Might Look Like

Depending on the tools and materials available and the ingenuity of the local farmers and craftsmen, the new yoke design may vary from one place to the next. Our vision of an improved yoke that could be made in the village is shown in Fig. 19

Cost Factor

Some of the ideas presented will bring an added cost to the yoke either in time required for construction, or in materials and labor for an artisan to construct it. Yet the added cost to improve a yoke is minimal compared to the cost for an ox plow, a cart, a harrow, or a weeding tool. And an improved yoke will enhance the work of all the machines a farmer may buy to use with his oxen. I feel the yoke is the first and most important piece of equipment, and farmers should be encouraged to invest in having a good yoke which will help them get the most pulling power from their animals and prevent injury. An ox with a sore neck caused by a poor yoke will not be able to pull even the most expensive cart or plow.

Summary

This Tech Guide has reviewed the basic differences between yoke designs in North American and Africa. It has offered some possible suggestions for improving yoke designs and construction techniques. We encourage you to use this information creatively to look for ways of improving the yoke designs in your own area. We hope you will take the time to write us back with any suggestions you have that could be added to this tech guide.

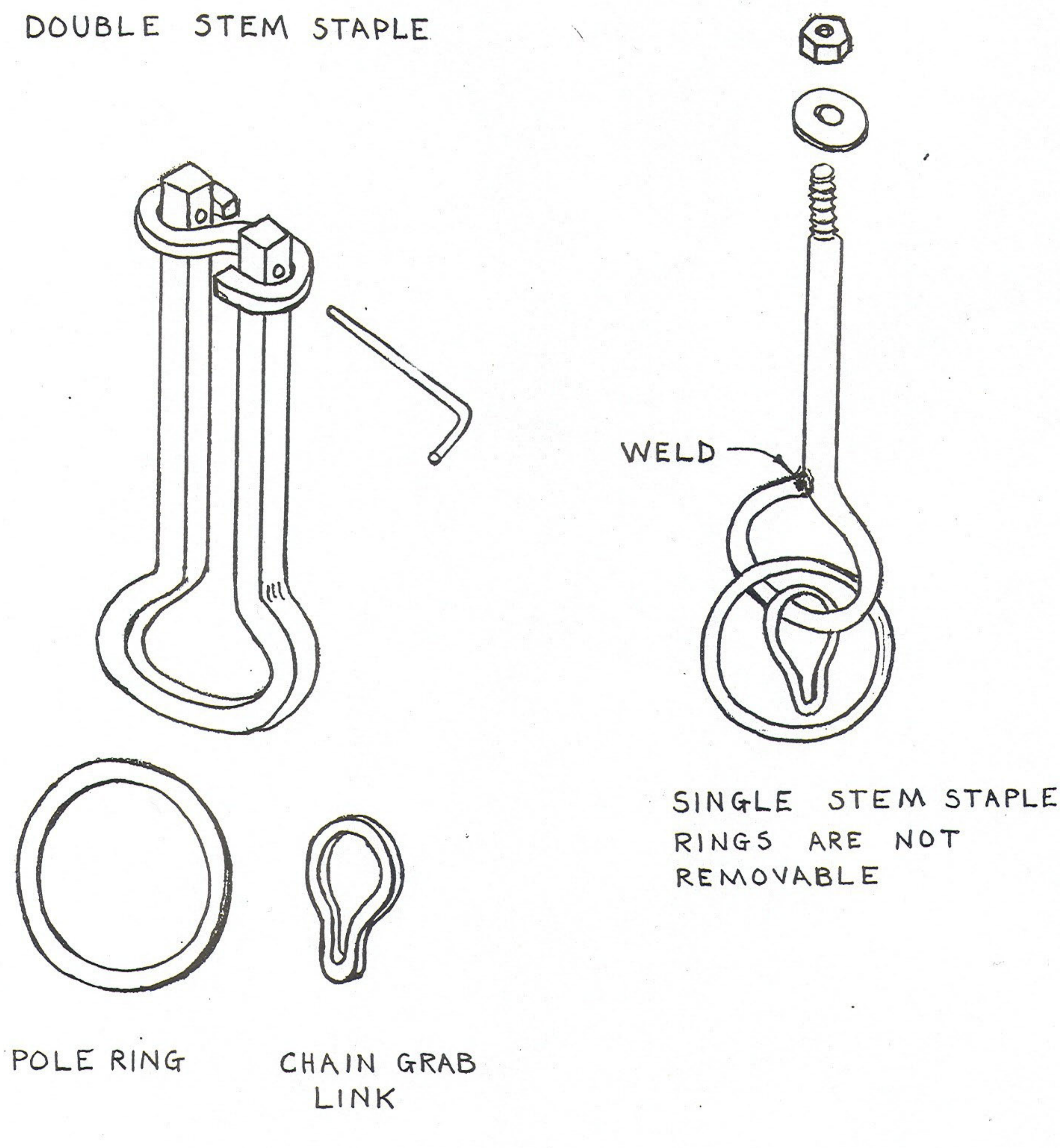
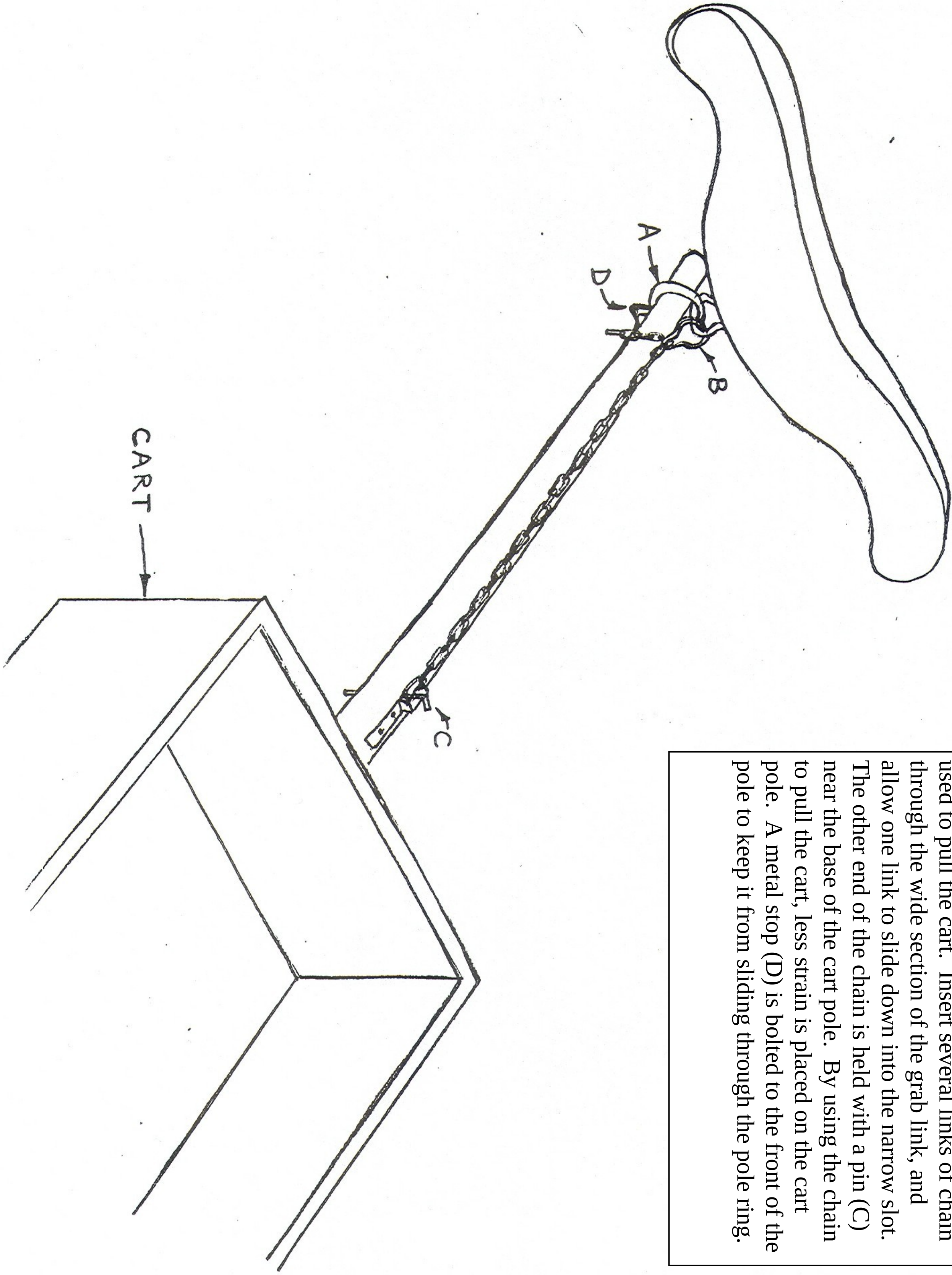


Fig. 18: Samples of yoke hardware that can be made by a village blacksmith.



The pole ring (A) holds the cart pole and steers the cart. The calabash shaped chain grab link (B) is used to pull the cart. Insert several links of chain through the wide section of the grab link, and allow one link to slide down into the narrow slot. The other end of the chain is held with a pin (C) near the base of the cart pole. By using the chain to pull the cart, less strain is placed on the cart pole. A metal stop (D) is bolted to the front of the pole to keep it from sliding through the pole ring.

Fig. 20: An example of an ox cart attached to an improved ox yoke.

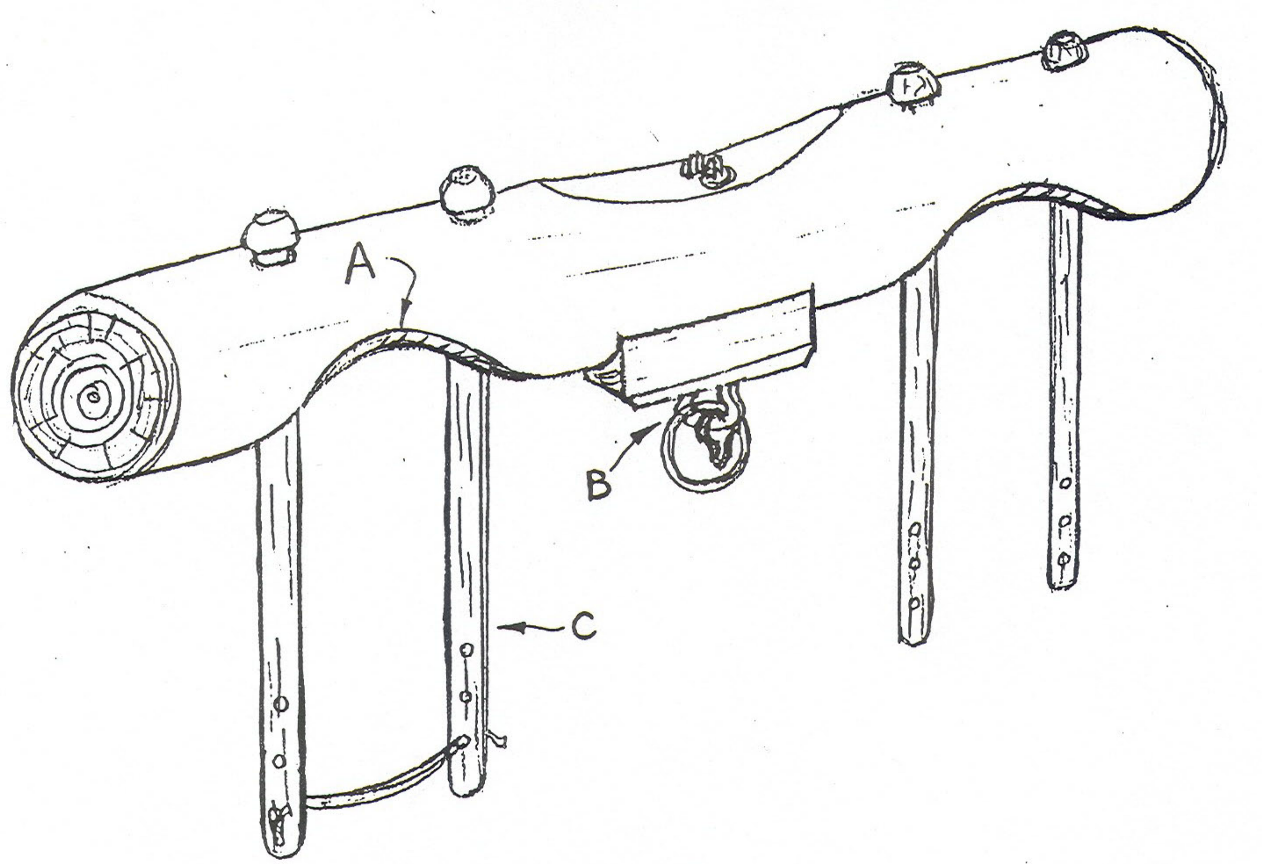


Fig. 19: One possible version of an improved yoke with a) carved neck seats b) dropped hitch point below the beam, and c) smooth round wooden staves positioned to fit the oxen's necks.

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