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The Rasulia Bladed Roller Thresher
ITDG Agricultural Equipment and Tools No. 38

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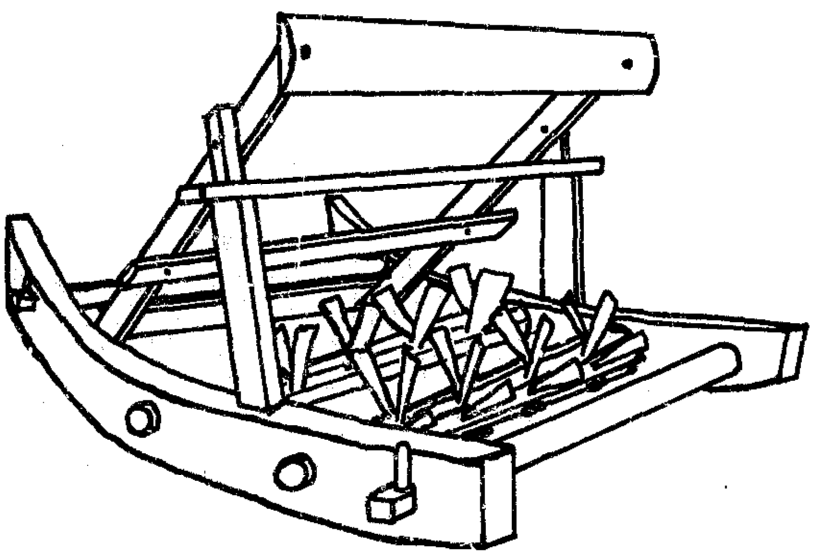
No. 38

THE "RASULIA" BLADED ROLLER THRESHER



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RASULIA ANIMAL DRAWN ROLLER THRESHER

Source

This implement was seen in use in Iran by Ed Abbot, who subsequently built examples at the Friends' Rural Development Centre, Rasulia, Hoshangabad, M.P. India.

I.T.D.G. has not yet had an opportunity to build or test the Rasulia thresher and this leaflet is based on information supplied by Ed Abbot.

Description

The thresher is apparently suitable for all types of corn and similar crops, and could be made and used anywhere where bullocks are available and suitable local craftsmen and materials can be found. It has proved to be 60% more efficient than the traditional Indian method of using bullocks to trample the harvested crops.

Construction.

The basic structure is a frame which holds two octagonal rollers on which are fixed the threshing blades. Above this frame a seat is provided together with a foot rest. The side frames are made by selecting a suitably sized bent log and cutting it in half lengthways. This produces [illegible] five feet by eight inches. Braces are made from a suitable [illegible]); they are squared off at the ends and firmly fixed [illegible]

The rollers are first carefully planed square and cut to length. Bearings are formed at each end, three inches long with a three inch diameter. Next, two lines are scribed the length of each face of the roller at a distance of 7/8" from the centre-line. The corners now marked are cut away, producing the required octagonal cross-section. The markings for blade-spike holes must now be made as follows. Centre-lines should be scribed on each face if this has not already been done. The first hole should be marked on any centre line two inches from the end excluding the bearing. Holes are now marked spirally at one inch intervals, till the final hole is reached two inches from the far end.

The holes are now drilled out to ½ inch diameter and the roller is ready for the fixing of the blades.

Blades are made from flat strips of iron or steel ½" x 2" such as are used for rims for bullock-cart wheels.

Blades are driven into the holes at the correct angle as described below, the projecting inch or so of the spike being bent over to retain the blade. This job is made much easier if a punch is made to the shape of the blade-spike and inserted red hot into the drilled hole at the correct angle, thus also serving to locate the blade as now described.

The angles at which blades are placed are crucial to efficient performance. The first blade should be placed parallel to the length of the roller, but the next blade (on the next face) is placed at 45° to the length of the roller, and the next is at right angles. The next is placed at 45° but tilted the 'other way', and so on until all blades are in place.

The rest of the structure is more or less straight forward and could be modified within practical limits to suit requirements.

Draught ropes are attached to the outer ends of the forward brace and thence to the yoke of a pair of bullocks, the operator directing them from a moderately comfortable sitting position.

N.B. The measurements in this design have been given in inches. A simple conversion table is shown below:

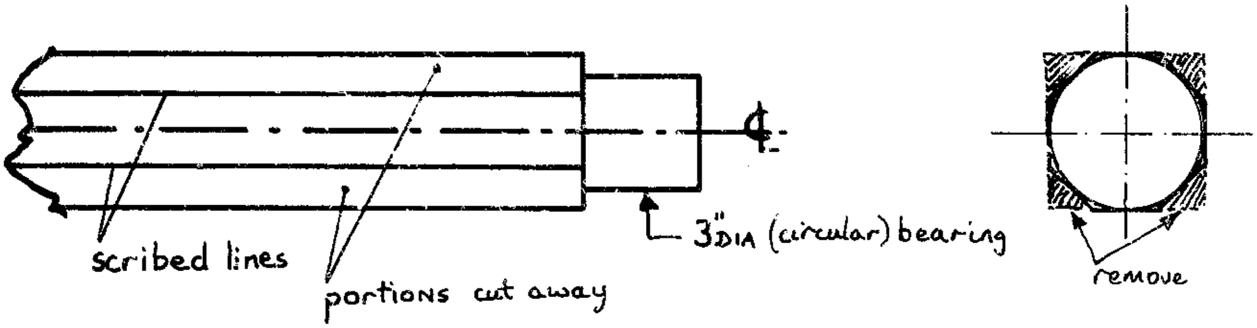
CONVERSION TABLE

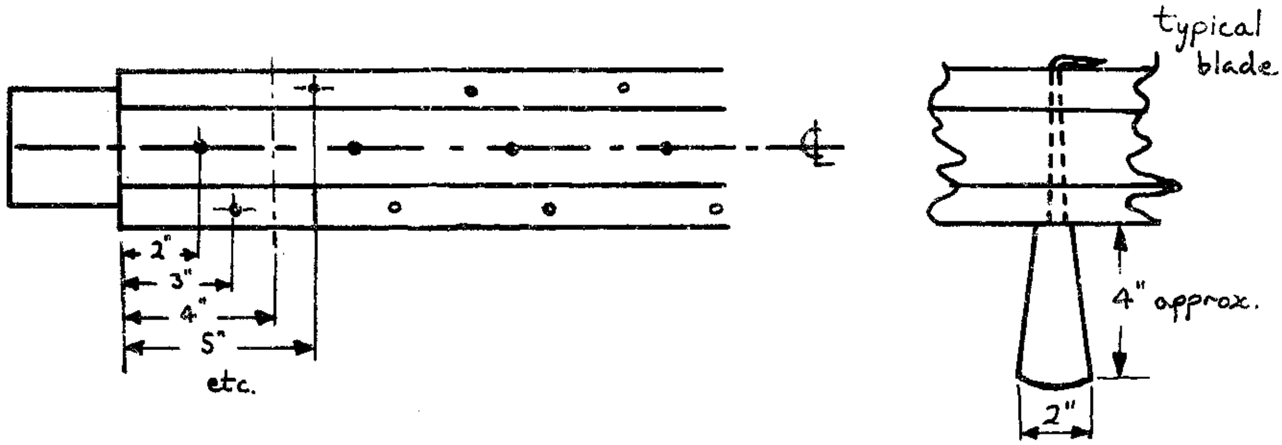
8th fractions and inches to millimetres (mm)

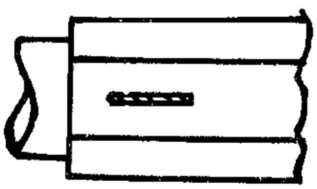
Inches	0 in	1 in	2 in	3 in
Fractions	mm	25·400	50·800	76·200
1/8 in.	3·175	28·575	53·975	79·375
1/4 in.	6·350	31·750	57·150	82·550
3/8 in	9·525	34·925	60·325	85·725
1/2 in.	12·700	38·100	63·500	88·900
5/8 in	15·875	41·275	66·675	92·075
3/4 in.	19·050	44·450	69·850	95·250
7/8 in	22·225	47·625	73·025	98·425

Inches	4 in	5 in	6 in	7 in.
Fractions	mm 101·600	127·000	152·400	177·800
1/8 in.	104·775	130·175	155·575	180·975
1/4 in.	107·950	133·350	158·750	184·150
3/8 in	111·125	136·525	161·925	187·325
1/2 in.	114·300	139·700	165·100	190·500
5/8 in.	117·475	142·875	168·275	193·675
3/4 in.	120·650	146·050	171·450	196·850
7/8 in.	123·825	149·225	174·625	200·025

Inches	8 in	9 in	10 in	11 in
Fractions	mm 203·200	228·600	254·000	279·400
1/8 in	206·375	231·775	257·175	282·575
1/4 in.	209·550	234·950	260·350	285·750
3/8 in	212·725	238·125	263·525	288·925
1/2 in	215·900	241·300	266·700	292·100
5/8 in	219·075	244·475	269·875	295·275
3/4 in	222·250	247·650	273·050	298·450
7/8 in	225·425	250·825	276·225	301·625







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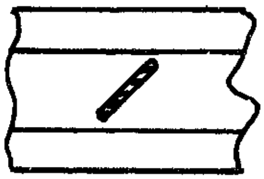

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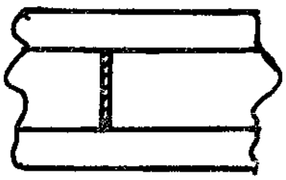
ANGLE SEQUENCE OF BLADES ON ROLLER



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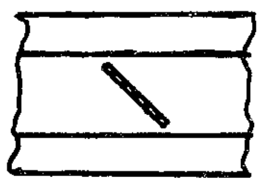
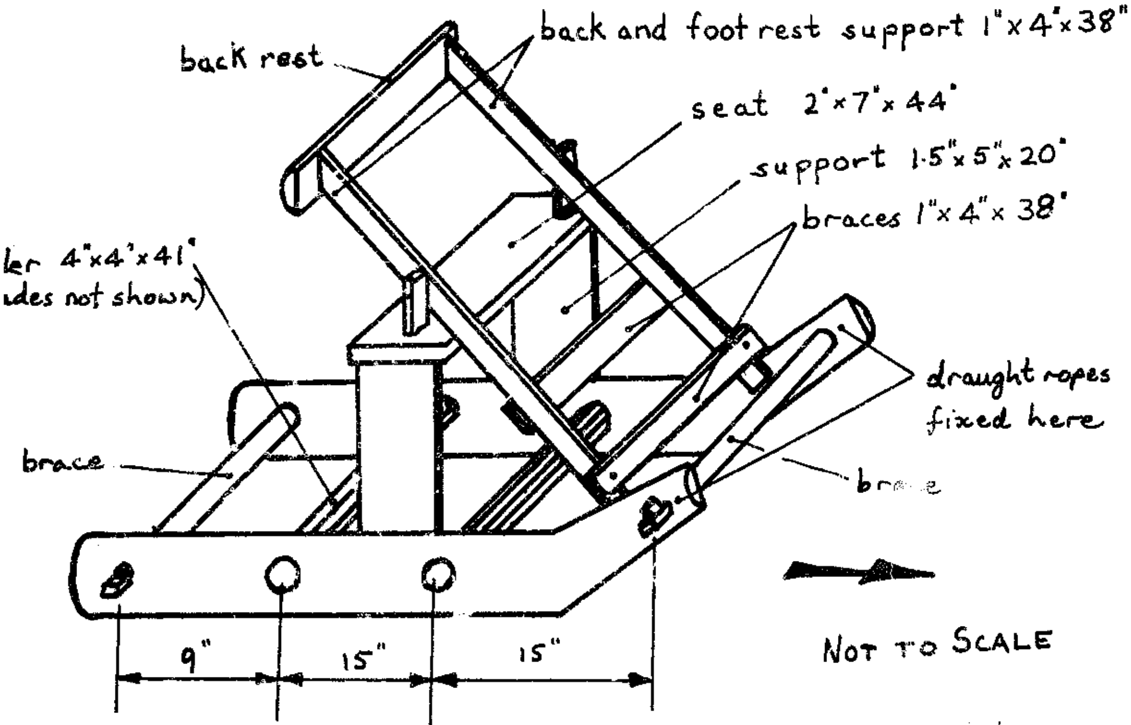
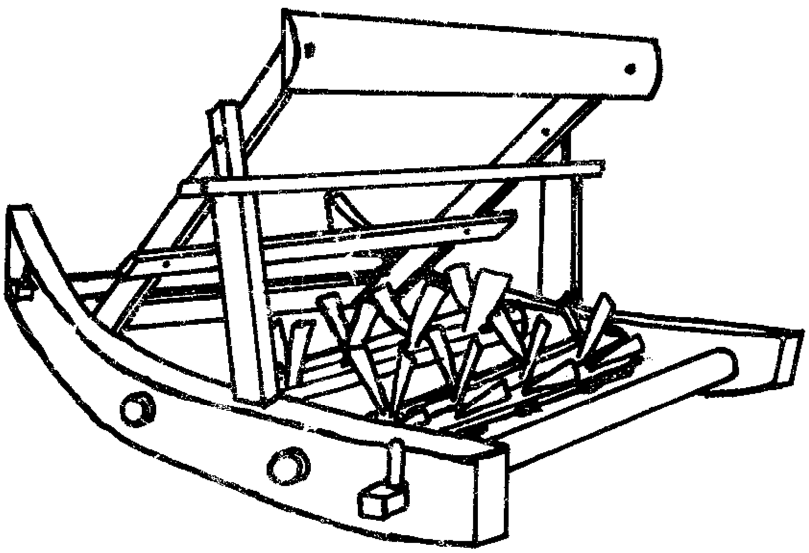


4 etc.



back rest
back and foot rest support 1"x4"x38"
seat 2"x7"x44"
support 1.5"x5"x20"
braces 1"x4"x38"
ler 4"x4"x41"
ides not shown)
draught ropes fixed here
brace
9"
15"
15"
NOT TO SCALE

picture



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A project of Volunteers in Asia

Oil Soaked Wood Bearings: How to Make Them and How They Perform

ITDG Agricultural Equipment and Tools No. 40

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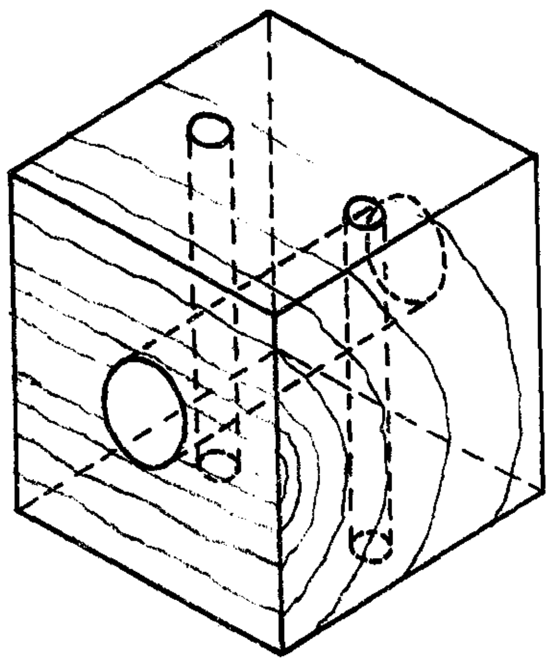
AGRICULTURAL EQUIPMENT AND TOOLS FOR FARMERS DESIGNED FOR LOCAL CONSTRUCTION

OIL SOAKED WOOD BEARINGS

How To Make Them And How They Perform

No. 40



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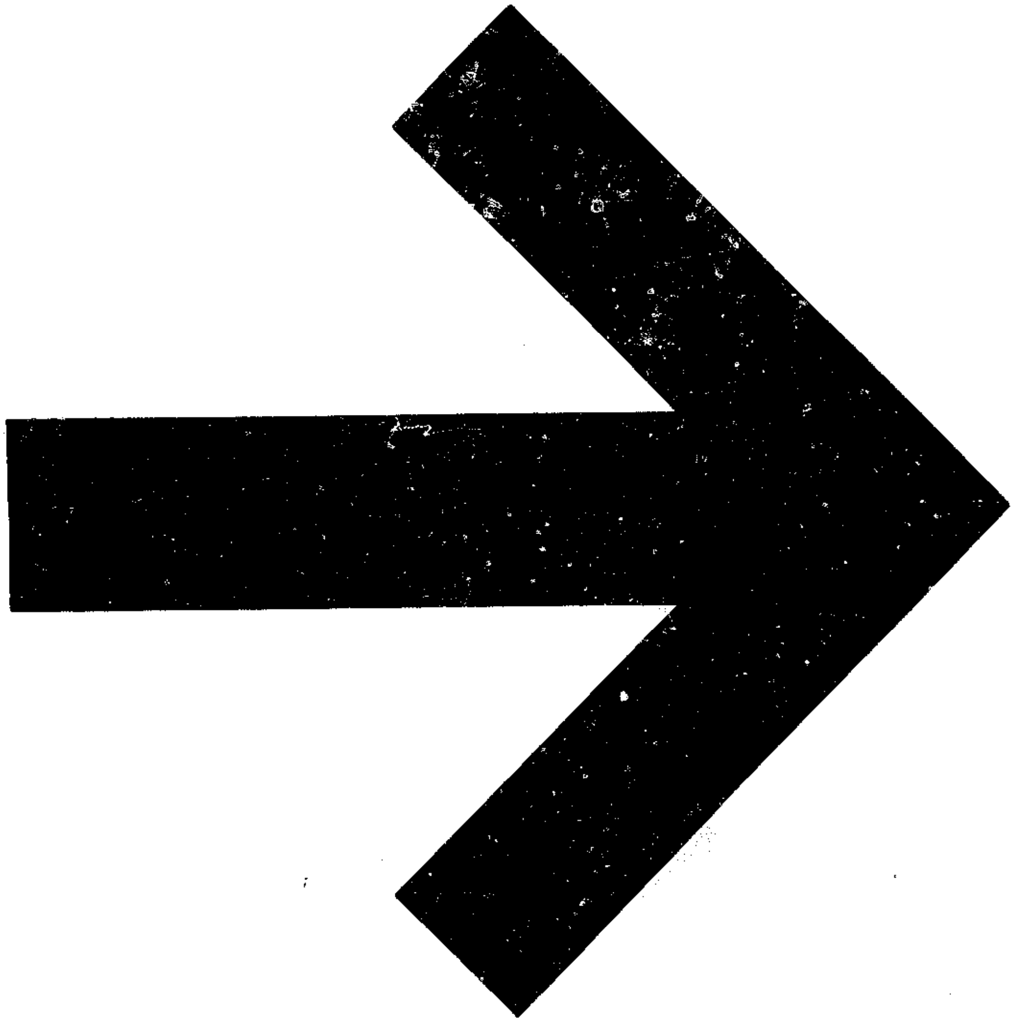


INDEX OF CONTENTS

Compiled by J. Collett from designs by H.S. Pearson

1. INTRODUCTION

The purpose of this leaflet is to provide some background information for both constructors and designers who wish to use wood bearings.

The type of wood to use, its treatment, lubrication, and expected performance will be discussed.

2. SOME ADVANTAGES OF OIL-SOAKED WOOD BEARINGS

Made from locally available materials.
Made by local craftsmen with woodworking skills.
Easily assembled.
Do not require lubrication or maintenance.
Operate under dirty conditions.
Easily inspected for wear.
Quickly repaired or replaced.
Can provide a temporary means of repairing a more sophisticated production bearing.
Require low tolerance on both the shafts and the housings.

3. CHOICE OF WOOD

The composition of wood is very complex, but in simple terms it consists of fibrous material bound together with a glue-like substance, water, resins, and oils.

3.1 Initial Selection

D.A.Atkinson (1972) stated that one of the essential characteristics to look for in the choice of wood is hardness.

- The harder the bearing surface, the less the deformation and the smaller the coefficient of friction
- The harder the bearing surface, the lower the rate of wear.
- The harder the bearing surface the less likely it is to breakdown prematurely, singe, and ultimately burn.
- The harder the bearing surface the greater its strength.

It is also worth noting that generally, the harder the wood, the greater its weight and the more difficult it is to work.

The oiliness of the wood is a particularly important consideration when the bearings are unlikely (or not intended) to receive lubrication during their service. Practical indicators that assist the identification of timbers which may have good self-lubricating properties are:

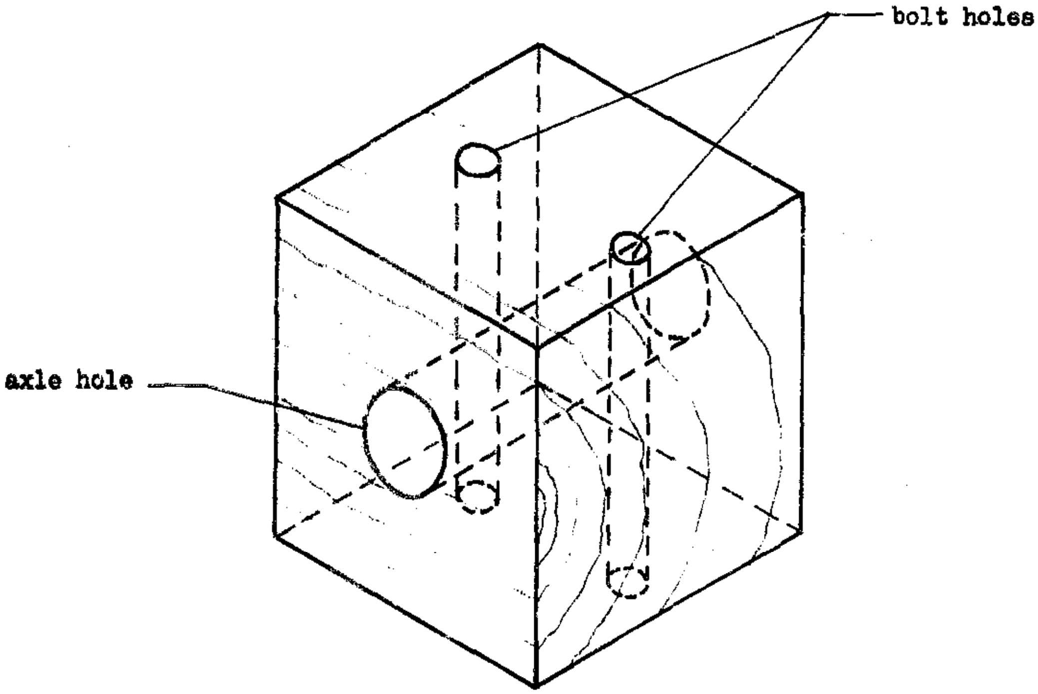
a) they are easily polished
b) they do not react with acids
c) they are difficult to impregnate with preservatives
d) glue does not easily stick to them

3.2 Other Considerations

High moisture content causes a reduction in hardness and results in greater wear. For most applications low moisture content is preferred and excess moisture must be removed to prevent subsequent shrinkage especially if the bearing is to be used as a bush.

The hardest wood is to be found in the main trunk just below the first branch.

Grain direction should be considered, and if possible advantage taken of the close grain to provide hardness at the wearing surface.



One-piece block bearing (full size)

Fig. 1.

The piece of timber selected for the bearing should be free from cracks. Some suitable timbers are listed in Table 1.

"Greasy " woods	Lignum vitae	(Guaiacum officinale)
	Tallowood	(Eucaliptus microcorys)
	Teak	(Tectona grandis)
	Blackbutt	(Eucaliptus pilularis)
Other woods	Poon	(Calophyllum tomentosum)
	Hornbeam	(Carpinus betulus)
	Degame	(Calycophyllum carididissimum)
	Boxwood	(Phyllostylon brasiliense)
	Pear	(Pyrus communis)
	Oak	(Quercus robur)
	Camphorwood	(Dryobalanops aromatica)

Table 1.

If the timber is not of the self-lubricating variety (or of doubtful self-lubricating characteristics) it can be soaked in oil to minimize the need for subsequent lubrication. It is important to have dry wood to assist maximum absorption of oil.

4. CONSTRUCTION

The following notes relate to experience gained in the "field" manufacture and testing of three types of wood bearing. All were of the oil-soaked variety.

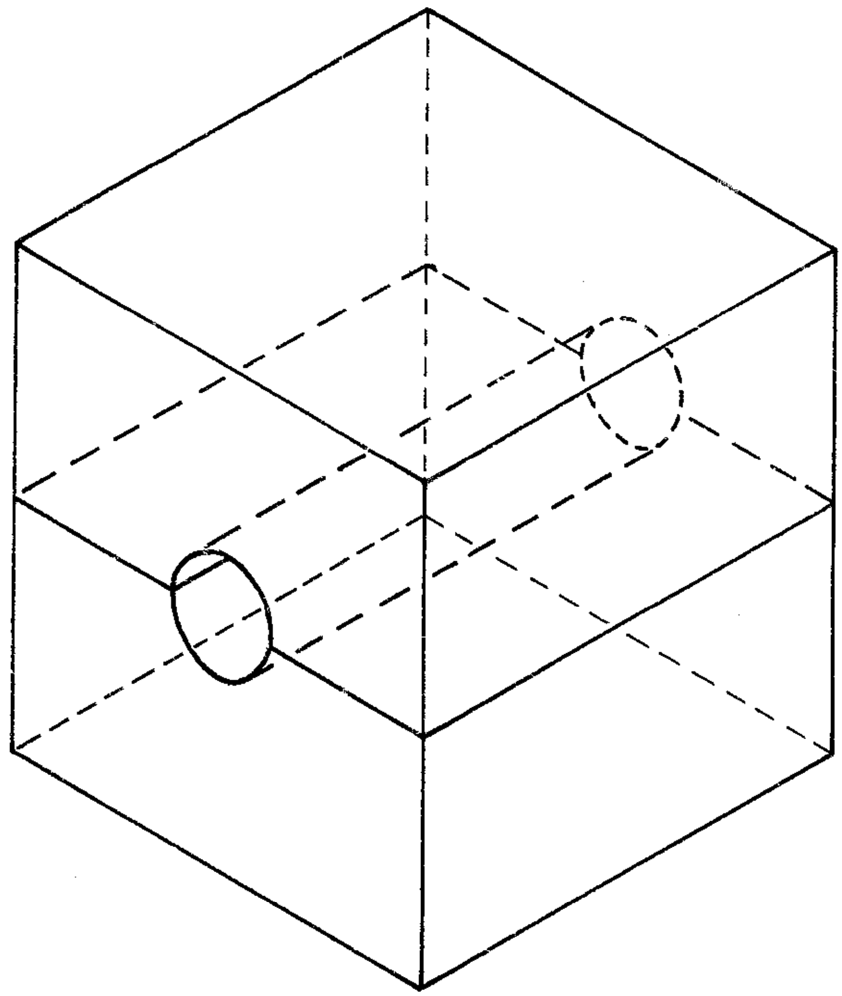
4.1 Types of Bearing

- Bush bearing
- Split-block bearing
- One-piece block bearing

4.2 General Remarks

H.S.Pearson (1975) has suggested that as a general rule-of-thumb guide to the size of timber needed for the bearing, the axial length of the bearing should be at least twice the shaft diameter. For example, for a 25mm diameter axle, the bearing should be at least 50mm long.

In the case of the block bearings, the thickness of bearing material at any point should not be less than the shaft diameter.



Split-block bearing (half size).
Fig. 2

The drilling of radial holes for lubrication purposes is only recommended by Pearson for the bush type of bearing. He found that if lubrication holes were drilled in block bearings not only were the bearings weakened but also the holes acted as dirt traps.

The bearing should be located whenever possible in a position where falling dirt will not directly enter the bearing. For example, if the axle is carried in bearings mounted under the floor of a cart instead of a fixed axle with bearings at the hub of the wheel, then dirt falling from the rim of the wheel will not fall directly onto the bearings.

If the bearing is expected to take side-thrust, large flat washers must be used, the one next to the end of the bearing being free to rotate on the shaft.

The bearing surface of the shaft should be perfectly round and smooth and polished in appearance.

4.3 How to Make the Bearings

Available timber often has rather doubtful self-lubricating properties and high moisture content. In this instance, a simple procedure for making an oil-soaked bush bearing has been devised by the Industrial Development Center, Zaria in Nigeria. Excess water is removed and subsequent shrinkage prevented. (Shambaugh, Pearson and Jibril, 1969).

a) Reduce the timber to a square cross section and bore a hole through the centre the same diameter as the journal on which the bearing will be working.

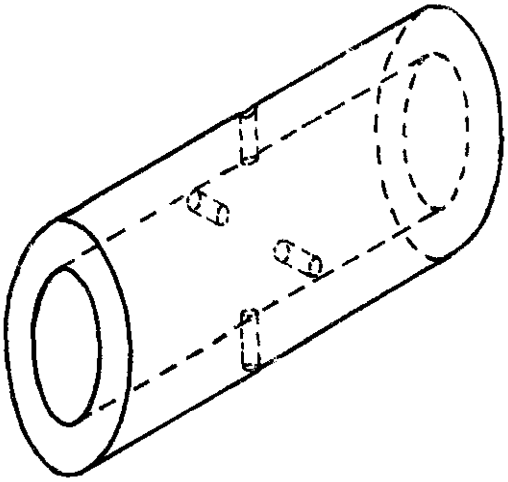
b) Place the blocks into a metal container of commercial groundnut oil and keep them submerged by placing a brick on top. Raise the temperature of the oil until the water in the wood is turned into steam - this will give the oil the appearance of boiling vigorously. Maintain the temperature until only single streams of small pin-size bubbles are rising to the surface of the oil. This may take anything from 30 minutes to 2 hours depending on the moisture content of the wood.

c) Remove the heat source and leave the blocks in the oil to cool overnight if possible. During this stage the wood will absorb oil. BE VERY CAREFUL IF YOU NEED TO HANDLE THE CONTAINER WHILST IT IS FULL OF HOT OIL. If the temperature of the oil is allowed to get too high after the bubbles have ceased to appear, the wood will change to charcoal and the bearings will be ruined.

d) Rebore the centre hole to compensate for any shrinkage that may have taken place.

e) Place on a mandrel and turn the outside diameter to the required measurement that will give the bush a press fit into the hub.

f) Bore four equally spaced holes through the wall of the bush at its mid-point and fill with lubricant - in general terms, the harder the lubricant the better, so animal fat, soap or tallow are preferable although grease is an excellent alternative.

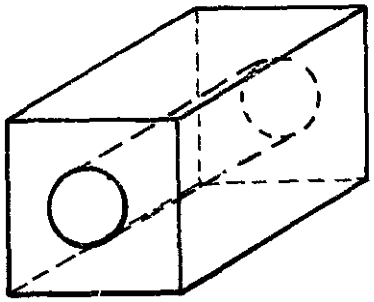


Bush bearing showing the four lubrication holes (full size).

Fig. 3

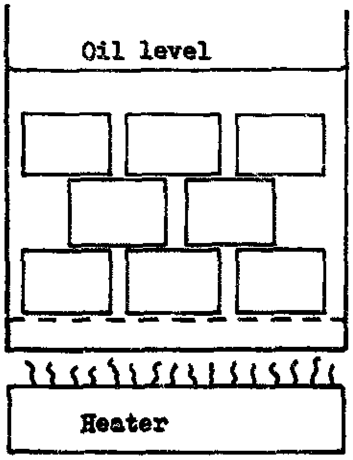
g) Finally press the bush into the hub.

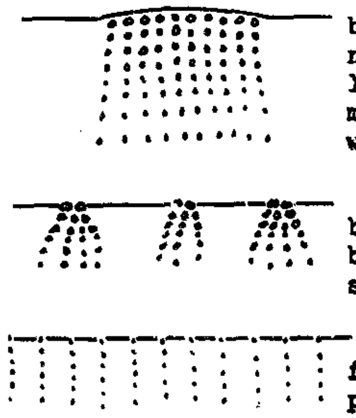
The forty bush bearings made and tested at Zaria were 2½" long by 1.550" outside diameter with a 0.855" bore. They were pressed into 1½" seamless black iron Class C pipe, and turned on a ½" pipe journal. The wood used was mahogany (being the most readily available) and rig tests with a loading of 100 lbs and a speed of 100 - 200 rev/min indicated sufficient lubrication. These test conditions were chosen to simulate the working forces on a 7" gauge wheel of an ox-drawn plough. Tests performed on bush bearings without the four radial lubrication holes again indicated sufficient lubrication.



INITIAL PREPARATION.

Saw timber into shape of an oblong block somewhat larger than the O.D of the finished bearing to allow for shrinkage and bore being off centre. Bore hole through centre of block the size of the journal.



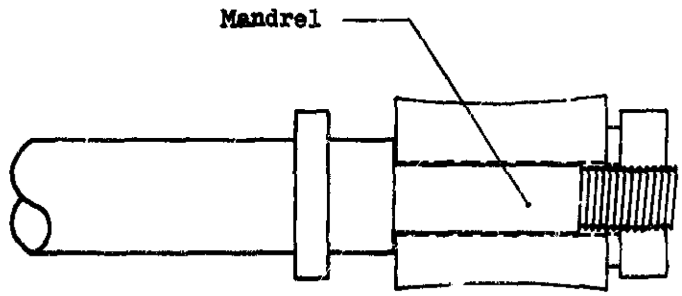


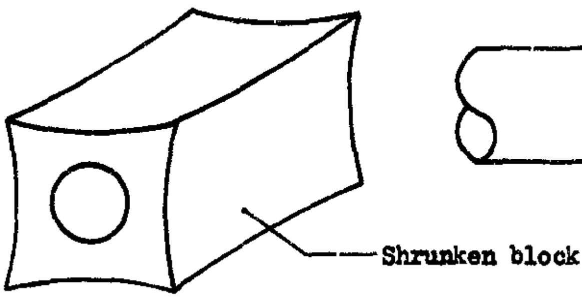
DEHYDRATION

Soon after submerging the bearing blocks in hot groundnut oil, many surface bubbles 1" in diameter, made from a multitude of smaller bubbles, will appear on the surface.

As the moisture content of blocks is reduced, the surface bubbles will become smaller in size.

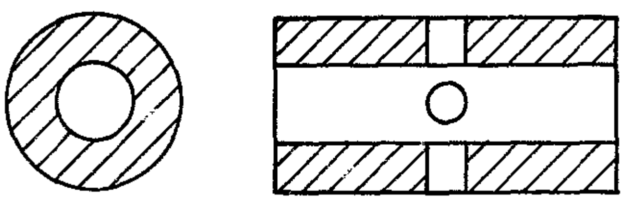
When the surface bubbles are formed from single streams of pin-size bubbles, the dehydration process has gone far enough. Stop heating, and let blocks cool in the oil overnight.





FINISHING

Re-drill centre hole and place shrunken oil-soaked bearing block on mandrel and turn to the desired size.



Cross section of the finished oil-soaked wood bearing showing grease reservoir holes.

On heavy equipment such as ox-carts or where it is not possible to push the axle through a bush bearing, the split-block bearing provides a more practical solution.

It is simple to fit and replace, and if wear takes place the two halves can be changed around. After further wear, the life of the bearing can be extended by removing a small amount of material from the matching faces.

A simple procedure was devised by the GRZ/ITDG Project at the Magoye Regional Research Station in Zambia for the production of such a bearing, again using an oil soaking technique. The timber in this case was teak, and used engine-oil provided a satisfactory alternative to groundnut oil. (Coombs & Pearson, 1974)

a) Reduce the timber to a square cross-section and cut lengthwise into two halves.

b) The two halves of the bearing must be clamped firmly together for the drilling operation. It is most important that the hole for the axle is bored exactly square through the blocks. For the best results an electric powered pillar-drill should be used although a hand powered pillar-drill would be quite satisfactory. If neither of these is available, a jig would have to be made to keep the drill bit in line.

   After drilling, the two halves should be tied together to keep them in pairs.

c) For soaking in oil an old 20 litre (5 gal.) drum is needed. Fill it three-quarters full with used engine-oil and bring to the boil over an open fire. GREAT CARE is needed when handling the drum of hot oil. Lift the drum off the fire and carefully place the pairs of bearings into the hot oil. Put a brick on top of the last pair to stop them floating, and leave the drum and contents to cool slowly overnight.

The split-block bearings measured 150mm x 150mm x 75mm with a 38mm diameter bore. They were field tested for reliability by installing them on ox-carts fitted with iron or pneumatic wheels and carrying loads of up to 2 tons.

A radial clearance on one of these assemblies of about 1mm was found to be essential. If carefully run in at low speeds (ox work), the clearance is increased to 1.5-2.0mm and the bearing surface attained a highly polished glass-like appearance. Having reached this condition it was found capable of withstanding journeys of a few kilometers at higher speeds (Landrover towing).

A soft pine-wood oil-soaked bearing was tested as an alternative to the hardwood bearing, and this also gave satisfactory performance but might have a shorter life.

For lower load, lower speed applications such as the seed-drive mechanism on a small planter, a smaller one-piece oil-soaked block bearing was used measuring 50mm x 50mm x 50mm with a 16m diameter bore, and this gave satisfactory results, although tests were not extensive.

The possibility of boring the axle hole by hot irons was not investigated but there should be no serious objections to this alternative.

5. PERFORMANCE

The following general points can be concluded:-

a) The running-in period is of critical importance. It is characterised by a high initial rate of wear whilst smoothing and polishing of the bearing surface takes place, after which wear becomes approximately proportional to time.

b) The greater the speed of rotation, the greater the wear, especially during the running-in period.

c) The greater the axle loading, the greater the rate of wear.

More specifically, wear is approximately proportional to load, BUT increases rapidly for small increments in speed.

Very high loading and low speeds should be avoided since this results in a jerking movement of the journal in the bearing and subsequent shaking and vibration will result in wear of other parts.

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Harrows: High-Clearance Peg Tooth, Triangular Spike Tooth, Flexible Peg Tooth and Japanese Harrow

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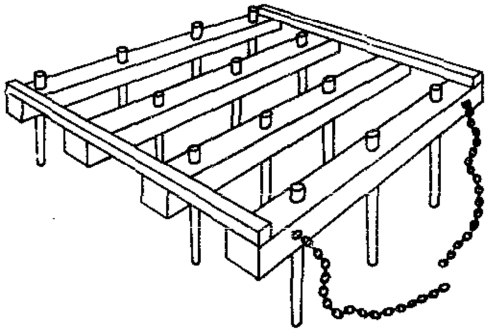
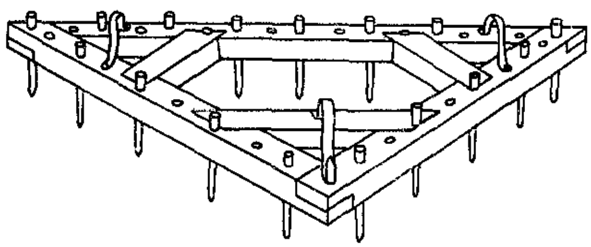
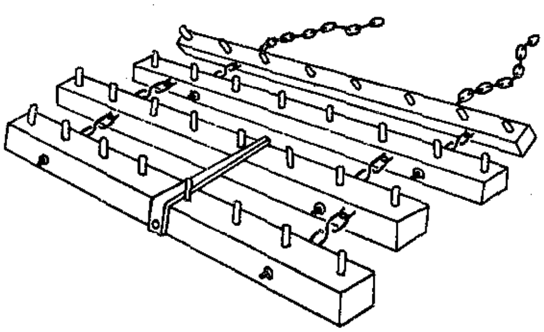
No. 41

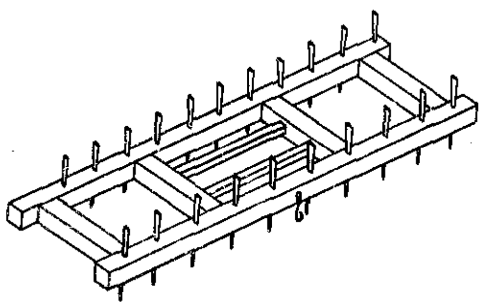
HARROWS

Triangular Spike-Tooth
High Clearance Peg Tooth
Flexible Peg Tooth
Japanese Harrow









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HIGH-CLEARANCE PEG-TOOTH HARROW

DEVELOPED BY: Ministry of Agriculture, Tanzania.

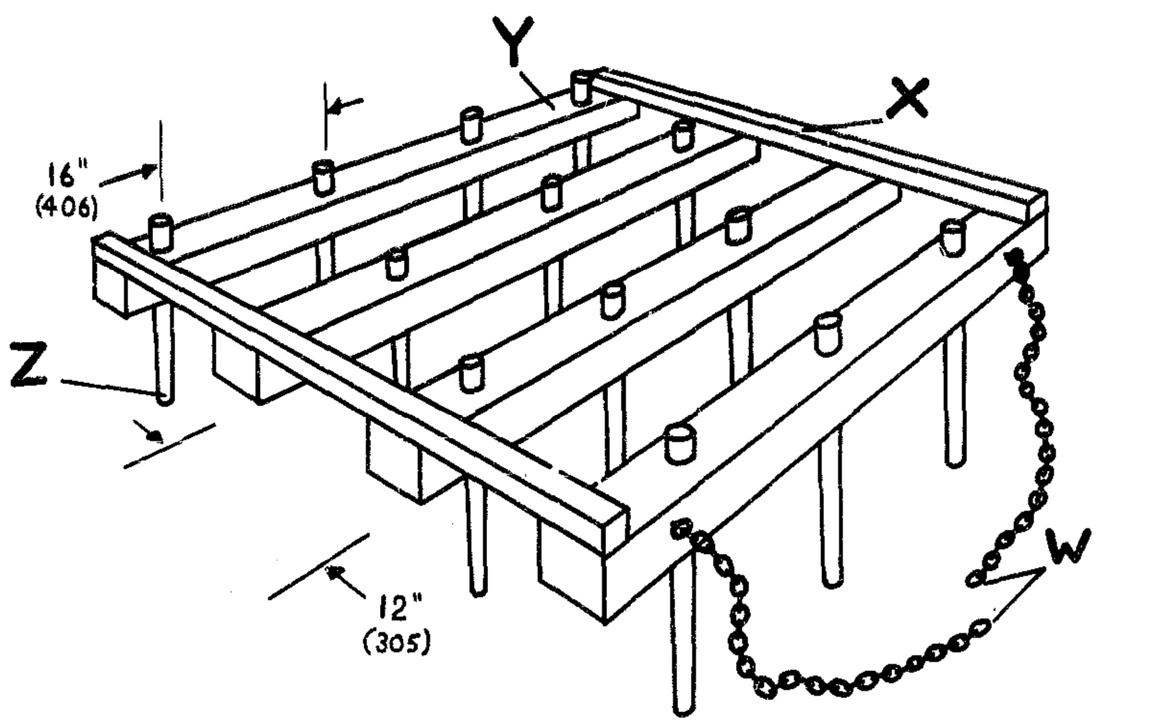
DESCRIPTION: This harrow is constructed entirely of timber. Its high ground clearance and wide tooth spacing make it suitable for working in minimal tillage systems where it is advantageous to leave a trash cover on the soil surface.

It can be used following sweep tillage operations to break down soil clods before crop planting, and also for covering of seed after broadcast seeding.

Note: Figures in brackets are in millimetres.

KEY:

ITEM	NAME	QUANTITY	ITEM DESCRIPTION
W	DRAUGHT CHAIN	2	Mild steel chain.
X	FRAME SIDE	2	Of 2" x 2" x 40" (51 x 51 x 1016) hard wood.
Y	CROSS BEAM	4	Of 4" x 4" x 60" (102 x 102 x 1524) hard wood.
Z	PEG	13	Of 1" (25) diameter hard wood, 16" (406) long with 10" (254) protruding below frame beams, peg teeth staggered in each row to give 4" (102) overall tooth spacing.



FLEXIBLE PEG-TOOTH HARROW

DEVELOPED BY: Locally-built design from Iran (extract from Central Treaty Organisation economic publication No. 47).

DESCRIPTION: A low-cost peg-tooth harrow designed for animal or tractor power.

The flexible linkage between the bars helps to make the harrow self-cleaning, and the linkage arrangement is designed to keep the teeth upright while in use. The bars are offset to give an average tooth spacing of 2" (51).

Note: Figures in brackets are in millimetres.

KEY:

ITEM	NAME	QUANTITY	ITEM DESCRIPTION
A	DRAUGHT CHAINS	2	Mild steel chain
B	LINKAGE ASSEMBLY	6	¾" (19) diameter mild steel eye-bolts and 'S' hook links.
C	AR	4	Each of 4" x 4" x 64" (102 x 102 x 1626) hard wood.
D	TOOTH	32	Each 10" (254) in length, of ¾" (19) diameter hard wood or ¾" (19) square section steel bar.

"JAPANESE" HARROW

DEVELOPED BY: Locally-built design from Japan.

DESCRIPTION: A simple rigid two-row harrow with its flat-steel teeth driven through the wooden frame. The teeth are spaced 6" (152) apart in each row.

This implement has a cutting action, the narrow edge of the teeth being parallel to the line of draught.

Note: Figures in brackets are in millimetres.

KEY:

ITEM	NAME	QUANTITY	ITEM DESCRIPTION
X	FRAME CROSS MEMBER	4	Each of 2" x 2" x 18" (51 x 51 x 457) hard wood.
Y	TOOTH	As required	Each of 1" x ¼" (25 x 6.3) mild steel, 9" (299) long and tapered towards working end.
Z	MAIN FRAME MEMBER	2	Each of 2" x 2½" (51 x 63) hard wood, 66" (1676) long.

TRIANGULAR SPIKE-TOOTH HARROW

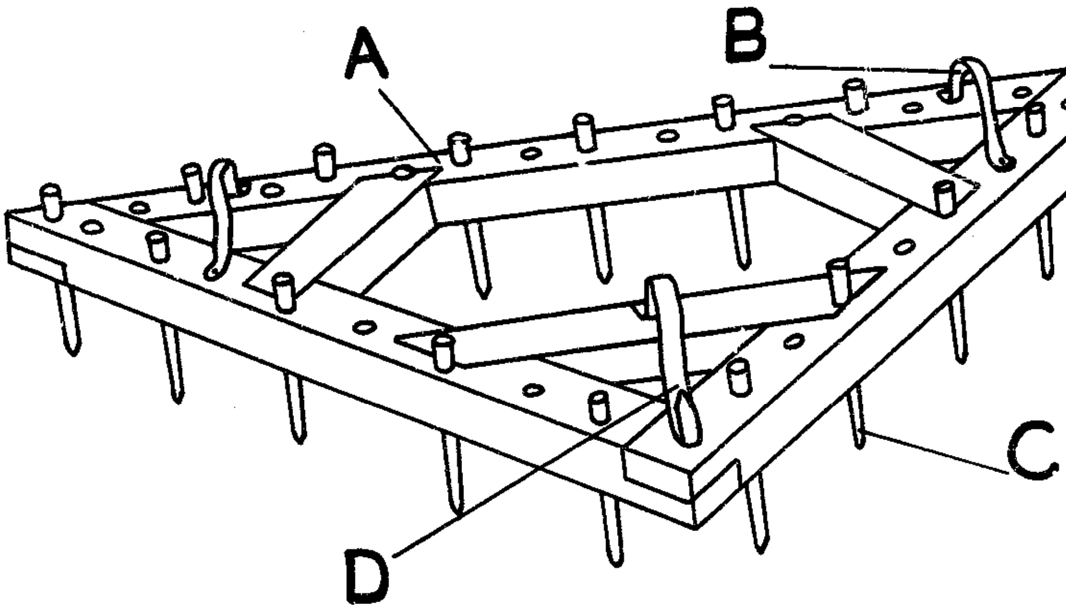
DEVELOPED BY: Originally designed in India.

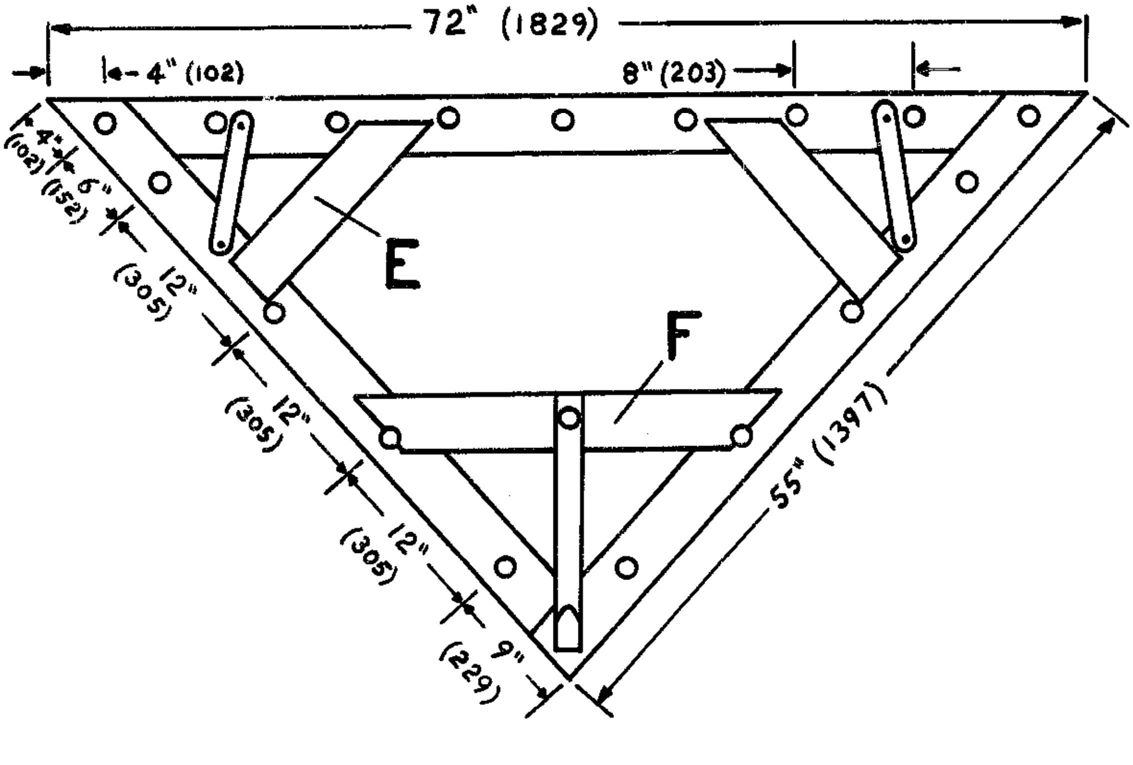
DESCRIPTION: The teeth of this harrow can be made of hard wood or mild steel. In the drawing overall tooth spacing is shown as 4". Tooth spacing can be varied to suit the soil conditions by removing teeth to give wider spacing or by drilling holes and inserting additional teeth to give closer spacing. The harrow can be used for preparing a seedbed, after ploughing, and for covering the seed after broadcasting. While in work the harrow should be horizontal and this is achieved by adjusting the length of the pulling rope or chain. The harrow can be loaded with logs or stones to give greater penetration when necessary. For transport to and from the field the harrow is turned on its back and runs on the skids.

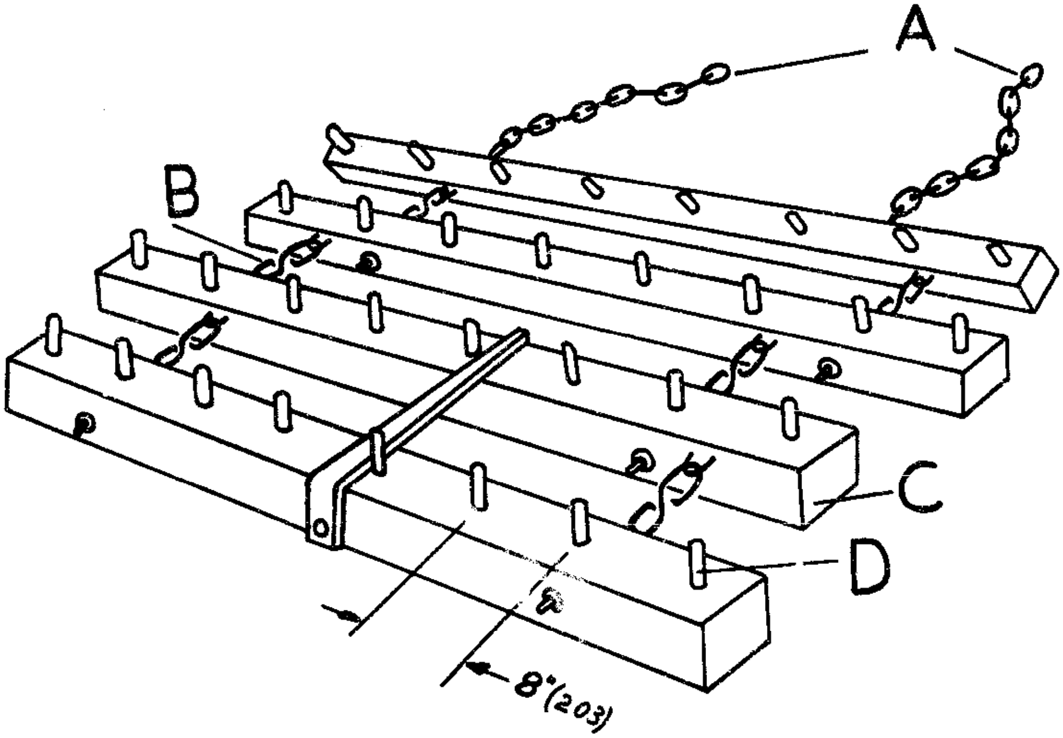
Note: Figures in brackets are in millimetres.

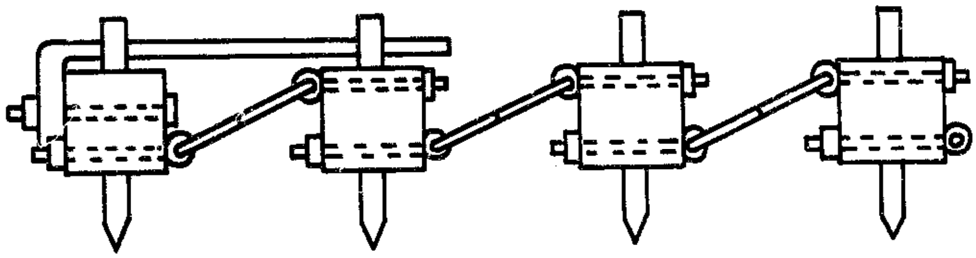
KEY:

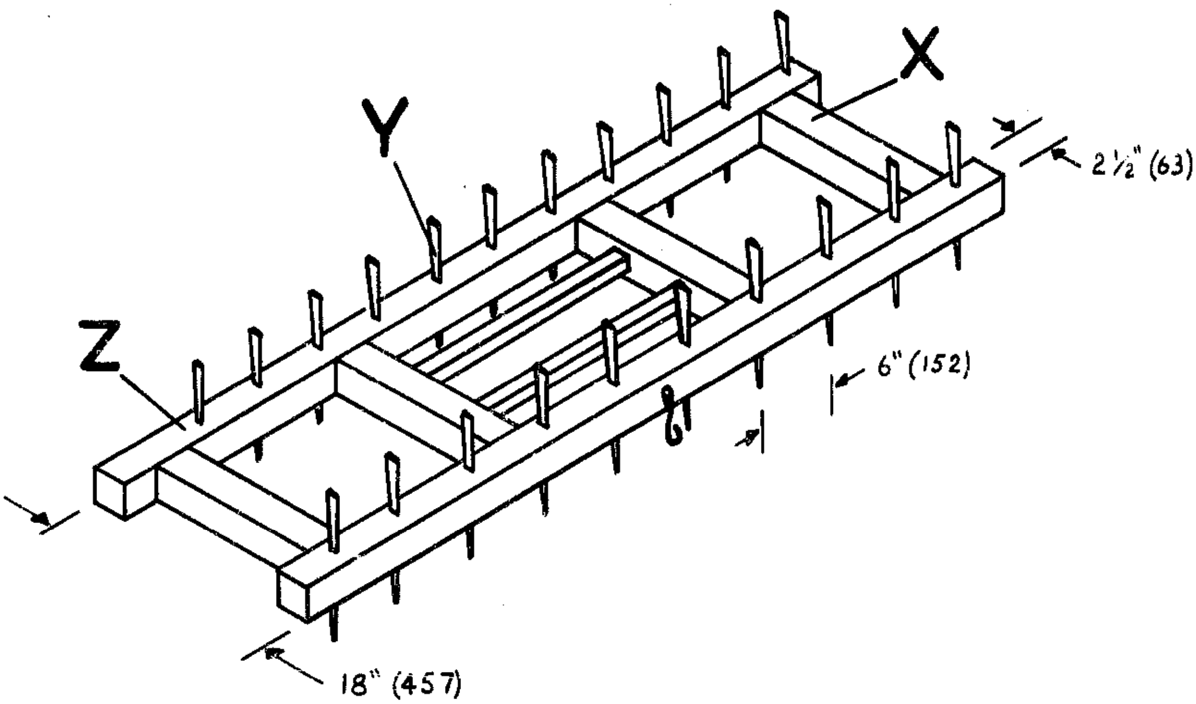
ITEM	NAME	QUANTITY	ITEM DESCRIPTION
A	MAIN FRAME	1	Made of one piece 3" x 4" x 72" (76 x 102 x 1829) and two pieces 3" x 4" x 55" (76 x 102 x 1397) hard wood.
B	SKID	2	Each of ½" x 1½" x 23" (12.5 x 38 x 584) mild steel.
C	TOOTH	(As required)	Each of ¾" x ¾" x 12" (19 x 19 x 305) mild steel or ¾" (19) diameter x 12" (305) hard wood.
D	TOWING HOOK/ SKID	1	½" x 1½" x 29" (12.5 x 38 x 737) mild steel.
E	REAR STRUT	2	Each of 3" x 4" x 17½" (76 x 102 x 444) wood.
F	FRONT STRUT	1	3" x 4" x 23½" (76 x 102 x 597) wood.


A
B
C
D


72" (1829)
4" (102)
8" (203)
4" (102)
6" (152)
12" (305)
12" (305)
12" (305)
9" (229)
55" (1397)
E
F


A
B
C
D
8"(203)




X
Y
Z
2 ½" (63)
6" (152)
18" (457)

42

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Eight Simple Surveying Levels
ITDG Agricultural Equipment and Tools No. 42

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AGRICULTURAL EQUIPMENT AND TOOLS FOR FARMERS DESIGNED FOR LOCAL CONSTRUCTION

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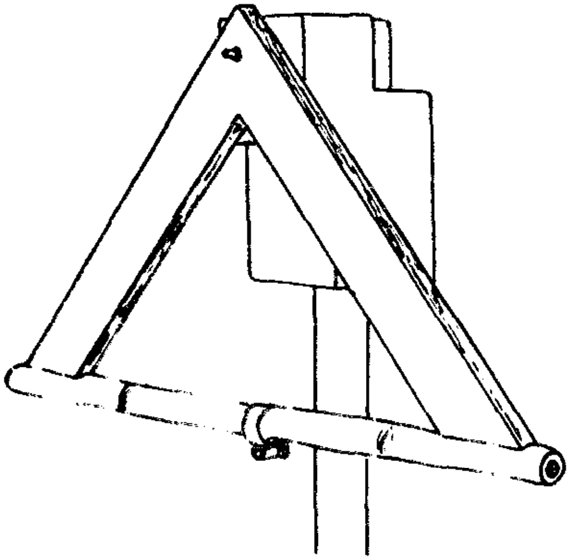
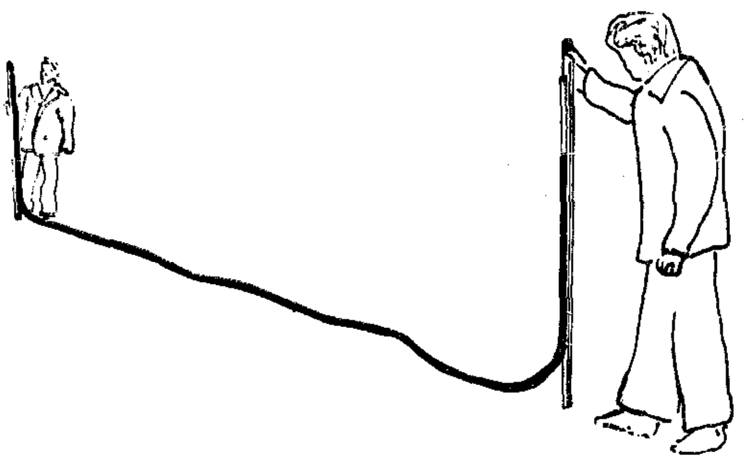


EIGHT SIMPLE SURVEYING LEVELS

CONSTRUCTED AND COMPARED BY
JOHN COLLETT
AND
JOHN BOYD



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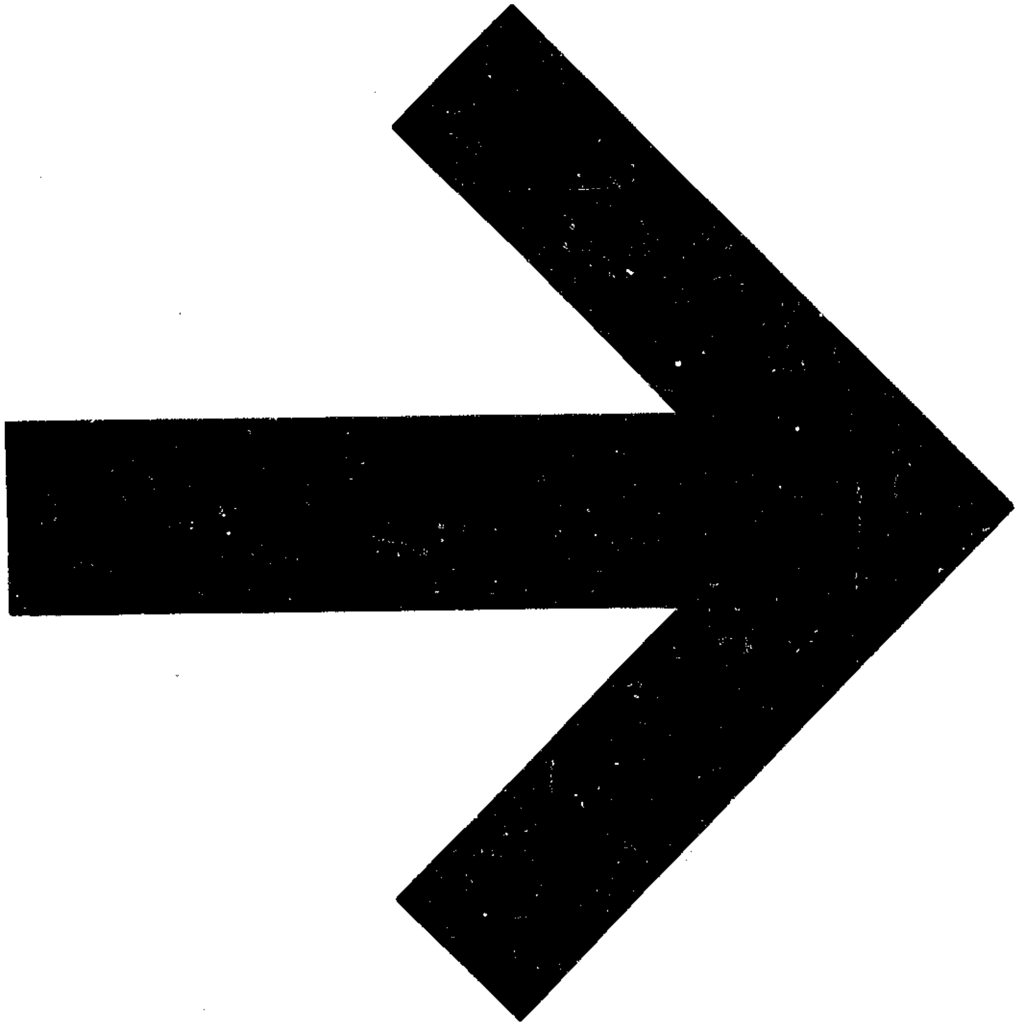


EIGHT SIMPLE SURVEYING LEVELS

Constructed and Compared by

John Collett

and

John Boyd

CONTENTS

SIMPLE SURVEYING LEVELS

Introduction

The surveying instrument most used on farms in developing countries is the level. It can be used to make a map before starting earthmoving work, it can be used to mark out on the ground either level contours, or else lines with a small, uniform slope for drainage, irrigation, soil conservation, roadmaking or building work.

Modern surveying instruments are very accurate, but expensive and easily damaged and need skilled workers to operate, adjust and repair them. The levelling work on small farms often does not require extreme accuracy because lines are being marked out on ordinarily rough field surfaces. There is, therefore, a case for examining alternatives to the modern surveyor's level which would be cheaper, simpler to operate and still reasonably accurate. This is what has been attempted here.

The Levelling Devices

The simple levelling devices tested can be divided into two groups:

1. *Levels with which the operator sights along a horizontal line to take readings on a graduated staff held by a second man some distance away.*

   This is the same method used with a modern surveyor's level.

2. *Levels which do not require sighting onto a distant staff.*

   The accuracy of these devices is not affected by the operator's eyesight or by the lighting conditions.

These simple levels did not have telescopes fitted with cross hairs, which are the costly parts of modern levels. Various types of simple sights were fitted and a clear target attached to the staff, but it was still not possible to read the staff consistently to within less than ± 5mm at a distance of 10m. The accuracy of any level which requires sighting onto a distant staff is affected by the operator's eyesight and the degree of daylight.

A modern surveyor's level is usually mounted on a tripod, which is itself rather expensive to buy, difficult to make and awkward to carry. For simplicity, the devices tested were supported on a simple pole, although a tripod would be necessary on very hard ground. The pole was 1.5m long and 28mm diameter. One end was sharpened to a point and fitted with a protective metal sheath. The mounting block was made from a 140mm x 90mm x 70mm piece of softwood and was drilled with a 30mm diameter hole to a depth of 80mm using a brace and bit. The top of the pole was smoothed with glass paper until the block rotated freely. A 6mm diameter hole was drilled to take a carriage bolt for securing the instruments to the block.

SQUARE AND PLUMB

Construction

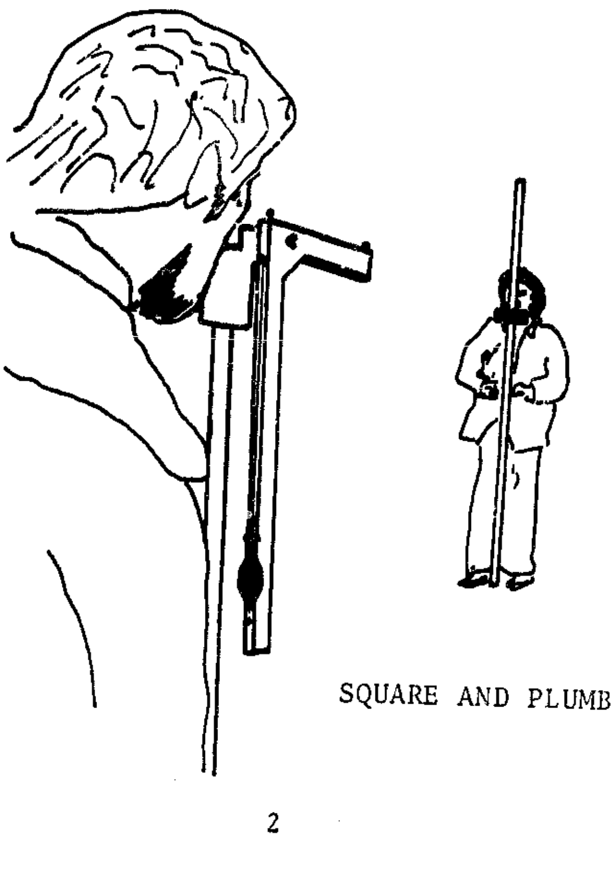
A right-angle square with arms 450mm long was cut from a sheet of 12mm thick plywood. A pair of sights was screwed into the top of the horizontal arm and a hook and marker fixed to the vertical arm for use with a plumb. The sights were adjusted so that when the plumb registered with the marker, the top edge was exactly horizontal. A 6mm diameter hole was drilled through the horizontal arm for the securing bolt.

Use

The instrument was attached to the mounting block by a carriage bolt and wing nut. It was aimed at the staff and then levelled by adjusting its angle until the plumb was exactly over the market. The wing nut was then tightened. It was difficult to read the staff through the sights, although a moveable target on the staff made sighting easier.

Results

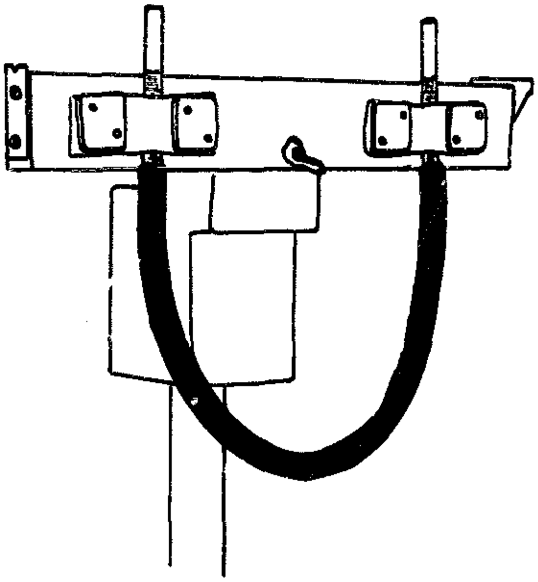
No testing was possible because the plumb bob was blown about by the wind.



SQUARE AND PLUMB

Construction

A 300mm length of planed 40mm x 20mm soft wood was fitted with two rubber straps made from motor tyre inner tube and secured with nails and thin hardboard pads. Each end was fitted with a sight cut from scrap sheet metal. A 6mm diameter hole for the mounting bolt was carefully drilled through the wood at the mid-point. A 100mm length of glass tube (7mm internal diameter) was inserted behind each strap and the lower ends joined with a 400mm length of rubber tubing. Water was poured into the U-tube arrangement until the level in each glass tube was about 30mm from the top. The ends were fitted with stoppers to prevent loss of water whilst transporting the instrument.

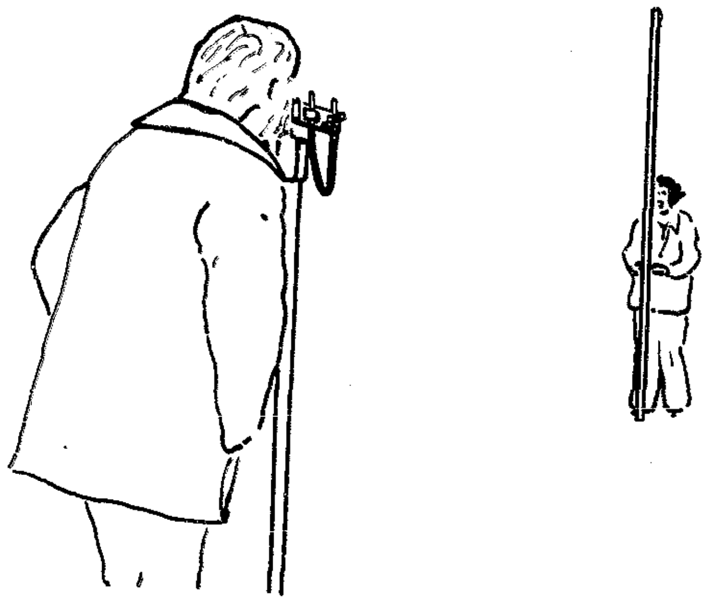


WATER MANOMETER

Uses

The mounting pole was pressed firmly in the ground as nearly vertically as possible. The mounting block was placed on top of the pole and the instrument secured by a carriage bolt and wing nut. The device was aimed at the staff at the first station, about 10 metres away. It was then levelled by removing the two stoppers and adjusting the angle until the two menisci were exactly level with the top edge of the wood. (Sometimes it was necessary to slide the glass tubes up or down in their rubber strap holders to achieve this condition.) Sighting from about 300mm behind the rear sight, it was possible to line up the horizontal front sight and read the staff. A moveable horizontal target on the staff made sighting easier.

TAKING A READING



Results

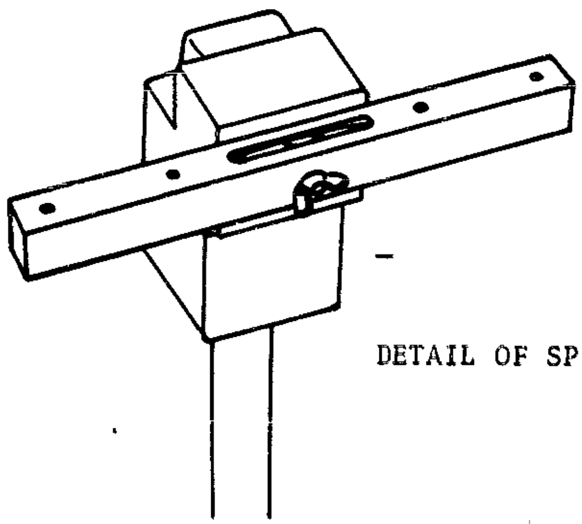
The staff could be read at a distance of 8-10 metres, but this range depends on the operator's eyesight. A 50 metre line was laid out 'on the contour' and checked with a modern optical surveying level. The worst error was 42mm in height over a horizontal distance of 8 metres.

Evaluation

Various types of water manometer have been described in surveying literature. Devices that require sighting along or through two menisci without the aid of a straight edge are difficult to use and liable to large errors. The inclusion of a sighting edge makes this a more practicable instrument. With care it would be used for setting level lines or graded lines of slopes not less than 1 in 200. The device must be kept upright when moving position to avoid loss of water, or alternatively the tubes can be stoppered.

Construction

A cheap wooden-cased spirit level 250mm long formed the basis of this instrument. A 6mm diameter hole for the securing bolt was drilled through the case, care being taken to avoid the glass tube.



DETAIL OF SPIRIT LEVEL

Use

The pole and mounting block were again used for support. The instrument was aimed at the staff and then levelled by adjusting its angle until the bubble was exactly between the centre marks. No sights were fitted to this device and sighting was achieved by looking along the top edge of the level. As before, a moveable horizontal target on the staff made sighting easier. Wind caused some movement of the apparatus, making exact setting of the bubble difficult. Wind effects could be eliminated if the level were mounted on a tripod.

Results

The ability to read the staff was dependent on the operator's eyesight and limited the range to 8-10 metres. A 100m line was laid out 'on the contour' and the worst error was measured as 30mm over a distance of 9 metres.

Evaluation

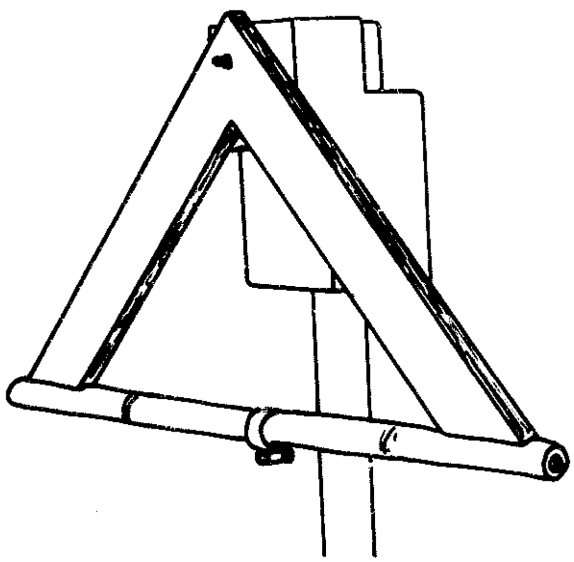
If a spirit level is available it is a simple matter to convert it into a sighting level. With care it could be used for setting level lines or graded lines of slopes not less than 1 in 300.

SPIRIT LEVEL

ROAD TRACER

Construction

This device consisted of a triangular wooden frame, free to swing on its supporting bolt. The base of the triangle served as a sighting tube and was made from a 450mm length of bamboo cane. The nodes were drilled out from each end. One end was fitted with cross wires (thin wire glued into slots) whilst the other end was covered with tape pierced with a viewing hole. A hose clip was used as the balance weight and this was placed over the bamboo tube before the latter was glued to the suspending A-frame. An 8mm diameter hole was drilled near the top of the A-frame so that the instrument could swing freely on the carriage bolt.



DETAIL OF THE ROAD TRACER SHOWING THE HOSE CLIP ON THE BAMBOO POLE

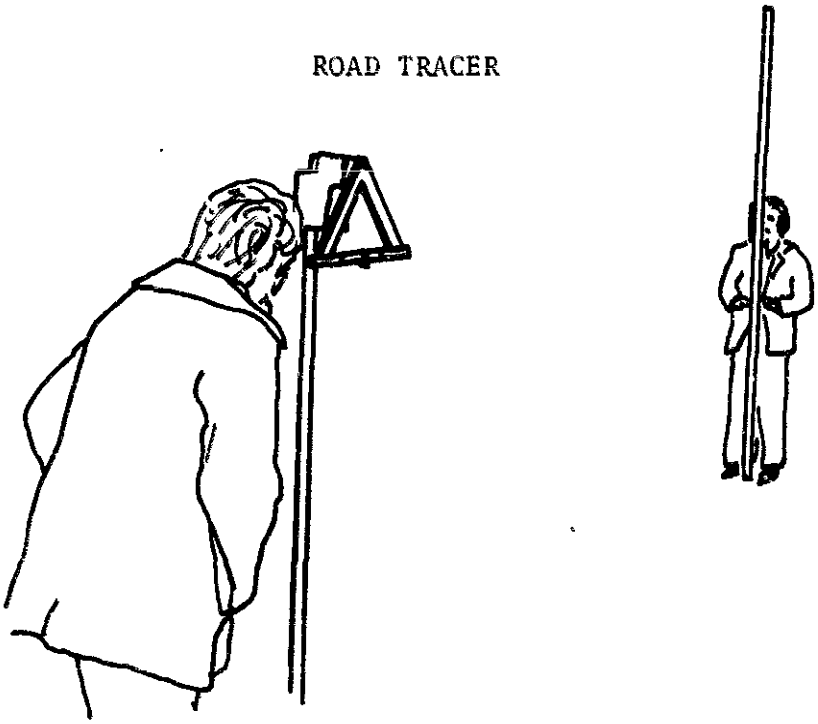
Setting the Instrument

The road tracer and the staff were placed side by side on a flat surface and the moveable target on the staff was adjusted to be exactly level with the cross wires. The staff was then moved to a point about 20m away from the road tracer, chosen so that the target appeared to be at the same level when viewed through the sighting tube. The positions of the staff and the instrument were then reversed to check if there was any difference in the reading. Adjustment for the error was made by moving the balance weight so that half of the difference in readings was removed. The weight was secured and the procedure repeated to check the setting.

Use

To set out a level contour line, after checking the setting of the instrument, the staff was placed next to the road tracer and the target adjusted to coincide with the cross wires. The staff was then moved to a point about 10 metres away and moved up or down the slope until the target again coincided with the cross wires when viewed through the tube. The road tracer was then swung slightly and allowed to come to rest again so that the reading could be checked. If the reading was confirmed, the position was marked with an arrow and the staff moved on. The device was adversely affected by any wind and it was essential to use a target on the staff.

ROAD TRACER



Results

The range was limited to a maximum of about 20 metres by the operator's eyesight. A line was laid out on the contour and checked with a modern instrument. The worst height error was 59mm over a distance of 10 metres.

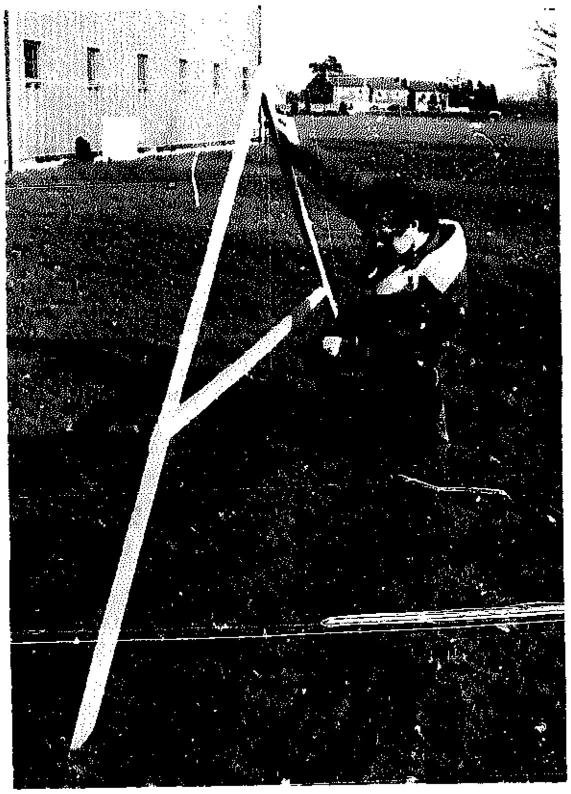
Evaluation

Care and patience are needed with this device to allow it to come to rest. Heavier construction, e.g. of steel, would make it less susceptible to movement by the wind. The need to 'set' the instrument and check both the setting and results is a disadvantage. Its use is restricted to level lines and graded lines of slopes not less than 1 in 200.

A-FRAME AND PLUMB

Construction

Two 2.5m lengths of 60mm x 20mm soft wood were laid together at one end and spread apart by 4m at the other. The joint was glued and screwed. Another piece of 60mm x 20mm wood was glued and screwed to the side pieces so that it formed the horizontal of the A-frame. The 'feet' of the frame were cut level after marking with a long straight piece of wood. A hook was screwed into the frame near the apex for attachment of the plumb.



Setting the Instrument

Two bricks were placed 4 metres apart and the A-frame was placed upon them. When the plumb came to rest, the position of the string was marked on the horizontal bar. The frame was then placed the other way round on the same bricks and the procedure repeated. A permanent mark was then made halfway between these two marks to show when the feet of the frame were exactly level.

Use and Results

To set out a level contour, one leg of the frame was placed at the starting point and the other was positioned so that the plumb registered with the permanent mark. This position was marked with an arrow. The frame was then moved up to this arrow and the procedure repeated. Care was taken to get the plumb as close as possible to the marker. Although the plumb was affected by the wind it was possible to damp the movement by allowing the cord to rub against the frame. A line was laid on the contour and the worst height error was 13mm in 4 metres.

Evaluation

Progress with this instrument can be quite fast even though each 'step' is limited by the physical span of the frame. The taller the frame, the more sensitive the instrument becomes to differences in level. The device described here could be used for setting level lines or graded lines of slopes not less than 1 in 300.

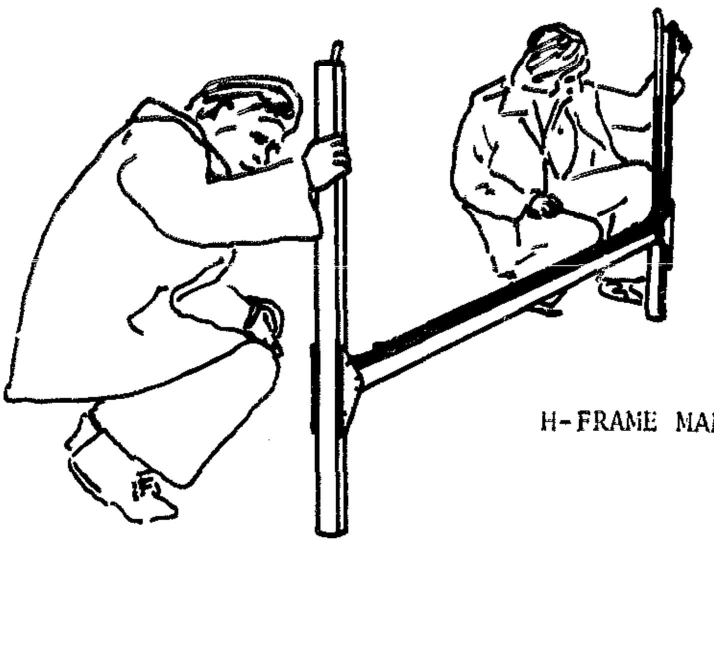
H-FRAME MANOMETER

Construction

The frame of this device was made from two 1m high uprights (50mm x 50mm softwood) and a 2.5m horizontal joined to form an H shape. A 1m length of clear plastic tube (12mm internal diameter) was secured to each end of a 2m length of metal conduit using hose clips. The conduit was attached to the horizontal of the frame with nails, and the plastic tube fastened to the uprights with soft wire. Water was poured in until the level was about halfway up each tube. The tube ends were stoppered to prevent loss of water during transport.

Setting the Instrument

Two bricks were placed 2.5 metres apart and the feet of the frame placed upon them. The stoppers were removed and a mark was made on each wooden upright, level with the bottom of the meniscus. The frame was placed on the bricks the other way round, the procedure repeated and two more marks made. A permanent mark was then made midway between the marks on each upright. Finally the stoppers were replaced for transport.



H-FRAME MANOMETER

Use and Results

A level line was laid out by placing the foot of one of the uprights at the starting point, removing the stoppers and moving the leading foot until the bottom of the meniscus was level with the permanent mark. With two operators, the following man could observe his reading to provide a check, (it should also be opposite the mark). The position of the leading foot was marked with an arrow, the stoppers replaced, and the frame moved forward to repeat the procedure. In this way a line was set on the contour and the worst height error was measured as 8mm over a distance of 2.5 metres.

Evaluation

Care was needed to avoid spilling water whenever the instrument was moved. Although each 'step' was limited to 2.5 metres, (the span of the frame) progress with the device was comparable with the previous levels. It could be used for setting level lines or graded lines of slopes not less than 1 in 300. A refinement could be made by attaching a scale to the uprights for measuring height differences.

FLEXIBLE TUBE WATER LEVEL

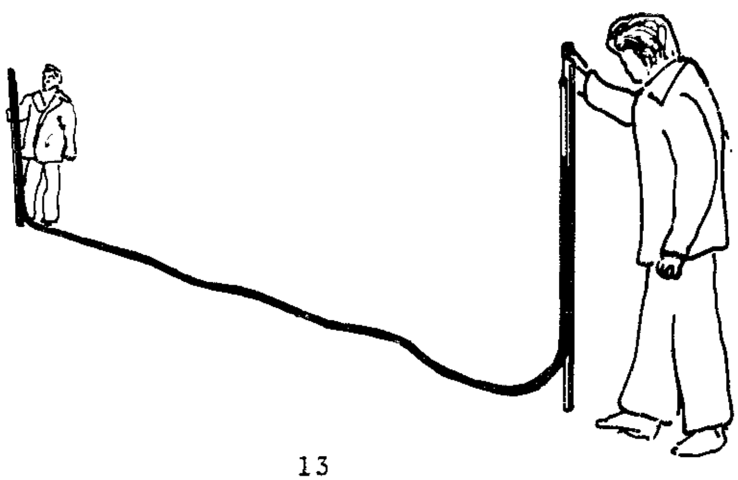
Construction

Two 1.6m wooden staves (40mm x 20mm) had battens (2m x 10mm) nailed to one side of the broad face. A 1.5m tape was carefully glued to each batten with the zero level with the end of the batten. The two ends of a 13m length of clear non-reinforced PVC tube (16mm internal diameter) were attached to the staves by drilling four 1.5mm holes at 400mm centres and using soft wire to secure the pipe firmly against the edge of the batten. The tube was then slowly filled with water, care being taken to expel all air bubbles, until the level was about 1m high in each of the stand pipes when they were held together. The ends of the tube were fitted with rubber stoppers to prevent loss of water during transport.

Use

To set a level line, the two stand pipes were brought together at the starting point, the stoppers removed and the readings taken level with the bottom of each meniscus. (The readings should be the same and may be marked with a pencil.) The ends of the tube were then stoppered and the lead man took his standpipe and stretched out the tube in the direction of the line. The stoppers were carefully removed and the lead man moved his standpipe up or down the slope until he obtained the original reading. (At this point, the following man could look at his reading which should also be the same - this provided a simple checking procedure.) An arrow was placed by the lead man, stoppers were replaced and both men moved forward to repeat the operation.

FLEXIBLE TUBE WATER LEVEL



Results

If care was taken, the accuracy of reading the meniscus was ± 0.5mm, (the smallest graduation of the tape being 1.0mm). It did not take long for the levels in the stand pipes to settle, and progress was quite fast. When moving the instrument the procedure to avoid spilling should be observed. A line was laid on the contour and the worst height error was 10mm over a 10 metre distance.

Evaluation

The accuracy of this device was far superior to the other instruments, and it was one of the fastest to use. However, its construction relies upon the availability of clear plastic pipe. This is only strictly necessary for the standpipe portions as the joining length could be any type of hose. The instrument does not rely on good eyesight for sighting purposes. A possible disadvantage is its bulkiness although the instrument described here was easily carried by one man. With care it could be used for setting level lines or graded slopes not less than 1 in 1000.

LINE LEVEL

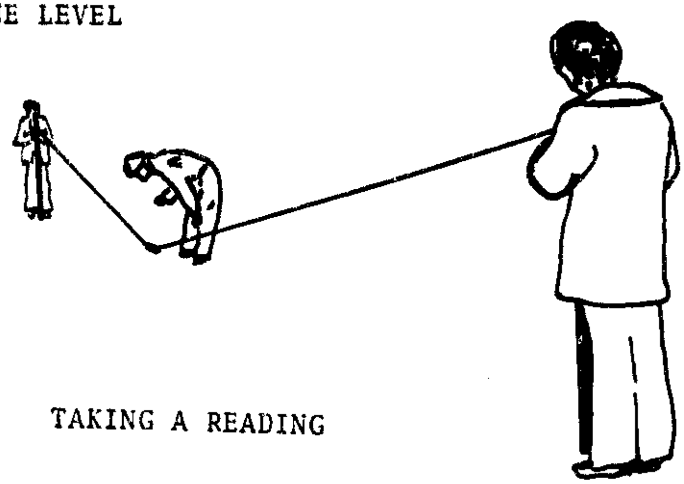
Construction

A cheap wooden-cased spirit level 250mm long formed the basis of this instrument. A small screw-eye was screwed into each end face (on the centre-line and close to the top face) and a 10m length of cord tied to each eye. Two staves were made by glueing 1.5m tape measures onto straight battens.

Use

Three people were needed to operate this device - one with a staff at each end of the cord, and the third at the centre watching the spirit level. The leading staff man either moved his position up or down the slope, (for laying out contours) or moved the string up or down the staff when measuring height differences. The centre man gave the instructions by observing the spirit level. Even though the device swayed around in the wind it was still easy to see the bubble, which came to rest after a few seconds.

LINE LEVEL



TAKING A READING

Results

The range of the device depends on the length of the line, in this case 20 metres. 5 arrows were set on the contour in 5 minutes and the worst height error was 55mm in 20m.

Evaluation

Of the instruments tested the line level gave the fastest rate of progress. Accuracy might be improved by suspending the level from the line in a different manner to ensure that it always hangs correctly. It was the most compact of the eight devices (the level and cord could be carried in a pocket) and with care could be used for setting level lines or graded lines of slopes not less than 1 in 300.

SUMMARY

Eight simple surveying levels were constructed and compared. Those which involved sighting onto a distant staff were the least satisfactory. Of the remaining four levels, the flexible tube water level was the most accurate, but the most expensive. The wooden A-frame and plumb line and the rigid H-frame manometer were simple to use but cumbersome to transport. The line level (small spirit level and cord) was cheap, fairly accurate,; quick to use and easy to carry, but needed three operators.

All the levels were made using simple hand tools. The materials used included wood, screws, nails, string, scrap sheet metal, glass, rubber tube, plastic tube, soft wire and a length of metal conduit.

CONCLUSIONS

All the devices were cheap and simple to construct. They did not require delicate handling or skilled operators. They were all accurate enough to be useful in irrigation, drainage, soil conservation, roadmaking and building at the farm level.

The four levelling devices which involved sighting onto a distant staff (water manometer, spirit level, square and plumb and road tracer) were more difficult to use, particularly in less than perfect lighting, and their accuracy depended largly largely on the operator's eyesight. In each case a robust tripod would have been some improvement over the mounting pole used, but would have made transport more difficult. The remaining devices which did not require sighting onto a staff seemed more suitable for unskilled operators.

The A-frame and plumb and the H-frame manometer were simple to make and use, but were cumbersome to transport and could only be used over fixed intervals equal to the lengths of the frames.

The flexible tube manometer was the most accurate of the devices. Measuring or marking out gradients of up to 1 in 1000 was possible with this instrument. It was one of the fastest to use but was the most expensive to construct. Being flexible, it could be used for levelling two points not in sight of each other - a common problem in building construction.

The line level was cheap to make, very easy to transport and a very quick means of laying out contours, but required three operators.

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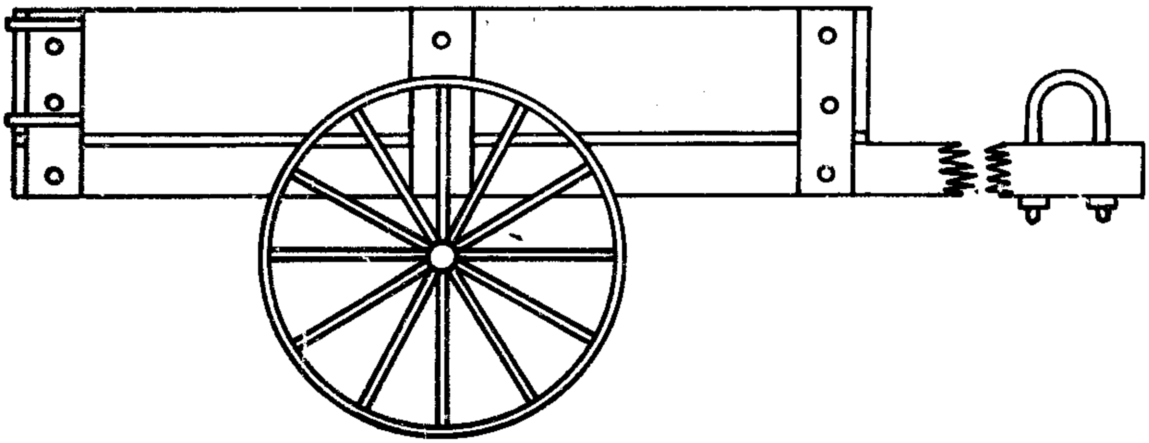


THE "WANANCHI" OX-CART

intermediate technology Development Group Ltd
Parnell House, 25 Wilton Road, London SW1V 1JS.
Telephone 01-828 5791-4

"WANANCHI" OX-CART

DEVELOPED BY: Originally designed by Rev. V. Swenson of Singida Mission and later developed further at T.A.M.T.U., Tanzania.

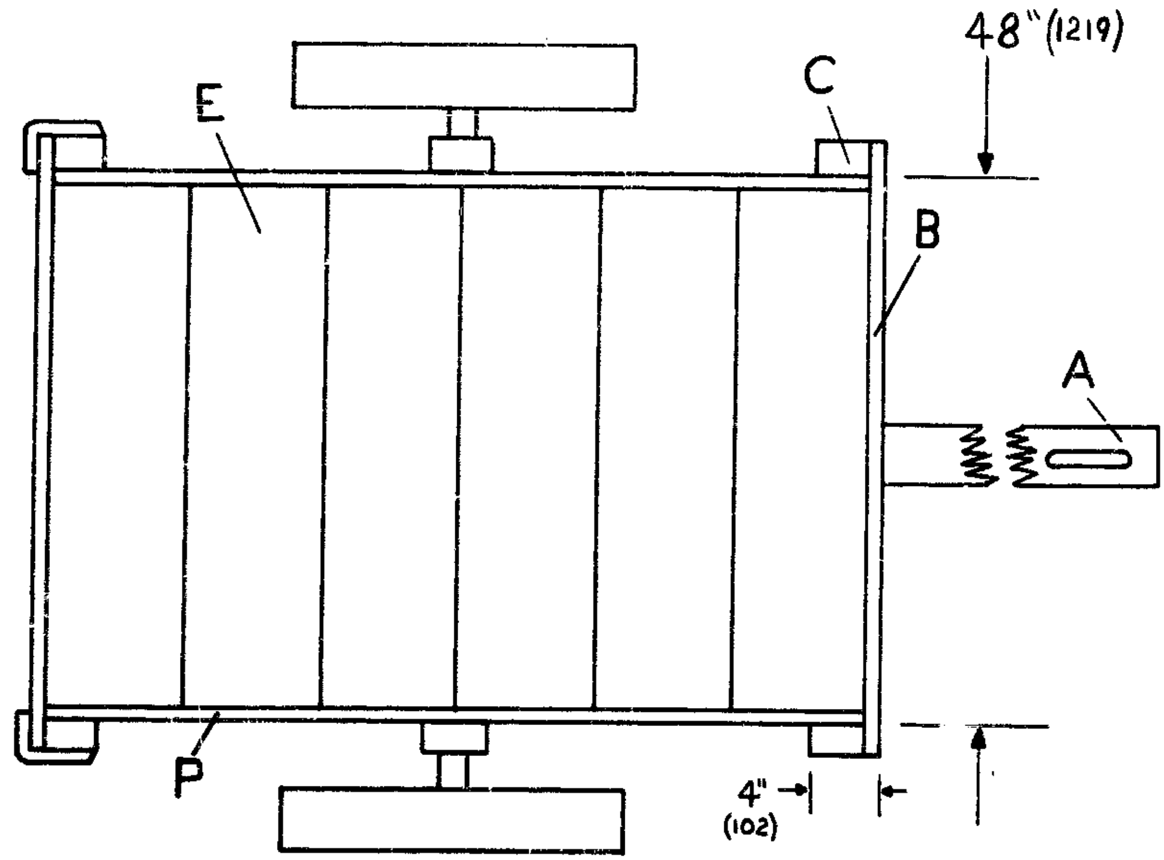
DESCRIPTION: Built to carry a load of 1400 lbs. (636 kg), pulled by two oxen. An important design feature of this cart is the wood-block axle bearings, each made of two pieces of wood, oil-impregnated by soaking in hot oil, the axle bearing hole of 1½" (38) diameter being drilled centrally through the blocks. This bearing design facilitates ease of maintenance and renewal of the bearings by carpenters in rural areas.

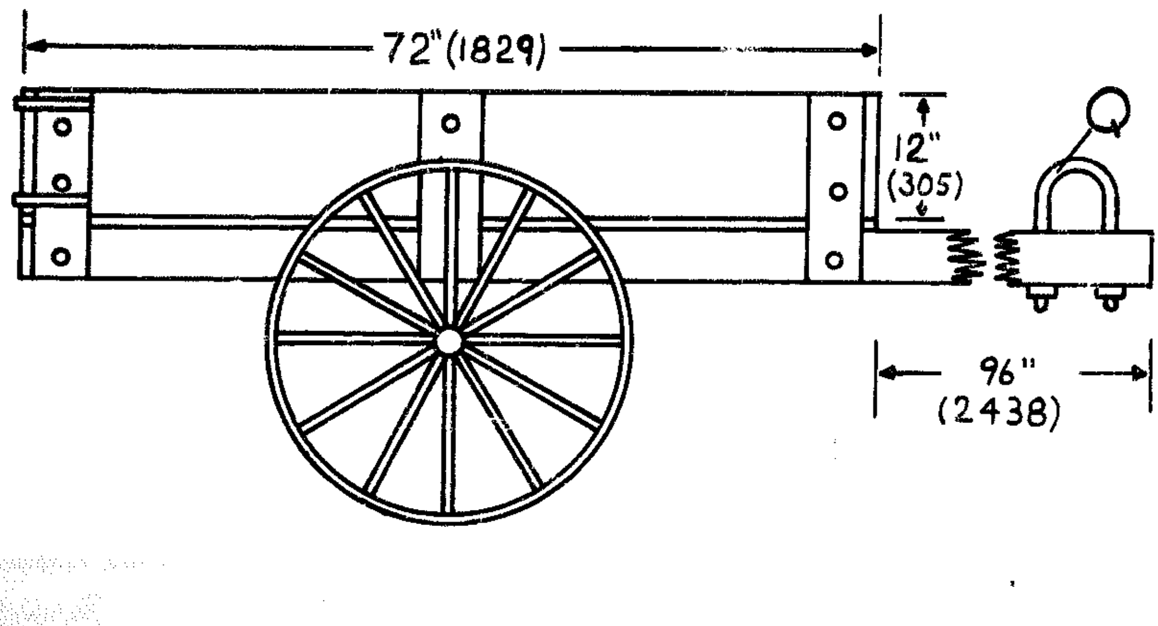
Each of the wheel assemblies is an integral unit, the wheel spokes welded to the axle shaft.

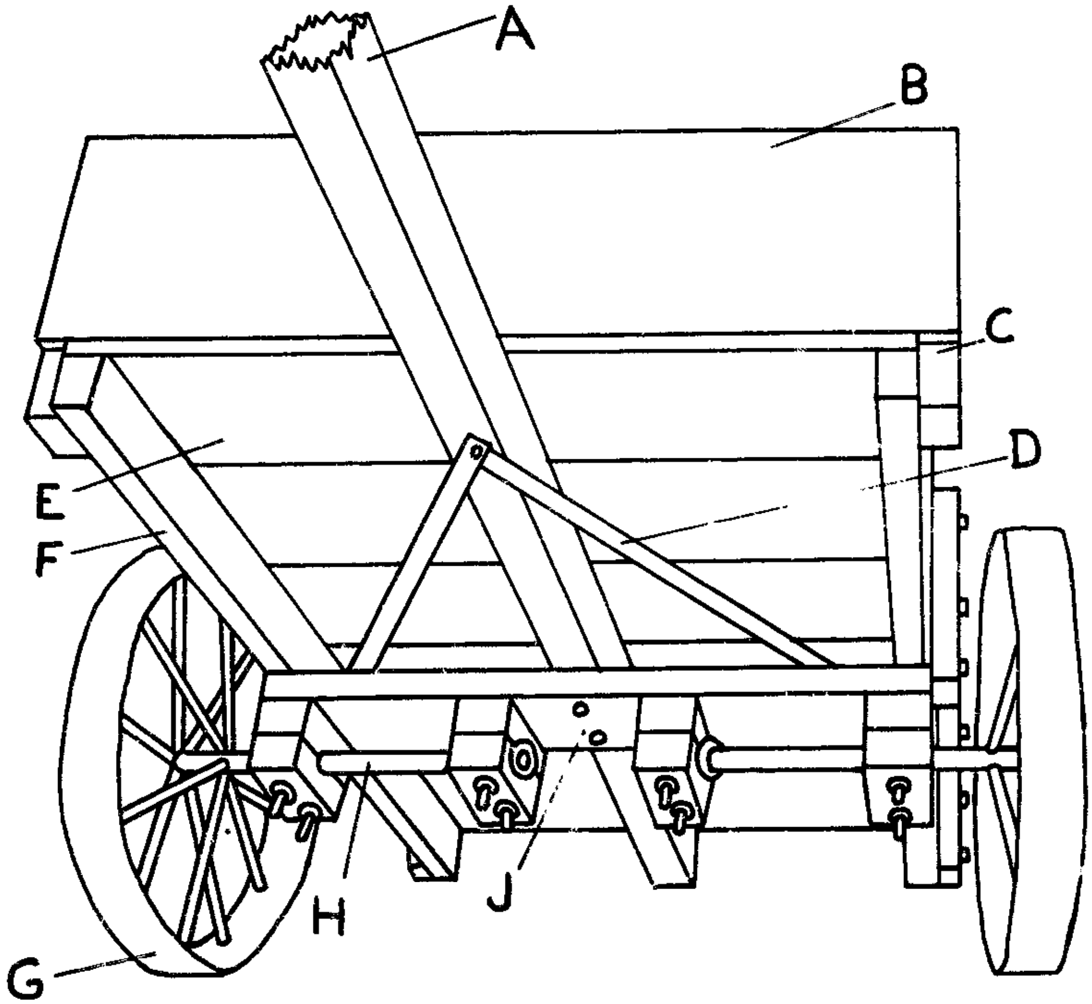
Note: Figures in brackets are in millimetres.

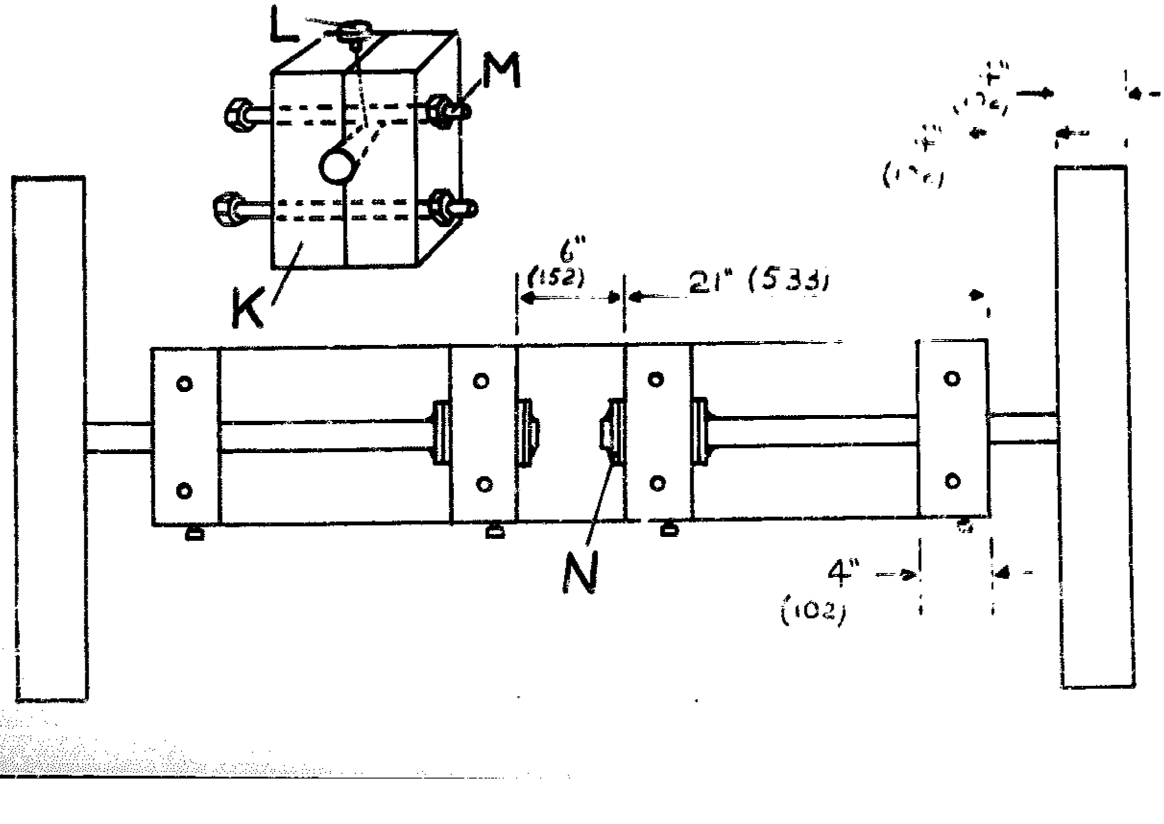
KEY:

ITEM	NAME	QUANTITY	ITEM DESCRIPTION
A	SHAFT	1	Of 4" x 4" x 168" (102 x 102 x 4267) soft wood, or a termite-resistant bush pole can be used instead.
B	FRONT/BACK BOARD	2	Of 1" x 12" x 52" (25 x 305 x 1321) soft wood.
C	SIDE SUPPORT	6	Of 2" x 4" x 17" (51 x 102 x 432) hard wood.
D	SHAFT BRACE	2	¼" x 1½" x 36" (6.3 x 38 x 914) mild steel.
E	FLOOR BOARD	6	Of 1" x 12" x 48" (25 x 305 x 1219) soft wood.
F	CHASSIS MEMBER	2	Of 2" x 4" x 72" (51 x 102 x 1829) hard wood.
G	WHEEL ASSEMBLY	2	Wheel rims of 4" x ⅜" (102 x 9.5) mild steel, 30" (762) diameter, with ¾" (19) diameter spokes of mild steel bar, 12 spokes per wheel.
H	AXLE	2	Each of 30" (762) x 1½" (38) diameter mild steel bar.
J	AXLE BEARING PLATE CHASSIS CROSS MEMBER	1	Of 2" x 10" x 48" (51 x 254 x 1219) hard wood.
K	WOOD-BLOCK BEARING	4	Each bearing consists of two pieces of hard wood 3" x 4" x 10" (76 x 102 x 254).
L	GREASE CUP	4	Of screw-type design.
M	BEARING BOLTS	8	10" (254) long x ½" (12.5) diameter mild steel.
N	FLAT WASHER	8	Of 1½" (38) inner diameter, in pairs each side of inner bearings to locate axles. Inner washers free to rotate and outer washers welded to axle.
P	SIDE BOARD	2	Of 1" x 12" x 70" (25 x 305 x 1778) soft wood.
Q	YOKE HITCH	1	'U' bolt of ½" (12.5) diameter mild steel.

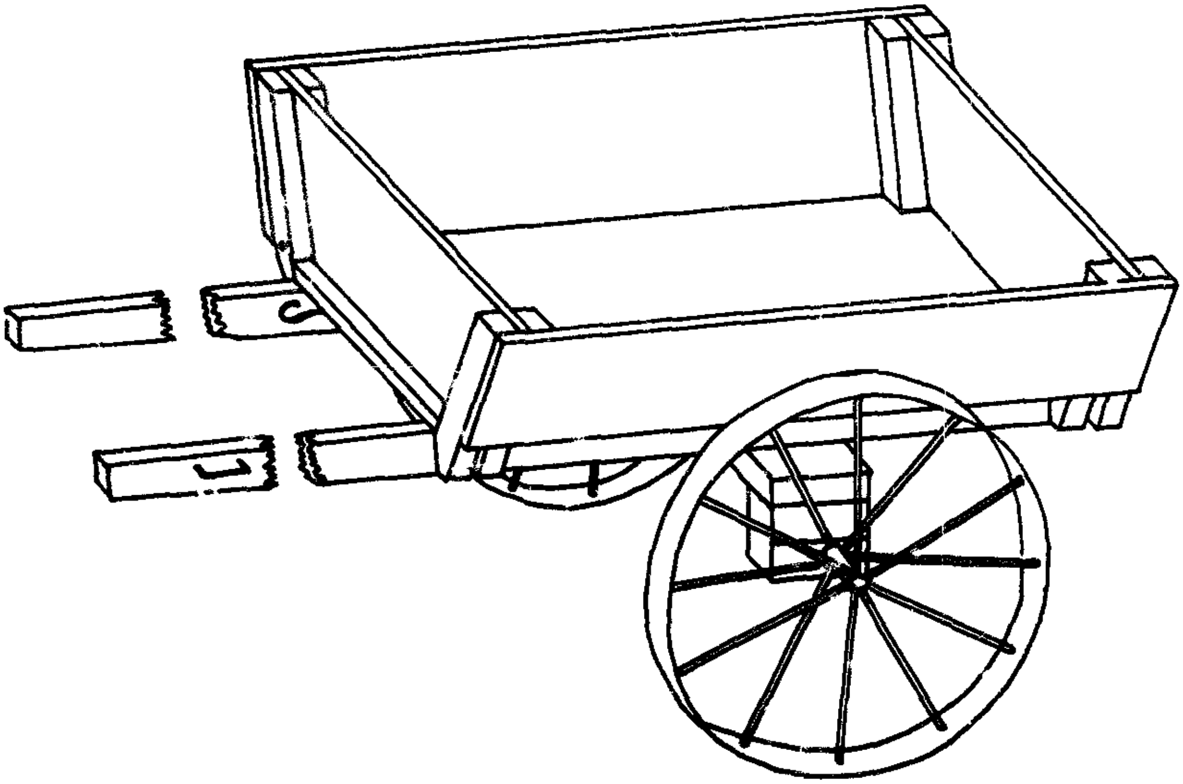

48"(1219)
E
C
B
A
P
4"
(102)


72"(1829)
12"
(305)
Q
96"
(2438)


A
B
C
D
E
F
G
H
J


L
M
K
6"
(152)
21" (533)
N
4"
(102)

No. 44B



CART FOR ONE DRAUGHT ANIMAL

intermediate technology Development Group Ltd
Parnell House, 25 Wilton Road, London SW1V 1JS.
Telephone 01-828 5791-4

CART FOR ONE DRAUGHT ANIMAL

DEVELOPED BY: J. Wirth, Engineer at the Tanzania Agricultural Machinery Testing Unit, Tanzania.

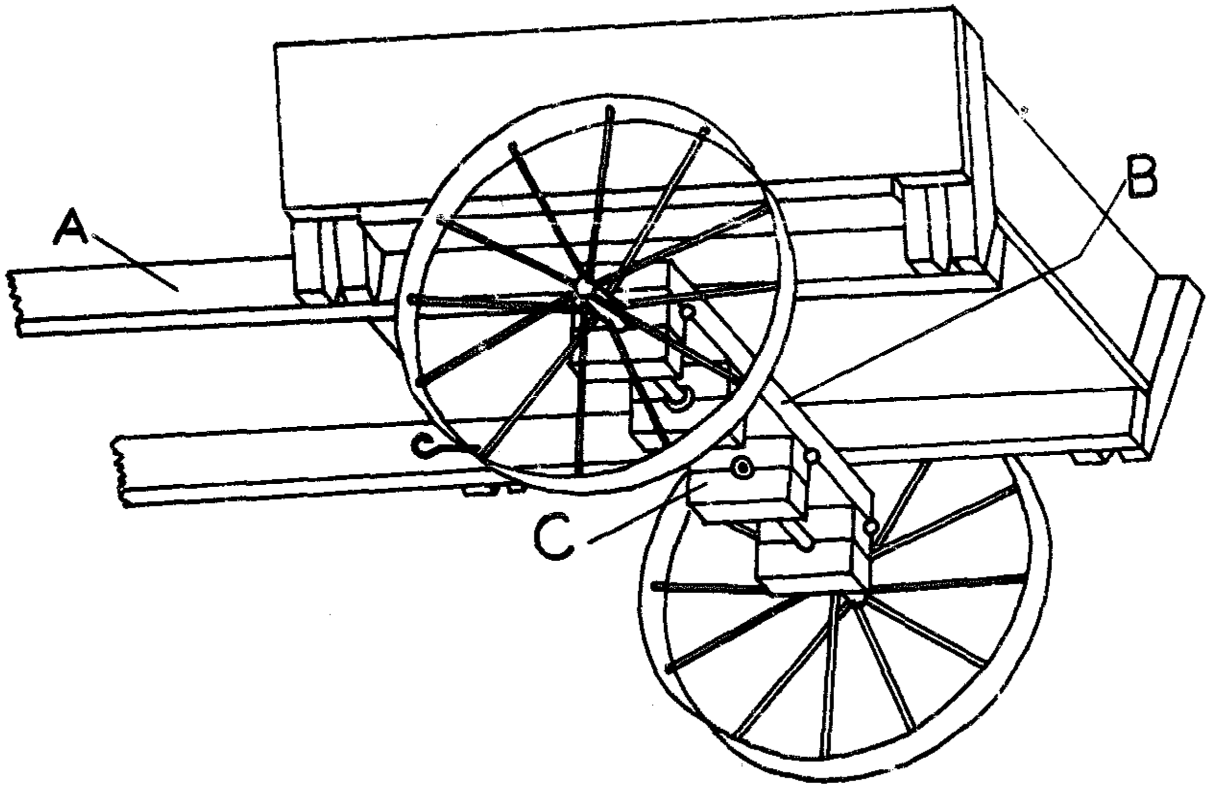
DESCRIPTION: Designed to carry a load of 700 lbs (318 kg), pulled by a single ox or donkey. The wood-block axle bearings fitted underneath the cart body are oil-impregnated by soaking in hot oil before drilling and assembly.

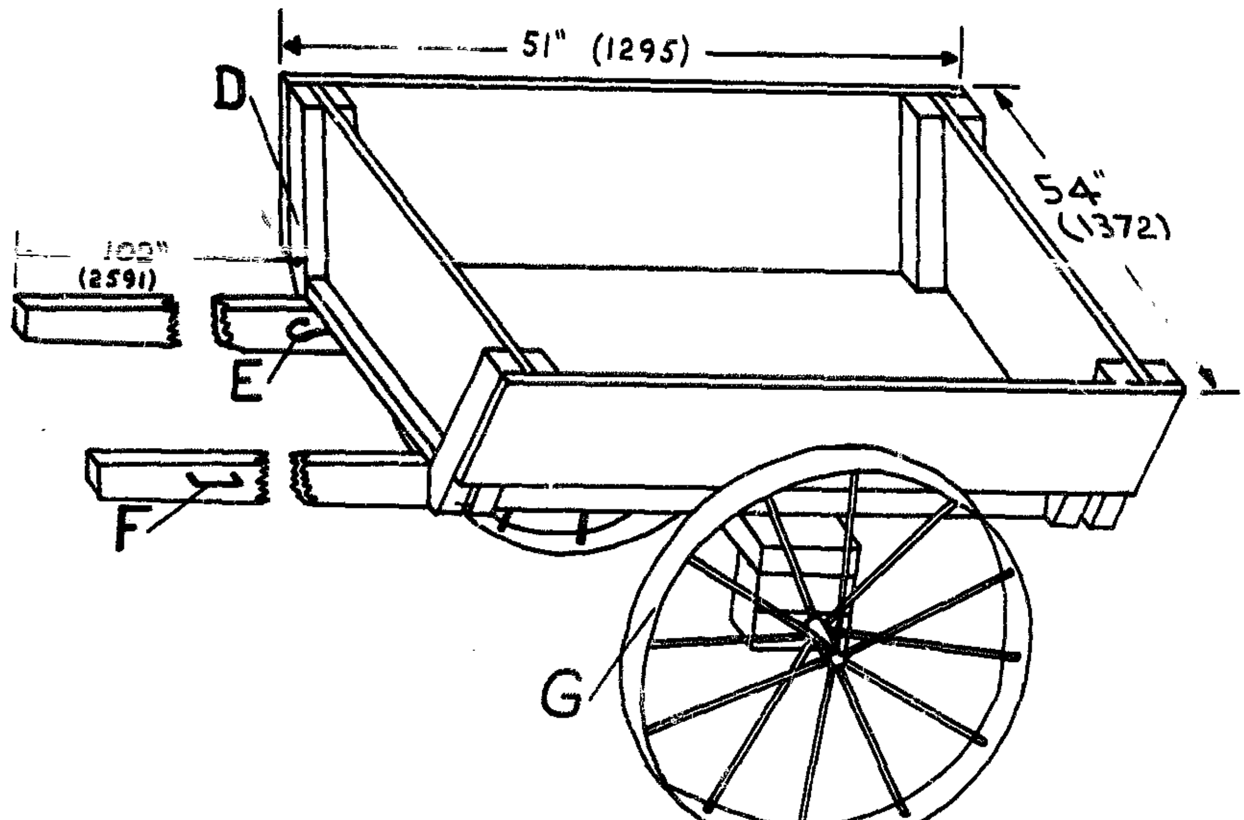
Both the front and back boards of the cart body are removable. The cart shafts can be made of tubular metalpipe instead of timber if extra strength is found necessary.

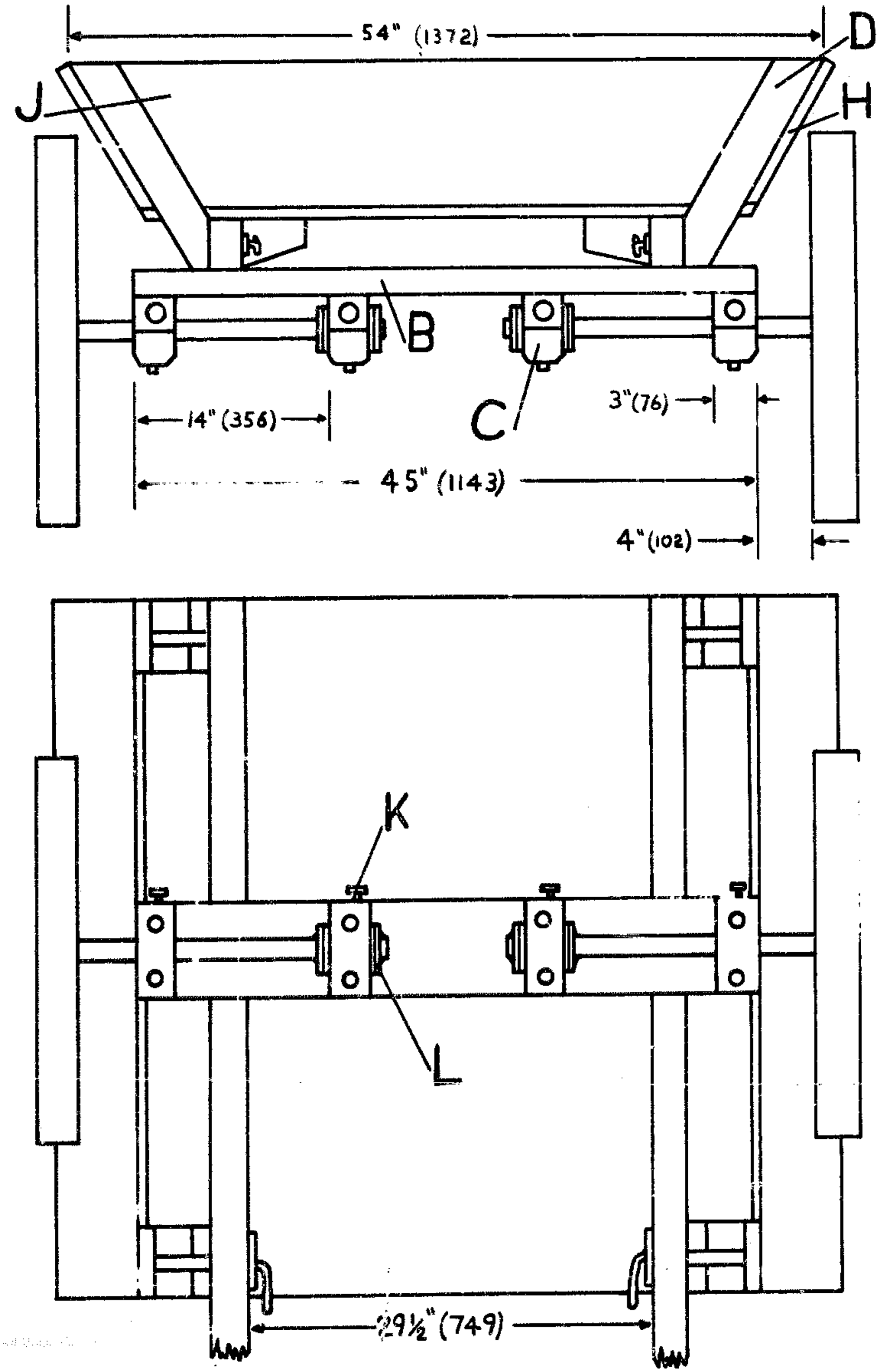
Note: Figures in brackets are in millimetres.

KEY:

ITEM	NAME	QUANTITY	ITEM DESCRIPTION
A	SHAFT/CHASSIS MEMBER	2	Of 2½" x 3½" x 153" (64 x 89 x 3886) wood. Shaft length can be varied to suit animal size.
B	AXLE BEARING PLATE/CHASSIS	1	Of 7" x 2" x 45" (178 x 51 x 1143) hard wood.
C	WOOD-BLOCK BEARING	4	Each bearing consists of two pieces of hard wood 2½" x 3" x 7" (64 x 76 x 178) with a 1¼" (32) diameter hole drilled centrally for the axle.
D	CORNER SUPPORT	8	Of 2" x 3" x 18" (51 x 76 x 457) hard wood.
E	DRAUGHT HOOK	2	Made from ½" (12.5) diameter mild steel bar.
F	HARNESS EYE	2	Made of ⅜" (9.5) diameter mild steel bar, bolt-heads countersunk on inside of shafts.
G	WHEEL AND AXLE ASSEMBLY	2	All parts of mild steel: wheel rims of 3" x ⅜" (76 x 9.5) 28" (711) in diameter; spokes of ½" (12.5) diameter bar, 12 spokes per wheel. Axle of 1¼" (32) diameter, 25" (635) long.
H	SIDE BOARD	2	Of 1" x 12" x 51" (25 x 305 x 1295) soft wood.
J	FRONT/BACK BOARD	2	Of 1" x 10½" x 54" (25 x 267 x 1372) soft wood.
K	GREASE CUP	4	Of screw-type design.
L	FLAT WASHER	8	Of 1¼" (32) inner diameter, in pairs each side of inner bearings to locate axles, inner washers free to rotate and outer washers welded to axle.

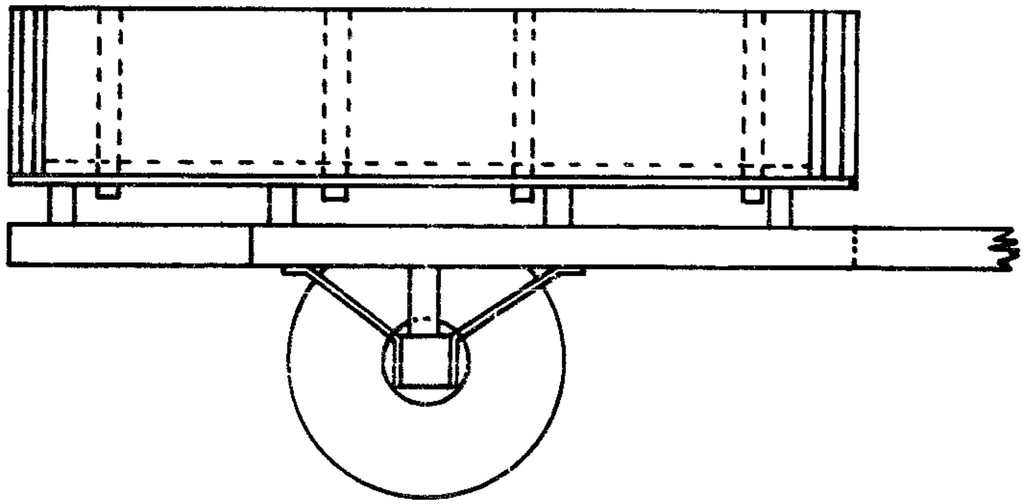

A
B
C


51" (1295)
54"
(1372)
D
102"
(2591)
E
F
G



54" (1372)
D
J
H
B
C
14" (356)
3"(76)
45" (1143)
4"(102)
K
L
29½" (749)

No. 44C



OX-CART USING OLD CAR WHEELS

Intermediate Technology Development Group Ltd
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OX-CART USING OLD CAR WHEELS

DEVELOPED BY: Rev. L.H. Robertson, Mlanje, Malawi.

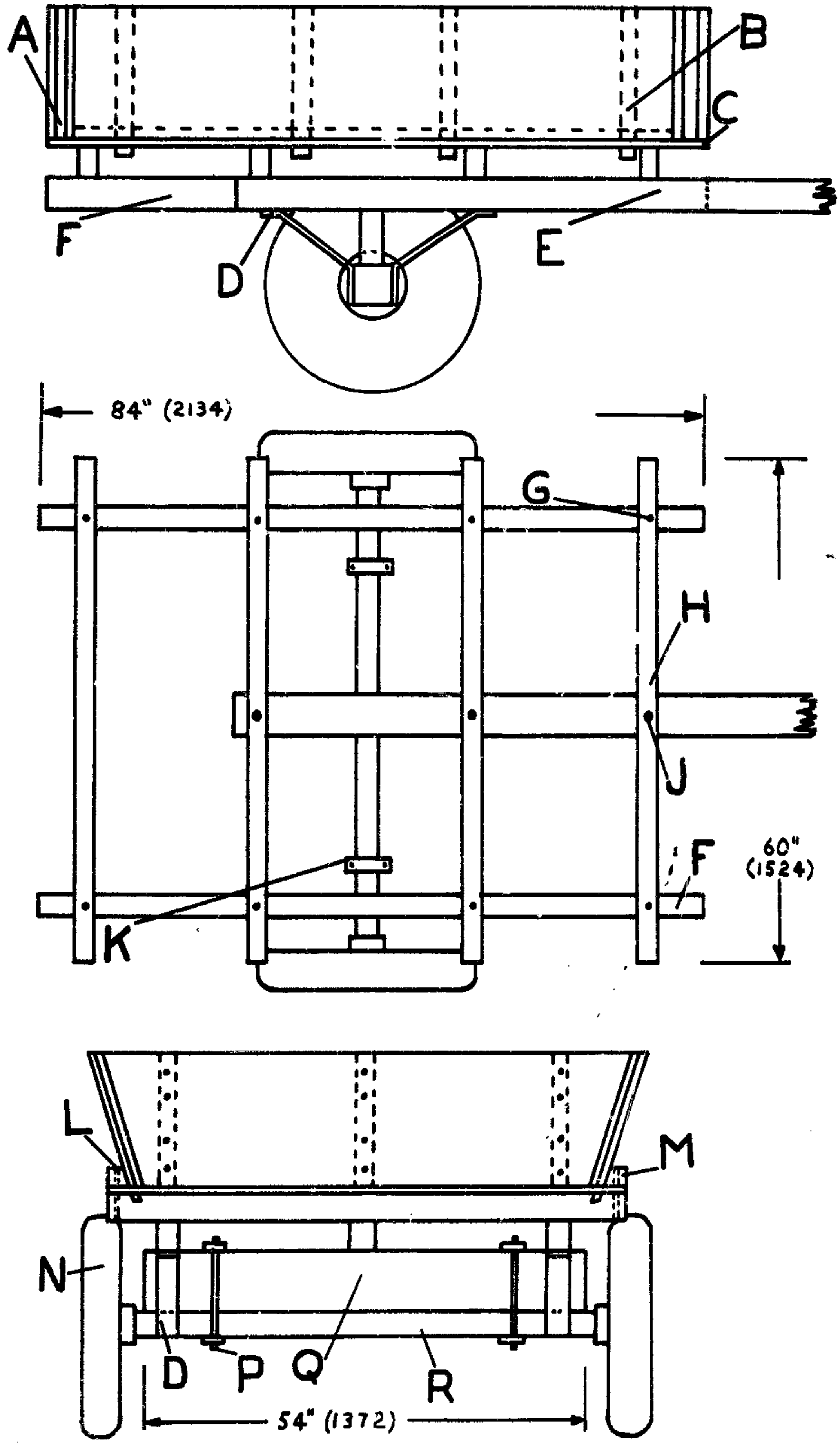
DESCRIPTION: This cart makes use of the front wheels from an old car or lorry, the wheel mountings being cut off and welded on to a box-section axle fabricated from angle iron. A car rear axle complete with differential can be used, but this adds unnecessary bulk and weight to the cart.

The cart chassis and body are constructed of wood, all parts being bolted together. The body side and end boards are made of planks ¾" (19) in thickness, and are detachable.

Note: Figures in brackets are in millimetres.

KEY:

ITEM	NAME	QUANTITY	ITEM DESCRIPTION
A	SLOT	4	Slots to provide for removal of end boards formed with 2" x 1" (51 x 25) wooden slats.
B	STAKE/RIB	14	2" x 1" (51 x 25) hard wood, of appropriate length to suit required height of cart sides.
C	FLOOR BOARD	5	Of ¾" x 12" x 84" (19 x 305 x 2134) soft wood.
D	BRACE	4	Of 2" x ½" x 16" (51 x 12.5 x 406) mild steel.
E	SHAFT	1	Of 4" x 4" (102 x 102) sawn timber, or a termine-resistant bush pole can be used instead.
F.	CHASSIS MEMBER	2	Of 4" x 2" x 84" (102 x 51 x 2134) hard wood.
G.	CHASSIS BOLT	8	Of ⅜" (9.5) diameter mild steel, 8" (203) long.
H	CHASSIS CROSS MEMBER	4	Of 3" x 2" x 60" (76 x 51 x 1524) hard wood.
J	SHAFT BOLT	3	Of ½" (12.5) diameter mild steel, 8" (203) long.
K	CLAMP PLATE	4	Of 2" x 4" x ½" (51 x 102 x 12.5) mild steel.
L	RIB SUPPORT BOLT	8	Of ⅜" (9.5) diameter mild steel, 6" (152) long.
M	SLIDE RIB SUPPORT	2	Of 1½" x 1½" x 84" (38 x 38 x 2134) hard wood.
N	WHEEL	2	Front wheels from an old vehicle.
P	AXLE CLAMP BOLT	4	Of ½" (12.5) diameter mild steel, 12" (305) long.
Q	AXLE SUPPORT MEMBER	1	Of 8" x 2" x 54" (203 x 51 x 1372) hard wood.
R	AXLE	1	Two pieces of 2" x 2" (51 x 51) angle iron, 54" (1372) long, welded together to form box section angle.


A
B
C
F
D
E
84" (2134)
G
H
J
F
K
60"
(1524)
L
M
N
D
P
Q
R
54" (1372)