

## **Training Manual**

### **Hand Rope Pump, P – Model**

#### **Module 1: Production**



*June 2006, Chibombo, Zambia*



*July 2006, Chimoio, Mozambique*

## **Arrakis**

**September 2006**

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## **1 Introduction**

This training manual is made as an aid for Technicians which were trained in the Production, Installation and Operation & Maintenance (O&M) of the PI model rope pump model as introduced in Mozambique, Zambia and India, in 2005 and 2006, by Jan de Jongh of Arrakis and Henk Holtslag of Practica-Foundation.

The manual is to be distributed to the participants, who can use it as a reference handbook.

Experiences indicate that for a successful production and installation of rope pumps on a large scale, the use of this manual has to be combined with hands on training by an experienced trainer.

The Manual has a modular set up, aimed at different functions which may be executed by the same group or separate groups.

E.g. a workshop might be involved in production, installation plus O&M, but could also restrict its activities to production alone.

The modules are:

- 1 Production
- 2 Installation
- 3 Operation and Maintenance



## **MODULE 1: PRODUCTION**

**This Manual describes the PI model used in Mozambique, Zambia and India, and is the latest version (version date September 2006)**

## **1.1 Introduction**

This section presents fabrication drawings, parts lists and some basic steps to be followed during production of the component parts.

### Numbering

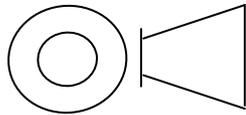
The pump drawing gives a total view of the rope pump and the main components are coded with numbers 10 to 90.

The parts of each component have additional numbers; e.g.

Pump handle is: 10 -1

### Drawing system:

The 2 –D American Projection drawing system is used following general engineering standards,



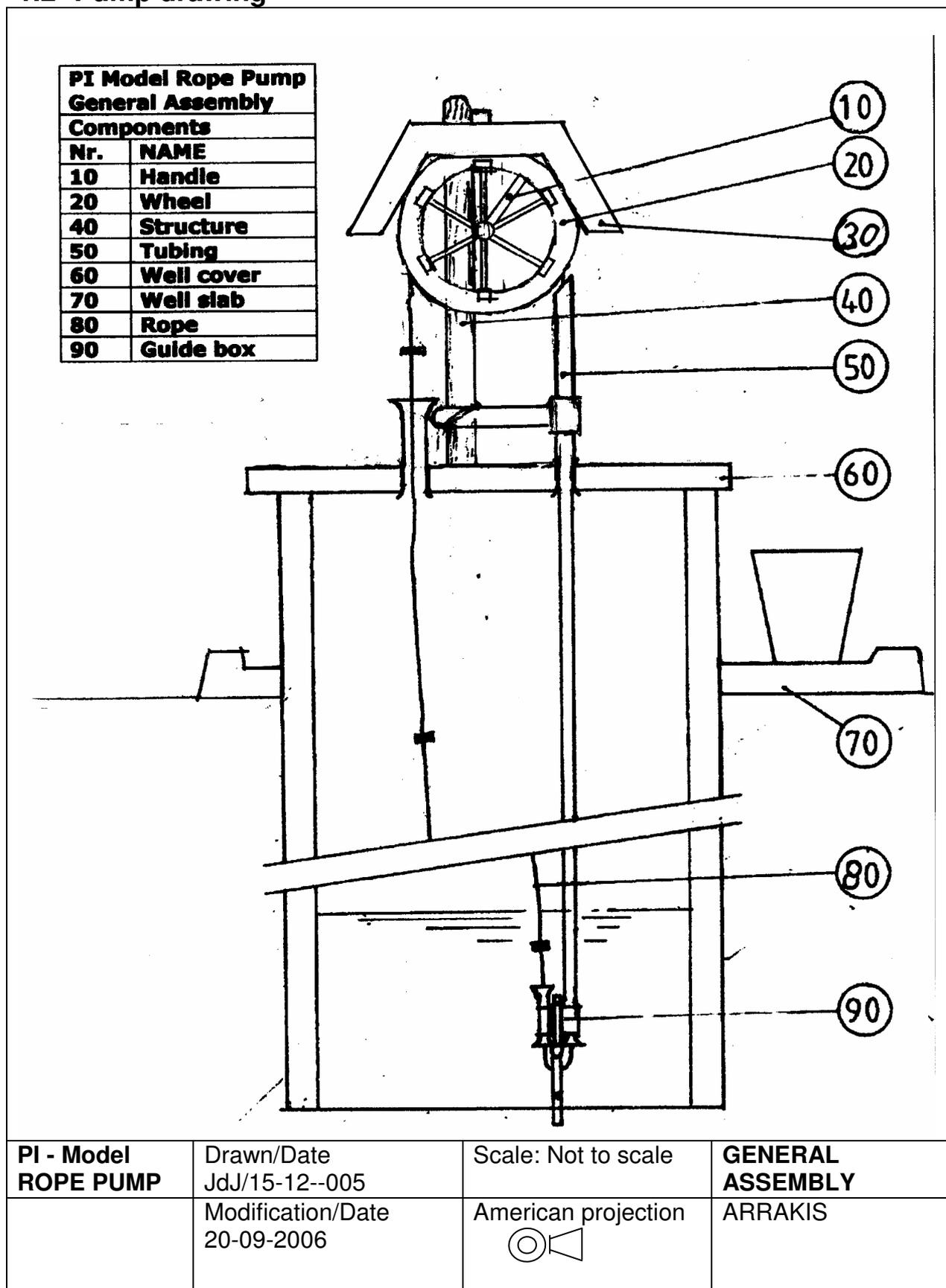
### Modifications:

The pump model version of this manual is defined by the date on the manual.

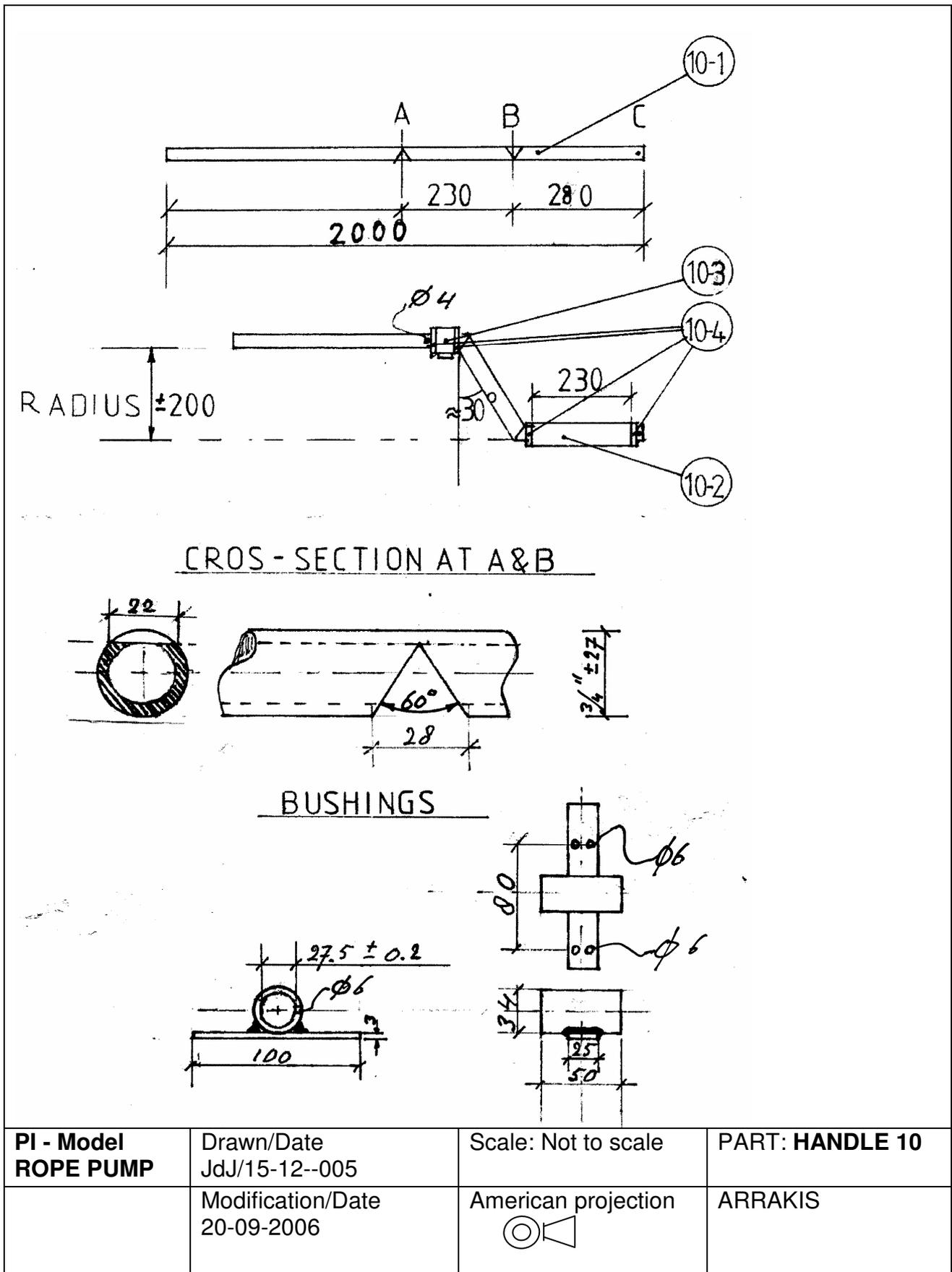
All drawings in this manual have the same date. All data given in this manual on parts, description of production steps, etc. refer to the pump model version of this date.

All eventual forthcoming, updated versions, will be documented in drawings with a new date.

## 1.2 Pump drawing



### 1.3 The Handle (10)



### Parts list Handle

Nr	Item	Material	Size	Length (mm)	Number	Remarks
10-1	Handle	Galv. pipe	3/4"	2000	1	Thickwalled pipe 3mm
10-2	Grip	PVC tube	1"	230	1	
10-3	Bushing	Galv pipe	1"	50	2	"Thickwalled" pipe 3 mm
10-4	Spacer ring	Galv pipe	1"	8	4	„
10-5	Bushing strip	Strip GI	25x3	100	2	

### Manufacturing Steps

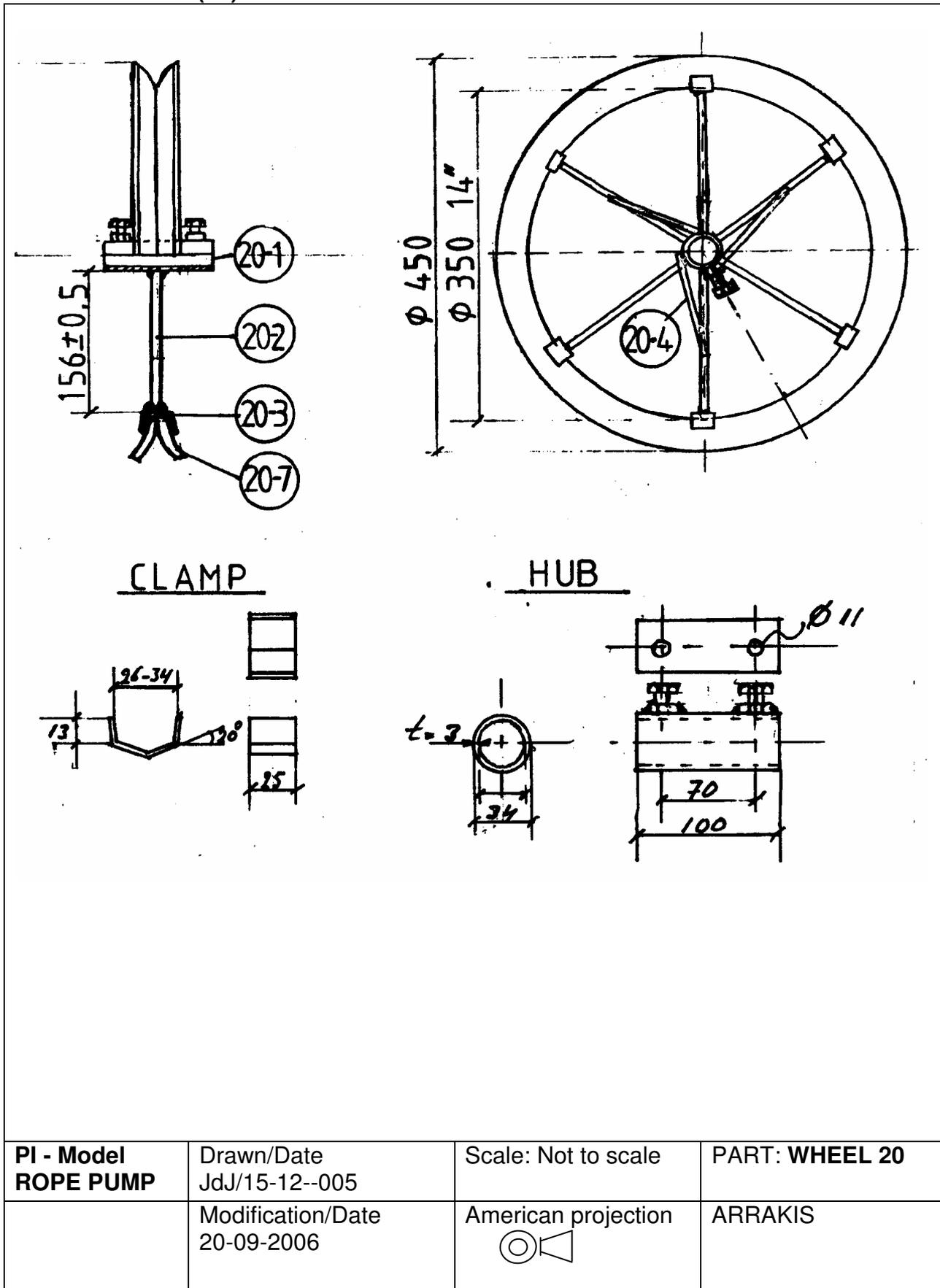
#### Handle

- 1 Cut V grooves at spots A and B.
- 3 Bend and weld; make sure that the tubes stay parallel
- 4 Weld spacer rings at point A and B with 3 spot welds, on one side

#### Bushings

- 5 Drill lubricating holes of 6 mm on top site of bushings 10-3
- 6 Make sure that clearance Tube/ Bushing does not exceed 0.5 mm  
If this is more, reduce size of bushing by cutting a piece , and tack weld again
- 7 File sharp edges, makes sure inside weld of tubes is smooth
- 8 Drill holes of 6 mm in bushing strips, 2 holes on top site, and 2 holes on bottom site.  
File off any burr.
- 9 Weld bushing strips to bushings, with filler of a piece of 6 mm bar or 3 mm welding rod. For standardized production use the jig.
- 10 Mount PVC grip tube and secure end of handle
- 11 After mounting the first bushing, add spacer ring and tack weld at three points.

1.4 The wheel (20)



PI - Model ROPE PUMP	Drawn/Date JdJ/15-12--005	Scale: Not to scale	PART: <b>WHEEL 20</b>
	Modification/Date 20-09-2006	American projection 	ARRAKIS

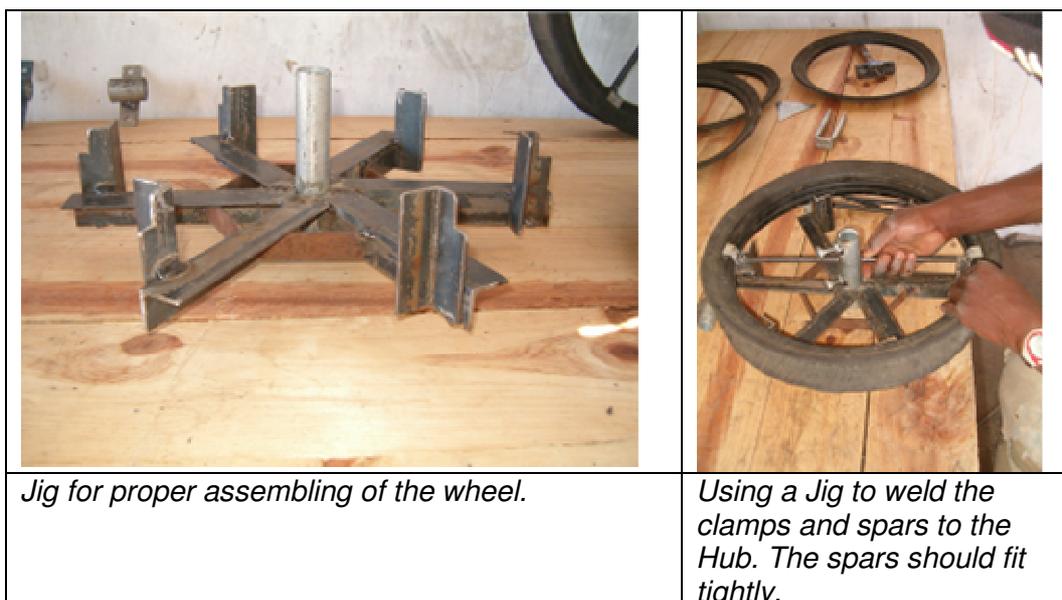
**Parts list wheel**

Nr	Part	Material	Size	Length (mm)	Amount	Observations
20-1	hub	Galv. pipe	1"	100	1	Thickwalled 3 mm
20-2	Spar	Bar,	Ø 10	156 +/- 0.5 mm	6	Depends on size of clamp , Tight fit between hub and clamp
20-3	Clamp	Strip	25x3	65	6	Depends on type of tire
20-4	Spar support	Bar	Ø 10	100	3	Optional
20-5	Nut	Galv.	M 10		2	
20-6	Bolt	Galv.	M10	25	2	
20-7	Wheel rings	Car tire	14"	45	2	

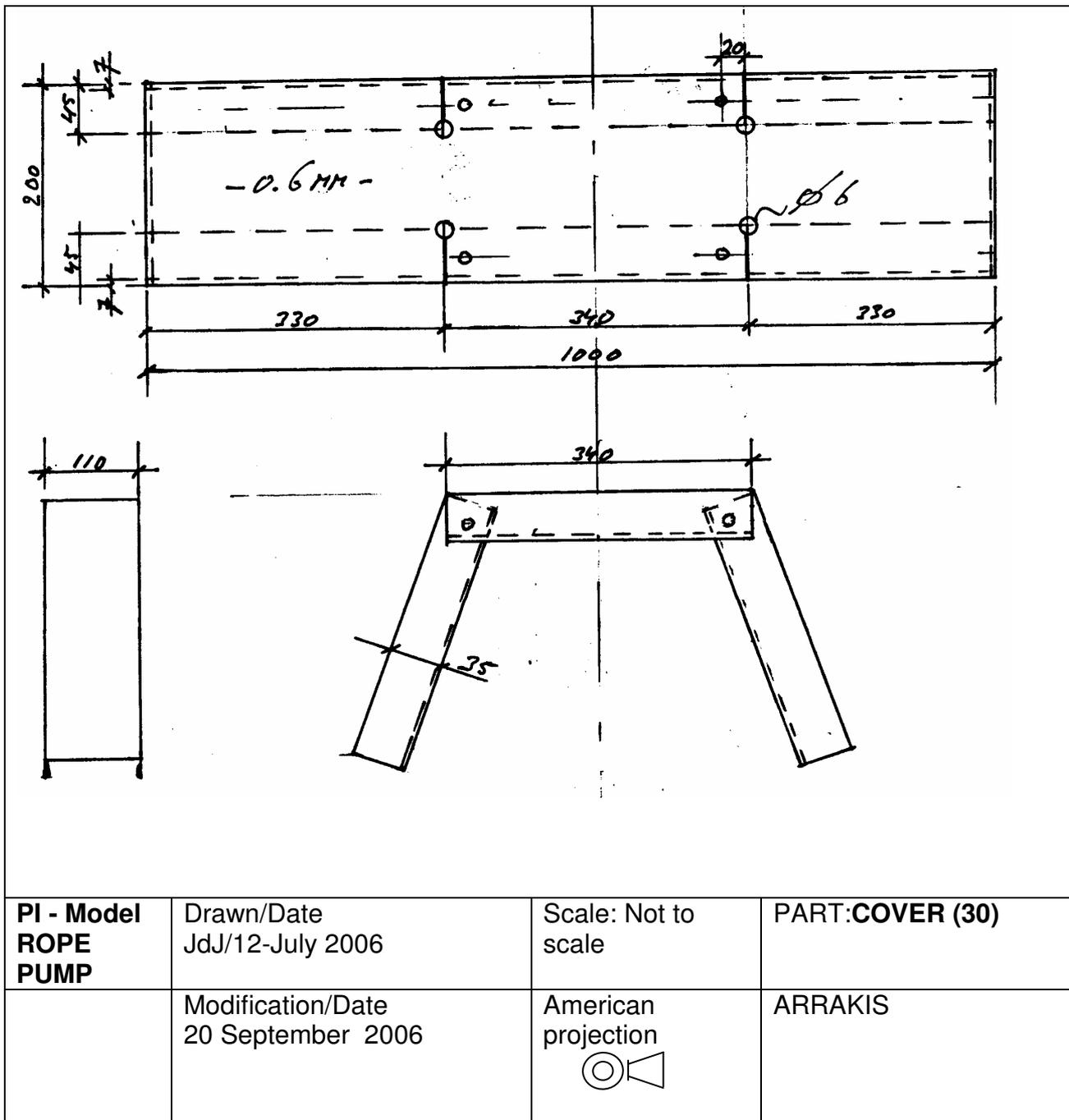
**Manufacturing steps:**

- 1 Cut all parts, tolerance +/- 1 mm, except indicated otherwise.
- 2 Cut rings 20-7 of car tire, use a compass.
- 3 Make clamps 20-3 according to shape of car tire, or cut 1 1/4" pipe through half over a length of 25 mm and make two clamps out of it.
- 4 Drill holes in hub 20-1 and weld nuts 20-5. Weld in steps to avoid damaging of thread of the bold and nut. Protect thread with grease.
- 5 Place the clamps over the wheel halves and place the hub with spars inside, then weld the spars to the clamps.
- 6 Weld the spar supports to the spars and hub.

To reduce labour time and to obtain better quality it is advised to use a jig.



1.5 The Cover for Hand dug wells (30)



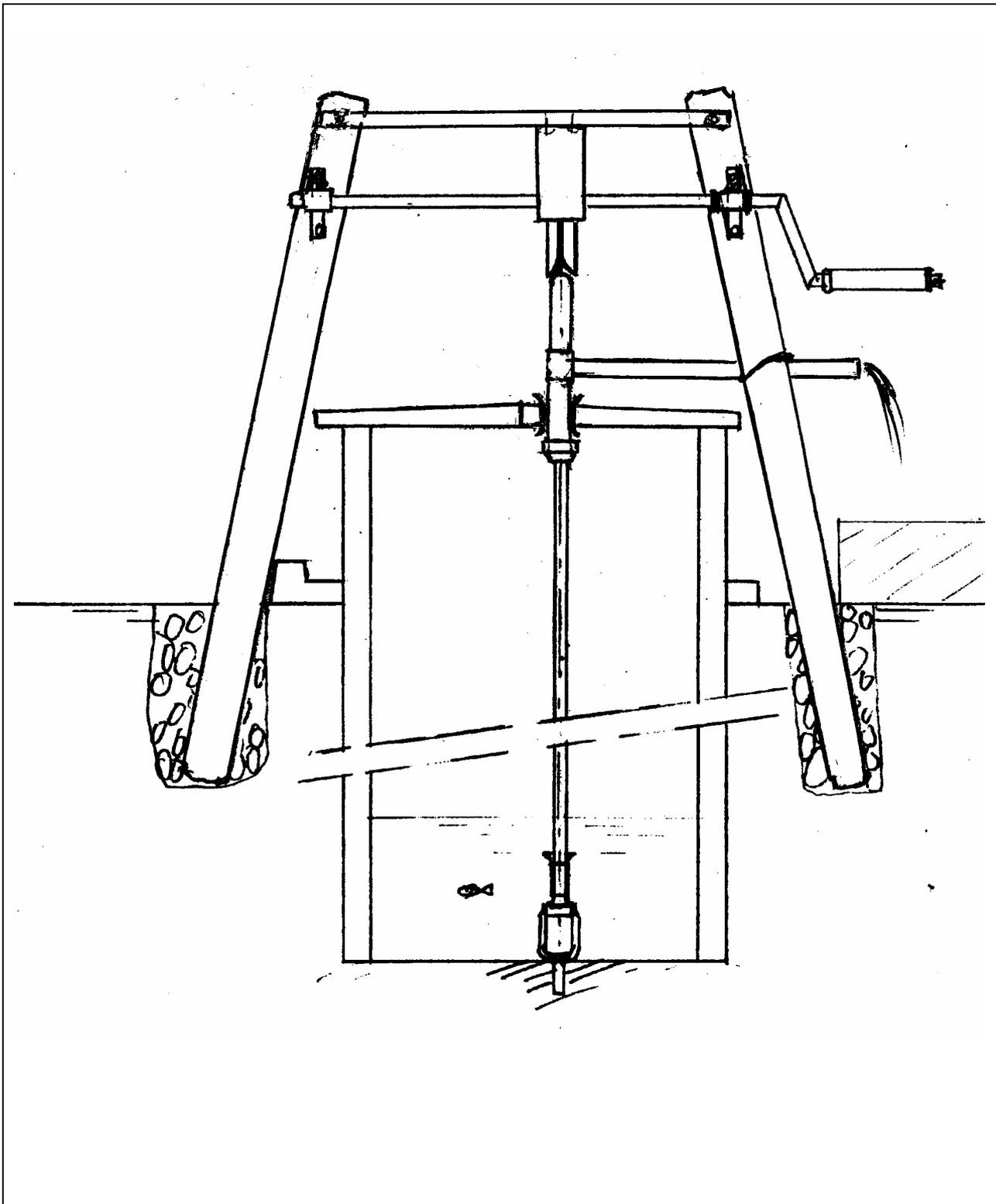
### Parts list

Nr	Item	Material	Size	Length (mm)	Number	Remarks
30-1	Cover p	Galv. sheet	1 mm	1000x200	1	* if 1 mm is not available, than minimally 0.6 mm is allowed.
30-2	Rivets	steel	Ø 3 mm	25 mm	8	

### Manufacturing steps

- 1 Cut the plate, file sharp edges
- 2 Drill 4 crack arrestor holes of 6 mm, at end of cutting lines.
- 3 Drill 4 holes of 3 mm (the rivet size), as indicated on top view
- 4 Fold the cover in shape at the dotted lines
- 5 Make the wooden cover support between the 2 poles
- 6 Mount cover on the support with 2 galvanised nails
- 7 Connect cover sides with rivets
- 8 Drill additional holes for another 4 rivets
- 9 Mount the rivets

1.6 The pump structure for Hand dug wells (40)



<b>PI - Model ROPE PUMP</b>	Drawn/Date JdJ/15-12—005	Scale: Not to scale	<b>PART:PUMP STRUCTURE 40</b>
	Modification/Date 12-July 2006	American projection 	ARRAKIS

## **Parts list pump structure**

The pump structure consists of two wooden poles of ca 3 a 4 m long and 10 cm thick on top site. The poles are placed inclined towards each other, to reduce the distance for the handle.

These poles are placed in dug out holes between 0.5 to 1 m deep, depending on soil type.

The holes are filled up with stones and sand.

**Remark:** depending on the height of the well rim and placing of the handle, a platform may be required to reach belly height of the handle.

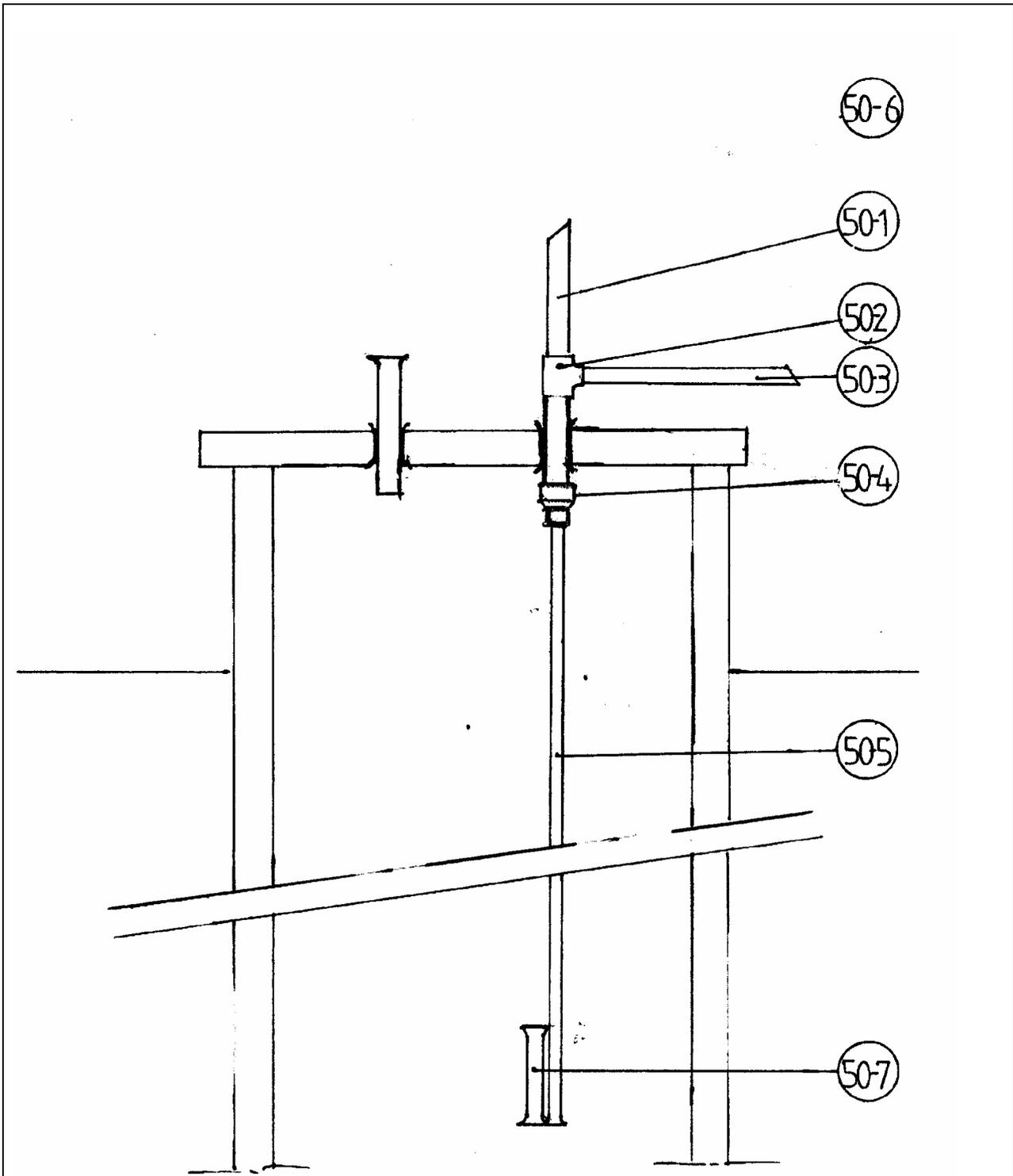
## **The pump structure for Borehole Wells**

The pump structure consists of two wooden poles of ca 2.5 to 3 m long and 10 cm thick on top site. The poles are placed vertically at a distance of 0.5 m., to make the handle as short as possible. The total pipe length to make the handle is now reduced to 1 m (instead of 2 m.)

These poles are placed in dug out holes between 0.5 to 1 m deep, depending on soil type.

The holes are filled up with stones and sand.

### 1.7 The tubing (50)



<b>PI - Model ROPE PUMP</b>	Drawn/Date JdJ/15-12--005	Scale: Not to scale	<b>PART: TUBING 50</b>
	Modification/Date 20-09-2006	American projection 	ARRAKIS

## 1.8 Selection of pump tubing

Diameter of the tubes depends on total elevation

**Elevation means distance between water level and outlet.**

**The elevation should be measured or estimated for the worst situation which is at the end of the dry season after some time of continuous pumping.**

### Recommended diameter of the Pump tube (or pump) tubes:

Elevation	0 - 5 meter	Tubes (inside diameter)	40 mm (1½ Inch)
"	5 - 10 meter	"	30 mm (1 Inch)
"	10 - 20 meter	"	23 mm (¾ Inch)
"	20 - 35 meter	"	18 mm (½ Inch)
"	35 - 60 meter	"	18 mm (½ Inch) Double handle

At the top, the top tube and outlet tube diameter should be one size bigger or double the diameter of the pump tube tube. The outlet tube should be fixed to the pump structure or another fixed point.

<b>Parts list tubing</b>		<b>For 10 m elevation</b>			
<b>Nr</b>	<b>Item</b>	<b>Material</b>	<b>Size</b>	<b>Length (m)</b>	<b>Number</b>
50-1	Top-tube	PVC tube	1 ½ "	Ca. 0.5 m	1
50-2	T-joint	PVC tube	1 ½ "	-	1
50-3	Outlet tube	PVC tube	1 ½ "	1 .5 m	1
50-4	Reducer	PVC	1 ½ - 1"	-	1
50-5	Pump tube (or rising main)	PVC tube	1 "	6 m	2
50-6	Return tube	PVC tube	1 ½ "	Ca 0.3 m	1
50-7	Return inlet	PVC tube	1 ½ "	0.3 m	1

### Manufacturing steps.

Normally the pump is mounted during the installation

Preparations are

- 1 Make flares at lower end of pump tube 50-5 and upper end of return inlet tube 50-7.
- 3 Make sure all PVC tubes have good connections (see installation part)
- 4 Make sure guide box tubes are mounted
- 5 Select top-tube, T-piece and reducer

## 1.9 Construction of well cover for hand dug well (60)

The well cover can be made, either in 2 halves, or in one conically shaped cover with a small square lid for installation and maintenance purposes.



*The mould is made, and tubes should be properly positioned.*



*Some reinforcement bars 6 mm plus wire should be placed. Not yet completed at the picture.*

Prepare cement and put it in the form of the well cover  
Standard diameter of cover is 1.20 m, but depending on well dimensions it could be taken different.



**Important:** The finished well cover should be left unused for about minimally one week for the cement to cure. The cover should be kept wet, continuously!

## 1.10 Rope with pistons (80)

### Rope

Polypropylene (PP) rope gives the best results.

Nylon can also be used, it is stronger than PP rope but it tends to “slide”. To avoid slipping it can be roughened with a stone or hacksaw. Also the wheel V groove can be roughened with a hack saw.

Rope length : twice the depth of the well, + 3 meters , + 5% (for the knots)

Rope thickness: For wells up to 35 m. the rope should preferably be 6 mm, but 5 mm is allowed as well. For wells deeper than 35 meter, it is recommended to use rope of 6 mm.

### Pistons

Pistons can be made of different materials but most common are Rubber or PE.

Rubber pistons can be made out of the side part of the car tire used to make the wheel. The rubber should not be too thick, maximum 4 mm, to be able to cut it with a knife or scissors.

Diameter of new pistons should be maximally 0.5 mm less than the inside diameter of the pump tube.

It is important that the hole is in the middle!

A special marker tool can be made to mark the piston, and keeping the hole in the middle.

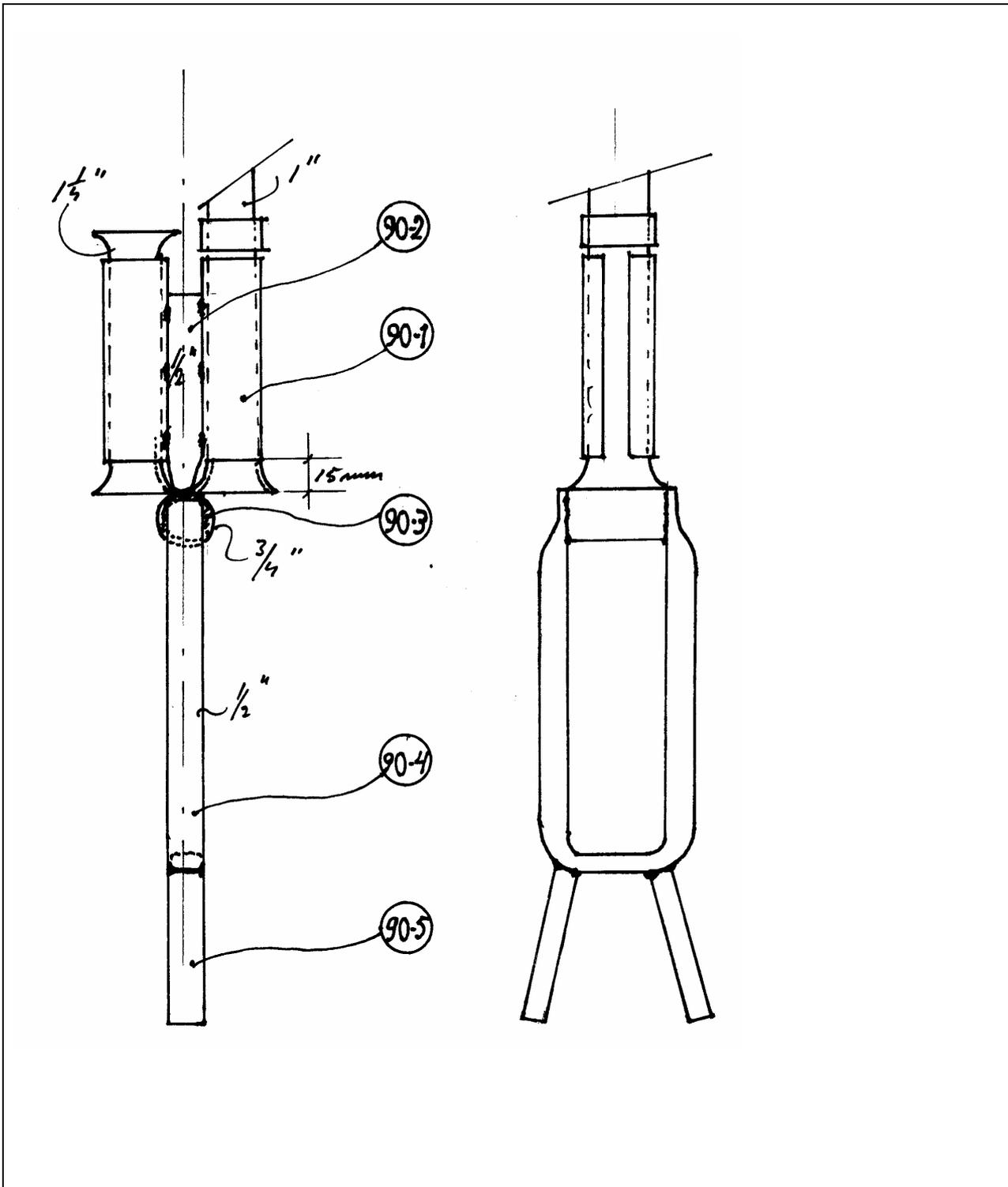


Piston made of rubber and a tool (a punch) to make standardized pistons

### Mounting of Pistons

- Number of pistons: sufficient for the complete rope placed at every one (1) meter.
- Pistons can be fixed to the rope with two knots.

1.11 Guide box for Hand Dug Well (90)



<b>PI - Model ROPE PUMP</b>	Drawn/Date JdJ/15-12--005	Scale: Not to scale	PART: <b>GUIDE BOX 90</b>
	Modification/Date 20-09- 2006	American projection 	ARRAKIS

**Parts list guide box based on a 1" pump tube tube.  
The indicated parts change with changing pump tube diameter**

Nr	Item	Material	Size	Length (mm)	Number	Observations
90-1-A	Tube clamp for pump tube	Galv. pipe	1 "	80	1	Depending on size of pump tube*
90-1-B	Tube clamp for return tube	Galv pipe	1 1/4"	80	1	Depending on size of pump tube*
90-2	Connect pipe	Galv Pipe	1/2 "	80	1	Flattened at the end
90-3	Rope guide	Galv pipe	3/4 "	45	1	
90-4	Rope container	Galv pipe	1/2 "	400	1	
90-5	Bottom connector	Galv pipe	1/2 "	100	2	

- Size of clamps are according to size of pump tube
- In case of 1" tubes, tube clamp for return tubes should be 1 1/4 " as in table.
- In case of 3/4" tubes, tube clamps for return tubes should be 1 "
- In case of 1/2" tubes, tube clamps for return tubes should be 3/4"

### Manufacturing steps

1 Tube clamps to be cut open and bend outwards, until PVC pipes fit. After mounting of pump tube and return tube in the clamps, the clamps can be tightened, with care, in a vice. Take care not to deform the PVC tubes in an oval shape so that the pistons cannot pass any more.

- 2 File sharp parts
- 2 Bend rope container and flatten pipe ends
- 3 Weld pipe 90-2 to rope guide
- 4 Weld rope container to rope guide
- 6 Weld tube clamps to pipe 90-2

For Boreholes with well casings of 3" or 2", the Guide boxes are slightly different, because they have to fit in the casings.

## **1.12 Painting**

To avoid corrosion, it is essential to paint the parts that have not been galvanized or where galvanization is damaged.

Steps :

- Remove all grease and oil with solvent,
- Remove all welding slack and rust with a hammer and steel brush.  
Make sure that your hands are free of grease.
- Paint first with anticorrosive primer paint. Paint the strip used for the wheel clamps.

**Allow painted objects to dry in the shade and NOT in the sun.**

When dried in the sun blisters will occur.

- After it is completely dry, paint all metal parts with finish paint (on oil basis).  
Make sure hands are free of grease during handling of objects.

Do not dilute the paint, except when it is really necessary (when the paint is too thick and can only be applied with great resistance). Use **only** paint diluter and nothing else.

Close the paint cans carefully after painting. Hold the can up side down for some time to control the closure and to let the paint inside lock the seam of the lid.

## ANNEXES

### ANNEX I Material list. One complete pump

The material list consists of 2 pages.

Table 1 contains all the parts with fixed dimensions, regardless of the pumping depth. Four tables number 2 a till 2 d contain the parts with variable dimensions, because PVC tubing for pump size and casing depends on total elevation height (from lowest waterlevel to highest outlet point).

For each of the following elevation heights, a separate table 2 is given.

<b>Elevation [m]</b>	<b>Rising main diameter</b>	<b>Table</b>
0-5	1 1/2"	2a
5-10	1"	2b
10-20	3/4"	2c
20-35	1/2"	2d

Table 1	TOTAL MATERIAL LIST	For PI Hand Rope Pumps				Total	Remarks
		Parts with fixed dimensions					
Nr. Sub	Part	Material	Size	Part	Nr	Net Length	
assembly				Length		(m)	Nr.
				(m)		(m)	
		Galv pipe	1 1/4"	0.08	1	0.08	
		Galv. pipe	1"	0.3	1	0.3	wall thickness 3.25 mm
		Galv. pipe	3/4 "	2	1	2	wall thickness 2.5 mm
		Galv. pipe	1/2 "	1.5	1	1.5	Wall thickness 2.5 mm
30_1	Cover Plate	Galv Sheet	0.6 - 1 mm	1	1	1	width 200 mm
40-1	legs	Wooden poles		3	2	6	
		Bar	Ø 10	1.5	2	3	
		Strip	25x3	1.5	1	1.5	
20_6	Galv. Nuts and bolts	Bolt	M10x25		6	6	or 3/8 ""
	wire	Galv wire	1.5 mm	10	1	10	
20_7	Wheel rings	Car tire, used	14"		2	2	Eventually 15" , not damaged
10.2	Handle grip	PVC Tube	1"	0.5	1	0.5	Wall thickness approx. 1.8 mm
	Nails	GI nails	70 mm		10		
	PVC Glue	Small tin or tube			1	1	
	Car Oil (10 W 40)	Litre		1	1	1	
	Paint anti corrosive	Litre		1	1	1	
	Paint Gloss	Liter		1	1	1	

**Table 2a PARTS for ELEVATION HEIGHT 0- 5 meter**

TOTAL MATERIAL		LIST						
Nr. Sub	Part	Material	Size	Part	Nr	Added	Total Net	Remarks
assembly				Length		Parts	Length	Nr.
				mm		Length	per Mat	
							Size	
	<b>Pump</b>	PVC Tube						
50-5	Pump tube	PVC tube	1 ½ "	6	1	6		1
50-1	Top-tube	PVC tube	2"	0.5	1	0.5		
50-7	Return inlet	PVC tube	2"	0.3	1	0.3		
50-6	Return tube	PVC tube	2"	0.7	1	0.7		
50-2	T-joint	PVC tube	2"	-	1			
50-3	Outlet tube	PVC tube	2"	1.5	1	1.5		
50-4	Reducer	PVC	2 - 1 ½ "	-	1			
80	<b>Rope</b>	Poly pr.	6 mm	14	1	14		2
60	<b>Cover</b>	Concrete	Cement Bag 50kg		2			3
70	Slab	Concrete	Cement Bag 50 kg		2			3
<b>60 &amp; 70</b>	Reinforcement bars	Iron rod	6 mm	8	1	8		
<b>Remarks</b>								
1	pump height 0- 5 m	*						
2	Optional Nylon rope							
3	Depending on size							

Elevation height is distance between water level (at its lowest point) to outlet.

**Table 2b PARTS for ELEVATION HEIGHT 5 - 10 meter**

TOTAL MATERIAL		LIST						
Nr. Sub	Part	Material	Size	Part	Nr	Added	Total Net	Remarks
assembly				Length		Parts	Length	
				(m)		Length	per Mat	
						(m)	Size	
	<b>Pump</b>	PVC Tube						
50-5	Pump tube	PVC tube	1"	6	2	12		1
50-1	Top-tube	PVC tube	1 ½ "	0.5	1	0.5		
50-7	Return inlet	PVC tube	1 ½ "	0.5	1	0.5		
50-6	Return tube	PVC tube	1 ½ "	0.7	1	0.7		
50-2	T-joint	PVC tube	1 ½ "	-	1			
50-3	Outlet tube	PVC tube	1 ½ "	1.5	1	1.5		
50-4	Reducer	PVC	1 ½ " - 1"	-	1			
80	<b>Rope</b>	Poly pr.	6 mm	26	1	26		2
60	<b>Cover</b>	Concrete	Bag 50 kg		2			3
70	<b>Slab</b>	Concrete	Bag 50 kg		2			3
60 & 70	<b>Reinforcement bars</b>	Iron rod	6 mm	8	1	8		
<b>Remarks</b>								
1	pump height 5- 10 m	*						
2	Optional Nylon rope							
3	Depending on size							

**Table 2c PARTS for ELEVATION HEIGHT 10 - 20 meter**

TOTAL MATERIAL		LIST						
Nr. Sub	Part	Material	Size	Part	Nr	Added	Total Net	Remarks
assembly				Length		Parts	Length	
				(m)		Length	per Mat	
						(m)	Size	
	<b>Pump</b>	PVC Tube						
50-5	pump tube	PVC tube	3/4"	6	4	24.0		1
50-1	Top-tube	PVC tube	1 "	0.5	1	0.5		
50-7	Return inlet	PVC tube	1 "	0.5	1	0.5		
50-6	Return tube	PVC tube	1 "	0.7	1	0.7		
50-2	T-joint	PVC tube	1 "	-	1			
50-3	Outlet tube	PVC tube	1"	1.5	1	1.5		
50-4	Reducer	PVC	1" – 3/4 "	1	1	1.0		
80	<b>Rope</b>	Poly pr.	6 mm	46	1	46.0		2
60	<b>Cover</b>	Concrete	Bag 50 kg		2			3
70	<b>Slab</b>	Concrete	Bag 50 kg		2			3
60 & 70	<b>Reinforcement bars</b>	Iron rod	6 mm	8	1	8.0		
Remarks								
1	pump height 10- 20 m	*						
2	Optional Nylon rope							
3	Depending on size							

**Table 2d PARTS for ELEVATION HEIGHT 20 - 35 meter**

TOTAL MATERIAL		LIST						
Nr. Sub	Part	Material	Size	Part	Nr	Added	Total Net	Remarks
assembly				Length		Parts	Length	
				(m)		(m)	per Mat	
							Size	
	<b>Pump</b>	PVC Tube						
50-5	Pump tube	PVC tube	½ "	6	7	42.0		2
50-1	Top-tube	PVC tube	1 "	0.5	1	0.5		
50-7	Return inlet	PVC tube	1 "	0.5	1	0.5		
50-6	Return tube	PVC tube	1 "	0.7	1	0.7		
50-2	T-joint	PVC tube	1 "	-	1			
50-3	Outlet tube	PVC tube	1"	1.50	1	3.0		
50-4	Reducer	PVC	1" – ½ "	-	1			
40-6	Tube support holder	Galv pipe	1"	0.03	1	0.03		3
80	<b>Rope</b>	Poly pr.	6 mm	82	1	82.0		4
60	<b>Cover</b>	Concrete	Bag 50 kg		2			3
70	<b>Slab</b>	Concrete	Bag 50 kg		2			3
60 & 70	<b>Reinforcement bars</b>	Iron rod	6 mm	8	1	8.0		
<b>Remarks</b>								
1	pump height 20- 35 m	*						
2	Optional Nylon rope							
3	Depending on size							