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The Rope Pump

From “Bomba de Mecate”
www.ropepumps.org

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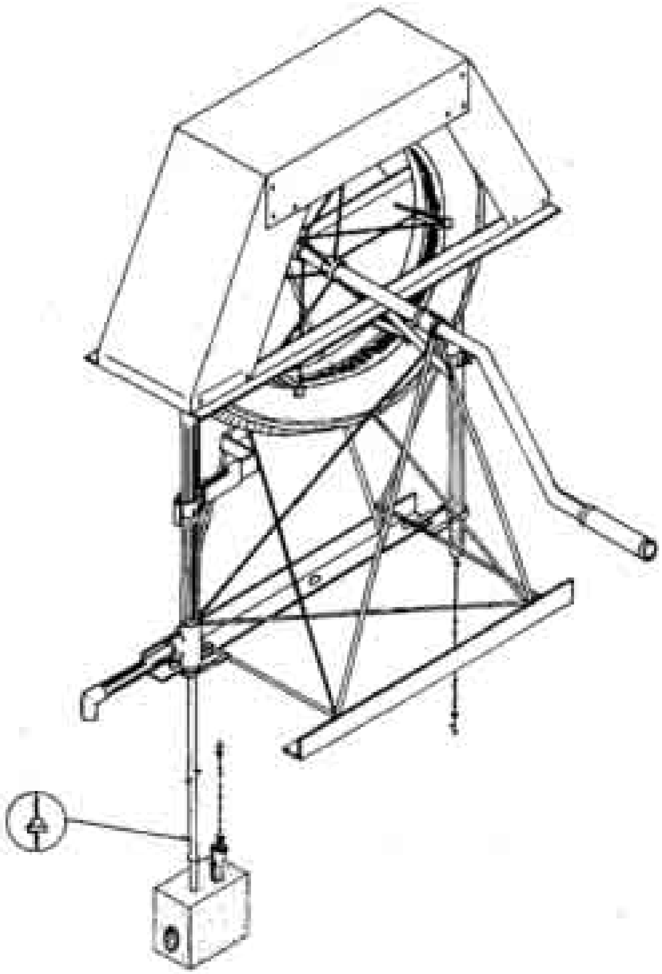

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Application specification

Rope pumps are installed on handdug wells and on drilled wells or boreholes. There is no need for the pumping pipe to be installed vertically which means that rope pumps can be installed as well at riversides for irrigation or at the side of e.g. scope holes.

Maximum depth reached by the rope pump.

- 40 metres standard
- 60 metres with adjustments and doble crank
- 80 metres in experimental phase

The water depth required in a well.
The minimum water depth in a well required for a rope pump is only 10 centimetre. The guide box is positioned on the bottom of the well as sand does not affect the functioning of the rope pump as can happen with other brand pumps. In extreme dry seasons when the water table goes down, the rope pump will keep on working until the well really dries up. In this case neither with rope and bucket water can be drawn. This is an important fact related to social acceptance too. When the water table in a well goes down and the traditional pumps can't reach the water any more, than the users blame the pump as they still can fetch water with their rope and bucket. In reality the pumps are OK, but the need to place the foot-valve at certain distance above the bottom of the well to prevent sand coming into the pump, causes this situation.
A handdug well should have of course preferably at least one metre of water. In practice the older wells will have a depth of about one metre below the groundwater level of the driest season of the last decennia.

The depths of the handdug wells found in Nicaragua can be distributed in:

- 45% in the range 0 - 10 metre
- 30% im the range 10 to 20 metre
- 15% in the range 20 to 30 metre
- 10 % deeper than 30 metre

The depth of the water table in drilled wells depends very much on the local geologic situation.

The four inch casing is the minimum diameter for the drilled wells to install standard rope pumps. The casing can be as small as two inch and still a rope pump with a small diameter guide box can be adapted.

Pumping Capacity of the rope pump according to depth:

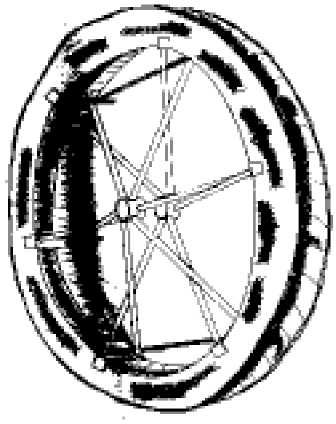
Depth(metres)	**Adult(Litres per minute)**	**Child(Litres per minute)**	**Time needed for an adult to fill a barrel (minutes)**
5	70	39	3
10	41	19	5
15	27	13	8
20	20	10	10
25	16	8	13
30	14	6,5	15
35	12	5,5	18
40	10	4,8	20

The pumping capacity indicated in the table is based on operation under normal conditions. Even for children it is easy to fill a bucket thanks to the high efficiency of the pump. This is an important requirement to obtain the social acceptance of the rope pump.

The diametre of the pipes is determined by the depth from wellhead to water level.

Depth (metres)	Pumping pipes	Discharge pipes
0 - 11 metres	1 " inch	2 " inch
11 - 19 metres	3/4" inch	1½" inch
19 - 50 metres	1/2" inch	1 " inch

The standards used in PVC pipe production differ from one country to the other and will thus influence in the indicated ranges.

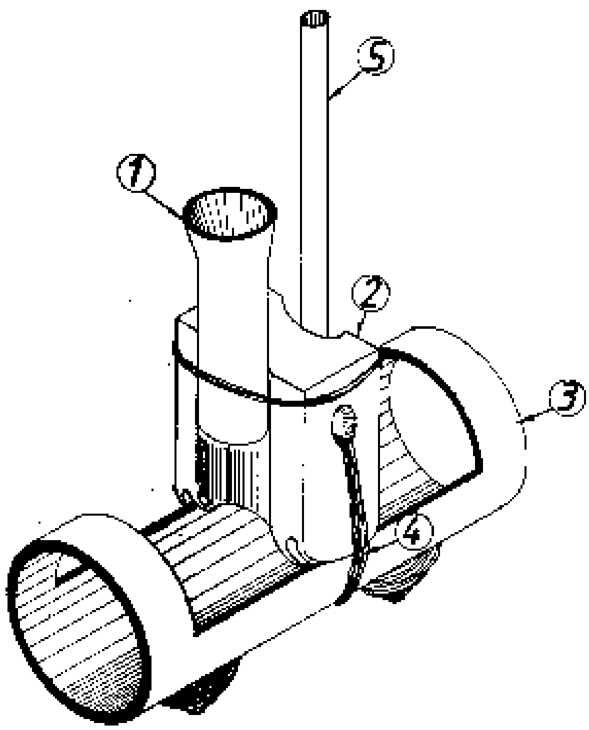


Wheel

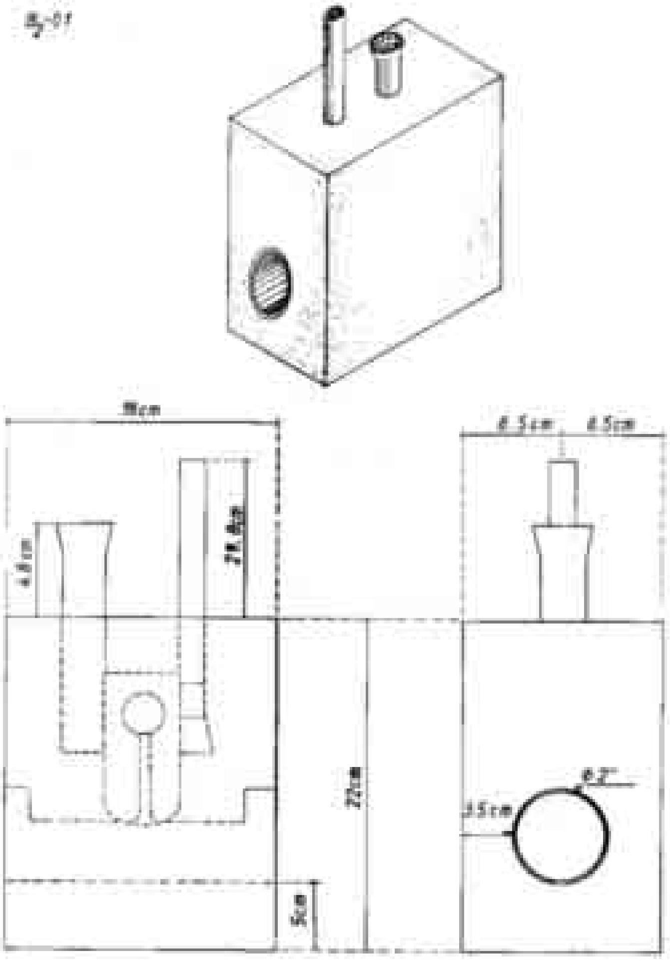
The function of the rope pump structure is to support the efforts of the axle, wheel, and crank, as well as fix the pumping pipe, both entry and exit sections. It is the esthetic part (Visible) of the pump and is installed on the well cover. The types of materials and their diameters depend on the use given to the equipment.
The structure is basically made out of pipes, iron rods, iron strip and angle iron. The pulley wheel is made out of the two internal rings cut out of truck tires and joined by clamps and spokes, which must be strong for intensive use. The 20" inch truck tires are used, but for wells deeper than 29 metres 16 " inch tires are used.

The Guide

The guide is installed at the bottom of the well and is where the pumping process is initiated. Its function consists of guiding the rope with pistons attached so that it enters into the pumping pipe from below, as well as maintaining the pipes taught (plumbed) with the appropriate tension. Therefore, the guide has various functions integrated into one piece. It serves as well as a counterweight to tauten the rope in order to avoid sliding on the wheel.



The guide is a concrete box with a base piece, an entry pipe, a pumping pipe and support pipe, and a ceramic piece inside. These parts of the guide must be made in such a way that the rope never touches the concrete, which would cause wear to it as well as to the pistons.
In the production are no iron parts involved and therefore, the rope pump is not susceptible to rust problems and can be used in very corrosive water.
The entry and pumping pipes on the guide have a wide mouth to facilitate the entry of the rope and pistons.
The water enters the guide through the base piece (2" PVC pipe) located at about five centimeters from the bottom of the guide. The guide itself is placed on the bottom of the well. This allows practically all of the water to be drained from the well. This is important when a well has very little water, as water can still be extracted, which would not be the case with a bucket and rope.



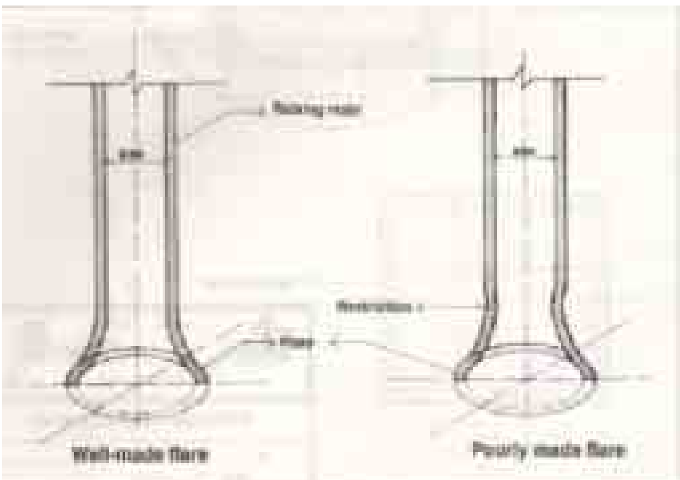


Figure 8.3: Restriction in the flare

The diametre of the pipes is determined by the depth from wellhead to water level.

Depth (metres)	Pumping pipes	Discharge pipes
0 - 11 metres	1 “ inch	2 “ inch
11 - 19 metres	3/4" inch	1½” inch
19 - 50 metres	1/2" inch	1 “ inch

Deficiencies have been encountered in the pipes depending on their origin of production. Examples of these, which can affect the pumping pipes, are:

- The inside diameter does not meet standards. This causes a problem when the diameter is smaller than what has been established because the piston will not fit or will fit but cause friction.
- The inside walls of the pipes are rippled, which can cause unforeseen friction.
- The jacket is not made correctly. Some jackets are found to have a narrowing, right before the widening, where the pistons stick.

Dust and dirt in the pipes are always obstacles when installing. Storing of the pipes, therefore, requires some care.
The type of pipes used for irrigation or drainage is less expensive but with a smaller wall thickness and is not used for rope pumps.
Metal or flexible pipes are never used in rope pumps, as they are not appropriate for this type of equipment.

Pistons

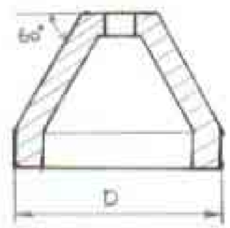
The pistons are one of the most sensitive parts of the pump. Together with the rope they form an endless chain. When the rope rotates it leads the piston through the pumping pipe, pushing the water inside upwards.
The piston is a cone shaped part with a hole on its top and must meet the following norms:

- Exact dimensions.
- Cone shape to reduce friction.
- Strong and water-resistant material.

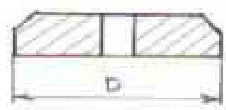
The piston diameters vary with depth as do the pumping pipe.

- Piston diameter is determined by the type of pipe to be used and the well’s depth. Pistons should be made of injected polypropylene or polyethylene. Neither rubber nor wood are recommended.
- The rope’s length, diameter and amount of pistons are determined by the well’s depth.
- Two-inch (0 - 3.5 metres depth) and 1 ½” inch (3.5 - 5 metres depth) pistons are used in wells which are not too deep or when motor driven rope pumps are used.
- A perfect fit is required between the pistons and the pumping pipe. The space between piston and inner wall of the pipe is only 0.15 mm for the 1/2 inch pipe and up to 0.40 mm for the 1 inch pipe. The production of the moulds thus requires high precision.

Piston production requires a small plastic injection machine, and different-size moulds. The pistons are made of high-density polypropylene or polyethylene. Polyethylene is poured in the injection machine hopper. As the plastic passes through the heated hopper bottom, it becomes fluid and is injected into the mould. As it cools, the plastic adopts the mould’s form.

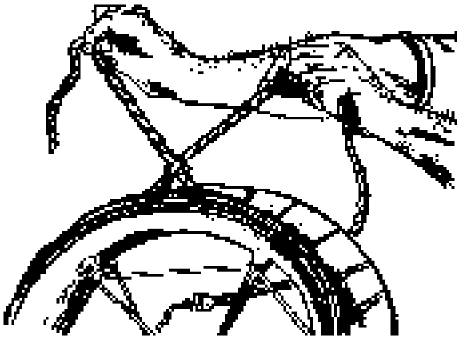


Polyethylene Piston
(High density PE)
Made with and motorised or manual injection machine



Rubber piston
Made of side part of a car tire

Diameter D = 0.5 to 1 mm smaller than inside diameter of rising main (Pump tube)



Rope

In Nicaragua an approximately 5 millimetres diameter polypropylene fibre rope is used.
The rope, together with the pistons, functions as an endless band transporting water. The pistons are located the entire length of the rope and are attached with two knots, one in front of the piston and one directly behind it.
When installing, the ends are attached by braiding. Knots are not used as they are difficult to untie when tautening the rope or for repairs.

The rope must have the following characteristics:

- Be sufficiently strong and durable.
- Must not be stretched during use. Rope that is stretched over time will cause a lack of tension on the wheel resulting in the pump beginning to slide.
- Must not be too smooth to avoid sliding on the wheel.
- Must be water?resistant.

Installing the rope

Place the rope, with the desired tension, over the pulley wheel to indicate where the knot should be made. Remove the rope from the pulley wheel and cut it, leaving about 5 extra inches at each end. Burn the ends with a cigarette lighter or matches and twist them while they are hot. Take the two ends and braid them together as shown in figure k2, then put the rope back on the pulley wheel. The tension is correct when the rope does not slip or slide back over the pulley wheel while pumping water.

PISTONS AND ROPE

- Piston diameter is determined by the type of pipe to be used and the well's depth. Pistons should be made of injected polypropylene or polyethylene. Neither rubber nor wood are recommended.

- Five different piston sizes are used.

- The rope's lenght, diameter and amount of pistons are determined by the well's depth.

Length and diameter variations for both the pistons and the rope

	Depth (meters)			
Component part (Unit)	0-11	11-19	19-29	29-40
Piston nominal diameter (inches)	1	¾	½	½
Rope length (Meters)	27	43	63	85
Rope diameter (inches)	1/8	1/8	1/8	1/4
Amount of pistons (unit)	26	42	62	84
Entrance pipe diameter	1.5	1	¾	¾
Pumping pipe diameter	1	¾	½	½

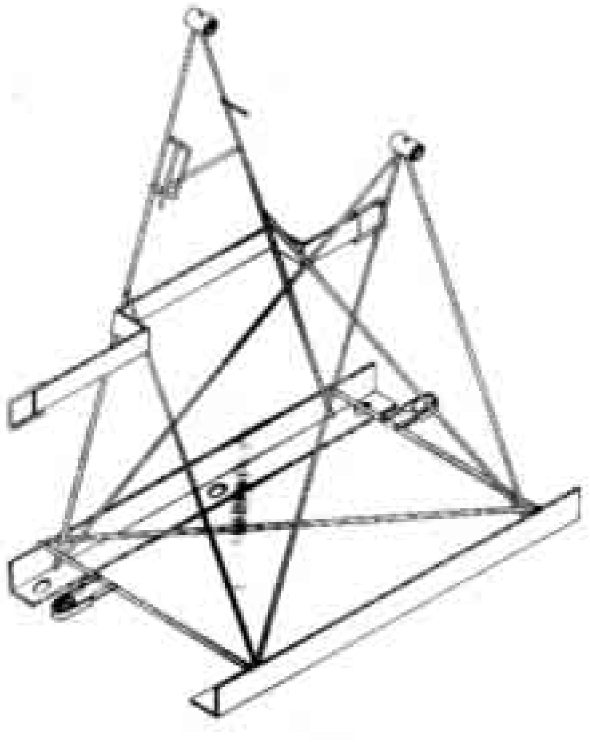
- Two-inch (0 - 3.5 meters) and 1 ½" inch (3.5 - 5 meters) pistons are used in wells which are not too deep or when motor pumps are used.

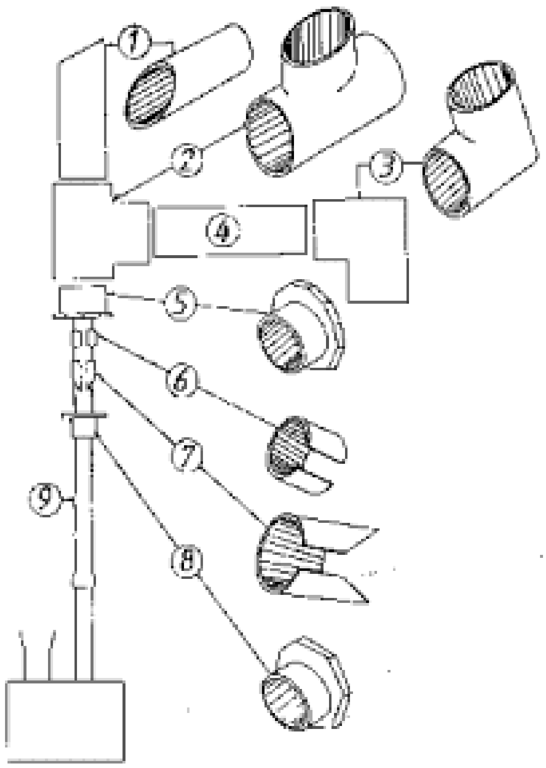
THE CRANK

The function of the crank is to turn the wheel by means of power applied by the user. It consists of an axle with two 60-degree bends. The crank or axle is made of ¾" pipe, which is black pipe for the family and extra-strong pumps and galvanized pipe for the community pump. The diameter of this pipe is 27 millimeters, while the thickness of the material is 2.0 millimeters.

The radius or distance between the axle and the handle of the crank is 33.5 cm. This radius is large for children doing the pumping but is necessary in order to exert the maximum force related to the weight of the water column, which has a maximum of 10 kilograms. The radius can be a little smaller for adults because of their strength or larger because of the length of their arms. This maximum strength also depends on the depth of the well in which the pump is being used.
An important detail is the first bend at the axle. Care must be taken to ensure that the bend begins past the bushing. Beginning the bend right at the bushing will wear the axle causing it to break.

The roller and the handle are 15 centimeters in length, long enough for two children's hands or one adult hand. The spacers on the handle are made of the same pipe as the handle without any space between them so as to avoid the hand getting caught between the handle and spacers. Experience has shown that despite their short life span, PVC can be used and replaced by opening the pipe lengthwise. There may be a need to seek alternatives for the bushings and handle should the pipe not be available on the market. These should fit snuggly around the axle pipe. Bushings can also be made of iron strip.
As indicated in the drawings, the angle of the bends is 90o, although they can be a little wider causing the handle to be further from the wheel structure, making the distance or radius between the axle and handle decrease slightly, which should be corrected. At the same time there is an increase in the distance between the handle and the wheel structure. This distance between the handle and the structure is important when installing the pump. The rope must be able to descend freely into the well without touching the wall, therefore the pump should be as centered as possible on the well. On the other side, the handle should remain outside the well wall so as to make the pumping process as comfortable as possible. Depending on the infrastructure of the well and the thickness of the well wall, it may be advisable to leave the handle farther from the structure using a less pronounced bend. This situation, of course, depends on the local customs regarding the production of well walls.
Depending on the depth of the wells, pumps with one or two handles are used. Pumps with two handles are used to increase power and the work becomes social for users.





MATERIALS FOR THE CRANK

Quantity	Material	Measurement	Section
1	**Black pipe**	**¾" x 100 cm**	**Shaft**
1	**Galvanised pipe**	**1" x 15 cm**	**Roller**
2	Galvanised pipe	1" x 1 cm	Spacer

LEG ASSEMBLY.

The difference between the family pump and the extra-strong pump is mainly in the structure and thickness of materials used. The leg supports of the family pump are made from 3/8" or 9 mm corrugated iron. This diameter can be considered as the minimum thickness to be used. There have been cases of damaged structures after several years of use of the family pump with legs this diameter. They were without exception pumps that had undergone intensive use. This more than justifies the family and extra-strong models.
There is a “horizontal cross” support between the two legs beside the brake, which is necessary to lessen the blow from the brake.

THE WHEEL.

TIRE RIMS AND THEIR DIAMETER.

The wheel is made from the two rims cut from tires with 20" hubcaps, usually used by buses and trucks. The rims are from the part of the tire that is mounted on the hubcap and always has steel wire in it for reinforcement. They are not the sides of the tires, which have been used in some previous rope pump designs. These tires always have wire in the part that is in contact with the road and in the rims used for rope pumps. Some brands also have this wire in the sides of the tires, making them inappropriate for the pumps as they are nearly impossible to cut and will always have wires protruding from the cut section.
Cutting these rims is an art. Experts in this activity need five minutes to cut two rims from a tire using a very sharp knife, a mallet and water for lubrication. Tire rubber is used for producing shoes, rocking chairs, beds, etc, causing tire rims to be known as waste from this industry. The cost of this material is minimal, less than a third of a dollar and with a little incentive the rims are cut correctly for use in rope pumps.

The rope touches the rubber on what was the inside part of the tire. This rubber often has an engraved design, which helps to avoid the rope sliding on the wheel. After a year or more of use, this design disappears leaving the surface smooth. After about three years of use the rubber becomes worn where the two rims meet and where the rope moves along it, exposing the wire threads.
The steel wires are located under this layer. As the rubber becomes worn with the movement of the rope, the surface becomes smoother and the rope tends to slide. This depends on the weight of the water column and the tension in the rope. Therefore, it is important to look at the functioning of the rope pump after several years of use.

The rims from these specific-sized tires are used for the following reasons:

1. A large wheel implies more contact between the wheel and the rope than a smaller one (i.e. 16" hubcap) and therefore less sliding. The limits of 11, 19 and 29 meters are also based on sliding problems, which appear over time.

2. Using rims from smaller tires implies that the force to be applied to the crank will be smaller and at the same time less water will be pumped. To compensate for this, the crank must be turned more rapidly, which is less comfortable.

3. Rims with smaller diameters (20") have less consistency, are more flexible and require more clamps and support when used in a rope pump.

Using a tire for a 20" hubcap leads to an optimum use with regard to :

- The ergonomic functioning of the body with respect to the maximum force to be applied, the radius of the turn of the crank, and speed.

- Stops sliding that occurs when using smaller tires.

This situation is coincidental and moreover, the 20" diameter is the size most commonly found on the market. A smaller wheel could result in a more esthetically pleasing image. The pumps are used on different ranges of depth and therefore it is impossible to speak of an optimum situation for each depth. What is true for a rim from a tire using a 20" hubcap is true for those from larger or smaller-sized hubcaps at different depths. The problems arise in the limits of the ranges. Smaller rims are used for deeper wells with the same size pumping pipe, while the problems of sliding indicate the need for an application at less depth.
There are also 22" hubcaps whose tire rims require even more force to be applied, therefore their use is less advisable with regard to force and more advisable when avoiding sliding. Another design aspect that plays a role is the speed of the rope. If the rope moves very rapidly, it carries large amounts of water, which splashes off the wheel. This occurs when the pumping pipe is small compared to the depth of the well.

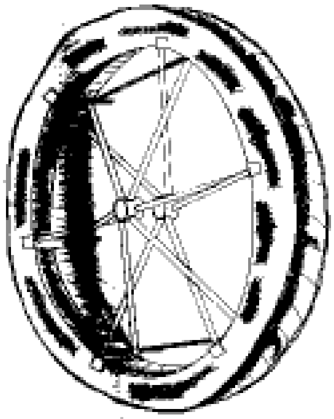
Manual for Construction of the Nicaraguan Rope Pump

Materials for the Nicaraguan rope pump:

- 1.2 m of round iron 10 mm - to make 6 spokes for the wheel
- 5 cm of 1" pipe for central axle + 3 x 5 cm (cut in half longitudinally) for rims + 10 cm for bearings
  + 5 cm for spacers
- 2 bolts and nuts to fix the wheel to the handle
- 1 old car tyre of 13" - it should be the kind without steel inside - not the Radial kind
- 1.5 m of 3/4" galvanised pipe to use for handle
- 15 cm of 1" galvanised pipe to use at the end of the handle
- 1 piece of 50 mm PVC pipe - for the rope to enter the guide block
- 30 or 40 mm pipe to reach from the guide block and to the top of the well. The diameter depends on
  the depth of the well (see later)
- 1.5 m of 50 mm PVC pipe for the water outlet
- 1 50 mm 90º PVC piece
- 1 50 mm "T" of PVC
- 1 fitting from 30 (or 40 mm) to 50 mm
- strong rope (polypropylene) - double length of the well depth + 4 m extra for the knots and for turning around the wheel at the top
- washers of the correct diameter to fit exactly inside the pipe. 1 washer for every meter.
- bricks to line the well, unless it is very hard soil
- bricks to build the house over the well
- cement (1/4 bag) to build the guide block
- 3-4 bags of cement to build the well cover and the water runoff system and to plaster the well
- 3 x 60 cm of 6 mm round iron to place in the well cover
- 2 pieces of 1 m angle iron 40x40 for the base of the pump structure
- 1 m of flat iron - 40 or 50 mm - to hold the pipe to the structure
- 12 m of 9 or 12 mm round iron for pump structure
- paint

The wheel

In order for the rope & washer pump to function well it is important to have a good and solid wheel around which the rope turns.
The wheel must be able to pull the rope with the washers which pushes water up from the well through the pipe. To prevent the rope from slipping there must be rubber on the wheel. To prevent this rubber from getting off the wheel, the wheel is made of rims made of 1" pipe , which is cut to make two "U" formed parts. Six such half pipes function as rims and are welded at the end of the spokes made of 12 mm round iron. Two circular pieces of rubber from 13" car tyre sides are clamped together with strong wire or nails and placed over the rims. When the wheel corresponds in size to the rubber circles, so that the rubber parts have to be forced over the "rim" of the angle, the rubber parts will stay in place.



The wheels above are made of spokes of 12 mm round iron and pieces of 1” pipe, which are cut in half and welded at the end of the spoke.

This photo shows a different kind of wheel made of angle iron.

The center of the wheel is made of a 1” pipe, with a nut and bolt welded on to fasten it to the handle.

One of the rubber parts has been taken off.
The rubbers must be cut from the tyre so that they fit exactly in the groove formed by the angle iron.
Notice that it is the former inside of the tyre which now turns out. This side is better in avoiding the rope slipping.

The rubber circles are cut out from a car tyre by cutting along the part of the tyre which normally touches the road.
The photo shows the rubber tyre as it looks after the circular pieces have been cut off.
You must use tyres without steel wires at the sides.

The central axle is made of a piece of 3/4“ pipe, where a hole has been drilled and a nut has been welded on.
The handle with which the wheel is turned, goes through this central axle, and it is fastened by tightening a bolt through the nut.
It is better to use two bolts and nuts, instead of the one shown here.

The guide box at the bottom of the well.
The system is that the rope comes into the guide box through the short PVC pipe with the largest diameter.
The pipe has been heated in both ends to make it funnel shaped to better guide the rope and the washers into the pipe (the top end), and to better hold in the concrete (at the bottom end).
This piece of PVC is 50 cm long and is at least 50 mm in diameter.

The other pipe is the one where the water is pushed up from the well as the rope and the washers are moved upwards by the turning of the wheel.
The bottom part of this pipe is also made funnel shaped so that it holds better in the concrete.
Only a short piece of 50 cm is moulded in the concrete. Later - at the actual pump site - the rest of the pipes are glued on.

The diameter of the pipe, which carry the water to the top, depends on the depth of the well.

Depth of well in meters	Diameter of pipe in mm
0 to 4 m	50 mm
4 to 10 m	40 mm
11 to 20 m	30 mm
20 to 35 m	24 mm

Before installing the pipes in the well, it is good to check that the washers can pass through the pipes without problems. Some PVC pipes have defects inside, which can prevent the washer from passing.
It is also good to store the pipes so that sand and dirt does not enter into the pipes.

The rope has to run under an axle to be able to make the turn in the concrete box. This axle is made of the bottom of a glass bottle filled with concrete.

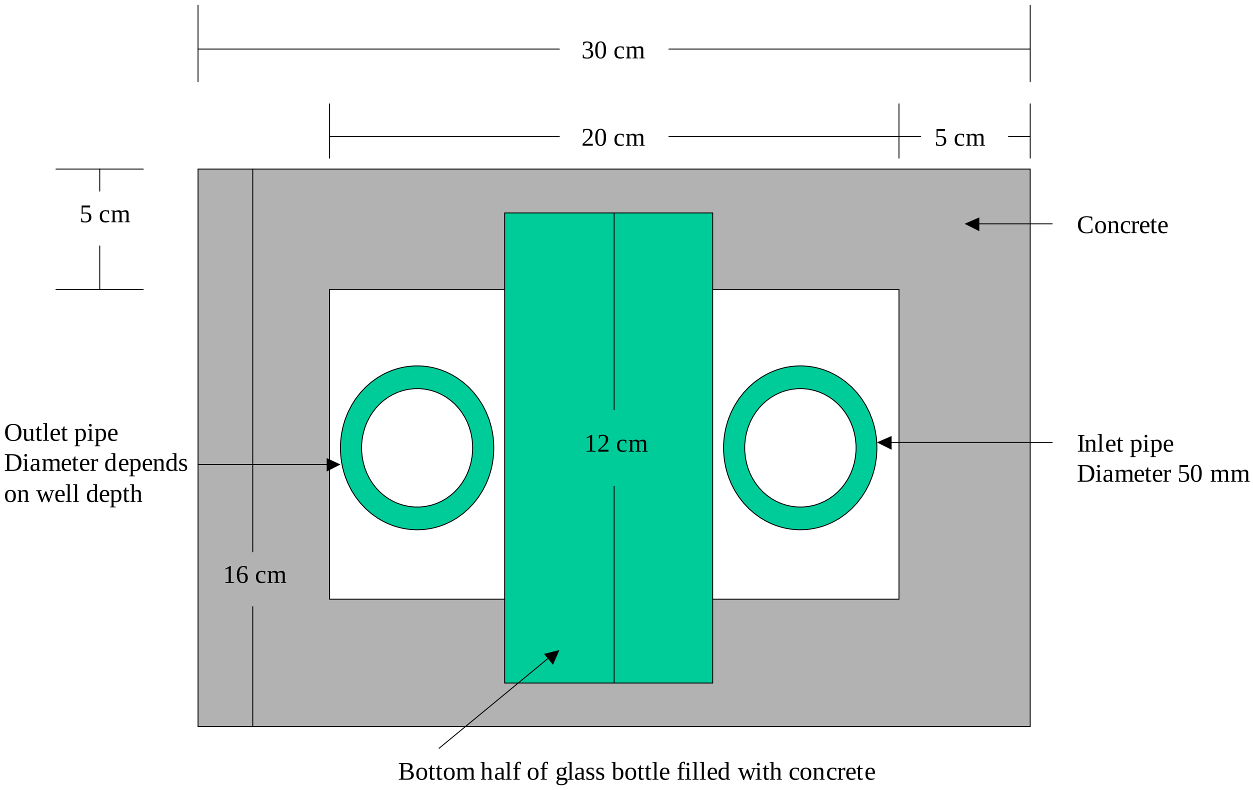
The bottle is cut to make a clean cut using a piece of rope (not nylon but natural fibres) tied around the bottle 15 cm from the bottom. The bottle is warmed over a candle or small fire in the area around the rope. Then the bottle is put into cold water and it will break along the line where the rope was.
The bottom of the bottle is then filled with concrete, which is left to dry.

The concrete is made of cement and sand without gravel or stones. It is mixed 1:6 - that is one part cement and 6 parts sand. Make sure the sand is washed (for example river sand) so that there is no clay mixed in the sand which will weaken the concrete. If you have small stones (pea size) they can also be mixed with the sand.
The guide box is made with two forms - an inner form and an outer form.
The inner form is made of wood or metal and has the shape of a pyramid with a flat top. The inner form is placed on flat ground. The bottle, which has been filled with concrete earlier, is placed in the groove on the top of the form. The two short PVC pieces are placed on the form on the templates.
The outer form, which is open at the top, is placed over the bottom form. The system is made so that it can only be placed in one position. The easiest system is that this form is made of 4 metal sheets 5 mm thick with hinges in all corners. It is then easy to remove afterwards. It should have a ridge so that the inner form always comes into the right position.
Concrete is poured down between the two forms. Make sure that there are no air bubbles in the concrete by poking a thick steel wire into the concrete. The two pipes stick up through the hole in the top of the form, and a short board across the form secures that they are in the right place. The top of the concrete is levelled out to form a flat surface.

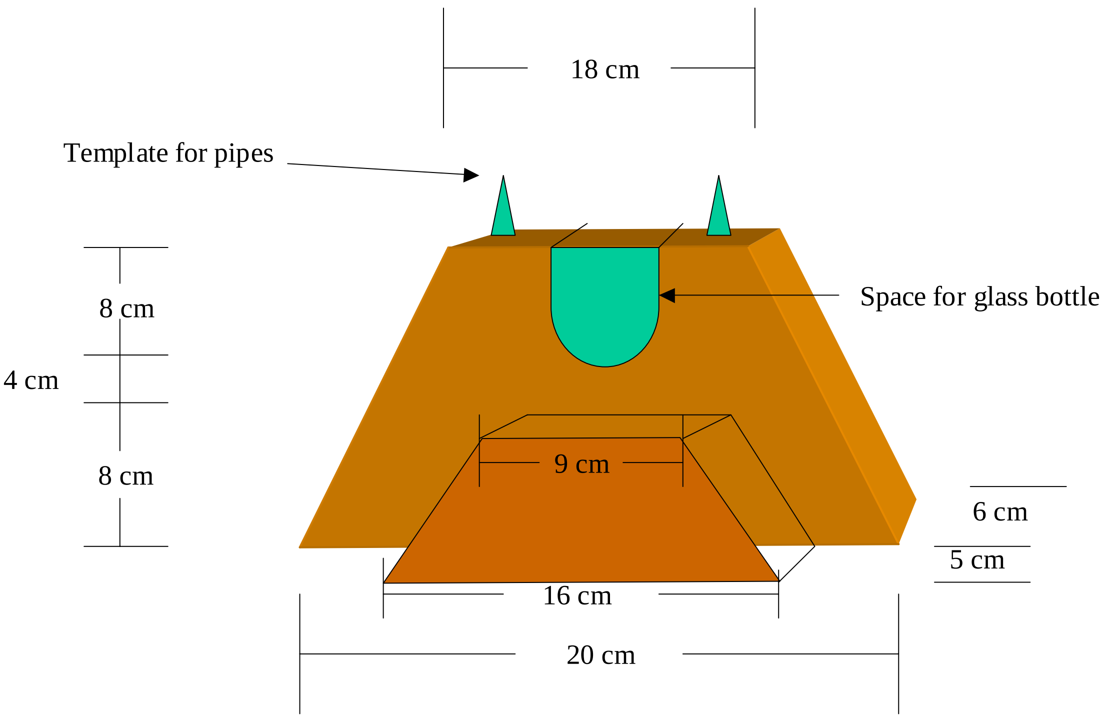
The forms to make the guide block

The following drawings show the measures of the two forms.

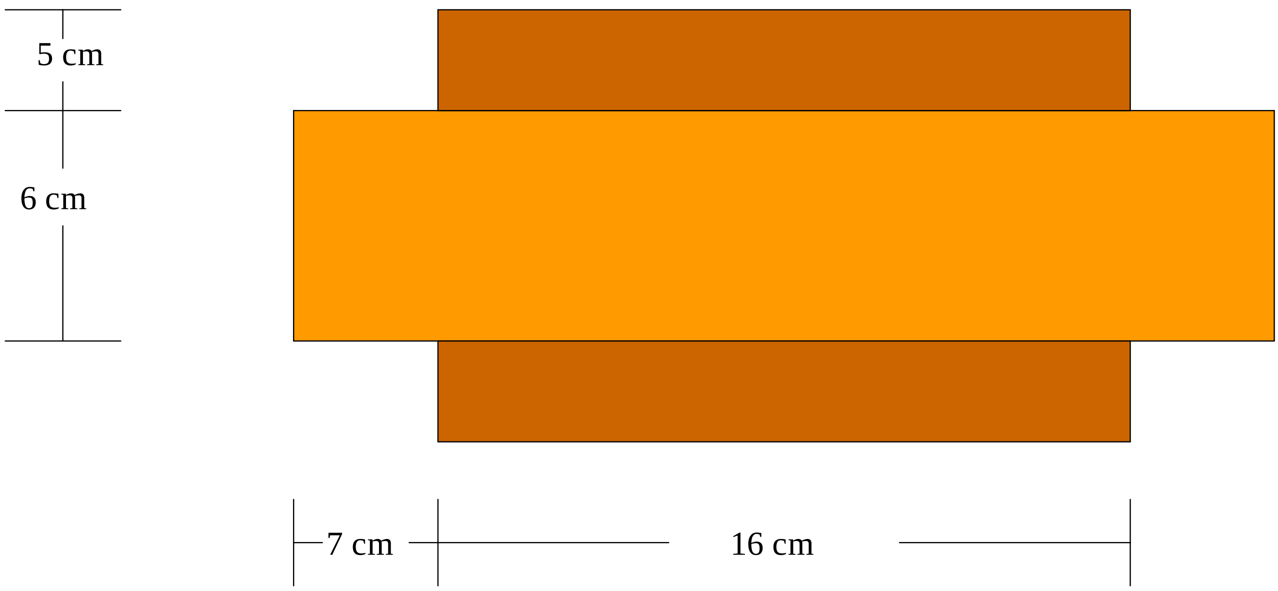
Bottom view of guide block



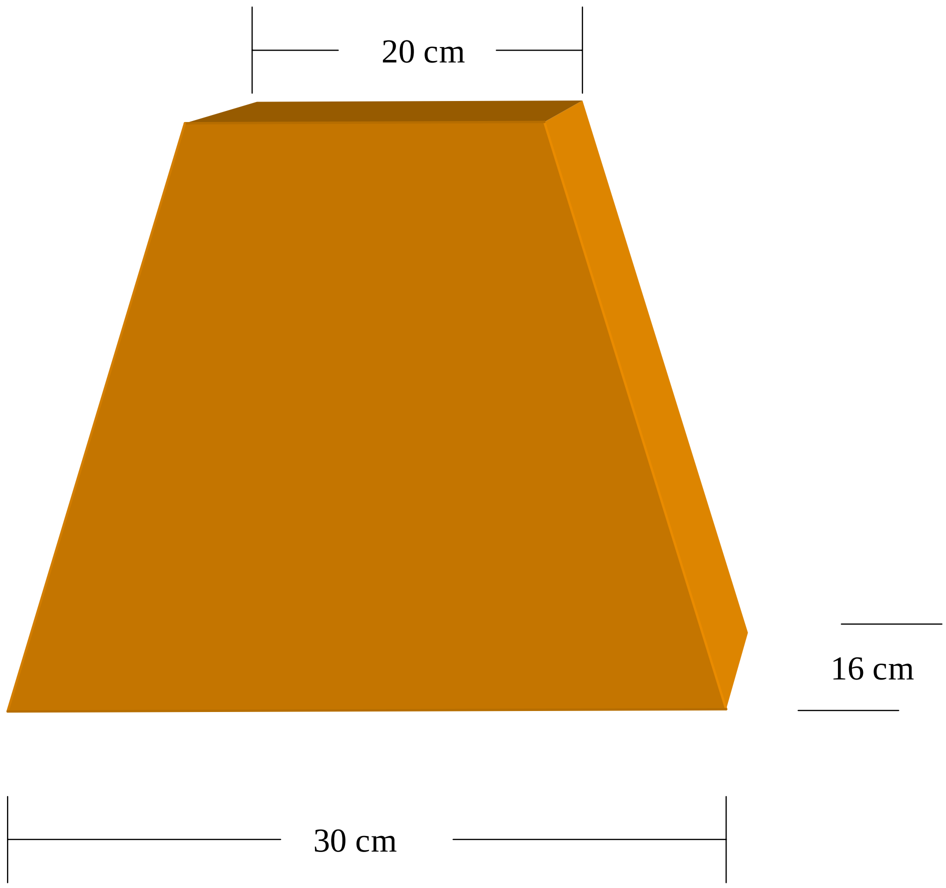
Side view of inner form for guide block



Top view of inner form for guide block



Side view of outer form for guide block
Open at the top



The two forms to make the guide block can here be seen.
The inner form is the one on which the concrete is poured. Before pouring the concrete, the glass bottle filled with cement is placed in the large groove, and the two PVC pipes are placed at the sides of the bottle over the two round iron pieces.
The outer form consists of four metal sheets which are hinged together.
As you can see there is a ridge on the inside of one of the sheets. This ridge fits to the side of the inner form, so that the inner form only can be placed in one position. This ensures that the inner form is placed correctly before the concrete is poured.