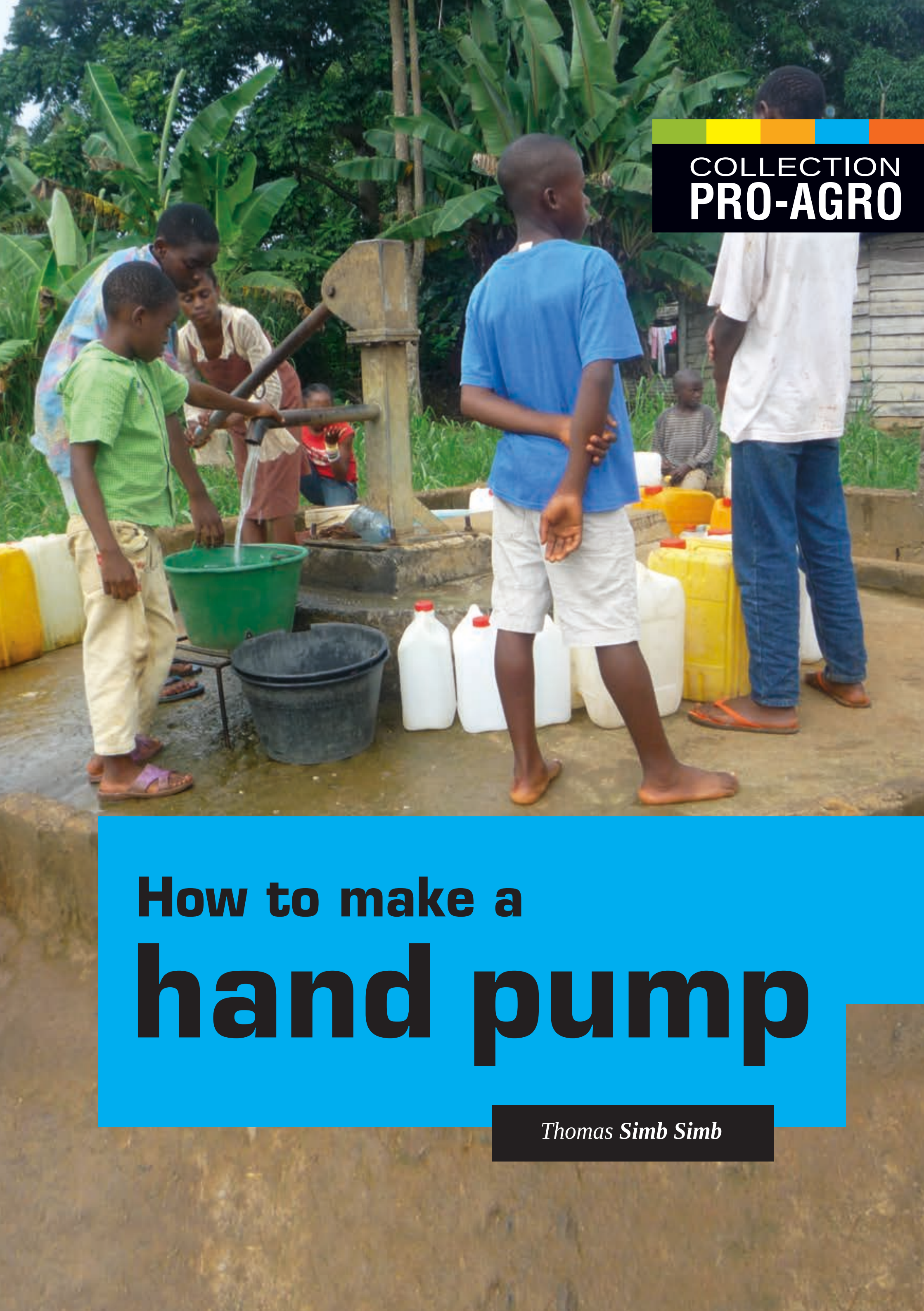

COLLECTION PRO-AGRO

How to make a hand pump

*Thomas **Simb Simb***

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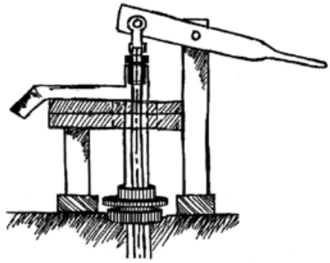


General information

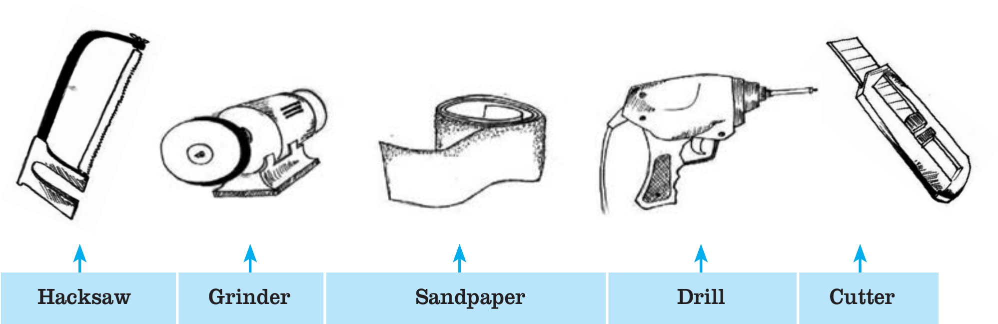
Access to clean water remains a priority in Africa, and improving access is key to fighting water-borne disease. In rural and peri-urban areas, even if populations manage to dig a well, drawing water is another matter. All too often women and children have to apply considerable energy to draw water from the well. In addition, an inappropriate water source can become the main cause for water pollution and can lead to accidents (falling into the well). In order to facilitate access to water for these populations, this guide presents a hand pump that is made from materials available locally.
The hand pump operates with a plunger and is submerged in the water. It is made from PVC pipes, old tyres and wood. It is recommended for wells up to 25 metres deep (it has not been tested for greater depths), and can draw around ten litres per minute. The easy availability of the materials, low production costs and simple maintenance means that the hand pump is accessible for poor populations.

The pump comprises several parts:
• **The strainer:** the lowest part of the pump that draws in the water while filtering out solid particles.
• **The foot valve:** this regulates the flow of the water and prevents it returning to the strainer.
• **The plunger or piston:** the lowest part of the pump rod that creates the pull effect on the water through the strainer, raising it through the cylinder.
• **The pump rod:** this part connects the pump handle with the plunger and transmits the force of the user.
• **The rising main:** this is a vertical column attached to the strainer and which channels the pumped water.
• **The pump head and stand:** this part of the pump is above ground and serves as a structural support and transmits the human force to the rest of the pump.

1

TOOLS AND MATERIALS REQUIRED

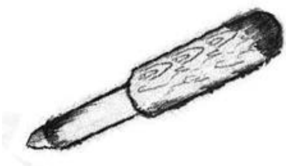
To make a deep well hand pump, the following items are required:



- 5 mm and 10 mm drill bits
- Three tubes of PVC glue to assemble the pieces
- A precision metal compass to mark the circular dimensions
- A protractor
- A ruler
- A set of cutters to cut the heavy lorry wheel
- Six PVC pipes Ø 42/50 for the rising main and the strainer
- Five PVC pipes Ø 21/25 for the pump rod
- A tee and PVC pipe Ø 50 for the outlet
- A galvanized tee Ø 20/27 that connects the pump rod to the pump handle
- A threaded nozzle Ø 25/32 that connects the pump rod to the galvanized tee

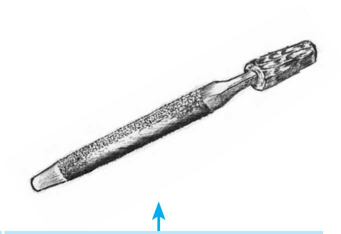
• A piece of wheel rim from a lorry, 20 cm x 60 cm, to make the valve
• A piece of rubber inner tube, 20 cm x 40 cm, also to make the valve
• A 6 m plank

In rural areas without electricity, the following can be used:
• A grinding stone or a manual grinder to sharpen knives and make various parts smooth
• Simple sharp knives, adapted to cutting rubber and regularly soaked in water to make cutting easier; they can also be used to replace the cutters
• A bucket or dish with water in it
• A round file to smooth the insides of various parts, or even the outsides
• A nail with a handle (an awl) to make holes when hot



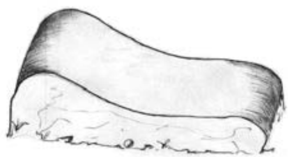
An awl

Water bucket



Round file

Sharpened knife



Grinding stone

2
MAKING THE PARTS

2.1 Strainer

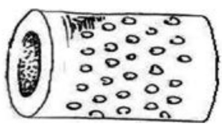
The strainer is made from a PVC pipe Ø 42/50 and 50 cm in length, pierced with a regular pattern of holes. It also needs a plug and a cap, both made from the same type of PVC pipe.

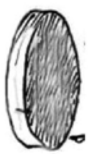
>>> Strainer pipe

Use a saw to cut off a 50 cm section of PVC pipe Ø 42/50. Draw 5 mm diameter circles separated equally by 15 mm. Use a 5 mm drill bit, or the hot awl, to make the holes according to the marked circles. Make the holes 10 cm in at each end of the pipe. In areas without electricity, the holes can be made with a hot awl and then filed to the right dimensions.

Piercing holes with a hot awl

Strainer pipe





Plug

>>> Plug

Using a hacksaw, cut 45 cm of PVC pipe Ø 42/50. Make a slit lengthwise. Heat the pipe until it becomes soft and pliable, then flatten it and let it cool. Using a compass, mark out a circle of 50 mm diameter. Cut out the circle with the hacksaw, leaving an extra 4 mm around the marked line. Grind or file down the edge to end up with a plug exactly 50 mm in diameter.

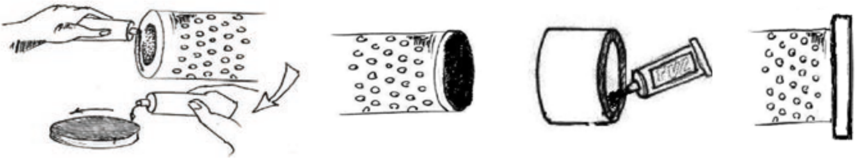
Cap

>>> Cap

Make a 10 cm wide cap with a diameter of 50 mm by heating a 10 cm strip of pipe until it becomes soft. Then wrap it around the strainer pipe.

>>> Assembling the strainer

Put glue on the lower part of the strainer pipe and one side of the plug, and then glue them together. Put glue on the cap and glue it onto the plugged end of the pipe to create the strainer.



Put glue on the plug and the base of the pipe	Plug glued onto the pipe	Put glue on the cap	Cap glued onto the plugged pipe

2.2 Suction valve

The suction valve is composed of

- An inlet valve made of hard rubber (from old lorry tyres) 5 mm thick and 34 mm in diameter, attached to a PVC pipe 120 mm long;
- A valve casing support made from hard rubber to ensure the valve is watertight: 5 mm thick and Ø 26/42;
- Two valve guides made of PVC pipe 4 mm thick and Ø 26/42. They are separated by a section of PVC pipe 54 mm long and Ø 26/42. They centre the back and forth movement of the inlet valve.

>>> Inlet valve

Cut out a section of hard rubber 5 mm thick. Mark out two circles sharing the same centre: one of 4 mm and the other of 34 mm diameter. Cut out and remove the inner circle of 4 mm, and then trim the rubber to cut out the larger 34 mm circle. Sand down the edge of the circle with the grinder.

Cut out a section of rubber | Sand down the rubber | Sanded down rubber | Marking out the circles | Valve disc

In areas without electricity, the outside sanding can be done with a grinding stone or a file.

Smoothing the edges with a grinding stone

Cut a T-shaped stem of 6 mm in diameter out of the flattened and smoothed PVC pipe. Push the stem through the valve disc up to the point of the "T" and affix the two components with glue. This is now the valve.

Flattening the cylindrical PVC pipe

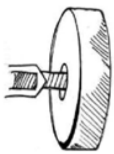
Cutting out the valve stem

Valve stem inserted in the valve disc

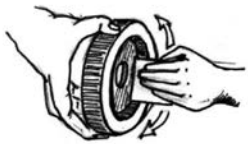
>>> Valve casing support

Cut out a piece of hard rubber 42 mm in diameter and 9 mm thick. Make a hole 34 mm in diameter and 4 mm deep. Make another hole 26 mm in diameter from one end of the piece to the other. Smooth with sandpaper. In areas without electricity, first use a file for the internal smoothing, before finishing with sandpaper.

Sanded rubber



Making the valve hole



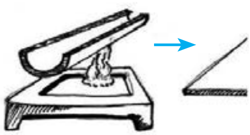
Valve casing support

Using a file for smoothing

>>> Valve guides

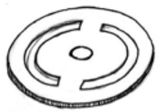
Cut a length of PVC pipe Ø 42/50 lengthwise. Make a slit, then soften and flatten. Draw concentric circles with the following diameters: 6, 28, 34 and 41 mm. Using cutters or a knife, remove the 6 mm circle, as well as the band formed between the 28 mm and 34 mm circles, although make sure to leave two 6 mm strips on opposite sides. Cut out the 41 mm circle and sand it down. Make a tube of Ø 26/42 and 54 mm high.

Sliced pipe



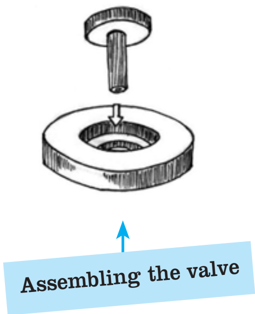
Flattening the pipe

Cutting out the valve guide



Valve guide

Glue a guide to each end of the Ø 26/42 pipe. Insert the valve into the casing support, pushing the stem through the central holes in the guides. Glue the casing support to the guide to complete the suction valve.



2.3 Plunger

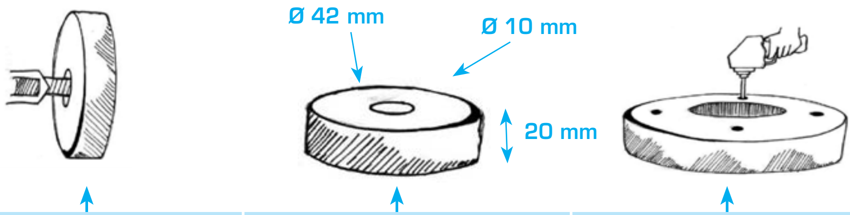
The plunger has four 15 mm holes through which the water can pass. It is composed of:

- A disc made of hard rubber 20 mm thick with a diameter of 42 mm to ensure that the plunger is watertight;
- Two filled PVC pipes 30 mm long, and with a diameter of 41 mm, which will allow the plunger to lift the pumped water;
- A stem 10 mm in diameter, 220 mm long, which connects the plunger to the pump rod;
- A check valve made from a 1 mm strip that prevents water flowing back down from above the plunger. This is the top part of the plunger.

The plunger determines the success of the pump by regulating the flow of water produced.

>>> The hard rubber disc

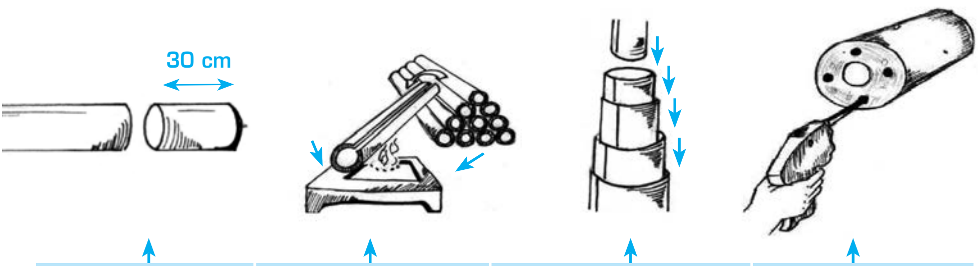
Take a piece of lorry tyre and cut out a circle of 44 mm diameter and 20 mm thick, using the cutter or a knife. Then, with a drill bit of 10 mm or a heated nail, make four equally spaced holes in the flat side of the disc. Grind the disc with a grinder and/or a file, and then sand it, to produce a disc with a diameter of 42 mm.



Make axial holes	**Disc**	**Make holes for the water to flow through**

>>> Filled pipes

Cut 30 mm of PVC pipe Ø 42/50. Inside this pipe, insert a series of pipes of decreasing diameter by slicing the pipes lengthwise, heating them then pushing them in, cutting off the part that sticks out. Glue each part inside the other. Take a 10 mm drill bit and make four equally distant holes around the rim.



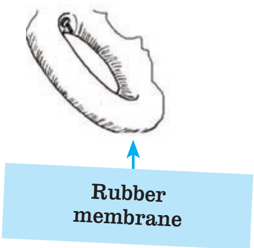
Cut off a section of pipe	**Softening the pipe in the fire**	**Make the smaller pipes and insert them inside each other**	**Make holes for the water to flow through**

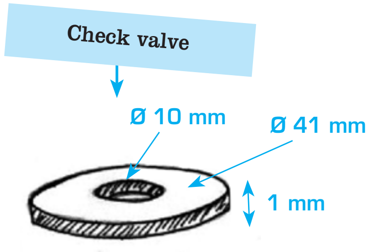
>>> Stem

Glue together the 220 mm long stems. Shape them with the grinder into a stem Ø 10 mm.

>>> Check valve

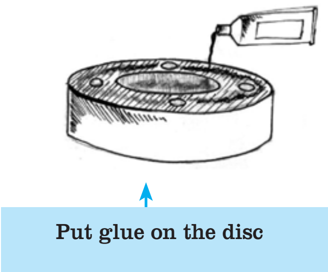
Cut out a rubber membrane 1 mm thick, diameter 41 mm, from an inner tube. Make a central hole Ø 10 mm.

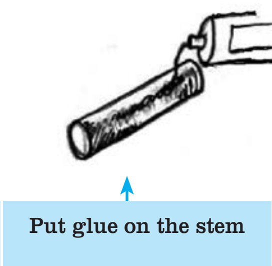


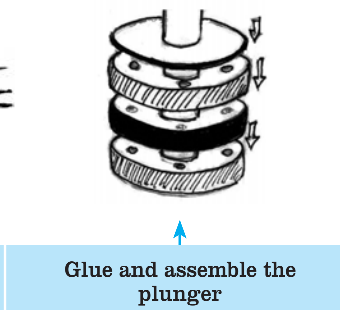


>>> Assembling the plunger

Glue the stem to one of the filled pipes. Glue the disc to the stem and the pipe, making sure that the holes are aligned (use a pen to poke through the lined up holes). In the same way, glue the second pipe to the disc and the filled stem. Above the second filled pipe, place the membrane or check valve and glue it to the stem.





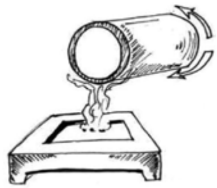


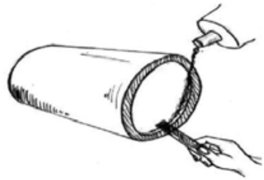
2.4 Pump rod

The pump rod is a cylinder made from Ø 21/25 diameter PVC pipes, with centralizers.

>>> Cylinder

Glue together sections of Ø 21/25 diameter PVC pipe. Soften one end of the pipe above a fire, and then insert it into a second pipe of the same diameter, for a depth of 10 cm in order to enlarge the heated pipe. Glue the normal diameter pipe inside the extended end of the other pipe. Repeat the operation with other pipes in order to obtain the desired length.





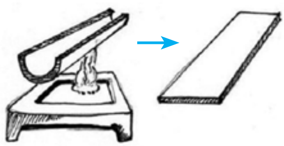
Heating the pipe	Put glue on the end of the pipe	Gluing and assembling the pipes/cylinder

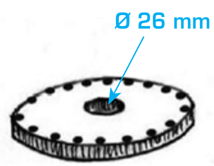
The lower part of the cylinder is filled to a depth of 40 mm with smaller diameter pipes glued inside each other, to produce an internal diameter of 11 mm. Close off the upper part completely.

>>> Centralizers

The centralizers centre the cylinder inside the rising main. They are made from PVC pipe 41 mm in diameter and 4 mm thick, with 16 holes around the edge that allow a flow through of water.

Flatten pieces of softened PVC pipe and cut out circles of 41 mm diameter. Make a central hole of 26 mm diameter by using a drill or a heated nail, then sand with sandpaper. Using a 5 mm drill bit, make 16 holes equally spaced around the edge of the circle (Use a protractor to mark out two perpendicular diameters, and then divide each section by four).





Flattening the pipe	Cutting out the centralizer	Drilling the holes in the centralizer	Centralizer

>>> Assembling the cylinder and centralizers

Coat the centre hole of the centralizers with glue, as well as at every 50 cm of the cylinder. Leave 50 cm between the plunger and the first centralizer, and do not place a centralizer above the outlet of the rising main. Glue the centralizers to the cylinder.

2.5 Rising main

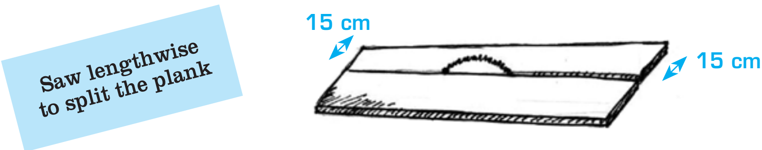
The rising main is made of PVC pipes Ø 42/50. It is put together in the same way as the pump rod: enlarge the end of a pipe, glue a section of normal-diameter pipe inside the widened pipe, making sure that the enlarged end is towards the upper end of the cylinder.

2.6 Pump head and stand

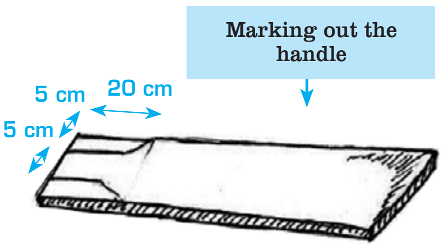
The pump head and stand is composed of a handle and a support stand:

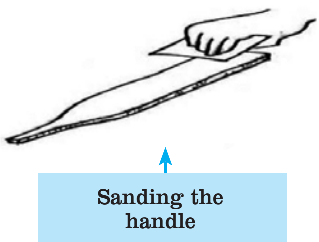
>>> Pump handle

The pump handle is a wooden bar that transmits human force to lift water out of the well.
Select which side to smooth first, and then straighten it with a jointer (planer). Next, plane the edges. Use a thickness planer to make the desired width and thickness of the plank. Mark off 15 cm in the width, and then split the wood along its length, using a circular saw.



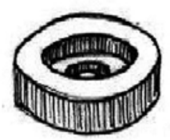
Mark off a length of 120 cm. Use a radial arm saw to cut across the mark. Mark off 20 cm along the length edge, and then 5 cm in the width. Make a curve where the two lines cross. Use a bandsaw to cut out the indents marked out in the previous step. Sand the whole handle with sandpaper.



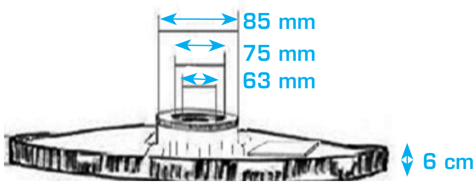


>>> Platform and outlet

The platform (or slab) is made of reinforced concrete 1.8 m in diameter, of proportions 350 kg/m3 (comprising 350 kg of cement, 0.8 m3 of gravel and 0.4 m3 of sand to produce 1 m3 of concrete). Steel bars are inserted in the slab 15 cm apart. Insert 8 mm bars starting from the outer edge and working inwards; then insert 6 mm bars around the edge of the platform and attach them to the 8 mm bars. The thickness of the platform is 6 cm at the outer edges, rising to 10 cm at the outlet of the well. The outlet is raised with 20 cm of concrete. The external diameter of the raised outlet is 85 mm. The diameter of the well hole is 75 mm going 10 cm down from the top of the raised outlet. A 63 mm hole is extended to go through the platform to a depth of 20 cm. Finally, make a hole 40 cm x40 cm in the platform with a concrete cover in order to make a manhole for well maintenance.



Flange raising the outlet



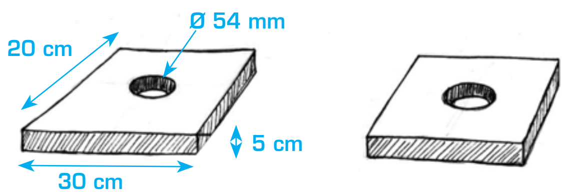
Platform and outlet

>>> Pump stand

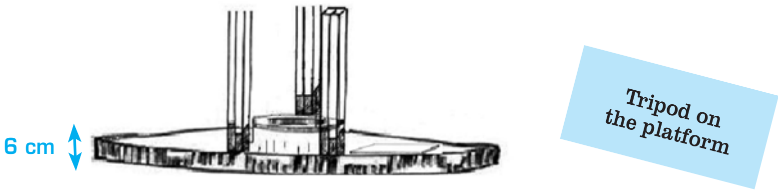
The stand is made of a wooden tripod with two planks nailed on top. Each leg is composed of two posts 10 cm x 15 cm made by planing and sawing pieces of wood, following the process described above.

In the prepared plank, cut out two pieces 30 cm long, 20 cm wide and 5 cm thick. In each piece, make a hole Ø 54 mm for the pump to pass through. Centre the hole 15 cm in along the length, and 10 cm in along the width.

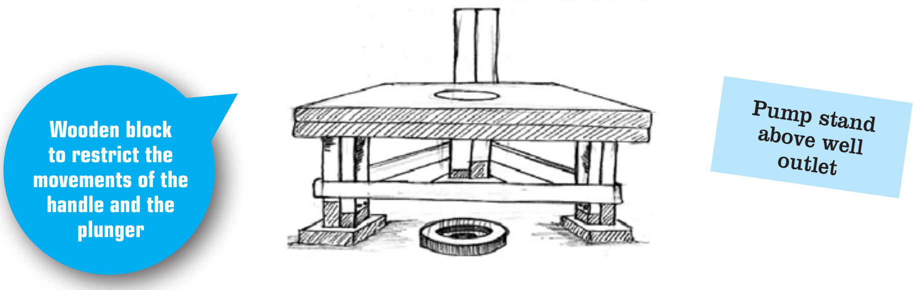
Plank for the stand



Embed two posts 45 cm high at a distance of 15 cm on each side of the outlet of the bore hole or well. Perpendicular to the line between these two posts, embed a third post 80 cm high.



Nail the 30 cm x 20 cm planks to the three posts, making sure the holes in the planks are aligned above the outlet hole.



Make a hole in the third post 70 cm above the ground, using a drill, to hold the screw. Nail a piece of wood 15 cm wide and 5 cm thick, 3 cm from the handle and to the right of the post, to limit the movement of the handle.

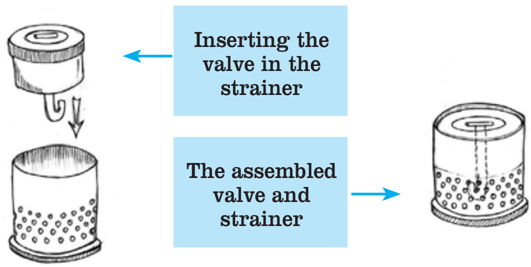
Brace the posts with pieces of wood 10 cm wide, set 20 cm above the ground, to complete the framework of the stand.

There are two ways of embedding the posts in the ground. The first, longer-lasting, solution is to cast a metal casing in the concrete, and then set and bolt the post in the casing. The second is to plant the post directly in the ground or in the concrete; this solution will not last as long because the moisture absorbed in the wood will not evaporate easily.

3 ASSEMBLING THE PUMP

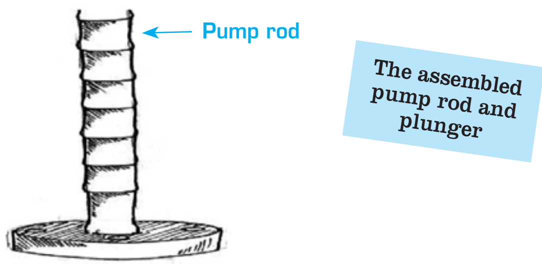
3.1 Assembling the suction valve and strainer

Apply glue all around the suction valve, making sure that the inlet valve is sitting in its casing in order to avoid getting glued. Apply glue to the unperforated part of the strainer pipe, and then insert the suction valve into the strainer, ensuring there is a 10 cm space left.

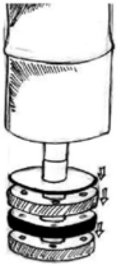


3.2 Assembling the pump rod and the plunger

Apply glue to the lower part of the pump rod. Do likewise along the shaft of the plunger, insert the pump rod in the plunger shaft and leave the assembled parts to dry in the open air.



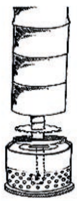
3.3 Mounting the pump rod—plunger to the cylinder



Insert the pump rod inside the cylinder from the bottom up, making sure that the pump rod—plunger unit is longer than the rising main.

The assembled pump rod, plunger and cylinder

3.4 Assembling the rising main and the strainer pipe



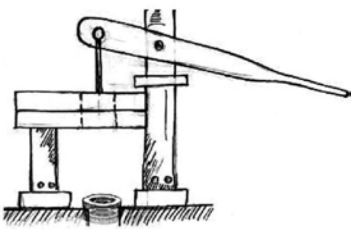
Enlarge the end of the cylinder pipe after softening it by heating. Glue the strainer inside the cylinder with PVC glue and leave to dry.

The assembled inner components of the pump

3.5 Assembling the pump handle and pump stand

Make a hole in the handle 15 cm from the attachment point to the pump rod, and a second hole of the same diameter by the third post of the stand. Place the handle on the right of the post and attach it with bolts.

The assembled pump handle and pump stand

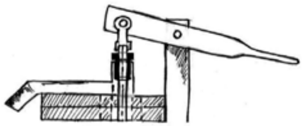


3.6 Assembling the pump head

>>> Assembling the pump, handle and stand

Cut out a ring of hard rubber 5 cm thick, with an internal diameter of 25 mm and an external diameter of 41 mm; and two rings 5 cm thick, with internal diameter 32 mm, external 50 mm. First glue the smaller ring to the pump rod, then glue the larger ring on top, to make a "T" shape to restrict the downward movement of the pump rod.

Watertight ring for the pump rod

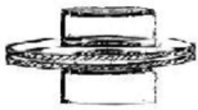


The assembled handle and pump

Using a drill or heated nail, make a hole perpendicular to the axis of the pump rod and the threaded nozzle Ø 25/32, at the part with 32 mm diameter. Use a screw Ø 14/80 to assemble the threaded nozzle and the pump rod. Attach with a bolt and screw it onto the galvanized tee Ø 20/27.

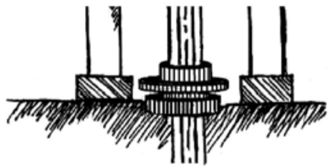
Make a hole 5 cm from the end of the handle, making sure that it is aligned along its axis. Insert a screw Ø 14/80 in the hole, as well as in the galvanized tee and bolt them together.

Make watertight rings to prevent pumped water that may have been contaminated from re-entering the well.



Watertight ring for the pump outlet

Mounting the pump outlet

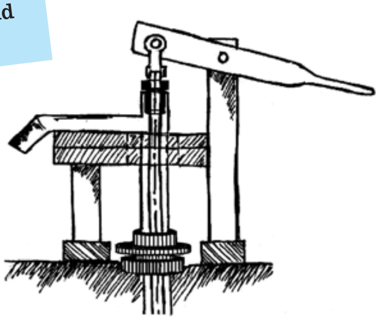


Cut four rings 5 cm thick, with internal diameter of 50 mm and external diameter of 75 mm. Then cut five strips 1 cm thick, internal diameter 50 mm, external 85 mm.

Glue two of the rings to the pump cylinder, then the five strips, followed by the other two rings, to form a plug around the outlet and to act as an extra support for the pump. Insert the pump through the hole in the planks of the stand. The tee that forms the pump spout is attached to the rising main.

Let the pump rest on the plank with its spout.

The assembled above-ground structure



4

OPERATING THE PUMP

Lower the pump into the well or bore hole, with the strainer positioned a maximum of 0.5 m above the bottom of the construction and a minimum of 0.5 m from the surface of the water. The pump can operate in a depth of 1 m of water. During pumping, when the plunger rises, the closed valve creates a vacuum in the bottom of the pump which draws the water. The water enters the strainer to fill this vacuum.

When the plunger descends, the open valve allows the water to pass above the plunger. The plunger rises again, raising the water and creating a new vacuum in the lower part of the pump. During the subsequent descents, the water flows continuously to above the plunger. Since the check valve prevents the water returning, it continues to amass as the plunger rises and falls, until it reaches the surface of the ground.

5 COSTS

While a ready-made pump would cost around 700 000 F CFA, or 1 067 euros, the cost of this pump of 24 m, without installation and in an area without electricity, is only 168 575 F CFA, or 257 euros, based on the following table:

	Unit	*Quantity*	*Unit cost (F CFA)*	**Total cost (F CFA)**
PVC pipe Ø 42/50	m	36	750	27 000
PVC pipe Ø 21/25	m	30	425	12 750
Hacksaw, Ø 50 tee, galvanized tee, drill bits, threaded nozzle, nuts and bolts, sandpaper, file, knife, bucket	Unit	1	30 000	30 000
Tube of PVC glue (1 kg)	Kg	3	2 000	6 000
Precision compass	Unit	1	5 000	5 000
Rubber			10 000	10 000
6 m plank (54 x 300 mm)	Unit	1	7 500	7 500
Labour and renting equipment			55 000	55 000
Contingencies	%	10	188 250	15 325
PUMP TOTAL				**168 575**
Pump installation				
Reinforced concrete	m^3	0,5	150 000	75 000
TOTAL				243 575

6

ADDITIONAL INFORMATION

6.1 Conclusion

Using this pump will reduce the risk of contaminated water and prevent people falling into wells while fetching water. Women and children, who are more involved with fetching water, will need less effort to get water. The physical energy thus saved can be transferred towards studies (for children) and other daily activities, thereby improving conditions of family life.

It is important to note, however, that installing a well pump is not a guarantee of the quality of the water. Other complementary developments will be necessary, for example, ensuring that the water is not contaminated in any way. In addition, the method of fetching water must preserve the quality of water intended for consumption.

6.2 Useful contacts

Engineers without Borders – Cameroon
Water and Sanitation Programme
P.O. Box 96 Eséka – Cameroon
Tel.: +237-77-65-30-04
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www.isf-cameroun.org

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Email: Christina@arecop.org
http://diandesa.org/Home.html

Chinese Society for Agricultural Machinery
No 1 Beishatan Deshengmen Wai
Beijing 100083 (Chine)
Tél. et téléc. : 0086-10-6204 3686
www.agro-csam.org/asecond/introduction/introductionen.asp

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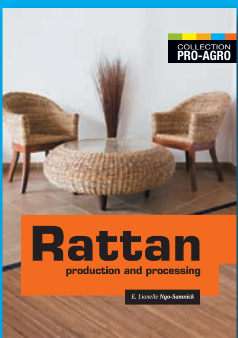

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How to make a hand pump

Pro-Agro is a collection of practical, illustrated guides that are jointly published by CTA and ISF Cameroun. They are an ideal source of information for farmers, rural communities and extension workers in tropical and subtropical regions.
This technical manual provides detailed instructions on how to make a submerged hand pump, using PVC pipes, old tyres and wood. The model described functions to a depth of 24 m. Its low cost means it is highly affordable, and the materials used to make it can be easily found. Maintenance is relatively simple, and the extended handle means that the pumping action significantly reduces the effort required by users. In addition, the hand pump reduces risks of water contamination and accidents (falls), especially in areas where water is drawn with a bucket and rope.

• **The Technical Centre for Agricultural and Rural Cooperation (CTA)**) is a joint international institution of the African, Caribbean and Pacific (ACP) Group of States and the European Union (EU). Its mission is to advance food and nutritional security, increase prosperity and encourage sound natural resource management in ACP countries. It provides access to information and knowledge, facilitates policy dialogue and strengthens the capacity of agricultural and rural development institutions and communities. CTA operates under the framework of the Cotonou Agreement and is funded by the EU.
• **Engineers without Borders (ISF)** is a network of professionals in more than 52 countries to promote human development through improved access to scientific and technical knowledge. In Cameroon, ISF works together with local people to improve their livelihoods and strengthen their technical capacity by sharing and diffusing information adapted to their needs.

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