

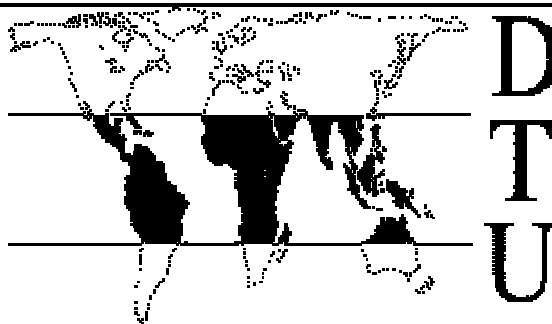
## The Manufacture of Direct Action Handpumps for use with Domestic Rainwater Harvesting Tanks



Prepared by Vince Whitehead

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Development Technology Unit  
School of Engineering, University of Warwick  
Coventry, CV4 7AL, UK  
Tel: +44 (0)24 76523122  
Fax (0) 24 76418922  
Email: [dtu@eng.warwick.ac.uk](mailto:dtu@eng.warwick.ac.uk)  
[Http://www.eng.warick.ac.uk/DTU/](http://www.eng.warick.ac.uk/DTU/)



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**Contents**

**Introduction..... 3**

**2 List of tools required for handpump manufacture ..... 4**

**3 The DTU Handpump ..... 6**

    3.1 Manufacturing procedure..... 6

    3.2 DTU Handpump assembly drawing ..... 7

    3.3 Cost example for 2.5m long DTU Hand pump ..... 8

**4 The Tamana Hand Pump ..... 9**

    4.1 Manufacturing procedure..... 9

    4.2 Tamana handpump assembly drawing ..... 11

    4.3 Cost example for 450mm long Tamana handpump ..... 12

**5 The “Harold” handpump ..... 13**

    5.1 Manufacturing procedure..... 13

    5.2 Harold handpump assembly drawing..... 14

    5.3 Cost example for 2.5m long Harold handpump ..... 15

**6 The Enhanced inertia handpump ..... 16**

    6.1 Manufacturing procedure..... 16

    6.2 Enhanced inertia handpump assembly drawing..... 17

    6.3 Cost example for 2.5m long Enhanced inertia handpump ..... 18

**Appendix 1 Footvalves..... 19**

**Appendix 2 How to cut a thread in PVC pipe ..... 20**

**Appendix 3 Pull rod bushes and inlet details..... 23**

**Appendix 4 The floating valve ..... 24**

**Appendix 5 The piston/valve seal cutter ..... 25**

**Appendix 6 Fixture for slitting Harold pump pull rod ..... 26**

**Appendix 7 How to make the Harold pump moulded cup ..... 27**

## **Introduction**

Following the work of building some partially below ground tanks at Kyera Farm, Mbarara, Uganda for the collection of rainwater, there was a need to extract water from the tanks simply and effectively without incurring a large expense or relying on materials and spares being brought from overseas. During July and August 2000 a few designs and ideas were tried which caused sufficient interest from several NGO's to hold a training workshop at Kyera Farm. This manual is a direct result of that interest, it contains sufficient information for someone with access to a set of basic tools and a reasonable amount of practical skill to manufacture the handpumps without too much difficulty. Within this manual there are details of four types of direct action handpumps for use with domestic roof water harvesting (DRWH) tanks.

The main objective in the design of these hand pumps was to produce low cost handpumps, which can be manufactured and maintained with locally available materials and locally available skills.

It must be mentioned that these pumps are not intended for community use and are for household use only as community pumps require a much more robust design. All these pumps have been used at depths between 2.5 to 3m but may be used at beyond this subject to practical limitations. There may be situations where these pumps may be used for purposes other than with DRWH tanks, for example in irrigation, you are encouraged to apply them wherever there may be a use for them.

The following designs and parts list may be adapted or exchanged to suit the availability of materials or personal preferences, e.g. choice of foot valve or exchanging the handle from one pump to another.

I apologise for using both imperial and metric units in this manual, many items purchased in Uganda were found to use both units, please use the nearest equivalents wherever possible.

I would be grateful for any feed back you may have on any aspect of these pumps whether this is criticism or possible improvements.

Please forward any correspondence to:-

Development Technology Unit  
School of Engineering  
University of Warwick  
Coventry, CV4 7AL, England.  
Email:- [dtu@eng.warwick.ac.uk](mailto:dtu@eng.warwick.ac.uk)

## **2 List of tools required for handpump manufacture**

This list is a good guide of what tools are required for the handpumps but it may be found that other tools may make manufacture easier or more cost effective. It may depend on what tools are available.

1 Hacksaw and blade

2 Hammer

3 Pliers

4 Pipe wrench

5 Hand drill

6 Set of drills (2mm, 3mm, 4mm, 5mm, 6mm, 7mm, 8mm,)

7 Screwdriver

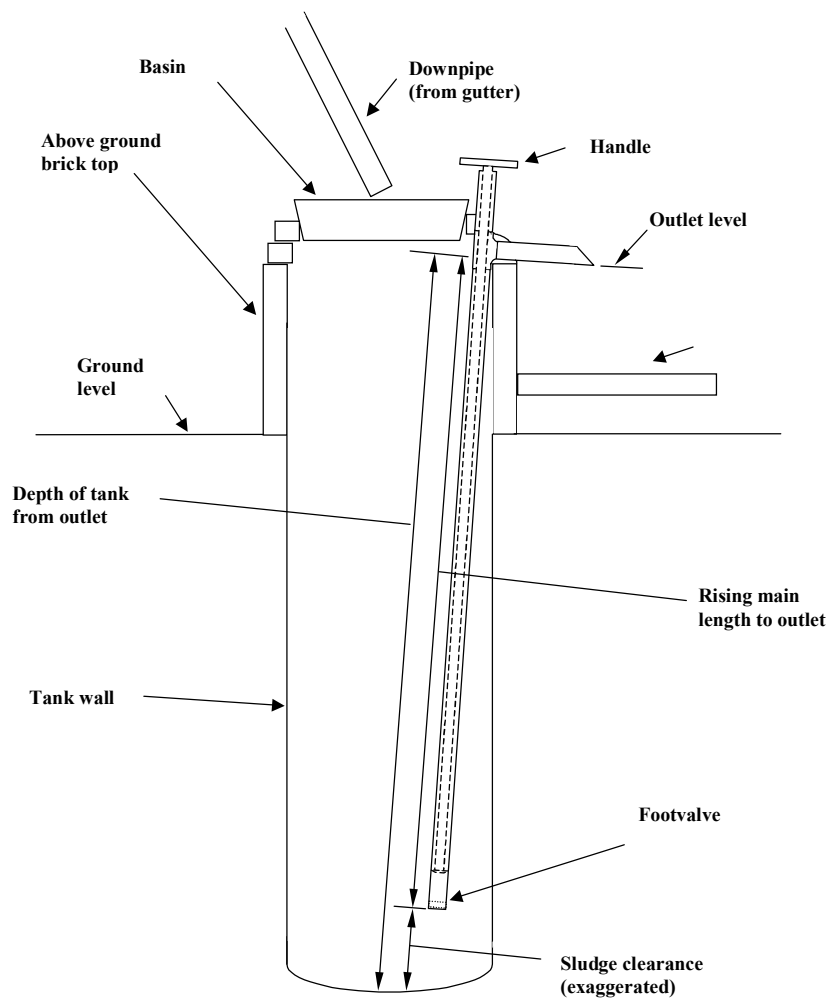
8 Set of files (150mm triangular, 250mm half-round, 250mm rough)

9 Scissors

10 Tape measure

11 Stove (or some adequate heat source)

12 Sandpaper



**Figure 1 Principle components of domestic rainwater harvesting tank**

A typical domestic rainwater harvest (DRWH) tank is shown in Figure 1 illustrating some of the major components and showing the handpump in position. It is important to note with the handpump that the footvalve must not come in to contact with the base of the tank and should ideally have sufficient clearance for any build up of sludge.

At the top of the tank the handpump protrudes through a small gap in the brickwork and is held rigidly with a small amount of sand and cement. This is placed around the Tee to restrain any movement from forces generated during operation. On larger tanks the handpump may protrude through a small hole in the cover, a mound of mortar is built up around the Tee to securely hold this in position. When maintenance is required the mortar can be carefully removed and the pump withdrawn.

Most containers used for collecting water in West Africa are plastic jerricans, so the distance from the handpump outlet to the stand should be about 25 to 50mm greater than the height of a 20 litre jerrican.

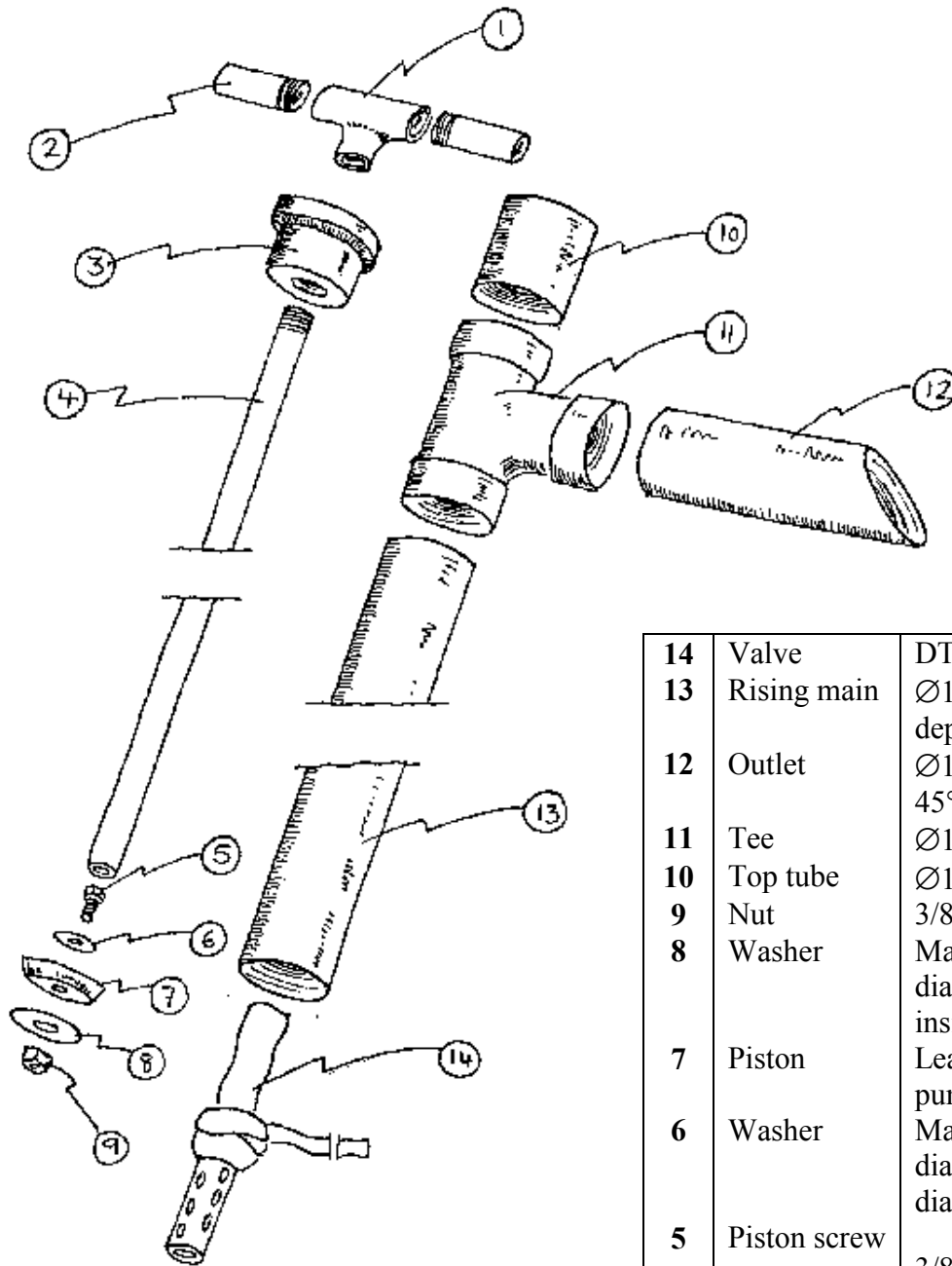
### 3 The DTU Handpump

The DTU Handpump is simple lift pump and uses a leather stirrup pump piston, which is available from most cycle shops. The principle of operation is as follows: As the handle is lifted the water above the leather washer is lifted with it, during this stage the footvalve is opened and the water fills the rising main below the leather piston. On the downstroke the footvalve is closed and the water in the lower section by passes the leather washer to the upper section, repeat operations transfers water to the outlet. It will be noticed during operation that water will pour from the outlet on both strokes, this is because the push rod displaces water within the rising main.

#### 3.1 Manufacturing procedure.

- Measure depth of tank (from outlet level to bottom of tank) and subtract some small amount to ensure that the footvalve is not touching bottom of tank. This is to stop sediment from being drawn up in to the handpump (This may be around 250 - 300mm)
- Select a straight piece of  $\text{Ø}1\frac{1}{2}$ " PVC pipe with a smooth internal bore (This will cause less wear on the leather piston) and cut to required lengths as indicated in the following assembly drawing. Also cut the top tube and the outlet.
- Make sure the internal surface of the tee is clear of any obstructions, as this will interfere with inserting/removing the leather piston, file any obstructions until the leather piston passes through the tee.
- Make up the DTU or low cost valve (as shown in Appendix 1) and fix to the bottom of rising main.
- Push top tube and tee on to rising main and measure or calculate the total distance from the top of the top tube to the top of the footvalve. From this subtract approximately 50mm and cut the pull rod to this measurement, this will ensure that the piston will not hit the footvalve at the bottom of the pull rod stroke.
- Thread the top end (details on threading PVC pipe is shown in Appendix 2) of the and pull rod and fit a  $\text{Ø}\frac{1}{2}$ " PVC/GI Tee, also fit the two threaded handles and slide on the wooden support bush.
- Securely fix the  $\frac{3}{8}$ " BSW (or an M8) screw in to bottom of pull rod. This can be done by heating the end of the pipe and pushing the PVC material in to the thread to stop the head of the screw from coming out of the pipe. A series of four saw cuts can be cut in to the end of the pipe to a depth equal to the saw blade (about 12mm) this will help when pushing the hot PVC material on top the thread.
- Place on the screw the washer, leather, second washer and the  $\frac{3}{8}$ " BSW Nut on to the  $\frac{3}{8}$ " BSW screw alternatively use a M8 screw and nut.
- Grease the leather washer (make sure that it will not taint or contaminate the water).
- Fit on the outlet tube on to the tee.
- Insert the pull rod into the rising main.
- Test operation of the handpump.
- If the handpump operates satisfactorily use PVC cement on the three joints of the PVC tee.

### 3.2 DTU Handpump assembly drawing



|    |               |  |
|----|---------------|--|
| 14 | Valve         | DTU type (see Appendix 1)  |
| 13 | Rising main   | Ø1 1/2" PVC (length to suit depth of tank)   |
| 12 | Outlet        | Ø1 1/2" x 8" (200mm) (end at 45°)  |
| 11 | Tee           | Ø1 1/2" PVC  |
| 10 | Top tube      | Ø1 1/2" x 8" (200mm)   |
| 9  | Nut           | 3/8" BSW or M8   |
| 8  | Washer        | Made from PVC pipe, outside diameter = 1 1/4" (30mm), inside diameter = 3/8" (8mm) |
| 7  | Piston        | Leather washer from stirrup pump   |
| 6  | Washer        | Made from PVC pipe, outside diameter = 1" (25mm), inside diameter = 3/8" (8mm)     |
| 5  | Piston screw  | 3/8" BSW x 3/4" (M8 x 20mm)  |
| 4  | Pull rod      | 1/2" PVC pipe (length to suit rising main)   |
| 3  | Pull rod bush | To suit pipe (see Appendix 3)  |
| 2  | Handles       | 1/2" PVC pipe x 4" (100mm) (2 pieces)  |
| 1  | Tee           | 1/2" PVC or GI   |

### 3.3 Cost example for 2.5m long DTU Hand pump

| PART No. | NAME             | UNIT | SIZE/ LENGTH                    | COST PER MATERIAL LENGTH (UGS) | COST/PUMP (UGS)  | COST/PUMP US Dollar (\$1=UGS1775) <sup>1</sup> |
|----------|------------------|------|---------------------------------|--------------------------------|------------------|--|
| 1        | Tee              | Inch | Ø½" GI (or PVC)                 | 500                            | 500              | 0.28   |
| 2        | Handles          | Inch | Ø½"PVC x 4" (100mm)<br>2 pieces | 7,500 per 20ft                 | 250              | 0.14   |
| 3        | Pull Rod Bush    | No   | 1                               | 260                            | 260              | 0.14   |
| 4        | Pull Rod         | Inch | Ø½"PVC x 80" (2000mm)           | 7,500 per 20ft                 | 2,500            | 1.39   |
| 5        | Screw            | No   | 3/8" BSW X 1" or M8 x 25mm      | 500                            | 500              | 0.28   |
| 6        | Washer           | No   | 3/8" (8mm)                      | 100                            | 100              | 0.06   |
| 7        | Piston           | No   | Ø1 ½" leather                   | 500                            | 500              | 0.28   |
| 8        | Washer           | No   | 3/8" (8mm)                      | 100                            | 100              | 0.06   |
| 9        | Nut              | Inch | 3/8" (or M8)                    | -                              | -                | 0.00   |
| 10       | Top tube         | Inch | Ø1 ½" PVC x 8" (200mm)          | 12,500 per 20ft                | 420              | 0.23   |
| 11       | Tee              | Inch | Ø1 ½" PVC                       | 2,500                          | 2,500            | 1.39   |
| 12       | Outlet           | Inch | Ø1 ½" PVC x 8" (200mm)          | 12,500 per 20ft                | 420              | 0.23   |
| 13       | Rising Main      | Inch | Ø1 ½" PVC x 86" (2150mm)        | 12,500 per 20ft                | 4,480            | 2.50   |
| 14       | Foot Valve (DTU) | No   | 1                               | 675                            | 675              | 0.38   |
|          |                  |      |                                 |                                | <b>UGS13,205</b> | <b>\$7.36</b>                                  |

Material cost (UGS) = 13,205  
 (Labour Cost/day = 2,500)  
 Labour cost for 4 hrs = 1,250  
**Total cost = 14,455 (\$8.14)**

DTU VALVE COST: ¾" PVC pipe x 8" @ 10,000/20ft = 333  
 Inner tube x 4" = 90  
 2ft of inner tube strip = 250  
**Total cost = 673 (\$0.38)**

<sup>1</sup> Source: <http://finance.yahoo.com/m5?a=1&s=USD&t=UGX> (Sept 2000)



## 4 The Tamana Hand Pump

This slightly modified version of the Tamana handpump, which is used as suction pump, relies on a seal from the piston/valve and the bore of the PVC cylinder.

During operation and on the upstroke, the piston/valves lays flat on the PVC supports, this creates a lower pressure below the piston/valves which draws water in to the cylinder through the footvalve. As the push rod is depressed the piston/valves are slightly raised from their piston supports and water flows through the holes of these into the cylinder above the piston/valves. On each stroke water is discharged through the outlet, this is because on the downstroke the volume of the pull rod displaces water as with the previous handpump.

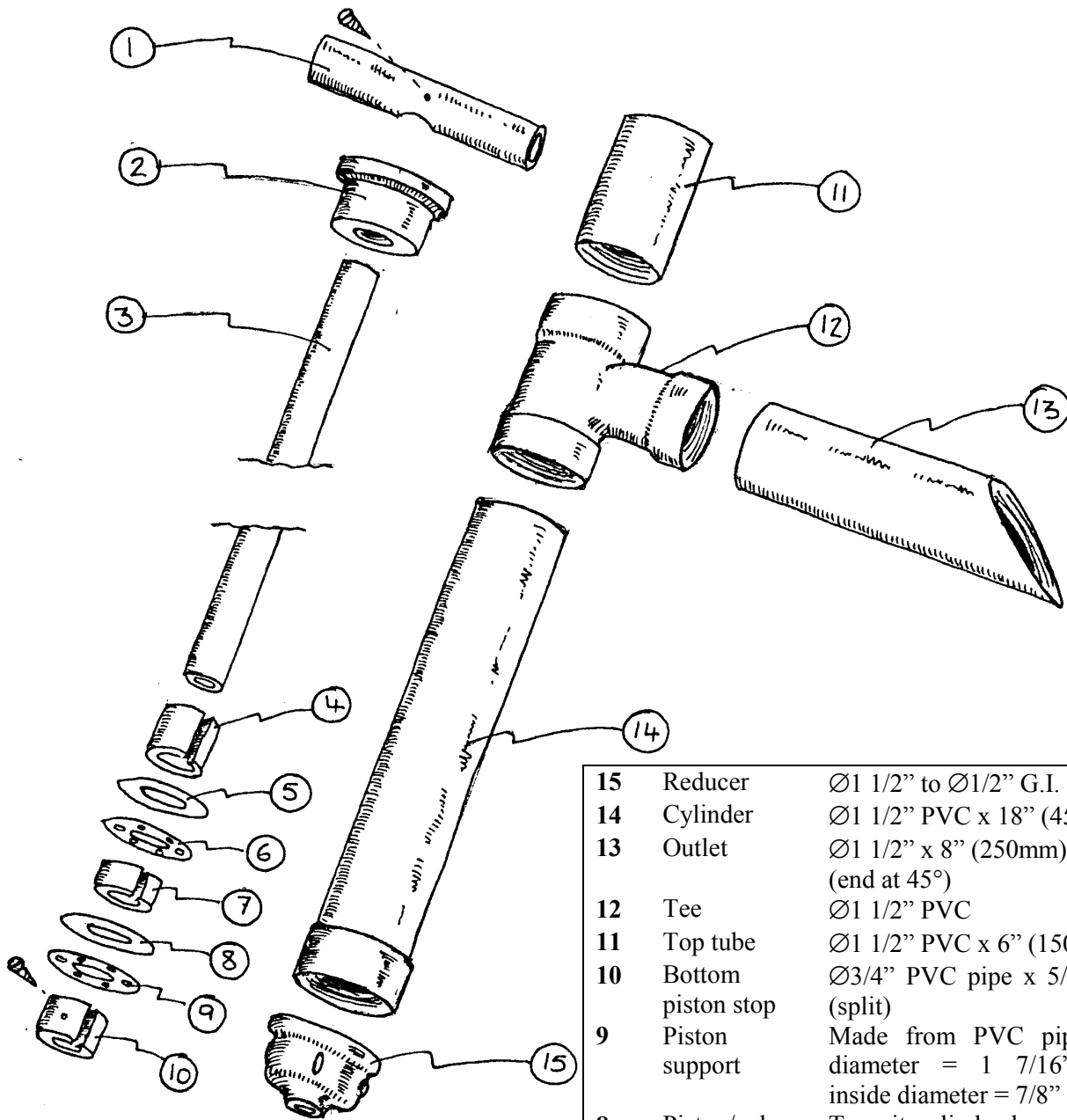
Labyrinth seals (a series of seals) can improve the time between seal replacements, this version uses only two as a demonstration but more could be added. A suitable length of ½ " PVC pipe is connected to the reducer which leads in to the DRWH tank and a floating valve is used for the intake (see Appendix 4 for details of the floating valve). The PVC pipe can either be threaded (as described in Appendix 2) and fitted with elbows to reach down in to the tank or it can be bent by heat application. The latter can be done by putting a wood stopper at one end of the pipe and pouring sufficient sand inside the pipe a few inches beyond where the bend is to be. Heat gently and evenly around the bend area and bend slowly until the desired angle is achieved. Cold water can be poured on to the pipe to set it quickly.

### 4.1 Manufacturing procedure

- Select a piece of Ø1 ½" PVC pipe (with a swaged end) with as smooth as bore as is possible and cut to 450mm long. Chamfer the swaged end and thread (using the method described in Appendix 2).
- Cut the top tube and outlet to length, to the dimensions shown in the following table).
- Cut three lengths of Ø3/4" PVC pipe and split each one lengthways. Their faces must be square with the bore.
- For the PVC supports: mark out two concentric diameters on a flattened piece of PVC pipe, the larger diameter is 1/8" smaller than bore of Ø1 ½" PVC pipe and the smaller diameter is the same as the outside diameter of the pull rod. Cut out the central hole out first, as this is easier. Then mark out 8 equally spaced holes and drill them 5mm diameter. Finally cut out the outside diameter and file smooth. N.B. The piston supports are made from PVC pipe by splitting, heating and flattening a suitable piece of pipe.
- Cut out two rubber piston/valves using the piston/valve cutter shown in Appendix 5.
- Assemble together as shown in following drawing, making sure that top and bottom piston stops are pushed up towards each other trapping the piston/valves in place, screw top & bottom piston stops in this position.
- Cut a 250mm piece of Ø3/4" PVC pipe for the handle, make a hole in the centre for the pull rod to pass through.
- Place a wood support bush on to pullrod and fix handle in place.

- Cut a small disc of PVC to 22mm diameter and cement this to the top of Ø½" PVC pullrod.
- Check that the piston assembly passes through the Ø1 ½" Tee, file any obstruction till this is achieved.
- Assemble and test.
- If pump works satisfactorily, cement the three joints around the Ø1½" Tee ensuring that pipes are in line with each other.

#### 4.2 Tamana handpump assembly drawing



|    |                    |   |
|----|--------------------|---|
| 15 | Reducer            | Ø1 1/2" to Ø1/2" G.I.   |
| 14 | Cylinder           | Ø1 1/2" PVC x 18" (450mm)   |
| 13 | Outlet             | Ø1 1/2" x 8" (250mm)<br>(end at 45°)  |
| 12 | Tee                | Ø1 1/2" PVC   |
| 11 | Top tube           | Ø1 1/2" PVC x 6" (150mm)  |
| 10 | Bottom piston stop | Ø3/4" PVC pipe x 5/8" (16mm)<br>(split)   |
| 9  | Piston support     | Made from PVC pipe, outside diameter = 1 7/16" (36mm),<br>inside diameter = 7/8" (22mm) |
| 8  | Piston/valve       | To suit cylinder bore (use piston cutter shown in Appendix 5)                           |
| 7  | Centre piston stop | Ø3/4" PVC pipe x 5/8" (16mm)<br>(split)   |
| 6  | Piston support     | Made from PVC pipe, outside diameter = 1 7/16" (36mm),<br>inside diameter = 7/8" (22mm) |
| 5  | Piston/valve       | To suit cylinder bore (use piston cutter as shown in Appendix 5)                        |
| 4  | Top piston stop    | Ø3/4" PVC pipe x 5/8" (16mm)<br>(split)   |
| 3  | Pull rod           | Ø1/2" PVC x 25" (625mm)   |
| 2  | Pull rod bush      | To suit pipe (see Appendix 3)   |
| 1  | Handle             | Ø3/4" PVC x 8" (250mm)  |

### 4.3 Cost example for 450mm long Tamana handpump

| PART No. | NAME               | UNIT   | SIZE/ LENGTH  | COST PER MATERIAL LENGTH (UGS) | COST/ PUMP (UGS) | COST/PUMP US Dollar (\$1= UGS1775) <sup>2</sup> |
|----------|--------------------|--------|---|--------------------------------|------------------|---|
| 1        | Handle             | Inch   | Ø½" PVC x 8" (250mm)  | 10,000 per 20ft                | 335              | 0.19  |
| 2        | Pull rod bush      | No.    | 1   | 2000                           | 260              | 0.14  |
| 3        | Pull rod           | Inch   | Ø½" PVC x 25" (625mm)   | 7500 per 20ft.                 | 780              | 0.43  |
| 4        | Top piston stop    | Inch   | Ø¾" PVC x 5/8" (16mm)   | 10,000 per 20ft.               | 26               | 0.01  |
| 5        | Piston valve       |        | To suit cylinder  |                                | 50               | 0.03  |
| 6        | Piston support     |        | 1 7/16" (36mm) outside diameter, 7/8" (22mm) inside diameter  | 12500 per 20ft.                | 26               | 0.01  |
| 7        | Centre piston stop | Inch   | Ø¾" PVC x 5/8" (16mm)   | 10,000 per 20ft                | 26               | 0.01  |
| 8        | Piston/valve       |        | To suit cylinder  |                                | 50               | 0.03  |
| 9        | Piston support     | Metric | 1 7/16" (36mm) outside diameter, 7/8" (22mm) inside diameter. | 12500 per 20ft.                | 26               | 0.01  |
| 10       | Bottom piston stop | Inch   | Ø¾" PVC x 5/8" (16mm)   | 10,000 per 20ft                | 26               | 0.01  |
| 11       | Top tube           | Inch   | Ø1 ½" PVC x 8" (250mm)  | 12500 per 20ft.                | 420              | 0.23  |
| 12       | Tee                | Inch   | Ø1 ½"   | 2500                           | 2500             | 1.39  |
| 13       | Outlet             | Inch   | Ø1 ½" PVC x 8" (250mm)  | 12500 per 20ft.                | 420              | 0.23  |
| 14       | Cylinder           | Inch   | Ø1 ½" PVC x 18" (450mm)                                       | 12500 per 20ft.                | 940              | 0.52  |
| 15       | Reducer            | Inch   | Ø1 ½" – Ø1/2"   | 2000                           | 2000             | 1.11  |
|          |                    |        |   |                                | <b>7885</b>      | <b>4.39</b>                                     |

Material Cost (UGS) = **7,885**      (**\$4.39**)  
(Labour Cost/day = 2,500)  
Labour cost for 4hrs = 1,250  
**Total cost (UGS) = 9,135**      (**\$5.09**)

*N.B. there will be additional cost to this as the Ø ½" PVC pipe to the tank and the floating valve have not been included.*

<sup>2</sup> Source: <http://finance.yahoo.com/m5?a=1&s=USD&t=UGX> (Sept 2000)

## 5 The “Harold” handpump

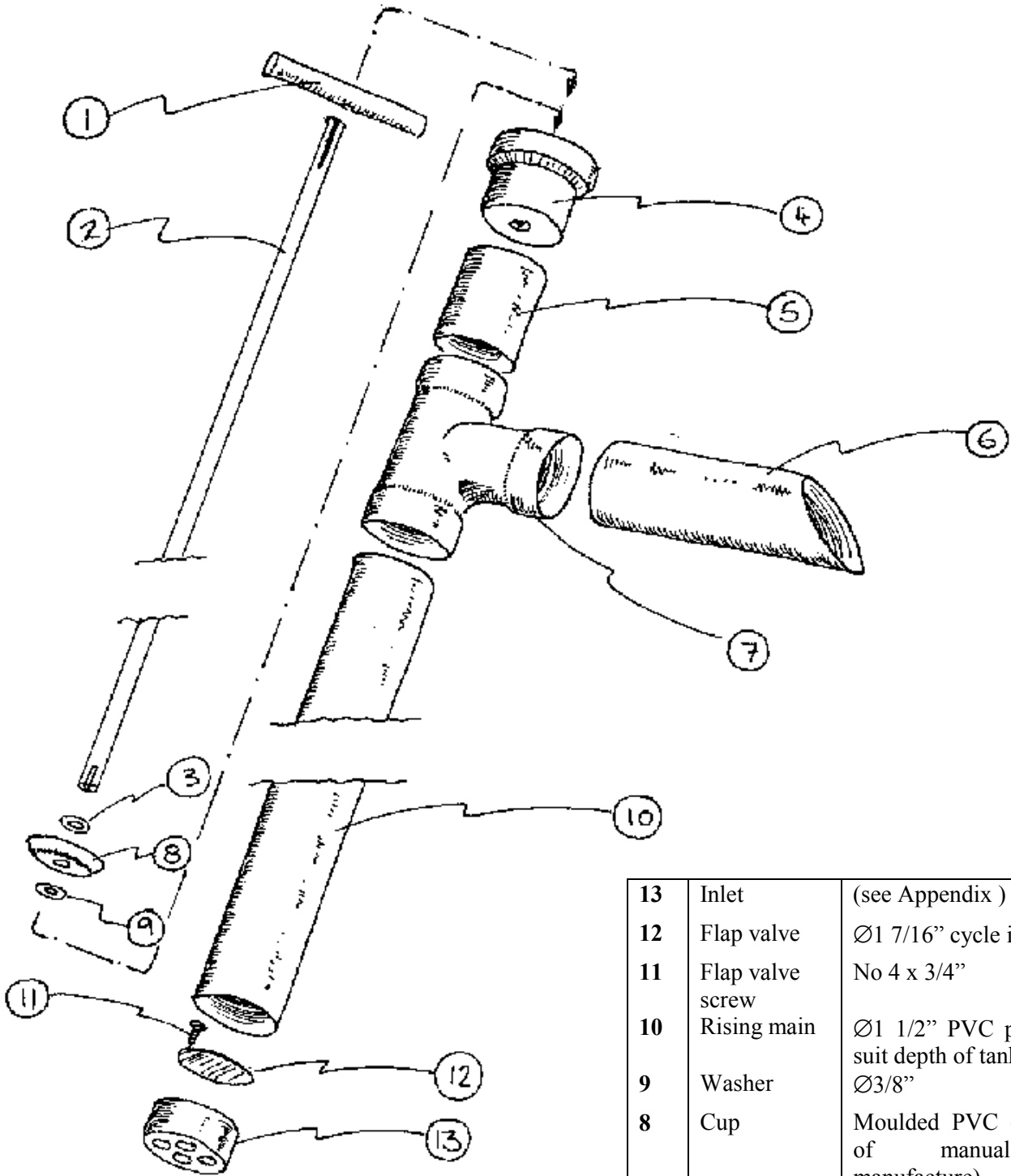
This is another lift pump, though it does not rely on having a seal or a flexible membrane within the rising main. The piston as such is a moulded plastic cup which is slightly smaller than the bore of the rising main, this is shaped in such a way that it has greater resistance on the up stroke and water is lifted by the cup. A small amount of water will leak past the gap around the cup. During the upstroke the footvalve opens allowing water into the rising main. On the down stroke the foot valve closes, and the water within the rising main flows around and above the cup. Repeated operation lifts water to the outlet and very little is displaced on the return stroke because of the small volume of the pull rod.

Despite the gap around the moulded cup the pump discharges a surprising amount of water per stroke.

### 5.1 Manufacturing procedure

- Measure the depth of the tank from the outlet to the bottom of the tank and subtract some small amount to ensure that the footvalve is not touching bottom of tank. (This may be around 200 to 250mm)
- Select a straight section of  $\text{Ø}1\frac{1}{2}$ " PVC pipe and cut to the required length.
- Cut the top tube and outlet to the right length as shown in the following table.
- Push these sections together with the Tee, and fit a footvalve to the bottom of the rising main (see Appendix 1 for footvalve assembly)
- Measure the distance from the top of the top tube to the top of the foot valve, subtract 1" from this and cut a section of  $\frac{3}{8}$ " or 8mm steel rod to this length.
- Slit one end with a hacksaw to a depth of 16mm and the other end to a depth of 30mm (if a hand vice is unavailable see Appendix 6).
- Cut an 8" long piece of  $\text{Ø}\frac{1}{2}$ " PVC pipe for the handle and drill a  $\frac{3}{8}$ " or 8mm diameter hole at the midpoint. Insert the handle on the pull rod, so the handle is level with the bottom of the 30mm slit.
- Prize open the two halves of the rod with a screwdriver and gradually push and hammer back the steel around the handle until the handle is firmly held in place.
- Slide on the wood support bush towards the handle.
- At the other end insert a piece of copper wire through the slit and wind round several times, push the washer up to the wire, then fit on the moulded cup (see Appendix 7) and bottom washer. Wrap the remaining copper wire around the rod above the washer to retain it. Push a screwdriver blade into slot and gently prize open the two halves so that the assembly is held firm.
- Check that there is no obstruction in the  $1\frac{1}{2}$ " Tee, making sure that the pull rod assembly will pass through the Tee, file clear if needed.
- Push the assembled pull rod down into the rising main and test operation.
- If the pump works okay cement the three joints around the Tee making sure the pipes are all in line with each other

5.2 Harold handpump assembly drawing.



|    |                  |  |
|----|------------------|--|
| 13 | Inlet            | (see Appendix )                                  |
| 12 | Flap valve       | Ø1 7/16" cycle inner tube                        |
| 11 | Flap valve screw | No 4 x 3/4"                                      |
| 10 | Rising main      | Ø1 1/2" PVC pipe x (to suit depth of tank)       |
| 9  | Washer           | Ø3/8"  |
| 8  | Cup              | Moulded PVC (see back of manual for manufacture) |
| 7  | Tee              | Ø1 1/2" PVC                                      |
| 6  | Outlet           | Ø1 1/2" PVC pipe x 8" (end cut at 45°)           |
| 5  | Top tube         | Ø1 1/2" PVC pipe x 8"                            |
| 4  | Pull rod bush    | To suit pipe (see Appendix 3)                    |
| 3  | Washer           | Ø3/8"  |
| 2  | Pull rod         | Ø3/8" steel x (to suit depth of rising main)     |
| 1  | Handle           | Ø1/2" PVC x 8"                                   |

### 5.3 Cost example for 2.5m long Harold handpump

| PART No. | NAME          | UNIT | SIZE/ LENGTH                      | COST PER MATERIAL LENGTH (UGS) | COST/ PUMP (UGS) | COST/PUMP US Dollar (\$1= UGS1775) <sup>3</sup> |
|----------|---------------|------|-----------------------------------|--------------------------------|------------------|---|
| 1        | Handle        | Inch | Ø½" PVC pipe x 8" (200mm)         | 7500 per 20 ft                 | 250              | 0.14  |
| 2        | Pull rod      | Inch | Ø3/8" or 8mm steel x 95" (2375mm) | 2000 per 20 ft                 | 792              | 0.44  |
| 3        | Washer        | No.  | 3/8" or 8mm                       | 100                            | 100              | 0.06  |
| 4        | Pull rod bush | No.  | 1                                 | 260                            | 260              | 0.14  |
| 5        | Top tube      | Inch | Ø1 ½" PVC pipe x 8" (200mm)       | 12500 per 20 ft                | 420              | 0.23  |
| 6        | Outlet        | Inch | Ø1 ½" PVC pipe x 8" (200mm)       | 12500 per 20 ft                | 420              | 0.23  |
| 7        | Tee           | No.  | Ø1 ½" PVC                         | 2500                           | 2500             | 1.39  |
| 8        | Molded cup    | No.  | 1                                 | 12500 per 20 ft                | 26               | 0.01  |
| 9        | Washer        | No.  | 3/8" or 8mm                       | 100                            | 100              | 0.06  |
| 10       | Rising main   | Inch | Ø1 ½" PVC pipe x 89" (2225mm)     | 12500 per 20 ft                | 4635             | 2.58  |
| 11       | Wood screw    | No.  | 4 x ¾" (20mm)                     | 1000/box                       | 20               | 0.01  |
| 12       | Valve         | Inch | 1 7/16" diameter or 38mm          | 20                             | 20               | 0.01  |
| 13       | Inlet         | No.  | 1                                 | 260                            | 260              | 0.14  |
|          |               |      |                                   |                                | <b>9,830</b>     | <b>5.46</b>                                     |

Material Cost (UGS) = 9,830  
(\$5.46)

(Labour Cost/day = 2,500)

Labour cost for 4hrs labour = 1,250

**Total cost (UGS) = 11,503 (\$6.16)**

<sup>3</sup> Source: <http://finance.yahoo.com/m5?a=1&s=USD&t=UGX> (Sept 2000)

## 6 The Enhanced inertia handpump

The Enhanced inertia Pump is a lift pump, which again does not rely on a seal within the rising main but uses a central tube to lift the water, which overflows in to the rising main. On the upstroke the central foot valve is closed and the main footvalve is opened letting water in to the rising main. As the handle is depressed the central tube footvalve is opened letting water in to the central tube, meanwhile the main footvalve is closed. Repeat operations gradually brings water up the central tube, this then flows through the holes in the central tube in to the rising main and is eventually discharged at the outlet. A good commercial example is manufactured by made by the "New Zealand Pump Company"

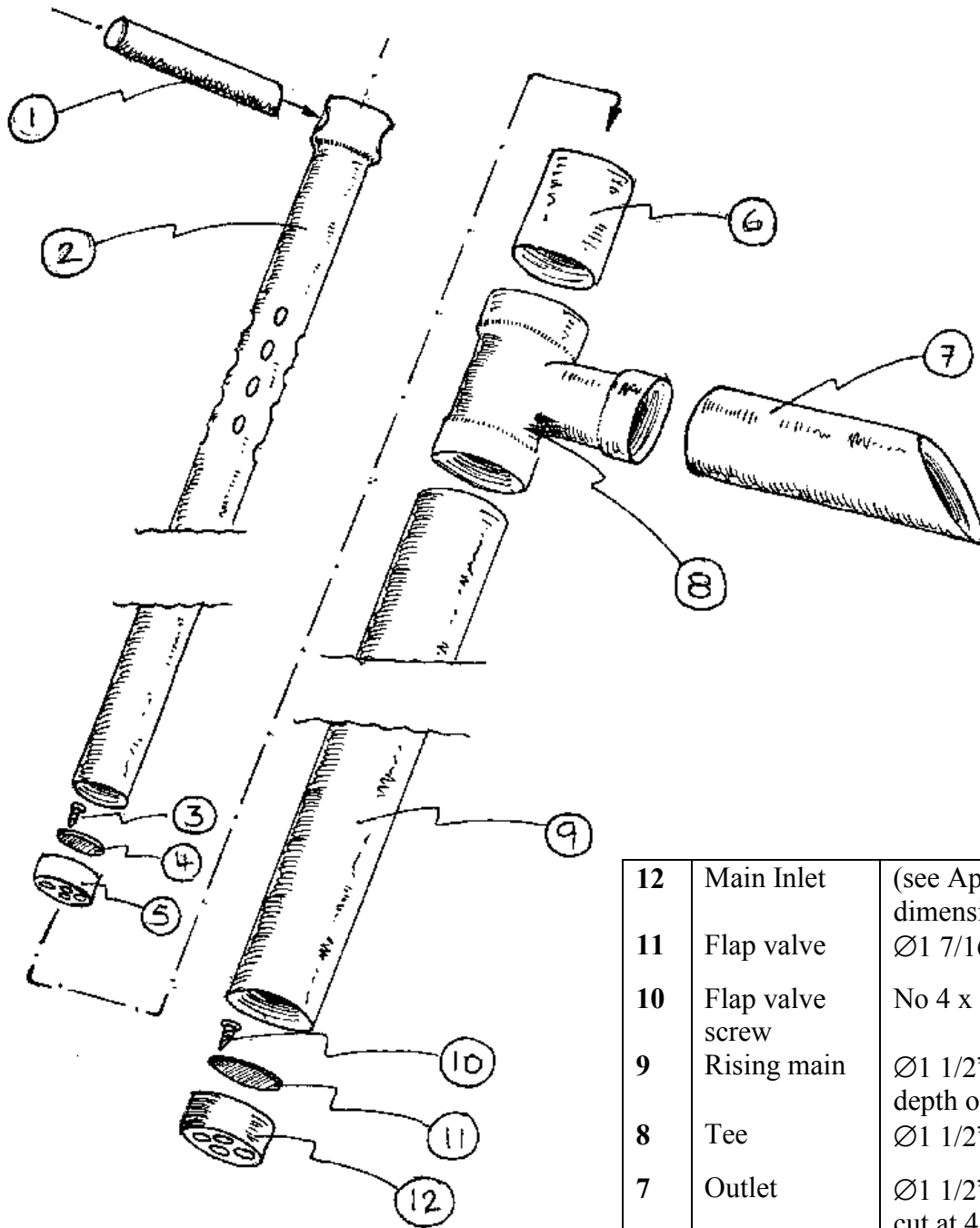
This handpump seems to operate best when short strokes are used. The flow is steady on both strokes of operation again because of the high displacement from the central tube full of water on the downstroke.

### 6.1 Manufacturing procedure

- Measure the depth of the tank from the outlet to the bottom of the tank and subtract some small amount to ensure that the footvalve is not touching bottom of tank. (This may be around 8" - 10")
- Select a straight piece of Ø1 ½" PVC pipe and cut to the required length.
- Cut to top tube and outlet from Ø1 ½" PVC pipe (see following table for dimensions)
- Make up the low cost valve or DTU valve and fit to bottom of Ø1 ½" PVC pipe. Make sure that it is a good tight fit, though once it is wet it will expand.
- Push together top tube, Tee and outlet and measure the distance to top of footvalve, from this subtract approx. 2" and cut a piece of Ø1 ¼" PVC pipe to this length. Use the swaged end for the top of the central tube as this seals the two tubes when the handpump is not being used.
- Cut a series of holes approximately 8mm diameter, which starts about 250mm below the top of central tube to around 200mm in length. The number of holes is not too important so long as there are sufficient holes for water to escape through and not too many that it weakens the tube.
- Cut a hole in top of central tube 7/8" or 22mm diameter for the handle.
- Cut the handle from a piece of Ø½" PVC x 200mm long and PVC cement it in to the hole in the central tube.
- Cut a PVC disc to fit in top of central tube and cement in place.
- Make up a foot valve and fit to the bottom of central tube. Note that the wood inlet needs to be a good tight fit inside the tube.
- Fit together and test.
- If test is okay, cement the three joints of the Tee ensuring that pipes and Tee are all in line with each other.



## 6.2 Enhanced inertia handpump assembly drawing



|    |                  |  |
|----|------------------|--|
| 12 | Main Inlet       | (see Appendix 3 for dimensions)            |
| 11 | Flap valve       | Ø1 7/16" cycle inner tube                  |
| 10 | Flap valve screw | No 4 x 3/4"                                |
| 9  | Rising main      | Ø1 1/2" PVC pipe x (to suit depth of tank) |
| 8  | Tee              | Ø1 1/2" PVC                                |
| 7  | Outlet           | Ø1 1/2" PVC pipe x 8" (end cut at 45°)     |
| 6  | Top tube         | Ø1 1/2" PVC pipe x 8"                      |
| 5  | Central inlet    | (see Appendix 3 )                          |
| 4  | Flap valve       | Ø1 3/16" cycle inner tube                  |
| 3  | Flap valve screw | No 4 x 3/4"                                |
| 2  | Central tube     | Ø1 1/4" PVC pipe x (to suit rising main)   |
| 1  | Handle           | Ø1/2" PVC x 8"                             |

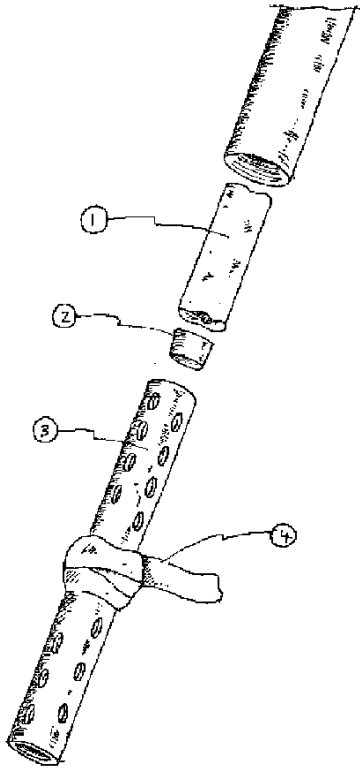
### 6.3 Cost example for 2.5m long Enhanced inertia handpump

| PART No. | NAME         | UNIT   | SIZE/ LENGTH                 | COST PER MATERIAL LENGTH (UGS) | COST/ PUMP   | COST/PUMP US Dollar (\$1=UGS1775) <sup>4</sup> |
|----------|--------------|--------|------------------------------|--------------------------------|--------------|--|
| 1        | Handle       | Inch   | Ø½" PVC pipe x 8" (200mm)    | 7500 per 20ft                  | 250          | 0.14   |
| 2        | Central tube | Inch   | Ø1¼" PVC pipe x 83" (2075mm) | 11000 per 20ft                 | 3800         | 2.12   |
| 3        | Wood screw   | No.    | 4 x ¾" (20mm)                | 1000/box                       | 20           | 0.01   |
| 4        | Valve        | Inch   | 1 3/16" diameter or 30mm     |                                | 50           | 0.03   |
| 5        | Inlet        | No.    | 1                            | 2000 per 20ft                  | 260          | 0.14   |
| 6        | Top tube     | Inch   | Ø1½" PVC pipe x 8" (200mm)   | 12500 per 20ft                 | 420          | 0.23   |
| 7        | Outlet       | Inch   | Ø1½" PVC pipe x 8" (200mm)   | 12500 per 20ft                 | 420          | 0.23   |
| 8        | Tee          | No.    | Ø1½" PVC                     | 2500                           | 2500         | 1.39   |
| 9        | Rising main  | Inch   | 1½" PVC pipe x 86" (2150mm)  | 12500 per 20ft                 | 4480         | 2.50   |
| 10       | Wood screw   | No.    | 4 x ¾" (20mm)                | 1000/box                       | 20           | 0.01   |
| 11       | Valve        | Metric | 1 7/16" diameter or 38mm     |                                | 50           | 0.03   |
| 12       | Inlet        | No     | 1                            | 2000                           | 260          | 0.14   |
|          |              |        |                              |                                | <b>12530</b> | <b>6.98</b>                                    |

Material Cost = 12,530 (\$6.98)  
 (Labour Cost/day = 2,500)  
 Labour cost for 4hrs. = 1,250  
**Total cost = 13,780 (\$7.68)**

<sup>4</sup> Source: <http://finance.yahoo.com/m5?a=1&s=USD&t=UGX> (Sept 2000)

## Appendix 1 Footvalves

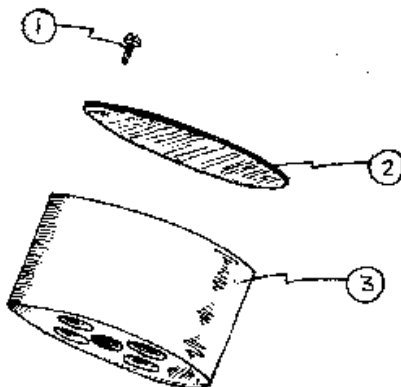


**The DTU valve** is a simple one way valve, which has only four key components. The manufacturing procedure is as follows:

- Cut off a length of  $\text{Ø } \frac{3}{4}$  " PVC pipe 8" long
- Drill a number of  $\text{Ø } \frac{3}{8}$ " holes at the top and bottom sections, leaving a gap in the middle of about  $2 \frac{1}{2}$ "
- Make up a wood plug and wedge this in at the top of the PVC pipe.
- Slide a 4" length of cycle inner tube over the PVC pipe and start wrapping the rubber strip round the centre of the pipe and trapping the bottom of the inner tube sleeve.
- Make sure that when wrapping the rubber strip round that it is very tight. Wrap sufficiently round so that it is a good tight fit inside the bore of the rising main.
- Continue to wrap the remainder of the rubber strip round the pipe to seal the valve and rising main together.

**The low cost valve** needs little explanation, as it is self-explanatory. The important point is that the inlet needs to be a good tight fit inside the bore of the rising main as the forces generated during operation could dislodge it.

It may be preferable to make the inlets on a wood lathe but if there is no access to one then careful selection of a suitable piece of wood and some filing will suffice. Dimensional details of the inlets are given in Appendix 3.



|   |                        |
|---|------------------------|
| 1 | Screw                  |
| 2 | Rubber inner tube disc |
| 3 | Wood inlet             |

## **Appendix 2 How to cut a thread in PVC pipe**

There are many occasions where threads are required on PVC pipes so that other fittings can be fitted to the pipe. This often involves the use of expensive equipment, which is not always available when needed and the charge for this service can be expensive.

The method described here was tried out in Uganda after finding the above mentioned problems and was found to be a useful and successful solution that was very low cost. Though it requires some tools, a little bit of skill and some patience, once it has been made it will last for many threading operations and re-sharpening is simple to do.

The following example is for a Ø1/2" PVC pipe, but the same procedure is used for other sizes.

Tools required:

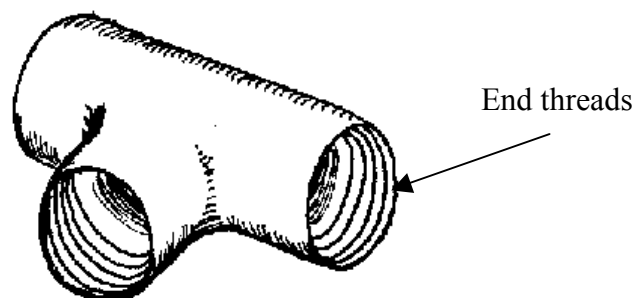
One hacksaw blade (preferably 24 teeth per inch)

A small 6" (150mm) long triangular file (the width across the face should preferably be no more than 3/16" or 4mm)

Pipe grips or a vice.

10" (250mm) flat file

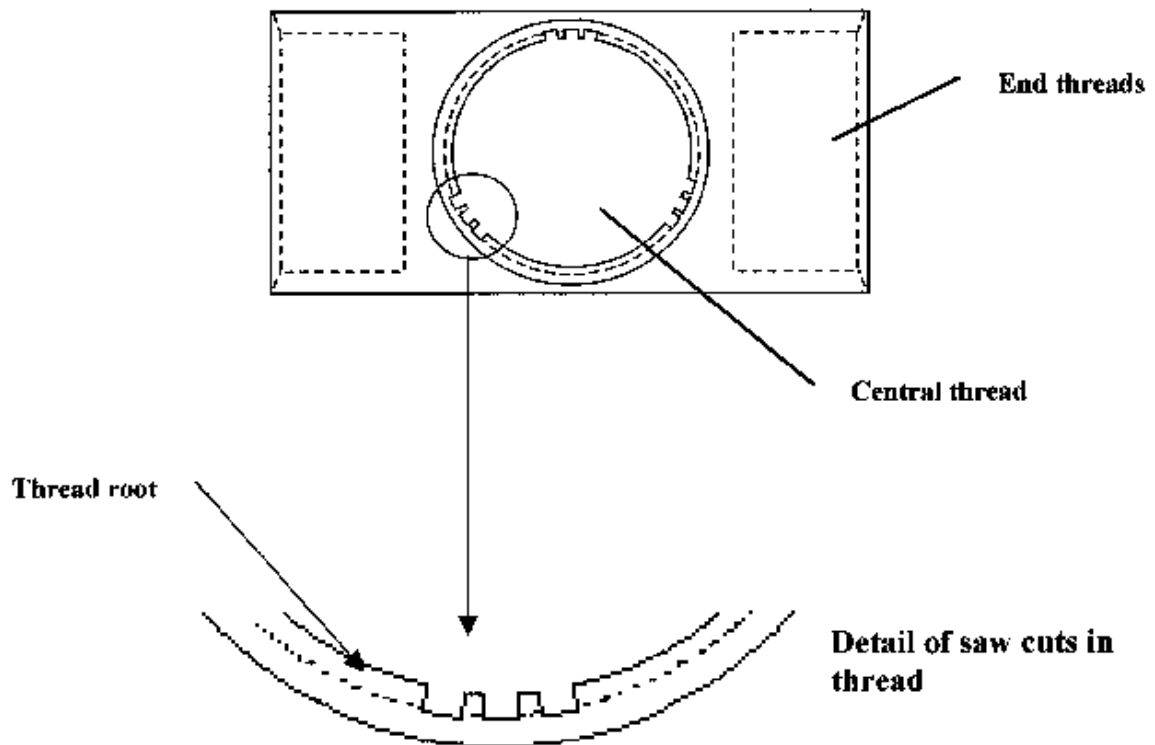
The reliability of the threads for higher-pressure applications has not been checked and care will be needed if this is tried.



**Figure 4 Galvanised Iron tee**

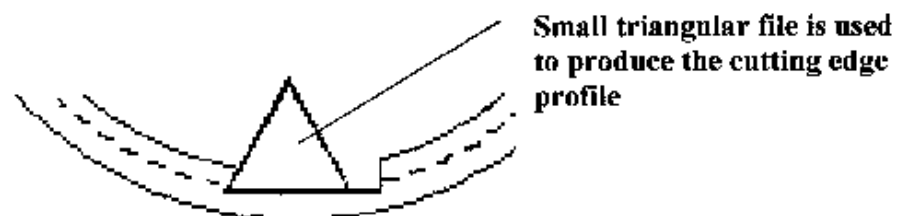
Take a standard GI Ø1/2" tee as shown in Figure 4 and make three equally spaced saw cuts

- Take a normal GI  $\text{Ø}\frac{1}{2}$ " Tee fitting as shown in Figure 4 and make three equally spaced saw cuts with the hacksaw blade in the central part of the Tee to just beyond the roots of the thread as shown in Figure 5.



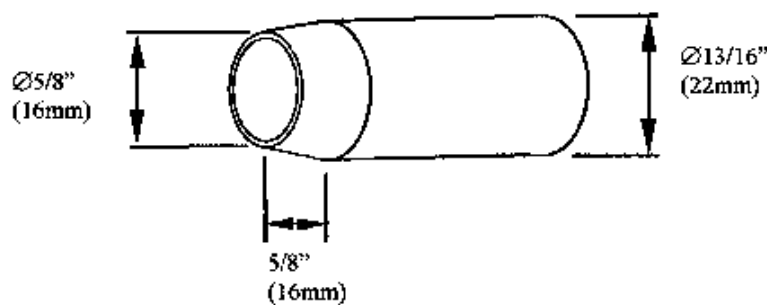
**Figure 5 The GI Tee with the saw cuts equally spaced round the central thread**

- Make additional saw cuts as close as is practically possible to the first thread so that it is slightly wider than one of the faces of the triangular file, this is to ease the burden of filing.
- Proceed to file each of the saw cuts so that the roots of the thread can no longer be seen.
- File the left-hand side of the slot, as this will be the cutting edge, so that the profile is the same angle as the file i.e.  $60^\circ$  as shown in Figure 6.



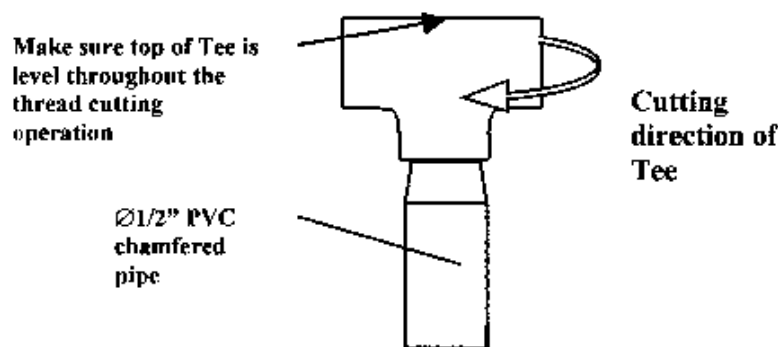
**Figure 6 The GI Tee with detail of the cutting edge profile on thread**

- Using a rough file chamfer the end of the pipe to be threaded to the dimensions shown in Figure 7.



**Figure 7 Chamfer dimensions for the  $\text{Ø}1/2''$  PVC pipe**

- Hold the pipe firmly in an upright position (using a vice or pipe grips) and apply a generous amount of grease or Vaseline to the thread cutter or to the pipe end. This will reduce the friction while thread cutting.
- Place the thread cutter on top of the pipe and gently start to turn/thread it on to the prepared pipe, making sure that the top of the GI fitting is level as shown in Figure 8.



**Figure 8 Starting the thread cutting**

- Turn several times (by inserting a screwdriver or steel rod through the Tee) then remove and clean out the thread of any plastic that has built up. For every revolution of the thread cutter turn back again half a revolution, this will break off the material being cut and avoid clogging of the cutting edge space.
- Repeat the operation until a sufficient length of thread (no more than the length of thread inside the Tee) has been cut.

Re-sharpening the cutter is simply done by filing the cutting edge with the small triangular file until the blunt edge has been removed.

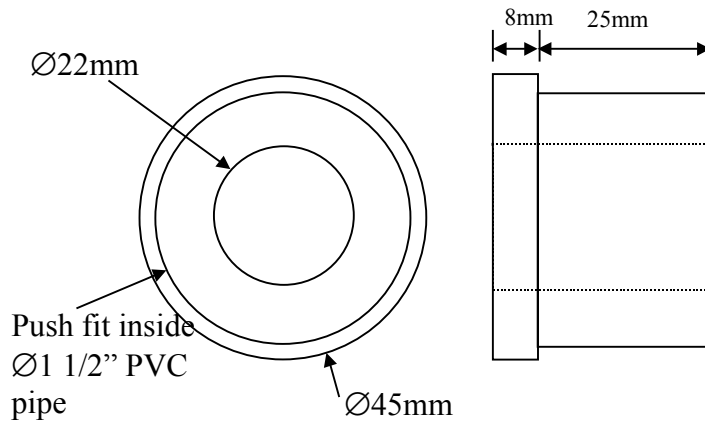
Polythene bags cut in to thin strips and wrapped round the thread is a good low cost substitute for PTFE tape.

Please note that it may take several attempts before a satisfactory thread has been made so practice on spare pieces of material until confidence and the quality is built up.

**Appendix 3 Pull rod bushes and inlet details**

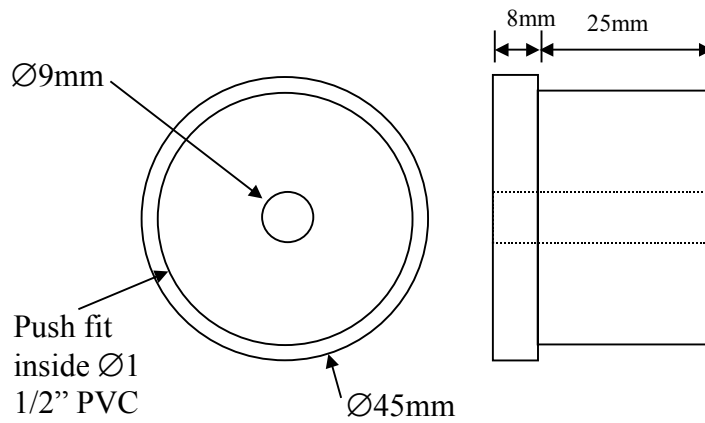
**Pull rod bush for DTU and Tamana handpumps**

**Material: Hardwood**



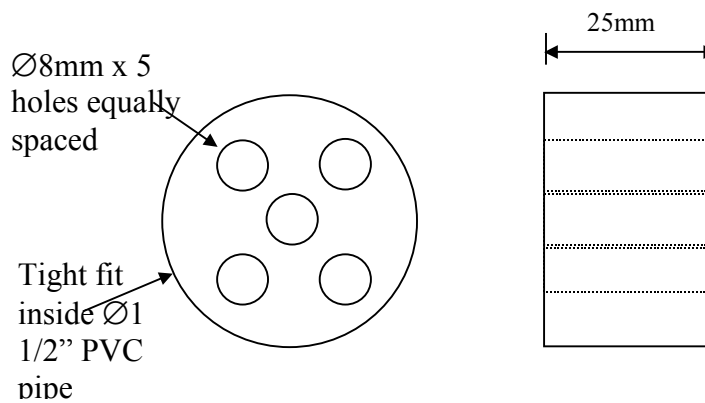
**Pull rod bush for Harold handpump**

**Material: Hardwood**

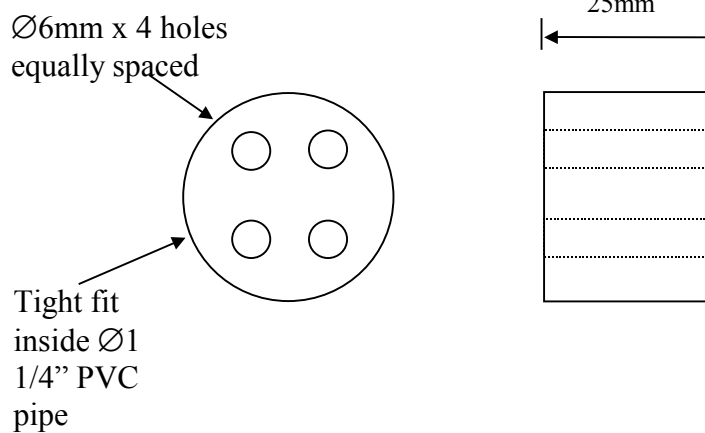


**Inlet for Ø1 1/2\"/>**

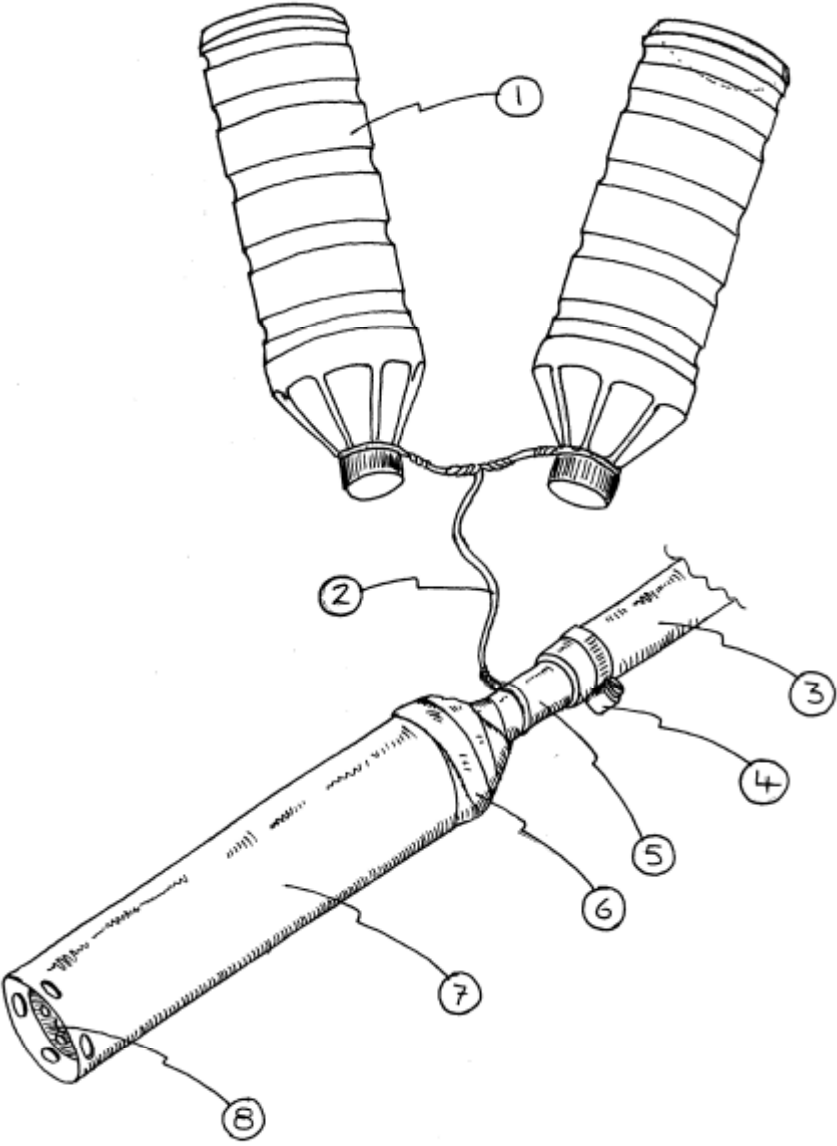
**Material: Hardwood**



**Inlet for Ø1 1/4\"/>**



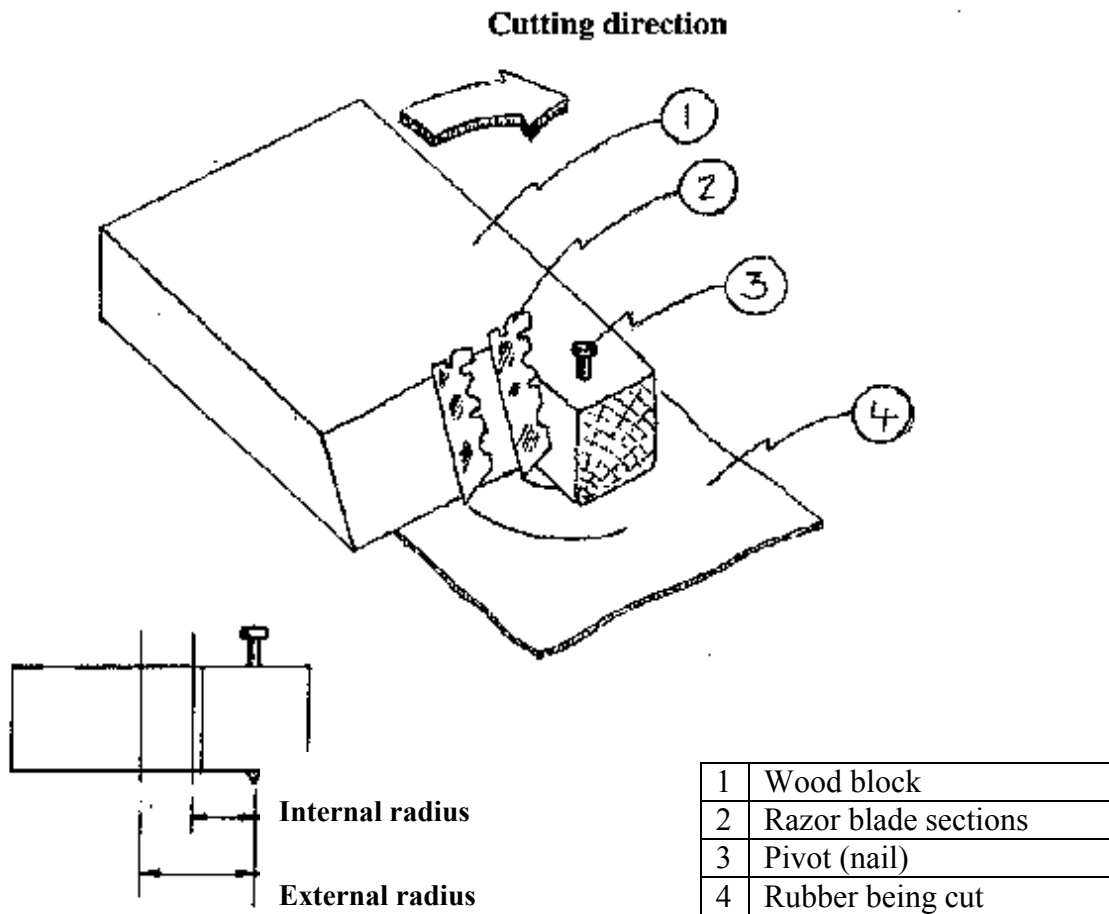
Appendix 4 The floating valve



|   |                                       |
|---|---------------------------------------|
| 1 | Plastic bottles                       |
| 2 | Insulated copper wire                 |
| 3 | Flexible hose                         |
| 4 | Hose clip                             |
| 5 | Ø1/2" PVC pipe (approx. 150mm long)   |
| 6 | Rubber inner-tube strip               |
| 7 | Ø1 1/2" PVC pipe (approx. 200mm long) |
| 8 | Wood inlet valve (see appendix 1)     |



## Appendix 5 The piston/valve seal cutter



The Tamana seal cutter is made from a suitable piece of wood with dimensions of 50mm x 12mm x 75mm.

The angle of the cut out is at 45° cut sufficiently far back so that the pivot pin and razor blades are all in line with each other.

A razor blade is broken in half and one end of each is broken again to give the acute cutting edge as shown.

After hammering a nail in for the pivot mark off as accurately as possible the internal and external radii taken from the outside diameter of the pull rod and the bore of the rising main respectively on to the wood. The razor blades are then pushed in at these marks making sure the bottom of the blades are at the same height as the pivot point.

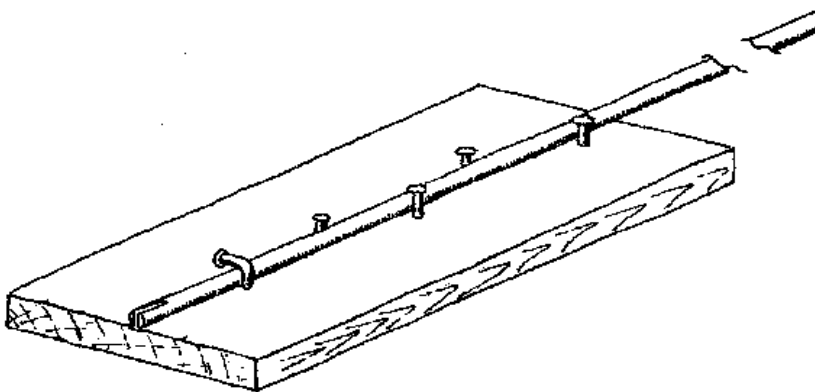
Cut out a small square of rubber inner tube slightly larger than the finished diameter and put the pivot in the centre of the square. Hold this with one finger while rotating the block in a clockwise direction as shown until the disc is cut through.

## Appendix 6 Fixture for slitting Harold pump pull rod

The difficulty in obtaining a low cost vice has led to the development of this simple method of work holding. It uses parts and tools that are easily available and will hold a rod firmly enough to saw a slot in the ends.

It uses a series of nails that are staggered down the length of the rod as shown in the figure below. These are hammered into place on alternate sides whilst it is laid flat on a piece of wood. This traps in to position. The nail nearest the end to be sawn is bent over the bar so that it stops the rod from lifting upwards and sideways while sawing, and is turned sideways when removing the pull rod after sawing.

When starting the cut keep the saw at an angle of around 25 degrees and keep it at this angle until the right length of the saw cut is achieved. Then twist the rod round 180 degrees and saw to the same length. Once this is done gradually lift the saw up while sawing until it is 90 degrees to the pull rod. After sawing the rod can be removed by rotating the bent nail out of the way and the bar can be slid out.



## Appendix 7 How to make the Harold pump moulded cup

Using the diagrams shown on the following page the procedures are:-

- 1 Cut a length of  $\text{Ø}1\frac{1}{2}$ " PVC pipe to 50mm long
- 2 Cut lengthways.
- 3 Heat gently and open at split
- 4 Heat again to produce a flat strip by pressing on a flat surface.
- 5 While not and pliable, use the wooden form to press into a short length of  $\text{Ø}1\frac{1}{2}$ " PVC pipe and hold till set (approx. 1 minute).
- 6 Mark off the centre of the cup and drill to suit the pull rod diameter (8mm).
- 7 Cut off cup so that target diameter is about 2mm less than inside diameter of  $1\frac{1}{2}$ " PVC pipe.
- 8 Remove sharp edges with sandpaper.

### How to make a wooden form for moulded cup.

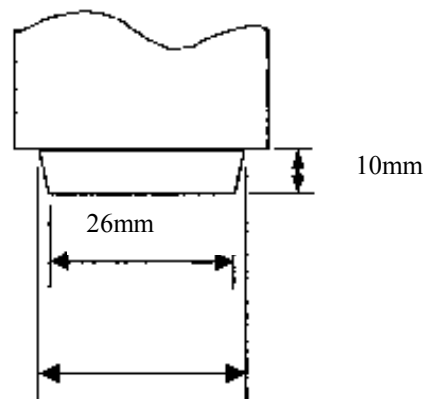
Cut a length of  $\text{Ø}1\frac{1}{2}$ " PVC pipe off at about 25mm long.

Using the inside diameter and mark off with a pen onto the end of a suitable piece of wood.

Mark off a second diameter of  $\text{Ø}26\text{mm}$  (this will give an angle of approximately  $12^\circ$ )

Mark off length of form to 12mm long.

File the taper to shape (or alternatively use a wood lathe)



To suit inside diameter of pipe minus 2 x wall thickness

Sketches of manufacturing the moulded cup

