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HANDPUMP TESTING AND DEVELOPMENT

Part 3 New Design: Particle Separator Foot Valve and Rod Guide

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1. INTRODUCTION

1.1 Background

The design work presented in this report, can be seen as a part of the project Handpump Testing and Development, run at the Lund Institute of Technology. The objective of the project is to improve handpumps in general and the below ground pumping element in particular. The test work comprises:

1. Long time endurance tests in a test rig where 12 cylinders can be operated at the same time. This will mainly give information on which materials are most efficient for piston sealings, the minimum of wear to be expected on the valves and the connection between pump-rod and handle.

2. Measurements with high accuracy of force, flow, mechanical efficiency and pressure flux at a pump stroke. This is done in another test rigg with only one cylinder in order to avoid disturbances. The measurements and the following calculations are made with a micro-computer system.

3. Testing of new designs. These can be evaluated and compared to conventional designs under the same conditions, in the test rigs.

Further information on the project is given in the papers "Handpump Testing and Development.
Part 1. Project Description, Sweden 1982 and
Part 2. Interim Report, Sweden 1982.

1.2 Development Work

Much of the design work presented below refers to models worked out by Oscar Carlsson, SCC, prior to the start of this testing programme. The particle separator has not been tested in the laboratory, but in field tests in India. The result from the first examples tested is very promising. The plastic foot valve has been further elaborated from experience gained in laboratory test in Sweden. Several modifications have been evaluated and we can now propose a model appropriate for series production. The pump rod guide is installed in the test rig. Since the rising main in the rig is only of 1 m of length, the guide operates under very easy conditions. We can only say that should there be any problems in the laboratory, there will be many more problems in reality. Results from the field test of the guide are not yet available.

2. PARTICLE SEPARATOR

2.1 General

The introduction in a handpump of a device for separation of particles from the water, is motivated by the fact that small-sized particles are responsible for a great deal of the wear that occurs both on moving parts, like valves, and on the cylinder and the cup-seals. If the lifetime of the cup-seals can be substantially prolonged by the use of a simple separator, this device will have a great impact on the functioning and the utilization of the pump and also on economy through the reduction of the resources required for maintenance.

The particles in the water originate from:

1. Sand and dirt entrapped in the construction during transportation and installation.
2. Metalparticles from the pump due to continuous wear during operation.
3. Mineral particles from the tube-well.

2.1 Function

In a deep-well handpump, the particles will be suspended in the water in the rising main. Both particles loosened from the main or the pumpstand and particles sucked in with the tubewell water, will sedimentate when the water column is still in periods between operation, especially during the night. In the cylinder the settling particles are stopped by the piston. Thus a lot of them will accumulate on the piston-seal and there be a cause of extensive wear.

To avoid this, the separator is placed right above the cylinder. At the upward movement of the piston, the separator serves only as an extension of the rising main. Whenever settling occurs in the water column, the particles that reach the separator are directed to a side pocket around the main. As the particles are trapped here, they will not be accumulated in the cylinder. The sand pockets will be made large enough to last for three years of operation or whatever is required. When the cylinder is removed for maintenance, the separator is emptied.

Together with the separator, the installation of a piece of pipe, 1 m long and with the same diameter as the cylinder is recommended. The pipe, placed below the cylinder inlet will serve as a settling column or a clarifier. Particles with a settling velocity higher than the limit, about 0.5 m/s, will then never enter the cylinder. Smaller particles with low settling velocity will be pumped up with the water and either pass through the pump or settle later on and reach the particle separator.

2.3 Design

The separator (see figure 2.1) is constructed from a specially designed separator nut (1), a standard 1 1/4" pipe (3), which is screwed into a separator lower nut (4) connecting the separator with the cylinder. A standard 2 1/2" pipe (2) forms the outer wall of the separator and thereby also forms a sand pocket. The pump rod (5) is guided by the upper separator nut. In this design, the separator can be made to fit any type of cylinder with 1 1/4" pipe connection.

The separator has also been designed especially for the India Mark II handpump model. The difference from the original model is shown in figure 2.2. The lower nut is dimensioned to fit directly on the IM II cylinder.

The separator designed for direct mounting on the SWS-cylinder, is shown in figure 2.3. It can be screwed to the top of the cylinder, although a lower separator nut (4) is needed to fix the inner 1 1/4" pipe and to form the sand pocket. The figure show the separator together with a cylinder equipped with the new designed plunger and foot valve.

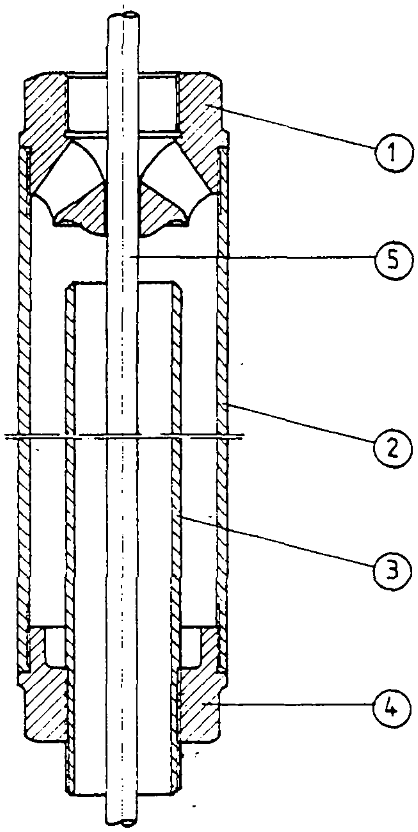


Figure 2.1 Principle of particle separator.

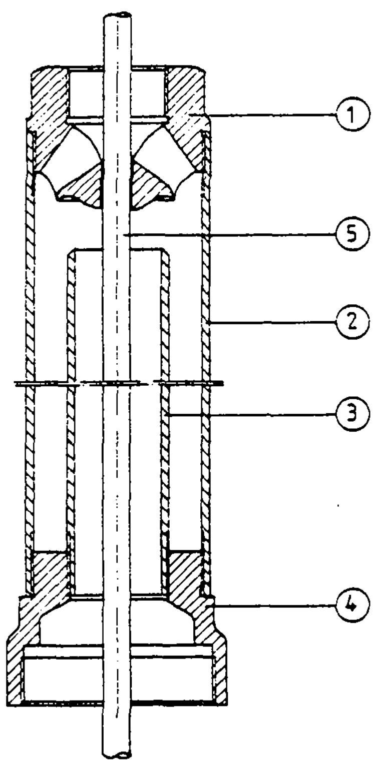
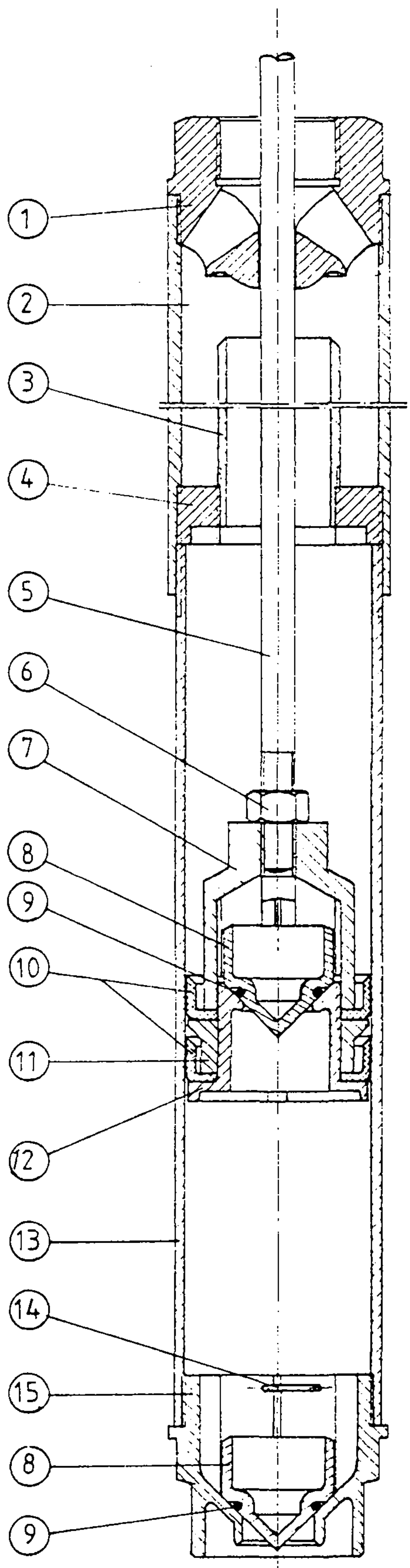


Figure 2.2 Particle separator designed to fit the India Mark II cylinder.



1. Separator nut
2. Pipe 2.5"
3. Pipe 1 1/4"
4. Separator lower nut
5. Rod
6. Hex nut
7. Plunger yoke body
8. Valve
9. O-ring
10. Pump bucket
11. Spacer
12. Plunger valve seat
13. Cylinder pipe
14. Stop pin
15. Lower nut valve seat

Figure 2.3 Particle separator designed to fit the SWS cylinder.

3. FOOT VALVE

3.1 General

The advantages of the new type of foot valve are primarily that:

- The valve as a whole is made of thermoplastics (PVC or POM). In a series production it can therefore be made in an extrusion process to a very modest production cost.
- The valve consists of only two parts, a combined lower nut and valve seat and a moving part. To have few parts in the construction is advantageous considering production costs, handling and maintenance work in the field; then is no risk for some detail to be lost or forgotten and the storage of spareparts is simplified.
- The moving part is cone-shaped which is advantageous considering the flow of water through the valve. The shape and the relatively large opening at the bottom inlet, gives the valve a low head-loss when operating. The head-loss at an increasing flow rate is shown in figure 3.1 comparing the plastic foot valve with some other standard types.
- The leakage through the valve, when closed, has been shown to be negligible. The tightening with a rubber o-ring has proven to be reliable.

One disadvantage with the use of plastics for the whole lower nut is that a slight deformation of the valve can occur, if the valve nut is screwed very hard in the cylinder. There is no reason to screw it much harder than what can be done by hand. If for some reason in the field it is screwed hard, the cone might get stuck so that the valve will not operate. To overcome this problem, a brass ring is pressed in behind the threadings at the upper part of the valve. This will give a stability to the construction and the operation of the valve will not be dependent on how it is mounted on the cylinder.

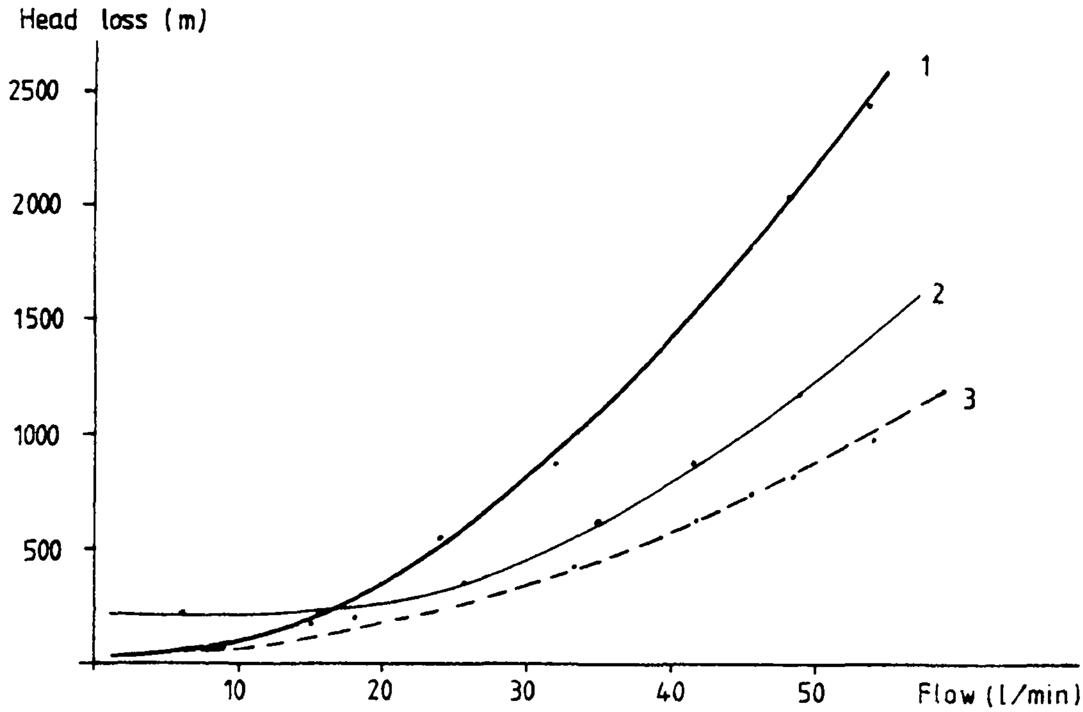


Figure 3.1 Head-loss in footvalves at different flow rates.
1: Rubber Ball Valve
2: India Mark II Valve
3: New Plastic Foot Valve

3.2 Function

The valve consists of two parts. The combined seat and lower nut, which is screwed into the lower end of the cylinder and the coneshaped moving part, which opens and closes. The cone has the same angle, 45^0,as the valve seat. In the closed position the static pressure on the cone is taken up by the valve seat on which the cone rests. To ensure complete tightening, a rubber o-ring is fixed in the cone. When the valve is closed, the o-ring is pressed together about 10%, so that the load on the cone, the static pressure, is still taken up by the whole surface of the valve seat.

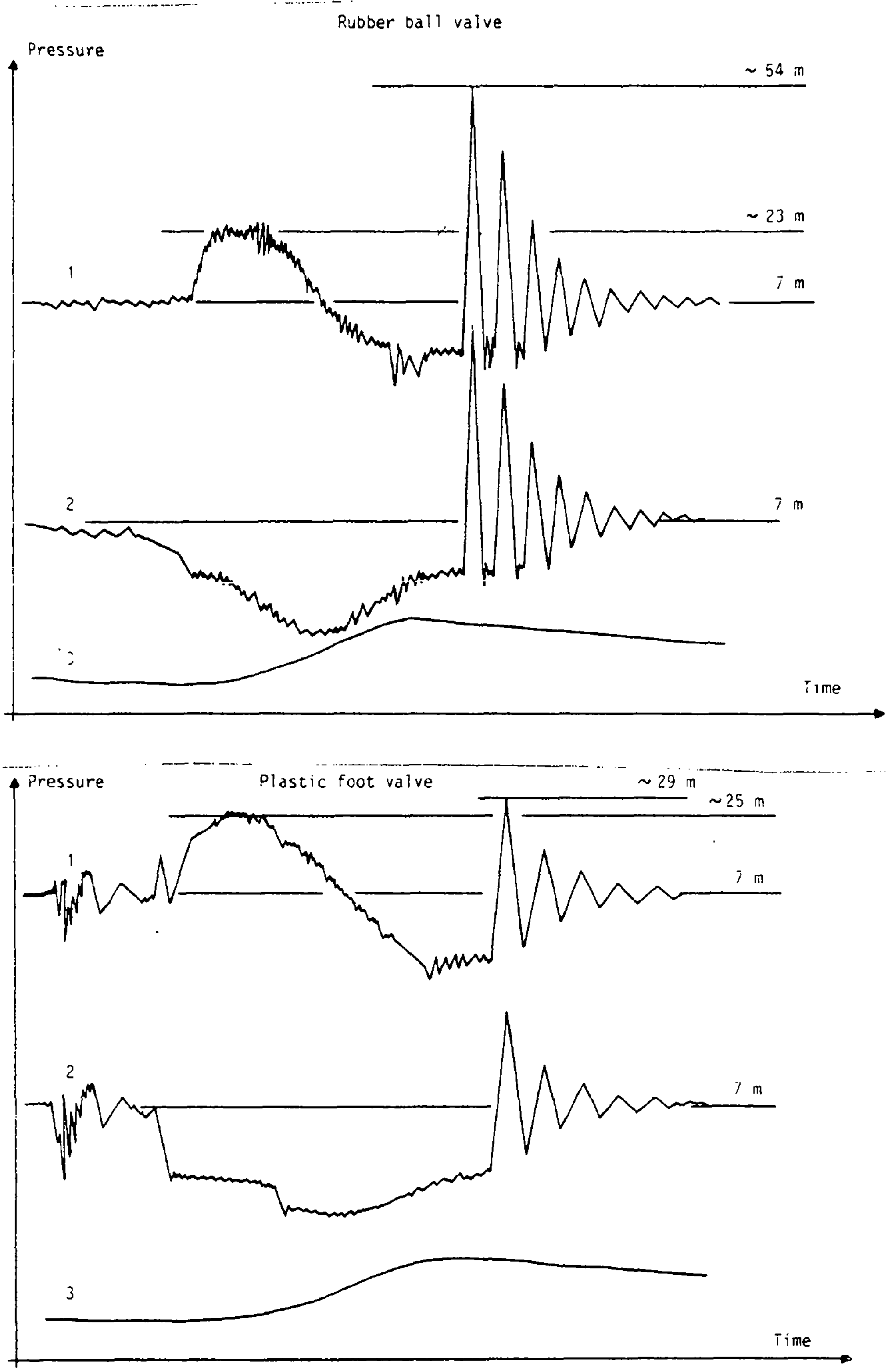


Figure 3.2 Comparison of pressure variation during a pumping cycle, between a rubber ball valve and a plastic valve.
1. Pressure above the piston
2. Pressure under the piston
3. Curve indicating the movement of the piston.

A new approach in this design is that the cone is steered by four guides on the side of the cone. This is different from most other valves, where, when guides are used, they work in the bottom inlet opening of the valve. Because the guides in this case are situated in a higher position, the inlet area is larger which is better from a hydraulic point of view.

The density of the cone is only somewhat higher than the density of water. This enables a rapid response to changes in the flow direction and velocity, i.e. a smooth opening and closing of the valve. Measurements indicate that the pressure peaks following the closing of the valve are lower in this type of valve compared to, for example the rubber ball valve, see figure 3.2.

3.3 Design

Figures 3.3 and 3.4 shows the valve seat and the cone, the two parts of the plastic foot valve. Both POM and PVC valves of this design have been tested for long periods in the laboratory as well as in the field. The figure shows a design intended for machining. When the valve is to be produced by an extrusion moulding process,the design has to be adjusted. The walls at the bottom part must be thinner, to avoid deformation during the moulding process.

The valve seat part has also been produced in gun metal. The same type of plastic cone is used for this valve. At the moment the gun metal valve is being tested in the laboratory. There is some uncertainty as to whether there will be any adverse effects on the cone with this combination of materials. So far however the laboratory test is very promising.

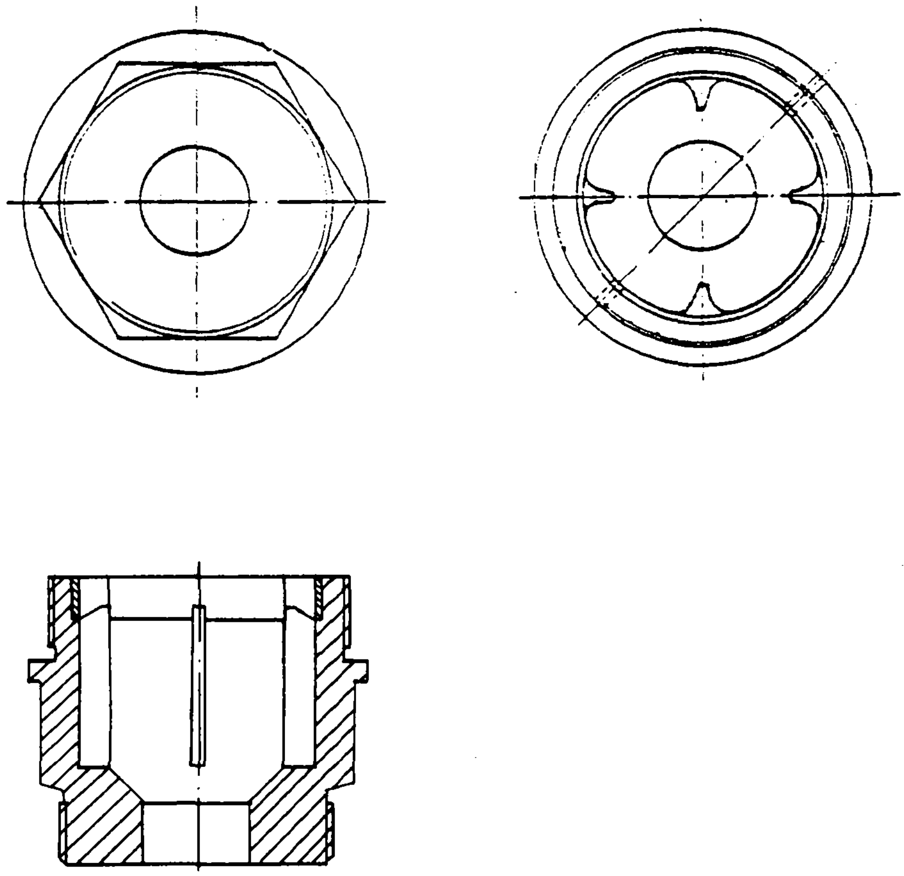


Figure 3.3 The plastic foot valve designed for machining.

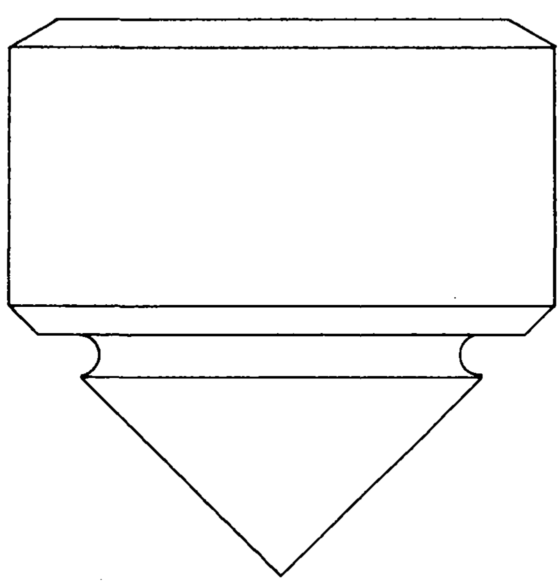


Figure 3.4 The plastic cone without the rubber o-ring.

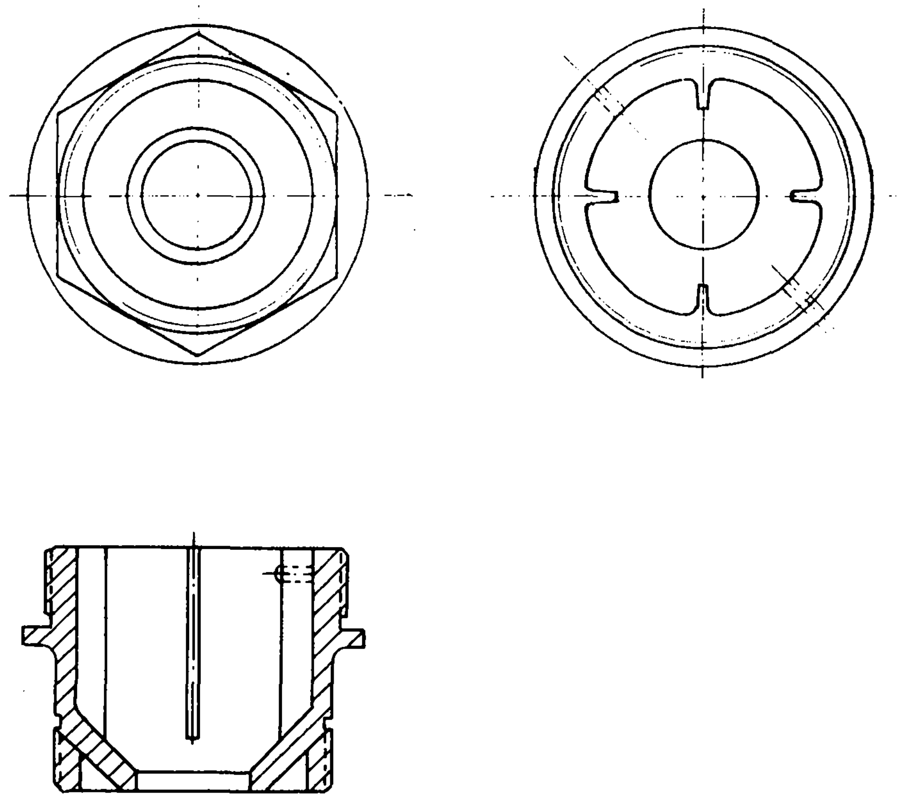


Figure 3.5 The foot valve designed for gun metal moulding.

Figure 3.6 Picture of a PVC-valve.

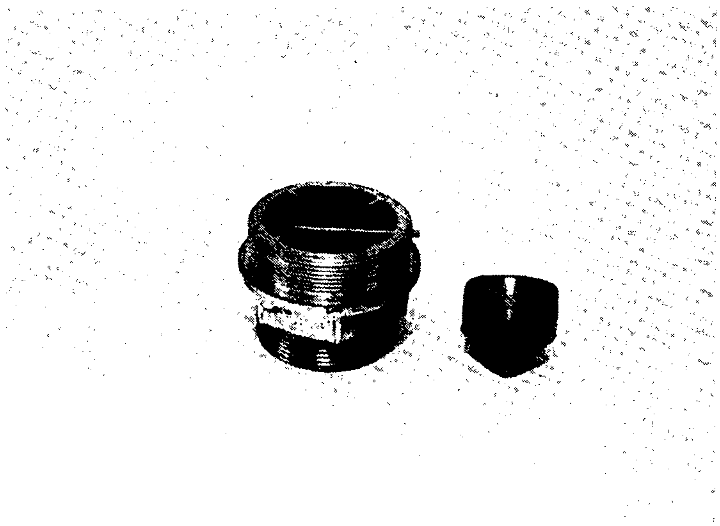


Figure 3.7 Picture of a gun metal valve with PVC cone.

4. ROD GUIDE

4.1 General

In many cases breakdown of handpumps is caused by "snaking" of the pump rod or because the rod and/or the rising main deviates from the vertical line. If, for reasons like this, the rod constantly touches or hits the main pipe, the wear will sooner or later result in a break of the rod, the coupling or the pipe.

To keep the pump rod in a centric position in the pipe, a guide has been designed. The guide is easy to install and does not affect the mechanical efficency of the pump to a considerable extent, i.e. the friction between the guide and the rod and the head-loss over the guides in the pipe are low. Further testing in field conditions is, however, required.

4.2 Function

The guide is installed in the couplings between different parts of the drop pipe, which enables the diameter of the guide to be as big as the outer diameter of the pipe. The installation is also easy to make and still the guide is fixed and can not move with the rod at each pump stroke.

The steering of the guide is done in two points on the rod. The risk is thus very small that a break in some part of the guide might put it in a position where it would lock the rod and hinder the operation of the pump.

4.3 Design

The guide is produced by moulding in gun metal. Little machining afterwards is required, which means that the cost of each guide can be kept low.
The principe of the guide is shown in figure 4.1.

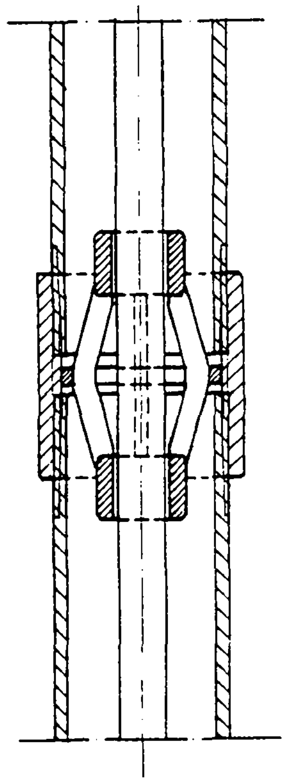


Figure 4.1 Design of the pump rod guide.