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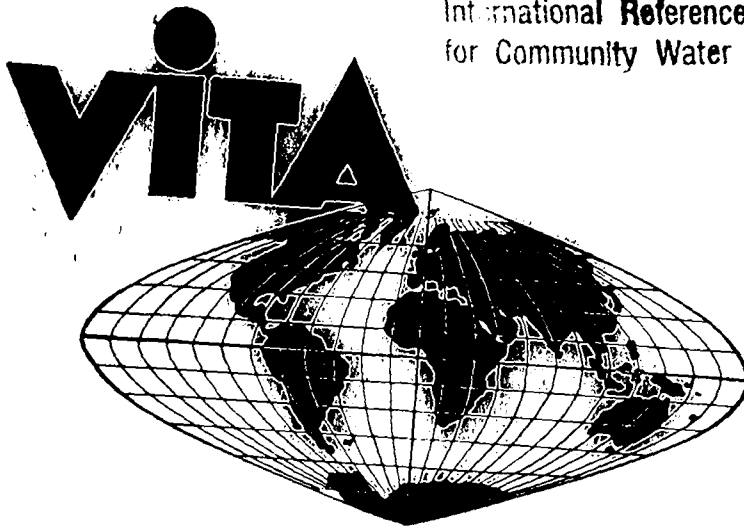
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**HAND PUMPS FOR VILLAGE WELLS**

by

**C.D. Spangler**

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## 1. Introduction

Manually operated pumps of various designs are used in most countries to lift relatively small quantities of water from wells for either family use and/or irrigation. There are two general types of pump, piston and diaphragm. Both types have two check valves, either on each side of the diaphragm (fig. 1) or one below the piston and the other incorporated into the piston (fig. 2). The diaphragm pump will pump the largest quantity of water, but can only operate when the water level in the well is within about 15 feet or less of the pump. It is a suction type pump. The piston pump may either be operated as a suction pump or, if the water level is more than about 20 feet below the surface, the piston can be installed below the lowest water level and thus become a deep well pump.

Shallow well or suction pumps use atmospheric pressure to lift the water by producing a partial vacuum with the diaphragm or piston. The theoretical maximum lift for a suction pump is 34 feet but, due to frictional resistance and inefficiencies in pump design and operation, the practical maximum lift is about 15 feet for the diaphragm and 20 feet for the piston.

Choice of pump is determined by the distance from the surface of the ground to the lowest water level in the well during the dry season. If this distance is less than about 15 feet, either a diaphragm or piston pump can be used. For domestic use, a piston pump is the best and will discharge about 5-15 gallons per minute. The diaphragm pump will pump up to 25 gallons per minute and can be used for irrigation and watering livestock. (The remainder of this paper will discuss exclusively the piston pump. More information about diaphragm pumps may be obtained from The Edson Corporation, 460 Industrial Park Road, New Bedford, MA 02745, USA.)

If the water level drops more than about 20 feet below the ground surface during part of the year, a piston pump is required with the piston located below the lowest water level.

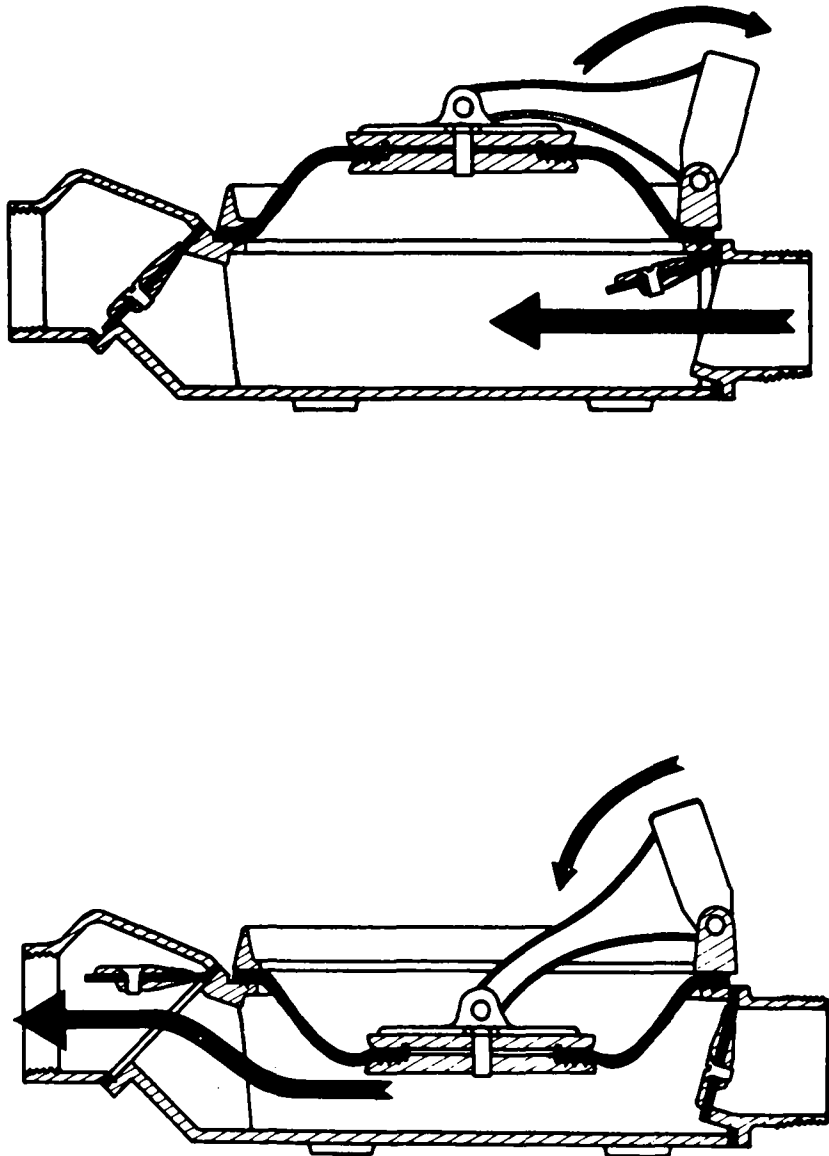


Fig. 1 Diaphragm Pump  
(Courtesy Edson Corp.)

Pump discharge depends on the diameter of the piston, the length of the stroke and the number of strokes per minute. If the water level is less than 30 feet below the surface of the ground, the cylinder could be up to 4 or 5 inches in diameter. If the water level is farther from the surface, the longer column of water that must be lifted becomes heavier and a greater effort is required to operate the pump. The greater the distance to the water level, the smaller the diameter of piston should be, so it is not too hard to pump. It is also possible to vary the distance from the well to the post supporting the pump handle to give better leverage. The closer the handle pivot is to the well, the easier it will be to pump, but the length of stroke will be smaller and so will the discharge.

## 2. The Piston Pump

Piston pumps have a lower valve, a cylinder containing a piston with a valve incorporated in it, a rod to connect the piston to the handle, and a discharge pipe. The traditional pump stand is made of cast iron and supports the handle and contains the discharge spout. Direct suction pumps, or shallow well pumps, have the piston, lower valve and cylinder contained in the pump stand. Deep well pumps have the cylinder with piston and valves below the lowest water level in the well and suspended from the base of the pump stand by the discharge pipe.

The standard pump was designed for the use of a single family and the continual use in most villages causes it to wear rapidly. In attempting to prevent rapid wear, the pump has been modified to strengthen the wear points and this has resulted in a heavier, more elaborate and more expensive pump which is more difficult to maintain and repair. Pump cylinders were usually cast iron, but it is not possible to get the surface smooth enough to prevent rapid wear and replacement of the leathers or buckets. A brass cylinder or thin brass liner has been used and is much smoother than cast iron. An even better material is now available at lower cost - poly-vinyl-chloride (PVC) pipe. PVC pipe is available in most countries and is usually lower in cost than any other pipe material in sizes below 4 inches (100 mm) in diameter. The use of this material in wells makes it possible to develop a pump that is much simpler, less expensive and easier to maintain and repair. The pump stand has usually been cast iron and good quality cast iron is difficult to obtain from many local foundries and is now much more expensive than previously. The pump stand ordinarily supports the handle, but a simpler arrangement using local materials is to have the handle supported on a separate post beside the well, and pump stand. The post supporting the handle can be made of concrete, bricks or wood, depending on local availability and cost. The handle can be made of wood that can be replaced locally when worn or broken. The attachment of the pump rod to the handle should have some play because the pump rod moves vertically while the end of the handle moves also a small distance horizontally as it describes a small arc. The handle should also have a stop on the support pier so it will not strike the top of the pump stand.

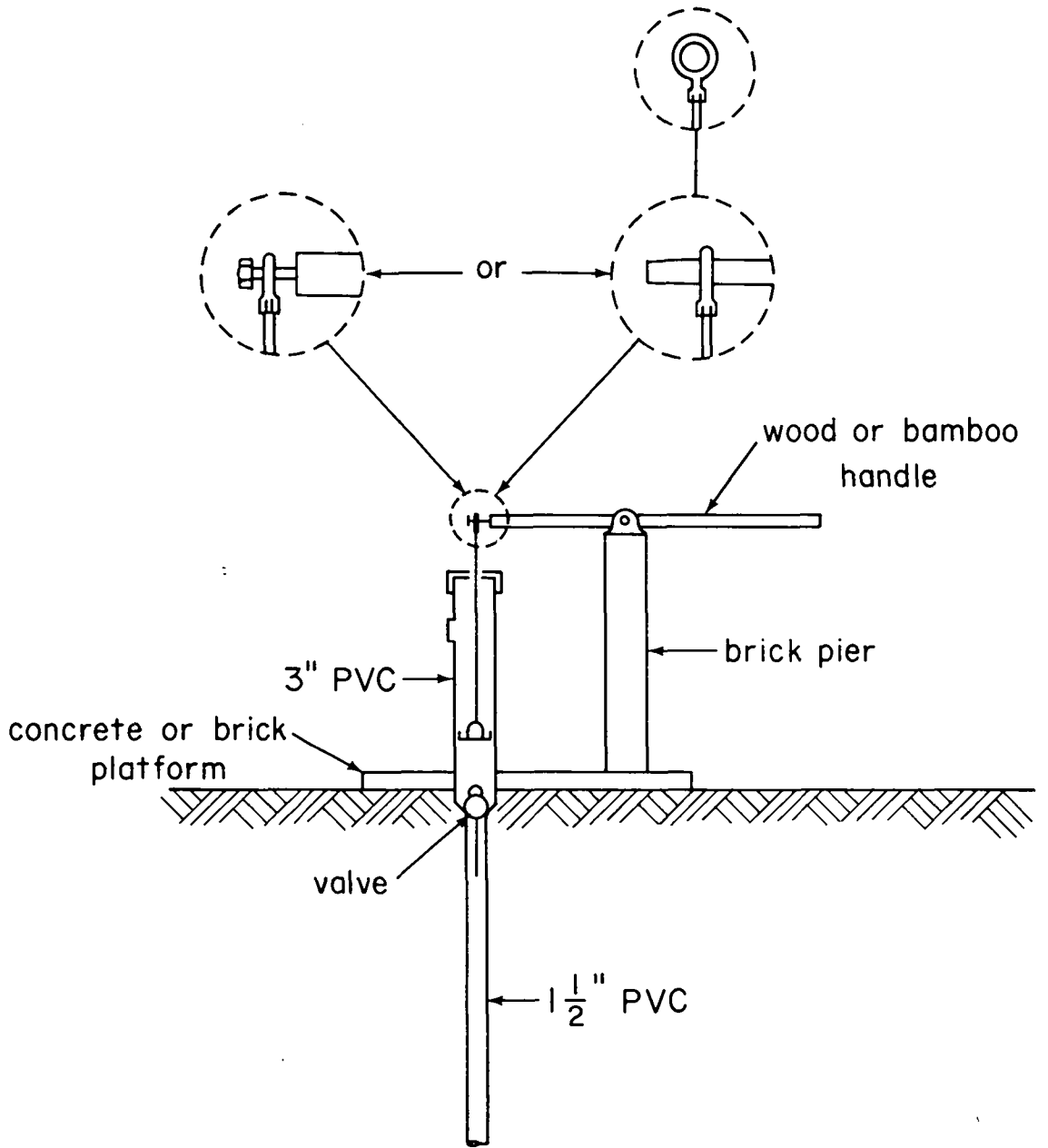


Fig. 2 Shallow Well Pump

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The distance from the post supporting the handle to the pump can vary so as to get the best leverage, depending on the depth to water and on the weight of water, piston and rod to be lifted. The pump stand without the handle only provides a passage for the rod, a channel for the upward flow of the water, and a discharge spout. In shallow wells it also contains the cylinder and supports the suction pipe. Since the pump stand does not bear the load and stress caused by the handle, it need not be so strong and does not have to be of cast iron.

Three possible pump designs are presented. These pumps are designed to be inexpensive, simple, easy to repair, and make maximum use of local materials and skills. It is suggested that a local design should be developed using these ideas and several pumps should then be given a field test to work the "bugs" out of the design. Experimentation may be necessary to obtain a satisfactory attachment of the rod to the handle. Thought and careful field testing should lead to improvements in the design, lower cost, and easier repairs.

### 3. Shallow Well Pump

Fig. 2. The suction type pump is usually used with shallow wells but may also be used with deep driven, jetted or drilled wells where the pressure in the aquifer is enough to keep the water level at all times within 20-25 feet of the ground surface. The pump stand is a length of 3" PVC pipe which also serves as the pump cylinder. The well casing itself may be the suction pipe in the case of driven or small-diameter jetted or drilled wells. In the case of dug wells, the 1 1/2" suction pipe is suspended from the 3" PVC pump stand which in either case must be set firmly in the platform. The spout need only be a 2" hole in the side of the PVC pump stand with a small lip so the water will pour into a bucket or can.

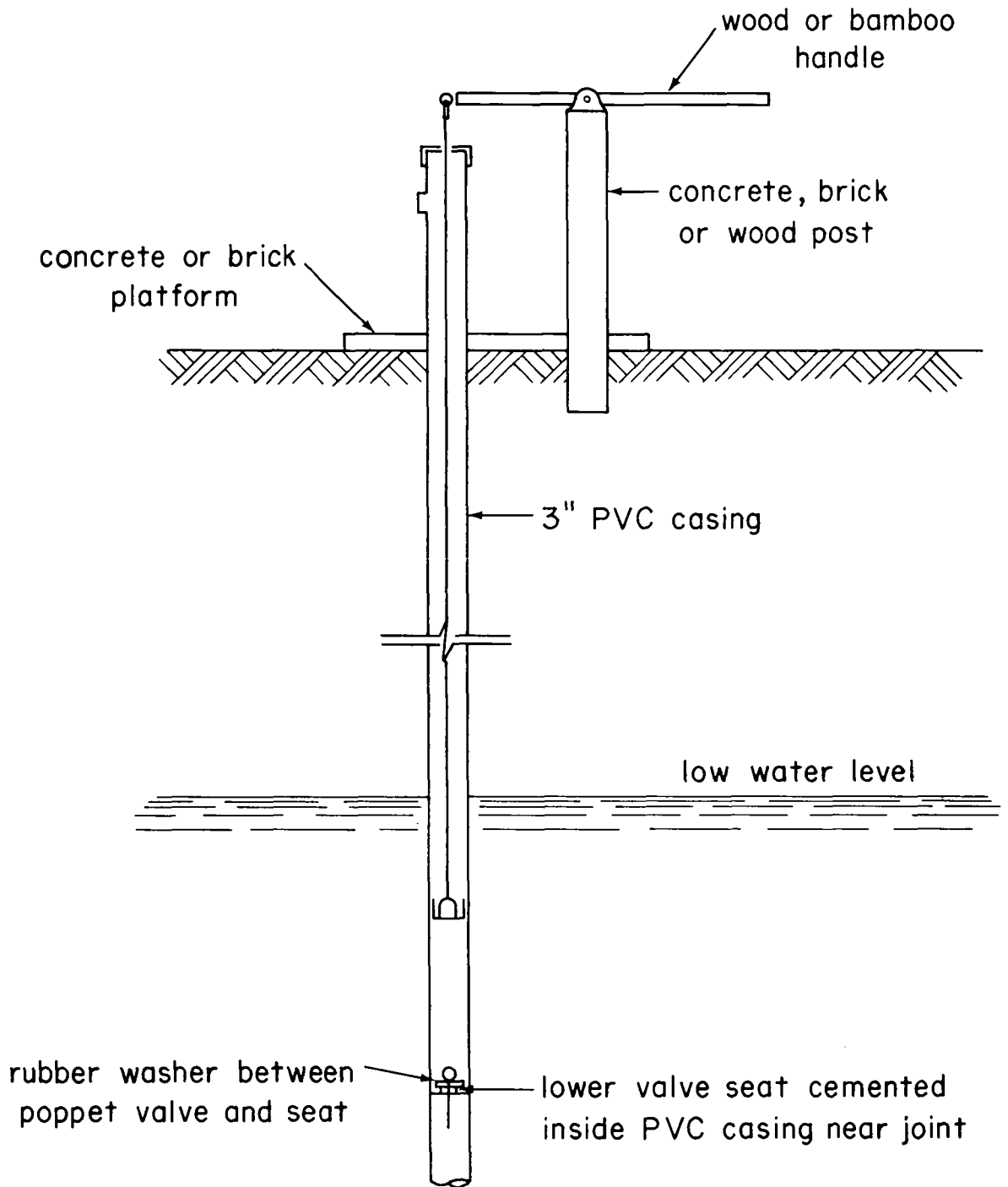


Fig.3 Deep Well Pump



The top of the pump stand should be several inches above the spout and have a removable cap with a slot to allow for the small back and forth movement of the rod. To remove the piston and replace the leather bucket it is only necessary to disconnect the rod from the handle, remove the cap and pull out the piston. If the lower valve is a poppet type valve it can have a small loop at the top and can be fished out using a wire with a hook at the end.

If the PVC pump stand needs protection, a concrete pipe, brick pier or wooden post can be placed around it, with the spout extending beyond the protection. Such a pump will use a minimum of expensive materials and should be easily repaired.

#### 4. Deep Well Pump in Cased Well

Fig. 3. PVC casing can be used in either jetted or drilled wells. In jetted wells the hole is full of water and the PVC casing can be placed in the hole with little possibility that there will be caving before the casing is in place. The same is true of wells drilled by the rotary process. With percussion drilled wells the best procedure is to drive a metal casing and then insert a PVC casing and screen after the aquifer has been penetrated. The metal casing is then removed to be used again. In wells with PVC casings, the PVC casing can also act as the cylinder.

If the water level is less than 50 feet below the surface, the handle support should be placed to enable the pumper to lift the column of water in a 3" PVC casing without too much exertion. If the water level is deeper than 50 feet, a 2 1/2" or 2" PVC casing may be required.

The lower valve seat can be of PVC and can be cemented inside the casing at a joint below the farthest travel of the piston.

Length of rod is chosen to place the piston below the lowest water level in the well. The piston may be standard, with one or two leathers. The rods can be metal or wood. The wooden rods have several advantages: they do not corrode, they are lighter in weight, and usually can be produced from wood available in the country, creating a small local industry and saving the foreign exchange which would be needed for imported metal rods. Because the wood rods are usually buoyant in water and have a greater diameter than metal rods, thereby displacing more water, a well having a deep water level would be easier to pump with wooden rods than with metal rods. The top of the well and the handle support are the same as in the suction type pump. It is easy to remove the rod and piston for repairs.

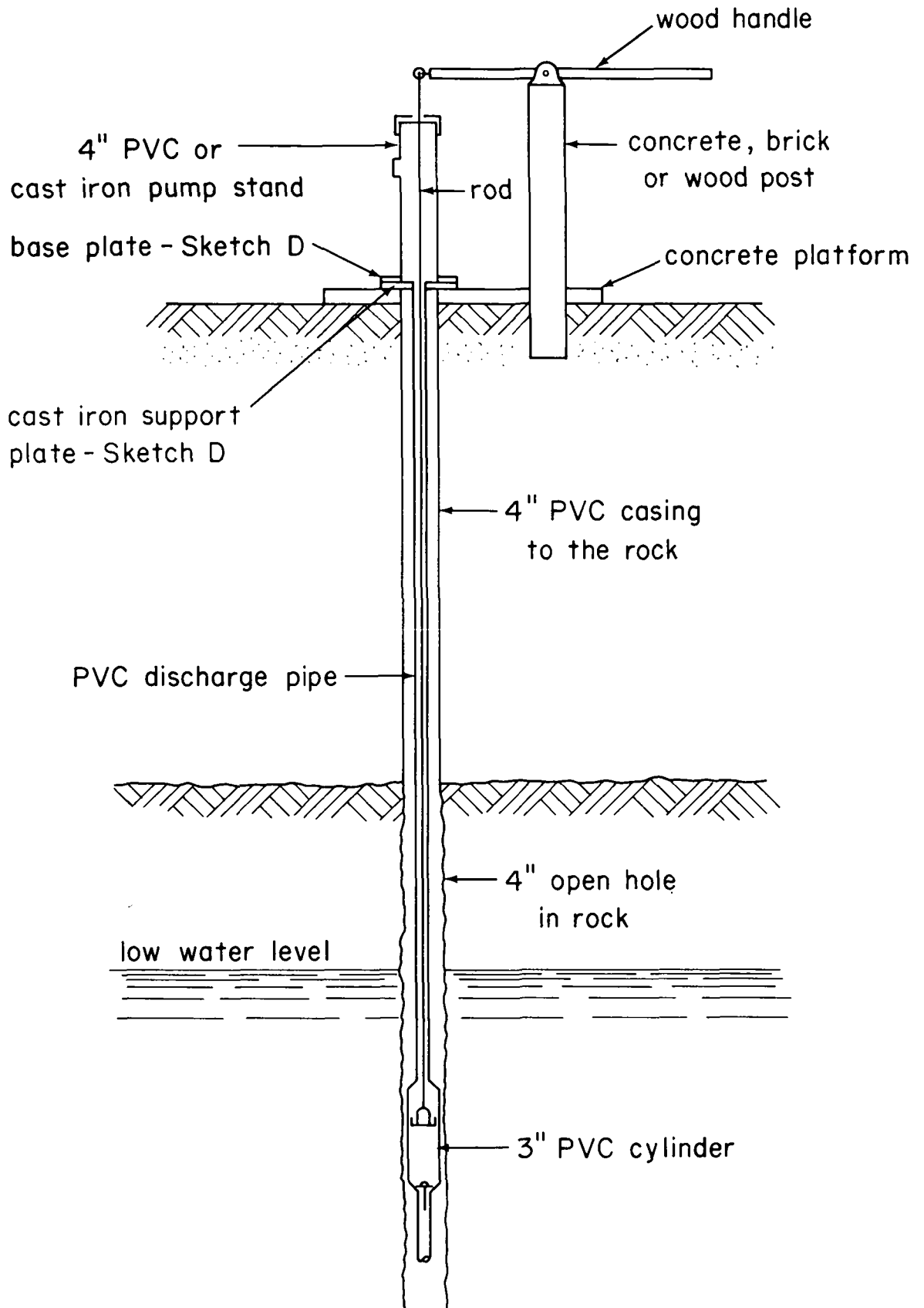


Fig. 4 Deep Well Pump - Uncased Hole in Rock

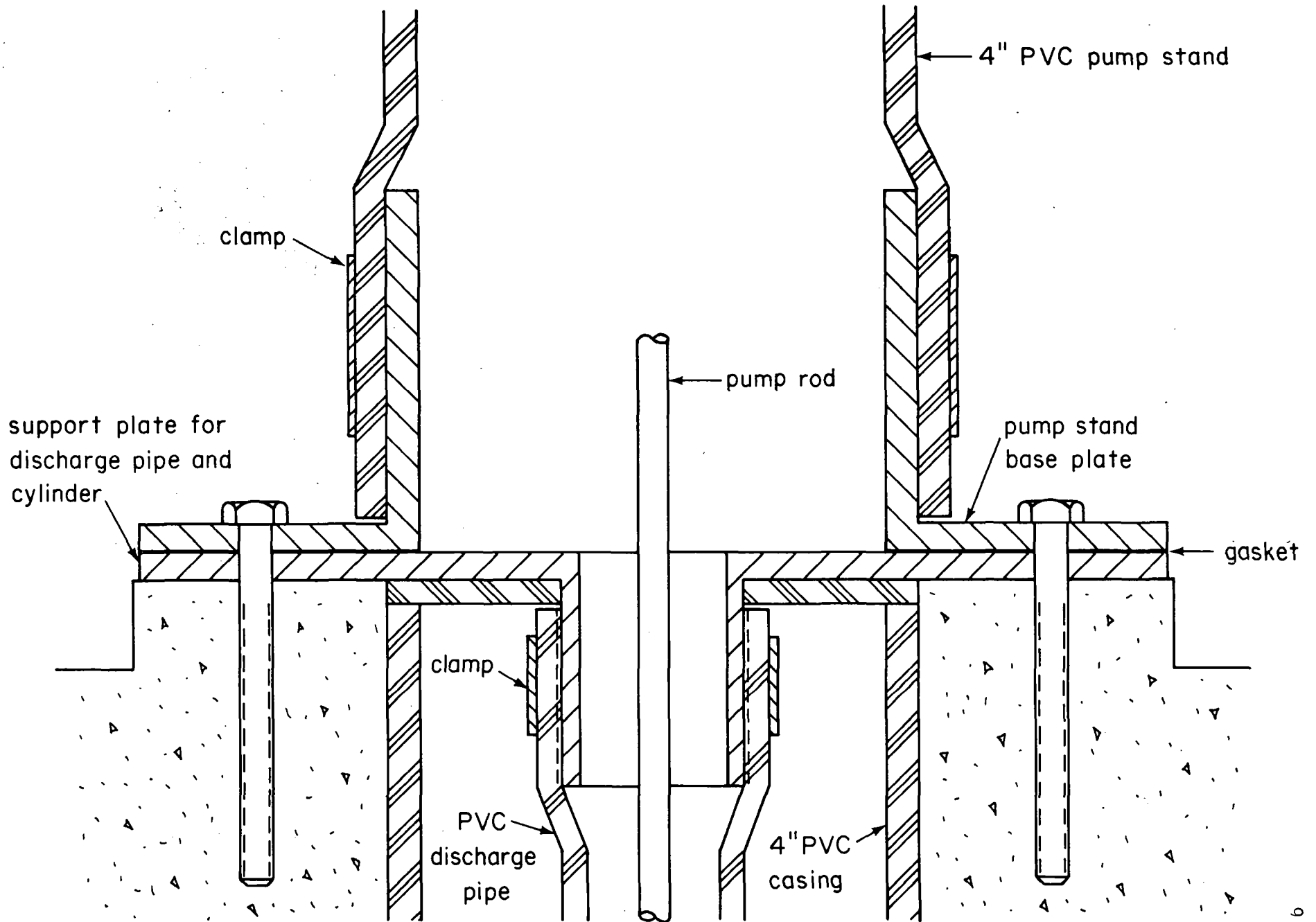


Fig. 5 Pump Base

## 5. Deep Well Pump in Uncased Well

Figs. 4 and 5. In this case the PVC casing only extends to the rock. The standard cylinder (PVC) is suspended by the discharge pipe from a support plate bolted to the platform. The pump stand can be cast iron, or PVC pipe clamped to a base plate, bolted to the platform.

The discharge pipe, if metal, would be threaded to the support plate. If PVC is used for the discharge pipe, which is preferable, the end can be heated and expanded slightly to slip over a short pipe extension of the support plate. The PVC pipe is clamped to the short pipe extension.

The cylinder can be of 3" PVC and will contain the lower valve and piston. The rod passes down through the discharge pipe. If the rod is of wood, care should be taken that the discharge pipe is large enough in inside diameter not to restrict the upward flow of water between the rod and the pipe.

The discharge pipe should have clamped or threaded joints every 20 feet so the pipe can be disconnected when it is necessary to remove the cylinder for repairs. A joint in the rod should be located at each joint in the discharge pipe. If the cylinder is of metal, it should have an inside sleeve of thin-walled PVC pipe to provide a smooth surface that will greatly prolong the life of the leather bucket.

## 6. Pump Components

The pump should be simple, dependable and as low in cost as possible. The object should be to develop a pump that can be produced in quantity by local technology to meet the needs of most of the rural population in the area. A pump similar to that shown in fig. 2 has been developed in Thailand at a cost of about US\$20 which delivers about 15 US gallons per minute. It is being used for irrigation as well as for domestic purposes.

Pump components can usually be manufactured or fabricated in most countries. The parts are relatively simple and machine shops or small metal working factories or foundries can supply parts for a given design. Most countries now have plants to extrude PVC pipe, even where the raw material is imported. The seal between the piston and the cylinder wall is usually provided by a leather disc with a turned up edge called a "bucket". In some countries these are made of molded rubber. Quality control is important if good leather or rubber buckets are to be obtained. These

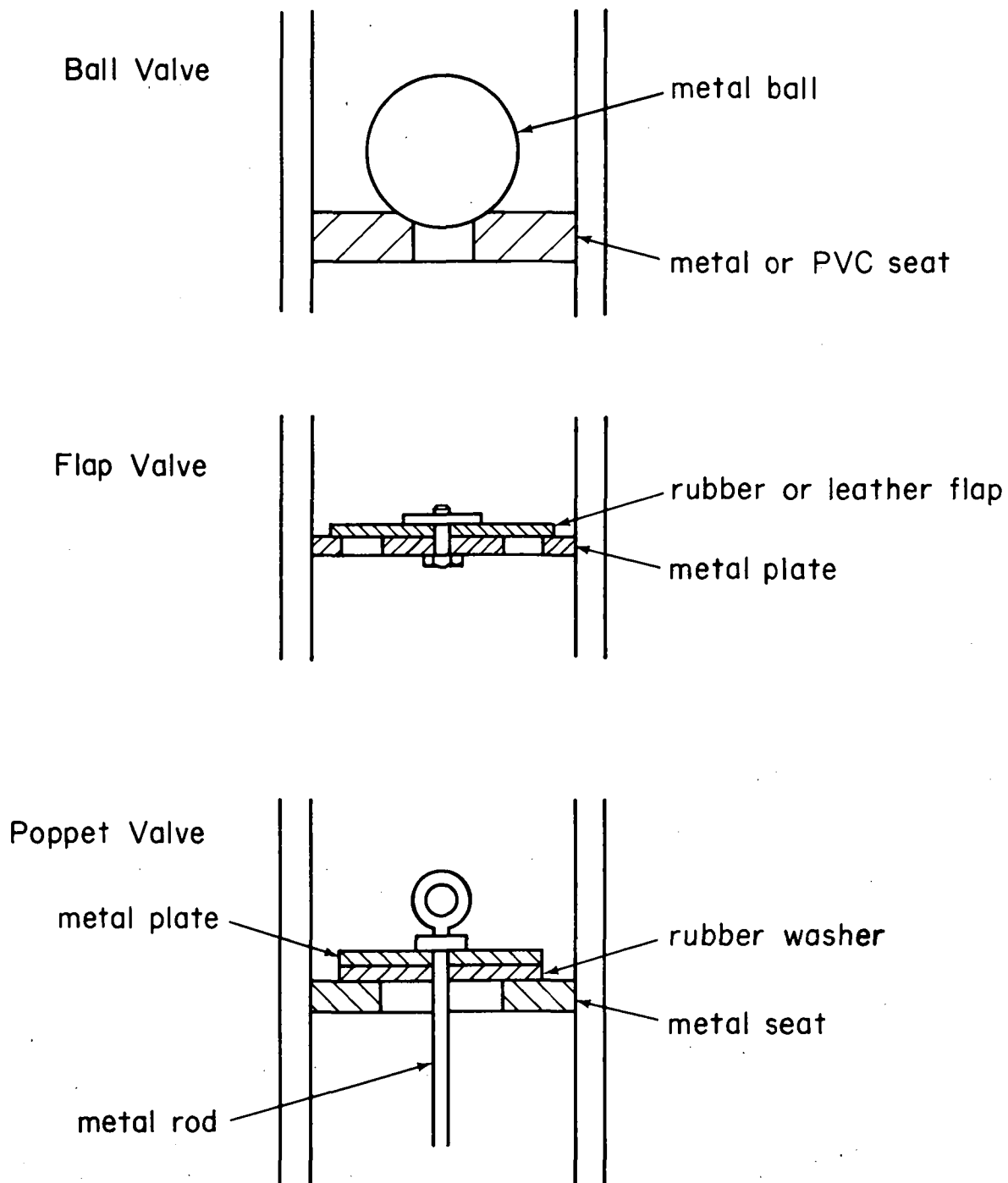


Fig. 6 Types of Valves

are not expensive and if good ones cannot be obtained locally, they can be imported from many countries in the developing world, for example India, Pakistan, Korea, Thailand, and probably many others.

The lower valve can be a ball valve in a seat, a leather or rubber flap valve, or a poppet valve. (Fig. 6) If the lower valve seat is a PVC ring, it can be cemented inside the casing at a joint as the casing is assembled.

Another method has been used by Rev. George Cotter of the Buhangija Mission in Shinyanga, Tanzania. This is "to crimp or squeeze in place the plastic ring (PVC) which acts as a seat for the steel ball making the foot valve. Once the length of PVC pipe has been determined, the lower end is immersed in hot oil until soft, the ring is inserted an inch or two up the pipe, and common auto radiator hose clamps are used to squeeze the pipe above and below the ring position. The hose clamps can be used again and again as the PVC pipe will not return to its original shape once it has cooled. The easiest way to handle the hot oil is simply to have a paint can (or other metal container) of used engine oil. This can be reheated indefinitely." \* He also suggests that the end of a section of PVC pipe can be softened and flared to fit over a metal pipe or another section of PVC pipe by this same method.

A simplified piston with a molded rubber bucket is used in Korea (fig. 7). This should be much less expensive to fabricate than the standard type piston with poppet valve.

## 7. Installation

Hand operated piston type pumps are the most common mechanical device for lifting water from both shallow and deep wells. Unfortunately, the standard pump designed for single family use does not stand up too well under 12-hour-a-day use in a village, and in many programs half or more of the pumps have failed before they have been in service 6 months.

Most villages have not established a responsible local official or committee to maintain the pump, and the lack of funds, tools and spare parts in the village complicate the problem. Usually a government agency has installed the well and pump and the villagers take the attitude, "It is a government well, let the government maintain it." In most countries, maintenance by the government is very expensive because it

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\* "Shinyanga Lift Pump", VITA Pub. No. 4311.6, Out of Print.

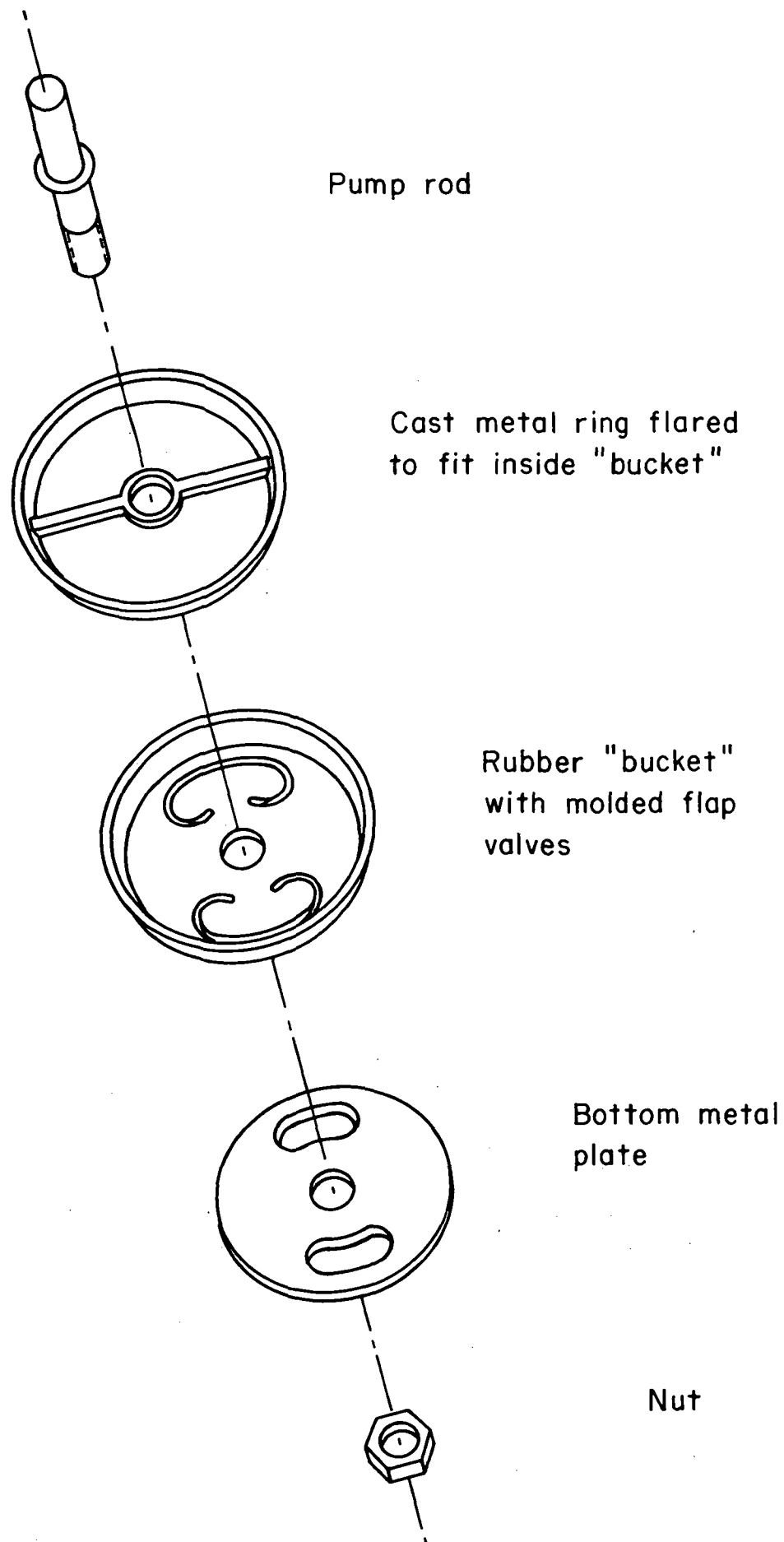


Fig. 7 Simplified piston with molded rubber "bucket"

means motor vehicles, drivers, mechanics, tools, fuel, and organization with administrative people, clerks, supervisors, storage of spare parts, and a method of notification for emergency repairs. Government maintenance is not required if a program is properly set up, pumps are designed for easy maintenance, and spare parts are readily available to the village. In most countries, lack of technical skills in the village to repair the pump is no longer a problem, because in most villages there are bicycles, motorcycles, and small gasoline or diesel engines to pump irrigation water or grind grain, and these devices are much more complicated than a hand pump. If the village can maintain these more sophisticated devices, it can maintain a hand pump.

A well and pump should not be installed unless the village, through its leaders, agrees that they want the well, they are willing to contribute labor, local materials and, if possible, some cash to the installation; and also will agree to pay for spare parts and repairs to keep the pump operating. Village ownership and responsibility for maintenance should be incorporated in a formal written agreement between the agency installing the well and the village leaders. The well should be turned over to the village in a public ceremony at which time the local official or water committee that will be responsible for the well should be presented with a copy of all the data on the well and pump, some spare parts, any special tools required, a repair manual for the pump, the name and address of the nearest place where additional spare parts can be obtained, and a name, address and phone number to notify in case a problem develops that is beyond the village capability.

#### VITA's Services

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