ABSTRACT

Only 20 per cent of the world's rural population have access to safe drinking water.

One remedy for this situation is to install handpumps on wells, wherever possible. However, most handpumps used in developing countries today are imported from the developed world where the pump is designed to be used by one family.

These pumps cannot stand the severe use required in developing countries, working continuously every day for 6-7 hours. Most available handpumps are expensive, complicated, a high percentage are inoperative. This report reviews all available testing and experience with handpumps. This information is summarized for each type of pump and criteria for evaluating the different pumps are presented.

The report commends one very simple handpump, the Blair Pump, in which polyvinyl chloride pipes are used as the pump cylinder and piston. In addition, seven other pumps, for both deep and shallow wells, are deemed most appropriate for developing countries. Recommendations for improvement of handpumps are suggested.

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ACKNOWLEDGEMENTS

Grateful appreciation is expressed to the following individuals who have assisted me in the preparation of this report:

Dr. Daniel A. Okun, my advisor, for suggesting the topic of this report and for his constant guidance and patience.

Dr. John Briscoe, for reviewing a rough draft of this report and for making many helpful suggestions.

Mr. Saul Arlosoroff and Mr. Christopher R. Schulz, of the World Bank, for providing references and information on handpumps.

Mr. Robert Edwards for helping in the preparation of this report.

Mrs. Phyllis Centry, for transcribing my hand-written pages into a neatly typed manuscript.

Finally, I would like to acknowledge my brothers, sisters-in-law and friends, with special thanks to my oldest brother Professor Cheng-Chih Fan and his wife, for their financial support.

Also special thanks are extended to my friends, Mr. and Mrs. Harold Jackson who have given me their love, support and encouragement throughout my studies in graduate school. It is to them that I dedicate this work.

I. INTRODUCTION

NEED FOR HANDPUMPS

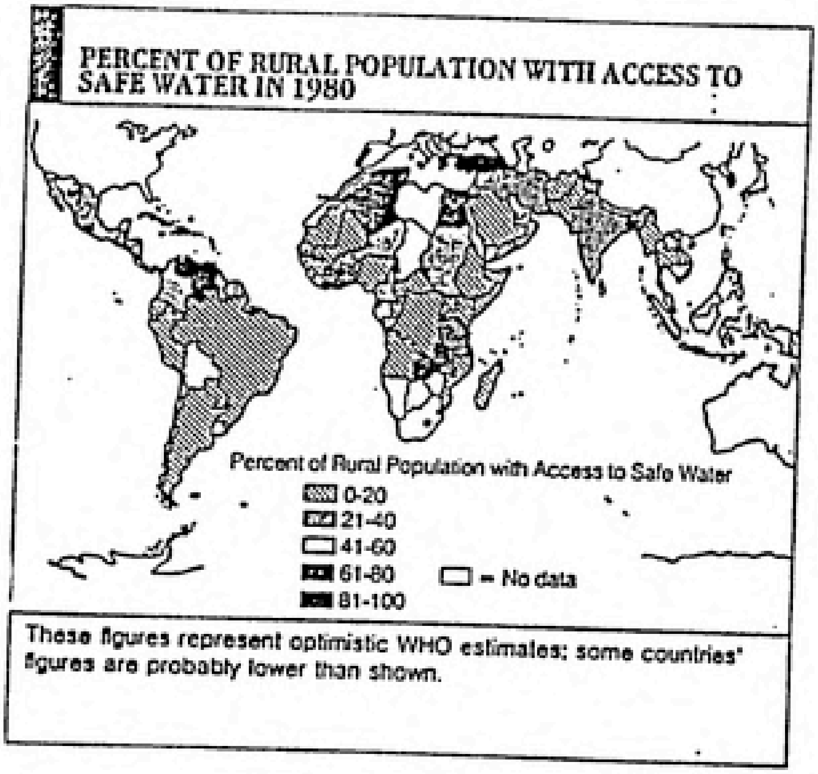
The World Health Organization has estimated that 80% of the rural population in Africa, Asia and Latin America do not have access to safe drinking water (Figure I-1). Water supply in rural areas in developing countries is generally drawn from open wells or streams without treatment. Open wells are easily contaminated by contact with the dirty hands of people drawing water when they handle the bucket and rope and streams can be contaminated with human and animal excreta.

Eighty percent of diseases in developing countries, such as typhoid, cholera, dysentery, hepatitis and diarrhea, are related to contaminated drinking water supply. It is estimated that each year diarrhea in its various forms kills 10 to 20 million children under the age of five. The guinea worm plagues rural populations with an estimated 10 to 48 million cases each year (Morrison, 1983).

The United Nations declared the 1980s the International Drinking Water Supply and Sanitation Decade with the goal of safe water and sanitary facilities for all by 1990. However, most developing countries lack the technical and financial resources to provide water supply and sanitation systems in rural areas.

Experts from the World Bank, the United Nations Development Program, the United Nations Children Fund, the World Health Organization, the United Nations Environment Program and other related organizations

FIGURE I.1



(SOURCE: Cairncross and Feachem, Jhon Wiles & Son, 1983) recognize this and recommend that providing handpumps for water supply is a simple technical solution. Hand pumps do not require a power source such as electricity and do not require advanced technical knowledge to operate and maintain. It is estimated that by the end of 1990 seven million new handpumps should be provided for the 1.4 billion people of the rural population. This number is based on 200 people per pump. In addition, replacement pumps numbering 2.5 million will be needed to serve at least 500 million people; thus about 9.5 million handpumps will be needed during the UN Water Decade. World Water Journal estimates that some 20 million or more handpumps may be needed by the year 2000 (World Water, 1981e).

HANDPUMPS

Various manually operated pumps are used in most developing countries to withdraw water from wells or boreholes for either family use or irrigation. In general, piston and diaphragm are two types of pump. Diaphragm pumps are suction type and can only work when the water level is less than 15 feet below the surface. Piston pumps can be operated as a suction pump, or can be a lift pump when water level in the well is more than about 20 feet.

In developing countries most village handpumps in use today are reciprocation pumps. They are the evolutionary products of over a century of design modifications. Although over the past ten years many international organizations have sponsored research to develop new kinds of handpumps in developing countries, the same principles of handpump analysis and evaluation are used.

Nomenclature

Pump Components

The components used for pumping from wells and boreholes can be roughly separated by function into three parts (Figure I-2): (1) the pump stand assembly on the well; (2) the connecting assembly which connects the above-ground components and the below-ground components; and (3) the cylinder assembly in deep-well lift pumps (Figure I-3) which is located below the ground in contact with the water. In shallow well (Figure I-4) the cylinder assembly is in the body of the pump above ground.

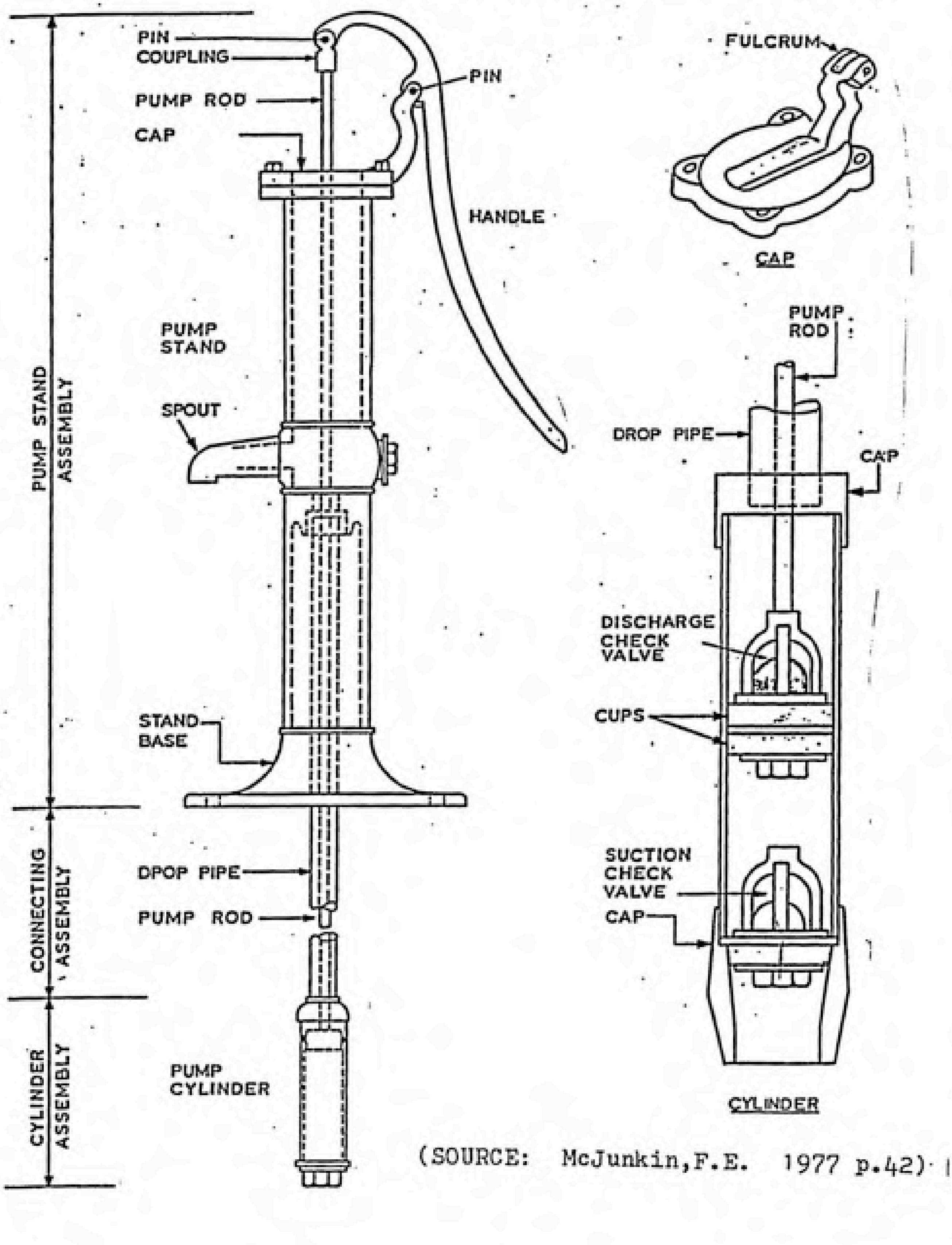
According to the location of these three parts, wells are divided into two categories, deep wells and shallow wells. In deep wells, the three parts are separate from each other (Figure I-3). Deep well pumps are called "lift pumps". In shallow wells the connecting-rod and cylinder assembly may be located in the pump stand (Figure I-4). These are called shallow well "suction pumps".

Principle of Handpump Operation

Figure I-5 shows a hand-operated, shallow-well suction pump. The pump design includes a valved plunger which reciprocates and a check-valve within the pump stand assembly. The following eight steps outline the operating procedure of this type of pump.

1) The pump is primed by the first upstroke. When the plunger is raised a vacuum is produced under the bottom surface of the plunger in the cylinder. In the well, the atmospheric pressure on the water is greater than the air pressure on the water in the suction pipe. Therefore the air and water within the pipe are forced upward. The air

FIGURE I.2 | HAND PUMP NOMENCLATURE |



(SOURCE: McJunkin, F.E. 1977 p.42)

FIGURE I.3

DEEP WELL LIFT PUMP

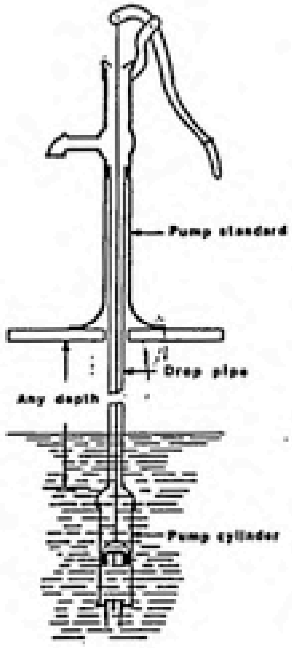


FIGURE I.4

TYPICAL SHALLOW SUSTION PUMP

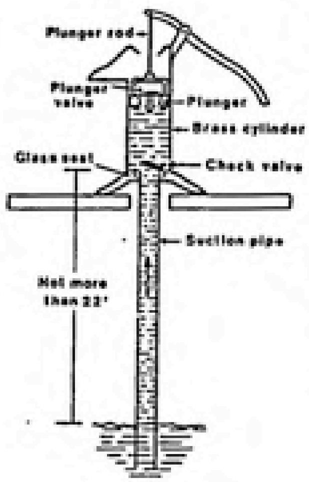
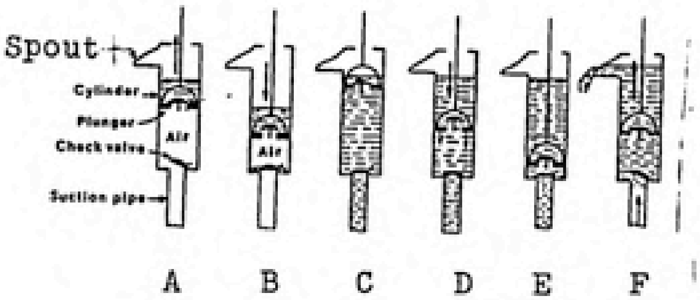


FIGURE I.5 ILLUSTRATION OF OPERATION OF PLUNGER-TYPE PUMP

First upstroke



(SOURCE: McJunkin, F.E. 1977 p. 27-29)

from the pipe fills in the space in the cylinder below the plunger (Figure I-5A).

2) When the plunger rod moves upward a certain distance in the cylinder, the plunger stops and the check valve closes due to its own weight. Therefore the air stays in the cylinder.

3) During the downstroke, air is compressed between the plunger and the check valve. When the air pressure becomes greater than the atmospheric pressure above the plunger and the weight added to the valve and plunger then the valve opens allowing air to escape to above the priming water (Fig. 4B).

4) The second upstroke has the same effect as the first. Air and water rise higher as the upstrokes and downstrokes are repeated until the water from the well fills the cylinder (Figure I-5C).

5) With the next downstroke, the plunger and valve move down toward the bottom and since water cannot be compressed the valve opens (Figure I-5D).

6) As the plunger reaches the cylinder bottom, it stops and the valve closes, keeping the water within the cylinder (Figure I-5E).

7) On the following upstroke, water is brought out through the spout. At the same time water in the well is forced by the vacuum up towards the cylinder (Figure I-5F).

Rate of Discharge

For a single acting reciprocating handpump, the theoretical rate of discharge is the product of the cylinder volume (V) swept by the plunger during its upwards motion and the number of plunger pumping strokes per unit time (N). That is: $Q = VN$ (Figure I-6). Rewriting for Q in terms of cylinder diameter (D) and the ratio of the cylinder circumference to its diameter (pi)

$$Q = \pi/4\ D^2\ N\ S \qquad (1)$$

Figure I-6 shows the relationships of these variables.

During the pumping action, the plunger changes direction and the values do not always close instantly. There is also leakage between the plunger and the cylinder wall as the plunger moves up and down. In general this leakage results in the actual discharge of the pump being 5 percent to 15 percent less than the theoretical rate of discharge.

Energy Requirement

The power or rate of work is expressed as below.

$$P = QH/e$$

if

Q is the rate of discharge in liters per minute

H is the pumping head in meters

e is the pump's mechanical efficiency in decimal.

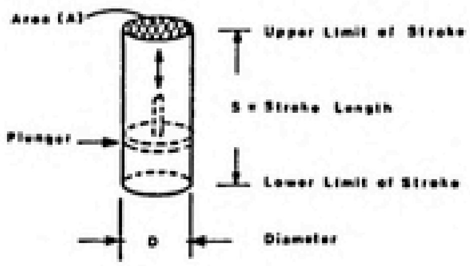
Therefore:

$$\text{Power (in HP)} = QH/4569e \qquad (2)$$

Human Power

The power capacity available from a human being varies from individual to individual, the location, and the length of the working period. Table I-1 gives the value of man generated power. The average adult human being can develop between 0.08 to 0.10 horsepower (60 to 75 watts) 8 hours per day and 48 hours per week. Also, for people who are in poor health, malnourished, short stature or old, the value should be decreased. In bad environments, such as in tropical, high humidity work

FIGURE I.6 SWEPT CYLINDER VOLUME



(SOURCE: McJunkin,F.E. 1977 p. 44)

TABLE I.1

MAN GENERATED POWER

AGE OF MAN	USEFUL POWER BY DURATION OF EFFORT (in H.P.)					
Years	5 min.	10 min.	15 min.	30 min.	60 min.	480 min.
20	0.29	0.28	0.27	0.24	0.21	0.12
35	0.28	0.27	0.24	0.21	0.18	0.10
60	0.24	0.21	0.20	0.17	0.15	0.08

Modified from Krendel (1967).

(SOURCE: McJunkin,F.E. 1977 p.57)

environments; the value also should be decreased. Poorly designed handle movement that does not allow many muscle groups to contribute to operating the pump will also reduce the value.

It is generally accepted that the average adult human being can offer 0.08 to 0.10 horsepower (60 to 75 watts) working for a long term work period. For short bursts of energy the power developed may be ten times as much as this (Stern, 1983).

If assuming a handpump has a typical mechanical efficiency about 55 percent and people can develop 0.10 HP, equation (2) becomes

$$QH = 251.$$

That means at a head of 15 meters the discharge rate Q would be about 16.7 liters per minute.

PROBLEMS WITH HANDPUMPS

The first problem is that there are insufficient handpumps. It is the task of the 1980s, the International Drinking Water Supply and Sanitation Decade, to provide 9.5 million pumps to people in rural areas in developing countries.

Handpumps themselves have problems. The traditional cast iron handpumps are not durable; usually they are hard to install, to operate, and to maintain. The handle assembly especially is not durable, and a field report from India specifies that 70 percent of the pump breakdown was due to faulty or broken handles (Janssens, 1983). The cup seals frequently must be replaced. Another problem of the pump itself is that the pumps are imported from foreign countries, thus the spare parts are not easily obtained in developing countire. Even if there are some spare parts, they usually can be found only in a warehouse far from the local village.

Up until recently service to pumps was the job of trained mechanics who covered their area in trucks. In developing countries there is a shortage of trucks, fuel, spare parts equipment, and even of skilled manpower. The results of these shortages are a high percentage of inoperative pumps.

The cost of maintaining the hand pump is a deterrent to developing countries. In order to keep the pump working, the average maintenance cost is estimated at about $400 per pump per year. In some instances maintenance costs consist of 85 percent of the total cost of the rural water supply (World Water, December 1981c).

The Water Decade is promoting the VLOM concept. VLOM means Village Level of Operation and Maintenance. The ideal is for all routine care of the handpump to be done by a village caretaker with minimum tools and equipment.

INFORMATION ON HANDPUMPS AND THEIR PROBLEMS

Information on handpumps may be found in three sources:

1) Laboratory test reports and technical journals;

2) Field test reports;

3) Manufacturer advertisements and specifications.

The identification of many pumps may be found in books and journals, but very little information is available on them until a search is made back to the manufacturer or laboratory that made the tests.

Researchers all over the world are studying the cost-effective pump with VLOM concept. For the past decade, innumerable handpumps have been manufactured around the world. The pump manufacturers always promote their own products. What has not been considered often is that the conditions in the field are completely different from the indoor laboratory tests.

In fact, handpumps installed in developing countries have encountered many problems in operating and maintenance. One can easily find literature describing individual pumps. Now what people need is readily available information that compares the individual pumps and their features to each other. But the information that compares the pumps to be used in different countries is not available.

Of course, all the designers and manufacturers think that their product is the best. Therefore, in the country different designs and manufactured pumps have been installed, but no one knows which one is the most appropriate. Those working in the "Water Decade" will be anxious to know which pumps are best to meet certain conditions in different countries, but there are not any such articles to provide the information.

THE OBJECTIVES OF THE REPORT

The objectives of this report are to provide comparative data on all of the existing handpumps that may be obtained and installed by developing countries. Both laboratory and field test data are used.

The following areas are given special attention in the report:

1) How easy is it to obtain all of the raw material to manufacture the pump? Is the pump simple to manufacture? Can the pump be manufactured locally?

2) How easy is the pump to install? Does it need lifting tackle? How many people are there needed to install it?

3) How easy is it to keep the pump in working order? How often must maintenance be performed? Which parts must be replaced periodically? Which parts are likely to break or fail?

4) How expensive is it to purchase and to operate?

From all these aspects it will be possible to recommend specific hand pumps to match the conditions found in a country. Finally, criteria for an ideal pump are proposed and improvements of handpumps suggested.

SOURCES OF REFERENCE

The major reference base consists of reports from UNDP, WHO, UNICEF, WB, Consumers' Association Testing and Research Laboratories, and technical journals such as World Water and Waterlines, as listed in the References.

LIST OF HANDPUMPS

Pumps are listed in categories in order, with those for which the most information is available being listed first. Appendix A is a complete list by country of origin.

1. Pumps with description laboratory testing and field experience: (see Chapter II) Volanta Pump, Moyno Pump, Maldev Pump, Korat Pump, New No. 6 Pump, Kenya Pump, Petro Pump, Jetmatic Pump, Abi-Vergnet ASM Pump, Nira AF76, Rower Pump, India Mark II Pump, Consallen Pump, Mono Pump, Hydro-Pompe Vergnet Pump, Battelle/AID Pump, Kangaroo Pump, Kardia Pump, Turni Pump, Waterloo Pump, Dempster Pump, ABI Pump, and Monarch Pump.
2. Pumps with description and field experience: (see Chapter III) Blair Pump, Plastic Pipe Pump, Bamboo Pump, Deplechin Pump, Shinyanga Pump, Marumby Pump, and Lucky Pump.
3. Pumps with description and laboratory testing: (see Chapter IV) Ethiopia BP 50 Pump, Nepta Pump, Vew A18 Pump, Fungmaq Pump, Bandung Pump, Sumber Banger Pump and Drogon No. 2 (D) Pump.
4. Pumps with field experience: (see Chapter V) Bangladesh Deep-Set Pump, Tredle Pump, ESW-81 (82) Pump, Local Experimental Shallow-Well Pumps (Papua New Guinea), Clayton-Marks Pump, Bourga Pump and Sarvodaya Pump.
5. Pumps with laboratory testing and manufacturer information: (see Chapter VI) Godwin W1H51 Pump, GSW1205 Pump, and Climax Pump.
6. Pumps with manufacturer information: (see Chapter VII) Duba Tropic Pump, Stewarts Pump, Lioyds Pump, SYB-100 Pump, SWN81 Pump, Sholapur (Mission or Jalna-Type) Pump, Bangalore Pump, U.S.T. (KUMAS1) Pump, Pompe a Balancier Pump, Pompe a Pieds Pump, and JAMHP Pump.
7. Pumps with name: (see Chapter VIII) Maya No. 6 Pump, Tara Pump, Hand Driven Ejector Pump, Royale Pump, Africa Pump, Majestic Pump and Sialkot Pump.

BACKGROUND ON HANDPUMP LABORATORY TESTING AND FIELD EXPERIENCE

Introduction to Description Handpumps Laboratory Test Data

In order to improve the quality of life in developing countries, the experts who are working for the International Drinking Water Supply and Sanitation Decade (IWSSD) believe that clean drinking water and sanitation could have more impact than any UN program ever conceived to reduce human suffering. Even though in the developed world handpumps have almost become antique curios, in the developing countries of Asia, Africa, and Latin America there is new interest in using handpumps. Since the 1960s high speed water drilling and light weight PVC pipe were used for community water supply wells. Installation of handpumps in wells is the simplest and cheapest way of supplying water to rural areas. Thus, handumps will play an important role during the Water Decade.

Most handpumps used in developing countries are imported from the developed world where the pump is designed to be used by one family once each day. They could not stand the severe use required in developing countries, working continuously every day for 6-7 hours. Under these conditions conventional handpumps are unreliable and have many shortcomings, such as: low efficiency requiring greater pumping effort, low discharge, frequent breakdowns, and poor seals allowing contamination from the ground surface. Imported pumps are expensive and also have problems because spare parts must be bought from foreign countries. In the 1970's thousands of villages were provided with handpumps, but over 80% of them were out of order between three months and a year later. As described by C. Payne Lucas, "The landscape of the

Third World is littered with pumps that do not work." (Enfo, Vol. 5, No. 2, 1983)

In response to these problems, studies have been conducted by researchers around the world such as; the World Bank, United Nations Development Program, the United Nations Childrens' Fund, the World Health Organization, the United Nations Environmental Program, the United States Agency for International Development, and related organizations. They were especially interested in handpumps with simple construction and low-cost which can be manufactured locally using local materials and commonly available skills and techniques. The pumps should also be able to stand heavy use or misuse, with low maintenance, and can be repaired by the local villagers.

In 1966 the United States Agency for International Development (AID) contracted with the Battelle Memorial Institute - Columbus Laboratories to develop a dependable handpump suitable for use in rural water supplies in developing countries.

In 1977 the Overseas Development Administration of the United Kingdom was anxious to know the following data:

1) What kinds of problems are there in the field where handpumps were working.
2) A comparison of pumps to decide which is better for use in developing countries.
3) The technical information of pump performance, manufacturing quality, engineering design assessment, ergonomic and user information, and abuse and endurance test.

This information could then be sent back to pump manufacturers and design departments to help in improving their products.

First they tested twelve different pump designs chosen to represent as many design types as possible. They were all deep-well pumps including traditional and newer designs which can be operated by hand or foot.

The pumps selected from eight countries are shown in Table IX-1. These data are included in their final report of January 1981 (Overseas Development Administration Handpumps Laboratory Testing Final Report, January 1981).

In]980 the World Bank with UNDP funding commissioned the Consumers' Association Testing and Research Laboratories to continue work on handpump assessment, in cooperation with the beginning of the International Drinking Water Supply and Sanitation Decade in 1981. Three batches of six pumps selected from 16 countries were tested. This report gives these results, from the laboratory testing of handpumps from the Rural Water Supply Handpumps Project. This information comes directly from their publication; "Laboratory Testing of Handpumps for Developing Countries" (World Bank, 1984) (see Table IX-2 and Table IX-3).

Introduction to Field Experience with Handpumps

At the end of 1981 UNDP/World Bank decided to field test the pumps in 20 countries: Kenya, Tanzania, Malawi, and Sudan in East Africa; Ghana, Ivory Coast, Niger, Upper Volta and Mali in West Africa; Bangladesh, India and Sri Lanka in South Asia; Malaysia, Thailand, Philippines, Papua New Guinea and China in South East and East Asia;

and Dominican Republic, Honduras and Peru in Latin America.

Individual handpump field experiences were published in technical journals such as World Water, Waterlines, Civil Engineering/ASCE, African Water and Sewage and United States Agency for International Development Handpump program in the individual countries.

This report contains several parts, they are:

1) pumps with description and field experience

2) pumps with field experience

3) pumps with description and laboratory testing in CATR

4) pumps with field experience

5) pumps with laboratory testing in ODA and manufacturer information

6) pumps with name.

In this report all the basic information is from field tests or technical journals. My contribution is in reviewing the existing handpump laboratory tests and experiences in developing countries, and giving my opinion about the advantages and disadvantages of the handpumps.

II. PUMPS WITH DESCRIPTION, LABORATORY TESTING, AND FIELD EXPERIENCE

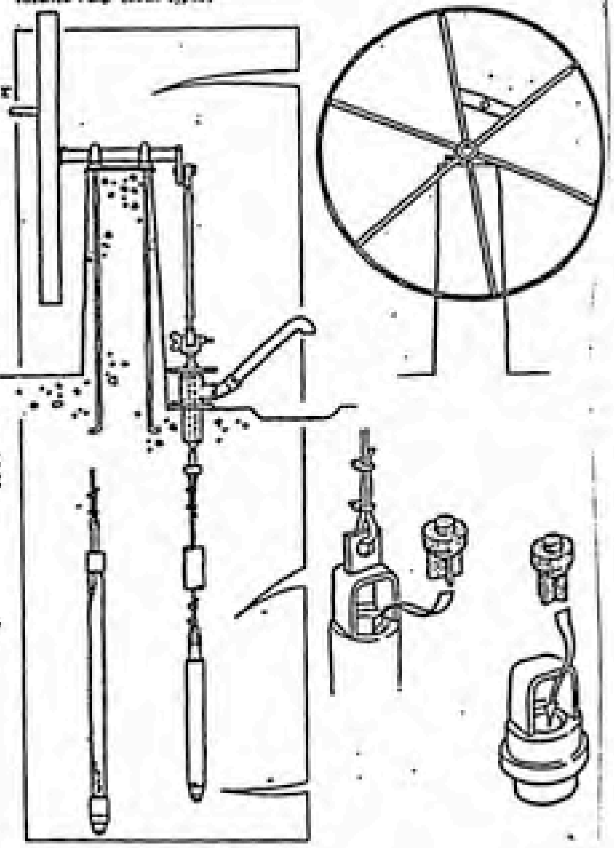
INTRODUCTION

This chapter includes information on all pumps with laboratory testing and field experience. They are in two groups. The test data were available only for the first group. The first group was tested by Consumers' Association Testing and Research Laboratories in England. The second group includes pumps tested by three different laboratories: Overseas Development Administration; Consumers' Association Testing and Research Laboratories in England; and Battelle Memorial Institute, Columbus Laboratories, in America.

PUMPS WITH TEST DATA PRESENTED HERE

Country of Origin	Name	Deep or Shallow	Field Testing Countries
Holland	Volanta	Deep	Upper Volta
USA, Canada	Moyno	Deep	Ivory Coast, Ghana, Upper Volta, Nicaragua
Malawi	Maldev	Shallow	Kenya, Tanzania, Malawi Thailand, Philippnes, Sudan, China
Thailand	Korat 608A-1	Deep	Thailand
Bangladesh	New No. 6	Shallow	Bangladesh, India, Sri Lanka
Kenya	Kenya	Deep	
Sweden	Petro	Deep	Kenya, Sudan

Philippines	Jetmatic	Deep	Philippines
Ivory Coast, France	Abi-Vergnet ASM	Deep	Upper Volta, Mali, Ivory Coast
Finland	Nira AF76	Deep	Tanzania
Bangladesh	Rower	Shallow	Bangladesh, India, Sri Lanka, China



Volanta Pump Description

The Volanta pump is made in Holland and in Upper Volta. It uses a heavy fly wheel to generate a conventional reciprocating action but in many other ways is unconventional.

Two types of cylinder were supplied; these are referred to hereafter as cylinder types 1 and 2. Type 1 had a machined nylon cylinder body and a stainless steel plunger, with a turned bronze sealing ring. Type 2 had a glass reinforced plastic cylinder body and a long, close-fitting stainless steel plunger, with no other seal.

Connection between the above- and below-ground parts was by cable in the samples supplied for testing, though the manufacturer now supplies steel rods. The complete cylinder is designed to be extractable from the well, using the connecting cable or rods, without the need to remove the uPVC rising main.

Above ground the pumpstand is unusually large. For testing, the pumps were supplied with supporting steel framework, but in field installations the crankshaft would be supported by a concrete pillar as shown, or by a fabricated steel box. The pump stroke is adjustable to compensate for operating depth.

Materials of Construction

Above Ground Assembly

COMPONENT	MATERIAL(S)
Crankshaft	Steel
Crankshaft Bearings	Standard self-aligning plummer blocks
Flywheel and Handle	Steel
Connecting Rod	Steel tube with standard self-aligning ball races at each end
Spout	Steel tube, hot dip galvanised
Cable	Steel, contra-wound to resist twisting
Crosshead Assembly	Stainless steel shaft, steel fittings, with PA 10 nylon guide ring

Cylinder Type 1

COMPONENT	MATERIAL(S)
Cylinder Body	PA 10 nylon
Plunger	Stainless steel
Sealing Ring	Bronze
Foot Valve Body	Stainless steel
Valve Poppets	Moulded rubber

Cylinder Type 2

COMPONENT	MATERIAL(S)
Cylinder Body	Epoxy bonded glass fibre composite
Plunger	Stainless steel
Foot Valve Body	Stainless steel
Valve Poppets	Moulded rubber

WEIGHTS & MEASURES

Weights

Pump stand :	76.5 kg
Cylinder type 1:	9.4 kg
Cylinder type 2:	10.0 kg
Drop Pipe (per m):	1.7 kg

Dimensions

Nominal cylinder bore (both types):	50 mm
Drop pipe size:	3.0 inch
Outside diameter of below-ground assembly:	101 mm

The pump stroke, and therefore the nominal volume per stroke, are variable depending on depth. (see pump performance)

Manufacturing Techniques

Above-ground assembly — Steel fabrication
Machining of steel and plastic
Concrete craft

Manufacturing the pumpstand demands basic skills in machining and steel fabrication. It may be suitable for manufacture in some developing countries.

Cylinder Type 1 — Machining of metals and plastic
Rubber moulding.
Welding of stainless steel

The cylinder is machined from a solid billet of nylon, the stainless steel plunger and bronze sealing ring must be machined to close tolerances and high standards of finish.

Cylinder Type 2 — Fabrication of glass reinforced plastics
Machining
Rubber moulding

The cylinder body is fabricated from epoxy resin reinforced with glass fibres. Achieving a consistent high quality in the finished component is likely to demand considerable skill and experience. The plunger must be machined to a close tolerance and with a good standard of finish.

Ease of Installation, Maintenance and Repair

Ease of Installation
The most time-consuming installation job is likely to be constructing the concrete plinth. In other respects installation is straightforward and will not require lifting tackle. It is necessary to adjust the pump stroke and the length of the connecting rod to suit the depth of water in the well.

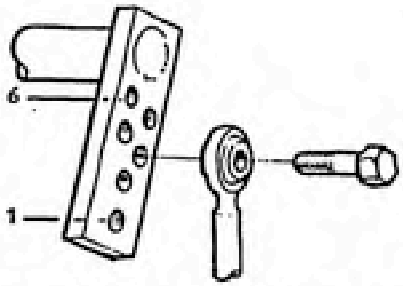
Ease of Pumpstand Maintenance and Repair
The most frequent maintenance operation is likely to be tightening the gland at the top of the connecting rod, but this is a very simple task. Indeed all pumpstand maintenance should be straight forward, requiring only a few spanners and simple hand tools.

Ease of Below-ground Maintenance and Repair
Both types of cylinder are designed to be extracted from the well on the end of the connecting assembly without the need to remove the rising main. Our experience suggests that the rods which the manufacturer now supplies are likely to be more reliable than cables.

PUMP PERFORMANCE Volume Flow, Work Input and Efficiency

The description of the method can be found in the Test Procedure. Examples of performance graphs are given in Appendix II.

Rotating crank arm showing positions able to be selected for operation at different water depths.



The manufacturer's recommendations for the crank position were as follows:

Position	1	2	3	4	5	6
Depth (m)	< 15	15 - 21	21 - 30	30 - 40	40 - 55	55 - 80
Crank throw (mm)	310	240	190	150	120	100
Position selected for test	7m	Users	25m		45m	

Cylinder Type 1

HEAD	7m				25m			45m			
Pumping Rate (revs/min)	18	24	26	34	19	27	35	21	27	33	37
Vol/revs (litres)	0.61	0.61	0.60	0.58	0.33	0.33	0.33	0.23	0.25	0.25	0.25
Work input/rev(J)	140	119	99	92	140	132	136	157	156	181	181
Efficiency (%)	29	35	41	43	57	61	59	65	69	60	60

Cylinder Type 2

HEAD	7m			25m			45m		
Pumping Rate (revs/min)	23	31	37	22	29	37	20	28	36
Vol/rev (litres)	0.61	0.61	0.61	0.32	0.33	0.34	0.24	0.25	0.25
Work input/rev (J)	128	120	118	148	162	151	144	180	190
Efficiency (%)	32	34	35	53	49	54	73	59	58

NOTE: It was difficult to accelerate the flywheel and sustain the target operating speed within the nine revolution limit of the potentiometer. See the manufacturers comments in the verdict.

ENDURANCE A detailed description of the endurance test method can be found in the Test Procedure.

General Comments

The cable originally supplied broke several times in the early stages of the endurance test. The type 2 cylinder was replaced by the second sample after 24 hours because debris from a broken cable had dropped into the cylinder causing a deep score in the bore. Springs were introduced into the cable to represent the inherent elasticity of 45 m of cable - the actual cable length in the test installation was less than 5 m - but these fatigued very rapidly. The manufacturer supplied thicker cable of galvanised steel rather than stainless steel, and this was used to replace the original cable as necessary when the latter broke.

Because the stresses in the short cable used for this test were not considered to be entirely representative of conditions in the field, cable breakages have not been highlighted as pump failures. However, failures of components related to the cable, but not the cable itself, are noted.

For performance testing the length of the above-ground connecting rod was adjusted to the 7 m depth setting. This enabled the pump stroke to be adjusted for operation at 7, 25 or 45 m. This caused premature wear in the wellhead gland, and for the endurance test it was necessary to adjust the connecting rod for the stroke specified for 45 m.

The upper cable fixing point broke in both pump types, and at the lower fixing point several cable thimbles broke up as a result of localised stress. On one occasion, debris from a broken thimble dropped into the type 2 cylinder causing the plunger to seize in the bore. Conventional steel thimbles were replaced by turned acetal pulleys and the method of attachment was modified to improve the distribution of stress. The modified components were still in good condition at the end of the test.

At the 3000 hour inspection, the type 2 cylinder could not be extracted from the taper seat in the rising main. Kieselguhr, which was added to the water for the third 1000 hour stage, had accumulated between the cylinder body and the rising main, and the cylinder was 'sand locked'. It was released by removing the lower section of rising main, but in the field this would entail removal of the complete below-ground assembly.

Leaking joints in the rising main for the type 2 cylinder could not be cured by conventional pipe sealing compounds. However, worm-drive hose clips applied around the outside of the joints ensured an adequate seal.

Breakdown Incidence Breakdowns are shown in bold type.

Cylinder Type 1

Hours	
0	Inspection & full performance test
1027	Inspection & volume flow
2054	Cable top fixing point broken
2094	Inspection & volume flow
2828	Cable thimble broken at bottom connection
3125	Inspection & volume flow; Cable thimble broken at bottom connection
3451	Cable thimble broken at both top and bottom connections - replaced by turned acetal pulleys
3699	Cable top fixing point broken
4164	Inspection & full performance test

Cylinder Type 2

Hours	
0	Inspection & full performance test
1027	Inspection & volume flow
2094	Inspection & volume flow
2931	Cable top fixing point broken
3125	Inspection & volume flow; Cylinder 'sand-locked' in rising main; Cable thimble broken at bottom connection
3214	Leaking joints in rising main
3410	Debris from broken thimble on bottom connection caused plunger to seize – thimble replaced by turned acetal pulley
4164	Inspection & full performance test

<u>FINAL INSPECTION</u> Cylinder	(a)	Cylinder bore pitted, even in the unswept areas
	(b)	Plunger scratched, but otherwise no perceptible wear
Valves		Some wear on plunger and foot valves, but otherwise in good condition and still serviceable
Pumpstand		Well head gland leaking slightly when pump stationary but satisfactory when operating pump
Filter		Thickly coated with sand and general debris but still working
Corrosion		Some rust on cylinder end cap

<u>Estimated total amount of water pumped in 4000 hours</u> ... 1.9 million litres

VERDICT

The Volanta pump with the two types of cylinder as supplied for this test proved to be unreliable in use.

Users found the pump difficult to start and maintain a steady rhythm. In the field with more time available there will be an opportunity for users to develop a better technique. Nevertheless it is recommended that consideration be given to a simpler pumpstand using a conventional lever arm at a considerable cost saving.

Many problems were encountered with the method of fixing the cables and some months after starting this test programme the manufacturer decided to discontinue the type 1 cylinder assembly.

The pump has now been substantially modified in response to the results of these laboratory tests and to information from the field. Steel rods with hook-and-eye connections are now used in place of cable.

The type 1 cylinder is no longer in production and it is interesting to note that in the tests it performed generally better than the type 2 cylinder.

If the modifications prove to be successful in future tests, then the Volanta may be suitable for community water supply in developing countries. It also has considerable potential for local manufacture providing adequate skills and quality control can be maintained for the cylinder assembly.

EXPERIENCE WITH VOLANTA PUMP

According to Field Trial Sites Chosen in 20 Countries (World Water Journal, February 1983c). The Volanta pump to be field tested in Upper Volta, West Africa.

Volanta pump was manufactured in Upper Volta and has been installed in Badie 180 km southwest of Ouagadougou, Upper Volta. This pump is very easy to maintain. In order to inspect or repair below-ground components, the flywheel has to be detached from the down-shaft fittings. The piston is mounted on the 3 meters long interlocking rods. These can be removed or installed within 15 minutes.

In Upper Volta, the Volanta pump project includes an education program dealing with health and proper use of a village water supply in addition to maintenance and installation.

ADVANTAGES AND DISADVANTAGES

Advantages

The major advantages are two. One is the flywheel and pedestal are set at the side of the well. The below-ground components can be withdrawn without moving the pump stand. Another is that by using 3 meters length interlocking rods, it is quick and easy to dismantle the pump. If labor is impossible, it can be belt-driven by a diesel motor.

Disadvantages

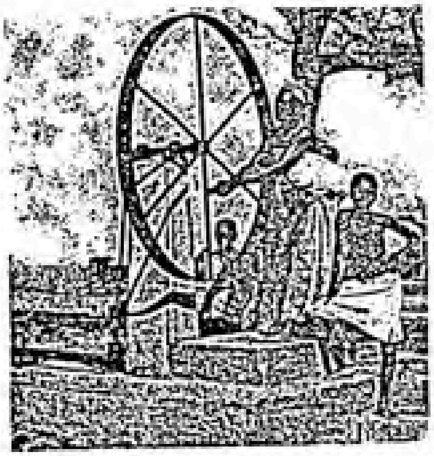
It was mentioned that the considerable skill, experience and quality control in manufacturing the pump is required. These rigid standards are not easy to meet in developing countries.

The big flywheel uses a lot of steel, resulting in the high price of $845, that cannot be afforded by villagers without a government subsidy.

The flywheel is potentially hazardous to people especially to children because of the inertia. The rotating crank arm could be dangerous too.

The big wheelfly is difficult to start and maintain at a steady rhythm. It is very difficult to reconcile to these conflicting requirements of safety and ease of operation in a flywheel-operated handpump.

FIGURE II. 1 Information About Volanta Hand Pump



VOLANTA
HAND PUMPS

Fabricated by JANSEN-VENNEBOER

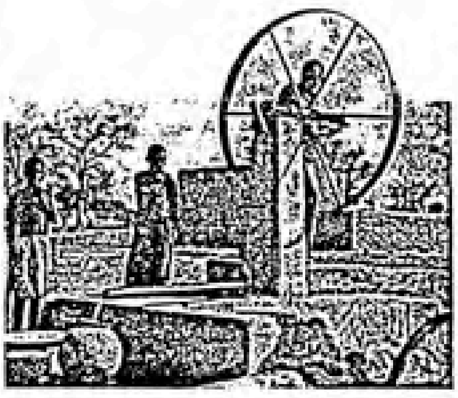
Dutch water engineers, in close co-operation with aid agencies, developed a completely new type of handpump.

This pump fulfils following requirements:

- Low operational and maintenance costs
- Operating from shallow wells as well as 80 metres bore holes
- Easy to drive, also for women and children
- Capacity almost 2000 l/h.
- High efficiency in operation
- No lifting equipment needed

This village-level-operation and maintenance handpump will solve your drinking water problems in the rural areas.
The pump is easy adaptable to other modes of energy.

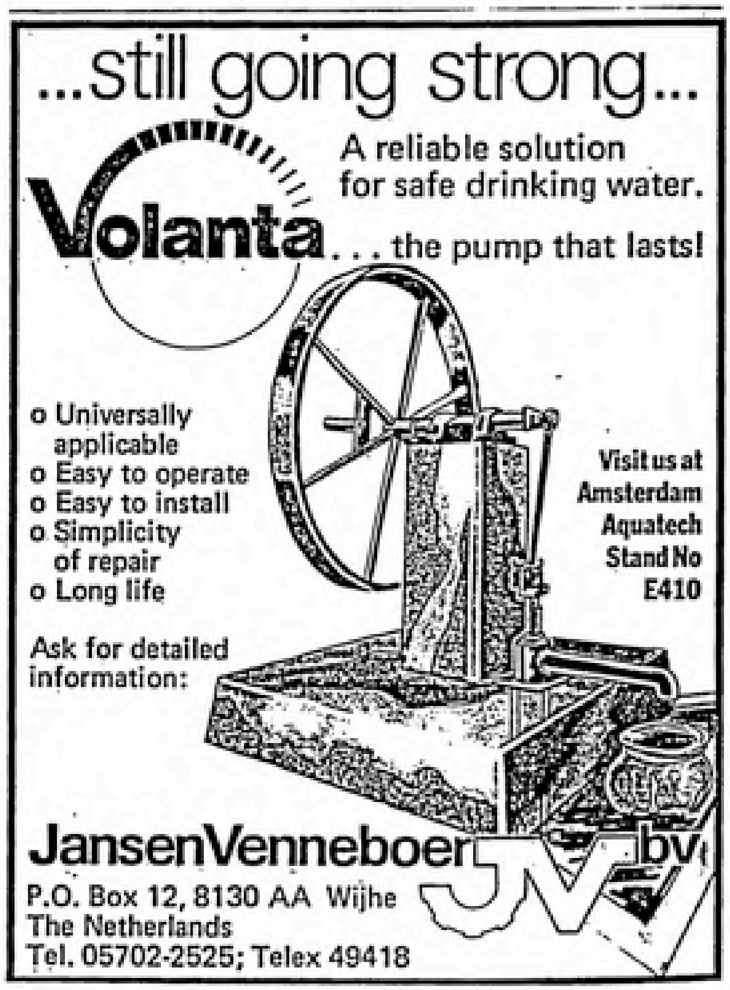
(SOURCE: World Water December 1981, p. 31)



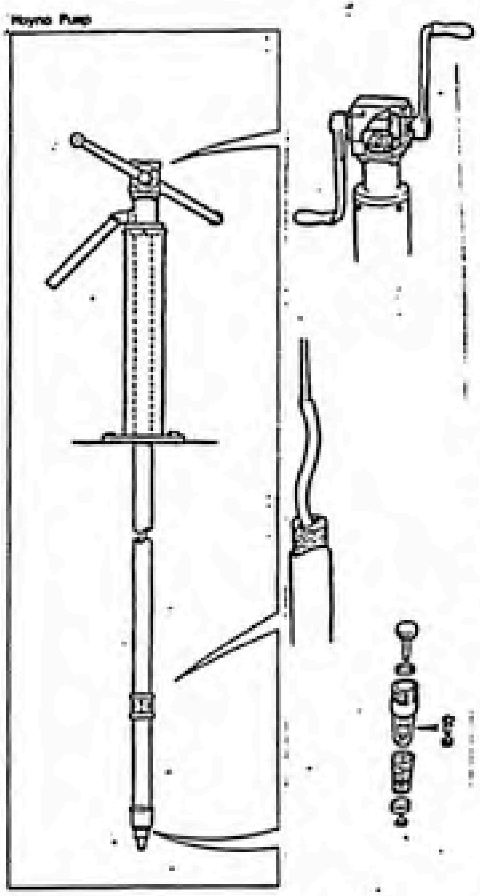
Some manufacturers have already begun to respond to the UN challenge to produce a VLOM pump. This Volanta pump from Insto of the Netherlands uses a cable to drive the cylinder instead of screwed rods. As a result, the manufacturer says, installation or dismantling is quick, simple operation for one man with no special tools. Flywheel operation can be handled by a five-year old child, and the pump is said to be suitable for depths of 4-100m.

World Water understands that Danish manufacturer Grundfos is also working on a VLOM pump design, but the company says it has no news for publication yet.

(SOURCE: World Water December 1981, p. 25)



(SOURCE: World Water August 1984, p. A 30)



Moyno Pump Description

The Moyno pump tested was made by Robbins and Myers in the U.S.A., is a positive displacement pump, which has a plated helical steel rotor within a double-helical elastomeric stator. The pump rods rotate instead of reciprocating up and down. The pump is operated by a pair of rotary crank handles, driving a gearbox and one-way clutch. The pumpstand is very robust, of all-steel construction. The twin handles make the pump suitable for operation either by one or two people.

Materials of Construction

COMPONENT	MATERIAL(S)
Pumpstand column	Fabricated steel, galvanised
Pump top (gearbox)	Cast steel
Handles	Cast steel
Bearings	Proprietary taper roller bearings
Gears	Mild steel
Rotor	Steel, hard chrome-plated
Stator	Moulded elastomer in steel tube
Foot valve	Gunmetal with brass strainer
Drop pipe	Galvanised steel
Pump rods	Galvanised steel

WEIGHTS and MEASURES

Weights	Pumpstand	48.0 kg
	Cylinder assembly	16.0 kg
	Pump rods	1.2 kg. per metre
Dimensions	Drop pipe size:	1.25 inches
	Outside diameter of below-ground assembly:	75 mm
	Pump rod diameter:	0.5 inches

Manufacturing Techniques

The manufacturing techniques required to make the pump are listed below:-

Above-ground Assembly	Iron and steel foundry
	Steel fabrication
	Complex machining

The pumpstand demands advanced manufacturing techniques and skills. It would not be suitable for manufacture in a developing country.

Below-ground Assembly	Iron foundry
	Gunmetal foundry
	Simple machining
	Hard chrome plating
	Specialised processes (pumping element)

The pumping element demands advanced and specialised manufacturing techniques and a high degree of skill. It would be particularly unsuitable for manufacture in a developing country.

Ease of Installation, Maintenance and Repair

Ease of Installation

A die and diestock for threading the pump rod, together with clamps and hexagon keys were supplied with the test samples.

Ease of Pumpstand Maintenance and Repair

Frequent attention to the pumpstand is unlikely to be required. A broken handle could be replaced in the field, but internal repairs to the gearbox assembly may demand workshop facilities.

Ease of Below-ground Maintenance and Repair

Frequent attention to the below-ground assembly is unlikely to be required. However, any repair requires removal of the complete below-ground assembly, and if the pumping element is faulty it must be replaced as a unit. In general, this pump requires an exchange rather than a maintenance routine.

PUMP PERFORMANCE

Volume Flow, Work Input and Efficiency

The description of the method can be found in the Test Procedure.

HEAD	7 m			25 m			45 m		
Nominal pumping rate (rev/min)	30	40	50	30	40	50	30	40	50
Vol/rev (litres)	0.23	0.23	0.23	0.20	0.20	0.20	0.15	0.15	0.16
Work input/rev (J)	130	144	140	139	152	166	195	209	198
Efficiency (%)	11	10	11	35	32	29	34	31	36

ENDURANCE

A detailed description of the endurance test method can be found in the Terms of Reference.

General Comments

The pump was tested at 40 revolutions per minute at a simulated head of 45 metres.

The Moyno failed once in the 4000 hour test programme, after 3178 hours. A rubber block is fitted in the bottom of the cylinder to prevent the rotor striking the base of the cylinder during installation. Although when first installed there was a clearance of 30 mm or so between the bottom of the rotor and the block, the block had worked its way up the cylinder bore and fouled the rotor, making the pump very difficult to turn. It was replaced in the correct position and the problem did not recur.

At the end of the test, the pump was generally in very good condition, with little corrosion. Wear was confined to the elastomeric stator which had been scored in several places by sand, but this was insignificant.

Breakdown Incidence

Breakdowns are shown in bold type.

Hours:	1072	2044	3060	3178	4063
Inspection and full performance test	Inspection and volume flow	Inspection and volume flow	Inspection and volume flow	**Rotor Seized**	Inspection and full performance test

FINAL INSPECTION

Pumpstand		In good condition throughout
Cylinder Assembly	(a)	Rubber stator grooved by sand particles, but still serviceable
	(b)	Steel rotor in good condition, highly polished
	(c)	Considerable quantity of sand in foot valve, though still working
Corrosion		No significant corrosion, though paint flaking off cylinder housing

Estimated total amount of water pumped in 4000 hours ..... 1.5 million litres.

VERDICT

A robust pump, in good condition after 4000 hours of endurance testing. The rate of delivery was low, and the pump was hard work to operate at first, though it became slightly less hard with further use. Although generally reliable in these tests, any repairs needed in the field will be difficult and expensive. It may not be ideal for community water supply because of the difficulties of operation and low rate of delivery. Expensive.

EXPERIENCE WITH MOYNO PUMP

Experience

In Haiti, West Indies the pump is installed to withdraw the water from 45.5 m depth of well. In Ghana, West AFrica they ordered 500 pumps after using and being satisfied with the way the pump operated. The average depth of the Ghana well was 2.5 m (test pump in Ghana). In Togo, West Africa even a child could pump water from a depth of 14.8 m without hard work. In Jakarta, Indonesia the early model pump worked for over three years without any maintenance or repairs being needed.

ADVANTAGES AND DISADVANTAGES

Advantages

The mechanism is totally enclosed in the pump stand.

Since the bottom of the rotary part must be immersed, no priming is required, no contamination can occur.

As there is only one moving part in the pumping elements, there is no potential of contaminating the water in the well.

There is a brass check valve with a self-cleaning strainer in order to keep large particles of silt or sand from entering the pump.

The pump can be converted to alternate power sources such as electric motors and gasoline engines.

Disadvantages

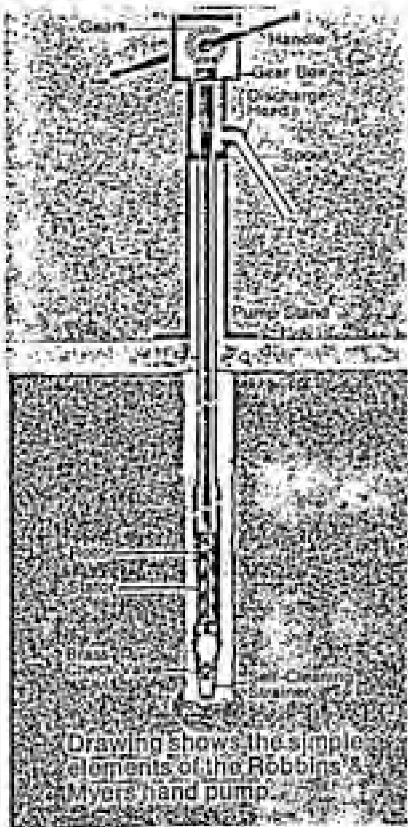
Since the bottom of the rotary part must be immersed, the pump cannot be used as a suction pump.

If the pumping element is faulty, the whole element must be replaced.

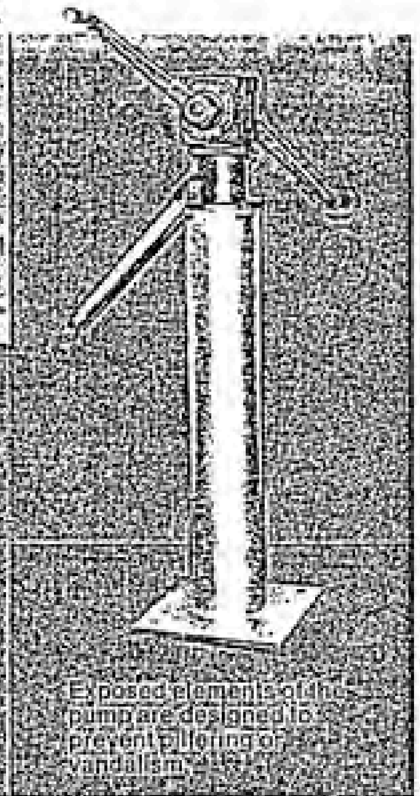
Most of the effort must be supplied by the arms and shoulders only; smaller users with limited reach could not maintain a smooth circular motion of the handles.

The rate of delivery was low and expensive.

FIGURE II. 2 Information About Moyno Hand Pump



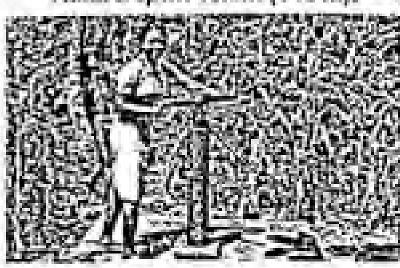
Drawing shows the simple elements of the Robbins & Myers hand pump.



Exposed elements of the pump are designed to prevent pilfering or vandalism.

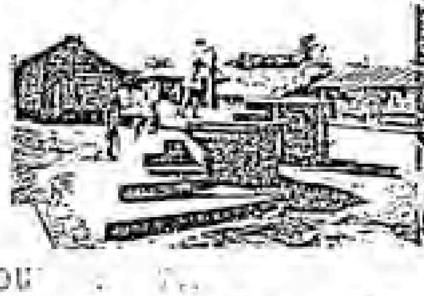
This pump replaces water from an irrigation ditch in Haiti. Depth: 45.5m (148 ft.).

One of 10 test pumps in Ghana which led to an order for 500 more. Average depth: 21.5m (70 ft.).



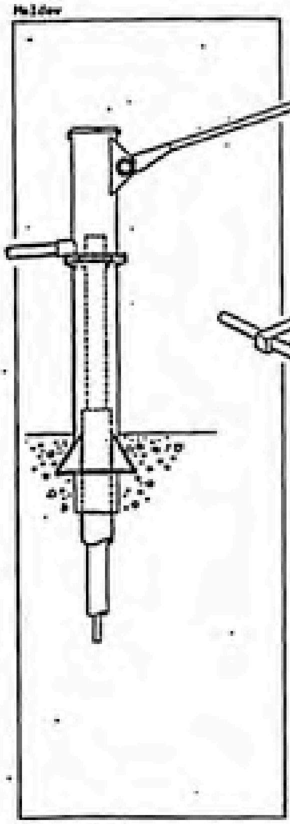
A child in Togo demonstrates the ease of pumping water from a depth of 14.8m (50 ft.).

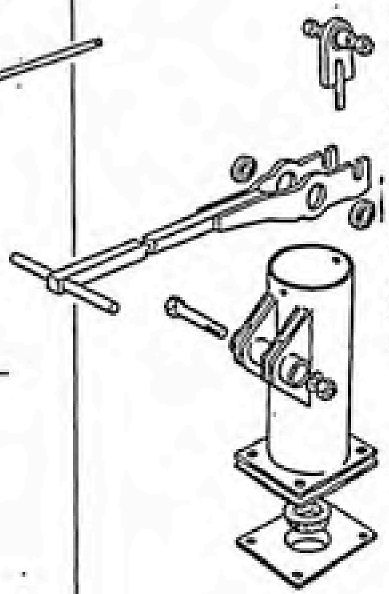
Early model pump near Jakarta, Indonesia. No maintenance or repairs in over three years.



(SOU[illegible] [illegible] Year Review 1982 Inside Back Cover)

Maldev





Maldev Pump Description (Malawi Pump)

At present, the Maldev consists of an above-ground assembly only. The pump was tested with a prototype below-ground assembly designed by Ken McLeod and later with a Funymaq cylinder assembly.

The Maldev pump head was designed and made in Malawi, initially with ODA assistance, for use with conventional reciprocating deep-set cylinders. It is fabricated from steel sections and the pedestal is intended to be concreted-in at the well head. The height and dimensions of the mounting flange are identical to the India Mk II pump. The handle bearings are sealed ball races. It is designed to allow a 2.5 inch diameter plunger to be extracted without the need to dismantle the pumpstand. The handle is offered in various lengths to compensate for operating depth and cylinder size.

Materials of Construction

COMPONENT	MATERIAL(S)
Upper body and cap	Steel tube and plate
Handle	Steel bar and plate
Bearings	Sealed ball races
Hanger	Steel
Pedestal	Steel tube and plate

WEIGHTS and MEASURES

Weights	Pumpstand complete: 51.1 kg
Dimensions	Not applicable

Manufacturing Techniques

The manufacturing techniques required to make the pump are listed below:

Simple but heavy steel fabrication
Skilled welding
Simple turning, drilling and threading

The Maldev has been designed for manufacture in a developing country. Both the fabrication and machining are straightforward, and no specialised processes are required. However, considerable skill in welding is demanded, and careful quality control is essential. It is suitable for manufacture in developing countries, but potential manufacturers must be carefully selected.

Ease of Installation and Maintenance

Ease of Installation

Installation of the pumpstand is generally straight-forward. Lifting tackle will also be required to cope with the weight of the below-ground assembly unless plastic rising main is used. The pedestal is concreted in at the wellhead around the well casing and the top of the pumpstand assembly can be installed with the handle pre-assembled. Some care is needed to ensure a satisfactory water-tight joint between the rising main and the pumpstand, but otherwise assembly is straight-forward and requires only basic skills.

Ease of Pumpstand Maintenance and Repair

The pumpstand is generally robust and unlikely to require frequent maintenance, however more frequent attention may need to be given to the joint between the rising main and the pumpstand to keep it watertight.

PUMP PERFORMANCE

Volume Flow, Work Input and Efficiency

The description of the method can be found in the Test Procedure.

HEAD	7 m			25 m			45m			
Pumping Rate (strokes/min)	29	41	48	20	30	37	20	30	37	45
Vol/stroke (litres)	0.47	0.48	0.48	0.52	0.51	0.52	0.46	0.51	0.50	0.48
Work input/stroke (J)	53	55	59	179	185	193	253	271	268	273
Efficiency (%)	60	59	55	70	67	66	80	82	82	76

These results were obtained from the prototype head with an experimental 'McLeod' type cylinder as the below-ground assembly.

ENDURANCE

General Comments on the Pump Head

The pump was tested at 40 strokes per minute at a simulated head of 30 metres.

Several problems were encountered with the original seal between the rising main and the pumpstand. After 2188 hours the rising main was not secure in the pumpstand and slipped through the seal on each upstroke of the cylinder. It was re-tightened but thereafter persistent leaks occurred until the seal was replaced by the later type now supplied with the pump. Even then a persistent slight leak remained between the rising main and the pumpstand until the end of the test.

The original endurance test sample was not representative of current production. One of the handle bearings broke up during the first 1000 hours. Subsequent examination revealed that the ball race had been damaged while being hammered into its housing. The endurance test was therefore restarted using a newer pumpstand, to which the comments in this report refer exclusively. This sample was tested using a Funymaq cylinder as the below-ground part.

Breakdown Incidence

Breakdowns are shown in bold type.

Hours:						
0	1021	2096	2188	2409 2426 2918	3131	4137
Inspection	Inspection	Inspection	Rising main not secure in pumpstand	Leaking around rising main inside pumpstand	Inspection	Inspection

Final Inspection

1. Joint — Slight leak at joint between rising main and pumpstand
2. Bearings — Considerable free play in handle bearings
3. Corrosion — No significant corrosion

Estimated Total Amount of Water Pumped in 4000 hours......5.0 million litres

VERDICT

A robust pumpstand but still requiring some development of the method of fixing the rising main, clearly designed to use appropriate manufacturing skills with VLOM in mind. Although capital-intensive manufacturing facilities are not necessary, strict quality control is essential to achieve a reliable product.

There is scope for reductions of both cost and difficulty of manufacture by using plastic plain bearings rather than ball races in the handle and hanger.

Polyacetal bearings have therefore been made for both these applications and field trials are in progress. Good preliminary results have been received and further samples have been installed on heavy usage pumps to gain further experience.

Once the principle has been thoroughly tested out successfully, changes can be made to the design which will simplify the manufacture, and reduce the cost of this head.

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EXPERIENCE WITH MALDEV PUMP

In Malawi over last 15 years, almost all of the piped water projects have used surface water to provide 30% of the country's needs. But perennial surface water sources which can be tapped were severely limited. As a result, Malawi has no choice except to develop groundwater resources. Seventy percent of the rural population is served by groundwater. It was estimated that by 1990 a predicted 5.5 million people have to rely on their sole source of safe water - groundwater.

In an Upper Livulezi pilot project, experience with the handpump is not the only advantage. There is also the organization which involves the Malawi professional staff, who will manage the pump site with outside technical assistance. For example, one professional on the staff job includes organizing drilling rigs, well-digging teams and a maintenance crew. He also goes through the villages, speaking with villagers and local officials. Each village has two tasks; one is to help select a well location which is acceptable, and the other is to elect a village committee that will be in charge of handpump maintenance.

The construction of a borehole or well is a very important factor in determining the performance of each handpump. In Livulezi valley project:

- PVC well screen and slotted casing with a hundred fold increase of ideal gravel pack material in diameter from 0.7 to 2.5 mm were used to increase water entering the well, to stop sand intrusion into the well to extend pump life period.

- The special pump head was designed so tat the connecting rods can be pulled out by two people without using winch in about 15 minutes.
- Hinged rods are used for removing them by people without tools.
- Injection moulded plastic foot valves and piston are used in downhole components. So one spanner will be able to extract damaged parts and to replace them easily and quickly.
- Malawi pump heads and the components are made locally, and the spare parts can be supplied locally. If the pump is broken, the village caretaker will collect some money from the community to buy the components from the local store.

The performance of Malawi pump installed in Malawi, south of Tanzania, and other African countries such as Kenya and Sudan, and in an Asian country, Thailand, satisfied the needs of villages because the pump gave a better flow rate and was easier to operate. The Malawi pump used in the Livulezi pilot project is closer to the Village Level Operating and Maintenance (VLOM) concept, as one man riding a bicycle would be able to service several pumps at very little maintenance cost. (NOTE: Malawi Pump also named Maldev, Afridev.)

ADVANTAGES AD DISADVANTAGES

<u>Advantages</u>

The best advantages of the pump is using the hinged rods to remove the connecting rods through the top of pump without removal of the pump head.

The T-piece, which can be placed on the end of the handle, obtains a better mechanical advantage than a straight handle.

Users can use muscles from several parts of the body to make pumping water easier.

Malawi pump and spare parts can be supplied locally.

Since villagers think of handpumps as their own property, they are anxious to take care of them.

Users are better organized regarding handpump maintenance.

Disadvantages

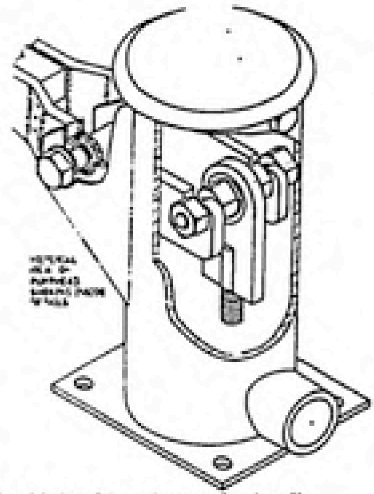
Although the newly designed pump head is convenient for withdrawing the below-ground components, there are lots of moving parts inside the head. Frequent lubrication is necessary.

The pump head is not durable. During continuous operation the ball race and the handle bearings may be damaged.

FIGURE II.3

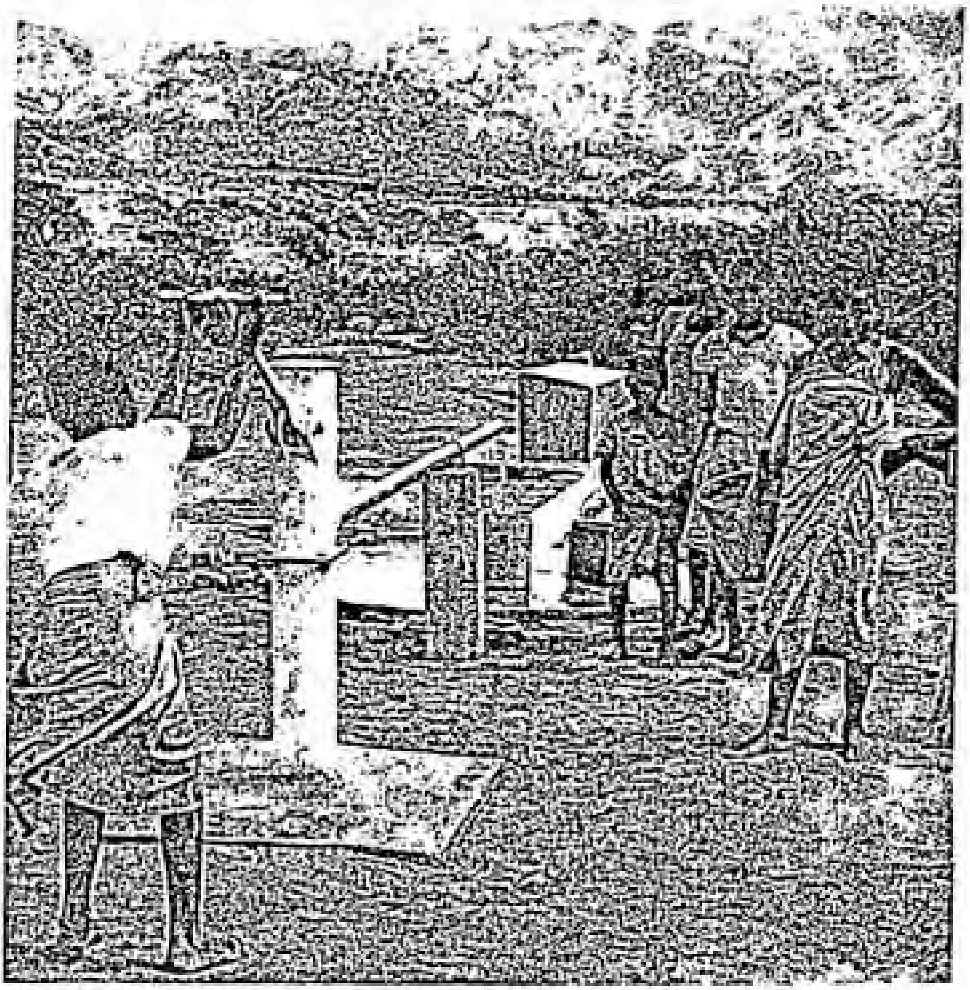
Information About Maldev Hand Pump

Project workers remove connecting rods through the top of the Malawi borehole pump. Eventually this will be a one-man operation with the rods hinged and not bolted together.



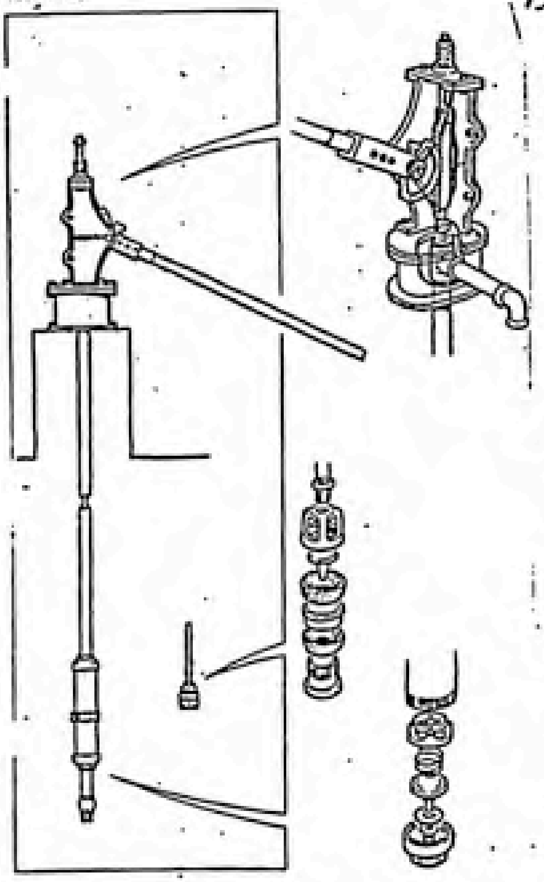
The Malawi handpump in detail.

(SOURCE: World Water November 1982, p.23)



The Malawi borehole pump. An extension to the outlet pipe keeps waste water away from the pump head, reducing the risk of borehole contamination. The concrete washing slab being provided at each water point is a great success and keeps the women away from polluted rivers. The tee piece on the pump handle gives the user a better mechanical advantage than a straight handle.

(SOURCE: World Water Water Decade: 2nd Year Review p. 10)



Korat Pump Description

The Korat 608 A-1 is a deep-well force pump, made in Thailand. The pumpstand is mainly cast iron with a rack and quadrant mechanism and a wooden handle. It must be mounted on a plinth at least as tall as the largest container to be used. The cylinder is seamless brass tube, and the plunger has two conventional leather cup seals. There are two foot valves, one in the base of the cylinder, the other at the end of a short dip tube below.

Materials of Construction

COMPONENT	MATERIAL(S)
Pumpstand body	Cast iron
Quadrant and rack	Cast iron
Handle	Wood
Handle bearings	Proprietary ball races
Cylinder	Extruded brass
Plunger	Cast gunmetal and bronze
Cup seals	Leather
Foot valve	Cast gunmetal and leather
Drop pipe	Galvanised steel
Pump rods	Mild steel

~~WEIGHTS & MEASURES~~

Weights	Pumpstand	47 kg
	Cylinder assembly	5.5 kg
	Pump rods	1.1 kg per metre
Dimensions	Nominal cylinder bore:	76 mm
	Actual pump stroke:	80 mm
	Nominal volume per stroke:	363 ml
	Drop pipe size:	1.50 inches
	Outside diameter of below-ground assembly:	90 mm
	Pump rod diameter:	0.5 inches
	Maximum usable cylinder length:	255 mm

Manufacturing Techniques

The manufacturing techniques required to make the pump are listed below:-

Above-ground Assembly	Iron foundry Brass & gunmetal foundry Basic machining Wood work

The pumpstand is principally constructed of 8 iron castings. All involve relatively simple patterns and moulding skills. Machining is mainly straightforward lathe and drilling work. The designs of the components are suitable for basic tooling and hence inexpensive but effective quality control.

Below-ground Assembly	Brass & gunmetal foundry Leather cutting and forming Basic machining

Brass foundry work, lathe work, drilling and assembly require similar skill levels to those needed in the pumpstand.

The cylinder was generally in good condition after 4000 hours, with no significant wear. The leather cup seals and valves showed signs of wear, but still worked satisfactorily.

Breakdown Incidence

Breakdowns are shown in bold type.

Hours:	1072	2044	3060	3595	4029
				Quadrant and Rack Seized	**Handle Quadrant and Rack Worn Out**
Inspection and full performance test	Inspection and volume flow	Inspection and volume flow	Inspection and volume flow		Inspection and full performance test

FINAL INSPECTION

Pumpstand	(a)	Quadrant teeth almost entirely worn away - rack teeth also worn but could be upended and used for a while with a new quadrant
	(b)	Both guide rollers behind rack seized on their shafts
	(c)	Upper guide rod had "picked up" on its bush
Cylinder		Slight scratching of cylinder bore but no significant wear
Plunger	(a)	Plunger valve noticeably worn on its diameter but still working
	(b)	Some scratches on both cup leathers, and one distorted, but still serviceable
	(c)	Small amounts of sand lodged behind both cup leathers
Foot Valves	(a)	Leather sealing washer in cylinder foot valve has compressed, allowing metal-to-metal contact between valve and seat
	(b)	Split rubber seal in dip tube foot valve
Corrosion		Noticeable corrosion of all ferrous parts, particularly lock nut between connecting rod and plunger, and dip tube valve body.

Estimated total amount of water pumped in 4000 hours ...... 3.5 million litres.

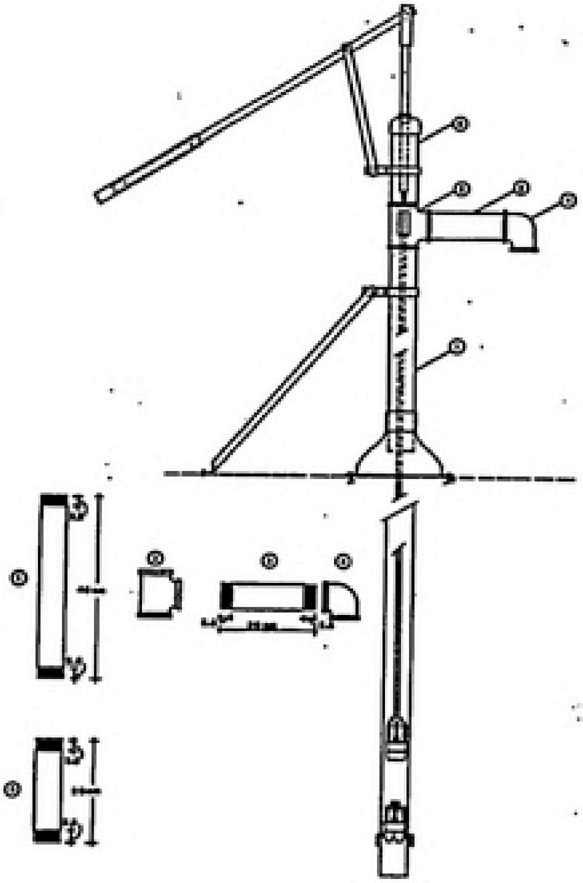
VERDICT

A robust pump potentially suitable for community water supply. The rack and quadrant will wear in time but they can be easily replaced. It might be better to consider an India Mk II approach eliminating the rack and simplifying the quadrant. Easy to maintain or repair above-ground, difficult below-ground, though cylinder assembly robust and reliable. Potentially dangerous moving parts should be permanently shrouded. Moderately priced.

EXPERIENCE WITH KORAT PUMP

The Korat pump was developed for use throughout rural Thailand. The pump body and the cylinder are made of 2-inch seamless pipe. Steel balls are used in the check valves. Local hardwood and leather are used for the handle and piston cups. The pump is suitable for rural water supply. the pump was assembled by a local machine shop (Figure II-4).

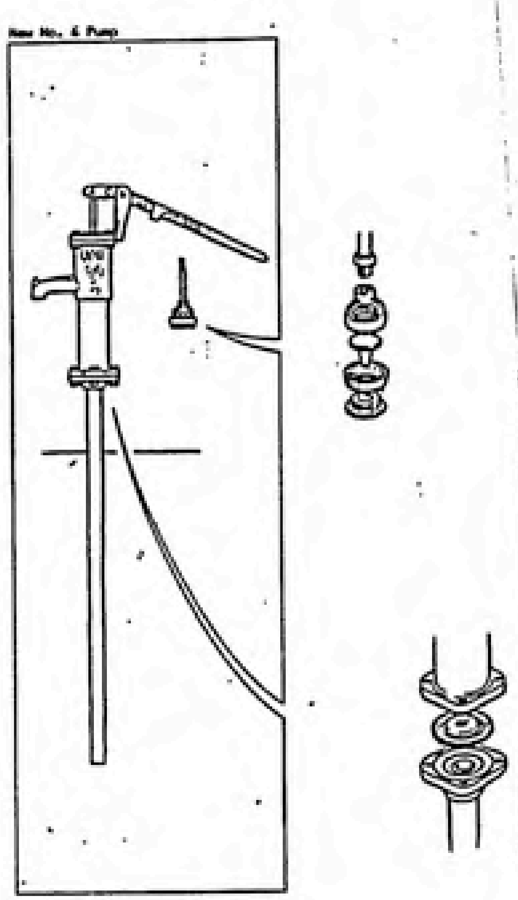
FIGURE II. 4 Korat Hand Pump



PUMP MADE IN KORAT (THAILAND) OF PIPE COMPONENTS

(SOURCE: McJunkin, F.E. 1977 p. 187)

New No.6 Pump Description



The New No. 6 is a shallow-well suction pump, made in Bangladesh and constructed almost entirely of cast iron. It is mounted directly onto a 1.5 inch rising main. The plunger uses a moulded PVC cup washer. The check valve is a simple leather flap, weighted with cast iron.

It appears crude and rather rough at first sight, but is commendably simple and robust.

Materials of Construction

COMPONENT	MATERIAL(S)
Pumpstand body	Cast iron
Handle	Cast iron
Bearings	Mild steel pivot shafts bear on holes drilled in iron castings
Plunger	Cast iron
Cup seal	Moulded PVC
Base valve	Leather

WEIGHTS and MEASURES

Weights	Pumpstand	31.0 kg
Dimensions	Nominal cylinder bore:	90 mm
	Actual pump stroke:	219 mm
	Nominal volume per stroke:	1393 ml
	Drop pipe size:	1.5 inches

Manufacturing Techniques

The manufacturing techniques required to make the pump are listed below:-

Iron Foundry	Plastic moulding
Simple machining	Leather crafting

The New No.6 is well-suited for manufacture in developing countries where adequate skills in iron foundry work and basic machining are available. The pump has been designed intelligently to avoid close tolerances in casting or machining.

Ease of Installation, Maintenance and Repair

Ease of Installation.

The drop pipe must be securely installed to support the pumpstand, otherwise this suction pump is easy to install. Only basic tools and skills are required.

Ease of Maintenance and Repair

This pump is likely to require frequent attention to the plunger and check valve, but is very simple. Most jobs can be done with flat spanners and pliers. A pipe wrench may be needed to dismantle the plunger, which may become heavily corroded.

PUMP PERFORMANCE

Volume Flow, Work Input and Efficiency

The description of the method can be found in the Test Procedure.

HEAD	7 m		
Nominal pumping rate (strokes/min)	20	30	40
Vol/stroke (litres)	1.30	1.20	1.29
Work input/stroke (J)	148	121	134
Efficiency (%)	59	67	65

ENDURANCE

A detailed description of the endurance test method can be found in the Test Procedure.

General Comments

The pump was tested at 30 strokes per minute at 7 metres head.

The original cup washer and plunger valve were badly worn after 1000 hours, and were replaced. The cup washer failure was probably due to the initial roughness of the bore. The replacements lasted the remaining 3000 hours of the test programme, though both were badly worn at the end. The check valve was also replaced at 1000 hours, and the replacement also lasted out the remainder of the 4000 hours.

The final inspection revealed wear in the handle pivot shafts and the associated holes in the handle, pump top and connecting rod eye. The pump was still working however, and would probably continue for some time.

Corrosion was extensive. The cast iron pumpstand has no protective coating and was rusting wherever it had got wet. Because of rust the plunger was impossible to dismantle and the retaining screw could not be removed from the check valve weight.

The cylinder was in good condition at the end of the test. The original machining marks in the bore were still clearly visible although the high spots had been removed.

Breakdown Incidence

Breakdowns are shown in bold type.

Hours:	1072	2044	3060	4063
	Cup Washer and Check Valve Worn Out			
Inspection and full performance test	Inspection and volume flow	Inspection and volume flow	Inspection and volume flow	Inspection and full performance test

FINAL INSPECTION

1. Pump Body and handle
   (a) Pivot holes in handle, pump top and connecting rod eye all noticeably worn - pins also worn though still serviceable
   (b) Cylinder bore somewhat less rough than when new, but machining marks still clearly evident - no significant wear
2. Plunger
   (a) Cup seal badly worn
   (b) Plunger valve noticeably worn on its circumference - both valve faces also worn
3. Check Valve — Leather flap deeply indented
4. Corrosion
   (a) Plunger could not be dismantled because of rusted screw threads
   (b) Check valve weight could not be removed from leather flap because of corrosion of retaining screw
   (c) Considerable rust on unprotected cast iron of pump body, but no effect on pump performance

Estimated total amount of water pumped in 4000 hours ..... 8.6 million litres

VERDICT

A very simple, cheap and sturdy suction pump. Needs to be primed and therefore susceptible to contamination and abuse, hence, not very suitable for drinking water supply. Initial roughness of the bore causes early failure of the cup washer and should be improved. Likely to wear considerably when heavily used. Suitable for manufacture in developing countries with iron foundry skills.

INFORMATION AND EXPERIENCE

The Department of Public Health Engineering (DPHE) in Bangladesh, assisted by UNICEF, developed a new model "New No. 6 Pump", which is a cross between the Battelle pump and the Old Maya No. 6 pump.

A description of the major improvements can be found in Hand Pumps (McJunkin, 1977). Specifically, changes include use of polyvinyl chloride (PVC) cup seal or bucket and enlarged bearing surfaces on all cast iron moving parts and pivot pins, thus increasing the working efficiency and lifespan.

New No. 6 pump is easy to install. The installation of pump stand is by threading connections to well onto a 1.5 inch rising main. A PVC cup washer is used on the plunger, and a leather flap check valve is weighted with cast iron. These are placed in a cast iron cylinder. Because of the severe shortage of pig iron and the casting technology in Bangladesh, new No. 6 pump has a redesigned base plate of the pump stand (threaded connections to well casing). Therefore New No. 6 pump is about 15 percent lighter than the Battelle Shallow well configuration (9 kg).

Experience

In Bangladesh, PVC cup seals have a 2-3 times longer life span than leather buckets. Also, PVC cup seals are very cheap. PVC cups are lubricated by water that may be making the iron cylinder walls smoother.

ADVANTAGES AND DISADVANTAGES

Advantages

The PVC cups were used and improved maintenance.

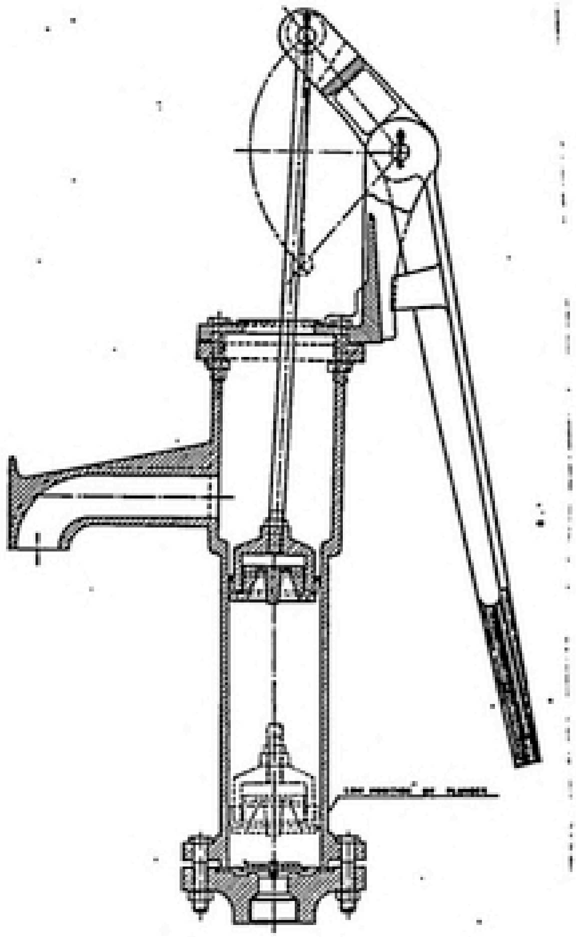
The pump configuration is light and is easy to transport and install.

Disadvantages

Needs to be primed and it is easy to contaminate.

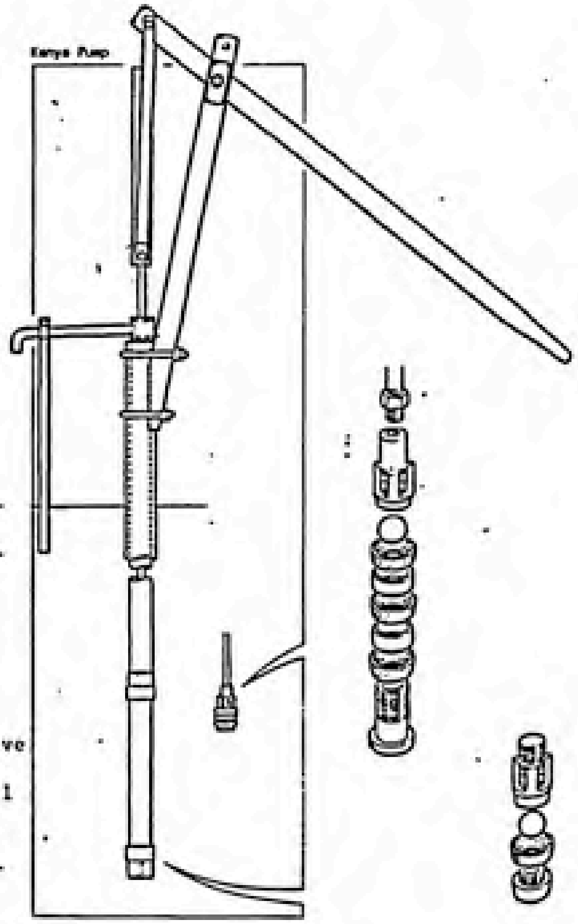
It is not suitable for drinking water supply.

FIGURE II.5 New No.6 Hand Pump



(SOURCE: McJunkin, F.E. 1977 p. 148)

Kenya Pump Description



The Atlas Copco Kenya, made in the country of its name, is a conventional deep-well force pump. The pumpstand is designed to an established, almost traditional, pattern. It is made of wood, steel and standard galvanised iron pipe and pipe fittings. The pumpstand is designed to clamp onto a 4 inch well casing.

The cylinder is seamless brass tube, the plunger has three cup leathers and both plunger and foot valves contains stainless steel balls. The foot valve has a screw thread to allow it to be attached to the plunger, so that both plunger and foot valve may be extracted without removing the cylinder or rising main, provided at least 2.5 inch pipe is used.

Materials of Construction

COMPONENT	MATERIAL(S)
Fulcrum upright	Wood
Handle	Wood
Bearings	Mild steel pivot shafts bear on drilled holes in wood
Outlet elbow and spout	Galvanised steel pipe fittings
Guide tube and links	Mild steel
Cylinder	Extruded brass, gunmetal end caps
Plunger	Gunmetal, stainless steel ball valve
Cup seals	Leather
Foot valve	Cast gunmetal, stainless steel ball valve, leather seal
Pump rod	Standard 0.5 inch galvanised pipe

WEIGHTS and MEASURES

Weights

Weights	Pumpstand	67.0 kg
	Cylinder assembly	6.5 kg
	Pump rods	1.5 kg. per metre

Dimensions

Nominal cylinder bore:	59 mm
Actual pump stroke:	295 mm
Nominal volume per stroke:	807 ml
Drop pipe size:	2 inches
Outside diameter of below-ground assembly:	84 mm
Pump rod diameter:	21.5 mm (0.5 inch galvanised steel pipe)
Maximum usable cylinder length:	400 mm

Manufacturing Techniques

The manufacturing techniques required to make the pump are listed below:-

Above-ground Assembly	Steel forging and welding
	Basic machining
	Woodwork

The pumpstand is simple to manufacture, requiring basic skills in steel fabrication, simple machining and woodwork. It is suitable for manufacture in developing countries where timber of a suitable quality is readily available.

Below-ground Assembly	Brass/gunmetal foundry Machining Leather craft

The below-ground assembly requires generally higher levels of manufacturing skill than the pumpstand. It would not be suitable for manufacture in some developing countries.

Ease of Installation, Maintenance and Repair

Ease of Installation

The 4 inch well casing must protrude at least 350 mm above ground, to attach the fulcrum upright. The spout support should be concreted in. The below-ground assembly will be heavy if 2.5 inch galvanised iron rising main is used. Assembly would be straightforward with good diagrammatic instructions.

Ease of Pumpstand Maintenance and Repair

The design of this pumpstand lends itself to innovative repair using indigenous materials and should not be difficult.

Ease of Below-ground Maintenance and Repair

Provided 2.5 inch rising main is used, the plunger and foot valve may be extracted without removing the rising main, so lifting tackle would not be needed.

PUMP PERFORMANCE

Volume Flow, Work Input and Efficiency

The description of the method can be found in the Test Procedure.

HEAD	7 m			25 m			45 m		
Nominal Pumping Rate (strokes/min)	30	40	50	30	40	50	20	30	40
Vol/stroke (litres)	0.76	0.78	0.77	0.75	0.77	0.76	0.77	0.75	0.76
Work input/stroke (J)	119	122	141	271	300	290	500	493	528
Efficiency (%)	43	43	37	67	62	63	67	67	63

ENDURANCE

A detailed description of the endurance test method can be found in the Test Procedure.

General Comments

The pump was tested at 40 strokes per minute at a simulated head of 45 metres. Within 200 hours of the start of the 4000 hour endurance test, the pump rod connecting tube, and the guide tube on which it slides, were worn through. This rapid wear was caused by misalignment of the connecting links. Alignment of these links depends on the angle of the timber upright, and that in turn depends on the accuracy of the groove cut in its base. This groove had been roughly cut, and as a result the connecting tube was constantly biased to one side. Wedges were inserted between the upright and the well casing to minimise the out-of-line forces in the connecting links.

Breakdown Incidehce

Breakdowns are shown in bold type.

Hours:	153	1024	1350	2037	2153	3140	4147
	Connecting Tube Worn Through		**Loose connecting link stud**		**Severe Handle Wear**		
Inspection and full performance test		Inspection and volume flow		Inspection and volume flow		Inspection and volume flow	Inspection and full performance test

FINAL INSPECTION

1. Pumpstand (a) Connecting tube and guide tube considerably worn
   (b) All pivot holes in handle noticeably worn - some severely

2. Cylinder Slightly scratched but no significant wear - generally in good condition

3. Plunger (a) Valve cage distorted by hammering from valve ball
   (b) Valve seat pitted
   (c) Cup seals in good condition

4. Foot Valve (a) Valve cage distorted by hammering from valve ball, otherwise in good condition
   (b) Sand has penetrated filter and accumulated in filter cap

5. Corrosion Considerable rust on plunger rod, otherwise little corrosion

Estimated total amount of water pumped in 4000 hours ......7.4 million litres

VERDICT

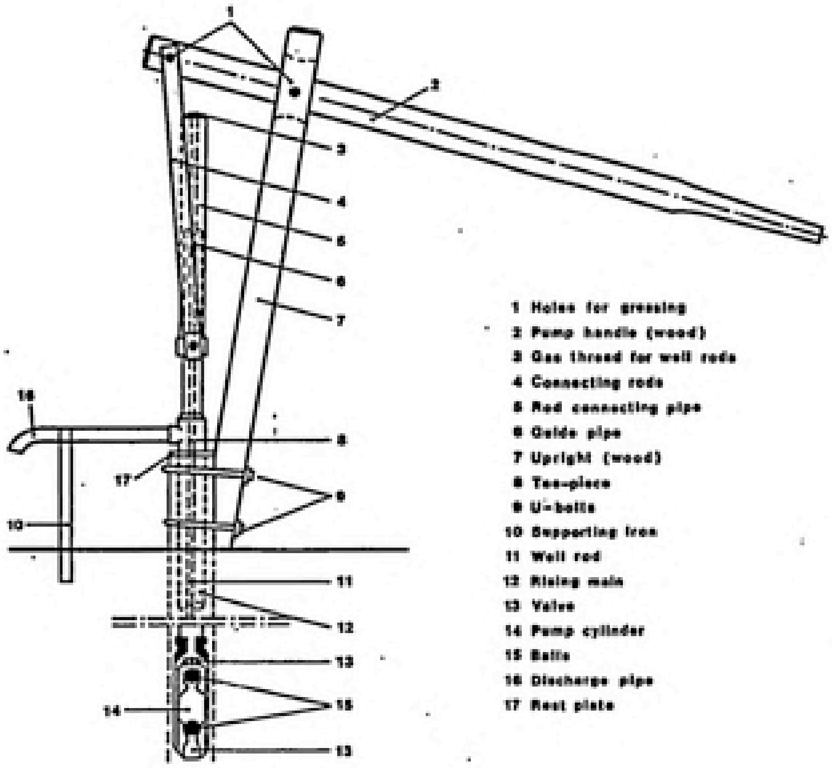
A simple but cumbersome pump. Likely to need frequent maintenance aboveground, much of which could be avoided by small design changes. In particular the endurance test showed that more accurate alignment of the fulcrum upright and replacement of the original link pivots greatly increased the durability of the pumpstand. Possibly suitable for community water supply. Very heavy below-ground and therefore difficult to extract rising main, but plunger and footvalve may be removed on rodding, and in many respects could be maintained locally. Approaching a VLOM pump, but requires that at least the upper part of the well casing be made of steel. Expensive.

INFORMATION AND EXPERIENCE

Kenya pump is an alternative to pumps made of cast iron components in the use of standard pipe components or welded fabrication. This is not necessarily cheap, but it does eliminate the necessary foundry which does not exist in some countries. For example, this pump is manufactured in Nairobi, Kenya. The handle and the fulcrum link are made of wood. The pump stand is made of galvanized iron pipe, a brass cylinder with ball valves is used. The pump can stand rough handling and requires little maintenance. But a brass cylinder results in expensive construction (McJunkin, 1977). This pump is widely used in East Africa, and has good operational records for wells of moderate depth. Wooden handles, which are locally assembled, result in cost savings and suitability for local repair or replacement. Other information is not available.

FIGURE II.6 Kenya Hand Pump (Deep Well Type)

"KENYA" HAND PUMP (Previously "Uganda" Hand Pump)

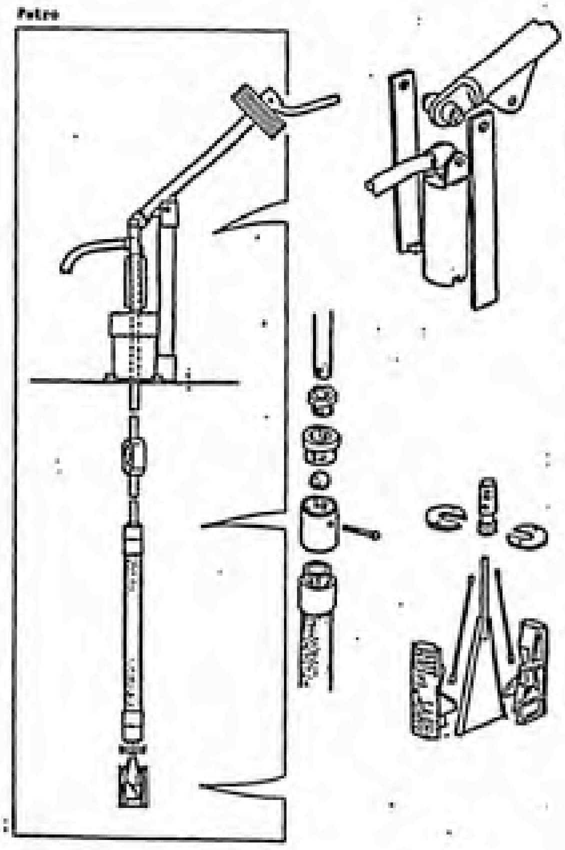


(SOURCE: McJunkin, F.E.1977. p.72)

Petro Pump Description

The Petro is an unconventional pump using the changing volume of a stretched rubber hose to provide the pumping action. The functions of rising main and pump rod are combined in a single component and the cylinder assembly is anchored in the well casing by an arrangement of two wedges faced with carborundum grit.

The pumpstand is fabricated from steel sections and is designed to ensure that the necessary pre-stress on the rubber hose is applied automatically during installation. Up to 10 counterweight discs may be added to the handle to balance the weight of the below-ground assembly in a particular installation.



Materials of Construction

COMPONENT	MATERIAL(S)
Fulcrum upright	Steel
Handle and links	Steel
Spout	Steel
Outer guide tube	Steel
Guide assembly	Glass-filled nylon
Pumping element	Reinforced rubber with light alloy fittings
Clamp assembly	Steel, glass-filled nylon, carborundum grit
Well cap	Steel
Pivot pins	Steel

WEIGHTS AND MEASURES

Weights

Pump stand : (excluding handle c/weights)	30.0 kg
Cylinder:	6.0 kg
Handle Counterweights (each):	4.3 kg
Rising Main (per metre):	1.6 kg

Dimensions

Actual pump stroke:	120 mm
Drop pipe size:	0.75 inch
Well diameter range	97 mm minimum 120 mm maximum

Manufacturing Techniques

The techniques required to manufacture the pump are listed below:

Above-ground Assembly	Steel forming and welding Machining - turning, drilling, milling etc.

The pumpstand demands well-developed skills in machining and steel fabrication. Specialised processes are not required, however, and the pumpstand may therefore be suitable for manufacture in some developing countries.

Below-ground Assembly	Machining - turning, drilling, milling etc. Plastics moulding Specialised processes (pumping element)

The pumping element demands specialised manufacturing techniques and rigorous quality control. It would be particularly unsuitable for manufacture in developing countries.

Ease of Installation, Maintenance and Repair

Ease of Installation

We understand that the manufacturer considers lifting tackle to be unnecessary for installation at depths up to 45 m. However since the weight of a 45 m below-ground assembly would be some 78 kg excluding water, it may be very difficult to manhandle. We recommend the use of simple lifting tackle. The manufacturer's installation manual is clear and well illustrated and installation should be straight-forward. It should not be difficult to ensure that the anchor is secure in the well.

Ease of Pumpstand Maintenance and Repair

Servicing the pumpstand is very straightforward requiring only simple hand tools. The handle pivots may require occasional lubrication.

Ease of Below-ground maintenance and repair

It should not be difficult to release the anchor provided the threaded coupling at the bottom of the pumping element can be successfully detached. In other respects below-ground maintenance will be similar to installation.

PUMP PERFORMANCE Volume Flow, Work Input and Efficiency

HEAD		7			25			45	
Pumping Rate (strokes/min)	30	39	51	30	40	49	29	37	49
Vol/stroke (litres)	0.26	0.25	0.25	0.25	0.25	0.25	0.25	0.26	0.24
Work input/stroke (J)	74	78	86	112	120	123	178	202	201
Efficiency (%)	23	22	20	54	50	49	61	57	53

ENDURANCE A detailed description of the endurance test method can be found in the Test Procedure.

General Comments

The pump was tested at 40 strokes/minute at a simulated head of 45 metres.

This pump proved to be a good deal more reliable than the Petro tested for the ODA in 1978/9.

The pump completed the first three 1000 hour stages without failure. However the down-hole anchor could not be released for inspection of the pumping element at the end of the third 1000 hour stage. Although given three full turns the pumping element sprang back. As it was not possible to free the anchor from the well top, the manufacturer was contacted by telephone for advice and permission to remove the bottom section of the well. With the bottom section removed, the anchor was released easily by pulling down on the wedge. The thread on the anchor wedge rod was found to have locked in the socket. When released the stainless steel threads were found to have seized. This could present a very serious problem in the field where access to the pumping element from below would be impossible.

The manufacturer agreed that we should try to use the same pumping element to complete the endurance test. The element showed no signs of distress other than slight flattening induced by twisting.

After 3634 hours the outflow from the pump was reduced to approximately 30% of the original volume flow due to a split in the pumping element. This is likely to have been caused by twisting the pumping element when attempting to release the down-hole anchor for inspection after the third 1000 hour stage. A new pumping element was fitted and the endurance test was completed with the original down-hole anchor.

Breakdown Incidence

Breakdowns are shown in bold type.

Hours 0	1062	2112	3127	3644	4169
Inspection and full performance test	Inspection and volume flow test	Inspection and volume flow test	Inspection and volume flow test **Pumping element seized in anchor. Anchor could not be released**	**Pumping element split**	Inspection and volume flow test

Final Inspection:

1. Pumpstand — Further free play in pumpstand fulcrum points; outer connecting links worn and could be disconnected on the upward stroke of the handle
2. Guide — Worn but still serviceable
3. Pumping Element — Replacement in good condition
4. Corrosion — Slight corrosion on pumping element end fittings and rust spots on rising main where guide had rubbed through the zinc coating

Estimated Total Amount of Water Pumped in 4000 hours......2.7 million litres

VERDICT

This Petro pump proved to be much more reliable than the sample tested in 1979/80 for the Overseas Development Administration. However, the results of this later test suggest that the anchor may not be suitable for unsupported uPVC well-casings and may also be difficult to dislodge for below-ground repairs. The method of attaching the pumping element to the anchor must be modified to prevent seizure.

The pumpstand may be suitable for manufacture in a developing country but the pumping element demands very specialised manufacturing skills.

Further work by CATR, carried out as a separate project, to investigate the effect of using the anchor in unsupported uPVC pipe has confirmed that this is inadvisable and that alternative arrangements should be made.

EXPERIENCE WITH PETRO PUMP

At the end of 1981, the Petro pumps were selected for field trials in the countries of East Africa, Kenya, Sudan. More information in other countries is not available.

Laboratory tests were performed in 1979/80 for the Overseas Development Administration on Petro, and in 1984 INT/81/026 for the Consumers' Association Testing and Research Laboratories on Petro. Their comments are:

Advantages

The pump stand is durable to prevent accidental damage to the handle or the pump body.

It can be installed in a small diameter well (around 50 mm)

There are no cup seals or buckets and no mechanical friction. Even water containing fine sand or silt can be pumped and wear to the pump hose is eliminated. So the pump has long life and long service intervals.

Nineteen millimeter (19 mm) diameter galvanized pipe is used both as pump rod and as riser pipe which results in savings of piping.

Disadvantages

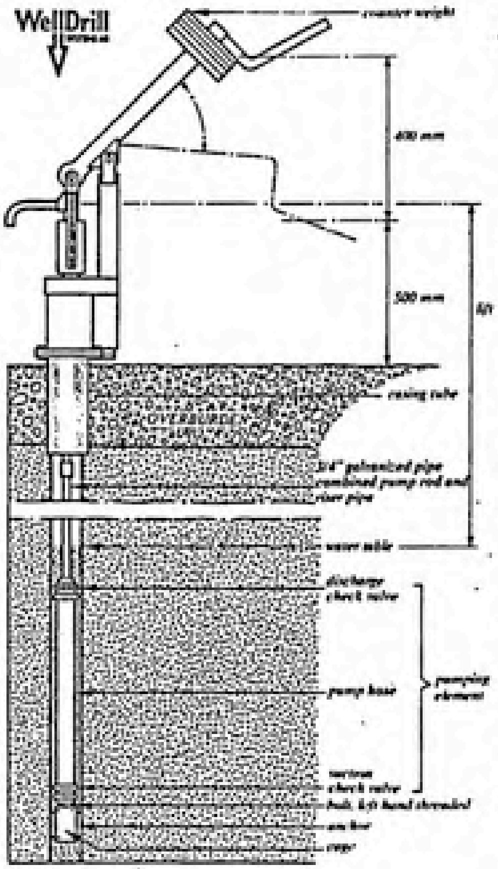
Forty-five meters (45 mm) below ground assembly is too heavy to lift. It would be around 78 kg (excluding water). It may be very difficult to man handle without a lifting tackle.

The water delivered is very low-rate. More efforts should be offered to fill the water container.

It is expensive; $456 per pump with 20 m below-ground assembly.

Anchored cylinder assembly would not be suitable for unsupported upvc well-casings. Also it is very difficult to dislodge for repairing the below-ground elements.

FIGURE II. 7 Information About Petro Pump



DRILLING FOR WATER?

Petro Pump

The conventional pumps on the market must have very good seals (leather washers) between plunger assembly and cylinder-wall to obtain good pumping results.

These seals, especially when the pump is used frequently, wear quickly, and must be replaced. The task of replacing seals, can often be extremely difficult, since tools and maintenance knowledge are scarce. For conventional pumps in deeper wells, the problem of lifting the heavy pump assembly (which is necessary for changing the seals), can prevent normal maintenance procedures.

To eliminate this problem, WellDrill has designed the patented plunger-free (piston-free) PETROPUMP, which is based on a wire-reinforced rubber tube. The tube will change its internal volume when stretched.

The Petropump underground part consists of a Petropump rubber tube, two non-return valves, an anchor fixing the pump to the walls of the well and a 3/4" pipe, acting both as pump rod and as riser pipe.

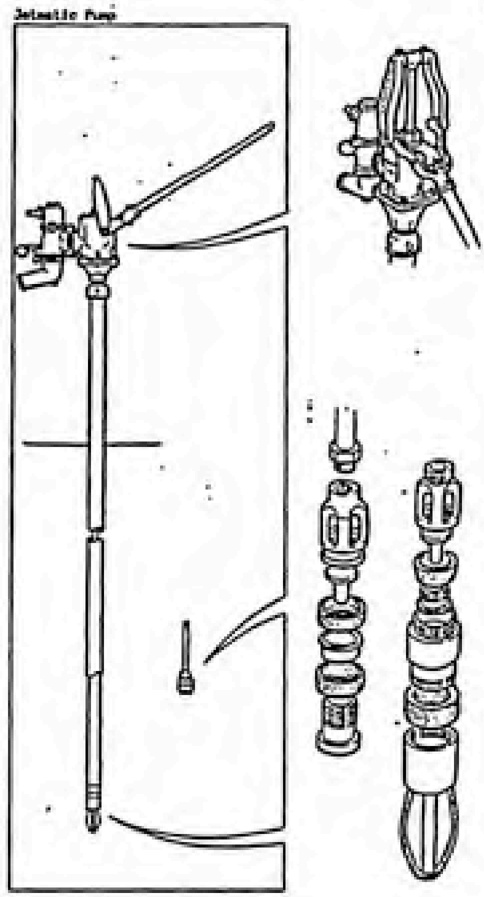
The Petropump offers the following main advantages:

- no mechanical friction
- long life and long service intervals
- can be installed in wells with small diameters
- easy to install and to take up for inspection
- easy to pump with
- great savings in the costs and weights of piping

(SOURCE: World Water December 1981, p. 16)

Jetmatic Pump Description

Jetmatic Pump



The Jetmatic pump is made in the Philippines, under licence from Kawamoto Pumps of Japan, and is very similar to the Dragon pump. Like the Dragon, it can be supplied either as a shallow-well suction pump or as a deep-well force pump. We have tested the pump in its deep-well configuration. Unlike the Dragon, the shallow-well cylinder is not retained. The pumpstand is therefore very compact, and simply fits on the protruding end of the rising main which must be at least 440 mm above ground, to prevent the handle touching the ground at the lowest point of its travel.

The pumpstand is principally cast iron, with a discharge valve in the spout allowing either free discharge or delivery under pressure through a hose or pipe. The tubular steel handle moves through an unusually wide arc of 178°.

The deep-well cylinder is unusually small, only 46 mm bore, to fit inside 2 inch rising main, which is very much smaller than the cylinder used in the Dragon pump. At the lower end of the cylinder are two steel loops which appear to be designed to grip the inside of the rising main. Turning the cylinder clockwise then expands a rubber ring which anchors and seals the cylinder against the inside of the rising main. The foot valve has a tapered rubber ring which fits a machined taper in the base of the cylinder. The plunger can be screwed onto the foot valve to remove it, without removing the cylinder. In other respects the plunger is conventional, and has two leather cup seals.

Materials of Construction

COMPONENT	MATERIAL(S)
Pump head	Cast iron
Handle fork and link	Cast iron
Bearings	Mild steel pivot pins bear on holes drilled and reamed in iron castings
Spout assembly	Cast iron with rubber valve
Operating rod	Mild steel
Handle	Steel tube, rubber end cap
Cylinder	Extruded brass
Plunger	Cast gunmetal or bronze
Cup seals	Leather
Foot valve assembly	Bronze housing, rubber clamp steel guard

WEIGHTS and MEASURES

Weights

Pumpstand	16.3 kg
Cylinder assembly	3.0 kg
Pump rods	1.1 kg per metre

Dimensions

Nominal cylinder bore:	46 mm
Actual pump stroke:	175 mm
Nominal volume per stroke	291 ml
Drop pipe size:	2 inches
Outside diameter of below-ground assembly:	74 mm
Pump rod diameter:	0.5 inches
Maximum usable cylinder length:	553 mm

Manufacturing Techniques

The manufacturing techniques required to make the pump are listed below:-

Above-ground Assembly	Iron foundry Brass/gunmetal foundry	Basic machining Rubber moulding

The pumpstand requires a moderate level of foundry skill, and the ability to carry out simple machining. The handle linkage demands careful manufacturing quality control to ensure easy assembly and satisfactory operation. It may be suitable for manufacture in some developing countries, but is not ideal.

Below-ground Assembly	Brass/gunmetal foundry Steel fabrication Basic machining	Rubber moulding Leather craft

The below-ground components demand similar levels of manufacturing skill to those required in the pumpstand.

Ease of Installation, Maintenance and Repair

Ease of Installation

The rising main must be secure in the wellhead, to support the pumpstand. It should protrude sufficiently to allow clearance under the spout for the tallest vessel likely to be used. Installing the pumpstand only on an existing rising main would be a simple, one-man task. The rising main should be 2 inch diameter, to allow the cylinder to pass through for maintenance. The bottom of the pumpstand is threaded 1.25 ANPT not the more common ISO Standard pipe thread.

Ease of Pumpstand Maintenance and Repair

The pumpstand may require frequent attention to worn handle components and the gland nut.

Ease of Below-ground Maintenance and Repair

The foot valve and plunger may be extracted through the rising main, provided pipe of at least 2 inch diameter is used, and lifting tackle would not be required. The pumpstand must first be removed, however.

PUMP PERFORMANCE

Volume Flow, Work Input and Efficiency

The description of the method can be found in the Test Procedure.

HEAD	7 m			25 m			45 m		
Nominal pumping rate (strokes/min)	30	40	50	30	40	50	30	40	50
Vol/stroke (litres)	0.29	0.29	0.29	0.28	0.27	0.29	0.28	0.28	0.28
Work input/stroke (J)	60	54	50	110	103	107	173	173	161
Efficiency (%)	32	36	39	62	63	66	71	72	77

ENDURANCE A detailed description of the test method can be found in the Test Procedure.

General Comments

The pump was tested at 40 strokes per minute at a simulated head of 45 metres and failed at 280 hours when the cylinder was dislodged within the rising main. It was refitted and the problem did not recur. The pump failed at 3149 and 3875 hours when the pump rod broke within the thread. Components of the handle mechanism had to be replaced after 1000 hours because of wear, though the replacement parts survived until the end of the 4000 hour test programme. At each intermediate inspection, the spout discharge valve was found to be seized through lack of use, and it was freed off.

In the final inspection, the foot valve, plunger, leather cup seals and cylinder were all in good condition, with few signs of wear. The gland nut was badly worn. The plunger rod and the steel loops on the cylinder anchor were corroded and may not have been satisfactory if used again.

Breakdown Incidence

Breakdowns are shown in bold type.

Hours:	280	1024	2037	3140	3149	3875	4144
	Cylinder Dislodged	**Handle Parts Worn Out**			**Pump Rod Broken**	**Pump Rod Broken**	
Inspection and full performance test		Inspection and volume flow	Inspection and volume flow	Inspection and volume flow			Inspection and full performance test

FINAL INSPECTION

1. Pumpstand (a) Gland worn
   (b) Slight wear in pivot pins and bushes
2. Cylinder (a) Some sand between cylinder and rising main but cylinder not difficult to remove
   (b) Slight scratching of bore, but cylinder in good condition
3. Plunger Generally in good condition
4. Foot Valve Generally in good condition
5. Corrosion (a) Considerable rusting of plunger rod
   (b) Rust on steel loops of cylinder retainer

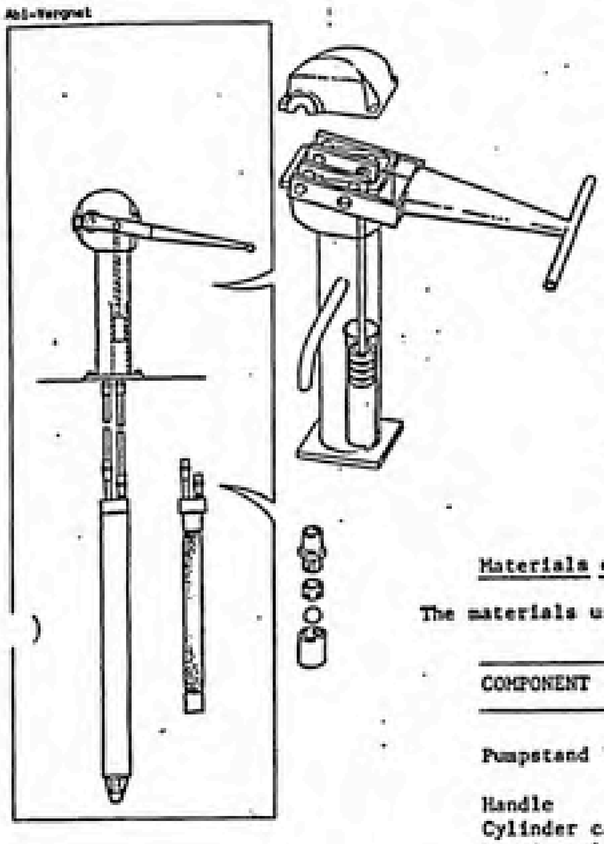
Estimated total amount of water pumped in 4000 hours ...... 2.7 million litres.

VERDICT The Dragon pump, from which the Jetmatic is derived, was designed for family use, possibly serving up to 15 people. The Jetmatic is unlikely to be sufficiently robust for community water supply, from deep wells. The rate of delivery is low, and intensive use will produce rapid wear, failure in the moving parts of the pumpstand, and pump rod breakage. The complete cylinder can be extracted without removing the rising main. Possibly suitable for manufacture in some developing countries, but not an ideal design. Cheap.

EXPERIENCE WITH JETMATIC PUMP

The jetmatic (also trade named Fuji, Jetmatic, Dragon, Lucky and Wilson) is widely available throughout the Philippines. This is the only pump available through the Rural Waterworks Development Corporation water program and the primary pump used in Barangay Water Program's Level I projects. (BWP provides three levels of service to its beneficiaries: Level I service consists of hand pumps; Level II provides piped water systems with stand pipe connections; and Level III service provides piped water systems with in-house connections.)

The pump is only for use in wells where the water table is 25 feet or less. The cost of the jetmatic pump varies from $25 5o $50, depending on the quality of materials and the country where it was produced. The cast components have thin cross sections and the bearing surfaces are small. Mating surfaces are often poorly machined and casting defects are sometimes epoxied over. The pump uses a four-inch rubber cup. The rubber cup will not form a seal with the cylinder walls when it has worn down a little. This, coupled with a leaky foot valve, requires that the pump be primed daily or even more frequently. The local engineers who install jetmatic pumps say that the expected lifetime of the pump being used by an average of ten households (sixty people) is about three years. The most common causes of failure are broken cast parts and worn out bearing surfaces. (WASH Field Report No. 54, August 1982)



Abi-Vergnet Pump Description

The Abi-Vergnet is a hybrid pump working on hydraulic principles. There are no mechanical links between the above- and below-ground parts.

The Vergnet cylinder is a product of high manufacturing technology. A flexible rubber tube encased in stainless steel dilates and collapses in response to a primary cylinder in the pumpstand to which it is connected by a plastic hose. When the flexible membrane expands, water is forced to the surface through a second hose.

The pumpstand is partly cast-iron and partly fabricated. The main handle bearings are compressed carbon composite material. The primary cylinder inside the pumpstand column is a stainless steel tube. The primary plunger is machined from brass and uses a number of leather ring seals. The primary cylinder is replenished by water flowing in through a small hole in the part of the cylinder which is exposed by the plunger near the upper limit of its travel.

Materials of Construction

The materials used for the principal components are detailed below:

COMPONENT	MATERIAL(S)
Pumpstand body & cap	Cast iron top and cap Steel body and baseplate
Handle	Mild steel
Cylinder casing	Stainless steel
Pumping element	Rubber, with light alloy fittings
Top cap and valves	Brass with stainless steel balls and acetal fittings
Primary plunger assembly	Gunmetal with leather seals
Foot valve	Brass/gunmetal with stainless steel ball and plastic shield

WEIGHTS & MEASURES

Weights

Pumpstand : 60 kg (including handle)
Cylinder: 9 kg

Dimensions

Nominal cylinder bore: 58 mm
Actual pump stroke: 145 mm
Nominal volume per stroke: 383 ml
Drop pipe size: 26 mm I/D x 32 mm O/D
Maximum outside diameter of below-ground assembly 96 mm

Manufacturing Techniques

The manufacturing techniques required to make the pump are listed below:

Above-ground Assembly	Iron and gunmetal foundry Steel fabrication	Basic machining

This pumpstand demands basic skills in iron foundry and considerable skill in steel fabrication. It may be suitable for manufacture in developing countries where these skills exist. It would not be difficult to modify the pumpstand design for all-fabricated manufacture. The handle requires careful jigging for welding.

Below-Ground Assembly	Hot pressing of brass Light alloy foundry Plastics moulding	Machining Welding (of stainless steel) Specialised processes (pumping element)

The pumping element assembly demands advanced, specialised manufacturing techniques, and a high degree of skill. It would be particularly unsuitable for manufacture in a developing country.

Ease of Installation, Maintenance and Repair

Ease of Installation

Installation although straight-forward demands a good deal of care. The pump is supplied with lightweight polyethylene tubing to connect the cylinder with the pumpstand and will not require lifting tackle.

Ease of Pumpstand Maintenance and Repair

The Pumpstand is likely to require very frequent replacement of the leather sealing rings on the primary plunger, particularly if the replenishing hole in the primary cylinder has not been satisfactorily deburred during manufacture.

Ease of Below-ground Maintenance and Repair

The lightweight connecting tubes mean that the cylinder can be extracted without the need for lifting tackle. The cylinder itself is easy to dismantle provided the appropriate hexagon keys are available.

PUMP PERFORMANCE

Volume Flow, Work Input and Efficiency

The description of the method can be found in the Test Procedure.

HEAD	7 m			25 m			45 m		
Pumping Rate (strokes/min)	30	38	49	32	40	50	32	42	50
Vol/stroke (litres)	0.28	0.27	0.27	0.26	0.26	0.26	0.24	0.25	0.25
Work input/stroke (J)	127	130	139	185	194	211	262	250	286
Efficiency (%)	15	14	13	34	32	30	39	43	38

ENDURANCE TESTS

A detailed description of the endurance test method can be found in the Test Procedure.

General Comments

The pump was tested at 40 strokes/minute at a simulated head of 45 metres, subsequently reduced to 20 metres.

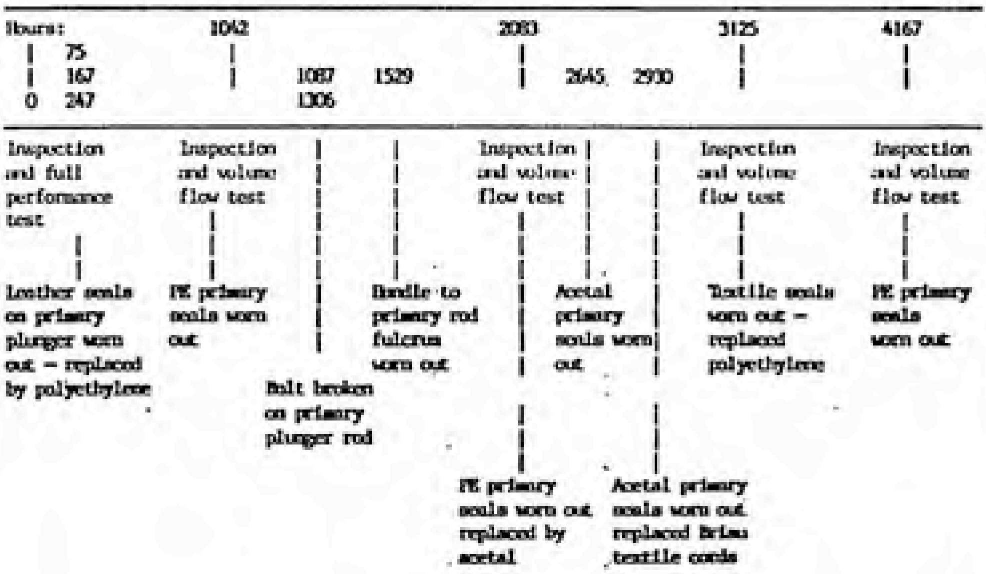
The below-ground assembly completed the 4000 hour endurance test without failure and remained in good working order at the end. By contrast the pumpstand was very unreliable.
The original leather seals fitted by the manufacturer to the primary plunger wore out in 75 hours. They were replaced twice but it became clear that the average life of leather seals was approximately 80 hours. We believe the seals were damaged by the replenishing hole in the primary cylinder which had not been satisfactorily deburred during manufacture. The leather rings were replaced by polyethylene seals machined from bar stock. The first set of these were worn out at the 1000 hour inspection and they were replaced by a second set. During the second stage the bolt connecting the primary plunger rod to the handle pivot broke twice and was eventually replaced by a high tensile bolt. The handle to primary rod fulcrum had worn out after 1529 hours and the handle assembly was replaced. At the inspection after the second 1000 hour stage the second set of polyethylene primary plunger seals were worn out.

To experiment with alternative materials the polyethylene seals were replaced by others machined from acetal bar stock. These wore out in less than 600 hours however, and a second set in less than 300 hours. They were replaced by textile cord seals but these wore out in less than 200 hours. Polyethylene seals were fitted once again to complete the endurance test and as before these wore out in approximately 1000 hours.

It is clear that the pumpstand needs substantial modification if its reliability is to approach that of the below-ground components.

Breakdown Incidence

Breakdowns are shown in bold type.



Final Inspection:

1	Seals	Final set of polyethylene seals worn out
2	Plunger	Plunger worn by contact with cylinder bore
3	Handle	Some wear of handle and bushes but still serviceable
4	Pumping Element	Pumping element in good condition, including ball valves
5	Corrosion	Further rust inside pumpstand Further corrosion of pumping element end caps

Estimated Additional Amount of water pumped to breakdown...0.3 million litres

Estimated Total Amount of Water Pumped in 4000 hours......1.5 million litres

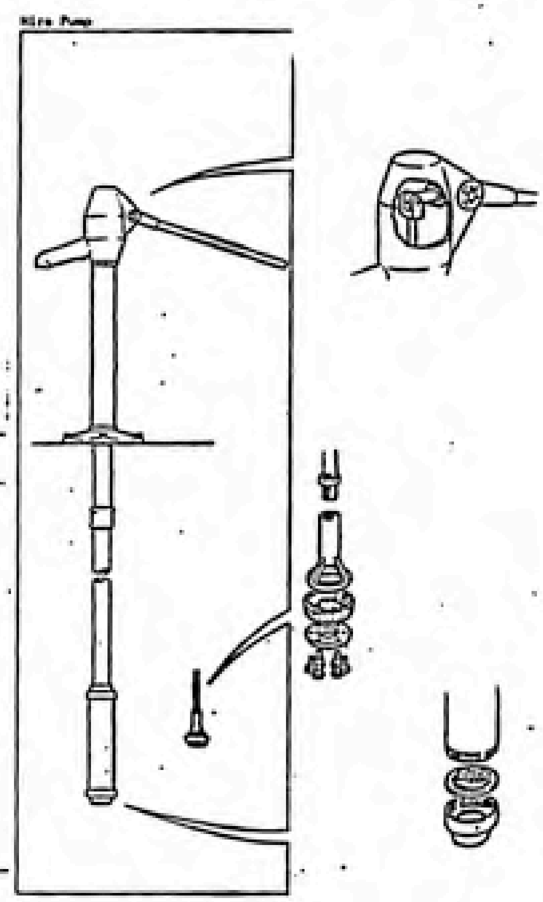
VERDICT

A sharp contrast was observed between the endurance of the pumpstand and of the below-ground pumping element. The latter proved to be very reliable and remained in good condition at the end of the test. The pumpstand was unreliable and quite unsuitable for community water supply. However, this pump is inherently simple to install and to maintain below-ground, and it is therefore strongly recommended that a reliable VLOM pumpstand should be developed.

Nira Pump Description

The Nira is a deep-well force pump, made in Finland. The pumpstand has a tubular steel column with a cast iron base, and a cast iron handle socket and spout assembly. The handle was originally steel bar but has since been changed to steel tube. The steel parts of the pumpstand are galvanised, the iron castings are protected by a nylon coating.

The 76 mm bore cylinder is seamless brass tube with threaded collars soft-soldered to each end. The cup washer and plunger valve are combined in a single rubber moulding. The foot valve is of similar design, also moulded in rubber.



Materials of Construction

COMPONENT	MATERIAL(S)
Pumpstand column	Steel, galvanised
Pump top	Cast iron
Handle	Mild steel
Bearings	Stub-backed bronze bushes with stainless steel pivot shaft
Fulcrum link	Cast gunmetal
Pivot pin	Stainless steel
Pump rod fork	Hot pressed brass
Cylinder	Brass, with soft-soldered end spigots
Plunger	Cast bronze with brass valve seat
Cup seal	Moulded rubber
Foot valve	Moulded rubber
Drop pipe	Galvanised steel
Pump rods	Stainless steel

WEIGHTS and MEASURES

Weights	Pumpstand	29.5 kg
	Cylinder assembly	4.0 kg
	Rising main	5.2 kg/metre
	Pump rods	0.7 kg/metre

Dimensions	Nominal cylinder bore:	76 mm	Outside diameter of below-ground assembly:	95 mm
	Actual pump stroke:	127 mm	Pump rod diameter:	10 mm
	Nominal volume per stroke:	576 ml	Maximum usable cylinder length:	310 mm
	Drop pipe size:	2 inches		

Manufacturing Techniques

The manufacturing techniques required to make the pump are listed below:-

Above-ground Assembly	Iron foundry	
	Brass/gunmetal foundry	Machining
	Steel fabrication	Plating
	Rubber moulding	Protective plastic coating

With the exception of the protective plastic coating, no specialised processes are required. However, the Mira is not an ideal design for manufacture in a developing country. Considerable skill in foundry work is demanded, particularly for the pumpstand top, and in steel fabrication, machining and rubber moulding.

Below-ground Assembly	Brass/gunmetal foundry Hot brass pressing Rubber moulding	Machining Soft soldering

The below ground assembly demands similar levels of manufacturing skill to those needed in the pumpstand. The requirement for soft soldering arises from the need to attach threaded end spigots to the thin brass tube of the cylinder barrel.

Ease of Installation, Maintenance and Repair

Ease of Installation

The manufacturer supplied thread locking compound with the test samples. A grease gun is needed to lubricate the handle bearing. The below-ground assembly will be heavy, but in other respects installation is straightforward providing care is taken in handling the cylinder to avoid damaging the thin wall, and cutting the pump rod to the correct length.

Ease of Below-ground Maintenance and Repair

The pumpstand is easy to dismantle, and does not need to be removed from the wellhead. The handle bearings would be easy to replace in a workshop; in the field, replacement of the complete fulcrum casting might be required.

Ease of Pumpstand Maintenance and Repair

Repairs require removal of the complete below-ground assembly. For plunger seals and foot valve, manufacturer's spares are essential. Again, care is needed in handling the cylinder to avoid damaging the thin wall.

PUMP PERFORMANCE

Volume Flow, Work Input and Efficiency

The description of the method can be found in the Test Procedure.

HEAD	7 m			25 m			45 m		
Nominal pumping rate (strokes/min)	30	40	50	30	40	50	30	40	50
Vol/stroke (litres)	0.62	0.63	0.65	0.64	0.65	0.65	0.60	0.59	0.59
Work input/stroke (J)	55	59	72	264	209	254	395	398	404
Efficiency (%)	76	71	61	59	75	63	66	65	63

19

ENDURANCE A detailed description of the endurance test method can be found in the Test Procedure.

General Comments

The Nira was tested at 40 strokes per minute at a simulated depth of 36 metres, the maximum originally specified by the manufacturer. The handle broke several times within the 4000 hours. The original, round bar handle broke after only 314 hours. A new tubular handle was supplied by the manufacturer, but that in turn broke after a further 2200 hours or so, and a second sample 189 hours later. One of the tubular handles was repaired by welding and completed the remainder of the 4000 hour test. In response, the manufacturer now recommends the 76 mm cylinder for a maximum depth of 18 metres, and will offer a 50 mm cylinder for greater depths.

At the 1000 hour intermediate inspection, all the setscrews used to assemble the plunger were badly corroded, and the head of one screw had broken off. Because of this the plunger could not be dismantled and was therefore replaced completely.

In the final inspection, little wear was found in the valves, cup seal, cylinder and handle bearings. The six setscrews in the plunger were corroded but unbroken. There was no significant corrosion elsewhere.

Breakdown Incidence

Breakdowns are shown in bold type.

Hours:	314	1072	2044	2828	3017	3060	4063
Breakdowns	Handle Broken			Handles Broken	Handles Broken		
Inspections							

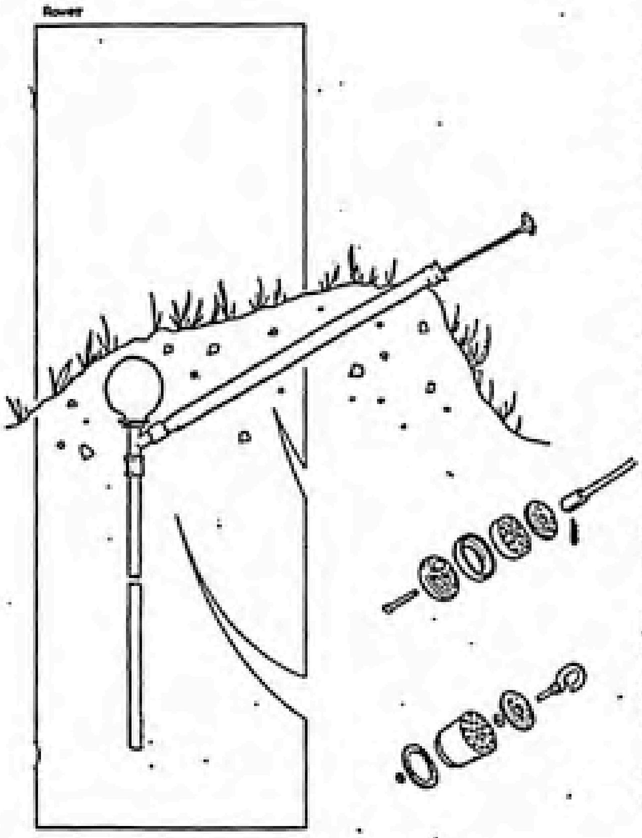
Hours	Inspection
0	Inspection and full performance test
1072	Inspection and volume flow
2044	Inspection and volume flow
3060	Inspection and volume flow
4063	Inspection and full performance test

FINAL INSPECTION

1.	Pumpstand	Slight wear in handle fulcrum bearing but otherwise in good condition
2.	Cylinder	Light scratches on bore but no other signs of wear
3.	Plunger	Both sealing washer and valve in good condition
4.	Foot Valve	In good condition
5.	Corrosion	Noticeable corrosion of setscrews used to assemble plunger

Estimated total amount of water pumped in 4000 hours..... 6.2 million litres.

VERDICT The manufacturer now recommends a maximum depth of 18 metres, using a 3 inch cylinder, and supplies a smaller cylinder for greater depths. Some small design changes and a thicker cylinder wall could make this a robust pump, potentially suitable for community water supply. Although the design does not demand highly specialised manufacturing processes, the levels of skill required make it unsuitable for manufacture in many developing countries. Moderately priced.



Rover Pump Description

The Rover pump is a high capacity low-lift pump designed for irrigation, made in Bangladesh. The pump is fitted with a surge chamber. The cylinder is a simple length of extruded uPVC tube with heat swaged ends. The operator pulls directly on the plunger rod by means of a T-handle. The plunger is fitted with a single leather cup washer and simple rubber flap valves cut from tyre inner tubes are used for both the plunger valve and check valve.

The pump is normally embedded in earth for support and protection, as shown, or alternatively may be supported by a smaller earth bank and protected by strips of bamboo bound around the cylinder. It is usually operated in a seated position.

WEIGHTS & MEASURES

Weights

Pumpstand complete : 3.5 kg

Dimensions

Nominal cylinder bore:	54 mm
Actual pump stroke (max):	980 mm
Nominal volume per stroke:	2.24 litres
Drop pipe size:	1.5 inch
Maximum outside diameter of below-ground assembly:	59 mm

Materials of Construction

COMPONENT	MATERIAL(S)
Handle	Fabricated steel with injection moulded plastic spacers.
Angled Connector	Galvanised steel pipe
Cylinder	uPVC water pipe with heat-swaged ends
Plunger assembly	Aluminium with rubber valve
Cup Seal	Leather
Check valve	Moulded polyethylene with rubber valve flap
Surge chamber	Aluminium

Manufacturing Techniques

The techniques required to manufacture the pump are listed below:

Steel cutting and welding	Sheet leather and rubber work
Simple machining	Manipulation of uPVC tube
Plastics moulding	Spinning (of aluminium)

The Rover pump has been designed for manufacture in a developing country. Most of the components are easy to make, though some skill is required in heat forming uPVC tube. Care is needed in machining, and spinning the surge chamber is a skilled process.

Ease of Installation, Maintenance and Repair

Ease of Installation

The Rower pump should be easy to install, particularly if plastic pipe is used. The most important tool may well be a spade or shovel to construct the earth bank. Care must be taken to achieve airtight joints in the drop pipe as any leaks will significantly affect the efficiency of the pump.

Ease of Maintenance and Repair

Pumpstand maintenance is very straightforward and will require only the simplest hand tools.

PUMP PERFORMANCE

Volume Flow, Work Input and Efficiency

The description of the method can be found in the Test Procedure.

Results - with surge chamber

HEAD	7 m		
Pumping Rate (strokes/min)	11	15	19
Vol/stroke (litres)	1.63	1.80	1.72
Work input/stroke (J)	168	192	180
Efficiency (%)	66	64	65

Results - without Surge Chamber

HEAD	7 m		
Pumping Rate (strokes/min)	11	14	19
Vol/stroke (litres)	1.62	1.70	1.72
Work input/stroke (J)	179	194	210
Efficiency (%)	62	59	56

ENDURANCE

General Comments

The pump was tested at 19 strokes/minute at a suction head of 7 metres.

PUMPS WITHOUT TEST DATA HERE

Country of Origin	Name	Deep or Shallow	Field Testing Countries
India	India Mark II	Both	Malawi, Bangladesh, India, Sri Lanka, Sudan, Kenya, Tanzania Mali, Ghana, Niger, Thailand, Philippines Upper Volta, Ghana
England	Consallen LD5	Deep	Malawi, Sudan, China, Philippines, Sri Lanka, Thailand
England	Mono ES30	Deep	Nigeria
France	Hydro-Pompe Vergnet	Deep	Niger, Mali, Ivory Coast, Upper Volta
USAID	Battelle/AID	Both	Dominican Republic, Honduras, Peru, Costa Rica, Nicaragua
Holland	Kangaroo	Deep	
Germany	Kardia	Deep	China
Germany	Turni	Both	China
Canada	Waterloo (IDRC)	Shallow	Malaysia, Ethiopia, Malawi, Nicaraguq (both shallow and deep wells)
USA	Dempster	Deep (Shallow) Both	Thailand, Peru, Honduras, (Nicaragua) Dominican Republic
Ivory Coast	ABI	Deep	Ivory Coast, Mali Upper Volta
Canada	Monarch	Deep	Ghana, Ivory Coast

INDIA MARK II HAND PUMP

India Mark II Handpump Description

In 1967 the deep-well handpumps manufactured in India were the same configuration as the traditional multipivot design (Figure II-8A). They were designed for single family operation in rural areas and farms once a day per hour in Europe and America.

In India, due to the low grade brittle cast iron and multipivot existing of the Indian pump heads, there were many problems during operation. Now the pump is an improvement on the traditional cast-iron pumps which could not stand regular rough handling (around 80 percent of the handpumps were broken down at any one time). India Mark II (Figure II-8C) was based on "Sholapur Conversion Head" (Figure II-8B).

The unusual features of the pump are that:

- Two heavy-duty sealed ball bearings pre-packed with grease and requiring no field lubrication was employed to act as the handle pivot, replacing the three unlubricated pivot pins of the cast iron pump. A quadrant which formed part of the handle was designed in such a way that a chain, bolted to its upper end and passing over it, would maintain a vertical line with the plunger rods to which the other end of the chain was attached.
- All contraction was of fabricated steel instead of cast iron.
- The pump was not attached at the well casing (Figure II-8D).

A modified version of the India Mark II handpump to meet the recommendations of UNDP/World Bank research project for a simple village pump has been developed by Inalsa of India (a subsidiary of the Delhi Cloth Mills in Delhi), the mark II's biggest manufacturer.

<u>Materials of Principle Components</u>

Component	Material(s)
Pump head	Hot dip galvanized standard mild steel
Pedestal	Hot dip galvanized standard mild steel
Handle	Hollow pipe
Cylinder	A top quality standard brass cylinder, sleeved in cast iron
Piston	A five web heavy duty
Buckets	First grade quality leather buckets
Valves	Gun metal valves with rubber seating
Rod	Steel
Riser main	Rigid PVC or ABS

<u>Weights and Measures</u>

Information of the modification pump is not available. The original India Mark II weight of over 300 kg.

TEST RESULTS

<u>Pump Performance</u>

The manufacturer, Inalsa, offers the following claims:

- Operational capability of drawing water from depths of 16 meters to 100 meters. Pump handle suitably designed to reduce pump effort at greater depths.

- Each pump yields up to 1000 liters of water per hour; sufficient for 250 families.

- The pump can be suitably adapted to motorized operation with minor modifications. Also available for operational depths less than 16 meters.

There are five factors underlying the Indian experience:

- The design of a new type of handpump with far lower maintenance requirements.

- Rigid control of pump manufacturing standards to assure very high quality control.

- A high standard of initial pump installation.

- The careful design of a three-tier maintenance organization that depends on district level four-man mobile units.

- Top level government recognition of the maintenance problems and a commitment to finance the program's recurring costs (Baldwin, George B., 1983).

EXPERIENCE

India Mark II pumps have been used in 37 countries. Since the mid-1960s some 300,000 Mark IIs have been installed in India and Africa, and 100,000 a year are being purchased (Morrison, 1983). But precise information about the modified India Mark II is not available. The large number of original India Mark II handpumps sold were tested and developed for almost ten years.

The pumps are tested against various parameters such as ease of manufacture, installation and use, mechanical and volumetric efficiency, frequency of breakdowns and maintenance required, resistance to abuse, neglect and corrosion, overall design, user acceptability, and adequacy of a sanitary seal as well as safety. In the final analysis the India mark II has been highly rated (Kalra, K.S., 1982).

The maintenance costs on original India Mark II is still average $200 a year. With the modification, it may be possible to bring it down to $50-$80 a year. India Mark II pumps have three different kinds for use in shallow-well, mediate-well, and deep-well.

India Mark II handpump is easy to install, operate and maintain at village level with little training. It is suitable for boreholes of 100 mm but is not suitable for installation in boreholes of 150 mm diameter.

By March 1984 there were 46,000 India Mark II installed in a 150 mm diameter casing with the reversion of the casing which has to be cut 55 mm below ground level.

The experiences concluded in India of using handpumps are that not only the quality control efforts being given to pump production but also the duration of pumping function and its subsequent maintenance requirement are depended upon the initial installation quality. India Mark II is widely used in handpump rehabilitation programs in Jagtiani, India.

ADVANTAGES AND DISADVANTAGES

Advantages

The pump can be made in three different depths:

deep well - 25 m - 100 m

intermediate well - 6-25 m

shallow well - less than 6 m.

It is easy for large communities with different kinds of geological conditions to buy the same brand pump to supply their drinking water.

Since the lower part of the pedestal is embedded in a concrete base, there is no possibility of contaminated water finding its way into the well if the concrete base has been properly done.

A hollow pipe handle was used to eliminate the shock-loading from the connecting rod.

It is sturdy and durable and can withstand continuous operation by large communities for long periods. Needs no servicing for a year.

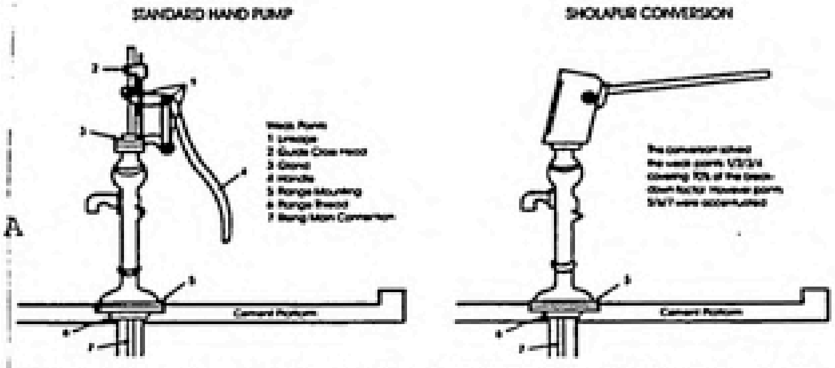
The handle has a 8:1 mechanical advantage. This improvement allows one person to lift a column of water 20-25 m in height easily.

Disadvantages

It was commented by Daw, Raj Kumer, Executive Officer, Action for Agricultural Renewal in Maharashtra, India Mark II is not the best pump because they are too heavy to remove the cylinder for service (World Water-Water Decade: 1st year Review, 1981 and World Water, August, 1984).

FIGURE II.8 Information About India Mark II Hand Pump

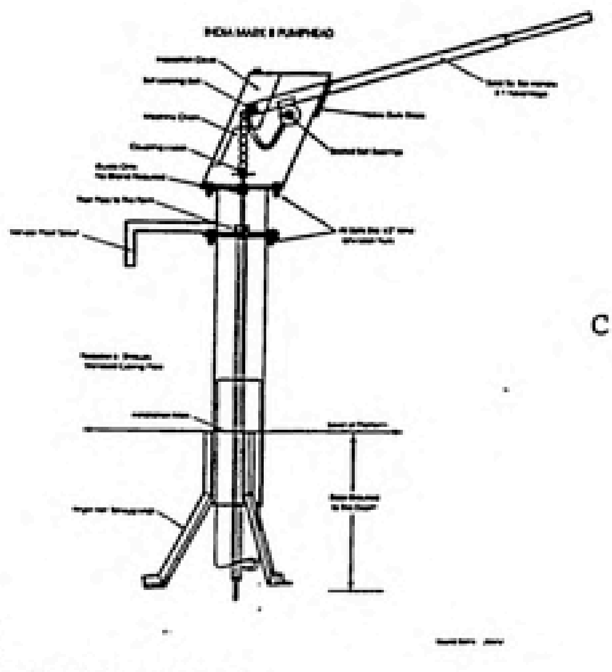
A



B

The original standard handpump design and the Sholapur head, showing improvements.

(SOURCE: Baldwin, George B. 1983 p.9)

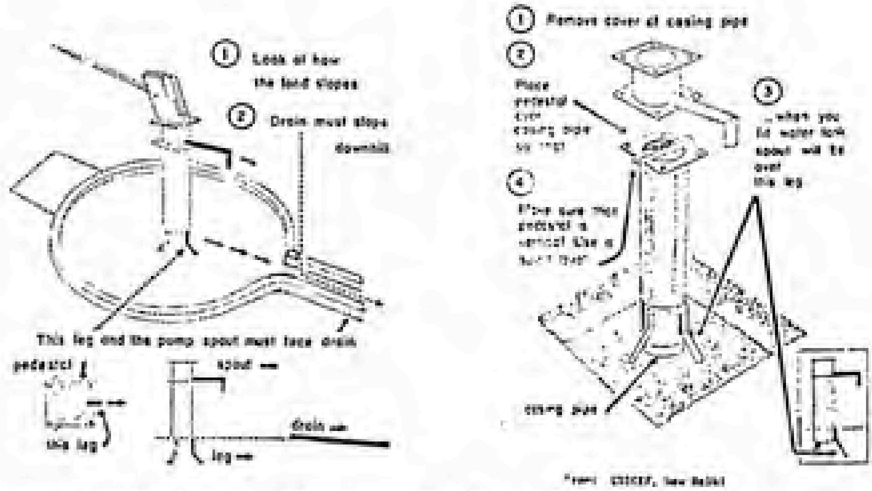


C

The Indian Mark II pumphead.

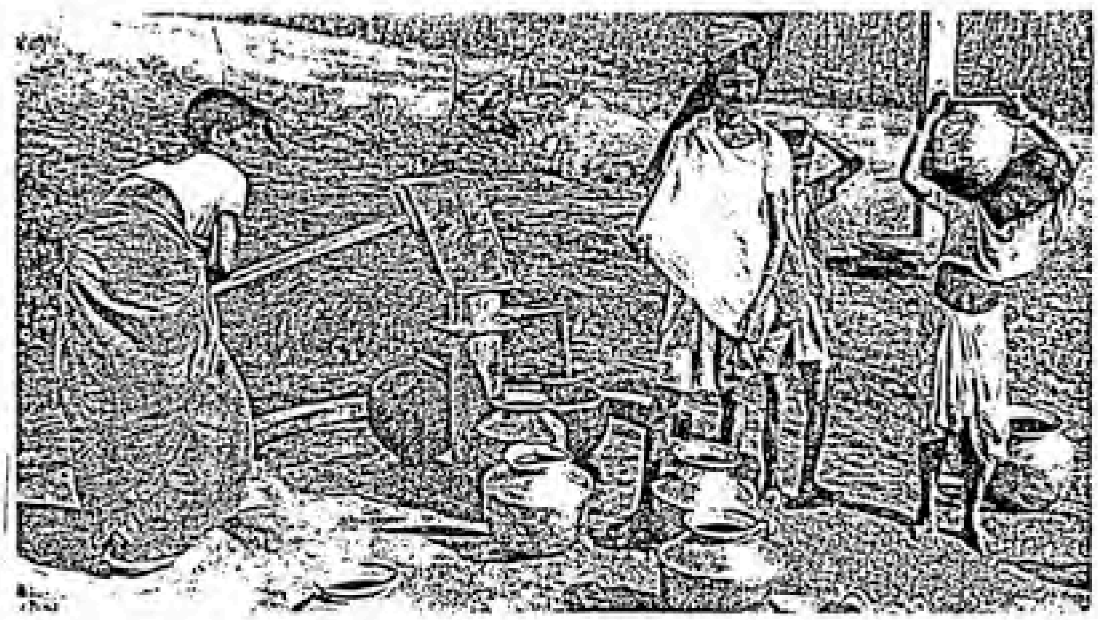
(SOURCE: Baldwin, George B. p.8)

D

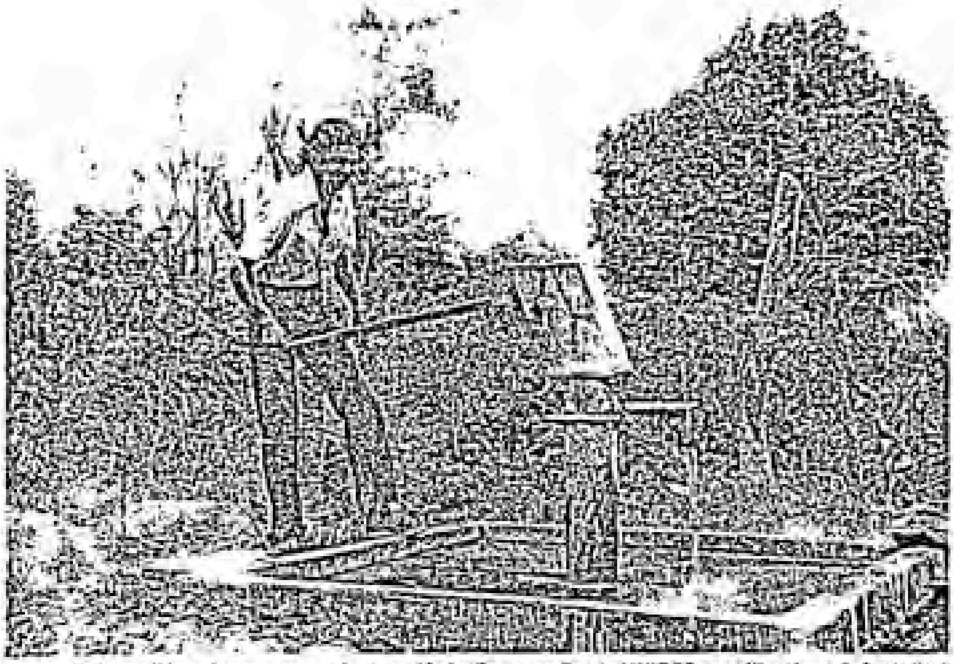


Key aspects of installing the Mark II (UNICEF, Delhi).

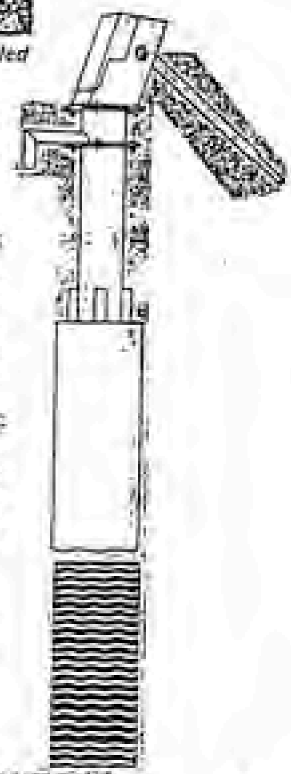
(SOURCE: Baldwin, George B. 1983 p.10)



(SOURCE: UNDP in Collaboration with UNICEF and WHO p. 15)



The India Mark II handpump, manufactured in India according to UNICEF specifications, is installed in all tubewells in India and Sri Lanka being drilled with UNICEF assistance.



The INALSA India Mark II Deep Well Hand Pumps are your guarantee for potable water for years and years.

* The most economical means of providing drinking water supply in rural and outlying areas.
* Operational capability of drawing water from depths of 16 metres to 100 metres and even more. Pump handle suitably designed to reduce pumping effort at greater depths.
* Each pump yields upto 1000 litres of water per hour; sufficient for 250 families.
* All steel construction to withstand rough handling in community use.
* Totally sealed from external contamination.
* Easy to install, operate and maintain at village level with little training.
* Tested and certified for quality by an international firm of engineers.
* Over 70,000 pumps are already proving their worth, providing potable water to rural communities in over 28 developing countries including India.

The INALSA India Mark II Deep Well Hand Pumps are suitable for bore holes of minimum 100 mm inner diameter. We also offer brass cylinders which facilitate installation in smaller bore holes of 80 mm inner diameter.

The pump can be suitably adapted to motorised operation with minor modifications. Also available for operational depths less than 16 metres.

INALSA also offers Shallow Well Hand Pumps made from fabricated steel structure. Ideal for community use. With very low maintenance cost.

For further details please contact :

INDUSTRIAL & ALLIED SALES PRIVATE LIMITED

Surya Kiran, 19 Kasturba Gandhi Marg,
New Delhi-110001 (INDIA). Cable : INALSA.
Telex : 31-3536 INAL IN. Telephone : 352317.

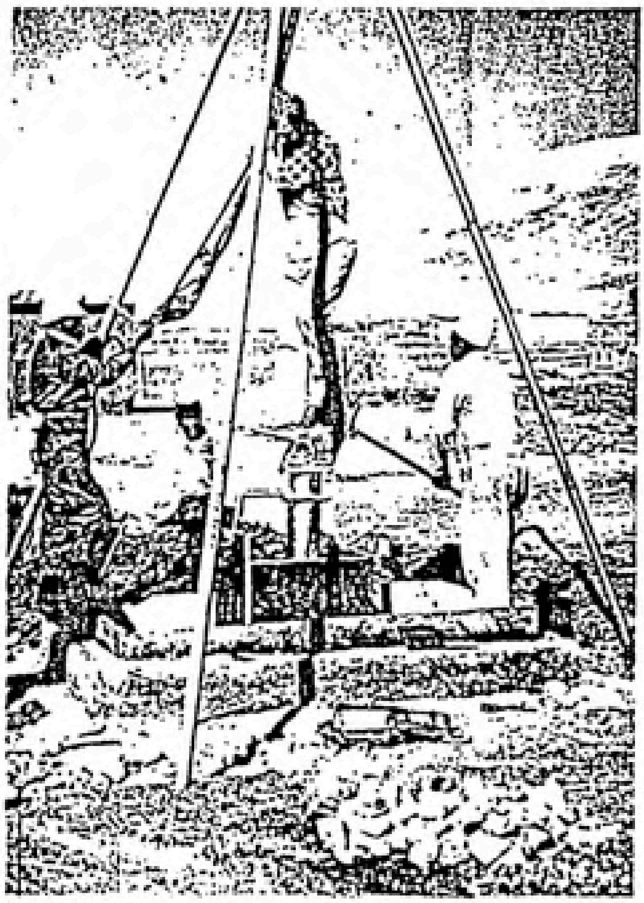
(SOURCE: World Water Water Decade:
1ST Year Review p. 45 and p. 19)

It is worth calling attention to some of the features of the Mark II:

- It is made from welded steel plates, not cast iron. This gives more strength per kg of material and greater uniformity in fabrication, but rusts, whereas cast iron does not. The original anti-rust treatment was to use an epoxy paint on sand-blasted metal. This was not good enough: when Britain's Consumer Association testing laboratory at Harpenden Rise found that the pump was susceptible to rust, UNICEF and the Crown Agents moved to hot dip galvanizing. This increased the pump unit-cost by nearly 10 percent.
- The number of fulcrum points has been reduced to one, which rotates in a sealed ball bearing with a life of several years. Thus, there are no points needing any oiling or greasing. It was a Swedish engineer, working for a voluntary agency in Maharashtra in the early seventies, who deserves credit for this critical innovation which led to the 'Sholapur' head.
- The handle is a mild steel bar with an 8:1 mechanical advantage. A normal pump handle has an advantage of around 4:1. This improvement allows one person to lift a column of water 20–25m in height easily.
- When the water table is at these depths, conventional pumps often require two or more adults to pull the handle which, in addition to being harder work than some can perform, exerts great strain on several pump parts.
- The pump is not attached to the well casing; it is embedded independently in concrete. This means there are no base-plate nuts and bolts to come loose, and no possibility of contaminated water finding its way into the well if the cement-work has been properly done.
- Except where the handle enters the head, the latter is completely enclosed. Children cannot drop pebbles into the mechanism, sometimes a source of trouble.
- With the change from a hollow pipe handle to a solid bar handle, most of the shock-loading was eliminated from the connecting rods, resulting in a substantial reduction in failures in this area.
- The pump's attachment to the concrete platform is strengthened by iron legs (sprags) set at an angle to the pedestal. The casing pipe is no longer under stress as it is not attached to the pedestal. This 'sprag' mounting has also reduced failures in the top connection of the rising main if installation is properly carried out.

In early 1979 a complete Mark II, including cylinder, rising main, and connecting rods, cost US$182 of which the pumphead itself accounted for about one-third. The Mark II costs less than an imported pump and only modestly more than a conventional Indian-made cast iron pump with much lower reliability. The estimated annual recurrent cost per well fitted with a Mark II is about US$30. This includes full cash costs of the mobile units and their district workshops but excludes any allowance for vehicle or building depreciation.

(SOURCE: Baldwin, George B. 1983 p. 9-10)



(SOURCE: World Water [illegible] Decade: [illegible] Year Review p.20)

(SOURCE: World Water December 1981 p.7)

CONSALLEN PUMPS

Consallen Handpump Description (One Handle and One Spout Consallen Handpump)

This Consallen pump (Figure II-9) is designed and manufactured in England for use in deep-well or bore holes. In 1977 the Overseas Development Administration of the UK Government tested twelve different deep-well pump designs in the Consumers' Association Testing and Research laboratories. CATR concluded that Consallen pump was the best one in their test for overall design.

Some features of these pumps are:

- A specially designed threaded connection is used to attach the pumping cylinder to the pumphead. This allows easy adjustment of depth and the removal of the cylinder for maintenance. Also a pre-cast concrete well cap is used which ensures the accurate positioning of the pump head.

- The below-ground components are improved to approximate the VLOM concept. A cement jointed 2 inch ID ABS plastic pipe is used as a rising main, which is easy to run into a 4-inch borehole in one continuous length.

- An extractable piston has been introduced; it can be easily withdrawn together with the foot valve.

- Stainless steel pull rodding is standard.

Materials of Principle Components

Component	Material(s)
Standard rising main	ABS Plastic
Rodding System	Stainless steel
Cylinder	Stainless steel
Pump stand	Mild steel hot dig galvanized
Pistons	Polyurethane

Weights and Measures

The pumps are suitable for borehole of 100 mm with 50 mm ABS plastic pipe rising main. The rising main and rodding system weighs only, 40 kg per 30 meters.

TEST RESULTS

Pump Performance

The pumping cylinder in 50 mm size at 40 strokes per minute yields 14 liters per minute, where water is at any depth from ground level to 60 meters or more.

EXPERIENCE

A one-handle one-spout Consallen pump was used in Nigeria and other areas of Africa for seven years. By September 1984 two thousand Consallen handpumps installed in Kano, Nigeria. This experience demonstrated that the Consallen's plastic drop-pipe makes installation very simple without using lifting tackle. More information is not available.

ADVANTAGES AND DISADVANTAGES

Consallen pump is the best one of twelve handpumps tested not only in overall design but also in frequency of maintenance and breakdown, corrosion resistance and safety, and high marks also for ease of manufacture, performance efficiency, resistance to abuse or neglect, and well head sealing (World Water, Dec. 1981c)

Advantages

The galvanized steel pump stand prevents vandalism and contamination.

The stainless steel pump cylinder and polyurethane piston of uniform size and quality are longer lasting and proof against wear.

Plastc rising main and guided stainless is light and corrosion proof, allowing the removal of below-ground components by hand without the use of heavy lifting tackle.

Disadvantages

In general, the price of the pump is not cheap.

The handle has three large ball bearings, which require frequent lubrication.

The short straight spout gives the opportunity to children putting in stones and foreign matters.

Consallen Pump Description (A Double-Handled Double-Spouted Handpump)

In December 1982, a double-handle double-spouted handpump was installed on a single borehole in Ghana. This deep-well pump was designed by United Kingdom manufacturer, Consallen. The difference from the one handle pump is that when repair or maintenance work was needed, the pump could still be used. Also boreholes can still be used when a breakdown occurred. Thus the double handle and double spout handpump gives an opportunity to reduce the construction of boreholes which is the biggest expense in the handpump project.

The features of these pumps are:

- Two independent and complete pumping systems each having an individual handle and spout in the same unit which can be put in a 5 inch or 4 inch casing. It allows two people to operate the pump at the same time.

- If the double pump is installed in a 5 inch casing, the cylinder needing repair can be withdrawn without disturbing the second pump at all.

- In a 4 inch casing, since one 2.5 inch diameter cylinder must reset on top of the other at the base of the well, so that it may sometimes be necessary to remove both systems. However, Consallen's managing director, Vincent Allen, points out that plastic drop-pipe and stainless steel rods is a quick operation, requiring no lifting gear, so that the unaffected pump can be reinstalled and working again very quickly, while the broken one is repaired (World Water, Dec. 1982). Other precise information is not available.

TESTING

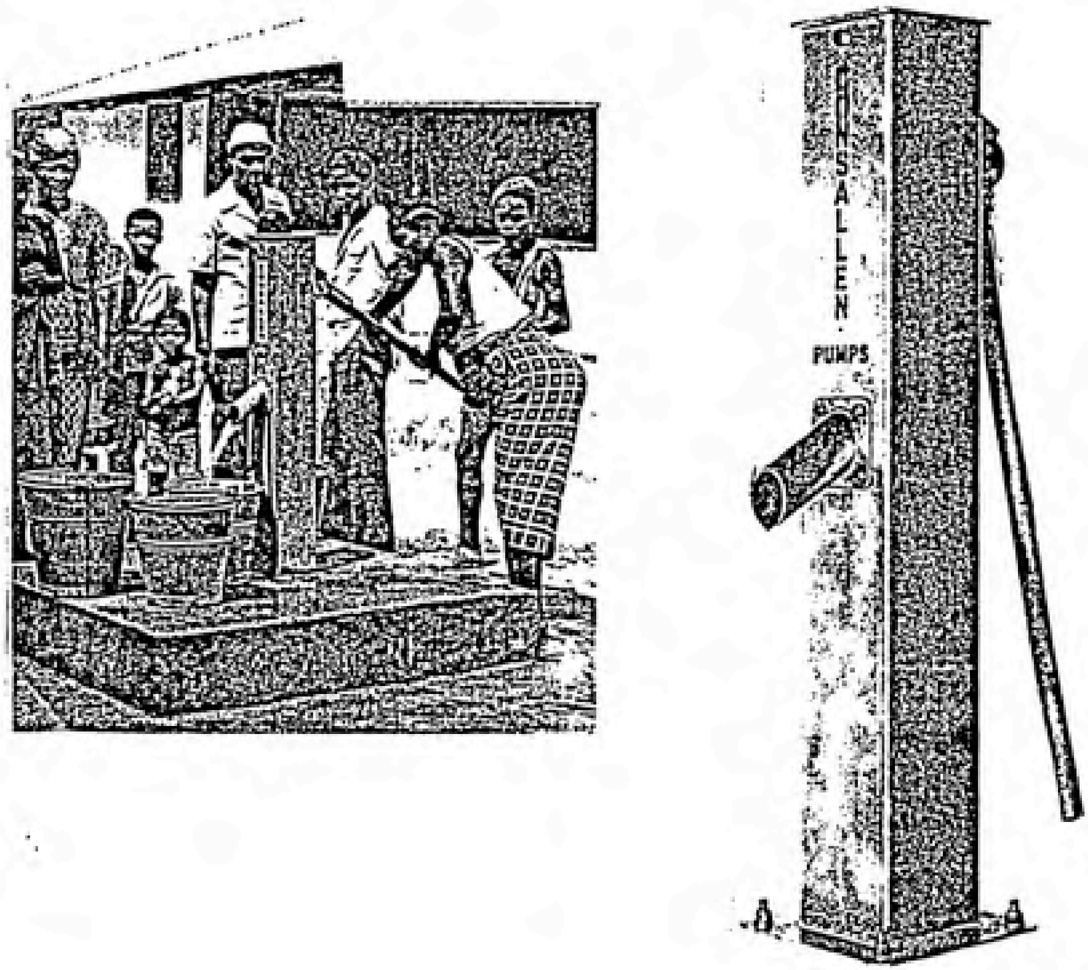
Performance

Two people work independently at the same time from a single borehole, resulting in double the yield.

EXPERIENCE

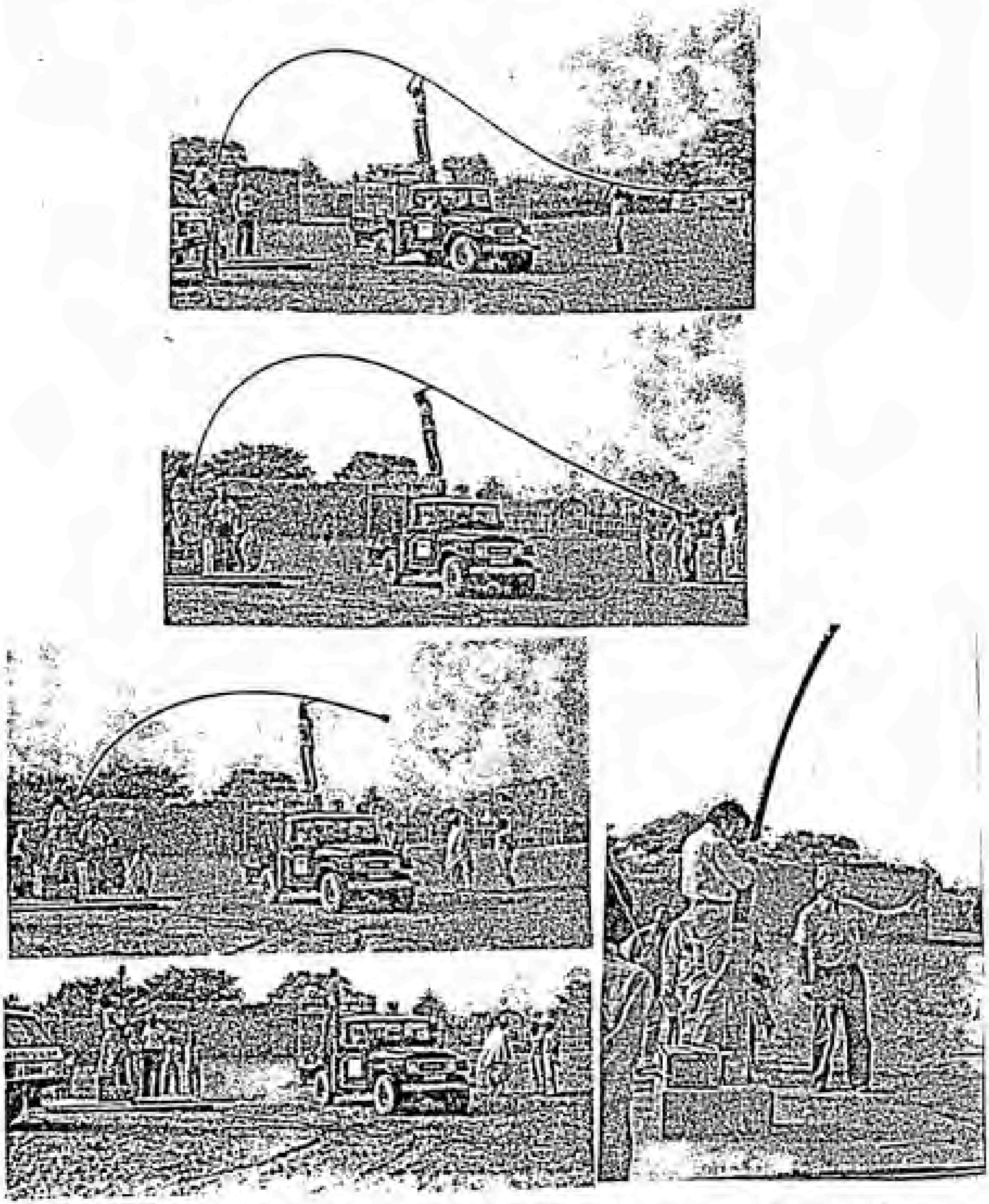
According to Field Trial Sites Chosen in 20 Countries (World Water Journal,Feb., 1983c), a double-handled double-spouted Consallen handpump is to be field tested in Malawi, East Africa. Other information is not available.

FIGURE II.9 Information About Consallen Hand Pump



(SOURCE: World Water Water Decade: 1ST Year Review p.34)

This New Development Brings the Consallen Hand Pump Even Closer to the VLOM Ideal



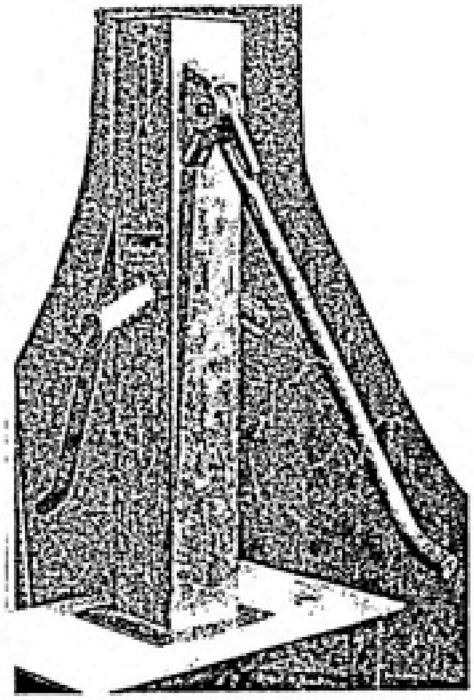
(SOURCE: Watrelines April 1984 Inside Front Cover)

Installation of Consallen Pump

The Consallen's plastic drop-pipe makes installation and removal of the underground equipment a simple operation (above). The completed installation (below) is the closest currently available to the UN panel's VLOM pump ideal.

(SOURCE: World Water Water Decade: 1ST Year Review p.12.)

Information About Consallen Hand Pump



By providing two totally independent pumping systems in the same borehole, the well can continue in use even when repair or maintenance work is needed. The double unit also means increased yield from each borehole, and a reduced per capita cost for rural water supply schemes.

(SOURCE: World Wter December 1982 p. 28)

MONO HANDPUMP

Mono Handpump Description

Mono pump (Figure II-10) is a hand-operated rotary helical screw-type pump. The rotor has a twin helix configuration and the rubber stator a triple helix, meaning that sealed cavities are formed between the rotor and stator which progress along the pump element towards the discharge and whenever the rotor is turned. It is because of this design that silty and sandy water can be pumped with minimal damage to the element.

Monolift DW15 is an improved model, in new drive head a non-lubricated established nylatron gears and an undirectional ratchet were used. The pump element is immersed in water and entirely self-priming with a positive displacement which drives the water up the riser pipe (Africa Water and Sewage, 1983).

Design features include:

- No valves with metal to metal faces.
- Washers do not need frequent replacement.
- Large tolerances between cylinder and casing.
- Mono pump design is close to the village level operation and maintenance concept.
- The handles are encased in a heat insulating plastic that prevents hand burns.
- The below-ground components are suitable for groundwater temperatures between 5-35°C.

Material of Principle Components

Component	Material(s)
Pump stand column	Fabricated steel, galvanized
Gear box	Cast steel

Handle	Cast steel
Stator	Rubber
Rotor	Steel, hard chrome-plated
Drop pipe	Galvanized steel
Pump rods	Galvanized steel

Weights and Measures

Precise values are not available.

TEST RESULTS

Pump Performance

Precise values are not available. Mono lift pumps are suitable for depths from 45 meters for hand driven pumps and up to 200 meters with motor driven pumps. Maximum flow rates are 3400 liters/hour when hand driven at low heads and 1100 liters/hour when motor driven at high head.

In 1981 laboratory tests were performed on the Mono pump, model ES30, of ODA handpump laboratory testing. The results of test show high leakage between the rotor and stator, making it difficult to get any water when the water head is more than 20 meters deep. By changing cylinders designed for specific water temperature ranges which make old model pump to be worked better than original.

No tests were performed on the newer model DW15, but it appears to work much better than the older model (African Water and Sewage, 1983).

EXPERIENCE

This pump is installed in Nigeria, but practical example is not available.

ADVANTAGES AND DISADVANTAGES

Advantages

The configuration of the pump eliminates all the conventional pump elements such as stuffing boxes which cause contamination and breakdown.

Routine maintenance of inspecting the "O" ring seal once a year and extracting the pump components for inspection every three years, it is close to VLOM.

A steady, non-pulsating flow is delivered by turning of the handles.

Mechanism entirely inside the pump stand for safety and hygiene.

It is suitable for the place where water was likely to contain sand.

A right angled bend outlet spout prevents foreign matters from being inserted into the pumping system.

The pump may be easily adapted to different power sources; for examples, animals, solar/photovoltaics, and wind.

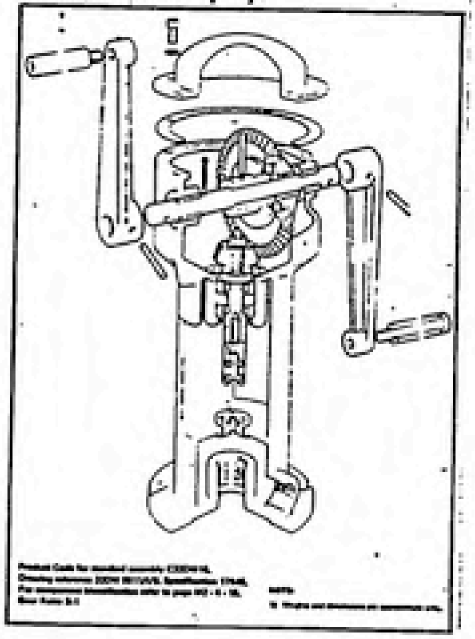
Disadvantages

It is expensive #370.4 (complete to 10 m)

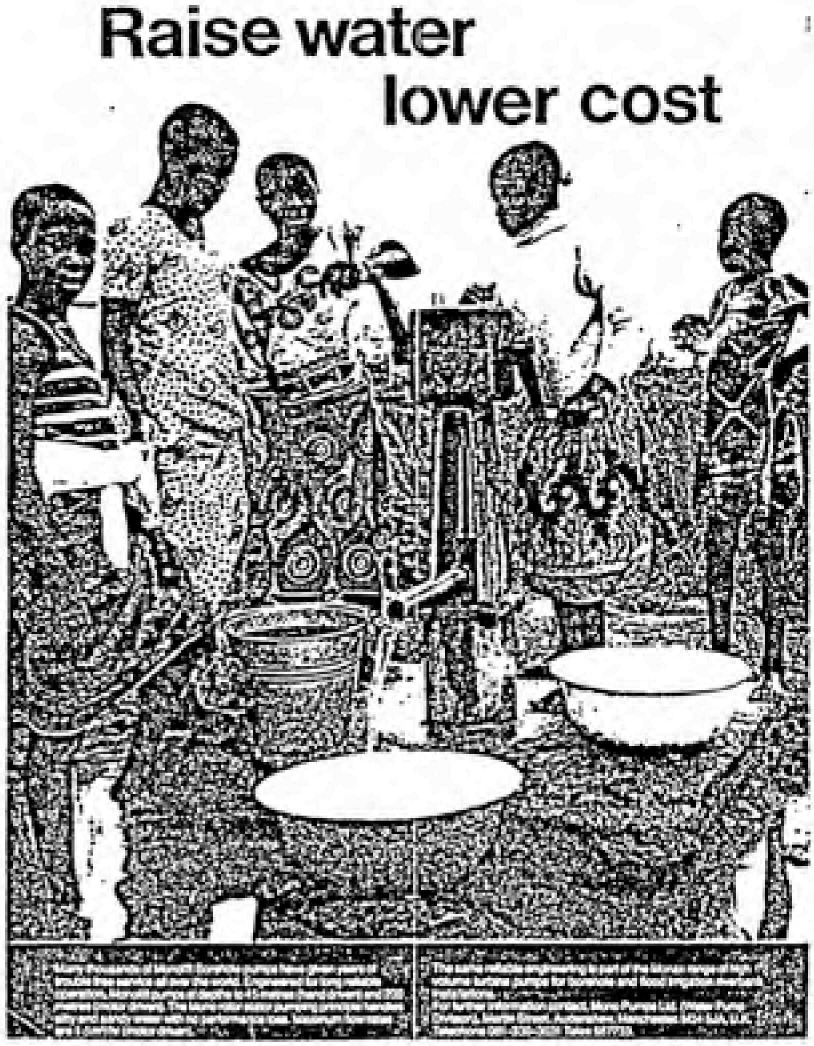
FIGURE II.10 Information About Mono Hand Pump

African engineers being trained in the installation of the new Monolift handpump.

A cut-away diagram of the new pump head on the Monolift DW15 handpump.

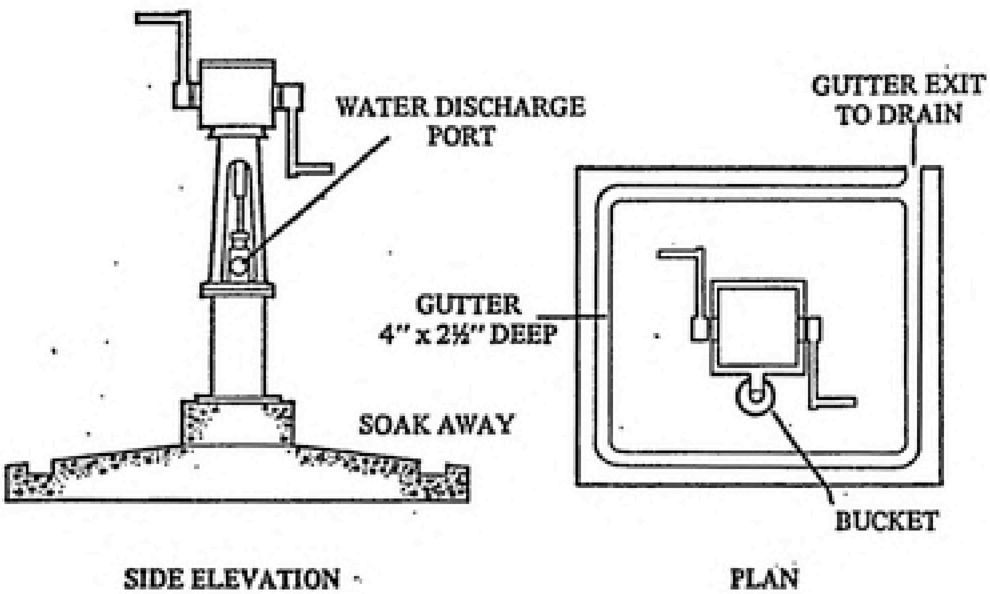


(SOURCE: African Water and Sewage September 1983 p. 38)



(SOURCE: World Water December 1981 Inside Front Cover)

Mono-lift pump in Nigeria — detail of top end, (by permission of MONO PUMPS ENG. LTD).



(SOURCE: Pacey, Arnold 1977)

HYDRO-POMPE VERGNET PUMP (DEEP WELL PUMP)

Hydro-Pompe Vergnet Pump Description

In 1973, the Inter-African Committee for Hydraulic Studies (CIEH) was studying the use of small handpumps for water supply in West Africa. The "hydro-Pompe Vergnet" (French-made by Mengzin) includes a novel operating mode. The major part of the pump is that a rubber sleeve is put inside a rigid cylinder which is embedded in well water (Figure II-11). The pump is foot-operated, pumping water by using an up and down motion to expand and contract the rubber sleeve. For each down stroke the sleeve expands once and a certain amount of water is pumped.

The hydraulic pilot pipe is completely separated from the discharge pipe. The immersed pump body has a very simple, non-corrosive mechanism system. The principle of operating can be found (McJunkin, 1977).

Some features of this pump are:

- Rotating components such as handle, pump rods and leverages have been eliminated.

- The moving parts (pedal, operation piston, etc.) are located in the pump head and are readily accessible at the surface. It is easy to check or change the wearing elements.

Materials of Principle Components

Component	Material(s)
Cylinder	Stainless steel
Piston rings seals	Leather or urethane
Pilot pipe	Light-weight flexible piping (in well less than 30 m deep)
Discharge Pipe	Light-weight flexible piping (in well less than 30 m deep)

Sleeve	Rubber

<u>Weights and Measures</u>

4 inch-dia. plastic tubing	6 inch-dia. plastic tubing

4 inch or more well casing is needed

Other precise values are not available

TEST RESULTS

<u>Pump Performance</u>

Pumping Capacity

Discharge Head	Yield
20 m	1.5 m^3/h
40 m	0.7 m^3/h
50 m	0.5 m^3/h

EXPERIENCE

This pump is widely used in Africa and is being tested in Upper Volta and can be used in different geological formations such as the basement complex and coastal sedimentary zone. In Togo, 230 of the villages of the basement complex are equipped with 4 inch-diameter plastic tubing, Vergnet foot pumps, and kerbstones for sealing the well top. In 40 villages in the coastal sedimentary zone, 6 inch-steel tubing was used.

In Mali and the Ivory Coast with the similar conditions of Togo, three types of Vergnet pump have been used from depths

0-30 m	4A type are used
35-45 m	4C2 type are used
45-60 m	4C1 type are used

One or two trainees with a simple set of tools can do daily maintenance, including maintenance on the easily pulled light-weight flexible piping without using tripod or scaffolding. During regular use of 8-10 hours per day, the pump may need major repair after one to two years.

Many laboratory tests. The rubber sleeve operated for over 2 million cycles, without failure. However, some modifications were made. The PVC rigid cylinder was replaced by stainless steel, and the leather cup seals were replaced by using piston rings with leather or urethane seals.

ADVANTAGES AND DISADVANTAGES

Advantages

Since rotating components are eliminated, lubrication is unnecessary.

Because the pump is foot-operated it can be pumped with more power (almost whole body's weight) and less fatigue than conventional lever-operated pump and is easily operated.

The pilot piston and pilot cylinder are completely closed, thus there is no contamination.

It is easy to maintain.

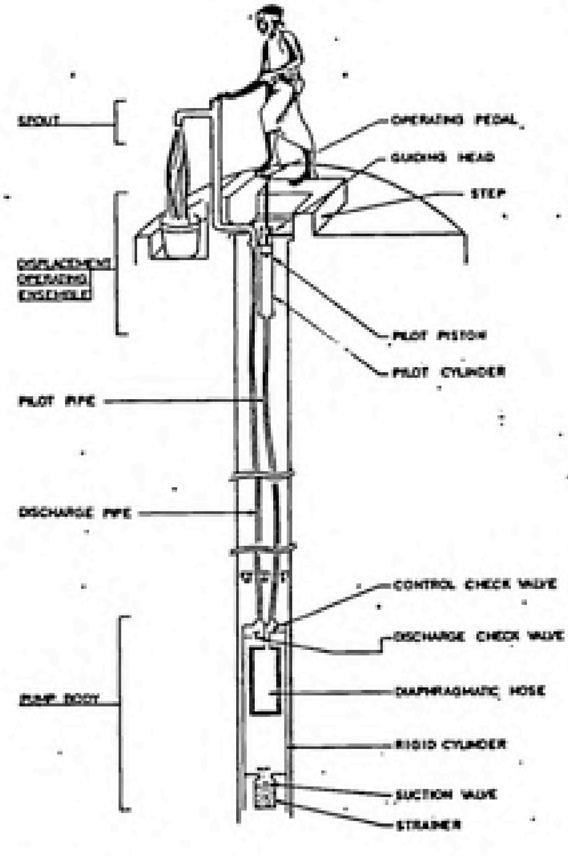
Disadvantages

Since the rigid cylinder must be immersed in water it cannot be used as a suction pump.

Many spare parts must be imported, as it is not convenient to manufacture them locally.

Its cost is too high.

FIGURE II.11 Information About Vergnet Hand Pump

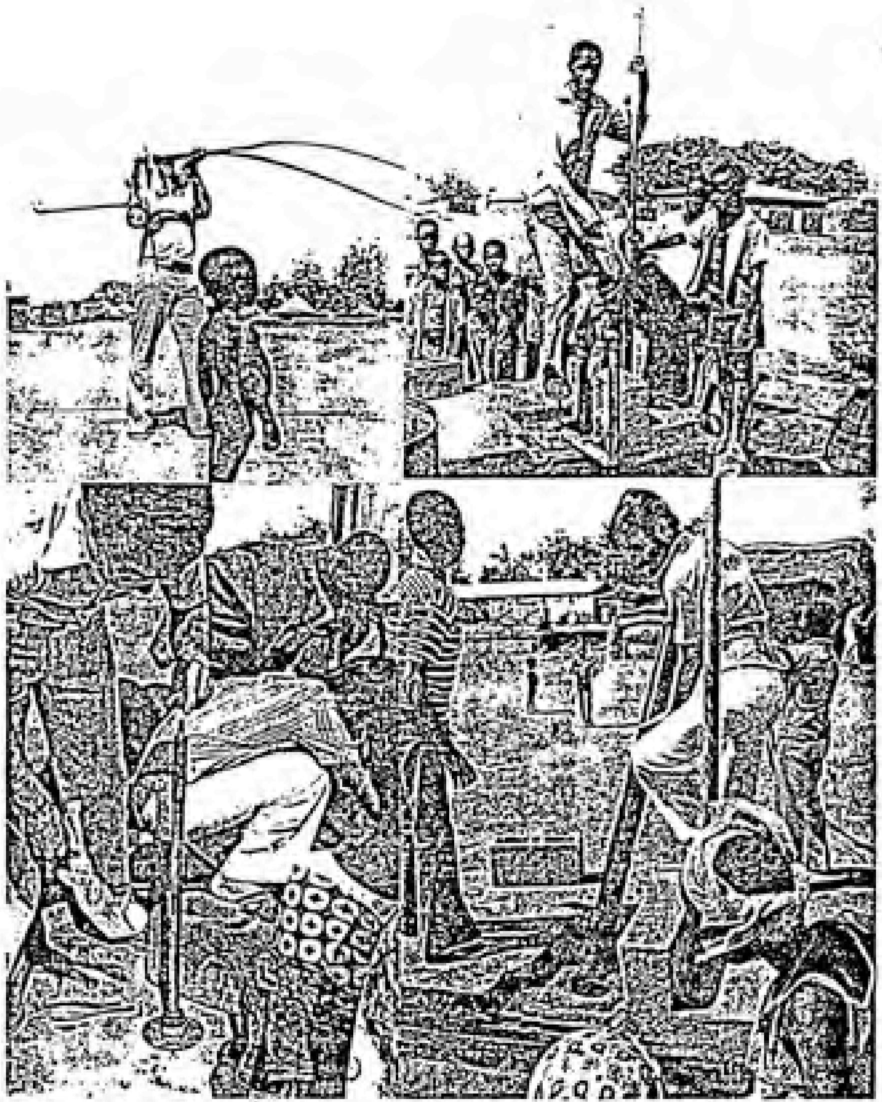


HYDRO-POMPE VERGNET
SCHEMATIC, ARRANGEMENT

(SOURCE: McJunkin, F. E. 1977 p. 153)

French Vergnet

(SOURCE: World Water February 1983)



Photos: Courtesy of L.A. Orihuela

HYDRO PUMP "VERGNET"

From top right, counterclockwise: (1) pump in operation, (2) control pedal, driving piston and cylinder, mounting plate, and attached flexible control and delivery hoses after removal from well, (3) replacing leather cap and piston, and (4) lifting the pumping cylinder from the well. This cylinder contains the elastic expansion chamber and the three valves (suction, delivery, and repriming).

(SOURCE: McJunkin, F. E. 1977 p.155)

BATTELLE/AID PUMP

Battelle/AID Pump Description

In 1966 the United States Agency for International Development (USAID) contracted with the Battelle Memorial Institute-Columbus Laboratories to manufacture a dependable handpump which would be suitable for use in rural areas in developing countries. There are two kinds of Battelle pumps: one, the deep-well pump; and two, the shallow-well pump. In both deep and shallow well pumps, the pump stand is manufactured from pig iron with high skilled casting technology.

Deep-well cylinders were made of PVC which is economic and effective and pump castings can be made locally.

On pump head, two bolted pins are used to connect the pump rod to the handle and to connect fulcrum to the handle.

Steel pipe and leather cup are used as a below-ground component. The configuration of the pump is shown on Figure II-12.

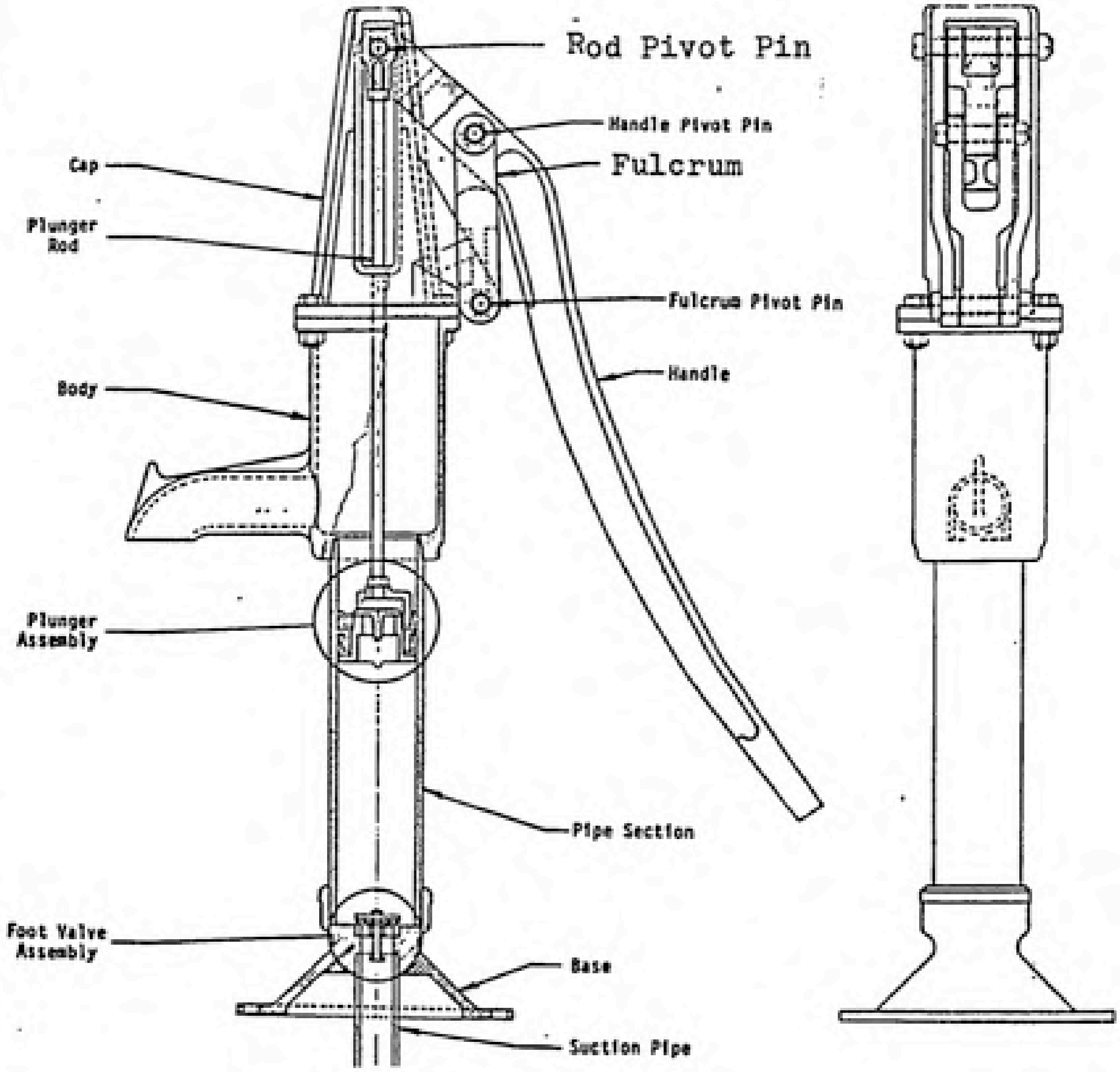
EXPERIENCE

Four Battelle deep well pumps have been installed in Thailand. Conclusions reached after testing are that: (a) PVC cylinders are economic and effective; (b) pump castings can be made locally; (c) some parts such as pump rod extension and pump cap rod guide should be redesigned to eliminate excessive wear.

In Nigeria 100 Battelle deep wells were manufactured. High prices and improper components such as under-sized drop pipe and over-sized pump rod couplings made the pump very difficult to work with 3-inch diameter clyinders at depths of 55 meters.

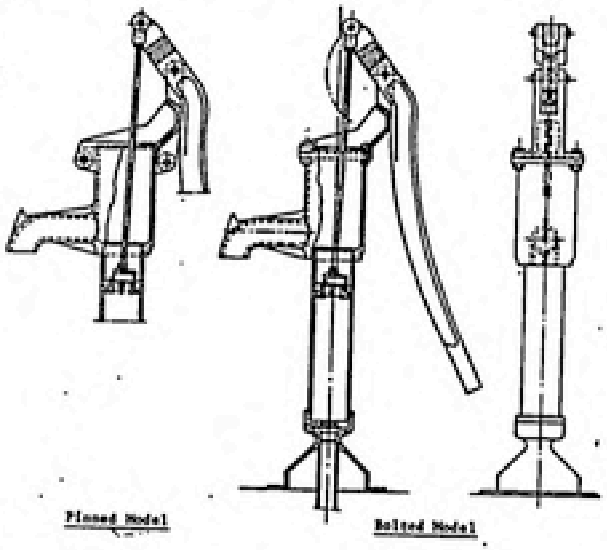
FIGURE II.12 Information About Battelle Hand Pump

BATTELLE PUMP-SHALLOW WELL CONFIGURATION



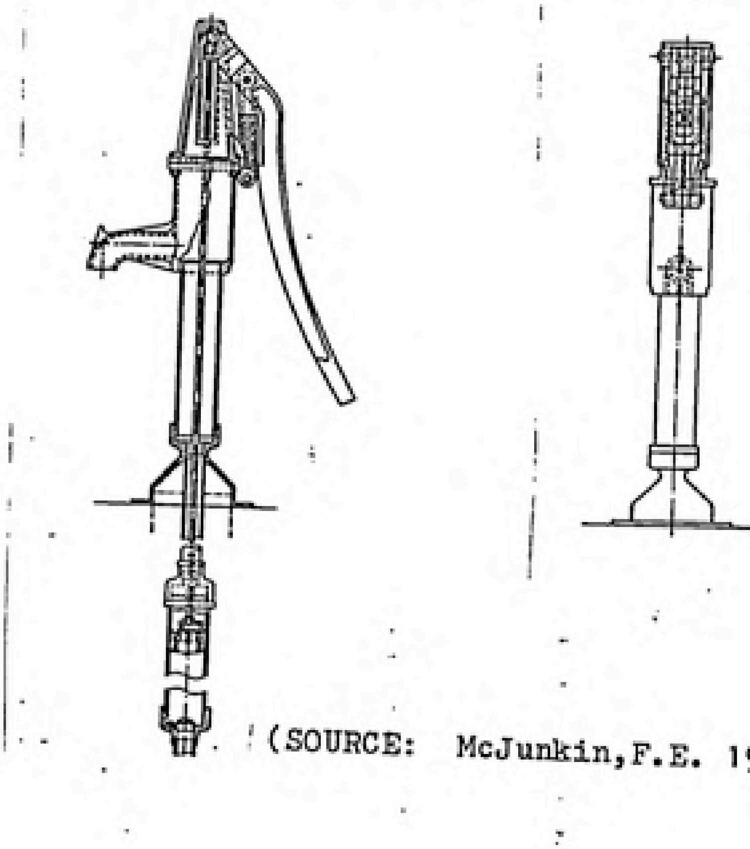
(SOURCE: WASH Field Report August 1982 p.10)

BATTELLE PUMPS-SHALLOW WELL CONFIGURATION



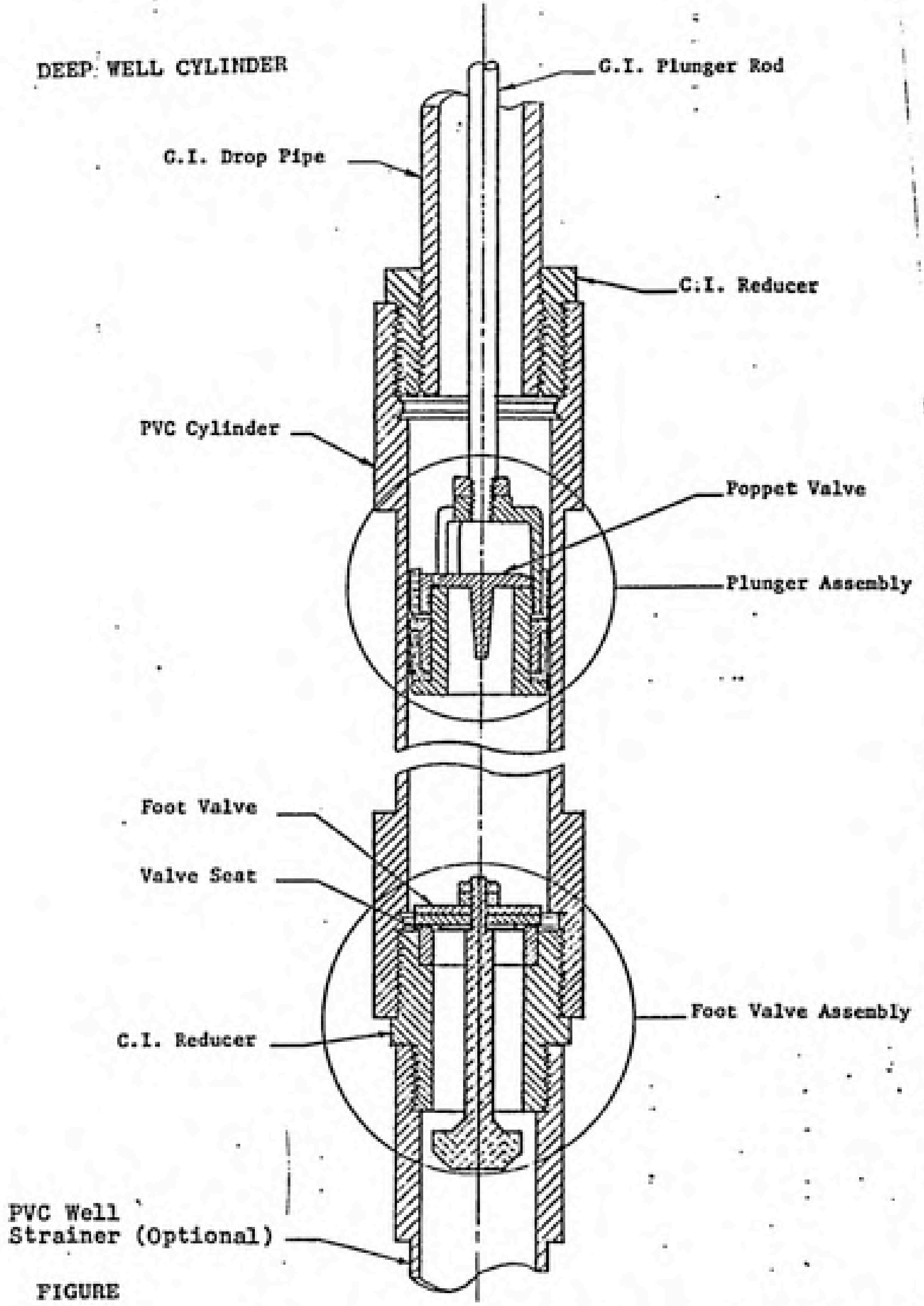
(SOURCE: McJunkin, F.E. 1977 p.133)

Battelle Pumps-Deep Well Configuration



(SOURCE: McJunkin, F.E. 1977 p.134)

DEEP WELL CYLINDER



FIGURE

(SOURCE: WASH Field Report August 1982, p.13)

KANGAROO PUMP

Kangaroo Pump Description

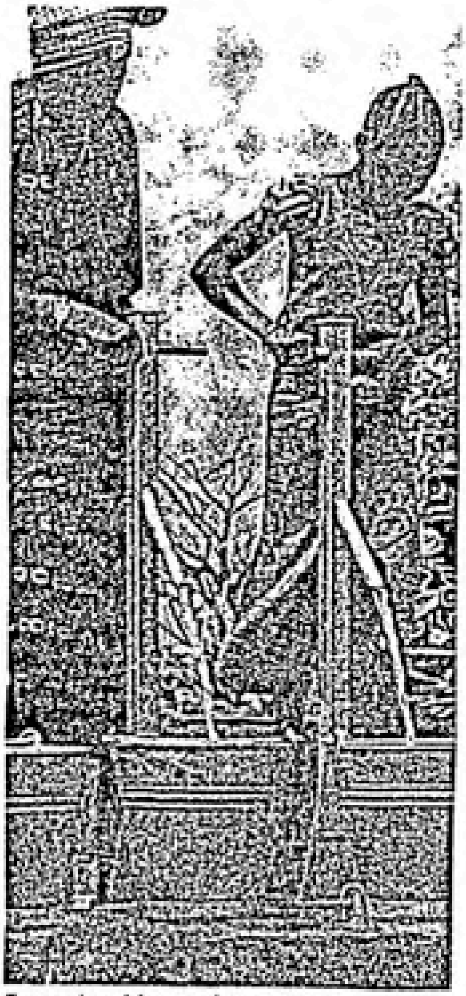
Kangaroo pump (Figure II-13) is manufactured in Dutch. It has been tested in several water supply projects. The pump head consists of two pipes sliding over each other with a spring fitted in between. The outside sliding pipe is connected to the pump rod, and operates the piston in the pump cylinder. The downward stroke serves to compress the spring, which is then left to produce the water discharge upward stroke (McJunkin, FE 1977). The cylinder and drop pipe are the same of the Shinyanza pump, but with a different superstructure, further minimizing maintenance requirements because of the absence of the pump handle. A similar pump has been tested in Ethiopia. This pump is being used in Tanzania.

Performance

Cylinder diameter 4 inches	Up to 6 meters depth
Cylinder diameter 3 inches	Up to 10 meters depth
Cylinder diameter 2 inches	Up to 20 meters depth

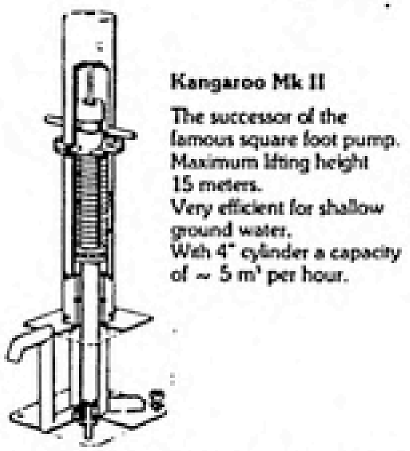
Capacity range is 600-2000 liters/hour. Other Kangaroo characteristics are the same as those of the Shinyanga pump.

FIGURE II.13 Kangaroo Hand Pump

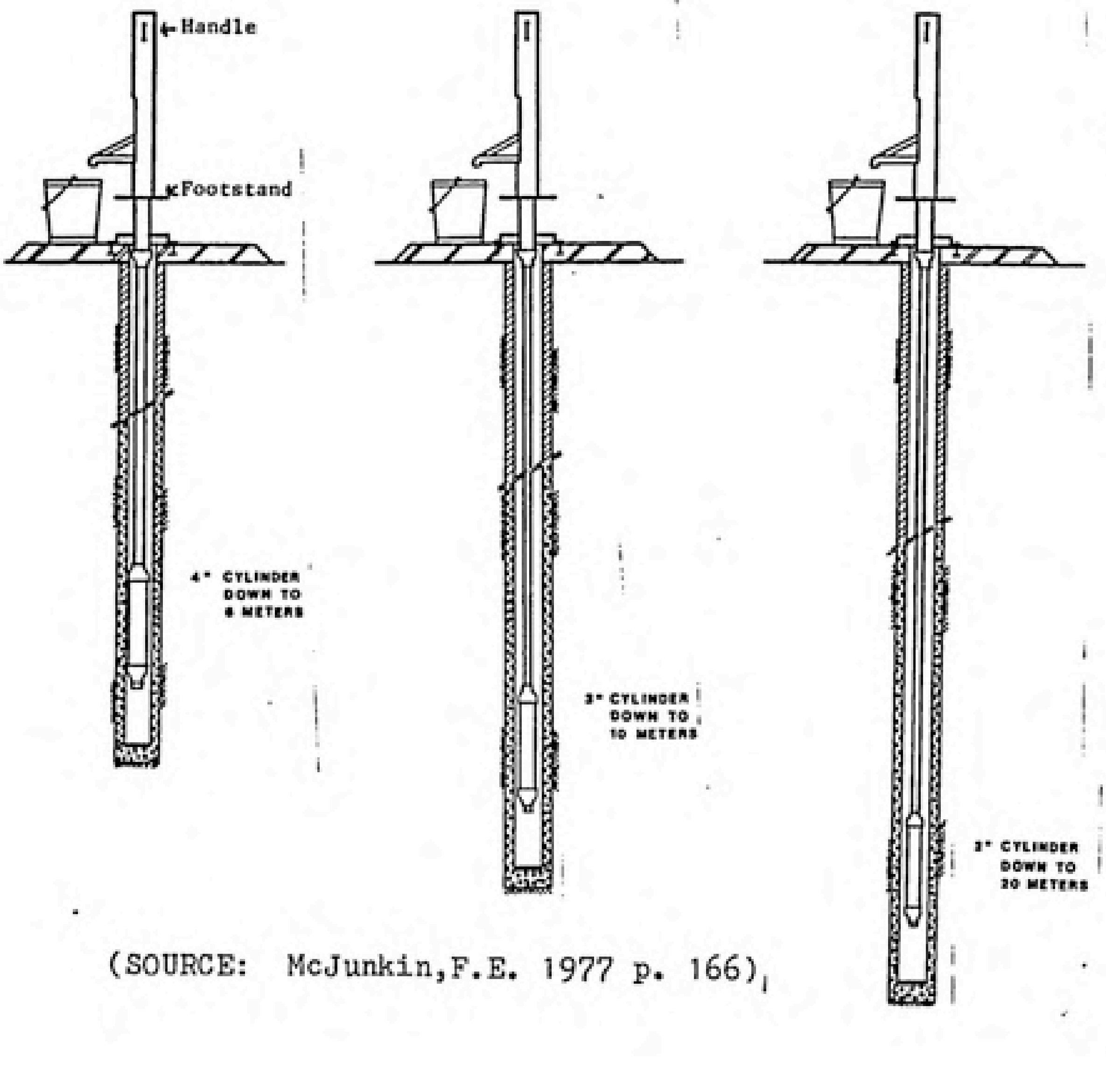


Two pairs of feet to the pumps.

(SOURCE: World Water November 1982 p. 39)



(SOURCE: Waterlines April 1983 p. 33)



(SOURCE: McJunkin,F.E. 1977 p. 166)

KARDIA PUMP

Kardia Pump Description (Deep-well pump)

This pump (Figure II-14) is designed and manufactured by the German company Pressag AG. It is a lift pump with the pump stand made of galvanized steel sheets. All moving parts are covered in the pump stand, avoiding the risk of theft and damage. It is suitable for wells of depths up to 40 m.

Materials of Principle Components

Component	Material(s)
Pump stand	Galvanized steel sheets
Cylinder	SBF PVC
Rising main	SBF PVC

Weights and Measures

Precise values are not available, but the pump was designed and manufactured under the VLOM principle. The minimum diameter of the borehole must be equal to or larger than 100 mm, and with a rising main diameter of 40 mm (African Water and Sewage, September 1983e).

TEST RESULTS

Pump Performance

The capacity of the pump, from depths up to 40 m is 100 liters per hour with only 40 strokes per minute.

EXPERIENCE

Kardia pump was used in Senegal, however precise information is not available, but laboratory tests were performed under the World Bank testing program. The pump was successful in a 4,000 hours endurance test of the Consumer Association Test Program in England. It was concluded that the pump is most reliable with minimum of maintenance and easy to operate by women and children (World Water May 1984a).

ADVANTAGES AND DISADVANTAGES

Advantages

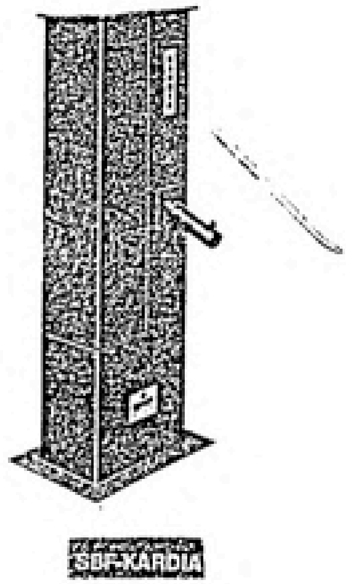
The rising main and cylinder are made from SBF PVC. They are easy and fast to install without special tools and have no corrosion problems.

The concrete well cap is used which prevents contamination.

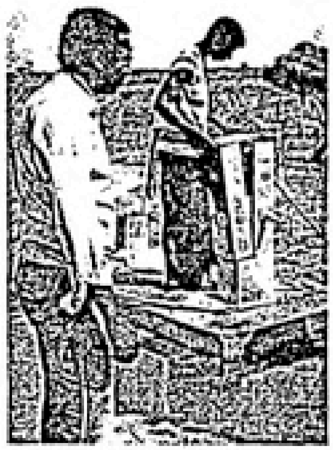
Disadvantages

The short straight spout allows children to put stones and sticks into the pump.

FIGURE II.14 Information About Kardia Hand Pump



(SOURCE: World Water May 1984 p. 55)



Kardia pump installation in Senegal

(SOURCE: World Water May 1984 p.75)

TURNI PUMP

Turni Pump Description

This pump is designed under the VLOM principle and manufactured by the German company Pressage AG. It is a positive displacement pump operated by two cranks. It has a durable and corrosion pump stand and rising main string. It also has a unique, plug-connected pump rod for easy installation. Its own installation rig can be delivered upon request.

Materials of Principle Components

Materials of principle commponents are the same as for the Kardia pump (page 119).

Weights and Measures

The total weight of the pump unit is around 75 kg. The pump was designed and manufactured under the VLOM principle (African Water and Sewage September 1983e).

TEST RESULTS

Pump Performance

The precise values are not available. It was said to have high rates of efficiency through different gear ratios (World Water, May 1984a).

EXPERIENCE

Experience in any country is not available. The Turni pump has recently completed the 4,000 hours endurance test of the UK testing laboratory CATR. Pressay says some of the results were described as excellent. Also it delivers a constant flow of water with an increasing efficiency rate from depths between 3.5 and 60 m. A freewheeling drive prevents damage on reverse rotation of the handles (World Water, May 1984c).

ADVANTAGES AND DISADVANTAGES

Advantages

The drop pipe (rising main pipe) and cylinder are made from PVC and they are easy to maintain.

The pump has a long and angled spout to prevent children from putting stones and foreign matter into the pump stand.

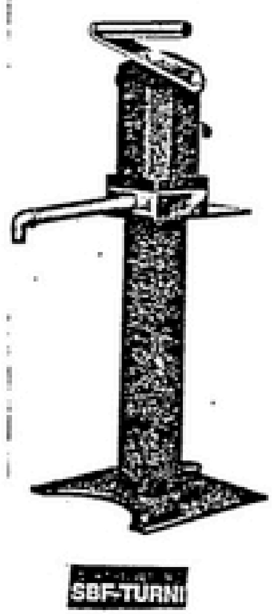
The galvanized steel pump stand prevents vandalism and contamination.

The pump is easily adjustable to different sources of energy: diesel, wind, solar, animal-drive etc.

Disadvantages

Information is not available.

FIGURE II.15 Turni Hand Pump



(SOURCE: World Water May 1984 p.55

WATERLOO (IDRC DEVELOPED) PUMP

IDRC Developed Pump Description (FIgure II-16)

IDRC-developed pump is based on the Waterloo pump, which was designed at the University of Waterloo in 1976 and sponsored by the International Development Research Center. The Waterloo handpump design focuses on simple, low-cost below-ground components for manual shallow-well pumps.

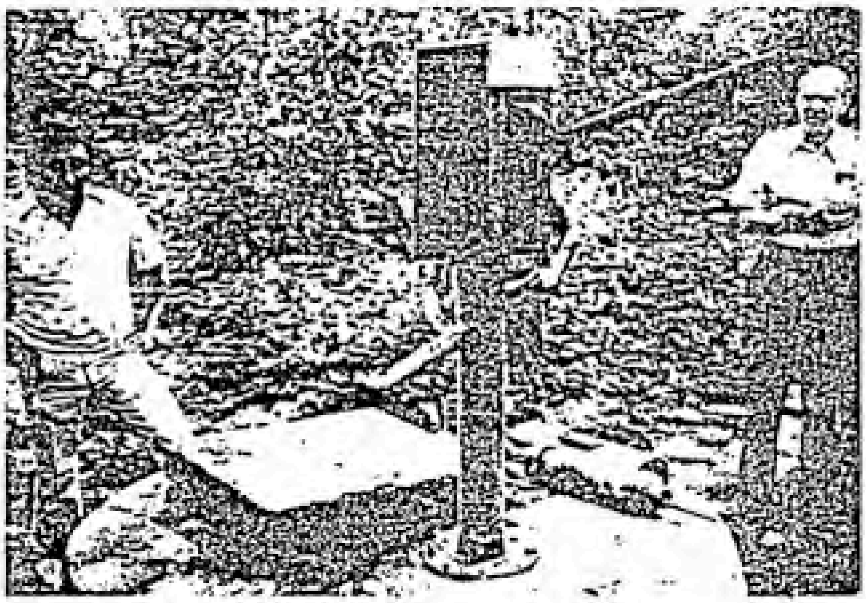
The below-ground components of original Waterloo pump are made of rigid polyvinyl chloride and polyethylene.

In 1977 this design was tested at the Consumers' Association testing Facility in England. The results of this testing program showed that the Waterloo design was reliable and efficient. In 1978, after the laboratory testing was complete, the IDRC conducted research projects in six countries (two in Africa and four in Asia) to field test various parameters of the pump under different environmental conditions. Different versions of the Waterloo pump were used in each country depending on local materials and manufacture.

The IDRC design of the piston assembly consists essentially of polyvinyl chloride (PVC) piston with polyethylene rings or leather cup seals which depended on the materials available in different countries.

Example of IDRC-developed pump installed in Nicaragua is shown in Figure II-16. Detail of IDRC designed pump in four Asian countries can be found in Sharp, Donald and Graham, Michael eds. (1982).

FIGURE II.16 The IDRC Hand Pump



The above photo is of the IDRC-developed pump that was installed at Llano Grande (Site No.7), in Nicaragua. The pump is made of indigenous materials (wood, galvanized iron pipe, and PVC pipe) and represents a design that simplifies hand pumps mechanically by substituting plastic pipe for traditional steel and cast iron. The casing is three-inch PVC pipe that serves as the drop pipe and the cylinder housing the piston assembly (this allows the piston and check valve to be brought up for inspection by pulling up the plunger rod without disassembling the drop pipe). Both piston and check valve are made of the same interchangeable components: perforated plastic discs with flapper valves covering the holes. The pump handle is made of standard galvanized iron pipe and the pivot points use oil-impregnated wooden bearings.

(SOURCE: Office of International Programs Engineering Experiment Station Georgia Inst. of Technology, Jan. 1979 p. 45)

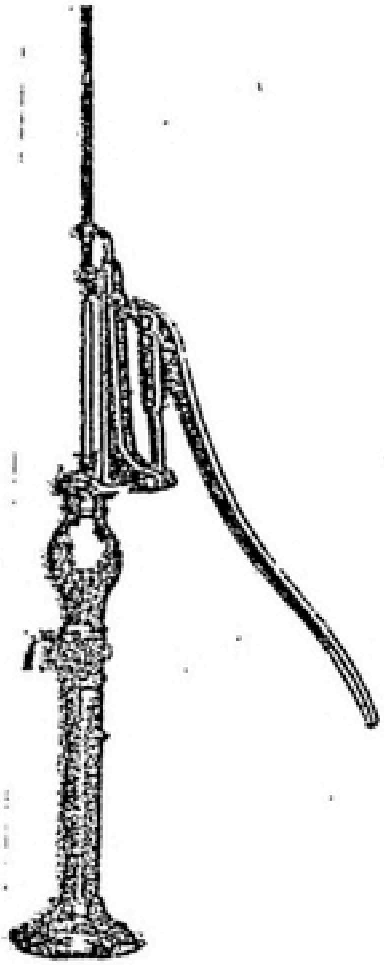
DEMPSTER HANDPUMP

Dempster Pump Description

Dempster handpumps have several models. Figure II-17 shows Model 210F. These pumps are adapted for wells of any depth. They are neat in design and substantially built. They are equipped with a 4-bolt adjustable flanged top, extra long handles and heavy steel bearer pins. Tops are fitted with stuffing box and packing for a tight seal on the piston rod. The 4-position handle adjusts for up to 10-inch stroke and there is a large capacity air chamber for smooth pumping force.

In 1977 Dempster pump was chosen with which to compare the AID pump field test in Costa Rica. More information is not available. Laboratory tests were performed on Dempster model 23F(CS).

FIGURE II.17 Dempster 210F Hand Pump



(SOURCE: Office of International Programs Engineering Experiment Station Georgia Inst. of Technology, Jan. 1979 p. 20)

"ABI" HAND PUMP

"ABI" deep-well pump is made in Ivory Coast and field tested in Ivory Coast, Mali and Upper Volta.

More information is not available.

FIGURE II.18 "ABI" Hand Pump

"ABI"

THIS HAND PUMP IS USED IN WEST AFRICA

(SOURCE: McJunkin,F.E. 1977 p.151)

III. PUMPS WITH DESCRIPTION AND FIELD EXPERIENCE

INTRODUCTION

This chapter includes information on all pumps with field experience but no independent laboratory testing.

TABLE FOR PUMPS WITH FIELD EXPERIENCE

COUNTRY OF ORIGIN	NAME	DEEP OR SHALLOW	FIELD TESTING COUNTRIES
Zimbabwe	Blair	Shallow	Thailand, Papua New Guinea, China, Malawi, Tanzania, Sudan, Kenya
Thailand	Plastic Pipe	Both	Thailand, Korea
Nigeria/Indonesia	Bamboo	Shallow	Indonesia, Nigeria, China
Belgium	Deplechin	Deep	Mali, Niger
Tanzania	Shinyanga	Shallow	Tanzania
Brazilia	Marumby	Shallow	Nicaragua
Japan	Lucky	Shallow	Thailand, Costa Rica

BLAIR PUMP

Blair Pump Description

This pump (Figure III-1) was designed by the Blair Research Laboratory, Salisbury, Zimbabwe in 1976 and finally improved for mass manufacture by prodorite. The Blair pump is a very simple pump with a galvanized iron "Walking Stick" handle (the only one above ground part), which functions both as pump handle and water spout. Below ground, the pump is basically two plastic cylinders, one inside the other. Two identical valves are fitted at the base of cylinders. The walking stick handle is attached to the inner pipe which is the moving piston. As it is lifted up and down, water is forced out of the hollow handle.

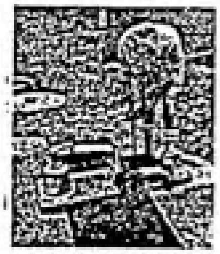
Principle of Blair Pump Operation

Figure III-2 shows a hand-operated shallow well Blair pump. The pump design includes a piston assembly with a hollow pushrod and water spout (galvanized iron 'walking stick' handle) at one end, and a fixed cylinder assembly.

FIGURE III.1

Blair Hand Pump

SOURCE: Data Sheet-Prodorite Ltd. Harare (   ) p.4



Blair (Zimbabwe/Malawi)

(SOURCE: World Water February 1983)

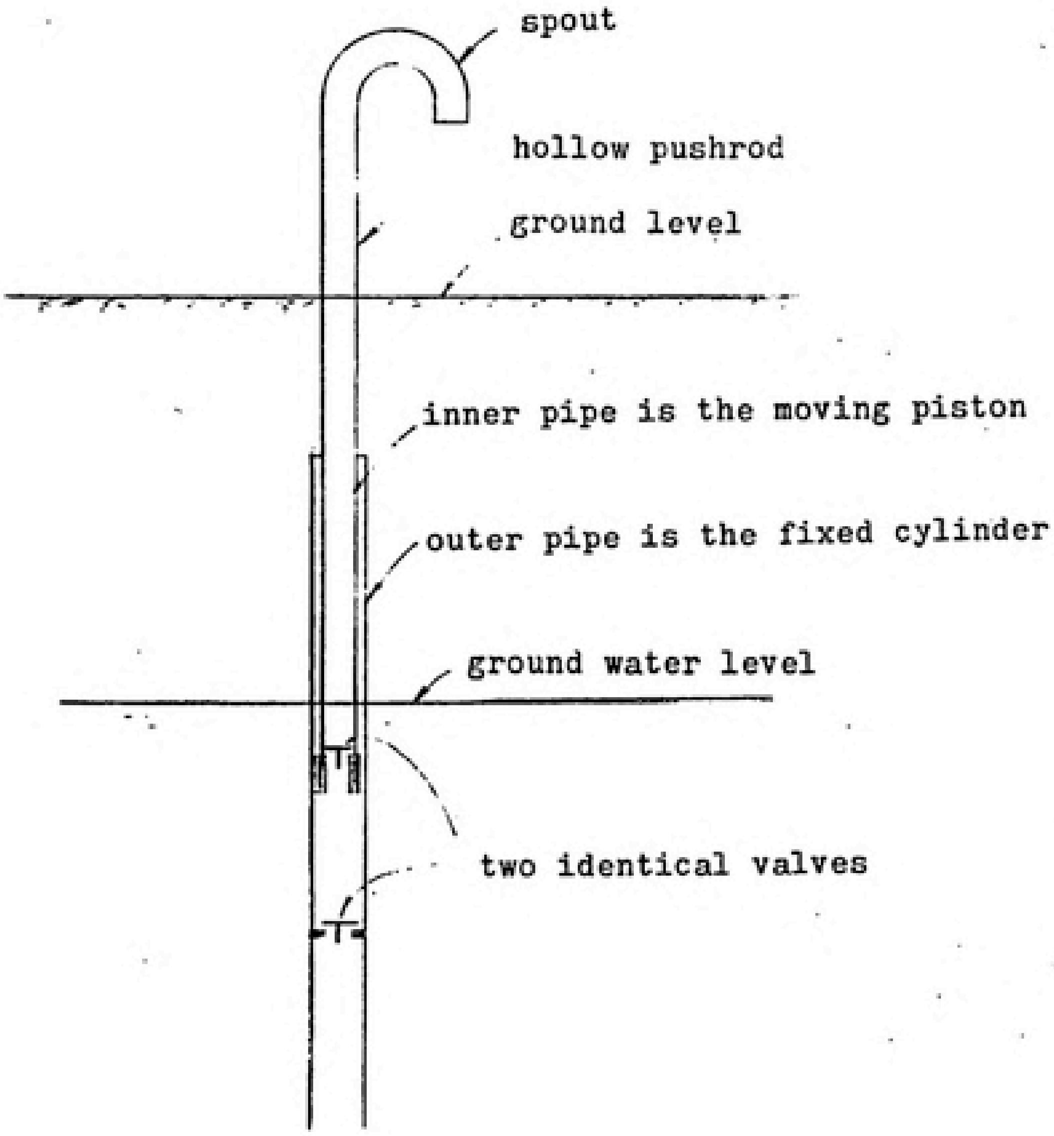


FIGURE III.2 Blair Pump

The following steps outline the principle of Blair Pump operation

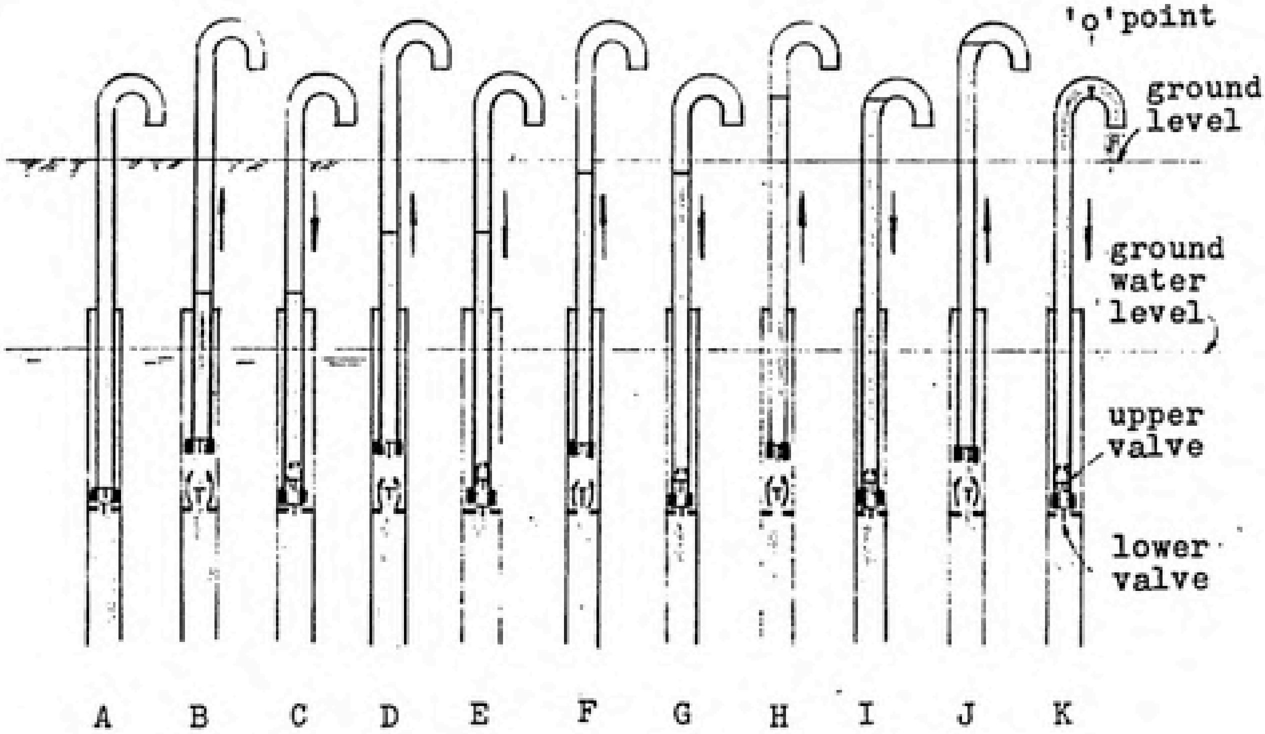


FIGURE III.3 ILLUSTRATION OF OPERATION OF BLAIR PUMP

1) Before pumping begins the piston is down. Water fills the cylinder up to ground water level as shown in step A.

2) When the piston is lifted, the upper valve is closed and the water inside the inner pipe is lifeted, the lower valve opens, due to ground water pressure, and water enters the cylinder as shown in step B.

3) When the pushrod is forced down, the lower valve is closed. Due to the incompressibility of water, the upper valve opens and water is forced into the inner pipe (hollow pushrod) as shown in step C.

4) Steps D, F, H and steps E, and G are the same as step B and step C, but the water in the inner pipe is as shown in fitures D through H.

5) Until the downstroke in step I the water rises in the pushrod up to the "O" point.

Step J lifts the column of water and at the downstroke, step K, the water comes out of the spout.

After step I, every upstroke will lift the column of water and downstroke will deliver the water (Figure III-3).

Some features of the Blair pump are:

- Leather seal and lever mechanism are eliminated.

- The pump does not depend on precision fitting or seals to function.

- The inner PVC pipe (or piston) moves within the other pipe (or cylinder) lubricated by water which is present between the two during the pump's downstroke.

- Adequate quantities of water will be delivered for domestic purposes even if valves and piston leak.

- Installing the pump also is very simple, inserting and screwing into a pre-cast concrete head block that is cemented to the existing concrete slab, protecting and sealing the well.

- Since the pumping motion is like the local way of grinding maize, it is easily operated even by a teenage girl or boy.

- The only maintenance required is to clean the foot valve. This can be dismantled by one person with simple tool, a monkey wrench. The PVC piping is easily lifted even with the deeper installation pumps.

Materials and Principle Components

Above-ground components: galvanized iron

Below-ground components: two cylinders made from specially compounded grade of uPVC. Outer cylinder is made from 50 mm PVC pipe. Other information is not available.

Weights and Measures

Total weight of 15 m length pump inner pipe including water is almost 10 kg. The local handman who has taken on responsibility for installation could easily lift pipe and water without help. Blair pump was initially designed as a shallow-well handpump operated at depths of 6 m or less.

TEST RESULTS

Pump Performance

Precise values for the pump performance are not available. In average village operating conditions, the pump delivers 20 liters per minute and doubling this volume is possible. A young teenager would use 30-40 strokes to fill a bucket.

EXPERIENCE

Many unprotected shallow-wells at depths of less or equal 6 m scattered around the remoter rural areas of Zimbabwe can be installed with Blair pump with reasonable cost and performance. Blair pump has performed well at depths of up to 15 m and Prodorite is currently monitoring over a period of time a pump installed in an 11.5 m deep communal well. This pump has been deliberately sited near a village shop where it will suffer regular rough handling. So far, after a year, there is no sign of wear or weakness (World Water, May 1982).

According to Prodorites managing director, Ernest Berk, Prodorite's mass produced version has gone further and is now a "no-maintenance unit" (World Water, May 1982). They have set up a laboratory test to simulate the use for 20-30 years by three to five families. The pump has shown no sign of wear. Another example is that precision fitting or seal is unnecessary when one of Prodorite's pumps installed at a village school continued to work after a valve's rubber ball broke.

Three different kinds of installation of Blair pump shown that the success of the pump is the extreme simplicity of its operation. It can be used in Zimbabwe and in many other developing countries which are generously endowed with ground water with 6 m of the sample.

ADVANTAGES AND DISADVANTAGES

Advantages

Since the above-ground part is iron walking stick, it is corrosion resistant. There is no removable parts so avoid to damage or steal.

The pump is a pressure developing unit and does not depend on the lift principle.

The components are light, it is easy to transport from manufacturer to site.

The pump has eliminated seals and levers and is lubricated by water that has "leaked" between the moving cylinder (piston) and stationary cylinder (outside PVC pipe) when the pump moves towards downstroke. It is easy to maintain.

It can be made locally in Zimbabwe and Malawi, where manufacturing standards would be maintained. The spare parts can also be provided easily without foreign exchange.

It is easy to handle the working motion, during operation. Users found that it is easy to bring several muscle groups into play.

Disadvantages

The high and rigid quality control throughout the manufacturing process is not available to some developing countries, thus in those countries Blair pump only can be used at water depths of less or equal 6 m below ground.

PLASTIC PIPE PUMP

Plastic Pipe Pump Description

The major idea is the use of smooth polyvinyl chloride pipe which is now available in most countries at lower cost than using a brass cylinder or a thin brass liner which has been used in the standard pump (conventional pump). The use of the PVC pipe will also prevent rapid wear and replacement of the leather cups or buckets.

The unusual feature of this pump is that the pump handle is supported on a separate post beside the well and the pump stand. Since the pump stand does not bear the load and stress caused by the handle, it does not have to use strong materials such as cast iron.

PVC pumps are designed to be simple, inexpensive, and easy to maintain and repair, and make maximum use of local materials and skills. For example, the post can be made of concrete, bricks or wood, and the handle can be made of wood or bamboo, which can be replaced locally when worn or broken.

Some feathers of these pumps are:

At shallow-well, the pump stand is a length of 3" PVC pipe also acts as the pump cylinders (Figure III-2A).

- Below-ground component is only the 1.5" PVC suction pipe suspended from the pump stand which to be set firmly in the concrete or brick platform, the spout needs to be a 2" hole in the side of the PVC pump stand with a small lip.

- The rods can be imported metal in shallow well or local wood rods.

At deep-well pump in cased well (Figure III-2B)

- If the water level is less than 50 feet below the surface 3" PVC casing is used, unless a 2.5" or 2" PVC casing may be required to ensure the pumping of water without much exertion.

- Most of time wooden rods are used.

At deep-well pump in uncased well (Figure III-2C)

- In this situation the 4" PVC casing only attaches to the rock.

- Four-inch PVC or cast iron pump stand is fixed on the support plate.

- Metal or PVC discharge pipe is used.

- Three-inch PVC cylinder contains the lower valve and the piston. If the cylinder is made of metal, it should have a PVC pipe liner to provide a smooth surface.

- The rod passes down through the discharge pipe.

- Every 20 feet on the discharge pipe and the pump rod there is a clamped or threaded joint.

EXPERIENCE

Plastic pipe pump has been developed in Thailand. It delivers about 15 US gallons per minute. It is suitable for irrigation and domestic purposes and a simplified piston with a rubber bucket is used in Korea, and this should be much less expensive than the standard type one.

ADVANTAGES AND DISADVANTAGES

<u>Advantages</u>

It is a very simple configuration pump and all the materials can be found locally.

It is easy to maintain. To remove the piston and replace the leather bucket, all the thing needed is to disconnect the rod from the piston, and the poppet type valve can be fished out using a wire with a hook at the end.

Most developing countries now have plants to extrude PVC pipe. The seal is usually a leather disc or molded rubber. These are not expensive in many countries such as India, Pakistan, Korea, Thailand can be obtained.

Disadvantages

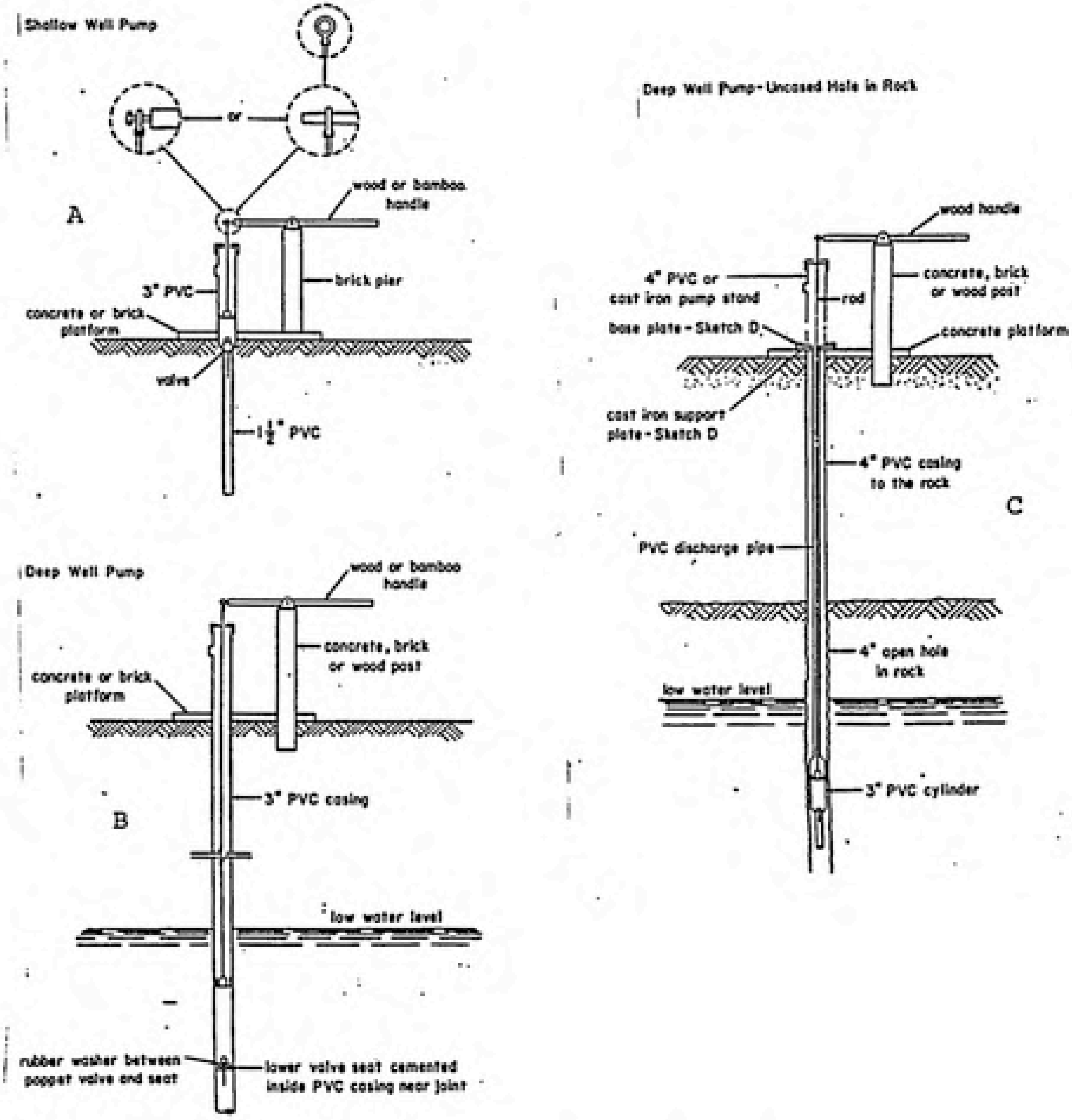
To manufacture the PVC pump, quality control is very important, if the good seal (leather or rubber bucket) is to be obtained. Actually in some developing countries, it is impossible to maintain the rigid quality control.

Plastic pump stands are less sturdy and more subject to wear and breakage than stands of other materials.

Pumping sand in plastic cylinder results in rapid wear, but this shortcoming can be eliminated by carefully developing the well to stabilize the aquifer.

Many plastics are sensitive to ultraviolet radiation and should not be constantly exposed to sunlight.

FIGURE III.2 Plastic Hand Pump



(SOURCE: Spangler,C.D. 1975 p.6-8)

BAMBOO PUMP (NIGERIA AND INDONESIA)

Bamboo Pump Description

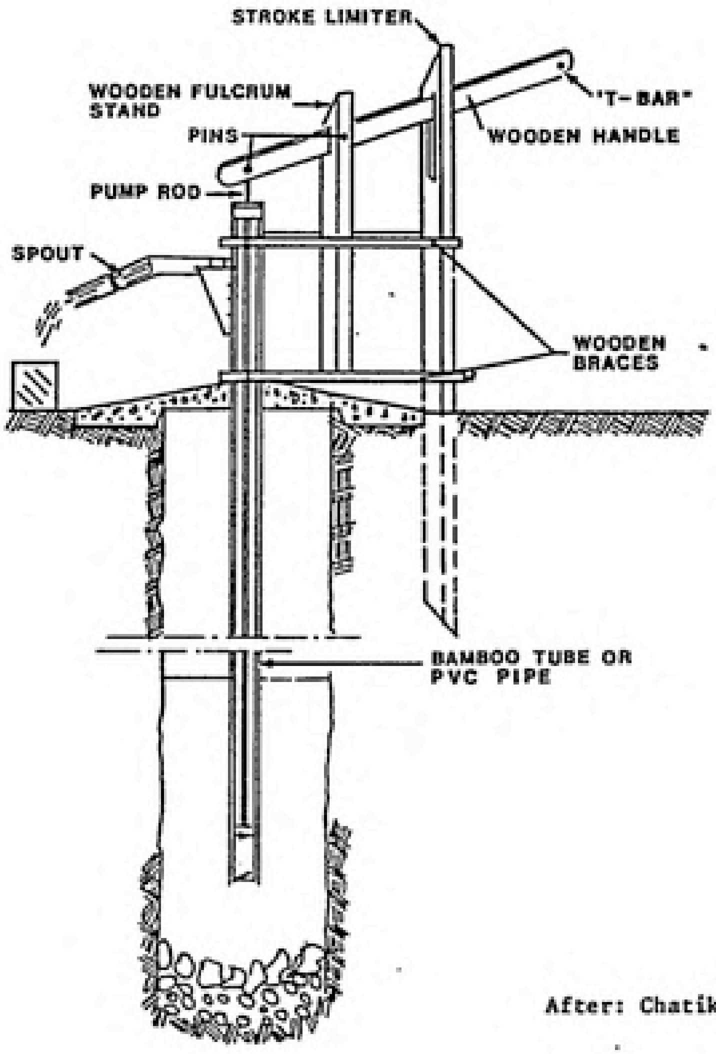
Properly constructed and maintained Bamboo pump, with light use, may last several years. They may be an economic choice in some situations; for example, pumps are used by households. Figure III-3 shows the "DIY" pump used in Nigeria (Chatiketu) (McJunkin, FE 1977). Another type of Bamboo pump developed by Mr. Yusuf and used in many families in the area of Tasikmalaya and Cianjur, Indonesia and in West Java for decades, lifted the water up to a depth of 8 m. The raw material used in the pump such as wood, bamboo, fiber, rubber, etc. are found everywhere in the countryside of Java. Since the pump configuration is simple, a skilled draftsman can construct the pump in only 2 days. The drop pipe and cylinder are made of bamboo, valves of rubber, and the piston is made of leather. In south of China where bamboo is available, pumps are used to deliver water for drinking.

The advantages of this pump are: cheap, easy to construct, it can be repaired by villagers and.made locally.

Disadvantage: it is not durable.

FIGURE III.3 BAMBOO HAND PUMP (GENERAL)

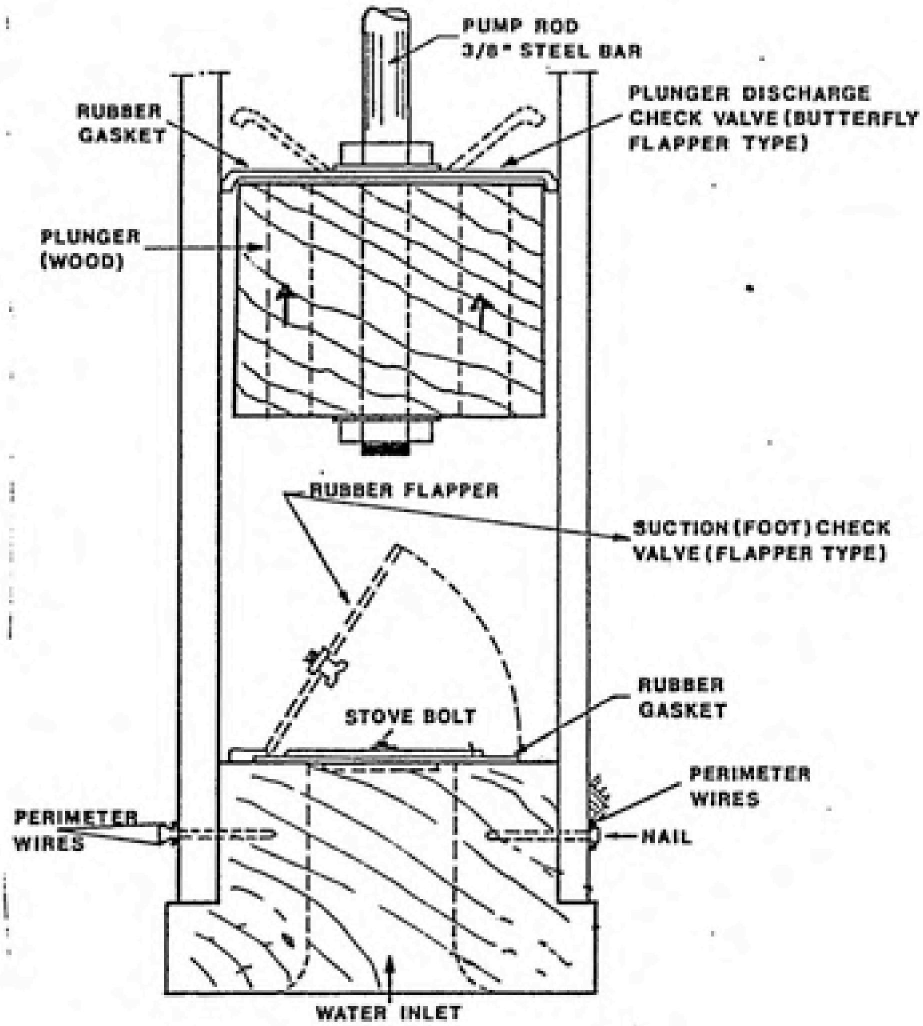
Bamboo Hand Pump



After: Chatiketu

(SOURCE: McJunkin, F.E. 1977 p. 191)

BAMBOO HAND PUMP (VALVES)



(SOURCE: McJunkin, F.E. 1977 p. 192)

DEPLECHIN (BELGIUM)

Deplechin Pump Description

- Deplechin pump (Figure III-4) is designed to give a minimum of 25 years continuous operation.

- Have been sold world wide for 35 years.

- Capacity up to 3260 liters/hour; lift up to 95 m.

- Parts below ground level PVC coated against corrosion.

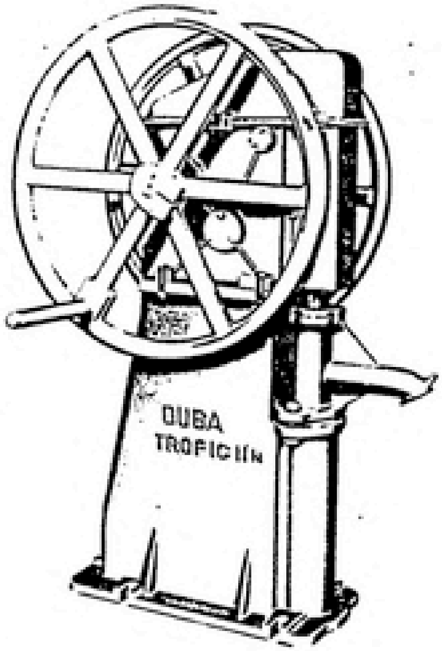
- Manual operation easily modified by adding diesel, animal or other mechanical drive.

- Easily installed and requires virtually no maintenance.

- Can be used for small community potable water supply and irrigation. (World Water, 1982)

Deplechin pump has been field tested in Niger and Mali, but information is not available.

FIGURE III. 4 Information About Deplechin Hand Pump



DEPLECHIN SPRL — Avenue de Maire 28 — B 7500 TOURNAI (Belgium)

Tel. 00-32-69-228152 — Telex 57399

(SOURCE: World Water November 1982 p. 46)

SHINYANGA PUMP

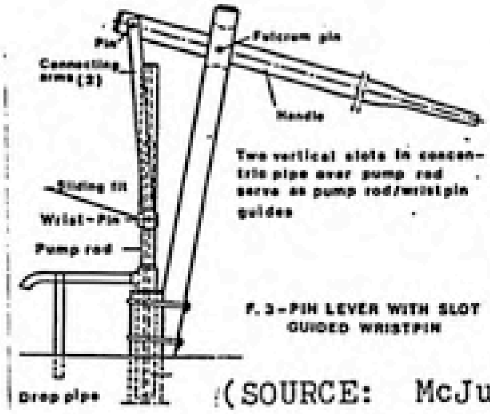
Shinyanga Pump Description

Shinyanga pump is used in Shinyanga District Shallow Wells project in Tanzania, october 1974. It is made in Shinyanga, Tanzania. The pump is based on the Craelius Uganda pump. Instead of a brass cylinder, the pump uses a polyvinyl chloride (PVC) plastic cylinder. A special imported cup seal is used which will last longer than the rest of the pump (maybe ten years). Also neoprene ball valves are used.

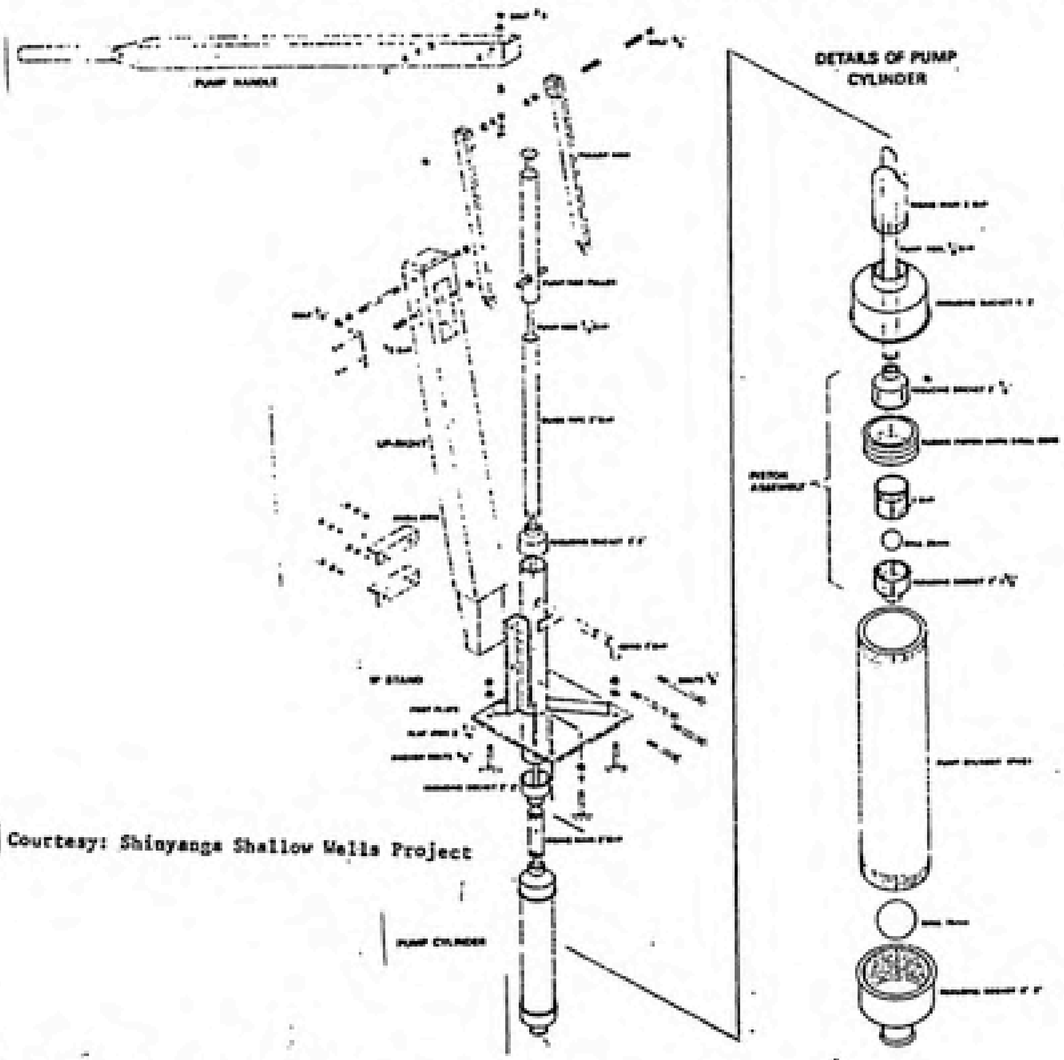
More information is not available.

FIGURE III.5 Shinyanga Hand Pump

Pump Stand and Handle



(SOURCE: McJunkin, F.E. 1977 p.67)



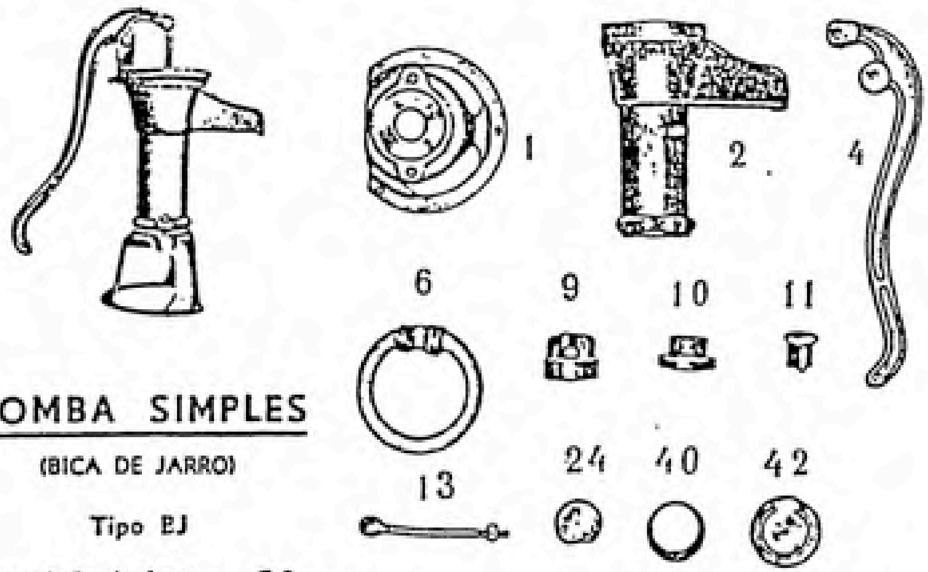
Courtesy: Shinyanga Shallow Wells Project

(SOURCE: McJunkin, F.E. 1977 p.185)

MARUMBY PUMP

In 1978, Marumby pump (Figure III-6) was chosen with which to compare the AID pump field test in Nicaragua. More information is not available.

FIGURE III.6 Marumby (Brazilian) Hand Pump



BOMBA SIMPLES

(BICA DE JARRO)

Tipo BJ

Para cano de 1¼" com pistão de ferro CrS____

ESPECIFICAÇÕES:

Sucção cano de (Suction tube)	1¼"	
Altura do corpo (Height of body)	280	mm.
Diâmetro interno do cilindro (ID of cylinder)	80	mm.
Rendimentos em 55 movimentos do pistão por minuto (Flowrate/min.)	22	L.
Sucção até (Suction depth)	7	m.
Pêso liquido (Weight of liquid)	13	kg.

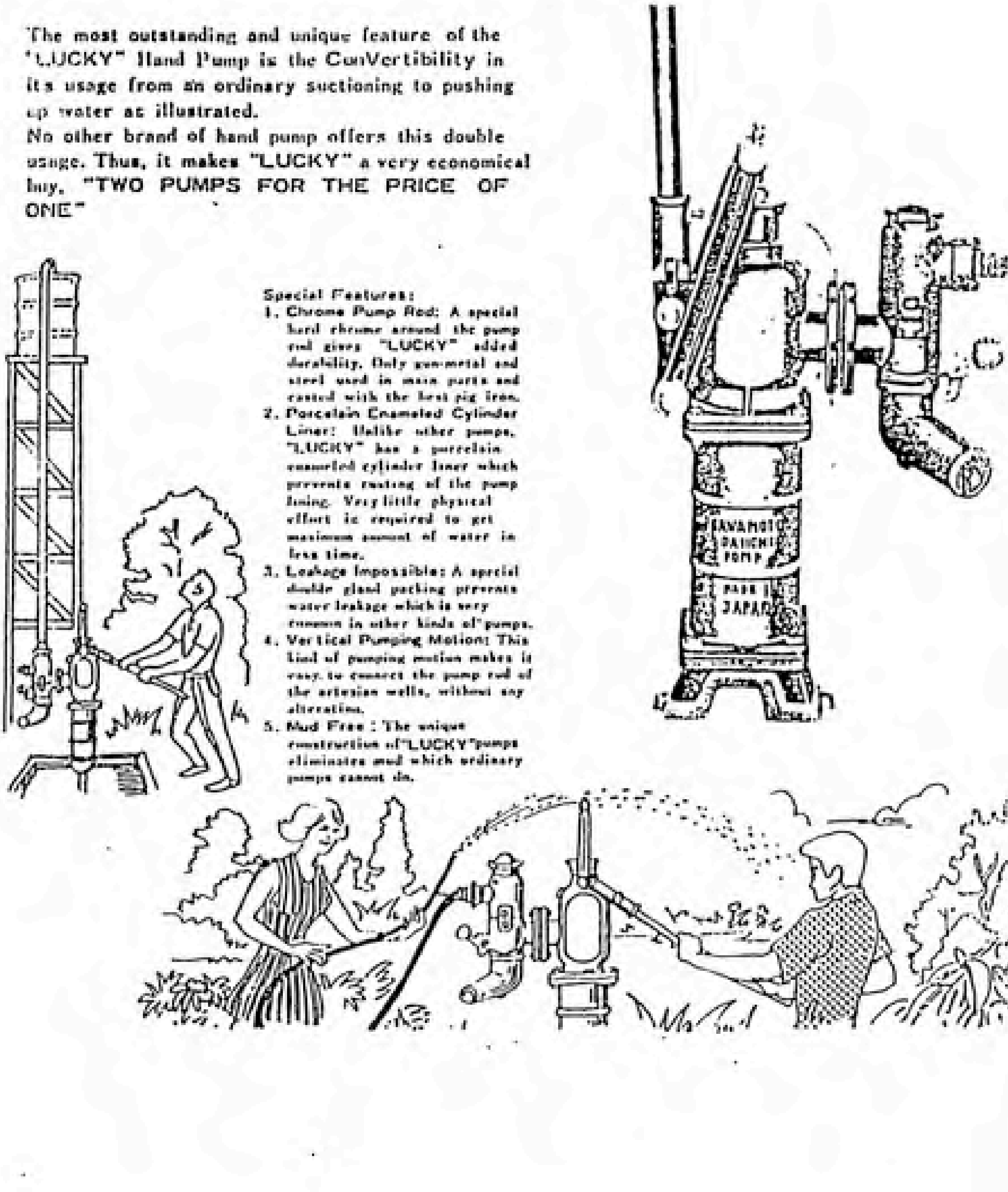
Peca n.º
1 - Prato (Plate)
2 - Corpo (Body)
4 - Alavanca (Handle)
6 - Anel suporte alavanca (Support ring)
9 - Corpo do pistão (Piston body)
10 - Porca do pistão (Piston nut)
11 - Válvula do pistão (Piston valve)
13 - Haste do pistão (Piston rod)
24 - Pêso da válvula (Valve weight)
40 - Manga de couro (Leather sleeve)
42 - Válvula de couro p/ prato (Leather valve for plate)

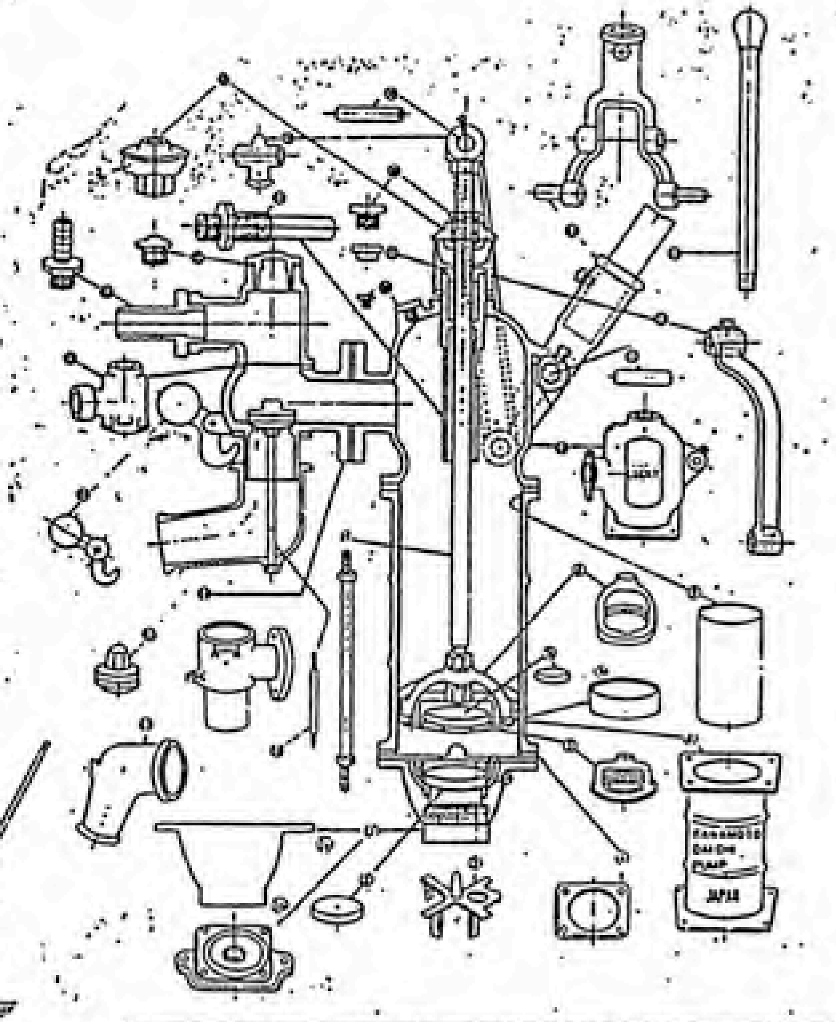
(SOURCE: Office of International Programs Engineering Experiment Station, Georgia Inst. of Technology, Jan. 1979 p.46)

LUCKY HANDPUMP

Lucky handpump is manufactured in Japan, the following information is obtained from manufacturers.

FIGURE III.7 Information About Lucky Hand Pump





- DRIVEN SUCTION VALVE BOX
- DUG SUCTION VALVE BOX
- VALVE
- VALVE GUIDE
- RUBBER PACKING
- LOWER PISTON
- CYLINDER
- BOWL RUBBER
- PISTON VALVE
- UPPER PISTON
- SLEEVE PORCELAIN ENAMELED
- CHAMBER
- HANDLE PIN
- DOUBLE ROD
- STEEL-PIPE HANDLE
- LEVER
- UNIVERSAL SPOUT
- FAUCET BOX
- FAUCET VALVE
- VALVE SPINDLE
- PISTON ROD
- STOP WATER WEIGHT
- FAUCET COVER
- UPPER FAUCET
- HOSE COUPLING
- INNER GLAND BOX
- GLAND BOX
- LEAKAGE SPOUT
- INNER GLAND
- GLAND
- ROD HEAD
- GUIDE PIN

DRIVEN-WELL

The underground water is sucked up through a suction pipe that is driven directly underground.

Art. No.	Sort of Well pump	Inside Diameter of Suction Pipe	Suction Capacity Per Hour	More Than Suction Lift	More Than Pushing Lift	Weight
G-700	Driven	1 1/4"	1,100 imp. gallon	30 feet	50 feet	20 kg
G-701	Driven	1 1/4"	1,100 imp. gallon	30 feet	50 feet	20 kg
G-702	Dug	1 1/4"	1,100 imp. gallon	30 feet	50 feet	20 kg
G-703	Dug	1 1/4"	1,100 imp. gallon	30 feet	50 feet	20 kg

AVAILABILITY:
Good for every existing dug well and fit for driven wells.

USE:
General home use, sucking, pushing up to a height, fire-preventing and watering.

SPECIFICATION:
Vertical size, 85cm high, steel-pipe handle of 70cm long equipped.

(SOURCE: Office of International Programs Engineering Experiment Station, Georgia Inst. of Technology, Jan. 1979 p.22-23)

IV. PUMPS WITH DESCRIPTION AND LABORATORY TESTING

INTRODUCTION

This chapter includes information on all pumps with laboratory testing but no field experience. The laboratory testing was performed by Consumers' Association Testing and Research Laboratory in England.

PUMPS WITH LABORATORY TESTING BUT NO FIELD EXPERIENCE

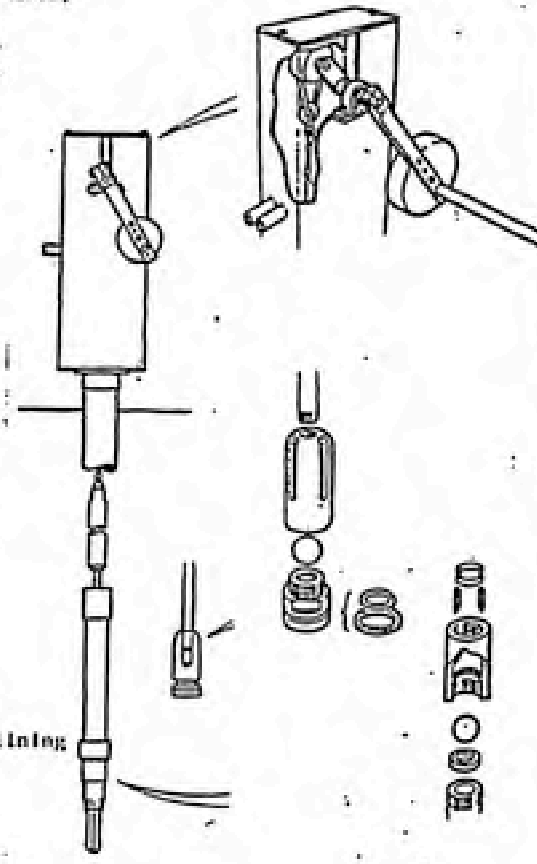
COUNTRY OF ORIGIN	NAME	DEEP OR SHALLOW
Austria	Vew A18	Deep
Ethiopia	Ethiopia BP50	Shallow
France	Nepta	Deep
Honduras	Fungmaq	Deep
Indonesia	Bandung	Shallow
Indonesia	Sumber Bangu	Deep
Japan	Drogon No. 2(D)	Deep

153

VEW Pump Description

The VEW A 18, made in Austria, is a reciprocating, deep-well force pump, with a rotary operating mechanism. The pump uses a cable rather than rods. The pumpstand is fabricated from stainless steel plate, with ball races for the crank pin and journals. As delivered, the top of the cable was attached to a saddle with the outer ring of two ball races running in a track in the crank pin. The handle counterweights were originally fitted on separate arms, at 90° to the handles themselves. The twin handles make the pump suitable for operation by two people, and two spouts are provided.

The heavy cylinder can be withdrawn through the 4 inch rising main and snap fits in a fixture at the bottom of the rising main. The maximum outside diameter of the below-ground assembly is 127 mm. The plunger seal is PTFE, backed by a concealed rubber O-ring. The plunger and foot valves use stainless steel balls.



Materials of Construction

COMPONENT	MATERIAL(S)
Pumpstand	Stainless steel
Handle	Mild steel
Bearings	Proprietary ball races
Crankshaft	Mild steel
Connecting link	Mild steel
Cylinder	Extruded brass with hard chrome lining
Cylinder end fittings	Stainless steel
Foot valve	Stainless steel
Dip tube	Stainless steel
Plunger assembly	Stainless steel body, brass rod, PTFE seal
Cable and counterweight	Stainless steel

WEIGHTS and MEASURES

Weights	Pumpstand	84.8 kg	Counterweight	14.0 kg
	Cylinder assembly	19.8 kg	Strainer assembly	11.5 kg
	Cable	0.2 kg/m		
Dimensions	Nominal cylinder bore:	70 mm	Outside diameter of below-ground assembly:	127 mm
	Actual pump revolutions:	180 mm		
	Nominal volume per rev:	693 ml	Maximum usable cylinder length:	390 mm
	Drop pipe size:	4 inches		

Manufacturing Techniques

The manufacturing techniques required to make the pump are listed below:-

Above-ground Assembly	Steel fabrication (including stainless steel) Presswork	Machining Flame cutting

The pumpstand demands considerable skill in manipulating and welding stainless steel, and heavy equipment to deal with the generous material sections.

Below-ground Assembly	Machining Hard chrome plating	Plastic moulding

The below-ground assembly demands machining to close tolerances, and considerable quantities of stainless steel bar stock. Some sophisticated manufacturing technologies and strict quality control would be essential.

Ease of Installation, Maintenance and Repair

Ease of Installation

Heavy lifting tackle will be essential to handle the 4 inch rising main, and could not readily be substituted by extra manpower. A cable-cutting tool will be needed. The pipe wrenches must be large enough to cope with 4 inch pipe. The base of the pumpstand is threaded 4 inch API and not to the more common ISO Standard pipe thread.

Ease of Pumpstand Maintenance and Repair

In its modified form, the pumpstand is unlikely to demand frequent attention. The crankshaft assembly must be replaced as a unit, however. The pumpstand need not be removed from the wellhead.

Ease of Below-ground Maintenance and Repair

The cylinder may require replacement of the plunger seal. Until recently, the manufacturer did not recommend this to be carried out on site. Replacement of the complete cylinder was preferred. However, we have been advised that the cylinder is now easier to dismantle in the field. The cylinder assembly can be extracted without removing the rising main, using the operating cable. The cylinder is heavy, but it may be possible to improvise the crankshaft assembly as a simple lifting tackle. If the cable breaks, it may be difficult to extract the cylinder.

PUMP PERFORMANCE Volume Flow, Work Input and Efficiency

The description of the method can be found in the Test Procedure.

HEAD	7 m			25 m			45 m		
Nominal pumping rate (revs/min)	30	40	50	30	40	50	30	40	50
Vol/rev (litres)	0.68	0.68	0.69	0.65	0.65	0.66	0.62	0.63	0.64
Work input/rev (J)	121	93	87	280	266	339	429	456	765
Efficiency (%)	38	49	53	56	59	47	63	60	36

ENDURANCE. A detailed description of the endurance test method can be found in the Test Procedure.

General Comments

The pump was tested at 40 revolutions per minute at a simulated head of 45 metres and failed after only 152 hours. The tendency of the operating cable to twist under tension had made the bearing saddle run out of true, causing rapid wear of the saddle and the crankshaft. Both were replaced, and a swivel was fitted in the cable. The handle broke at 277 hours, and the replacement bearing saddle and crankshaft were worn out after 598 hours.

The response from the manufacturer was commendably quick and the modifications have been noted earlier. The modified handles and crankshaft big end completed the test programme without failure.

In the final inspection, the plunger seal was found to be worn out, the plunger body was worn and also the plunger rod where it passed through the cylinder top. The cylinder bore was in good condition. There was some play in the big end but in all other respects the pumpstand was in good condition.

Breakdown Incidence

Breakdowns are shown in bold type.

```
Hours:              1024          2037           3062            4082
  152   598        | 1091      1945 |              |               |
   | 277 |         |  |          |  |              |               |
-------------------------------------------------------------------------
|  |  |  |         |  |          |  |              |               |
|  |Handle|        | Cable       |  |              |               |
|  |Broken|        | Broken      |  |              |               |
|  |      |        |          Cylinder|            |               |
|Crank  Crank      |           Jammed |            |               |
|Worn   Worn       |                  |            |               |
|Out    Out        |                  |            |               |
Inspection     Inspection     Inspection     Inspection     Inspection
and full       and volume     and volume     and volume     and full
performance    flow           flow           flow           performance
test                                                        test
```

FINAL INSPECTION

1. Pumpstand — Some play in crankshaft big end bearing, otherwise in good condition

2. Cylinder
   - (a) Some light scratches on cylinder bore, otherwise no signs of wear
   - (b) Small quantity of sand around cylinder snap fitting

3. Plunger
   - (a) Plunger seal circumference worn down excessively
   - (b) Scratches and more extensive signs of wear on plunger body
   - (c) Plunger rod worn against cylinder end fitting

4. Foot Valve — In good condition

5. Corrosion — Rust around cylinder snap fitting - no other corrosion

Estimated total amount of water pumped in 4000 hours ......6.0 million litres.

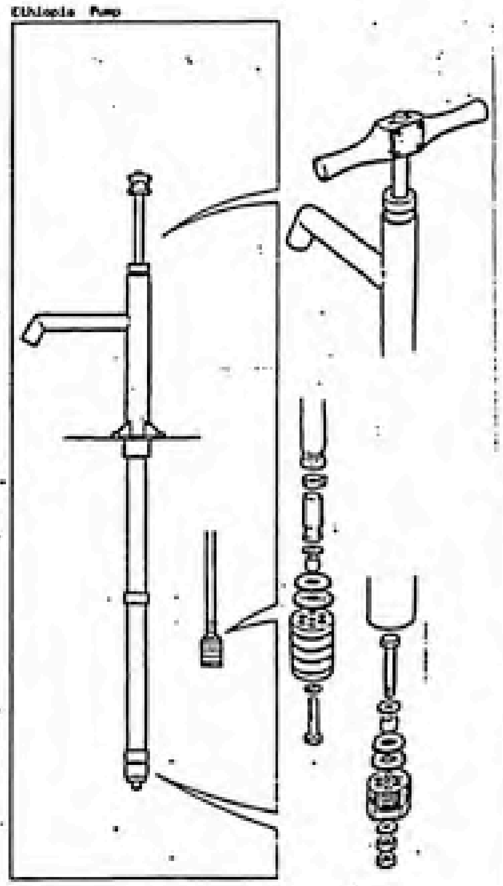
VERDICT Very expensive. Robust as modified by the manufacturer. Awkward to use, but designed to be operated by two people. Not suitable for manufacture in developing countries. Needs very heavy lifting tackle for installation, but cylinder may be withdrawn for maintenance on end of cable, possibly using crankshaft as windlass. Not suitable for boreholes of less than 130 mm diameter. Suitable for community water supply where the necessary maintenance skills and facilities are available.

Ethiopia Pump Description

The Ethiopia Type BP50 is a shallow-well force pump, originally developed from an IDRC design and makes extensive use of plastics below ground. For shallow wells a simple T-handle is attached to the top of the pump rod for direct action pumping. For depths greater than 12 metres, the pumpstand has a lever.

The pumpstand is fabricated from steel tube and plate. The rising main is 2 inch uPVC pipe, and is itself the cylinder. The maximum outside diameter of the below-ground assembly is 75 mm. The plunger has no separate seals; it is turned from high density polyethylene, and has a simple rubber flap valve backed by a steel washer. The foot valve is similar, its housing made from standard pipe couplings. The rods are also uPVC water pipe, stiffened with steel at the top. The handle is wood.

Ethiopia Pump



Materials of Construction

COMPONENT	MATERIAL(S)
Pumpstand	Steel tube - fabricated
Handle	Wood
Pump rod support	Mild steel
Pump rod bush	HD polyethylene
Plunger	HD polyethylene, rubber valve
Foot valve body	Fabricated from standard steel pipe fittings
Foot valve	HD polyethylene, rubber washer
Pump rod	PVC pipe

WEIGHTS and MEASURES

Weights	Pumpstand	11.3 kg
	Pump rods	0.4 kg per metre
	Rising main	1.4 kg per metre

Dimensions	Nominal cylinder bore:	50 mm - 2 inch rising main used as cylinder
	Actual pump stroke:	370 mm
	Nominal volume per stroke:	726 ml
	Drop pipe size:	2 inches
	Outside diameter of below-ground assembly:	75 mm
	Pump rod diameter:	22 mm - 0.5 inch bore PVC water pipe

Manufacturing Techniques

The manufacturing techniques required to make the pump are listed below:-

Above-ground Assembly	Steel fabrication Basic machining	Woodwork

The pumpstand requires basic skills and is therefore particularly suitable for manufacture in a devloping country.

Below-ground Assembly	uPVC fabrication Basic machining	Rubber crafting

Like the pumpstand, the plunger and footvalve demand only basic manufacturing skills.

Ease of Installation, Maintenance and Repair

Ease of Installation

This pump is light and easy to handle; the main requirement for skill is in making satisfactory joints in uPVC pipe.

Ease of Pumpstand Maintenance and Repair

Very straightforward. The most likely maintenance requirement will be replacement of the top bush, and this is easy.

Ease of Below-ground Maintenance and Repair

The plunger may be removed very easily; only the top bush in the pumpstand need be removed. Care will be needed in handling the pump rods however, and it may be prudent to have sockets and solvent cement on hand to repair accidental breaks. The length of the pump rods may require frequent alteration to compensate for wear in the rising main. Lifting tackle would not be needed to extract the rising main.

PUMP PERFORMANCE

Volume Flow, Work Input and Efficiency

The description of the method can be found in the Test Procedure

HEAD		7 m	
Nominal pumping rate (strokes/min)	30	40	50
Vol/stroke (litres)	0.60	0.62	0.63
Work Input/stroke (J)	112	117	141
Efficiency (%)	36	35	30

ENDURANCE

A detailed description of the endurance test method can be found in the Test Procedure.

General Comments

The pump was tested at 40 strokes per minute at 7 metres head. It completed the 4000 hour endurance test without failure. Wear in the plunger tended to increase the end float of the centre bolt, and remedial action was taken at the 1000 hour intermediate inspections. The intermediate check tests of volume flow also revealed progressive loss of cylinder performance, with the most pronounced loss during the fourth 1000 hour stage, when sand was introduced to the water.

In the final inspection, most parts of the plunger were clearly worn, particularly those parts forming the valve. Although still operating, the performance had fallen off considerably. The piston diameter had worn by 0.3mm or so, and the cylinder by about 1mm on diameter. Particles of sand were embedded in the HDPE plunger. In actual use the wear in the rising main could be compensated by altering the position of the plunger in the rising main. The pump rod bush in the pumpstand was worn, but this did not affect the performance.

Hours:	1024	2037	3140	4147
Inspection and full performance test	Inspection and volume flow	Inspection and volume flow	Inspection and volume flow	Inspection and full performance test

FINAL INSPECTION

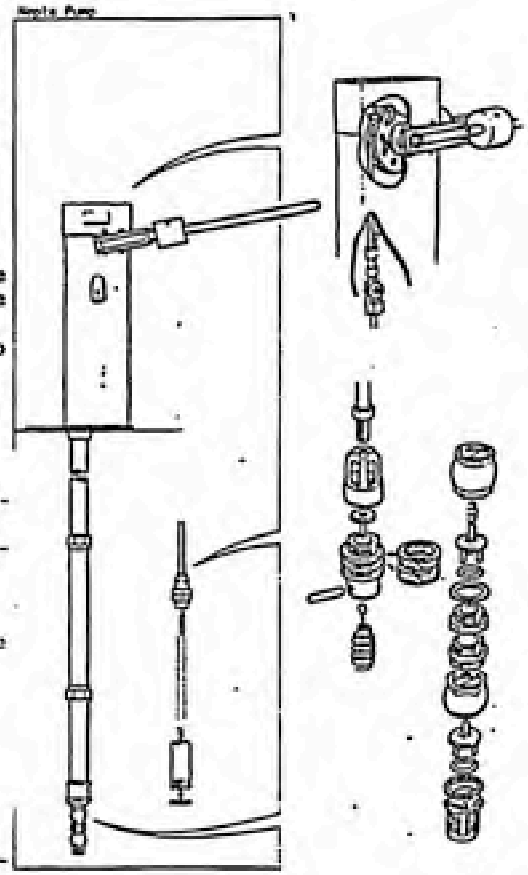
1. Pumpstand — Top bush worn but otherwise in good condition
2. Rising Main — Bore worn approximately 1 mm on diameter throughout swept area - many scratches from sand particles embedded in plunger
3. Plunger —
   (a) Worn approximately 0.3 mm on diameter
   (b) Many sand particles embedded in plunger
   (c) Plunger valve washer, sleeve and centre bolt all bady worn
   (d) Bolt hole through plunger noticeably worn
4. Check Valve — Hole in steel washer worn, but serviceable
5. Corrosion — Noticeable corrosion of ferrous parts in both plunger and foot valve.

<u>Estimated total amount of water pumped in 4000 hours</u> ...... 5.9 million litres.

VERDICT

An inherently simple, straightforward design, suitable for manufacture in developing countries and satisfying many of the requirements for VLOM. Suitable for community water supply but not for deep wells. Some users found it difficult to operate in the direct action mode. It does not require priming and therefore is not susceptible to contamination. The most likely maintenance requirement will be replacement of the top bush, and this is easy. It is more likely to wear out than to break down. Inexpensive.

Nepta Pump Description



The Nepta is a deep-well force pump, made in France. The pumpstand body is fabricated from sheet steel, the handle mechanism machined and fabricated from steel sections. The body is protected by a coating of nylon, the handle is galvanised. The pump rods are stainless steel attached at the top to approximately one metre of polyester cord, which wraps around a machined sector attached to the handle.

The cylinder is seamless brass tube. The machined plunger uses two sealing rings of square-section textile cord in place of conventional cup seals. Tension in the pump rod and polyester cord is provided by a stainless steel spring attached to the bottom of the plunger. Two foot valves are fitted, of similar design, each using a rubber O-ring seal.

Materials of Construction

COMPONENT	MATERIAL(S)
Pumpstand	Fabricated steel, nylon-coated
Handle and counterweights	Steel, galvanised
Bearings	Mild steel shafts in plain bronze shell bearings
Quadrant assembly	Fabricated steel, galvanised
Cylinder	Extruded brass
Plunger	Cast gunmetal or brass
Plunger seals	Textile cord
Drop pipe	Galvanised steel
Pump rods	Stainless steel with polyester cable coupling at pumpstand

WEIGHTS and MEASURES

Weights	Pumpstand	41.5 kg
	Cylinder assembly	15.5 kg
	Pump rods	0.7 kg per metre

Dimensions	Nominal cylinder bore:	50 mm	Outside diameter of below-ground assembly:	76 mm
	Actual pump stroke:	203 mm	Pump rod diameter:	10 mm
	Nominal volume per stroke:	399 ml	Maximum usable cylinder length:	620 mm
	Drop pipe size:	1.25 inches		

Manufacturing Techniques

The manufacturing techniques required to make the pump are listed below:-

Above-ground Assembly	Steel fabrication	Machining	Plating
	Sheet metal forming	Rubber moulding	

The pumpstand body is fabricated from formed sheet steel and coated with plastic for corrosion resistance. The machining of the pivot shaft and cable quadrant assembly requires careful quality control. The polyester cable at the top of the pump rod is a proprietary item.

Below-ground Assembly	Brass/gunmetal foundry Hot pressing of brass	Machining Rubber moulding

Care in needed in fitting the plunger packing to ensure a satisfactory seal in the cylinder bore.

Ease of Installation

Clamps and hexagon keys were supplied with the test samples. This pump needs attention to the final adjustments of the polyester cord and the handle counterweights. Care is needed to ensure a sanitary seal at the wellhead.

Ease of Pumpstand Maintenance and Repair

This pumpstand is unlikely to require frequent maintenance, and need not be removed from the wellhead. The bearings may be replaced when necessary; a hexagon key is needed, but this was supplied by the manufacturer.

Ease of Below-ground Maintenance and Repair

Repairs require removal of the complete below-ground assembly. The valves use O-ring seals which are easy to replace once the cylinder has been dismantled. If the spring is retained, it is likely to demand frequent replacement; care is then needed to avoid damage to the plunger.

PUMP PERFORMANCE

Nepta Pump Volume Flow, Work Input and Efficiency

The description of the method can be found in the Test Procedure

HEAD	7 m			25 m			45 m		
Nominal pumping rate (strokes/min)	30	40	50	30	40	50	30	40	50
Vol/stroke (litres)	0.39	0.40	0.39	0.38	0.39	0.40	0.38	0.39	0.39
Work input/stroke (J)	51	45	43	130	123	120	206	216	180
Efficiency (%)	52	60	61	71	76	80	81	78	94

ENDURANCE

A detailed description of the endurance test method can be found in the Test Procedure.

General Comments

The pump was tested at 40 strokes per minute at a simulated head of 45 metres.

The only failures in the 4000 hour endurance test were of the tension spring. The spring broke and was replaced during the first 1000 hour period. 289 hours later the replacement spring broke and was replaced. It was not replaced when it broke for the third time since the pump seemed to work satisfactorily without the spring. The pump completed the last 1000 hours of the test without a spring.

In the final inspection, all the valves were found to be in good condition, though there were signs of wear. The upper sealing ring on the plunger was noticeably worn, but the lower ring was in good condition and working well. The cylinder bore was in very good condition, with no signs of wear. There was some play in the handle bearings, but they were still serviceable.

Breakdown Incidence

Breakdown shown in bold type.

Hours:	1072	1318	2044	3060	4063
		Spring replaced			
Inspection and full performance test	Inspection and volume flow. Spring replaced		Inspection and volume flow	Inspection and volume flow	Inspection and full performance test

FINAL INSPECTION

1.	Pumpstand	Noticeable wear in handle bearings though still serviceable
2.	Cylinder	(a) No sign of wear (b) Leather sealing washer in lower cap split
3.	Plunger	(a) Upper seal worn, lower seal satisfactory and still serviceable (b) Plunger valve in good condition
4.	Foot Valves	Both valves in good condition
5.	Corrosion	(a) Rust on quadrant within pumpstand (b) Rust inside pumpstand casing where surface coating has been damaged (c) Some rust where galvanised iron pipe joins foot valve body

Estimated total amount of water pumped in 4000 hours ..... 3.8 million litres.

VERDICT

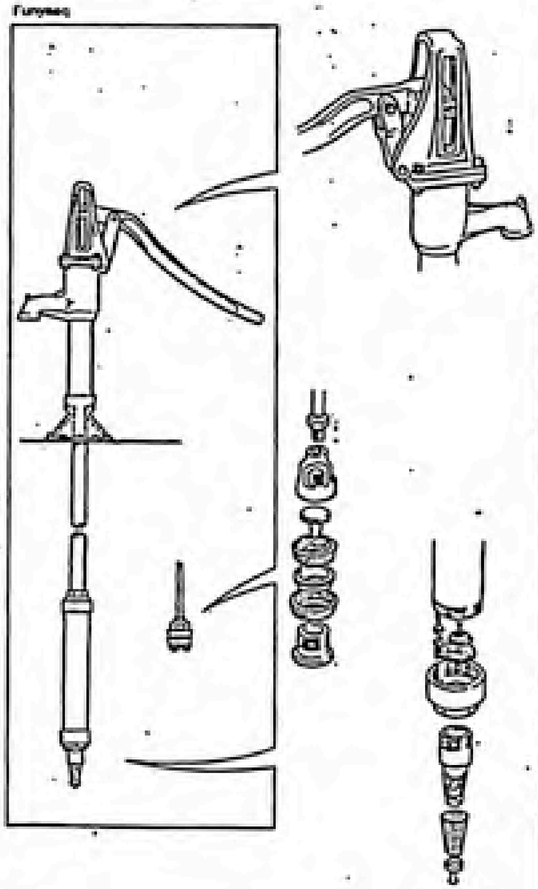
A reasonably robust and generally reliable pump, if the spring were designed out. The pump worked satisfactorily without the spring for the last 1000 hours of the endurance test. Adequate performance of this pump depends on accuracy of fitting the plunger seals. Potentially suitable for community water supply, but not suitable for manufacture in many developing countries. Preferred by smaller users. Expensive.

Funymaq Pump <u>Description</u>

This pump is a derivative of a deep-well design from AID/Battelle for manufacture in developing countries. The pumps tested were made in Honduras. The pumpstand is mostly cast iron though the column is a length of steel tube threaded at each end. It features a crosshead mechanism to guide the top of the pump rod.

The cylinder design is conventional except that uPVC tube is used in place of the more usual seamless brass tube, with cast iron end caps. Two leather cup seals are used on the plunger. Two foot valves are fitted. The upper foot valve in the base of the cylinder is a simple flap of leather with a cast iron weight. The lower foot valve is a proprietary Simmons item.

Neither rising main nor pump rods were supplied with the pumps.



<u>Materials of Construction</u>

COMPONENT	MATERIAL(S)
Pumpstand top	Cast iron
Pumpstand column and spout	2 iron castings, 1 steel pipe
Handle	Cast iron
Fulcrum link	Cast iron
Handle fulcrum bushes	Hardened steel)Approximately
Handle fulcrum pins	Hardened steel)50 Rockwell C
Connecting rod	Steel
Eye	Cast iron
Cylinder	PVC body with cast iron end caps
Plunger assembly	Cast gunmetal
Cup seal	Leather
Foot valve in cylinder	Cast iron with leather flap
Simmons foot valve	Cast gunmetal with rubber seal

<u>WEIGHTS & MEASURES</u>

<u>Weights</u>	Pump Stand:	51.0 kg (including handle)
	Cylinder:	8.0 kg (including Simmons foot valve)
<u>Dimensions</u>	Nominal cylinder bore:	70 mm
	Actual pump stroke:	190 mm
	Nominal volume per stroke:	731 ml
	Drop pipe size:	1.25 inch *
	Pump rod diameter:	7/16 inch *
	Outside dia. of below-ground assembly	105 mm
	Maximum usable cylinder length:	320 mm

* Not supplied but designed for these sizes.

It is interesting to note that there are significant differences between this pump and the Sumber Banyu although both pumps were derived from same design. In particular the castings of the Funymaq were a good deal heavier.

Manufacturing Techniques

The techniques required to manufacture the pump are listed below:

Above-Ground Assembly	Iron foundry Simple machining

Basic skills in iron foundry and machining are required, but careful quality control is essential to ensure smooth operation of the handle assembly and interchangeability of parts for maintenance or repair. It is essential that the handle fulcrum pins and bushes are hardened. The pumpstand would be suitable for manufacture in developing countries with the appropriate skills, provided that the necessary quality control could be assured.

Below-ground Assembly	Iron and gunmetal foundry Simple machining	Leatherwork

Basic skills in foundry work and machining are required. The cylinder would be suitable for manufacture in many developing countries.

Ease of Installation, Maintenance and Repair

Ease of Installation

The Funymaq requires a substantial complement of tools and equipment and a good deal of skill or experience to install it. Lifting tackle would not be required if plastic rising main could be used.

Ease of Pumpstand Maintenance and Repair

The pumpstand is likely to require frequent lubrication of the handle and fulcrum link pivots. Eventually these components will need to be replaced but most tasks are easy, requiring only spanners and pliers, though a drift and hammer may be needed to remove the pivot pins.

If our samples were representative of normal production then replacement parts may not be interchangeable with original components, possibly making on-site repair impossible.

Ease of Below-ground Maintenance and Repair

The cylinder is likely to require frequent attention to the leather footvalve and possibly to consequent damage to the cylinder or breakages of the pump rod. Below-ground repairs require removal of the complete below-ground assembly.

PUMP PERFORMANCE Volume Flow, Work Input and Efficiency

The description of the method can be found in the Test Procedure.

HEAD	7 m			25 m			45m		
Pumping Rate (strokes/min)	29	38	51	20	29	37	21	30	37
Vol/stroke (litres)	0.69	0.70	0.70	0.69	0.69	0.69	0.68	0.69	0.68
Work input/stroke (J)	125	134	134	261	277	304	404	459	468
Efficiency (%)	37	35	35	64	61	55	74	66	64

ENDURANCE

A detailed description of the endurance test method can be found in the Test Procedure.

General Comments

The pump was tested at 40 strokes/minute at a simulated depth of 30 m.

The Funymaq pump proved to be much more durable than the Sumber Banyu pump tested in 1981/82, although both pumps were derived from the same design. In particular the handle pivots which had caused so much trouble in the Sumber Banyu pump endured throughout the test on the Funymaq. However, like the Sumber Banyu, the flap type leather foot valve broke away, in this case after 3127 hours. The pump continued to work because the Simmons foot valve supported the column of water, but the broken parts of the foot valve became entangled in the plunger, bent the pump rod and caused severe damage to the cylinder bore. It is strongly recommended that the flap type valve in the base of the cylinder should be omitted, or its quality should be much improved and the proprietary foot valve omitted.

Breakdown Incidence

Breakdowns are shown in **bold type**.

Hours: 0	1062	2112	3127	4169
Inspection and full performance test	Inspection and volume flow	Inspection and volume flow	Inspection and volume flow	Inspection and full performance test
			Foot valve flap broken away, pump rod bent, severe damage to cylinder bore	

Final Inspection

1 Cylinder — Replacement cylinder in good condition

2 Bearings — Considerable wear in handle bearings and guide blocks but all still servicable

3 Pumpstand — Hole in pumpstand top enlarged by connecting rod

4 Corrosion — Considerable corrosion of cylinder end caps and plunger rod, latter particularly around joint with plunger body

Estimated Total Amount of Water Pumped in 4000 hours......6.7 million litres

VERDICT

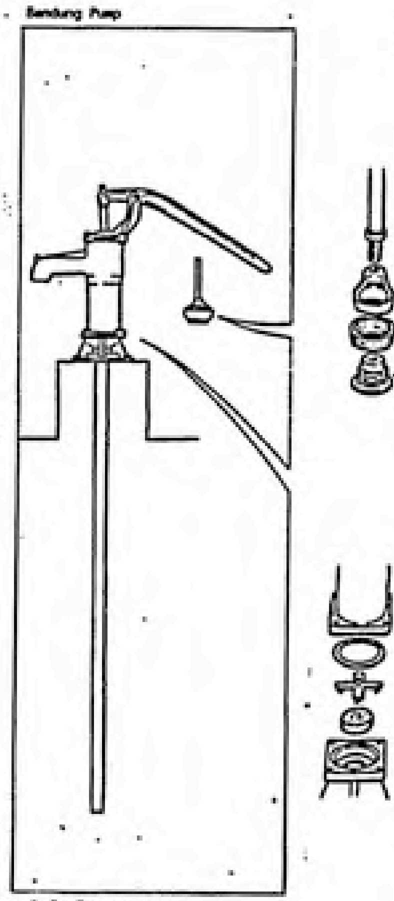
Different results were obtained for this Funymaq pump from Honduras than for the similar Sumber Banyu pump from Indonesia, although both pumps were derived from the same AID/Battelle design. In particular, the hardened handle fulcrum pins and bushes endured throughout the test, and the lift of the plunger valve and its location were better.

The leather foot valve is worse than redundant because it can break away and damage the plunger while the lower foot valve continues to support the column of water in the rising main. The damage is therefore worse than it would be if only one foot valve were fitted.

It is potentially suitable for community water supply, and for manufacture in developing countries with established iron foundry skills and effective quality control.

Bandung Pump Description

The Bandung is a shallow-well suction pump. It is mainly constructed of cast iron, with an enamelled steel cylinder liner. The plunger uses a moulded rubber cup washer, and rubber discs are used as plunger and check valves.



ENGINEERING ASSESSMENT

Materials of Construction

COMPONENT	MATERIAL(S)
Pumpstand	Cast iron with enamelled steel cylinder liner
Handle	Cast iron
Bearings	Mild steel pivot pins bear on holes drilled and reamed in iron castings
Plunger	Cast iron
Cup seal	Moulded rubber
Base valve	Rubber with moulded plastic cage

WEIGHTS and MEASURES

Weights	Pumpstand	25.5 kg
Dimensions	Nominal cylinder bore:	96 mm
	Actual pump stroke:	135 mm
	Nominal volume per stroke:	977 ml
	Drop pipe size:	1.25 inches
	Maximum usable cylinder length	135 mm

Manufacturing Techniques

The manufacturing techniques required to make the pump are listed below:-

- Iron foundry
- Sheet metal forming
- Enamelling of steel
- Simple machining
- Rubber/plastic moulding

Where adequate skills in iron foundry work, simple sheet metalwork and basic machining are available, the Bandung may be well-suited for manufacture in a developing country. However, the Bandung demands stricter quality control during manufacture than the New No.6, which is of similar design.

Ease of Installation, Maintenance and Repair

Ease of Installation

Very straightforward.

Ease of Maintenance and Repair

The pump may require frequent attention, but most tasks are simple and could be accomplished with a few spanners. A drift and hammer may be needed to remove the pivot pins, however, and a pipe wrench to dismantle the plunger.

PUMP PERFORMANCE

Volume Flow, Work Input and Efficiency

The description of the method can be found in the Test Procedure.

HEAD		7 m	
Nominal pumping rate (strokes/min)	20	30	40
Vol/stroke (litres)	0.95	0.96	1.04
Work input/stroke (J)	94	93	102
Efficiency (%)	69	70	70

ENDURANCE

A detailed description of the endurance test method can be found in the Test Procedure.

General Comments

The pump was tested at 30 strokes per minute at 7 metres head. The cup washer was replaced three times in the 4000 hour endurance test. The seal tended to extrude into the clearance between the plunger and the cylinder wall, and split as a result. The two halves of the plunger were modified so that the cup washer was nipped near its outer edge; this prevented the outward extrusion of the rubber, and the last replacement cup washer did not split in over 1000 hours. However, the final inspection revealed cracks in the upper surface of the cup washer, although it was still working.

The pump proved difficult to prime after the 3000 hour check, but this was corrected by simply turning over the check valve block. Both valve blocks showed signs of wear in the final inspection, but were in working order.

The cylinder was in good condition at the end of the test, with no signs of wear.

The handle pivot pins, and their corresponding holes, were worn but still serviceable at the end of the test.

Breakdown Incidence

Breakdowns are shown in bold type.

Hours:	Event
	Inspection and full performance test
809	**Cup Washer Split**
1072	Inspection and volume flow
2018	**Cup Washer Split**
2044	Inspection and volume flow
3017	**Cup Washer Split**; Inspection and volume flow
4063	Inspection and full performance test

FINAL INSPECTION:

1.	Pump Body and Handle	(a)	Cylinder bore in good condition showing no signs of wear
		(b)	Fulcrum pins and bushes all worn, though pump still working
		(c)	Handle no longer contacts bottom stop (because of wear in fulcrum bearings) but fouls on connecting rod eye
2.	Plunger	(a)	Plunger valve noticeably worn though still serviceable
		(b)	Some cracks in upper surface of cup washer though still watertight
3.	Check Valve		Signs of wear but still serviceable
4.	Corrosion	(a)	Rust on sliding plate on pump top and associated contact areas of pumpstand
		(b)	Rust in plunger valve cage
		(c)	Rust inside pump body above cylinder lining

Estimated total amount of water pumped in 4000 hours ....6.9 million litres.

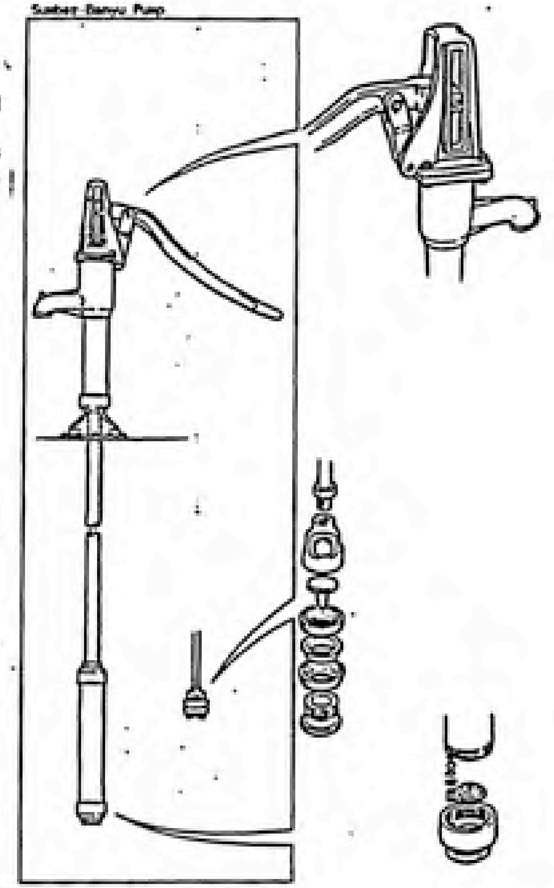
VERDICT

The Bandung pump is susceptible to accidental damage. It requires priming and is therefore susceptible to contamination, and hence is not recommended for drinking water supply. It could be more reliable with some design changes, to the pumpstand castings and the plunger. Cheap.

Sumber Banyu Pump Description

This pump was a derivative deep-well design from AID/Battelle for manufacture in developing countries. The pumps tested were made in Indonesia. The pumpstand is almost entirely cast iron, though the column is a length of steel tube threaded at each end. It features a crosshead mechanism to guide the top of the pump rod.

The cylinder design is conventional, except that uPVC tube is used in place of the more usual seamless brass tube, with cast iron end caps. Two leather cup seals are used on the plunger. The foot valve is a simple flap of leather with a cast iron weight.



WEIGHTS and MEASURES

Weights	Pumpstand	39.5 kg
	Cylinder assembly	5.5 kg
	Pump rods	0.8 kg per metre
Dimensions	Nominal cylinder bore:	78 mm
	Actual pump stroke:	180 mm
	Nominal volume per stroke:	860 ml
	Drop pipe size:	1.25 inches
	Outside diameter of below-ground assembly:	100 mm
	Pump rod diameter:	10 mm
	Maximum usable cylinder length:	303 mm

Materials of Construction

COMPONENT	MATERIAL(S)
Pumpstand	Cast iron head, spout and base, steel column
Fulcrum link	Cast iron
Handle	Cast iron
Bearings	Mild steel pivot shafts bear on mild steel wrapped bushes
Connecting rod	Mild steel
Cylinder	Extruded PVC, cast iron end caps
Plunger assembly	Gunmetal body
Cup seals	Leather
Foot valve	Leather with cast iron weight

Manufacturing Techniques

The manufacturing techniques required to make the pump are listed below:-

Above-ground	Iron foundry
Assembly	Basic machining

Where facilities and skills in iron foundry work and basic machining are available, this pump may be suitable for manufacture in a developing country. However, the handle mechanism and the crosshead assembly demand careful quality control to ensure proper assembly and smooth running. In the samples supplied, the components of the two pumps were not interchangeable, and the spares did not fit either pump. No jigs and fixtures appear to have been used in manufacture: this is essential to ensure the interchangeability of spares. The pivot shafts and bushes must be hardened.

Below-ground	Iron foundry	Basic machining
Assembly	Brass/gunmetal foundry	Leather crafting

Similar levels of skill are required for the below-ground components to those needed to manufacture the pumpstand.

Ease of Installation, Maintenance and Repair

Ease of Installation

The pumpstand may require some re-working of the various handle components to ensure smooth operation.

Ease of Pumpstand Maintenance and Repair

The pumpstand is likely to require frequent attention to the handle, fulcrum link and connecting rod eye, and their respective pivot pins. Most tasks are easy, requiring spanners and pliers only, though a drift and hammer may be needed to remove the pivot pins. Our experience suggests that replacement parts may not be interchangeable with the original components, possibly making on-site repair impossible.

Ease of Below-ground Maintenance and Repair

The cylinder is likely to require frequent attention to the foot valves and to broken pump rod joints. Below-ground repairs require removal of the complete below-ground assembly.

PUMP PERFORMANCE Volume Flow, Work Input and Efficiency

HEAD	7 m			25 m			45 m		
Nominal pumping rate (strokes/min)	30	40	50	30	40	50	30	40	50
Vol/stroke (litres)	0.83	0.86	0.85	0.82	0.81	0.81	0.80	0.80	0.81
Work input/stroke (J)	101	100	111	290	293	312	458	480	536
Efficiency (%)	55	58	52	69	67	63	76	73	66

ENDURANCE A detailed description of the endurance test method can be found in the Test Procedure.

General Comments

The pump was tested at 40 strokes per minute, initially at a simulated head of 45 metres.

The pump failed several times in the endurance test, due to rapid wear of linkages in the pumpstand, broken rods and worn-out foot valves. After five failures in the first 1000 hours, the simulated head was reduced to 30 metres.

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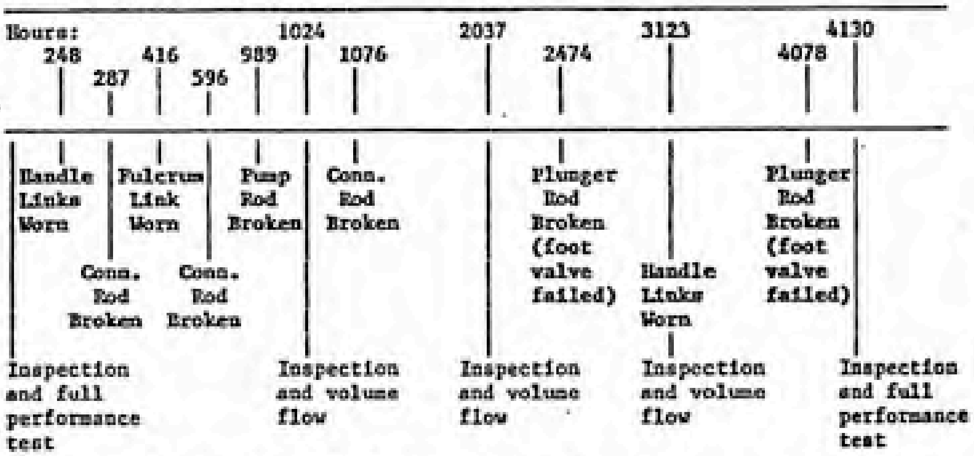
The handle, fulcrum link, connecting rod eye and their associated pivot pins wore rapidly, and had to be replaced several times in 4000 hours. The pump rod broke six times, twice in the connecting rod at the top, twice in the plunger rod, and twice in the intermediate rods. The connecting rod and plunger rod were supplied with the pumps. The plunger rod breakages were caused by failures of the foot valve. In each case, the leather had rotted away allowing the cast iron weight to foul the plunger.

In the final inspection, the plunger and cup seals were still in good condition, and the cylinder bore was polished but otherwise showed few signs of wear. The crosshead blocks and guides were worn but still serviceable. All other moving parts had been replaced at some stage during the 4000 hours. The cylinder end caps were heavily rusted.

<u>Breakdown Incidence</u> Breakdowns are shown in bold type.

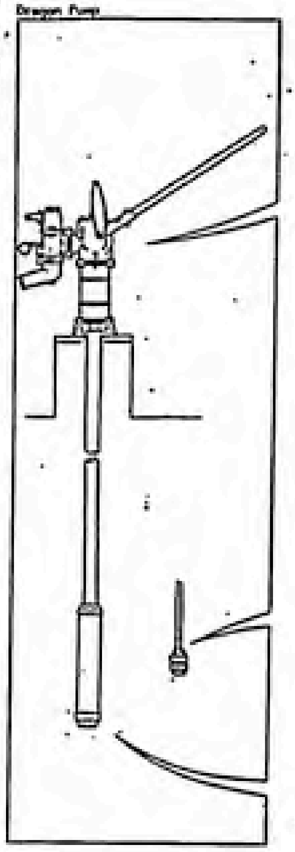


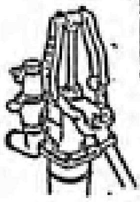
FINAL INSPECTION	Pumpstand	(a) Noticeable wear on stepped pivot pin and connecting rod eye fitted at 3000 hour inspection (b) Other handle pivot pins and bushes also worn (c) Crosshead guides and blocks worn but still serviceable
	Cylinder	Cylinder bore highly polished with no significant wear, though some scoring from sand particles - minor damage to cylinder bore from most recent plunger rod breakage
	Plunger	Both seals and valve in good condition
	Foot Valve	Recent replacement still in good condition
	Corrosion	Cylinder end caps heavily rusted - upper worse than lower

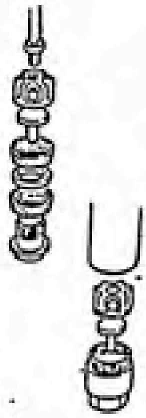
<u>Estimated total amount of water pumped in 4000 hours</u>......7.7 million litres.

<u>VERDICT</u> Not a reliable pump for deep-well use. Intensive use will produce rapid wear in the moving parts of the pumpstand. Manufacturing needs much better quality control in both foundry to prevent porosity and in the machine shop to ensure interchangeability of parts, and the pump may therefore not be suitable for manufacture in developing countries, even where foundry skills are available. The leather foot valve was undependable. The pump needs modification to be suitable for community water supply. Inexpensive. We understand that USAID are offering assistance to manufacturers in order to improve the general quality of the product including interchangeability of spare parts. They are also considering a replacement of the leather footvalve.

Dragon Pump







Dragon Pump Description

The Dragon pump, made in Japan, can be supplied either as a shallow-well suction pump or as a deep-well force pump. The pump was tested in its deep-well configuration. The pumpstand is principally cast iron, with a discharge valve in the spout allowing either free discharge or delivery under pressure through a hose or pipe. The tubular steel handle moves through an unusually wide arc of 178°.

In the deep-well configuration, the shallow-well cast-iron cylinder body with its enamelled steel liner, is retained as a pedestal. In addition, the pump requires a mounting plinth at least 305 mm high, to provide adequate clearance under the spout. The deep-well cylinder is conventional, seamless brass tube of 63 mm bore with cast iron end caps. The plunger has two leather cup seals, and the foot valve has a rubber seat.

Materials of Construction

COMPONENT	MATERIAL(S)
Pump head	Cast iron
Handle fork and link	Cast iron
Handle bearings	Mild steel pivot pins bear on holes drilled and reamed in iron castings
Spout assembly	Cast iron with plastic cap and hose connector and rubber valve
Operating rod	Mild steel
Handle	Steel tube, plastic end cap
Cylinder	Extruded brass, cast iron end caps
Cup seal	Leather
Foot valve assembly	Cast gunmetal, rubber valve seat

WEIGHTS and MEASURES

Weights

Pumpstand	19.0 kg
Cylinder assembly	5.0 kg
Pump rods	1.1 kg per metre

Dimensions

Nominal cylinder bore:	63 mm
Actual pump stroke:	180 mm
Nominal volume per stroke:	561 ml
Drop pipe size:	1.25 inches
Outside diameter of below-ground assembly:	70 mm
Pump rod diameter:	0.5 inches
Maximum usable cylinder length:	180 mm

Manufacturing Techniques

The manufacturing techniques required to make the pump are listed below:-

Above-ground Assembly	Iron foundry	Plastic moulding
	Basic machining	Plating

Some of the pumpstand castings require careful quality control in manufacture. Machining of the various components of the handle mechanism requires care to ensure correct alignment of the various pivot axes.

Below-ground	Iron Foundry	Basic machining
Assembly	Brass/Gunmetal foundry	Leather/rubber crafting

The skills required are similar to those needed for the pumpstand.

Ease of Installation, Maintenance and Repair

Ease of Installation

The pump requires a plinth to provide adequate clearance under the spout. The manufacturer supplied a wooden plank, drilled to accept the pump base plate to support the pump over an open well. For the purpose of this test a fabricated steel plinth was used.

Ease of Pumpstand Maintenance and Repair

The pumpstand would benefit from regular lubrication. The repairs most likely to be required are to the handle fulcrum components, the connecting rod and the gland nut. In all these cases, manufacturer's spares would be required. The pumpstand is easy to dismantle, and need not be removed from the wellhead.

Ease of Below-ground Maintenance and Repair

Repairs require removal of the complete below-ground assembly.

PUMP PERFORMANCE

Dragon Pump Volume Flow, Work Input and Efficiency

The description of the method can be found in the Test Procedure.

HEAD		7 m			25 m			45 m		
Nominal Pumping Rate (strokes/min)		30	40	50	30	40	50	20	30	40
Vol/stroke (litre)	(f)	0.55	0.55	0.55	0.54	0.54	0.54	0.52	0.53	0.53
	(p)	0,26	0.27	0.28						
Work input/ stroke (J)	(f)	122	120	128	244	252	257	340	358	366
	(p)	52	53	55						
Efficiency (%)	(f)	30	31	29	53	52	51	67	65	63
	(p)	33	34	34						

(f) = Full stroke
(p) = Partial stroke

The angle of the handle movement was nearly 180° and from observation it was anticipated that an improvement in efficiency could be obtained by using only the central 60° position of the handle movement. Tests conducted at 7 metres confirmed a slight improvement in efficiency which may be significant at greater depths.

ENDURANCE A detailed description of the endurance test method can be found in the Test Procedure.

General Comments

This pump was tested at 40 strokes per minute at a simulated head of 45 metres.

The pump failed at 2890 and 3207 hours when the pump rod broke within the thread at the top. Components of the handle mechanism including the gland nut had to be replaced after 2487 hours because of wear. The handle fulcrum had broken when wear allowed it to contact the retaining bolt. At each intermediate inspection, the spout discharge valve was found to be seized through lack of use and was freed off.

In the final inspection, the foot valve guide was almost completely worn away, and there was substantial wear of the valve stem. The leather cup seals and cylinder bore were in good condition, with few signs of wear. The gland nut was again very badly worn. The cast iron cylinder end caps and the plunger rod were corroded, but not sufficiently to interfere to any great extent with maintenance or performance.

Breakdown Incidence

Breakdowns are shown in bold type.

Hours:	1024	2037	2487	2890	3140	3207	4147
			Handle Fork Broken	**Pump Rod Broken**		**Pump Rod Broken**	
Inspection and full performance test	Inspection and volume flow	Inspection and volume flow			Inspection and volume flow		Inspection and full performance test

FINAL INSPECTION:

Pumpstand	Gland worn, slight wear in handle components, but generally in fair condition
Cylinder	No wear in cylinder bore though some scratches - generally in good condition
Plunger	Generally in good condition, including cup seals
Foot Valve	(a) Valve guide severely worn (b) Some wear on foot valve stem
Corrosion	(a) Cylinder end caps rusty (b) Considerable rust on plunger rod (c) Outlet diverter valve rusted solid

Estimated total amount of water pumped in 4000 hours ......5.1 million litres.

VERDICT

This pump appears to be designed for family use, possibly serving up to 15 people. It is unlikely to be sufficiently robust for community water supply. It is inexpensive, but intensive use will produce rapid wear in the moving parts of the pumpstand, and rod breakages are also likely (see comments on pump rod constraint on page 17). It is understood that the manufacturer is working on a new and more robust pump design for community use.

V. PUMPS WITH FIELD EXPERIENCE

INTRODUCTION

This chapter includes information on all pumps with field experience, but more information is not available.

PUMPS WITH FIELD EXPERIENCE

COUNTRY OF ORIGIN	NAME	DEEP OR SHALLOW	FIELD TESTING COUNTRIES
Bangladesh	Bangladesh Deep-Set	Deep	Thailand
Bangladesh	Tredle	n/a	China
Holland	ESW-81(82)	Deep	Tanzania
Papua New Guinea	Local experimental shallow-well pumps	Shallow	Papua New Guinea
Philippines	Clayton-Marks	Intermediate and Deep	Philippines
n/a	Bourga	n/a	Mali
Sri Lanka	Sarvodaya	n/a	Indonesia, Bangladesh, Sri Lanka

VI. PUMPS WITH LABORATORY TESTING AND MANUFACTURER INFORMATION

INTRODUCTION

This chapter includes information on all pumps with laboratory testing and manufacturer information. The laboratory testing was performed by Overseas Development Administration in England.

PUMPS WITH LABORATORY TESTING AND MANUFACTURING INFORMATION

COUNTRY OF ORIGIN	NAME	DEEP OR SHALLOW
England	Godwin W1H51	Deep
Canada	GSW1205	Deep
England	Climax	Deep

GODWIN PUMP

Godwin Pump Description

The Godwin is a gear lift deep well pump with over hundred years experience. It is designed and manufactured in England. Laboratory tests were performed on the Godwin pump Model WIH51 at ODA Handpump laboratory testing.

The new HMA suction pumps are of the reciprocating piston type. They are designed from the latest updated information published by World Authorities on Hand Pumps and Hand Pump Maintenance. Godwin is operated by a flywheel with crank. It can be used in most of world's dry regions. It gives continuous service and requires minimal maintenance (World Water, December 1981d).

Material of Principle Components and Weights and Measures

Precise values are not available.

TEST RESULTS

The only information obtained is that the new model of Godwin delivers water from 76 m depth when operated by one person and amximum depth of 122 m when operated by two men.

EXPERIENCE

Information is not available.

ADVANTAGES AND DISADVANTAGES

Advantages

The manufacturer is too general in relying on its worldwide reputation. They did not cite specific experiences in any country to show advantages of the pump. Also, the advertisement did not mention anything specific about the maintenance of the pumps. It just stated that it was rugged and reliable.

Disadvantages

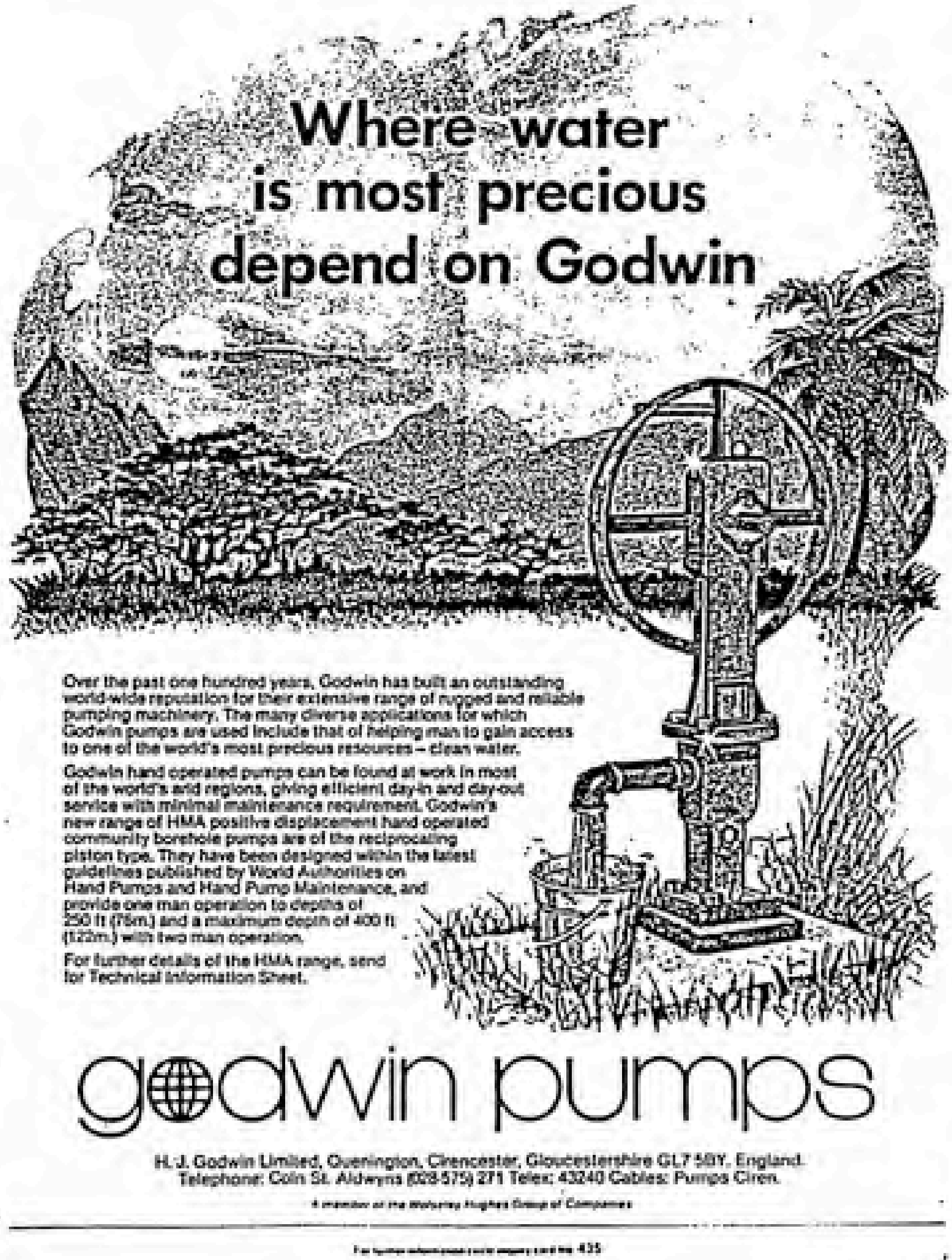
The wheel handle uses a lot of steel resulting in the high price #865.5, that cannot be afforded by villagers unless they have government subsidy.

The wheel handle is potentially harmful to user especially to children because of the moments. The rotating crank arm could be hazardous too.

The wheel handle may be difficult to start and maintain at a steady rhythm. It is very difficult to reconcile to these conflicting requirements of safety and ease of operation in a wheel handle handpump.

Once need to check or repair the below-ground components, pump head needs to be removed.

FIGURE VI.1 Godwin Hand Pump



(Source: ... December 1981 ...)

VII. PUMPS WITH MANUFACTURER INFORMATION

INTRODUCTION

This chapter includes manufacturer information on pumps in individual countries.

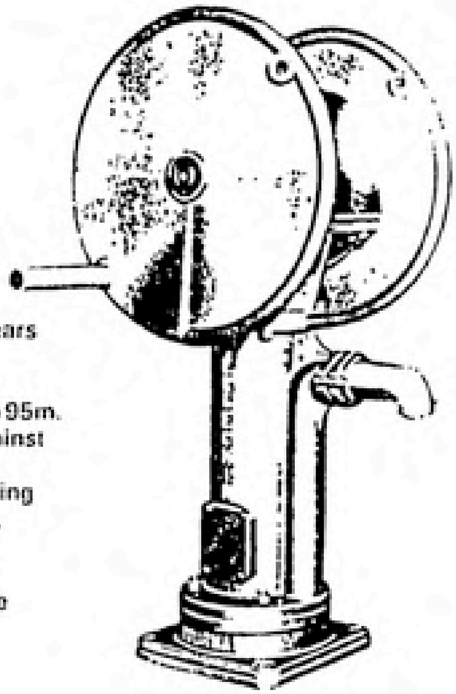
PUMPS WITH MANUFACTURER INFORMATION

COUNTRY OF ORIGIN	NAME	DEEP OR SHALLOW
Belgium	Duba Tropic Pump	Deep
Botswana	Stewarts & Lloyds	n/a
China	SYB-100	Shallow
Holland	SWN80 and SWN81	Deep
India	Scholapur Mission (Jalna)	Deep
India	Bangalore	Deep
Ghana	U.S.T. (KUMASI)	Deep
Senegal	Pompe a Balancier	n/a
Senegal	Pompe a Pieds	n/a
USA	JAMHP	Deep

DUBA HANDPUMP

Duba tropic pump is manufactured in Belgium where it is used as a deep well pump.

FIGURE VII.1 Information About Duba Hand Pump



—Are designed to give a minimum of 25 years continuous operation.
—Have been sold world wide for 35 years.
—Capacity up to 3260 litres/hour; lift up to 95m.
—Parts below ground level PVC coated against corrosion.
—Manual operation easily modified by adding diesel, animal or other mechanical drive.
—Easily installed and require virtually no maintenance.
—Can be used for small community potable water supply and irrigation.
—Install them . . . and forget them!

DUBA S.A. — Nieuwstraat 31 — B 9200 WETTEREN (Belgium)

Tel. 00-32-91-693496 — Telex 11133

(SOURCE: World Water November 1982 p.46)

STEWARTS AND LLOYDS PUMP

Stewart and Lloyds Pump Description

These handpumps - the S&L Rotary with a flywheel drive (Figure VII-2) and the S&L Lever Pump with a pivot handle (Figure VII-3) are manufactured by Stewarts and Lloyds. The characteristics of the pump are tough, rugged and reliable. It is very easy to operate. It is durable for years, and the spare parts are available from the pump manufacturer.

Other information is not available.

FIGURE VII.2

Stewarts and Lioyds Hand Pump with a Flywheel Drive

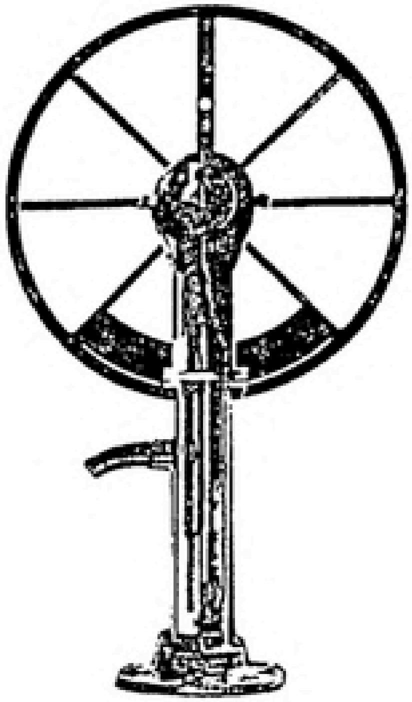
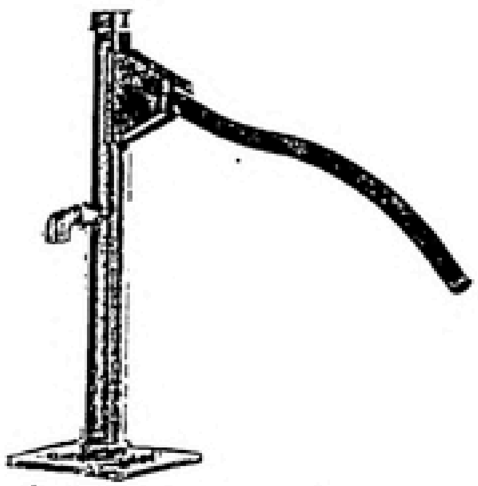


FIGURE VII.3

Stewarts and Lioyds Hand Pump with a Pivot Handle Hand Pump



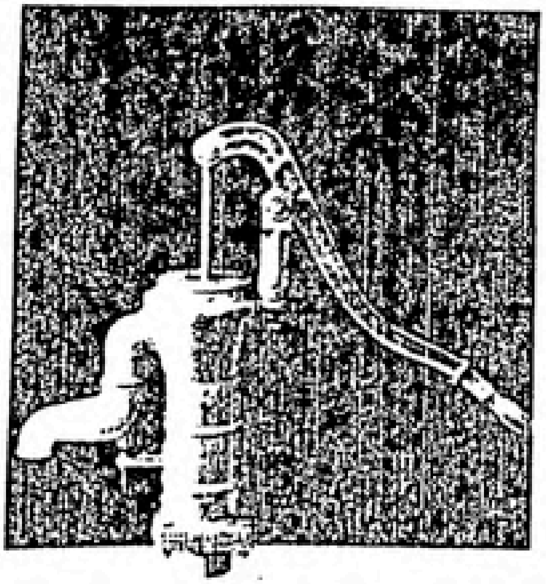
(SOURCE: World Water December 1981 P.39)

SYB-100 PUMP

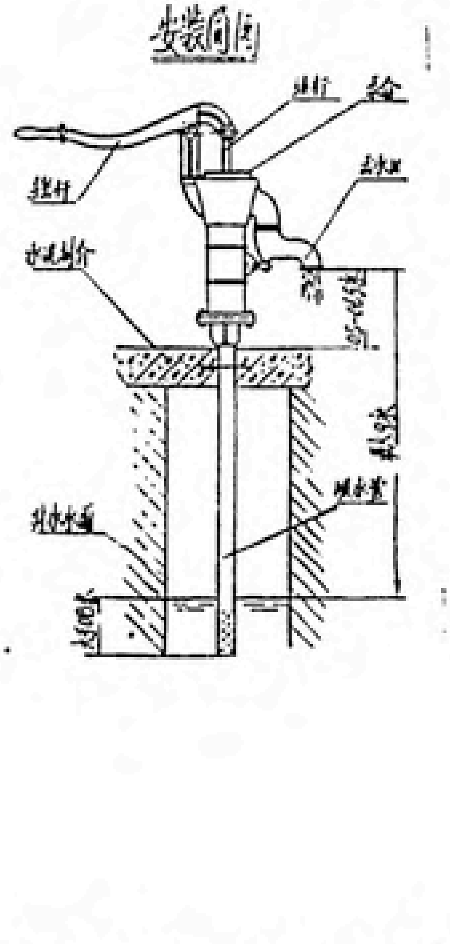
SYB-100 pump is widely used in south of China as a shallow well pump. Pump stand and handle are made of cast iron. The piston and foot valve are made of rubber. At 50-70 strokes per minute, it will deliver 60-75 liters of water per minute. The total weight of the pump is about 24 kg, it is very easy to handle. It is suitable for rural area drinking water supply.

FIGURE VII.4 SYB-100 Hand Pump

SYB-100 Hand Pump installation



SYB-100型手摇式吸水泵



(SOURCE: Chinese Academy of Agricultural Machinery)

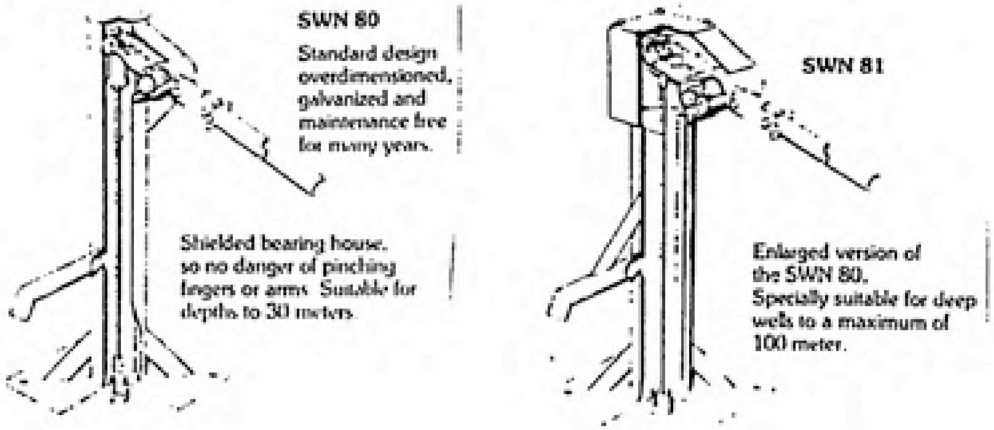
SWN PUMP

SWN type pumps are manufactured in Holland. SWN80 is a standard design overdimensioned. It is suitable for depths to 30 meters. SWN81 is an enlarged version of the SWN80. It is especially suitable for deep wells to a maximum of 100 meters. Also there is a version of the SWN pump used in irrigation. PVC casings and filters are used in SWN pumps. In deep well cylinders, all parts are corrosion resistant; such as PVC, neoprene, nylon, brass and stainless steel. Therefore, no replacements are needed for many years. Available sizes are 2", 2.5", 3" and 4".

SWN MODEL PUMPS

FIGURE VII.5 SWN 80 & SWN 81 Hand Pump

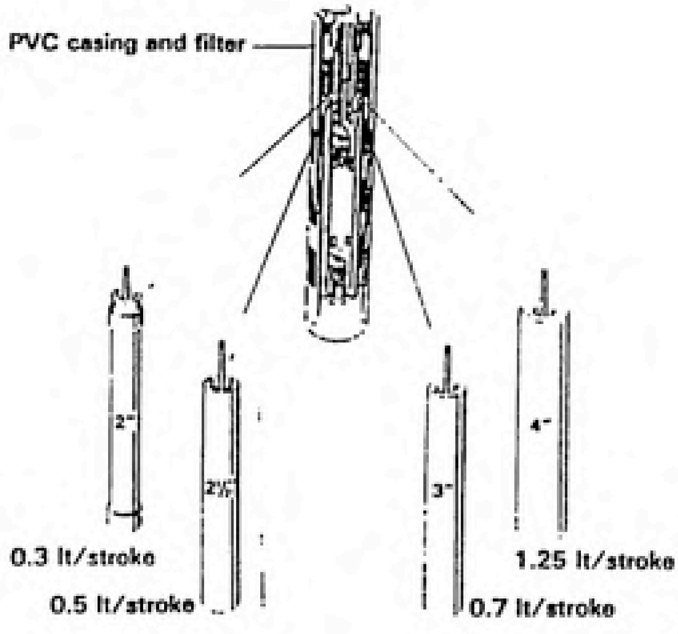
Hand operated equipment for low cost water supplies



(SOURCE: Watrelines Vol.1. No.4. 1983 p. 33)

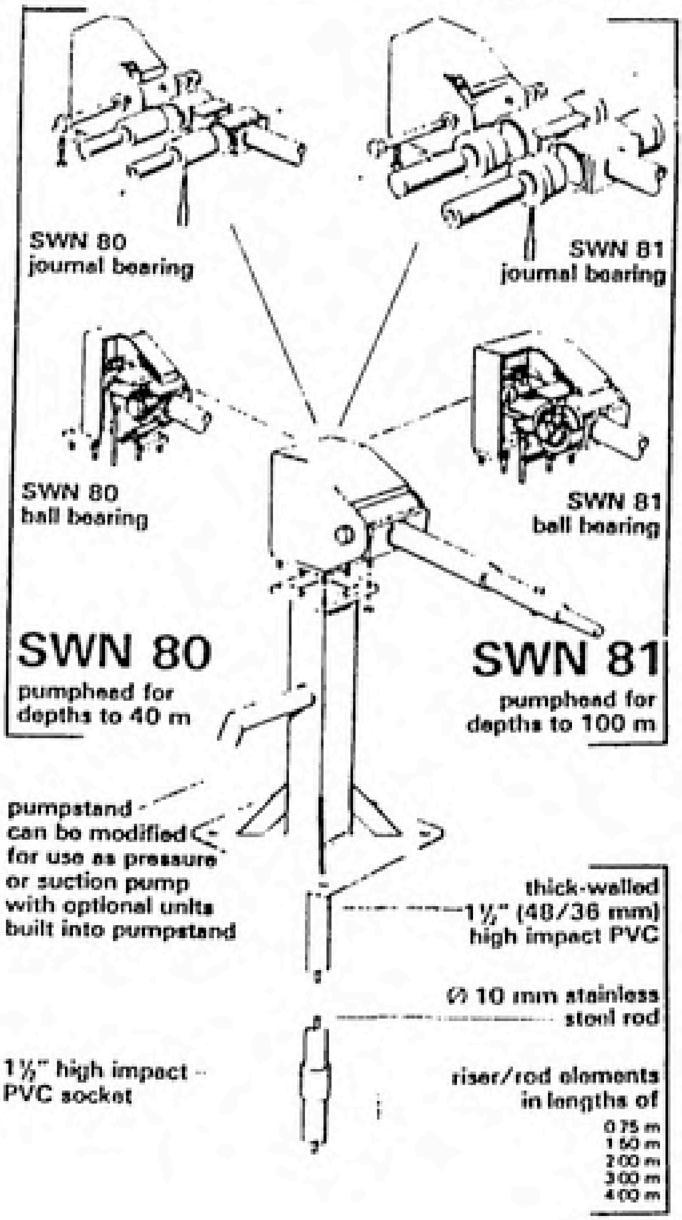
MADE
IN
HOLLAND

cylinder			casing and filter
	I.D	O.D	
2"	50	67	90/81
2½"	63	83	110/101
3"	75	90	110/101
4"	100	115	160/147
	sizes in mm		



Van Reekum Materials B.V.
P.O. Box 98
7300 AB APELDOORN, HOLLAND
Phone 55-213283 telex 36316

HAND OPERATED WATER SUPPLY EQUIPMENT



(SOURCE: World Water May 1984 p. A9)

SHOLAPUR OR MISSION OR JALNA-TYPE PUMPS

Sholapur or Mission or Jalna-Type Pump Description

The War on Want Mission was designed the Jalna pump in 1968. It has the following important features (Figure VII-6A):

- A single prelubricated and sealed pivot action.

- Totally constructed of fabricated steel instead of cast iron.

- The pump was not attached to the well casing.

The Jalna pump head field test results showed its better reliability over the traditional cast iron pump head. However, four weak points encountered are:

- Inadequate quality control which resulted in premature features of the pivot.

- Used of ordinary chain link caused wear between links which eventually caused the chain to break.

- Water tank to which the drop pipe was screwed was inadequately protected against rust. Since it was welded to the pump body it could not be repaired.

- Premature mounting of the pump head to the platform often caused the entire assembly to work free.

In 1971 the original Jalna design was changed by the Sholapur Well Service. Now the Sholapur pump is an almost totally sealed unit and has the ability to withstand a long period of operation without breakdown. The main changes were (Figure VII-6B):

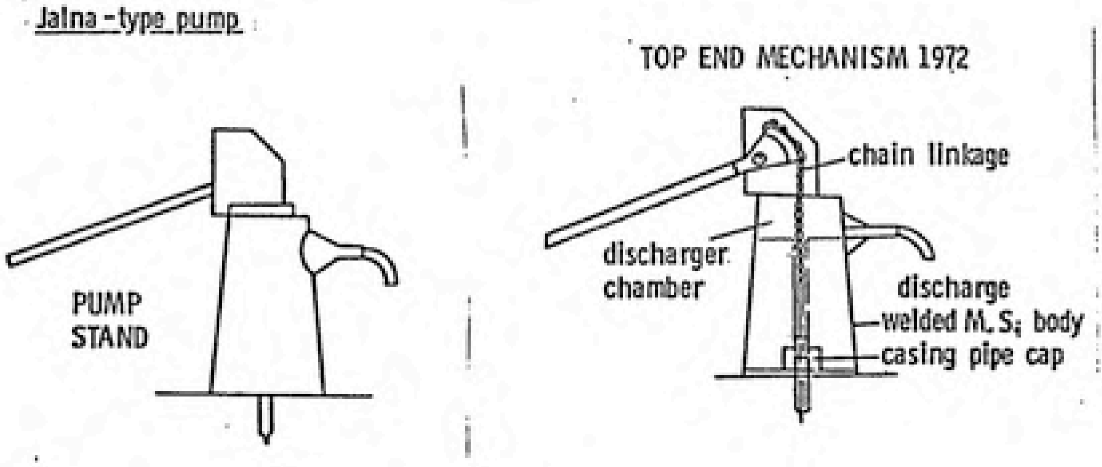
- The use of two heavy-duty sealed ball bearings pre-packed with grease in place of the original bearing.

- A heavy duty 1-inch pitch roller chain instead of links.

- The heavier gauge steel sheet was used to make a "box" in which the mechanism was enclosed (Figure VII-6B).

- Improvement in the pedestal for mounting the head by elimination of bolted connections.

FIGURE VII.6 Sholapur(Mission or Jalna-Type)Hand Pump

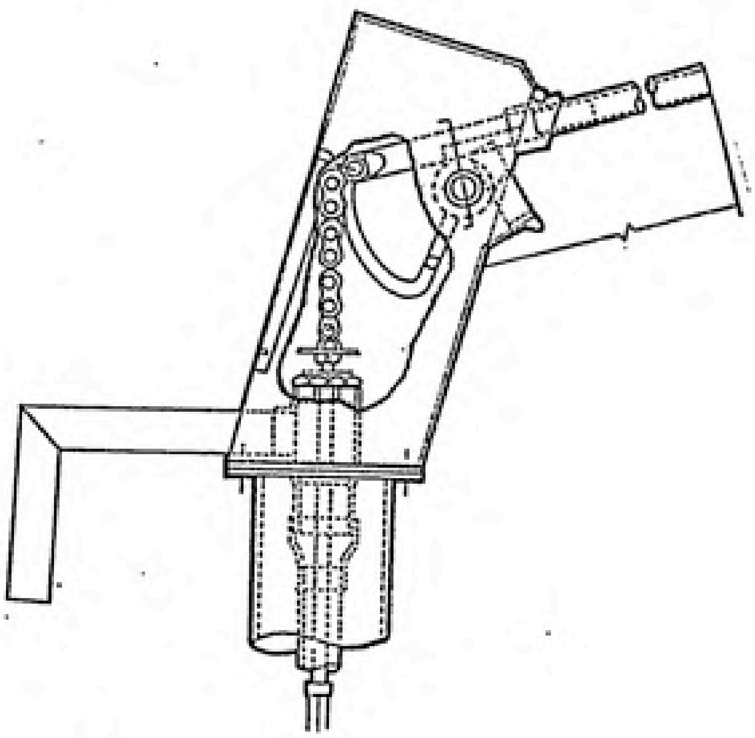


A

STANDARD DESIGN 1974

Jalna-type pump as used in 1972, and as modified by the Sholapur Well Service, 1974.

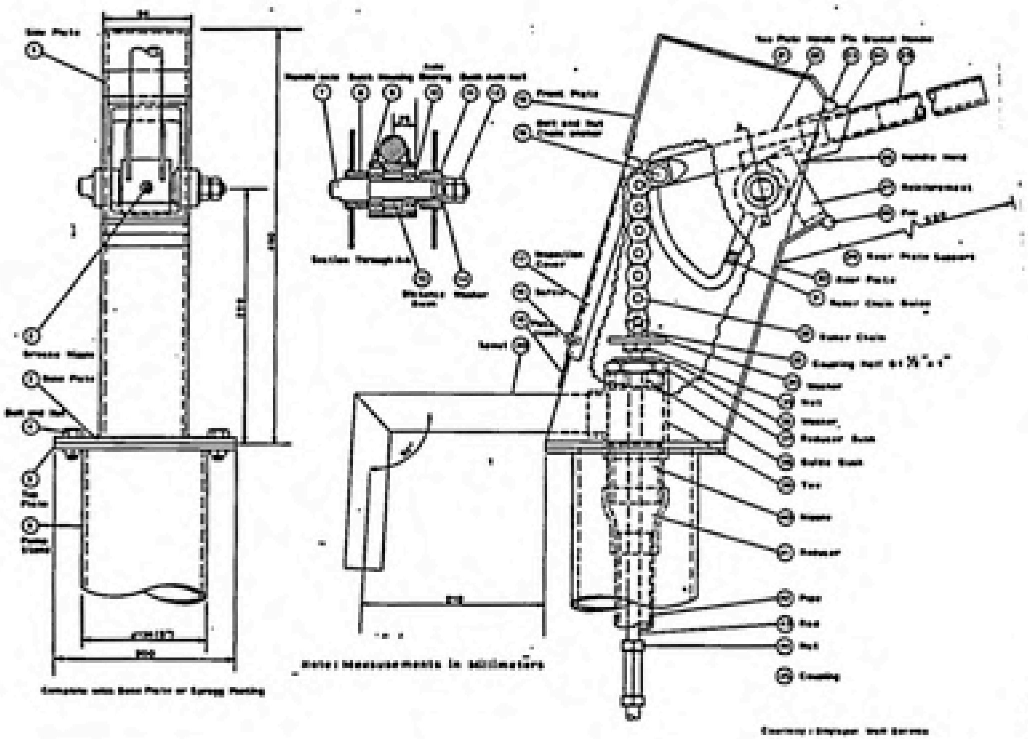
The Sholapur design eliminates the discharge chamber and has instead a gland or stuffing box, making maintenance a little less simple.



B

(SOURCE: Pacey, Arnold 1977 p.21)

Sholapur Deep Well Hand Pump Top End Mechanism



B

(SOURCE: McJunkin,F.E. 1977 p.157)

BANGALORE PUMP

Bangalore Pump Description

The Bangalore pump was developed by the Indian government of Karnataka, the World Health Organization (WHO) and the UNICEF during 1972-1974. The pump head is made of cast iron and is similar to the Sholapur pump head (Figure VII-6B).Some unusual features of this pump are:

- The use of only one pivot made possible by a roller-chain linkage. The single pivot utilizes ball bearings, and nylon balls are used in the plunger and foot valves.
- The bottom end of the chain is connected to the pump rod. The upper, which rides over a quadrant, is placed tangentially to the load-bearing end of the handle (Figure VII-6B).

More details can be found in McJunkin, FE, 1977 book.

Material of Principle Components

Component	Material(s)
Pump head	Welded steel
Plunger valve	Imported nylon ball
Foot valve	Imported nylon ball
Cup seals	Acrylo nitrile rubber
All other valves and plunger components	Made of rubber, nylon, neoprene, or glass or cotton fibre fabric impregnated with epoxy resin.
Cylinder	(Figure VII-7)

Weights and Measures

Precise values are not available.

TEST RESULTS

Pump Performance

A prototype cylinder and pump head were made and tested. It delivered water from 21 to 25 liters per minute. The test is the same as "four months of actual field use". After these tests the wear on the cylinder cup seals was minimal until 534 hours of testing (McJunkin, 1977).

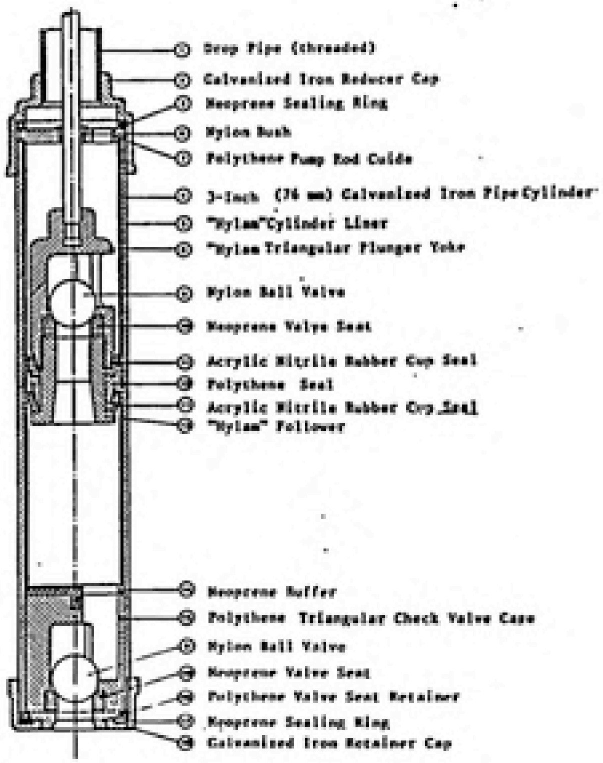
EXPERIENCE

Experience with this pump is not available in any country. Since the pump resembles India Mark II the characteristics are almost the same.

NOTE: The Bangalore pump was regarded as just a development project, and no mass production units were manufactured.

FIGURE VII.7 Bangalore Hand Pump

Bangalore Hand Pump Cylinder



(SOURCE: McJUNKIN, I977 p. I46)

U.S.T. (KUMASI) HAND PUMP

U.S.T. Hand Pump Description

In 1972, a pump was developed at University of Science and Technology, Kumasi, Ghana (Figure VII-8).

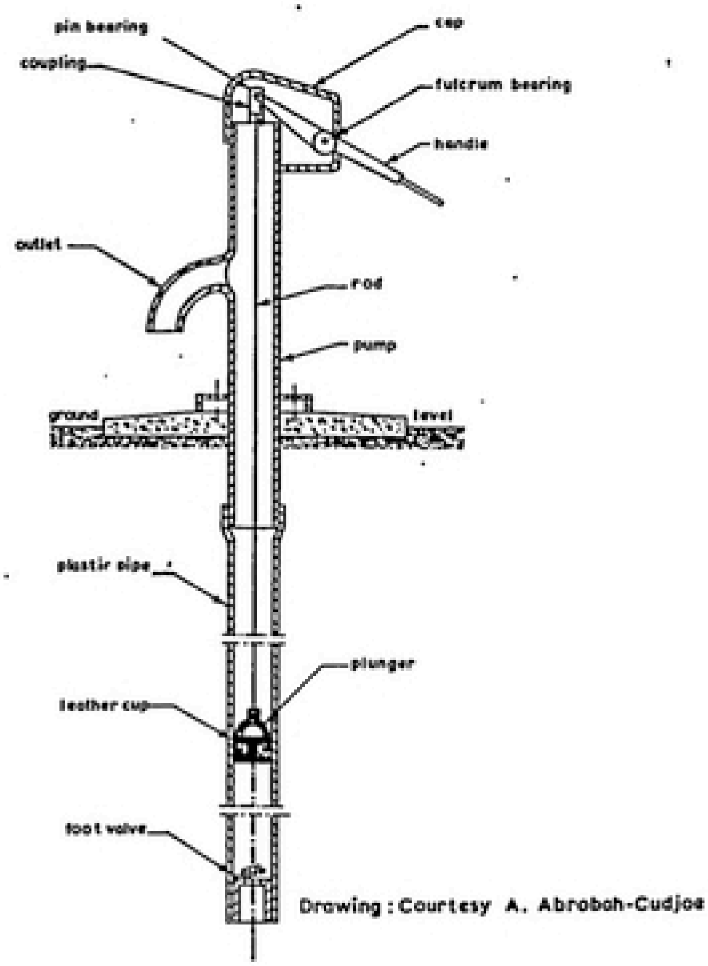
Above-ground components, the pump stand is made of welded steel. 3-inch diameter pump stand. The pump handle and pump rod are connected by a brass bushing and also the handle is linked at the fulcrum.

Below-ground there is a 3-inch diameter plastic pipe section that is fixed on the end of the pump stand. A plunger with a leather cup seal is cast from brass. Testing has been carried out at depths up to 30 meters.

This pump is suitable for local manufacture.

Other information is not available.

FIGURE VII.8 U.S.T. (KUMASI) HAND PUMP



(SOURCE: McJunkin,F.E. 1977 p. 159)

POMPE A BALANCIER AND POMPE A PIEDS PUMP

Pompe a Balancier and Pompe a Pieds are under development by SISCOMA in Dakar, use PVC drop pipe and well casing (also as the pump cylinder), a steel cable is used as the pump rod. The Pomp a Pieds is operated by foot using a treadle. More information is not available.

JAMHP HAND PUMPS

JAMHP Hand Pump Description

Figure VII.9 shows the description of the pump

ADVANTAGES AND DISADVANTAGES

Advantages

By using a tee piece at the end of the handle, there is a better mechanical advantage than just having a straight handle. The tee piece makes pumping easy.

Disadvantages

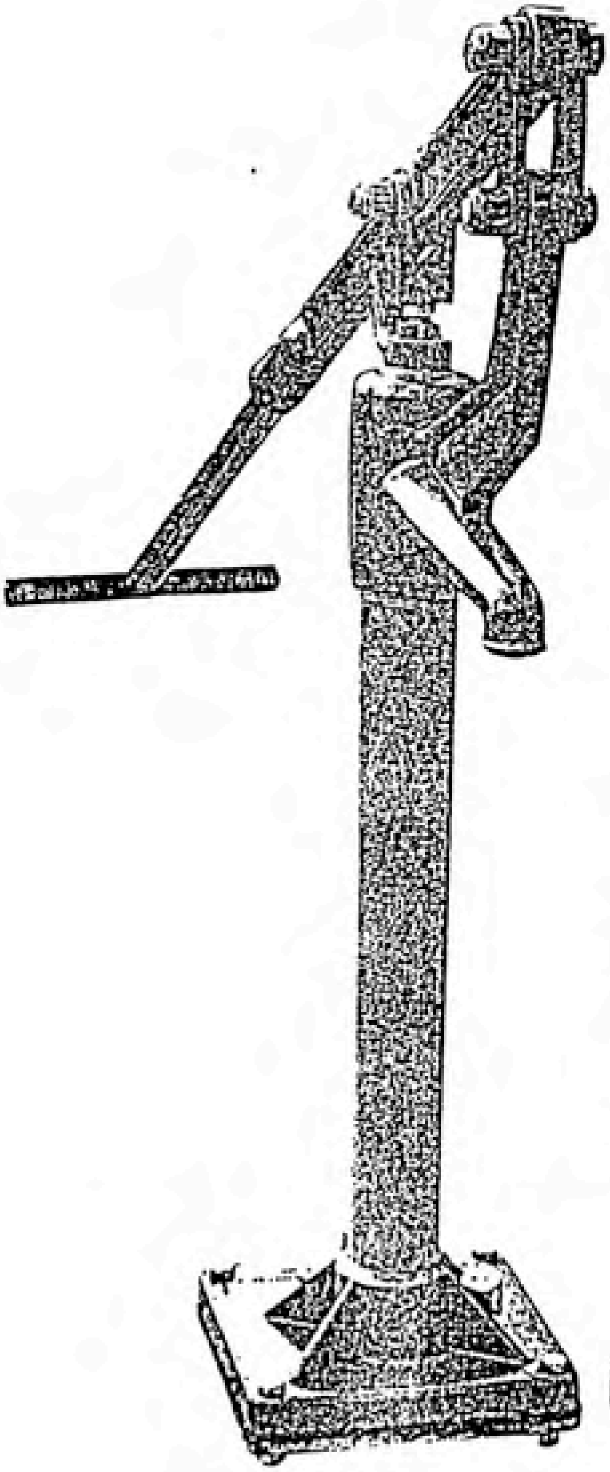
More lubrication is needed to make the system work well.

It may not be convenient to change the leather cup because of the pump head construction.

All the pumphead parts should be dismantled. Because the leather cup wears out often, one has to keep a supply of cups on hand.

Spout angle and length is not good enough. Children can insert foreign matter into the pump head.

FIGURE .9 JAMHP Hand Pump



Stout, durable borehole or tubewell hand pumps for depths to 30 meters

Utilizing an above-ground piston and cylinder for simple village level operation and maintenance.

30 minutes to install without lifting equipment; 5 minutes to maintain or change leather cup when necessary.

High continuous reliability with flow rates to 26.5 liters per minute with low work effort.

(SOURCE: Waterlines 1984 p.17)

VIII. PUMPS WITH NAME

INTRODUCTION

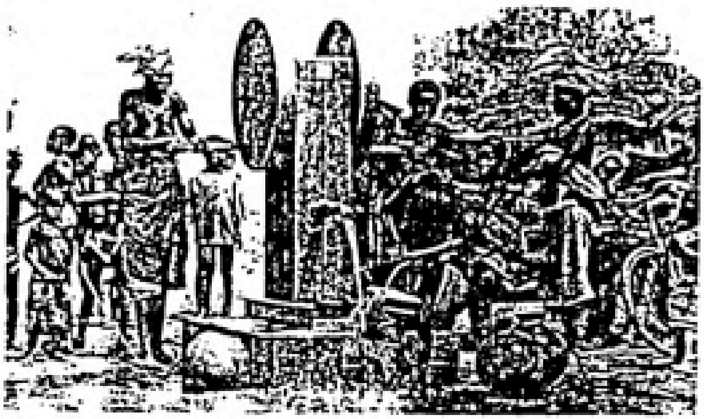
In this chapter, only the names of the following pumps were mentioned in technical reports or technical journal articles. I list them here for completeness.

COUNTRY OF ORIGIN	NAME	DEEP OR SHALLOW
Bangladesh	Maya No. 6	Shallow
Bangladesh	Tara	Shallow
England	Hand driven ejector	n/a
France	Royale	n/a
France and Ivory Coast	Africa	n/a
France	Majestic	n/a
Pakistan	Sialkot	n/a

"AFRICA" PUMP

"Africa" hand pump is manufactured in France and Ivory Coast. It is used in West Africa.

FIGURE VIII.1 "Africa" Hand Pump



(SOURCE: McJunkin,F.E. 1977 p.151)

IX. SUMMARY OF RESULTS OF HANDPUMPS TESTING AND EXPERIENCE IN DIFFERENT GROUPS OF TESTED PUMPS

TABLE IX.1 : SUMMARY OF RESULTS OF TESTING FOR ODA TESTED PUMPS

CODE	Manufacturer (Country of origin)	Model	Deep/shallow	Ex-Factory Cost per pump*	Type of pump	Ease of Maintenance & repair
A	Petropump (Sweden)	Type 95	Deep	£221.5 (excluding pipe)	Hand-operated diaphragmatic hose	3
B	Vergnet (France)	Hydropompe Type AC 2	Deep	£421.7 (complete to 50m)	Foot-operated hydraulic operation, diaphragmatic hose	4
C	Dempster (USA)	23 F(CS)	Deep	£56.5 (excl. pipe and rod)	Hand-operated lift pump	2
D	Mono (England)	ES 30		£370.4 (complete to 10m)	Hand-operated rotary, helical screw-type operation	2
E	Climax (England)	Not stated	Deep	£730.9 (complete to 21m)	Hand-operated flywheel-lift pump	1
F	Godwin (England)	WI H51	Deep	£865.5 (complete to 21m)	Hand-operated geared lift pump	1
G	ABI (Ivory Coast)	Type M	Deep	£358.3 (Excl. pipe & rod)	Hand-operated lift pump	2
H	GSW (Beatty) (Canada)	1205	Deep	£163 (Excl. pipe and rod)	Hand-operated lift-pump	2
J	Monarch (Canada)	P 3	Deep	£359 (complete to 30m)	Hand-operated lift pump	2
K	Kangaroo (Holland)	Not stated	Deep	£282.5 (complete to 20m)	Foot/Spring-operated lift pump	2
L	India (India)	Mark II	Deep	£54.9 (excl. pipe and rod)	Hand-operated lift pump	2
M	Consallen (England)	L D 5	Deep	£296.8 (complete to 20m)	Hand-operated lift pump	3

* Price basis late 1977/early 1978 equivalent in £

Note: This information was compiled in 1981 and has been included for completeness.. Many manufacturers, however, have since modified their pumps as a result of both laboratory tests and field information.

SOURCE : ABSTRACT OF ODA HANDPUMPS LABORATORY TESTING FINAL REPORT, JANUARY 1981

TABLE IX. (Cont.)

Results of Endurance Test				
Hours	Failures	Performance	Reliability	Wear
670	Pumping element disconnected. 962/ nut on handle loose. 1636/ pumping element split. 2848/pumping element failed. 3212/pumping element split	Adequate but low efficiency	Somewhat variable	Likely to be small
1317 2000	Significant wear in pedal rod guide Pedal rod guide worn right through	Acceptable, low efficiency	Fairly good	
930	Pump rod broken. 1130/pump rod broke again. 3037/split pin on hand fulcrum bearing fractured	Good	Poor	
	No failures occured. (However, continual oil leakage from gearbox)	Poor	Very good	
1323	Water leaking from pumpstand inspection covers. 1355/ Handle fractured	Good	Very good	Likely to be minimal
	No failures occurred	Adequate	Excellent	
	No failures occurred	Good	Good in test but sharp metal/metal stops may cause field problems	Unlikely to cause problems
	No failures occured	Fairly good	Quite good	
2772 3692	Wooden handle loose. Pump rod top guide bush worn through	Good	Quite good	
251 430	Spring in pumpstand broken No spares, pump removed from test	Poor	Very poor	
	No failures occurred	Fairly good	Excellent	Unlikely to be a problem
	No failures occurred	Quite good	Very Good	

* Rating : 1 poor, 5 very good

TABLE IX.2 : SUMMARY OF RESULTS OF TESTING FOR CATR BATCHES 1 AND 2 TESTED PUMPS

Manufacturer (Country of origin)	Model	Deep/ shallow	Ex-Factory Cost per pump[a]	Type of pump	Ease of Maintenance & repair*
Korat (Thailand)	608 A-1	Deep	295[a]	Hand-operated	4
Dragon (Japan)	No. 2 (D)	Deep+	362[b]	Hand-operated	2
Moyno (USA)	IV 2.6	Deep	550[c] 739[d]	The pump rods rotate instead of reciprocating	1
Nepta (France)		Deep	650[d]	Hand-operated	2
Kenya (Kenya)		Deep	(669)	Hand-operated	4
New No. 6 (Bangladesh)		Shallow Suction	(33)	Hand-operated	5
Nira (Finland)	AF76	Deep	203[e]	Hand-operated	3
Ethiopia (Ethiopia)	Type BP50	Shallow force°	(75)	T-handle hand-operated	5
VEW (Austria)	A18	Deep	1583[a]	A rotary operating mechanism	1
Jetmatic (Philippines)		Deep	32[f]	Hand-operated	3
Bandung (Indonesia)		Shallow Suction	(54)	Hand-operated	4
Sumber Banyu ("SB") (Indonesia)		Deep	(85)	Hand-operated	3

Rating : 1 poor, 5 very good

TABLE IX.2 (Cont.)

		Results of Endurance Test
Hours	Failures	Performance
3595 4029	Quadrant and Rack Seized Handle Quadrant and Rack Worn Out	adequate average efficiency
2487 2890 3207	Handle Fork Broken Pump Rod Broken Pump Rod Broken	is not adequate for community water supply average officiency
3178	Rotor Seized	is not adequate for community water supply low efficiency expensive
1072 1318	Spring Replaced Spring Replaced	adequate.but expensive good efficiency
153 1350 2153	Connecting Tube Worn Through Loose connecting link stud Severe Handle Wear	a simple but cumbersome pump,adequade, good efficiency,expensive
1072	Cup Washer and Check Valve Worn Out	a very simple, cheap and and sturdy suction pump. Needs to be primed not suitable for drinking water supply, good efficiency
314 2828 3017	Handle Broken Handles Broken	adequate, but require high level skills good efficiency
		an inherently simple pump adequate, suitable for community water supply in developing counties inexpensive low efficiency
152 277 598 1091 1945	Crank Worn Out Handle Broken Crank Worn Out Cable Broken Cylinder Jammed	not suitable for manufacture in developing counties awkward to use, suitable for community water supply where the maintenance skills and facilities are available
280	Cylinder Dislodged 1024 Handle Parts Worn Out 3149 Pump Rod Broken 3837 Pump Rod Broken	is not adequate for community water supply, low efficiency
809 2018 3017	Cup Washer Split Cup Washer Split Cup Washer Split	is easy to accidentally damage and contaminate, good efficiency but is not recommended for drinking water supply
248	Handle Links Worn 287 Conn. Rod Broken 416 Fulcrum Link Worn 596 989 1076 Conn. Rod Broken 2474 Plunger Rod Broken (foot Valve failed) 3123 Handle Links Worn 4078 Plunger Rod Broken (foot valve failed)	is not suitable for community water supply,good efficiency inexpensive

TABLE IX.2 (Cont.)

Reliability	Wear
Good the rack and quadrant will wear in time but they can be easily replaced	Unlikely to be a problem
Good	Likely to be small with family use
Good in test but any repairs needed in the field will be difficult	Likely to be small
Good	Likely to be mimimal
Good in many respects could be maintained locally it is close to VLOM	Likely to be small although pumpstand is difficult to align and wears rapidly when misaligned
Good	Likely to wear considerably when heavily used
Very good	Unlikely to be a problem
	More likely to wear out than break down the most likely maintenance requirement will be replacement of the top bush
Poor in test but the modified handle and crankshaft big end works well completed the test program without failure	Likely to be small
Unlikely to be sufficiently robust for community water supply	Intensive use will produce rapid wear
Good	Small
Poor	Not good in test needs modification to be suitable for community water sup supply handle pivots caused much trouble

TABLE IX.2(Cont.)

+	Was supplied as shallow-well pump with additional components for conversion to deep-well use
o	12 metres nominal maximum depth
*	Cost if 50 purchased in one order. Figures in () are 1981 prices, otherwise 1982.
a	Supplied complete for 20 m depth
b	Supplied complete for deep-well use
c	Pump only
d	With 20 m below-ground assembly
e	Pump and cylinder
f	Without connecting rod and rising main

TABLE IX.3 : SUMMARY OF RESULTS OF TESTING FOR CATR BATCH 3 TESTED PUMPS PLUS BLAIR PUMP

Manufacturer / Country of Origin	Model	Deep or Shallow Well	Price (US$)* Approx	Type of pump	Ease of Maintenance & repair
Abi-Vergnet Ivory Coast (Pumpstand); France (Pumping element)	ASM	Deep	636[a]	Hand-operated hybrid pump working on hydraulic principles	4
Petro (Sweden)		Deep	465	Hand-operated pump using the changing volume of stretched rubber hose to provide the pumping action	2
Funymaq (Honduras)		Deep	Not supplied	Hand-operated	3
Maldev (Malawi)		#	Not supplied	Hand-operated	5
Rower (Bangladesh)		Shallow	13.50 in Bangladesh	Hand-operated, the operator pulls directly on the plunger rod by means of a T-handle	5
Volanta (Netherlands)		Deep	845[a]	It uses a heavy flywheel hand-operated pump	4
Blair (Zimbabwe)		Shallow	143	Hand-operated	5

* Cost if 50 purchased in one order

\# The Maldev is a pumpstand only. A below-ground assembly is under development for deep wells.

a Supplied complete for 20 m depth.

Rating : 1 poor, 5 very good

TABLE IX.3(Cont.)

Results of Endurance Test

Hours	Failures	Performance
	See page 212	Is simple to install and to maintain below-ground components low efficiency,expensive pumpstand is unsuitable for community water supply
3127 3644	Pumping element seized in anchor. Anchor could not be released Pumping element split	Is not adequate for community water supply low efficiency
3127	Foot valve flap broken away, pump rod bent, severe damage to cylin-er der bore	Adequate for community water supply,average efficiency
2188 2409 2426 2918	Rising main not secure in pumpstand Leaking around rising main inside pumpstand	Clearly designed to use appropriate manufacturing skills with VLOM in mind good efficiency,inexpensive
		A true VLOM pump suitable for low-lift irrigation
	See page 213	If the modifications prove to be successful in future tests, it may be suitable for community water supply
	Pump had withstood over six million pumping strokes without single breakage and minimal wear	Clearly designed to use appropriate manufacturing skills with VLOM in mind good efficiency,inexpensive

TABLE IX.3(Cont.)

Reliability	Wear
Pumpstand is not reliable	
Good	Downhole anchor unsuitable for use in ,PVC pipe
Good except for foot valve problems noted	The broken parts of the foot valve became entangled in the plunger, bent the pump rod and caused severe damage to the cylinder bore
A robust pumpstand but still requiring some development of the method of fixing the rising main	
Very good	Unlikely to be a problem all wear-ng ing parts are easy to replace
Two types of cylinder as supplied in test proved to be unreliable in use	
Very good	

Abi-Vergnet Pump

Breakdowns are shown in bold type.

TABLE IX.3(Cont.)

Hours	Event
0	Inspection and full performance test
75, 167, 247	**Leather seals on primary plunger worn out – replaced by polyethylene**
1042	Inspection and volume flow test
1042	**PE primary seals worn out**
1087, 1306	**Bolt broken on primary plunger rod**
1529	**Bridle to primary rod fulcrum worn out**
2083	Inspection and volume flow test
2083	**PE primary seals worn out replaced by acetal**
2645	**Acetal primary seals worn out**
2930	**Acetal primary seals worn out replaced Brima textile cords**
3125	Inspection and volume flow test
3125	**Textile seals worn out – replaced polyethylene**
4167	Inspection and volume flow test
4167	**PE primary seals worn out**

Volanta

Breakdowns are shown in bold type.

Cylinder Type 1

TABLE IX.3 (Cont.)

Hours	Event
0	Inspection & full performance test
1027	Inspection & volume flow
2054	**Cable top fixing point broken**
2094	Inspection & volume flow
2828	**Cable thimble broken at bottom connection**
3125	Inspection & volume flow **Cable thimble broken at bottom connection**
3451	**Cable thimble broken at both top and bottom connections – replaced by turned acetal pulleys**
3699	**Cable top fixing point broken**
4164	Inspection & full performance test

Cylinder Type 2

Hours	Event
0	Inspection & full performance test
1027	Inspection & volume flow
2094	Inspection & volume flow
2931	**Cable top fixing point broken**
3125	Inspection & volume flow **Cylinder 'sand-locked' in rising main** **Cable thimble broken at bottom connection**
3214	**Leaking joints in rising main**
3410	**Debris from broken thimble on bottom connection caused plunger to seize – thimble replaced by turned acetal pulley**
4164	Inspection & full performance test

X. CONCLUSION

CONCLUSION FOR HANDPUMPS

One of the most important factors of successful water supply projects is a reliable pump to ensure satisfactory operation. In most developing countries the majority of the people are still in a low-income bracket, living in rural areas with a shortage of technical, physical and financial resources. Their demands are for low cost water supply equipment which is easily maintained from locally available resources (such as raw materials and spare parts) and also which can be operated or repaired by semi-skilled or unskilled villagers. In rural areas the financial considerations are a very severe constraint, thus technical simplicity and low cost are essential.

The typical lever-operated, single action (cylinder) reciprocating (plunger) handpumps installed in developing countries were originally designed and manufactured for single families in Europe and North America and could not stand up to villager use in rural areas where each pump served up to 100 or even 1000 people. Typically the pumps and spare parts used in developing countries are imported. Also the pumps are made mainly of cast iron and steel. They are not only expensive, but also are not readily available locally, because the configurations of the pump make them heavy and complex. Thus, they could not be repaired by villagers with little skill and without lifting equipment and special tools. The imported components result in long delays causing the broken pumps to not be repaired. High failure rate of the conventional manual pumps is common during the past decade in developing countries.

Through all the handpump laboratory and field testing the results clearly indicate that none of the pumps will universally function under all environmental conditions or with all user groups. All the pumps show some compromises between ease of operation, performance, ease of installation and maintenance, expense and durability.

The selection of the appropriate pumps for rural water supply use depends upon local conditions. However, some basic conditions should be fulfilled. The most important are to ensure an adequate quantity of delivered water at appropriate hydraulic lift and to fit in with local cultural and geographical environments. In addition, the pumps installed in developing countries normally should meet the criteria which follow.

1) MADE IN COUNTRY OF USE

Ideally the design should be simple enough to be manufactured in the country of use and require a minimum of imported parts or material. However in developing countries not yet industrialized or with limited resources this may not be possible. In such cases a simple design remains important. The choice would have to be from outside the country of use but from a source which can be depended upon and with attention to transportation distance and transportation facilities.

2) TROUBLE-FREE OPERATION

A new handpump must have a trouble-free operational span, after installation, of at least one year. It must be selected to meet the needs of the service population, in general about 300 people.

3) PRICE

The price of a pump is important, but the reliability and quality of the pump are even more important. It has sometimes happened that designers and manufacturers having realized the need for an affordable or simple pump, have installed "cheap" pumps which are made of low-quality materials. The result is disillusioning and the beneficiaries (villagers, users) began a natural and inevitable return to traditional - often polluted - water sources.

4) EASE OF INSTALLATION

Environmental conditions, available materials, and level of expertise of those expected to adopt and maintain the pump must be taken into account. The quality of the initial installation governs the duration that the pump will function without breakdowns and its subsequent maintenance requirements. Therefore simplification of installation is very important. Installation should be possible using common tools without the use of special lifting equipment, using simple skills and minimum manpower.

5) EASE TO OPERATE

Ease of operation is an important consideration, because traditionally women and older children are most often the ones who carry the water. The pump, therefore should be capable of operation by women and older children using minimal force.

6) EASE OF MAINTENANCE

This is related to simple design and the elimination of the high costs of routine maintenance and repairs. One can assume that any needed maintenance or repair will have to be made by someone with little technical skill, therefore ease of maintenance and repair is essential.

7) HYGIENE

One of the key considerations of a water supply project is the public health factor. There are two aspects which should be mentioned. First, the handpump itself should keep out all possible sources of contamination. The pump head should be totally enclosed so that there is no chance of pollution to the tube well through the pump head, and the pump stand construction should be sealed at the top of the well. Second is that the well structure must not only be strong enough to support the pump and its users, but it also must be capable of keeping out all sources of contamination.

CONCLUSION: SUMMARY OF RECOMMENDED HANDPUMPS FOR RURAL WATER SUPPLIES IN DEVELOPING COUNTRIES

With regard to the installation of hand pumps in developing countries, the following factors should be considered:

If the population to be served does not grasp from the outset the importance of clean drinking water, then material aid will not be effectively utilized. It is only when the population is itself convinced of the necessity for safe drinking water, that they will actively seek all available means to improve the condition of their supply; then even a minimum of aid can often achieve maximum results.

All too often, however, international support to developing countries fails to achieve its goals despite vast quantities of technical and material aid because the local population is not committed to the program. Thus, upon completion of the project and with the departure of the foreign advisers, the project is not adequately or efficiently maintained - at a tremendous loss for all concerned. Accordingly, any study of handpumps for developing countries must also consider this factor of self-motivation, initiative and commitment on the part of an informed local population.

Selection of handpumps is not simply a question of dealing with the design of a pump, but with the functioning of the whole system. A handpump is a system with several components. If one of those components malfunctions, the entire system breaks down and water is no longer delivered. Thus, a thorough understanding of such facts as how this pump functions, what can go wrong, and what components wear out the fastest, is essential for adequate maintenance. Up to now, it appears that too little attention has been given to this aspect of handpump technology. Therefore there must be a concerted effort to sensitize and educate all users not only on how the system works, but also on its limitations, to ensure that pumps function correctly. In other words, the rural water supply managers, planners and participants should always keep the following five areas of handpump project-related activities in mind; these are identified as the major issues for the International Drinking Water Supply and Sanitation Decade by United Nations Development Programme:

1) rural emphasis and community participation

2) education and communication support

3) training required personnel

4) choosing the right technologies

5) maintenance.

The purpose of installing a pump is to withdraw water, but this can not be done without a good well site and proper construction of the boreholes.

The borehole is the most important factor determining the performance of a water point. Wells should be properly developed and only when sand intrusion into the well is seen to be limited is it really worth thinking about improvement of pump design and manufacture. Sand will destroy any pump. None of the variety of different pumps installed on the correctly constructed boreholes has broken down in 15 months of operation (World Water, 1982). So one should first know the hydrology of the place where it is proposed to set up the pump.

With regard to the selection of handpumps the following table, - Summary of Recommended Handpumps for Rural Water Supplies in Developing Countries, is provided based upon a review of available data on 65 pumps from 30 countries.

These are the eight pumps I recommend after studying all available information about sixty-five handpumps. Pump in dotted box is recommended as the best pump in its category. Pumps in solid boxes are recommended as pumps that are better than the others but not equal to the "best".

SUMMARY OF RECOMMENDED HANDPUMPS FOR RURAL WATER SUPPLIES IN DEVELOPING COUNTRIES

NAME OF HANDPUMP/ COUNTRY OF ORIGIN	COST	SUITABLE FOR COMMUNITY DRINKING WATER SUPPLIES: Q liters/stroke	H raising water head (m)	J work input Joules/stroke	RESISTANCE TO CONTAMINATION	MANUFACTURE IN DEVELOPING COUNTRY
DEEP WELL PUMPS						
1) Korat 608-A/Thailand	$295 to 20 m (1982) (a)	0.36	25	175	Good	Needs effective quality control.
2) Consallen/England	$2968 to 20 m (a) (late 1977 early 1978	40 stroke/ min: 0.35	≥65	n/a; adult can easily operate	Good	Suitable for manufacture in developing countries
3) Volanta/Netherlands	$845 to 20 m (a)	0.61	25	162	Spout may be contaminated by animal	Needs effective quality control and special skills
4) Nepta/France	$650 to 20 m (1982) (a)	0.38	25	130	Good	The polyester cable at the top of the pump rod is a proprietary item
SHALLOW WELL PUMPS						
5) Maldev/Malawi	n/a; pump head only tested (a)	0.47	7	53	Very good	Needs effective quality control and special skills
6) New No. 6/ Bangladesh	$33 (1981) (a)	1.29	7	134	Susceptible to contamination; not suitable for drinking water supply	Requires special skills
7) Blair/Zimbabwe	90-mm pump is approximately $143. 60-mm mass-produced version is $57 (b)	0.58	6	Young teen-ager can operate easily.	Good	Needs effective quality control
8) Ethiopia/Ethiopia	$75 (1981) (a)	0.60	7	112	Spout can be contaminated by fecal contamination	Suitable for manufacture in developing country

HANDPUMP NUMBER	Ease of Instal. PEOPLE NEEDED	LIFTING TACKE NEEDED	---- Ease of Maintenance ---- HOW THE BELOW-GROUND COMPONENTS CAN BE EXTRACTED	PEOPLE NEEDED	REGULAR MAINTENANCE ITEM	---- Ease of Repair ---- PEOPLE NEEDED	LIFTING TACKLE NEEDED	THE CRITERIA OF IDEAL HANDPUMP MET BY EACH PUMP	RATE FOR CHOOSING OF RURAL WATER SUPPLY
DEEP WELL PUMPS									
1)	2	yes	Pumpstand must first be partially dismantled	2	Regular lubrication is required	2	yes	1,2,3,7	Better
2)	2	no	Pumpstand is not needed to remove from the wellhead	2	Require frequent lubrication on ball bearings	2	no	1,2,4,5,7	Better
3)	2	no	Without the need to remove the rising main	2	Tightening the gland at the top of the connecting rod	2	no	2,4,5,6	Good
4)	2	yes	The pumpstand is not needed to remove from the wellhead	2	The bearings may be replaced when necessary.	2	yes	2,4,5,7	Good
SHALLOW WELL PUMPS									
5)	2	No, if plastic rising main is needed	Not necessary to extract	1	The joint between the rising main and the pumpstand may need frequent attention to keep it watertight	1	no	1,2,4,5,6,7	Better
6)	1	no	Not necessary to extract	1	Requires frequent attention to the plunter and check valve	1	no	1,2,3,4, 6	Good
7)	2	no	The pumpstand is not needed to remove from the wellhead	1	The only maintenance is to clean the foot valve	1	no	1,2,3,4,5,6,7	The best
8)	1	no	The top bush in the pumpstand need be removed	1	Replacement of the top bush is easy	1	no	1,2,3,4,6	Good

(a) adapted from A World Bank Technical Paper, ISSN0253-7494; No. 19 (1984). (b) adapted from Enfo. vol. 5, no. 2 (1983)
These are the eight pumps I recommend after studying all available information about sixty-five pumps.
Pump in dotted box is recommended as best pump. Pumps in solid boxes are recommended as better pumps.

XI. RECOMMENDATIONS

Improvement of the Handpumps

The following are recommended improvements in the design of handpumps.

1. Standardization of pump components to simplify repair and maintenance. Proliferation of hand pump models in a single program leads to difficult maintenance problems - inventories, spare parts, purchasing, lubricants, training, etc.

2. The use of lightweight but strong parts. Plastic extrusion moulding is predominant in developing countries. Use of plastics components will mean that, in most cases, a trained villager will be able to remove the pump cylinder, piston and drop-pipe for repair, eliminating the need for heavy lifting gear.

3. The handpump components likely to wear out should be inexpensive, easily accessible and capable of being installed by those who have to maintain the pump. Wear on such parts should be seen easily. The wear should not cause the pump to be taken out of use.

The trouble-free operational life of a handpump is not only dependent on the quality of the pump but also on the quality control of installation. The quality of initial installation controls the pump durability and its subsequent maintenance requirements.

A major consideration of the success of the rural water supply system lies with the participation of the village communities. When each community is asked to pay a regular fee to maintain the pump, they feel the water supply belongs to them and are more willing to take care of it.

To complete the VLOM concept, training is needed at a lower level of expertise to enable local villagers to handle simple but important tasks, such as lubricating pumps at certain periods, repairing concrete well structures, and painting exposed pump parts to prevent rust.

A simple administrative system should be established through which major pump problems can be reported to higher authorities.

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70. World Water (December 1981f), Laboratory Tests Endurance and User Reactions, p. 27.

71. World Water (December 1981g), INSTO Volanta Hand Pumps, p. 31.

72. World Water (December 1981h), Kawamoto Pumps Offer You Affluent Water and Life, p. 35.

73. World Water (December 1981i), A Water Supply You Can Depend On, p.39.

74. World Water - Water Decade : First Year Review (1981a), p. 34.

75. World Water - Water Decade: First Year Review (1981b), inside back cover.

76. World Water (May 1982), Zimbabwean Hand Pump Passes Village-Level Endurance Tests, pp. 36-37.

77. World Water (September 1982), Modified India Mark II Seeks to UN VLOM Handpump Spec, pp. 38-39.

78. World Water (November 1982a), Africa and the Water Decade, p. 20.

79. World Water (November 1982b); Malawi's Livulezi Provides a Primer for Pump Studies, pp. 22-26.

80. World Water (December 1982), Full Standby Provided by Twin-Handled Pump, pp. 28-29.

81. World Water - Water Decade: Second Year Review (1982a), The Malawi Pump Prototype Is Put Through Its Paces, p. 10.

82. World Water - Water Decade: Second Year Review (1982b), Badie Villagers Show the Way in Upper Volta Maintenance Scheme, pp. 29-31.

83. World Water - Water Decade: Second Year Review (1982c), Philosophy of VLOM - According to Bom, p. 30.

84. Reprint from World Water (February 1983a), First VLOM Prototypes Expected This Year, pp. 2-4.

85. Reprint from World Water (February 1983b), Lab Test Narrows the Choices, p. 4.

86. Reprint from World Water (February 1983c), Field Trial Sites Chosen in 20 Countries, p. 5.

87. World Water (May 1984a), SBF Handpumps, p. 55.

88. World Water (May 1984b), Pb Pumpen Goese Kg, p. 70.

89. World Water (May 1984c), Interface: Handpumps Pass Endurance Trials, p. 75.

90. World Water (August 1984), Hand Operated Water Supply Equipment, p. A9.

91. World Water (September 1984), Lab Tests Highlight Design Deficiencies, pp. 40-41.

APPENDICES A. List of Pumps Considered in the Report

Country of Origin	Name	Deep* or Shallow	Information Available	Page No.	Comment
Austria	Vew A18	Deep	D,LT	154-156	
Bangladesh	New No. 6	Shallow	D,LT,FE	49-54	Recommended
Bangladesh	Rower	Shallow	D,LT,FE	77-79	
Bangladesh	Bangladesh Deep-Set	Deep	FE	175	
Bangladesh	Tredle	n/a	FE	175	
Bangladesh	Maya No. 6	Shallow	N	201	
Bangladesh	Tara	Shallow	N	201	
Belgium	Deplechin	Deep	D,FE	146-147	
Belgium	Duba Tropic Pump	Deep	M	181	
Botswana	Stewarts & Lloyds	n/a	M	182-183	
Brazil	Marumby	Shallow	D,FE	150	
Canada	Monarch	Deep	D,LT,FE	80	
Canada	Waterloo (IDRC)	Shallow	D,LT,FE	125-126	
Canada	GSW1205	Deep	LT,M	176	
China	SYB-100	Shallow	M	184-185	
England	Consallen LD5	Deep	D,LT,FE	92-99	Recommended
England	Mono ES30	Deep	D,LT,FE	100-105	
England	Climax	Deep	LT,M	176	
England	Godwin W1H51	Deep	LT,M	177-179	

Country of Origin	Name	Deep or Shallow	Information Available	Page No.	Comment
England	Hand driven ejector	n/a	N	201	
Ethiopia	Ethiopia BP50	Shallow	D,LT	157-159	Recommended
Finland	Nira AF76	Deep	D,LT,FE	74-76	
France	Hydro-Pompe Vergnet	Deep	D,LT,FE	106-110	
France	Nepta	Deep	D,LT	160-162	Recommended
France	Royale	n/a	N	201	
France and Ivory coast	Africa	n/a	N	202	
France	Majestic	n/a	N	201	
Germany	Kardia	Deep	D,LT,FE	119-121	
Germany	Turni	Both	D,LT,FE	122-124	
Ghana	U.S.T.(KUMASI)	Deep	M	196-197	
Holland	ESW-81(82)	Deep	FE	175	
Holland	Kangaroo	Deep	D,LT,FE	116-118	
Holland	Volanta	Deep	D,LT,FE	21-29	Recommended
Holland	SWN 81(82)	Deep	M	186-188	
Honduras	Fungmaq	Deep	D,LT	163-165	
India	India Mark II	Deep	D,LT,FE	81-91	
India	Bangalore	Deep	M	193-195	
India	Sholapur (Mission, Jalna)	Deep	M	189-192	
Indonesia	Bandung	Shallow	D,LT	166-168	
Indonesia	Sumber Bangu	Deep	D,LT	169-171	

Country of Origin	Name	Deep or Shallow	Information Available	Page No.	Comment
Ivory Coast	ABI	Deep	D,LT,FE	129	
Ivory Coast, France	Abi-Vergnet ASM	Deep	D,LT,FE	70-73	
Japan	Drogon No. 2(D)	Deep	D,LT	172-174	
Japan	Lucky	Shallow	D,FE	151-152	
Kenya	Kenya	Deep	D,LT,FE	55-59	
Malawi	Maldev	Shallow	D,LT,FE	36-43	Recommended
Nigeria/ Indonesia	Bamboo	Shallow	D,FE	143-145	
Pakistan	Sialkot	n/a	M	201	
Papua New Guinea	Local experimental shallow-well pumps	Shallow	FE	175	
Philippines	Clayton-Marks	Intermediate and Deep	FE	175	
Philippines	Jetmatic	Deep	D,LT,FE	66-69	
Senegal	Pompe a Balancier	n/a	M	198	
Senegal	Pompe a Pieds	n/a	M	198	
Sri Lanka	Sarvodaya	n/a	FE	175	
Sweden	Petro	Deep	D,LT,FE	60-65	
Tanzania	Shinyanga	Shallow	D,FE	148-149	
Thailand	Korat 608A-1	Deep	D,LT,FE	44-48	Recommended
Thailand	Plastic Pipe	Both	D,FE	139-142	
USA	Dempster	Both	D,LT,FE	127-128	

Country of Origin	Name	Deep or Shallow	Information Available	Page No.	Comment
USA	JAMHP	Deep	M	199-200	
USAID	Battelle/AID	Both	D,LT,FE	111-115	
USA, Canada	Moyno	Deep	D,LT,FE	30-35	
Zimbabwe	Blair	Shallow	D,FE	131-138	Recommended
n/a	Bourga	n/a	FE	175	

D -- detailed description

LT -- independent laboratory testing

FE -- field experience

N -- name only

M -- manufacturers information

*Deep(>6m); Shallow(≤6m)

B. Addresses of Manufacturers of Recommended Pumps

BLAIR

Manufacturer	Prodorite (PVT.) Ltd.,
Address	21 Leyland Road, Ardbennie Industrial Sites, P.O. Box 2887, Harare. Zimbabwe

MALDEV

Manufacturer	Petroleum Services (Malawi) Ltd.
Address	Box 1900, Blantyre, Malawi.

NEW NO. 6

Manufacturer	Engineers Wood Steel Industries Ltd.,
Address	67 Tejgaon Industrial Area, DHAKA-8, Bangladesh

ETHIOPIA TYPE BP50

Manufacturer	E.W.W.C.A.
Address	UNICEF, PO Box 1169, ADDIS ABABA, Ethiopia.

CONSALLEN

Manufacturer	Consallen Pumps Ltd.,
Address	291 High Street, Epping, Essex CM16 4BY U.K. United Kingdom.

KORAT 608 A-1

Manufacturer Saha Kolkarn Factory

Address 94-96 Soi Sukapiban 2,
Ramintra,
Bangkhen,
BANGKOK,
Thailand.

VOLANTA

Manufacturer Jansen Venneboer B.V.

Address Industrieweg 4,
Postbus 12, 8130 AA Wijhe
The Netherlands

NEPTA

Manufacturer Briau SA

Address BP 0903,
37009 Tours Cedex,
FRANCE