AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

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Batch 52

1. SUBJECT CLASSIFICATION	
A. PRIMARY	TEMPORARY
B. SECONDARY	

2. TITLE AND SUBTITLE
The continued development and field evaluation of the AID hand-operated water pump, final report

3. AUTHOR(S)
Fannon,R.D.; Frink,D.W.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1970	41p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Battelle

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

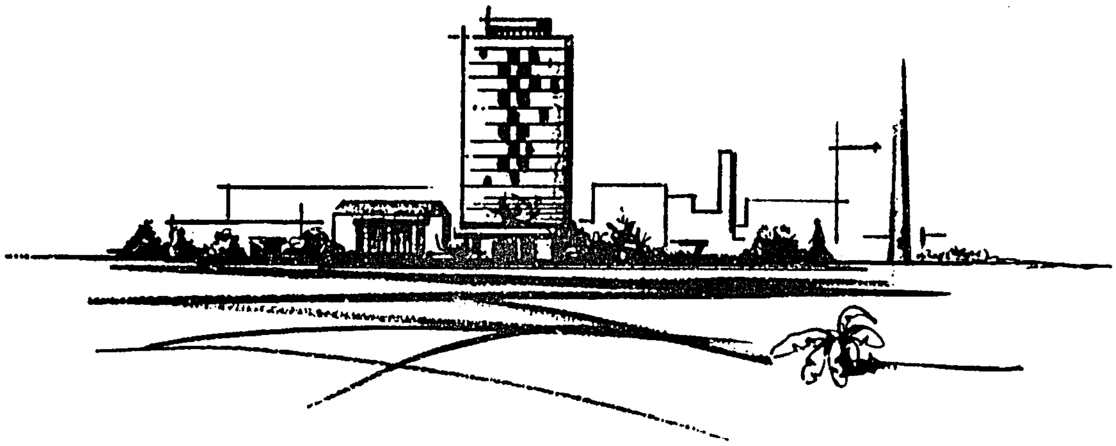
9. ABSTRACT
(SCIENCE AND TECHNOLOGY--Engineering--Hydraulics R & D)

10. CONTROL NUMBER	11. PRICE OF DOCUMENT
PN-AAD-309	

12. DESCRIPTORS	
	13. PROJECT NUMBER
	14. CONTRACT NUMBER CSD-2174 Res.
	15. TYPE OF DOCUMENT

AID 590-1 (4-74)

RESEARCH REPORT



BATTELLE MEMORIAL INSTITUTE

COLUMBUS LABORATORIES

FINAL REPORT

on

THE CONTINUED DEVELOPMENT AND FIELD EVALUATION OF THE AID HAND-OPERATED WATER PUMP

to

OFFICE OF THE WAR ON HUNGER
HEALTH SERVICES DIVISION
AGENCY FOR INTERNATIONAL DEVELOPMENT

August 28, 1970

Contract No. AID/csd-2174

by

R. D. Fannon, Jr. and D. W. Frink

BATTELLE MEMORIAL INSTITUTE
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

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THE CONTINUED DEVELOPMENT AND FIELD EVALUATION OF THE AID HAND-OPERATED WATER PUMP

by

R. D. Fannon, Jr. and D. W. Frink

INTRODUCTION

One of the most immediate needs of rural families in the small communities of developing nations is a safe and adequate water supply. A water source can be easily contaminated if the water is obtained by direct dipping, or by a rope and bucket. Therefore, the best solution to this need is usually a well and a dependable hand pump. Because repair facilities are often limited, the hand pump must be dependable even though it is subjected to severe use. It should have few parts and few points of wear. Since low cost is also important, it should be easily manufactured in the country of its ultimate use. Unfortunately, in many underdeveloped areas no pumps are available to meet all, or even most of these requirements.

In recognition of this need, the Agency for International Development initiated a program (Contract No. AID/csd-1434) with the Battelle-Columbus Laboratories to define the requirements and specifications of hand water pumps suitable for developing nations. The results of this effort are summarized in Battelle's final report to AID dated September 29, 1967. In the conclusions of that report, the following additional work was deemed advisable:

(1) Dissemination of information to interested agencies and organizations

(2) Field evaluation of a proposed pump design

(3) Further research on valves, cup seals, and cylinders

(4) Development and implementation of educational programs.

On June 28, 1968, a second contract was initiated at Battelle in regard to Items 3 and 4. Assistance was to be given to the field evaluation of the basic pump design that was selected during the first contract. At the same time, the pump design was to be optimized with respect to life, reliability, and cost through the development of improved valves, cup seals, and cylinder coatings. The following report describes the results of the continued effort, which was concluded on June 28, 1970.

SUMMARY AND CONCLUSIONS

During the previous program, a simple piston pump design was identified as being the most suitable for the needs of developing nations. In the continued effort, it was envisioned that Battelle would contribute to the field evaluation of this basic configuration by assisting a manufacturer in the production of a number of pumps, by preparing a manual for field installation and operation, and by evaluating reports and components from the field. At the beginning of the program, manufacturing specifications and drawings were prepared for the previously selected pumps design. However, arrangements could not be made for fabricating and supplying the pumps for field evaluation. The remaining funds allocated for field evaluation were redirected toward additional component development, and toward the dissemination of information to interested parties. The different activities are summarized in the following sections.

Plunger-Valve Development

The metal valves presently used in pump plungers are subject to wear and malfunctioning. Two designs of improved plunger valves were evolved. One is a flapper valve made of neoprene-impregnated nylon. The valve is similar to the flapper valves commonly used in pump cylinders. The other design is a serrated flapper valve which requires a modified plunger configuration. Both types of valves were operated over 5000 hours in shallow-well and deep-well pumps without signs of deterioration. It was concluded that the serrated flapper valve, which is particularly simple and inexpensive to make, should be used for the majority of pump applications. The weighted flapper valve, which is more conventional in appearance and more resistant to pressure, should be used where the acceptance of something different might be a problem, and in deep wells where multiple cups are required.

Selection of Optimum Cup Material

Leather is the standard material for plunger cup seals, and its basic properties are specified for any materials to be used in plunger cups. The most important of these properties is the ability to stretch to conform to the cylinder walls. Because plunger cup wear is the most frequent cause of pump repair, other materials were studied in an attempt to find a better cup material. Corfam was found to be the best material available. It is very similar to leather, but is more uniform and more durable. Although the cost of Corfam is generally higher than leather, its improved performance capabilities will more than offset the price differential. Thus, it was concluded that plunger cups should be made of Corfam.

Evaluation of Cylinder Coatings

In the previous program it was concluded that the cost and maintenance of hand pumps could be substantially reduced if the cast-iron cylinder walls were made smoother by some type of nonmetallic coating. Effort during the follow-on program has been directed toward finding a satisfactory coating which does not require special processing, such as heat treating. Three types of coatings were evaluated--epoxy, vinyl, and uralkyd. All of the coatings performed well, with no peeling or wear. Epoxy was judged to be the most desirable because it is the hardest in the air-dried condition. The material cost of the epoxy is approximately 5 to 10 cents per cylinder.

Additional Component Investigation

During the above component testing, two additional problem areas were revealed: (1) excessive erosion of the iron cylinder seat beneath the flapper valve and (2) wear of the housing by the bronze plunger valve to the point that the pump would not operate. With the decision to discontinue the field evaluation work, design consideration was given to these problems. It is believed that the use of a bronze seat in the cast-iron cylinder would correct the erosion problem. The poppet-valve life could be extended by a longer guide for the poppet.

At the request of UNICEF, an investigation was also conducted to extend the life of the pump-handle pivots. A sleeve bearing material called Rulon J was selected to operate with pins made of 17-4 PH stainless steel hardened to about 35 Rockwell C. The ability of this bearing combination or equal combination to operate satisfactorily without lubrication should significantly extend the life of the pump-handle pivots. It is anticipated that this bearing combination would be needed only in those areas of exceedingly heavy pump utilization.

Information Dissemination

A press release regarding the development of the hand pump was made by AID and Battelle on June 27, 1969. As of June 28, 1970, 66 inquiries about the program had been received at Battelle from 20 countries. In response to those interested in making the pump, 25 packets of information were sent, each containing a set of drawings, a final report on the first program, and selected pictures. Reduced amounts of information were sent to 33 inquiries from those who were interested in more general aspects of the pump. In addition, 135 copies of the final report on the first program were sent to AID so information could be forwarded in response to inquiries received at AID.

RECOMMENDATIONS

Battelle believes that the basis has been established for the manufacture of satisfactory hand pumps for developing nations. The widespread interest in the pump is impressive evidence of the need for such a device. The following steps should be accomplished so the people in the developing nations can benefit from the work accomplished to date:

(1) The specifications and drawings should be modified to include flapper-type plunger valves, a Corfam cup seal, and an air-dry epoxy cylinder coating, but it should remain clear that the final configuration and degree of sophistication is the choice of the indigenous manufacturer.

(2) Manufacturers should be chosen in selected developing nations, and pump fabrication, with demonstrations, should be initiated.

(3) Field evaluations should be conducted in areas of the selected nations with the indigenously manufactured pumps.

(4) A course on pump fabrication and installation should be included in the AID-sponsored Ground Water School at the University of Minnesota.

RESEARCH ACTIVITIES

In accordance with the statement of work, the follow-on contract was to consist of the following four tasks:

(A) Supervise and evaluate the field testing of Battelle-designed pumps to be provided, installed, and field-monitored by others. This task was to include the following steps:

(1) Collaborate with the manufacturer in the production of pumps and provide patterns, molds, and fixtures devised during the previous contract

(2) Prepare a manual providing instructions for field installation, operation, maintenance, and reporting on pump performance

(3) Evaluate reports from the field

(4) Evaluate valves, cups, and other pump parts returned from the field

(5) Recommend necessary pump design changes

(B) Develop and evaluate a flapper-type plunger valve of synthetic materials as a possible substitute for the presently used metal valves

(C) Determine the optimum synthetic material and configuration combinations for plunger cups to replace presently used leather cups

(D) Continue the testing of cylinder materials, undertaken under the previous contract, to find a suitable coating which does not require heat treatment in the manufacturing process.

When it was decided to discontinue the field testing effort, two additional tasks were undertaken:

(E) Investigate the adequacy of additional, selected pump components

(F) Disseminate pump information to interested organizations.

Task A. Field Evaluation

During the previous program, a simple pump design was evolved to meet the needs of developing nations. The basic pump consisted of a body, a fulcrum, a handle, a single cylinder, a plunger, and two check valves--one in the plunger and one in the cylinder. Figure 1 shows the design incorporated in a shallow-well pump. In this type of pump the suction cylinder is attached above ground to the pump body since the water can be lifted from the ground by suction. Figure 2 shows the selected pump design incorporated in a deep-well pump. In this type of pump the suction cylinder is placed below ground in or near the water source. A rod extends from the pump handle down through the connecting pipe (shown foreshortened in Figure 2) to the suction cylinder. The primary action of the plunger in a deep-well pump, therefore, is to lift the column of water to the pump body. Appendix A contains assembly drawings and parts lists for both types of pumps.

Features that were incorporated in the basic pump design for developing nations were

(1) Low production cost

(2) Long life under severe conditions

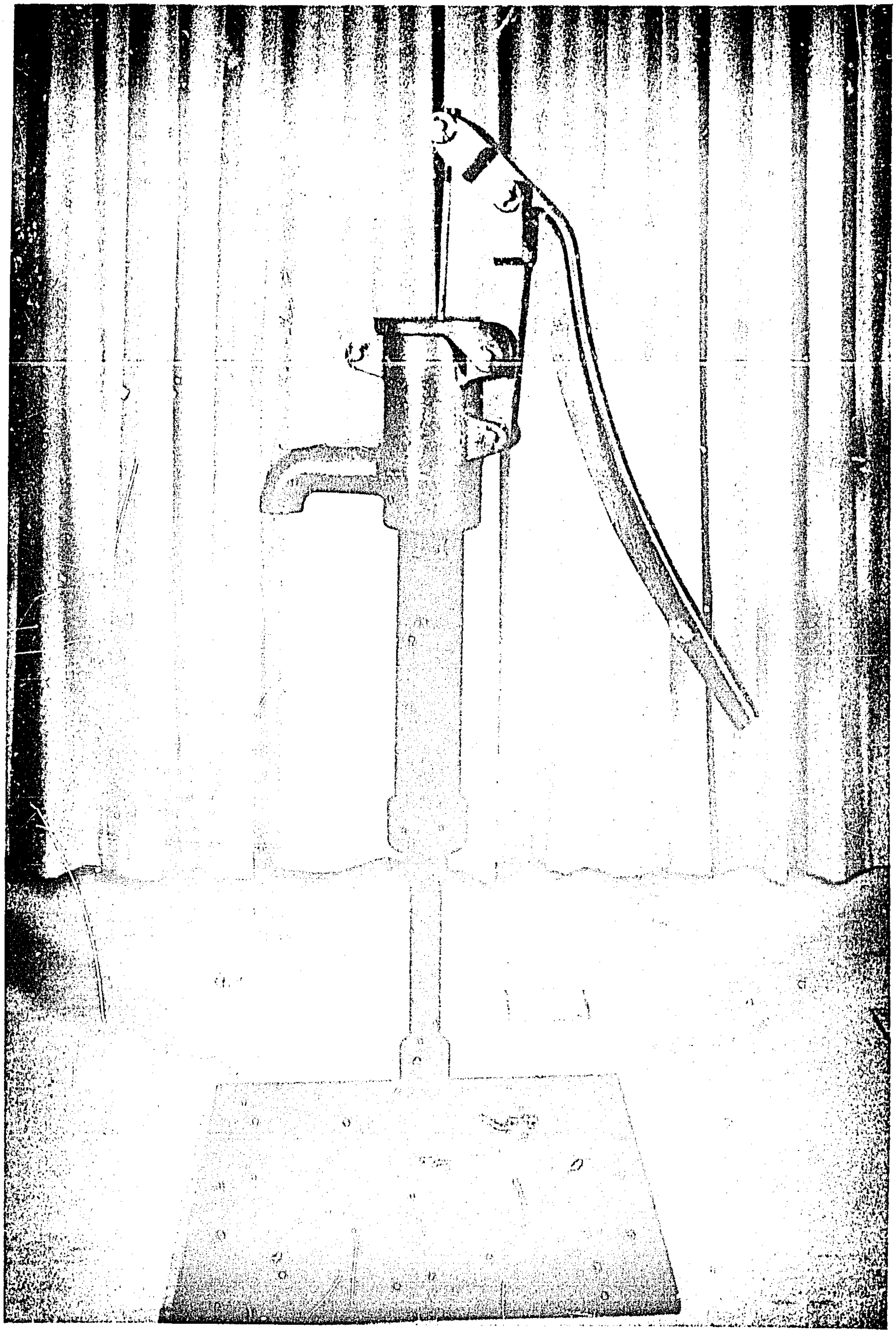

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FIGURE 1. SHALLOW-WELL VERSION OF AID PUMP

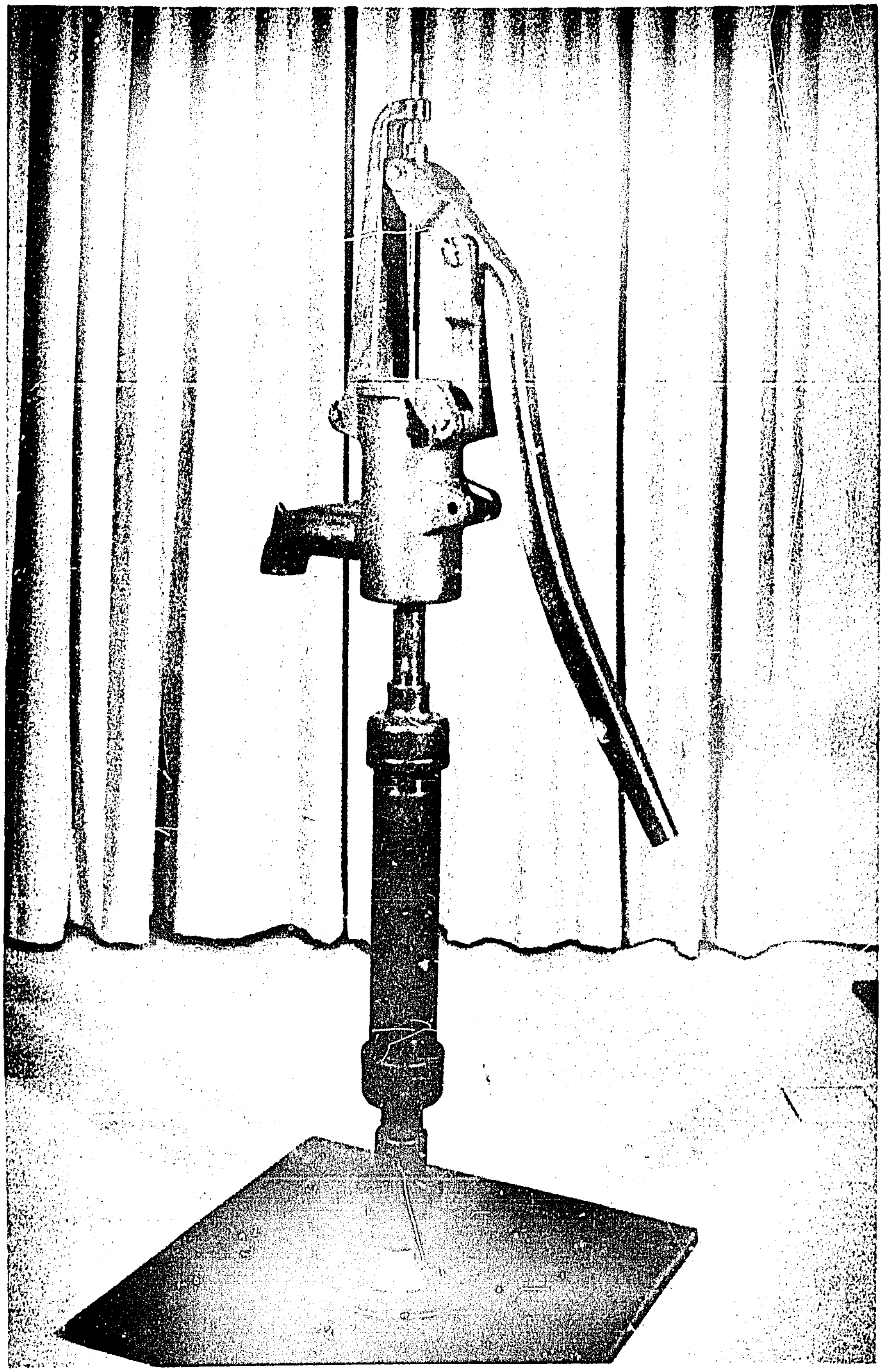

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FIGURE 2. DEEP-WELL VERSION OF AID PUMP

(3) Easy maintenance with simple tools and unskilled labor

(4) Suitable for shallow- or deep-well installation with only minor changes (cylinder location and plunger rod length)

(5) Capable of being manufactured in developing countries with a minimum of capital investment

(6) Easily operated by small people, including women and children

(7) Containing features to discourage pilfering and vandalism.

The field evaluation effort required a third party to arrange for the manufacture, installation, and field monitoring of the pumps. During discussions with the Contract Technical Monitor, it was decided that UNICEF would be the best agency for accomplishing these functions. Accordingly, meetings were held with representatives of UNICEF to discuss the pump design and to select specifications that would be mutually acceptable. Some conflict of objectives was encountered because the AID-Battelle approach was to have the pumps made in the nations that would use the pumps, while UNICEF wanted to purchase the pumps for distrubition in selected outlying areas. However, a mutually acceptable design was established.

Drawings and specifications were then prepared for the selected design. The drawings consisted of assembly drawings, subassembly drawings, and detail drawings for 2-1/2-inch and 3-1/2-inch cylinders, for shallow-well and deep-well pumps. The specifications covered the necessary aspects of procurement, manufacturing, and shipping. (The drawings and specifications did not include the improvements that were investigated later during the follow-on program.)

Considerable time was spent in communicating, through telephone calls, letters, and visits, with the UNICEF Procurement Officer in New York. In addition, drawings and specifications were sent to the United Nations in New York, UNICEF in France, and WHO in Switzerland. Unfortunately, it was not possible to obtain approvals from all the necessary organizations in time to select a manufacturer, fabricate the pumps, and complete the field evaluation of the pumps.

When it became apparent that the field evaluation could not be completed as planned, it was agreed during discussions with the Technical Monitor that the work outlined under Tasks E and F would be conducted. This work is described in later sections of the report.

Task B. Plunger-Valve Development

The two most common types of check valves used in hand pumps are the poppet valve and the flapper valve. A poppet valve is always used in the plunger;

however, the lower check valve in the cylinder is either a flapper valve or a poppet valve. Most of the shallow-well pumps use leather flapper valves in the bottom of the cylinder, while most of the deep-well pumps use poppet valves.

During the previous program, three important conclusions were drawn concerning valves:

(1) Nylon impregnated with neoprene is an excellent material for flapper valves since it has a high resistance to flexural failure and it is not adversely affected by changes in temperature or by wetting-drying cycling.

(2) Metal plunger valves should be improved to minimize wear and increase life.

(3) An attempt should be made to develop a flapper-type plunger valve using neoprene-impregnated nylon to reduce the cost and increase the reliability of plunger valves.

Two flapper-type plunger-valve designs were evolved and evaluated as a part of the follow-on program. Each of these is discussed below. In accordance with a request by UNICEF, the experimental valves were fabricated for a 2-1/2-inch-diameter cylinder.

Weighted Flapper Valve Design

Figure 3 shows a typical pump plunger with a metal poppet valve located in the middle of the plunger. Figure 4 shows the typical wear sustained by a metal poppet.

Figure 5 shows a weighted flapper valve installed in a pump plunger in place of the metal poppet. The neoprene-impregnated nylon flapper is attached to the plunger with two screws. To facilitate this attachment, three supports are used for the pump rod attachment rather than the four shown in Figure 3. A metal weight is attached to the back of the flapper to keep the flapper from floating and to insure that the flapper makes a satisfactory seal with the seat.

The plunger shown in Figure 5 was cast from bronze. The assembly was operated in a typical shallow-well pump for more than 5000 hours. A visual examination of the parts after the test showed no sign of wear or fatigue.

Serrated Flapper Valve Design

The second flapper-type plunger valve that was developed and evaluated is shown in Figures 6 and 7. It is similar to a valve described by drawings

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FIGURE 3. TYPICAL PUMP PLUNGER WITH METAL POPPET VALVE

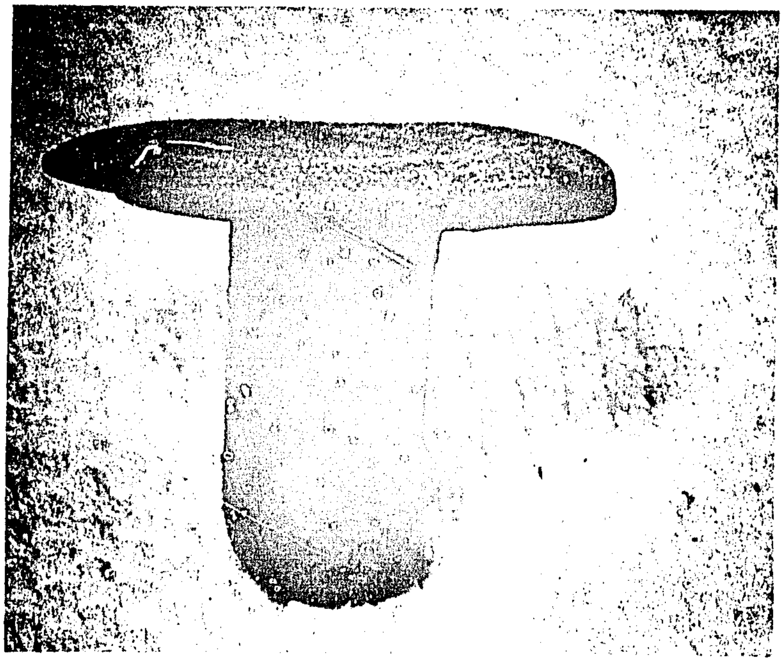

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FIGURE 4. WORN CAST-IRON POPPET FROM PLUNGER VALVE AFTER SEVERAL TEST PERIODS

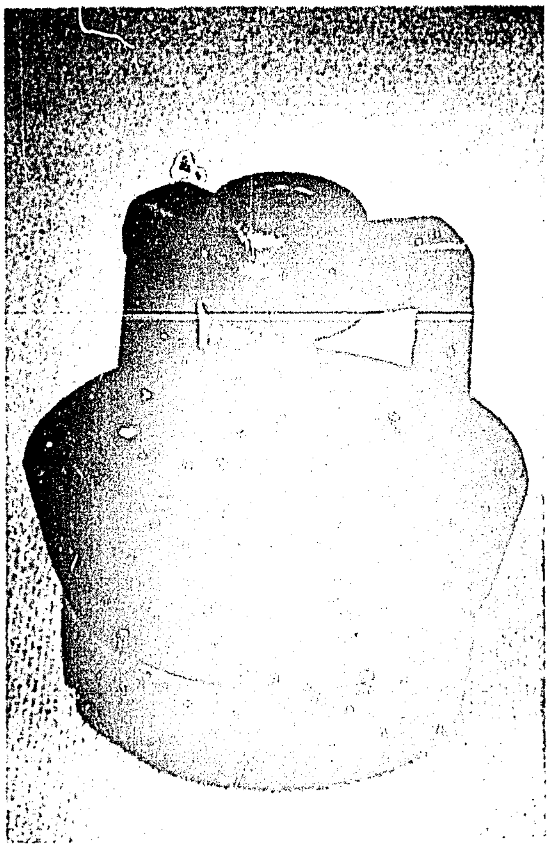

FIGURE 5. WEIGHTED FLAPPER VALVE INSTALLED IN PUMP PLUNGER

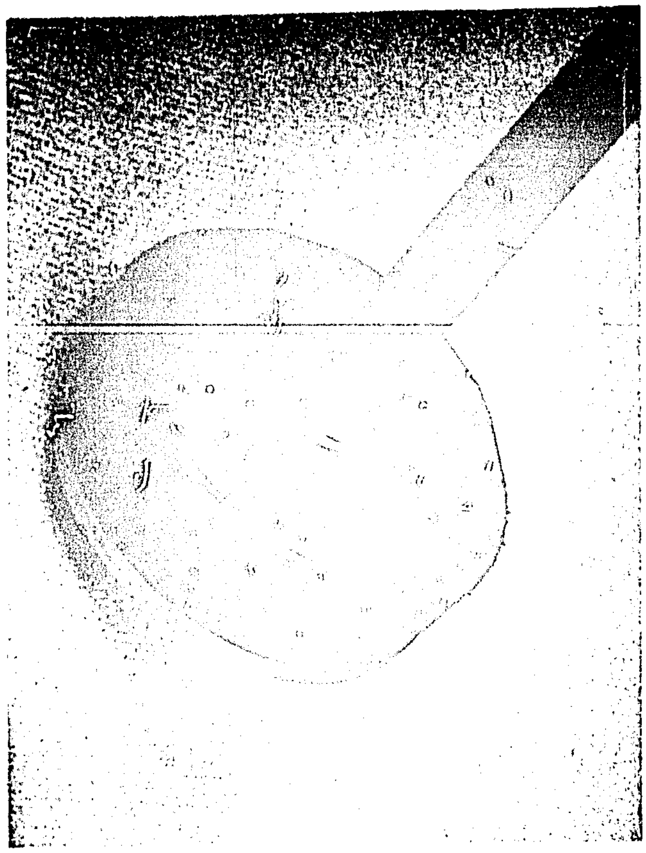

FIGURE 6. ASSEMBLED SERRATED FLAPPER VALVE AND PLUNGER

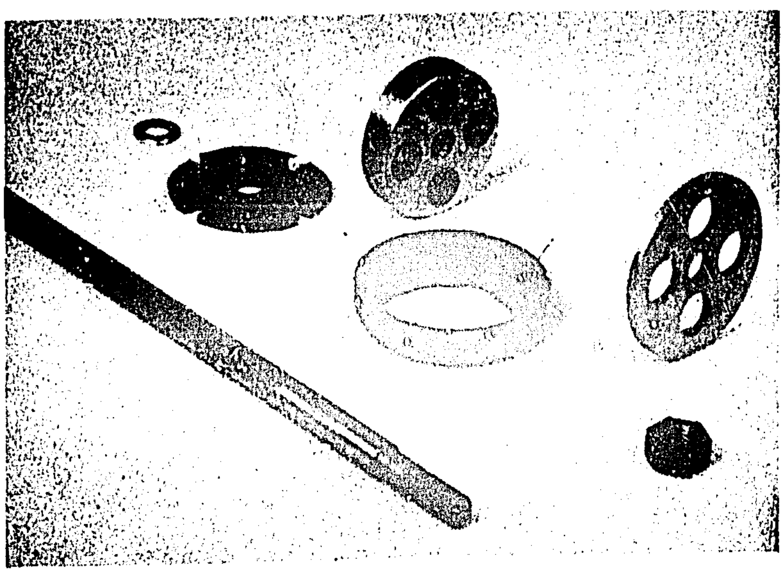

FIGURE 7. DISASSEMBLED SERRATED FLAPPER VALVE AND PLUNGER

from the Department of Sanitation in Lima, Peru. The drawings were sent to Battelle by Dr. Charles Spangler, who was formerly with PAHO.

The serrated flapper valve is composed of parts which are simple to make. The cup seal is a standard shape. The flapper can be stamped or cut from sheet material, and the metal supports can be made from castings or from bar stock. As with the weighted flapper valve, the serrated flapper valve was operated for over 5000 hours with no detectable signs of wear or fatigue.

Valve Comparison

It is believed that both flapper-type plunger valves will provide significantly longer life than the conventional metal poppet valves. However, the two flapper valves are somewhat different, and their differences are summarized below:

(1) The weighted flapper valve is more conventional in appearance and may be more acceptable to those who are familiar with standard pump plungers.

(2) The serrated flapper valve is less expensive to manufacture.

(3) Both flapper-type plunger valves operate equally well for shallow-well pumps and for deep-well pumps for depths to 50 feet.

(4) The weighted flapper valve should be used for wells deeper than 50 feet primarily because of the ease of adding additional cups.

Task C. Selection of Optimum Cup Material

The work during the previous program showed that high-quality leather is a good material for plunger cup seals. (A typical cup seal is shown in Figure 7.) Wide tolerances are acceptable and long life can be expected with fairly smooth cylinders. However, very poor leather is produced in some geographical areas, and even good leather is deteriorated (cracked) by alternately wetting and drying. In addition, poor storage conditions can cause excessive deterioration of cups held in stock. Thus, a part of the follow-on program was directed toward finding a leather substitute that would have uniform properties and be less affected by wetting and drying and by poor storage conditions.

Five materials, including leather, were selected as being typical of the candidate materials that are presently available for cup seals:

(1) Rek-Syn, manufactured by the E. F. Houghton & Company--a relatively stiff elastomer-plastic material with a low coefficient of friction

(2) Vix-Syn, also manufactured by the E. F. Houghton & Company--a relatively stiff elastomer-duck material

(3) Corfam (in three compositions), manufactured by DuPont:

   (A) A relatively thin Corfam coated on the exterior with graphite. Test cups were purchased from the Lubrikup Company, Williamsport, Pennsylvania

   (B) A medium flexible Corfam impregnated with wax and coated on the outside with rubber. Test cups were purchased from the Page Belting Company, Concord, New Hampshire

   (C) A stiff Corfam; test cups were purchased from the Page Belting Company

(4) Rulon J, a flexible polymeric-reinforced Teflon; test cups were purchased from the Dixon Corporation, Bristol, Rhode Island

(5) Leather of two types:

   (A) Oak-tanned, with the hair side out; test cups were purchased from the Dempster Company, Beatrice, Nebraska

   (B) Chrome-tanned, with the hair side out; test cups were purchased from the E. F. Houghton & Company.

All of the cup materials were operated for approximately 1000 hours in plastic cylinders or in epoxy-phenolic-coated metal cylinders at 55 strokes per minute with a 5-1/2-inch stroke. These hours of operation are equivalent to approximately one year of pumping at the rate of 1500 gallons per day. This quantity was established by AID as the average quantity of water pumped by hand in many communities of the developing nations. With the exception of a 2-inch Corfam cup molded by the Lubrikup Company and a 2-1/2-inch Rulon cup, all the cup materials were evaluated in both shallow-well and deep-well pumps.

Rek-Syn

Figure 8 shows Rek-Syn cup seals after 964 hours of operation. The test showed that the material has low friction and is wear resistant. However, as the cups wore, the material did not stretch to maintain good contact with the pump-cylinder walls. Pumping effectiveness was reduced and it was apparent that the cups had a shorter useful life than leather cups.

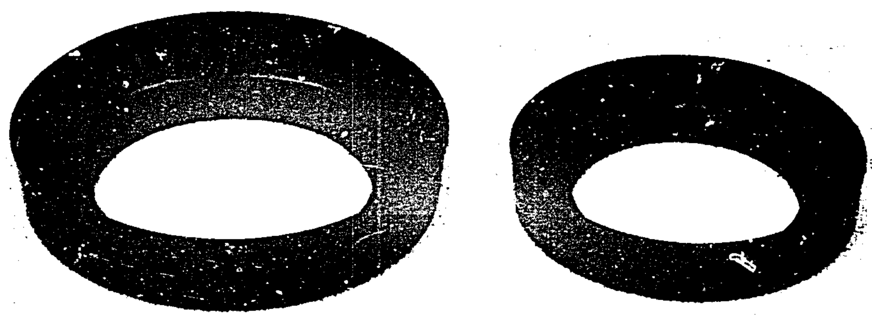

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FIGURE 8. REK-SYN CUPS AFTER 964 HOURS OF OPERATION

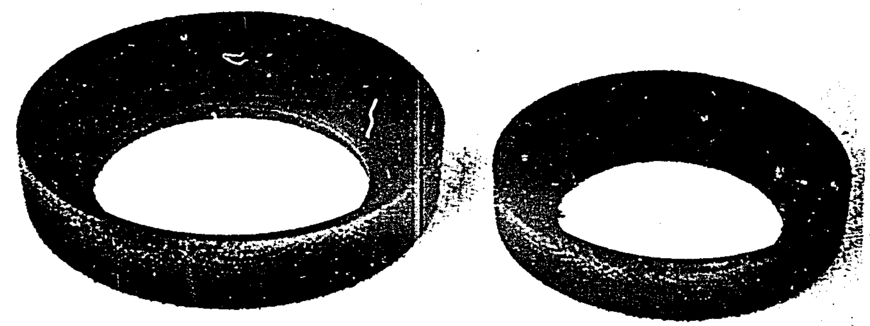

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FIGURE 9. VIX-SYN CUPS AFTER 1020 HOURS OF OPERATION

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FIGURE 10. VERY FLEXIBLE 3-INCH CORFAM CUP AFTER 1121 HOURS OF OPERATION AND 2-1/2-INCH RULON J CUP AFTER 949 HOURS OF OPERATION

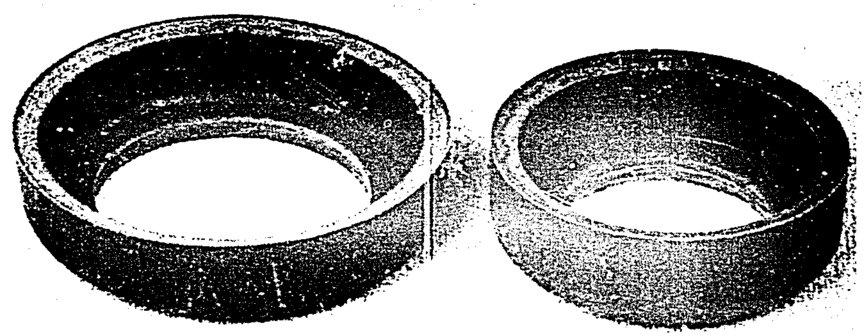

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FIGURE 11. MEDIUM FLEXIBLE 3-INCH CORFAM CUP AFTER 1040 HOURS OF OPERATION AND STIFF 2-1/2-INCH CORFAM CUP AFTER 1150 HOURS OF OPERATION

Vix-Syn

Figure 9 shows Vix-Syn cup seals after 1020 hours of operation. Although the cups were still functioning at the end of the test, they showed more wear than any other test material. In addition, as with the Rek-Syn cups, the Vix-Syn cups did not stretch as much as the leather cups.

Corfam

Cups made of the three Corfam materials were operated for over 1000 hours. Figure 10 shows a very flexible 3-inch cup, while Figure 11 shows a 2-inch medium flexible cup, and a 2-1/2-inch stiff cup. Good wear resistance was exhibited by all of the Corfam cups. However, the very flexible cup and the stiff cup had the same difficulty maintaining contact with the cylinder walls that was exhibited by the Rek-Syn and Vix-Syn cups. In contrast, the medium flexible Corfam cup exhibited good stretch and maintained good contact with the cylinder wall. In lots of 100 to 1000 pieces, the 3-inch cup was estimated to cost from $90 to $100 per hundred.

Rulon J

Rulon J is a fluorocarbon made to run dry against soft materials such as aluminum and brass. Figure 10 shows a 2-1/2-inch Rulon J cup seal after 949 hours of operation. Although the cup was still functioning at the end of the test, the plunger had begun to chatter during the last week of testing. This seemed to be caused by the narrow, stiff wall of the cup which did not conform well with the cylinder wall.

Leather

The leather cup seals were tested primarily as a control against which the other materials could be compared. Figures 12 and 13 show chrome-tanned and oak-tanned leather cup seals after approximately 1000 hours of operation. The more expensive, chrome-tanned, wax-impregnated leather cups showed very little wear and remained soft even after drying. The oak-tanned, nonwaxed leather cups showed a definite wear and became stiff when dry. The price of 3-inch chrome-tanned leather cups is approximately $128 per hundred in lots of 500 cups.

Plunger-Cup Material Comparison

Based on the laboratory tests summarized above, the following conclusions were reached concerning the selection of plunger-cup seal materials:

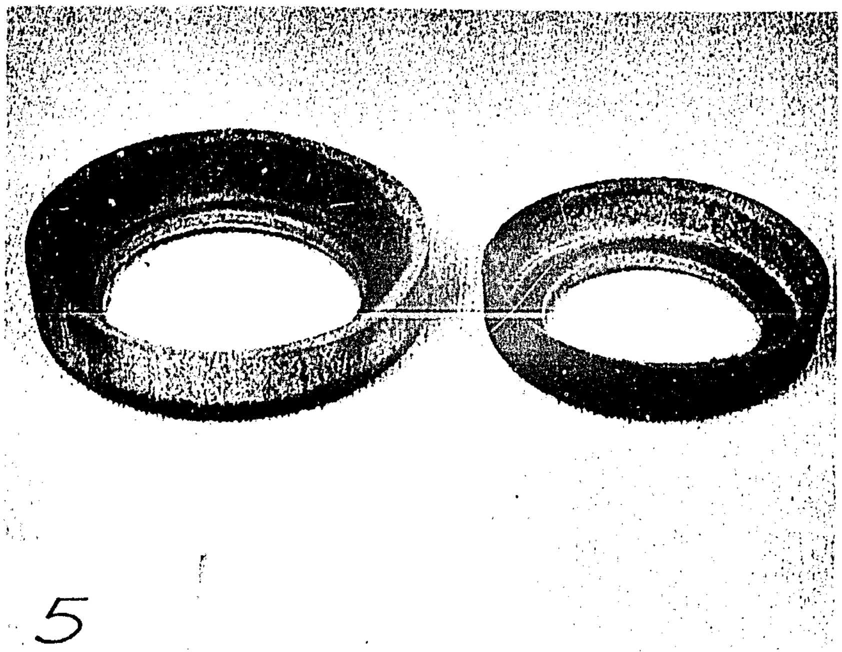


FIGURE 12. CHROME-TANNED, WAX-IMPREGNATED LEATHER CUPS AFTER 948 HOURS (3-INCH) AND 1106 HOURS (2-1/2-INCH) OF OPERATION

FIGURE 13. OAK-TANNED, NONWAXED LEATHER CUPS AFTER 1147 HOURS (3-INCH) AND 1039 HOURS (2-1/2-INCH) OF OPERATION

(1) Wax-impregnation of leather is one of the major factors in extending the life of leather cup seals because the leather tends to remain soft whether wet or dry

(2) Wax-impregnated Corfam cup seals of the proper flexibility, coated on the outside with nitrile or urethane rubber, will provide better performance than the best leather cup seals

(3) The major factor limiting the performance of cup seals made from other materials is the reduced ability of the materials to stretch and conform to the cylinder walls as compared with Corfam and leather.

Task D. Evaluation of Cylinder Coatings

The greatest single factor in pump longevity is the smoothness of the cylinder bore. During the previous program, it was found that commercially available steel pipe could be converted into relatively smooth pump cylinders with a nonmetallic coating. However, the successful epoxy phenolic coating evaluated during the first program requires a moderate amount of baking on the pipe as a part of its processing. As simple and easy as this process is in the United States, a coating that did not require baking would be more acceptable in some developing nations. Therefore, one objective of the follow-on program was to find a satisfactory cylinder coating that did not require special processing, such as heat treating.

After a review of candidate cylinder coatings, three coatings were selected for evaluation:

(1) Marine epoxy
(2) High-build vinyl
(3) Pigmented uralkyd.

The coating materials were evaluated by using each to coat a 2-1/2-inch-diameter pipe specimen and a 3-inch-diameter pipe specimen. Each of the six pipe specimens, as shown in Figures 14, 15, and 16, was then operated for over 1000 hours with leather plunger cup seals at 55 strokes a minute with a 5-1/2-inch stroke.

Prior to application of the coatings, the pipe specimens were cleaned in the following manner. The cylinders to be coated with the marine epoxy and the uralkyd were cleaned with methylethylketone, mineral spirits, and soap and water. The cylinders to be coated with high-build vinyl were cleaned with methanol, mineral spirits, and soap and water. The cleaning solutions were applied with rags and a steel brush, and the cylinders were allowed to air-dry.

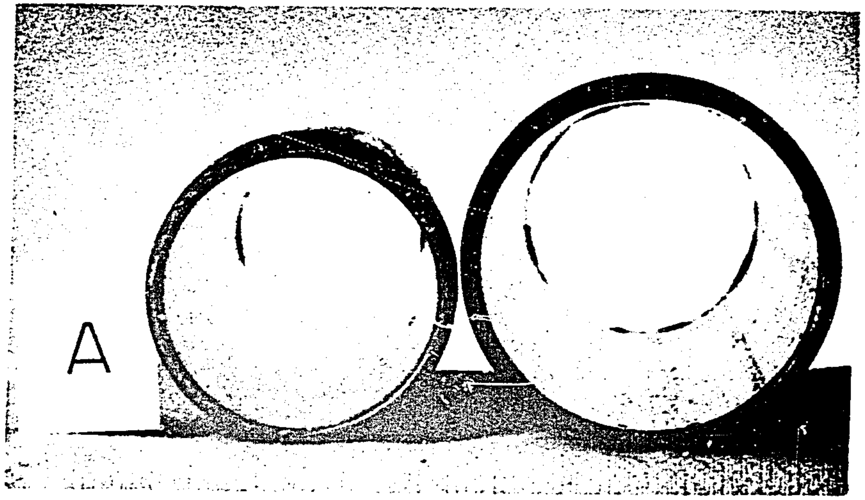


FIGURE 14. VINYL-COATED PIPE SPECIMENS AFTER 1000 HOURS OF OPERATION

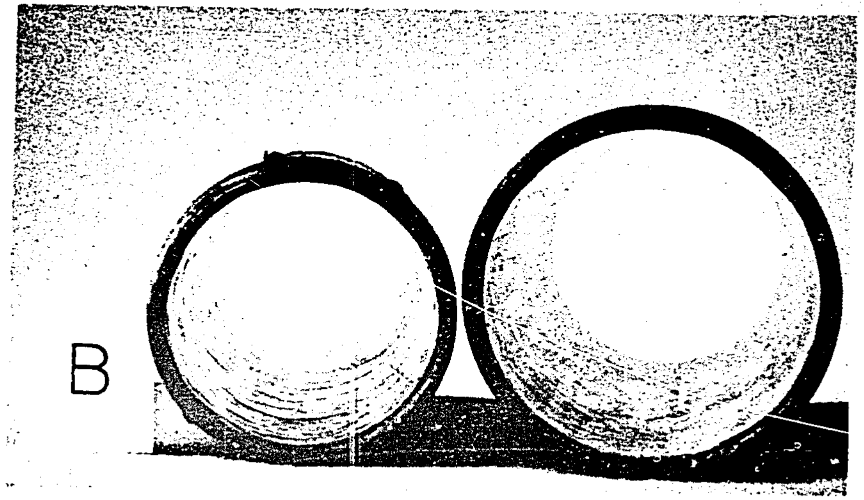


FIGURE 15. EPOXY-COATED PIPE SPECIMENS AFTER 1000 HOURS OF OPERATION

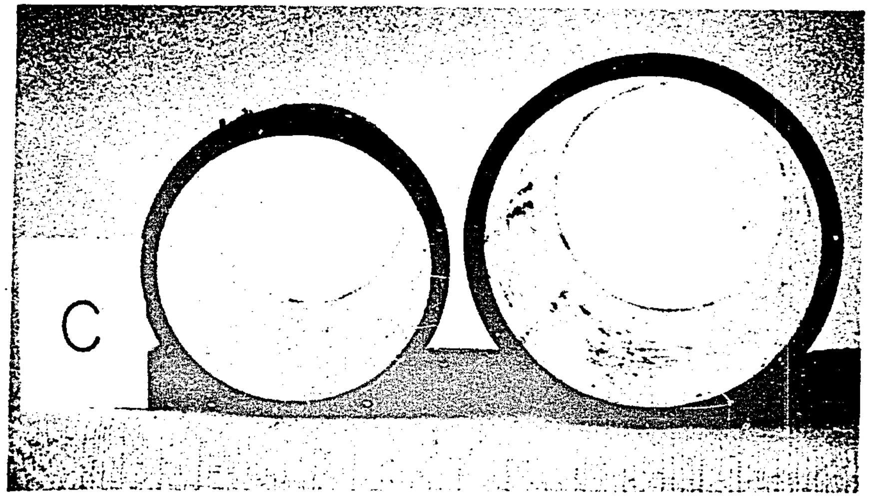


FIGURE 16. URALKYD-COATED PIPE SPECIMENS AFTER 1000 HOURS OF OPERATION

Each coating was applied by placing a cap over one end of the pipe, placing the selected solution in the pipe, placing a cap over the other end of the pipe, and rolling and turning the pipe to distribute the solution over the pipe wall. The end caps were then removed and the excess solution was allowed to drain back into the container.

Primers were required for two of the coatings. For the epoxy, the primer consisted of epoxy thinned at the rate of 1 pint of solvent to 4 pints of epoxy. A vinyl wash primer was used for the vinyl.

The pipe specimens were allowed to air-dry in the vertical position with a free flow of air. To limit the amount of running, an electrical fan was used to circulate air through the cylinders to accelerate drying. With this arrangement, the specimens were dry to the touch in 8 to 10 hours, but should be allowed to cure 24 hours before recoating and 2 weeks before use.

The marine epoxy coatings were approximately 0.008 inch thick and had a smoothness of about 40 to 60 CLA (centerline average). The high-build vinyl coatings were about 0.006 inch thick and had a smoothness of about 26 CLA, while the pigmented uralkyd had a thickness of about 0.004 inch and a smoothness of about 10 CLA. The CLA values included the roughness due to running. For comparison, good cast-iron cylinders made in the United States have a smoothness of from 40 to 200 CLA. The baked epoxy phenolic that was tested during the previous program had a smoothness of from 12 to 18 CLA.

The cylinders were inspected following the 1000 hours of testing. No appreciable wear could be detected visually, and there were no breaks in any of the coatings. Likewise, very little wear was noticed on the leather cups. Thus the performance of the coatings was estimated to be equal and satisfactory.

The epoxy and vinyl coatings are estimated to cost about 10 to 15 cents per cylinder, while the uralkyd coating is estimated to cost somewhat less. Because the epoxy coating was found to be somewhat harder than the other coatings, and because a harder coating should be more resistant to wear from the cup seal, the epoxy coating was judged to be the best for pump use.

Task E. Additional Component Investigations

Two types of additional component investigations were completed as a result of the decision to discontinue the work related to field evaluation of the pumps. One type consisted of an investigation of cylinder-foot-valve performance, while the other type consisted of an investigation of pins and bushings for the pump-handle pivots.

Cylinder-Foot-Valve Investigation

In conjunction with the tests of the plunger cup seals and the cylinder coatings that have been described previously, over 10,000 hours of operation were achieved for the cylinder foot valves. This was equivalent to 10 years of hard use.

After approximately 5500 hours of operation, the flapper foot valve of the shallow-well pump showed excessive erosion of the valve seat. It is believed that this condition could be improved if a bronze seat were placed under the flapper valve. Bronze has been used successfully to combat such erosion in other applications. Because of the cost of inserting the bronze seat, this design should be used only for installations where particularly long life is required.

After approximately 8300 hours of operation, the metal poppet in the cylinder of the deep-well pump wore the poppet valve housing to the point that the poppet tended to cock and stick open. This prevented pumping. The best solution to this problem is believed to be neoprene-impregnated nylon flapper valves. Longer operation could be obtained with the metal poppet valve by using a longer guide section.

Pins and Bushings

Bearings are required where the pump handle pivots on the body, and where the pump handle attaches to the oscillating rod. UNICEF requested that an investigation be made to find better bearings for these locations.

A search was made for nonlubricated bushings which would have good weatherability, long life, low absorptivity, and low cost. Although several materials seemed to be candidate, Rulon was judged to be significantly better relative to the other materials. Rulon is a specially compounded TFE fluorocarbon made by the Dixon Corporation.

The material selected for the pins was a hardenable stainless steel, 17-4 PH. This material is in general use, and it has not only corrosian resistance, but also good hardness. The heat-treated condition selected for evaluation was H1025, which gives a pin hardness of about 32 Rockwell C.

A Rulon T-Liner was chosen to be evaluated first. A T-Liner bearing is made up of a shell of metal (stainless steel or cadmium-plated steel) in which a strip of Rulon is placed. T-Liner bearings were placed in the handle at the fulcrum and at the rod end. The bearing at the rod end lasted satisfactorily over 10,000 hours. After 5133 hours of operation, one of the steel shell bearings at the fulcrum which had been improperly inserted had worn through and the Rulon had been destroyed. The T-Liner bearings were replaced with a solid-Rulon bearing and no wear could be detected after 5300 hours of operation. The performance of the pins was satisfactory in all cases.

It is thus recommended that solid Rulon bearings and 17-4 PH stainless steel pins or equal be used when improvement of the handle bearings is justified. For long-term retention, it is recommended that the Rulon bearings be pressed and glued into place.

Task F. Information Dissemination

A joint AID-Battelle press release prompted a surprising response from all over the world. Appendix B shows the release and the recipients of the release. With the discontinuance of the field-evaluation effort, and with a large expression of interest as a result of the press release, it was decided that the dissemination of project information to interested parties would be in keeping with the overall objective of eventually having the pumps used by the developing nations.

Of the 66 requests for information that were received, 58 were believed to be of sufficient merit to receive project information. Represented in the requests were: 20 countries, 21 universities and foundations, 12 Government agencies, and 24 businesses.

As listed in Appendix C, 25 responses consisted of packets containing a full set of drawings, a parts list, a final report on the previous program, and a letter containing pertinent information. The remaining 41 replies contained all of this information except the drawings and the parts lists. A few replies contained selected assembly drawings. In addition, 135 copies of the final report on the first program were forwarded to AID for distribution in response to requests for information.

FUTURE WORK

Countless people in the developing nations need reliable hand pumps to supply them with life-giving water. The most difficult steps for satisfying this need still have to be accomplished. Although there are a number of ways of reaching the ultimate objective, the following appear to be principal steps in any program:

(1) Incorporate the information gained during the follow-on program in the drawings and specifications

(2) Select areas in developing countries for pump fabrication, demonstration, and evaluation

(3) Assist manufacturers and government agencies in the selected countries

(4) Establish personnel to obtain and evaluate data on the fabrication and operation of the pumps

(5) Arrange for instruction in pump fabrication to be taught during the Ground Water Course presently available at the University of Minnesota.

Step 1

Drawings and specifications were prepared at the beginning of the follow-on program for the field evaluation efforts. Since the pumps for field evaluation were not made, and since pump improvements were developed in the follow-on program, the pump drawings and specifications should be revised to include the results of the follow-on program. This will insure that the pumps which are eventually fabricated for field testing will include all of the recommended features. This can be done by Battelle-Columbus in about one week.

Step 2

It is expected that a number of developing countries will eventually use the AID pump. However, certain areas are more desirable than others for field testing the hand-pump configuration. In selecting countries for field testing, it will be important to identify those which maintain good relationships with the United States and for which there are no major problems of communication--either because of language difficulties or because of poor mail service. It will also be necessary to select countries that recognize the need for hand pumps. This will insure good cooperation during follow-up to obtain the test results. Finally, it will be necessary to select countries that have typical water problems so that the performance of the test pumps can be fairly evaluated. It appears that this selection process should be conducted by personnel from AID and from Battelle-Columbus.

Step 3

Considerable discussion will be required with personnel from the selected countries concerning manufacturing and field evaluation procedures. Meetings will probably be held first with personnel from the government agencies of the selected countries to discuss the overall manufacturing and field testing plans. If these discussions are held with one person from AID and one person from Battelle-Columbus, it should be possible to select the best approach to be used in each country. Follow-up discussions will probably then be necessary between the Battelle employee and personnel from the manufacturing facilities to discuss technical features of the pump. Although no large problems are envisioned in making the necessary arrangements, such discussions should avoid the development of unnecessary misunderstanding and confusion.

Step 4

Probably the most critical aspect of the field evaluation effort is the feedback of information from the manufacturer and from the operation of the pumps. In some cases it may be possible to have local government personnel obtain the necessary information. In general, however, it is believed that two procedures should be followed. In the case of the manufacturer, it will probably be best for a person from Battelle-Columbus to visit each manufacturer after the field pumps have been fabricated to obtain a detailed description of the manufacturer's experience. In the case of the pump installations it will probably be best to have a record kept of any parts needed for a period of time, say a year, and then to have selected pumps returned to Battelle-Columbus for examination. Information from the manufacturers and the pump installations can then be examined to determine whether changes should be made in the pump design.

Step 5

The Ground Water Course which is available at the University of Minnesota would seem to be a good place to start the systematic description of the operation and benefits of the AID pump. With materials available from the development program, it should be easy for a short course to be set up on the pump. This could be accomplished by a person from Battelle-Columbus.

APPENDIX A

ASSEMBLY DRAWINGS AND PARTS LISTS FOR AID HAND PUMP

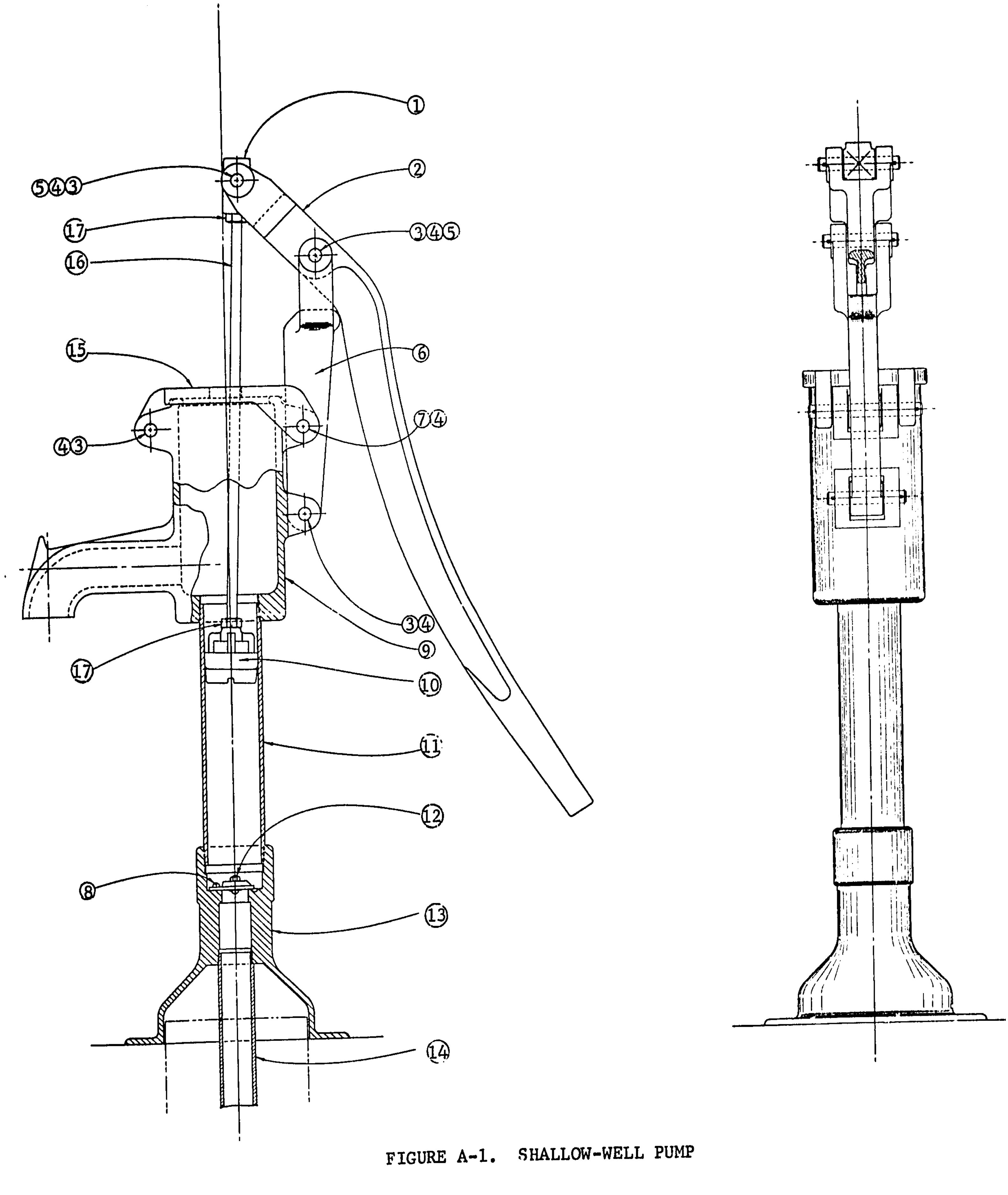
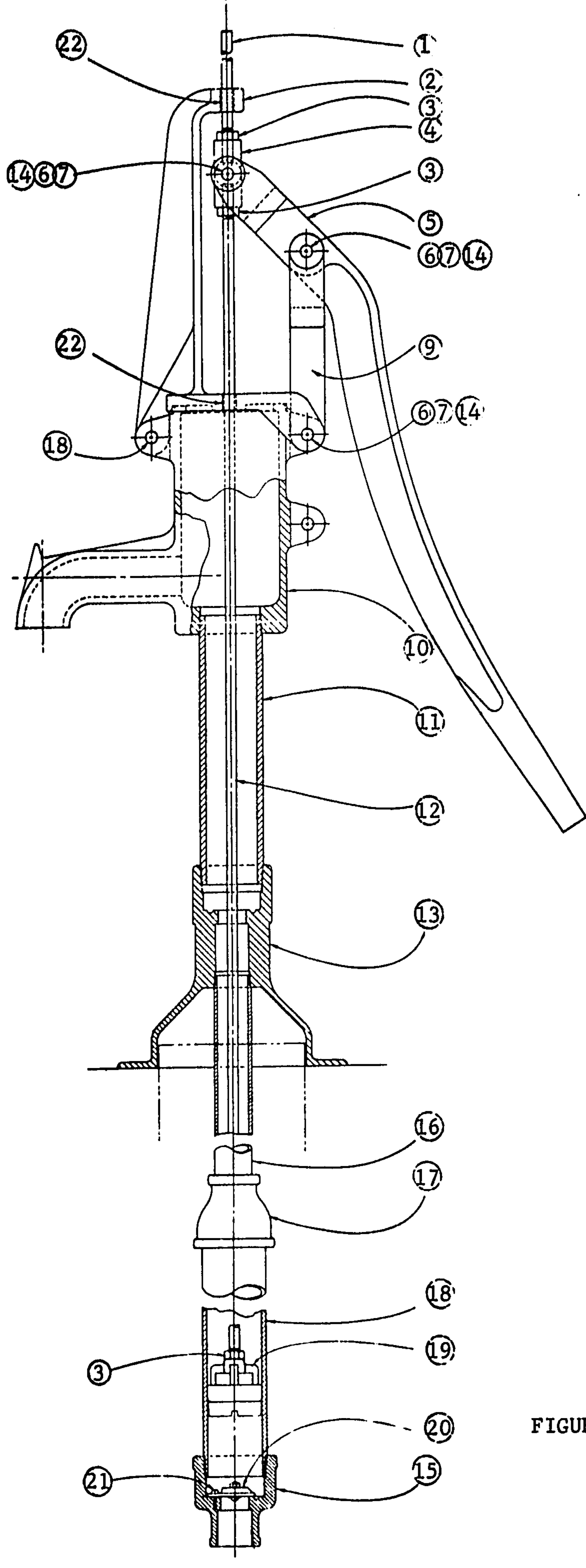


FIGURE A-1. SHALLOW-WELL PUMP



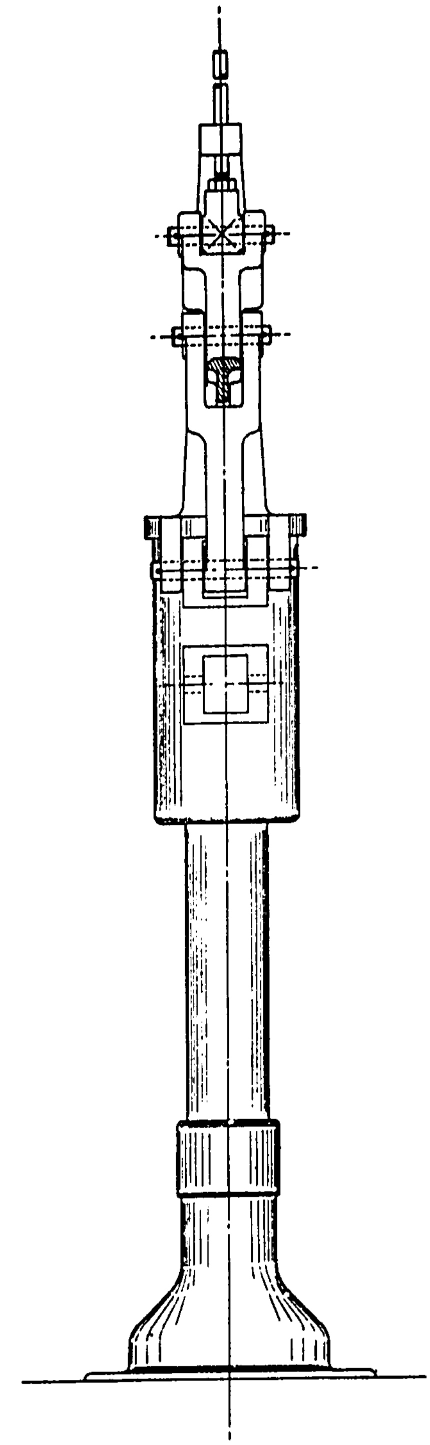


FIGURE A-2. DEEP-WELL PUMP

PARTS LIST FOR SHALLOW-WELL PUMP

1. Rod End
2. Pump Handle
3. Pin
4. 1/8-in. Extended Miter – Cotter Pin
5. Experimental Bearings*
6. Fulcrum
7. Pump Cap Pin – Rear
8. No. 10-24 x 1/2-in.-long Brass Round Head Screws
9. Pump Body
10. Plunger Assembly
11. Pump Cylinder
12. Lower Check Valve Assembly
13. Pump Stand
14. 1-1/4-in. Galvanized Steel Pipe
15. Pump Cap
16. Pump Rod
17. 7/16-14 UNC-2B Hexagonal Jam Nut

* Various Bearing Materials Being Considered

PARTS LIST FOR DEEP-WELL PUMP

1. Bearing Rod
2. Pump Rod Guide
3. 7/16-14 UNC-2B Hexagonal Jam Nut
4. Rod End
5. Pump Handle
6. Pin
7. 1/8-in. Extended Miter – Cotter Pin
8. Pump Cap Pin – Rear
9. Fulcrum
10. Pump Body
11. 12-in.-long Sch. 80 Seamless Galvanized Pipe – Thread Each End 8 N.P.T. x 2-1/2-in. long
12. 7/16-in.-diameter Standard Galvanized Pump Rod and Couplings
13. Pump Stand
14. Experimental Bearings*
15. Lower Valve Housing
16. 1-1/4-in. Galvanized Steel Pipe
17. Cast Iron Pipe Reducer
18. Pump Cylinder
19. Plunger Assembly
20. Lower Check Valve Assembly
21. No. 10-24 NC-2A x 1/2-in.-long Brass Round Head Screws
22. Sleeve Bearings*

* Various Bearing Materials Being Considered

APPENDIX B

PRESS RELEASE ON AID HAND PUMP

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PRESS RELEASE ON AID HAND PUMP

The following news release about the AID hand pump was issued in June, 1969, to news media in the United States, Canada, England, France, Germany, India, Spain, Sweden, and Venezuela. Total distribution included 128 technical, 65 national, and 2 local publications. Foreign distribution was made to 5 publications in Canada, 5 in England, 2 each in India, Sweden, and Venezuela, and 1 each in France, Germany, and Spain.

It is interesting to note that even though only 8 countries outside the continental United States received copies of the release, requests for additional information about the pump have been received from 20 foreign countries (see Appendix C).

NEWS FROM Battelle Memorial Institute
COLUMBUS LABORATORIES
505 KING AVENUE COLUMBUS, OHIO 43201 • TELEPHONE 299-3151 • AREA CODE 614

For Immediate Release

A new version of the once-common hand water pump has been designed by a Columbus, Ohio, industrial research organization for manufacture and use in the less developed countries.

Engineers of the Columbus Laboratories of Battelle Memorial Institute produced the design under a $58,000 research contract with the Agency for International Development (AID). It includes features which should help solve some of the major problems in the developing countries in the manufacture and operation of standard pumps.

The design for the new pump is said to make possible:

* long life under rigorous operating conditions
* ease of maintenance with simple tools and unskilled labor

(MORE)

* manufacture in developing areas with minimal investment
* adaptation to both deep and shallow wells
* low production costs.

Prior to the start of the pump development program in July, 1966, AID and Battelle officials surveyed the need for water pumping equipment in urban and rural communities in East Pakistan, India, Jordan, the Philippines, and Thailand. They found numerous areas in which as many as 300 people depended upon a single pump for their water supply. This resulted in day and night operation and consequent heavy strains upon equipment often substandard in design and manufacture.

Thus, in addition to a shortage of pumps, there were frequent breakdowns of pumps already installed. Some of the causes were poorly fitting parts, corroded parts, and lack of replacement parts. Fits were so poor in some instances that bolts had to be wrapped with jute before they would hold the parts together.

Pump maintenance is also hampered by the scarcity of skilled labor. Chances are that when a pump breaks down it will be disassembled and forgotten, while the people revert to using rope and bucket.

(MORE)

The research team evolved a design that incorporates inexpensive corrosion-resistant cylinders and a minimum number of parts and threaded fasteners. Most of the components are of cast iron. The simple piston design is flexible enough to adapt to the technical levels of nations with a small industrial base.

Research is continuing in an effort to develop simpler methods of insuring cylinder smoothness, find substitutes for the leather used in cups, and evaluate designs for improved valves.

In addition to developing the design, the research team devised a plan under which the pump can be manufactured in the less developed countries in small foundries with very few power tools.

Mailing Date: 6/27/69
44-69

APPENDIX C

LIST OF INQUIRIES FOR AID HAND-PUMP INFORMATION

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LIST OF INQUIRIES FOR AID HAND PUMP INFORMATION

Requests for information were received from 66 sources, as listed below. The 25 sources marked with an asterisk received packets of information containing a full set of drawings, a parts list, a final report from the previous program, and a letter. The remaining 41 sources received similar information with the exception of the drawings and the parts list.

Government Agencies

*CEDECO
Kimpese
Rep. Dem, du
Congo

Shelter Research Division
Office of Civil Defense
Department of the Army
Washington, D.C., USA

*Forest Industrial Advisor
U.S. Embassy (U.S. AID)
Vientiane, Laos

*U.S. AID
Bureau for Latin America
Washington, D.C., USA

U.S. AID "Punto IV"
Quito
Washington, D.C., USA

*Department of Agriculture, Stock and Fisheries
Port Moresby, Papua

Sanitary Engineering Division
Edgewood Arsenal
Edgewood, Maryland,,USA

*U.S. AID, Capital Development and Industry
Rio de Janeiro, Brazil

*U.S. AID
Mission to Nepal
Kathmandu, Nepal
(c/o Washington, D.C., USA)

*U.S. AID, Department of Agriculture
Bangalore, India

*U.S. AID, U.S. Embassy
Vientiane, Laos

Businesses

*American Alloy Corp.
Cleveland, Ohio

*Banaspati Company
Rajpura, Punjab, India

Clark Equipment Company
Buchanan, Michigan, USA

*Amrit Banaspati Company, Ltd.
Rajpura, Punjab, India

Camp, Dresser, & McKee International, Inc.
Boston, Massachusetts, USA

Dames & Moore
Atlanta, Georgia, USA

Businesses (Continued)

*Dinamica, SA
San Jose, Costa Rica

General Merchant & Importer
Saigon, Vietnam

Indocean Engineers
Hyderabad, India

*Larsen & Toubro, Ltd.
Bombay, India

Miller Felpax Corporation
Winona, Minnesota, USA

Penn Central Company
Cleveland, Ohio

Raymond Beunet Associates
Concord, N.S.W., Australia

*Singapore Foundry & Machine
Singapore

*TNC International, Ltd.
Bangkok, Thailand

Union Carbide, India, Ltd.
Madras, India

Do Buzi Company
Beira, Mozambique

Gould Pumps, Inc.
Seneca Falls, New York, USA

James M. Jennings Associates
Columbus, Ohio, USA

Manufacturer's Representative
Saigon, Vietnam

Modern Agriculture Company
Alexandria, Virginia, USA

Punji Sons, Private, Ltd.
New Delhi, India

Republic Steel Corporation
Cleveland, Ohio USA

Southern Alloy Foundries Private, Ltd.
Madras, India

*Tropical Products Institute
London, England

Universities

*Engineering Research Institute
(Central Public Health)
Nehru Marg, Nagpur-3, India

Research & Training Institute-
Mlingano
Tanga, Tanzania

*University of Philippines
(College of Veterinary Medicine)
Quezon City, Philippines

Massachusetts Institute of Technology
Department of Mechanical Engineering
Cambridge, Massachusetts, USA

*University of Lagos
(College of Medicine)
Lagos, Nigeria

University of Reading
London, England

Foundations

AFPRO
New Delhi, India

*CARE, Inc. (for Chile)
New York, New York, USA

International Institute of Rural Reconstruction
New York, New York, USA

Meals-for-Millions Foundation
Santa Monica, California, USA

*Pan American Development Foundation
Washington, D.C., USA

Dr. Jose P. Rizal - Gen. Douglas MacArthur Memorial Foundation
Milwaukee, Wisconsin, USA

VIDSCO
California, USA

*World Neighbors
Oklahoma City, Oklahoma, USA

American Council of Voluntary Agencies for Foreign Service
New York, New York, USA

*ICAITI
Guatemala, Central America

*Material Resources Program
Church World Service
New York, New York, USA

National Institute of Agricultural Engineers
Bedford, England

Public Welfare Foundation, Inc.
Washington, D.C., USA

The Thomas A. Dooley Foundation, Inc.
San Francisco, California, USA

VITA
Schenectady, New York, USA

Publications

Engineering
London, England

New Scientist
London, England

Foundry
Cleveland, Ohio, USA

World Farming
Kansas City, Missouri, USA

Individuals

Mr. S. R. Bhatt
Surat, India

Mr. R. Mahaderan
Madras, India

*Mr. Robert G. Unruh
Asuncion, Paraguay

Mr. Amin M. Lakhani
Cambridge, Massachusetts, USA

Mr. S. Sood
West Bengal, India

Countries

- Australia
- Brazile
- British West Africa
- Congo
- Costa Rica
- England
- Guatemala
- India
- Laos
- Mozambique
- Nepal
- Nigeria
- Papua
- Paraguay
- Philippines
- Singapore
- Tanzania
- Thailand
- United States
- Vietnam