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FIELD RESEARCH AND TESTING OF A WATER
HAND PUMP FOR USE IN DEVELOPING COUNTRIES

AGENCY FOR INTERNATIONAL DEVELOPMENT

Contract No. AID/csd-3305

Project No. 931-17-521-454

A.I.D.
Reference Center
Room 1E56 NS

FIRST ANNUAL RESEARCH REPORT

on

FIELD RESEARCH AND TESTING OF A WATER
HAND PUMP FOR USE IN DEVELOPING COUNTRIES

to

AGENCY FOR INTERNATIONAL DEVELOPMENT

Contract No. AID/csd-3305
Project No. 931-17-521-454

by

R. D. Fannon

June 28, 1972

BATTELLE
Columbus Laboratories
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June 28, 1972

Mr. A. Dale Swisher
Environmental Health
Office of Health
Technical Assistance Bureau
Agency for International Development
Washington, D.C. 20523

Dear Mr. Swisher:

Enclosed are 35 copies of our First Annual Report describing the activities on your program, "Field Research and Testing of a Water Hand Pump for Use in Developing Countries". The report follows the outline prescribed by you in your letter of March 9, 1972. If there are any questions concerning the discussion, please do not hesitate to call us.

A detailed account of the trip to Thailand and Nigeria will follow in a few days.

Sincerely,

A handwritten signature in cursive script that reads "Robert D. Fannon Jr." with a long, sweeping flourish at the end.

Robert D. Fannon, Jr.
Research Engineer
Equipment Development Division

RDF:jah

Enclosures

cc: Mr. V. C. Perelli
Contracting Officer
Office of Procurement
Contract Services Division
Agency for International Development
Washington, D.C. 20523

REPORT SUMMARY

FIELD RESEARCH AND TESTING OF A WATER
HAND PUMP FOR USE IN DEVELOPING COUNTRIES

AID/csd-3305

by

Battelle, Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

Robert D. Fannon, Jr., Principal Investigator

Contract Period June 30, 1971 to April 30, 1974
Report Period June 30, 1971 to June 30, 1972
Total AID Funding to Date \$41,000
Total Expenditures \$33,374.94 (Estimated) (1)
Estimated Expenditures Next Year \$9,175.00

NARRATIVE REPORT SUMMARY

During the first year of the program the principal accomplishments were as follows.

- All drawings, specifications, and bill of materials were updated to reflect all improvements on the original design.
- Thailand and Nigeria were picked as two of the developing countries in which to introduce the AID hand pump and to conduct field evaluation programs.
- Boxes were shipped to these countries containing a demonstration pump, a full set of patterns, and core boxes and sufficient cups and flapper-valve material for twenty pumps.
- Two selected areas were visited by the principal investigator and a machinist/technician to introduce the pump, to instruct and advise in its fabrication, installation, and operation, and to start an evaluation program.
- Patent application was found to be unnecessary to maintain unrestricted use of the pump by developing countries.

(1) Total costs include estimated June, 1972, expenditures.

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SECTION 102 - PATENTS

FIELD RESEARCH AND TESTING OF A WATER
HAND PUMP FOR USE IN DEVELOPING COUNTRIES

by

R. D. Fannon

GENERAL BACKGROUND

Approximately three-quarters of the population of developing countries depend upon wells and groundwater supplies for their domestic water needs. For most, a hand pump is the main item required for extracting the water without contaminating the source. To be satisfactory, this hand pump must be dependable, be able to operate under severe use with a minimum amount of repair, be of simple construction with as few points of wear as possible, be of moderate cost, and preferably, be capable of manufacture in the country of its ultimate use. In two previous AID research programs, such a pump has been designed and evaluated under laboratory conditions. This program continues the quest for supplying a superior pump to developing nations through a 2-year field-evaluation program to determine optimum configurations. The results of the first program (Contract No. AID/csd-1434) are described in our summary report to AID dated September 29, 1967. The results of the second program (Contract No. AID/csd-2174) are described in our summary report to AID dated August 23, 1970.

PROJECT OBJECTIVES

"The objective of this project is to introduce, demonstrate, and test in not less than three selected developing countries a water hand pump previously designed by the contractor under another contract with AID for use under overseas condition, i.e., dependable, able to operate under severe use with minimum repairs, of simple construction, moderate cost, and capable of manufacture in the country of ultimate

use. The contractor will make such modifications in the present design as the final evaluations suggest."⁽¹⁾

CONTINUED RELEVANCE OF OBJECTIVES

Unexpectedly, the most difficult portion of the program to date is the selection of three developing countries with both facilities to produce a hand pump and economic means to buy and install pumps so that a meaningful evaluation could be made. The project review board, during the review and appraisal meeting February 24, 1972, made five recommendations, three of which are as follows.

- (1) "Battelle personnel should proceed to Thailand as quickly as possible and get the initial test under way. This trip should not be delayed pending identification of a second test site. If agreement is reached with Nigeria or another second site is selected prior to return of Battelle personnel to the U.S., it may be visited enroute home.
- (2) "If Battelle can affirm through one or two demonstrations that the design unquestionably meets overseas requirements and the pump can be indigenously produced AID/W will, at that time, consider reducing the number of test sites from three to two.
- (3) "Similarly, the advisability of reducing the 24-month field test to 18 months at each site will be reviewed by AID/W at a later date."⁽²⁾

The program is proceeding as recommended, and when changes are required, they can be made.

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- (1) The objectives as stated in the Contract.
 - (2) Review Team Report - Battelle Hand Pump Contract TA/H, A. Dale Swisher, P.E., March 9, 1972.

ACCOMPLISHMENTS TO DATE

The program has three general phases of work: preparation, field evaluation, and data collection. To accomplish this work the following tasks must be completed.

- Update all drawings, specifications, and bill of materials
- Select areas in three developing countries for introduction of the pump and field test of the design
- Prepare patterns and other materials for assembly of three pumps for introduction to selected areas
- Visit the three selected areas to arrange the program including fabrication, installation, and evaluation
- Assemble patterns, core boxes, and other necessary materials exclusive of the iron to produce a reasonable number of pumps for introduction and evaluation purposes; these will then be shipped to the cooperating manufacturers
- Apply for U.S. patents
- Make second visit to the selected areas to provide additional technical assistance and start evaluation programs
- Accumulate field data (over a 2-year period) and answer technical inquiries
- Assemble final report and finalize drawings and specifications to reflect field evaluation.

The first six of these tasks have been completed.

Drawings and Specifications

Phase I resulted in a basic pump design; Phase II yielded improvements. The purpose of this portion of the program was to put all the information together in the form of working drawings, specifications, and bill of materials

so that patterns could be made and machined, and purchased items ordered. This was done, and copies of updated material were sent to the program monitor.

Selection of Three Developing Countries

Surprisingly the most difficult task to date was the selection of developing countries in which to conduct the pump evaluation. The two basic requirements were

- (1) A foundry/machine shop that is interested and capable of participating in the program must be available to make and sell pumps and to help conduct a test program.
- (2) Economic means, individually, collectively, or a sponsored program of some type, must be available to buy, install, and maintain the manufactured pumps.

Sixteen inquiries were sent out to ten countries:

India	Iran	Mexico
Philippines	Guatemala	Korea
Thailand	Brazil	Sweden.
	Seirinam	

With the exception of Thailand the responses to the inquiries were negative. It seems almost unbelievable that such little interest was shown, although more favorable secondary reactions have been received.

Three Thai government agencies (Accelerated Rural Development, Ministry of Health, and Department of Mineral Resources) have been reported to have an interest in the pump as well as the AID Mission hydrogeologist, Mr. John Smith. It has also been reported that the AID Mission Director in Laos expressed an interest in the pump, and perhaps buying pumps from Thailand. In light of this enthusiasm, Thailand was chosen as the first of the developing countries in which to work.

In January, 1971, Mr. Erik Fraser of CARE in Nigeria sent a letter requesting more information regarding the pump and possibilities of manufacturing the pump in Nigeria. Mr. Ralph Montee, CARE, New York, advised that CARE is engaged in a program requiring 300 pumps and that two foundries in Lagos are capable of producing the pump as well as a supply of materials. Because of the need and facilities available, Nigeria was chosen as the second developing country for our field evaluation.

As agreed on February 24, 1972, by the Review Board, plans were made to begin work as soon as possible in these countries without waiting for a third country to be selected.

Patterns and Demonstration Pumps

As soon as the two countries were decided upon, two complete sets of patterns and core boxes were made, and two demonstration pumps were assembled. It was also decided at the review board meeting that materials would be sent to the selected countries prior to the first meeting; consequently, a box containing a demonstration pump, a set of patterns and core boxes to produce the cast components, and enough cups and valve material to make 20 pumps was shipped to each country.

Visit to the Selected Countries

Between the 19th of April and the 18th of May, Thailand and Nigeria were visited by the Battelle team: Mr. Robert Fannon, Project Engineer, and Mr. William Shalley, Technician. The program was enthusiastically received in both countries.

Visit to Thailand

The three most interested Thai Government agencies were visited:

Accelerated Rural Development (ARD)
Ministry of Health
Department of Mineral Resources.

ARD was currently the most progressive of the groups and had an active well drilling program. It was decided to work more closely with this group. This group was also quite aware of the Battelle program.⁽³⁾ After showing the demonstration pump in Bangkok, the team's efforts were shifted to Khon Kaen, in northeast Thailand, the center of the ARD Well Drilling Program.

Working with Mr. Samuel Bargnesi, the AID Well Drilling Advisor, the team installed the demonstration pump with the plastic cylinder on a deep well in a village about 12 miles from Khon Kaen. The patterns and core boxes, shipped from Battelle, were taken to a backyard, one-man foundry where quite satisfactory castings were made. Machining seemed quite satisfactory both in commercial machine shops in Khon Kaen and that by the machinist at the new ARD maintenance facility. Local hardware stores carried plastic pipe suitable for making the cylinders, and ARD stores stocked the remaining supplies with the exception of the valve material which will probably have to be imported. Religious holidays and a review of the ARD program by the American Ambassador prevented the completion of several more pumps. However, there is no question about the availability of the necessary facilities and materials and the capability to produce the hand pump in Thailand.

(3) An In-Depth Study of The ARD Well Drilling Project by John W. Reave, Samuel J. Bargnesi, April 1, 1971, page 25.

The ARD well-drilling program in northeast Thailand has a goal of 100 wells (100 feet deep or more) per year. Even though quite a number of Korat Gear Pumps are in the warehouse, ARD plans to install as many AID pumps as can be made. Apparently, John Smith will not be associated with the program, but rather his assistant, Khun Sa-Ard, will monitor the efforts in Thailand. He will endeavor to get representatives from Mineral Resources, Ministry of Health, and other agencies to go to Khon Kaen to see the operation of the pump. Hopefully, these agencies may secure a few pumps to be installed on their own wells. If more agencies want to try out the pump, production of the castings may have to be moved to a larger foundry.

Two things should be noted with respect to Thailand efforts:

- (1) Eleven threads per inch with a standard taper seems to be standard for 3-inch pipe rather than 8 threads. This is perfectly satisfactory and makes a stronger joint⁽⁴⁾ than the 8 threads per inch because the thread is not cut as deep.
- (2) A type of 3-inch to 1-1/4-inch reducer obtainable in Khon Kaen is such that it can be used as a cylinder end cap. Where needed, a brass bushing can be inserted and a flapper valve attached. Again, this is quite satisfactory.

Visit to Nigeria

On arrival to Lagos the team learned that there are no currently sponsored well drilling programs of any type; however, CARE is completing active, large-scale water-treatment programs. In addition, CARE is actively pursuing rural water-supply programs. One such program calls for 300 wells and hand pumps. Here, as in northeast Thailand, most are of the deep-well type.

(4) See section on Further Examination of Plastic Cylinders.

Mr. William Rayman and Mr. Erik Fraser of CARE arranged with Nigerian Foundries, Limited, to make the pump. The program was quite enthusiastically received by Romeo and John Barberopoulos, owners of the foundry. They are currently making many fittings for municipal water systems in all the Nigerian states, and they believe they can make and sell the hand pumps to the same groups. Wells and hand pumps are needed in Nigeria and it is believed that when the pumps become available with spare parts (which have a high import duty) and maintenance, they will be even more in demand. Several government officials expressed interest in the pump during our visit.

The Nigerian Foundry is a modern foundry with molding machines, small pattern shop, and a few machine tools. They are in the process of expanding: a larger cupola with a crane assist for pouring is almost ready, larger molding machines are on order, and another lathe has been purchased. The Nigerian Foundry is presently a foundry only, not a manufacturer, and they do quite a bit of work with the Addes Engineering Works, a nearby machine shop.

Before the team left Nigeria, parts for five deep-well pumps had been cast, and one completed pump had been machined and assembled. It is planned that several pumps will be installed in the Lagos area, and at least one in each of the other states for demonstration. Mr. Robert Berg, Chief, Office of Capital Development and Finance, US AID, will monitor the program and assist where possible.

Several other obstacles remain to be handled. Since there are very few hand pumps in Nigeria, there is virtually no 1-1/4-inch drop pipe, pump rod, couplings, pump cups, or plastic pipe of the proper size. These things can be imported--as most manufactured items are. The high cost of machining;

is a second obstacle. The AID pump design lends itself to this problem well; however, some effort may go into casting a one-piece pump. Ordinarily this would reduce the flexibility of the design, but because deep-well pumps would be used almost exclusively, because of the high cost-low efficiency machining, and because of the high import duty on many types of items, every effort must be made to make the pump as inexpensively as possible.

One other item of interest, in many areas of Nigeria the so-called potable water has a pH of less than 6, and corrosion between galvanized drop pipe and brass pumps or cylinders is greatly accelerated. This prompted consideration of plastic end caps as well as plastic cylinders.

Patents

The main purpose behind Phases I, II, and III for the Development and Field Evaluation of a Hand Operated Water Pump is to provide in total or in part an improved means by which people in developing areas may obtain, without an outside power source, potable water for personal use. To assure the use of the design and pertinent information by anyone without restriction, patenting of the pump was investigated. According to the Battelle Patent Department, a United States patent cannot be obtained (and is not necessary) by Battelle personnel (and assigned to the United States) or anyone else. This is based on 35U.S.C.102; conditions for patentability, novelty, and loss of right to patent; which provides in part that a person shall be entitled to a patent unless the invention was described in a printed publication anywhere more than one year prior to the date of application for patent. In this case no patent is as good as obtaining one. A copy of the entire Section 102 can be found in the Appendix. It is our understanding that most foreign countries follow similar

codes and practices to the United States. Descriptions of the pump and other data appear in the Phase I and Phase II final reports dated September 29, 1967, and August 28, 1970, respectively.

Additional Plastic Cylinders Evaluation

One of the questions continually asked was, "How deep can you use the plastic cylinders?" Theoretically if the maximum working pressure of 3-inch schedule 40 PVC plastic pipe is 130 psi and water pressure per foot of head is 0.433 psi, then plastic 3-inch cylinders should be capable of pumping in a well where the head did not exceed $130 \div 0.433$ or 300 feet. However, the threaded ends would reduce this figure somewhat. The externally threaded ends would make less difference than internally threaded ends. Internal pressure of 130 psi would place a force of 318 pounds on the end caps. Sample 3-inch cylinders were made using 8 and 11 American standard taper pipe threads and placed in a tensile test machine. Failure occurred at 7180 pounds and 9940 pounds, respectively. It is our opinion that 3-inch, schedule 40, PVC plastic pipe with externally threaded ends should be capable of pumping in wells with a 200-foot head of water.

Because of the acidic condition of the water in some of the areas in Nigeria and because of the high machining cost, the use of plastic end caps is being investigated. If such an arrangement is possible a less expensive, noncorrosive cylinder can be made.

DISSEMINATION OF INFORMATION

No results are yet available for dissemination from work conducted under the Phase III contract. However, reports describing the work conducted

under the Phase I and Phase II programs are needed. To supply the requests 100 copies of these reports are being made and 20 to 25 copies will be mailed within the next ten days.

It has just been learned through correspondence with Mr. B. Z. Diamant, Project Manager, WHO/UNDP Rural Water Supply Project, Acora, Ghana, that attempts are being made to develop a hand pump according to the design recommended in our past reports. More information will become available in the coming months.

STATEMENT OF EXPENDITURES

Project cost statement of expenditures through any given month becomes available two weeks following the end of that month. Therefore, costs incurred through May 31, 1972, are listed in the first column and estimated June costs are listed in the second column. An exact financial statement for the year June 30, 1971 to June 30, 1972, will be given in the next quarterly report. The expenditures thus far seem reasonable for the work carried out and according to schedule.

	<u>Total Costs Through May, 1972</u>	<u>Estimated Costs For June, 1972</u>
Direct Salaries	\$ 8,873.14	\$1,358.30
BCL General Overhead	6,660.56	1,032.25
Departmental Burden Overhead	2,342.31	366.72
Travel	211.80 ⁽⁵⁾	4,120.78
Other Direct Costs	905.71	730.00
Materials and Supplies	<u>6,733.37</u>	<u>40.00</u>
Total	\$25,726.89	\$7,648.05

(5) Although the Staff Time reflects the recent trip, the travel expenses have not cleared accounting.

FUTURE WORK

During the coming year correspondence will be maintained with AID personnel in Thailand and Nigeria, and with those persons producing and/or evaluating pumps in the field. These would include CARE and the Nigerian foundries. It is also anticipated that a second trip will be made to the two areas already visited. The exact nature of the trip and the time are yet to be determined. Much depends upon the progress of the program setup in these areas. Work in a third country has not yet been determined, but decisions concerning pump introduction and evaluation will be made in the coming year.

Data concerning pump fabrication and installation and evaluation of operation will be collected during the year. Any design or practice changes that seem pertinent to make will be considered. Past reports will be disseminated on the basis of need as requested.

It is believed at this time that the anticipated work will be within the budget as modified by the Review Board February 24, 1972. An estimated breakdown is as follows.

Direct Salaries	\$2,500
Consulting	1,000
BCL General Overhead	1,900
Departmental Burden Overhead	675
Travel	2,200
Other Direct Costs	400
Materials and Supplies	<u>500</u>
Total	\$9,175

APPENDIX

35 U.S.C. 100. *Definitions.* When used in this title unless the context otherwise indicates—

- (a) The term "invention" means invention or discovery.
- (b) The term "process" means process, art or method, and includes a new use of a known process, machine, manufacture, composition of matter, or material.
- (c) The terms "United States" and "this country" mean the United States of America, its territories and possessions.
- (d) The word "patentee" includes not only the patentee to whom the patent was issued but also the successors in title to the patent.

35 U.S.C. 101. *Inventions patentable.* Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

35 U.S.C. 102. *Conditions for patentability; novelty and loss of right to patent.* A person shall be entitled to a patent unless—

- (a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for patent, or
- (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the United States, or
- (c) he has abandoned the invention, or
- (d) the invention was first patented or cause to be patented by the applicant or his legal representatives or assigns in a foreign country prior to the date of the application for patent in this country on an application filed more than twelve months before the filing of the application in the United States, or
- (e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or
- (f) he did not himself invent the subject matter sought to be patented, or
- (g) before the applicant's invention thereof the invention was made in this country by another who had not abandoned, suppressed, or concealed it. In determining priority of invention there shall be considered not only the respective dates of conception and reduction to practice of the invention, but also the reasonable diligence of one who was first to conceive and last to reduce to practice, from a time prior to conception by the other.

35 U.S.C. 103. *Conditions for patentability; non-obvious subject matter.* A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

35 U.S.C. 112. *Specifications.* The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same, and shall set forth the best mode contemplated by the inventor of carrying out his invention.

The specifications shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention. A claim may be written in independent or dependent form, and if independent form, it shall be construed to include all the limitations of the claim incorporated by reference into the dependent claim.

An element in a claim for a combination may be expressed as a means or step for performing a specified function without the recital of structure, material, or acts in support thereof, and such claim shall be construed to cover the corresponding structure, material, or acts described in the specification and equivalents thereof.