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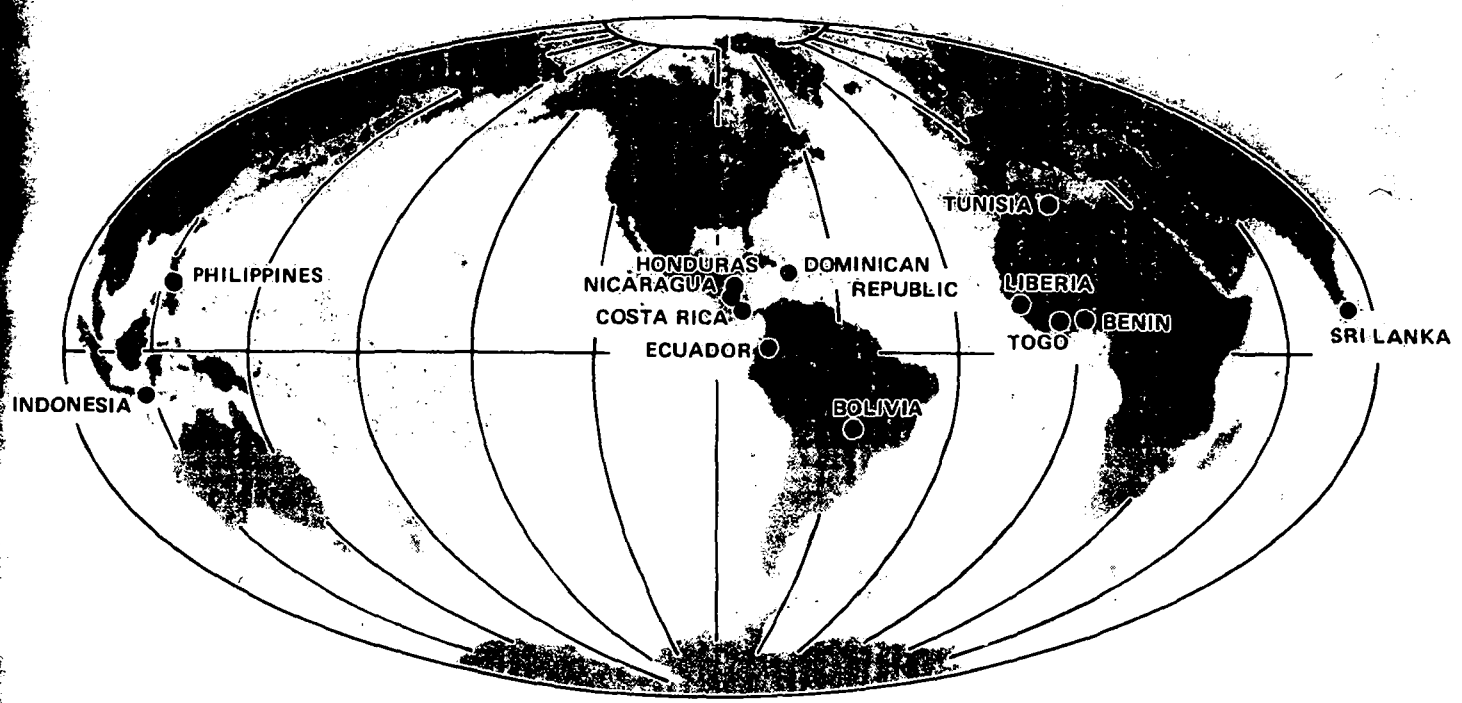
THE AID HAND-OPERATED WATER PUMP:



A CLASSIC EXAMPLE OF TECHNOLOGY TRANSFER

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ATLANTA, GEORGIA 30332

THE AID HAND-OPERATED WATER PUMP: A CLASSIC EXAMPLE OF TECHNOLOGY TRANSFER

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by

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EXECUTIVE SUMMARY

In September 1976, the Georgia Institute of Technology (Georgia Tech) was contracted by the Agency for International Development (AID) to select two developing countries for local manufacturing and field testing of the AID hand-operated water pump. The scope of work included technical assistance to foundries and machine shops in the manufacturing operation and evaluating the performance and acceptability of the hand pump when heavily used.

Nicaragua and Costa Rica were chosen as initial test countries based on several factors including the existence of adequate manufacturing capabilities, upcoming hand pump programs planned by AID in collaboration with the Ministry of Health in both countries, and enthusiasm about the project goals and the resulting development spin-offs. Local manufacture of the AID hand pump was completed and field trials initiated between January 1977 and September 1979. The AID pump was subsequently determined to be reliable, sturdy, easily maintained, low in cost compared to imports, and capable of being manufactured in developing countries. As a result of the Nicaraguan and Costa Rican field tests, minor design modifications were recommended that proved successful in later field tests.

An assessment was then made of existing manufacturing capabilities for the Dominican Republic and a market analysis performed to determine the relative cost of local manufacturing versus importing. The AID hand pump was found to be appropriate, and in August 1978 Georgia Tech was contracted to help develop local manufacturing capabilities and conduct field tests. Even though a prototype available from Nicaragua provided guidance in fabricating the AID hand pump in the Dominican Republic, the first batch of finished pumps clearly showed difficulty in adhering to specified tolerances. However, of the 24 test pumps manufactured, 21 were installed and functioned well. These initial manufacturing problems were resolved through technical assistance, and the Dominican Republic has officially accepted the AID hand pump for its own use.

An AID hand pump program began in Indonesia in early 1978 with Georgia Tech personnel performing a manufacturing feasibility study, and based on initial findings an AID/Georgia Tech contract was signed in September 1978. This contract required that Georgia Tech provide technical assistance in producing 230 AID hand pumps, install 60 of the pumps in six Provincial Development Program (PDP) areas with 35 of the pumps in the Bandung area, 10 in the Jakarta area, and 11 at

sanitarian schools, monitor the performance of the pumps and feed back data to the manufacturer for tightening of quality controls when defects appear, and assess the feasibility of manufacturing the pumps in three PDP areas. Prospects for wide use of the AID hand pump in Indonesia now appear promising as the Cooperative for American Relief Everywhere (CARE) has installed over 200 of these pumps for its own rural water supply programs. The Asian Development Bank (ADB) is also considering its use for 3,000 wells in the Sulawesi region. Other organizations are expected to use the pump as additional foundries are identified and exposed to the marketability of the pump. It is noteworthy that at one rural village where a test pump was installed, local residents took up a collection to purchase three additional pumps, developed well sites, and installed the pumps themselves. Such initiative is admirable and both Georgia Tech and AID are proud of fostering this type of accomplishment.

In October 1979, Georgia Tech personnel were asked to determine the feasibility of manufacturing the AID hand pump in Sri Lanka. In March 1980, a local manufacturing program began at a foundry and machine shop. The pumps produced thus far appear to be of excellent quality. By August 1981 the installation phase of the project should be completed, with a monitoring and evaluation period extending through December 1981. By the time the project is completed, the manufacturer should be capable of producing the pump at a high level of quality without external technical assistance and supplying national and international organizations on a large-scale basis.

In April 1980, a Georgia Tech team visited Tunisia to determine if the AID hand pump program would be suitable for the country. Surveys of Tunisian foundries, machine shops, plastics manufacturers, and retail hardware stores indicated that local manufacture of the pump was both technically and economically feasible as a viable alternative to expensive imports. In August 1980, a contract was signed between USAID/Tunisia and Georgia Tech to provide technical assistance related to local manufacture of the AID hand pump, evaluation of pump performance, and water quality improvement. In January 1981, a prototype pump of very good quality was produced and approval was given to proceed with the production of 40 pumps by April 1981.

The AID hand pump program was expanded to Ecuador in August 1980. Initial results indicated that a hand pump program would improve living conditions by providing safer, more convenient water, as well as stimulating industrial develop-

ment and reducing foreign exchange requirements. Based on this information, a contract was signed between USAID/Ecuador and Georgia Tech in September 1980 to provide technical assistance in locally manufacturing AID hand pumps and assuring their applicability for introduction into bilateral health projects that include water supply components. Plans call for installing AID pumps in June 1981 in rural areas of Ecuador by CARE, the Peace Corps, Voz Andes Hospital's Community Development Department, the Ecuadorian Institute of Sanitary Works and the Center for the Rehabilitation of Manabi. Georgia Tech will perform training in site selection, well preparation, installation techniques, proper disinfection of water, bacteriological analysis of water, and maintenance and repair. These activities should result in national acceptance of the AID hand pump into future Ecuadorian rural water supply programs.

Honduras, the Philippines, Bolivia, Togo, Benin and Liberia have also been surveyed by Georgia Tech to determine if the AID hand pump is appropriate and can be manufactured at a competitive cost. Manufacturing, field testing, and pump performance monitoring and evaluation activities are expected to begin in Honduras and the Philippines soon because of positive results from the surveys and an interest on the part of the respective AID Missions and host country organizations in promoting the pump. Bolivia has already developed and accepted a World Bank-funded hand pump that is locally manufactured. Togo and Benin were not appropriate for the AID hand pump since most of the wells were too deep. Liberia did not have sufficient manufacturing capabilities to support a pump program.

Introducing the local manufacture of the AID hand pump in developing countries is a classic example of effective technology transfer. Georgia Tech has established a methodology for working with private sector manufacturers and government organizations to stimulate the local fabrication, installation, and use of the pumps as well as monitoring of water quality. This methodology is simple and easily applied in a variety of countries with a variety of devices other than hand pumps. However, much detailed work is involved in initiating the local manufacture of any product such as the AID hand pump. The manufacturer must be assisted in reaching a satisfactory level of quality control, and the implementing organizations must be made aware of the product capabilities and problems. Such a program requires patient, prolonged, and understanding work with personnel from private, government, and international organizations to share the knowledge and techniques of industrial nations through adaptation rather than duplication and procurement.

INTRODUCTION

The Georgia Institute of Technology is committed to the three major activities of teaching, research, and public service. Each of these activities has played a key role in responding to the needs of local, state, regional, national, and international communities for updating basic and advanced technical knowledge and skills. Thus, this publication has been prepared to describe a development activity related to rural water supply technology transfer serving the international community during the past five years. Georgia Tech is grateful to the Agency for International Development (AID), especially to officials of the Environmental Health Division, Office of Health, Development Support Bureau, Washington, D.C. for the opportunity of participating in this endeavor.

During the period from 1964 to 1975, AID contracted with the Battelle Memorial Institute to design a low cost, easily maintained hand-operated water pump that could be manufactured in developing contries. In September 1976, Georgia Tech was contracted by AID to select two developing countries for the local manufacture and field testing of this pump. The scope of work included technical assistance to foundries and machine shops in the manufacturing operation and evaluating the performance and acceptability of the pump when heavily used. Georgia Tech was chosen for these tasks because of its experience in stimulating small-scale industry in developing countries.

Nicaragua and Costa Rica were chosen as initial test countries because of:

- Adequate existing manufacturing capabilities
- Upcoming hand pump programs planned by AID in collaboration with each country's Ministry of Health
- Enthusiasm over the project goals and the resulting development spin-offs by the governments

Local manufacture of the AID hand pump was completed and field trials initiated between January 1977 and September 1979. The AID pump was subsequently determined to be reliable, sturdy, easily maintained, low in cost compared to imports, and able to be manufactured in developing countries. As a result of the Nicaraguan and Costa Rican field tests, minor design modifications were recommended that proved successful in later field tests.

Technology transfer programs have since begun in the Dominican Republic, Indonesia, Sri Lanka, Tunisia, and Ecuador. These hand pump programs represent the application of technology transfer in its most complete form to developing countries and have clearly indicated that further use of the AID hand pump should be encouraged. The pump can be manufactured in a developing country at a competitive, profitable price and at an acceptable level of quality if adequate facilities are available. However, the availability of adequate manufacturing facilities and sufficient market demand are factors that must be determined for each developing country. Acceptance by villagers has been excellent with regard to aesthetics, simplicity, and ease of use.

Several national and international agencies have adopted or are considering adoption of the AID hand pump for their own use. The organizations include:

- o Ministry of Health in the Dominican Republic
- o Ministry of Health in Nicaragua
- o Voz Andes Hospital's Community Development Department in Ecuador
- o Ministry of Health in Ecuador
- o Peace Corps in Ecuador
- o Cooperative for American Relief Everywhere (CARE)
  - Indonesia
  - Tunisia
  - Sri Lanka
  - Ecuador
- o Asian Development Bank (ADB) in Indonesia
- o Ministry of Industry in Indonesia
- o Ministry of Health in Indonesia
- o Ministry of Agriculture in Tunisia
- o Ministry of Local Government, Housing and Construction in Sri Lanka
- o United Nations Childrens Fund (UNICEF) in Sri Lanka

The AID hand pump program has had a positive impact on the rural health (though admittedly difficult to quantify), employment generation, spare parts availability, and foreign exchange requirements. In addition, national pride is instilled when local capabilities are used for manufacturing a relatively complicated

product rather than importing. These impacts are extremely important in the development of a country, as recognized by AID Missions, and should never be underestimated. AID hand pump programs represent not just the single aspects of health improvement, rural development, urban development or capital development, but an integration of all of these objectives.

The following chapters give a general overview of the AID hand pump program and Georgia Tech's methodology for technology transfer. This methodology, if carefully followed, can serve as an operational model for the transfer of a wide variety of technologies ranging from hand pumps to solar-powered water systems, home water disinfection to large community water treatment, or manually operated drilling tools to large high-production drilling rigs. All of these programs would work to match university, public, and private sector expertise with host country needs and market demands.

Figure. 1

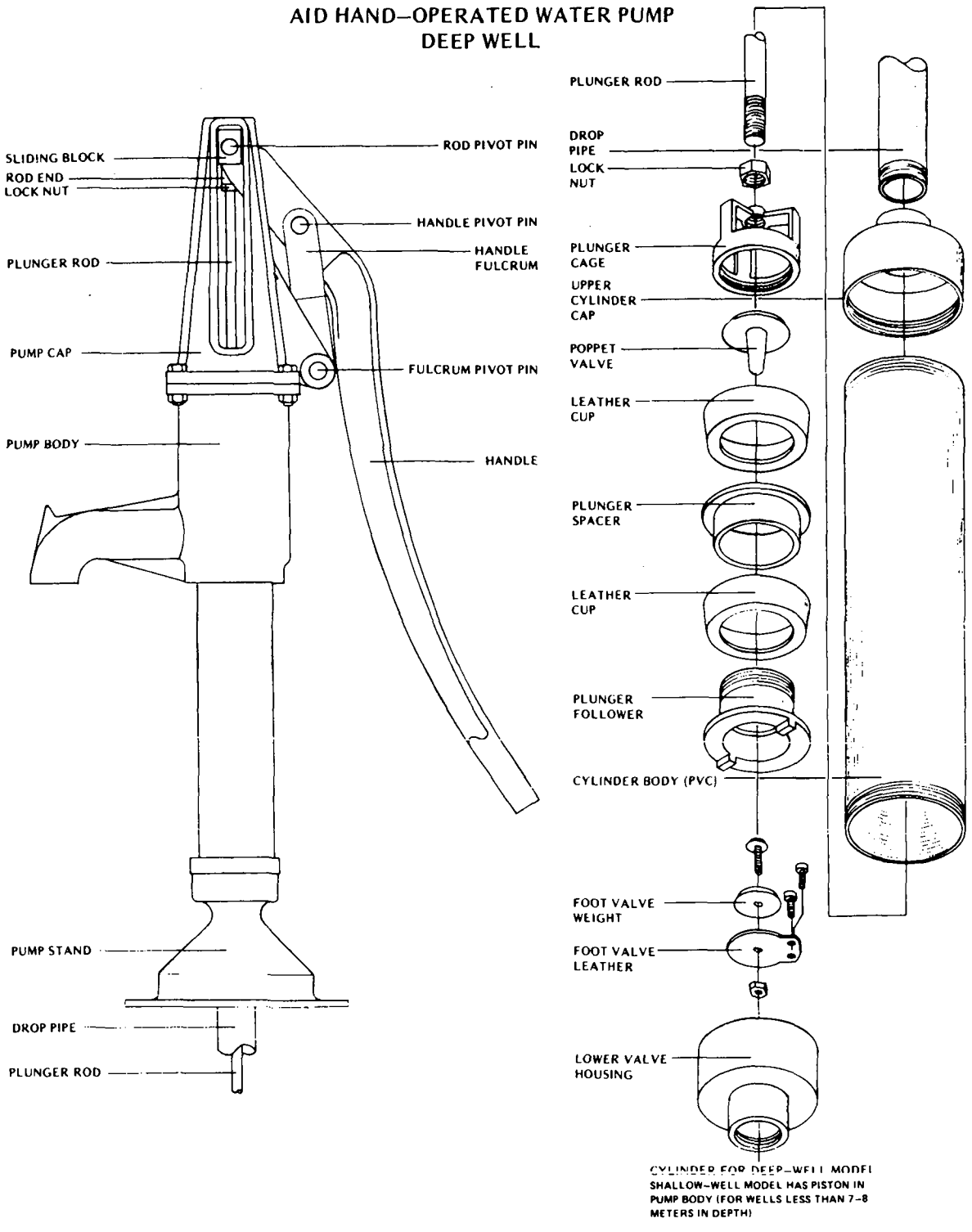
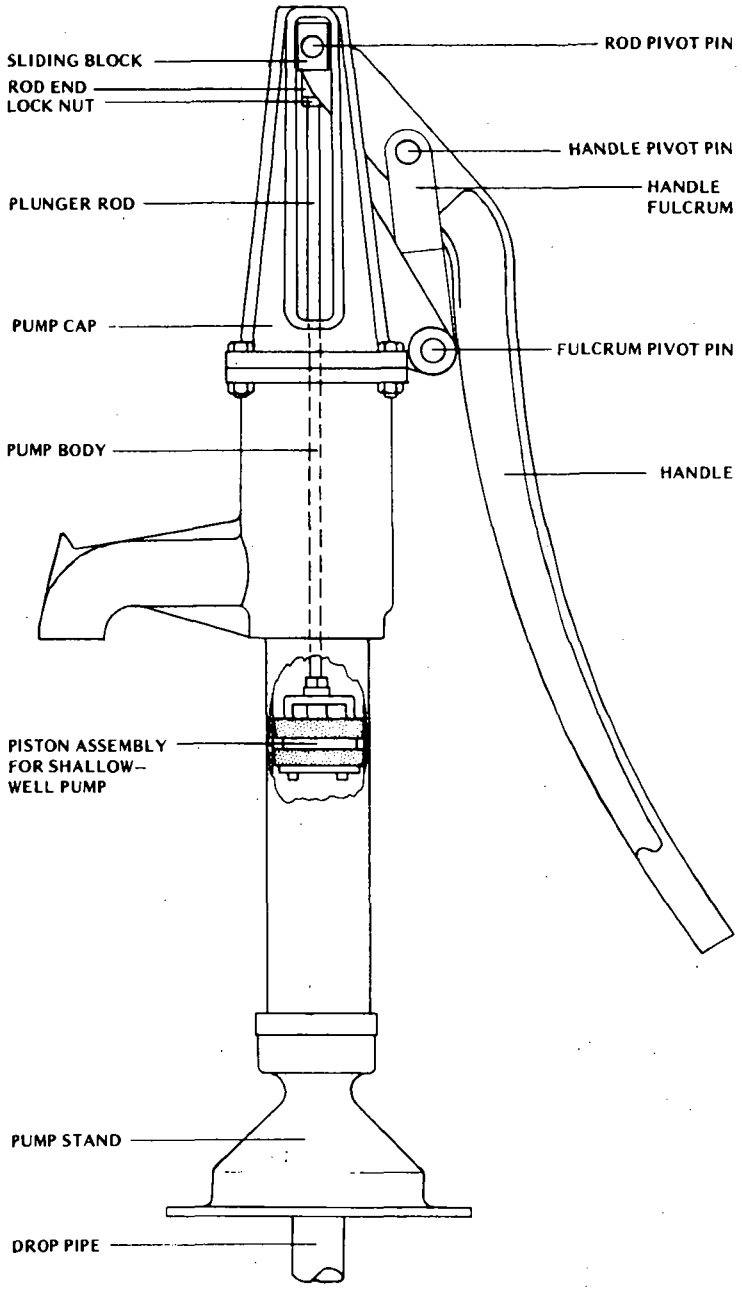

AID HAND–OPERATED WATER PUMP
DEEP WELL
SLIDING BLOCK
ROD END
LOCK NUT
PLUNGER ROD
PUMP CAP
PUMP BODY
PUMP STAND
DROP PIPE
PLUNGER ROD
ROD PIVOT PIN
HANDLE PIVOT PIN
HANDLE FULCRUM
FULCRUM PIVOT PIN
HANDLE
PLUNGER ROD
DROP PIPE
LOCK NUT
PLUNGER CAGE
UPPER CYLINDER CAP
POPPET VALVE
LEATHER CUP
PLUNGER SPACER
LEATHER CUP
PLUNGER FOLLOWER
CYLINDER BODY (PVC)
FOOT VALVE WEIGHT
FOOT VALVE LEATHER
LOWER VALVE HOUSING
CYLINDER FOR DEEP-WELL MODEL
SHALLOW-WELL MODEL HAS PISTON IN PUMP BODY (FOR WELLS LESS THAN 7–8 METERS IN DEPTH)

Figure. 2

AID HAND–OPERATED WATER PUMP
SHALLOW WELL

(For Wells less than 7–8 meters in depth)



NICARAGUA

Guatemala, El Salvador, Nicaragua and Costa Rica were visited by project personnel in the fall of 1976 to determine:

- o Existing manufacturing capabilities for producing the AID hand pump
- o Relative local manufacturing cost versus import costs
- o Applicability of the hand pump to rural water supply programs

All four countries were found to have sufficient manufacturing capabilities and the prices quoted for manufacturing the AID hand pump were much less than those for comparable imported hand pumps. Nicaragua and Costa Rica were chosen to be initial test countries because they also had upcoming AID-funded rural water supply programs that could utilize the AID pump. In addition, a high level of enthusiasm was exhibited by the AID Missions and each host country for such a test program.

Nicaragua had a rural water supply loan from AID that called for the installation of 300 hand pumps by the end of 1979. The AID/Georgia Tech program complemented this program by providing technical assistance in hand pump selection, installation techniques, repair, and maintenance. The program also enabled the Ministry of Health in Nicaragua to take advantage of locally manufactured hand pumps produced at a cost lower than commercially available imported pumps.

Program activities began in Nicaragua in January 1977 when a local foundry, Complejo Metalurgico Especializado, S.A. (COMETALES), was contracted to manufacture 20 AID hand pumps. The U.S. manufactured Dempster heavy duty Model 210F pump and a Brazilian Marumby pump were used for comparison since they were both locally available imports. A hand pump developed by the International Development Research Centre (IDRC) of Ottawa, Canada and the U.S. manufactured Moyno hand pump were also used for comparison. Unfortunately, the Moyno pump was added to the test program in the latter stages of the project and civil disorders prevented extensive monitoring of its performance. Thirty representative sites were selected to receive the initial test pumps installed by a Ministry of Health team with the Moyno pumps installed approximately a year after the rest. Immediately following installation, the wells were disinfected with a chlorine-yielding substance.

During the survey of manufacturing facilities in Nicaragua many foundries were identified but pattern makers, a very necessary requirement for local production, were practically nonexistent. One foundry was located that had all of the necessary resources, including pattern makers, to manufacture a quality hand pump. A contract was signed for the manufacture of eleven deep-well AID hand pumps (the plunger and the cylinder located below the well's water level when installed) and nine shallow-well AID hand pumps (the plunger and the cylinder located in the pump stand above ground). The prices for these pumps in 1977 were as follows:

Shallow-well model	$69 each
Deep-well model	$75 each
Patterns	$1,000 (one-time charge only)

By comparison, in 1977 the Dempster hand pump cost $257 delivered (pump, cylinder, and transportation), the Brazilian Marumby hand pump cost $45 delivered, and the IDRC hand pump cost $70, when fabricated in Nicaragua. The Moyno hand pumps cost $400 each, plus packing and shipping, for an average total unit cost of $470. The Moyno hand pump price of $400 was actually a price for demonstration and advertising purposes reduced from $800, and now sells for approximately $500 per unit in lots of less than 100 pumps.

Two major manufacturing problems became apparent when the field tests began. First, the weakest point on the cap of the deep-well pump was where maximum stress was being applied by the handle fulcrum upon the pivot arm of the cap, thus causing the pivot arm to break off from the cap. Because of an indented contour on the top plate of the pump body, it was not possible to cast the pump body as specified by the design drawings since the patterns for the pump could not be removed from the molding sand without destroying the mold. Therefore, the manufacturer eliminated the indented contour on the top plate of the pump and then did not have enough clearance between the pivot arm of the cap and the top of the pump body. In order to obtain a better fit between the pump cap and the pump body, the manufacturer milled away a fillet on the pivot arm, leaving a notch at the point of maximum stress. To alleviate the entire problem, the pump cap was redesigned by lifting the pivot arm up and away from the pump body and positioning it so that it did not absorb as much of the stress caused by the downward force of the pump handle. The redesigned cap was put into production successfully at the

manufacturer's foundry and installed on the pumps in the field, solving the initial problem.

The second major problem encountered with the AID hand pump in Nicaragua was a lack of three inch PVC pipe for the deep-well cylinders. As a result, the manufacturer used undersized PVC pipe and expanded it by heating. Quality control for such a process was very difficult and the results were unacceptable. While several of these PVC cylinders were installed in the field, it was decided that metal cylinders coated internally with epoxy would have to be used until the three inch PVC could be made available locally or imported from another country. In July 1977, the correct size PVC was obtained from a local manufacturer and acceptable cylinders were produced according to specifications. These new cylinders were far superior to both the epoxy-coated cylinders and the cylinder made by expanding the undersized pipe.

The majority of the manufacturing and quality control problems encountered were to be expected when a new product like the AID hand pump was introduced into local production for the first time. As subsequent orders were processed and personnel became more familiar with the pump, quality control was refined to the point where the orders were considered to be normal high quality production. Further, all design weaknesses were satisfactorily overcome as a result of modifications made by project personnel and ultimately proved to be workable in other developing country environments.

The hand pumps used for comparison were extremely valuable in providing performance data. The Dempster pumps performed well and gave no major problems. The IDRC pump performed relatively well, but had some difficulty with the foot valve sticking in the open position, as well as with consumer acceptance. The Moyno pump also performed well even though it's late inclusion into the test program provided only limited information.

The Marumby pump presented major problems. The handle and pump cap connection point was weak and in three of the five pumps tested, the pump cap had to be replaced due to breakage at this point. Spare parts were also difficult to find and the local distributor did not carry a large inventory of extra pumps for replacement purposes. This factor enhances the argument for locally manufacturing pumps so that spare parts can be made readily available.

The AID hand pump was chosen over the other pumps by the Nicaraguan Ministry of Health's PLANSAR (Planificacion de Sanitacion y Aquas Rurales) unit

for its overall performance and benefits from local manufacture. In addition, the foundry (COMETALES) began regular production of the pump shortly before the AID/Georgia Tech program ended, thus displaying its ability to manufacture a quality hand pump without further external technical assistance. However, civil disorder erupted later that led to an overthrow of the existing government and the Ministry of Health's hand pump program was discontinued even though the foundry was still offering the pump as one of its products.

Despite the unfortunate series of events that led to the discontinuance of the use of the AID hand pump in Nicaragua, the AID/Georgia Tech program was very successful since it allowed project personnel to obtain field data resulting in refinement of the pump for local manufacture, installation, and operation/ maintenance requirements in other countries.

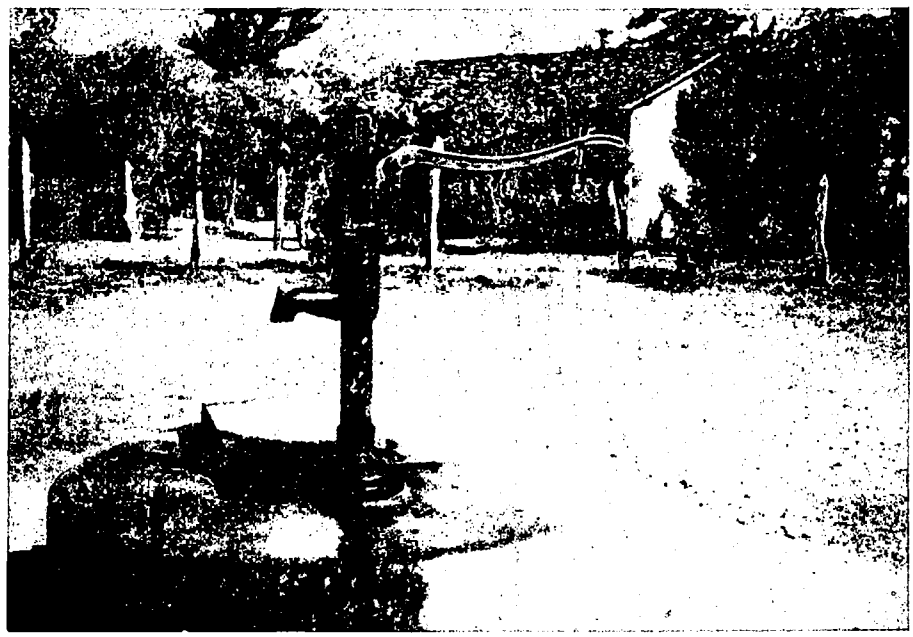


FIGURE 3. AID DEEP-WELL MODEL HAND PUMP (NICARAGUA)

FIGURE 4. AID SHALLOW-WELL MODEL HAND PUMP (NICARAGUA)

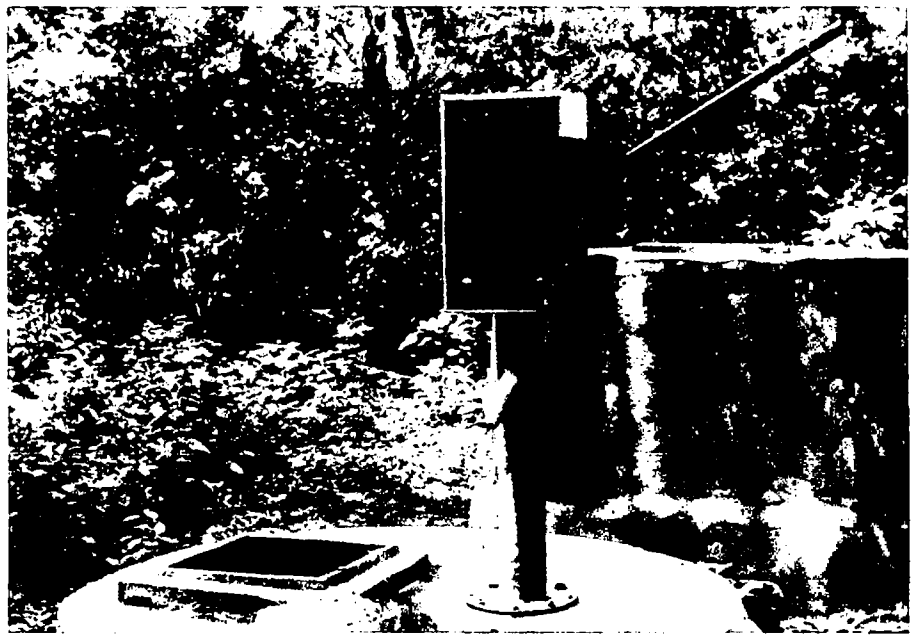


FIGURE 5. INTERNATIONAL DEVELOPMENT RESEARCH CENTRE HAND PUMP (NICARAGUA)

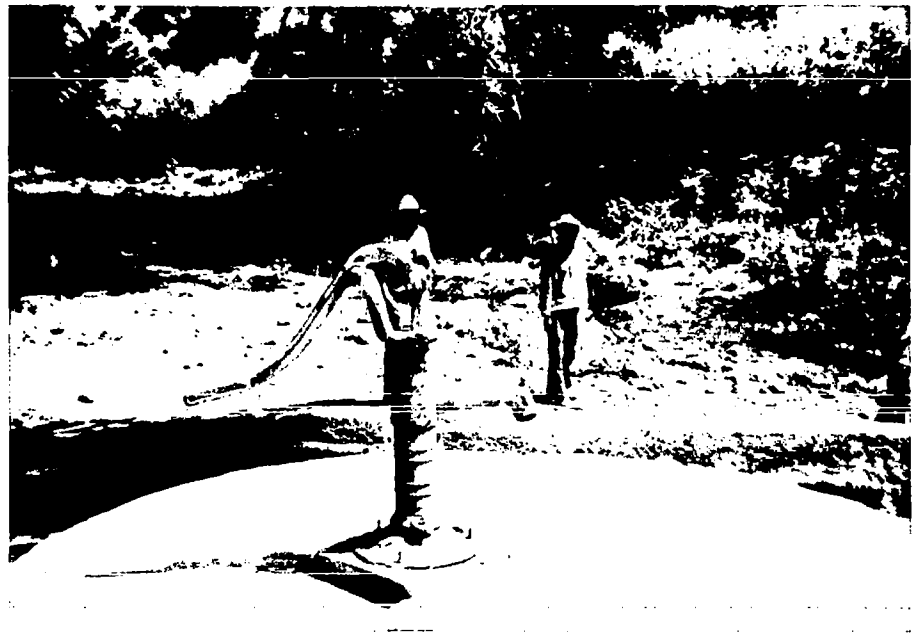


FIGURE 6. BRAZILIAN MARUMBY HAND PUMP (NICARAGUA)

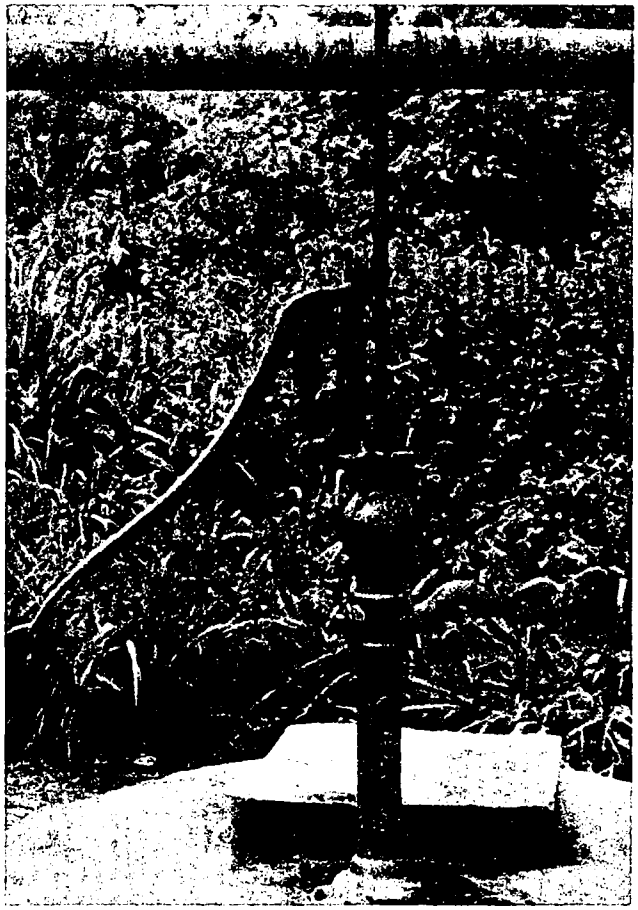


FIGURE 7. UNITED STATES DEMPSTER HAND PUMP (NICARAGUA)

COSTA RICA

Costa Rica was chosen as a test country for evaluating the performance and acceptability of the AID hand pump because of a large well and hand pump program loan and because of the country's need and interest in a locally manufactured hand pump. Provisions of the loan specifically included installation of hand pumps on a large-scale basis and, as with Nicaragua, it was felt that a locally manufactured pump had many advantages that should be included in the Costa Rican loan program. These advantages included employment generation, spare parts availability, reduction of foreign exchange requirements, and lower cost than for commercially available imported hand pumps.

A machine shop, Mecanizados Mofama, S.A., which purchased rough iron castings from a local foundry, was contracted to manufacture 20 AID hand pumps. These pumps, eleven deep-well and nine shallow-well, were installed in April 1977. The Dempster and the Japanese Lucky pump were chosen for comparison. The test pumps were installed at 31 representative sites (16 AID hand pumps and 15 comparative pumps) and as in Nicaragua, the pumps were installed by Ministry of Health engineers and technicians. However, in Nicaragua most of the sites had to be completely developed whereas in Costa Rica, existing wells with inoperable pumps were used by merely replacing broken pumps with the test pumps.

A contract was signed with Mecanizados Mofama, S.A. in January 1977 for the manufacture of nine shallow-well pumps and eleven deep-well pumps. The prices of the AID pumps in 1977 were as follows:

Shallow-well model	$ 98 each
Deep-well model	$128 each
Patterns	$498 (one-time charge only)

For comparison, the Dempster cost $257 in 1977. The Lucky pump from Japan cost $63 delivered.

Mecanizados Mofama, S.A. encountered several manufacturing problems while producing the AID hand pump. Most of these problems were related to the manufacturer's unfamiliarity with the pump and from poor castings. The foundry producing the castings had no laboratory facilities and used scrap iron as the source of raw materials. As a result, the pump castings produced were rough in texture, contained voids and inclusions, and would be considered unacceptable by U.S.

standards. However, subsequent castings produced for replacement parts showed a significant improvement as the foundry gained production experience. In addition, no replacement parts broke during a subsequent 12-month monitoring period under high use and a variety of field conditions.

In general, the functional performance and acceptance of the Costa Rican manufactured AID hand pump was satisfactory, but initial casting defects were encountered that necessitated the replacement of several handles, caps, and handle fulcrums. In all cases, these failures were caused by a lack of quality control at the foundry. Better foundries were available, but unfortunately none were interested in initial small orders, even though the potential for much larger orders existed.

The foundry also had difficulty in casting the deep-well pump cap as designed by Battelle and, as a result, proposed that the design be substituted with a less complicated cap similar to that used on Dempster hand pumps. The proposed design change was approved by project personnel, put into production, and field tested. the test results were acceptable but not as good as those of the modified Battelle design used in Nicaragua. The Costa Rican redesigned cap used a stuffing box as a piston rod guide that quickly wore out, while the Nicaraguan redesigned cap used sliding blocks that showed excellent resistance to abrasion caused by friction.

Even though Costa Rican Ministry of Health officials decided not to adopt the AID hand pump for future installations, they later made the decision to locally manufacture a hand pump that contained many of the features of the AID pump. For Georgia Tech and AID, field test results clearly highlighted the modifications necessary to make the AID pump acceptable in a developing country environment. These modifications were essentially to use the cap design modifications developed for Nicaragua on both deep-well and shallow-well models and to use a double-cup arrangement with the piston assembly for longer life of the cups and for a better seal.

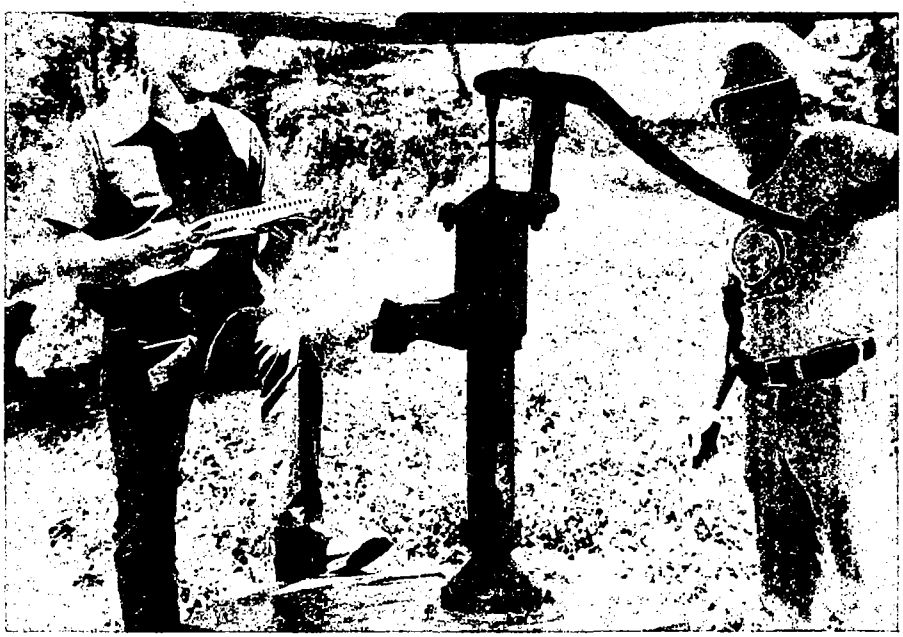


FIGURE 8. AID DEEP-WELL MODEL HAND PUMP WITH CAP DESIGNED BY COSTA RICAN FOUNDRY

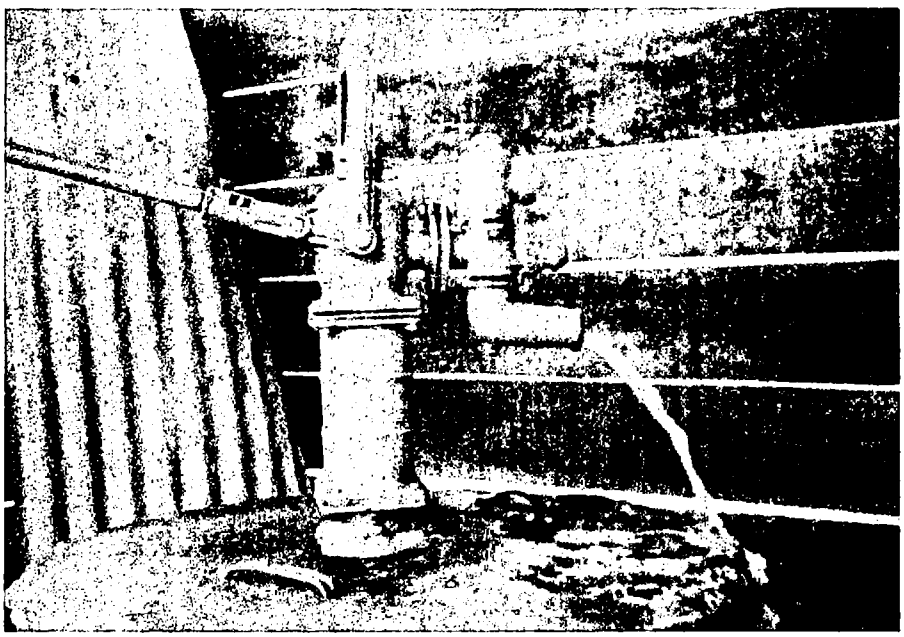


FIGURE 9. JAPANESE LUCKY HAND PUMP (COSTA RICA)

DOMINICAN REPUBLIC

An inspection and assessment of existing manufacturing capabilities, a market analysis, and determination of the relative cost of manufacturing the AID hand pump locally versus importing hand pumps preceded the introduction of the pump into the Dominican Republic. It was concluded that the AID hand pump was appropriate for the Dominican Republic, and in August 1978 Georgia Tech was contracted to develop local manufacturing capabilities and conduct field tests that would clearly show any manufacturing defects that needed to be corrected.

The interest by USAID/Dominican Republic and the Dominican Republic Ministry of Health was due to an upcoming AID health sector loan that included drilling wells and installing hand pumps in the western region of the country. Georgia Tech was contracted to carry out the following activities:

- Assist local manufacturers in producing the AID hand pump
- Select field test sites and help prepare them for pump installation
- Assist Ministry of Health personnel and rural villagers in the installation, maintenance, and repair of the pumps
- Determine well water quality at pump sites by chemical and bacteriological analyses
- Test the locally manufactured pumps under field conditions to improve manufacturing quality control

Two integrated foundry and machine shop businesses, INDUSTROQUEL and Astilleros Navales Dominicanos, were chosen to manufacture the AID hand pump in the Dominican Republic. INDUSTROQUEL was a small shop in which the owners themselves function as machinists, production supervisors, salesmen, accountants, and overall managers of the business. Astilleros Navales Dominicanos was a very large and bureaucratic operation owned by the government, but operated on a competitive basis with the private sector. The latter appeared to have the best equipment and had a functional organizational structure with a sales manager, a chief engineer, and a supervisor for the machine shop and foundry operations.

Before contracting with the two manufacturers, an agreement was made to produce the shallow-well pump for $110 and the deep-well model for $135. However, after producing the first order, six shallow-well and six deep-well pumps

by each, the manufacturers revised their quotes to $175 for the shallow-well and $198 for the deep-well pump. This price increase resulted in a loss of competitiveness with imported pumps, but even so, many advantages of local manufacture still existed. Recently, the Ministry of Health in the Dominican Republic received bids for 1,000 AID hand pumps, where the competition resulted in an accepted bid of $128 for both models from a local foundry and machine shop establishment, Equipo Tecnico Industrial.

In manufacturing the AID hand pump in the Dominican Republic, a prototype was available from Nicaragua that was very helpful to the pump manufacturers. However, the working drawings had to be translated into Spanish and the correct PVC pipe for lining the shallow-well pump was not available. In order to solve this problem, the PVC manufacturer had to run a special order of the correct size pipe. Project personnel now choose the nearest oversized outside diameter PVC pipe and turn it down to the correct size on a lathe so that standard diameter PVC pipe may be used. The first batch of finished pumps clearly showed manufacturing difficulties in adhering to specified tolerances. However, subsequent production has vastly improved.

Of the 24 test pumps manufactured, 21 were installed. All of these pumps are functioning well, especially those that have been kept lubricated. They have been in the field for close to 2 1/2 years with many not requiring even the first changing of leather cups.

As part of the project, work was peformed related to the quality of the water in the wells where the pumps were installed. An attempt was made to properly seal the wells to prevent the entrance of contamination and to disinfect the water. Some of the wells were placed too close to latrines (as close as 16 feet in one case). Even in these cases the wells were still used for testing because, prior to installation of the hand pumps, the villagers were using water from the wells and it was felt that the test results would provide useful information.

Concrete aprons were built extending five feet around the wells and a curb was placed around the aprons to keep sullage water away. A cover was placed over a manhole on the top of the well upper-structure used to provide access for the villagers to draw water in case the hand pump failed. A concrete pedestal was formed below where the hand pump rested after installation to prevent water from entering the well at the base of the pump where the pump's drop pipe passed through the upperstructure. However, the pedestal did not prevent water from entering the

well at this point. A section of PVC pipe is now added when forming the pump supporting slab that serves both as a form for the well opening and prevents water from entering the well by extending approximately one inch above the slab.

In most cases, the wells were not adequately disinfected at the time of pump installation. A hand pump technician from the Ministry of Health was responsible for installing the pumps and disinfecting the wells. Though properly instructed in the correct dosage to "shock" chlorinate the wells, he felt that the increased dosage over what he was accustomed to administering was unnecessary. It is felt that the technician probably reverted to his own dosage when he was not being closely watched. This incorrect technique coupled with the fact that the Dominican Republic is underlaid with extensive fractured and fissured limestone and basalt, resulted in the analysis showing only one well with a low contamination level after pump installation.

Initial manufacturing problems were resolved through technical assistance and the Dominican Republic has officially accepted the AID hand pump for its own use. The Ministry of Health has entered an order for 1,000 hand pumps and later increased the order to 2,600. Thus, the overall impact of the AID/Georgia Tech program for the Dominican Republic is quite sizeable when all of the resulting benefits are weighed.

For 2,600 pumps at $128 each, AID and the Dominican Republic have already saved an estimated $450,000 by eliminating imports. The cost of stimulating local manufacture and providing quality control technical assistance was $45,000. Thus, the net savings of this program to date is over $400,000, and as other organizations and private consumers purchase the AID hand pump the net savings will increase. For the first time the Dominican Republic can boast complete local manufacturing of a heavy duty, low cost, low maintenance hand pump. The project also confirmed the soundness of the modifications recommended during testing in Nicaragua and Costa Rica.

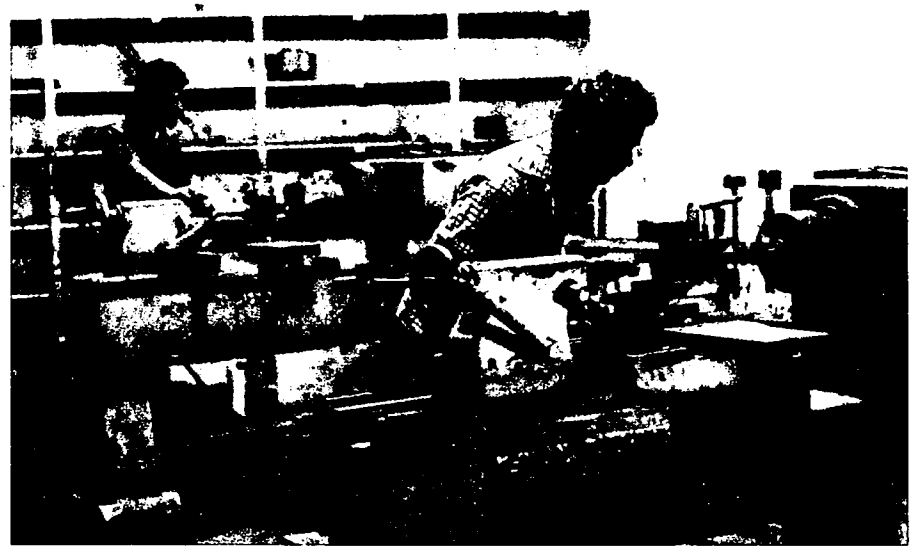


FIGURE 10. PRODUCTION OF THE AID HAND PUMP IN THE FOUNDRY/MACHINE SHOP, EQUIPO TECNICO INDUSTRIAL (DOMINICAN REPUBLIC)

FIGURE 11. MASS PRODUCED AID HAND PUMPS (DOMINICAN REPUBLIC)

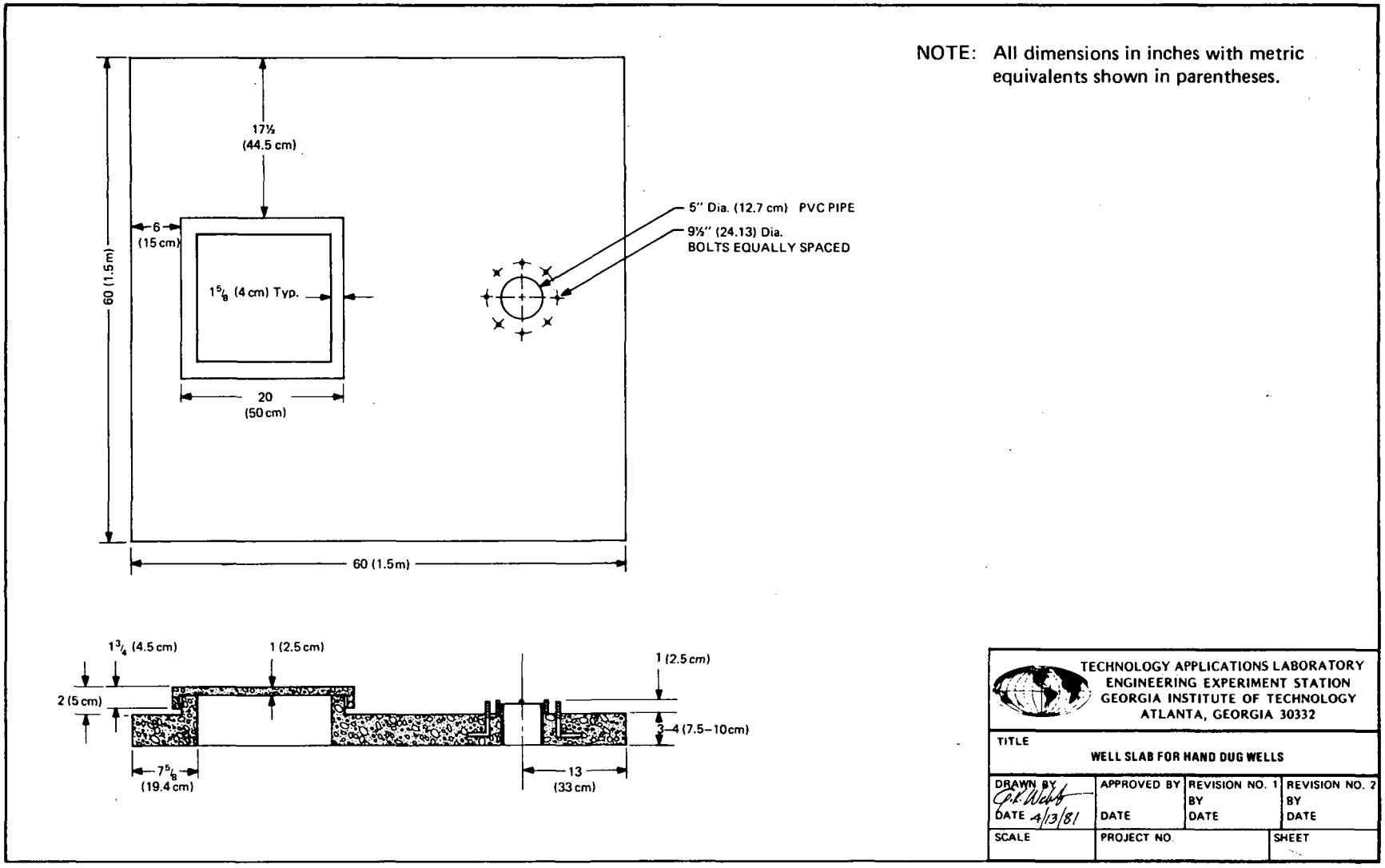


FIGURE 12. DIAGRAM OF WELL SLAB FOR HAND-OPERATED WATER PUMP

INDONESIA

The Indonesian AID hand pump program began in early 1978 when Georgia Tech personnel visited the country to:

- Explain the advantages of the AID hand pump to USAID/Indonesia and Indonesian government officials
- Estimate local costs for manufacturing the AID pump and compare with costs of purchasing locally available hand pumps (both locally manufactured and imported)
- Determine whether a market existed in Indonesia for hand pumps and if sufficient manufacturing capabilities were available for producing the AID pump

Data gathered from personal observations and very cooperative inputs by USAID/Indonesia, the Indonesian Ministries of Industry, Health, and Public Works, the World Health Organization (WHO), and CARE led to the conclusions that:

- The AID hand pump could be manufactured in Indonesia at an acceptable level of quality at several foundries and machine shops
- The AID hand pump could be manufactured at a reasonable cost
- The need for both urban and rural potable water supply programs involving cost-effective hand pumps was overwhelming

Based on the above findings, an AID/Georgia Tech contract was signed in September 1978 whereby Georgia Tech would provide technical assistance in producing 60 AID hand pumps. These 60 pumps were manufactured, tested, and accepted by Georgia Tech personnel for subsequent installation in the field in March 1979.

In August, 1979 the program was expanded to include:

- The coordination of manufacture, quality control, and formal acceptance of 170 additional deep- and shallow-well AID pumps
- Site selection and development and installation of 35 AID hand pumps in the Bandung area of Indonesia with a 12-month monitoring/evaluation and reporting period
- Site selection and development and installation of ten AID hand pumps in the Jakarta area of Indonesia for a WHO/Ministry of Health independent monitoring activity

- o Site selection and preparation, supervision, and installation of 20 AID hand pumps in six AID Provincial Development Program (PDP) project areas (Bengkulu, Kupang, Semarang, Banjarmasin, Surabaya and Banda Aceh)

- o Area assessment and evaluation of the feasibility of the local manufacture of the AID hand pump in at least three PDP areas

- o Provision of three AID hand pumps to each of 11 sites for village sanitarian schools as training aids

The AID hand pumps were manufactured by Celco Technical Industry, Ltd. in Bandung at a cost of $50 for the shallow-well pump and $60 for the deep-well model. The manufacturer's reluctance to accept quality control techniques suggested by project personnel was a major problem. As an example, simple jigs and fixtures were made for the manufacturer and not used until project personnel threatened to refuse payment for any pumps made without the use of these manufacturing aids. As a consequence, the manufacturer began using the jigs and fixtures and found that not only was production increased, but quality was consistent and pump components became interchangeable. Prior to use of the recommended manufacturing techniques, components were somewhat custom-made for each pump and if a replacement part was needed, it probably would not fit the pump for which it was intended.

A second quality control problem was due to the manufacturer's reluctance to establish adequate inspection procedures during the various production stages, a matter that has improved during the project but still is less than desirable. As an example, field data showed that the manufacturer neglected to consistently use high quality and properly sized leather for the pump's foot valve. Thus, failure of this very simple and inexpensive component resulted during use in the field. With better inspection procedures, the manufacturer would have prevented these failures.

Initially, leather cups wore out at an unacceptable rate, but this stopped after sand in the newly drilled wells settled down. Project personnel were also able to train installation teams to locate the pump cylinder so the presence of the sand would be minimized.

AID hand pumps are presently being installed in six PDP areas, the feasibility of manufacturing the pump in three PDP areas is being assessed, and at least one of three pumps designated for each of 11 sanitarian schools is being installed. In general, AID pumps installed in the field have responded well with the exception of the leather foot valve wearing out too frequently. This problem is being addressed

through a better selection of leather and through alternative designs. Prospects for wide use of the AID pump now appear promising, as CARE has installed over 200 of these pumps and ordered 200 more for its own rural water supply programs. ADB is considering its use for 3,000 wells in the Sulawesi region. Other organizations are expected to use the pump as additional foundries are identified and exposed to the marketability of the pump. It is noteworthy that at one test site, villagers have taken up a collection and purchased three more pumps, developed well sites, and installed the pumps themselves.

CARE is providing villagers in the Bandung area with a set of tools and spare parts and training them in repair and maintenance. To date, the villagers are maintaining the pumps with minimal supervision by CARE personnel. As time goes by, the villagers should increase their maintenance and repair competency and are expected to be self-sufficient by the time the project terminates. This is a remarkable feat and CARE is to be congratulated for its endeavors.

FIGURE 13. MR. TANO T. JAKRASASMITA, THE OWNER/MANAGER OF CELCO TECHNICAL INDUSTRY, DISPLAYS HIS WOODEN PATTERNS OF THE AID HAND PUMP (INDONESIA)

FIGURE 14. A TYPICAL INSTALLATION PHASE OF THE AID HAND PUMP PROGRAM (INDONESIA)

SRI LANKA

In October 1979, Georgia Tech engineers were chosen to determine the feasibility of locally manufacturing the AID hand pump as well as other equipment applicable to water supply programs in Sri Lanka. Along with the AID hand pump, the investigation centered around the use of Robo devices developed by University of Maryland rural water supply specialists. This equipment includes the Robovalve, the Roboscreen, and the Robometer. The Robovalve is a plastic faucet that shuts off automatically to prevent water waste and associated health problems due to improper drainage. The Roboscreen is a plastic well screen/filter for removing suspended contaminants. The Robometer is a user-activated, pay-as-you-go water meter that reduces administrative costs by eliminating meter readers. The Robo devices were included in the Sri Lanka program to demonstrate their potential for local manufacture and applicability to rural water supply programs in developing countries.

In order to determine the manufacturing capabilities in Sri Lanka, project personnel visited wholesale and retail establishments, foundries, machine shops, and plastics manufacturers. Sri Lanka was found to be an ideal country for introduction of the AID hand pump since local manufacturers offered an attractive price and had the capability to manufacture a quality pump. Furthermore, the Government of Sri Lanka was committed to the goals of the United Nations Water Decade, and international development agencies concerned with Far East countries were gearing up for large programs in water and sanitation.

Well screens in Sri Lanka were seldom used, even with large capacity well installations, and thus the market was small for such technology as the Roboscreen. Manufacturing capabilities did exist, but manufacturer's quoted prices appeared to be unreasonably high.

Water faucets were available at hardware stores, but the bulk of these faucets were expensive and of poor quality. The Robovalve was an excellent alternative for replacing existing faucets because of its superior design, but quoted prices for its local manufacture also appeared to be unreasonably high.

Price quotes were not obtained for the Robometer because a prototype was not available, but there were sufficient plastics manufcturers, foundries, and machine shops to produce such an item in Sri Lanka. It was felt that the Robometer

would be applicable in existing and upcoming piped water programs, most of which included the user paying for the water. Historically, in cases where there was a charge for water and meters were used to measure consumption, there was a problem of revenue collection that the Robometer could reduce or eliminate. Meters presently used were imported and cost anywhere from $150 to $300 while the Robometer production cost was estimated to be between $12 and $20.

Based on the above findings, USAID/Sri Lanka contracted with Georgia Tech in March 1980 for an AID hand pump program comprised of two tasks. The first task, still underway, calls for the following:

- o Subcontract a selected Sri Lankan foundry to manufacture at least 88 AID hand pumps
- o Provide working drawings and prototypes of the AID pump and sufficient technical assistance to insure high quality finished products
- o Provide technical assistance in quality control
- o Formally accept and certify all AID hand pumps manufactured

A contract was signed in March 1980 with a foundry and machine shop, Somasiri Huller Manufactory, for the production of 90 AID hand pumps. The contract calls for 45 shallow-well pumps at a unit cost of $78 and 45 deep-well pumps at a unit cost of $84. Working drawings, prototypes of the pump, and technical assistance have been supplied the manufacturer. Somasiri Huller is still working to complete the order because of a backlog of production, but the pumps produced thus far are of excellent quality. Other organizations such as a British consulting firm and UNICEF are waiting to enter orders for the AID hand pump for their own use.

While Somasiri Huller initially agreed to manufacture the AID pumps at $78 (shallow-well) and $84 (deep-well), experience with the finished pumps has shown that these prices were underestimated. The contract with the manufacturer has now been amended to reflect a price of $160 per pump (shallow-well or deep-well). Despite the fact that this $160 figure is twice the original estimate, it is still attractive as an alternative to the only other hand pump being used in Sri Lanka, the India Mark II, which costs slightly over $300 delivered.

As mentioned previously, the AID hand pumps produced thus far are of excellent quality and the second task of the project has begun. This task calls for:

- o Installing the completed AID hand pumps in five major areas over newly prepared or reconditioned existing wells

- o Disinfecting well waters with a chlorine-yielding compound
- o Analyzing well waters for water quality
- o Providing spare parts and training in hand pump maintenance procedures to village caretakers.
- o Monitoring and evaluating pump performance to provide quality control information to the manufacturer

By December 1981, Somasiri Huller should be capable of producing the AID hand pump at a high level of quality without external technical assistance and able to supply national and international organizations on a large-scale basis. However, to meet the demand from these organizations, Somasiri Huller will have to increase production capacity or a second supplier will have to be developed.

FIGURE 15. A PARTIAL MOLD PREPARED FROM THE PATTERN OF THE AID HAND PUMP SPOUT. MOLTON IRON WILL BE POURED INTO IT FOR CASTING OF THE PUMP COMPONENT (SRI LANKA)

FIGURE 16. AID HAND PUMP COMPONENTS AFTER CASTING (SRI LANKA)

FIGURE 17. SERUPITA, SRI LANKA VILLAGERS HELP DEVELOP AN EXISTING WELL FOR INSTALLATION OF TWO AID HAND PUMPS

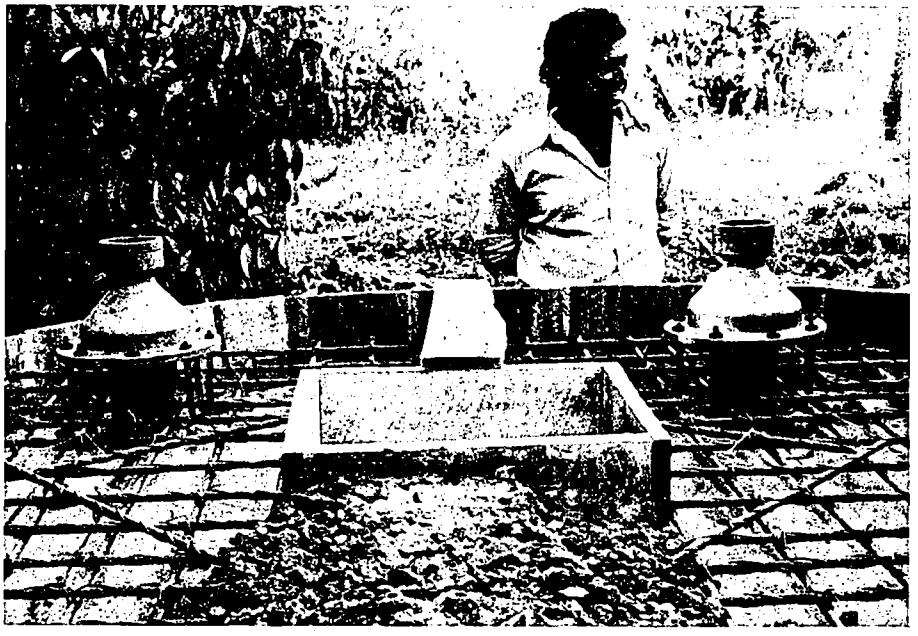


FIGURE 18. SLAB FOR AID HAND PUMPS (SRI LANKA)

FIGURE 19. FINAL TOUCHES ADDED TO THE SLAB AT SERUPITA (SRI LANKA)

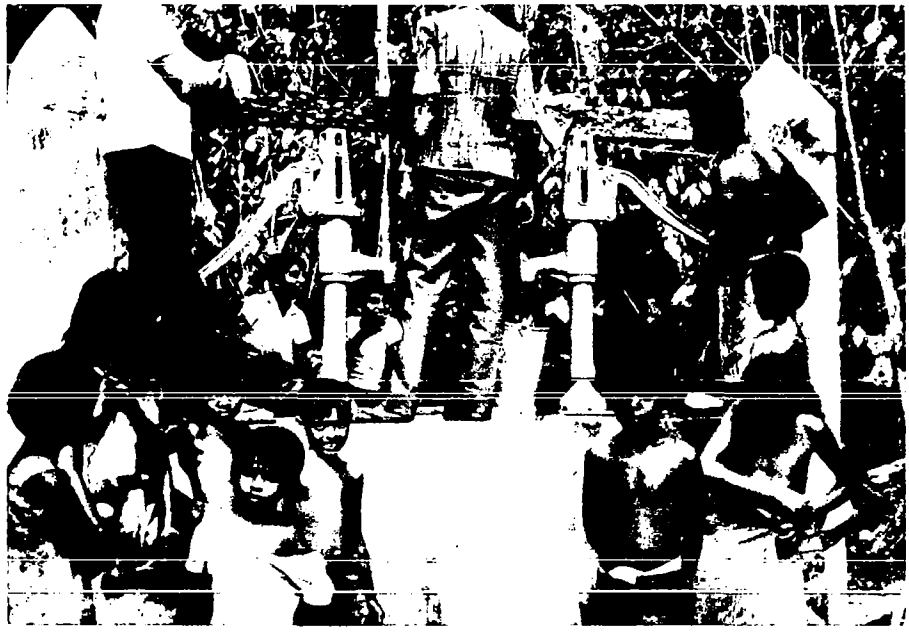


FIGURE 20. AID HAND PUMPS INSTALLED AND READY FOR HEAVY USAGE (SRI LANKA)

TUNISIA

In April 1980, a Georgia Tech team visited Tunisia to determine the feasibility of locally manufacturing AID hand pumps and Robo devices. Field trips at that time indicated a serious lack of adequate water supplies in rural areas. Where sources of water were available, rural citizens traveled long distances to water their livestock and gather water of questionable quality for domestic use. In many cases, the volume was insufficient to meet the demand.

Surveys of Tunisian foundries, machine shops, plastics manufacturers, and retail hardware stores indicated that local manufacture of the AID hand pump and the Robo devices was both technically and economically feasible as a viable alternative to expensive imports. One foundry, Les Founderies Reunies, was chosen to manufacture a quality AID hand pump at an attractive unit price of $232. The imports being considered by the Government of Tunisia, USAID/Tunisia, and CARE were the U.S. manufactured Moyno at $500 and the French manufactured Vergnet at $800. Two plastics manufacturers, Societe des Applications Plastique and Inoplast, were determined to be capable of producing Robo devices. In particular, Societe des Applications Plastique seemed well-suited to manufacture the Robovalve and Inoplast had the expertise and equipment to fabricate the Roboscreen.

In August 1980, a contract was signed between USAID/Tunisia and Georgia Tech to provide technical assistance to the Government of Tunisia and USAID/Tunisia in manufacturing AID hand pumps, Roboscreen, and Robovalves. The contract also called for testing the products under conditions existing in Tunisia. More specifically, Georgia Tech was to carry out the following program of work:

- Provide technical assistance to USAID/Tunisia, the Government of Tunisia, and private volunteer organizations (PVO's) implementing rural water supply programs
- Oversee production of 40 AID hand pumps, 200 Robovalves, and 500 feet of Roboscreen
- Provide working drawings, prototypes, and technical assistance in proper production techniques and quality control
- Inspect, test, and accept the AID hand pumps, Robovalves, and Roboscreen
- Develop at least ten sanitary wells and upper structures, install AID hand pumps and Roboscreen, disinfect well waters, and determine chlorine residuals

- o Monitor and evaluate performance of the AID pumps, Robovalves, and Roboscreen
- o Provide feedback to manufacturers for quality control

In September 1980, an order was placed with Les Founderies Reunies for 40 AID hand pumps at a unit cost of $232. This price will be adjusted before final payment is made because of modifications requested by USAID/Tunisia and CARE. The traditional AID deep-well hand pump has previously been manufactured with a three inch inside diameter cylinder that is connected to the pump by a 1 1/4 inch drop pipe during installation. In Tunisia, this approach was not thought to be practical because of the difficulty in removing the piston assembly for periodic changing of leather cups that normally requires two to three hours. Consequently, the AID pump manufactured in Tunisia will have a 2.1 inch diameter PVC drop pipe that also serves as a cylinder. This allows leather cups to be changed by removing the pump cap and pulling the piston assembly up through the drop pipe and pump, changing the leather cups, and replacing the piston assembly back through the pump body and into the drop pipe. This approach should enable maintenance crews to change leather cups in less than 30 minutes.

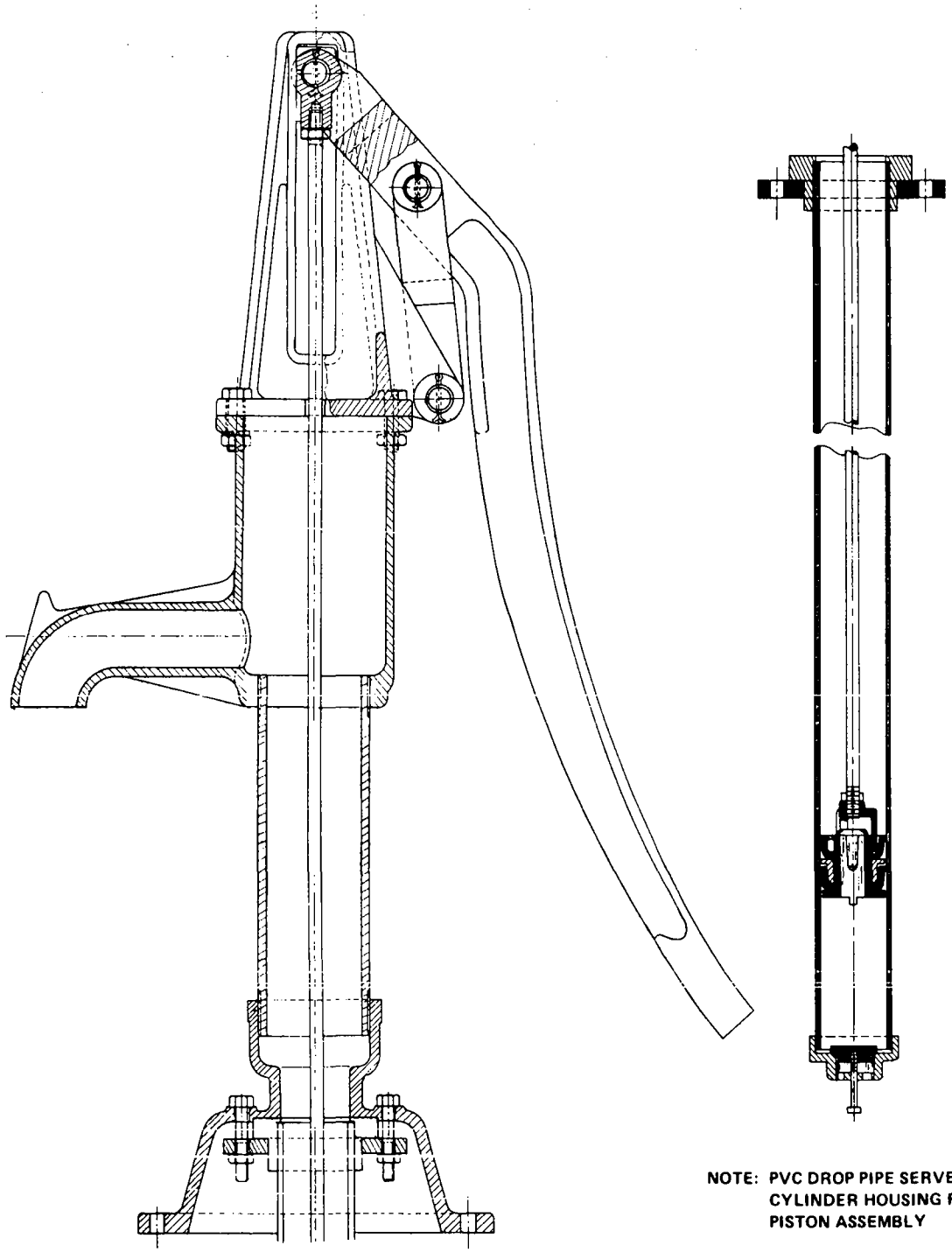
In January 1980, Les Founderies Reunies presented a production prototype of the AID hand pump to AID/Tunisia and Georgia Tech personnel for approval before going into regular production. The prototype was mounted over a drum of water and thoroughly tested. After a complete inspection, it was concluded that the pump was of very good quality and should perform well in the field. Approval was then given to proceed with the production of the 40 ordered pumps, which will be ready for installation in April 1981.

A public standpost model of the Robovalve has been field tested in Tunisia from models supplied by AID/Washington. While field test data has shown some design problems, it is felt that, with certain modifications, an order for 200 valves can be placed in the near future with Societe des Applications Plastique. Societe des Applications Plastique has a quality-conscious operation that includes in its product line items from cigarette lighters to plastic tables and chairs. Plastic containers are also produced that are adaptable to household water containers with purification units. Production equipment and machinery are new, in good condition, and well laid out in the plant for efficient operations. Therefore, it is expected that this company will produce a quality Robovalve once an order is placed even though quality control technical assistance will be required.

During April and May 1981, the AID hand pumps will be installed in the field after capping preselected existing wells. Installation will be a joint effort of Georgia Tech, CARE, and Ministry of Agriculture personnel. If the pump performs as expected, the Government of Tunisia and CARE will use it in future hand pump programs. At the same time the AID hand pumps are being installed, production orders will be placed for manufacturing the Robovalves. Because of a reluctance by Tunisian Ministry of Agriculture engineers to accept the concept of plastic well screen, the Roboscreen will probably not be introduced until a later date.

Figure. 21

AID HAND–OPERATED WATER PUMP, DROP PIPE AND PISTON ASSEMBLY MANUFACTURED IN TUNISIA

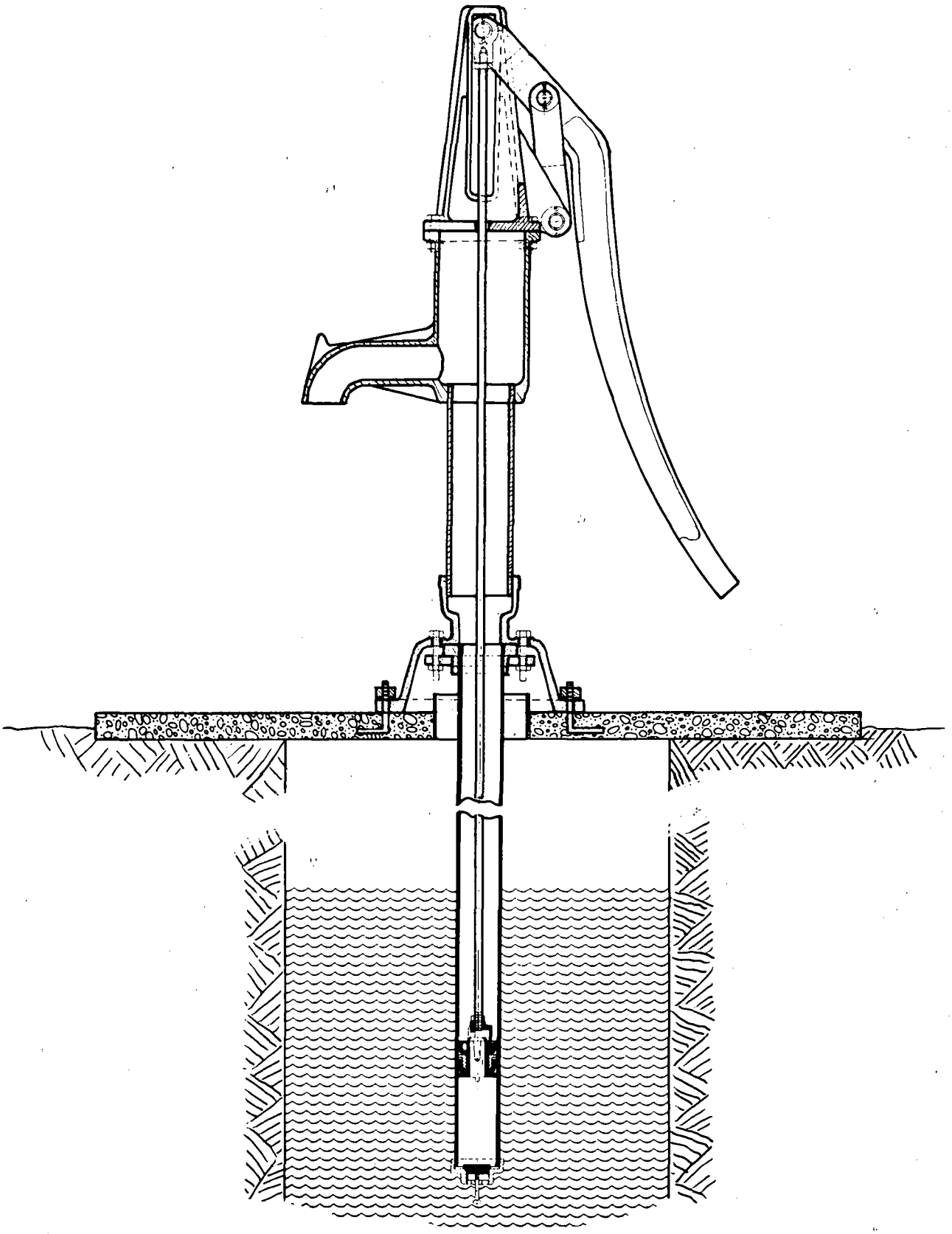


NOTE: PVC DROP PIPE SERVES AS CYLINDER HOUSING FOR PISTON ASSEMBLY

Figure. 22

TYPICAL AID HAND–OPERATED WATER PUMP

INSTALLATION IN TUNISIA



ECUADOR

In August 1980, a Georgia Tech team visited Ecuador to determine the feasibility of locally manufacturing the AID hand pump, Roboscreen, Robovalve, and Robometer. The study revealed that much could be done to improve living conditions for Ecuadorian citizens, especially those in the rural areas, by providing safer and more convenient water.

The leading causes of death in Ecuador were found to be related to underdevelopment and poor environmental conditions, and were often preventable. Even though the country's health status was related to many socioeconomic factors, environmental sanitation and water supply had the most widespread impact. In 1978, household connections to public water systems supplied most of the urban population, but for over half of the population living in the rural areas, coverage was a dramatically low 16%. Therefore, the effect of lack of access to potable water on health and overall economic development was found to be substantial. The Government of Ecuador and development agencies such as USAID/Ecuador, CARE, and the Community Development Department of Voz Andes Hospital were working toward improving these conditions. Because of this interest and a great need for an improved water supply in Ecuador, it seemed natural to stress local manufacture of as much of the needed hardware as possible.

In September 1980, a contract was signed between AID and Georgia Tech to provide technical assistance to the Government of Ecuador and USAID/Ecuador in locally manufacturing AID hand pumps, Robovalves, and Roboscreen and assuring their applicability for introduction into bilateral health projects. The contract, still current, is to:

- Oversee production of at least 100 AID hand pumps, 2000 Robovalves, and 1,000 feet of Roboscreen
- Provide working drawings, prototypes, and technical assistance in proper production techniques and quality control
- Inspect, test, and accept the finished AID hand pumps and Robo devices before installation in the field
- Train recipient organizations in the proper sanitary preparation of wells, equipment installation techniques, disinfection of water, bacteriological water analysis, and maintenance and repair of AID hand pumps

A contract has been signed with the Escuela Politecnica Nacional for the manufacture of the AID pumps at $150 per pump. The first order should be ready for installation in the field by May 1981. A contract has also been signed with an Ecuadorian plastics manufacturer, Industrias I.E.P.E.S.A., for injection molding Robovalves, Roboscreen, and pump cylinders. The unit cost of the Robovalves will be $1.75, the Roboscreen will cost $1.36 per linear foot for two inch inside diameter and $2.82 per linear foot for four inch inside diameter, and the pump cylinders will be $2.21 each excluding end caps and foot valve.

The AID hand pump will be manufactured to the same specifications as previously described except that the pump cylinder will be injection molded ABS plastic rather than PVC extruded pipe. This design change is required because PVC pipe could not be purchased in the desired diameter and wall thickness. This change is actually quite attractive since ABS has a lower coefficient of friction and is harder than PVC which should result in longer life for the leather cups and lessened susceptibility to abrasive materials such as sand for the pump cylinder.

In June 1981, the AID hand pumps and the Robo devices will be installed in rural areas of Ecuador by the following organizations:

- o CARE
- o Peace Corps
- o Voz Andes Hospital
- o Ecuadorian Institute of Sanitary Works (a department of the Ministry of Health)
- o Center for the Rehabilitation of Manabi (a provincial government development authority)

Training in site selection, well preparation, equipment installation techniques, proper disinfection of water, bacteriological water analysis, and maintenance and repair will be provided by Georgia Tech personnel.

These activities should result in national acceptance of the AID hand pump and the Robo devices into future Ecuadorian rural water supply programs. In June 1981, the first lady of Ecuador, Mrs. Martha de Roldos, will participate in a ceremony announcing the production of the first AID hand pump in Ecuador as a continuing commitment to rural development by the President.

OTHER COUNTRIES

Honduras, the Philippines, Bolivia, Togo, Benin, and Liberia have been surveyed by Georgia Tech to determine if the AID hand pump is appropriate and can be manufactured at a competitive cost. Manufacturing, field testing, and pump performance monitoring and evaluation activities are expected to begin in Honduras and the Philippines soon due to positive results from the surveys and interest on the part of the respective AID missions and host country organizations in promoting the AID hand pump's local manufacture. AID hand pump programs have not materialized in Bolivia, Togo, Benin, and Liberia.

In Bolivia, the need for hand pumps was great with an immediate market demand of over 9,000 units in April 1979 and sufficient manufacturing capabilities existing to produce the AID hand pump at a cost of approximately $70 each. However, the majority of the hand pumps being installed in Bolivia in 1979 were part of the Ingavi Integrated Rural Development Project and utilized the Ingavi hand pump, which was locally manufactured, inexpensive ($57), and easily maintained. The AID hand pump had certain advantages over the Ingavi hand pump as it was more suitable for deeper wells, sturdier, and probably more cost-effective over long periods of time. However, the Government of Bolivia was committed to using the Ingavi hand pump because it had been developed by the World Bank for its programs, which represented most of the rural water supply programs at that time. Under these circumstances it would have been needless and difficult to introduce another hand pump.

Togo and Benin were analyzed in June 1979 to determine the feasibility of locally manufacturing the AID hand pump. The majority of the rural villagers could be served by providing 8,000 pumps in Togo and 11,000 pumps in Benin. The necessary machine shops and foundry skills were available for manufacturing the pump. However, the AID pump was not considered appropriate for these countries by AID and national government officials because the wells in Togo and Benin were extremely deep. The majority were between 100 to 300 feet and the AID pump could only be used to a maximum of 150 feet (with a 2-3 inch cylinder). Using a hand-operated water pump at depths greater than 150 feet might be desirable but was beyond the limits of most reciprocating type hand pumps. As a result, two U.S. Moyno rotary hand pumps were installed in each country for demonstration and trial purposes. Even this type of pump was beyond practical human energy limits of the

strong, well-built men in Togo and Benin. The Liberty hand pump used in the Philippines would be most applicable in Togo and Benin since it has a wooden handle 20 to 30 feet in length for the extra leverage needed in such deep wells. The Liberty could pump routinely from 300 to 600 feet using a train of seven leather cup piston assemblies with a one-inch diameter drop rod.

Liberia was also investigated for possible local manufacturing of the AID hand pump. However, there were no foundries and machine shops with adequate manufacturing equipment and skills for producing such a product.

FIGURE 23. AN INGAVI HAND PUMP INSTALLED IN THE COMMUNITY OF ACHICA ARRIBA IN THE PROVINCE OF INGAVI, BOLIVIA

TECHNOLOGY TRANSFER METHODOLOGY

Georgia Tech has been heavily involved in international technology transfer programs for the past 17 years. These programs have included assistance to governments and development institutions worldwide in planning and implementing industrial and economic development projects. Georgia Tech has also participated in small industry development and assistance programs, economic development training, technical information service to industry, and feasibility and market studies. A continuing involvement with technology transfer is a major part of Georgia Tech's commitment to improving the quality of life in less developed countries. Technology transfer implies not only the adaptation of technology to existing environmental conditions, but also the maximum utilization of local resources, the stimulation of initiative and innovation, and the development of logistical support within a basic cost-effective framework. The AID hand pump programs at Georgia Tech have met these criteria and a methodology has been devised for working with private sector manufacturers and cooperating government organizations to stimulate the local fabrication, installation, and monitoring of water and sanitation technology.

This methodology is not complicated and can be easily applied in a variety of countries and with a variety of different devices. The AID hand pump programs have begun with a determination of applicability of the technology to be transferred. This phase has included investigating such factors as the need for water supply programs, population densities, and the existence of private or government infrastructures that have the capabilities and the resources for developing water supply programs. The demand for hand pumps is compared to existing or potential supply sources. Local manufacturing capabilities are analyzed for the level of expected quality at a price competitive with other available hand pumps.

If the first phase is positive, the second phase is implemented that involves a relatively small production run to test the true capabilities of the manufacturer. During this phase, the manufacturer is supplied with working drawings, prototypes, and technical assistance in production techniques and quality control procedures. Manufacturing cost data is recorded to assure the manufacturer that it is possible to produce the hand pump and realize a profit. During the different stages of production, quality control checks are required. Completed pumps are tested in-plant for overall performance and if found to be satisfactory, they are installed

in the field for performance monitoring and final evaluation. As manufacturing defects are discovered during field testing, information is fed back to the manufacturer and methods are formulated for correcting the manufacturing problems.

Field testing is a necessity for "debugging" the newly manufactured AID hand pumps, as well as having other valuable benefits. Since wells must be developed, well waters properly disinfected and analzyed chemically and bacteriologically, pumps installed over the well, and maintenance and repair provided, the hand pump recipients are given on-the-job training in each of these activities.

The use of host country counterparts should be mentioned, as they have played a major role in each country. The counterpart organizations are in-country international, national, or regional governmental agencies, development institutions, and/or PVO's that allow Georgia Tech more efficient utilization of funds. These counterparts carry out the day-to-day operations of the project while Georgia Tech personnel provide the technical and project management resources necessary to the success of the project. At the same time, they provide established working relationships with existing communities, industries, lending institutions, and government departments that save considerable time and effort when establishing operations in a new country.

Host country counterparts that have participated in the hand pump programs are CARE (Indonesia, Tunisia, and Ecuador), the Peace Corps (Nicaragua and Ecuador), Ministries of Health (Nicaragua, Costa Rica, Dominican Republic, Ecuador, and Indonesia), Ministry of Agriculture (Tunisia), the Central American Research Institute for Industry (Nicaragua, Costa Rica, and Ecuador), Voz Andes Hospital's Community Development Department (Ecuador), and AID Missions in all countries where the programs have been carried out. Without these organizations, the success of the AID hand pump programs would have been more difficult and extraordinarily high in cost.

Through its methodology, Georgia Tech has concluded that the AID hand pump can be manufactured in many developing countries at a competitive price when compared to imported hand pumps. The AID pumps have exhibited excellent operational and maintenance characteristics and the designs have proven to be readily usable and culturally acceptable in all field situations.

Much detailed work is involved in initiating the local manufacture of any product such as the AID hand pump in developing countries. Manufacturers must be assisted in reaching a satisfactory level of quality control, and developing country

implementing organizations must be made fully aware of the hand pump's capabilities and problems. Programs of this type require patient, prolonged, and understanding work with the personnel of a variety of private, government, and international organizations to share the knowledge and techniques of industrial nations with developing countries through adaptation rather than duplication and procurement.

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