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9. ABSTRACT

Following previous programs in which a simple piston pump was designed, this report is the evaluation of this simple piston pump in three areas (Thailand, Nigeria, and Bangladesh). As a result of these studies, these conclusions were drawn: 1) The basic pump concepts are satisfactory. 2) Five-eighths-inch diameter x 1 1/2 inch-long bearing surfaces are minimum and under extreme conditions, a larger size should be considered. 3) Non-rotating pinned assemblies seem satisfactory if use is not extensive and acceptable nuts and bolts not available. 4) A pump rod extension and single upper bearing does not provide satisfactory life under vigorous deep-well pumping. 5) Because of rising material costs, materials shortages, and difficulties in transportation, hand pumps should be as light as possible without jeopardizing pump function or long life. 6) A particular valve has not been proven better than another; however whatever valve is preferred, fabrication must be done with care for satisfactory operation. 7) The chemistry of the iron used for casting must be within an acceptable range to facilitate casting and make an acceptable product. 8) Installation of the complete pump must be done in an acceptable manner with the prescribed components. Based on the data accumulated, recommendations are given for pump configurations and materials of manufacture, including fabrication and installation comments.

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FINAL RESEARCH REPORT

on

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

to

AGENCY FOR INTERNATIONAL DEVELOPMENT

January 31, 1975

by

Robert D. Fannon, Jr.

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

BATTELLE
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201

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TABLE OF CONTENTS

TABLE OF CONTENTS
(continued)

Page

LIST OF FIGURES

LIST OF TABLES

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INTRODUCTION

Early in 1966, the Agency for International Development (AID) and the Battelle-Columbus Laboratories (BCL) discussed the increasing need for rural water supply systems for developing nations. It was decided during these meetings and subsequently substantiated that successful domestic water programs must be carried out within the country for which they are intended. Such programs not only provide a more reliable water system but also stimulate industry and business within the country.

The most basic need apparent was for a dependable hand pump. Basic specifications for such a pump were established early in the program and without exception they still prevail. These specifications are

(1) Low production costs
(2) Long life under severe conditions
(3) Easy to maintain with simple tools and unskilled labor

(4) Suitable for shallow or deep well installations with only minor changes (cylinder location)

(5) Capable of being manufactured by established firms within the developing countries with a minimum of capital investment

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

(7) Include design features which will discourage pilfering and vandalism.

A shallow well pump is defined here as a pump in which the cylinder is attached to the pump body above the ground. A deep well pump is defined as a pump in which the cylinder is separated from the pump body and submerged below the level of the water being pumped.

In addition to these specifications, it might also be appropriate to note here that any rural domestic water program of any size must contain the following:

(1) Funds must be available by which pumps can be made and wells sunk and/or means by which pumps and their installation can be purchased by consumers.

(2) Facilities must be available or provided in which pumps and associated products can be fabricated.

(3) Governmental organizations or private sales organizations must be available for pump distribution and installation. This would also include well drilling.

(4) Means must also be made available for spare parts distribution and pump maintenance.

(5) Effectiveness of any program depends upon good coordination with the local people in regard to operations and pump configuration. Each area can be different depending upon the local conditions, customs, and aesthetic values.

The program to develop an improved domestic water pump was conducted by Battelle for AID in three steps.

(1) Examination of existing conditions

(2) Pump development and laboratory evaluation

(3) Field evaluation programs

Although all three steps have now been completed, some development work in terms of improvements is still going on.

In the many visits to various developing countries the following conditions and practices are found to exist:

(1) Lack of pumps and facilities to make them

(2) Some areas had pumps given them, but many different kinds with little or no maintenance and with improper parts

(3) Lack of community spirit toward community water supply systems even to the extent of vandalism

(4) The reluctance of government officials to act as positively or as effectively as they could

(5) Inadequate pump design, both those made in the country and those being imported. The inadequacies may be described as follows:

  (a) Cylinders too rough

  (b) Plunger cups improperly sized (generally too large)

  (c) Highly stressed fulcrums and handles

  (d) Bearing surfaces too small

  (e) Valve seats poorly cast and machined

  (f) Fasteners (bolts and nuts) poorly made.

(6) Inadequate storage facilities--many of the parts are so deteriorated that they cannot be used.

(7) In many areas hand operated water pumps are in such demand that even so-called good pumps will not stand up under such rigorous usage. Good maintenance programs are required under all conditions.

A deep well and shallow well pump configuration was developed incorporating improvements for many of the deficiencies noted. Sample pumps were tested in the laboratory and then a field evaluation program conducted in three areas: Bangladesh (in cooperation with UNICEF), Nigeria (under direction of CARE), and Thailand (under direction of AID). The actual pump configurations varied some from one country to another, as it should, but the major design points remained the same. The pump configuration to be described reflects the latest field findings.

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

Never before have the objectives of this program been more appropriate. There seems to be more interest among benevolent-type agencies, governments of developing countries, institutions and manufacturers, toward improving rural conditions including domestic water supplies. Potable water is of prime interest among all the countries today, and in the developing countries of the world, hand pumps are still an important means of obtaining good water.

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(1) The objectives as stated in the Contract.

CONCLUSIONS

During the previous programs, a simple piston pump design was identified as being suitable for the needs of developing nations. In this continued effort, the simple piston pump was evaluated in three areas, and as a result of the knowledge gained, the following conclusions have been drawn.

(1) The basic pump concepts are satisfactory.

(2) 5/8-inch-diameter x 1-1/2-inch-long bearing surfaces are minimum, and under extreme conditions, a larger size should be considered. If at all possible, the cast iron bearing "hole" should be hardened, or if the skill and material are available, bearing inserts might be considered.

(3) Nonrotating pinned assemblies seem satisfactory if use is not extensive and acceptable nuts and bolts not available. However, bolted assemblies are preferred because machining is somewhat easier and will provide a more acceptable unit for continuous use.

(4) A pump rod extension and single upper bearing does not provide satisfactory life under vigorous deep well pumping. A sliding block design, which does not require a pump rod extension, has been substituted.

(5) Because of rising material costs, material shortages, and difficulties in transportation, hand pumps should be as light as possible without jepordizing pump function or long life.

(6) A particular valve has not been proven better than another; however, whatever valve is preferred, fabrication must be done with care for satisfactory operation.

(7) The chemistry of the iron used for casting must be within an acceptable range to facilitate casting and make an acceptable product.

(8) Installation of the complete pump must be accomplished in an acceptable manner with the prescribed components for satisfactory operation.

RECOMMENDATIONS

Based on the data accumulated during this program, the following pump configurations and materials of manufacture are recommended, including fabrication and installation comments.

Pump Configuration

Drawings 2001 and 2002 in Appendix A are assembly drawings of the shallow well and deep well pumps respectively. Option A of both pumps is the recommended version. Both pumps are assembled from a few basic, interchangeable parts.

Handle
Cap
Fulcrum
Body
Cylinder
Stand
Plunger Assembly
Valve Assemblies
Nuts and Bolts

The caps are interchangeable but of different design and the separate fulcrum is peculiar to the deep well configuration. The cylinder can vary in length depending upon the desired pump height, but in the case of the shallow well pump, it must be long enough to accommodate the pump stroke and must be smooth enough for pumping.

The simple shallow well pump cap provides a strong fulcrum for heavy use and the deep well cap provides firm wear resistant guide surfaces. The pump has a 7-1/2 inch to 8-inch stroke which is quite important when the water table is low, and a 6 to 1 ratio handle to help ease pumping. Jam nuts are used at all pump rod connections to help prevent rod separations.

The pump base is sized to fit over 6-inch well casing and will accept 1-1/4-inch to 1-1/2-inch drop pipe. General construction is such as to stand up under heavy use and yet be as light as possible.

The final design can be compared to the original design, the assembly drawings, of which appear in Appendix B. The major changes are

(1) Redesigned deep well pump cap

(2) Bolted on caps

(3) Approximately 20 percent reduction in weight.

Also shown on the assembly drawings are several options. Option B does permit pinned assembly as originally designed when proper nuts and bolts are not available. This is much less of a problem now than 10 years ago. Option C merely permits a deep well cylinder pump cap to replace the pump stand for the shallow well pump to be mounted on a "conventional" tube well.

Material

Except for the steel pipe and a few other parts, the pump is gray cast iron with a composition as close as possible to that shown in Table 1.

TABLE 1. RECOMMENDED SPECIFICATIONS FOR FOUNDRY PIG IRON

Silicon	Carbon	Manganese	Sulfur	Phosphorus
2.50 - 2.75	4.10 - 3.85	0.50 - 1.25	0.05 max	0.30 - 0.50
2.76 - 3.00	4.05 - 3.70	0.50 - 1.25	0.05 max	0.30 - 0.50
3.01 - 3.25	3.90 - 3.65	0.50 - 1.25	0.05 max	0.30 - 0.50
3.26 - 3.50	3.85 - 3.60	0.50 - 1.25	0.05 max	0.30 - 0.50

Manufacturing costs are continually changing with the rising material and labor prices, but early 1974 bids for the improved pump, in production lots, in Bangladesh were less than $20.00 each.

The carbon ranges listed are to be used only as an indication of the desired carbon content of the pig iron. It is very difficult, if not impossible, to make foundry pig iron to specified silicon and carbon contents. However, the carbon content and silicon content should be in balance in order to produce gray cast iron castings with less variations in composition. The silicon content should and can be supplied to the designated ranges, and the carbon content should be reasonably close to the values indicated. As an example, the silicon content may be specified as 2.76 to 3.25 percent - the corresponding carbon content should be in the range of 4.05 to 3.65 percent. The carbon contents are shown in a reverse order intentionally because as the silicon content increases in pig iron, the carbon content will decrease.

Coke specifications are also necessary to produce a satisfactory product. Table 2 indicates minimum standards.

TABLE 2. RECOMMENDED SPECIFICATION FOR FOUNDRY COKE (WEIGHT PERCENT)

Fixed Carbon	Volatile Matter	Ash Content	Sulfur Content
88.0 min	1.0 max	12.0 max	1.0 max

The values specified are to be used as a guide when purchasing foundry coke; however, every effort should be made to obtain foundry cokes that have a minimum ash content. An 8.0 to 10.0 percent ash content is very desirable. Sulfur content should also be as low as possible. The higher the sulfur content in the coke, the higher will be the sulfur content of the gray cast iron produced, and the greater possibility for metal problems caused by excess sulfur.

Cylinder Construction

Laboratory tests[1] and field evaluation indicate the secret of long cup life is the smoothness of the cylinder in which the plunger operates. An extruded brass cylinder has a smoothness of 8 to 12 micro-inches (CLA)[2]. In contrast, some of the machined iron cylinders taken out of storage were so rough (over 600) due to rust and poor casting that measurements were hard to make. Better castings with more careful machining measured between 200 and 300 microinches (CLA).

To obtain a very smooth finish, coated cylinders were developed. Two types of coated cylinders have been tested in the laboratory. One coating consists of an epoxy-phenolic resin requiring a low-temperature bake as part of the curing process. This coating is the toughest and most wear-resistant of the two coatings with a smoothness of 12 to 18 microinches (CLA). This coating performed well in limited field use and would be preferred if baking facilities can be made available. The second coating is an air cure epoxy coating which is not quite as tough and takes longer to cure than the baked coating. This has a smoothness of about 40 micro-inches (CLA). This coating has no field evaluation to date. Both types of coated cylinders can be used for shallow well and deep well pumps and are quite inexpensive to apply.

As an alternative, plastic pipe may be used for cylinder construction. Polyvinyl chloride (PVC) plastic pipe is as smooth as extruded brass, costs much less than brass, and field tests have shown it to wear as well. It is recommended for deep well applications. Although the PVC pipe cylinder is more expensive than a coated cylinder, the ease of manufacture (a simple cut-off operation) makes its use for sleeves in shallow well pumps very attractive. This is further discussed under other options.

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(1) See 1967 and 1970 reports.

(2) Center line average.

Cups and Valves

Good quality leather is recommended for making plunger cups. Dyes should not be used; however, wax impregnant is acceptable. No special treatment has yet been identified; however, a particular tanning or special treatment may be identified at a later date. Cups should not fit tight in the cylinders, but instead depend upon the water pressure or suction to seal the cup against the cylinder walls.

Two types of valves are currently used, poppet and flapper. There is much discussion about which type is best, and no firm answer is available. However, both types depend upon a generous, smooth, well-machined seat without holes, cracks, or discontinuity of any type. Poppet valves are cast iron or brass which is preferred and leather or rubber washers can be used to help improve the seal. Leather is still the standard material for flapper valves with a cast iron weight. The recommended design utilizes a poppet plunger valve and a flapper foot valve.

Bearings

The pinned joints should be no less than 5/8-inch diameter and the length such as to insure a projected bearing area of at least 0.94 square inch. If hard use of the pump is to be expected, even larger pins are recommended. Lubrication where possible almost always improves wear. Generally speaking, most shops in developing countries cannot afford the cost of special bearings, nor are they capable of properly fitting them, but hardening the cast iron bearing (hole) can be done and is recommended to greatly improve bearing life at a minimum cost. This can be done by heating the cast iron journals or "holes" to a cherry red and quenching in water. Almost any degree of hardness will improve the bearing life. Care must be taken, however, to guard against tempering one hole while hardening another.

Other Options

Because of different manufacturing facilities and skills, available materials, personal preferences, operating conditions, etc., the actual configuration must remain flexible. For example, the pumps in Bangladesh have traditionally been a one piece body and cylinder design. There would be strong oposition to change, therefore the one piece arrangement was maintained, but a PVC pipe insert was used to provide a smooth base. A slightly shortened arrangement was also desirable to fit into existing foundry boxes.

Other options, or perhaps improvements, that should be considered are

- The reappearance of "Corfam" for making plunger cups
- More widespread availability of a nylon fabric covered with Neoprene for making flapper valves
- The use of plastic pipe for constructing tube wells, for fabricating well screens, or for use as drop pipe.

Fabrication and Installation Comments

The operation and life of a pump for any given operating condition is not just a function of design, but how well the parts are made, assembled, the condition of the pump when it reaches the consumer, and finally how well it is installed. Based on the experience gained during this program the following comments are in order.

- When the foundry floor is used as the drag or bottom half of the mold, care must be taken to ram up and finish this part of the mold as well as the cope or top half of the mold.
- The castings should be properly cleaned and all sand removed before machining.
- The storage of coke under cover would save costs by preventing the coke from getting wet which requires more coke per charge.

- The use of simple jigs and fixtures would permit better interchanging of parts.
- Bearing surfaces should be made with as close tolerances as possible for longer operating life.
- Valve seats must be smoothly finished and without blemish to assure pumps maintaining their prime, which is a constant source of irritation.
- All unprotected (uncoated) iron surfaces such as iron cylinder boxes, valve seats, bearings, and threaded parts must be coated with an oil or grease during storage.
- Storage of all components should be under cover and off the ground.
- Installation should be done according to an approved plan which assures, among other things, a fixed, stable pump mounting, whether the well be a tube or cased well; properly sized deep well cylinders and/or handles for easy deep well pumping, and no larger than 7/16-inch pump rod and 5/8-inch hex couplings used in side 1-1/4-inch minimum size drop pipe.
- Proper inspection procedures must be used in the manufacture, storage, and installation of all pumps.
- All pump programs must include adequate maintenance procedures and supply of parts.

PUMP DESIGN PRINCIPLES

The fabricator, installer, and user should be aware of certain design limitations. First, it is recommended that no cylinder sizes over 3-inches diamater be used. It has been observed that leather cups tend to fail rather than wear out in 3-1/2-inch shallow well pumps. Apparently the strength of the cup is not sufficient to withstand the pressure or vacuum created by the pump action and buckling occurs during one portion of the stroke (stretching during the opposite portion of the stroke) causing the cup material to split circumferentially and fail.

Neglecting friction or insufficient flow passageway which can create a substantial load, 3-inch cylinders will require 3.06 pounds lifting force per foot of water being lifted. This means, for example, that for a shallow well with a 26-foot-deep water level, about (26 X 3.06) = 79.5 pounds of lifting force will be required. This is about the maximum lift for a shallow well pump, and for the recommended pump configuration approximately 14.2 pounds $(\frac{79.5 \times 5}{28})$ of force is needed at the end of the handle for operation.

In contrast, a deep well pump must operate under much more severe conditions. Again, for the deep well pump illustrated, a 100-foot water lift would require about (100 x 3.06 + 51.1) = 357 pounds of force (including the weight of 7/16 diameter pump rod but neglecting friction) and a handle force of almost $(\frac{357 \times 5}{28})$ = 64 pounds. Such an arrangement can be improved one of two ways: Make the handle longer or decrease the cylinder size. Most persons can see that increasing the handle length or lever arm decreases the force required for operation, but it may not be apparent in the case with the change in cylinder size. A 2-1/2-inch-diameter plunger requires about 2.12 pounds per foot of water lift for operation and for a 100-foot water lift including the weight of the rod but neglecting friction, (2.12 x 100 + 51.1) = 263 pounds of force would be required. The handle force required by the 3-inch cylinder. A 25 percent increase in handle length decreases the handle force about 20 percent to 51 pounds. Every effort should be made to keep the handle force below 40 pounds to permit operation by women and children. Table 3 summarizes the forces discussed.

TABLE 3. SUMMARY OF PLUNGER LOADS AND HANDLE FORCES FOR VARIOUS PUMP/WELL CONDITIONS

Effective Handle Length, in.	Cylinder Size, in.	Water Depth, ft	Plunger Load, lb	Handle Force, lb
28	3	26	79.5	14.2
28	3	100	357	64
28	2.5	100	263	47
35	3	100	357	51

Decreasing the bearing loading is another factor for reducing cylinder size. Loading is not appreciably affected by a change in handle length. Three Hundred psi is a maximum bearing load for mild steel pins and cast iron journals when lubricated and with a close "running" fit. Since most pumps operate with moving joints of a very sloppy fit, the bearing levels should be kept as low as possible for long life--perhaps below 100 psi if possible. The pumps currently under evaluation have bearings from 5/8-inch diameter to 3/4-inch diameter and at least 1-1/2-inch total length each joint. Wear, although much improved, can still be a problem. To sum up these points, cylinder diameter, bearing area of each joint, and handle length must be seriously considered and balanced out to provide long life and easy operation.

One last comment on this topic; the greater the lift of water the greater pressure and increase of wear of the plunger cup. Therefore, as wear becomes excessive due to depth, the number of cups should be increased. Trial operation should soon determine when a second or third cup would be required. It has been suggested by one pump manufacturer that water levels at the 50- and 125-foot depths would be levels at which cups would be added for 3-inch cylinders. As pressures become too great, cylinder size would have to be reduced to increase the cup life.

RESEARCH ACTIVITIES

To obtain the results discussed in this report, three test areas were arranged.

- Thailand. A test program was set up with an existing Thai rural development program.
- Nigeria. An arrangement was made through CARE to produce and test pumps in conjunction with a local foundry.
- Bangladesh. A UNICEF program utilizing the AID design concepts furnished needed data.

Quite unexpectedly, the most difficult portion of this program was the selection of three areas in which tests of the pump design might be made and for the most part, the lack of cooperation in obtaining data. In order to conduct a program in any area, two basic requirements must be met.

(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.

Inquiries were sent out to 10 countries:

India	Brazil
Philippines	Seirinam
Thailand	Mexico
Iran	Korea
Guatemala	Sweden.

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 reactions have been received during the last year.

Three Thai government agencies (Accelerated Rural Development, Ministry of Health, and Department of Mineral Resources) were reported to have an interest in the pump as well as the AID Mission hydrogeologist, Mr. John Smith. It was also reported that the AID Mission Director in Laos expressed an interest in the pump, and perhaps buying pumps from Thailand. In light of this apparent 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 a Review Board, plans were made to begin work as soon as possible in these countries without waiting for a third country to be selected.

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, on April 11, 1972, 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.

Because of later inquiries from UNICEF and the resulting action by Battelle and AID, Bangladesh became available as the needed third test area. By September, 1972, a survey visit had been made to Bangladesh and a program with UNICEF was under way. A design utilizing the AID principles, modified to use PVC plastic pipe cylinder liners was planned for shallow well use. On March 16, 1973, almost a year after materials had been sent to Thailand and Nigeria, patterns, core boxes, sample pumps, jigs and fixtures, and foundry supplies were sent to Dacca.

Summary of Activity in Thailand

Only the original visit to Thailand was possible under this program, however, two other visits were made en route to Bangladesh for the UNICEF program. At the beginning of the program castings were made, the required machining completed, and four deep well pumps installed for test under the Thai Accelerated Rural Development (ARD) program. Even though data sheets were provided and inspection assignments made, no information was sent to Battelle by ARD personnel or the AID advisor. The AID office in Bangkok did reply to several requests and supplied some data on pump operation and extension rod failure.

The two subsequent visits did reveal several important data on the pump rod extension and top cap failures. Conversations with Mr. Sam Bargnesi, AID Advisor; Mr. Abraham Grayson, AID Engineer, Khon Kaen, Thailand; and Mr. Fittro from AID, Laos, prompted an improved design.

Because it was felt that additional data with the newly designed cap was necessary, patterns, core boxes, and sample parts were sent to Thailand via Washington, December, 1973. To date, the new cap has only been laboratory tested and installation of the sample pump sent to Thailand is not planned until after this report is due.

In spite of the lack of interest due to production of a satisfactory Thai developed pump and only the 4 or 5 pumps produced and placed on test, the PVC plastic cylinders proved to be quite successful and important data were obtained.

(1) The PVC deep well cylinders proved to be much less expensive than the brass cylinders being used and performed as well. Consequently, PVC cylinders are standard equipment on the ARD program.

(2) The pump castings, as designed, can be made in small "rural" foundries and acceptably machined.

(3) The pump, as conceived, does operate satisfactorily; however, under rigorous use, the pump rod extension needs to be larger and the continual movement of the extension wears out the bearing surfaces in the pump cap in a year's time. The extension rod failures, which were caused by bending, and the short life of the cap prompted a redesign of this portion of the pump.

It should be noted that all the wells being drilled under the ARD program are deep wells and the experience gained was associated with deep well pump. About the minimum depth well on which test pumps were placed was 80 feet.

Summary of Activity in Nigeria

Only the original visit was made to Nigeria. Absolutely no problems were incountered in the casting of the iron parts. The Nigerian Foundry, operated by two brothers from Greece, utilizes relatively modern equipment. Machining was done by another company, and unfortunately their waste was high and general operation not too efficient. Several pumps were assembled during the visit, but without cylinders because the proper size PVC pipe was not available. Almost all the wells in Nigeria are deep well and in many cases, highly acidic.

Over 300 pumps were produced, but very few of them have been actually placed in service as far as we know. CARE has reported that, although the workmanship has improved considerably, the prices of the pumps were high, and there was difficulty pumping water from depths over 30 or 40 feet. Because the program's finances would not permit a second visit, firsthand information could not be obtained; however, confirming information has come from the foundry. Helpful information was obtained from the AID program monitor's trip to Nigeria and a visit by representatives of World Water Resources, New York. The reports were the same, "difficulty in pumping water". According to the program monitor, Mr. Dale Swisher, smaller than 1-1/4-inch drop pipe was being used as well as large diameter pump rod and pump rod couplings. The World Water Resources people believed that a 3-inch cylinder was being used at a depth close to 180 feet, and the foundry discussed valve problems. All three of these reported situations would certainly cause a serious decrease in water flow as well as a marked difficulty in pumping. These problems were discussed by letter with the foundry operators and CARE, and hopefully corrected by this time. We feel that a second follow-up visit to Nigeria would have prevented these problems.

Summary of Activity in Bangladesh

Two visits were made to Bangladesh. The first visit got the program under way providing technical assistance to the UNICEF program staff. A later follow-up visit was then made to furnish additional technical assistance, not only to the program staff, but to selected production facilities. In fact, an extended 4-month instruction program was carried out which included the hiring of additional Bengali staff members. Sample pumps, a modification of the AID shallow well design, were made by both Battelle and Bengali facilities, and placed on test. Also provided were patterns and core boxes, and simple jigs and fixtures.

The design proved quite successful in that for the first time a pump, under quite heavy use (16 to 20 hours per day), operated almost a year without maintenance. These pumps utilized a one-piece body and cylinder with a PVC pipe insert.

It was during these tests that two lessons were learned prompting some pump redesign. First, the scarcity of iron and coke made a lighter weight pump more desirable; and second, it was observed that under heavy continuous use, the pinned fulcrum attachment began to wear faster than laboratory tests indicated. This wear, coupled with the somewhat easier machining required for bolted covers than for pinned covers, prompted the change back to using nuts and bolts for assembly if satisfactory fasteners could be obtained. The recommended design not only reflects the use of threaded fasteners but the reduced weight as well.

The pump program in Bangladesh is under way and, although the pump currently in production resembles the old pump, quite a number of the AID improvements have been incorporated in the design. Currently, they are experimenting with "improved" cast iron cylinders and plastic cups and perhaps the next step will be the coating of the cylinder bore. It is anticipated that in the next few months all the bearing "holes" will be hardened. At least 40,000 "improved" pumps have been produced and installed to date.

Plastic pipe and screens are also being successfully used in tube-type wells except for the top section which is steel pipe. It is this section which is grouted in the earth and to which the pump is attached.

The new design deep well pump has also been sent to Bangladesh for evaluation. It has been recently installed but no data have been sent back on operation.

Although this program will be ended, it is planned that additional data from Bangladesh and the other test sites as well will be forwarded to AID as they become available.

INFORMATION DISSEMINATION

Because the work on this program has had such widespread interest and because much more interest is being given to the rural peoples of the world, a special program, AID/ta-c-1099, had to be set up to handle the requests for information. To date, 101 replies have been sent and it is expected that the prepared data will be updated and utilized after that particular program has been terminated. Currently, a program with Equador is being considered as well as some additional work with UNICEF regarding a program in Pakistan.

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 investion 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. It is our understanding that most foreign countries follow similar codes and practices to the United States. Descriptions of the basic pump and other data appear in the Phase I and Phase II final reports dated September 29, 1967, and August 28, 1970, respectively.

Expenditures

A statement of expenditures for the total program are summarized in the following Table 4.

TABLE 4. STATEMENT OF EXPENDITURES

	Total Costs Through January 31, 1975
Direct Salaries	$14,931.48
BCL General Overhead	11,384.35
Departmental Burden Overhead	3,964.95
Travel	4,716.84
Other Direct Costs	1,781.79
Materials and Supplies	9,769.76
Total without Fee	46,549.17
Fee	2,797.00
Total with Fee	49,346.17
Appropriation	49,422.00
Balance	$ 75.83

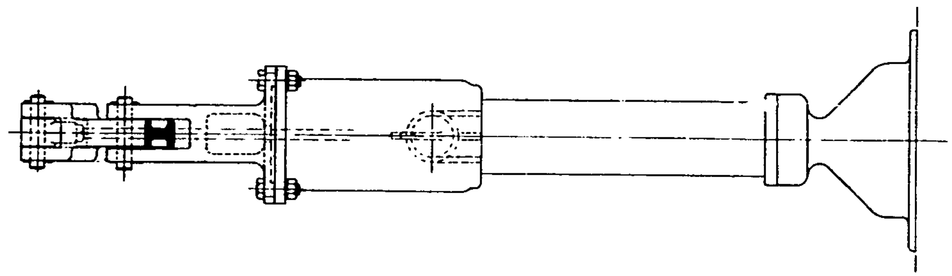
FUTURE WORK

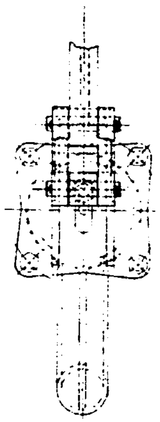
There is a tremendous task ahead for all the countries of the world; the populations of the developing nations are expanding at a terrifying rate and potable water is becoming more of a problem than ever before. The supplying of good water to billions of people is critical. There are still many unanswered questions; however, we must not let the knowledge and experience of this program end with this report. Battelle stands ready to assist wherever possible to develop better, safe water supplies.

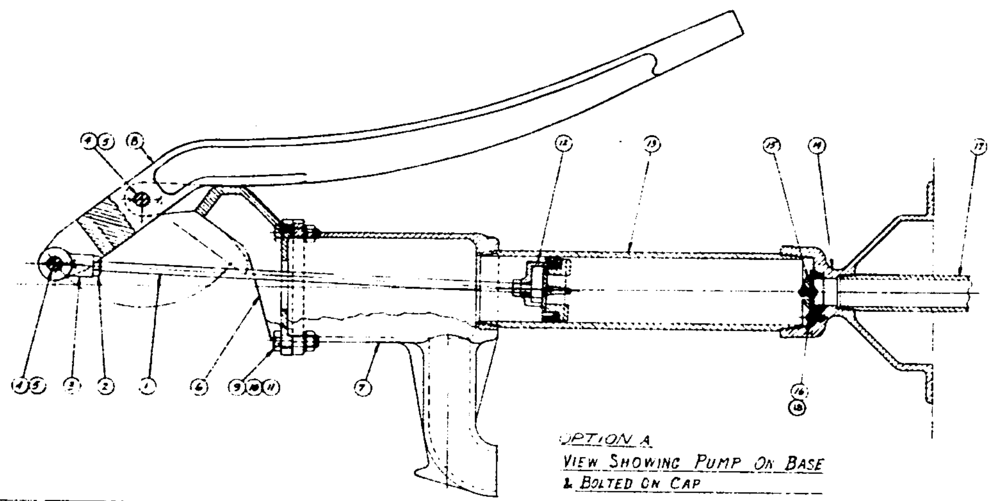
We want to thank AID and those persons associated with this program for the opportunity of working on this worthwhile program. If we can be of further service in any way, we would welcome the opportunity of doing so.

APPENDIX A

DRAWINGS OF RECOMMENDED DESIGN







OPTION A

VIEW SHOWING PUMP ON BASE & BOLTED ON CAP

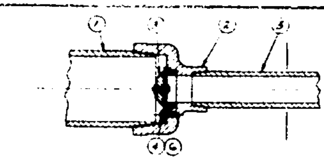
PART NO.	QTY	PART NO. OR IDENTIFYING NO.	SIZE	DESCRIPTION	SPECIFICATION
18	2	–	–	#10 PLAIN FLAT WASHER	BRASS
17	AR	–	–	1½ PIPE	[illegible]
16	2	–	–	MACHINE SCREW #10 RD HD BRASS	[illegible]
15	1	2015	B	CHECK VALVE ASSEM	
14	1	2010	D	PUMP STAND ASSEM	
13	1	2014	C	PUMP CYLINDER	[illegible]
12	1	2009	B	PLUNGER ASSEM - SINGLE CUP	
11	4	–	–	LOCK WASHER	[illegible]
10	4	–	–	NUT (HEX)	[illegible]
9	4	–	–	BOLT - HEX HD	[illegible]
8	1	2008	E	HANDLE	CAST IRON
7	1	2007	D	PUMP BODY	CAST IRON
6	1	2006	D	PUMP CAP	CAST IRON
5	4	–	–	COTTER PIN [illegible]	[illegible]
4	2	2005	A	PIVOT PIN	[illegible]
3	1	2004	B	ROD END	CAST IRON
2	2		–	PUMP ROD NUT (HEX)	[illegible]
1	1	2003	A	PLUNGER ROD	[illegible]

PARTS LIST

NOTE:
ASSEMBLY OF PUMP BODY, PIPE & PUMP STAND MUST BE TIGHT WITH AT LEAST 1/16" THREAD ENGAGEMENT AT EACH JOINT.

OPTION C

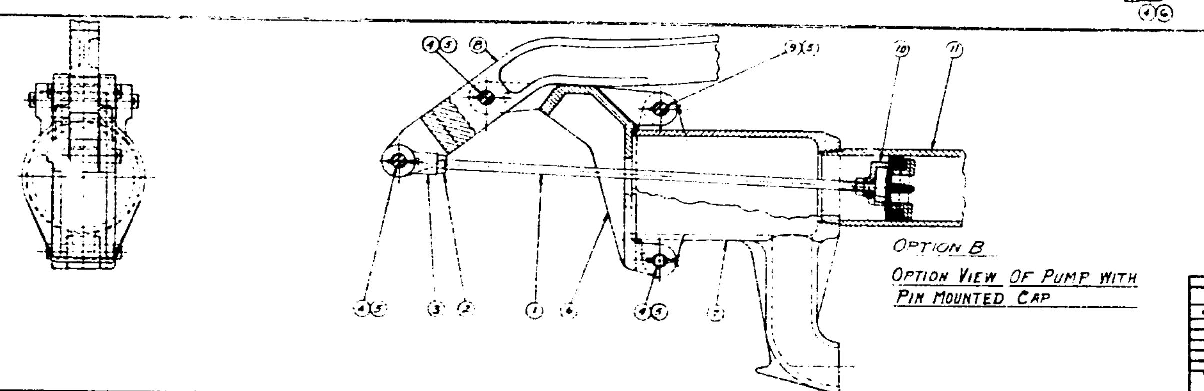
VIEW SHOWING LOWER VALVE HOUSING MOUNT DIRECTLY TO WELL PIPE



NOTE
ALL PARTS ABOVE PUMP CYLINDER ARE IDENTICAL TO THOSE SHOWN IN VIEW OF PUMP SHOWN ABOVE OR BELOW

PART NO.	QTY	PART NO. OR IDENTIFYING NO.	SIZE	DECRIPTION	SPECIFICATION
6	2	–	–	#10 PLAIN FLAT WASHER	BRASS
5	AR	–	–	1½ PIPE	[illegible]
4	2	–	–	MACHINE SCREW - #10 RD HD BRASS	[illegible]
3	1	2015	B	CHECK VALVE ASSEM	
2	1	2016	C	LOWER VALVE HOUSING ASSEM	
	1	2014	–	PUMP CYLINDER	[illegible]

PARTS LIST



OPTION B

OPTION VIEW OF PUMP WITH PIN MOUNTED CAP

NOTE:
ALL PARTS BELOW PUMP CYLINDER ARE IDENTICAL TO THOSE SHOW IN EITHER OF TWO VIEWS SHOWN ABOVE.

PART NO.	QTY	PART NO. OR IDENTIFYING NO.	SIZE	DESCRIPTION	SPECIFICATION
11	1	2014	D	PUMP CYLINDER	[illegible]
10	1	2009	B	PLUNGER ASSEM - SINGLE CUP	
9	1	2013	A	CAP PIN	[illegible]
8	1	2008	E	HANDLE	CAST IRON
7	1	2012	D	PUMP BODY	CAST IRON
6	1	2011	D	PUMP CAP	CAST IRON
5	8	–	–	COTTER PIN ([illegible])	[illegible]
4	3	2005	A	PIVOT PIN	[illegible]
3	1	2004	B	ROD END	CAST IRON
2	2	–	–	PUMP ROD NUT (HEX)	[illegible]
1	1	2003	A	PLUNGER ROD	[illegible]

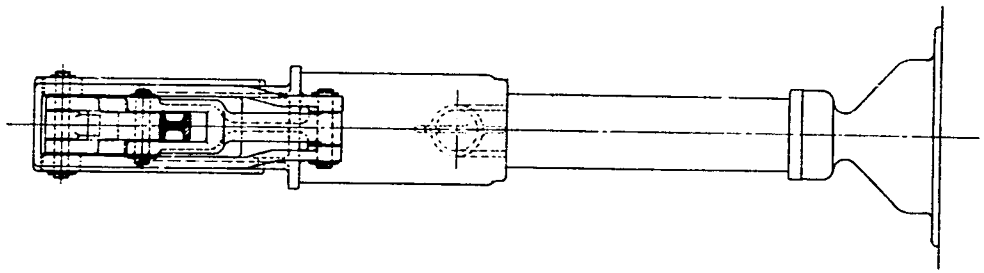
PARTS LIST

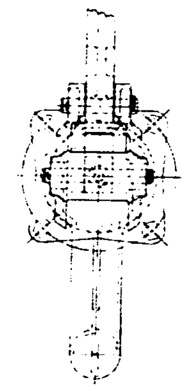
HAND PUMP ASSEMBLY
SHALLOW WELL TYPE

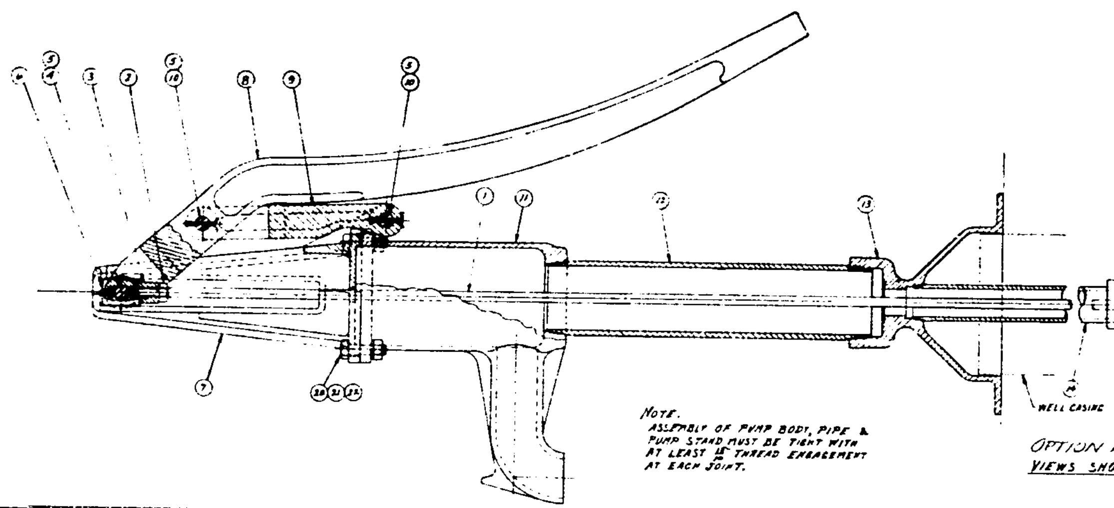
E 79986 644 2001

1:2 G1320-1 1 OF 1

2001





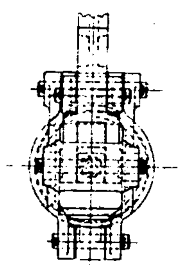


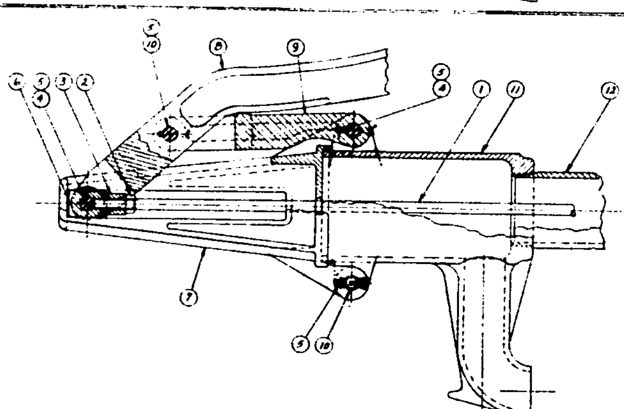
24	1	–	–	#10 PLAIN FLAT WASHER	BRASS
23	2	–	–	MACHINE SCREW - RD HD BRASS	[illegible]
22	4	–	–	LOCK WASHER	[illegible] SAE HEAVY
21	4	–	–	NUT (HEX)	[illegible] UNC
20	4	–	–	BOLT - HEX HD	[illegible]
19	1	2016	C	LOWER VALVE HOUSING	
18	1	2015	B	CHECK VALVE ASSY.	
17	1	2030	C	PLUNGER ASSEM.	
16	1	2014	C	PUMP CYLINDER	[illegible]
15	1	2025	C	CYLINDER END CAP	
14	1	–	AR	GALV. STEEL PIPE	[illegible] DIA.
13	1	2023	D	PUMP STAND	
12	1	–	–	2" SCHEDULE 40 PIPE	[illegible] LONG
11	1	2007	D	PUMP BODY	
10	2	2005	A	HANDLE PIVOT PIN	[illegible]
9	1	2029	C	HANDLE FULCRUM	
8	1	2008	E	HANDLE	
7	1	2027	D	PUMP CAP	
6	2	2026	B	SLIDING BLOCK	
5	6	–	–	COTTER PIN [illegible]	[illegible]
4	1	2013	A	ROD PIVOT PIN	[illegible]
3	1	2004	B	ROD END	
2	2	–	–	ROD NUT [illegible]	[illegible]
1	1	–	AR	GALV. PUMP ROD & COUPLINGS	[illegible] STD.
ITEM NO	QTY	PART NO OR DRAWING NO	[illegible]	DESCRIPTION	SPECIFICATION

PARTS LIST

NOTE.
ASSEMBLY OF PUMP BODY, PIPE & PUMP STAND MUST BE TIGHT WITH AT LEAST [illegible] THREAD ENGAGEMENT AT EACH JOINT.

OPTION A
VIEWS SHOWING BOLTED PUMP CAP





OPTION B
OPTIONAL VIEWS SHOWING PIN MOUNTED PUMP CAP.

NOTE:
ALL PARTS NOT SHOWN BELOW ARE THE SAME AS LISTED IN ASSEMBLY ABOVE

12	1	–	–	2" SCHEDULE 40 PIPE	[illegible] LONG
11	1	2012	D	PUMP BODY	
10	2	2005	A	PIN	[illegible]
9	1	2029	C	HANDLE FULCRUM	
8	1	2008	E	HANDLE	
7	1	2028	D	PUMP CAP	
6	2	2026	B	SLIDING BLOCK	
5	8	–	–	COTTER PIN [illegible]	[illegible]
4	2	2013	A	PIVOT PIN	[illegible]
3	1	2004	B	ROD END	
2	2	–	–	ROD NUT (HEX)	[illegible]
1	1	–	AR	GALV. PUMP ROD & COUPLINGS	[illegible] STD.
	QTY			DESCRIPTION	

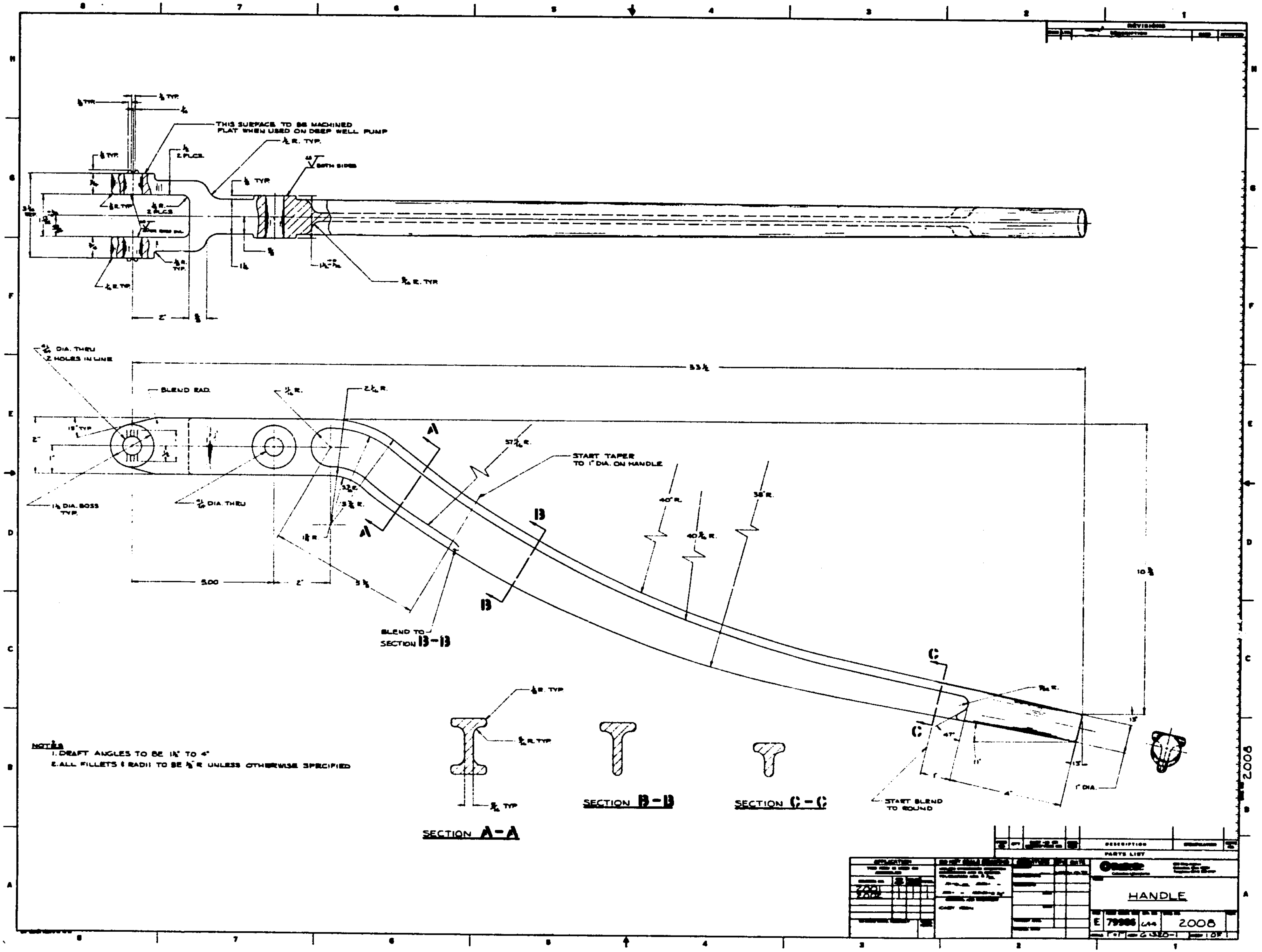
PARTS LIST

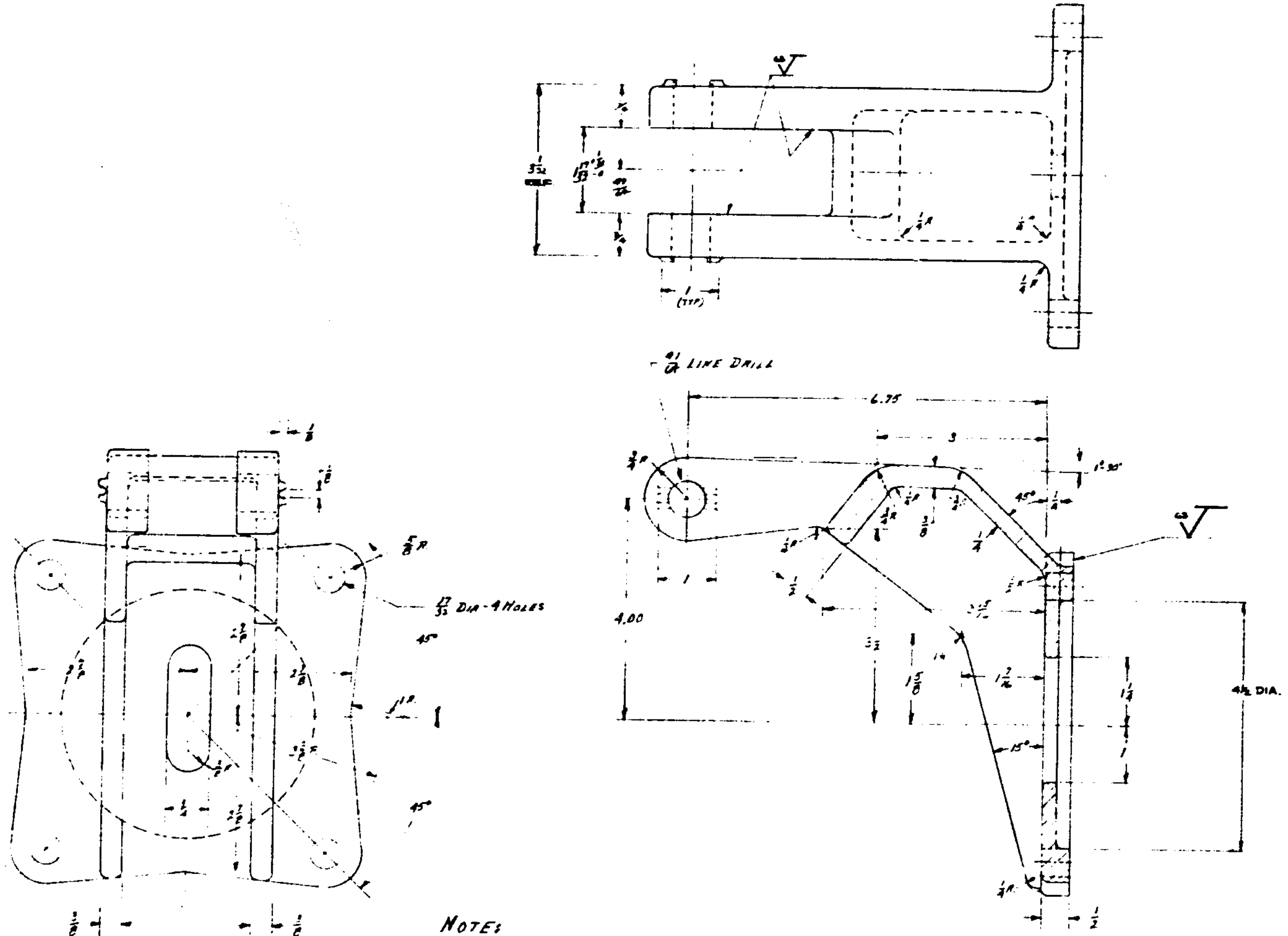
HAND PUMP ASSEMBLY
DEEP WELL TYPE

E | 606 | 2002

1"=2" | C-1320-1

2002


THIS SURFACE TO BE MACHINED FLAT WHEN USED ON DEEP WELL PUMP
DIA. THRU 2 HOLES IN LINE
BLEND RAD.
START TAPER TO 1" DIA. ON HANDLE
BLEND TO SECTION B-B
START BLEND TO ROUND
SECTION A-A
SECTION B-B
SECTION C-C
NOTES
1. DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛" R. UNLESS OTHERWISE SPECIFIED
HANDLE
2008



NOTES:

1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL RADII & FILLETS TO BE ⅛ UNLESS OTHERWISE SPECIFIED

APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

MATERIAL AND TREATMENT: CAST IRON

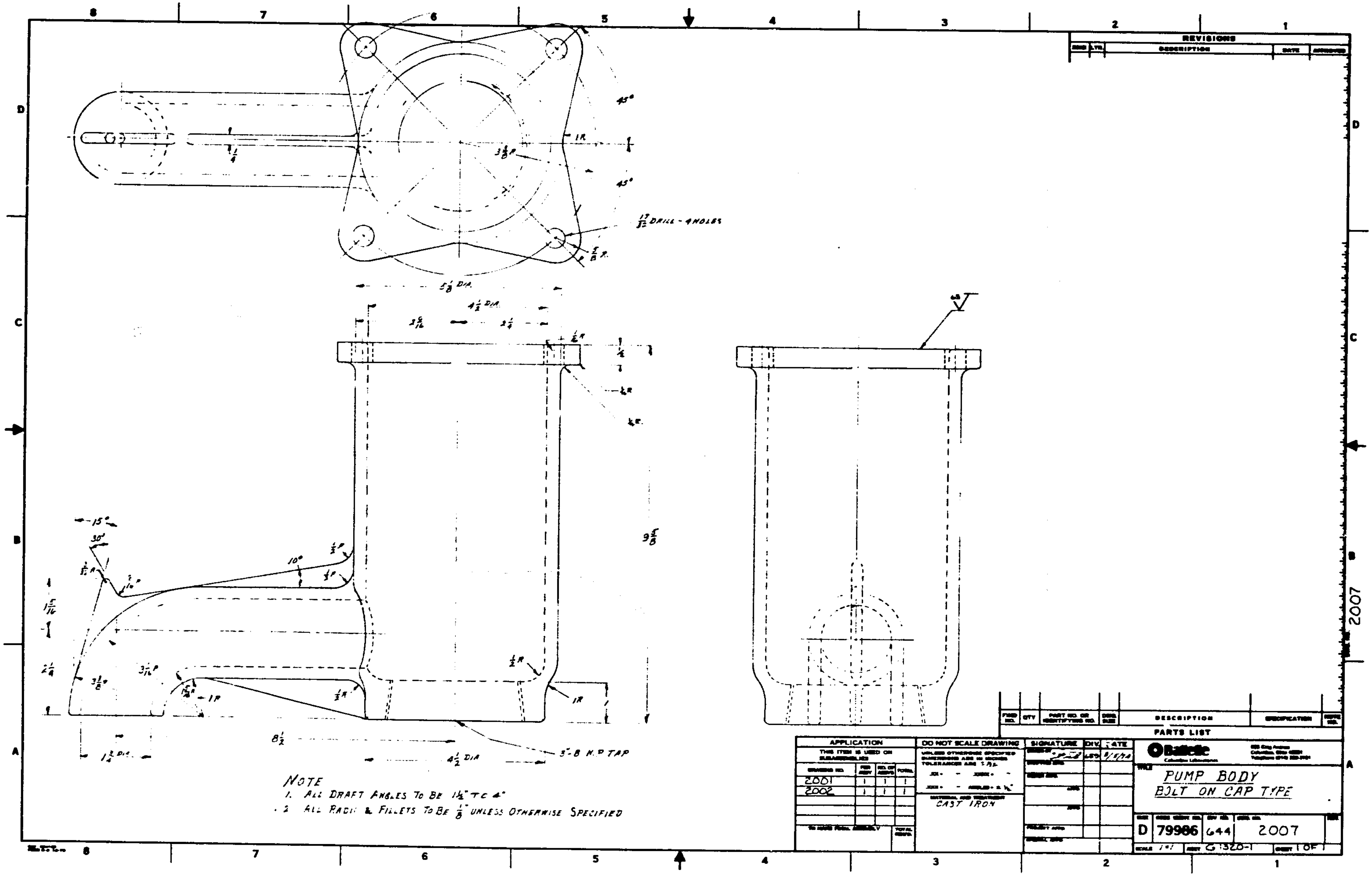
PARTS LIST

Battelle Columbus Laboratories

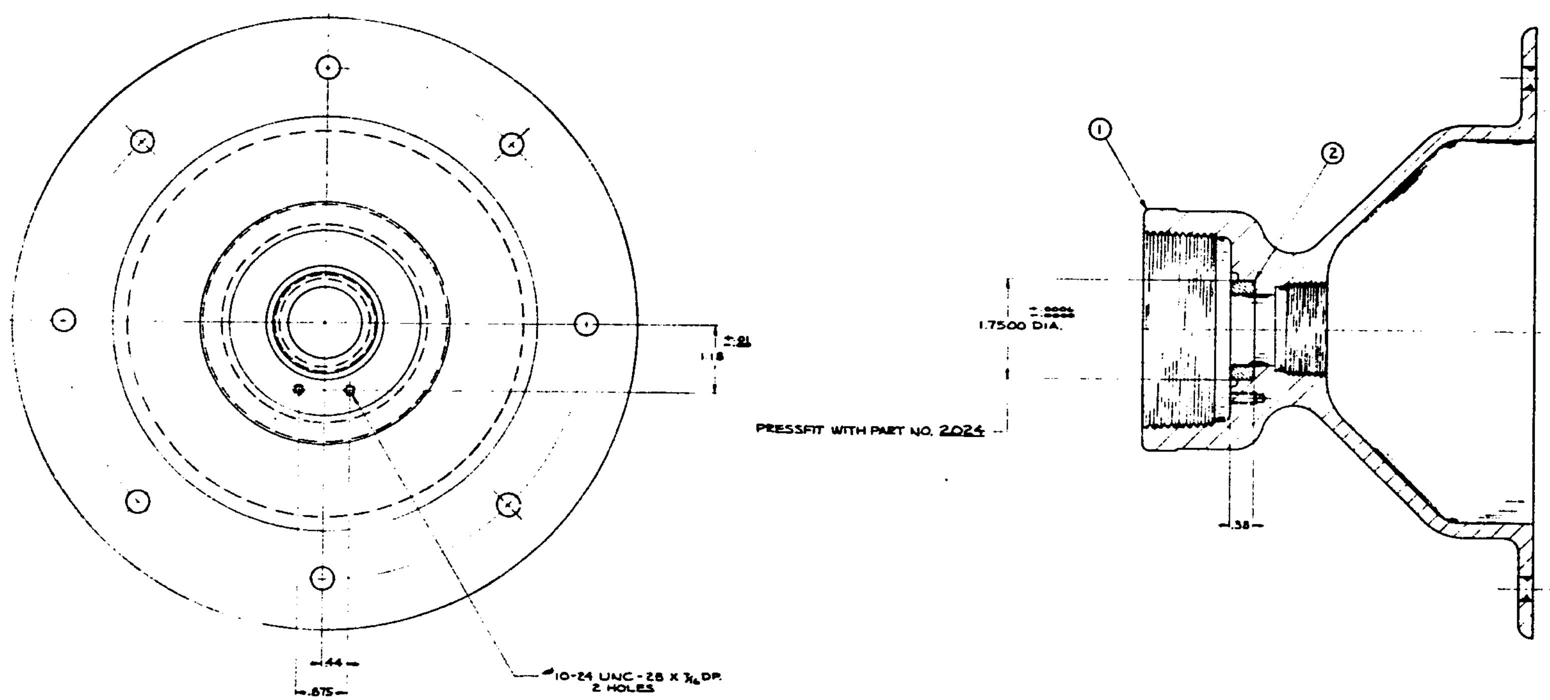
TITLE: PUMP CAP — SHALLOW WELL PUMP — BOLT ON TYPE

SIZE	CODE IDENT NO.	DIV. NO.	DWG. NO.
D	79986	644	2006

SCALE 1=1 — ASSY G1320-1 — SHEET 1 OF 1



REVISIONS
DESCRIPTION
DATE
APPROVED
45°
1R
$3\frac{1}{8}$ R
$\frac{17}{32}$ DRILL - 4 HOLES
$\frac{5}{8}$ R
$5\frac{1}{8}$ DIA.
$4\frac{1}{2}$ DIA.
$3\frac{5}{16}$
$2\frac{1}{4}$
$\frac{1}{8}$ R
$\frac{1}{2}$
$\frac{1}{4}$ R
$9\frac{5}{8}$
15°
30°
10°
$\frac{1}{2}$ R
1R
$8\frac{1}{2}$
$4\frac{1}{2}$ DIA
$\frac{3}{8}$ - 8 N.P TAP
$1\frac{3}{4}$ DIA.
NOTE
1. ALL DRAFT ANGLES TO BE $1\frac{1}{2}$° TO 4°
2. ALL RADII & FILLETS TO BE $\frac{1}{8}$" UNLESS OTHERWISE SPECIFIED
DESCRIPTION
SPECIFICATION
PARTS LIST
APPLICATION
THIS ITEM IS USED ON
2001
2002
DO NOT SCALE DRAWING
CAST IRON
SIGNATURE
DIV
DATE
Battelle
PUMP BODY
BOLT ON CAP TYPE
D
79986
644
2007
G 1320-1
1 OF 1



FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DWG. SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.
2	1	2024	A	BRASS VALVE SEAT		
1	1	2023	D	PUMP STAND		

PARTS LIST

APPLICATION

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1

DO NOT SCALE DRAWING

DATE: 1-15-[illegible]

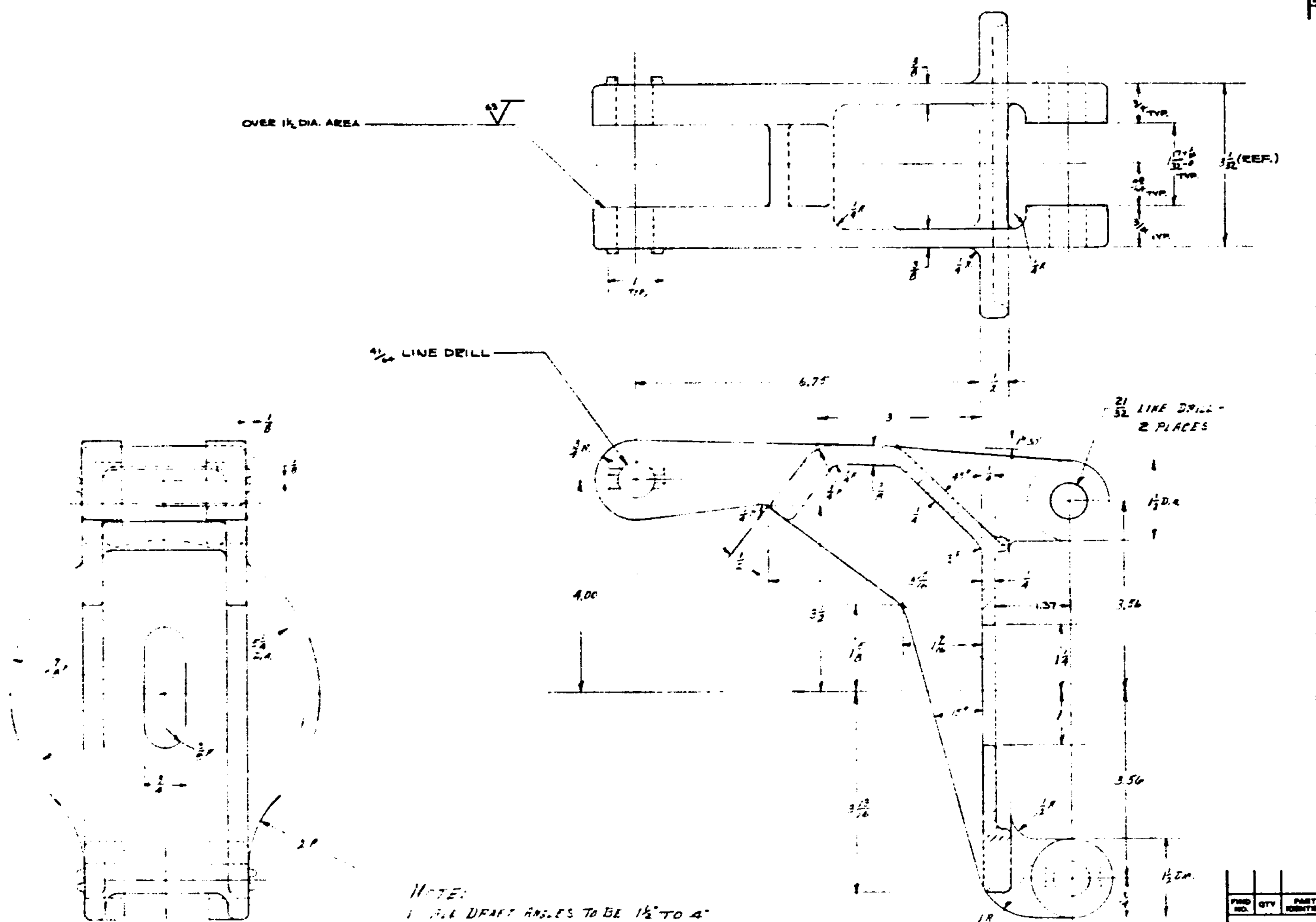
Battelle Columbus Laboratories

PUMP STAND ASSY.

SIZE	CODE IDENT NO.		DWG. NO.
D	79986	644	2010

SCALE 1"=1" ASSY G1320-1 SHEET 1 OF 1

2010



NOTE:
1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL RAD. & FILLETS TO BE ⅛ UNLESS OTHERWISE SPECIFIED

FIND NO.	QTY	PART NO. OR IDENTIFYING NO.	DWG SIZE	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION			
THIS ITEM IS USED ON SUBASSEMBLIES			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1

DO NOT SCALE DRAWING

MATERIAL AND TREATMENT: CAST IRON

Battelle Columbus Laboratories

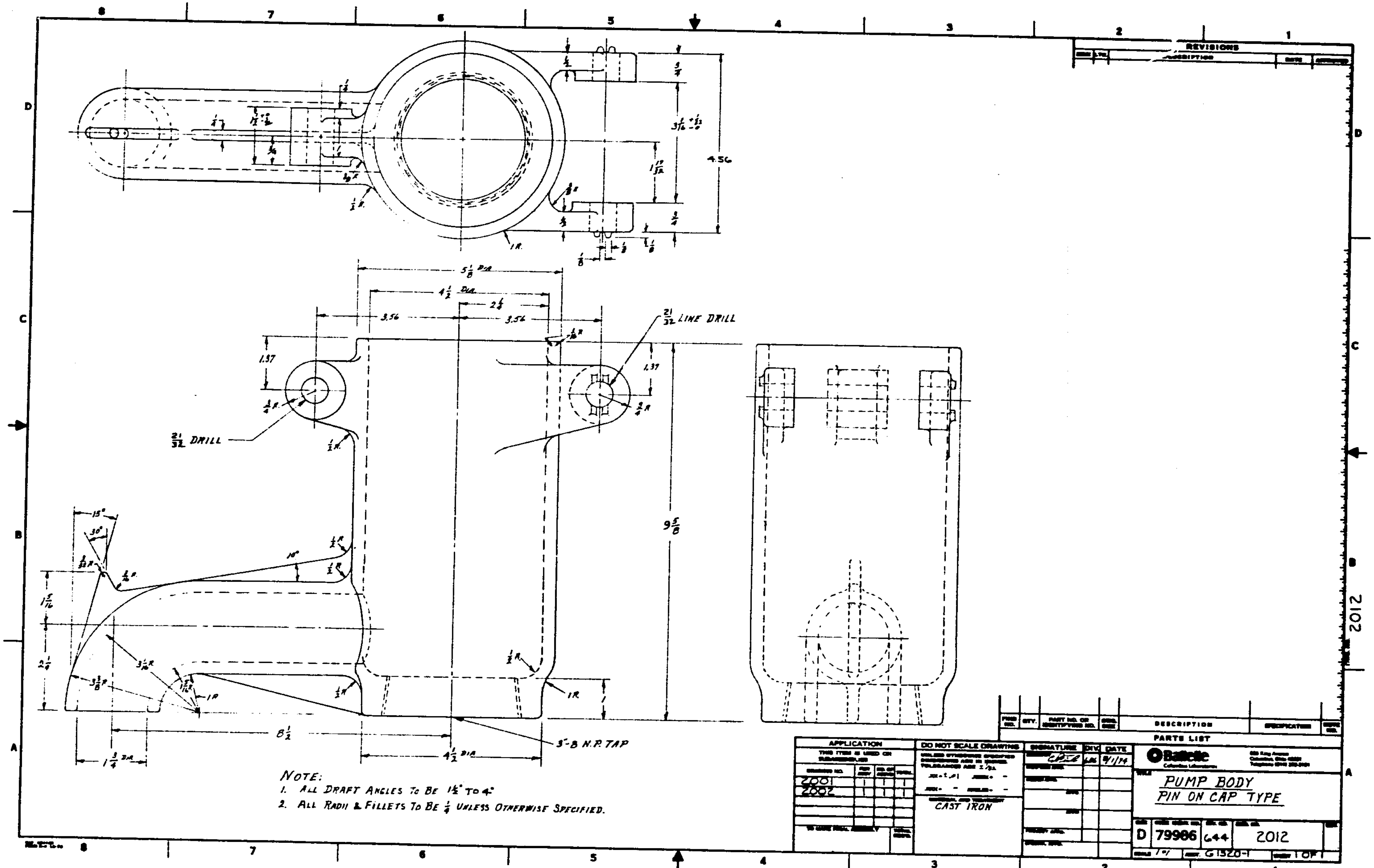
DIV. 606 DATE 7/29/74

TITLE: PUMP CAP SHALLOW WELL PUMP PIN ON TYPE

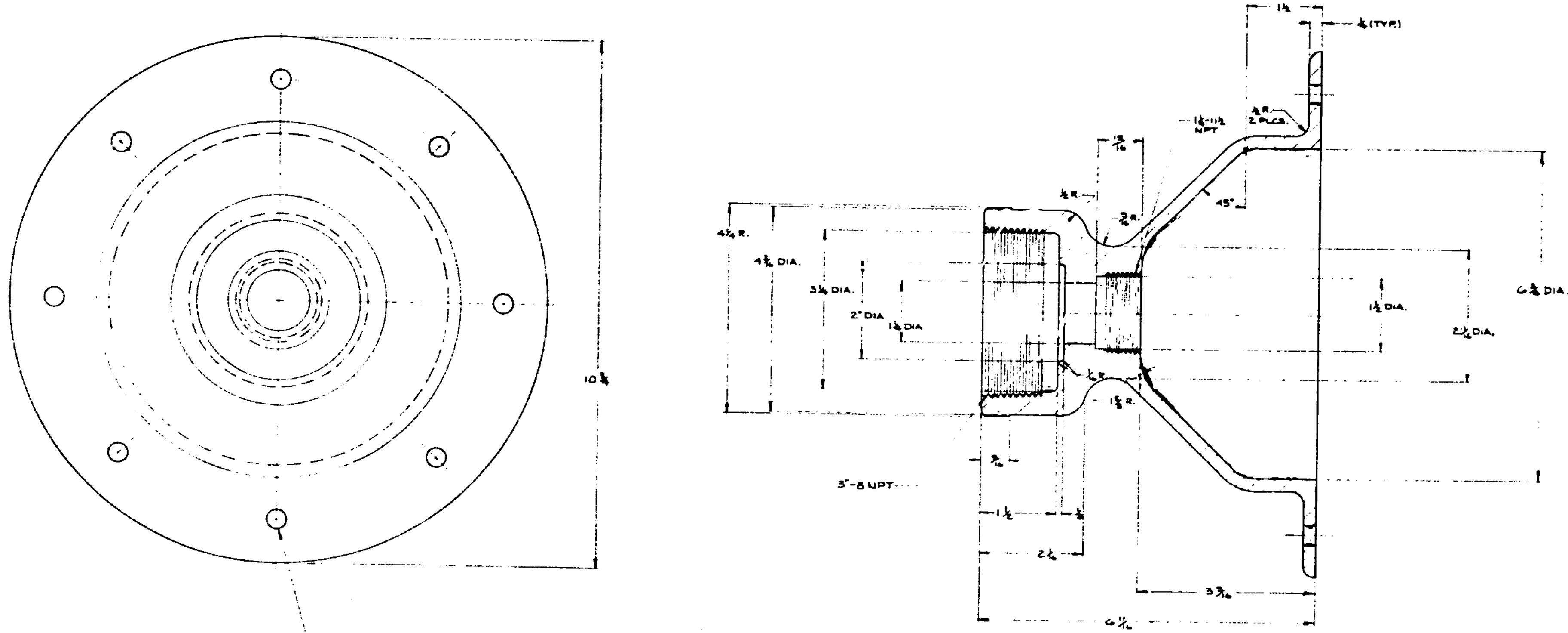
SIZE D | CODE IDENT NO. 79986 | DIV. NO. 644 | DWG. NO. 2011

SCALE 1=1 | ASSY G1320-1 | SHEET 1 OF 1

2011



21/32 LINE DRILL
21/32 DRILL
5/8 DIA
4 1/2 DIA
9 5/8
8 1/2
3/8-8 N.P. TAP
4.56
NOTE:
1. ALL DRAFT ANGLES TO BE 1 1/2° TO 4°
2. ALL RADII & FILLETS TO BE 1/4 UNLESS OTHERWISE SPECIFIED.
REVISIONS
PARTS LIST
DESCRIPTION
APPLICATION
2001
2002
DO NOT SCALE DRAWING
CAST IRON
SIGNATURE
DIV
DATE
9/1/74
Battelle
PUMP BODY
PIN ON CAP TYPE
D
79986
644
2012
G1520-1
1 OF 1



19/32 DIA. THRU
8 HOLES EQUALLY SPACED
ON 5" DIA. B.C.

NOTES:
1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛" R. UNLESS OTHERWISE SPECIFIED
3. MOUNTING HOLES SHOWN HERE ARE FOR ⅜" BOLTS, BUT FLANGE IS WIDE ENOUGH FOR ½" BOLTS & WASHERS

APPLICATION			
DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
2002	1	1	1

DO NOT SCALE DRAWING

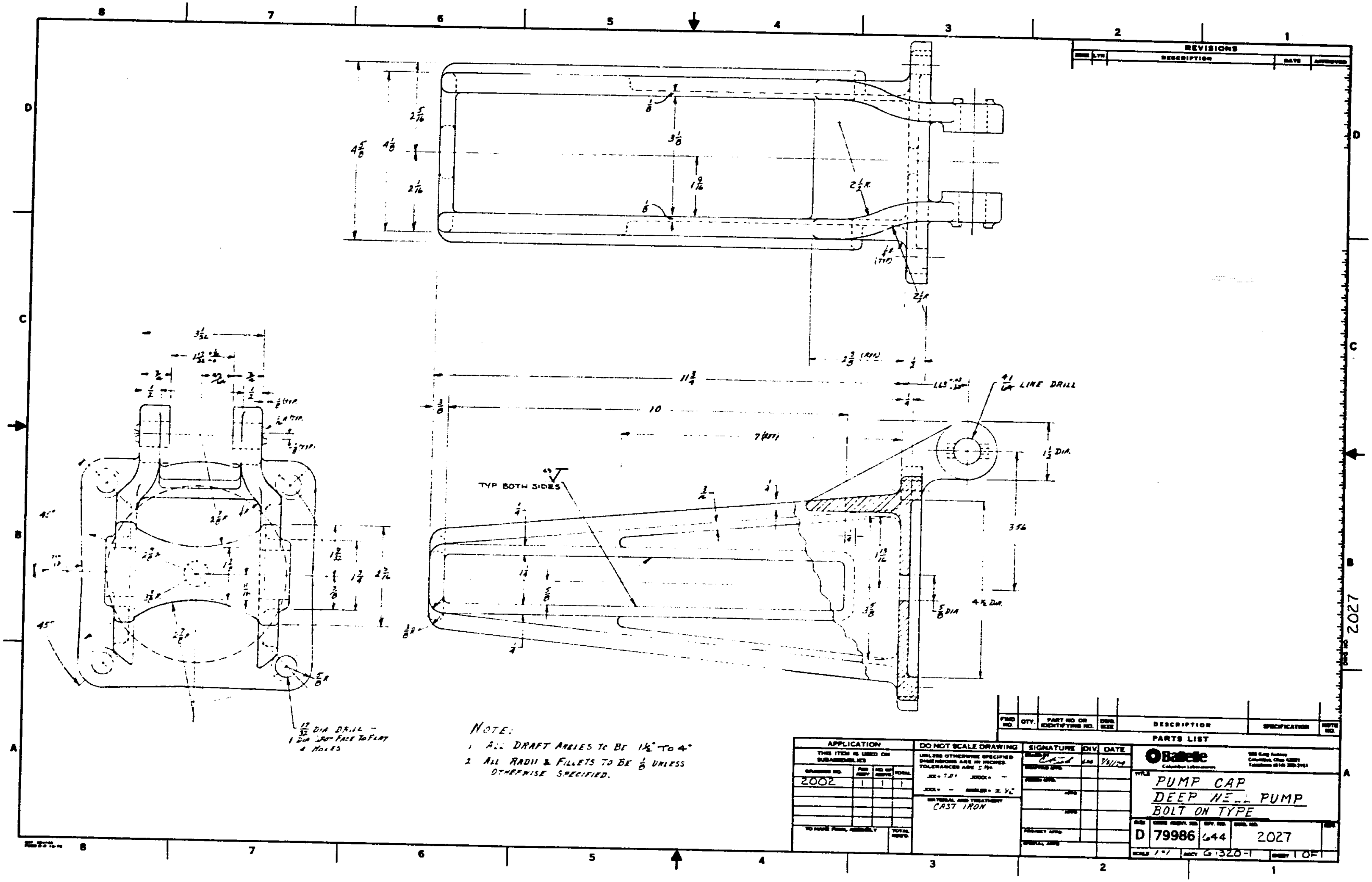
MATERIAL AND TREATMENT: CAST IRON

Battelle — Columbus Laboratories

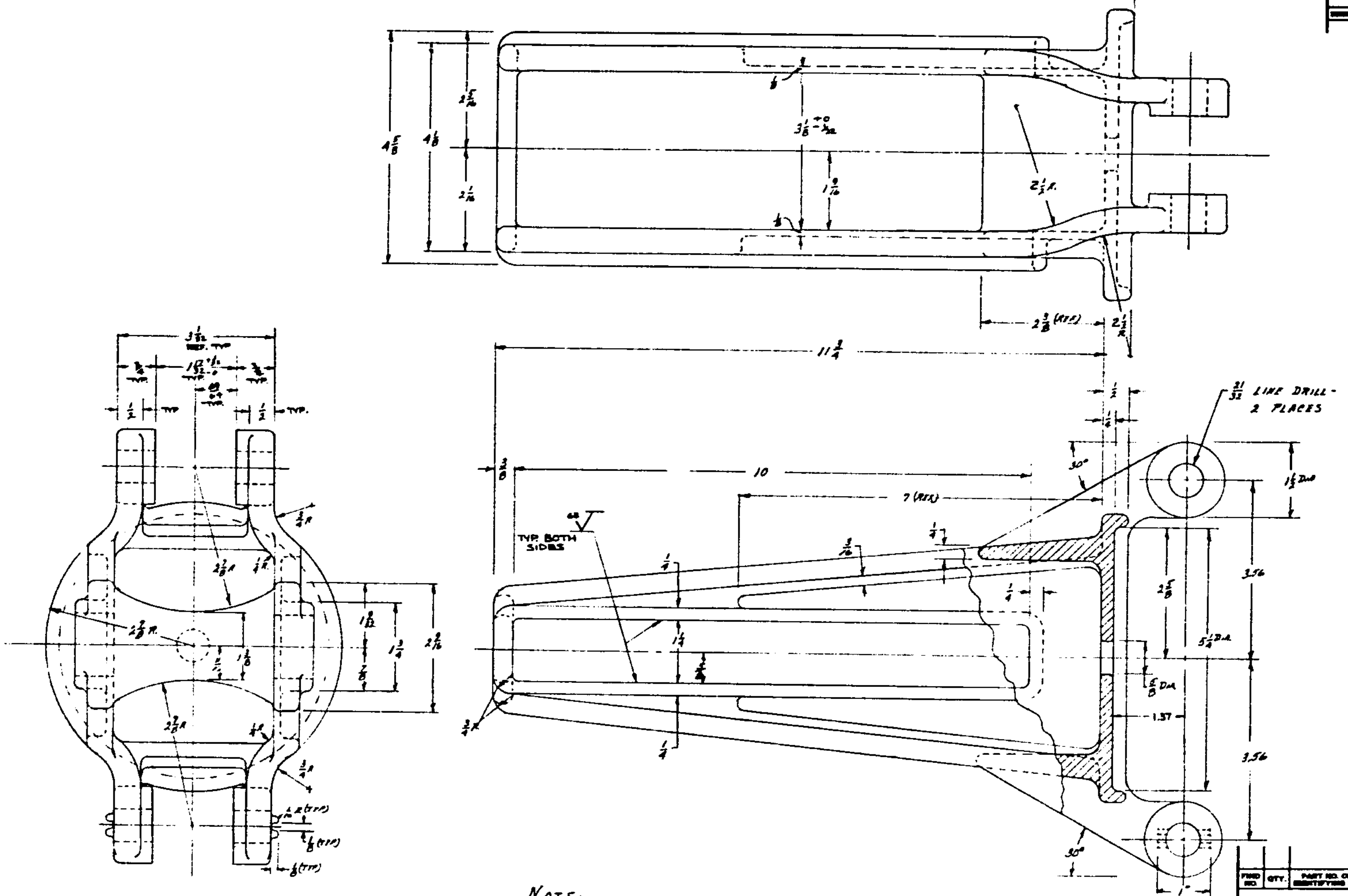
TITLE: PUMP STAND

SIZE: D | CODE IDENT NO. 79986 | DIV NO. 644 | DWG. NO. 2023

SCALE 1" = 1" | ACCT G1320-1 | SHEET 1 OF 1



NOTE:
1 ALL DRAFT ANGLES TO BE 1½° TO 4°
2 ALL RADII & FILLETS TO BE 1/8 UNLESS OTHERWISE SPECIFIED.
TYP BOTH SIDES
LINE DRILL
REVISIONS
APPLICATION
2002
DO NOT SCALE DRAWING
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.
CAST IRON
SIGNATURE
DIV.
DATE
PARTS LIST
DESCRIPTION
SPECIFICATION
Battelle
PUMP CAP
DEEP WELL PUMP
BOLT ON TYPE
D
79986
644
2027
G-320-1
1 OF 1



NOTE:

1. ALL DRAFT ANGLES TO BE 1/2° TO 4°
2. ALL RADII & FILLETS TO BE 1/8 UNLESS OTHERWISE SPECIFIED.

FIND NO.	QTY.	PART NO. OR IDENTIFYING NO.	DESCRIPTION	SPECIFICATION	NOTE NO.

PARTS LIST

APPLICATION

DRAWING NO.			
2002	1	1	1

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES.

MATERIAL AND TREATMENT: CAST IRON

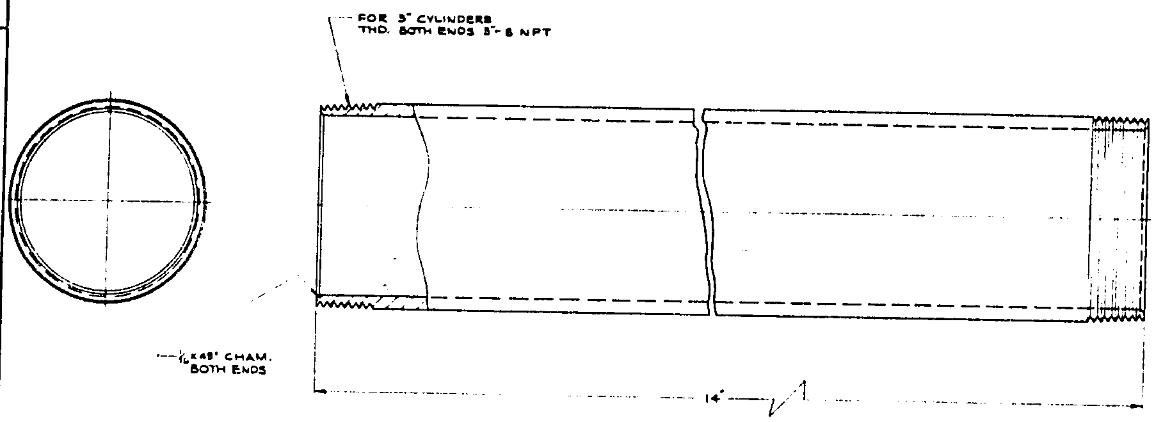
SIGNATURE | DIV. | DATE

Battelle Columbus Laboratories

TITLE: PUMP CAP
DEEP WELL PUMP
PIN ON TYPE

SIZE			DWG. NO.
D	79986	644	2028

SCALE 1=1 | G1320-1 | SHEET 1 OF 1



NOTE:
PIPE MAY BE MADE OF EITHER OF THE FOLLOWING MATERIALS FOR 3" CYLINDERS.
* 1ST OPTION - STD. P.V.C. 1120 PLASTIC PIPE (SCH. 40)
2ND OPTION - STD. BLACK STEEL PIPE (SCH. 40) COATED WITH .004 $^{+.004}_{-.000}$ THICKNESS OF SYNTHETASINE 1:00 (STONER-MUDGE) OR EQUIVALENT, ON ENTIRE SURFACE
3RD OPTION - STD. BLACK STEEL PIPE (SCH. 40) COATED WITH 2 COATS OF SOVAPON HI-BUILD EPOXY (MOBILE CHEMICAL CO.) OR EQUIVALENT OVER PRIMER
* PVC PIPE NOT TO BE USED IN SHALLOW WELL PUMP ASSY.

APPLICATION — THIS ITEM IS USED ON ASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
2002	1	1	1

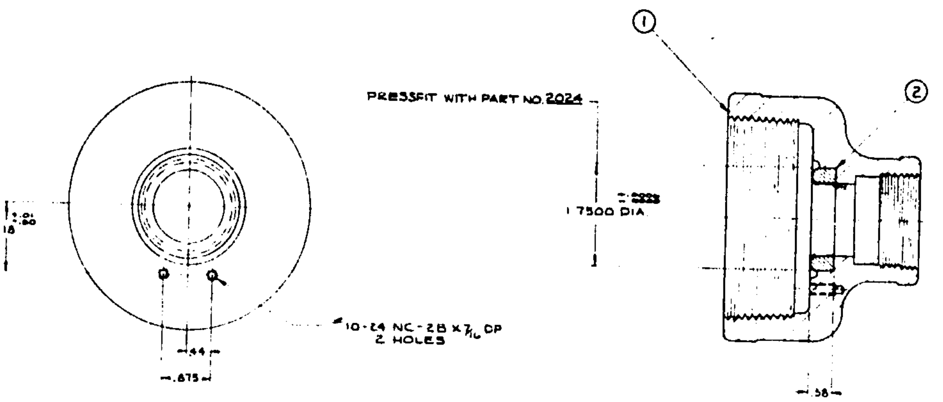
DO NOT SCALE DRAWING. UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES. TOLERANCES ARE: ± 1/32
MATERIAL AND TREATMENT: NOTED

DATE: 1-14-76 — DIV 659

Battelle Columbus Laboratories

TITLE: PUMP CYLINDER

SIZE: C | CODE IDENT NO: 79986 | DIV NO: 644 | DWG NO: 2014
SCALE: 1"=1" | ACCT: G1320-1 | SHEET 1 OF 1



FIND NO.	QTY	PART NO OR IDENTIFYING NO.	DWG SIZE	DESCRIPTION	SPECIFICATION	NOTE NO
2	1	2024	A	BRASS VALVE SEAT		
1	1	2025	C	CYLINDER END CAP		

PARTS LIST

APPLICATION — THIS ITEM IS USED ON SUBASSEMBLIES

DRAWING NO.	PER ASSY	NO. OF ASSYS	TOTAL
2001	1	1	1
2002	1	1	1

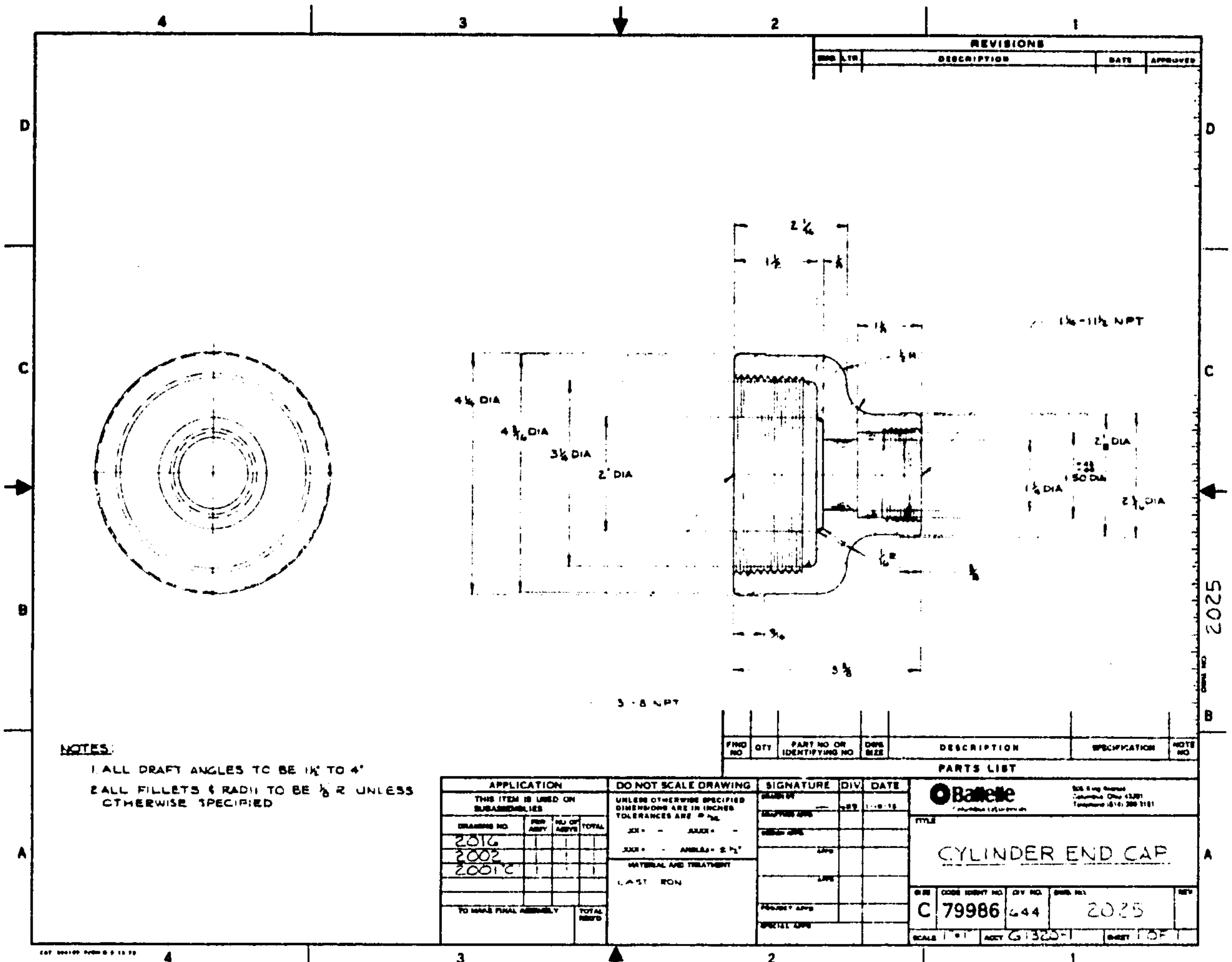
DO NOT SCALE DRAWING

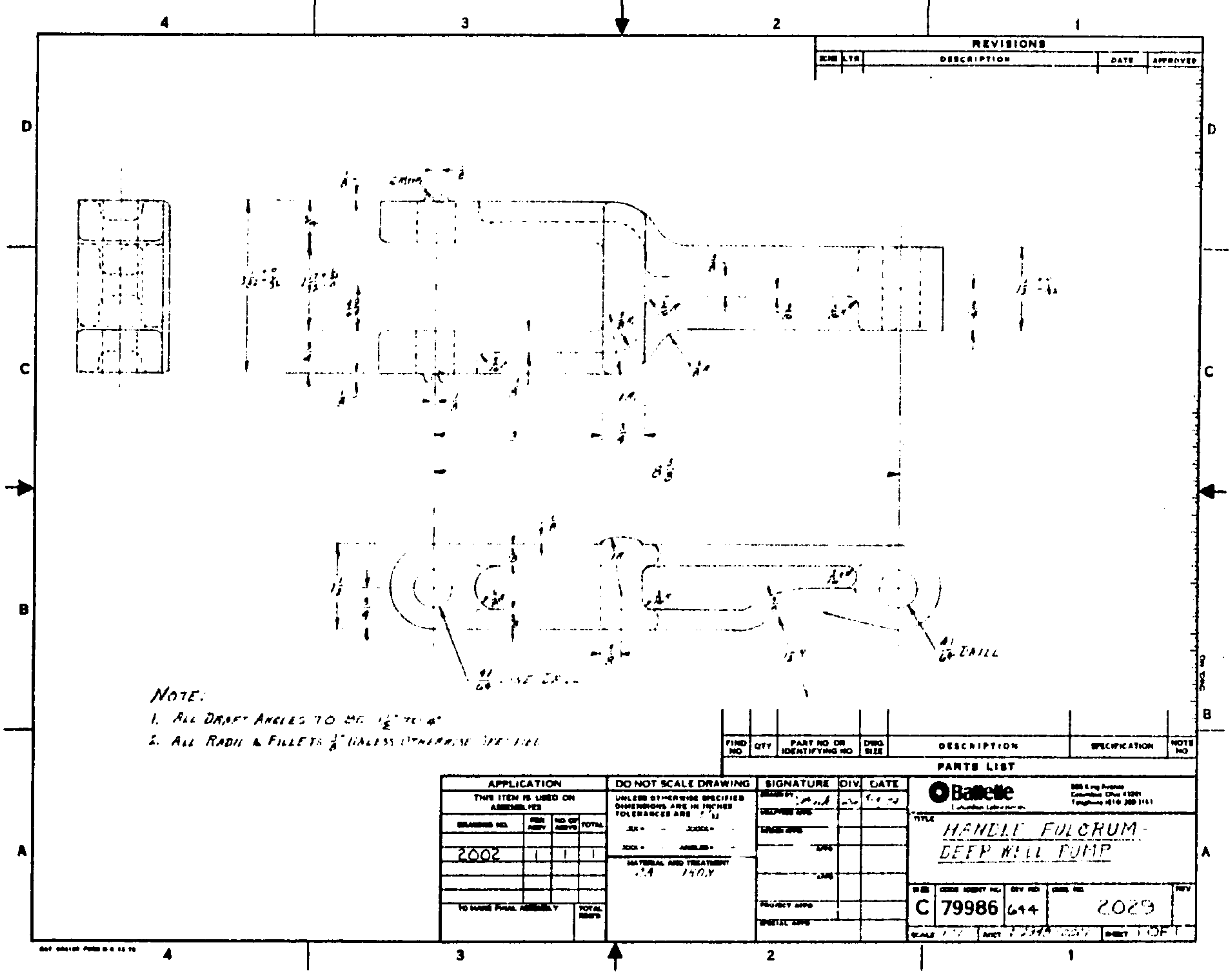
DATE: 1-14-76 — DIV 659

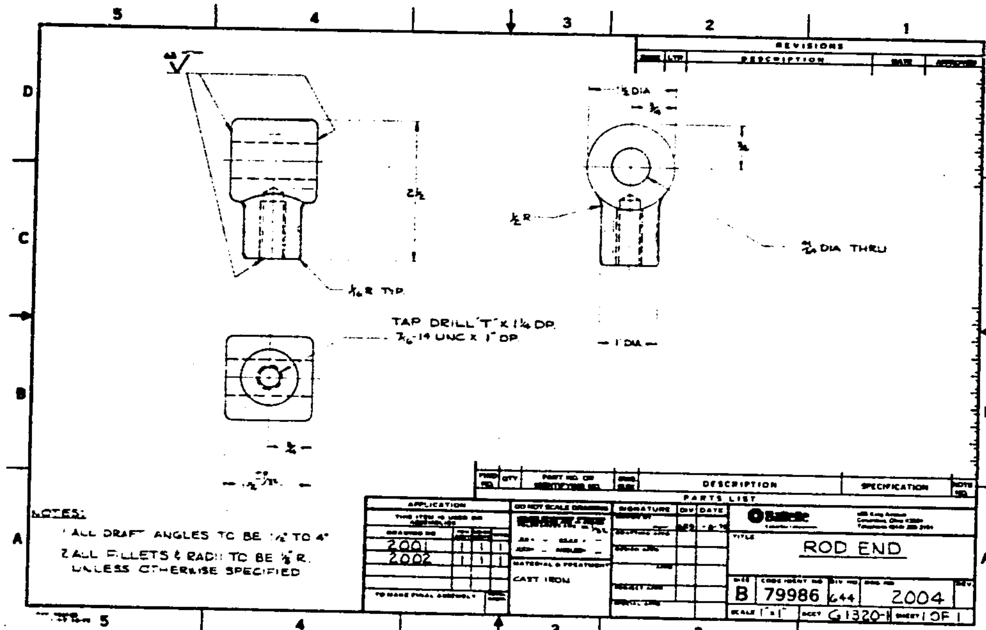
Battelle Columbus Laboratories

TITLE: LOWER VALVE HOUSING ASSY.

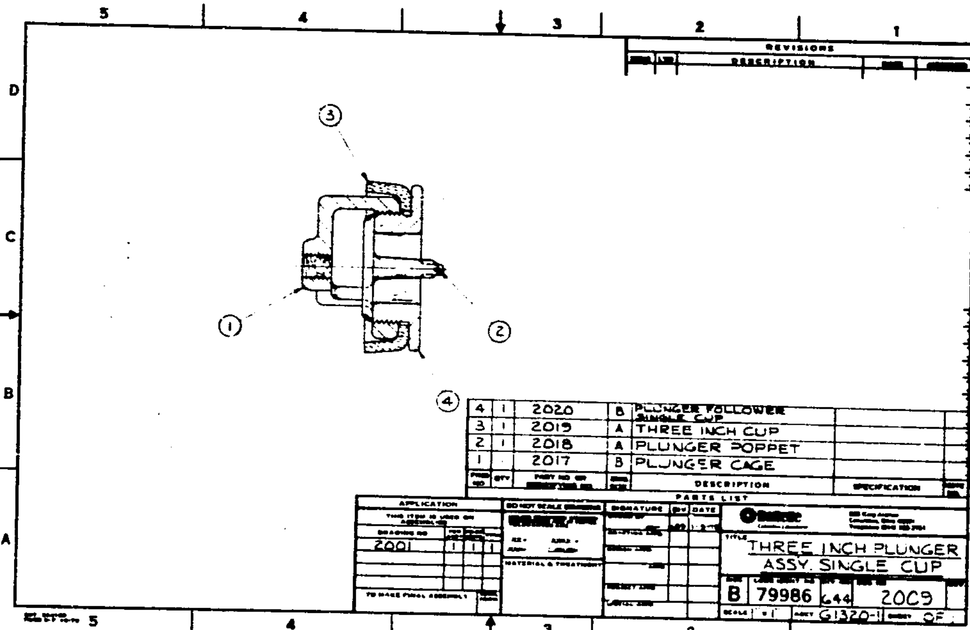
SIZE: C | CODE IDENT NO: 79986 | DIV NO: 644 | DWG NO: 2016
SCALE: 1"=1" | ACCT: G1320-1 | SHEET 1 OF 1


REVISIONS
DESCRIPTION
DATE
APPROVED
4⅛ DIA
2" DIA
1½-11½ NPT
3⅛
3-8 NPT
2025
NOTES:
1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛ R UNLESS OTHERWISE SPECIFIED
FIND NO
QTY
PART NO OR IDENTIFYING NO
DWG SIZE
DESCRIPTION
SPECIFICATION
NOTE NO
PARTS LIST
APPLICATION
THIS ITEM IS USED ON SUBASSEMBLIES
DRAWING NO.
2016
2002
2001C
TO MAKE FINAL ASSEMBLY
TOTAL REQ'D
DO NOT SCALE DRAWING
MATERIAL AND TREATMENT
CAST IRON
SIGNATURE
DIV
DATE
PROJECT APPD
SPECIAL APPD
Battelle
TITLE
CYLINDER END CAP
SIZE
C
CODE IDENT NO
79986
DIV NO
644
DWG NO
2025
REV
SCALE
1:1
SHEET
1 OF 1

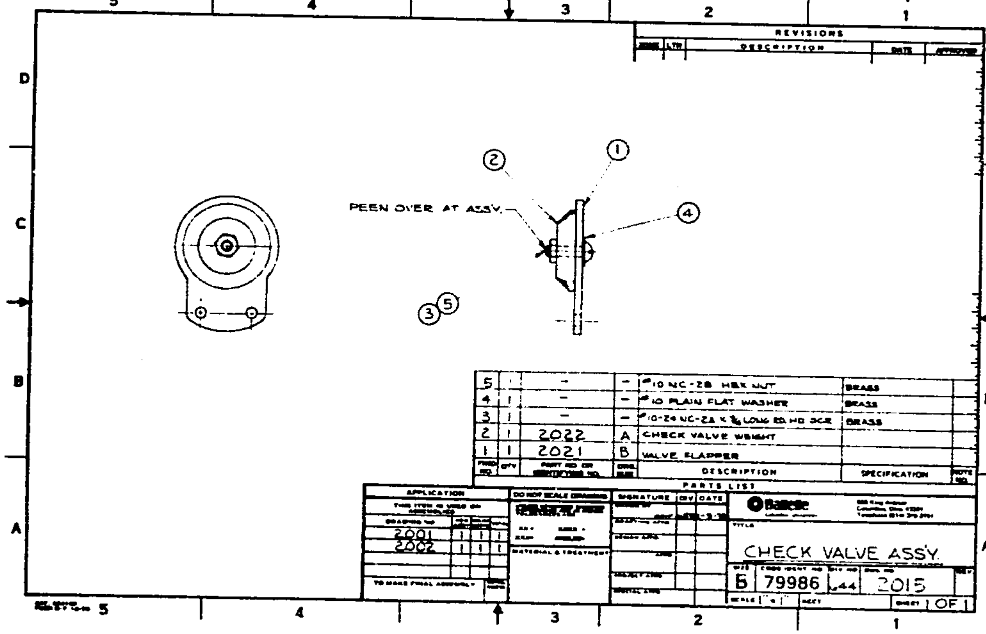

REVISIONS
DESCRIPTION
DATE
APPROVED
8⅜
NOTE:
1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL RADII & FILLETS ⅛ UNLESS OTHERWISE SPECIFIED
FIND NO
QTY
PART NO OR IDENTIFYING NO
DWG SIZE
DESCRIPTION
SPECIFICATION
NOTE NO
PARTS LIST
APPLICATION
THIS ITEM IS USED ON ASSEMBLIES
DRAWING NO.
2002
TO MAKE FINAL ASSEMBLY
TOTAL REQ'D
DO NOT SCALE DRAWING
MATERIAL AND TREATMENT
SIGNATURE
DIV
DATE
PROJECT APPD
SPECIAL APPD
Battelle
TITLE
HANDLE FULCRUM-
DEEP WELL PUMP
SIZE
C
CODE IDENT NO
79986
DIV NO
644
DWG NO
2029
SHEET
1 OF 1



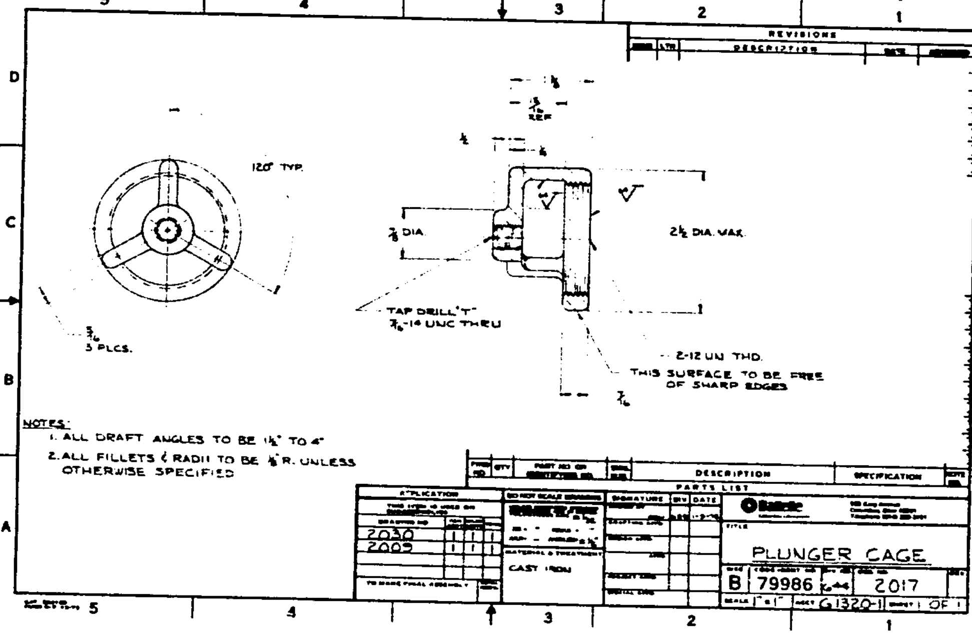
REVISIONS
DESCRIPTION
DATE
APPROVED
½ DIA
2½
½ R
¼ DIA THRU
⅛ R TYP.
TAP DRILL "T" X 1¼ DP.
⅞-14 UNC X 1" DP.
1 DIA
NOTES:
1. ALL DRAFT ANGLES TO BE ½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛ R. UNLESS OTHERWISE SPECIFIED
PARTS LIST
DESCRIPTION
SPECIFICATION
APPLICATION
2001
2002
CAST IRON
Battelle
ROD END
B 79986 644 2004
SCALE 1" = 1"
G1320-1
SHEET 1 OF 1



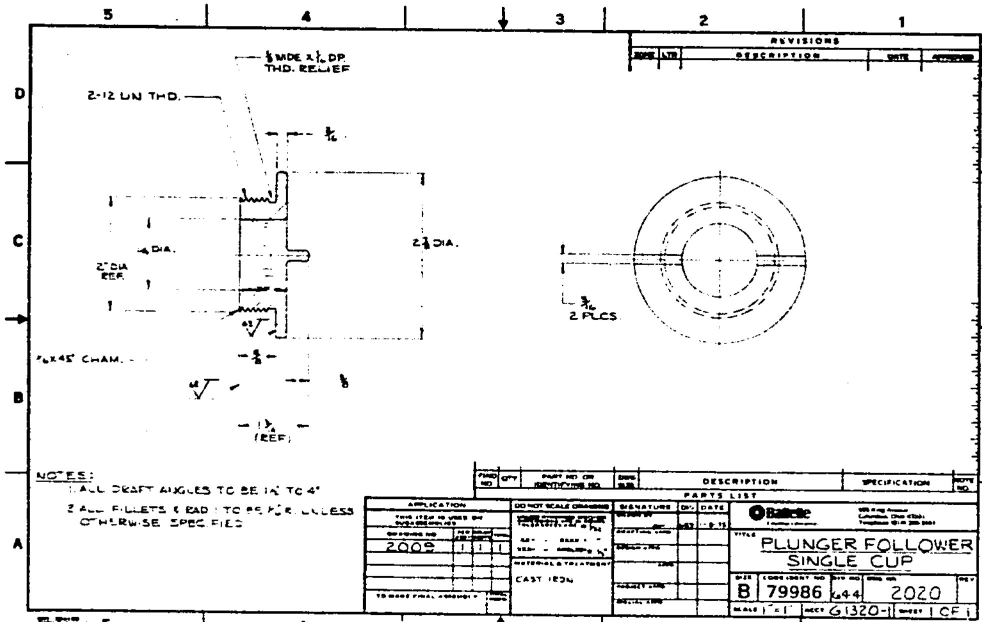
REVISIONS
DESCRIPTION
4 1 2020 B PLUNGER FOLLOWER SINGLE CUP
3 1 2019 A THREE INCH CUP
2 1 2018 A PLUNGER POPPET
1 1 2017 B PLUNGER CAGE
PARTS LIST
DESCRIPTION
SPECIFICATION
APPLICATION
2001
Battelle
THREE INCH PLUNGER ASSY. SINGLE CUP
B 79986 644 2009
G1320-1

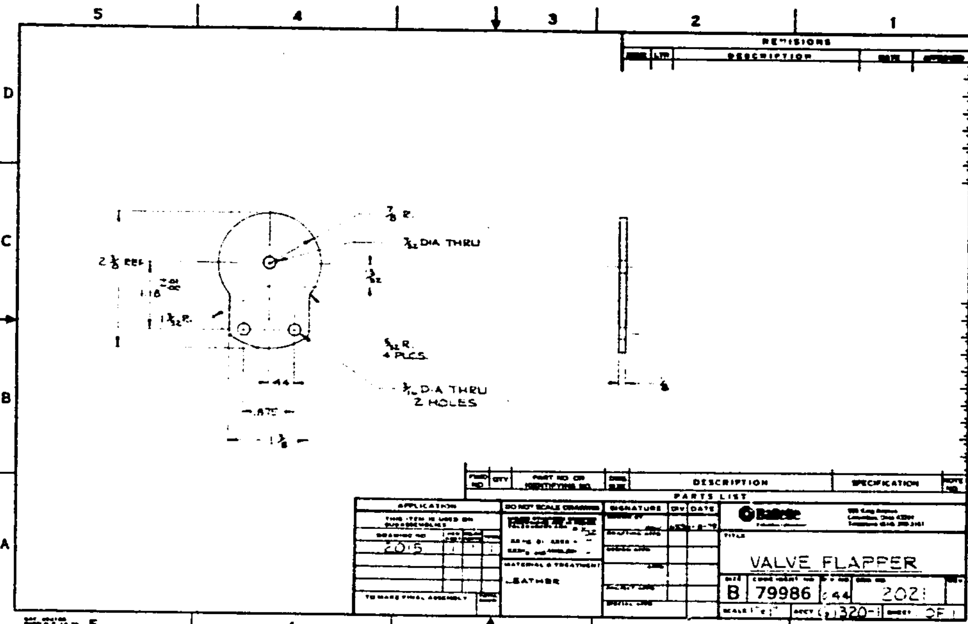


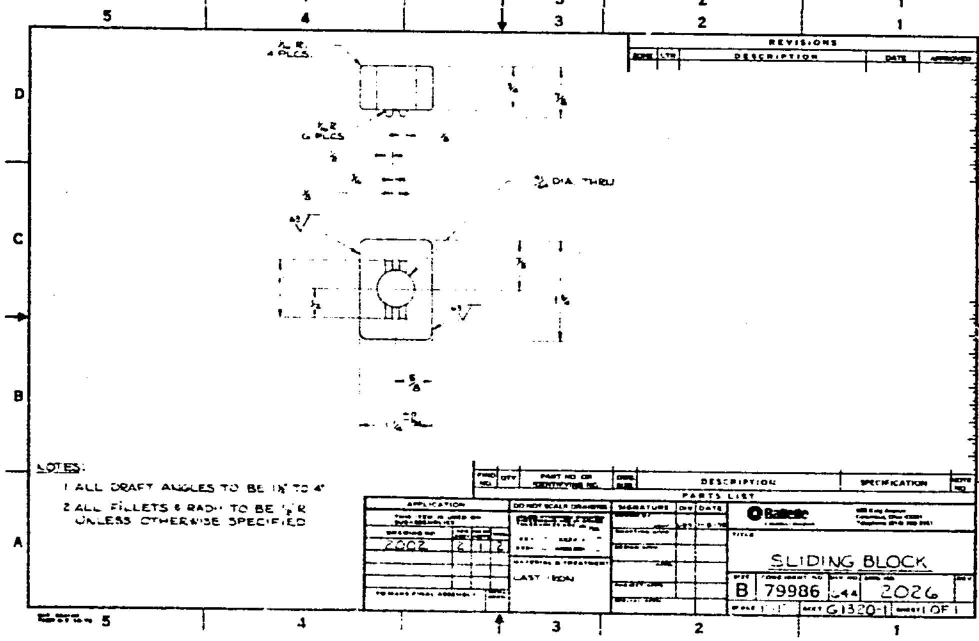
REVISIONS
DESCRIPTION
PEEN OVER AT ASSY.
5 1 — — #10 NC-2B HEX NUT BRASS
4 1 — — #10 PLAIN FLAT WASHER BRASS
3 1 — — #10-24 NC-2A X ⅜ LONG RD. HD. SCR. BRASS
2 1 2022 A CHECK VALVE WEIGHT
1 1 2021 B VALVE FLAPPER
PARTS LIST
DESCRIPTION
SPECIFICATION
APPLICATION
2001
2002
Battelle
CHECK VALVE ASSY.
B 79986 644 2015
SHEET 1 OF 1

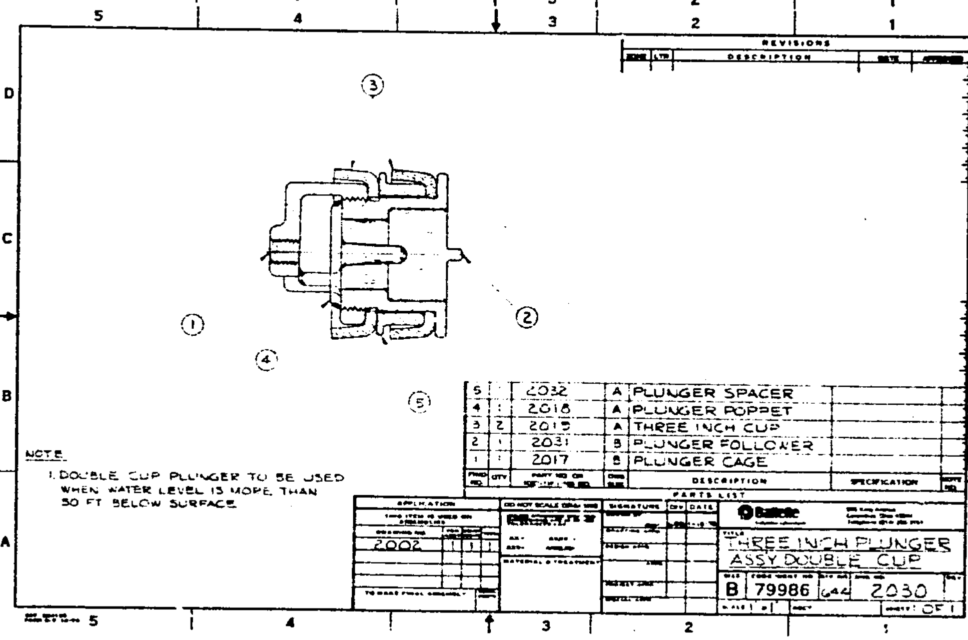


REVISIONS
DESCRIPTION
120° TYP.
⅞ DIA.
2½ DIA. MAX.
TAP DRILL "T"
⅞-14 UNC THRU
⅛ 3 PLCS.
2-12 UN THD.
THIS SURFACE TO BE FREE OF SHARP EDGES
NOTES:
1. ALL DRAFT ANGLES TO BE ½° TO 4°
2. ALL FILLETS & RADII TO BE ⅛ R. UNLESS OTHERWISE SPECIFIED
PARTS LIST
DESCRIPTION
SPECIFICATION
APPLICATION
2030
2009
CAST IRON
Battelle
PLUNGER CAGE
B 79986 644 2017
SCALE 1" = 1"
G1320-1
SHEET 1 OF 1

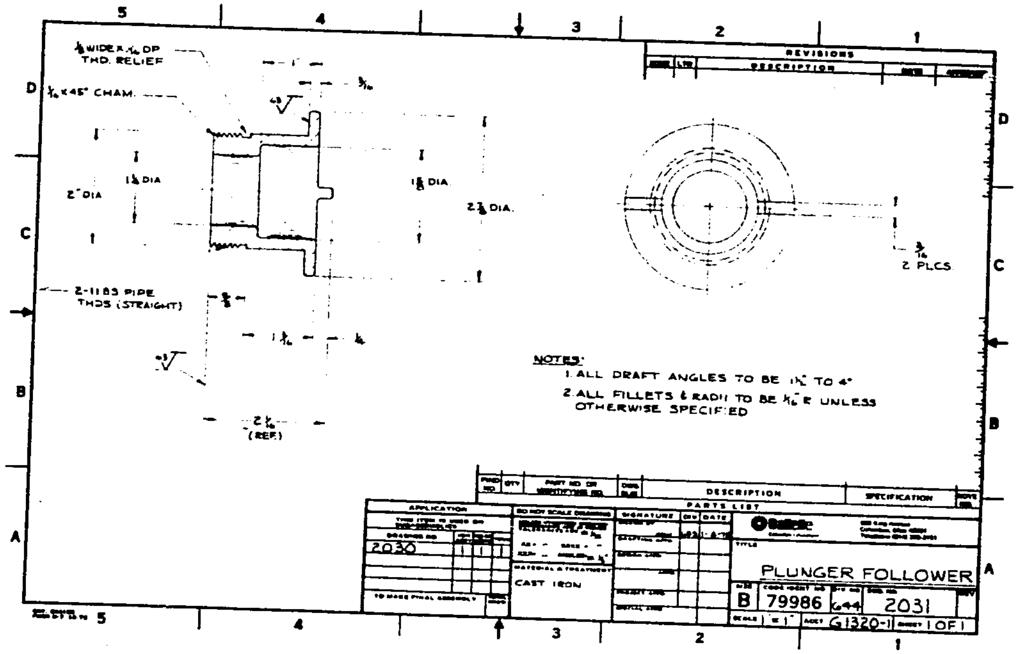




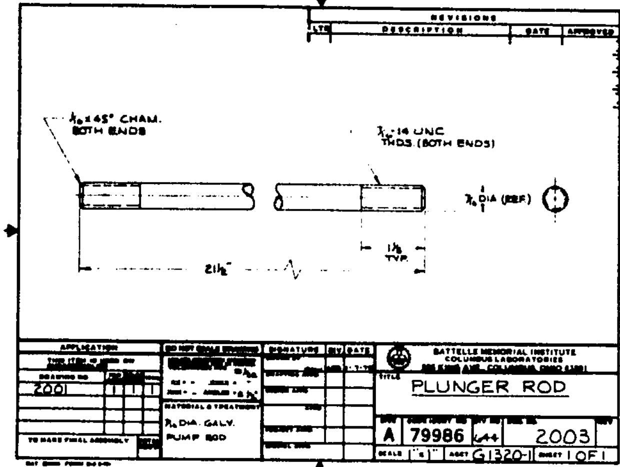


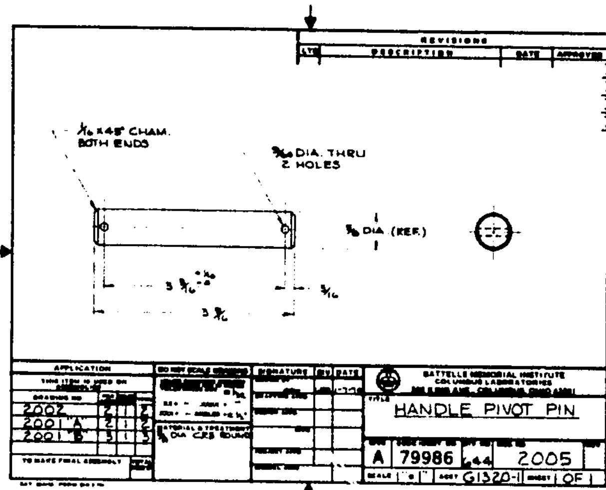


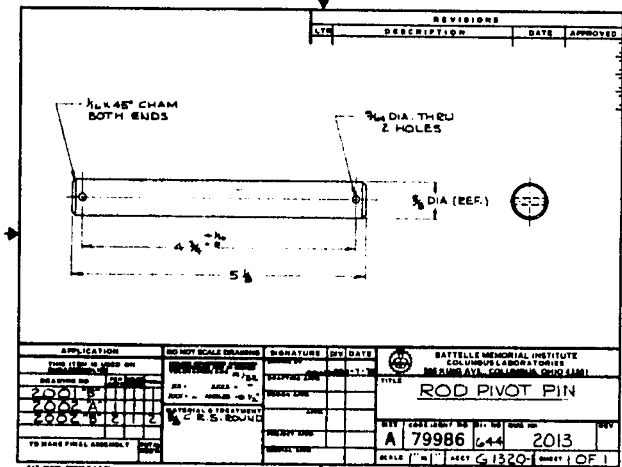
FIND NO	QTY	PART NO OR IDENTIFYING NO	DWG SIZE	DESCRIPTION
5	1	2032	A	PLUNGER SPACER
4	1	2018	A	PLUNGER POPPET
3	2	2015	A	THREE INCH CUP
2	1	2031	B	PLUNGER FOLLOWER
1	1	2017	B	PLUNGER CAGE

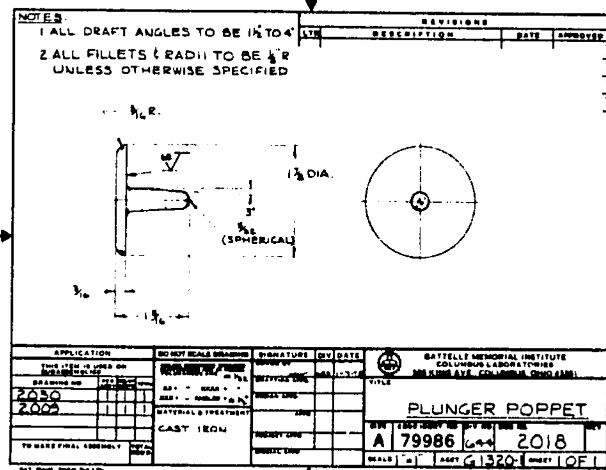


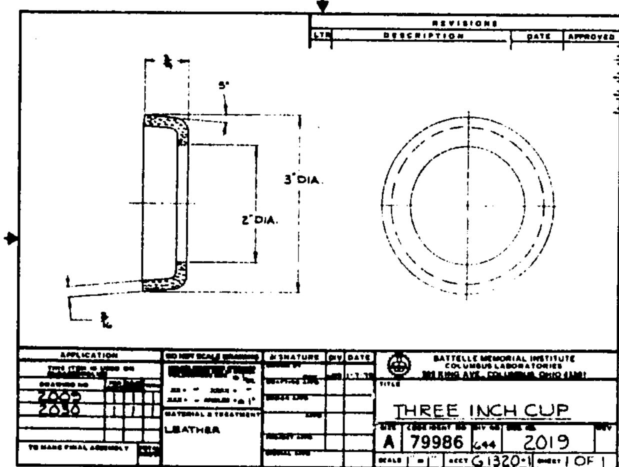
REVISIONS
THD. RELIEF
CHAM.
2" DIA
DIA
2-11.83 PIPE THDS (STRAIGHT)
(REF)
2 PLCS
NOTES:
1. ALL DRAFT ANGLES TO BE 1½° TO 4°
2. ALL FILLETS & RADII TO BE 1/16" R UNLESS OTHERWISE SPECIFIED
DESCRIPTION
SPECIFICATION
PARTS LIST
APPLICATION
2030
SIGNATURE
DATE
CAST IRON
TITLE
PLUNGER FOLLOWER
B
79986
644
2031
G1320-1
1 OF 1

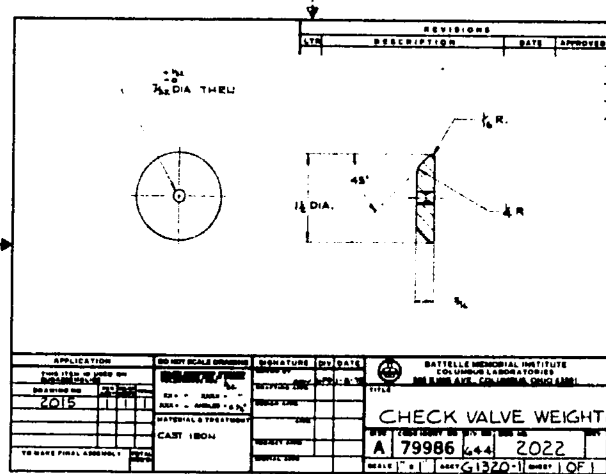

REVISIONS
BOTH ENDS
21½"
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
PLUNGER ROD
2001
PUMP ROD
A 79986 644 2003
G1320-1
1 OF 1

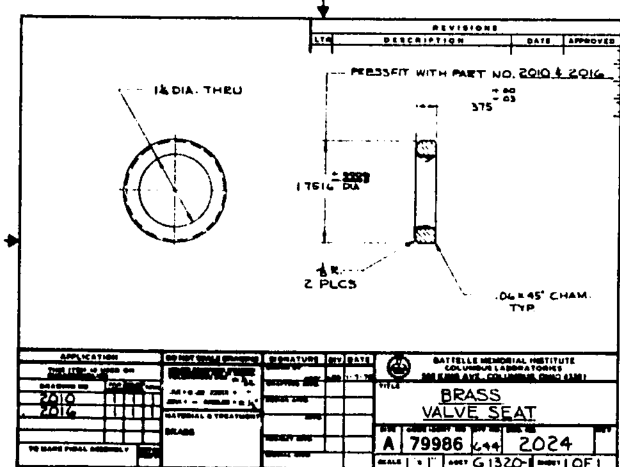

REVISIONS
BOTH ENDS
2 HOLES
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
HANDLE PIVOT PIN
A 79986 644 2005
G1320-1
1 OF 1

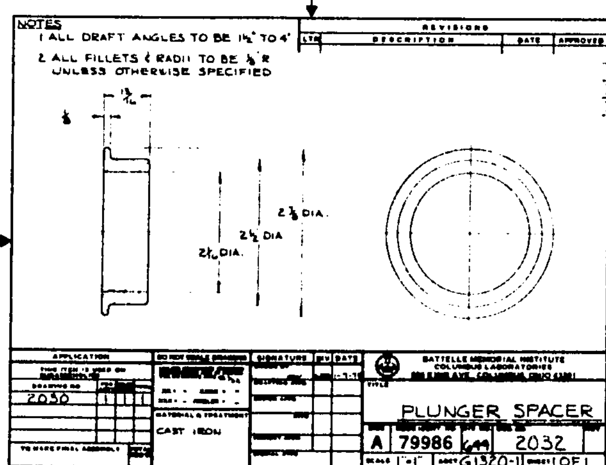

REVISIONS
BOTH ENDS
2 HOLES
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
ROD PIVOT PIN
A 79986 644 2013
G1320-1
1 OF 1


NOTES:
1 ALL DRAFT ANGLES TO BE 1½° TO 4°
2 ALL FILLETS & RADII TO BE ⅛" R
UNLESS OTHERWISE SPECIFIED
(SPHERICAL)
REVISIONS
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
2030
2005
CAST IRON
PLUNGER POPPET
A 79986 644 2018
G1320-1
1 OF 1


REVISIONS
3" DIA.
2" DIA.
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
2005
2030
LEATHER
THREE INCH CUP
A 79986 644 2019
G1320-1
1 OF 1


REVISIONS
DIA THRU
45°
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
2015
CAST IRON
CHECK VALVE WEIGHT
A 79986 644 2022
G1320-1
1 OF 1


REVISIONS
1⅛ DIA. THRU
PRESSFIT WITH PART NO. 2010 & 2016
2 PLCS
.04 x 45° CHAM.
TYP
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
2010
2016
BRASS
BRASS
VALVE SEAT
A 79986 644 2024
G1320-1
1 OF 1


NOTES:
1 ALL DRAFT ANGLES TO BE 1½° TO 4°
2 ALL FILLETS & RADII TO BE ⅛" R
UNLESS OTHERWISE SPECIFIED
REVISIONS
BATTELLE MEMORIAL INSTITUTE
COLUMBUS LABORATORIES
2030
CAST IRON
PLUNGER SPACER
A 79986 644 2032
G1320-1
1 OF 1

APPENDIX B

ASSEMBLY DRAWINGS OF DESIGN ON TEST

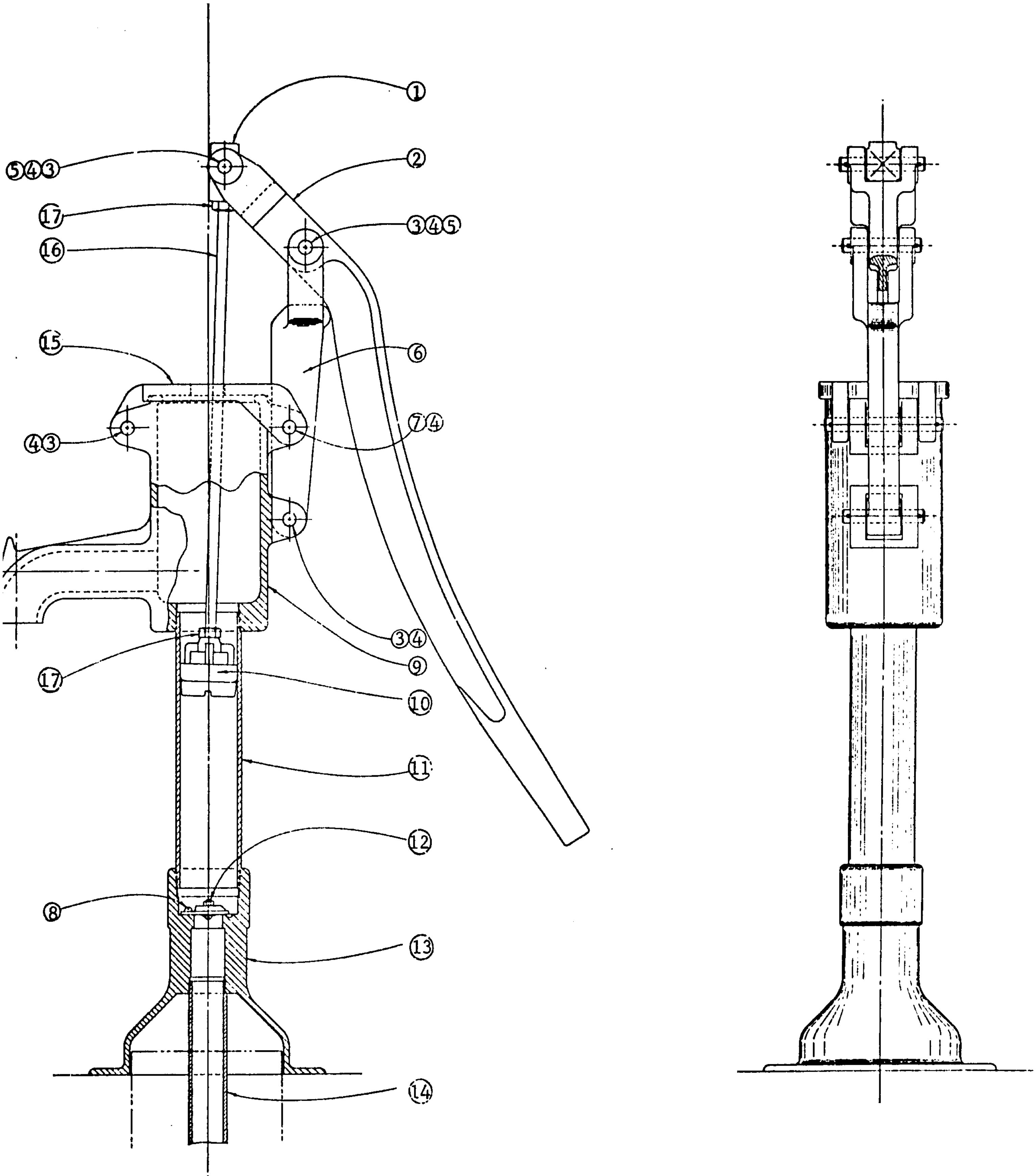
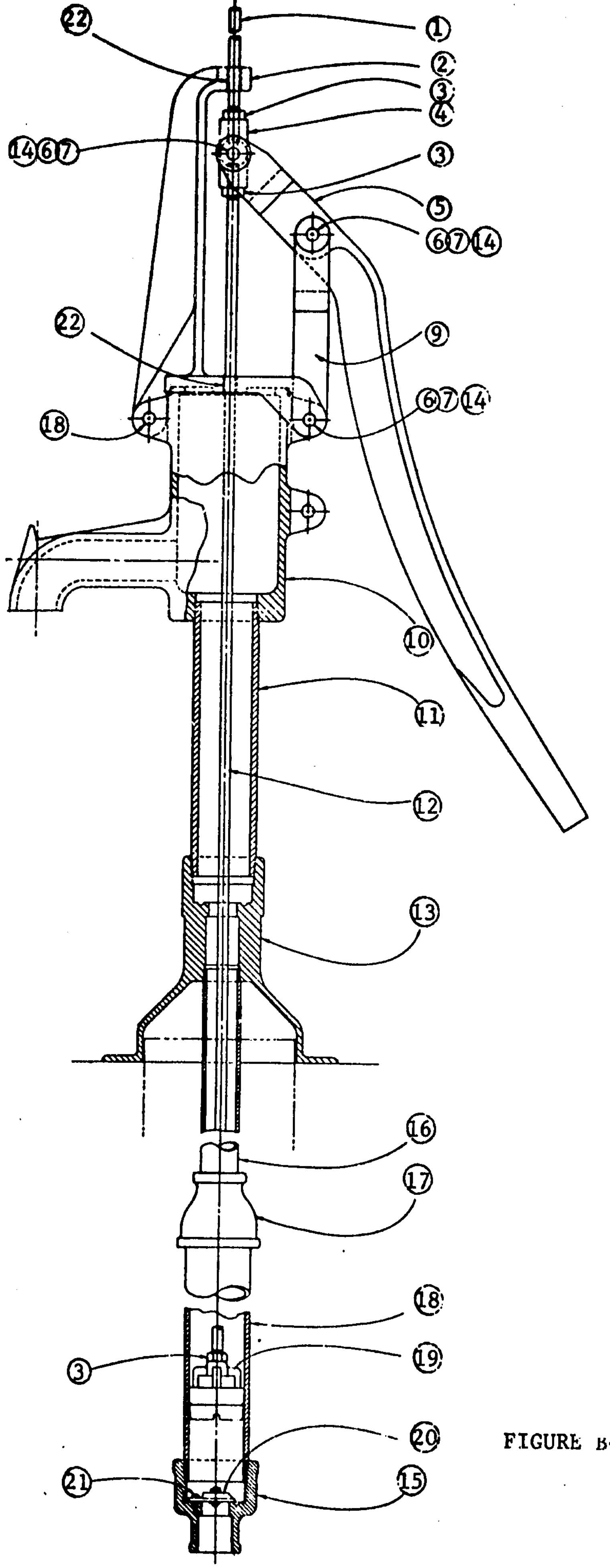


FIGURE B-1. SHALLOW-WELL PUMP



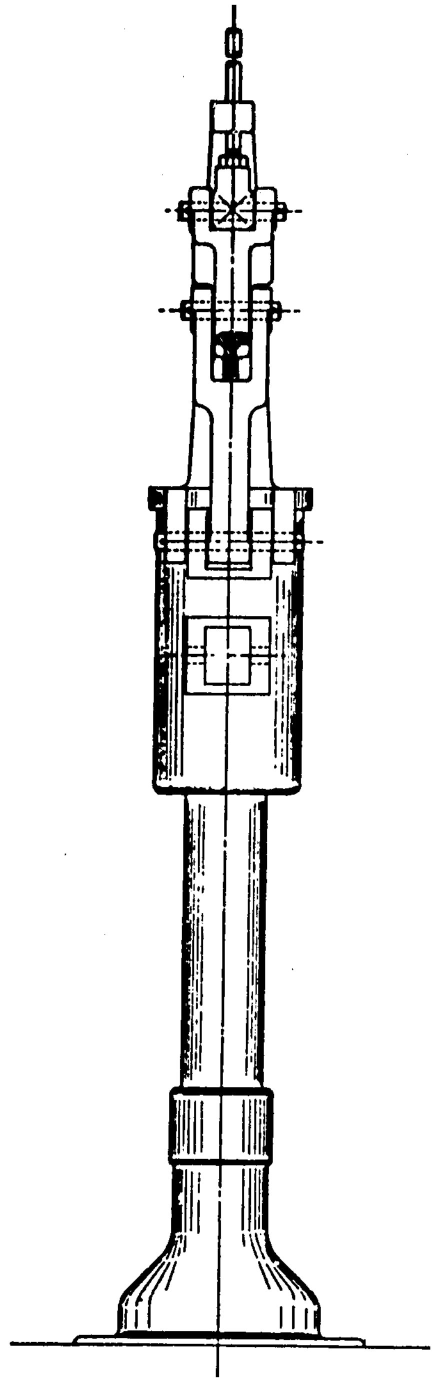


FIGURE B-2. DEEP-WELL PUMP

PARTS LIST FOR SHALLOW-WELL PUMP

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

* Various Bearing Materials Being Considered

PARTS LIST FOR DEEP-WELL PUMP

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

* Various Bearing Materials Being Considered

Battelle
Columbus Laboratories
505 King Avenue
Columbus, Ohio 43201
Telephone (614) 299-3151
Telex 24-5454

January 31, 1975

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

Dear Mr. Swisher:

Enclosed are 25 copies of our final report on your program, "Field Research and Testing of a Water Hand Pump for Use in Developing Countries". This report follows the outline used in preparing the 1967 and 1970 final reports. If time and funds permit, a second report more suitable for answering inquiries will be written.

The amount of actual testing conducted was below our expectations; however, the amount of useful information gained was quite high. Several modifications have been made to the original pump and a specific design is recommended.

Flexibility has been shown to be a key in final acceptance and some changes, however small, will likely be made to satisfy all those involved in the pump program.

During the course of this program, many people have shown an interest in the work being done and the knowledge gained, however used, will be worth much more than the costs involved in obtaining it.

Work is still going on in many areas of the world, including our test sites, and because of our involvement, additional information will be forthcoming to us. It is expected that these data will be forwarded to you for continued use and dissemination.

If we can be of further service or answer questions concerning this report, please call us.

Sincerely,

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

RDF:eb

Enclosures

cc: Ms. V. C. Perelli