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KINGDOM OF THAILAND

MINISTRY OF INTERIOR

ACCELERATED RURAL DEVELOPMENT OFFICE

**IMPROVEMENT OF HAND PUMP DESIGN
IN
THAILAND**

Equipment Control Division



PUBLISHED UNDER THE SPONSORSHIP OF

THE UNITED NATIONS CHILDREN'S FUND

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PREFACE

Village water supply is one of the most important problems in developing countries, especially in Thailand where more than 80 percent of the population live in rural villages. While people in municipal areas have been enjoying benefits from good quality water supply, supplies in rural communities have been far from adequate.

In general, potable (drinking) water and water used for other domestic purposes may be obtained from various sources including rain water, deep wells, shallow wells, ponds, reservoirs, rivers and canals. Of all these sources, deep well water is regarded as not only the safest water from waterborne diseases but also the highly economical source which can be rapidly developed for a given community.

In the effort to develop village water supply, more than 10,000 deep wells have been drilled and developed in Thailand up to the present time. Under the government's policy, not less than 1,000 deep wells have been drilled all over the country each year, and different government agencies are responsible for maintenance of these wells, including the Department of Mineral Resources, the Ministry of Industry; the Department of Health, the Public Health Ministry; the Office of Accelerated Rural Development and the Department of Public Works, the Ministry of Interior.

Records have shown that more than 90 percent of the existing wells in Thailand have been installed with hand pumps which are used as a means to lift water from these wells. In total, about 5 million rural Thai people have to depend upon these hand pumps to obtain water for drinking and other domestic purposes. While hand pumps have become an essential part of the daily life of these rural people, operation and maintenance of the pumps have also become persistent problems needed to be solved. Having realized such problems, the Office of Accelerated Rural Development, with a financial aid from UNICEF, took an initiative to conduct a hand pump testing and evaluation programme to be used as a basis for improvement of hand pump design.

Concurrent with this study, a study on shallow well hand pumps made of PVC material is being undertaken by the Department of Health. Additionally, Asian Institute of Technology will carry out a research on design and development of a typical hand pump which will be utilized in Thai rural communities in the future. The main emphasis of this study is placed on revision and improvement of the design of existing hand pumps, particularly the deep well reciprocating pump (cylinder submerged in water) so as to resolve current problems of hand pump maintenance to the maximum extent possible.

HAND PUMP EVALUATION AND TESTING IN THAILAND
FOR IMPROVEMENT OF HAND PUMP DESIGN

1. Introduction

1.1 Background Information

The provision of clean water for rural areas in Thailand was initiated in 1964. In the following year, the cabinet appointed an executive committee on this matter consisting of the members from various departments, and its responsibilities were planning and execution of the National Rural Water Supply Programme. The target of the programme was then set up to implement a plan to supply clean water to local inhabitants in some 50,000 villages throughout the country, by employing several means including:

- (1) Shallow dug wells and jet wells equipped with hand pumps.
- (2) Small diameter wells equipped with hand pumps.
- (3) Deep wells equipped with hand pumps.
- (4) Piped water supply.
- (5) Rainwater collection tanks.
- (6) Standard ponds.
- (7) Improvement of existing ponds.
- (8) Dikes and reservoirs.

The first phase of the plan was to provide clean water to rural inhabitants in 20,000 villages within 6 years, from 1966 to 1971, the latter being the year when the Second National Economic and Social Development Plan ended. The second phase of the programme was then included in the Third National Economic and Social Development Plan, with the target to provide clean water to the remaining 20,000 villages during the years 1972-1976. At the end of the Third Plan, the National Economic and Social Development Board made a request to the National

Institute of Development Administration (NIDA) for carrying out the evaluation of the program. Results showed that only 9.3 percent of rural population obtained water which is considered clean. In addition, it was reported that there had been several problems and obstracles prohibiting the project to reach its goal, and one of the causative factors was found to be the failure of hand pump operation.

At the national level, the responsibility for providing clean water is shared by several agencies as follows:-

(a) Department of Local Administration (DOLA)

This Department provides clean water to small communities through various activities including provision of various types of rainwater collection tanks, improvement of existing ponds, and assistanting in construction of shallow dug wells and jet wells equipped with hand pumps installed by local people and local contractors. At the end of 1977, a total of 32,410 shallow dug wells and jet wells had been constructed. Of this total number, 5,820 wells were installed with the hand pump. According to the survey conducted by NIDA in the Northeastern region, it appeared that as high as 34.7 percent of the hand pumps were inoperative during the investigation period.

(b) Department of Mineral Resources (DMR)

The Groundwater Division of the DMR provides clean water to rural people by means of deep wells. The depth of the wells varies from 100 feet to 350 feet, with an average depth of 185 feet. At the end of 1977, this Department had drilled 7,798 deep wells all over the country, of which 92.3 percent of these wells were equipped with hand pumps and the rest with motor pumps. NIDA reported that 18.6 percent of the hand pumps installed by this Department was out of operation during the survey undertaken in the Northeastern region. Under the present plan, Department's target is to construct 1,200 deep wells annually.

(c) Office of Accelerated Rural Development (ARD)

This Office was established with the principal policy to accelerate the development in underserved areas which are now covering 53 provinces. Its main tasks are to construct access roads linking villages in remote areas to district and to provide clean water in the underserved areas through construction of deep wells, shallow wells and standard ponds as well as improvement of existing ponds. At the end of 1977, 2,376 deep wells and 1,891 shallow wells equipped with hand pumps had been constructed. It was reported that 26.3 percent of these hand pumps were out of operation during the survey undertaken by NIDA. Under the World Bank Loan Project from 1977-1981, the ARD plans to construct 3,500 deep wells and 520 shallow wells to be equipped with hand pumps.

(d) Department of Public Works (DPW)

The Provincial Water Supply Division of this Department is also responsible for construction of deep wells to serve people in rural areas in all regions except the Northeastern region. Up to the present time, 1,971 deep wells have been constructed. However, the data on number of broken hand pumps are not available. Under the current plan, target of this Department is to construct 200 deep wells each year.

(e) Department of Health (DH)

The Department of Health has been providing piped water since 1966 through the national budget, community participation, and contribution from international agencies. From 1966-1977, 539 piped water schemes have been constructed serving 1,438,100 rural inhabitants, which is a small portion when compared with the country's total rural population. The Department of Health realized that, in order to provide more clean water, a new approach must be considered. As a result, the small diameter well programme for the communities of 500-1,500 people was introduced in 1976,

with the UNICEF assistance. As of September 1978, 130 small diameter wells equipped with hand pumps have been constructed, and there is a plan to construct 350 small diameter wells equipped with hand pumps annually.

There are also other agencies involved in the provision of clean water for the rural areas, but their inputs are relatively small. Hand pumps utilized by these agencies are of different prototypes. The five types of hand pumps which are widely used include: the Mineral Resource Department hand pump. Public Works Department hand pump, Health Department hand pump (Korat hand pump), ARD hand pump, local Administration Department hand pump. The Mineral Resources Department hand pump and the Public Works Department hand pump are the same prototype, and the Health Department, ARD and Local Administration Department are the Korat hand pump. Details of these hand pump types are given in Appendix A, and the Details Drawing are given in Volume 2 and 3.

1.2 Problem Identification

At present, about 19,000 hand pumps have been installed all over the country by the government agencies mentioned previously. Based on the random sampling survey conducted by NIDA, it is estimated that roughly 5,000 hand pumps are out of operation in any given day. This means that a wasteful capital investment for hand pump itself will be approximately US\$ 400,000 at a given time. Furthermore, the wells equipped with inoperative hand pumps will also be out of operation, and the capital investment cost of the wells ranging from US\$ 200-5,000 per well will also become worthless.

As a result of these inoperative hand pumps, the chance of supplying clean water to all rural communities will be lost. Moreover, a great number of wells have been constructed with community participation, in cash or in kind or both. Hence, villagers may view the loss of service as evidence that their contribution was a poor investment, thereby losing their regard for the operating agencies. In addition,

the operational failure of water wells will certainly induce psychological effects on the rural people, which may cause negative attitudes towards the Government as a whole.

The major problems which have been identified to be the causes of failure of hand pumps can be summarized as follows:-

(1) There are too many different types of hand pumps installed in rural communities. This results in difficulties for the local authorities as well as the villagers to maintain all of them because certain spare-parts of these pumps are not interchangeable.

(2) Hand pumps are not durable enough because of incompetent hand pump design.

(3) Quality of products is not good enough due to poor manufacturing quality control.

(4) Community participation in maintaining hand pumps is generally lacking.

(5) Some agencies have no maintenance units and facilities of their own for maintaining the installed pumps. Although maintenance units are available at other agencies, their capabilities are insufficient for servicing all the hand pumps which are in operation.

(6) There is no effective coordination of hand pump maintenance programmes among operating agencies at the grass-root level.

(7) Most hand pumps are installed in remote areas which are far from the responsible agencies, thereby making it difficult for the communities to communicate with the agencies when maintenance problems occur.

(8) Hand pump is presently installed improperly and not carefully enough, resulting in several defects and subsequent damages of the pumps.

(9) The budget allocated to each agency for operating preventive maintenance programmes is limited and not adequate.

(10) Spare-parts are not available on provincial and local markets due to shortage of manufacturers of these parts.

In summary, the failure of hand pumps in the country is generally caused by poor hand pump design, lack of effective maintenance strategies, lack of maintenance organization at a grass-root level, financial constraint, and shortage of spare-part manufacturers.

In order to solve the problems mentioned above a series of actions have to be taken and the improvement of hand pump design is considered to be the matter of the first priority. In This connection, the Office of Accelerated Rural Development approached UNICEF for financial assistance for the project of testing and evaluation of various types of hand pumps under field operations with the objectives as given below.

2. Objectives of Project

Specific objectives of the project are summarized as follows:

(1) To study actual utilization patterns of water obtained from hand-pump-equipped deep wells.

(2) To study performance, damages, and maintenance problems of various types of hand pumps which are being used in Thailand under actual field conditions.

(3) To improve installation, operation, maintenance, and repair techniques for each type of the existing hand pumps.

(4) To evaluate types of material used for the different types of the existing hand pumps and to compare their costs.

(5) To establish guidelines for hand pump maintenance.

(6) To improve hand pump design so that the improved hand pump will have the following characteristics: (i) withstand vigorous operation, (ii) operate easily, (iii) perform consistently with a considerable degree of durability, (iv) can be maintained locally, (v) has a low investment cost, and (v) become more versatile in its usage.

3. Programme of Work of Project

In order that the experimentation could be carried out to serve the objectives of the hand pump improvement project and to obtain data required for developing guidelines for hand pump maintenance, the project was divided into 10 major stages, (including (a) selection of sample deep wells, (b) deep well classification, (c) preparation of data recording forms, (d) hand pump installation, (e) data collection, (f) data analysis, (g) hand pump improvement, (h) installation of improved hand pumps, (i) monitoring of improved pump operation, and (j) evaluation and report).

The work schedule of this project is shown in Table 1. Details of each stage can be described as follows:

3.1 Deep Well Selection

The first stage of the project was to select deep wells for testing which were specified to have the following characteristics:-

(1) The wells which are located in Northeastern region where the majority of hand pumps were installed and the degree of water shortage is high and which are those considered to represent the wells existing in the region.

(2) The wells from which people obtained large amounts of water during most of the daytime in every day. The purpose was to test the installed hand pumps under heavy operational loads so as to obtain experimental data similar to those expected to be obtained under the actual operating conditions, and these data would be used in improving the pumps to make them applicable under various conditions.

(3) The wells which had different pumping levels ranging from 15 feet to more than 45 feet, in order to study their performance at these pumping levels.

Table 1

Work Schedule for Study Project

Task No.	Description	Time Period																			
		1977					1978						1979								
		J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J
a.	Selection of sample deep wells.	█	█	█																	
b.	Deep wells classification.				█																
c.	Preparation of data recording forms.					█															
d.	Installation of hand pumps.						█	█													
e.	Data collection.								█	█	█										
f.	Data analysis.											█									
g.	Improvement of hand pump.												█	█							
h.	Installation of improved hand pumps.														█						
i.	Monitoring of operation of new hand pumps.															█	█	█			
j.	Evaluation and report preparation.																		█	█	█

The time period required for this stage was 3 months, during which the survey was made of a total of 32 wells, of which 20 wells were selected for installation of the hand pumps to be tested.

3.2 Deep Well Classification

The deep wells selected for pump testing were classified into 5 groups according to their pumping levels:

- (1) Group 1: with pumping levels less than 15 feet,
- (2) Group 2: with pumping levels between 16-25 feet,
- (3) Group 3: with pumping levels between 26-35 feet,
- (4) Group 4: with pumping levels between 36-45 feet, and
- (5) Group 5: with pumping levels more than 45 feet.

The pumping level of a hand pump is defined as the static water level plus the draw down water level at a pumping rate of 5 gallons/minute (gpm).

This stage required approximately one month, mainly for reviewing characteristics of each deep well from its record. In addition, mapping of each selected deep well was carried out.

3.3 Preparation of Data Collection Forms

Data needed to be collected were divided into 5 categories, and the corresponding data collection forms were prepared, as follows:

(1) The form for recording daily water utilization: Details included in this form were related to hand pump operators (or individuals who fetched water with the aid of hand pump) such as sex, age, and data on hand pump operation including, number of operating strokes, operating period in each day, and type of water used (see details in Appendix C; Form Number C-1).

(2) The form for recording water utilization by each family: Significant details of this form were the number of persons in each family, volume of water used daily which was classified by type of water used and water sources, and means of water acquisition (see details in Appendix C; Form Number C-2)

(3) The form for recording operating time: Data collected included operating time of each operator, which was needed in analysing the length of time an operator had to wait before he could get water. This would also help in determining the appropriate number of operators per hand pump. (See details in Appendix C Form Number C-3)

(4) The form for recording data on the installation of the tested pumps: Data required were details relating to installation of different types of hand pumps, including the type of hand pump, length of time needed for installation, static water level, and characteristics of wells. (See details in Appendix C Form Number C-4)

(5) Repair report form: This form was used to gather such details as the date when a damage occurred, the date of commencement of repair, the date of completion, the total number of days needed for repair, the cost of accessories, details of damages found outside the hand pump before dismantling and of those found inside the pump after dismantling. (see details in Appendix C Form Number C-5)

This stage required about one month during which training of personnel assigned to the data collection task was carried out.

3.4 Hand Pump Installation

The purpose of the study was to investigate performance of the different types of hand pumps, namely (i) that of the Mineral Resources Department, (ii) that of the Public Works Department, (iii) that of the ARD which is the Korat hand pump, (iv) that improvised by the ARD Equipment Control Division (newly invented and never been tested before), and (v) that which is available on market (shallow well hand pumps).

As mentioned in Section 3.2, five groups of deep wells were selected for testing according to their pumping levels. Since the type of hand pump available on market is usually used for shallow wells, four of these pumps were installed at the wells of Group 2 (with the pumping levels ranging from 26-35 feet). As for the other types of hand pumps, four of each were installed as follows:

Type of Hand Pump	Number of Pumps Installed at the Groups of Deep Wells Mentioned in Section 3.2				
	Group 1	Group 2	Group 3	Group 4	Group 5
Mineral Resources Dept.	1	-	1	1	1
Public Works Dept.	1	-	1	1	1
Korat Hand Pump	1	-	1	1	1
ARD Equipment Control Division	1	-	1	1	1
Available on market	-	4	-	-	-

The time required for this stage was about two months which was used for teaming up personnel for hand pump installation and for collecting data relating to the installation.

3.5 Data Collection

(1) Data Collection Method

During this stage, data were collected using the different data forms mentioned in Section 4.3. An official was assigned to each of the selected hand pump to collect data for at least one month in the rainy season and for another month in the dry season, to be able to compare deep well water utilization in these two seasons. Other necessary data, such as installation details and repair data, were collected at appropriate time periods. For example, data on pump installation were gathered while the installation activities were being performed.

Besides, periodic inspections were undertaken to check defects of each type of hand pumps as well as to examine various deteriorating parts. In addition to the data collected during pump testing, data of other government agencies responsible for hand pump maintenance were requested and later used in comparison with the data collected during this test.

This stage required 10 officials to work in a period of about three months.

(2) Measures Taken to Minimize Influence of Factors Affecting Hand Pump Testing

The hand pump improvement project dealt primarily with field testing operations with the major purpose of obtaining data which are similar to those obtained under the actual operation of hand pumps as possible. However, previous experiences have shown that there are several uncontrollable factors which would affect the testing programme, and these can be described as follows:

(a) Attitude of operators towards hand pumps: It has been found that if villagers in a community have a good attitude towards the hand pump, they will operate the hand pump carefully and would not allow children to fool around with it. Additionally, they would be aware of the fact that the hand pump given by government should belong to the public or the village, thereby requiring their own proper attention and maintenance. On the other hand, if villagers have a negative attitude towards the pump, they will operate the hand pump without a proper care. They would be pre-occupied with the idea that the hand pump still belongs to the government and the government must be entirely and endlessly responsible for its maintenance.

(b) Character of community leader: If the community leader is a respectable person, such as a Buddhist monk or a village headman, the operators (or water users) would be very careful in operating the pump for fear of being reproached in case they cause any damages to the pump.

(c) Importance of hand pump: If a hand pump is installed at a community where deep well is the only water resource available, the hand pump would be regarded as very important, and it would receive good attention and care from villagers. On the contrary, if other water resources are also available, the importance of hand pump as a means of water acquisition would decrease.

(d) Education background: The education background of villagers is also important to the project. In general, people

with a higher level of education would stand a better chance to understand functions of the hand pump, and some may be able to examine or even repair defective and/or worn out parts. This would enable them to carry simple maintenance or minor adjustments to prevent undue damages. As for villagers who have little education, their capability in these aspects would also be little.

(e) Unity of village: Where the unity of a village is strong, villagers will share their responsibility in hand pump operation, and they may set up rules in using the hand pump by which they abide to obtain effective use of the pump. Some may even devote themselves to taking regular care of the pump.

(f) Tradition and culture of community: In most villages, children and teenagers still pay respect to grown-ups and the elderly. In such villages, children are generally taught not to fool around with the hand pumps, and damages to the pumps due to children are not common.

(g) Hand pump location: If a hand pump is located at or near the house of a respectable person of the community or in a wat, villagers are likely to use water pump more carefully and the children will not play near the pump. In addition, this respectable person will usually look after and maintain the hand pump himself.

(h) Number of government development projects in village: These projects may deal with rural youth development, occupational promotion, health development, and village water supply. Most of these projects also need cooperation from the community headman. In case there are too many projects in a village, the village headman would be unlikely to pay adequate attention to all of them. In case he disregards the importance of supply of domestic and portable water, hand pump maintenance may be seriously affected.

(i) Operation of Local government agencies: Hand pump maintenance will be carried out successfully if the responsible government agencies really pay attention to hand pump operation as well as maintenance.

From past experiences, it was expected during the planning stage of this study that the above-mentioned factors would likely affect results of hand pump field testing to varying degrees. Therefore, measures were taken during the study to decrease effects of these factors to the maximum extent possible, and these measures are described as follows:

(a) There must be no maintenance or adjustment of the hand pump during the field test.

(b) Villagers were allowed to use the hand pumps the way they used to do before the testing period began, even though they did it in an inappropriate or incorrect manner. Children were not prohibited from playing near or at the hand pump.

(c) When any damages occurred during the field test, the project official must be informed and he was the only person authorized to maintain the pump.

3.6 Data Analysis

All data collected were analysed according to the following types of data:

(1) Data Relating to Water Utilization:

Analysis was made of number and type of villagers using water with the aid of hand pump operation, purposes of water utilization, and utilization of water obtained from other resources as well as the type of villagers in this category.

(2) Data Concerning Hand Pumps

These were all the data required for hand pump design and improvement such as number of operating strokes, hand pump performance, volume of water per stroke, and repair and maintenance of different worn out parts of all types of hand pumps.

(3) Data Relating to Application, Maintenance and Repair

These data comprised locations of the installed hand pumps and persons who were in charge of hand pump operation.

3.7 Hand Pump Improvement

The major purpose of data collection and analysis for each type of hand pump was to find an appropriate measure to improve the pump. Redesign of worn out or defective parts, which depended on results of this study, would be aimed at meeting the following requirements:

(1) The cost must not be much higher than the cost of the old parts,

(2) Both repair and maintenance of the redesigned parts must be easier than before, and maintenance should require less effort or it should become virtually unnecessary,

(3) The new parts must be more durable and have longer life than the old one if they are operated under the same conditions,

(4) The improved parts must be able to be manufactured locally and/or available on the markets in provinces or districts, and the materials used must also be locally available,

(5) The improved parts must be able to replace the corresponding unimproved parts of each type of hand pump without a need for any modifications of any irrelevant parts, +

(6) The improvement must be compatible with character of operators, characteristics of water, and must not create any hazards. Specifically speaking, the following requirements must be met:

(i) Operating loads required must not exceed the capability of most hand pump operators,

(ii) All parts must not be easily loosened or removable, in order to prevent the parts from being removed as a toy or being taken apart accidentally or unintentionally,

(iii) All parts above the well must pose no danger to children,

(iv) The top part of the well must be tightly closed in order to prevent dirt or other materials from falling into the well which would contaminate water or become detrimental to the well,

(v) The hand pump handle must not be located higher than the average height of operators,

(vi) Any hand pump must be able to pump water from a deep well of a 80 feet depth which is the average maximum pumping level in Thailand.

3.8 Installation of New Improved Hand Pumps

At each selected well, a new improved hand pump will be installed to replace the old one. However, the new pump is to work under the same conditions as the previous pump, in order to be able to compare the function and performance of the old and new pumps. Hence, the same size and length of drop pipe are to be used. For this stage, a period of about one month and two official teams will be required for installation activities.

3.9 Monitoring of Improved Hand Pump Operation

In the monitoring stage, efforts will be made to collect technical data relating to operating load, water discharge per stroke, damaged and worn out parts, etc. When damages, deteriorating parts, or poor performance of parts were found, improvement will be carried out immediately. Results of the improvement will then be monitored after the new pump has been installed.

The time period required for this stage will be about three months during which inspections of the improved hand pump will be conducted regularly.

3.10 Evaluation and Report

When the improvement is found to yield satisfactory results, evaluation of data on the old and the improved hand pumps of each type will be made. In general, comparisons will be performed of the following aspects:

- (1) Frequency and details of damages,
- (2) Worn out parts,
- (3) Prices of the old and the improved hand pumps as well as their parts,
- (4) Number of parts,
- (5) Life of corresponding parts,

- (6) Preventive maintenance including effort required for each maintenance, equipment and materials used for each maintenance operation, and preventive maintenance the hand pumps,
- (7) Various types of expense of hand pumps, to evaluate total cost, initial cost, maintenance cost and repair cost, and cost per hour of operation of all types of pumps,
- (8) Difficulty in installation and repair,
- (9) Efficiency of operation including operating load in each operating period, operating time for each stroke, etc.

In addition to comparison among different types of the improved hand pumps and the old ones, the collected data will be used in determining design criteria for the new pumps. In particular, these useful data included: (i) number of strokes per day, (ii) appropriate operating load for each stroke, (iii) appropriate height of hand pump handle, (iv) appropriate amount of water discharge per stroke, and (v) appropriate size of cylinder.

The final report will also include detail drawings of existing hand pumps and details drawing of each part of the improved hand pumps. Time required for evaluation and report preparation will be about three months.

In summary, it required approximately one and a half years in carrying out this hand pump improvement project. The project was commenced in June 1977 and was continued through January 1979.

4. Summary and Analysis of the Basic Data

Data obtained after installation of various types of hand pumps are the basic data that had been collected after the completion of the fifth stage of this experimental project. Such data included water

utilization, hand pump operation and hand pump repair. As mentioned earlier, four pumps of each of the five different types were installed, making a total number of 20, and these pumps were used by villagers of 2,401 households (with an average household size of 6 persons) in 19 villages. The above-mentioned data are summarized and analysed as follows:

4.1 Water Utilization

Water utilization in the daily life of each family is not only for drinking and domestic purposes but also for animal raising and plant watering which are also essential. The major occupations in these families are relating mainly to farming, animal raising, and homelot gardening. The main sources of water include rainwater, shallow wells, deep wells, and natural ponds. Results of the study have shown that deep wells are the most popular source of water supply in these areas. Water utilization can be summarized in Table 2, which show the following finding:

(1) The average volume of water used for all purposes was 21.8 litres per household per day.

(2) The average water used for watering plants and homelot gardens was as high as about 31 percent of the total water used. This is due to the fact that household incomes in the study areas were relatively low, averaging approximately 8,000 baht per year. Thus each household had to depend upon crops from their homelot gardens as the main source of food supply to reduce daily living expenses.

(3) Water used for animal raising, which constituted about 18 percent of all the water utilized, was also important. This is because most families raise animals mainly for their labour in farming and to a lesser extent for food supply.

(4) Although the procedure of selecting the deep wells for testing led to the selection of the 19 villages where amounts of water obtained from deep wells were relatively large, it was found that deep well water made up only about half of the total amount of water utilized. This is

Table 2

WATER UTILIZATION

No. of Village 19

No. of Families 2,401

water resources Use of water	Quantity of water using in a day, litres					Total %
	Rain	Shallow well	Deep well	Others	Total	
Portable	77.5	4,150.0	1,922.0	330.0	6,479.5	12.39
Bath	12.0	1,946.5	9,141.0	671.5	11,771.0	22.50
Washing	4.0	1,805.5	5,886.5	408.0	8,104.0	15.49
For animals raising	-	2,524.0	5,268.0	1,708.5	9,500.0	18.16
For plant watering	-	5,503.0	3,166.5	7,788.5	16,458.0	31.46
Total	93.5	15,929.0	25,384.0	10,906.5	52,313.0	100.00

probably because these deep wells, which were equipped with hand pumps, could not supply all the water needed.

(5) With respect to drinking water, the results show that rural people prefer the water from shallow wells to that from deep wells, although they do realize that deep well waters are usually safer. This is likely because they are accustomed to the taste of shallow well water, and most of them feel that deep well waters are not palatable.

(6) Rainwater is found to be used to the least extent of all sources of water. This is due to the fact that it needs somewhat permanent containers to store the rainwater, and these containers are relatively expensive for most rural families.

4.2 Hand Pump Operation

Operation data comprised details of hand pump operators (or water fetchers) such as sex, age, and other data relating to the operation including of operating strokes by each operator, number of strokes the hand pump was operated each day, and volume of water pumped up each day. The summary of these data is shown in Table 3.

The findings obtained from analysis of the operation data are interpreted as follows:

(1) Most of hand pump operators, or about 85 percent, were women. This finding is considered common for rural areas in Thailand where women have to take care of most of household work including water fetching.

(2) About one third of hand pump operators were children with ages below 15 years, and this is also normal in rural areas where most of children in working ages are taught to help their parents in all activities in which they can participate. Hence, the hand pumps should be designed and installed in such a manner that they can be easily operated by working-age children. This means that proper considerations should be made of the following design criteria: the size of the hand pump

HAND PUMP OPERATION

Village name	Daily user				no. of user/day			distance (metre)			operating strokes			Average Quantity of water (litre)
	Female		male		ave.	max.	min.	ave.	max.	min.	ave.	max.	min.	
	child.	adult	child.	adult										
NHONG KUNG KEE KUANG	42.00	82.38	11.14	7.52	143	184	83	205	400	-	5,170	6,637	2,287	5,170
KOK SOONG	0.74	14.30	0.09	2.78	18	27	6	103	400	-	2,229	3,950	796	1,205
JODE YAI	10.46	13.21	1.90	4.00	30	119	5	214	400	-	2,103	11,365	446	1,137
NHONG SAUW	24.71	89.79	9.79	28.13	152	189	54	204	673	-	8,955	10,904	3,350	4,592
LAUW NA DEE	28.12	72.88	8.08	8.32	117	168	80	272	1,000	-	6,559	9,048	4,411	4,685
PIA PHARN	37.67	68.62	4.33	7.76	118	181	30	134	280	-	10,266	13,084	2,058	7,333
NON MUANG	23.53	37.78	8.99	6.70	77	143	18	133	300	-	2,601	3,445	1,212	1,561
NON SOM BOON (UD)	5.03	15.59	1.00	7.90	30	49	18	115	300	-	1,686	2,547	995	911
SAVANG VA REE	14.17	35.00	1.50	1.67	52	106	13	201	500	-	3,789	7,088	690	1,943
DAENG NOI	11.26	40.52	1.30	5.44	59	90	15	131	300	-	5,144	14,163	336	5,144
HIN LARD	35.23	69.82	5.77	14.55	125	209	37	82	225	-	5,685	9,943	1,700	4,061
HUEY JOE	19.79	10.89	1.18	2.86	35	75	17	150	300	-	3,693	7,739	1,772	1,996
BAN KHENG	2.77	13.43	2.40	7.43	26	35	10	91	240	-	3,042	4,709	972	3,042
BAN KAMIN	14.11	16.63	6.05	1.74	39	65	22	203	800	-	1,794	2,829	972	1,281
HUEY SANOOK	0.78	1.00	0.83	3.74	6	9	2	26	100	-	547	1,433	107	281
NON SOM BOON (KK)	16.83	17.00	3.75	2.13	40	68	18	50	200	-	3,752	6,868	1,566	1,924
SA PAN TONG	25.29	84.24	4.14	6.10	120	157	52	114	200	-	5,000	8,785	1,123	3,000
DONG CHANG	2.81	1.58	8.50	9.00	22	28	8	200	250	-	1,293	3,001	329	776
HUA NA KUM	15.15	24.68	5.15	3.53	49	114	9	260	800	-	1,275	2,991	232	1,275
Percent	26.29%	56.43%	6.83%	10.45%										
	82.72%		17.28%											

handle assemblies, the length of the handle, and the force to be exerted by the operator's hand in order to operate the hand pump.

(3) The maximum number of operating strokes of each hand pump was found to be 10,266 strokes/day, and the average was about 4,000 strokes/day. These data are useful bases in redesigning and improvement of the hand pumps, and emphasis should be made to manufacture a pump with low friction, wear and tear under the maximum operating load of not less than 10,000 strokes per day. For example, if a hand pump is to be designed or improved to have an operation life of at least 6 months, all parts of the hand pump must be designed or improved to withstand the maximum operating conditions of more than 1,800,000 strokes without any damages.

(4) The maximum walking distance from the operator's house to the deep well was 1,000 metres. Therefore, in selecting the site for drilling a deep well or for digging a shallow well in order to install a hand pump, the walking distance should also be considered as well. It is recommended that the walking distance should not exceed 500 metres and that the deep well should be drilled at or near the center of the village where the population is dense. However, other factors as previously stated in Section 5 should also be considered for well drilling site selection.

(5) As a result of relatively large numbers of the hand pump operators per day found in this study, it is indicated that one hand-pump-equipped deep well may not be sufficient for each village.

4.3 Hand Pump Capability, Mechanical Characteristics, Operating Force and Price of Hand Pump

This data are summarized for each type of the tested hand pumps in Table 4 through Table 7.

By comparison of the capability data among different types of hand pumps the results can be discussed as follows:

Table 4 Hand Pump Capability

Type of Hand Pump	Time Use Sec	Discharge litre	Operating stroke	Discharge Rate litre/min	Discharge Rate litre/stroke
Mineral Resources Dept.	30	20	20	40.0	1.000
Public Works Dept.	36	20	28	33.3	0.714
Korat Hand Pump	40	20	37	30.0	0.541
ARD Equipment Control Division	45	20	39	26.7	0.513

Table 5

Type of Hand Pump	Diameter of Cylinder inch	Stroke length inch	Mechanical Advantage
Mineral Resources Dept.	3	6	4
Public Works Dept.	3	6	4
Korat Hand Pump	3	4	6
ARD Equipment Control Division	3	2	8

Table 6

Type of Hand Pump	Operating Load per Head in Foot of Water	Operating Load per Head in Foot of Water When Mechanical Advantage = 4
Mineral Resources Dept.	0.4815	0.4815
Public Works Dept.	0.4710	0.4710
Korat Hand Pump	0.3226	0.4838
ARD Equipment Control Division	0.2212	0.4424

Table 7

Type of Hand Pump	Price Bath	Number of Parts
Mineral Resources Dept.	1,509	85
Public Works Dept.	1,643	85
Korat Hand Pump	1,500	89
ARD Equipment Control Division	2,200	72

(1) The Department of Mineral Resources (DMR) hand pump gives the highest water discharge not only in litres/minute but also in litres/stroke. This is because it has the longest pumping stroke as compared with those of the remaining three types. Although the DMR hand pump requires a longer time for each operating stroke, the pumping time does not vary directly with the time for each operating stroke. Other factors influencing the pumping time include operating force, mechanical advantage, pumps handle heights for operating comfort, and the arc swept by the end of the handle.

(2) The ARD Equipment Control Division hand pump requires the lowest operating force per one foot of the lifted water column at a given (adjusted) mechanical advantage. This means that this type of hand pump has the lowest friction losses at various contacting parts assuming that back leakage between the plunger and the cylinder wall during each pumping time is the same for all types of the tested pumps.

(3) In addition to the analysis of the basic data as stated in Items (1) and (2) above, the advantages and disadvantages of cylinder crank and the performance of these hand pumps can be compared as follows:

(a) Mineral Resources Department Hand Pump

Advantages:

(i) The air chamber helps maintain continuous flow of water instead of intermittent flow.

(ii) The hand pump handle is made of single piece of cast iron, with appropriate shape and size, which causes no pain to the operating hand, and the handle is long lasting.

Disadvantages

(i) The contact between the axle and bushing is a direct contact between the two metal parts, which causes rapid wear if lubrication is not carried out sufficiently.

(ii) There are several moving parts. If the axle becomes impaired the handle would move to and for horizontally, which would cause damages to other parts more easily.

(iii) The vertical movement of the pumping rod needs a sliding crosshead which is relatively loose. This would affect the vertical movement of the pumping rod, causing vibration while functioning. Thus, the pumping rod may become bent or worn out more easily.

(iv) The plunger could slam the upper and lower parts of the cylinder if it is not properly installed, and this would easily create damages to the cylinder and pumping rod.

(b) Public Works Department Hand Pump: Since the major characteristics of this type of hand pump are the same as those of the Mineral Resources Department pump, it has the same advantage and disadvantages as described above.

(c) Health Department Hand Pump. (Korat Hand Pump)

Advantages:

(i) Vertical movement of pumping rod depends on rack and pinion. The pinion sector rotates on the axle pin causing the rake to move up and down against two fixed rollers which lead to better vertical movement. This would result in less vibration at the pumping rod making it difficult to be bent or to be broken.

(ii) There are only a few moving parts subject to wear and tear.

(iii) There are shock absorbing springs to prevent the plunger from slapping upper and lower parts of the cylinder.

Disadvantages:

(i) There is no air chamber to keep water running continuously during the operation.

(ii) The handle and pinion sector are separate parts. Thus, pump operation easily causes damage to the handle at the point of contact between handle and pinion sector.

(d) ARD Equipment Control Division Hand Pump

Advantages:

(i) The ball bearing at rotating parts significantly minimize maintenance problems.

(ii) The use of crank shaft for fixing the highest and the lowest movement levels of the plunger can prevent plunger from slamming to the cylinder's upper and lower parts.

Disadvantages:

The disadvantages of this type of hand pump are exactly the same as those of the Korat Hand Pump.

The comparisons of advantages and disadvantages among different types of hand pumps as shown above are restricted to the upper part from the pump handle to the pump rod linkage mechanism. The lower part, which includes the drop pipe, pump rod, plunger and cylinder, is generally of the same character for all four types of hand pumps. As for this part, there is one obvious difference, i.e., the cylinders of the hand pumps of Mineral Resources and Public Works Departments are made of brass while those of the Health Department Type 608 and ARD Equipment Control Division are made of PVC. The brass cylinder is usually more durable than the PVC cylinder. Additionally, the PVC cylinder is more liable to damages when it is dismantled for maintenance because it can be broken while being tightened with excessive force.

4.4 Deterioration and Damages of Hand Pumps

The data on deterioration and damages of each type of hand pump were collected by each responsible maintenance unit during the testing period of this project. However, collection of these data has currently been continued even though the project has ended since January 1979. Based on the data gathered during the testing period, the following findings can be summarized:

(a) Mineral Resources Department Hand Pump

(i) Average number of operating strokes: 3,500 strokes per day.

(ii) Worn out parts:

1. Severe deterioration was found at the three rotating parts. The most severely worn out part was observed at the first rotating spot (see Illustration No. 1).

2. The cotter pin was missing.

3. All nuts became loosened.

(iii) Damage: The top rod was broken once.

(b) Public Works Department Hand Pump

(i) Average number of operating strokes: 3,500 strokes

(ii) Worn out parts:

1. Severe wear and tear were found at all of the three rotating spots especially at the first one (see Illustration No. 1).

2. The cotter pin was missing.

3. Various nuts became loosened.

(iii) Damage: The pump rod of one hand pump was broken at the coupling.

(c) Department of Health Hand pump (Korat hand pump)

(i) Average number of operating strokes: 2,400 strokes per day.

(ii) Worn out parts:

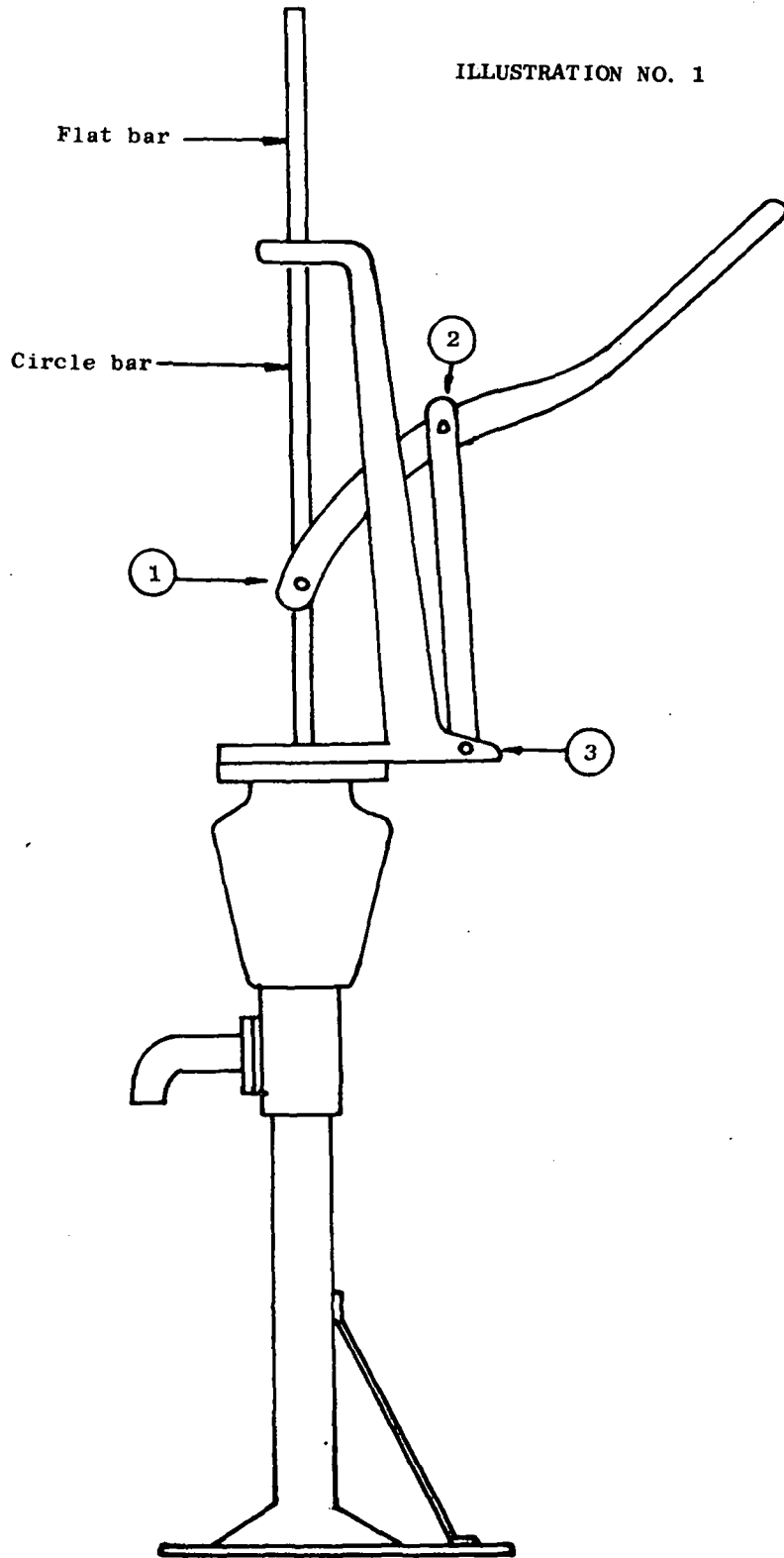
1. All of the rotating parts were found to be worn out especially the first rotating spot (see Illustration No. 2).

2. The pinion sector and the rack were slightly worn out.

3. The nut and the handle became loosened.

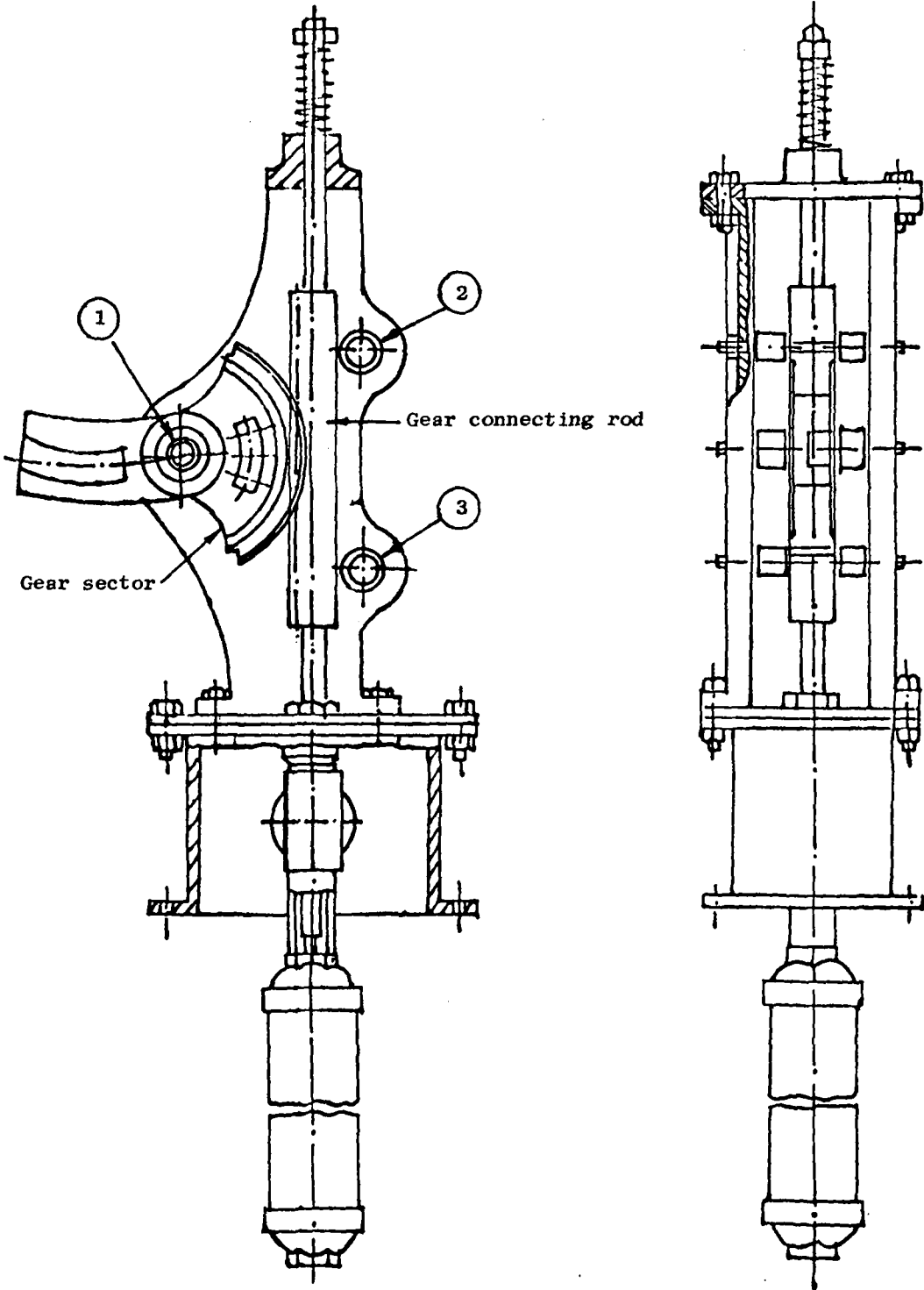
(iii) Damage: None was found.

ILLUSTRATION NO. 1



DMR HAND PUMP

ILLUSTRATION NO. 2



KORAT HAND PUMP

(d) ARD Equipment Control Division Hand Pump

(i) Average number of operating strokes: 4,200 strokes per day.

(ii) Worn out part: The crosshead was slightly worn out.

(iii) Damage: None was found.

5. Improvement of hand pump design5.1 Hand Pump Improvement

Analysis of data on worn out and damaged parts of each type of hand pumps was used as a guideline for its improvement. Based on the results of this study, each type of hand pumps was improved and then re-installed for further testing. These improvement were made separately for the two different parts of each pump, namely (i) the upper part from the pump body and hand pump handle down to the pump rod linkage mechanism, and (ii) the lower part including the pump rod, the coupling and, the cylinder assembly. Experiences of the hand pump testing programme have indicated that improvements of each hand pump type should be as follows:

(1) Improvement of Upper of Hand Pump(a) Mineral Resources and Public Works Department Hand Pumps

As previously stated, the characteristics of these two types of hand pumps are the same. Improvements made as follows:

(i) Use better grade nuts and bolts and put to every nut and bolt with lock washer in order to prevent from loosing

(ii) Strengthen the fulcrum link, by using a bigger one.

(iii) Add brass bushes into all bores that have moving parts in them, such as all bores in the handle, fulcrum link in order to lower the cost of repair (When a bore is deteriorated, it can be replaced easily by putting the new bush instead of changing the whole new part)

(iv) Change the top bar from a flat one to a circular one which allow to put coil springs into it to absorb impact during working.

(v) Change all pins from plain ones with holes for cotter pins locking into bolt and nut type pins in order to prevent them from loosing.

The revised hand pump details drawing are given in Appendix D.

(b) Department of Health Hand Pump (Korat Hand Pump)

Improvement were made as follows:

(i) Lengthen the strokes length to get more water per stroke by extending the fulcrum from the pump rod and, as a result modifications will be made of the following items.

1. Body frames.
2. Handle gear.
3. Gear connecting rod.

(ii) The pump base, which previously makes standing of the pump body and holds the lower part of hand pump, was improved by increasing the height and make it as a reservoir in order to get continuous flow of water, this improvement also make the upper part of the pump sealed no space for waste water or foreign matter fallen into the well as it has before.

(iii) Add ball bearing to the handle gear fulcrum, which is the most critical wear, this improvement also lower the force exerted at the pump handle.

(iv) Add brass bushes into all bores in the pump body frame, in order to lower the cost of repair as stated before.

(v) Strengthen and enlarge the handle so that it will last longer and can be operated easily.

The revised parts details drawing of the Korat pump are given in Appendix D.

(c) ARD Equipment Control Division Hand Pump

Improvement were made as follows:

(i) Lengthen the stroke length to get more water per stroke by extending the crank shaft in proportion to the connecting rod, and by lengthening the U - joints.

(ii) Improve the pump base in the same manner as described for the Health Department hand pump.

(iii) Strengthen the handle by making as Z - Sided assembly locked together by nuts and bolts.

The revised parts details drawing of this pump are given in Appendix D.

(2) Improvement of Lower Part of Hand Pump

As the lower part of all hand pump covered in this project are almost the same, the differences are the kind of material and some dimension of parts. So the improvements should be generally made the same as follows:

(i) Increase the size of the drop pipe from $1\frac{1}{4}$ inch to $1\frac{1}{2}$ inch in order to have enough room for a centering guide. (Except the Public Works Department hand pump which already has $1\frac{1}{2}$ inch drop pipe).

(ii) Use brass cylinder instead of PVC cylinder (Except the Mineral Resources Department and the public Works Department hand pumps which already have brass cylinder).

(iii) Increase the size of the pump rod from $\frac{7}{16}$ inch to $\frac{1}{2}$ inch.

(iv) Lengthen the pump rod coupling.

(v) Add a brass centering guide for the pump rod by put it in the drop pipe coupling between the ends of two pieces of pipes.

The details drawing of the revised lower parts of the pumps are given in Appendix D.

5.2 Data Collection and Analysis after Installation of Improved Hand Pumps

As states previously, different parts of each type of hand pumps were redesigned based on analysis of data on hand pump damages obtained from the field tests. These parts were manufactured, and the new improved hand pumps re-installed at corresponding testing locations and were then operated in the same manner as they were previously. The installation and testing plan are as follows:

<u>Type of pump</u>	<u>No. Installed</u>	<u>Testing Duration Day</u>	<u>Ave. Operating Stroke/Day</u>
Mineral Resources Dept.	1	60	2,484
Public Works Dept.			
Dept. of Health	2	60	5,790, 767
ARD Equipment Control Division	1	60	3,752

Data collection to be carried out during this testing period was properly planned so that the data can be used as the basis in making the following comparisons between the improved pumps and the corresponding old pumps:

- (1) Details of hand pump damages
- (2) Operating period when first observation of was made of deterioration
- (3) Total price of hand pump
- (4) Total number of parts
- (5) Operating ages of different parts

- (6) Preventive maintenance
- (7) Total cost (initial plus operating costs)
- (8) Operational efficiency

The details of these comparison are given in Appendix B.

6. Recommendations

As a result of the field testing, it is recommended that the DMR's hand pump and the Korat hand pump be used for the National Rural Water Supply Programme. Other types of hand pump should be eliminated from the programme.

Additionally results of this study have indicated that the improvement of hand pump operation has to take into account the hand pump itself and the other factors as well, i.e., the improvement of the well drilling plans and operations, as well as the maintenance and repair activities. The following are recommended.

6.1 Improvement of Hand Pump

With respect to the improvement of the hand pump, the related activities should include improvement of hand pump design, quality control of hand pump manufacture, and improvement of installation work.

(1) Improvement of Hand Pump Design

The following factors should be taken into consideration:

- (a) The improved hand pump should suit actual operating conditions in rural areas, i.e., (i) it should requires minimum maintenance, (ii) an operating time before its spare - parts have to be changed should standardized so that replacements can be done regulary even though, for some instance, significant wear and tear have not occurred, and (iii) spare - parts should be replaced easily and with low costs.

(b) The pump should be easy to operate with respect to the required operating force and the heights of the pump and its handle.

(c) The pump should not be too expensive.

(2) Quality Control of Hand Pump Manufacture

With regards to quality control, the items which should be considered carefully include manufacturing materials, size of each part, and the center line of the pump. All of the parts, including the plunger and cylinder assembly, the pump rod, pipes threads, and joints, should be inspected thoroughly before the pump is assembled.

(3) Control of Hand Pump Installation

Hand pump installation is one of the most important steps which determine the life of the pump. Poor installation can lead to a greater force to operate the pump and subsequent damages of the pump. Hence, hand pump installation should be carried out under supervision of experienced field personnel.

6.2 Hand Pump Programme

A hand pump programme normally includes the following activities: installation, maintenance, repair, and manufacture, for which recommendations can be described as follows:

(1) Hand Pump Installation

Due to the fact that installation of a hand pump by a well drilling operation unit can result in operational problems and damages, it is recommended the following steps be taken in installation of a pump:

(a) Check various parts of the hand pump to be installed, especially the plunger and cylinder assembly, the length, size and thread of the drop pipe; and the length of the pump rod (which should be compatible with the length of the drop pipe) Additionally, attempts should be made to avoid field cutting and joining of the

drop pipe. In other words, it is more appropriate to cut the pipe and standardize the thread for upper part of the pump rod at the operation unit or center, not in the field.

(b) Transportation of various parts of hand pumps from one unit to the operation site for installing should be carried out with care in order to avoid damages to the transported parts.

(c) Pipe connection and assembly of parts should be carried out correctly, with tools and accessories being used correctly for various tasks, especially in connecting the drop pipe with the pump rod which has to be screwed in tightly. In order to prevent undue wear and tear of the thread, which is one of the major problems causing the drop pipe and the pump rod to be broken, an appropriate pipe connection compound should be applied sufficiently at the thread.

(d) To facilitate hand pump operation, the pump handle should be located at an appropriate level neither too high nor too low from the ground level. By taking children operators into account, the maximum height of the handle should not exceed 1 meter.

(e) There should be a fairly wide concrete slab around the deep well provided with a proper drainage.

(f) After a hand pump has been installed, there must be neither holes nor leak to allow the water to flow back into the deep well nor an opening to allow undesirable materials such as pebbles or pieces of wood to fall or to be put into the well.

(g) The number of pieces of the drop pipe should be kept to a minimum and the length of the drop pipe should be more or less the same as the pumping level of the deep well. A drop pipe which is too long can easily cause damages to the drop pipe and pump rod due to excessive vibration.

(h) Records should be made for each deep well and hand pump installed, and should include details of the following items:

- (i) Type and model of the hand pump,
- (ii) Size, type and length of the drop pipe,
- (iii) Size and type of plunger and cylinder assembly,
- (iv) Size, type and length of the pump rod,
- (v) Size of the deep well,
- (vi) Static water level,
- (vii) Yield of the deep well,
- (viii) Draw down level, and
- (ix) Other related details.

(2) Improvement of Well Drilling Plan

Based on the present study, which comprised selection of deep wells for the testing programme, collection of daily water utilization data, and analysis of the data, the criteria for the deep well drilling plan for Thailand are recommended as follows:

(a) To establish an extensive plan for well drilling operation, a nation-wide master plan should be drawn up to suit local conditions such as the source and quality of ground water, and the number of population in each community. This plan should then be subdivided into three categories:

(i) A plan for drilling deep wells for agricultural water supply should be established for areas where the existing ground water resources are of high quality and ample quantity, and in areas where no sources of surface water are available. Where surface water is available development of such a source for irrigation water supply should be given a higher priority because its operating cost is much lower than that of a ground water supply system.

(ii) A plan for drilling community water supply deep well should be drawn up for fairly populous areas where the existing ground water sources are of high quality and sufficient quantity.

(iii) A plan for drilling deep well equipped with hand pumps should establish for areas where the existing ground water sources are of good quality and, where shallow wells can provide

sufficient supplies, they should be the first choice of development because operating costs of this third plan are extremely high.

After the master plan has already been established, the responsibility of well drilling operation of each responsible unit should be distinctively divided according to the objectives of the deep well. If there are many units having the responsibility for the same objective of the deep well in a province especially for drilling operation of hand-pump-installed deep wells for rural domestic water supply, such a responsibility should be assigned to the government unit that will be responsible for the whole area of the province. This would facilitate the repair and maintenance operation in the future because all hand pumps installed in a given province would be of the same type.

In case the plan for drilling operation can be divided according to the objective, of wells operating costs in each area would be lower than they are at present. For example, a hand-pump-installed deep well for domestic water supply usually require smaller casing, screen or slotted pipe than the well for the irrigation purpose. In this case, the purpose of the well drilling and development will be limited to obtaining a water yield which does not exceed the capacity of the hand pump.

(b) After the master plan has been established, the operation schedule for drilling hand-pump-installed deep wells for domestic water supply should be prepared based on the following criteria:

(i) Since the site to be selected for well drilling is the site where the hand pump is to be installed, it is necessary to take into account various factors that would affect maintenance of the pump. Additionally, it would be a worthwhile investment to install the hand pumps at the places where they will be utilized by as many people in the village as possible. The following are the criteria for selecting a drilling site:

1. The site should be located at the community center,
2. The site should be located near or in the public area under the responsibility of the respectable people. such as in the

temple boundary or in the area close to the village headman's house.

(ii) The total number of deep wells to be drilled for hand pump installation in each community should be large enough to be able to serve the population growth, in order to minimize the expenditure of future well drilling. If more than two hand-pump-installed deep wells are provided in each community, water shortage would not be a serious problem when one hand pump is out of order. It is suggested that the number of people to be served by a hand-pump-installed deep well should not exceed 300.

(3) Hand Pumps Maintenance and Repair

In most parts of rural areas in Thailand, maintenance and repair of hand pumps can be said to be a joint effort between the villages and the responsible agencies. For basic maintenance such as regular lubrication and minor repairs, the task can be assigned to responsible persons such as village chief (Kamnan), village headman (Pu yai ban), teacher or Buddhist monk. However, in case of major damages which are beyond the capacity of these people, including pump rod damage and pump failure, the responsible agency must be informed so that appropriate repairs can be made by experienced personnel of the agency.

In carrying out the above-mentioned joint effort, only a few practical guidelines for the basic maintenance and minor repairs are provided to the responsible villagers. Although maintenance and repair training courses for these people are sometimes arranged by some of the responsible agencies or units, these are not a regular undertaking. As for the maintenance programmes of the central responsible agencies, the operation can be divided into two systems. For the first system, which is employed by the Mineral Resources Department, mobile maintenance units are set up to monitor the performance of their own hand pumps, and to maintain and repair them when the needs arise. The other system is practised by the office of Accelerated Rural Development (ARD) and the Department of Health. In this latter case, each central responsible agency assigns the

maintenance and repair responsibility to its own local or the provincial units. By using this system, the maintenance and repair work of the ARD hand pumps is under the responsibility of the ARD provincial Chief who works at the Provincial Organization, which is a local administrative unit. Likewise, the Provincial Health Officer is responsible for the maintenance and repair work of the Public Health Department hand pumps in each province.

The current maintenance and repair programmes utilizing the joint effort as mentioned above factoring some problems. These include: (i) inadequate maintenance and repair capabilities of villagers, (ii) insufficient maintenance and repair budget allocated to each of the responsible agencies, and (iii) relatively poor quality of each type of hand pump. These problems have already been stated in the part relating to background of the problems, and can be divided into two major categories, namely administrative problems and technical problems. Results of field testing of this hand pump improvement project have indicated that the problems largely result from poor techniques which are to be solved according to recommendations given previously. However, once the technical problems have been solved, the associated administrative problems should also be solved, as follows:

(a) Management of Maintenance and Repair Work: This should be undertaken based on the following guidelines:

(i) Level of responsibility: there should be two levels of maintenance and repair responsibility: provincial and villages levels. This means that when a central responsible agency has installed hand pumps at deep wells, each of the deep wells should be officially handed over to the Changwat (Provincial) Organization. The Changwat Organization should then establish its own hand pump maintenance and repair units to execute the maintenance and repair activities in the entire province. However, the central agencies will provide the technical backstopping to the Changwat Organization.

With this arrangement, administrative problems will be reduced by a great extent because the Changwat Organization will be the sole agency responsible for maintenance and repair of all hand pumps in the province. As a result, the hand pump maintenance and repair programme will become more effective and economical. Travelling expenses, the main component of the overall expenditure, will be reduced substantially from those incurred under the current programme using mobile units which are responsible to the central responsible agencies.

(ii) Maintenance and repair budget: Sufficient maintenance and repair budget must be obtained each year. Records must be made of the existing number of hand pumps as well as the repair and maintenance costs to be used for determining the average repair and maintenance cost for each pump, and to prepare a correct budget statement for the following year. If possible, the budget should be allocated from the revenue of the Changwat Organization. However, if the budget is too large for the Changwat Organization to handle, the central responsible agency will have to be in charge of this matter by subsidizing the Changwat Organization with the amount of money estimated on the basis of the records of the number of hand pumps installed in that province and the average repair and maintenance cost per pump. Additionally, the budget should be large enough to be also able to cope with the projected or planned number of hand pumps to be installed in that fiscal year.

(iii) Designation of responsibility: Specific responsibilities should be designated to both the villagers and the local responsible units. At the village level, a capable villager should be selected to be responsible for the maintenance task, and his duties should include all simple maintenance activities. As for the work which is beyond this villager's capacity, this has to be handled by the local responsible unit in order to avoid undue damages to the hand pump and to prolong its life.

(iv) Operation schedule: The operation schedule for the work of the local responsible unit must be set up with due considerations, so as to obtain an effective and economical maintenance programme. This should include the time schedule for officials to go out to maintain each hand pump, the kind of each operation, and total expenditure for each operation. Such a local-level operation schedule should be prepared in advance to be used as the annual operation schedule.

(v) Personnel and appurtenances: Sufficient personnel, equipment and vehicles for local responsible unit should be estimated based on the operation schedule mentioned in Item (iv) above.

(vi) Sufficient stock of accessories and spare-parts of hand pumps should be provided to each local responsible unit, and this should also be estimated in advance using the above - mentioned operation schedule.

(vii) Records of hand pump maintenance and repair should be made on a regular basis and should be checked periodically for their correctness, and these records should be used for improvement of the maintenance and repair programme in the following years.

7. Conclusion

7.1 This handpump study dealt entirely with the field testing, the data collected were those obtained under the actual field conditions. These are considered excellent bases for the improvement of handpump design, handpump installation, well drilling plans and the plans for handpump maintenance and repair. However it is not possible to evaluate the effect of the water level on the force required to operate the handpump due to the fluctuation of water level in each well which was not controllable.

7.2 The findings and recommendations on the types of handpumps to be used for the National Water Supply Programme has been presented to the meeting among various agencies involved with the National Rural Water Supply Programme. The meeting agree that the DMR and the Korat handpumps be used for the National Rural Water Supply Programme as recommended until the better type of handpump is found.

APPENDIX A

CHARACTERISTICS OF HAND PUMPS CURRENTLY IN USE IN THAILAND

Several types of the existing hand pumps installed in Thailand are used by different government agencies which are responsible for deep well and shallow well provision in rural areas. Each agency has been trying to improve its own hand pump model, which can be either the one donated by foreign countries or that of its own invention.

To review the characteristics of the hand pumps currently in use in Thailand, different types of hand pumps are described as follows:

1. Mineral Resources Department Hand Pumps

The prototypes of the hand pumps used by this department are the Demster, Red Jacket or other hand pumps donated by, or procured from, the U.S. This type of hand pump has a 3-pin lever with a crosshead, and the cylinder which is generally has a plunger with 2 plunger cup seals and a valve poppet at the plunger. The lower valve is of the spring activated poppet type having a 3" cylinder, $\frac{7}{16}$ " pumping rod, and $1\frac{1}{4}$ " drop pipe (See Figure A-1).

2. Public Works Department Hand Pumps

The prototype of the pumps used by this department is the same as that of the Mineral Resources Department. It also has a 3-pin lever with a crosshead. The sizes of most parts are nearly the same as the Mineral Resources Department hand pump, but its $1\frac{1}{2}$ " drop pipe is slightly larger. (See figure A-2)

3. Health Department Hand Pumps (Korat hand pump)

The cylinder and the plunger of this type of hand pump are the separate parts. The rack and pinion were invented by Mr. Manop Suphaphan of the Health Department in late 1950's, and the hand pump is called the Korat hand pump, named after the second name of Nakhon Ratchasima Province where the Design is Originated (formerly Health Department Type 608).

The cylinder of this hand pump is similar to that of the Mineral Resources and Public Works Department hand pump, and has the following characteristics: 3" cylinder and $1\frac{1}{4}$ " drop pipe (See Figure A-3)

4. ARD Type

The prototype of this type of hand pump is the Korat hand pump, with a 3" cylinder made of PVC and a $1\frac{1}{4}$ " drop pipe (See Figure A-3).

5. Local Administration Department Hand Pumps

This type of hand pump is used for shallow wells. Its prototype is the Korat hand pump, with the cylinder and the drop pipe having the same sizes as those of the Korat hand pump (See Figure A-3)

6. ARD Equipment Control Division Hand Pumps

This type of hand pump is especially designed for testing purposes by the Equipment Control Division, Office of the Accelerated Rural Development. The pump is a rotary crank type, with the cylinder and other parts having the same sizes as those of Type 608. (See Figure A-4)

The above-mentioned hand pumps as well as their spare-parts, are usually not available on the market. The hand pumps which can be purchased on the market are those of the type having the cylinder integral with the pump body, and are used for shallow wells or deep wells with a pumping level of less than 25 feet. The pumps of this type are generally installed at small private tube wells having a diameter up to 2".

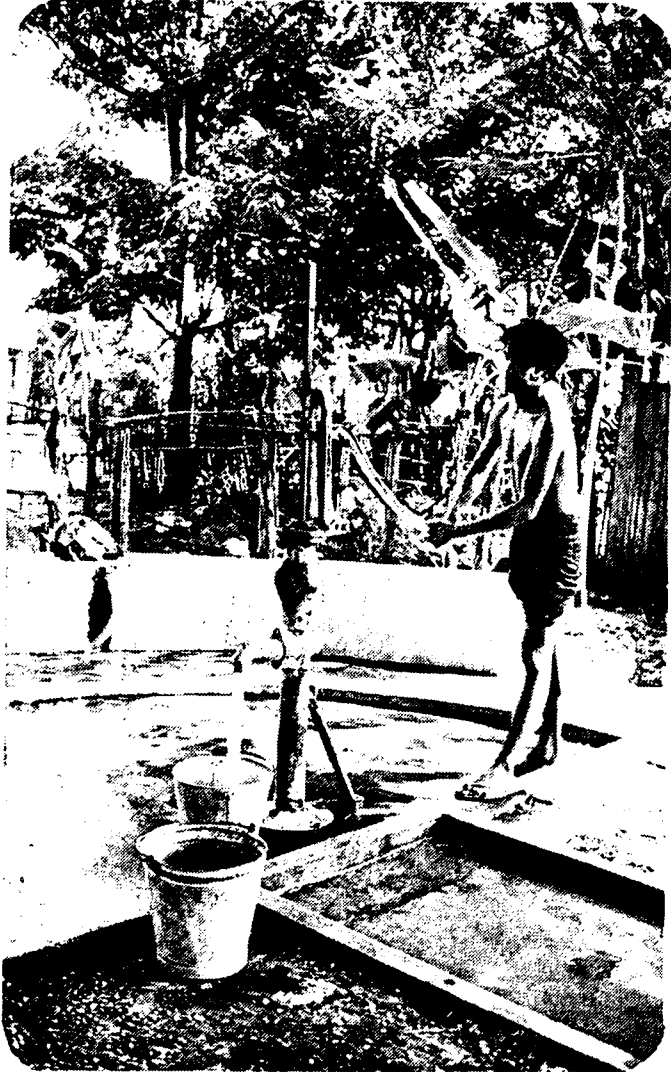


Figure A - 1

Mineral Resources Department Hand Pump



Figure A-2

Public Works Department Hand Pump

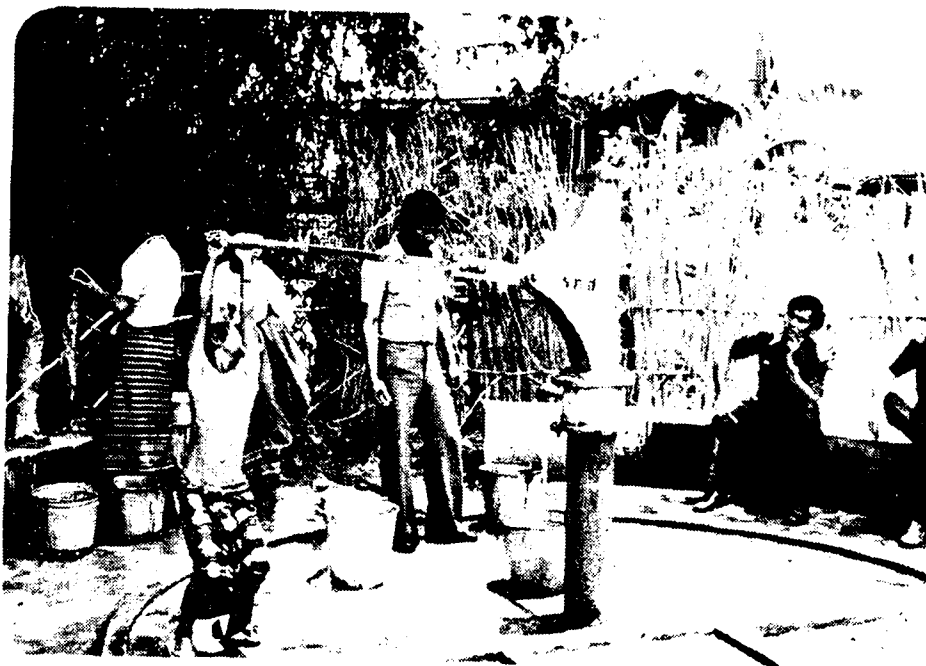


Figure A-3

Korat Hand Pump

(Health Reapartment, Local Administration Department and
ARD Hand Pumps)

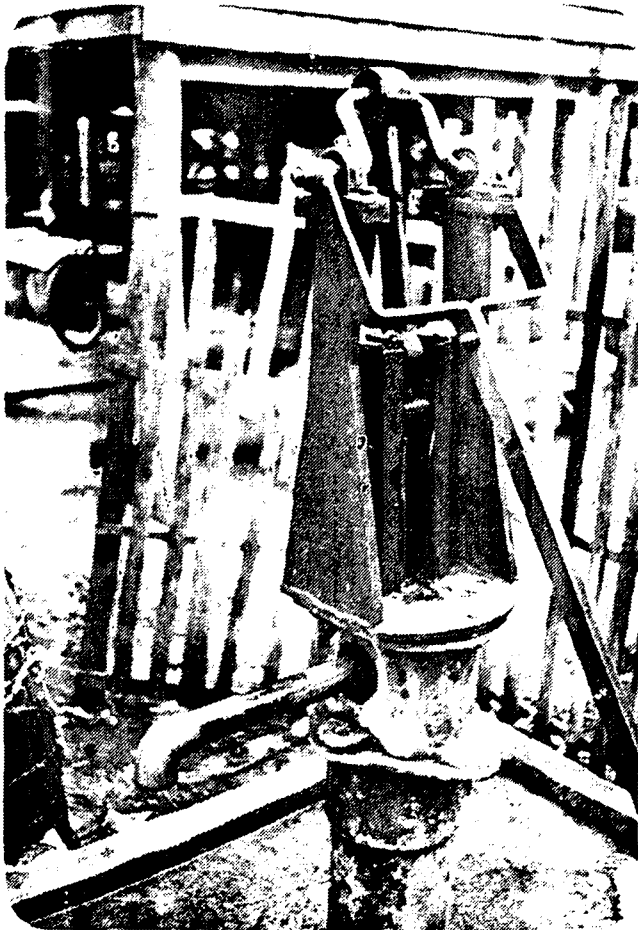


Figure A-4

ARD Equipment Control Division Hand Pump

APPENDIX B

COMPARISON BETWEEN OLD AND IMPROVED HAND PUMPS

1. Comparison of Details of Hand pump Damages.

TABLE B1 - 1

MINERAL RESOURCES DEPARTMENT HAND PUMP

• Operation Duration	Description of Damaged Part	
	Old Hand Pump	Improved Hand Pump
1 st month	No damage	No damage
2 nd month	No damage	No damage
3 rd month	Top rod was broken	No damage
4 th month	Pump rod was broken	No damage
5 th month	Plunger cup was worn out	Plunger cup was worn out
6 th month	Fulcrum link was broken	No damage

TABLE B1 - 2

HEALTH DEPARTMENT HAND PUMP (KORAT HAND PUMP)

Operation Duration	Description of Damaged Parts	
	Old Hand Pump	Improved Hand Pump
1 st month	Handle was broken	No damage
2 nd month	No damage	No damage
3 rd month	No damage	No damage
4 th month	Pump rod was broken	No damage
5 th month	Plunger cup was worn out	Plunger cup was worn out
6 th month	Cylinder was broken	No damage

TABLE B1 - 3ARD EQUIPMENT CONTROL DIVISION HAND PUMP

Operation Duration	Description of Damaged Parts	
	Old Hand Pump	Improved Hand Pump
1 st month	No damage	No damage
2 nd month	Handle was broken	No damage
3 rd month	No damage	No damage
4 th month	Pump rod was broken	No damage
5 th month	Plunger cup was worn out	Plunger cup was worn out
6 th month	Cylinder was broken	No damage

**2. Comparison of Operating Periods when First Observations
of Deterioration of Different Parts are Made**

TABLE B2 - 1

MINERAL RESOURCES DEPARTMENT HAND PUMP

Part	Period When Observation of First Deterioration Were Occured, month	
	Old Hand Pump	Improved Hand Pump
Flat bar	2	-
Guide Flat bar bushing	1	-
Circle bar	-	2
Circle bar bushing	-	1
Guide circle bar bushing	-	1
Fulcrum link	2	No.deterioration
Fulcrum link bush	-	1
Bottom fulcrum pin	2	2
Top fulcrum pin	2	2
Eye pump pin	2	2
Pump handle	2	No.deterioration
Pump handle bush	-	1
Plunger cup	2	2
Connecting rod guide	-	1

TABLE B2 - 2KORAT HAND PUMP

Part	Period When Observation of First Deterioration Were Occured, month	
	Old Hand Pump	Improved Hand Pump
Handle gear bush	1	-
Stud	2	2
Bush	1	1
Roller	2	2
Gear connecting rod	2	2
Gear tooth connecting area at handle gear and gear connecting rod	3	3
Piston seal or Plunger cup	2	2
Top connecting rod	2	2
Stuffing box plate	3	3
Connecting rod	2	2
Connecting rod guide	-	1

TABLE B2 - 3ARD EQUIPMENT CONTROL DIVISION HAND PUMP

Part	Period When Observation of First Deterioration Were Occured, month	
	Old Hand Pump	Improved Hand Pump
Crank shaft	2	2
Pump top connecting rod	2	2
Pump top connecting rod bushing	1	1
U-joint pin	2	2
Main bearing at body frame	No.deterioration	No.deterioration
Piston rod guide	1	1
Ball bearing	No.deterioration	No.deterioration
Handle	1	2
Piston seal or Plunger cup	2	2
Stuffing box plate	3	3
Connecting rod	2	2
Connecting rod guide	-	1

3. Comparison of Total Number of Parts of Hand Pump

TABLE B3COMPARISON OF TOTAL NUMBER OF PARTS OF HAND PUMP

Type of Hand Pump	No. of Parts per Set (at 60 ft. setting)	
	Old Hand Pump	Improved Hand Pump
Mineral Resources and Public Works Department Hand Pump	85	94
Korat Hand Pump	89	92
ARD Equipment Control Division Hand Pump	72	75

4. Comparison of Operating Ages of Hand Pumps

TABLE B4 - 1

MINERAL RESOURCES DEPARTMENT HAND PUMP

Part	Operating Age, month	
	Old Hand Pump	Improved Hand Pump
Pump top gasket	4	6
Flat bar	12	-
Circle bar	-	> 12
Circle bar bushing	-	6
Guide circle bar bushing	-	6
Fulcrum link	6	> 12
Fulcrum link bush	-	6
Bottom fulcrum pin	8	12
Top fulcrum pin	8	12
Eye pump pin	8	12
Pump handle	12	> 12
Pump handle bush	-	6
Cylinder gasket	4	6
Circle bar spring	-	6
Cylinder wire spring	8	12

Part	Operating Age, month	
	Old Hand Pump	Improved Hand Pump
Bolts & nuts	4	6
Connecting rode guide	8	12
Pump body	> 12	> 12
Base plate	12	12
Plain spout	> 12	> 12
Spout gasket	> 12	> 12
Pump top	> 12	> 12
Piston rod	depends on installing condi tion	> 12
Cylinder shell	> 12	> 12
Top cap	> 12	> 12
Bottom cap & inlet valve seat	> 12	> 12
Inlet valve housing	> 12	> 12
Inlet valve	> 12	> 12
Inlet valve lining	> 12	> 12
Plunger follower	> 12	> 12

Part	Operating Age, month	
	Old Hand Pump	Improved Hand Pump
Plunger cup spacer	> 12	> 12
Plunger valve	> 12	> 12
Plunger cup	4	6
Plunger cage	> 12	> 12
Plunger rod	depends on installing condition and water properties	
Pipe	depends on installing condition and water properties	
Coupling	8	12

TABLE B4 - 2

KORAT HAND PUMP

Part	Operating Age, month	
	Old Hand Pump	Improved Hand Pump
Body	> 12	> 12
Handle gear	12	> 12
Gear connecting rod	6	12
Connecting rod	6	12
Top connecting rod	6	12
Stuffing box plate		
Pump base	> 12	> 12
Spring	3	6
Bush	3	6
Stud	6	12
Cover	> 12	> 12
Handle gear bush	3	-
Pipe	depends on installing condition and water properties	
Pipe coupling	6	12
Hex. coupling	6	12

Part	Operating Age, month	
	Old Hand Pump	Improved Hand Pump
Cylinder	3	6
Top cap	> 12	> 12
Low cap	> 12	> 12
Plunger	> 12	> 12
Poppet valve	> 12	> 12
Piston	> 12	> 12
Spring cover	> 12	> 12
Spring	6	12
Piston seal	3	6
Ball bearing	-	6
Connecting rod guide	-	12

TABLE B4 - 3

ARD EQUIPMENT CONTROL DIVISION HAND PUMP

Part	Operating Age, month	
	Old Hand Pump	Improved Hand Pump
Body frame	> 12	> 12
Crank shaft	6	> 12
Ball bearing	6	6
Pump top connecting rod	12	12
U-joint	12	12
U-joint pin	6	12
Handle	3	6
Pump top connecting rod bush	3	-
Pipe	depends on installing condition and water properties	
Pipe coupling	4	4
Hex. coupling	6	12
Cylinder	3	6
Top cap	> 12	> 12
Low cap	> 12	> 12
Plunger	> 12	> 12

Part	Operating Age, month	
	Old Hand Pump	Improved Hand Pump
Poppet valve	> 12	> 12
Piston	> 12	> 12
Spring cover	> 12	> 12
Spring	6	12
Piston seal	3	6
Connecting rod guide	-	12

5. Comparison of Maintenance Data of Hand Pumps

TABLE B5 - 1MINERAL RESOURCES DEPARTMENT HAND PUMP

Maintenance Period	Description	Material Used
<u>OLD HAND PUMP</u>		
1 week	<ul style="list-style-type: none"> - Grease all fulcra and contact area - Tighten all bolts and nuts 	<ul style="list-style-type: none"> - Grease - Damage bolt or nut was replaced by the new ones.
2 month	<ul style="list-style-type: none"> - Inspect all parts of hand pump installed upper ground level. 	<ul style="list-style-type: none"> - Damage part was replaced by the new ones.
4 month	<ul style="list-style-type: none"> - Inspect all parts. 	<ul style="list-style-type: none"> - Parts would be replaced; <ul style="list-style-type: none"> - bolts and nuts - gasket and plunger cup
8 month	<ul style="list-style-type: none"> - Inspect all parts. 	<ul style="list-style-type: none"> - Parts would be replaced; <ul style="list-style-type: none"> - all fulcrum pin - coupling - cylinder wire spring
<u>IMPROVED HAND PUMP</u>		
1 week	<ul style="list-style-type: none"> - Grease all fulcra and contact area - Tighten all bolts and nuts 	<ul style="list-style-type: none"> - Grease - Damage bolt of nut was replaced by the new ones.
3 month	<ul style="list-style-type: none"> - Inspect all parts of hand pump installed upper ground level. 	<ul style="list-style-type: none"> - Damage part was replaced by the new ones.

Maintenance Period	Description	Material Used
6 month	- Inspect all parts	- Parts would be replaced; - bolts and nuts - gasket and plunger cup - all bushing - circle bar spring
12 month	- Inspect all parts	- Parts would be replaced; - all fulcrum pin - coupling - connecting rod guide - cylinder wire spring

TABLE B5 - 2

KORAT HAND PUMP

Maintenance Period	Description	Material Used
	<u>OLD HAND PUMP:</u>	
1 week	<ul style="list-style-type: none"> - Grease all fulcra and contact area - Tighten all bolts and nuts 	<ul style="list-style-type: none"> - Grease - Damage bolt or nut was replaced by the new ones.
1 month	<ul style="list-style-type: none"> - Inspect all parts of hand pump installed upper ground level 	<ul style="list-style-type: none"> - Damage part was replaced by the new ones
3 month	<ul style="list-style-type: none"> - Inspect all parts. 	<ul style="list-style-type: none"> - Parts would be replaced; <ul style="list-style-type: none"> - bolts and nuts - gasket and piston seal - cylinder - all bushing - spring at the top of the pump
6 month	<ul style="list-style-type: none"> - Inspect all parts. 	<ul style="list-style-type: none"> - Parts would be replaced; <ul style="list-style-type: none"> - rollers and studs - coupling - cylinder wire spring
	<u>IMPROVED HAND PUMP</u>	
1 week	<ul style="list-style-type: none"> - Grease all fulcra and contact area 	<ul style="list-style-type: none"> - Grease
3 month	<ul style="list-style-type: none"> - Inspect all parts of hand pump installed upper ground level 	<ul style="list-style-type: none"> - Damage part was replaced by the new ones.

Maintenance Period	Description	Material Used
6 month	- Inspect all parts	- Parts would be replaced; - bolts and nuts - gasket and piston seal - cylinder - all bushing - ball bearing - spring at the top of the pump
12 month	- Inspect	- Parts would be replaced; - rollers and studs - coupling - connecting rod guide - cylinder wire spring

TABLE B5 - 3

ARD EQUIPMENT CONTROL DIVISION HAND PUMP

Maintenance Period	Description	Material Used
	<u>OLD HAND PUMP</u>	
1 week	<ul style="list-style-type: none"> - Grease all fulcra and contact area - Tighten all bolts and nuts 	<ul style="list-style-type: none"> - Grease - Damage bolt or nut was replaced by the new ones
1 month	<ul style="list-style-type: none"> - Inspect all parts of hand pump installed upper ground level. 	<ul style="list-style-type: none"> - Damage part was replaced by the new ones.
3 month	<ul style="list-style-type: none"> - Inspect all parts 	<ul style="list-style-type: none"> - Parts would be replaced; <ul style="list-style-type: none"> - bolts and nuts - gasket and piston seal - cylinder - bushing
6 month	<ul style="list-style-type: none"> - Inspect all parts 	<ul style="list-style-type: none"> - Parts would be replaced; <ul style="list-style-type: none"> - studs or pins - ball bearing - coupling - cylinder wire spring
	<u>IMPROVEMENT HAND PUMP</u>	
1 week	<ul style="list-style-type: none"> - Grease all fulcra and contact area - Tighten all bolts and nuts. 	<ul style="list-style-type: none"> - Grease - Damage bolt all nut was replaced by the new ones.

6. Comparison of Total Cost of Hand Pumps

TABLE B6 - 1INITIAL COST

Type of Hand Pump	Initial Cost, Baht	
	Old Hand Pump	Improved Hand Pump
Mineral Resources Dept. Hand Pump	1,509.-	2,100.-
Public Work Dept. Hand Pump	1,643.-	.
Korat Hand Pump	1,500.-	2,500.-
ARD Equipment Control Division Hand Pump	2,200.-	3,000.-

TABLE B6 - 2OPERATING COST

Type of Hand Pump	Operating Cost, Baht/month	
	Old Hand Pump	Improved Hand Pump
Mineral Resources and Public Works Department Hand Pumps	60	50
Korat Hand Pump	50	40
ARD Equipment Control Division Hand Pump	40	30

7. Comparison of Man-Hours for Dismantling and Installation

TABLE B7COMPARISON OF MAN-HOURS FOR DISMANTLING AND INSTALLATION

Type of Hand Pump	Man-Hours Required for Dismantling and installation/one time	
	Old Hand Pump	Improved Hand Pump
Mineral Resources and Public Works Department Hand Pumps	6	8
Korat Hand Pump	5	7
ARD Equipment Control Division Hand Pump	5	7

8. Comparison of Operational Efficiency

TABLE B8 - 1MINERAL RESOURCES AND PUBLIC WORKS DEPARTMENT HAND PUMPS(Cylinder depth....⁶⁰.....feet)

Description	Old Hand Pump	Improved Hand Pump
Force exerted at the pump handle, kg	26.0	16.6
Pumping capacity, litres/stroke	1	1.136
Operating time, sec/stroke	1.5	1.193

TABLE B8 - 2KORAT HAND PUMP

Description	Old Hand Pump	Improved Hand Pump
Force exerted at the pump handle, kg	7.0	17.6
Pumping capacity, litres/stroke	0.71	1.227
Operating time. sec/stroke	1.3	1.571

TABLE B8 - 3ARD EQUIPMENT CONTROL DIVISION HAND PUMP

Description	Old Hand Pump	Improved Hand Pump
Force exerted at the pump handle, kg	10.0	16.8
Pumping capacity, litres/stroke	0.51	0.909
Operating time, sec/stroke	1.15	1.436

APPENDIX CDATA COLLECTION FORMS

Form no. C-2

Daily Water Utilization by Each Family

1. House no.
2. No. of member....., male.....,female.....
3. Daily water usage:
 - 3.1 Portableunit
 - rain
 - local water supply
 - shallow well distance from house to well:..... meter
 - deep well distance from house to well:..... meter
 - pond
 - other.....
 - 3.2 bath.....unit
 - local water supply
 - shallow well
 - deep well
 - pond
 - other.....
 - 3.3 washingunit
 - local water supply
 - shallow well
 - deep well
 - pond
 - other.....
 - 3.4 for animals.....unit
 - shallow well
 - deep well
 - pond
 - other
 - 3.5 for agriculture
 - shallow well
 - deep well
 - pond
 - other

Form no. C-3

Operating Time Record

No. of Member	Time (O'clock)		
	arrive	begin to operate	finished

Form no. C - 4

Installation Record

Well no..... No. of Testing Group.....

Name of Village

Tam Bon

Amphur

Changwat

Type of Hand Pump

Depth of SettingFt.

Static Water LevelFt.

Time Needed for InstallationMan-Hours.

Well characteristics.....
.....
.....
.....

Form no. C-5

Repair Record

Well no.....

Date that damage occurred.....

Date of commence repair

Date of completion

Damage found outside of hand pump before dismantle

1.

2.

3.

4.

5.

Damage found inside after dismantle

1.

2.

3.

4.

5.

Total days for repair

No. of man-hours.....

Cost of accessories

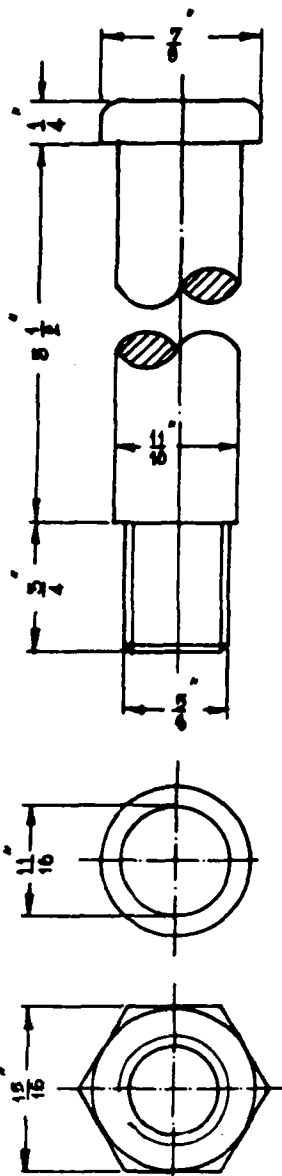
APPENDIX D

REVISED PARTS DRAWING

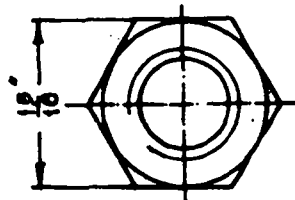
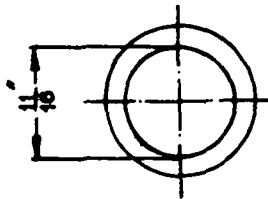
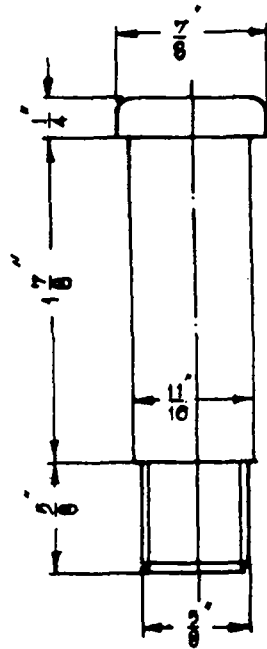
1. Revised Parts Details Drawing

Department of Mineral Resources Type.

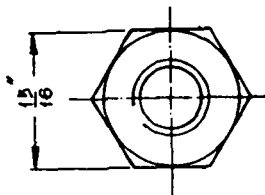
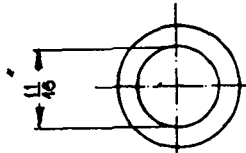
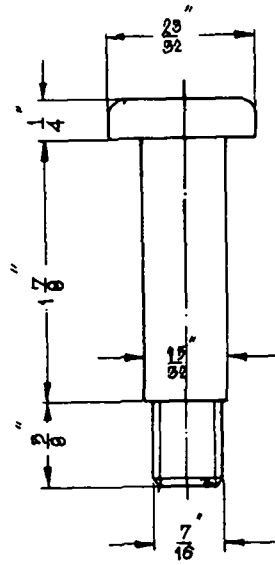




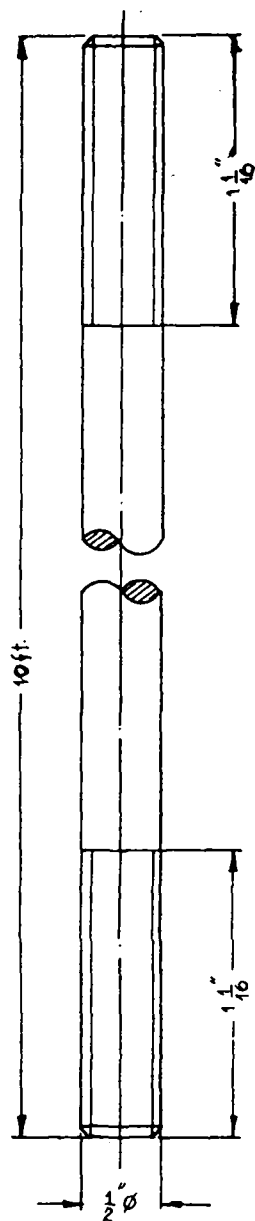
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PART NAME	BOTTOM FULCRUM PIN		
SCALE	1 : 1	MATERIAL	STEEL



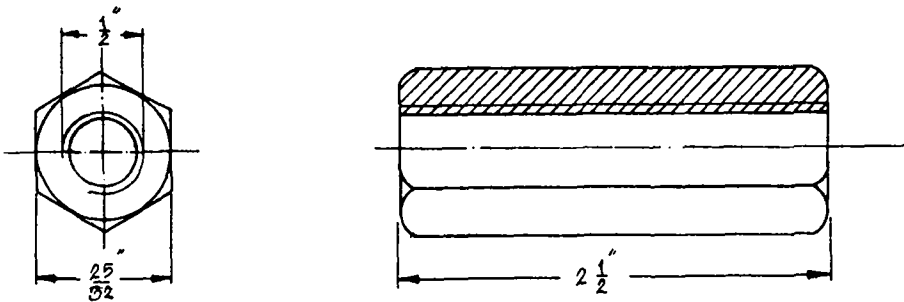
TYPE	DEPARTMENT OF MINERAL RESOURCES(REVISED)		
DRAWING NO.	01 - 16 - R	PART NO.	21 - R
PART NAME	TOP FULCRUM PIN		
SCALE	1 : 1	MATERIAL	STEEL



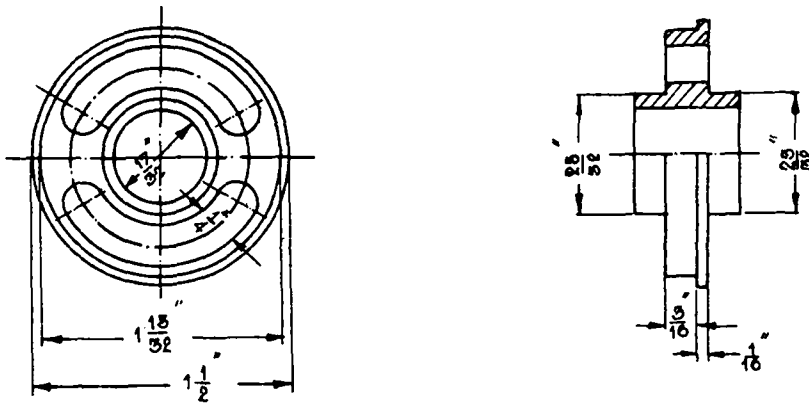
TYPE	DEPARTMENT OF MINERAL RESOURCES(REVISED)		
DRAWING NO.	01 - 17 - R	PART NO.	22 - R
PART NAME	EYE PUMP PIN	MATERIAL	STEEL
SCALE	1 : 1	DRAWN BY	



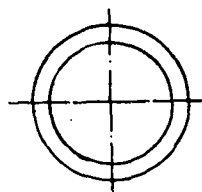
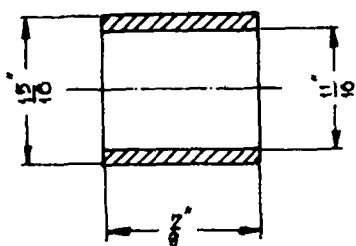
TYPE	DEPARTMENT OF MINERAL RESOURCES (REVISED)		
DRAWING NO.	01 - 34 - R	PART NO.	41 - R
PART NAME	PLUNGER ROD	MATERIAL	STEEL
SCALE	1 : 1	DRAWN BY	



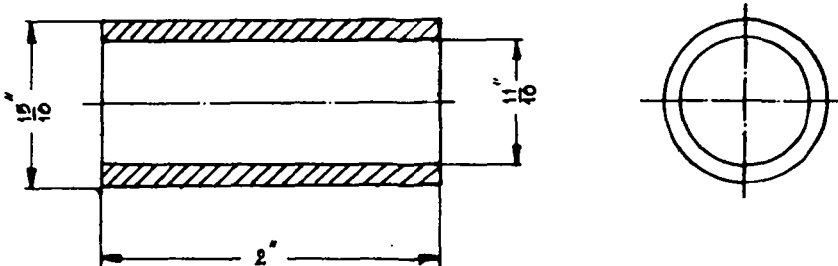
TYPE	DEPARTMENT OF MINERAL RESOURCES (REVISED)		
DRAWING NO.	01 - 36 - R	PART NO.	44 - R
PART NAME	COUPLING	MATERIAL	STEEL
SCALE	1 : 1	DRAWN BY	



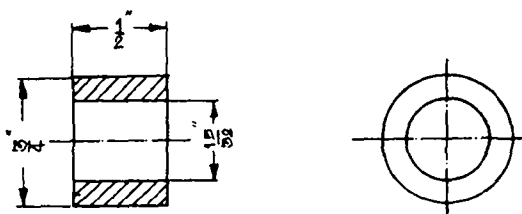
TYPE	DEPARTMENT OF MINERAL RESOURCES(REVISED)		
DRAWING NO.	01 - 37 - R	PART NO.	45
PART NAME	CENTERING GUIDE MATERIAL	MATERIAL	BRASS
SCALE	1 : 1	DRAWN BY	



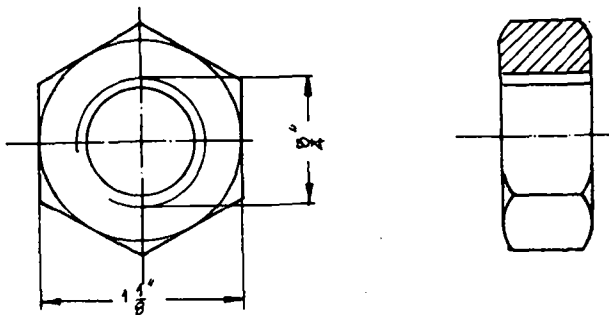
TYPE	DEPARTMENT OF MINERAL RESOURCES (REVISED)		
DRAWING NO.	01 - 38 - R	PART NO.	46
PART NAME	PUMP HANDLE BUSH		
SCALE	1 : 1	MATERIAL	BRASS



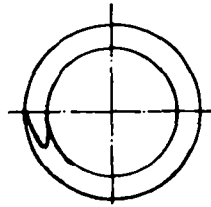
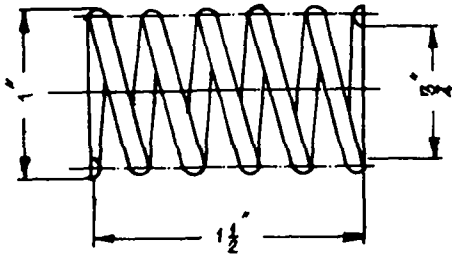
TYPE	DEPARTMENT OF MINERAL RESOURCES (REVISED)		
DRAWING NO.	01 - 39 - R	PART NO.	47
PART NAME	FULCRUM LINK BUSH		
SCALE	1 : 1	MATERIAL	BRASS



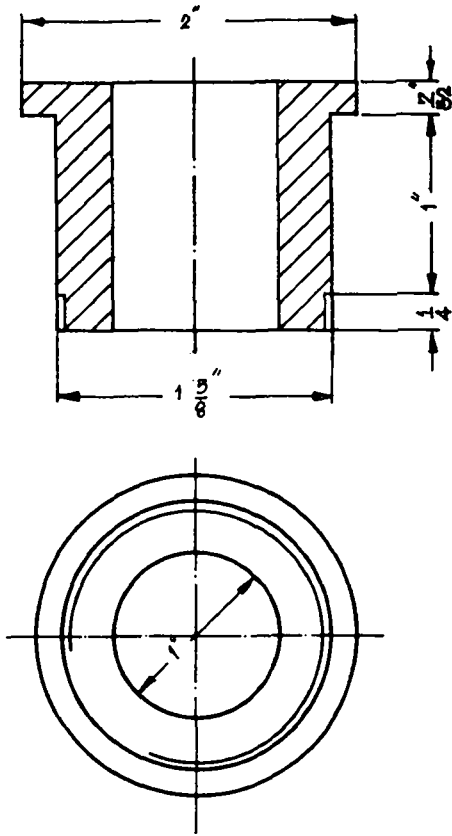
TYPE	DEPARTMENT OF MINERAL RESOURCES (REVISED)		
DRAWING NO.	01 - 40 - R	PART NO.	48
PART NAME	CIRCLE BAR BUSHING		
SCALE	1 : 1	MATERIAL	BRASS



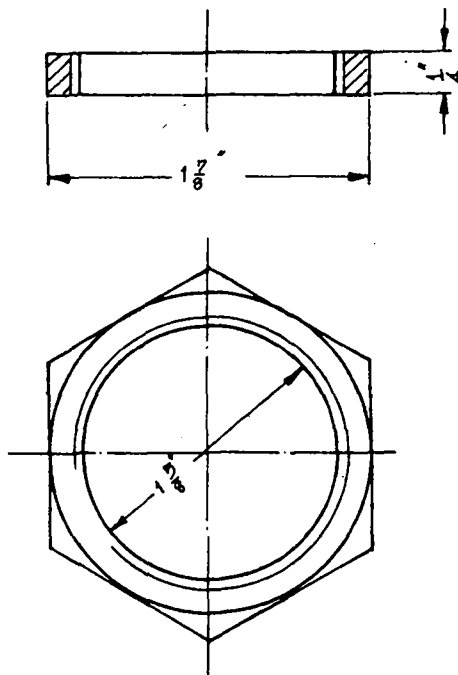
TYPE	DEPARTMENT OF MINERAL RESOURCES (REVISED)		
DRAWING NO.	01 - 41 - R	PART NO	49
PART NAME	CIRCLE BAR LOCK NUT		
SCALE	1 : 1	MATERIAL	STANDARD



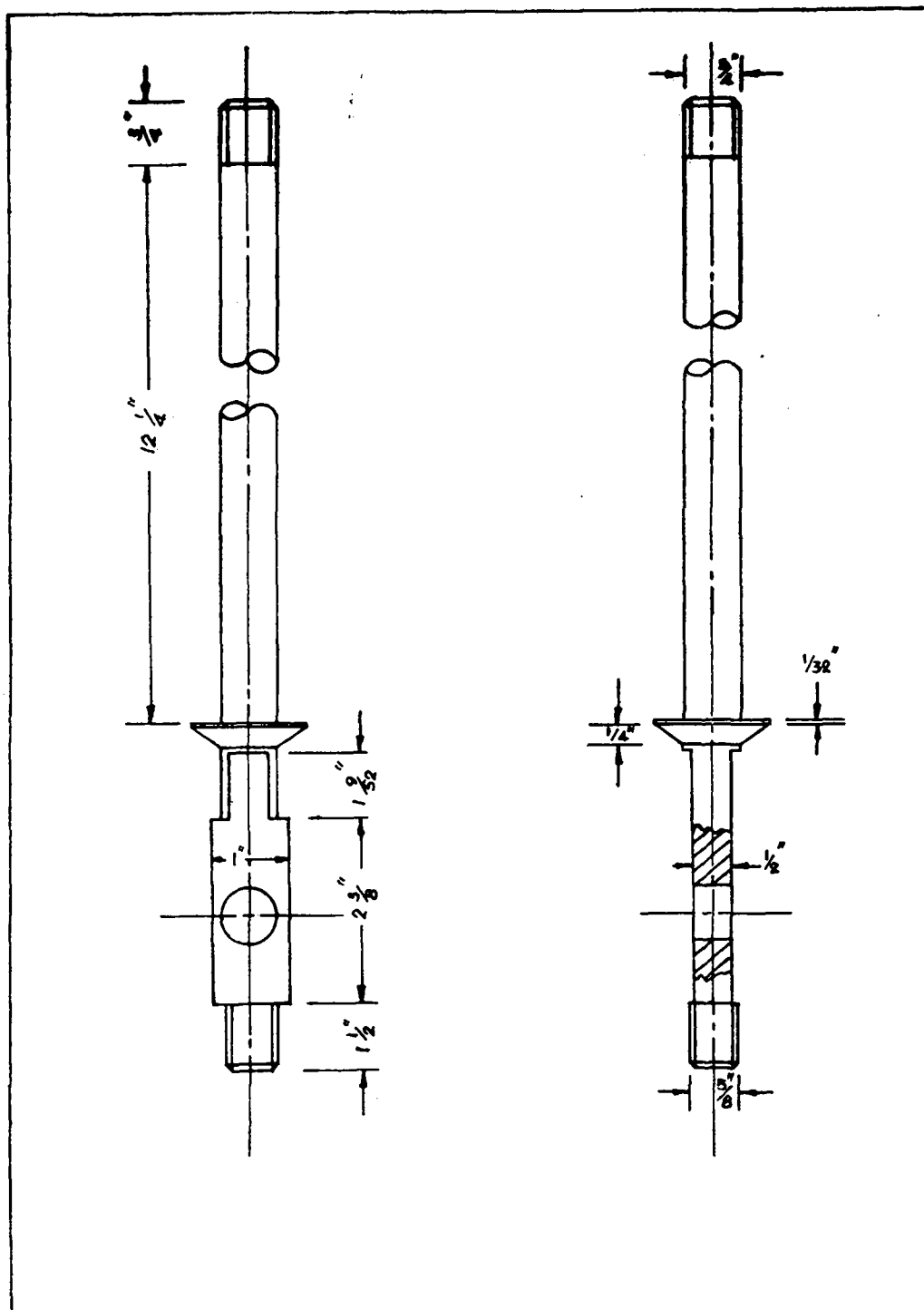
TYPE	DEPARTMENT OF MINERAL RESOURCES(REVISED)		
DRAWING NO.	01 - 42 - R	PART NO.	50
PART NAME	CIRCLE BAR SPRING		
SCALE	1 : 1	MATERIAL	SPRING WIRE



TYPE	DEPARTMENT OF MINERAL RESOURCES(REVISED)		
DRAWING NO.	01 - 43 - R	PART NO.	51
PART NAME	GUIDE CIRCLE BAR BUSHING		
SCALE	1 : 1	MATERIAL	BRASS



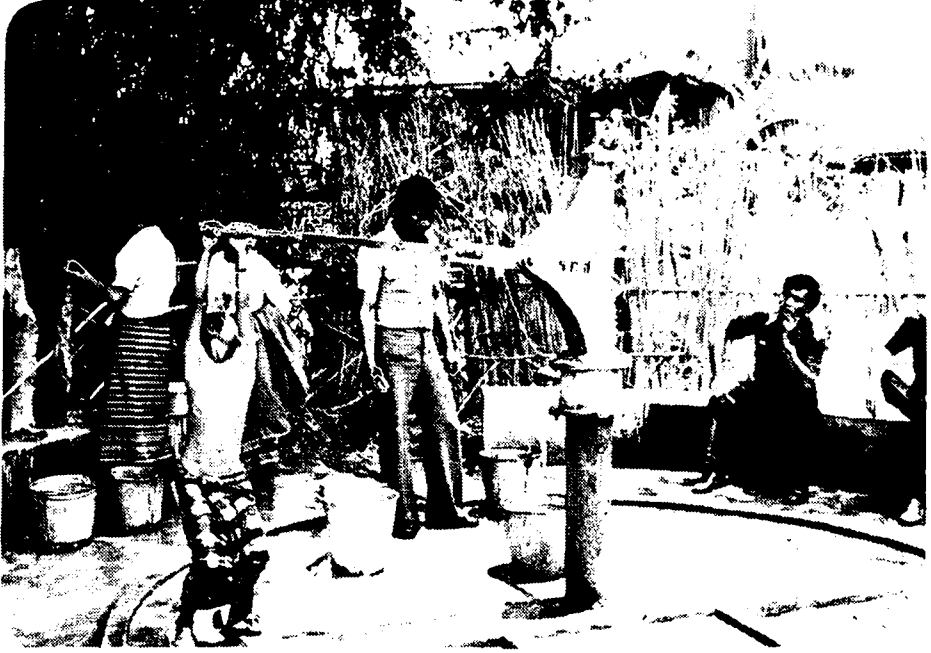
TYPE	DEPARTMENT OF MINERAL RESOURCES(REVISED)		
DRAWING NO.	01 - 44 - R	PART NO.	52
PART NAME	GUIDE CIRCLE BAR BUSHING LOCK NUT		
SCALE	1 : 1	MATERIAL	BRASS

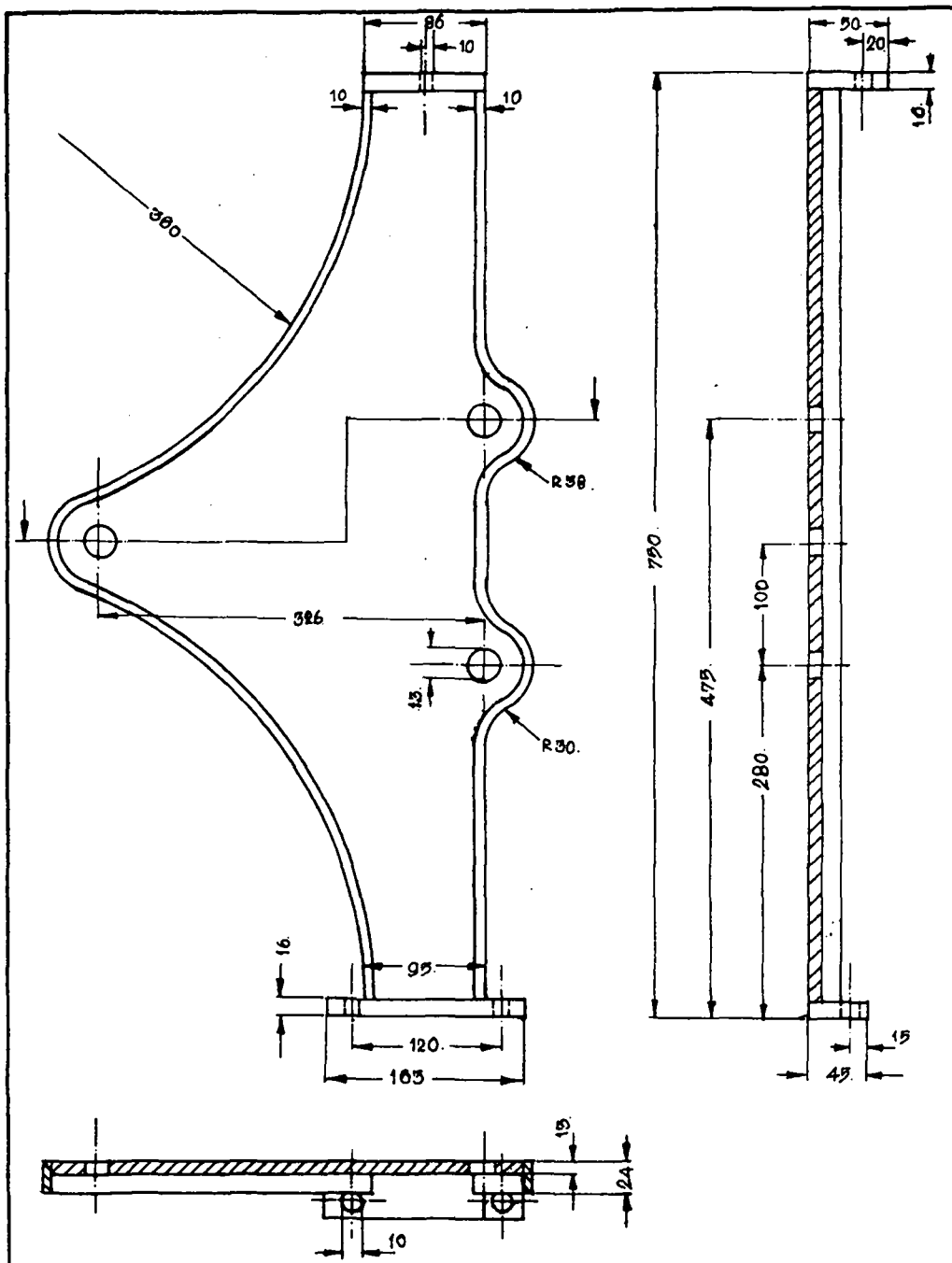


TYPE	DEPARTMENT OF MINERAL RESOURCES(REVISED)		
DRAWING NO.	01 - 45 - R	PART NO.	53
PART NAME	CIRCLE BAR	MATERIAL	STEEL
SCALE	1 : 2	DRAWN BY	

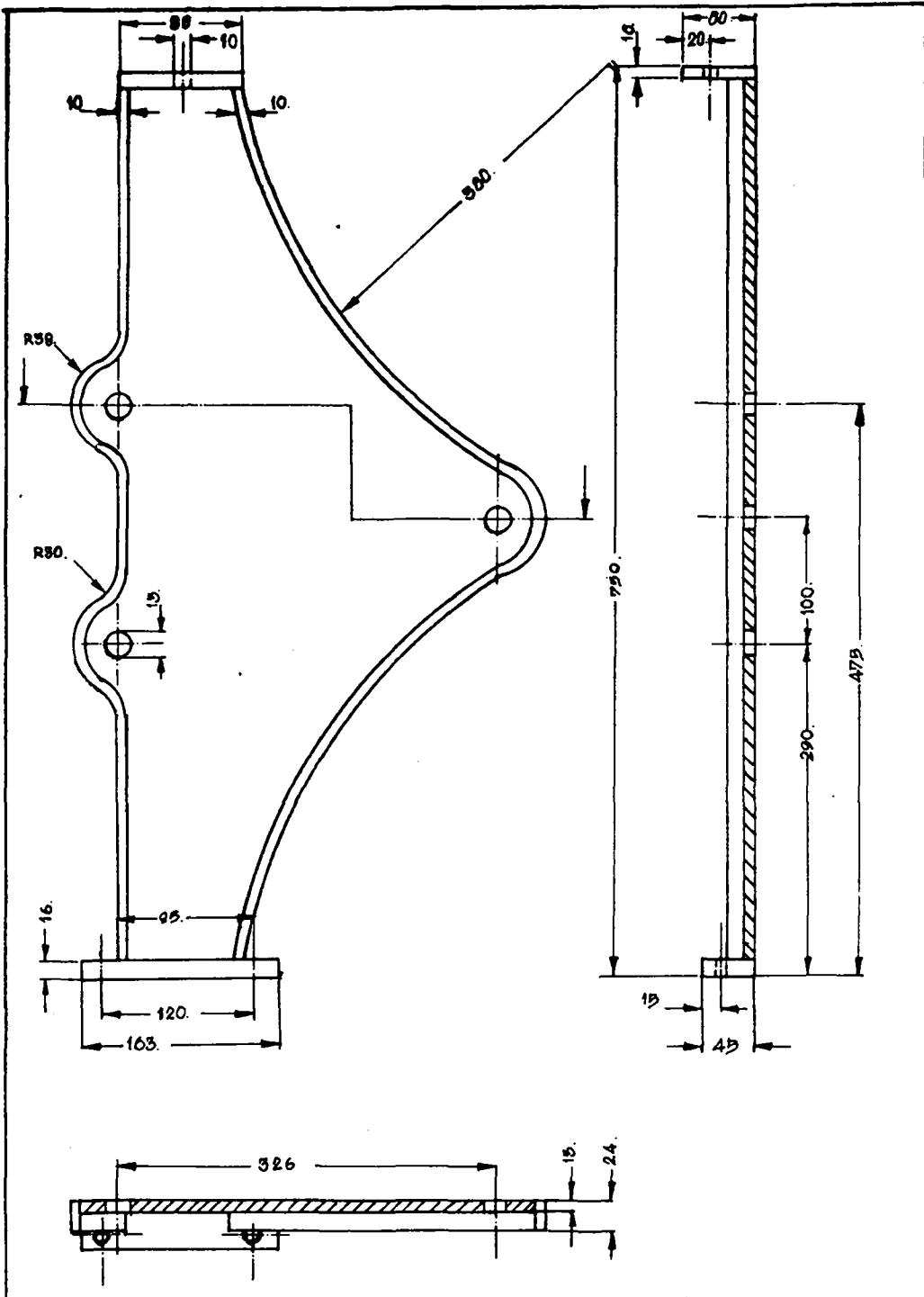
2. Revised Parts Details Drawing

Health Department Type or Korat Hand Pump.

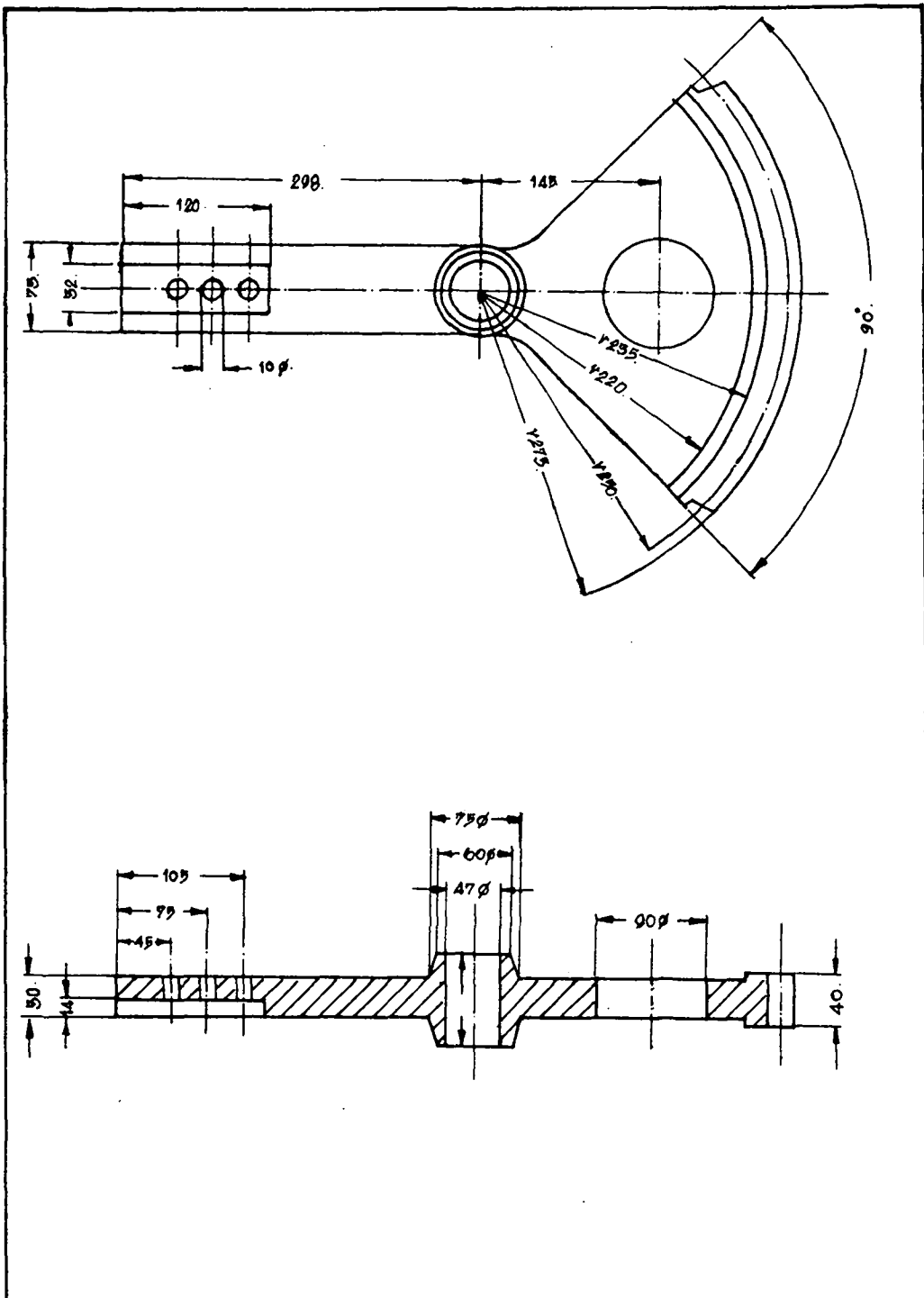




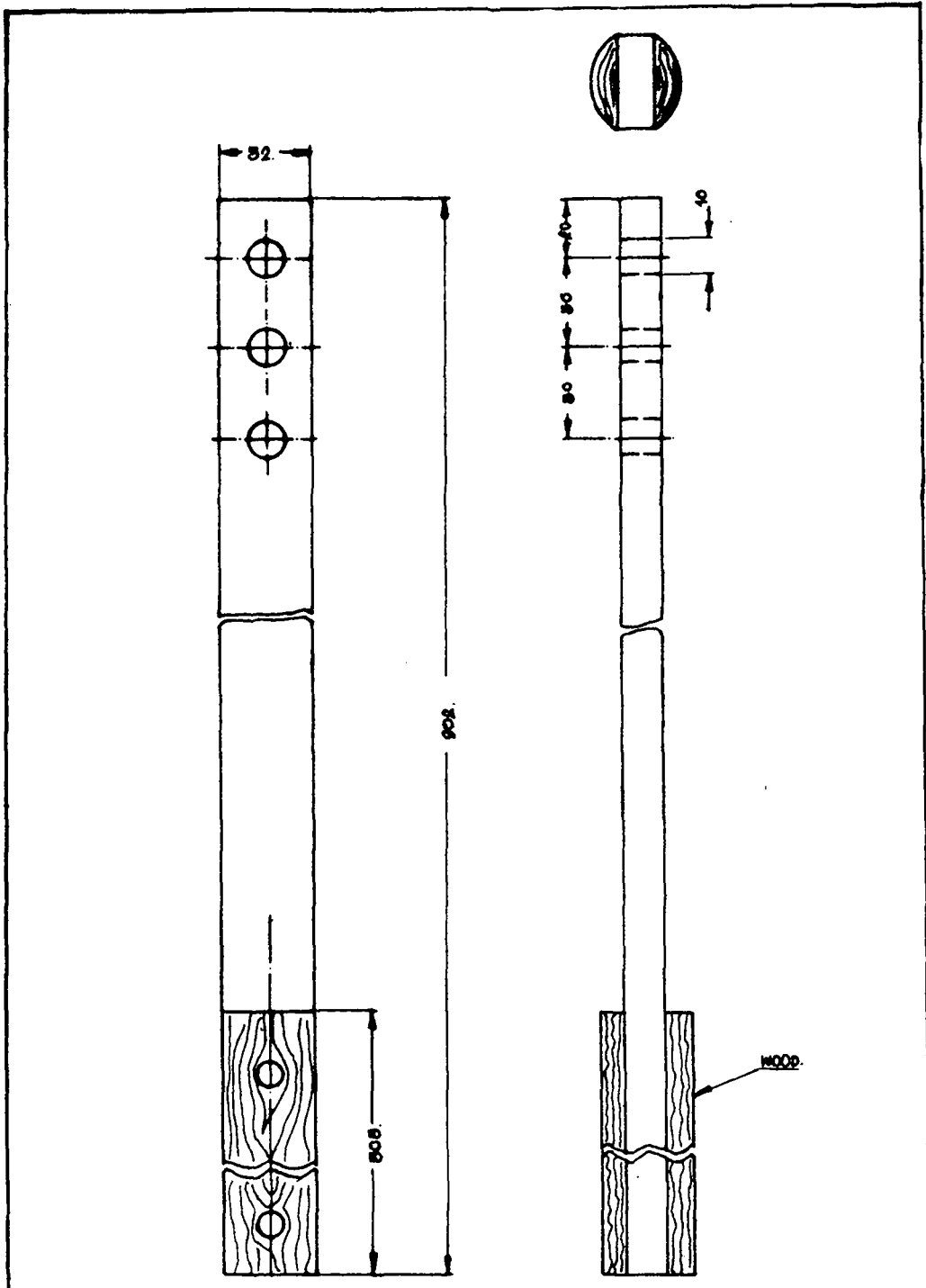
TYPE	A. R. D. REVISED		
DRAWING NO.	03 - 03 - R	PART NO.	1 - R
PART NAME	BODY FRAME	MATERIAL	STEEL
SCALE	1 : 5	DRAWN BY	



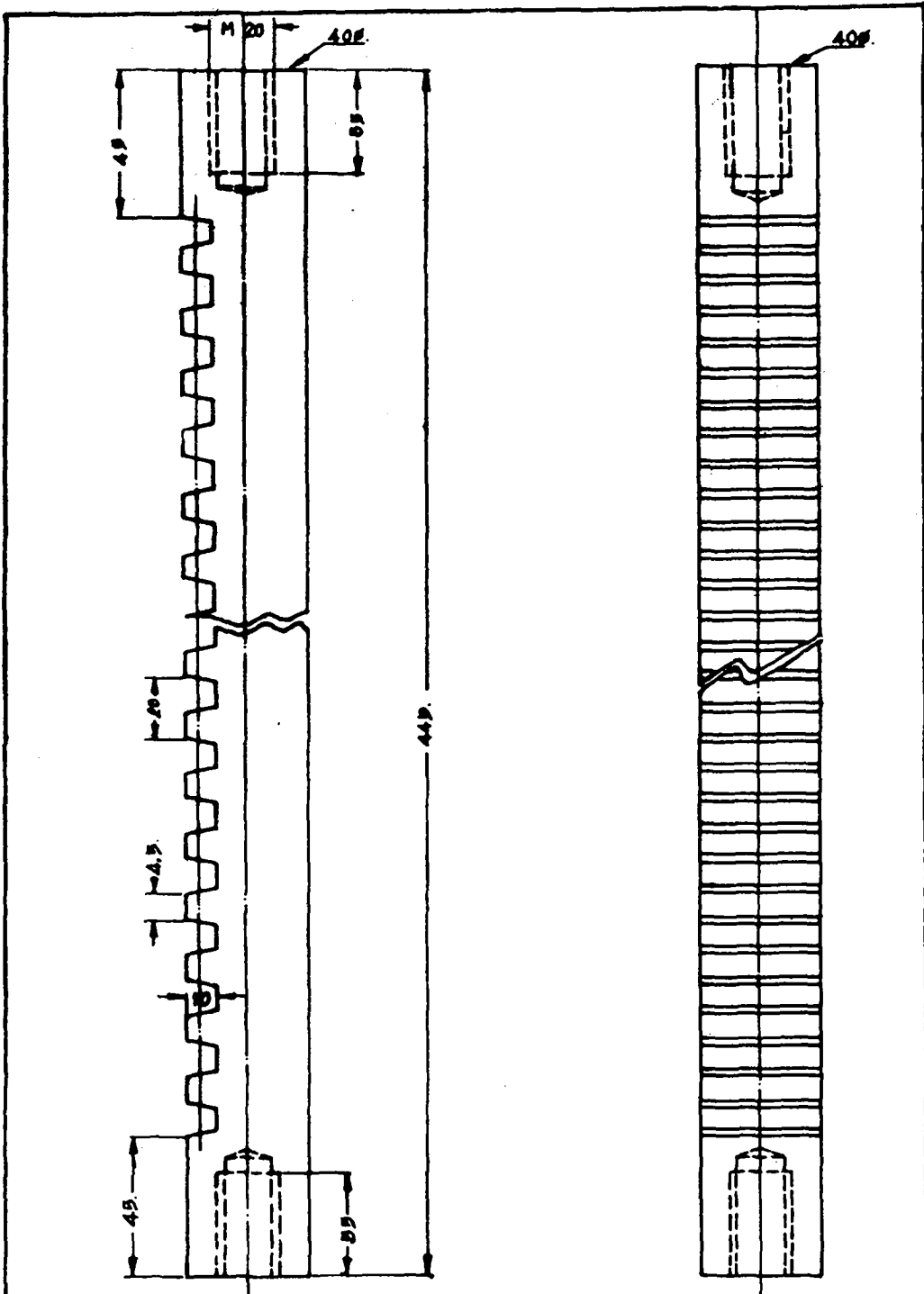
TYPE	A. R. D. REVISED		
DRAWING NO.	03 - 03 - R	PART NO.	2 - R
PART NAME	BODY FRAME	MATERIAL	STFEL
SCALE	1 : 5	DRAWN BY	



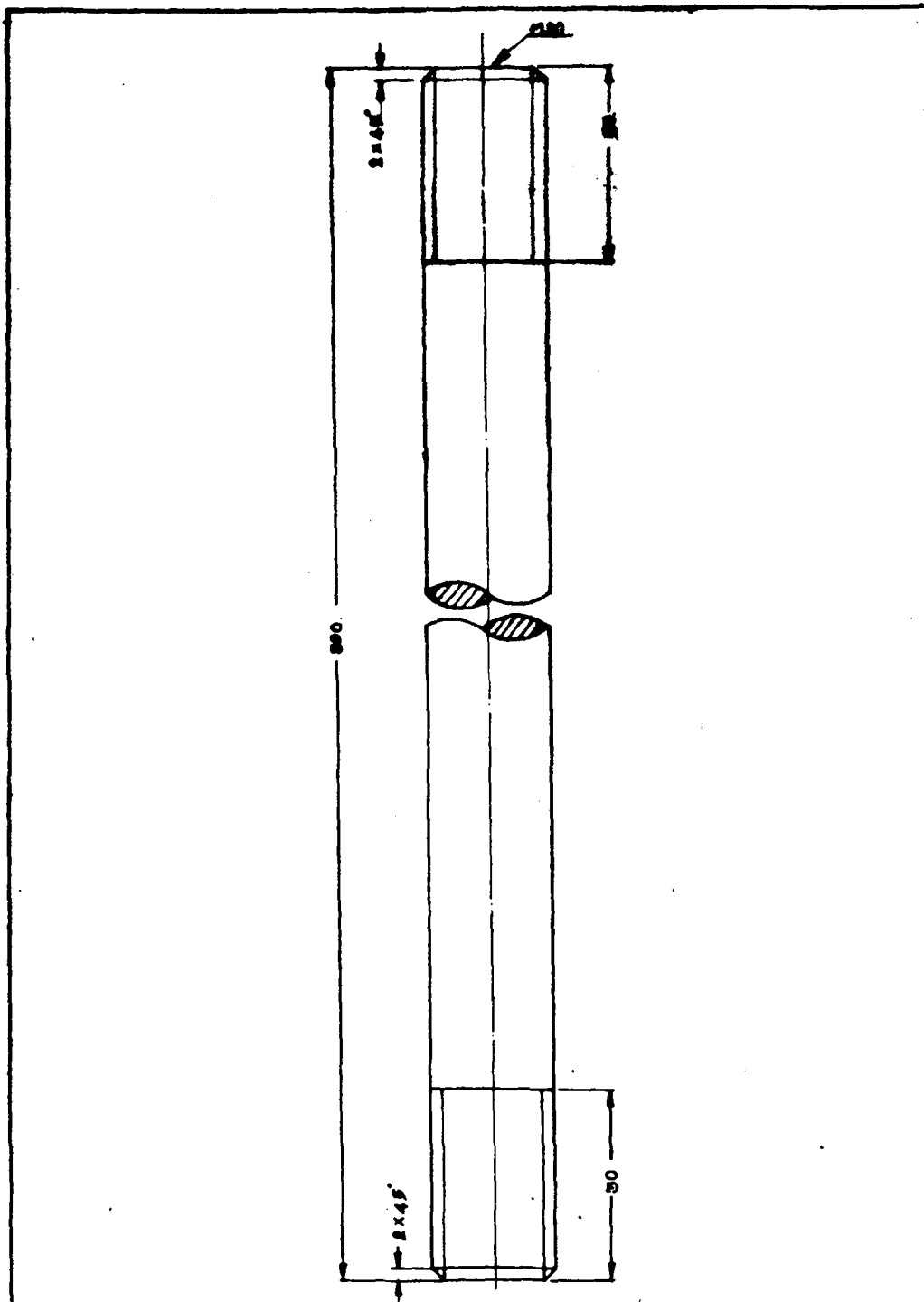
TYPE	A. R. D REVISED		
DRAWING NO.	03 - 04 - R	PART NO.	3 - R
PART NAME	HANDLE GEAR	MATERIAL	CAST IRON
SCALE	1 : 1	DRAWN BY	



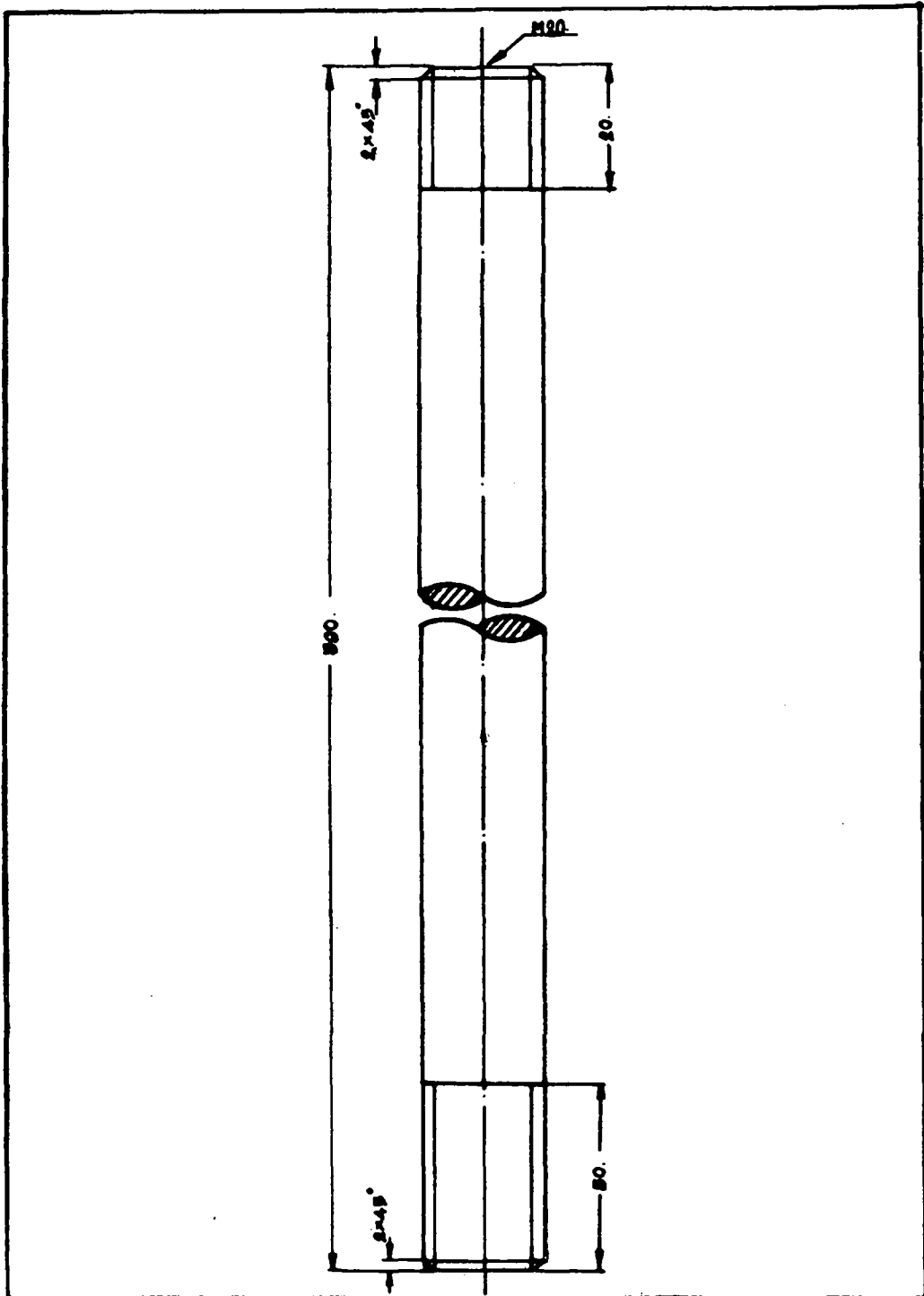
TYPE	ACCELERATED RURAL DEVELOPMENT OFFICE		
DRAWING NO.	03 - 06 - R	PART NO.	28 - R
PART NAME	HANDLE	MATERIAL	STEEL
SCALE	1 : 2	DRAWN BY	



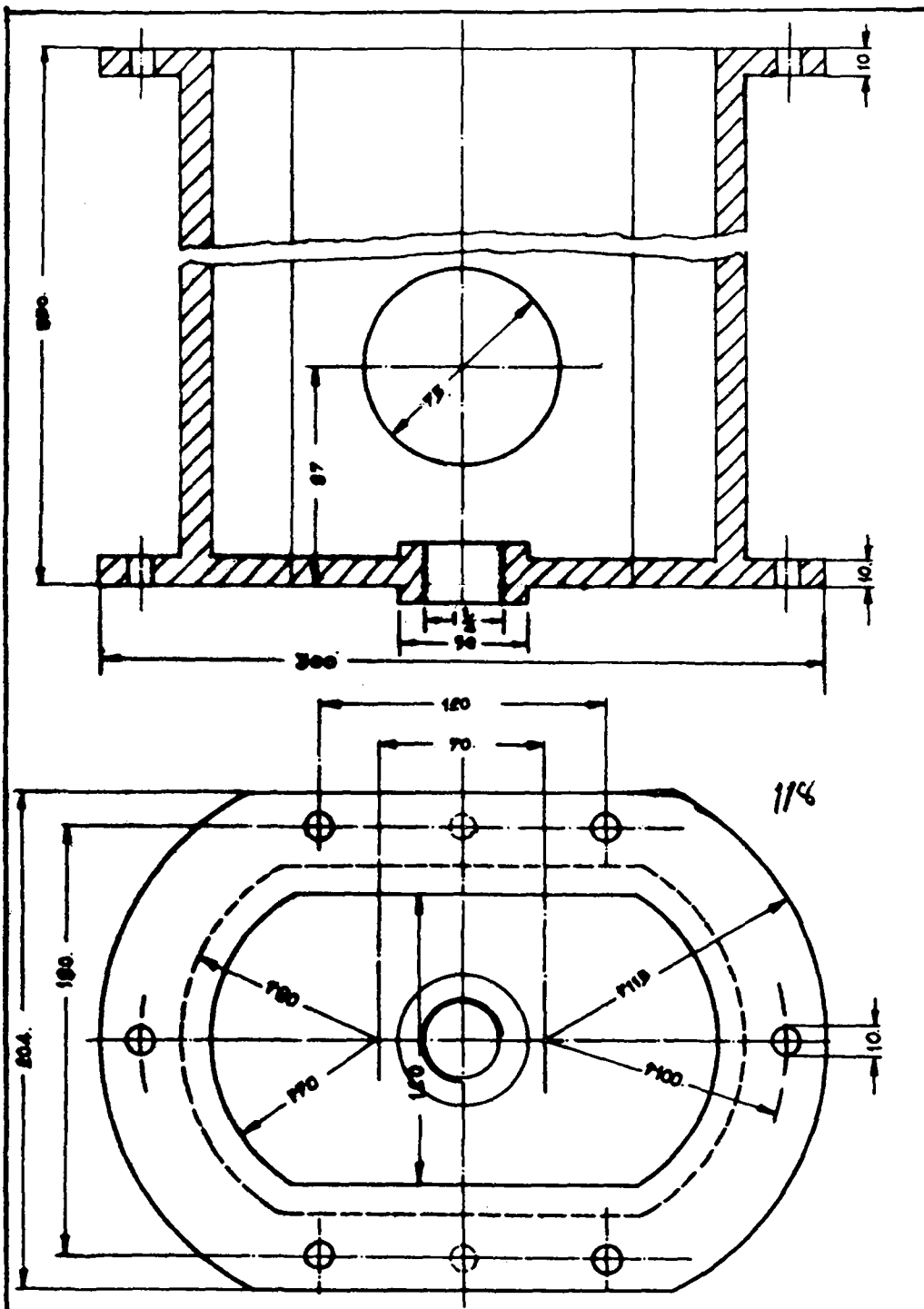
TYPE	A. R. D. REVISED		
DRAWING NO.	03 - 07 - R	PART NO.	4 - R
PART NAME	GEAR CONNECTING ROD		
SCALE	1 : 2	MATERIAL	CAST IRON



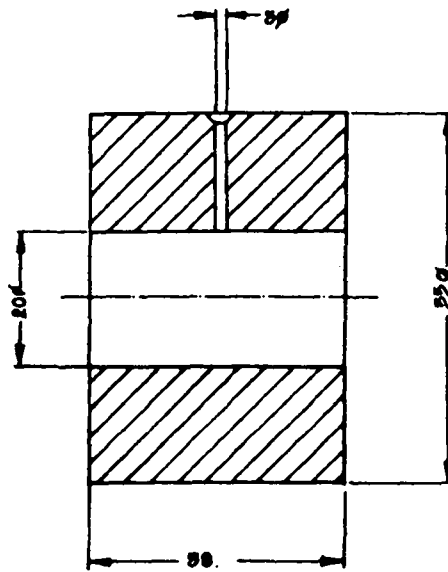
TYPE	A. R. D. REVISED		
DRAWING NO.	03 - 08 - R	PART NO.	5 - R
PART NAME	CONNECTING ROD		
SCALE	1 : 1	MATERIAL	STEEL



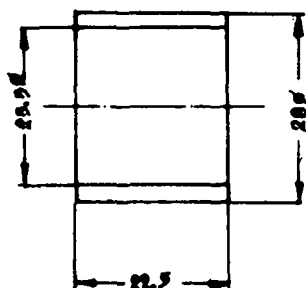
TYPE	A. R. D. REVISED		
DRAWING NO.	03 - 09 - R	PART NO.	6 - R
PART NAME	TOP CONNECTING ROD		
SCALE	1 : 1	MATERIAL	STEEL



TYPE	A. R. D. REVISED		
DRAWING NO.	03 - 11 - R	PART NO.	B - R
PART NAME	PUMP BASE	MATERIAL	CAST IRON
SCALE	1 : 2.5	DRAWN BY	



TYPE	A. R. D. REVISED		
DRAWING NO.	03 - 14 - R	PART NO.	11 - R
PART NAME	OLLER	MATERIAL	STEEL
SCALE	1 : 1	DRAWN BY	

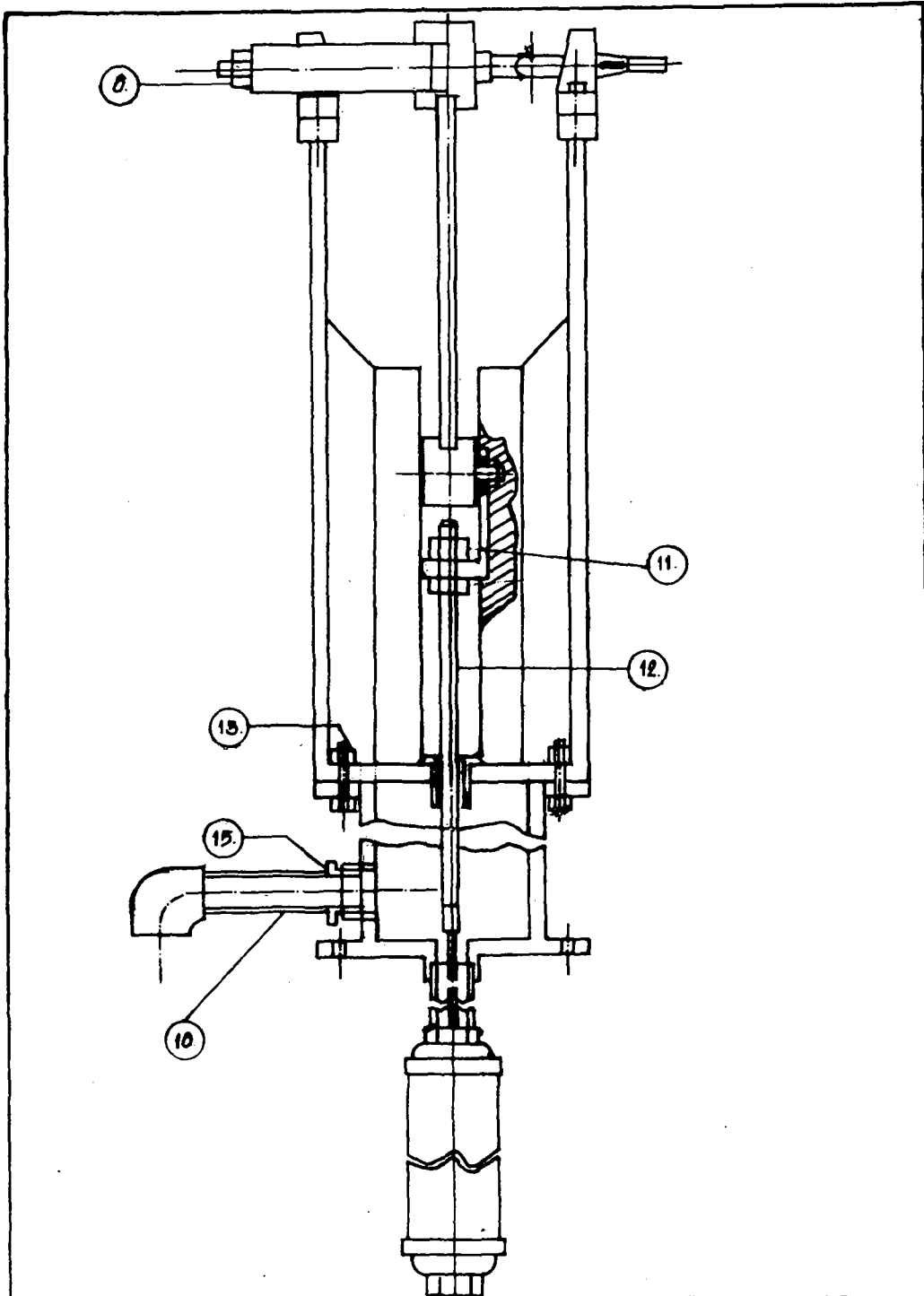


TYPE	A. R. D. REVISED		
DRAWING NO.	03 - 15 - R	PART NO.	12 - R
PART NAME	BUSH	MATERIAL	STEEL
SCALE	1 : 1	DRAWN BY	

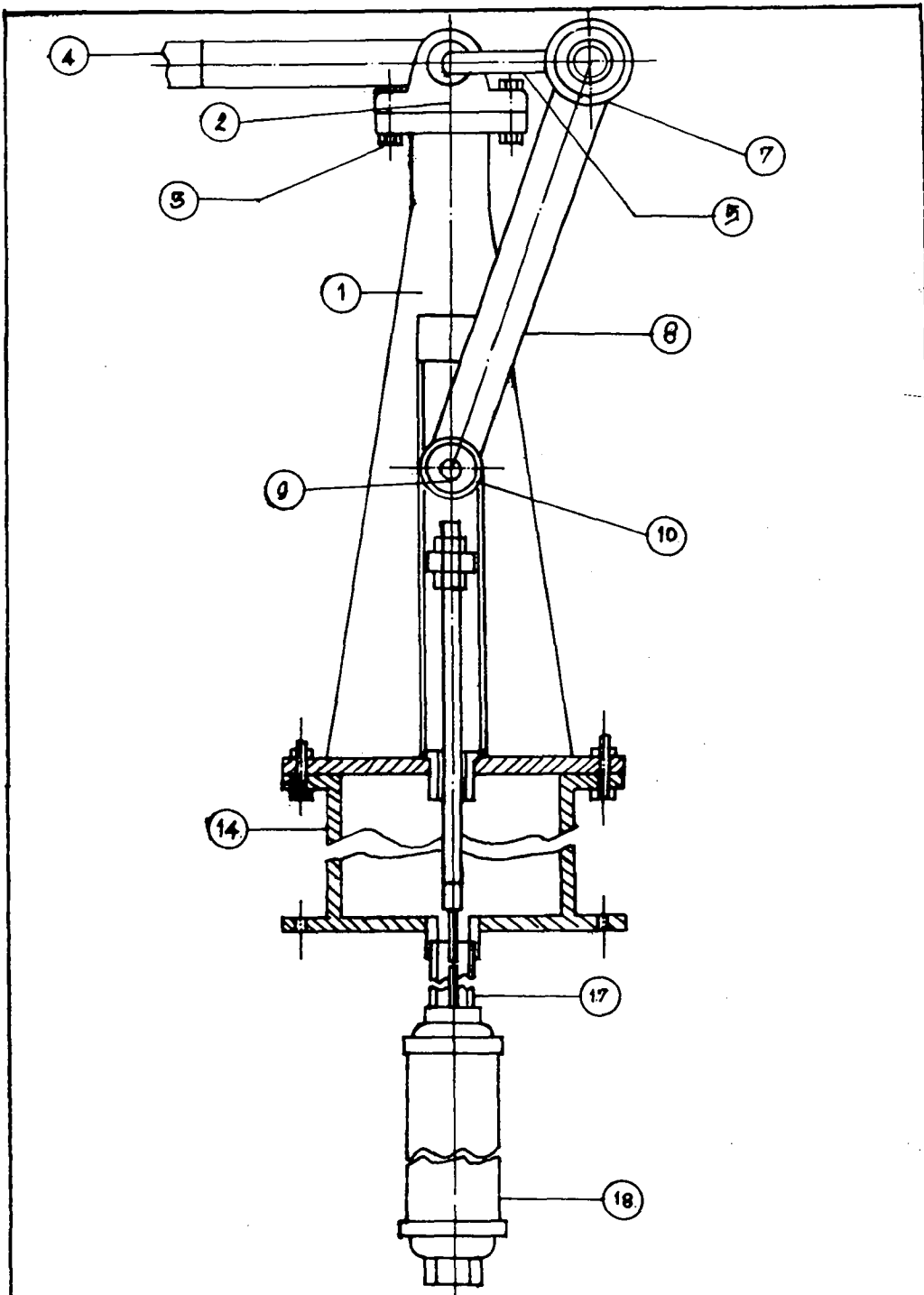
3. Revised Parts Details Drawing

ARD Equipment Control Division Type.

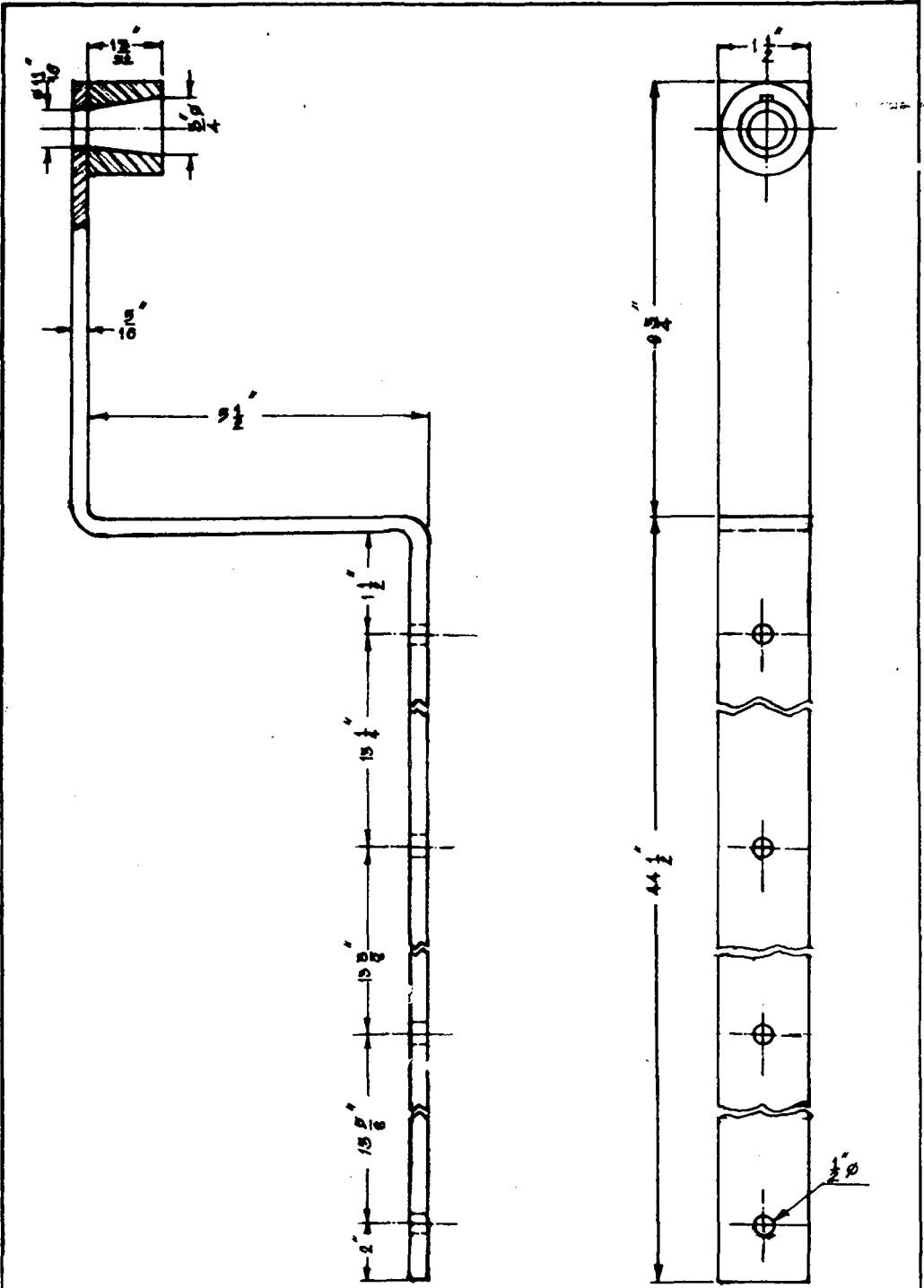




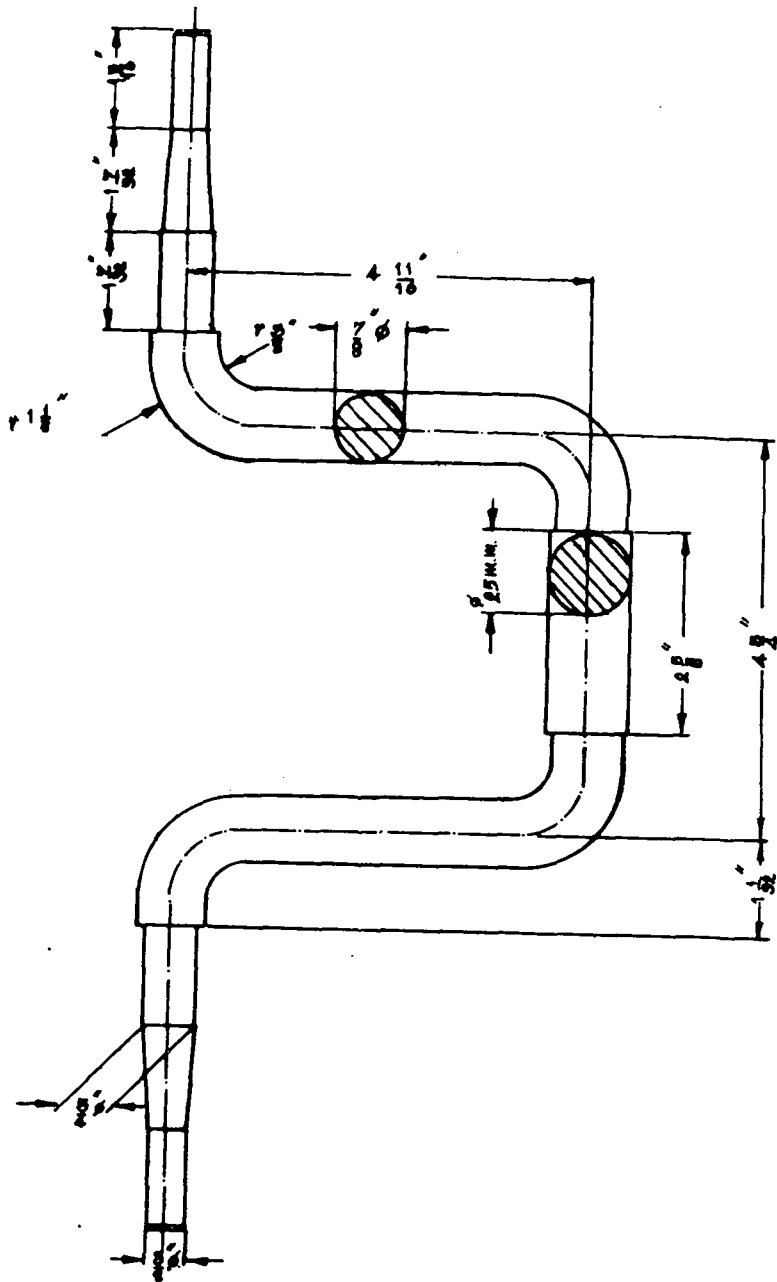
TYPE	ARF EQUIPMENT CONTROL DIVISION		
DRAWING NO.	04 - 01	PART NO.	
PART NAME	HAND PUMP ASSEMBLY (FRONT VIEW)		
SCALE	1 : 5	DRAWN BY	



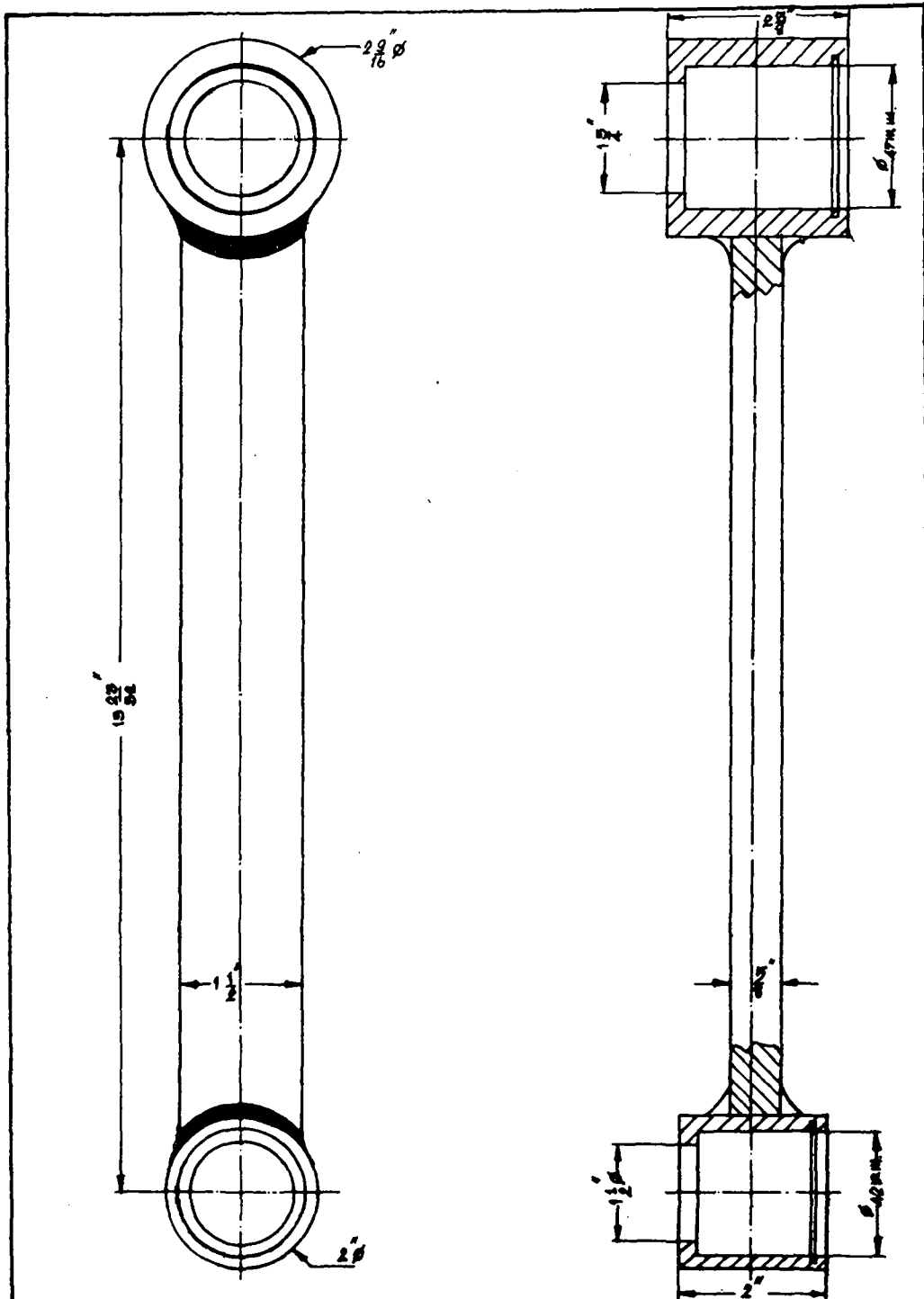
TYPE	ARD EQUIPMENT CONTROL DIVISION		
DRAWING NO.	04 - 02	PART NO.	
PART NAME	HAND PUMP ASSEMBLY(SIDE VIEW)		
SCALE	1 : 5	DRAWN BY	



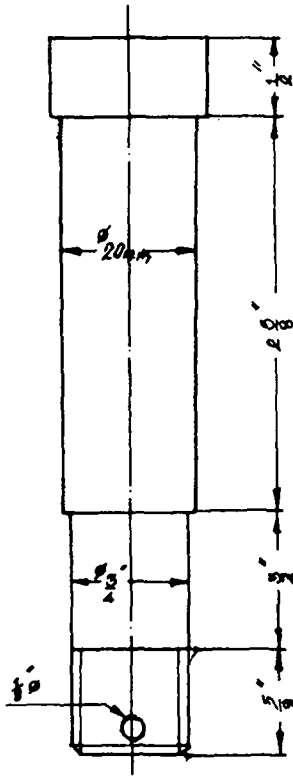
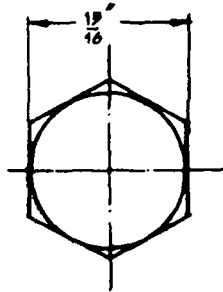
TYPE	ARD EQUIPMENT CONTROL DIVISION		
DRAWING NO.	04 - 03	PART NO.	4
PART NAME	PUMP HANDLE	MATERIAL	STEEL
SCALE	1 : 2.5	DRAWN BY	



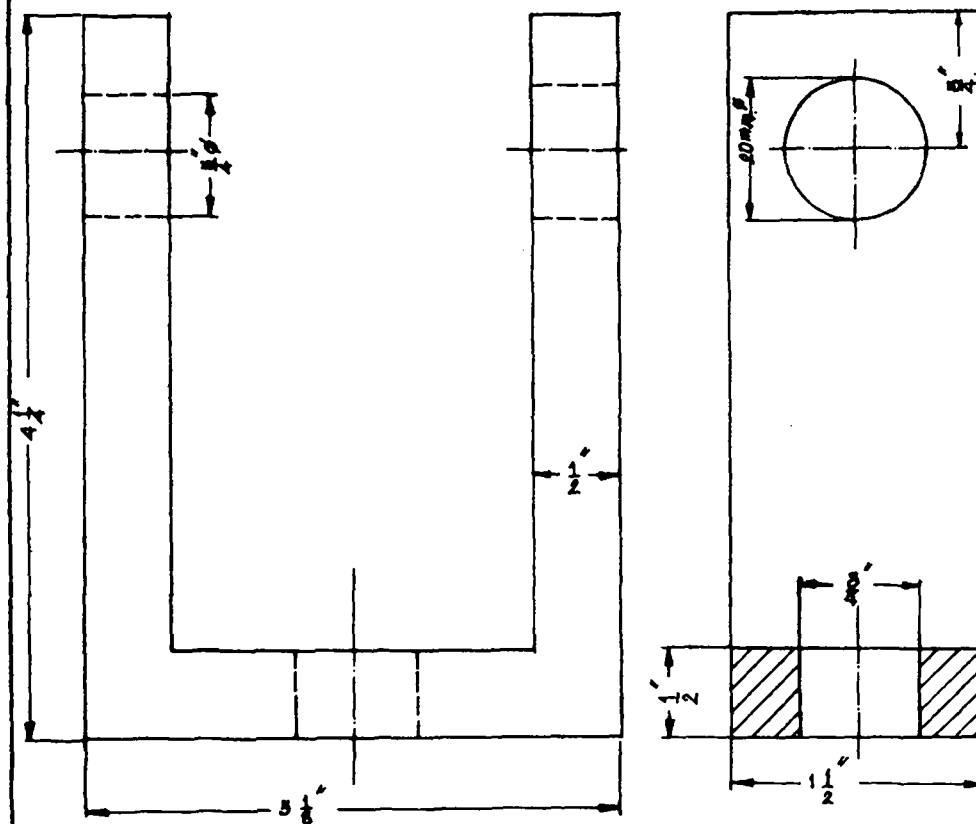
TYPE	ARD EQUIPMENT CONTROL DIVISION		
DRAWING NO.	04 - 04	PART NO.	5
PART NAME	CRANK SHAFT	MATERIAL	STEEL
SCALE	1 : 2	DRAWN BY	



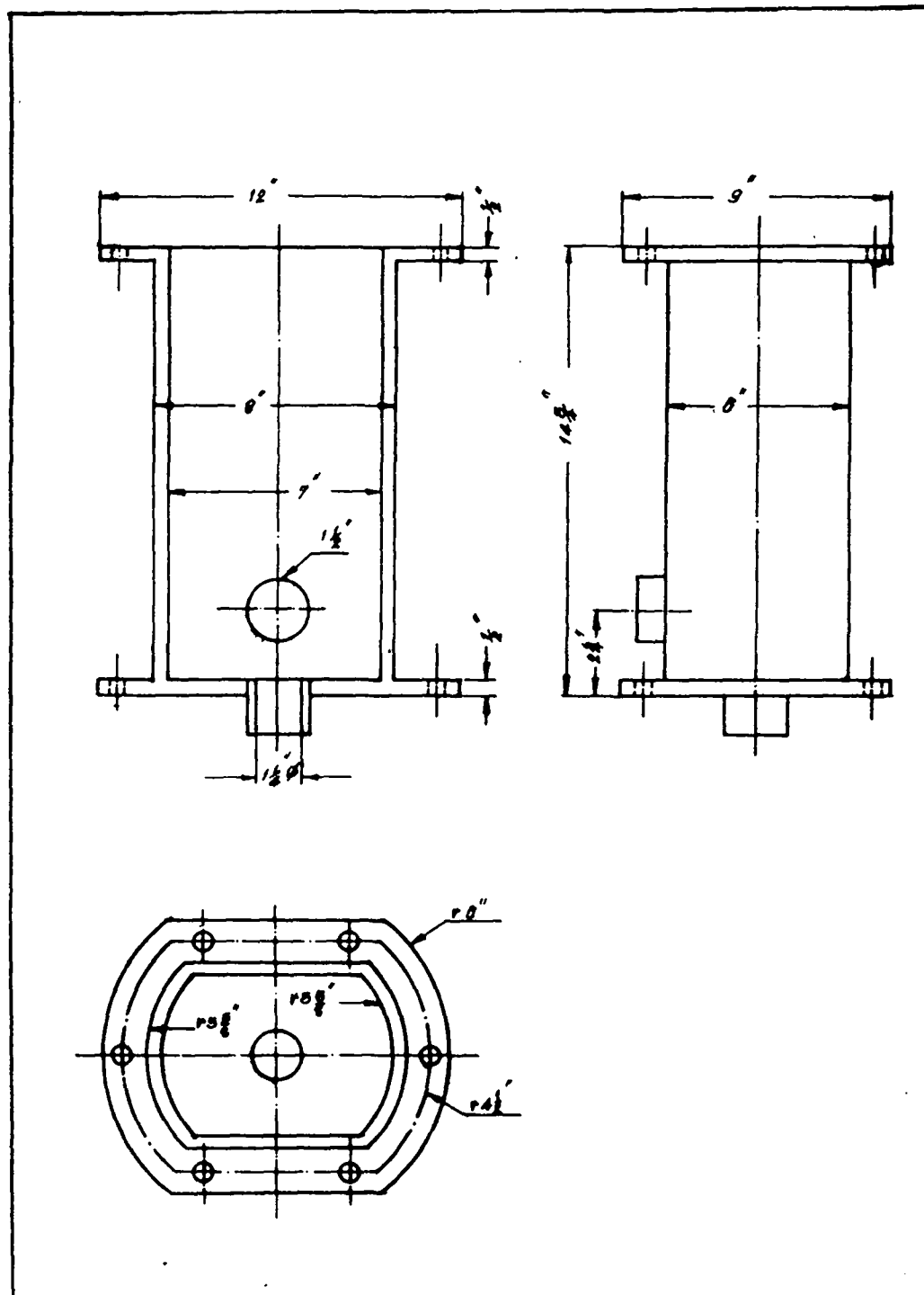
TYPE	ARD EQUIPMENT CONTROL DIVISION		
DRAWING NO.	04 - 05	PART NO.	8
PART NAME	CONNECTING ROD		
SCALE	1 : 2	MATERIAL	STEEL



TYPE	ARD EQUIPMENT CONTROL DIVISION		
DRAWING NO.	04 - 06	PART NO.	9
PART NAME	U - JOINT PIN	MATERIAL	STEEL
SCALE	1 : 1	DRAWN BY	



TYPE	ARD EQUIPMENT CONTROL DIVISION		
DRAWING NO.	04 - 07	PART NO.	11
PART NAME	U - JOINT	MATERIAL	STEEL
SCALE	1 : 1	DRAWN BY	



TYPE	ARD EQUIPMENT CONTROL DIVISION		
DRAWING NO.	04 - 08	PART NO.°	14
PART NAME	PUMP BASE	MATERIAL	CAST IRON
SCALE	1 : 5	DRAWN BY	

APPENDIX E

WORKING GROUP AND ACKNOWLEDGEMENT

LIST OF WORKING GROUP

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5. Technical Group, ARD Field Operations Center, Khon Kaen, Thailand.

Consultants

1. Mr. Vithu Vibhatapathya, B.S.M.E., Deputy Secretary General of ARD Office, Bangkok, Thailand.
2. Mr. Prasit Wilailuksn, M.S.C.E., Director of ARD. Field Operations Center, Khon Kaeu, Thailand.
3. Mr. Pricha Chulavatchana, M.S (San.Eng.) National Officer, UNICEF, Bangkok, Thailand.

Acknowledgement

The ARD wishes to express the appreciation to the UNICEF for making this report possible. We are particularly indebted to Mrs. Catherine Deeks, UNICEF Senior Programme Officer for her assistance. Mr. Damrongsakdi Nitipavachon and Miss Jarinee Sophonpit are thanked for their comments and reviews of this report. And we would like to thank officers from Mineral Resources Department, Ministry of Industrial and Public Works Department, Ministry of Interior, for supplying existing hand pump for the testing programme, Finally, we also wish to express our thanks to all printers in the ARD printer's shop for printing this report.

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- NIDA(1978) : Evaluation on National Rural Water Supply Programme, published in Thai version under the joint sponsorship of NESDB and UNICEF.
- NESDB(1977) : Report of a Workshop on National Rural Water Supply Programme, held at Khon Kaen, April 7 - 10, 1977 in co-operation with UNICEF.
- NESDB(1978) : Report of Workshop on Handpump and Drilling Rig, held at Chiangmai, January 18 - 20, 1978, in co-operation with IDRC.
- John & Showcross (1978) : Handpump Maintenance, interim report to International Reference Centre for community water supply.