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DESIGN AND DEVELOPMENT OF A TWO POST ROTARY-PERCUSSION DRILLING RIG

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ABSTRACT

A two-post Rotary Percussion drilling rig (AMDP Model 2 Drilling Rig) for shallow tubewell irrigation development was successfully developed at the Agricultural Mechanization Development Program, University of the Philippines at Los Baños.

Consisting of a 5 horsepower horizontal shaft gasoline engine as the prime mover for rotary drilling, 4 horsepower direct coupled water pump for jetting, overhead platform mounted on two post system, a reduction gear box, hoist and cable system sub-assembly, sliding engine mount sub-assembly and basic strut supports; it is capable of drilling into various soil formations up to 100 feet and even deeper.

This paper presents the design features and especial capabilities of said drilling rig.

INTRODUCTION

The total irrigation development in the Philippines is about 47%, with more than three million hectares of potential irrigable areas. The area served by existing gravity irrigation systems is only about 1.5 million hectares (National Irrigation Administration Corporate Plan 1990-2000). The average national cropping intensity of rice is 143% with an average yield of 3.08 tons/ha and 1.94 tons/ha in the irrigated and rainfed farms respectively (Department of Agriculture 1990).

Existing irrigation systems were designed for cropping intensity of 150 to 200 percent. A combination of technical, hydrologic and socioeconomic factors contributed to the failure of realizing this target (David, 1990). The actual yield levels in irrigated areas were also below the 4.5 to 5.0 tons/ha target.

Shallow tubewell irrigation development has been given less emphasis by the agencies concerned without realizing its full potential. If the cropping intensity of rainfed farms could be increased from one to two cropping per year, the country would be more than self-sufficient in rice. This can be achieved at lesser cost by tapping the shallow aquifer resources of the country. Table 1 shows the areal extent of groundwater formations for the shallow well and deep well areas by region.

Table 1
Areal extent of ground water formations.
(Source: National Water Resources Council, 1982)

Region	Shallow well areas (sq km)	Deep well areas (sq km)	Difficult areas (sq km)
1	5528	9377	6640
2	5021	17136	14242
3	8640	2391	5246
4	6732	11804	28387
5	2320	7125	8170
6	4455	11491	4277
7	1190	9040	4720
8	2206	13230	5996
9	2370	5912	10403
10	3185	11727	13376
11	4521	16730	10442
12	5596	7060	10635

Realizing this potential, the Department of Land and Water Resources (LAWREAT) of the College of Engineering and Agro-industrial Technology (CEAT) of the University of the Philippines at Los Baños in collaboration with the Agricultural Mechanization Development Program (AMDP), launched an integrated small scale irrigation and mechanization development program in two pilot regions. Activities were focused on R & D of suitable drilling rigs, characterization of shallow aquifers, installation of limited shallow tubewell systems, and improvement of well drilling and development techniques.

MATERIALS AND METHODS

The first AMDP Model 1 drilling rig (Figure 1), was a modification of a rig adopted from foreign technology by the International Rice Research Institute. It was field tested in the pilot area in Pampanga. Several problems were encountered namely: (1) very cramped working space around the tripod, its braces and wires, (2) frequent replacement of the packing materials in the swivel mechanism, (3) tedious process of alternately hammering and jetting/surging during the final well construction stage, (4) the 18-foot tripod assembly was difficult to transport and

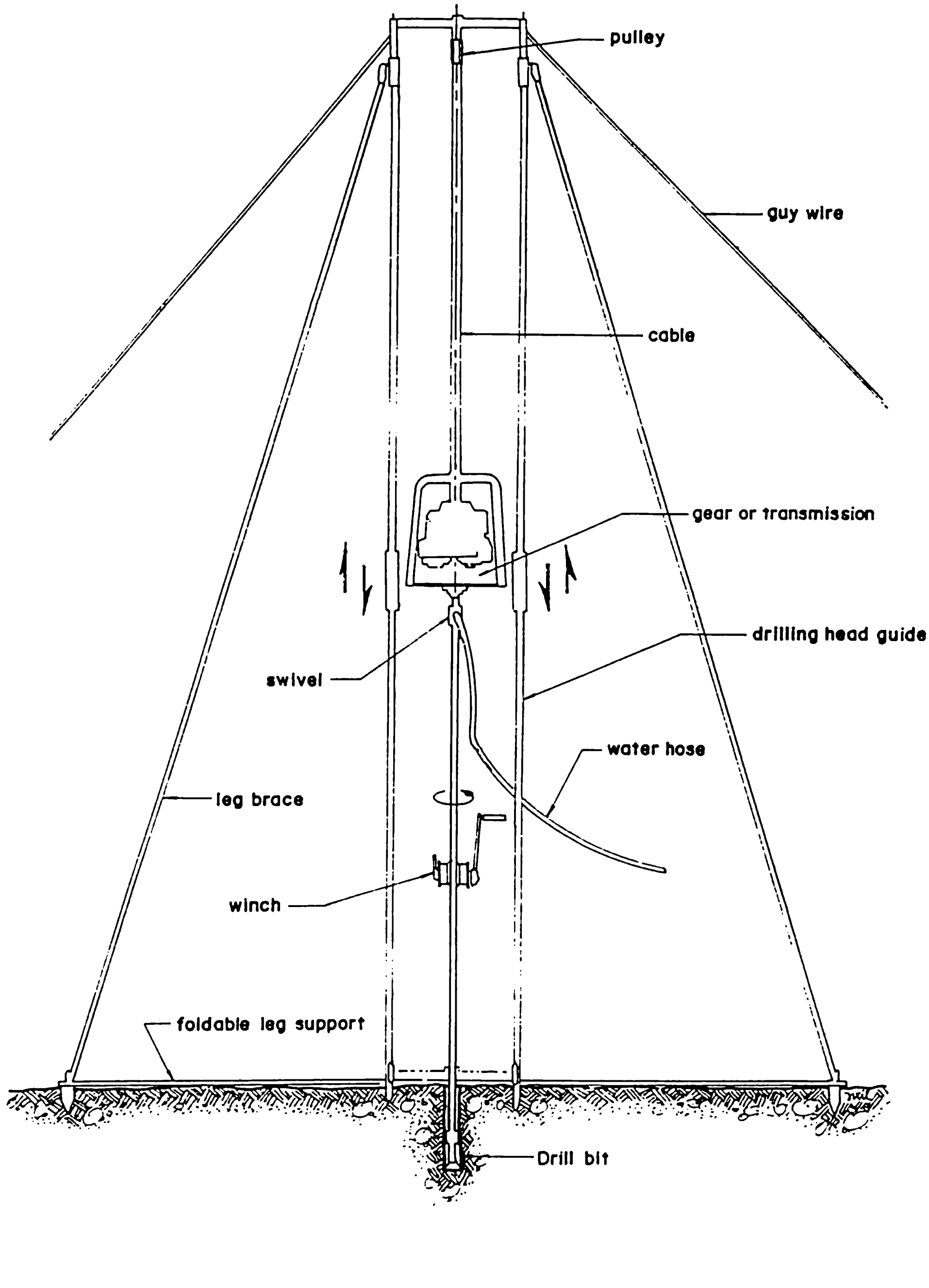


Figure 1
Schematic Diagram of AMDP Drilling Rig Model 1.

unstable causing the drilling stem to gyrate during operation resulting to frequent cave-ins especially in loose soil formations, and (5) difficulty of assembly and disassembly of the drilling stems.

A second model, AMDP Model 2 Drilling Rig (Figure 2), was developed to overcome the problems in Model 1. It has circumvented said shortcomings. the AMDP model 2 drilling rig has the following features:

1. It has two post with four struts which allows wider working space around the drill stem (about 300 degrees arc free working space) and greater stability.

2. It can be easily transported due to its collapsible parts and components. The rig has two tiers with the first tire 12 feet high. The upper tier can be detached during transport.

3. It uses a horizontal shaft engine and is fitted with a reduction gear box which are available in most urban areas.

4. The swivel assembly is sealed by a more durable material eliminating frequent replacement which results to down time.

5. The gear box can easily removed to facilitate the lowering down of the well shaft into the bore.

6. Hammering and jetting operations can be done simultaneously allowing fast driving of pipes or well shafting.

7. The lever type hammer makes pipe driving operation less exhausting.

8. The rig can be tilted in any direction with respect to the vertical axis as required.

9. Three to four persons can set up and operate the rig.

Figures 2 to 3e exhibit the set up of the Model 2 drilling rig for drilling operations, tubewell pipe assembly, hammering assembly with the traditional system, jetting/surging operation alternately with hammering, and simultaneous hammering and jetting using the lever type hammer system respectively.

DESIGN AND DEVELOPMENT

The following criteria were used as the guidelines in developing the AMDP Model 2 drilling rig:

1. Availability of raw materials and standard parts such as pipes, angle bars, driveline components, gear box, etc.

2. Sufficient working space around the drilling stem.

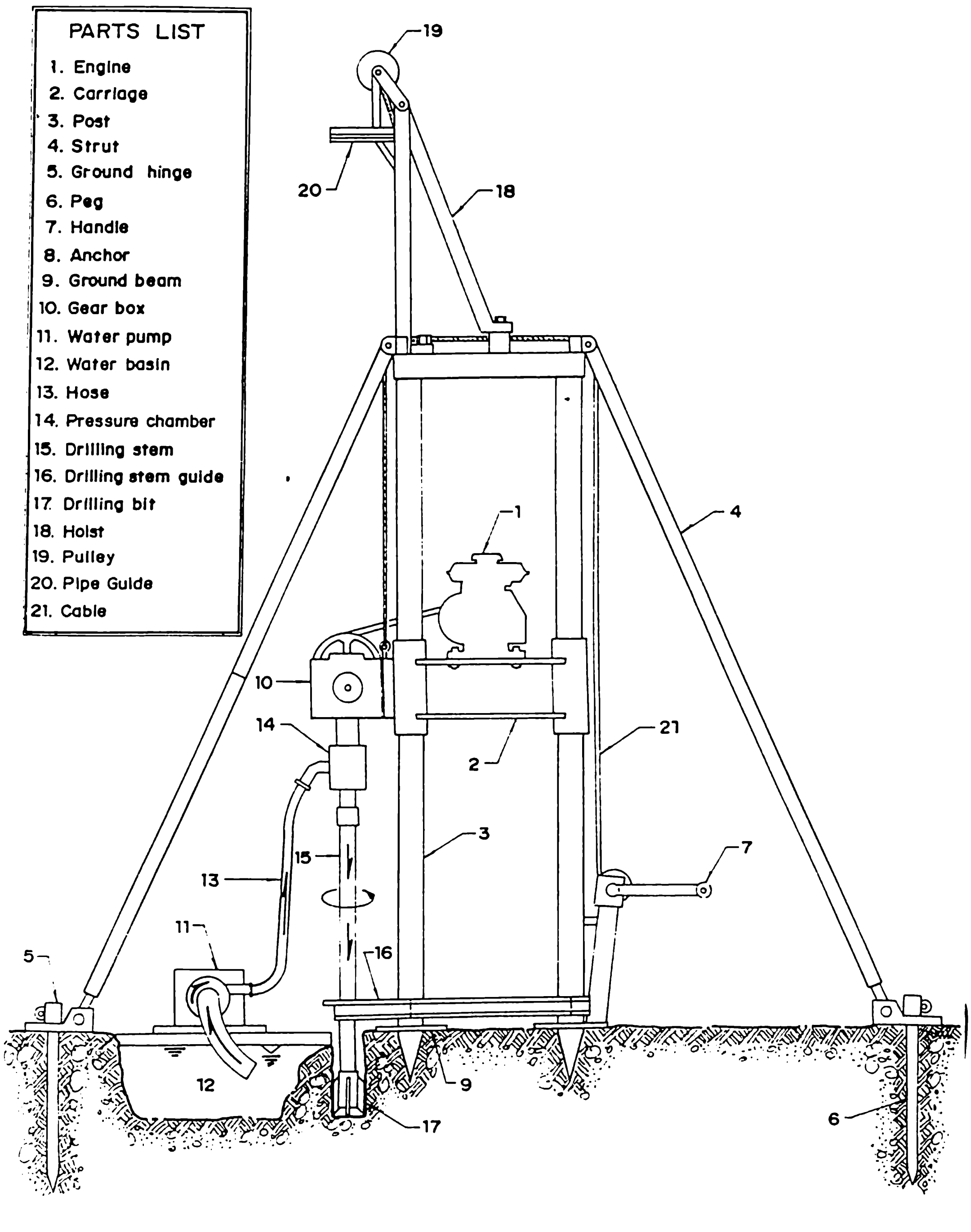


Figure 2
Operating Set up of the AMDP Model 2P Drilling Rig for Drilling Operation

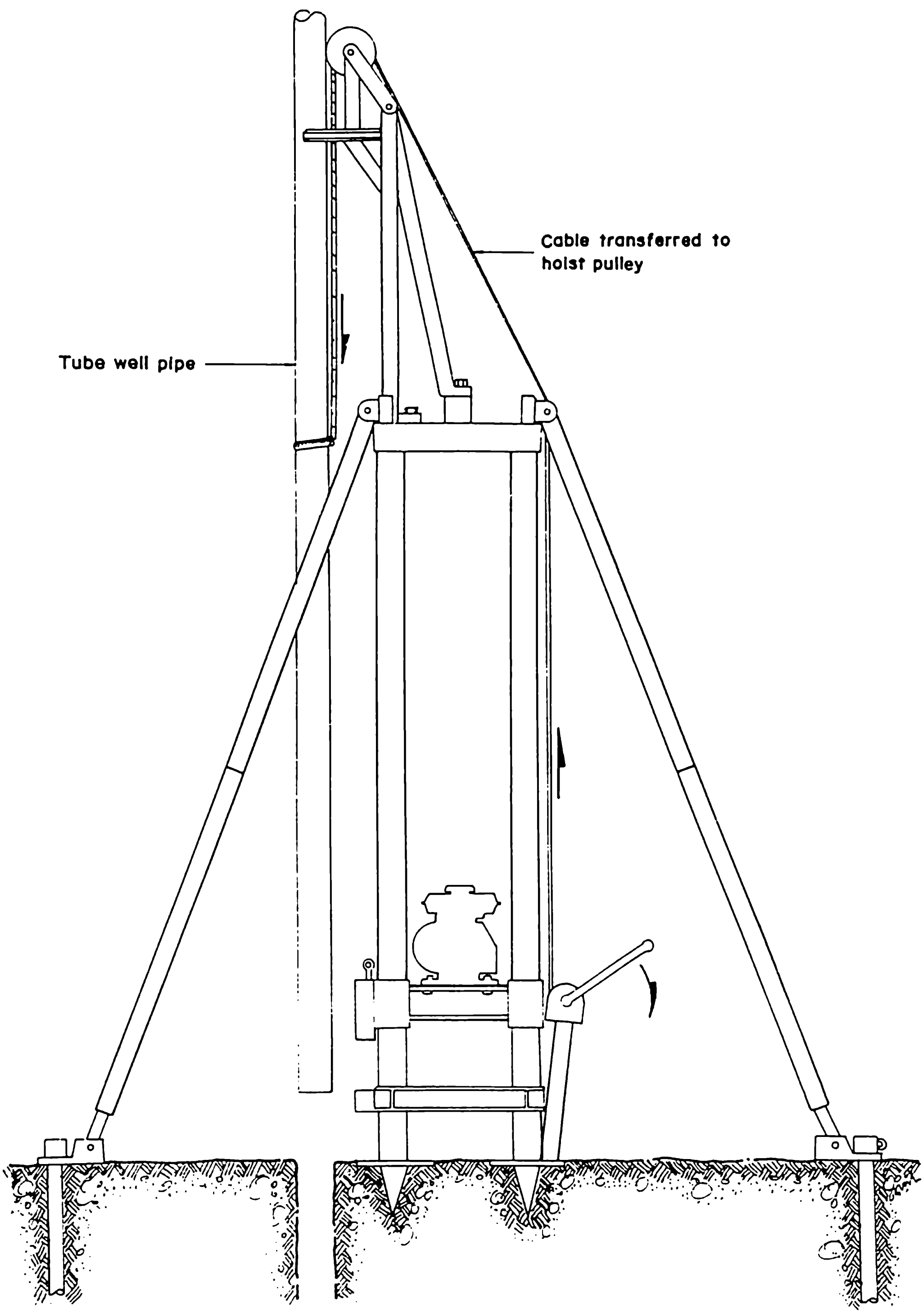


Figure 3a
Drilling Rig Set up for Assembling the Tube Well

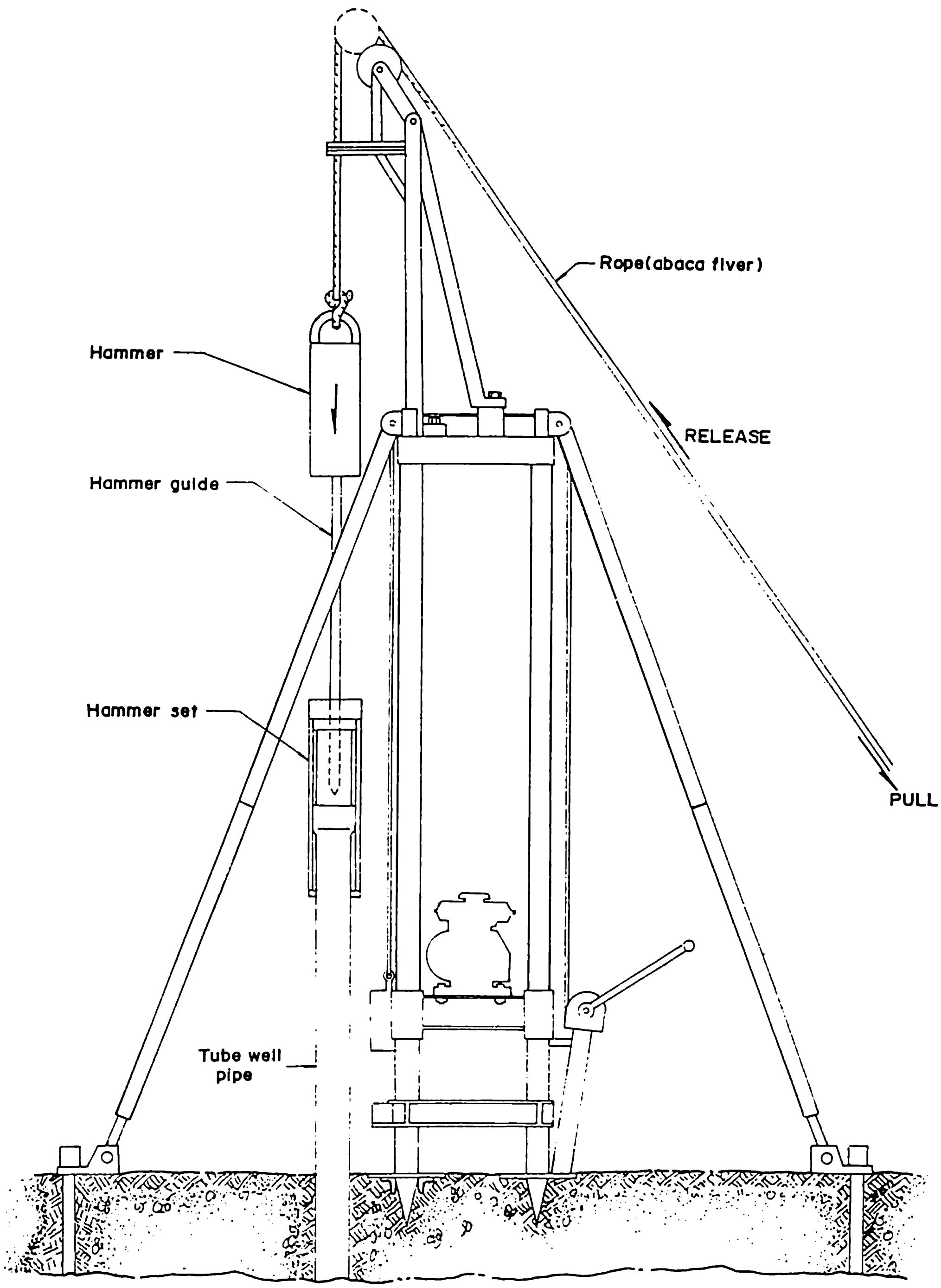


Figure 3b
Hammering Assembly Using the Hammer with
One to One Mechanical Advantage.

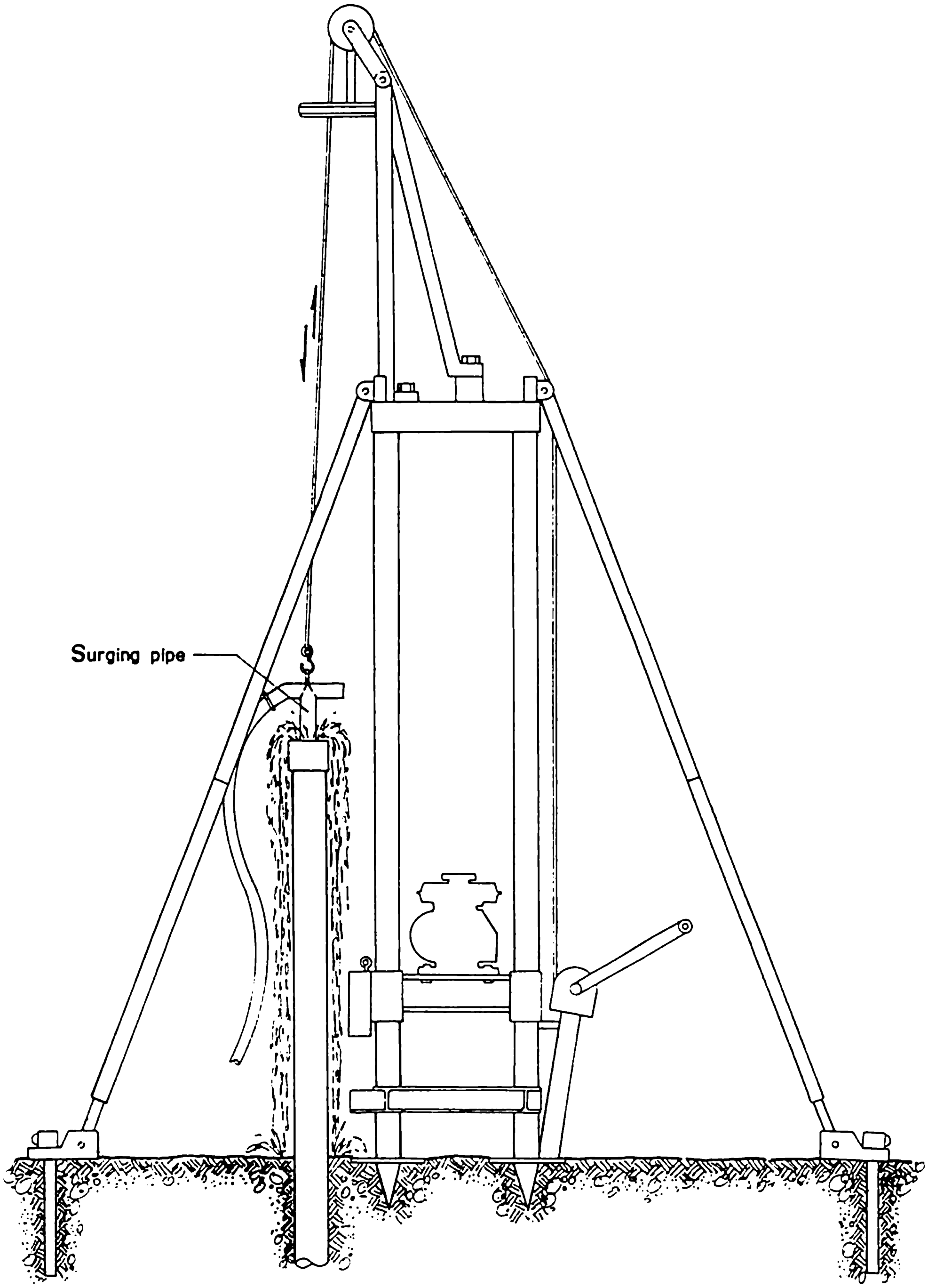


Figure 3c
Surging Assembly Prior to Further Hammering of the Tube Well Pipe.

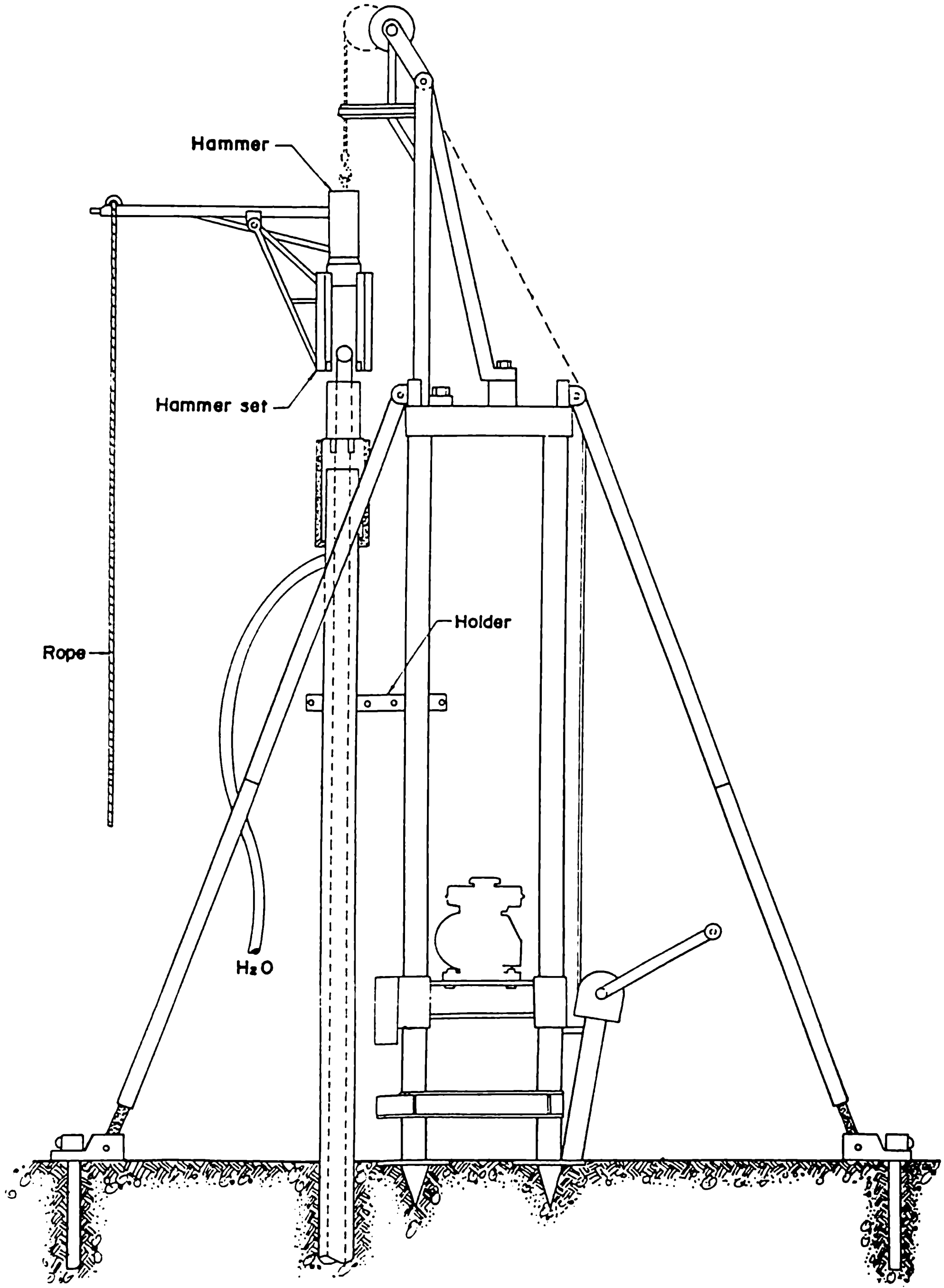


Figure 3d
Assembling the Lever Type Hammer for Simultaneous Surging and Hammering Operation.

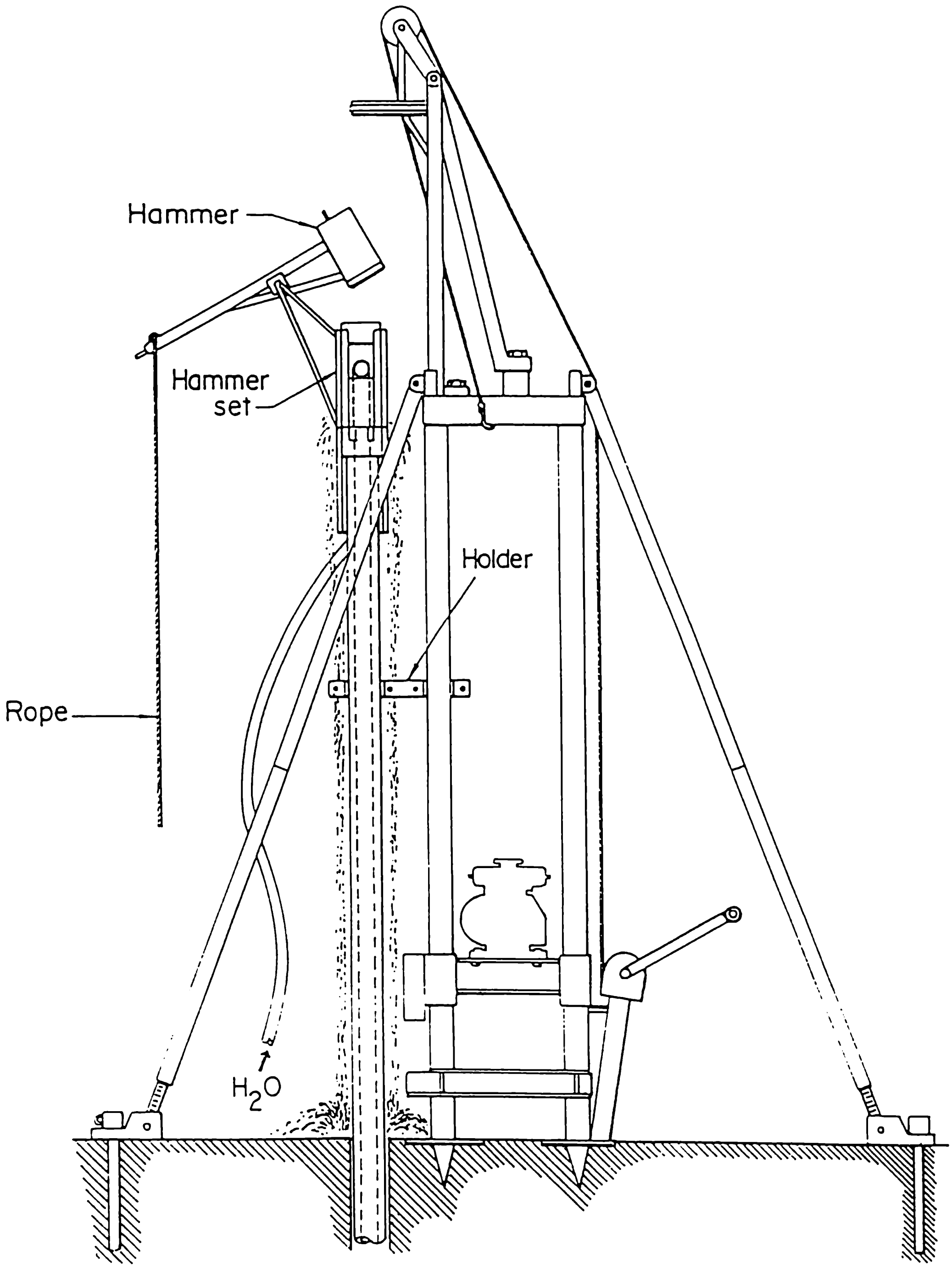


Figure 3e
Operating Set up of the Lever Type Hammer Assembly for Simultaneous Surging and Hammering.

3. Collapsible design for ease of assembly, disassembly and transport.

4. Reliability of the critical components including the swivel, drilling stems, and structural support of the entire assembly.

5. Ease of operation, repair and maintenance.

6. Operation safety and prevention of drilling stems from falling down into the bore during assembly and disassembly.

RESULTS AND DISCUSSION

Referring to Figure 2, the rig is composed of the following major components: posts, sliding engine base, overhead platform, clamp, upper tier, struts, ground hinge, gear box, swivel, drilling stem, drill bit, cable winder and stabilizer.

The post is made of two-inch diameter nominal size schedule 40 B.I. pipe. The lower end that engages the ground is pointed while the upper end is fitted with a receptor for adapting the overhead platform on which top is bolted the upper tier.

The engine base is where the horizontal shaft engine is fixed and provided with two bushings that fits into the two posts. On the drilling side a gearbox is attached together with the swivel which is also provided with square thread to adapt the drilling stem at whose end is fitted with drill bit. Belt and pulley drive engage or disengage the gearbox to the engine by a belt tensioner.

Cable attached to the engine base passes over the rollers on top of the overhead platform then down to the cable winder which is used for raising or lowering the engine base together with the gearbox, swivel, drilling stem and drill bit.

The entire assembly is supported by four collapsible struts whose upper end is hinged to the overhead platform while the lower end is attached to the ground hinge. A one meter peg is driven thru the ground hinge to secure the system. Minor adjustment of the rig assembly relative to vertical axis is made by rotating the power screw connecting the ground hinge and struts.

Swivel Design

High pressure water from the pump enters the drilling stem through the swivel. Figure 4 is a cross sectional view of the swivel showing its design features.

A three inch nominal diameter schedule 40 G.I. pipe was used as pressure chamber and welded with bearing housings at both ends. A water inlet pipe is welded at the midsection of the pressure chamber where an appropriate bore is located. Two double zeal (rubber zeal) bearings were press fitted into the bearing housings. Each bearing housing was provided with screw caps which could be removed to permit installation of packing materials when the bearing starts to leak. The bearing bore was fitted with a perforated pipe whose lcwer end served as adaptor of the drilling stem and its upper end is attached to the gear box output shaft. This design is relatively expensive but durable. More than 10 wells were drilled and installed before it started to leak.

Drill bit design

The drill bit (Figure 5) is provided with square thread that fits to the end of the drilling stem. Two sets of fins were welded to the drill bit body. The outer fins were made out of used vehicle leafspring. Tapering outward, it was designed to inscribe a circle through the soil formation as it rotates. While the inner fins were made of tool steel. It assist the outer fins in pulverizing the soil formation. For greater durability, tungsten carbide could be welded at the tips of these fins.

Drilling stem

The drilling stem (Figure 6) is made of 31.75 mm diameter nominal size schedule 40 B.I. pipe. Each piece is provided with a male square thread at one end and a corresponding female thread on the other end. The effective length in 183 centimeters (5 feet). The thread was designed such that as the drilling stem rotates, the resisting torque of the soil formation tends to tighten the threads.

Drilling guide sub-assembly

The drilling guide (Figure 7) is attached at the base of the post. It guides and prevent the drilling stem from excessive gyration during operation. On top of it is a pipe holder that prevents the drilling stem from falling into the bore during disassembly and assembly of additional drilling stems.

The unit (Model 2 Drilling Rig) was pilot tested in Pampanga. Aquifer characteristics and soil formations were determined at the drilling sites. Figure 8 is a well log in an AMDP, CEAT experimental site in Barangay San Miguel, Magalang Pampanga. Four inch diameter shallow tube wells were installed and developed.

One major problem encountered in using the AMDP Model 2 drilling rig is transporting it across the rice field. The system has to be totally disassembled and loaded into a vehicle to bring it to another site. If the field can't be traversed by vehicle, the system has to be hauled on shoulder part by part.

CONCLUSIONS AND RECOMMENDATIONS

The AMDP Model 2 drilling rig was successfully designed, fabricated and pilot tested. It has minimized the problems encountered in the first model. Particularly the swivel design was durable but expensive. The system can drill thru various soil formations but was difficult to

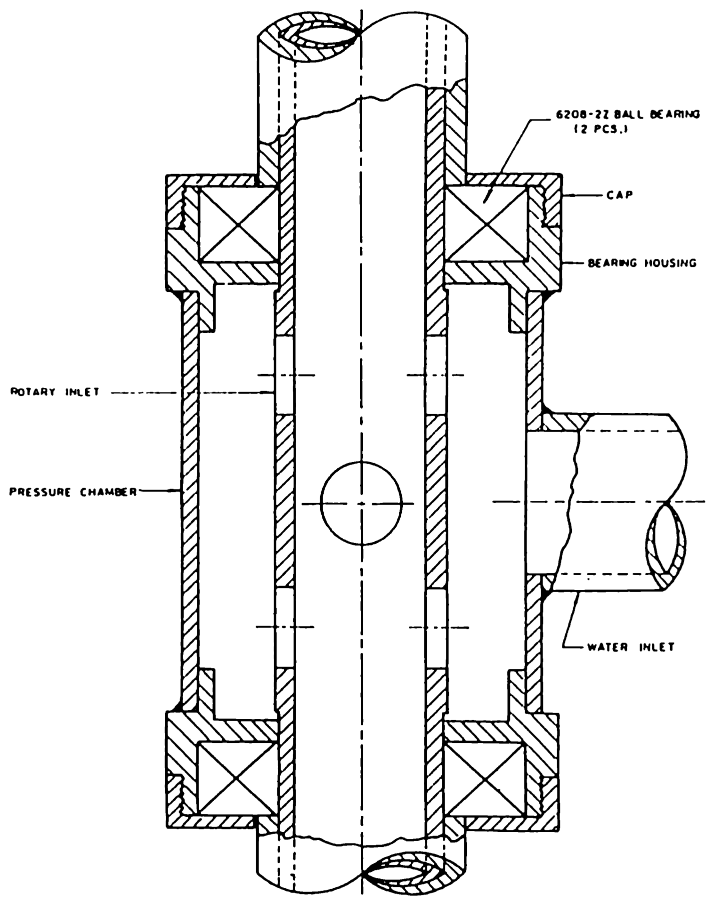


Figure 4
Cross Sectional View of the Swivel Design.

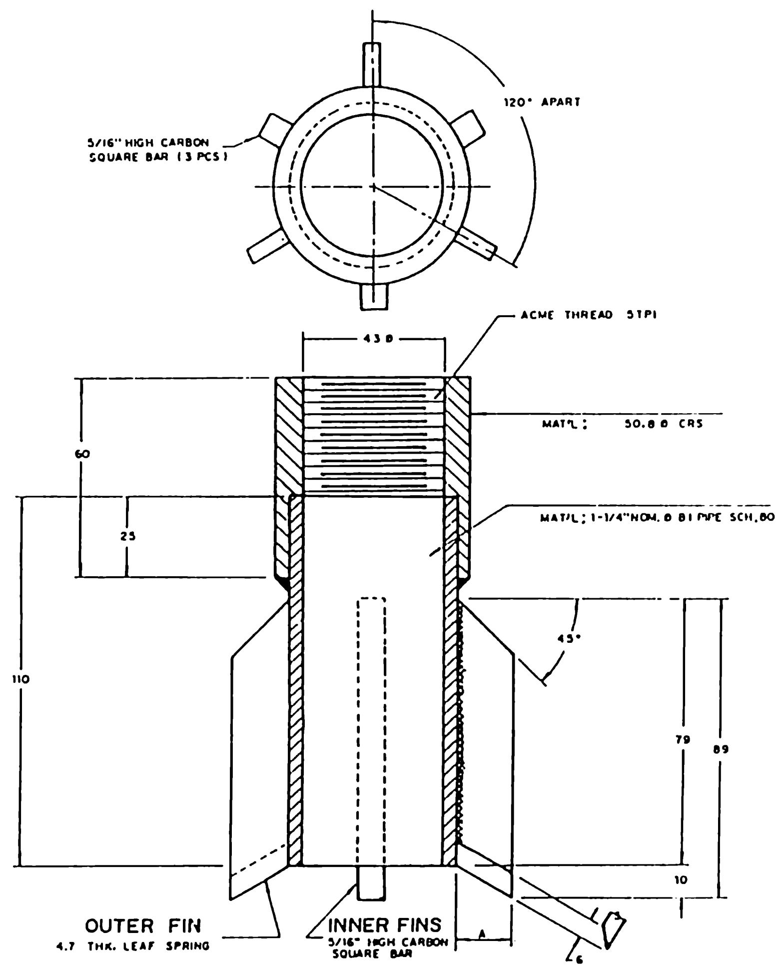


Figure 5
Drill Bit Assembly.

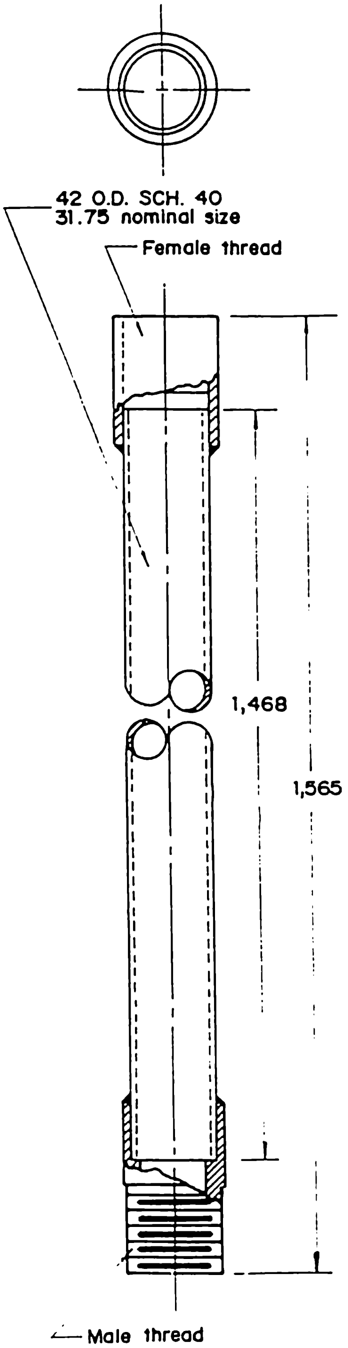
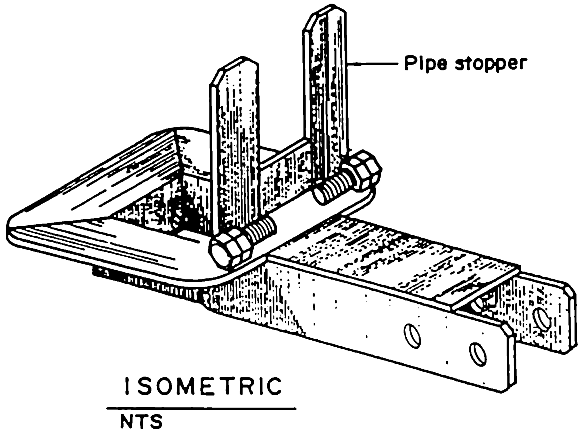


Figure 6
Drilling Stem Assembly



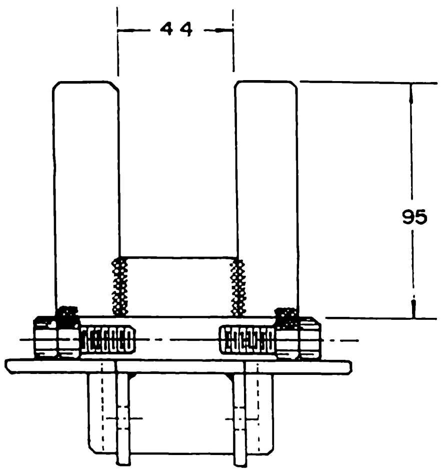


Figure 7
Drilling Guide Assembly

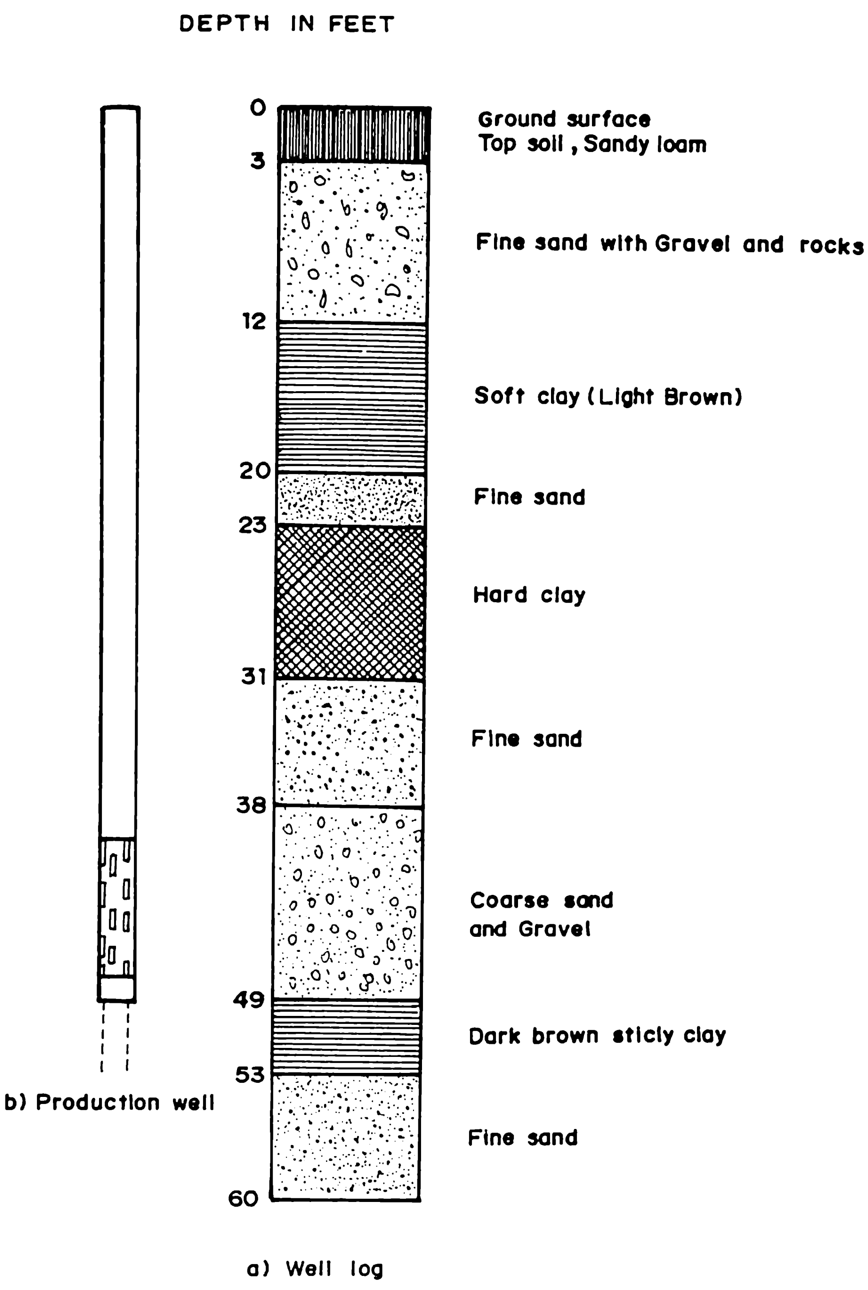


Figure 8
Well Log and 4-inch Diameter Shallow Tube Well in a AMDP, CEAT Experimental Site in Barangay San Miguel, Magalang, Pampanga.

transport across rice fields where vehicle cannot traversed. It has to be carried on shoulder part by part.

Lighter but durable materials could be used to decrease the weight of the system. Transport problem could be eliminated by redesigning it to a self-propelled or trailer-mounted drilling unit. Further simplification can be achieved by making it a single post drilling rig.

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