UNIVERSITY OF SCIENCE AND TECHNOLOGY

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With the Author's compliment

History

The suggestion of developing an appropriate type of hand operated well pump and starting its manufacturing in Ghana came from the Housing and Planning Research Department of the U.S.T., Kumasi in 1971. By that time this department had made some preliminary work on it, especially collecting the report and drawings of the Batelle Memorial Institute about an investigation of a well pump. These were handed over to the Department of Mechanical Engineering.

Being aware of the importance of such a project in a developing country we first made inquiries about the number of pumps needed per annum and the production possibilities. Finding them promising we adopted the drawings, ordered 10 sets of the cast parts and started production in the workshop of the Engineering Faculty. We completed the first prototype by the Open Day of the University on 5 - 2 - 1972. (fig. 1)

It achieved great publicity, it was reported in all of the Ghanaian papers and was on the T.V. It was referred to as a sound initiative of the University and a good example for the whole country.

The report of the Batelle Memorial Institute contained two types of the pumps, a shallow well type and a deep well type (figs. 2 and 3).

At the shallow well type the piston operated above the ground level while at the deepwell type it had a longer rod and operated below the ground level, not higher than about 20 ft above the drawn down water surface. On the other hand the shallow well type had a fixed fulcrum and the upper end of the rod moved along a circular arc, i.e. sideways too, while the deep well type had a pivoted fulcrum and a guided rod end.

This combination did not seem to be the right one the angular movement of the piston being greater in case of a short rod than in case of a long rod, so we decided to start with the simpler shallow well type, but to apply the guided rod.

These decisions seemed to be logical but, as it turned out later, neither of them was very fortunate because of the following reasons:

1) We had trouble with the guide, being difficult to get the two guide-holes in the centre line of the barrel and get the forked end of the handle moving in the same plane. We had to use some rigs for the machining and had to require greater accuracy all these effecting the cost of the pump.

2) We had trouble with the inner coating of the barrel. We used seamless, black steel pipe for the barrel as a direct consequence of the barrel being a constitutional part of the pump body. We wanted to get it sprayed from inside with the same paint which is used for cars. Possibly because the paint did not get hard enough before assembling the pump, it came off within a few hours time. Although the pump worked well (and it is still working) without any inside coating and the changing of the leather cup was very simple, we were not contented with this situation.

3) The idea of using plastic pipe for the barrel, instead of having difficulties with coating, made it inevitable to put the barrel below the ground level, for protection, and make the rod longer which, on the other hand, made the upper guide unnecessary.

Because of these reasons and bearing in mind that the vast majority of the wells in Ghana are deeper than 20 ft. and that the same type can be used for shallow wells, too, we redesigned the whole pump after the first prototype.

The second pump, made out of the castings available but according to the new principles, was installed on 21st April, 1972 at Ayigya, a village next to the University Campus. The well here, drilled by the Ghana Water and Sewerage Corporation for this purpose, was 105 feet deep, the standing water level being in a depth of 42 feet. The rising pipe of the pump was 80ft long, the piston rod 70 feet long.

There was no problem whatever with the installation, with lowering the plastic pipes in 20 feet long units, connecting them by solvent cement, fixing the pump body on the concrete cover, then lowering the piston and connecting the units of the piston rod and finally connecting the rod end with the handle by a pin. The pump worked well and caused a great jubilation on part of the village people.

But one morning we found the pump in an inclined position supported by an apt branch. The cast iron base part was broken. It was a very bad casting and we had not made sufficient allowance for bad casting. (In the new design the base part was stronger already.)

We changed the broken casting the next day and used the opportunity for changing the leather cup for a better one and since that time the pump is working perfectly.

Description of the Pump.

The pump (Fig. 4) is held by a cast iron base part anchored to the concrete cover by four $\frac{3}{4}$in. thick bolts. The anchor bolts were originally fixed in a rig and welded to a steel ring. This ring is to be put in the concrete concentrically with the bore hole and is holding the four bolts in their proper position.

The bore-hole-pipe, usually, 5in diameter, should extend from the concrete cover by $\frac{1}{2}$in. This stops the water from flowing back in the bore hole. The base part holds the 3in. diameter galvanised steel pipe by means of a robust clamp.

On the top of the steel pipe sits the pump body, having sealed, threaded connection. The body has a fulcrum part cast in one piece, which holds the pin of the handle. The upper end of the handle is connected with the rod end by another steel pin. The rod end and the lower hole in the handle have bronze bushes.

Rubber buffers stop the handle at both ends of the stroke. A cast iron lid covers the pump body fixed by a brass screw. The lid has a long hole in the middle in which the rod moves.

The lower end of the steel pipe is connected with a plastic pipe by means of a pipe clip. The steel pipe has a circular groove here not deeper than the normal pipe thread. The plastic pipe is pressed in this groove by the clip in warm state. The seal is provided by solvent cement.

All the other connections between plastic pipes are made with solvent cement. As for the strength, the C type plastic pipes are garanteed for a pressure of 256 ft of water (at a temperature of 30°C), and so are the solvent cement connections. There can be no problem with a load of some 80 feet of water, as a maximum.

In the lower end of the suction pipe a foot valve is fixed by the same method as the steel pipe in the upper end. The foot valve has to be equipped with the flap leather and with the weight first. It is advisible to coat the pipe clip with solvent cement from outside to save it from rusting.

The piston or plunger works somewhere in the middle of the lowest plastic pipe i.e. the length of the piston rod is less by about 6 ft than that of the plastic pipe, the upper end of the rod being higher by about 4 more feet. The piston can work at any point of the suction pipe except of the connection point and not higher than 20 ft above the lowest water level. The maintainer may be given a rule to cut off 1 ft of the piston rod (or to change one part of it by a shorter one) whenever he changes the leather cup to avoid wearing off the plastic pipe at one particular point.

The lower end of each plastic pipe and that of the steel pipe is chamfered in the bore to enable pulling out the piston with the leather cup without difficulty.

The piston parts are made of cast brass or bronze. The rod is of steel connected by brass nuts. The nuts are longer than twice the length of the thread on the rod that the end of the thread should go tight and should secure the nut from turning off. The nuts are very smooth and rounded off from outside because they may touch the inside of the plastic pipe.

The plastic pipe has the following advantages:

1) It resits corrosion perfectly.
2) It is smooth and this minimizes the wear of the leather cup.
3) It is light, easy to get it vertical when lowering in the bore hole.
4) It is cheaper than steel pipe.
5) It is produced in Ghana.

It has one disadvantage, namely, that it has to be cut at the joints when taking out of the well. (This may happen to the steel pipe as well if the threads rust together). But the plastic pipes are very easy to cut by a saw and a new muff can be made on the one end of each, afterwards.

It may give a problem that the plastic pipes are not straight enough. We made use of the 5in bore hole pipe to hold them straight by fixing small pieces of wood as distance keepers to the outside of the plastic pipes. We applied 4 pieces of wood of the appropriate size to the middle and 4 to one end of each plastic pipe and fixed them by copper wire and solvent cement.

The stroke volume of the pump is 0.9 litre = 0.2 gall. A bucket of 4 galls. can be filled by 20 strokes. (Volumetric losses are negligible). Doing one stroke in two seconds the filling time is 40 sec. In case of a deep well this may require too big effort but even in this case a bucket can be filled within one minute.

The force required on the handle depends on the depth of the water surface. In case of a depth of 50 ft, for example (most of the wells are less deep than that) the weight of the water to be lifted is 76 kgf = 167 lbf. The weight of the rod and piston in the water has to be added which in case of a length of 50 ft, is about 13 kgf = 29 lbf. The ratio of the arms of the handle is 1:5.4 and so the force calculated for the handle

$$\frac{1}{5.4}(167 + 29) = 36 \text{ lbf in this case.}$$

Some 3 lbf out of the 36 are balanced by the weight of the handle. The friction is negligible. So finally the force to be exerted by the operator while pushing down the handle is 33 lbf = 15 kgf. The handle comes up by itself. This effort can be expected from a man or even from a woman for a short time but it is too much for children. We are going to provide the pumps for such deep wells with a longer handle.

Installation of the Pump

All parts of the pump have to be carried to the site by a truck long enough for 20 ft long pipes.

The concrete cover must be ready and hardened (allowing at least 3 days for hardening) the bore-hole-pipe extending ½in, the four bolts extending 2in. It must have a horizontal surface around the hole of an area of about 1ft x 1ft and from here sloping down in each direction.

The installation starts with lowering the first plastic pipe, with the foot valve in it, in the hole. Below the muff on the upper end it has to be wrenched by a firm clamp. The lifting of one end can be assisted by a wood or bamboo of about 15ft length having a steel fork on the upper end.

As next a tripod of bamboo has to be stood up above the hole. The legs are 18ft long and there is a ring on the top of 10in diameter.

The muffled end of the next plastic pipe is to be fitted in this ring by means of the forked bamboo and then the lower end of the second plastic pipe fitted in the muff of the first one. The tripod has to be adjusted so that the pipe should be vertical.

Next task is the connecting of the two plastic pipes by solven cement. The inside of the muff and the end of the next pipe have to be cleaned by acetone first and then the solvent cement can be spread on both surfaces. After fitting them together and putting on some more solvent cement on the rim, we have to wait for one hour.

After one hour the clamp has to be removed and the second plastic pipe lowered in the bore hole. Then the exercise has to be repeated if the depth of the well requires so.

The last plastic pipe has the steel pipe part fixed to its upper end and the lifting of this end must be done more carefully. No heating of the plastic pipes is necessary on the site.

Three connections take practically the whole morning. The assembling can be continued after a lunch break and it takes about two more hours. This means that by the time the pump gets started that last connection has had time to harden for about three hours.

After lowering the last plastic pipe the pump stand has to be put on the steel pipe and fixed by the clamp. The pipe clamp can be removed and the base anchored by the four bolts.

The pump body is to be screwed on as next, using hemp and graphite for seal. The lowering of the piston assembly follows, screwed on the first portion of the piston rod. This must be held very carefully not to let it fall in the bore-hole. A patent pipe wrench is very useful which can be fixed at any point of the rod and left there alone. The lifting of the upper end of the rod is assisted by the forked bamboo once more and fitted in the ring of the tripod first.

For the connection of the rod the long brass nuts must not be turned round by a wrench to avoid spoiling their smooth surface, the lower end of the next rod has to be wrenched by the tool while the upper end of the former part is held on by-the patent wrench.

The last part of the piston rod is fitted with the rod end part and can be easily connected with the handle and the handle fixed in the fulcrum by pins.

At last the lid can be put on the pump body and fixed by a screw. Then the tripod can be removed the pump is ready to be started. As the piston is always below the standing water surface, the pump does not need priming. It may happen that, while pumping, the water level draws down and the suction pipe gets empty but it gets refilled during the next night at latest. But even this can be avoided by using sufficient long rising pipe.

Experiences and Further Plans

Up to the present we have had but a short time for a field test of the pump. But except of the breaking of one base part, we have had no bad experience.

The weak points of all types of pumps are the bearings, the leather cup and the foot valve. We have bronze bushes and smoothly finished pins for bearings and, according to the report of the Batelle Memorial Institute, there was no appreciable wearing on the leather cup operating in plastic coated barrel for 4500 hours.

The check valve leather in the foot valve may go wrong after long use. This can be changed in our pump only by cutting the rising pipe. The pipes can be reused with a very little vastage of length but on the site it is advisable to change the whole piping and the foot valve for new ones in such case and do the new muffing of the pipes and changing of the check valve leather in the workshop.

On the Open Day we asked several visitors to fill a 4 gallon bucket and took the time necessary for it. The results were the followings:

	Years Old	Sec/4 galls.
Boy	7	46
"	7	36
"	5	72
"	8	30
"	6	40
"	6	40
Girl	7	58
"	13	56
"	18	36
"	19	40
"	19	29
Woman		50

533 : 12 = 44.5

The average is 44.5 s/4 galls = 11.1 s/gall which gives an output of 5.4 galls/min = 325 galls/hour.

This pump took the water from a depth of 7ft. The children enjoyed the operation very much. But at Ayigya, where the depth was about 50 ft we saw that small children could not operate the pump so later we prolonged the handle by a 40 cm long pipe. It was here in Ayigya that we concluded from experience that pumping must not be started before completing the whole construction work because the crowd of people wanting water renders any further work impossible.

In the future we shall first complte 10 more pumps in co-operation with Ghana Water and Sewerage Corporation and allocate them in the neighbourhood of Kumasi for field testing. After some 6 months of observation the Ghana Water and Sewerage Corporation will take decision in the question of starting the mass production.

During this time, besides of recording all experiences, we are going to accomplish the following modifications.

(a) As we have difficulties in getting the cast iron parts, we shall change the upper part for welded steel construction.

(b) The welded handle will have longer arm and it will be wider at the pivoted point to reduce its transverse movement.

(c) We shall try to use synther-bronze or tephlon bushes in the bearings which do not require lubrication.

Kumasi, June 1972.

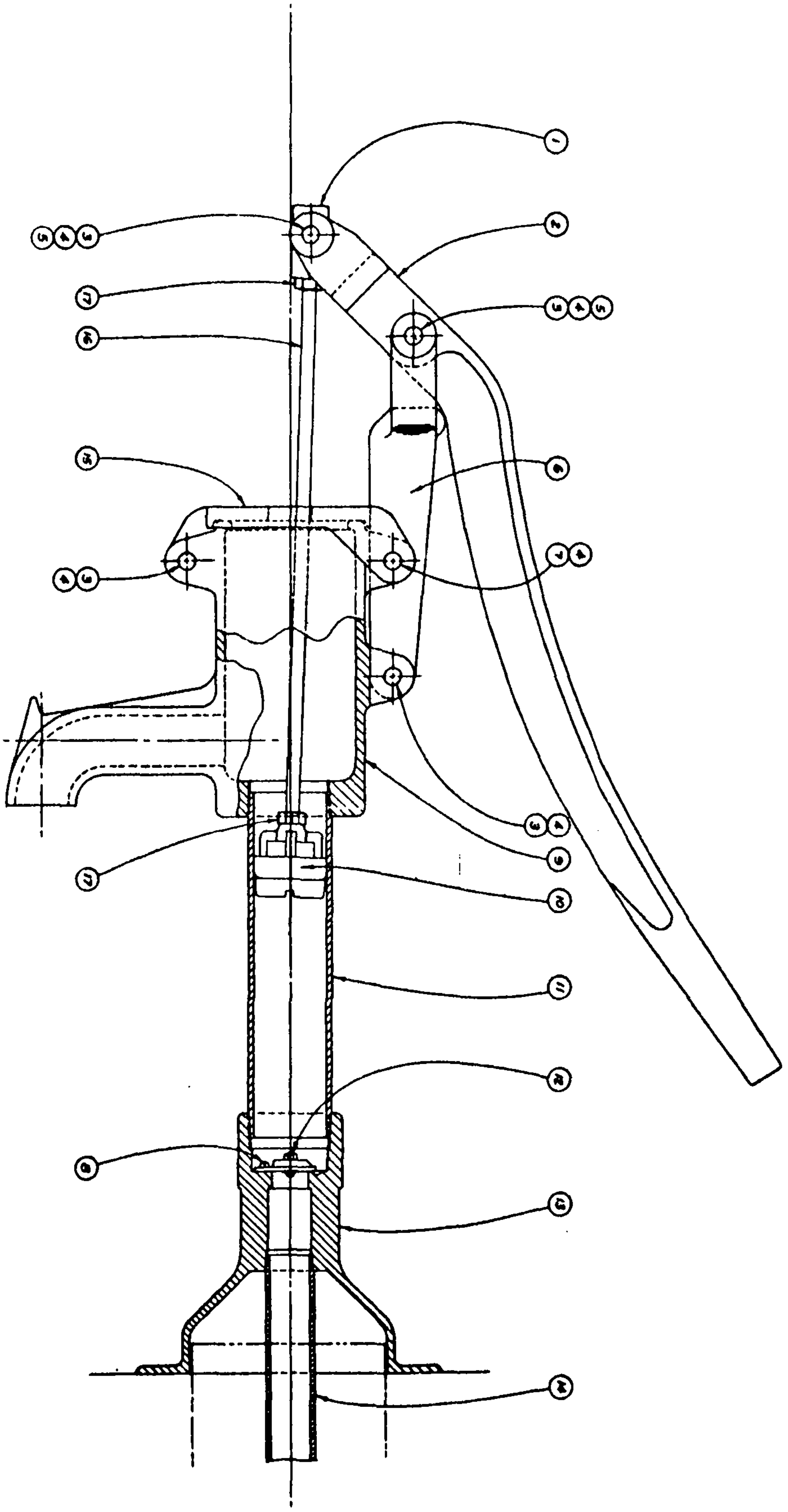


figure 2

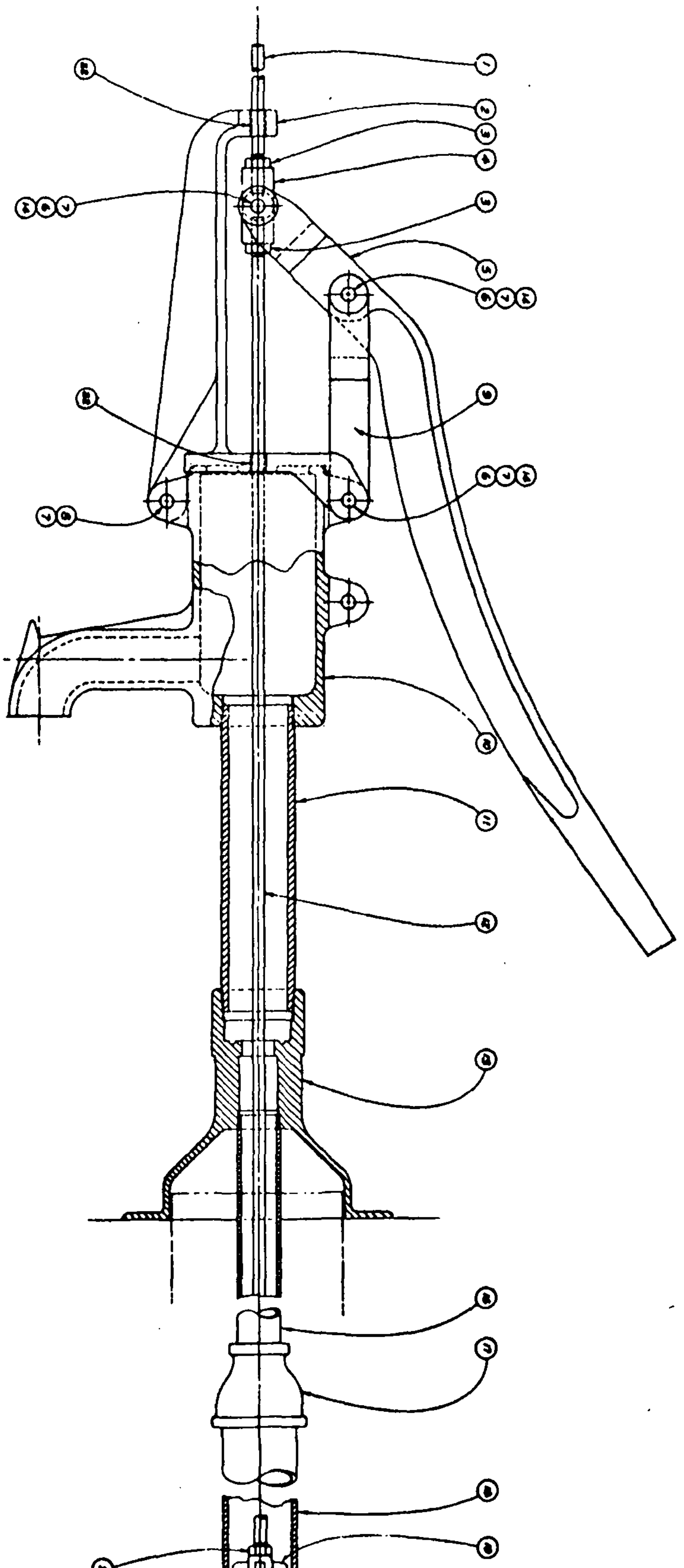
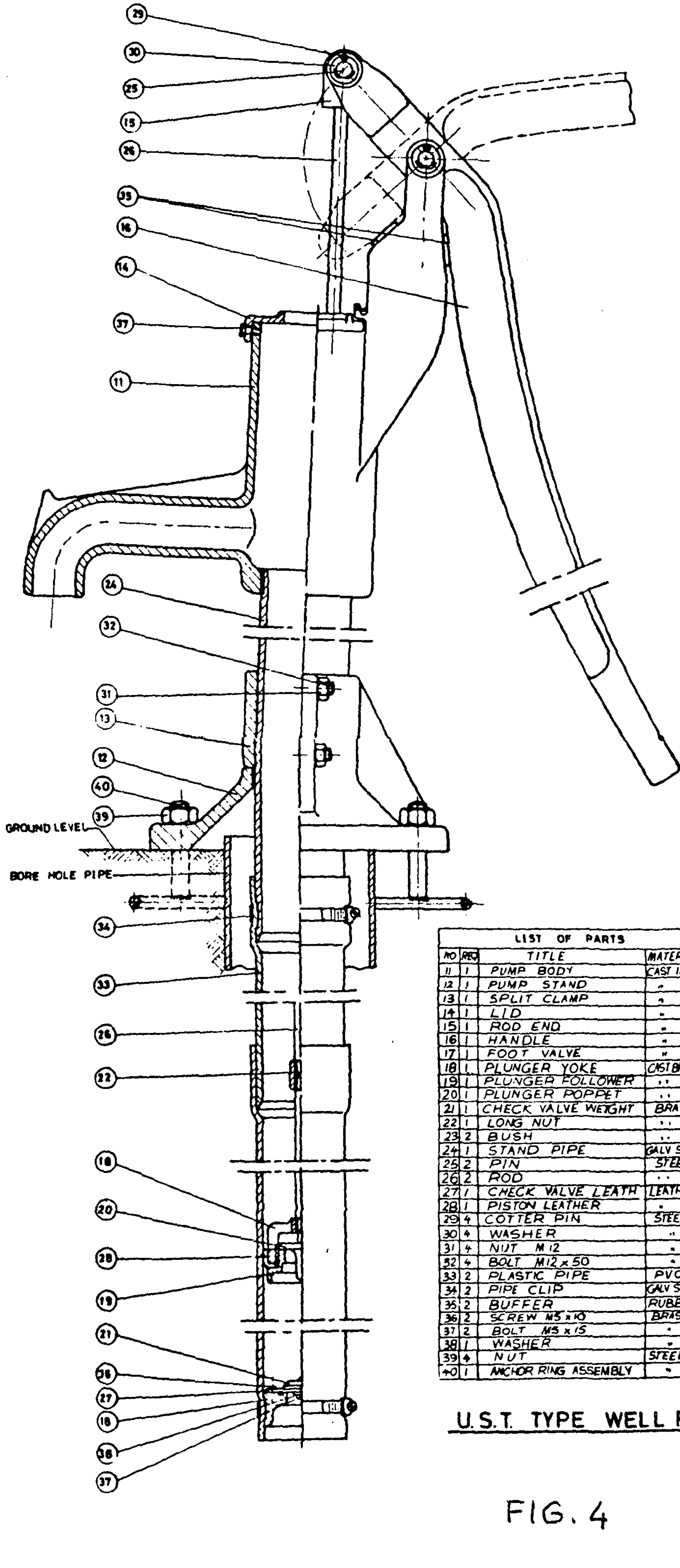


figure 3



LIST OF PARTS			
NO	REQ	TITLE	MATERIAL
11	1	PUMP BODY	CAST IRON
12	1	PUMP STAND	" "
13	1	SPLIT CLAMP	" "
14	1	LID	" "
15	1	ROD END	" "
16	1	HANDLE	" "
17	1	FOOT VALVE	" "
18	1	PLUNGER YOKE	CAST BRASS
19	1	PLUNGER FOLLOWER	" "
20	1	PLUNGER POPPET	" "
21	1	CHECK VALVE WEIGHT	BRASS
22	1	LONG NUT	"
23	2	BUSH	"
24	1	STAND PIPE	GALV STEEL
25	2	PIN	STEEL
26	2	ROD	"
27	1	CHECK VALVE LEATH	LEATHER
28	1	PISTON LEATHER	"
29	4	COTTER PIN	STEEL
30	4	WASHER	"
31	4	NUT M12	"
32	4	BOLT M12 x 50	"
33	2	PLASTIC PIPE	PVC
34	2	PIPE CLIP	GALV STEEL
35	2	BUFFER	RUBBER
36	2	SCREW M5 x 10	BRASS
37	2	BOLT M5 x 15	"
38	1	WASHER	"
39	4	NUT	STEEL
40	1	ANCHOR RING ASSEMBLY	"

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FIG. 4