COURSE MANUAL

MAINTENANCE OF HAND PUMPS AND RURAL SANITATION

CONDUCTED BY :

THE ALL INDIA INSTITUTE OF HYGIENE & PUBLIC HEALTH
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SPONSORED BY :

THE CENTRAL PUBLIC HEALTH AND ENVIRONMENTAL ENGINEERING ORGANISATION
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FOREWORD

With the advent of independence and the concept of a Welfare State, Public Health Engineering or Environmental Engineering has emerged as a specialised field in this country. With the launching of Five Year Plans, considerable expansion of activities in this field is taking place all over the country.

Training of personnel needed to execute and maintain these projects on Environmental Health is a pre-requisite for effective implementation of these projects. The All-India Institute of Hygiene & Public Health has been a pioneering Institute for post-graduate training and research in this field for more than a quarter of a century. During the current Fifth Plan period, a high priority is given for schemes providing Rural Water Supplies & Rural Sanitation and a large sum of out-lay is earmarked for this purpose. To design, execute and maintain these rural schemes, a large number of auxiliary Engineering workers, properly trained, are needed.

Hence, the Institute accepted the responsibility of conducting this short term course on "Maintenance of Hand-pumps & Rural Sanitation" sponsored by the Ministry of Works & Housing, and has conducted the first course from 3rd Nov. to 15th Nov., 1975, at the Rural Health Unit & Training Centre, Singur. It is hoped that more and more State Health Organizations, Community Development Departments and others engaged on these schemes will take advantage of this opportunity and their staff oriented in proper execution and maintenance of Rural Water Supply & Sanitation works for the benefit of the rural people.

(PROF. A.K. BANERJEE)
Director

P R E F A C E

Our country being largely Rural where over eighty per-cent of population still live in villages, problems of Rural Water Supply & Sanitation, call for highest attention. Realising this need, both Central and State Governments are already providing larger and larger sums of money during the successive plan periods to provide protected drinking water and facilities for safe disposal of human excreta, and a better living environment in the villages. Success of implementation of these schemes for providing a better living environment to the villagers largely depends on the army of peripheral health workers who form the backbone of health services in rural areas. A variety of workers are involved in this programme namely overseers in Community Development Blocks, District Boards, health inspectors attached to Primary Health Centres and village level workers, etc. Besides, many of the graduate engineers working at the sub-division and district level who are responsible for design, and construction of rural sanitation schemes still do not possess specialised training in environmental engineering, particularly in the field of Rural Sanitation. Unless these workers are properly oriented to the job they are expected to carry out, economy and efficiency in those services cannot be maintained. The Expert Committee constituted by the Ministry of Works and Housing, in 1974, to review the existing training programmes in the field of Environmental Health, recommended that training of these auxiliary health engineering workers in the principle and practice of Rural Water Supply & Sanitation is essential and a short-term Refresher Course should be immediately instituted at different centres in the Country.The All India Institute of Hygiene and Public Health, was chosen by the Ministry of Works & Housing, as one of the venue for starting such a course for the first time in the country. Accordingly, the Institute was asked to plan and conduct the course during November 1975. The course is carefully planned to impart basic knowledge on the principles of construction of Rural Water Supplies by providing wells and tube-wells, maintenance of hand-pumps, construction of sanitary latrines, manure pits, etc. Besides, basic knowledge on rural housing, composting, gobar gas plant, school sanitation, etc. are also included in the course content. An elementary knowledge on communicable diseases common in rural India and importance of environmental sanitation, in the control of these diseases and the role of health education in rural sanitation is also included. Emphasis is laid more on practical work rather than theoretical class room lectures. As this is the first course offared lasting for a period of 2 weeks, the course will be critically evaluated and the course content will be modified for the subsequent courses, to meet the desired objectives.

(S.Subba Rao)
Professor of Sanitary Engineering

COURSE CONTENT

1. RURAL WATER SUPPLY

1.1. Sources of water:

Rain and snow constitute the primary source of all water. A part of water thus received evaporates; a part is held up on the surface to form 'surface water' in the form of rivers, lakes etc., and the rest percolates into the earth and gets stored in suitable layers and forms 'underground' water.

There are, therefore, three possible sources of water for our daily use.

(1) Rain water collected directly from roofs or special water sheds and stored in cisterns or ponds.

(2) Natural surface water in streams and lakes

and (3) Ground water which is the most important source for rural areas.

1.1.1. Rain Water:

Rain water as, a source of water supply is confined to farms and rural settlements and that too in semi-arid regions devoid of satisfactory ground or surface waters. Rain water again can be categorised as:

a) For small individual supplies where rain water from roofs are collected and stored in cisterns.

b) For community supplies - where rain water obtained from prepared water sheds or catchments is stored in reservoirs.

Characteristics:

Rain water, as it leaves the cloud, is absolutely pure; but in its passage through lower reaches of the atmosphere it collects various impurities both gaseous and suspended. Rain water is essentially soft and plumbo solvent.

Method of collection and storage:

(a) For individual supplies, rain water running off roof is led through gutters and down spouts to barrels or cisterns situated on or beneath the ground. Although rainfall is intermittent the storage renders the supply fairly continuous.

When the cistern water is used for sinking proper precaution is necessary. Proper lids etc are required to be provided to prevent the cistern from getting polluted. There should be a provision to discard the first flush which contains dust, bird-droppings, and other unwanted washings. To be absolutely safe for drinking, however, the cistern water should be boiled or chlorinated.

(contd.-next page)

(b) For public supplies, rain water ~~ix~~ collection from a catchment area, usually situated at a higher level and drained into collecting reservoirs or ponds.

For this purpose the sheds or catches to be selected would be naturally impervious or made high by groating, cementing, paving or similar means. Thus the ponds should be located over heavy clays, silt clays or clay ~~lamsx~~ loams.

1.1.2. Surface waters:

Surface waters include any waters which lie on or flow over the surface of the ground, such as -

a) Unpland waters
b) Lakes and natural ponds
c) Rivers and streams.

These waters are moderately soft and likely to contain a high degree of surface pollution, at the same time are also liable to human and animal waste pollution.

1.1.2.1.Upland waters:

This refers to sources of collections of water found in the hilly and the mountainous regions. Usually such waters are harnessed by constructing earth, concrete, or masonry diversion dams across a convenient place in a valley.

Characteristics:

The water being from the upper reaches of habitation is relatively pure, both from bacteriological and chemical point of view, are quite suitable for all purposes including drinking.

Protection needed:

The small storage reservoirs, although sited in hilly country side, are liable to pollution through human and animal wastes, particularly during monsoon. Hence as a general precaution of strict vigilance as to not to allow grazing of animals and human habitation is to be ~~followedx~~ followed. Chlorination also is desirable.

1.1.2.2.Lakes and natural ponds:

(i) Lakes: Fresh-water natural lakes when kept free from pollution by human and animal wastes forms admirable source of water supply.

Characteristics:

Normally lakes keep up a good quality, having been aided by affects of storage, sedimentation and dilution.

Protection needed:

Nevertheless, washing of soiled clothings, indiscriminate bathing, surface washings, animal washings, ablution etc are common sources of pollution from which it is required to be protected. Hence a strict vigilance prohibiting bathing and washings with a fenced area of the lake ear-marked as a collection site for tapping the water is required.

(ii) Natural ponds:

Ponds are comprise of relatively much less quantity of water which is more or less stagnant. Effect of dilution and self-purification being much less the degree of pollution and contamination is much more intense which increases due to evaporation of water.

These are therefore never recommended as a source of supply. However, in places where there is no other alternative one has to depend on the ponds for water supply and in that case one or two ponds in a specified area should be ear-marked for water-supply and should be properly protected to ensure least pollution to reach the source. On top of this, the ponds should be disinfected as and when required.

Even after all these precautions as indicated above the water obtained is not found potable due to turbidity etc simple domestic treatment would be necessary. As an example the simplest of the methods is cited as follows:-

Take a bucket (approx. 3 gallons) of water. Add roughly 1 gm.of alum to it and thoroughly mix it. (For this purpose a number of 1 gm. packets of Alum may be supplied to the villagers concerned from time to time). After about 10-15 mins. the turbidity will settle at the bottom leaving clear impermabant water at the top. This supernatant water may now be decanted into a second bucket.

The clear water in the second bucket is then disinfected by addiing just a pinch of bleaching powder and giving a rest for ½ hour.

1.1.2.3. Rivers and streams:

Rivers are nothing but the natural drainage channels of the land. They being grossly polluted are, as such, unfit for drinking purposes. They require elaborate treatment that renders it safe and suitable for human consumption. These being perennial and quantity being adequate enough for many people, usually form the source for cities where lakes and ponds are usually not found and spot sources of ground water fail to cater to the demand.

Characteristics:

Except where arising directly from snow mountains above the limits of human habitation, all rivers and streams may always be held to be grossly contaminated owing to the frequent discharge of sewage from habitations on their banks. Due to its long traverse it goes on picking up disolved and suspended impurities - organic and inorganic pollutions. Since it is just impossible to protect the long lengths of its banks it does not virtually form the source of water supply for rural areas.

1.1.3. Ground water:

This constitutes the most dominant source for drinking water supply in rural areas because of its availability in nature in pure form.

It is therefore envisaged that rural health workers should be well conversant with this and hence ground water is dealt in detail in separate chapter.

1.1.3. GROUND WATER

1.1.3.1. Occurrence:

Of the total annual rainfall about one third is evaporated from earth's surface and plant foliage and one third flows as surface run off. The remaining one third percolates into the ground. A part of this underground water finds its way through soil and rock to ~~xxxx~~ oceans, lakes, and underground streams; a part finds its way to the surface again by seepage where it may form springs, lakes, ponds, swamps etc. And a third part is stored into porous spaces, and cavities of the soil and rock.

To the Sanitary and water supply engineers the third part is most important in so far as they constitute the bulk of ground water storage in earth's crust. The earth's crust is made up of layers of different kinds of soil and rock. Some of them permits easy passage of water through them e.g. sand, gravel, loam, sand stone and sandy lime stone. There are other types, such as clay, shell, marble and granite which are practically impervious to water unless they have got cracks or seams. The general features of geological formations affecting undergrond water supplies are shown in Fig. ~~xxxxxx~~ A land spring is a simple out cropping of water, which has percolated into a permeable subsoil and followed the first impermeable stratum to a point at which it reaches the surface as shown in fig.1. Seepage of ground water into rivers and lakes are also illustrated in Fig.1 and Artesian wells and springs are illustrated in Fig.2.

~~xxx~~ Methods of tapping ground water by means of Dugwells, tubewells, Bore~~xxxx~~ wells, and infiltration galleries will be discussed subsequently.

1.1.3.2. Characteristics:

Fe, Mn, Hardness, Co_2, pH, N, Do, Cl, Fl, etc., organic quality and nature of ground water is largely determined by the nature of the soil and rock through which it has passed. If it has percolated through subsoil and rocks where there is very little soluble substance and if there is no form of pollution the water will be soft, free from dissolved minerals e.g., Fe, Mn and because of the filtering action of the soil purer and cleaner than rain water collected from roof. In practice however, such a spring or well is a varity. As a rule water dissolves certain minerals from the soil and carries them along in solution. Common salt, iron, sulphur, Calcium, Magnesium are the most common minerals found in ground water. While the bicarbonates and sulphates and colorides of calcium and Magnesium causes hardness, dissolved iron and Manganese are also undesirable since they make the water turbid and strains clothes. In addition to minerals the ground water in some places may pick up organic matter from decaying vegetation particularly from refuse dumps or may even be polluted in soils which has solution cavities directly communicating to surface pollution sources. Lime stone formations is one such soil where solution cavities may exist. In addition to the organic matters in soluble form ground water may contain microorganisms derived from soils particularly soil aerogenics. And when a particular source of ground water is polluted by by sewage or human faeces, pathogenic organisms may also be present. But generally in most situations, water from a strata deep seated, the bacterial

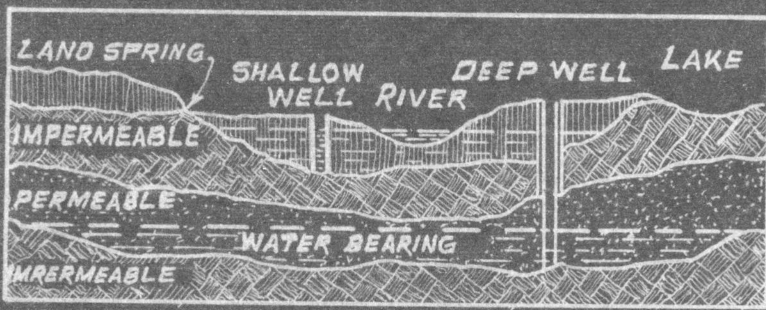


FIG.-1. SURFACE AND UNDERGROUND WATER SUPPLIES.

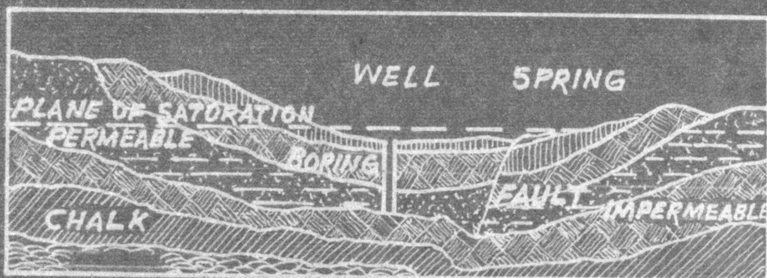


FIG.-2. ARTESIAN WATER SUPPLIES.

quality of ground water will be satisfactory and need no purification. There are instances reported in literature when water borne diseases such as typhoid, dysentry etc have spread through polluted ground water. Hence quality of ground water in a particular instance should be investigated and not presumed as safe.

1.1.3.3. GROUND WATER FLOW & ELEMENTARY WELL HYDRAULICS

Ground water aquifers may be either water table or artisian type. The former is one which is not confined by an upper impermeable layer. Water is virtually at atmospheric pressure and the upper surface of the zone of saturation is called the water table.

An artisian aquifer is one in which the water is confined under a pressure greater than atmospheric by an overlying relatively impermeable layer. The imaginary surface to which water will rise in an artisian aquifer is called piezometric surface. This surface may be above or below the ground surface at different parts of the same aquifer.

The openings and pores in a water bearing formation may be considered as a net work of inter connected pipes through which water flows at very slow rates few ft/day, from areas of recharge to areas of discharge. This imaginary network of pipes therefore serves to provide both storage and flow functions in an acquifer. Related to storage function there are two important properties known as 'porosity' and 'specific yield'.

The porosity of a water bearing formation is that percentage of the total volume of the formation, which consists of openings or pores. The amount of water yielded by or that may be taken from, a saturated formation is less than the amount it can hold and hence is not indicated by porosity. This quantity depends upon specific yield, which may be defined as the volume of water released from unit volm. of aquifer material when allowed to drain freely, under gravity.

The property of an aquifer which is related to its flow function is known as the permeability. It is a measure of the capacity of an aquifer to transmit water. It is related to the pressure difference and velocity of flow between two points, by the equation known as Darcy's law.

$$V = \frac{P\,(h_1 - h_2)}{l} \quad \text{or } Q = PIA$$

V = Velocity/ft/sec.

P = Co.eff. of permeability ft/day.

h_1, h_2 = pressure heads in feet.

L = length between the points.

I = Hydraulic gradient (ft/ft)

A = Cross sectional area of flow (Sqft).

Porosity is an important factor affecting the permeability and therefore the capacity of an aquifer for yielding water. Porosity must however be considered together with other related factors such as particle size, arrangement and distribution, continuity of pores and formation stratification.

Uniform sand 46%
Soft Bentonite clay 84%
Stiff glacial clay 37%

1.1.3.4. Tapping of ground water:

Ground water may be tapped either from natural sources such as springs, swamps etc or by digging wells, infiltration galleries etc. At low points along valleys, in ravines and gulleys where the surface of the ground dips down below the level of the water table or below the level where there is plenty of free water in the soil or rock, there is likely to be seepage of water to the surface. If the seepage is concentrated in one place a spring will be formed. If the seepage is along the line of an out cropping of rock a swamp may be formed. For tapping these ~~material~~ natural sources of ground water it is sometimes necessary to have some piping system as their locations may not be always convenient for communties.

By far the most universal way of tapping ground water is by means of digging or drilling wells upto the water bearing strata and lifting water therefrom mannually or by pumping.

1.1.3.5. Construction of wells:

There are two types of construction for deep or shallow wells, namely dugwells, and drilled & driven tabular wells. A well is a small dia opening in the ground to reach the ground water. Wells may be classified in different ways, viz., shallow or deep; Dug or Drilled etc. A shallow well is a well ~~wh~~ which draws water from unconfined aquifers including subsurface flow. A deep well is one which is sunk to a depth so that water is drawn from a water bearing strata located below at least one impervious layer. Dia or depth is not the criteria in this classification.

1.1.3.5.1. Dug wells:

The dug well is usually a round hole or shaft dug into the ground manually and extending below the level of ground water in dry weather. The whole is generally 3 to 10 ft in dia (may be bigger as well), and a steining constructed with ~~xx~~ stone, brick or concrete as shown in Fig.~~xx~~ Good constructionrequires the upper part of the wall (at least 10' from GL) to be water tight (by ~~wx~~ plastering with CM) to keep out surface water . The well should be preferably covered and the well steining should extend above ground, where well is not covered a 2½' high parapet alround should be provided. An impervious platform (at least 4'-5' wide) sloping away from the well should be provided with a drain leading to a soak pit or natural valley at least ~~15xx~~ 15' away from the well.

Dug wells are usually shallow, although in regions where the bed rock is deep,there are some deep dry wells. Use of fixed pulley with chain and bucket should be encouraged as indidual ropes and vessels are likely to contaminate the well water.

1.1.3.5.2. Drilled or driven wells:

There are four basic operations involved in the construction of these wells - drilling (boring or driving) operation, casing installation where necessary, grouting if necessary and strainer installation.

a) DRILLING OPERATION

(i) Boring:

This is generally undertaken with hand turned earth augers for small diameters and shallow depths, though power operated augers are also used. Augers may be spiral type or cutting bit type. The hole is started by forcing the blades of the bit into the soil with a turning motion. Turning is continued until the auger bit is full, it is then emptied and returned to use. Shaft extentions are added as needed to bore to the desired depth.

Wells deeper than 15' will require the use of a light tripod with a pully at the top, or a raised platform so that the auger shaft may be inserted and removed without disconnecting the entire shaft sections.

The method is used in boring to depths of about 50' in clay, silt and sand formations not subject to caving.

(ii) Driving:

Driven wells are constructed by driving into the ground a well point fitted to the lower end of a tightly connected pipe section - Figure X Equipments used includes a drive hammer, drive cap to protect the top, tripod, pully and a strong rope. Well points may driven either by hand or with the aid of machines.

A starting whole is first made by boring or digging to a depth of about 2' or more. If the water table is shallow enough, the hole should preferably penetrate it as driving is easier in a saturated formations. The well point is inserted into this hole and driven to the desired depth, subsequent lengths of riser pipe being added as necessary. The well point assembly should be guided as vertically as possible and the driving tool when suspended, should be hung directly over the centre of the well. The weight of the driving tool may range from 75 to 300 lbs. Heavier tools require the use of power hoist or drilling rig. Driven wells can be installed only in unconsolidated formations relatively free of cobbles or boulders. Hand driving is possible upto 30' where as machine driving can go beyond 50'.

(iii) Jetting:

Here the force of a high velocity stream or jet is used to cut a hole in the ground. The jet of fluid lossens the subsurface materials and transports them upward and out of the hole.

A tripod is used to suspend the drill pipe and the cutter. A pump having a capacity of approximately 150 gallons/min at 50 to 70 ps is used to force the drilling fluids through suitable hose and a small swivel head or through the drill pipe and bit. The fluid on emerging from the drilled hole, travels in a narrow ditch to a settling pit where the drilled materials settle out and then to a storage pit where from it is recirculated by means of a force & lift pump. A piston type reciprocating pumps would be preferred to a centrifugal and because of the greater maintenance required by the latter.

The spudding percussion action can be imparted to the cutter either by means of a hoist or by workmen alternatively putting and quickly releasing the free end of the manila rope. This may be done while other workmen rotate the drill pipe. Upto 50' may be achieved with water as drilling fluid without undue caving. When caving does occur, then a drilling mud should be recirculated.

iv) Sludger Method:

This method, which is supposed to have been developed in Bangladesh, uses only hand tools and locally available material such as bamboo for scaffolding. It is particularly suitable for inaccessible areas where labour is plentiful.

The reciprocating motion of the drill pipe is provided by a mannually operated bamboo lever, to which the drill pipe is fastened with a chain. A sharpened cutter is used as a bit at the lower end of the drill pipe. A man uses his hand to perform the functions of a check valve, as used in hydraulic percussion method. Water is added to the pit around the drill as the level drops.

Wells upto 250' have been drilled by this method in fine or sandy formations. Reasonably accurate formation samples, low cost, and less operating skill makes this process particularly suitable for underdeveloped countries.

(v) Hydraulic Percussion:

The hydraulic percussion method uses a similar string of drill pipe to that of the jetting method. The bit is also similar except for the ball check valve placed between the bit and the lower end of the drill pipe. Water is introduced continuously into the borehole outside of the drill pipe. A reciprocating motion applied to the drill pipe forces water with suspended cuttings into the drill pipe, trapping it as the valve closes on the upstroke. The fluid and cuttings are lifted to the top due to continuous reciprocating motion and are discharged into a settling tank. Casing is usually driven as drilling proceeds.

The method uses minimum of equipment and provides accurate samples of formations. It is well suited for use in clay and sand formations.

(vi) Hydraulic Rotary:

The hydraulic rotary drilling combines the use of a rotating bit for cutting the bore hole with that of continuously circulated drlling fluid for removal of the cuttings. A rotary drilling machine or rig consists of a drick or mast and hoist, a power operated revolving table that rotates the drill stem and drill bit below it; a pump for forcing drilling fluid via a length of hose and a swivel or through the drill stem and bit and a power unit or engine.

The fluid circulation system is similar to that of jetting method as described earlier.

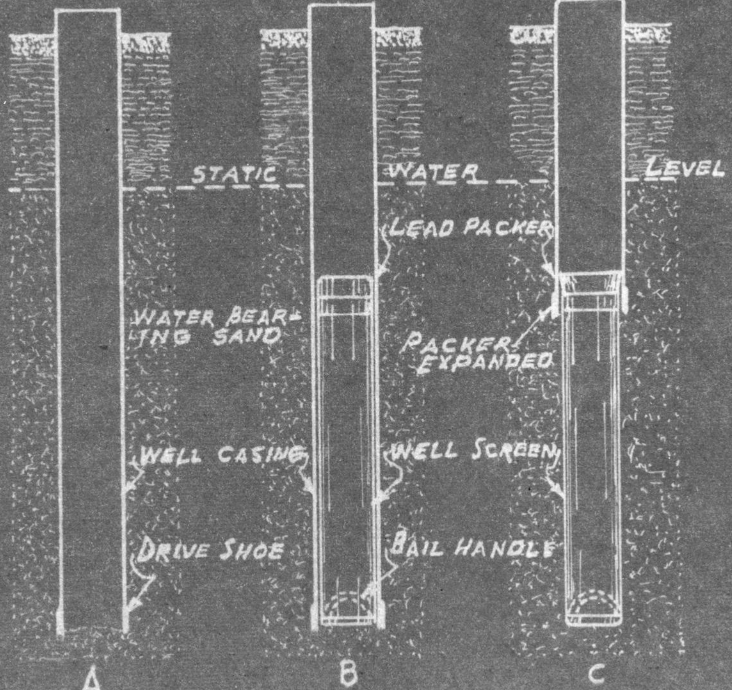


FIG-3 PULL-BACK METHOD OF SETTLING WELL SCREENS.

A- CASING IS SUNK TO FULL DEPTH O WELL.
B- WELL SCREEN IS LOWERED INSIDE CASING.
C- CASING IS PULLED BACK TO EXPOSE SCREEN IN WATER BEARING FORMATION.

Installation of well casing:

Setting of casing in an open bore-hole is not necessary for those drilling operations where the casing closely follows the drill bit. However in case of hydraulic rotary, jetting, hydraulic percussion on sludger method this operation is required. Before lowering the casing, one should ascertain that the bore-hole is free from any obstructions throughout its depth. Sometimes the hole is drilled to greater depth than is necessary so that any caving materials may fill the extra depth.

The first length of casing is lowered until the coupling, and then the second length is lifted into position and screwed into the coupling of the 1st length. The thrades of the casing and coupling should be coated with thin oil. Joints should be tightly screwed to avoid leakage. The procedure is repeated for as many successive lengths of casing as may be required.

Grouting and sealing:

Grouting means the process by which a slurry of watery mixture of cement and clay is used to fill the gap between the casing and the wall of the borehole, to prevent contaminated water from the upper stratas from entering the tubewell.

Puddle clay of the type suitable for use as drilling fluid can also be used for grouting. Mud circulation pumps which are normally used for drilling purposes, may be used for placing the slurry. It should be placed below the first few feet from the surface where it would not be subjected to drying and shrinkage.

Mixing of the grout may be done in a concrete mixer if available, otherwise for small walls it may be mixed in a clean 50 gallon oil drum. To 20 gals of water in the drum, 4 sacks of cement should be added and vigorously stirred with a paddle.

After cement grout has been placed no further work on the tubewell should be done on the well until the grout has hardened. Generally a period of 72 hours is allowed for this.

Installation of wall strainers:

There are various method from lowering the strainer, the choice being guided by the design of the well, drilling method, and type of problems encountered in the drilling operation.

One such method which is very simple and safe is the pull back method. It is applicable for both rotary dilled well as well as percussion method.

The strainer is lowered within the casing, which is then pulled back a sufficient distance to expose the strainer. The basic operational detail of setting a strainer by pull back method is indicated in Fig. 3.

In small dia tubewells, for hand pumping, 2 lengths of 6' strainers (metallic or plastic) are joined to form a 12' length strainer to which a blank pipe (4'-5' long) fitted with a shoe is joined. With the blank pipe with show facing downwards it is lowered into already jetted bore and as many lengths of suction G.I. pipe as needed are added and lowered till the pipe projects over the ground level. The wall is cleaned and developed before plugging the shoe by droping the tapered plug from top.

Sanitary protection of wells:

Of primary importance is the location of sewage disposal system e.g. septic tank, cesspool, outdoor privy etc with respect to the well. They should never be located upgrade from the well.

It may sometime happen that the slant of the bed rock is opposite to the slope of the ground. In such cases sewage may line its way back to the well even in the sewage system is at a lower elevation. Mostly shallow wells are exposed to such dangers. Deep wells which penetrates through one impervious layer are rather safe.

Another source of pollution is surface water. Dugwells should be so boxed that surface water cannot enter. They should have good sloping cone caps extending well above the ground surface.

In case of tubular wells, well casing should extend at least one foot above the general ground level. It should be surrounded at the ground surface by a cone slab (min. 4" thick) extending 2' in all direction, sloping outside. It is also a good practice to place a drain around which should discharge at a distance. A sanitary well seal should be provided at the top.

Care should be taken to see that all abandoned wells are properly sealed to prevent contamination of the aquifer.

The following table shows the minimum distance of wells from pollution sources.

Table 1 : Safe distance between a well and pollution sources.

Pollution source	Recommended min. distance
1) C.I. sewers with lead joints or mechanical joints.	10'
2) Septic tank or sewer or tightly jointed tile.	50'
3) Earth pit privy, seepage pit etc.	75'
4) Cesspool receiving raw sewage.	100'

1.2. Reciprocating Pumps : (Stroke Pumps, Plunger Pump).

Reciprocating or cylinder pumps have perhaps the widest application for small water supply systems in rural areas. They are adopted for manual, gas or oil engine and electric motor and combined manual and electric mortor operation. They belong to the category of constant displacement type i.e. the discharge rate is regardless of pressure head against which they are operating. However input power or driving force varies directly in proportion to the pressure head and must be doubled in the pressure head is doubled. Before discussing the types of reciprocating pumps that are used in pumping water from small wells in rural area some basic principles of pumping should be understood.

1.2.1. Basic Principles of Pumping A water well.

Except in case of fully artesian wells some external power is required to drive a pump and so cause it to lift the water from wells. The source of power may be man who uses his hand or leg to operate a lever upward and downward or forward and backward or who turns a wheel connected to the pump. In this case the pump is said to be manually operated or Hand pump. The power source may also be a windmill, a gasoline or diesel engine or an electric motor. Then it is called a 'Power Pump!

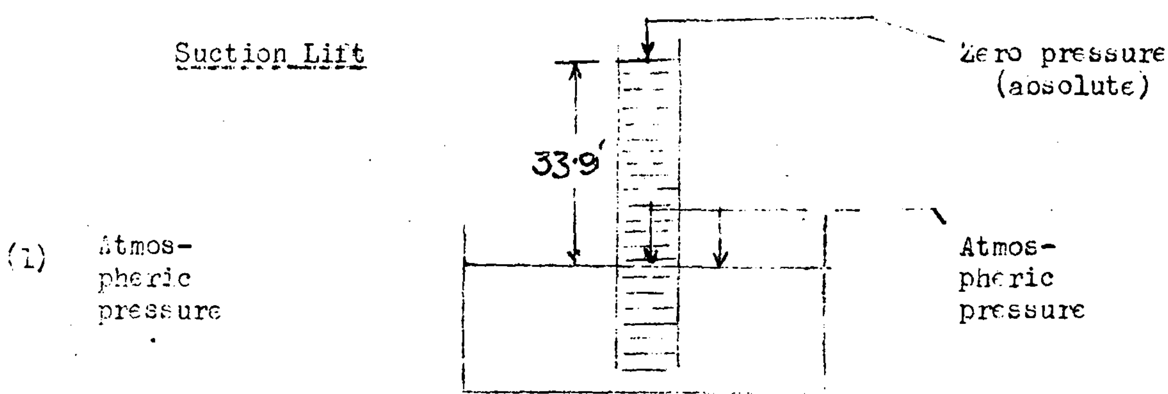


FIG.1: SUCTION LIFT

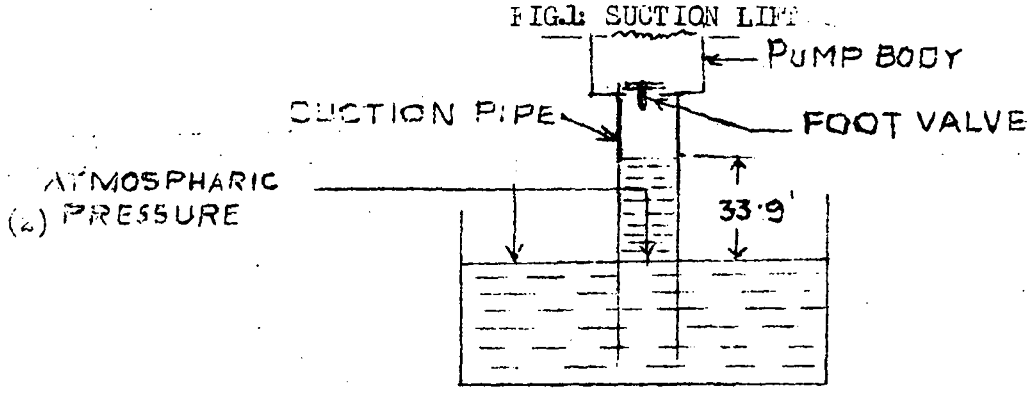


FIG.2: SUCTION LIFT IN STROKE PUMP.

Atmospheric pressure is 14.7 lbs/sq" (33.9' of water) at sea level. In fig.A, we have a pump installed ready for pumping. When we start pumping we first pump air in the suction pipe and thus push water from outside into suction pipe. In fig.B we find that even after removing all air inside the suction water does not discharge from the pump spout. Because, the atmosphere outside on the surface of water can push up water to a height equal to this pressure i.e. 33.9'. We can't increase the atmosphere pressure and so water can't raise any further. This is suction lift. Max theoretical lift is limited to atmospheric pressure at the place. Above pre decreases with increasing altitude of the place, further it will not even raise to 33.9' because no pump is 100% ~~efficient~~ efficient to create a complete vacum and also there is friction loss in suction pipe. Hence at sea level a best designed pump can a suction lift of about 25 feet while the suction lift of an average pump varies from 15' to 18'.

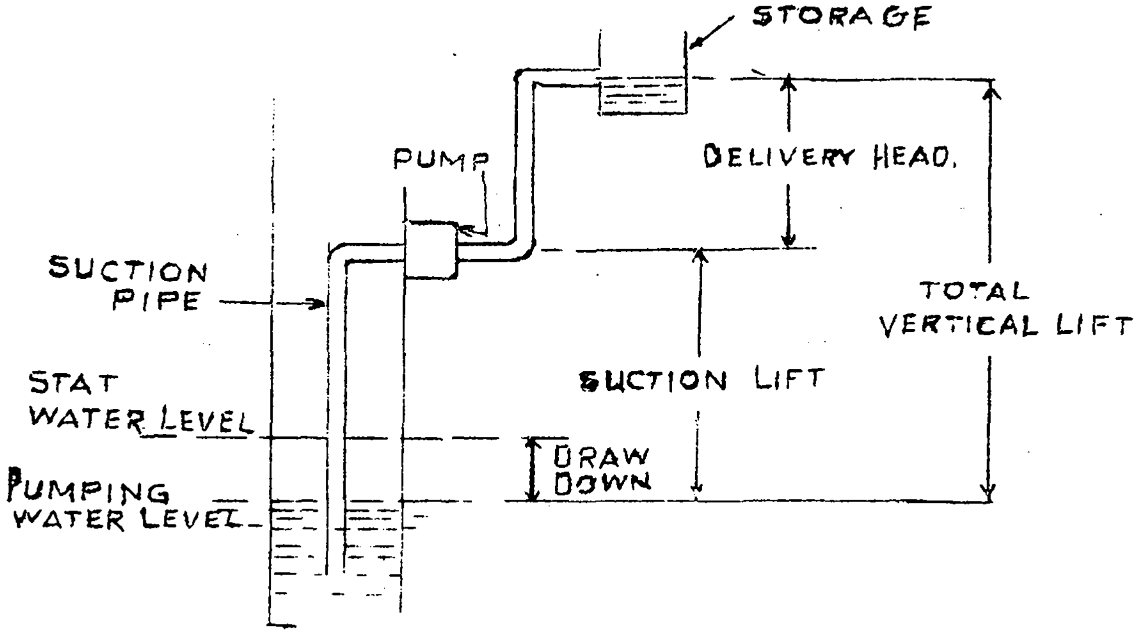


Fig: ILLUSTRATION OF SUCTION LIFT, TOTAL LIFT, DRAWDOWN, DELIVERY HEAD.

Once the pump starts lifting water the Static water table goes down and assume a new position. This is pumping water level.

Table
Recommended Suction lifts of Pumps at Sea level and at Higher altitudes

Altitude	Barometric pressure in lbs/squinch.	Equivalent head of water in feet	Maxian Practical suction lift of pump - feet.
Sea level	14.7	33.95	25
1320' above scalevel	14.02	32.38	23
2640' "	13.33	30.79	22
3960 "	12.66	29.24	21
5280 "	12.02	27.76	20
6600 "	11.42	26.38	19
7920 "	10.88	25.13	18
10560 "	9.88	22.82	16

Total lift:

When we add to suction lift friction loss, and delivery head we get Total lift against which pump has to lift water and the power required varies as total lift.

Delivery head:

Height to which water has to be raised above the centre line of the pump is called delivery head.

Draw-down:

The water-table is depressed when wells are pumped and assumes a new position. The depth by which water table is depressed is called 'Draw-down'. Pumps should not be worked with excessive drawdown for two reasons -

1) The suction lift is increased.
2) Causes blowing in of finer material into well because velocity of flow into well exceeds critical velocity of flow in the formation.

Limiting Suction lift:

It should not be exceeded as indicated in Table . Should it be necessary to lift water from a well from a level 25 feet or more below ground surface, some means must be found of lowering the pump into the well either completely submerging the pump in the water or taking it near enough to the water surface to permit suction lifting of the water.

The limiting suction lift is used to classify pumps into Surface type or Shallow well pumps or 'Deepwell pumps'.

Surface or Shallow well pumps:

They are those pumps which are placed at or above ground surface and are limited to lifting water by suction from a depth usually not greater than about 25 feet below the ground surface.

Deep well pumps:

Are those pumps which are placed within the well and are used for extracting water from depths generally in excess of 25' feet below the ground surface.

1.2.2. Hand Pumps:

Generally all hand pumps are of the Reciprocating or piston type pumps except the hand rotary pump. Depending upon the depth from which water is lifted, they are again classified into two groups viz., 1) Surface or Shallow well type 2) Deep well type.

1.2.2.1. Shallow well type Hand-pumps:

The Shallow well type hand-pumps work by the principle of suction lift. Hence, if the water table in the well or tubewell does not go below the recomended practical suction lift (vide table), while pumping, shallow well pumps can be installed.

1.2.2.1.1. How Pump works:

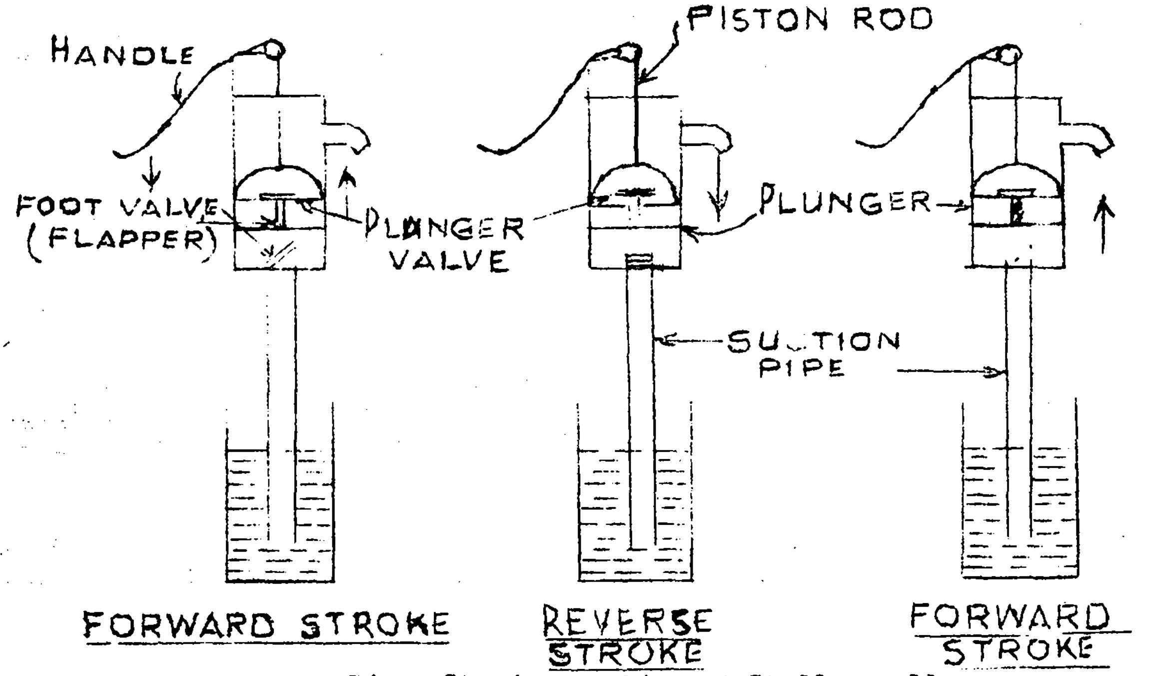


Fig. Showing working of Shallow well pump.

The main elements of the pump are a piston or a plunger with a valve, and a foot valve. The piston is moved up and down in a cylinder (forward or backward) by the handle. During the forward strike, the foot-valve opens, the plunger valve closes, causing a partial vacumm sucking water from the suction pipe at the same time pushing the water already collected above the plunger out of the cylinder through the spout. During the reverse or backward stroke, the foot valve is closed and the water collected below the plunger is pressed upward and opens the plunger valve raising it above the plunger and no water comes out of the spout. Hence for one complete stroke (one forward and reverse ~~motan~~ motion), water discharges from the spout only once. Hence it is called Single Acting. The amount of water discharged per stroke therefore depends on diameter of cylinder (or piston which closely fits in) and the length of stroke is theoretically equal to $\frac{\pi}{4} d^2 \times h$ where d = dia of cylinder and h is the stroke length. The more the length of stroke and larger the diameter greater is the lifted discharge per stroke. For a given diameter and stroke length discharge can be increased by increasing number of strikes per minute. Practically, there is a certain amount of slippage of water from top of plunger to the bottom. The slippage increases with use due to wear of bucket used in plunger. The slippage should not be more than 5% for a new pump or an used pump in good conditon. The efficiency of hand pumps with stroke length not more than 6" and number of strikes per minute ~~rangng~~ ranging from 15-30 ~~willn~~ will not be more than 50-70% and may drop down to 30-40% with use.

If the pump is made to discharge both during forward and reverse stroke, it is called double acting. Then the discharge per stroke is doubled. This requires a differential plunger. If instead of one cylinder and a piston, two cylinders with pistons are used, the discharge can be doubled. Such a reciprocating pump is called 'Duplex' pump. Similarly Triplex pumps are also built. Double acting or Duplex designs are not well suited for hand-pumps. They are better suited for power operation by electric motors and diesel or petrol engines.

Table

Theoretical Capacity of Hand-pump per stroke
(Figures are for one single acting cylinder)

Inner Dia. of cylinder	Area sq. inches	Length of stroke in inches & capacity in gallons						
		2	3	4	5	6	7	8
2	3.142	.027	.041	.054	.068	.082	.095	.109
2½	3.976	.034	.052	.069	.086	.103	.121	.138
2½	4.909	.043	.064	.085	.107	.128	.149	.170
2¾"	5.94	.051	.077	.103	.128	.154	.180	.206
3"	7.069	.061	.092	.122	.153	.184	.214	.245
3¼"	8.296	.072	.108	.144	.180	.215	.252	.287
3½"	9.622	.083	.125	.167	.208	.25	.292	.333
3¾"	11.045	.095	.143	.191	.238	.287	.334	.382

Doubling the diameter of cylinder quadruples its capacity. Comercially available shallow well type hand pumps have a cylinder dia ranging from 2½" to 3¾" and stroke length 4"–8", with a common length of 6". Hence a 3½" dia cylinder of stroke length 6" has a therotical capacity of 0.25 gallons per stroke.

1.2.2.1.2. Parts of a Shallow wells Type Hand-pump:

All hand-pumps consist of the following essential compartments:

i) Pump body (barrel or cylinder)
ii) Pump-base plate
iii) Pump-head (cover) with fulcrum
iv) Plunger assembly with popett valve
v) Piston or plunger rod
vi) Foot-valve or flapper valve with height & screw
vii) Handle
viii) Bolts and nuts for connecting base to body, head to body and handle to plunger rod and fulcrum
ix) Leather-bucket.

The pump body is fastened to the base by means of bolts and nuts. The Base is screwed on to the tubewell pipe (suction). The plunger assembly is inside cylinder and consits of a plunger yoke, a plunger follower(wherein the cut fits) and a plunger poppet valve. The piston rod is threaded at one end and the other end forms an eye. The threaded end is fitted to plunger yoke. The eye end is connected to the handle fork end by means of a bolt and nut. The barrel is topped by a head with a forked bracket, which acts as a fulcrum to handle. The handle is connected to this forked fulcrum by means of a bolt and nut. The head is connected to the body by 3 bolts and nuts. The componants are easly detachable and this could be easily repaired or replaced. The pumps are generally available in three sizes with cylinder bore diameters 3" (76 m), 3¼" (83 m) and 3½" (89 mm) comonly known as No.4, 5 and 6 respectively.

Drawings with dimensions of the components of an Average handp pump No.6, as obtained in the Calcutta market are shown in figure .

1.2.2.1.3. Commercially available hand pumps and their defects:

There are several brands of hand-pumps in the country. In this region alone there are at least five known brands, viz., Jerisko, Bisw-Kali, G.B., Lyoo and Kisan, which are popular. On examination of the hand pumps available in the market shows that they have almost similar features. There is however difference in the finish of and and minor variations in the dimensions of the componant parts (vide appendix A). Dimensions may vary from pump to pump even in the same brand. Thus indicating there is no standard of manufacture of these pumps.

A study undertaken by the All-India Institute of Hygiene and Public Health with the assistance of WHO/UNICEF showed the following deficiencies in the commercially available hand pumps:

i) Casting:

Low grade pig-iron with a high (0.5-0.60,) phosphorus content is used in the manufacture of component parts. Hence the castings are are hard and brittle, leading to breakage particularly head and handle. Excessive hardness is responsible for poor finish which contributes to excessive wear and tear of the components in contact.

ii) Pump cylinder:

Inner face of the cylinder is not smooth and cannot be machined smoothly because of low grade iron. Smoothness measured in terms of Error in wariness of the surface was of the order of +0.16 mm. A smooth finish should not have more than 5 microns (.005 mm). A better grade pig iron with not more than 0.15 - 0.2% of phosphorus should be used.

Plunger : The casting of plunger is generally poor with lot of blow holes. The thickness of yoke being inadequate threads are not cut full depth resulting in breaking of threads, thus requiring frequent replaceent of entire plunger assembly.

iii) Plunger valve (Poppet):

The surface finish of poppet, and its seat, is not smooth and flat. Thus the mating area is not 100% leaving clearance causing slippage of water resulting in lowering efficiency of pumping.

iv) Leather Bucket:

Although there is a wide variation in the leather bucket diameter, it does not materially affect the hydraulic performance of the pump because the leather when wetted swells and conforms to the surface of cylinder surface giving a water tight contact. It is the poor quality of leather that is used which results in excessive wear and tear. Bad tanning will make the leather too soft on being wet and thus does not give required water tight contact. Leather used in buckets needs standardisation and alternate materials like plastic, neoprine merits consideration for use. Plunger made of Hylum with a ball-valve of nylon and HL plastic seating is worth a trial.

v) Flapper valve (Foot-valve)

Flapper valve in effect is a non-retain or check valve made of leather fitted with a small weight by a ¼" x ½" G.I. bolt & nut, offering an air tight cover over the suction pipe. Because of the inferior quality of leather, poor taunning alternate drying and wetting the valve losses its elastic property and cracks at the contact point of weight and leather. Thereafter it does not give water tightness thus resulting in leakage. Generally it is not torn but distorted. Improper machining of the valve seat results in less than 100% mating area thus leading to air-leakage. Improvement of quality of leather, proper machining of valve seat to give 100% mating area or smooth plastic bush to the valve seat will minimise leakage of air and frequency of replacement of this valve. The bolts and nuts to fix valve-weight should be replaced by a countersunk screw. Leather may be replaced by plastic.

(vi) Handle and Head:

These two parts require less frequent replacement. Breakages are due to bad handling and brittleness of low grade cast-iron. The handle is fixed to the forked fulcrum in the head with bolts and nuts. The eye of the piston rod (plunger rod) is inserted in the forked end of the handle and fixed with bolts and nuts. The eye of the piston rod and hole in the hadle where bolt is inserted wear out enlarging holes and resulting in lateral ply of the handle. The eye of the piston rod then shears off droping the piston into pump cylinder. The increased lateral ply of handle acclerates wear of the holes in the handle and fulcrum which in turn effects efficiency of pump. There is an excessive clearance in the forked end (½") to accommodate piston rod. This also results in excessive lateral ply of the piston thus resulting in uneven wear of leather bucket, inner-surface of cylinder. This clearance should be reduced to 1/16". Nuts get loosened and drop off, bolts gets sheared. Use of better Grade C.I., reducing clearance in holes, use of ordinary M.S.pins or cintered pins instead of bolts and nuts, should remedy these defects. A copper or bronze bushing to holes is preferred but costly. Changing the fulcrum from pumphead to pump-body should reduce the slackening effect on bolts and nuts fixing head to pump body.

(vii) Base plate:

Base plate provides seating of the flapper and hold it tight with the pump-body to prevent leakage of air from outside when pumped. This requires good finishing for seat in the base, bottom rim of pump-body and tight fitting of bolts and nuts. The cleearance in holes for inserting bolts should be minimised.

(viii) Piston Rod (Plunger rod)

These are generally made of flats rounded at lower end for threading to connect to plunger assembly. Threads are not cut to full depth and threads wll be poor because the iron has been reheated to rounding at end. Hence it is better if round rods (½" dia) are used instead of flat iron.

(ix) Bolts & Nuts:

There are four sizes of Bolts and nuts used viz., 3½" x ½", 3" x ½", 4½" x ½" or 3/8", 3/4" x ¼" for connecting, handle to fulcrum, handle to plunger rod eye, base to body, valve weight to flapper leather respectively. There is excessive tolerance in holes through these are passed resulting in undesirable fly and minimising rigidity of fix.

This causes slackening of bolts and nuts and falling off, shearing of bolts etc. Further these are not provided with standard threads. Use of British standard threads reducing tolerance in holes to 1/16" to 1/32", use of M.S. pins instead of bolts and nuts to connect handle to fulcrum and reducing gap in the fulcrum are some of the suggestions to improve the conditions. Check nuts or jam-nuts may also help in reducing slackening effect.

1.2.2.1.4. Installation of Shallow well type hand-pump:

The hand pump is installed above ground and is directly connected to the tubewell. The base of pump has a threaded hole of 1½" dia. Hence all shallow tubewells of 1½" can be directly connected. The tubewell pipe should project above ground by about one foot. Before installing the pump, it should be dismantled to check all parts. The plunger should be fitted with wetted leather bucket of proper size and should be lowered into pump-cylinder with the popett valve in position. The flapper-valve should be placed in proper position in the base plate. The pump-body with the plunger in position should now be mounted on the base plate and fixed to it by means of bolts and nuts. The pumpbody with the base-plate should then be errected over the projecting G.I. suction pipe (tubewell) and the base screwed on to it properly taking care not to damage the threads or making a wrong thread. The pump should then be finally tightened to suction pipe by holding it with chain wrenches so that the jointat the base-plate is air tight. The pump head should now be fixed by means of bolts and nuts and the handle attached to the bulls eye of the plunger rod and fulcrum by means of bolts and nuts. Construction of a concrete platform alround should be done before installing the pump. In order that pump does not rattle with use the pump base-plate should be firmly fixed on a concrete pedestal around the suction pipe by means of foundation bolts and nuts. This requires additional 2-3 holes in the base-plate for foundation bolts.

Starting pump:

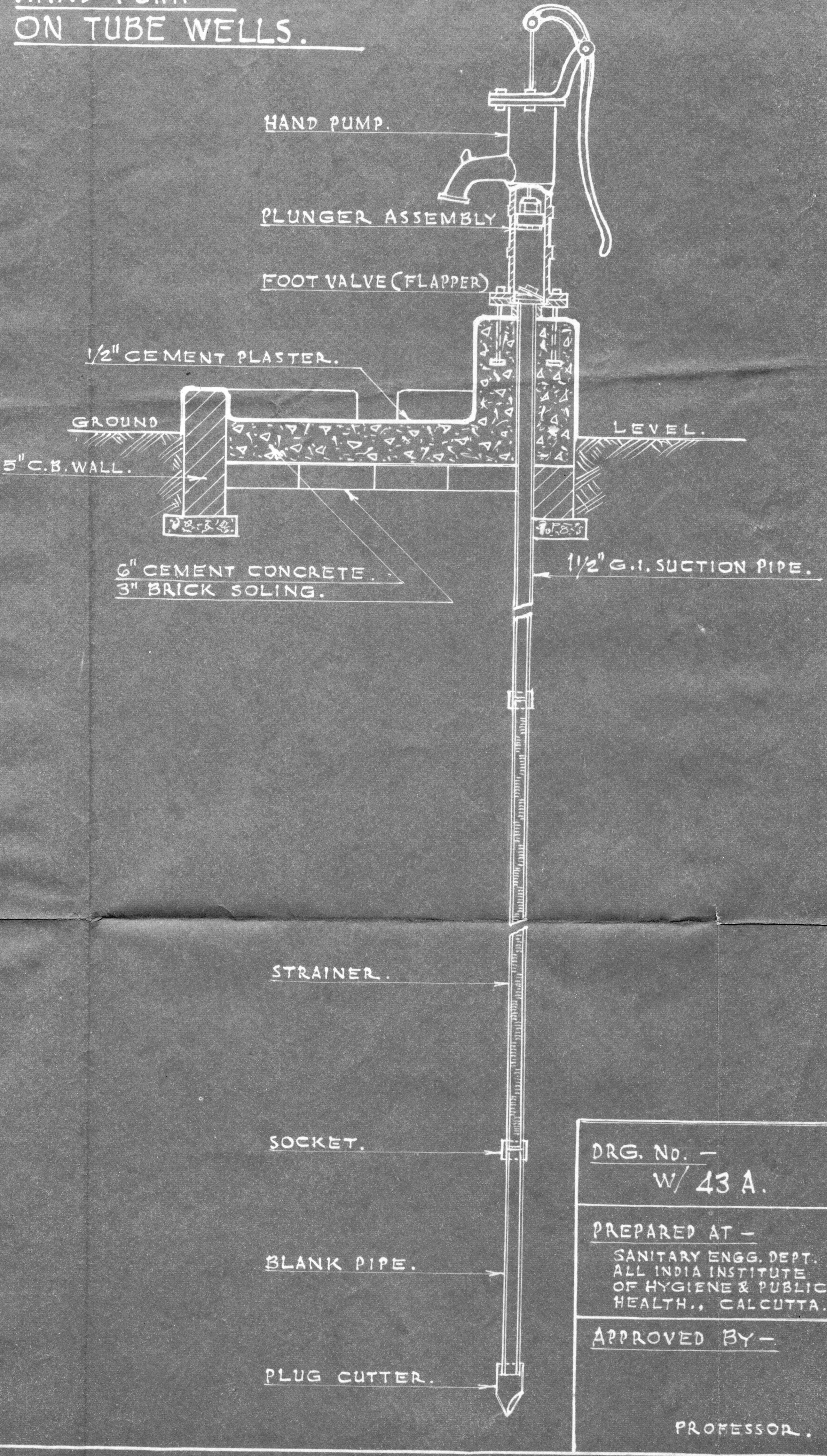
To start the pump initially it requires priming. Push the plunger to lowest position, fill up the cylinder with clean water. Closing the mouth of the spout by hand, work the handle several strokes to suck out all air in the tube above the water table. Now take out the hand from the spout still working the handle, water starts coming out of the spout. If no water flows even now, it means an air leakage, or leather bucket not properly swollen to give an airtight fit into barrel. Check base plate connection to tubewell for air leakage, check leather valve fitting and locate the trouble and set it right. The pump is now ready for use. When a pump is not used for long time or when there is a leakage in the flapper valve, priming has to be repeated as the water in the pump body will have either drained down to the tube or evaporated. Villagers use any water for priming the pump and swelling the leather bucket which may lead to contamination. Improvised pump designs obviate this problem. A leak proof foot valve will reduce the need for repeated priming except when newly installed.

1.2.2.2. Deep-well type hand-pump:

When the pumping water level in the well or tubewell is below the practical suction lift, it is necessary to lower the pump into the well and

FIGURE-9.

INSTALLATION OF SHALLOW WELL TYPE HAND PUMP ON TUBE WELLS.



DRG. No. – W/ 43 A.

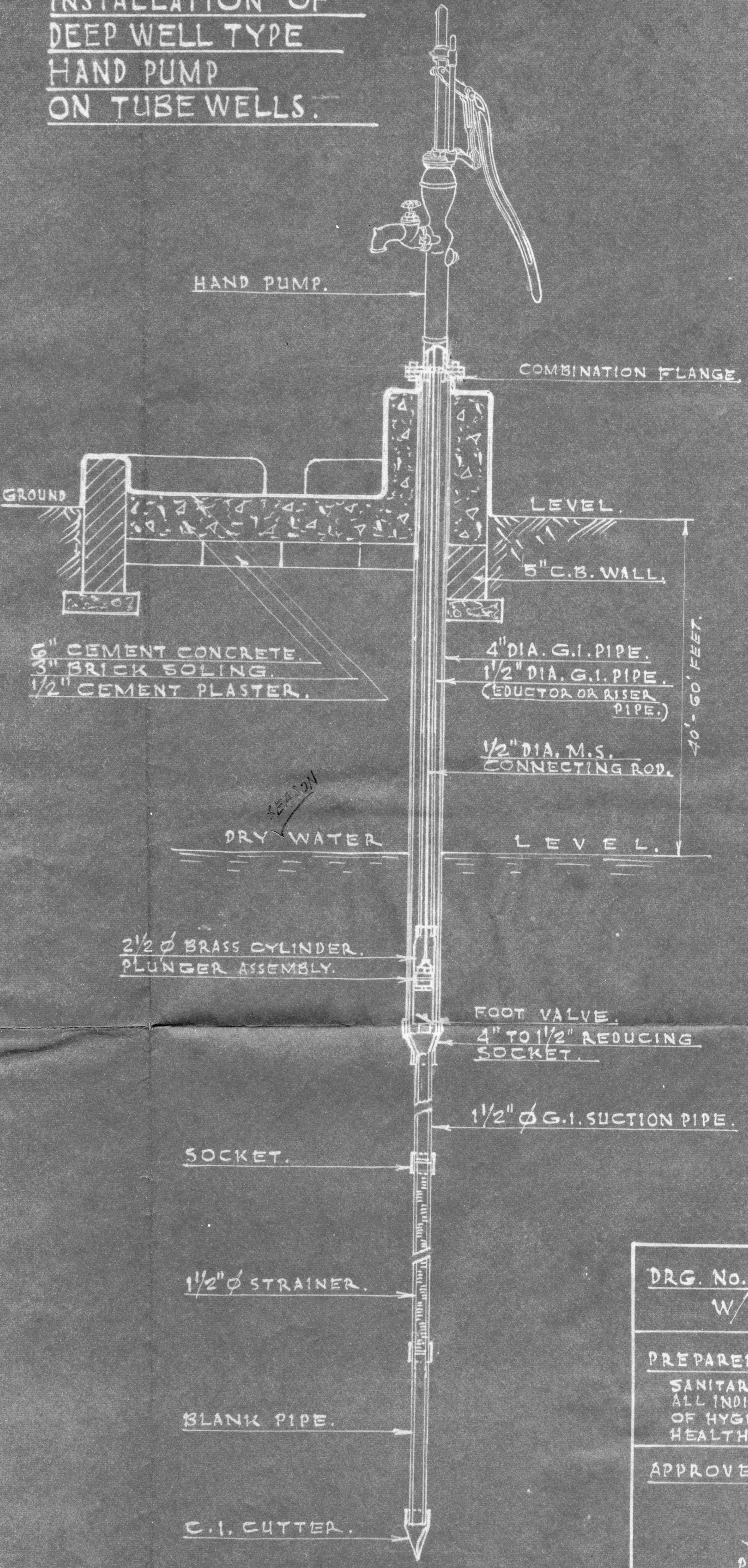
PREPARED AT –
SANITARY ENGG. DEPT.
ALL INDIA INSTITUTE
OF HYGIENE & PUBLIC
HEALTH., CALCUTTA.

APPROVED BY –

PROFESSOR.

FIGURE-10.

INSTALLATION OF DEEP WELL TYPE HAND PUMP ON TUBE WELLS.



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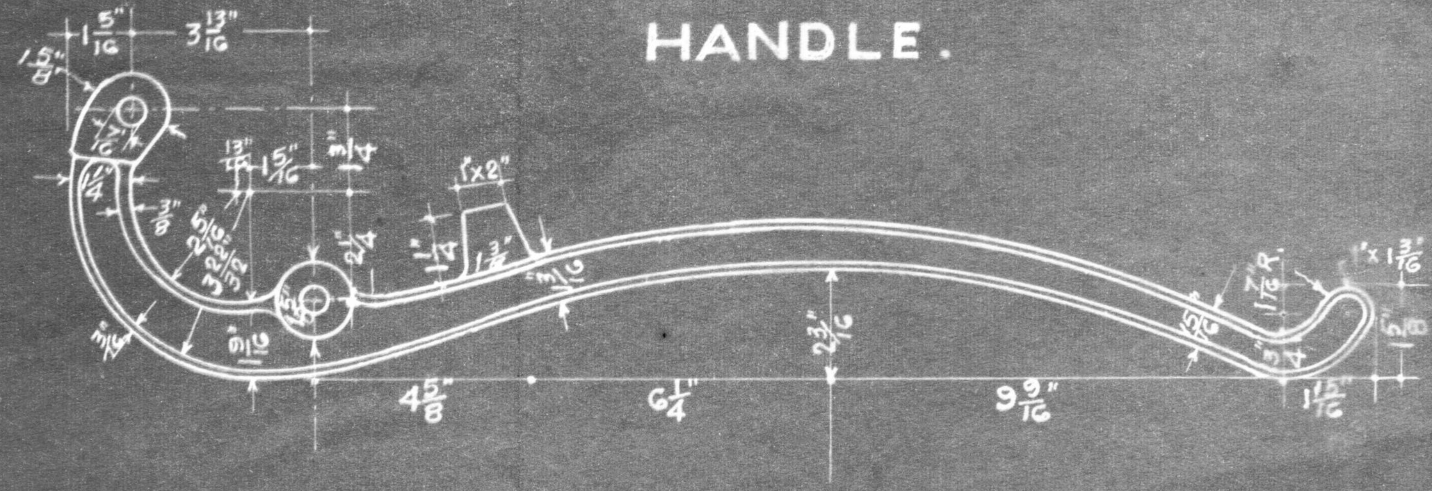
ALL INDIA INSTITUTE OF HYGIENE & PUBLIC HEALTH., CALCUTTA.

APPROVED BY —

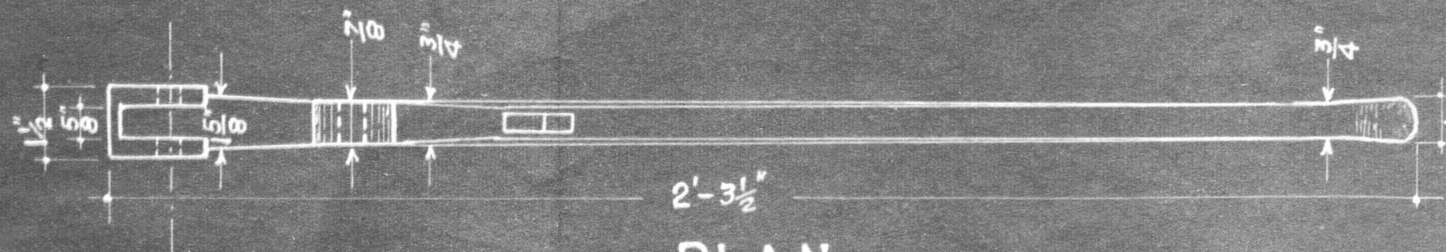
S. Subba Rao 24-9-76
PROFESSOR.

DETAILED DRAWINGS OF COMPO
WELL TYPE HAND

HANDLE.

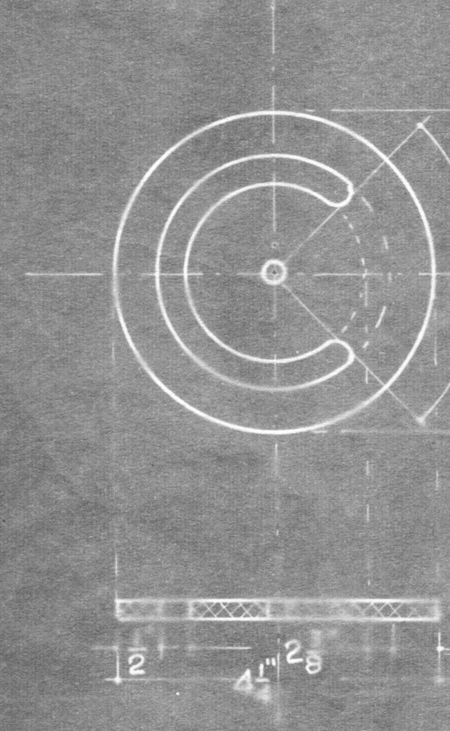


SIDE VIEW

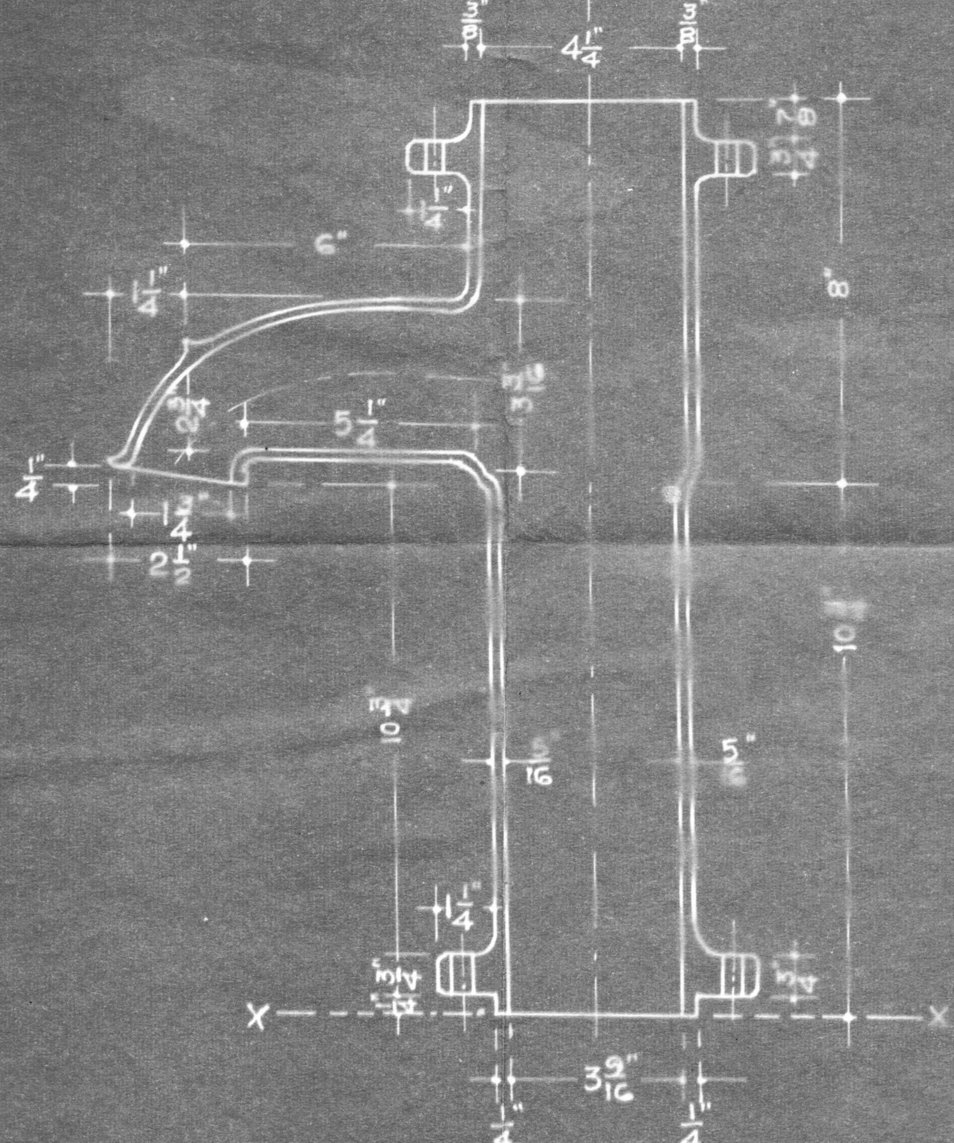


PLAN.

FLAPPER VALV

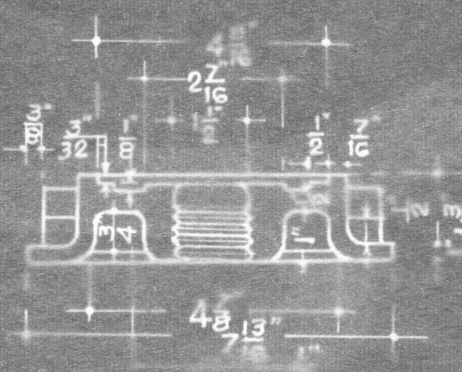


PUMP BODY.

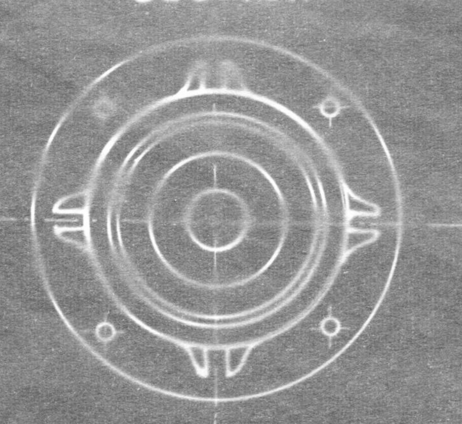


SECTION

PUMP BASE.

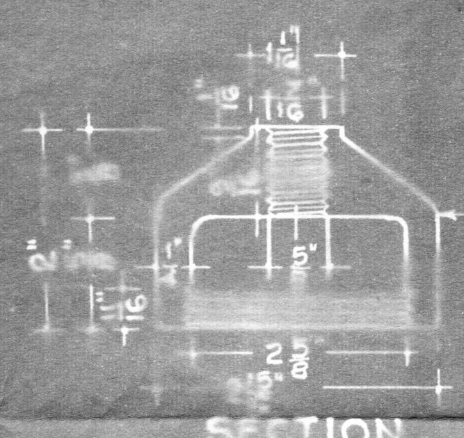


SECTION.

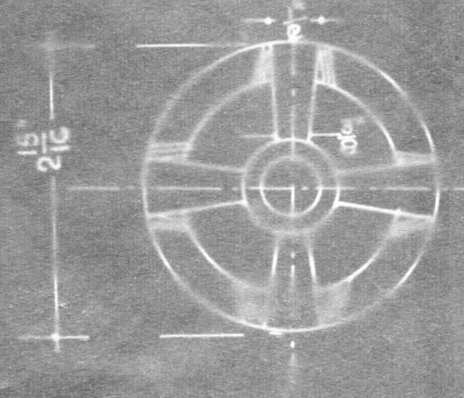


PLAN.

PLUNGER YOKE.

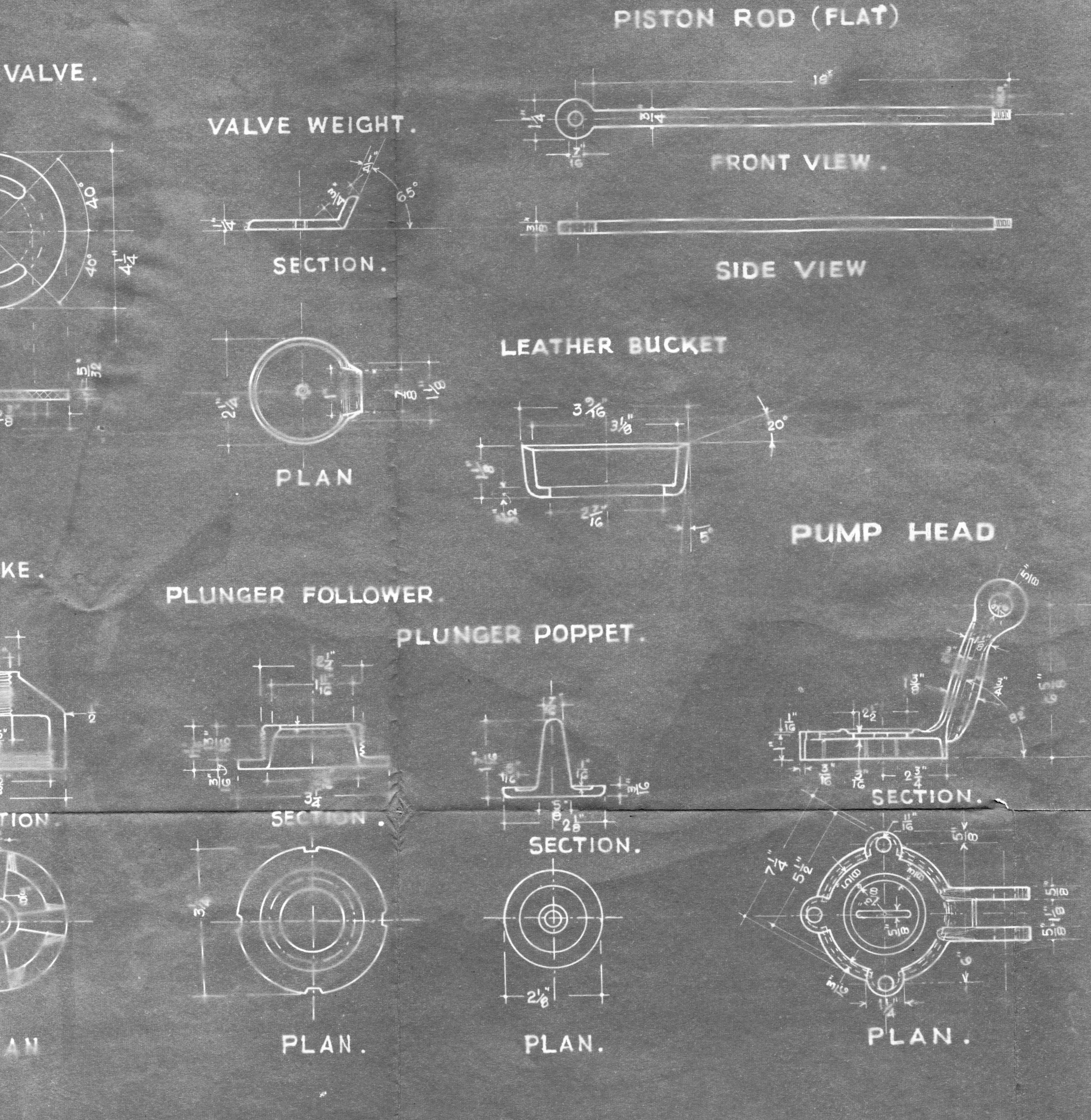


SECTION.



PLAN

OMPONANT PARTS OF A SHALLOW
AND PUMP.



this requires use of deep well type hand pumps. The pump elements namely the foot-valve and plunger with plunger valve are placed in a separate cylinder called pump-cylinder of 18"-48" long and diameters ranging from 2½" to 4". The cylinder is suspended in the well on a string of pipe called the drop pipe. The drop pipe is the discharge line of the pump. The plunger is attached to the lower end of ½" to 1" dia pump-rod or tie rod of sufficient length to reach a little above top of well. The pump-rod and plunger rod are made to work up and down in the cylinder by the pump head by connecting the upper end tie rod to the handle of the pump head. The cylinder which is generally made of brass is located below the working water table at least 4-5 feet below, to keep it always under submerged condition into work with a positive suction. The size of well-casing should be large enough for easy lowering of the pump cylinder. A 2½" dia cylinder is required at least 3½" or 4" casing dia. Hence a tubewell or Bored-well, shold be at least 4" dia upto the level at which the cylinder is located. The dia of tubewell can be reduced to even 1½" beyond this depth. In sandy and clayey soil, well has to be cased upto this depth. In rocky strata, casing is provided to the entire depth of soft soil. The installation drawing of both shallow well and deep well type pump are given in Appendix (~~xxxxx~~).

1.2.2.2.1. Parts of a deep well type Hand pump:

The essential parts of a deep well hand pump are:

i) Pump-cylinder
ii) plunger assembly
iii) Check valve
iv) Drop pipe or educator pipe
v) Pump rods or tie rods with rod-couplings
vi) Pump head
vii) Air-chamber (optional).

i) Pump-cylinder or Barrel.

Cylinder body is made of brass or C.I. with brass lining. The inside dia of cylinder and the stroke determines the capacity per stroke. An approximate formulae which can be applied to determine pump.

Capacity in Gallons per hour for 6" stroke = (Dia in Inches)²xstroke per min. in case of single acting cylinders.

For a normal strike of 40/mm and a stroke length of 6". The capacities for diff. sizes are as follows:

I. D. of cylinder	2"	2½"	3"	3½"	4"
Gallons/hour(Theo)	160	250	360	490	640
Suitable for Borewell size	4"	4"	4"	6"	6"
Drop pipe size	1¼"	1¼"	1¼"	1½"	2".

The overall length of the cylinder varies from 14" - 48" depending on stroke length and type of plungers, foot valve used and the number of buckets used in the ~~pa~~ plunger.

ii) Plunger Assembly:

The plunger assembly is similar to what has been described under the shallow well type hand pumps. A plunger yoke with a follower and spacers holds 2-3 leather buckets for providing water tightness.

The Plunger valve:

Poppet type or ball-valve type valves are used. The poppet may be of floating type or quick closing spring cushion poppet valve.

(iii) Check valve:

This is also a poppet type or a Ball-valve type valve. Poppet may be faced with rubber. The valve is held in place by a brass-cage which also holds the valve seat firmly in position. Action of valve is always perpendicular rising clear of seat at each stroke thus clearing itself of all foreign substance. Ballvalves in both cases were formerely made of Bronze, Myer's and now in the design developed by WHO the valve-seat is H.D.P/neoprene and ball is made of nylon.

Table
Dimensions of Single Acting Cylinder

Inside Dia and length of stroke	Overall length of cylinder for double leather plunger.	Capacity has stroke gap.	Can be used in well dia inches.	Drop pipe size inch.
2½"x10",	16	0.213	4	1¼
3" x 10"	16	0.306	4½	1¼
3½" x 10"	16	0.417	5	1½
4" x 10"	16	0.544	6	2
	Single leather plunger.			
2½" x 6"	10	0.128	4	1¼
3" x 6"	10	0.184	4½	1¼
3½" x 6"	10	0.250	5	1½
4" x 6"	10	0.326	6	2

(iv) Drop-pipe:

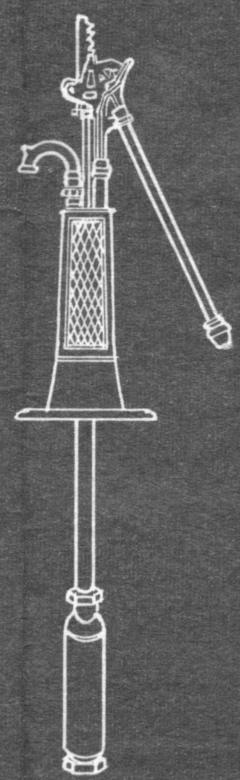
Generally of Galvanized iron. For open type cylinder, drop pipes are of the same size as pump-cylinder which enables withdrawal of plunger assembly for repair without pulling out the drop pipe. For closed type of cylinders, the drop pipe size is advantageously reduced as indicated in the table above. The advantage being less weight of pipe suspension and less cost. The disadvantage being the entire line of pipe should be withdrawn from the borewell to attend to plunger repairs.

Pipe is attached to cylinder by a reducing collar and at the top connected to pump head. All jts inthe pipe line should be air tight and water tight.

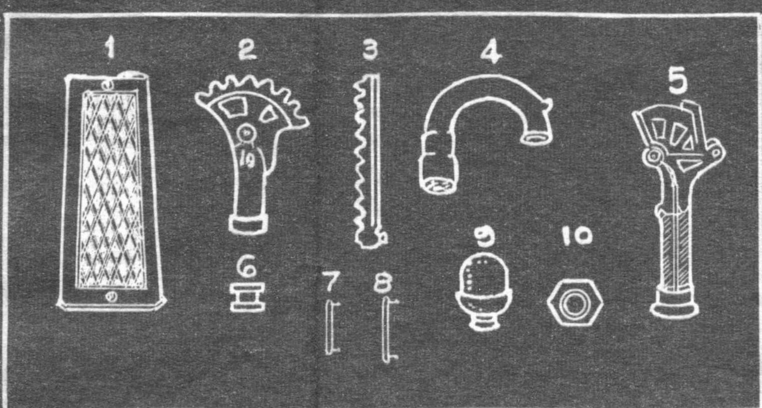
(v) Pump-tie rods:

Generally of Mild steel or hard wood. Rectangular or octagonal wood-rods have the advantage of less weight and thereby less energy to drive it up and down. M.S. rods of ½ - 1" fleats or threads with hexogenal M.S. rod-couplings are most commonly used. Pipes can also be used instead of rods. In case of pipe rods of long length, it is necessary to use guide couplings at every 10 feet to prevent buckling of pipe on its downword stroke.

FIGURE-11.



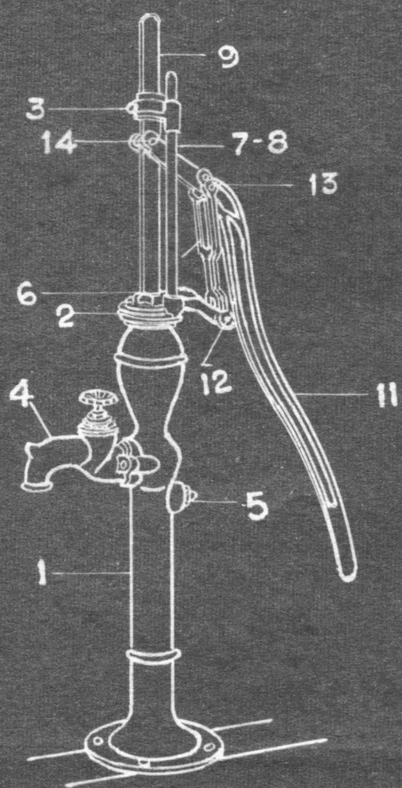
JALIWALA PUMP HEAD
(PATEL & CO.)

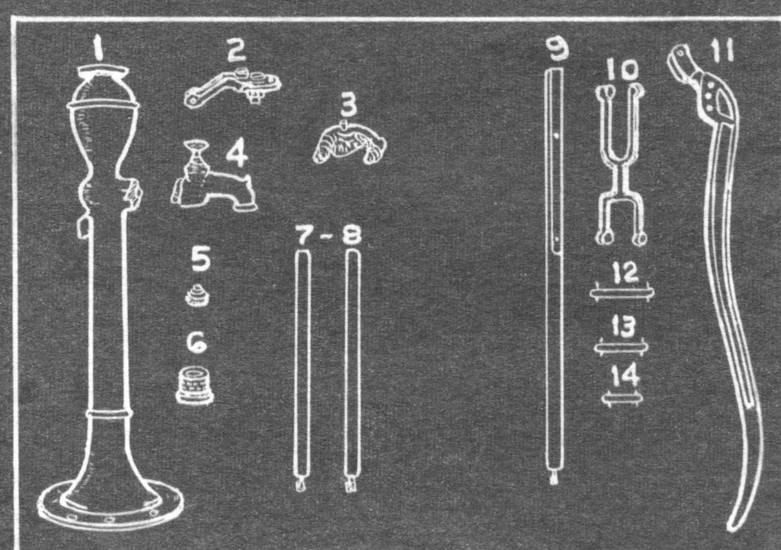


DESCRIPTION AND MATERIALS

1. PAIR OF GRATES (JALIS) C.I.
2. COG-GEAR (PANJA) C.I.
3. RACK OR DANTI WITH STUD. C.I.
4. BEND.
5. HOOD.
6. ROLLER. C.I.
7. PIN FOR ROLLER (3/8" M.S.)
8. PIN FOR COG-GEAR. (1/2" M.S.)
9. HANDLE END. C.I.
10. UNION. 1" (C.I)

DOUBLE GUIDE PUMP HEAD
(PATEL & CO.)





DESCRIPTION AND MATERIALS.

1. CHAMBER (STAND) ONLY. C.I.
2. FLANGE ONLY. C.I.
3. GUIDE WITH STUD. C.I.
4. COCK ASSEMBLY COMPLETE. C.I.
5. PLUG. 1¼"
6. STAND BUSHING 1½" x 1¼" C.I.
7-8. GUIDE RODS PAIR M.S.
9. PUMP ROD (PATTI) M.S
10. FORK OR DOUBLAI C.I.
11. HANDLE C.I.
12. FLANGE PIN ½" M.S.
13. HANDLE PIN ½" M.S.
14. ROD PIN ½" M.S.

(vi) Pump-Head:

The main feature of pump-head is the activating mechanism for imparting reciprocating motion to the pump-rod. Ever since hand pump has devised, various designs have been used for this purpose. The most common mechanism is a lever-mechanism, as described under shallow well type pump. The pump-handle forms the lever-arm with the fulcrum in the middle one end is complxk coupled to pump rod and other end being free where energy is applied by the hand. Since the movement of fixed end takes the form of a curve, different designs are used to change the piston of fulcrum itself so that the fixed end with the pump or tie rod moves alost vertical. A comm common type of this arrangement is a double fulcrum with guides for pump rod, whose details are shown in figure . Prichart lateral movement is minimised by providing a self-adjusting fulcrum (Loublai) and arxpair a pair of stout guide rods. Many manufactures in India use this design.

(vii) Air-chambers:

All reciprocacity pump including hand-pumps operated to discharge under pressure to an over-head tank or a distribution line requires an air-chamber to smothen out pulsation of pressure and produce an even discharge. The air or compression chamber is set either on top of pump-head or to one side on the spout leading to discharge line. When water is forced up, it compresses the air which in turn forces the water out in a steady stream. The capacity of air chamber should be at least 4-6 times the discharge per stroke.

1.2.2.2.2. Commercially available Hand pumps and their defects:

The following pumps manufactured in India are of this design:

1. Mayers hand-pump
2. Narmada "
3. Econ Hand pump
4. Mahasagar hand-pump
5. Patel pump
6. BISCO
7. B.I.H.

Defects noticed in these pumps are-

(1) Breakage of handle:

Handle is made of low grade L.C.I. which is brittle and breakable. As the villagers use the handle roughly, they break the handle quite often M.S. handle with solid 1" dia at pump rod end and tubular section for free-end prevents breakage.

(2) Shearing of Pump-rod:

½" thick rect.section pump-rods shear off at the connecting point with the handle. If this is changed to 1" dia circular section throughout breakage is minimised.

(3) Slipping of plunger-rod:

Due to unscrewing at the coupling between plunger rod and pump-rod, the plunger slips into cylinder. If the plunger rod is welded to coupling and introduce a checknut at the other end, this is prevented. A Universal coupling is better.

(4) The dublai is of C.I. which is brittle and thus breaks. M.S. alloy may be used for better performance but it will cost more.

(5) The coupling itself is weak. With ½" threads. Instead use of a 5/8" to ½" reducer coupling is recorded.

(6) The pump head has a base-flange which is fitted to the concrete pedestal. It is better to fix the base flange to the Tubewell casing, concentrically which ensures location of pump centrally to the well. For this the pump-base flange should be threaded internally and the caseing thread extermally so that the two can be pointed. The drop-pipe which is hanging in the well should then be held by an additional attachment to prevent its slippage into well.

(7) There are three pins attachmg handle to flange and handle to Dublai and handle to pump-rod, which wear-out and require replacement quite often. G.M. bushings or roller bearings to these pins reduces wear of pins but costly.

(8) The cylinder fitted with a brass-mesh strainer at the bottom ~~max~~ prevents entry of stlt and sand into cylinder, when installed on wells without strainers.

1.2.2.2.3. Gear mechanism: (Jaliwala Pump): consists of a cog-gear assembly as shown in the Figure . The handle is connected to a cog-gear, which matches with the teeth of a rack fitted on to top of pump-rod. Movement of handle moves the Cog-gear and pushes the pump-rod in opposite direction. The defect of this type of pump-head is the wear teeth in gears, Unless well lubricated. But villagers do not apply lubrication regularly hence gears wear out in a short time.

1.2.2.2.4. Pump head with chain and bracket mechanism (AFPRO PUMP)

In this mechanism the handle is connected to the pump-rod by a chain and is operated over a bracket with gears. The operation of the pump is is difficult as it is directly pulled by the chain without any mechanical advantage. The stroke length also is not more than 3"-4" and as such the discharge will not be more than 200-250 galls per hour.

1.2.2.2.5. Pump head with wheel and crank-shaft (Maya Single Wheel or double wheel circular hand pump).

A sigle wheel or double wheel is mounted on a hozc shaft, at the centre of which is a crane shaft. By rotating the wheal in a vertical plane, the piston-rod connected to the crank is moved up and down. The single wheel pump is having a very large circular wheel and is difficult to operate by women and children. The double wheel also causes lot of strain as the person has to move along wihh the handle for operating it. This discharge is also low. Further lubrication of bearings is generally not attended to by the villagers.

1.2.2.8.6. Combination hand and power pump:

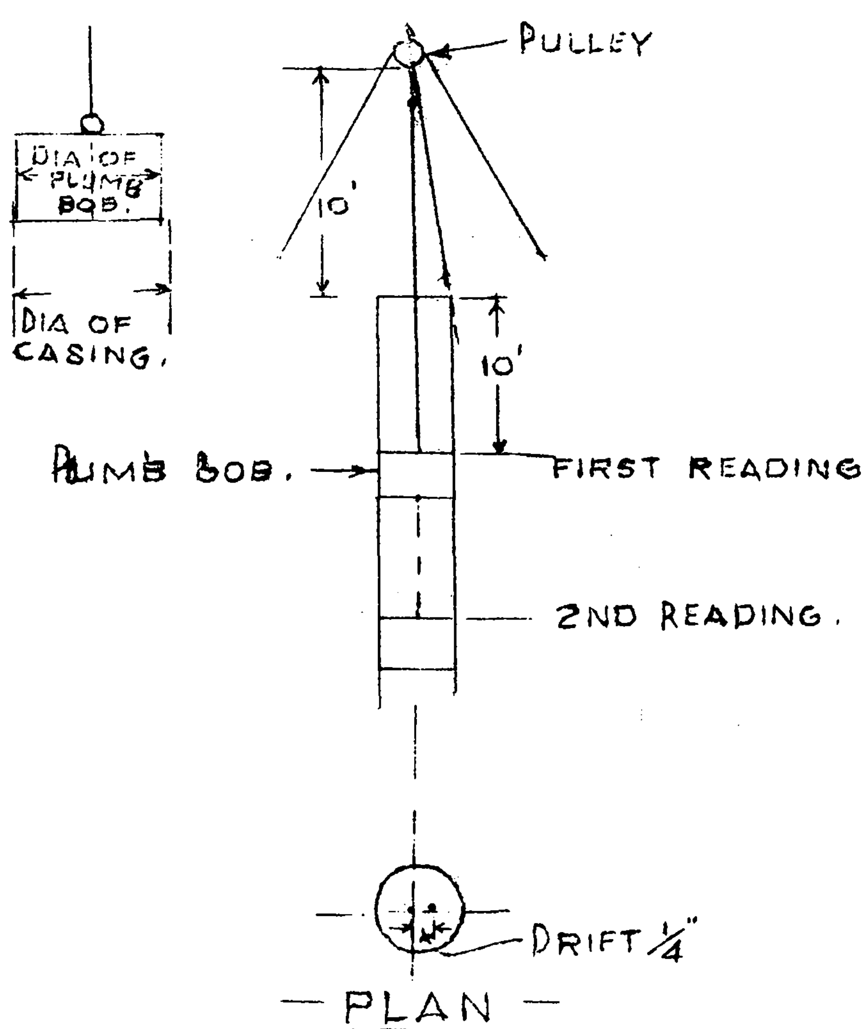
Myers double-side handpumps are also provided with ½-1 HP electric motors so that they can also be operated by electricity where available. The motor operates a gear through belt drive. An ecenitric cast integral with the gear operates the part through a rocker arm and connecting link. The gears and pinions are enclosed in an oil bath. This unit has limited use in rural areas as major part of rural areas are still not electrified. Further such units require, bringing power line to the spot and installing control equipments such as starter, no load and over load relays, etc and automatic control.

1.2.2.2.7. Installation of Deep-well type hand-pumps:

Prior to installation of pump, the following checks should be made:

1) Depth to water level in the borewell and the anticipated lowest water level to decide on the location depth of pump-cylinder and the length of drop-pipe and pump rod required.

2) If information is not already available in the verticality of the bore, it should be checked whether the bore is straight and if not whether the drift is within permissible limits. For this purpose a plumb bab of dia about ¼" less diameter than the I.D. of casing of well with an eye at top centre to which a string is attached is taken. Suspended the plumb-bob from a tripod with a pully at a height of 10' above G.L. and Centre it correctly over the centre of casing. Lower the bob by 10' and measure the drift of the string from the Centre at the top of casing. Let us say it has drifted by ¼". It means the well is twice the amount out of perpendicular ½". Lower another 10' and measure drift again let us say the drift is ½" now. It means the well is 3 times the drift out of perpendicular i.e. 1½". Continue measurement this way determining slant of the well by multiplying drift of chord x 1/10 the distance of plumb from the pt pulley. If drift of chord=1" at 100' depth from Pulley. Then slant of well=1x1/10x100=10 inches.



Generally speaking except in distances of more than 200' a drift or slant of 3 inches or less per 100 feet is considered to be of no consequence and a drift of 6 inches to 100 feet is considered undesirable and likely to cause serious pump trouble unless the well is much larger than the pump-cylinder. The common trouble is whipping of pump-rod shearing of rod at couplings.

3) Check pump-cylinder for proper working of plunger valve and check valve.

4) Attach first length pump-rod to the plunger through the top cap attach first length of drop pipe to the cylinder assembly (the pump rod lengths should always be chosen slightly larger than drop pipe lengths):

5) Clamp a pipe holding clamp near the upper end of the drop pipe.

6) Lower the assembly slowly into the casing of well holding tightly by wrenches.

7) Support the drop pipe on the clamp over the casing (The clamp length should be more than dia of casing).

8) Attach second length of pump rod to the coupling of 1st length, tighten firmly by kochi wrench.

9) Attach second length of drop pipe to 1st length and fasten tightly.

10) Clamp a second pair of clamps to 2nd length of drop pipe, release the bottom clamp and allow the second length of pipe and pump rod to lower into casing till it is supported by the top clamp on casing.

11) Repeat operation till the required length of drop pipe is added so as to lower the pump cylinder to the level required having at least 5' of water above the cylinder and the drop pipe projects 1'-2' above casing.

12) Attach drop-pipe to a combination base-flanger

13) Attach pump-head base to the flange and fix the pump head in a concrete pedestal by bolts and nuts.

alternately

fix the base-flange in concrete pedestal around the casing and fix the base of pump head to the borewell casing by a threaded joint. Insert suitable rubber packing to make the joint water tight. This gives a better concentric alignment of pump head over the borewell.

14) Connect pump-rod to the handle.

The pump is now ready to use. Detals of installation are shown in Fig.

1.2.2.2.8. Limiting size of drop pipe:

The diameter of drop-pipe determines the weight of water to be lifted against the net head of pumping. Net head is the total depth from the centre line of pump spout to the top of pumping water level minus the suction lift which atmipheric pressure can support.

For example if the pumping water level is 125 feet below the pump spout and atmphere pressure supports 25' of water. The net head will be 125-25=100 ft.

The water in 100' of 2" drop pipe would weigh about 137 lbs. To this we have to add the weight of pump rod. ½" M.S. rod of 125' length weighs about 150 lbs water displaced by pump rod weighs about 17 lbs. Net weight=137+150-17=270 lbs, which has to be lifted to get the water out of the spout. If we adopt a lever ratio of 7:1 to the handle i.e. in a total length 35" of a handle the fulcrum is 5" from the pump-rod end. A person will have to apply an energy equal to 270/7 = 38 lbs through a distance of 100 ft i.e. 3800 ft-lbs. This is not too bad. But if we increase the dia of drop pipe to 4" the weight to be lifted will be 97 lbs which is out of question for an average person to operate the handle. Some handles are made to change the length of stroke 6,8,10 inches by setting the hinge pin in the first, second or third hole of the handle. This would change the lever rates also. The range of lever-ratio should be 5:1 to 10:1. The drop pipe size should be normally 1¼" to 1½" and not exceed 2" for high lifts. For shallow lifts below 60 feet the drop pipe size could be increased to slightly above cylinder size so that cylinder and drop pipe could be permanently set in the well and whenever any repair to punger assembly check valve is required they can be drawn out through the drop pipe without draining out the drop pipe ~~the~~ and the cylinder themselves from the well casing as required when cylinder is larger than drop pipe.

1.2.2.3. Selection of Pump:

The proper selection of a pump for installation on a well involves the consideration of several factors. Some of the important factors which are often neglected merits discussion here.

The first factor to be considered is yield of well. It is a factor often overlooked in pump selection for small wells particularly when adopted for power pumping. It is obvious that the capacity of pump discharge should not be more than what the well can yield. Maximum well yields are to be determined by a Pumping Test. For small wells particularly these harnessed by hand-pumps, test pumping need not involve more than pumping of well at a specific rate (for hand pumps with single acting plungers 5 gpm) or a series of rates for a period of time in excess of the likely service requirement. The records of the test can be used to determine the specific capacity.

In hand-pumps where there is no specific rate of pumping nor specific period of pumping, the draw down while in use will be negligible. However the seasonal fluctuation in water table should be studied and the lowest water level during the year should be determined.

If the depth to lowest water level from ground level does not exceed the permissible suction lift choice of pump will be a surface or shallow type hand pump. If otherwise the depth of lowest water level during the year goes below suction lift, a deep-well ~~lift hand~~ type hand pump should be selected. In chosing a surface type hand pump, no other design criteria need be considered as most of these pumps give a discharge of 3-5 gpm and any brand which has a satisfactory performance could be used.

In case of deep well type hand pump, the size of pump cylinder, stroke length, depth at which cylinder assembly is located, size of drop pipe, size of pump-rod, these should be selected as already discussed in the preceeding paragraphs. Generally a cylinder size of 2"-2½" dia, a stroke length of 8"-10", and a drop pipe size of 1¼" - 1½", piston rod of ¾" - 1" dia should be sufficient for lifting from depths upto 200'. However, for the given lift, and a normal manual pumping rate of 25-30 strokes/hur and a stroke length of 8"-10", check should be made whether, the chosen dia of drop pipe is large to cause excess strain on the person. If so, the drop pipe size ~~shall~~ should be reduced not to exceed an energy requirement of 30 lbs and with a lever ratio of 5:1 to 10:1 for the handle.

Among other factors that affect the final selection cost of pump and cost of maintenance, reliability of the maintenance service, availabilty of spaces interchangability with other brands already in use, are important consideration.

1.2.2.4. Sanitary Protection of Pump Installations:

(1) Choice of pump-head should be such that it does not allow any contamination of water in the pump or the tubewell, by hand, dust, rain, birds, flies and similar source. The slotted pump heads tops are open to contamination. The use of round pump rods (Plunger rods) with a stuffing box surrounding it provides reasonable protection against contamination although this offers greater resistance for the movement of rod up and down.

(2) The pump-base should be of such design as to facilitate a water-proof seal with the well cover or casing. The pump base should be of a design to serve a two fold purpose. First to provide a means of ~~xxxf~~ supporting the pump on the well cover or casing top and second to protect the well opening or casing top from the entrance of contaminating water or other material. The base should be of solid, one place, recessed type, cast integral with the body or threaded to it.

(3) Although priming cannot be completely avoided in case of shallow well type pumps, a good foot valve designs and an addl. non-return valve connected to drop pipe below pump-foot valve will reduce leakage of water and thus minimize need for priming.

(4) The pump should be installed on a concrete platform surrounding the well with a lead off drainto take away the spent water to a soak pit.

(5) A draiage around the well should be provided to prevent water logging surrounding the pump.

1.2.2.5. Maintenance of Handpump:

Small diameter shallow tubewells fitted with handpump constitute the bulk of the rural water supply in our country. But lack of proper and prompt maintenance of these handpumps often poses a serious set-back in the water supply programme. Multiplying tubewells with improper maintenance leads us to nowwhere. If a tubewell, going out of order, is not repaired is as good as not being there. In fact to achieve success in water supply programme an adequate and efficient maintenance programme is imperative. The salient aspects of the maintenance of handpumps are presented in the following paragraphs.

1.2.2.5.1. Technical aspects:

The maintenance of hand pumps can be classified under three heads:

a) Major repairs viz., resinking of derilict tubewells.
b) Minor repairs viz., repairs to the suction pumps and
c) Repairs to platforms.

(a) Resinking:

The chokage of strainers or leakage in pipes in deeper layers calls for resinking.

Factors leading to resinking:

i) Chokage of strainer is indicated by the yield dropping down considerably even when the hand pumpe is in order. At this stage a back thrust of the handle is experienced. Finally the tubewell stops yielding any water.

The chokage of strainer is principally due to the fine sand sitting on the pores of the straining cloth and gradually blocking the strainer openings. The Calcium carbonate, formed, cements the sand particles and gives rise to a hard incrustration over the strainer.

Experiences with simple surging such small dia, shallow and under-developed tubewells is ~~xxx~~ discouraging. Thus in such cases it is ~~pull~~ necessary to the pipe out, recondition the strainer and reinsert the checked pipes or in a word resink it.

(ii) Leakage in the pipe indicated by mud or sand coming along with the water. The leakage may occur in the pipe or in the threads of the sockets or ~~pipxx~~ pipes or at times in the strainer. The soil corrosion and high HCO_3 content of the underground water leads to leakage. The vulnerable points seem to be at the joints or the socket region. Remedy of leakage is resinking.

Resinking process is carried out in three stages:

i) Lifting the pipe

ii) Reconditioned the strainer and/or replacement of the corroded and rejectable pipes if required.

iii) Reinserting the whole assembly into the same or a new bore depending on local conditions.

(i) The pipe is simply pulled with an endless chain pulley block. The lifting chain is tied with the pipe after removing the hand pump; and then 4 persons go on rotating the pipe in clockwise direction and thereby loosening it from the soil. Simultaneously a technical person like Tubewell Mistry goes on piling the pipe out by operating the chain pulley. ~~Ixx~~ In about a day or two the pipes are pulled out.

Sometimes lifting turns out to be very difficult due to the pipes being jammed too much in the soil; so much so that the pipe tears away leaving the strainers and portions of the pipes behind. In such cases efforts are still made recover the retained pipes with the help of what is known as the 'fishing tools'. Usually two types of fishing tools are used:

1) Inside taper
2) Outside taper.

Both of these are made of hard steel and are capable of cutting threads to the pipes in the hole itself. The base of the taper is of same dia, as the pipe and can be fixed with the pipe that has come out. The other end gradually tappers down to much lesser diameter and has threads all through. In case of inside taper such threads are on the outside surface of the instrument. As the taper ~~x~~ is lowered it touches the pipe or socket. It fits into the socket or the inside hole of the pipe after cutting required threads and finally lift the retained portions out.

But sometimes the inside taper does not work when the socket or the pipe end left behind is cracked or the pipe is torn not in the joint but in the other regions of it. In such cases outside taper is used. The outside taper has in the inside surface of it and its minimum dia is same as that of the outside dia of the pipe. The outside taper embraces the outside surface of the pipe or the socket cuts thread there and firmly grips it; and finally the retained portion is lifted out.

ii) Reconditioning the strainer is carried out in the workshop. Application of heat melts the 'rung', the soldering material; and the outer brass cover and the inner brass cloth of the commonly used strainer are separated out from the perforated base pipe. The base pipe is filed and cleaned, a new 60 mesh brass cloth or the old one, cleaned a-new, is wrapped around it and finally the protective brass sheet is cleaned and wrapped round the brass cloth. The whole assembly is soldered together to form almost a new strainer.

iii) Re-inserting the pipes along with the reconditioned strainer follows the same procedure adopted in cases of sinking a new tubewell. The reinsertion can be done in the same bore or in a separate one. It is obviously more economical to use the same bore, but sometimes local conditions necessitate to use a new bore. However, experience, judgement, coupled with availability of funds should form the deciding guide lines.

b) Minor repairs or repairs to hand-pumps:

The handpumps of the tubewell go out of order on and often because they are used by too many people, particularly children; and require immediate attention. The organisational set up rather than technical knowhow, which is quite simple, is more important.

Experiences at Rural Health Unit and Training Centre, Singur reveal that all the components of the hand-pump may need replacement. The maximum number of replacements is in nuts and bolts. These get loosened due to rough handling and then lost. Improper founding of pumps may be responsible for frequent loosening of bolts. Next in the list are leather buckets and leather valves. These components are subject to a great deal of wear and tear due to continuous movements and thrust and hence their high frequency of replacements. The other moving parts like plunger, piston or handle are made of metals and so their replacements are not too many. The stationary components like pumpbase, head and pumpbody need a few replacements. When the yield of a tubewell decreases the pump is subject to rough handling; and breakage of handle or piston rod is not unlikely under such circumstances. Table gives a data on the analysis of maintenance.

(c) Repairs to platform:

1.2.2.5.2. Organisational aspects:

An efficient machinery undertaking the maintenance service, a regular and strict checking and supervision, and a proper recording system can only make a maintenance programme successful.

The first thing would be the recipt of information by the agency undertaking the maintenance job.This calls for a quick and proper communication between the villagers and the concerned agency. There may be a number of ways by which this can be done. For instance i) A skilled or semiskilled person may visit each tubewell in a village and repair the nonfunctioning hand-pump, ii) The villagers may directly contact the department for the purpose, iii) The concerned personnel may contact the village leader, specially earmarked for the purpose, iv) The villager may write in a chit of paper the location of the tubewell going out of order and put in the convenient points, scattered all round the area. The mistry would visit those points, collect the chits and repair the tubewells on the spot, v) Local persons in each village may be trained and they may keep the village handpumps in order. And many more permutations and combinations may be tried. But the basic idea would be to see how correctly and how quickly the non-functioning tubewell is attended to.

Each of these and others may have their own merits and demerits. But the availability of funds and personnels; the extent of the area; the villagers' cooperation and the local conditions are required to be considered altogether in recommending a right way. In Singur area the experiences through a long period have lead the authority to recommend the method suggested in (iv) as above. The main advantage of the method is the lag time between the reporting and the repairing is the minimum. The method suggested in (v) apparently is quite sound, provided it is materialised properly. In fact the supervision part in the latter case becomes really too difficult.

The type of personnels to be employed for the purpose may deserve some discussion in the context. A fully skilled tubewell mistry would be desirable. Persons specially trained for the purpose and thus turning them to semiskilled labourers may be employed by the concerned authority. The number of such mistries to be employed would depend on the type and extent of area and the communication facilities particularly during the monsoon. Multiplication of tubewell numbers does not play the vital part in multiplying the tubewell mistries. In fact it is observed that increase in number of tubewells causes less strain on each of them and does not tangibly increase the total number of attendances required, and hence the work-load.

The other important aspect of the maintenance programme is checking and supervision without which the efficiency and economy of the programme is lost control of. The daily accounting system in which the field worker should give a regular account of what he did and what materials he spent to his supervisory staff is essential. Regular checking of the reports and surprise checking of the diaries are also envisaged. Apart from all this a regular field supervision followed by surprise field checking by a junior and senior supervisory staff respectively are extremely desirable. Some form of field checking, however, is a must.

1.2.2.5.3. Recording:

The last but not the least is the recording system, which is often neglected. An elaborate and efficient recording system not only enables one to allocate the correct funds for the maintenance programme in the budget provision but also enables him to right materials in right quantities in the right moments; on the contrary a hazard and inadequate recording system leads one to loose track of the material used, the quantum of works carried out and the resultant incorrect planning coupled with over or under stocking of materials. A proper recording system also acts as a means for counter-checking and provides facilities to the top supervisory officers for specific inspections they would like to make.

The recording system followed at Singur is presented briefly in the following lines to act as an useful guide line. The complaint chits, to be signed by the villagers after repair, are kept in a file upto a specific period. Every day material-expenditure accounts from the tubewell mistries are recorded in a permanent bound repair register. It is this permanent repair register that plays the most vital part of the system and satisfies all the advantages clamed for good recording. Besides a '<u>Tubewell Register</u>' containing all particulars viz., depth, dia, strainer etc of each tubewell and also the details of resinkings etc in each tubewell is maintained. Apart from the two mentioned, a '<u>Tubewell record card</u>' is also maintained to preserve the technical data for each tubewell. Such permanents cards contain not only sinking details but also the full data regarding all minor and major repairs carried out to it. These are very important permanent documents and their usefulness is comparable to the family folders maintained at the health centres.

1.2.2.5.4. Store & workshop:

A small store capable of accommodating at least two to three years' requirements of spare parts and pipes would be required wherefrom weekly or bi-weekly issues of required materials would be made. The workshop facilities are particularly required for reconditioning of strainers and servicing the force pumps used for resinking. The workshop facility also provides scope for innovating or improvising on spares or strainers in sorting out typical problems emanating from local conditions.

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1.3. Disinfection of Wells and Tube-wells

Water disinfectionprocesses involve specialised treatment for destruction or inactivation of disease producing (pathogenic) organisms, more precisely bacteria of intestinal origin. A satisfactory and universally accepted method of disinfecting water which is not grossly polluted is chlorination treatment.

Improper construction, maintenance or location are mainly responsible for bacterial contamination of well-water supplies. Under such situations all water used for drinking or culinary purposes must be boiled or treated adequately before use. Boiling, however, fails to rid the water of chemical contaminants; treatment may eliminate some.

Contamination of well-water may also be caused by one or more of the four probabilities: lack of or inadequate disinfection of a well following repair or construction; failure to seal the annular space between the drilled hole and the outside of the casing; failure to provide a tight sanitary seal at the place where the pump line passes through the casing. Sewage pollution of the well through polluted strata or a fissured or channeled formation. Added to these, instances of using most inadequate casings too short in length are also no uncommon.

When a new well is constructed or repairs are made to the well, pump or piping contamination from the work is highly probable. Consequently, disinfection of the well, pump and pipings is most essential before the water is supplied to the consumers.

Wells that have been newly constructed, repaired, altered, flooded or accidentally polluted must be thoroughly cleaned and disinfected after the work is completed. The side walls of the well or basin, the interior and exterior surfaces of the new or replaced pump cylinder and drop pipe, and the walls and roof above the water line, where a basin is provided, should be scrubbed clean with a stiff bristled broom/brush and detergent, as far as possible, and washed down or thoroughly sprayed with water followed by washing with a strong solution of chlorine (containing about 190 mg/1 of chlorine). A satisfactory solution, suitable for this purpose, may be prepared by dissolving either 3 oz. (about 86 gm) of bleaching powder or about 1 oz. (28.5 gm) of 70% high-test calcium hypochlorite, made into a paste, in 21 gallons (about 95 litres) of water. The well should be pumped until clear before disinfection is done.

To disinfect the average well, prepare a paste with 10 gm. of bleaching powder (25%) available chlorine) and dissolve in 50 litres of water. Pour the solution into the well after detaching the pump in the case of a tube-well. Replace pump and start pumping out water. Stop pumping when chlorine odour is perceptible. Prepare another dose of chlorine solution as above and pour this solution into the well. Allow the well to stand in a quiescent condition for at least 12 to 24 hours; then pump it out to waste, through the storage tank and distribution system, if exists, until the odour of chlorine disappears. It is advisable to return the heavily chlorinated water back into the well, between the casing and drop pipe where applicable, during the first 30 minutes of pumping to wash down and disinfect the inside of the casing in so far as possible. A water sample may be collected for bacteriological examination after a day or two when all the chlorine had been removed, to determine whether all contamination has been eliminated. If the well is not pumped out, chlorine may persist for more than a week.

A more precise procedure for disinfection of well is to base the quantity of disinfectant needed on the volume of water in the well. A simplified computation is given in the table below:

QUANTITY OF DISINFECTANT REQUIRED TO GIVE A DOSE OF 50 mg/1 CHLORINE

Diameter of well pipe (inch)	Gallons of water per ft. of water Depth	Ounces of Disinfectant/10 ft. Depth of water	
		25% Calcium Hypochlorite* (Bleaching powder)	70% Calcium Hypochlorite**
2	0.163	0.04	0.02
4	0.65	0.17	0.06
6	1.47	0.39	0.14
8	2.61	0.70	0.25
10	4.08	1.09	0.39
12	5.88	1.57	0.56
24	23.50	6.27	2.24
36	52.88	14.10	5.05
48	94.00	25.20	9.00
60	149.00	39.20	14.00
72	211.00	56.50	20.00
96	376.00	100.00	35.70

* CaCl (OCl)

** $Ca(OCL)_2$, also known as high-test calcium hypochlorite.

A heap teaspoonful of calcium hypochlorite holds approximately 1/2 oz. 1 liquid oz. = 615 drops.

1 U.S. gallon = 3.785 litres

1 oz. = 28.5 gm.

It should be well understood that disinfection is no guarantee that the water entering a well will be free of contamination. It is essential to ascertain the cause for pollution, if present, and should be removed. Until this is accomplished, all water used for drinking and other domestic purposes should first be boiled.

2. RURAL EXCRETA DISPOSAL

2.1. Importance of excreta disposal:

One of the basic steps towards improvement of rural sanitation is proper and safe disposal of human excreta, with a view to control the faecal borne diseases causing a large number of morbidity and debility.

The absence of, or inadequate and improper excreta disposal leads to indiscriminate placement of human excrement with consequent promiscous pollution of soil, tanks, canals, river , wells etc and thereby result in:

1) Increased prevalence of Ankylostomasiasis and Ascariasis on account of soil pollution.

2) Increased prevalence of water-borne diseases e.g., typhoid, dysentry, cholera and diarrhoea etc on account of contamination of sources of water supplies, and

3) Increased prevalence of fly borne diseasedue to contamination of food by flies which breed in large numbers and get access to excreta.

In brief, improper or non-disposal of human excreta brings about intestinal infections transmitted by faecal discharges of sick persons or carriers by way of water, soil, flies, food and soiled hands.

Control of above diseases steams from creating a barrier between the source of infection (i.e. the disease producing organisms in infected excreta) and the susceptible hosts - human population. Such a barrier would comprise of an arrangement that would not allow the infections from excreta to have access directly to the human being or to one's food and water. The most satisfactory arrangement would be to instal sewerage systems which would carry the excrements away into a treatment complex. But it is just inconceivable for rural India to-day for economic reasons. The alternative choice would be to provide individual sanitary latrines without the sewerage or water carriage system and thus human excrement alone the most dangerous contaminant, would be cared for.

2.2. Requirements of a sanitary latrine to villages:

The excreta disposal through sanitary latrine has two distinct parts:-

a) Collection of night soil and
b) its disposal.

The latrine proper is the means for collection of night soil whereas the sewer, or the septic tank or a pit or a trench etc is the means for its disposal. The sanitary conditions are to be maintained in both stages. Thus the construction of latrine should not give the flies or verminous access to the excrements nor it should give rise to the odour problem. Similarly the disposal stage should not give rise to the pollution of the soil, pollution of water and

(cont.next page)

physical nuisances giving rise to odour nuisance and fly nuisance; at the same time it should allow the night-soils to get digested. In the absence of the sewerage system the excrements can be either gathered and carried away into a separate common disposal place through conservancy departments; or disposed into a trench or a pit or a septic tank directly connected with the latrine. The farmer is not only subject to both fly and odour nuisance but expensive also. So the only choice left would be to connect the latrine to a place where it will be disposed of; or in a word it can be said that the latrine should be self-disposing type.

The above discussions thus suggest the following requirements of a rural sanitary latrine:

1. The excrements should not be accessable to the flies.

2. It should not be odourous.

3. It should not lead to soil pollution.

4. It should not pollute the sources of water.

5. The excrements should be disposed of and digested in the latrine itself or very near to it; or in other words it should be self disposing type, and

6. It should be within the local facilities and means of the villagers.

2.3. Principal of Sanitary Latrines in use:

Very many types of latrines have been used so far. The principal types of them are :

i) Septic-tank type

ii) Aqua privy

iii) Borehole latrines

iv) Varieties of pit privies

v) Vault privies

vi) Trench latrines, and

vii) Chemical closets.

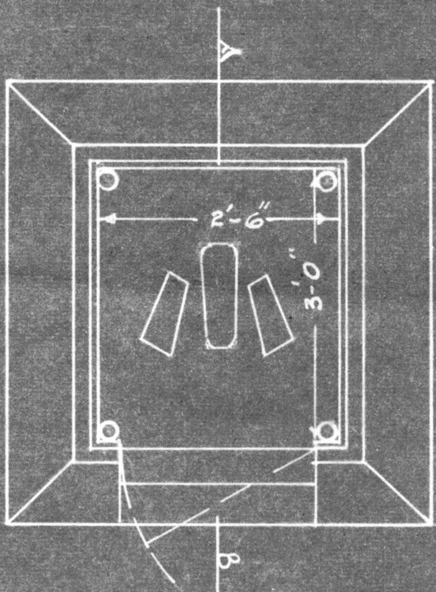
Of these, Septic tanks and Aqua privies consist of water tight masonry chambers into which the excreta from the latrine collect and get digested anaerobically. The details of these will be dealt with separately.

2.3.1. Bore-hole latrines:

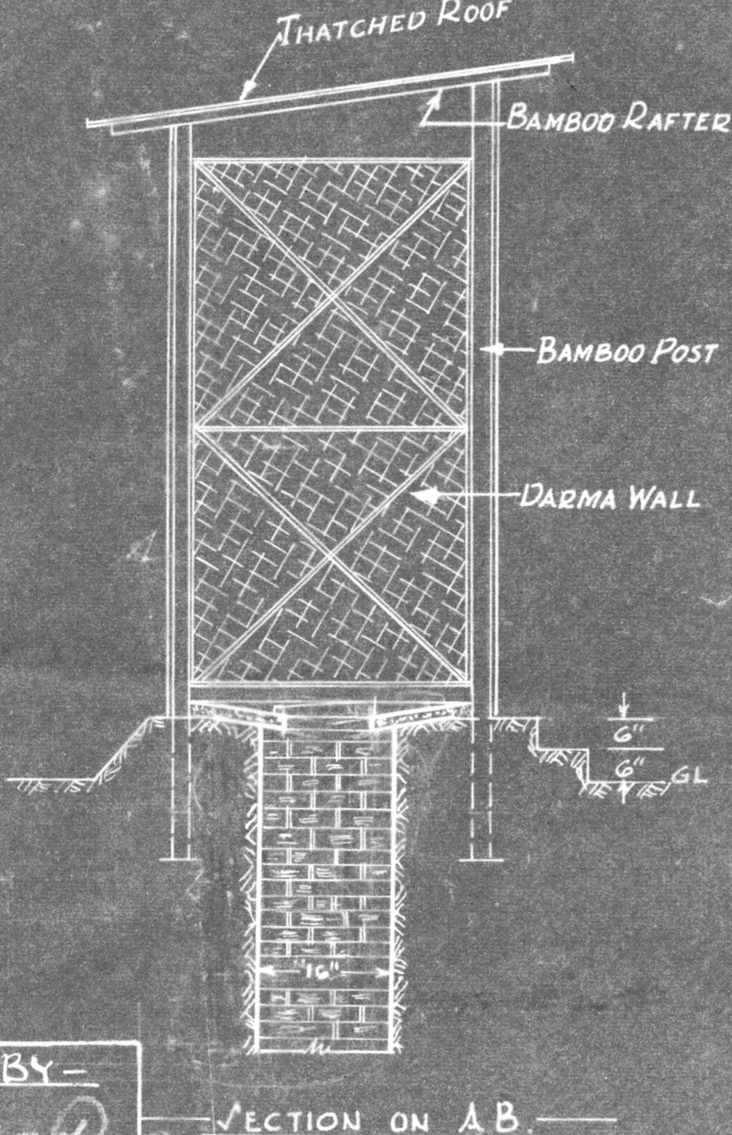
a) Details of construction:- This is the cheapest form of a self-contained hygienic latrine for rural family. It consists of a hole 14" to 16" to 18" in dia bored on to earth by means of an instrument known as auger. The nature of soil obviously restrict the depth of the hole, in fairly soft and porous soil where water table is not very high a depth of 16'-0" x 18'-0 to 20'-0" can be bored.

FIGURE - 13

BORED HOLE LATRINE



PLAN



SECTION ON AB

PREPARED AT-	APPROVED BY-
S.E. SECTION. A.I.I.H & P.H. CALCUTTA-12.	PROFESSOR.

A square or rectangular concrete squatting plate consisting of an opening in the centre and foot rests beside the opening is placed on top of the hole. An enclosure is thus built around the squatting plate for privacy.

(Ref: Figure entitled is Borehole Latrine - vide Sketch No.1 enclosed).

Excreta and ablution water fall into the borehole and undergo anaerobic digestion which is facilitated if there is subsoil water.

The concrete squatting plate provides the impervious flooring on which the eggs of ankylostoma will not hatch and thus prevents soil pollution. The narrowness of the hole makes it too dark for the flies to enter and thus prevents fly-nuisance.

The risk of caving of the hole is not high because of the narrowness of the hole again; but in very loose soil the upper part of the hole has to be lined with some stiff materials, such as bamboo matting, or a short length of pipe or oil drum or the like to prevent caving.

The borehole gets gradually filled with digested sludge, when it gets filled to within 2 to 3 ft from the ground, it is closed with earth; a new hole is dug, and the squatting plate and enclosure are re-erected at the new hole.

b) Life of the latrine: The life of the bore hole latrine is primarily based on the volume of sludge accumulation. No systematic field experimental data are yet available on the sludge accumulation and life of borehole latrine. However, the mathematical computations of anaerobic sludge (2.1 cft/ 100 users) forms the guide line for rough estimation of the life of such latrines.

In many parts of the West Bengal villages the subsoil water is high and the soil is loose and it is often difficult to put down a borehole deeper than 10'-0", as the sand keeps falling when the auger has gone 2 to 3 ft below water table. In such a borehole the effective depth of the borehole is quite low and based on the above mathematical estimate of sludge the life of such borehole, if night soil alone is put, works out to be 2 years for a family of 6 members. Allowing some provision for fresh night soil prior to closing a borehole the life could be taken as 1½ years on the safe side.

c) Merits and demerits of a borehole latrine:

Merits:-

1) Very cheap to instal.

2) Very quickly installed.

3) Hygienic.

De-merits:-

1) If the latrine is not discarded when the level of the night soil reaches 3 ft from ground level it will be subject to fly-nuisance.

2) It is not entirely free from odour nuisance because of absence of water seal.

3) Auguer is required for such a latrine. So a practical problem of provision, supply and operation of the auger may pose a handicap in borehole latrine programme.

4) Life of the latrine being short frequent re-construction of bore-holes would pose a serious set back in latrine promotion programme.

It is because of (3) & (4) in particular bore hole latrines are no more used in Singur area.

2.3.3. Pit latrines:

a) Details of construction:-

A number of designs of pit privies have been tried through out the country. Basically they are very similar and differs in construction etc to suit the local conditions and practices.

This essentially consists of a hole made on the ground which receives the night-soil from the toilet directly and the excrements get digested in the pit. In fact the bore-hole privy described earlier is just a special pit privy where the pit is bored by earth-auger. But in pit privies the pit can be even dug with any available instruments like spade etc and can be of any shape and size. The most popular shapes are rectangular or circular of which ~~circle~~ circular pit has proved to be more durable from the point of view of cave-in. A circular pit is preferred since the lining in the circular sections forming an arch requires less materials to withstand a given earth pressure than a rectangular section in which the lining would require to be built as a retaining wall resulting in the use of more materials with consequent higher lining cost.

The latrine seat consists of a concrete or wooden plate or platform with an opening into which a pan or with or without the water seal is installed. Sometimes the seat is placed a little away from the pit also. In some cases again, particularly in dry regions where availability of water is a problem and in very cold regions where water for ablution is not used water sealed pans are not used and instead a flap-trap is used. A number of different sizes and shapes of pans, different sizes and shapes of squatting plates having different constructional particulars, different pit linings have been used in different places and have taken different names. The most widely adopted pit latrines may be included in the following two types viz.,

i) Dug-well latrine

and ii) R. C. A. latrine

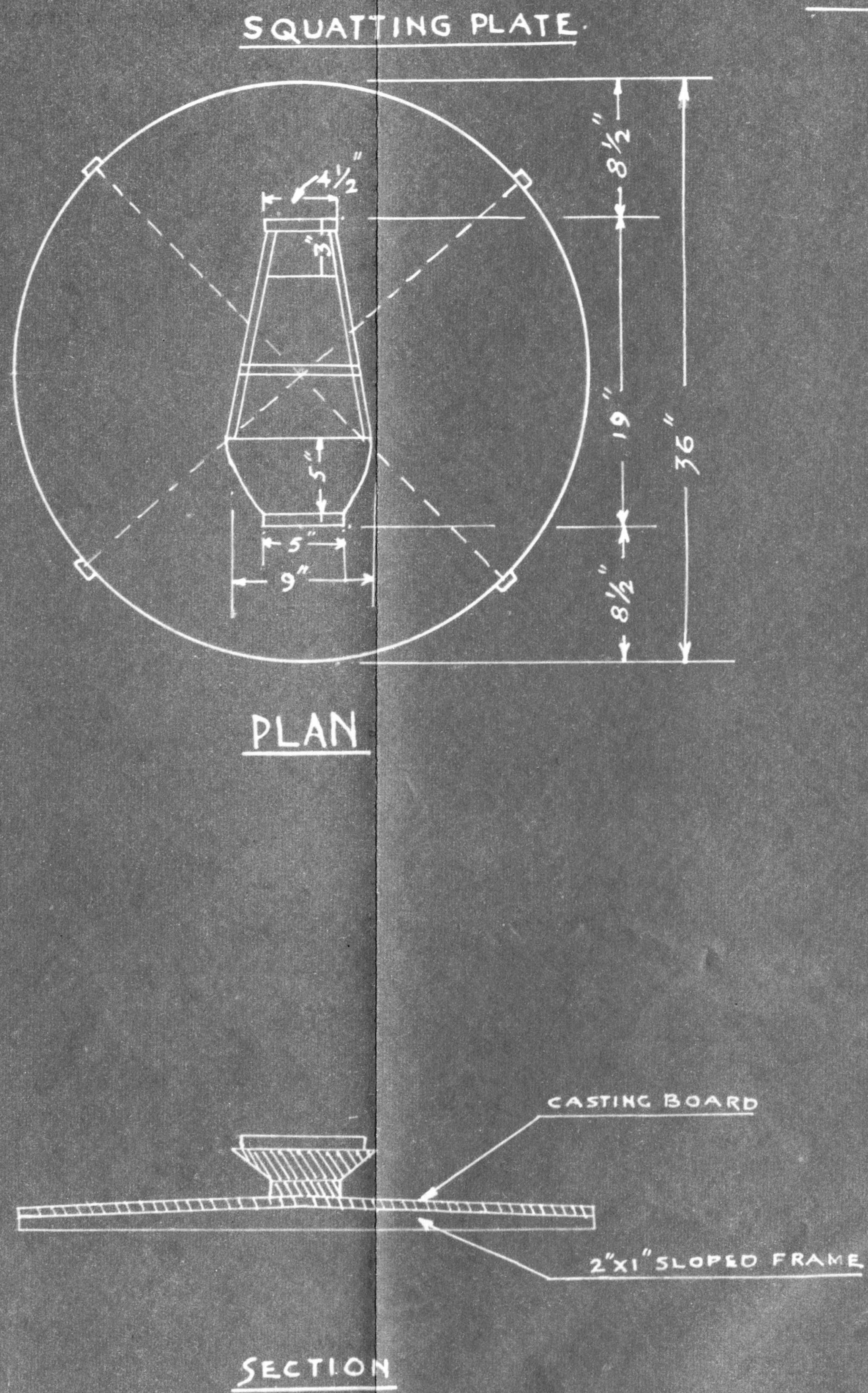
2.3.3. Dug-well latrine:

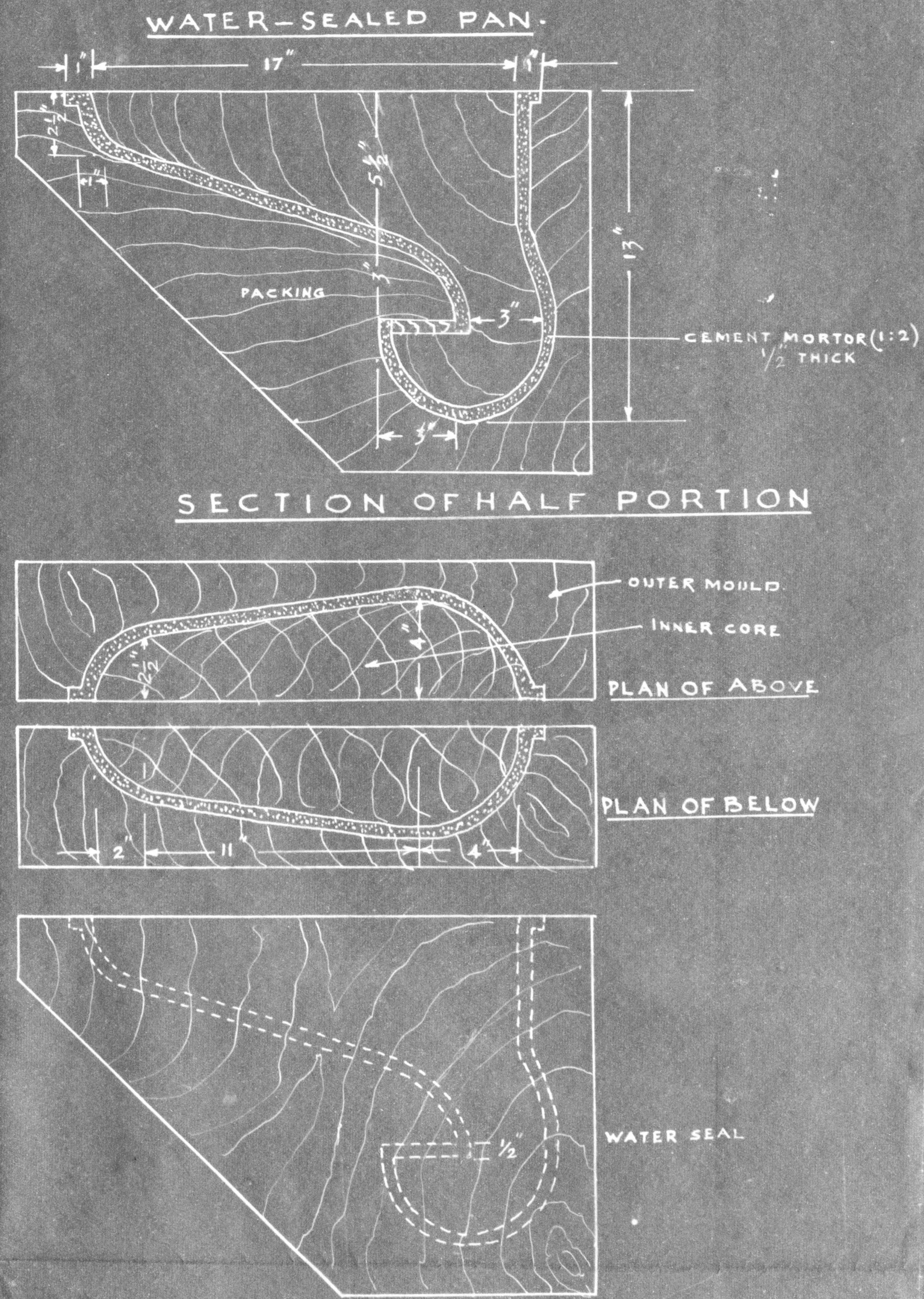
a) Details of construction:-

This consists of a small well 2'-6" in diameter and extends to about 2 to 3 ft below ground water level. The actual depth of the well (i.e. the pit) depends on the nature of the soil and is usually about 10 to 12 ft. In order to prevent the pit from caving in the entire pit is usually lined with pot-rings usually easily available in rural areas. In shift and clay-dominant soil pit lining may not be necessary or may be required only on top layers. But in sandy soil it is necessary.

FIGURE-15.

MOULDS FOR DUGWELL LATRINE.





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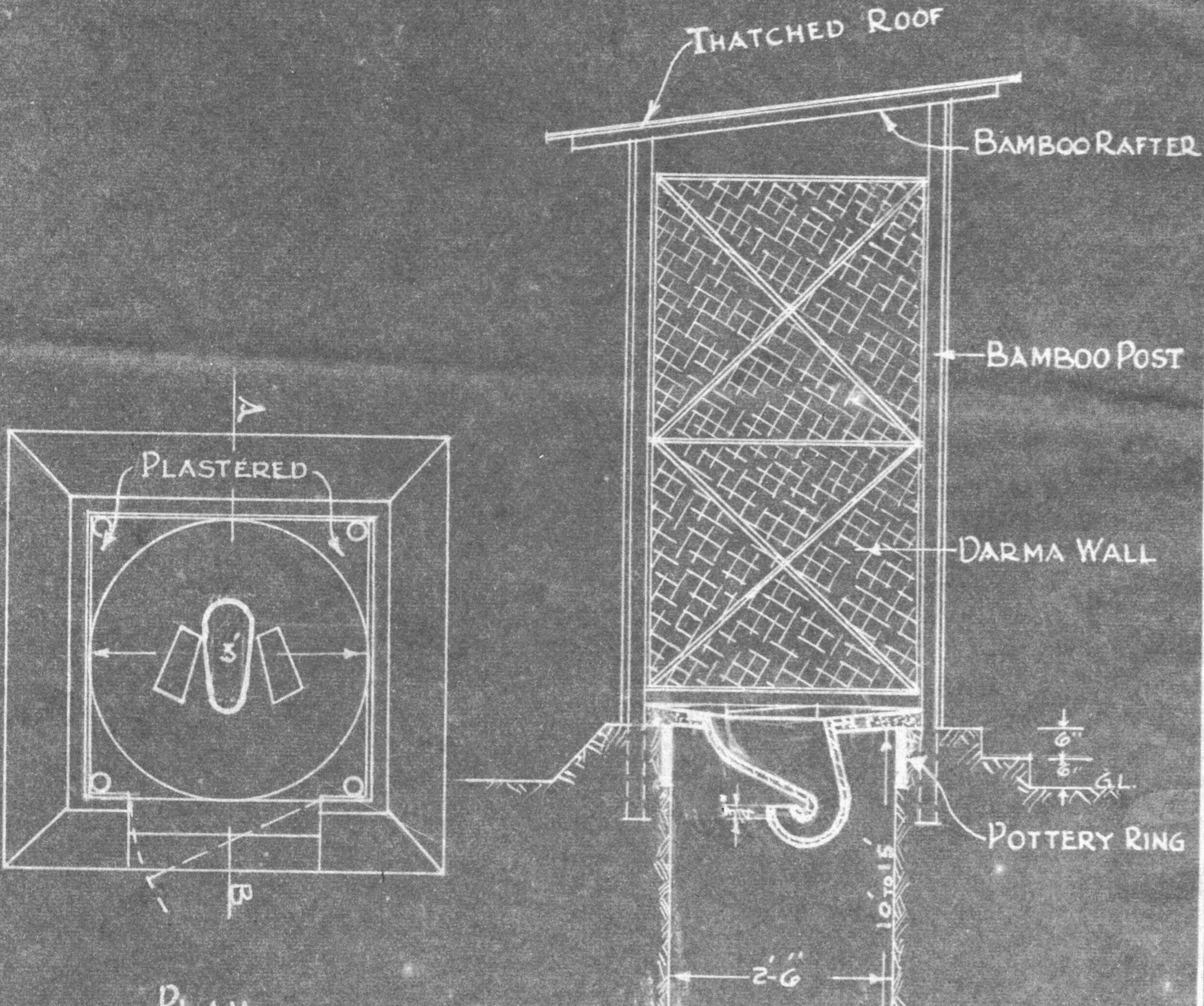
APPROVED BY-

DUG WELL LATRINE



PREPARED AT-	APPROVED BY-
S. E. DEPT. A. I. I. H & P.H. CALCUTTA-12.	PROFESSOR

On top of such constructed pit is placed a concrete squatting plate with a water-sealed pan. The squatting plate is of 3'-0" dia i.e. 6" more than the diameter of the pit, thereby having 3" bearing on all sides. The squatting plate should be installed 9" above the general ground level to avoid rain or flood water running into the pit.

A suitable super-structure is built around the squatting plate. The superstructure may be of bamboo-matting, corrugated iron-sheet, masonry work or any other suitable type dependent on local conditions. The most important point is to ensure imperviousness of the floor. The portion of the floor of the superstructure not covered by the squatting plate has to be cemented impervious.

b) Materials and Cost:

A. Pit and Seat:

Sl.No.	Particulars	Qty.	Cost Rs. P.
1.	Squatting plate with pan	1 no.	12.50
2.	Earthen rings (30" dia) for 12'-0" lining	L.S.	50.00
3.	Labour charges for digging pit	L.S.	10.00
4.	Bricks (2nd class)	50 nos.	10.00
5.	Cement	1/10 bags	2.00
6.	Sand	1 bag	1.00
		Total:-	85.50

B. Super-structure (3'-0" x 3'-0" x 6'-0" bamboo superstructure)

Sl.No.	Particulars	Qty.	Cost
1.	Bamboos of medium size	5 nos.	20.00
2.	Nails & ropes etc	L.S.	4.50
3.	Tiles (Ranigunge type)	30 nos.	20.00
	Alternative I: Country tiles (Khola)	90 nos.	10.00
	Alt. II: Thatching with straw	L.S.	5.00
4.	Labour charges	2 skilled ones.	10.00
		Total:-	54.50

Grand total:- Rs.140.00

(Ref: Dwg. for Dug.sq.plates and pans already available vide Sketch No. 2 - attached).

c) Life of the dugwell latrine:

The life of a dugwell latrine is usually about 6 years for an average family size of 5 members. A systematic study has just been completed in R.H.U & T.C., Singur and the report is being analysed after which the correct prediction can be made.

d) Merits and Demerits:

Merits:

1) It is perfectly hygienic if located properly.

2) There is no chance of soil pollution.

3) Fly nuisance is completely absent.

4) There is no odour nuisance either.

5) Reasonably priced, so that a villager can easily afford such a latrine although a little more expensive than bore-hole type.

6) Procurement and auger is not necessary and hence no organisational problem in construction of such latrines. Even a villager will be able to build up such a latrine.

7) Life of this type of latrine being much greater than bore hole type does not pose a serious handicap in latrine-promotion programme, although the latrine is not a permanent one.

Demerits:

1) With the increasing cost of pottery rings the pit linings are getting expensive day by day.

2) Risk of pollution of drinking water sources if not located safe distance apart from it.

and 3) Latrine is not permanent, every time with the pit being filled up a new latrine is to be installed.

2.3.4. RCA Latrine:

a) Construction details: - The modified dugwell latrine is but the innovation from the dugwell latrine and in this type the permanency of the toilet has been in view. The temporary nature of the dugwell and borehole latrine gives rise to:

1) Dissatisfaction among the persons owning the latrines towards the superstructure which is hardly made satisfactory in view of the temporaryhood of the toilet.

2) Botheration and inconvenience in reconstruction of the latrine in the event of the pit being filled up. The problem is acute when the family size is large.

3) Reluctance of the people who would not like to have a temporary type of latrine.

4) Set back in latrine promotion programme at the time of reconstruction in which a villager usually grow an apathy or feel it ~~xx~~ extremely inconvenient to get it reconstructed a new for want of suitable labourers in the time.

Salient points as above only emphasizes that the permanency of a latrine is very much desirable and has taken a concrete shape through modified dugwell latrine.

The principal modification is primarily to make the pit away from the superstructure. Here the latrine/~~xxxx~~ proper with pan and trap is connected to the pit, close-by, with 3" dia. ordinary clay pipe. In the event of the receiving pit being filled up the trap is reconnected with another pit. Thus when the receiving pit is filled up the latrine proper with its superstructure need not be reconstructed, all one has to do is to change the connection to second pit. By the time the second pit is filled up the contacts of the first pit would be digested having taken about a year to effect complete digestion. So, in the event of second pits being filled in, the first pit can be re-dug and used again with same success as before. Switching back the connection for the original pit would /be the only work left after redigging the original pit. Thus, by alternating the connection from first to the second pit and then from 2nd to the 1st the permanency of the latrine can be achieved.

The essential parts of such a latrine~~xxxx~~ are-

1) Pan

2) Trap

3) Lead off pipe

4) Circular pit

and 5) Concrete pit cover.

A circular pit similar to dugwell pit is dug, the diameter relaxable upto 3'-0" dia. A permanent masonry or such other superstructure with permanent floor of size 3'-0" x 3'-6". The RCA or such other type pan and trap capable of having 1/2" water seal and fitted on the floor. The open cut of the trap is connected by means of a lead off pipe (3"dia.) to the pit through an inspection chamber which facilitates the change of connection and removal of chokage if any.(vide fig.3 & 3(a) - A pan-trap. The distance between the seat and pit is kept within 3'-0" for easy flood of excrements.

(Materials & cost - next page)

b) **Materials and Cost:**

A) Pit & Seat (except floor)

Sl. No.	Particulars	Qty.	Cost. Rs. P.
1.	Mosaic pan and trap	1 set	6.00
2.	Earthen rings 30" dia lining 12'-0" depth	L.S.	50.00
3.	Earthen pipes 3" dia.	3'-0"	2.00
4.	2" thick 3'-0" dia pit cover	1 no.	8.00
5.	Labour charges to pit digging	L.S.	10.00
			76.00

B) Superstructure including toilet floor (5" C.B.W.)

a) Structure:

1.	Bricks (1st class)	600 nos.	125. 00
2.	Sand	1 cart	20. 00
3.	Cement	2 bags	40. 00
4.	Jhama Khoa	1 cft.	2. 00
			187.00

b) Roof:

i) When tiled roof:

1.	Tiles	30 nos.	20.00
2.	Bamboos	1 no.	5.00
			25.00

ii) R.B.C. roof:

1.	Bricks (1 class)	75 nos.	17.00
2.	Sand	L.S.	8.00
3.	Jhama Khoa	L.S.	2.00
4.	Cement	1/2 bag	10.00
5.	Reinforcements (1/4" M.S. roads)	60 rft.	10.00
			47.00

c) Door:

Bamboo door	L.S.	40.00

Labour charges:

i) Labour charges with tiled roof	L.S.	47.00
ii) -do- with R.B. roofing	L.S.	57.00

Thus the present cost of such a latrine-

1) With R.B.C. roofing is Rs. 407.00
say 410.00
2) With tiled roofing is Rs. 375.00.

N.B. Many of the materials like bamboos, bricks from local brick fields etc can be obtained either free or very cheaply so as to cut down the cost to by about 25 to 30%.

(Ref. Figure of RcA latrine, Singur - enclosed).

c) Merits and Demerits:

Merits:

It has all the merits of a dugwell latrine plus the permanency of the latrine. This may be considered the most suitable form of rural family latrine for rural excreta disposal programme.

Demerits:

The only demerit is that the initial cost of the latrine is a little over twice as expensive as dugwell latrine in view of a permanent masonry superstructure. But this can be compensated with the recurring cost the dugwell latrine is subject to. The expenditure, however, is not prohibitive for a villager.

2.3.5. Vault privy:

a) Details of construction:

It is of historical interest since it is the type, constructed of stone or brick, that was used in large ancient, medieval, and modern cities down to the time that water-carriage system was established.

It consists of a watertight concrete or the stone vault over which the seat is pa placed. The average cubic content would be 3 cft/capita so that it can function without being emptied for about 6 months. The trap of the vault should extend 5" to 8" in above the ground level and should be banked to divert surface water away from the vault.

The theory on which the vault toilet was originated is that the excreta would become dry and inoffensive so that they could be easily removed from the vault. But it does not happen, as the contents tend to become liquid rather than dry. However, the contents of the privy would be taken out and buried when it is 2/3rd full.

b) Merits and demerits:

Merits:

1) In dry and very cold places where water is a scarcity or is not used, water sealed latrines would not work. In such circumstances vault bricks still has a place.

2) There is practically no chance of pll pollution of water sources unless of course a crack develops in the vault.

Demerits:

1) Odour problems present.

2) A concrete vault would be relatively a little too expensive.

3) Usually the cleaning door and the seats are not well maintained and in effect give access to the flies.

4) Cleaning the semiliquid excrements poses a serious problem; and the scavengers usually scatters a great deal of the material over the ground and render the latrine highly insanitary.

5) Neglect in cleaning leads to overflow of the vault resulting in a great nuisance.

2.3.6. Trench latrines:

These only deserve mentioning here since these are very temporary and unsuitable for rural families, although ~~all~~ are quite suitable for places ~~place~~ whereas there is a sudden influx of people e.g. in fairs and festivals.

Several temporary superstructures are built across a long trench and after use sand is sprinkled on top of the excrements. Finally the top 1 ft of the trench should be filled with earth or ash and closed.

2.3.7. Chemical toilets:

These again are not envisaged for rural excreta disposal programme in any case. All the same it can be used either outdoors or indoors. However, because of the cost of the necessary chemicals as the daily care required, they are seldom used out of doors where other types of toilets are acceptable. Their chief application in indoors for elderly or infirm people.

The toilet seats are placed directly over the tank or bowl containing caustic chemicals and water, caustic soda being most favourable.

2.3.8. Water-pollution and pit privies:

The chance of pollution of ground water is quite high if the pits are located close to the water sources. Thus a safe distance is of very important consideration. The field studies and experiments in the line are not very many but a general guide line is to fix a safe distance of 50'-0" from the water source tapping the water-table. Some trends of thought somehow exaggerate the risk of pollution and feel that the safe distance would be 100 ft. However, Dyer, Bhaskaran et al observed that pollution did not flow beyond 10'-0" distance from the latrine sunk in a sandy soil. To be on the safe side 25'-0" can be taken as the safe distance. An extract from the Report of the Environmental Hygiene Committee, Oct. 1949, P.106 is quoted here as follows:-

"We wish here to state that the risk of pollution of ground water by borehole and other types of latrines has been some what exaggerated. Under conditions of use in villages, in sandy soil, loamy soil or clayey soil, the risk does not extend beyond 25ft. A radius of 25 ft gives a factor of safety".

2.3.9. Public latrines for rural areas:

Experience with public latrines has not proved its suitability for the following reasons:-

1) They are not usually maintained in Sanitary condition.

2) The seats are often kept unclean and unfit for subsequent users.

3) It requires full-time attention by scavenger which is often not available.

2.3.10. Choice of latrines:

Sanitary aspects coupled with cheapness determine the choice of latrines in rural areas. Although Septic tank and aqua privies are ideal from sanitary point of view, their prohibitive costs do not allow them to be recommended for rural family latrine. The obvious choice would be some form of a pit latrine. Experience in Singur recommends dugwell or modified latrine for the purpose.

Apart from the technical knowhow and the organisation to technically help the villagers to instal latrines or subsidy, if any, a systematic follow up programme is necessary to keep the already installed latrines in order and keeping track of the use position of the existing latrines. Maintenance of latrines is as well important to achieve success in excreta disposal programme for which we can not solely depend on the villagers. This can only be done through a programme of systematic follow-up.

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3. RURAL HOUSING

3.1. Salient features:

It is necessary to provide shelter for protection from bad weather and privacy required for family life. Each and every family require comfortable and healthful living conditions. Housing does not mean mere provision of a place to live in. The environment including basic amenities like water, open space, etc ~~from~~ form part and parcel of the housing. Healthful housing helps in preventing the transmission of respiratory infections like common cold, T.B., influenza, diphtheria, measles, skin infections such as scabies, ringworm as well as rat and insect borne diseases.

Prevailing wind direction guides the orientation of the dwelling house. In rural areas, the building should not occupy more than one third of the site area. A house should have a minimum of two living rooms of 140 sq.feet each and 10' height and ample verandah space. The number of rooms depends on the size of the family. Each house should have a sanitary latrine. The latrine should be located away from the house and where it will not contaminate the drinking water source. A bathing platform may be constructed near the well or tubewell. The waste water from the bath and the well may be drained to a soak pit located at one end of the compound. In villages, it is often seen that verandahs or one of the rooms of the house proper is used as a kitchen. Both the practices are undesirable and they should be discouraged.

A separate kitchen with a minimum floor area of 50 sqft detached from the main house is very much desirable in rural areas. If cattle have to be accommodated, a separate shed should be constructed. This may be located in the back yard and a manure pit may be provided to dispose of the wastes from the cattle shed.

The plinth may be 2' to 3' above ground. The floor may be of impervious material and finished smooth. Brick flat with cement plastering will be sufficient. With a view to provide natural lighting and ventilation, window area should be 1/10th of the floor area in the living rooms and 1/5th of the floor area in kitchen. Windows should open to outside air or to an open verandah. Plastering and white washing of the walls and ceiling will improve the lighting inside the rooms.

3.2. Materials of construction:

Village houses have to be cheap. Mud walls properly stabilized and protected with plaster will be satisfactory. Tile and thatch roofs are most common in rural areas. Thatch roof harbour dirt and dust. It is highly inflammable and liable to catch fire. Also it needs frequent replacement.

Amenities:

In general, villagers are deprived of a satisfactory supply of safe water. Tubewells and dugwells have been used quite frequently to serve the rural community. A properly protected ground water source will satisfy the needs of the rural homes.

Collection and disposal of human excreta is a very difficult problem in the villages. At present, a very small fraction of the rural homes has latrines and majority of the latrines are insanitary. The aim should be to provide a sanitary latrine in each home. In rural areas, individual families have to take care of the collection and disposal of garbage. Manure pits have been used with success for the disposal of ~~aagax~~ dry wastes from the households and the cattle shed.

4. VILLAGE SANITATION

4.1. General:

About 80% of the total population in India live in villages. Improvement of general sanitation is the responsibility of the Government and the health department should take all necessary steps to improve the conditions in rural areas.

Improvement schemes should be prepared only after surveying the existing environmental conditions in any given village. This include population, communication facilities, P & T offices, built up area and total area, areas of parks, playgrounds, type of houses, maintenance of houses, extent of overcrowding, ventilation and lighting, public and private water sources and protection from contamination, collection and disposal of solid wastes and human excreta, nature and condition of food handling establishments such as tea stalls, markets, groceries, public buildings like Schools, Libraries, Community halls, health services to control Communicable diseases, Immunization, M&CH services, Vital Statistics, School Health services etc. Type of industries and nature of pollutants discharged; facilities for disposal of the dead etc.

After completing the survey on the above, analyse the data and compare the facilities with the recommended standards to know the type and magnitude of the problems. The problems should be arranged in the order of their importance to take follow up programme based on the priorities.

A safe water supply to each villager and a sanitary latrine to each home will go a long way in the improvement of village sanitation. Technical guidance is very much wanting in the villages. Demonstration Centres should be set up where the villagers can get the benefit of the rational and scientific approach to their problem. Much of the sanitation can be achieved with very little capital investment and if proper guidance is made available to the villagers.

4.2. Composting and Manure Pit:

Composting is an integrated method for disposal of Refuse and night soil. It is an economical and sanitary method of disposal. Generally composting is carried out in trenches or pits. The size of the trench would vary with the population and quantity of refuse to be handled. Usually the trenches are 4' wide, 3'-0" deep and the length is 15'-20".

6" of Refuse and 2" of night soil are placed in alternate layers in the trench taking care to see that the bottom and top layer is of refuse. At the end of each working day, it is necessary to cover the top of the heap with a layer of earth of about 2" thick to prevent smell, fly breeding and to conserve moisture. Within few days after filling the trench, the temperature in the trench rises to 60°C to 65°C which is sufficient to kill the pathogenic organisms and fly larvae. After 4 to 5 days, 2-3 gallons of water/ 60 foot length of the trench is added and the compost is covered with a layer of mud paste. After 4-6 months the manure is ready for application to land, after drying for a month. Precautions should be taken for controlling flies. The old trenches can be used again.

Manure pits are recommended for disposal of refuse and animal wastes. Improper disposal of the wastes cause fly breeding rat harbourage and create nuisance. This problem can be solved by disposal in manure pits. These are 4' deep, 6' wide and 10'-15' long and divided into several compartments. The compartments are used in succession and good manure is available in course of time. Care should be taken to cover the pit with 12" thick dry earth to prevent fly breeding etc.

4.3. Septic Tank and Disposal of effluent:

Septic tank is a water tight chamber, where the sewage is collected, and retained for a period 24 hours to facilitate the separation of solids from liquid. The organic solids undergo decomposition with the help of anerobic bacteria. The time required for this sludge digestion process depends on the microorganisms present and the temperature. Usually it takes about 2 months time for our climatic conditions. The digested sludge gets accumulated at the bottom of the tank which require to be removed at an interval of 1 to 2 years. The effluent from the septic tank can be satisfactorily disposed of by land treatment. The septic tank effluent contain eggs and larvae of hookworm. So the effluent should not be discharged into a stream or a river without proper disinfection.

For disposal of effluent from Septic tanks, soakage pits and sub-surface tile drains are also considered wherever soil conditions permit.

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5. SCHOOL SANITATION

5.1. Importance of School Sanitation:

a) On account of conglomeration of pupils, who may include both carriers and susceptibles, the opportunity for spread of disease is quite considerable needing thereby social attention for providing sanitary environment.

b) Lack of Health Education often dissuade the villagers from using sanitary facilities.The provision and use of sanitary facilities like latrine etc would impart a very useful health education to the school children. If the school children are made to use these facilities, it might form a habit to them. They, being, the future adult population, would try to implement these facilites in their homes and as such the sanitation programmeas such would gain a new tempo.

5.2. Sanitary requirements of rural schools:

(1) Site

a) Topography - Best situated in an elevated ground which is easily drained during rains. It should not be subject to water loggigg.

b) Location - The school should preferably be located centrally so that most distant part of the village is not farther than a mile.

c) Approach - Approach roads should be reasonably good and should not be water-logged during rainy season.

d) Accident hazards - Proximity to busy roads and ponds should be avoided as far as possible.

(2) Structure

The building structure should:

a) be safe enough

b) protect pupils from rain, sun and wind

c) not be damp.

(3) Overcrowding

a) The floor area of the class rooms should not be less than 5 sq. ft/pupil.

b) There should be adequate corridor space.

c) Built up area to open area should preferably be 1:3. There should be at least adequate open space which could be used as a play ground.

(4) Ventilation

The class rooms should have a ventilating area at least 20% of the floor area. The windows, doors and eve-spaces would comprise the ventilating area.

5) Lighting

a) No sophisticated lighting standard is suggested for rural schools comfortable readability of newspaper prints would form a good yardstick.

b) Absence of glare in the black-board is also solicited.

c) The general principle of cutting down direct sun light and administering light from the left of the pupils may be followed.

East-west orientation of the building and white washing to the inside walls often improves the lighting standard a great deal and should be kept in view while planning.

6) Accounstics

Here again no sophisticated standard is suggested.

a) Interference between classes should be avoided by ensuring partition walls between classes.

b) The room should not be too long to generate echo.

7) Furniture

The general principle should be to provide furniture not leading to a permanent postural defect. Thus,

a) provision of benches with back rest is most desirable.

b) The height between the sitting bench and the desk should be so adjusted that the distance between the eyes and the reading materials should not be less than 1 ft and greater than 1½ ft.

c) The feet should always rest against the floor while seated.

d) If sittig on the floor is practised - the floor must be impervious and there should be a desk to keep the reading materials at the specified distance.

e) Black-board should provide sharp contrast between chalk mark and the base. The distance between the board and the nearest bench should not be more than 6'-0".

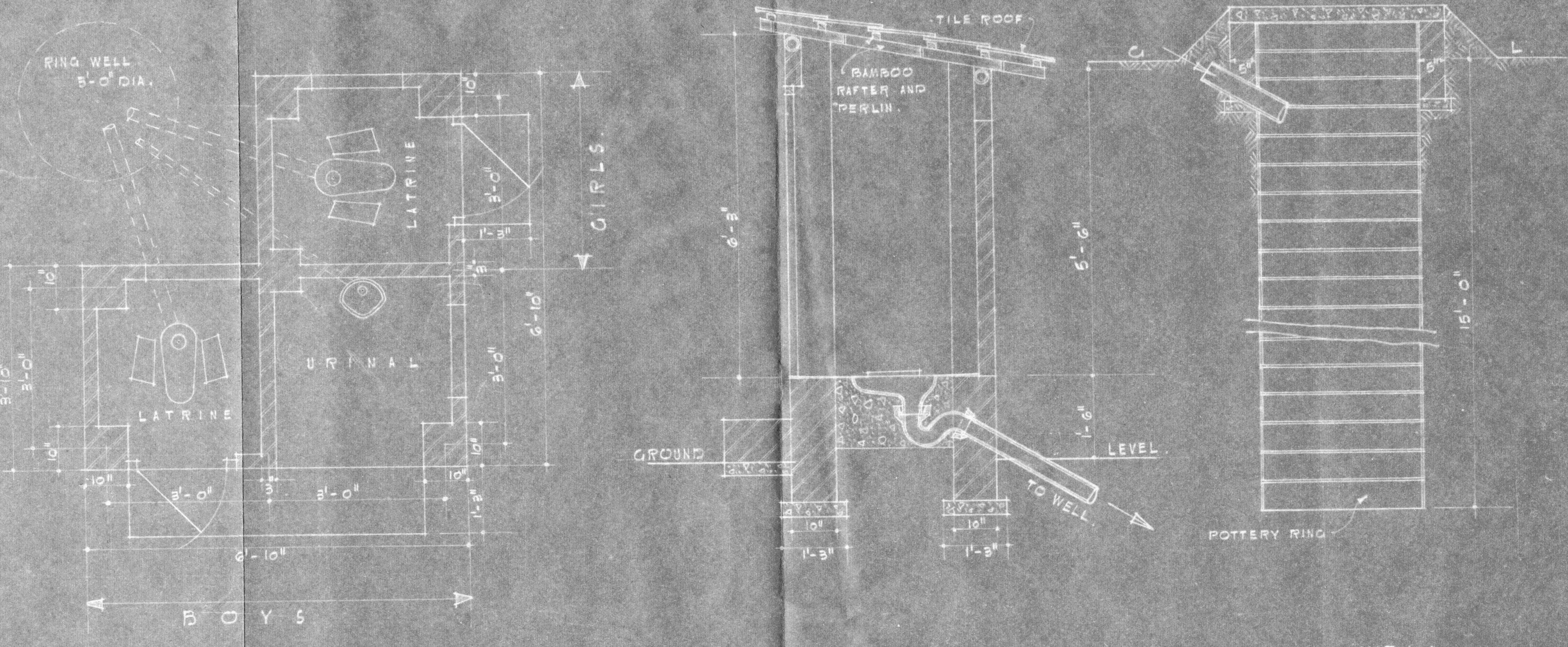
8) Latrines and Urinals:

General standard is to provide a latrine for 100 pupils and a urinal for 50 pupils. For rural primary schools, however, 3 latrines (1 for boys, 1 for girls and 1 for teachers) and 2 urinals (for boys) may be considered satisfactory.

9) Water-supply:

Safe and adequate water supply is envisaged. Most satisfactory would be to have a tubewell or a sanitary well as the source of supply and to have a sanitarily maintained storage facilities.

In rural primary schools a tubewell fitted with a handpump and with proper platform with adequate drainage facilities would form a satisfactory standard.



P L A N — CROSS SECTION — SEC. of WELL

TYPE PLAN of LATRINE & URINAL FOR SCHOOL.	SCALE – 1/2" TO A FOOT	DRAWING No. – D/27A.	DRAWN BY – [signature] 9.2.60	CHECKED BY – [signature] 11/2/60	APPROVED BY – [signature] 11/2/60	PREPARED AT – S. E. SECTION. A. I. I. H. AND P. H. CALCUTTA.

10) Refuse disposal:

Provision and maintenance of refuse disposal in rural schools is important from educative and aesthetic point of view rather than health hazard, as because, garbage component of the refuse is negligible. The refuse disposal in such cases should consist of -

a) Waste-paper baskets in class rooms.

b) A manure pit or a field incinerator for disposal.

11) Eating facilities:

Normally a rare facility in a rural primary school. If present it must have impervious floor, arrangement for disposal of garbage and dish washing and hand-washing facilities in a sanitary way.

Design of school latrines and water-supply to latrine blocks used in Singur area:

(i) A typical school latrine, as used in Singur is enclosed for useful guidance. The modified dugwell latrine consisting of 2 to 3 latrine seats and 2-3 urinal connected to a pit is envisaged. This has been locally designated as "Sanitary Block". A typical sanitary block consists of 3 latrine seats and 2 urinals. The pit used is of 3'-0" dia, and is 10'-12' deep, and lined with earthen rings for support. The superstructure is built with 5" brick wall with a normal foundation. The roof is of reinforced brick concrete (R.B.C.) and the floor is cemented. Care is taken to ensure the utilisation of a minimum space. Figure 1 gives the details.

An interesting and useful means of providing running water supply to the sanitary block is also presented below:

Each latrine unit has been provided with a tap which is fed from a reservoir built outside the block. A ½" dia. pipe moulded opposite to the spout of the hand pump of the tubewell discharges water B of the said reservoir (2'-0" x 2'-0" x 3'-0") built at ground level. From the floor of the tank a 3/4" dia delivery pipe is laid upto the sanitary block and connected to the tap (½") fitted inside each of the latrines. The head of water in the tank over the delivery pipe causes adequate flow into the taps. Whenever the handpump is used some water flows into the tank through the ½" pipe connecting the handpump and the tank, which is thus filled up without any additional effort.

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6. COMMUNICABLE DISEASES AND THEIR CAUSATION

6.1. Communicable disease and environment

Health and disease are two important components of community life. Environment plays a very important role in maintenance of health as well as in causation of disease. Broadly speaking the environment has three factors for consideration physical biological and social. All these environmental factors have great influence in maintenance of health and causation of the diseases. Man is subjected to two types of diseases communicable and non-communicable. Communicable diseases are those which are caused by agents microbial in nature and transferable from one to another. Thus the main characteristic of these diseases is the power of spread which some times breaks out in epidemic form. This epidemic may be rapidly spreading and explosive in nature or slowly moving progressive in nature. A continuously prevalent disease in an area is called endemic. Some times communicable diseases are sporadically present in an area. An epidemic diseases spreading into more than one country is called pandemic.

6.2. Causation

The communicable diseases have been very well studied in respect of their causation and as a result effective measures have been evolved for prevention and control and attempts have been made for eradication of some diseases.

As regards causation there are three important cardinal factors agent, host and environment. Communicable diseases, result from the interaction of these three factors. No one factor can result in disease. Introduction of agent results infection, the human body reacts against this infection. The end result is a disease and cure or no cure or in fatality or there may be no disease at all.

Different communicable diseases have different characteristics according to their etiological agents. Fundamentally these agents are classified in certain groups. But simply they are virus, reckettsiac, bacteria including cocci, bacilli, spirochaeta, vibrio, protozoa, helminths.

The diseases are often named according to the etiological agents e.g.

Viral diseases	Influenza, infectious hepatitis, smallpox, dengue, mumps, etc.
Rickettsial diseases	Typhus group of fevers.

Bacterial diseases	Cholera, typhoid, bacterial dysentery, tuberculosis, diphtheria, tetanus, whooping cough, etc.
Protozoal diseases	Malaria, kalaazar, amoebic dysentery, giardia intestinalis.
Helminth	Hook-worm diseases, round-worm, thread-worm, tape-worm, filariasis, guinea-worm infection.

Reservoir of infection is man or animal.

Man may be a case and suffering from the disease and act as a source of infection or he may be a carrier without showing any symptom. Portal of discharge - The infectious agents are excreted from the infected person a case or carrier according to the nature of the organism, from the respiratory system in the act of coughing sneezing and in sputum - influenza, tuberculosis, from gastro-intestinal system in the act of vomiting and in faecal matter - cholera stool.

Discharge of wound infection is also discharge from infected mucous membrane. Portal of entry - The infectious agent enters into the body by one of the three means: (1) Inhalation (2) Ingestion or swallowing (3) Inoculation through skin or mucous membrane.

6.3. Transmission or mode of spread

Aeticlogical agents have different modes of spread. Some are spreading by direct contact e.g. venereal diseases and scabies. Besides these there are indirect contact - through droplet, airborne, dustborne spreading influenza, tuberculosis, etc. fomites, finger, fly-food and water may spread infection like cholera, typhoid, dysentery, poliomyelitis, etc. Diseases spread by insect bite - mosquito borne infection, malaria, filariasis, dengue, yellow fever encephalitis, etc. Diseases spreaded by contaminated wounds are tetanus, rabies (direct bite by animals).

6.4. Important communicable diseases in rural India

Cholera, typhoid fever, dysenteries, malaria, filariasis, guineaworm infection and intestinal parasitic infections - Hookworm, ascariasis etc.

1. Cholera has a very wide range of manifestation. An ambulatory mild case with diarrhoea only may be vibrio positive. While there may be also usual acute case with diarrhoea, vomiting and dehydration and called severe type requiring intravenous transfusion. There will be at the same time asymptomatic excretors of

vibrio cholerae in the community who are suspected to be the source of infection to new cases.

i) Occurrence: The disease is endemic in West Bengal, Tamil Nadu, Andhra Pradesh, Orissa, Bihar, Madhya Pradesh, Uttar Pradesh. Where there are cases of diarrhoea - the stool should be examined for vibrio cholerae.

ii) Prevention and control: Protected water supply, sanitary disposal of nightsoild, personal hygiene, anti-cholera inoculation. Notification and isolation and treatment of cases particularly for rehydration are the essential anti-cholera measures.

2) Typhoid fevers or enteric fevers: Symptoms are generally continued fever lasting for more than 7 days. Salmonella typhi and para-typhi are the casual agents.

i) Occurrence: The disease is endemic throughout India. The agents can be isolated and identified from blood, during early stage and from stool during later part of illness also from healthy carriers. The cases may be mild, moderately ill and severe. The severe cases often meet with fatality. There are satisfactory methods of treatment with antibiotics.

ii) Prevention and control: Environmental sanitation including protected water supply, sanitary disposal of nightsoil and garbage, TAB inoculation and personal hygiene are the essential measures.

3) Dysenteries: Symptoms are frequent loose motions with mucous and blood. Casual agents are shigella group of bacilli or amoeba - The disease increases in rainy season when fly nuisance also increases.

i) Occurrence: Throughout India. Bad sanitation including garbage disposal and disposal of nightsoil for treatment - sulphonamides and antibiotics are available.

ii) Prevention - General sanitation and protected water supply and personal hygiene are the essential measures.

4). Malaria: Presenting symptoms are intermittent fever, headache etc. Causal agents - Malaria parasites - P.vivax, P. falciparum etc. Spread by - bite by infected mosquito female anopheles - which breed in different collection of clear water. They are of different species - A.philippinens, A.culicifacias etc. The parasite grows in man as well as in mosquito in two cycles:

In man - human cycle - asexual

In mosquito - mosquito cycle - sexual.

National Malaria Control Programme was launched in 1953.
National Malaria Eradication Programme was started in 1959-60.

i) Important measures: (1) anti-mosquito - insecticide residual spray with DDT, (2) blood examination of fever cases, (3) radical treatment of positive cases, (4) antilarval measures in urban areas.

5) Filariasis: Obstruction of lymph flow or elephantaisis of limb is the commonest symptom of filariasis. Disease can be detected muchearlier in a person by finding microfilaria inperipheral blood at night of an infected man. Causal-agents are W.bancrofti and B.malayi.

Mode of spread - By bite of mosquito harbouring infective larvae. Obtained by biting another infected man.
In the mosquito the microfilaria only gets matured - Vector-mosquitoes are culex fatigans and mansonia masonioides Culex fatigans breed in collections of dirty water. Mansonia breeds in collections of water having pistia plants.

i) Prevention and Control: Anti-mosquito measures particularly prevention of breeding of specific type of mosquito Anti-culex measures. Anti-larval - use of insecticide against the adult mosquito. Underground drainage has been shown special importance. Pistia control has shown wonderful result in the State of Kerala.

For microfilaria - Treatment with diethylcarbamazine is effective.

6) AsAscariasis: Among the diseases of intestinal parasites ascariasis affects mostly the children belonging to the poor environment conditions. Symptoms are variable and often vague. Sometime digestive disturbance, abdominal pain, vomiting, restlessness, disturbed sleep are reported. Worm is passed through stool or is vomited out. Mode of spread - Infected person passes with faeces embryonated eggs in soil, which reach mouth through contaminated food, vegetable etc. and hatch in intestinal canal. The larvae penetrate the wall - through the circulatory system - enter liver, lung, etc. and air passage and again swallowed - get ledged in the intestine where they settle and get maturity.

Deworming by treatment is essential for prevention and control. Sanitary disposal of night soil and prevention of soil contamination in areas is also necessary.

7) Hookworm: - Disease - A chronic disabilitating disease with vague symptoms, persons often suffer from anaemia. The disease is prevalent in rural areas almost all over in India.

Causal agents are Ankylostoma duodenale and Nector amerieanus. Necator americanus is found most frequently here. A bare footed person is susceptible - Infected persons contaminate soil by indiscriminate defaecation - . The eggs in the faeces develop into larvae stages 1 to 3, the third stage is the infective and is also to penetrate the skin - then through lymphatic and blood to lung to airpassage and swallowed to reach small intestine to get attached to the wall and develop to adult and produce. The adult suck blood from intestinal wall.

i) <u>Prevention and Control</u>: Use of latrine is the most important measure against the disease - Health Education is necessary for this.

De-worming by drug is also possible but latrine is the final answer.

8) <u>Guinea-worm disease</u>: Infected person suffers from local and general symptoms. The gravid female worm about 1 meter long migrates from deep tissue usually of leg and when the worm prepares to discharge larvae there is burning and itching - when the person gets down in step wells and his or her affected legs are incontact with water the larvae come out and swim. They are swallowed by cyclopse. If by chance these water is drunk people get infected, the cyclopse, get digested in the stomach and the larvae get liberated and enter the subcutaneous tissue where they grew. The disease is prevalent mostly in Rajasthan and the other western states of India.

<u>Prevention and control</u>: Convertion of stepwell into draw well and other measures against cyclopse. Water should be boiled before drinking or the water may be passed through a piece of cloth to prevent the cyclopse.

R.C.A. MOULD.

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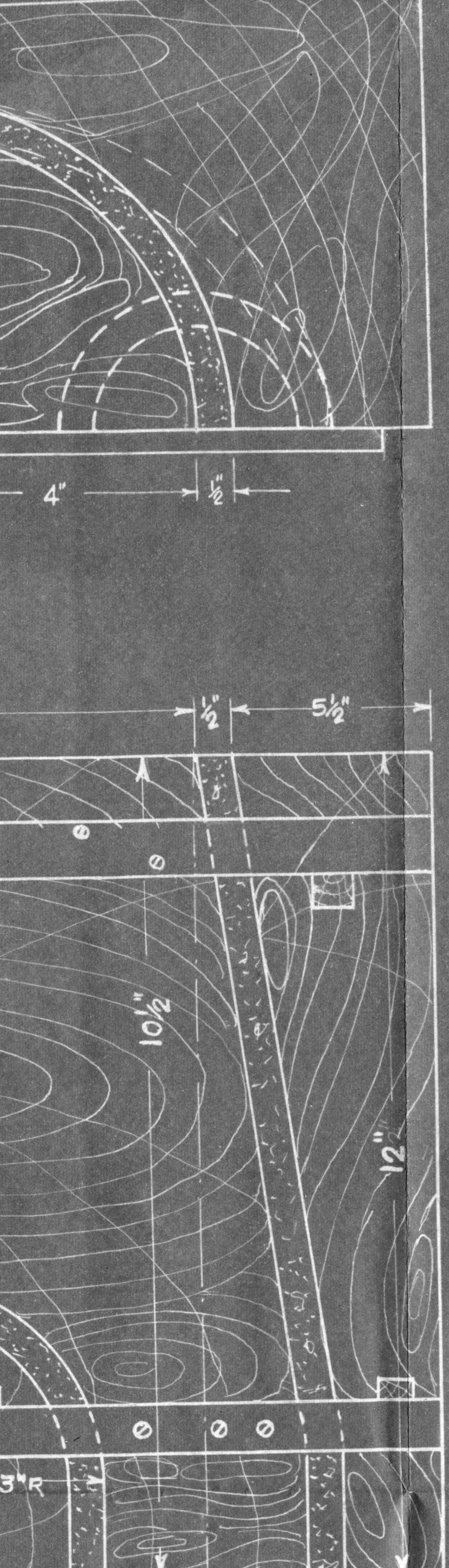
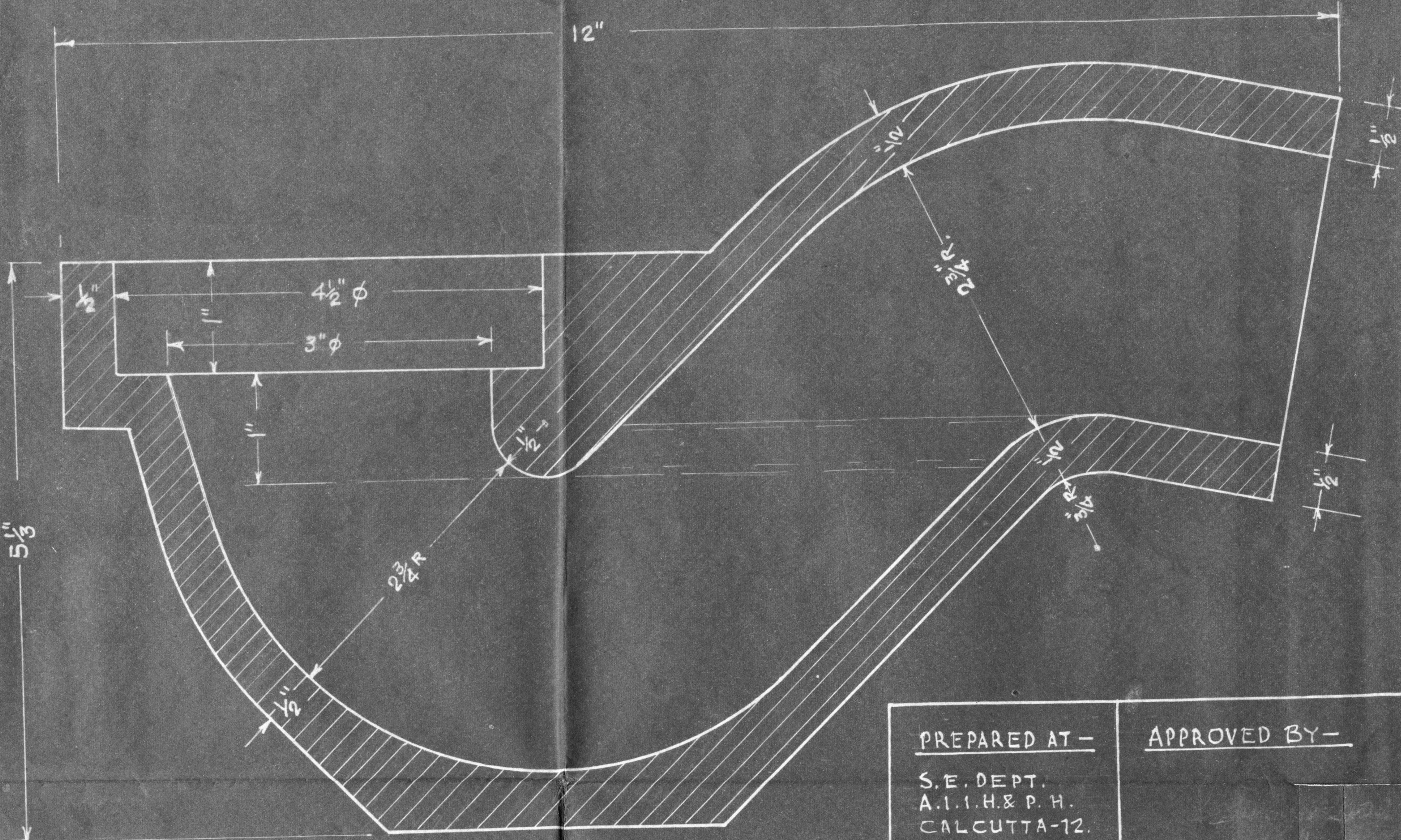


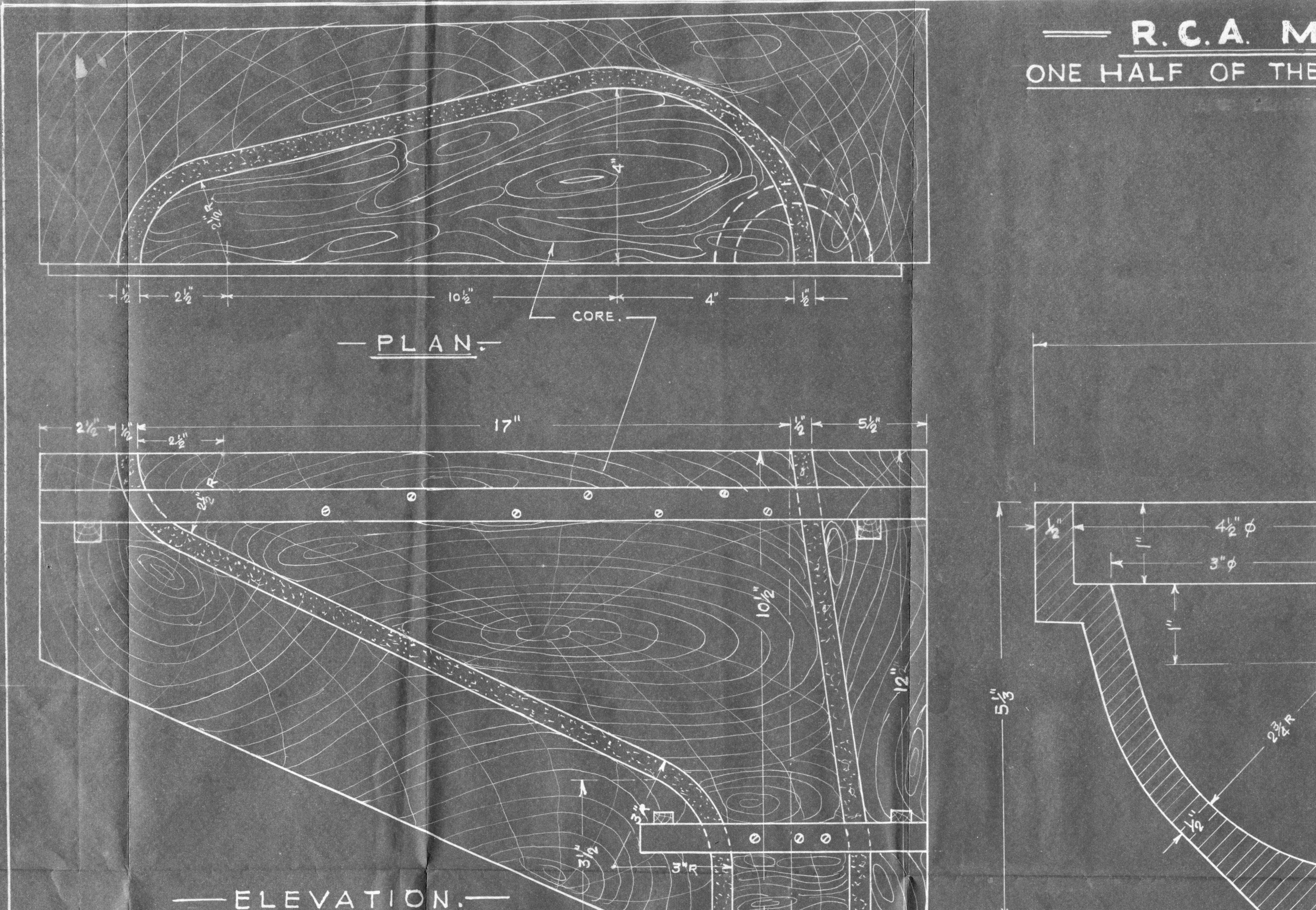


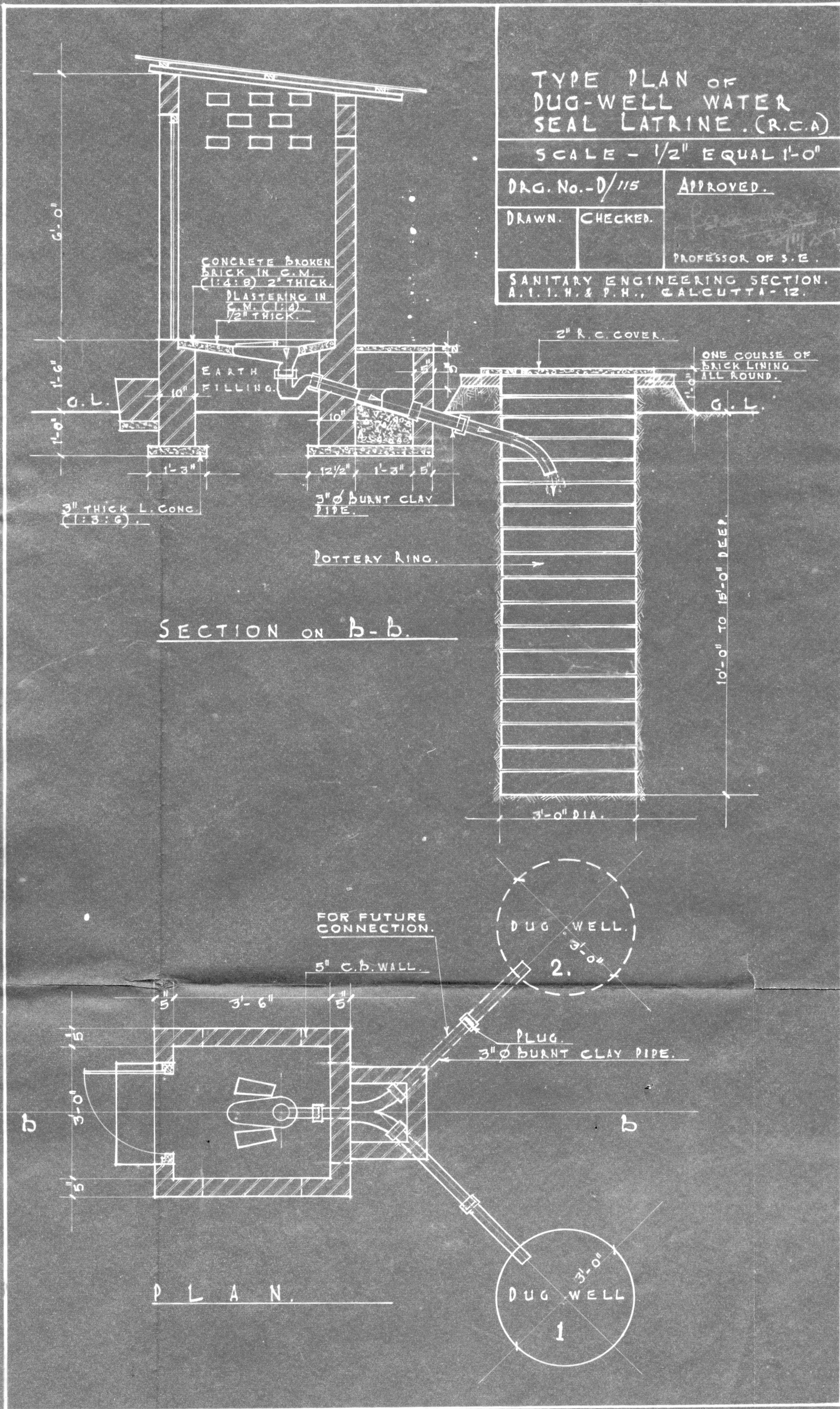
SECTION OF TRAP

PREPARED AT —	APPROVED BY —
S.E. DEPT. A.I.I.H.& P.H. CALCUTTA-12.	PROFESSOR.

R.C.A. M

ONE HALF OF THE




TYPE PLAN OF
DUG-WELL WATER
SEAL LATRINE. (R.C.A)
SCALE - 1/2" EQUAL 1'-0"
DRG. No.-D/115
APPROVED.
DRAWN.
CHECKED.
PROFESSOR OF S.E.
SANITARY ENGINEERING SECTION.
A.I.I.H. & P.H., CALCUTTA-12.
CONCRETE BROKEN BRICK IN C.M. (1:4:8) 2" THICK.
PLASTERING IN C.M. (1:4) 1/2" THICK.
6'-0"
1'-6"
1'-0"
G.L.
10"
EARTH FILLING.
1'-3"
12 1/2"
5"
3" THICK L. CONC. (1:3:6).
3" Ø BURNT CLAY PIPE.
2" R.C. COVER.
ONE COURSE OF BRICK LINING ALL ROUND.
POTTERY RING.
10'-0" TO 15'-0" DEEP.
3'-0" DIA.
SECTION ON B-B.
FOR FUTURE CONNECTION.
5" C.B. WALL.
3'-6"
3'-0"
DUG WELL.
2.
PLUG.
3" Ø BURNT CLAY PIPE.
b
PLAN.
DUG WELL
1