WATER SUPPLY FROM TUBE WELLS.

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The genesis of tube wells.—Use of wire gauze.—Development of tube wells.—Recent types.—Influence on water level.—Large discharges and excessive head.—Iron in waters from tube wells.—Suction valves.—New pattern foot valve.—Tube wells for the small land-holder.

The Genesis of Tube Wells.

The tube well, as we know it to-day, has been produced by a comparatively slow process of evolution from the ordinary ancient well, and the almost imperceptible change, from the drawing of water vertically from a horizontal surface of water bearing stratum, to the drawing of water horizontally from between the layers of numerous strata, appears to have been made first some fifty years ago in California. In its earliest form it consisted of a circular hole cut in the ground, and carried to some considerable depth into the water-bearing stratum ; into this hole the pipe through which the water was to be withdrawn was inserted, the mouth, or lower end of the pipe, being kept rather more than midway between the subsoil water surface and the bottom of the hole or well. The space below and surrounding the pipe was filled in with broken stone, generally of a coarse grade, resembling road metal. Wells of this form yielded a higher discharge than the ordinary [illegible] and were considerably cheaper to construct, but, as is obvi[illegible], they could only be successful in a porous subsoil, such as various grades of gravel. In districts where this type of tube well was found to diminish in discharge after a short period of working, it was discovered that such diminution was due to sand and fine particles of subsoil having been washed into the interstices of the stone shrouding, and gradually choking the draw-off or suc[illegible] pipe.

To correct this failing, it was necessary that the v[illegible]ocity of the water passing through the subsoil should be reduced [illegible] such an extent that the finer particles of subsoil would not be held in suspension, and in order to achieve this a longer pipe was used and was perforated with a large number of holes of various diameters along its walls ; thus, the stream of water to the tube

distributed over a greater area, and hence the velocity was reduced. Owing to the length of the tube employed, however, it could no longer be inserted in a well-like hole, as in the earlier forms, and therefore sheet iron casing pipes were employed, and the material dredged out from the interior. The perforated tube was lowered and shrouded with broken stone, and then the casing pipe was withdrawn.

Tube wells constructed according to this method proved highly satisfactory in coarse subsoils, but in districts where the subsoil contained much sand the tubes choked sooner or later; consequently, methods had to be found for excluding sand from the tubes in a more satisfactory manner than had been attained by using broken stone as a screen.

Use of Wire Gauze.

In the early seventies, development was so rapid that it is difficult to follow the various stages, but the introduction of a fine woven wire screen wrapped round the perforated tube constitutes the main feature. The larger sizes of tubes, when made in this form, were sunk in the old way by first sinking a casing tube, but smaller sizes were provided with a driving point and driven direct into the earth, a protective covering of perforated metal being wrapped over the wire gauze in order to protect the fine screen from damage due to friction with the soil. The objection to the use of a wire screen in contact with a perforated tube is the enormous loss in the waterway area of the tube, which is accounted for as follows: Assume the wire screen to be of the ordinary square mesh pattern, having say 2,500 meshes to a square inch, or fifty spaces to a lineal inch. In a gauze of this description, the thickness of the wire is practically equal to the space between the wires, so that, considering the wires lying in one direction only, the original area of the hole is reduced by one-half by these wires alone, and the effect of the wires lying at right angles to the first lot further reduces the remaining area by one-half, leaving one-fourth of the original area as an available waterway, the loss being seventy-five per cent. When the tube body has been perforated with the maximum number of holes consistent with the strength necessary to resist the pressure and other stresses to which it will be subjected, then the length required for a given discharge has to be increased *four fold* when the tube is to be close wrapped with a wire screen; thus increasing the cost

very considerably both of the tube and of the boring necessary for its installation.

It was not until the beginning of the present century that any rapid strides were made in developing the construction of tube wells, when the demand for cheap water supplies, mainly for irrigation purposes, and the contemporary improvement of centrifugal pumps, caused a boom in these wells, which resulted in several hundreds of designs coming on the market.

Development of Tube Wells.

Among the most noteworthy of these are some forms still in use in the United States. These include the Thompson tube (Fig. 1), consisting of a perforated iron tube having a thick wire wound spirally around it, and over that a fine wire gauze screen. The object of the spiral wire is to keep the wire screen out of contact with the perforated tube and thus obtain a full waterway area. Owing to the fragile nature of the wire screen employed, however, it was liable to be pressed against the perforated tube between the coils of the wire sustaining spiral, and thus to defeat the object of its construction. This form of tube well was constructed and sunk experimentally at Lahore, in 1909, by the Buildings and Roads Department, and its use in this respect is of considerable interest, as it marks the commencement of a system of water supply in India which has borne considerable fruit.

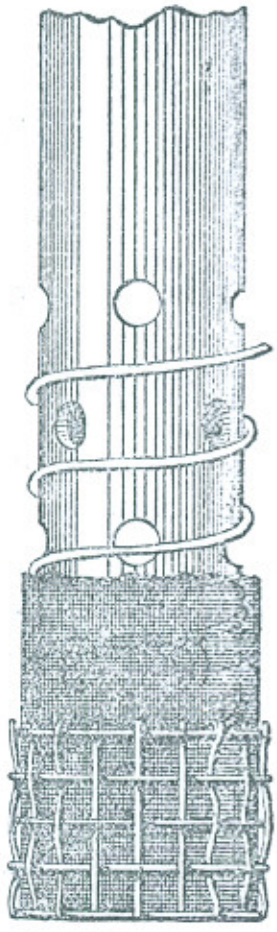


Fig. 1

In order to strengthen the fragile gauze used in this type of tube well or strainer, the tube is further protected either by an outer covering of heavy wire netting, or by an outer and reversed spiral wire as in the Moresi tube. In order to reduce the cost, the distance and outer nettings or wires are usually made from a metal inferior to that of the fine gauze or actual screen, so that the combination is only suitable in districts where the subsoil water is free from acid, or unfitted for setting up galvanic action. The writer used this combination screen as a temporary measure, in 1912, on a convoluted tube well at

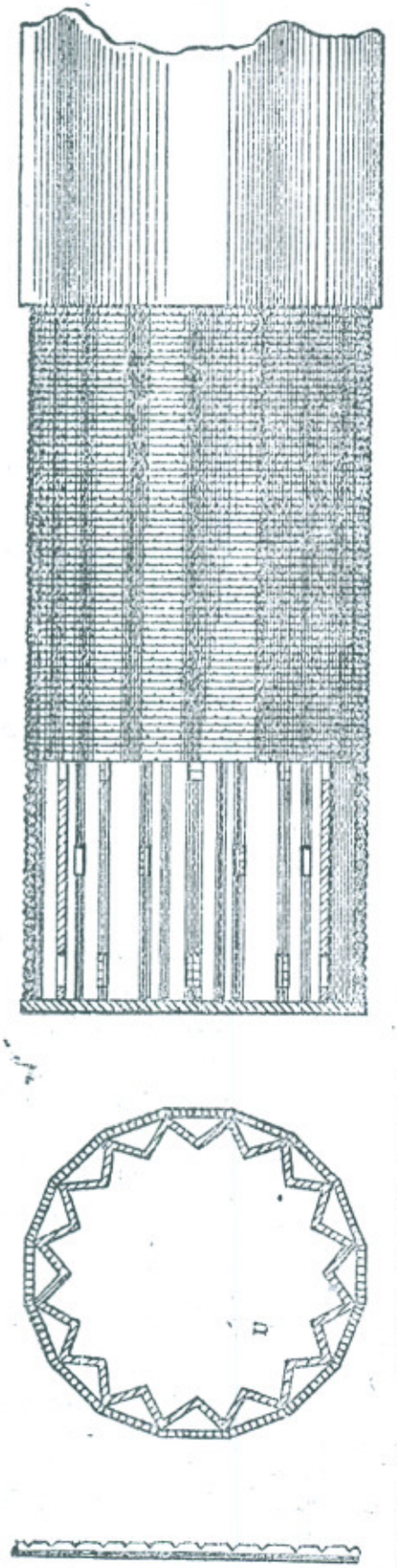


Fig. 2.

Dera Ghazi Khan, where the water is somewhat saline, the result being that within six months the outer screens were completely corroded, the iron oxide in combination with the silica forming practically an impervious matrix on the surface of the screen proper, and thereby defeating the object of the tube.

There are two main objections to the use of square meshed gauze as a screen, the chief being that owing to the fineness of the wire required to obtain a correspondingly fine mesh, the material is fragile and easily damaged, and has practically no margin to allow for the corrosion which may take place in certain soils, and although tube wells with these fine gauze screens have worked successfully for periods of twenty years in several districts, yet these cases may be taken as the exception rather than the rule. The other objection is, that this form of tube requires to be sunk inside a casing tube, which is withdrawn after the tube proper has been placed in position, and this necessitates the installation of a tube of considerably less diameter than the casing tube employed so that for the boring done the discharge is less than would have been the case if the tube well had been sunk without a casing.

These early designs for tube wells, having a heavy and substantial screen of fine aperture, include the Smith tube, where the screen is a metal plate, with apertures formed by a cut on three

sides of a rectangle, which is then upset so as to leave in the plate a fine slot of the required opening. Another form is Cook's tube, consisting of a plain pipe, having slots cut into it at right angles to the axis, the cross section of the slots being of V section with the open part of the V on the interior of the pipe. The advantage claimed for this form of section is that particles of sand entering the slot are less liable to jamb in the opening than if the sides were cut parallel. This tube possesses the advantage of being sunk without the aid of a casing pipe, but its single body form necessitates the use of a longer tube than in the case of double tubes.

One form of heavy pattern tube is Stuke's design (Fig. 2), consisting of a star-shaped body, round which is wound a wire of ordinary circular section, which acts as the strainer, the water passing between each turn of the wire which is serrated at regular intervals. A modification of this are two forms of oil well tube, in which the circular wire is not serrated, but is wound

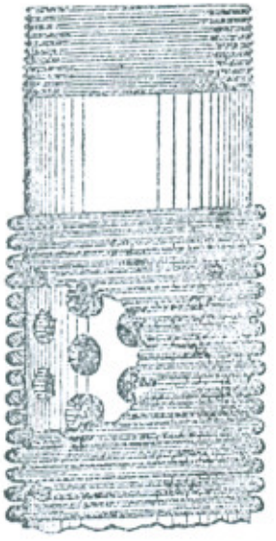


Fig. 3.

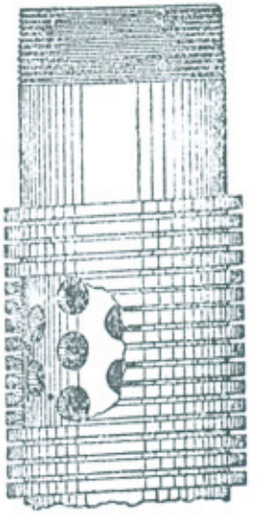


Fig. 4.

OIL WELL TUBES.

with a waterway space between each turn of the wire, while in order to obtain the advantage of the V shaped opening, described in Cook's tube, the wire is drawn to a more or less triangular section. This strainer is applied to a plain perforated pipe, and is made with either galvanized iron or brass wire so that a heavy make of tube can be obtained at a very reasonable cost.

Recent Types.

A tube well of more recent origin than the foregoing is the "Treble Shell Screen," suitable for insertion in certain soils without a casing tube. It consists of a wrought iron pipe, the perforations of which are countersunk to an area of four times the area of the perforation ; the tube is then covered with a galvanized spacing net, over which is secured slotted, quicksand, copper wire covering, protected from damage in sinking by galvanized steel straps; this tube is claimed to be indestructable, but it requires a length of six diameters to secure a waterway area equal to the tube diameter. Other recent forms include the "Johnston" all brass screen, the ribbon tube well, and the convoluted tube well.



Fig. 5.

The "Johnston" all brass screen (Fig. 5) consists of a cage shaped frame, formed by vertical rods held in position by annular rings; the screen proper being formed from brass rings of an approximately Z shaped cross section, where one portion of the Z forms the outer surface of the screen, presenting a V shaped annular slot for the passage of the water, while the other portion of the Z, forming the inner surface, is perforated. This form possesses the advantages of Cook's tube, without the blinding action noticeable on single body tubes, and, therefore, a shorter length of tube is required for a given discharge. This tube can be sunk without a casing tube, but engineers in the United States generally prefer to sink the casing tube to the full depth, and thus avoid any risk of damage to a tube of which the initial cost is high.

The ribbon tube well, as its name implies, consists of a specially shaped ribbon, wound upon itself somewhat as a pipe lighting spill is made from paper ; the ribbon is so shaped that a waterway passage, varying in width from ·004 to ·03 of an inch, is obtainable, the cross section of the inlet being V shaped as in Cook's tube. When heavy ribbon is employed, tension straps are attached to the outside, and this forms the complete tube well. Tubes made in this manner have been in use for several years in Southern India, but in the United States a light

section of ribbon is employed as a screen only, and this is applied to a standard form of tube body.

The convoluted tube well, used to some extent in India, consists of a sheet steel tube formed with longitudinal outwardly projecting corrugations. The tube is perforated to its maximum extent between the corrugations, and the depth of these is such that the screen proper is held away from the tube body just sufficiently to permit of the waterway area in the screen equalling the waterway area of the perforations. In districts where conditions render it more economical to use a casing tube for sinking tube wells, the screen used consists of heavy copper wires, lying parallel, and applied circumferentially to the tube ; the wires being kept at their required distance apart by pairs of copper ribbons, and the whole presenting the appearance of the ordinary verandah chick, familiar in India—the wires representing the canes and the ribbons the strings which secure them. For districts where it is necessary that this type of tube well should be sunk without a casing tube, a particular form of slotted copper plate is used as a screen. Fig. 6 illustrates a combination convoluted and ribbon tubes.

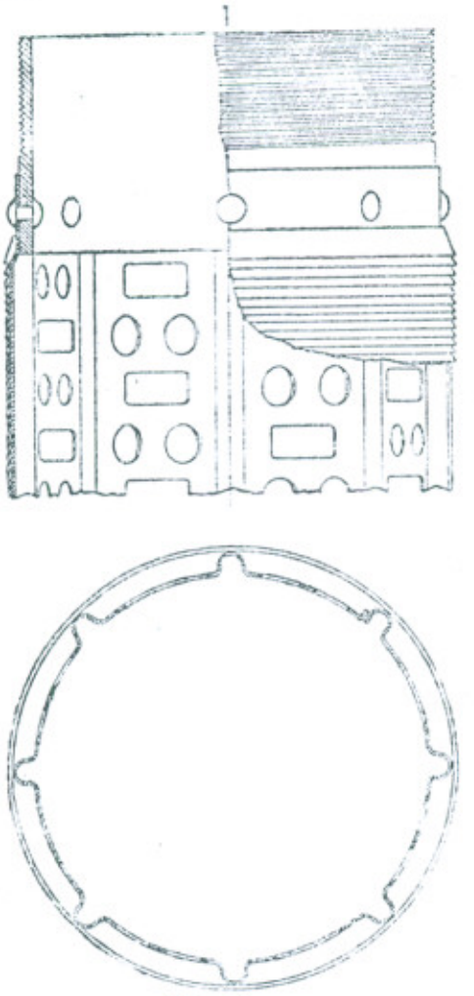


Fig. 6.

In mentioning the above forms of tube wells, an attempt has been made to select as great a variety as possible of tubes in use for discharging up to five cusecs. There are many others in the market, but their designs are more or less similar to one or more of those already described.

Influence on Water Level.

The quantity of water which can be withdrawn from the subsoil, by a tube well, depends primarily on the texture of the

subsoil ; that is, on its ability to pass water through its pores or interstices under a reasonable pressure, and secondly on the

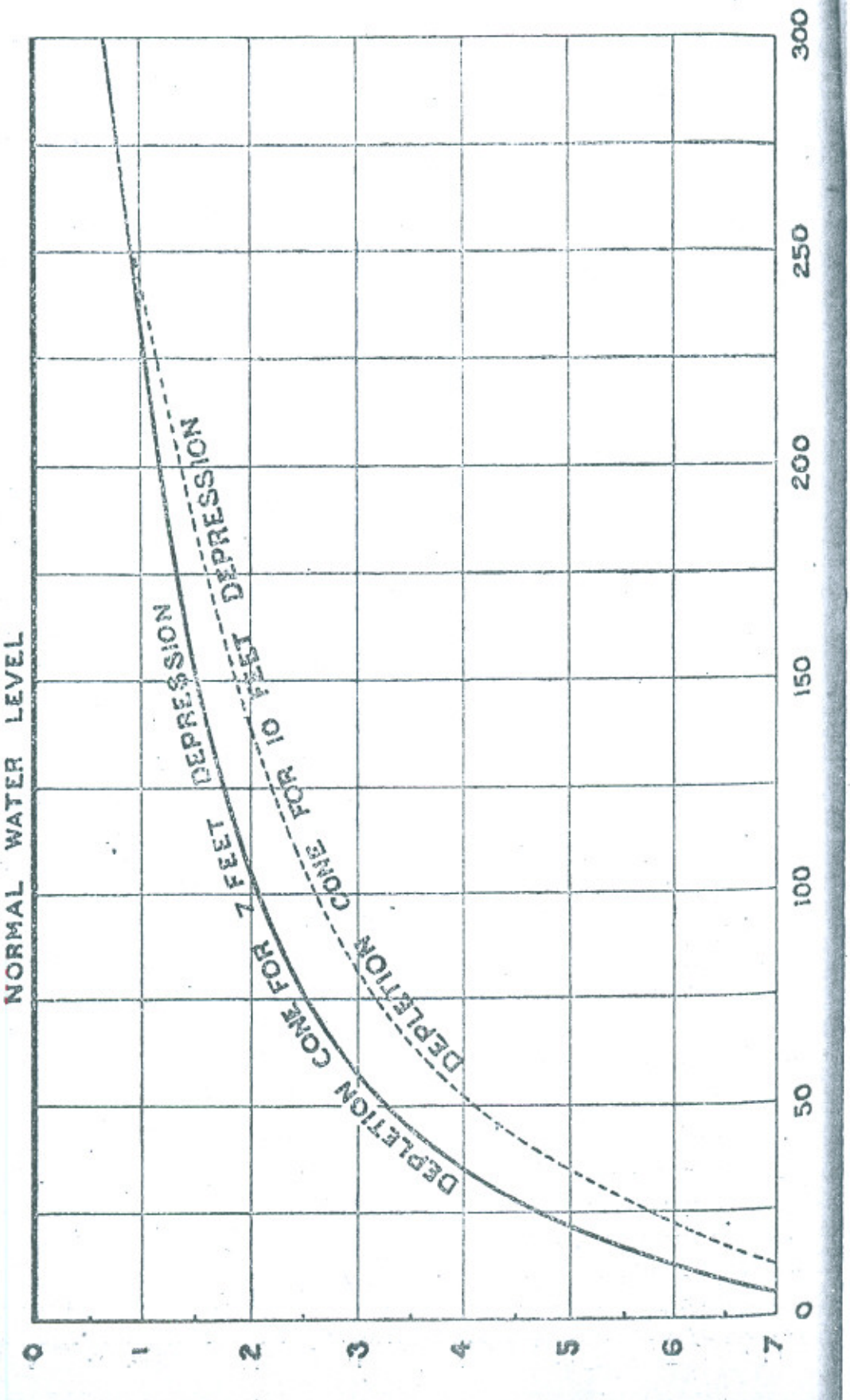


Fig. 7.

superficial area of the soil over which the water is to be withdrawn. In other words, the working of a tube well is identical with the working of an ordinary well, in so far that a gravel stratum at the bottom of the ordinary well will pass a larger supply of water than, say, a fine sandy clay, both being worked under the same head, and further, that in any one stratum, the superficial area has to be doubled if the discharge is to be doubled and the head kept constant. In tube wells, as with ordinary wells, a combination of these two principles affords a very considerable variation in discharge, and thus, by increasing the pressure or head, within limits, a considerable increase in discharge is obtained. When a head has been created by withdrawing water from a tube, the subsoil water surface curves back to approximately its original level, at some considerable distance from the tube well, and on stopping the pumping, the water rises to within a few inches of its original level in a very short time. Fig. 7 shows two curves of water depletion in the same subsoil. It will be observed that in the first hundred feet distance from the tube well the curve is very steep, but beyond that distance it generally flattens out, coming to within nine inches of its original level at a distance of approximately three hundred feet. Even in the case of the greater head, the curve joins the lesser head curve about two hundred and fifty feet from the tube. From three hundred feet to the point where the depletion curve merges into the normal water level is practically infinity. If therefore one foot of depression be neglected (and for all practical purposes this may be done) then tube wells may be placed from five to six hundred feet from one another without any appreciable effect on the water level or power loss.

Unfortunately the writer has been unable to obtain a sufficiently large number of depletion cone levels, but, from observations made, it appears that after constantly working a tube well for some considerable time, the curve of the depletion cone gradually flattens out ; the rate at which this takes place depending on the porosity of the subsoil. Punjab soils show a marked decrease in the water surface curve in periods varying from six months to two years.

It would seem reasonable to suppose that this flattening of the curve will continue until the cone of depletion coincides with the hydraulic gradient for the tube, excepting the slight curvature due to the combined effect of capillary attraction and gravity ; the hydraulic gradient depending of course on the porosity of the subsoil and the velocity of the subsoil water flow. This flattening of the cone of the depletion curve means that there is a gradual

diminution in the discharge from the tube, until the depletion curve assumes its staple gradient, due to the reduction in head in the immediate neighbourhood of the tube ; for although the theoretical head remains constant, the horizontal distance which the water has to travel under this head is gradually increasing, and the friction offered to its passage through the subsoil corresponds to an actual loss of head—an increasing and measurable quantity. This point has to be taken into account in sinking tube wells from which a constant discharge is required.

Large Discharges and Excessive Head.

As stated above, the discharge from a tube well can be increased by increasing the draw down or head, within limits which depend on the porosity of the subsoil. If the critical velocity of the subsoil be exceeded, then a packing of the soil on the outside of the tube results, and the discharge is diminished, but assuming that the critical velocity of the subsoil is not being exceeded, the question arises, what is the economical discharge to take from a tube well in a particular soil ? This resolves itself into a question of the subsoil water level only, and in districts where the subsoil water level is low, it is much more economical to pump large discharges than in districts where the subsoil water is close to the ground surface.

Experiments carried out with convoluted tube wells, discharging up to three cusecs, have shown that with this discharge the critical velocity of the subsoil was just exceeded, while at two and a half cusecs, the percolation velocity was well within the critical velocity. In this subsoil, which was a moderately fine sand, a discharge of two and a half cusecs, was obtained under a depression head of sixteen feet nine inches, while a discharge of one and a quarter cusecs was obtained under a draw down of nine feet. When the critical velocity of the subsoil is not exceeded, the theoretical discharge of a tube varies directly as the head, and therefore a discharge of two and a half cusecs would be expected under a head of eighteen feet ; the fact that the discharge was obtained under a head fifteen inches less than this may be accounted for by slight errors in timing, or may be due to the velocity approaching the critical velocity of the subsoil and causing slight irregularities. The fact that the two and a half cusecs were obtained at a slightly less head than would be expected, supports the statement that when the subsoil water is close to the ground surface it is uneconomical to take large discharges from a tube well, for the following reasons.

Assume that the subsoil water level is ten feet below ground surface, and compare the power required to raise one and a quarter cusecs with the power required to raise two and a half cusecs.

For $1\frac{1}{4}$ cusecs, the total lift is :—

Water level	...	... 10 feet
Draw down	...	... 9 ,,
Friction	...	... 1·5 ,,
Total head		... $20\frac{1}{2}$ feet

For $2\frac{1}{2}$ cusecs, the total lift is :—

Water level	...	... 10 feet
Draw down	...	... 16·75 ,,
Friction	...	... 2 ,,
Total head		... 28·75 feet

The power required on the pump inlet for the smaller discharge is :—

$$\frac{468{\cdot}75 \times 10 \times 20{\cdot}5}{33{,}000} = 3{\cdot}063 \text{ H. P.}$$

while for the two and a half cusecs discharge the power at the pump inlet is :—

$$\frac{937{\cdot}5 \times 10 \times 28{\cdot}75}{33{,}000} = 8{\cdot}167 \text{ H. P.}$$

so that the actual power loss when pumping the larger supply is :—

$$8{\cdot}167 - 2\,(3{\cdot}063) = 2{\cdot}041 \text{ H. P.}$$

and, when average power plant is applied, the loss would be approximately 18 B. H. P. – 13·5 B. H. P. = 4·5 B. H. P. so that in a working day of say twelve hours, 54 break horse power hours are absolutely lost, and therefore a large discharge on a low lift requires careful consideration before a scheme of this nature is embarked upon. In irrigation schemes, in particular, the maintenance charges are a first consideration.

In districts where the water level is some considerable depth below ground surface a large discharge becomes a much better paying investment. For example, assuming the subsoil

water level at fifty feet below the ground surface, then for $1\frac{1}{4}$ cusecs discharge the total lift is as follows :—

Water level	...	50 feet
Draw down	...	9 ,,
Friction	...	2·75 ,,
Total lift	...	61·75 feet

and for $2\frac{1}{2}$ cusecs the total lift is :—

Water level	...	50 feet
Draw down	...	16·75 ,,
Friction	...	3·00 ,,
Total lift	...	69·75 feet

The power required on the pump inlet for the smaller discharge is :—

$$\frac{468{\cdot}75 \times 10 \times 61{\cdot}75}{33{,}000} = 8{\cdot}771 \text{ H. P.}$$

and for the two and a half cusecs discharge the power is :—

$$\frac{937{\cdot}5 \times 10 \times 69{\cdot}75}{33{,}000} = 19{\cdot}815 \text{ H. P.}$$

The power loss in pumping the larger supply being :—

$$19{\cdot}815 - 2\,(8{\cdot}771) = 2{\cdot}273 \text{ H. P.}$$

so that with an average power plant, the loss would be 43 B. H. P. – 38 B. H. P. = 5 B. H. P.

It is thus seen that in the deep lift the loss or waste in pumping amounts to 11·6 per cent., while in the lesser lift, the loss is 25 per cent., and, therefore, it is only in cases of a very deep subsoil water level, where the interest on the initial cost of a single discharge tube well plant is less than the interest on the cost of two smaller plants by the working cost of the lost power, that a large discharge plant can be expected to be a financial success.

The above calculations are based on average conditions in the Punjab, and from subsoil observations elsewhere it may be said that they hold good for India generally. In the United States there are many districts where subsoil conditions are so favourable that discharges up to five cusecs are taken from

depths of fifty and sixty feet on economical lines, but these conditions apparently do not exist, or at least are not general, in India.

Iron in Waters from Tube Wells

In a recent number of the Agricultural Journal, the late Mr. J. H. Barnes, Imperial Chemist to the Government of India, contributed an interesting article on iron in water supplies from tube wells, and gave many valuable analyses of waters from several of the tube wells in the Punjab. These analyses show that the percentage of iron was lower in waters drawn near the hills, than in waters drawn from tube wells situated some hundreds of miles from the hills. In no case was the iron percentage excessively high, but Mr. Barnes considered that, for domestic purposes, water supplies when taken from deep strata should receive treatment for iron elimination.

The installation which is the worst offender from an iron point of view, is the Dera Ghazi Khan water supply, where iron in the ferrous state amounts to 0·825 part per million, and is sufficient to discolour all vessels used to contain water. Many water supplies in Britain, Germany and America contain more iron than is traced in Mr. Barnes' analysis of Indian waters, and some of these receive treatment, while others do not. It is, therefore, a question for consideration whether it is worth while treating waters for this iron, but when one considers that aeration at least can be given at very little initial cost, and practically a nominal maintenance cost, it certainly would be advisable to include an aeration plant in many tube well water supply schemes. The additional head required for this would not necessarily exceed two feet, and as tube well supplies are pumped in any case the matter is easily arranged. A distributor and sprinkler on the Stoddart principle can be simply made up at site, and the whole plant situated under cover of the elevated tank roof, and in all proposed schemes where analysis shows that the iron percentage is sufficiently high to cause discolouration of domestic vessels, an aeration plant ought to be included in the project.

Suction Valves

There are few cases in which a foot valve is not a necessity in tube well pumping schemes, and if the ordinary standard types of mushroom, or hinged flap valve are employed, a considerable amount of expensive masonry or iron work has to be used in the work on account of the large size of these valves.

For example, assume that a tube well has been sunk for a discharge of 1½ cusecs, the plain pipe of the tube well being ten inches in diameter ; for this discharge a convenient size of pump suction pipe would be eight inches diameter. Now an ordinary mushroom valve, in order to have a free waterway area, requires to have the waterway opening *ab* (Fig. 8) equal to the diameter of the suction pipe, plus the area taken up by the web

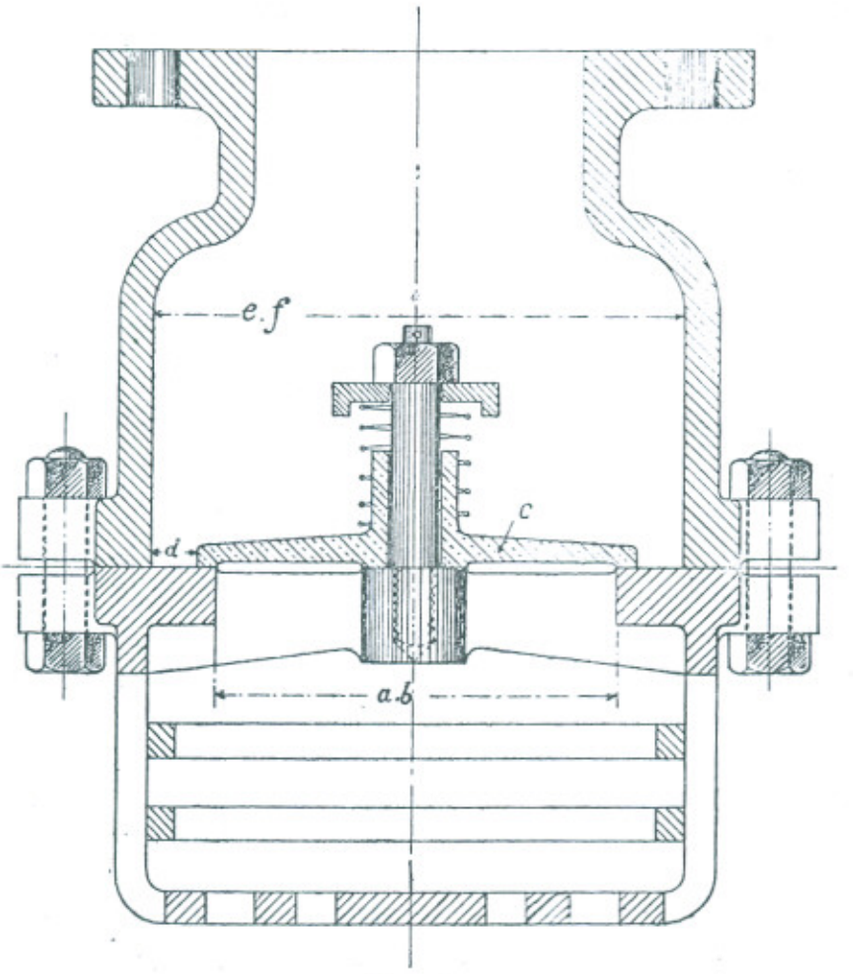


Fig. 8.

which supports the valve spindle. In the case under consideration the diameter would be 8·5 inches, while in order to form a water-tight joint between the valve and its seating, the valve *c*, must overlap the opening to a certain extent, in this case 0·5 inch, making the diameter of the valve 9·5 inches. Further, for the free passage of water past the valve, the annular space *d* requires to have an area equal to the area of the suction pipe, thus making the total internal diameter *ef* of the casting 12·5 inches for an eight inch valve, and to this has to be added the thickness of metal in the casting and bolt ways, making the overall dimensions 15·75 inches. Whatever the size of the valve used,

the proportions are approximately the same, *i.e.*, the overall dimension of the valve is roughly twice the diameter of the suction pipe. Obviously an eight inch valve of this type cannot be inserted in the ten inch pipe of the tube well, and to enlarge this pipe sufficiently to take the valve, or to use a casing pipe large enough to take the valve, renders the work from a financial point of view impracticable.

The practice hitherto has been to fix this ordinary type of valve near or below the natural water level, and to extend the suction pipe below the valve. This entails the use of a chamber sunk low enough to take the valve, and adds considerably to the cost of the work. If the valve be placed any distance above water level, considerable difficulty is experienced in priming the suction pipe, and waste of time in starting the plant results.

New Pattern Foot Valve.

In order to avoid this unnecessary work and to reduce the initial cost in tube well installations, a form of foot valve has

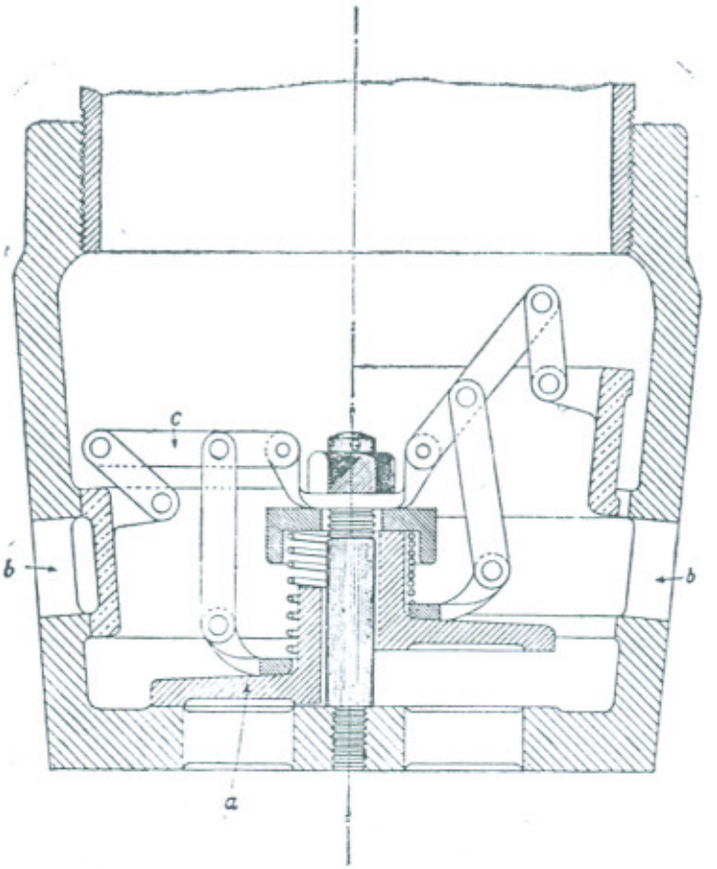


Fig. 9.

recently been manufactured, which, while having the full water-way area of the suction pipe, has an overall dimension less

than two inches in excess of it, and therefore can be used at the bottom of the suction pipe in the manner usual in pumping plants, and can be inserted in the plain pipe of the tube well. Fig. 9 shows the general arrangement of this valve, which, it will be observed, is of the sleeve type, the casting being of conical section, carrying an ordinary mushroom valve *a* of small area on the truncated portion of the cone, while the wall of the cone is perforated with rectangular openings *b*, the area of which, combined with the area of the mushroom valve opening, equals the area of the suction pipe. These openings are covered by an internal sleeve of gunmetal, and this is connected by a loose lever trident *c* to the mushroom valve. The lift of this valve is such, that the annular opening under its edge, when lifted, is equal in area to the waterway area of the valve, and the amount of lift of the sleeve, in order to uncover the openings *b*, is roughly three times the lift of the mushroom valve, while the lever connection between this valve and the sleeve is so proportioned as to maintain the correct ratio of lift. The object of having the sleeve and its seat of a conical section is to ensure a water-tight fit after wear has taken place, the amount of taper provided being sufficient to prevent locking or jambing of the sleeve in its seat.

The action of the valve is as follows:—On the pump being started and the air pressure in the suction pipe reduced, the mushroom or pilot valve is forced up by the external water pressure, and, in lifting, raises the sleeve, thus uncovering the full waterway area required in the valve.

Foot valves of this description cost nearly fifty per cent. more than the standard foot valve, but the additional cost is saved many times over in the reduction in masonry and iron work used in erecting the plant. In districts where the subsoil water level is at such a depth as to render vertical spindle, centrifugal, or reciprocating pumps economical, then drowned pumps may not require foot valves, while a reciprocating pump inlet can be made on the sleeve valve principle.

A further advantage in the use of this valve is due to the greater quantity of the water being drawn through the side of the valve instead of from the bottom mushroom valve. This arrangement allows the air in solution, as it is released from the subsoil and rises rapidly through the water, to continue rising vertically in the water column between the suction pipe, and the plain pipe or sump. When water is drawn into the suction pipe from a horizontal mouth, it carries into the

pipe a larger percentage of air than when the air has a free field of vertical rise to the atmosphere, and water is withdrawn at right angles to that field.

At the meeting of this Congress last year it was asserted that the amount of air pumped with the water depended on the position of the pump; needless to say, this view is entirely erroneous, for if no outlet from the tube well is provided for the escape of the air, it must pass through the pump, whatever its position happens to be.

Tube Wells for the Small Landholder.

During the past six years, the development of tube wells in India for irrigation purposes has been chiefly in the direction of what one might term the large unit type; that is, tube wells capable of irrigating two to three hundred acres and upwards; one reason for this being that the demand has mainly been from proprietors who own large areas of land, and are desirous of having these irrigated as cheaply as possible; but the construction of a tube well irrigation plant, like most constructional works, does not mean that a plant for unit discharge is going to prove twice the cost of a plant for a half unit discharge, although, within the limits already referred to, most plants have been sunk for moderately large discharges. The consequence of this is that, until recently, little has been done for the small landholder, whose area is insufficient for the larger type of tube well, and who is unwilling to co-operate with his neighbours and have a tube well put down for the benefit of several holdings.

The Agricultural Department has put down many hundreds of small borings in ordinary irrigation wells for augmenting the supply in these, and this class of work has proved of considerable value in those districts where an impervious stratum is met with at a reasonable depth below the floor of the existing well, but in the many large tracts of the Punjab where no such impervious stratum exists this class of work could not be carried out.

In order to increase the water supply in wells in these districts, at a reasonable cost, the Department carried out experiments some eighteen months ago with a small size, modified, convoluted, tube well. The results of these experiments were so satisfactory, that during the past year one hundred and sixty-three of these have been sunk, the area irrigated by each tube

averaging ten acres, while the average cost complete has been under Rs 100 a well. For several months of the year, materials could not be obtained for the manufacture of these tubular wells, and considering the current high price of metals it would appear that this class of work has a future before it.