into agricultural practice, it is only fair to the farmer to say that eventually such items always find an honoured place.

Be sure of what you recommend,
That towards advancement it doth tend,
The ryots' lot will thus improve,
And from the groove he'l move! move! move!

A. Carruth.

Borehole yields. *(Continued).*

Methods by which subterranean supplies of water may be made more available :—

The water-bearing strata of the earth's crust may be broadly divided into three classes.—

(1) Hard metamorphic rocks with fissures and cracks in them. (2) Stratified beds of rocks of varying degrees of porosity (3) massive or stratified deposits of sand or gravel. The conditions of yield from the bores sunk into these strata vary with their nature and consequently the methods by means of which the yields may be augmented will differ accordingly.

1. *Supply from fissures aud cracks.* Here there is no question of percolation at all. The flow from the bore depends primarily upon the main source of supply from which water rises into the crack and secondly on the size of the crack. In many cases we have no control on the principal source of supply. As the flow of water through the fissure depends upon the size of the latter, we may increase the flow of water through this fissure by enlarging it and there is only one feasible method for enlarging a tortuous fissure occuring in the body of a rock. The method is known as "torpedoing" and consists in blasting the rock at the

bottom of the borehole. A charge of dynamite is introduced at the bottom of the borehole and exploded. If the rock in the neighbourhood contains faults or fissures, the explosion will widen them and may even cause new fissures, thus opening up new channels of supply into the borehole. This method is not always successful, and should be employed with caution. Sometimes torpedoing may end in adverse results. In the disturbance caused by the explosion, some of the water yielding fissures may get choked up and in consequence the supply from the borehole may be considerably reduced. Torpedoing may be tried freely in dry or almost dry bores as a last resource in getting at underground reservoirs of water and it is to a certain extent hazardous to attempt it in any successful bore.

This method of shattering rock at the bottom of a bore may sometimes be advantageously tried in the case of the strata belonging to the second category mentioned above. The flow from these strata depend to a certain extent on the area of the free surface at which the water flows out from the body of the stratum. This free surface in the case of a borehole under normal conditions is that portion of its internal surface which is intersected by the stratum. If the rock surrounding the bore is disintegrated, then the flow into the bore from the stratum will be accelerated along the lines of the fissures that might have been formed. In the case of a porous stratum there is no danger of choking up any existing fertile fissures by explosion, for water can percolate through any portion of the stratum. Hence torpedoing deserves a trial in the case of bores resting on strata like chalky-beds or laterite formations.

Conduits. When the water-bearing stratum occurs at the ground level or at shallow depths and if it is of considerable thickness, the method of driving conduits into the same is recommended. Such strata overlie beds of impervious strata like clay. The flow from such strata cannot be artesian and depends

only upon the rate of percolation from the surrounding medium which may be either one of composite structure like laterite or one of loose structure like sand. Conduit is a tunnel excavated laterally into the sides of a well, which should be of fairly large dimensions. In dealing with this method we are therefore outside the province of "Boring" proper. But as it forms in some instances an alternative method of securing water in localities where the drilling of a bore hole is impracticable, mention of the method is made here. The conduit simply serves the purpose of increasing the free surface at which water flows out from a stratum. Then the question will arise: if the area of percolation is to be enlarged, why not increase the diameter of the well? In other words, a tank might be excavated. There are two things which militate against this method being adopted. Firstly the cost will be prohibitive and secondly a greater area than might otherwise be utilized will have to be sacrificed. The driving of a tunnel is not an easy matter and in sandy soils the method will have to be modified as the exigencies of the situation suggest or demand. An example may be quoted here where an analogous method was proposed to be adopted for a tentative water-works in one of the District capitals of the Presidency. A river in which freshes occur for a very limited period during the year but which has always a small quantity of spring water flowing in it runs close to the town. The river-bed is composed of a thick-layer of sand which entraps a good deal of water when the river is in freshes. It is this water that is caught in the pores of the sand that gives rise to perennial springs in the river bed. It was proposed to sink a number of deep wells of a medium size 100′ or so apart and to connect the wells with one another by earthenware pipe lines laid at a considerable depth from the bed level. The pumping would be done from one of the wells centrally situated and as the water is pumped up from this well, it would be kept continually replenished by the water that percolates into the whole system of

wells. A deep tank would have answered the same purpose but the construction of a stable tank in a river bed is, for obvious reasons, a matter of impracticability. A ryot of Perumpanniyur in the Tanjore district has been led to the adoption of the same device in a parallel situation by a long series of trials. The village lies in the heart of the Delta. Through dint of perseverence on the part of this ryot and at his initiative, it is said that a borehole was drilled in this place to the great depth of 400′ and it appears that even at that depth the alluvial bed was not completely pierced through. Owing to practical difficulties, the boring was given up. After the lapse of some years, he tried to prospect again for underground water and as luck would have it, the attempt again ended in a mishap to the lining pipes and the borehole was abandoned. The ryot owned a pumping installation with a 6″ pump which baled water from a big well sunk in a tank. Neither the well nor the tank were very deep. The tank was about 6′ deep. The soil and subsoil are made up of sand and contain and readily yield large quantities of water. Seeing that the boring quest ended in a fiasco on two occasions, the ryot proposed to sink more wells closely together in the same tank and connect them together by conduits. By this method he could tap water from a considerable depth which if he were to do by means of an open tank would involve the investment of a large sum of money. In the case of the Ayyangudipallam installation the same method could have perhaps been adopted with profit. This method may however fail in seasons of drought for the in-flow of water into the wells and conduits depends upon the level of the water table which the pervious stratum supports. In the dry season, the level of the water table in such strata gets considerably low and the water table itself may vanish at the higher points of the valley if the stratum has a definite fall in any direction. Again as has already been stated, under a pumping strain, the cone of depression gets very widely extended and in consequence the water level in the

vicinity of the borehole or the well, for we are speaking more of wells than of boreholes now, gets depressed considerably. It is this depression of the water level that necessitates the sinking of deep wells and the extraction of water from as great a depth as possible. Deep wells of a large size are enterprises involving heavy outlay of capital. There is therefore a limit to the depth of the wells dictated by economy and if we want to penetrate the strata to a great depth we must have recourse to boring. It is thus the very common practice of locating boreholes in existing wells has arisen. A case which illustrates this point may again be quoted from the Tanjore District. In Mannargudy which is situated in the lap of a river which almost encircles the town, a borehole was put down in a well for an enlightened and an enterprising ryot some years ago. The depth of the borehole was only 130′ and the result was quite satisfactory. The well ran generally dry in summer though it was 50′ deep. After the sinking of the borehole the supply from the well increased considerably. The example of this ryot was followed by a few other ryots of the place with equally good results. It is quite probable that the river bed is in some way connected with an expansive and pervious stratum situated more than 100′ below ground level. The water table was however low. It is not a 'syncline' ending in an outcrop at some higher level from Mannargudy. If it were so, the water level in the bore would also be high. It is a huge pervious deposit. It contains a good deal of water and the amount of water which it holds does not fluctuate very much with the changes in the quantity of rainfall in any year. This reservoir appears not only to be fed by the local rainfall but by freshes in the river. The only defect with this splendid reservoir of water is that its effective depth is low. In such situations, deep pumping installations are a necessity. But deep pumping means extra costs of installation and extra running charges. Under favourable circumstances this consideration may not deter a ryot from installing a deep pumping plant. If, for example, the quantity of water that could be

pumped up is quadrupled when the cost of pumping as a result of increased lift is doubled, the pumping of water from a greater depth will still remain a business proposition. A good deal of improvement might perhaps be effected in this way in the case of many boreholes which have been declared to be of an unprofitable yield. Whatever may be the nature of the stratum from which the supply is drawn the supply from it will increase as we approach nearer and nearer to it and as the effective depth from which the supply is drawn is increased. The second condition is as important as the first in the case of gravelly and sandy soils. It might be of very little import in the case of hard pervious rocky strata like laterite and limestone. But in all cases the fact that the lower the level of pumping the better the yield holds good. In the United States of America, in river valleys composed of massive layers of gravel and sand, enormous quantities of water are pumped annually from great depth for 'truck' farming. It is stated that the number of boreholes and the quantities of water drawn are so great that water companies have been formed to unite the whole thing into a business organization. It is said that continuous pumping for a number of years has lowered the water table in some of the tracts mentioned considerably and that the diminished output from the boreholes has led to the creation of water laws. Similar organizations are unknown in this country. The great anicut systems are controlled by the Government. There are two well lift irrigation systems in this Presidency which are prominent by their uniqueness viz., the Rashikulya and the Divi pumping projects. There is however scope in this country for lift irrigation systems based on underground supplies being formed in favourable localities. The magnitude of them will however depend upon the available supplies of water and the possibilities of the concentration of a number of them within a manageable area.

When deep pumping has to be resorted to, there are two possible methods by means of which the yields for a borehole may

be made continuous and steady. The method is to construct a deep well, perhaps more than 50′ deep and disconnect the lining pipes of the borehole at the bottom of such a well. The pump will no doubt have to be placed sufficiently low so that the suction lift may not exceed 25′. The second method is to connect the suction of the borehole direct. This method does not appear to have been adopted in this Presidency as yet. There are however situations in which it will prove a par-excellance method for two reasons viz., (1) it will obviate the construction of a very deep well and the concommitant heavy expenditure, (2) with a vaccum of 25′ above the foot valve the inflow into the bore from the surrounding strata will be accelarated. By such direct coupling of the pump with the borehole, the finer particles which generally tend to choke up the borehole will be forced out. There are instances where the supply from a bore was reduced on account of the presence of fine sand around the borehole entrance. In such cases the introduction of large sized sand and gravel into the borehole improved the supply from the borehole. The fine sand from the bore was ejected along with water which was pumped up and the heavier sand and gravel took its place, rendering the percolation of water into the bore easy. The box of long strainers, a devise which does not appear to have been introduced in this Presidency as yet, is attended with distinct advantages in such soils and deserves trial. The theory of the strainer is based on the following argument. The inflow into a borehole depends mostly upon the surface of percolation and very little upon the diameter of the bore. The surface of percolation will greatly increase if one or two lining pipes of the bore which lie at its bottom are perforated. A strainer is simply a perforated pipe. Regarding the relation between the magnitude of inflow into a bore and its diameter, it has been found that the increase in water supply due to an enlargement of the diameter of the borehole is scarcely of any practical importance. Hence the auguary to effectively tap the water from the sandy strata is to draw the

supply through a greater height. Where there is no strainer, all the inflow into the borehole takes place through the bottom opening of the lining pipes. The frictional resistance felt by the inflowing water will therefore necessarily be greater than that in a long open strainer. With the increase in resistance, the flow will decrease. Our endeavour should therefore be to reduce this resistance to the minimum and the strainer is designed to achieve this object. The length of a strainer will depend upon the depth of pervious stratum, the total height of the cone of depression etc. The strainer will be of great use when sunk in river valleys etc., consisting of masses of drift sand. An instance may be quoted here where it could have been of immense benefit. In Nidamangalam there is a pumping installation the source of supply being a 12′ or 10′ diameter well supported by a borehole. The installation is situated on the banks of one of the numerous branches of the Cauvery. The overflow from the bore is very little so much so a 9 H. P. engine with a $2\frac{1}{2}$″ pump drained the well supported by the bore in about half an hour. The owner of the installation was advised to disconnect one of the top pipes by sinking a smaller diameter well in the outer well. But the effect of this proved to be of no practical value. In this case it is quite probable that the principal stratum pierced through by the line of pipes and from which the supply is drawn, is connected with the sand forming the river bed. It may be of considerable thickness. Probably a 20′ strainer coupled direct to the suction of the pump would have improved matters. The use of the strainer is limited to the sandy strata. Hard strata like chalky and laterite beds do not require any lining pipes. The question of strainers does not arise for these hard strata.

If the superincumbent layers of loose soil are not very thick, a well may be sunk till the hard stratum is reached. If they happen to be of considerable thickness lining pipes will have to be introduced to cover these. In almost all cases, except in the case

of powerful artesian bores, the construction of a well serves an important purpose. The pump may be installed low and if possible the engine itself. The suction lift of a pump as has already been stated above, is practically limited to 25' and hence in situations where deep pumping is a desideratum, the pump has to be installed at a fairly great depth from the ground level. We shall deal with 'Methods of Deep Pumping' in the next article.

H. Venkatramaniah.

Milk from cow to consumer on the Government Dairy Farm, Bangalore.

or

The Care and treatment of milk from the time it is drawn off the cow till it reaches the consumer.

Now-a-days we hear much about "clean milk," not only as regards suspended impurities visible to the naked eye but clean from a bacteriological point of view. In every health officer's report we see the wail set up for better quality of milk and also tbe reason for greater infant mortility. To sum up, he sets the defective milk supply as the root cause. It has been clearly shown by eminent bacteriologists beginning with L. Pasteur, that milk forms one of the best sources for the growth of such fell diseases as consumption, enteric, etc. Under such conditions it is no great wonder that the Indian Government should have Dairies of their own, un on modern principles under trained managers, for the production of milk under the best sanitary conditions for the benefit of the Military. In the following few pages I will try to give what I have seen in the Military Dairy Farm at Bangalore as regards the treatment of the milk ere it reaches the consumer.