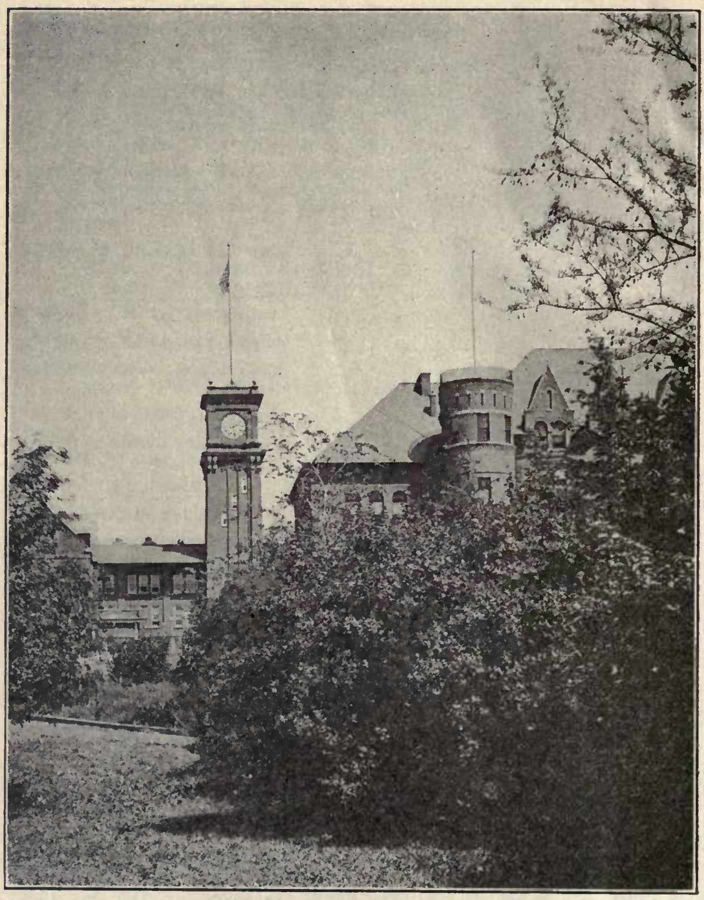


Administration Building and Bryan Hall

MONTHLY BULLETIN

OF THE STATE COLLEGE OF WASHINGTON

PULLMAN, WASHINGTON

VOL. IV JANUARY, 1922 Number 8

Well and Spring Protection

By M. K. SNYDER
Municipal and Sanitary Engineer

ENGINEERING BULLETIN No. 9

Engineering Experiment Station
H. V. CARPENTER, Director

1922

Entered as second-class matter September 5, 1919, at the postoffice at Pullman, Wash., under Act of Aug. 24, 1912

The ENGINEERING EXPERIMENT STATION of the State College of Washington was established on the authority of the act passed by the first Legislature of the State of Washington, March 28th, 1890, which established a "State Agricultural College and School of Science," and instructed its commission **"to further the application of the principles of physical science to industrial pursuits."** The spirit of this act has been followed out for many years by the Engineering Staff, which has carried on experimental investigations and published the results in the form of bulletins. The first adoption of a definite program in Engineering research, with an appropriation for its maintenance, was made by the Board of Regents, June 21 st, 1911. This was followed by later appropriations. In April, 1919, this department was officially designated, Engineering Experiment Station.

The scope of the Engineering Experiment Station covers research in engineering problems of general interest to the citizens of the State of Washington. The work of the station is made available to the public through technical reports, popular bulletins, and public service. The last named includes tests and analyses of coal, tests and analyses of road materials, testing of commercial steam pipe coverings, calibration of electrical instruments, testing of strength of materials, efficiency studies in power plants, testing of hydraulic machinery, testing of small engines and motors, consultation with regard to theory and design of experimental apparatus, preliminary advice to inventors, etc.

Requests for copies of the engineering bulletins and inquiries for information on engineering and industrial problems should be addressed to Director, The Engineering Experiment Station, State College of Washington, Pullman, Washington.

The Control of the Engineering Experiment Station is vested in the Board of Regents of the State College of Washington.

BOARD OF REGENTS

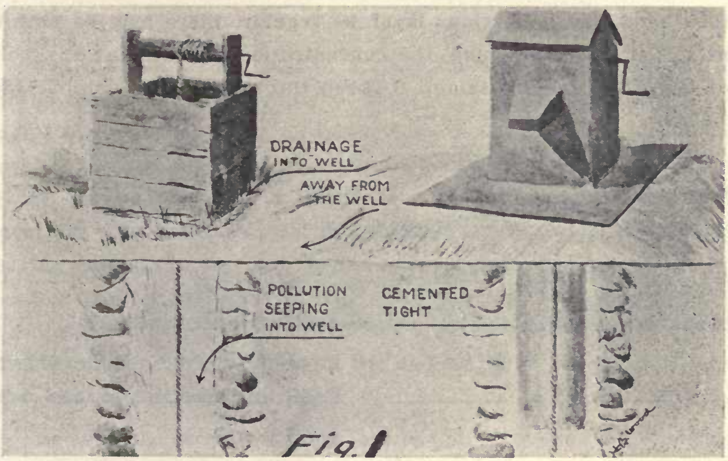
EXPERIMENT STATION STAFF

Director	Dean H. V. Carpenter, B.S., M.S.
Experimental Engineering	Homer J. Dana, B.S., M.S., M.E.
Electrical Applications	Philip S. Biegler, B.S., M.S., E.E.
Electrical Standardizations	Harry F. Lickey, B.S.
Automotive Engineering	Aschel C. Abell, B.S.
Steam Engineering	A. R. Nottingham, M.E.E.
Mechanical Design	E. B. Parker, B.S.
Engineering Materials	G. Everett Thornton, B.S.
Gas Power	William A. Pearl, B.S
Steam Power	Robert L. Rhoads, M.S.
Mining Engineering	Louis O. Howard, A.B., M.E.
Metallurgical Engineering	Chester G. Warfel, M.E.
Economic Geology	Olaf P. Jenkins, A.B., A.M.
Irrigation and Structures	Osmar L. Waller, Ph.B., Ph.M.
Municipal Engineering	Morris K. Snyder, B.S.
Highway Engineering	Howard E. Phelps, B.S., C.E.
Topographical Engineering	Frederic W. Welch, B.S., C.E.
Architectural Engineering	Rudolph Weaver, B.S.
Agricultural Engineering	L. J. Smith, B.S.
Physics	Brenton L. Steele, B.A., M.A.
Physics	Forrest G. Tucker, B.A., M.A.
Chemical Engineering	Clare Chrisman Todd, B.S., Ph.D.

AN AIRPLANE VIEW OF THE CAMPUS AS IT LOOKS TODAY. THIS PICTURE WAS TAKEN FROM THE PLANE OF A FORMER STUDENT OF THE COLLEGE, DAVE MATTHEWS. THE CROSS TO THE RIGHT INDICATES THE SITE OF THE NEW MEN'S DORMITORY. THE ARROW TO THE LEFT POINTS TO COMMUNITY HALL, THE GIRL'S DORMITORY WHICH WAS FINANCED IN A SIMILAR MANNER BY ALUMNI AND FRIENDS OF THE COLLEGE

Introduction

The water supply for practically all rural communities comes from one or more of five sources. These are, (1) wells, (2) springs, (3) rivers and lakes, (4) canals, and (5) rain or snow-water. In general, adequate protection of rivers, lakes and canals is practically impossible because of their great length and the many sources of pollution that may affect them. Rain and snow-water come to earth already laden with impurities from the air. The problem then, in connection with rivers, lakes and canals, and rain and snow-water, is not primarily a problem of protection but of purification.



In the case of wells and springs, due to the filtering and purifying action of the soil, water from such sources is usually pure unless contaminated by some man-made cause, such as privies, cesspools or barn yards. See Fig. 1. For wells and springs, then, the problem is primarily one of protection.

Springs

The term "spring" is properly applied to water emerging from the ground at a single point or within a restricted area, but the distinction between springs and general seepage is not always very sharp. We often hear the expression "springy ground" applied to large areas where there is considerable seepage water coming to the surface. There are all gradations between the concentrated outflow characterizing the true springs and these extended damp areas known as "springy ground."

For the purpose of this bulletin, we will divide springs into three classes:

First Class. This class of springs is that in which the water, is brought to the surface at the out-crop of a porous stratum where it is underlaid by a relatively impervious one. If the surface of the impervious layer be irregular, the flow will collect in the valleys of the impervious layer and large true springs may result. If, on the other hand, the impervious layer be regular, there may be nothing but a long "seepage line," the concentration of water at any point not being more than enough to keep the surface soil damp. (See Fig. 2).

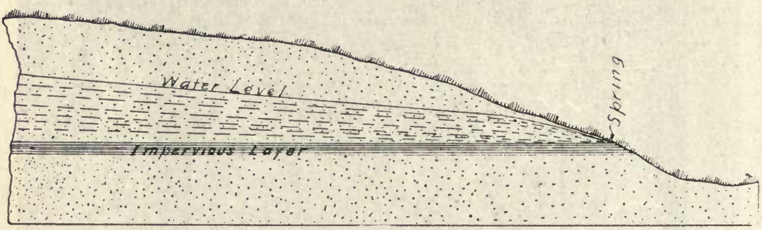


Fig 2
1st Class Spring

Second Class. Under this class are considered those springs where the water-bearing stratum is confined between two more or less impervious ones. These springs are artesian in character. In this class of spring, the water finds it way to the surface at points where the upper impervious layer is not present, or through breaks or cracks in this upper layer. (See Fig. 3).

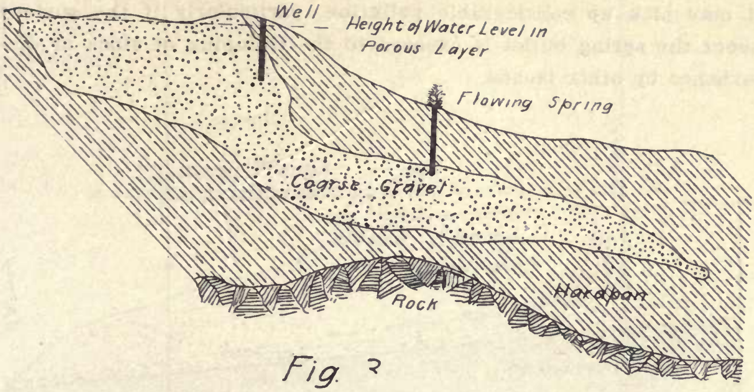


Fig. 3
2nd Class Spring at Avon Mass.

Third Class. This class of springs includes those in which the porous stratum in the vicinity of the spring is neither overlaid nor immediately underlaid by an impervious one. They are mere overflows of the ground water and occur whenever the carrying capacity of the porous material is insufficient to convey the entire flow. Naturally they are somewhat intermittent in character, often disappearing entirely in dry periods and reappearing some time after wet weather has set in. The normal outflow of normal ground waters in valleys along stream lines is of this type, but true springs may develop wherever the conditions of the underlying strata are such as to cause concentration of the flow.

In sparsely settled regions, springs, if protected at their outcrop, usually furnish safe sources of supply. In thickly settled regions, where there may be many houses along the line of the underground flow, and above the outcrop of the spring, we often have springs contaminated by the drainage from privy vaults and cesspools. (See Fig. 4). This is particularly true in limestone regions, for in such regions the underground water flows along openings and cracks in the rock, and is not filtered through the soil at all.

The chief danger comes from pollution or contamination, at and near the immediate outlet of the spring. When the water comes close to the surface, percolating water carrying pollution from the surface may mix with it and also as it comes through the surface soil it may pick up considerable pollution, particularly if the surface about the spring outlet is exposed to the tramping of stock or disturbance by other means.

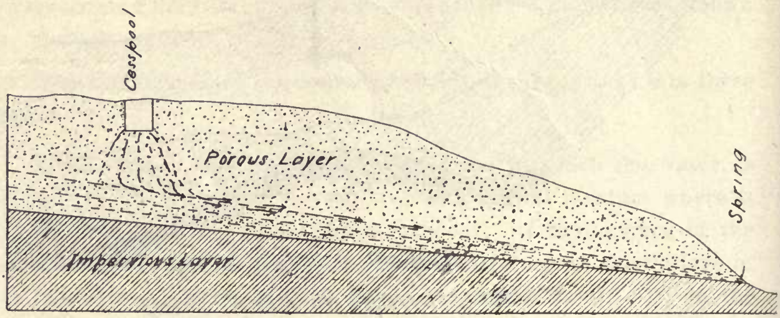


Fig 4
Cesspool Pollution of Springs

Protection of Springs. The first step, then, in insuring a wholesome supply from a spring, is to protect the outlet of the spring. The outlet of the spring should be surrounded by a fence to keep stock and other distrubing and polluting sources from approaching close to the spring. The surface of the ground around the spring should be so formed as to keep all surface drainage from passing into or over the outlet of the spring. The outlet should be further protected by being surrounded with a box, preferably of masonry, extending two or more feet into the ground and covered tightly over the top so as to exclude leaves, dust, vermin of all kinds and larger animals which might enter the spring. (See Fig. 5.)

In many cases where the spring is of the seepage type or where the emergence is not a single point, the spring may be made to yield a much larger amount of water, and at one point, by putting in open joint drain tile in a trench three or four feet deep, dug along and just above the line of outcrop of the seepage, and across the line of flow of the seepage water. In this way the discharge is brought to one point. The water may be brought to the surface through an iron or other pipe, thus preventing the possible pollution of the water at the outlet by surface drainage, or by stock.

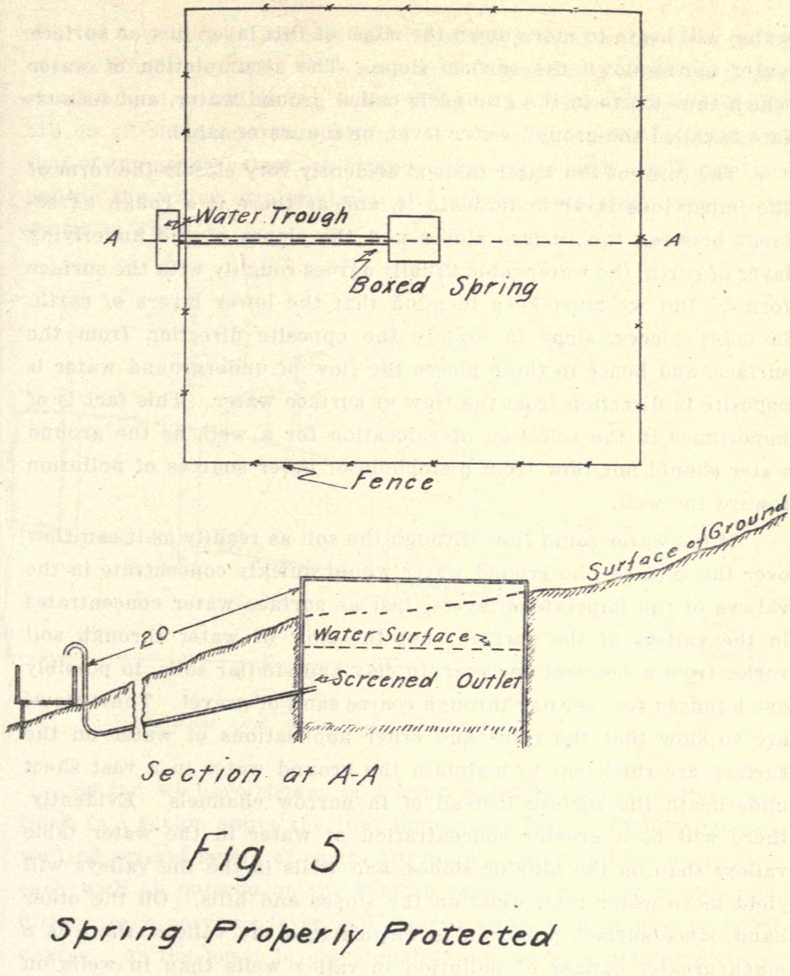


Fig. 5

Spring Properly Protected

Ground Water

Water falling upon the surface of the ground is carried away in three ways; by evaporation, by surface flow and by percolation. The water which percolates into the ground and passes beyond the reach of vegetation, obeying the law of gravitation, passes on down until it reaches a layer of earth which is impervious or until it reaches a layer which is already full of water. When this layer is reached, the water will begin to move down the slope of this layer just as surface water moves down the surface slope. The accumulation of water which thus exists in the ground is called ground water, and its surface is called the ground water level, or the water table.

The form of the water table is evidently very closely the form of the impervious layer underneath it, and as there is a rough agreement between the surface slopes and the slopes of the underlying layer of earth, the water table usually agrees roughly with the surface forms. But we must keep in mind that the lower layers of earth, in many places, slope in exactly the opposite direction from the surface, and hence in these places the flow of underground water is opposite in direction from the flow of surface water. This fact is of importance in the selection of a location for a well, as the ground water should not flow from a slophole or other sources of pollution toward the well.

If the water could flow through the soil as readily as it can flow over the surface, the ground water would quickly concentrate in the valleys of the impervious layers, just as surface water concentrates in the valleys of the surface; but the flow of water through soil varies from a few feet per year, in clay and similar soils, to possibly one hundred feet per day through coarse sand or gravel. These flows are so slow that the rains and other applications of water on the surface are sufficient to maintain the ground water in a vast sheet underneath the surface instead of in narrow channels. Evidently, there will be a greater concentration of water in the water table valleys than on the hills or slopes, and wells in the the valleys will yield more water than wells on the slopes and hills. On the other hand, since surface pollution is washed into the valleys, there is a much greater danger of pollution in valley wells than in wells on slopes or hills.

Since the ground water is supplied by percolation from the surface, anything which increases the surface supply of a region increases the ground water of that region. This is plainly seen in the rise of the water table with the progress of the irrigation season and its fall soon after the close of the season; also in the plentiful supply in wells in wet years and the scant supply in dry years. This same cause operates when water is supplied to the surface in a very restricted area, but in this case instead of the ground water level rising over a whole region it rises only in this restricted area, causing a small mound or hill in the water table. The water flows down this hill on all sides, and thus we find the flow on one side opposite to that of the general flow. A cesspool may cause such a hill and thus pollute the water of a well actually up the main slope from it, as shown in Fig 6.

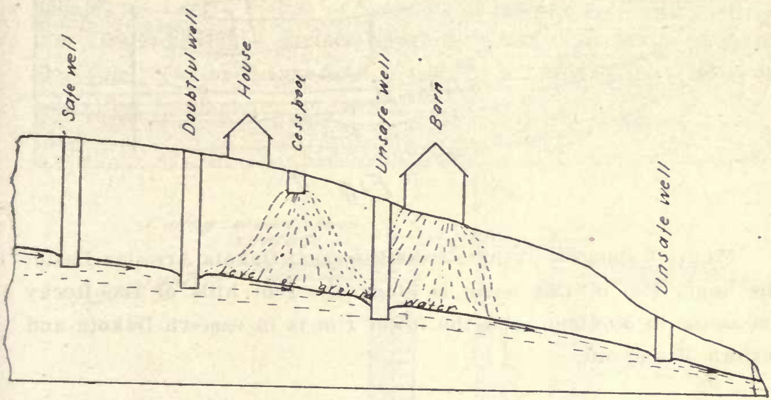


Fig 6
Cesspool and Barn Pollution of Wells

So far, we have spoken of ground water as though it were confined to a region above the first impervious layer. In many places, we find several layers of earth, alternately pervious and impervious, each with an outcrop on the surface somewhere. Under such conditions, each pervious layer will contain water to a greater or lesser degree. As the lower layers probably outcrop at a greater distance away, these layers will be much less liable to pollution than the surface layers, and it is for this reason that deep wells usually yield safer supplies than shallow wells. (See Fig. 7.)

Just as we have surface depressions that fill with water forming lakes, so we have depressions in the impervious strata underneath the surface that must fill with water up to the rim of the impervious strata. If such a depression is found in successive pervious and impervious layers, as described above, the water in the intermediate pervious layers will be under pressure and the water will rise in a well sunk into one of these layers. If the ground surface is below one of the rims of depression, a flowing well will result. Such depressions are called artesian basins.

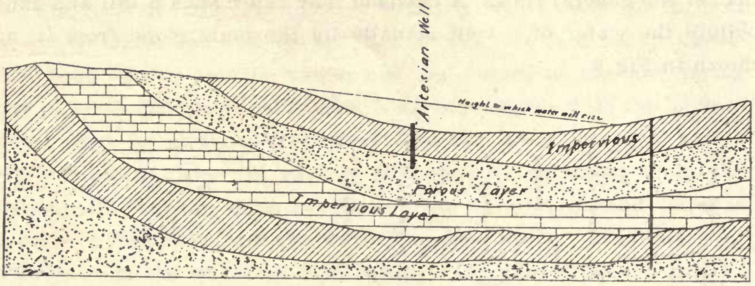
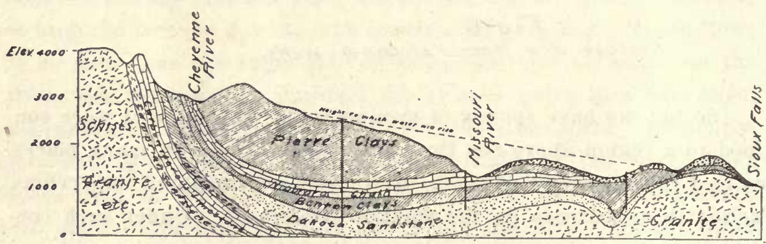


Fig 7

Figure 8 shows a section across the great Dakota Artesian Basin. The upper rim of this basin is along the foot hills of the Rocky Mountains in Montana, and the lower rim is in eastern Dakota and western Minnesota.



Section through Dakota Artesian Area

Fig. 8

Wherever the underlying impervious layer comes close to the surface of the ground, as is often the case in valleys or along their margins, we will find either marshes or damp, springy ground; if the layer actually outcrops, we have a seepage line or some well defined springs. Some springs are of an artesian nature, being formed by natural breaks in the upper impervious layer of an artesian area. (See Fig. 3.)

Wells

Wells are probably the most common source of water supply for the farm and when properly placed and cared for are certainly very convenient and furnish dependable wholesome supplies. Although no two wells are exactly alike in all particulars, there are, in reality, only a few distinct types, and for the purposes of this bulletin we will classify all wells under two heads, (1) open wells and (2) closed wells. We will define open wells as those having a surface opening of twelve inches or more in diameter, and closed wells as those wells having a surface opening of less than twelve inches in diameter. The open type well is usually a dug well from three feet to six feet in diameter. (See Fig. 9.)

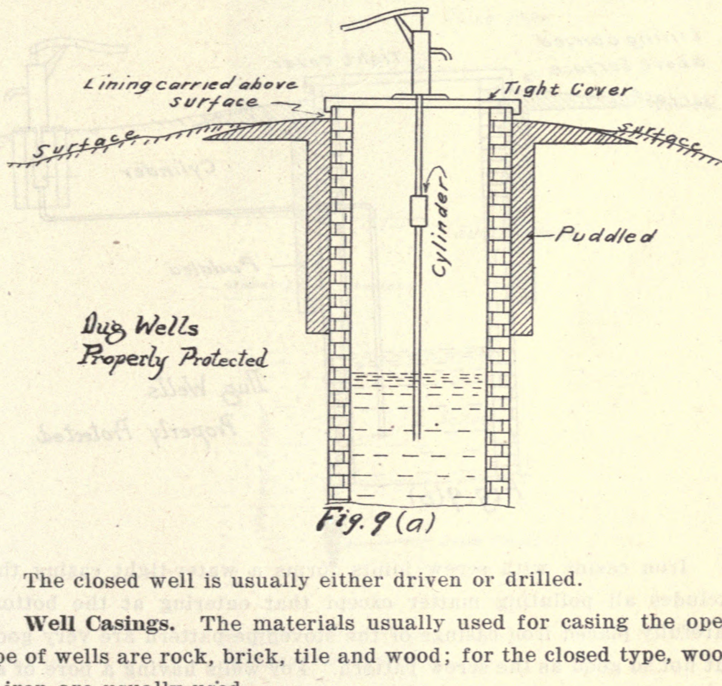


Fig. 9 (a)

The closed well is usually either driven or drilled.

Well Casings. The materials usually used for casing the open type of wells are rock, brick, tile and wood; for the closed type, wood or iron are usually used.

Wood is never a desirable material, although it may be very cheap. Near the surface of the ground it shrinks so that wide cracks are open for the entrance of vermin and polluted surface water, and it soon rots out at the water line. The rotting of the wood favors the development of bacteria.

Rock, brick or tile when laid with uncemented points, offer easy entrance to vermin and polluted surface water. In this respect they are no better than wood, but they will not rot. If laid in cement mortar, they form a tight, durable casing that will exclude all vermin and all pollution, except that entering at the bottom. For open wells of large diameter, rock or brick laid in cement mortar are recommended; for open wells of smaller diameter, glazed tile with cement points are easier to place and just as good as the stone or brick. In all cases, the earth just outside the casing should be puddled so as to close the opening between the casing and excavation. (See Fig 9.)

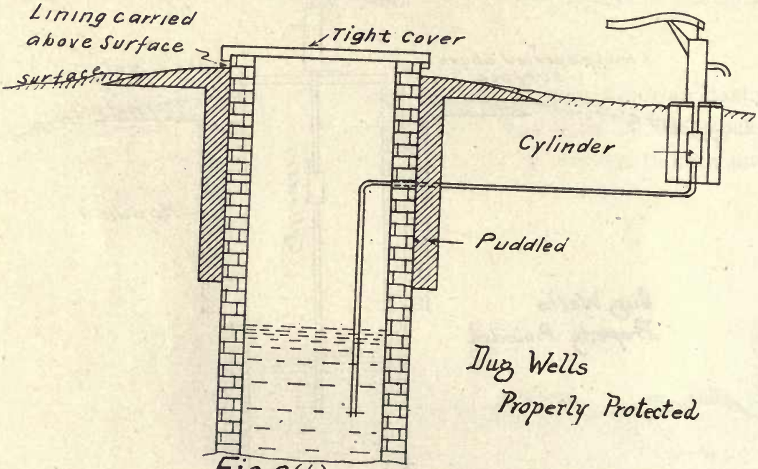
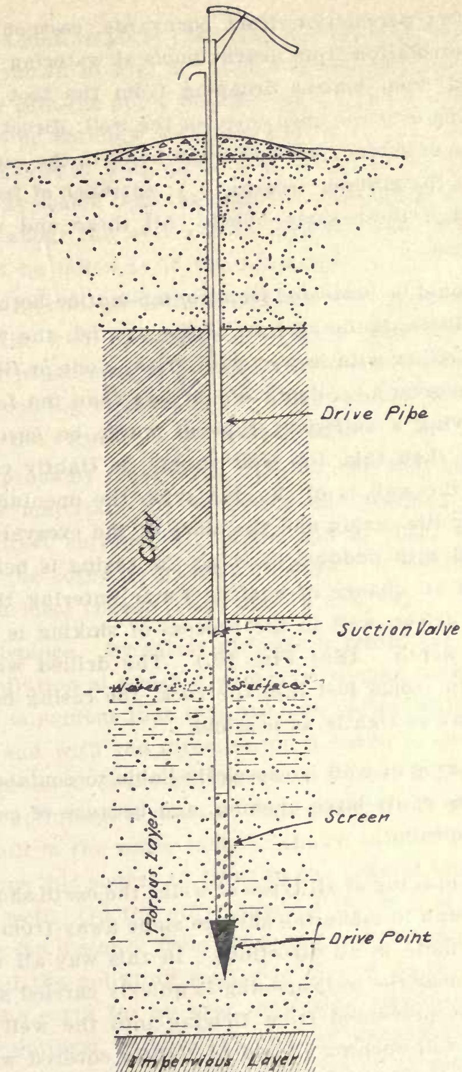


Fig. 9(b)

Iron casing with screw joints forms a water-tight casing that excludes all polluting matter except that entering at the bottom. Carefully placed iron casings of the stovepipe pattern are very good, but not so good as the screw pattern. For wells having a bore of six inches or less, iron is practically the only material used.

Protection of Wells. The safety of a well depends on the purity of the water at its source, and on the protection of the well itself from surface pollution. Polluting matter enters a well in a variety



Driven Well

Fig 10

of ways; direct percolation from barnyards, cesspools, privies and slop holes; percolation from nearby pools at watering troughs, direct contamination from matter dropping from the feet of persons or animals passing over the open cover of the well; direct contamination from entrance of surface wash through holes in the casing at or near the surface of the ground, (see Fig 1.); entrance of frogs, snakes, or rodents through these same holes. All these and more must be guarded against.

Wells should be protected from contamination both above ground and below. Beneath the surface of the ground, the well should be tightly cased, either with iron or with brick, stone or tile, set in Portland cement mortar to a depth of not less than ten feet. Should a water bed giving a sufficient flow of water be encountered at a greater depth than this, the well should be tightly cased down to this bed. If the well is of the dug type, the opening between the brick, stone or tile casing and the sides of the excavation should be carefully filled with puddled earth as the casing is being put in, so as to shut off all chance of surface water entering the well. (See Fig 9.) The driven well in the process of sinking is tightly cased for its entire depth. (See Fig. 10.) The drilled well should be cased tightly for some feet into the rock, the casing being made to fit the rock bore as tightly as possible.

The open type of well is especially liable to contamination from the top, because of its large opening, and because of carelessness in covering this opening.

About the opening of all types of wells, the earth should be banked up high enough to make the surface slope away from the well for twenty feet or more in all directions. In this way all water falling on the ground near the well opening is quickly carried away, and all surface wash is prevented from flowing into the well or near its opening. The well opening should be tightly covered with a watertight cover, having a diameter two or three feet greater than the opening itself. This cover should rest firmly and tightly upon the casing beneath so as to prevent the entrance of rodents or vermin of any kind. In fact, the cover should go down over the casing like the cover to a bucket.

It is a good plan to place the pump in a shallow well to one side of the well as shown in Fig. 9. If this is not done, care should be taken to seal or calk the pump into the cover in such a way as to prevent water passing through the pump opening.

The closed type of well, on account of the small well opening is much more easily sealed than the open type, but the same precautions as to banking about the well and to covering and sealing the well opening should be taken as in the open type.

The whole aim should be to exclude all surface water from direct entrance into the well, to exclude all vermin from the well, and to exclude matter which may be brought near the well opening by stock or by persons coming to the well for water, and to keep this matter removed from the vicinity of the well opening.

Wood is probably most often used for the well cover, but it is not a suitable material. By shrinking and warping, it opens the well to the direct entrance of vermin and of filth, which may be carried on to the cover by persons or stock. A reinforced concrete slab makes an ideal cover. (See Figs. 9 and 10).

Safety Distance. By safety distance is meant the distance from a source of pollution at which a well may be sunk with a fair degree of safety. It is evident that this distance varies with the character of the earth and with the direction of the well from the source of pollution, as referred to the ground water slope. If the well is above the source of pollution, it must be far enough away so that the formation of a hill in the water table as shown in Fig. 6 will not cause the water from this source to flow up the general slope far enough to reach the well. On the other hand, if the well is below the pollution source the distance from source to well will have to be much greater, as all the polluting matter is carried down the slope, contaminating the earth for an ever increasing distance. If the earth is reasonably uniform, without any well defined channels along which the water passes, the safety distance is from 75 to 100 feet above the source of pollution to from 200 to 250 feet below the source. If there are well defined water channels in the earth, no distance below the source of pollution is safe. Should a well that is not subject to continuous pollution become contaminated by the accidental entrance of polluting matter from the surface, probably the best treatment is to introduce into the well a small quantity of chloride of lime, and then pump the well hard so as to remove as much of the contaminated water as possible. The chloride will destroy any harmful bacteria that may be present. Care should then be taken to preclude the possibility of a second pollution. If the well is subject to continuous pollution (Fig. 11) the only sure treatment is to fill it up and dig a well in a safe place or else remove the source of pollution and apply chloride, both to the source and to the well.

ENGINEERING BULLETINS PUBLISHED BY THE STATE COLLEGE OF WASHINGTON ENGINEERING EXPERIMENT STATION.

1. Sewage Disposal for the Country Home.
   Septic tanks and underground distribution systems.
   By O. L. Waller and M. K. Snyder. Mar. 1914, July 1916.

2. How to Measure Water.
   Construction of weirs and tables for same.
   By O. L. Waller. Oct. 1915.

3. Water Supply for the Country Home.
   Water Sources, pumps, filters, storage tanks and cost data.
   By M. K. Snyder.

4. Construction and Maintenance of Earth Roads.
   Grades and grading, drainage and dragging.
   By L. V. Edwards. April 1916.

5. Cost of equipment and operation of same, with tables of efficency.
   By O. L. Waller. Aug. 1916 (out of print).

6. Fuel Economy in Domestic Heating and Cooking.
   Fuel Tables, heating equipment and care of same.
   By B. L. Steele. Dec. 1917.

7. Thawing Frozen Water Pipes Electrically.
   Method of Thawing and list of equipment needed.
   By H. J. Dana. Oct. 1921.

8. The Use of Ropes and Tackle.
   Illustrations of application to diffrent jobs.
   By H. J. Dana and W. A. Pearl. Dec. 1921.

9. Well and Spring Protection.
   By M. K. Snyder. Jan. 1922.

10. Water Purification for the Country Home.
    By M. K. Snyder. Feb. 1922.

11. Farm Water Systems.
    By M. K. Snyder and H. J. Dana. (In preparation).

12. Commercial and Economic Efficiency of Commercial Pipe Coverings.
    By H. J. Dana. (In preparation).