similar porous rocks, usually affords the principal source of supply.

Facility of Entrance.—The facility with which water enters the well depends in part on the rock features enumerated and in part on the nature of the well. In loose materials water accumulates most easily in stone-curbed and similar types of dug wells, and only less so in tightly-curbed dug wells with open bottoms. Where the water bed is a strong one and the materials are sufficiently consolidated to prevent them from entering the well the water will freely enter an iron casing, open at the bottom. In weak water beds in soft materials, and in quicksands, either perforated casings or casings equipped with long screens are necessary to permit the entrance of the required amount of water. In many of the harder rocks the walls will stand without caving, and casings are, therefore, unnecessary, the water entering at any point without hindrance.

Storage Capacity of Wells.—Where strong water beds exist storage is unnecessary, the water entering from the rock as fast as the pumps demand. Where the supply is derived from weaker beds, especially those having only small seeps, storage is a significant factor, and the type and size of the well are of great importance. The volume of tubular wells of equal depth varies with the square of their diameters; hence a 6-inch well will hold nine times as much water as a 2-inch well of the same depth, and a 3-foot well thirty-six times as much as a 6-inch well. Dug wells are, therefore, of advantage in clays and similar materials where the water enters more slowly than it can be lifted by the pumps, for they permit accumulations that may tide over periods in which the amount used is greater than the supply. For the deeper rock waters dug wells are impracticable, and small-bore drilled wells must be used even where the supplies are slight. To get the best results the wells are generally made as large as can be afforded and sunk considerably below the point of entrance of the water to afford the necessary storage.

Depth of the Water.

The depth of the water is a factor of importance in the determination of the type of well to be sunk. A dug well, for instance, is suitable only when the water is within 30 or 40 feet of the surface, although many deeper dug wells exist. A punched well is commonly limited to depths of 50 feet, and a bored well is with difficulty carried to depths greater than 100 feet. Driven wells are most suitable at depths of less than 150 feet, although they are sometimes successfully extended to depths of 250 to 300 feet, or even to 400 or 500 feet or more, where the conditions are favorable. Jet wells are usually sunk only where it is not necessary to go much more than 100 feet from the surface. Wells of the California type are frequently extended to depths of 1,000, and occasionally to depths of 2,000 feet. Hydraulic rotary wells are successful to depths of 1,000 or 2,000 feet in the proper rocks. The percussion or churn drill may be used for all depths down to 5,000 feet, or deeper if special outfits are provided. Diamond drills have been successfully used to depths of 6,000 feet.

Relative Cost of Wells of Different Types.

So many items, such as accessibility to fuel, cost of labor, trade combinations, knowledge of water conditions, relative availability of different outfits, and local practice, enter into the cost of a well that few definite statements can be made. Instances are not uncommon where wells of certain types have been put down for one-tenth the price demanded for wells of the same type in other regions where conditions are essentially similar. In general, however, if only actual outlay of money is considered, the dug well is the cheapest, for it may be constructed by the owner himself at times when he has nothing else to do. Bored and driven wells do not require expensive rigs, and are often cheaper than dug wells when paid labor is employed in their construction. California wells for deep bores in soft materials are moderately cheap where the proper outfits are available, but unfortunately their use is as yet confined mainly to a single region. The jet process is adapted to the sinking of a large number of adjacent wells in soft materials, especially sand, and is occasionally successful for single wells, although in most places driven wells can be put down at less cost. The hydraulic and rotary processes may be cheaper than straight drilling where there are numerous alternations of hard and soft material. Of the processes in use for drilling in rock the standard rig (percussion drill) is the cheapest, the calyx and diamond systems being generally used only when cores of the rocks penetrated are desired. A more detailed comparison of the methods is given in the subjoined table. Although the relative costs indicated are fairly constant over the country as a whole, the cost of any method

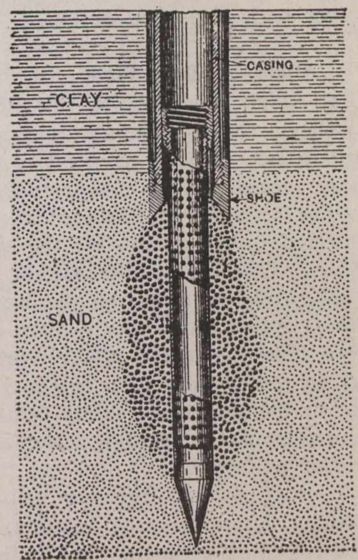

Fig. 2—Diagram Showing Formation of Sand Packing Through Pumping.

in a particular locality may be entirely abnormal, owing to the lack of drilling outfits capable of doing the work or to the existence of peculiar conditions rendering its operation difficult.

Safety of Wells.

The safety of a well depends on the purity of the water at its source and on its protection against the entrance of contaminated waters and polluting solids. The type of well does not affect the purity of the original source; but if the water supply is primarily pure, its maintenance in that condition depends largely in construction that prevents contamination.

Polluting matter finds entrance to wells in a variety of ways. In dug wells it enters through the crevices in the stone, brick, or wood curbing, or possibly through the brick itself; in bored wells it enters through the uncemented joints of the tiling or through cracks between the staves of tubular wooden curbing; and in drilled and driven wells through leaky joints or holes eaten in the iron casing by corrosive waters. By cementing the interior surfaces of stone or brick-curbed wells, by replacing wood by cement or other impervious curbs, and by substituting new pipes for leaky iron casings the entrance of polluting matter through the walls can be prevented. Little or nothing enters the small tubular wells from the top, and they may, therefore, be regarded as free from danger of pollution from this point. The larger open wells should be protected by a water-tight