considerable depths and having several water strata capable of utilization.

Standard Drilled.—Sunk by percussion of heavy drill, 1½ to 12-ins. or more in diameter, lifted and dropped from portable rig or derrick by horse or steam power. Cased with iron pipe in soft materials; usually not cased in rock. Drillings removed by long bucket with valve in bottom. Can be used to advantage in all but the softest materials, but is particularly adapted to rock work, especially at great depths, being cheaper and quicker than other methods of drilling in rock.

Diamond-drill Hole.—Sunk by rotating hollow bit, usually 1¼ to 4-ins. in diameter, with rim fitted with black diamonds. Penetrates by abrasion due to rotation. Drillings removed by water forced down drill and up along outside of rods. Not adapted to water wells because of great cost. Used where cores of materials penetrated are required, or where hole is sunk at an angle with the vertical.

Wood.—Square wooden boxes in wells over 3-ft. in diameter; cylindrical curbs of narrow staves in wells under 3-ft. in diameter. Can be placed in any shallow well, but are never safe and should never be used.

Tiles.—Glazed sewer tile, cement tiles, and porous terra cotta tiles, laid without cement. Adapted to conditions similar to those of rock and brick curb.

Tiles.—Glazed sewer tile and cement tile with cemented joints. Same as cement-lined stone or brick curbs, except that it is more applicable to wells of small diameter.

Heavy Iron Casings.—Iron pipes, 1 to 4-ins. in diameter, with tight joints. Adapted to wells of all depths in which water is obtained from a stratum below the casing, or from strata between cased sections. Not adapted to strongly corrosive waters.

Sheet-iron Casings.—Iron pipes, 4 to 16-ins. in diameter, with snug joints. Adapted to wells of all depths, in loose material, in which it is desired to procure water from a number of strata.

### Summary of Advantages and Disadvantages of Different Types of Well Curbs and Casings.

Rock.—Allows all water to enter, thus utilizing all seeps. Material often costs little or nothing. As a rule requires little money outlay for labor. Polluting matter enters readily and well is never safe if near sources of contamination. Affords no filtration and permits dirt and soil to enter. Permits entrance of mice and other small animals at top.

Brick.—Where uncemented it allows all water to enter, utilizing all seeps. Filters out most of sediment. Does not allow small animals to enter. Involves little money outlay for labor. Polluting matter enters readily, and well is never safe when near sources of contamination. Material costs considerable.

Cement-lined Rock or Brick.—Safe from pollution (except that entering at bottom) as long as walls are not cracked. Prevents entrance of sediments. Prevents entrance of animals. Does not impart taste to water. Utilizes water from bottom only. Is unsafe if so shallow that polluting matter can reach its bottom. Costs considerably more than uncemented wells. May require skilled labor.

Wood.—Cheap in many localities. Can be used in wells of very small diameter. Does not taste of iron. Swells tight in wet ground, the water either entering at bottom or (after sudden rises) through shrunken portion at top. Pollution enters readily. Animals gnaw through. Wood rots, giving taste to water and favoring development of bacteria. Expensive in some localities.

Glazed and Cemented Tiles with Uncemented Joints.—Allows all water to enter, utilizing all seeps. Does not give taste to water. Does not require skilled labor. Polluting matter enters readily, and well is never safe if near source of contamination. Soil may wash in through joints. Requires some outlay for material.

Glazed and Cement Tiles with Cemented Joints.—Safe from pollution (except that entering at bottom) as long as joints are tight. Does not require expensive labor. Can be used only in soft materials containing considerable water.

Iron Casings.—Adapted both to rock and to unconsolidated materials. Safe from pollution except that entering at bottom. The cost in large, deep wells is considerable. Practically limited to wells under 14 ins. in diameter. Is subject to deterioration by corrosion and incrustation in some places. Utilizes but one water stratum (except where perforated).

### Yield of Wells of Various Types.

If an adequate supply of ground water is available, the yield of a well will depend on the character of the water-bearing material, the facility of entrance of water, the size or storage capacity of the well, and the nature of the pumps.

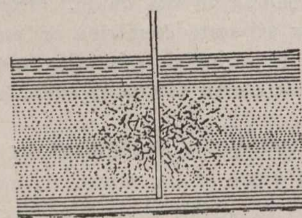

**Fig. 1—Diagram Showing Loosening Effect of Shooting Wells.**

**Character of the Material.**—The character of the water-bearing material is of the greatest importance in determining the yield of a well, as it is on the structure and texture of the water-bearing beds that the amount of water which they will give up depends. A close-textured clay, for instance, may hold as high as 45 per cent. and a chalk as high as 53 per cent. of its volume, while an open-textured sand may hold as little as 26 per cent. of its volume. Notwithstanding this a sand will ordinarily yield large supplies, whereas a chalk, and especially a clay, will yield little or no water. In quicksands water is usually present in large amounts, but owing to the absence of good foundations for the curbing and the ready flow of the fine sand through the minutest crevices, ordinary dug wells in such material are generally out of the question, and even driven wells equipped with the ordinary strainers usually soon become clogged. Driven or drilled wells equipped with special screens and sunk by experts familiar with the various methods of handling quicksand are usually the only types entirely successful in such material.

Structures, such as solution passages, bedding planes, or joints, play an important part in determining the yield of a well. A solution passage in limestone may afford inexhaustible supplies where the mass of the rock is practically destitute of water. In other rocks the bedding planes and joints may afford excellent supplies where no water is found in the rock itself. The amount of water present in the pores of different rocks is indicated by the following average porosities: Sandstones, 15 per cent.; shales, 4 per cent.; limestones, 5 per cent.; crystalline rocks, 2 per cent. The water present in the larger openings mentioned, though small in amount in comparison to that held in the pores, is yielded much more rapidly, and, except in sandstones and