

nent homes. The crude windmill has then given way to the shop-made mill, Pl. XLIII, with its neater appearance and greater efficiency. The contrasting conditions have been illustrated on Pls. I, II, and III.

The accompanying figure (87) shows two of these mills placed on opposite sides of a small earth reservoir, into which water is being pumped

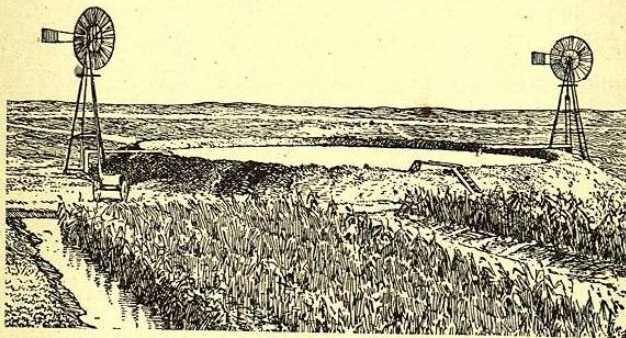


FIG. 87. — Windmill pumping into earth reservoir.

for irrigation. Sometimes as many as half a dozen mills are placed around a tank of this kind, a number of small mills being found better than one or two large ones. When the diameter of the wheel is increased much above 10 or 12 feet, the strength is considerably diminished and liability to injury during storm is greatly increased. Small, rapid-running mills, 8 to 12 feet in diameter, have, therefore, been found most economical. If one is injured, the others will usually continue pumping.

The disadvantage of windmills, as a class, is that most of them are constructed to operate only in moderate winds. The very lightest breezes often pass by without starting the wheel in motion. As the strength of the wind increases, the wheel begins to revolve, reaching greater and greater efficiency until the velocity is about 8 or 10 miles an hour. At greater speeds the mills are usually so constructed that they begin to turn out of the wind in order to protect themselves, and thus the efficiency begins to drop off rapidly as the wind becomes more and more powerful. When it approaches a gale the mill stops completely, and thus, at the time when with sufficiently strong construction the greatest amount of water could be pumped, the machine is standing idle.

One of the important inventions yet to be made is a simple, strong windmill which will continue in operation throughout a heavy wind. Many mechanics have tried their hand at something of this kind, but have not yet succeeded in producing a commercial article. The suggestion has been made that pumping by wind may reach its highest efficiency through the use of compressed air, the windmill operating some form of simple air compressor, from which a pipe will lead down into a well, and through it water be forced out by means of what is known as an air lift. If such a device is practicable the windmills can be located on the highest point of the farm, and the com-

pressed air be carried down to the lower-lying wells.

PUMPING BY STEAM AND GASOLENE.

Where the conditions are favorable, water is raised for irrigation by ordinary steam pumps or by machinery actuated by gas, gasoline, or hot-air engines. In the vicinity of cities and towns having waterworks, lawns and small gardens are thus irrigated by hydrant water, the area of each being small, but the aggregate amounting to many thousand acres.

Steam pumps have been installed for irrigation by some market gardeners and by farmers who have engines for threshing and other farm uses. Various forms of centrifugal pumps are generally employed, these being connected by means of a belt to the ordinary engines. Water is thus raised usually not to exceed 20 feet in height.

Gasoline engines are being largely employed where coal and wood for fuel are expensive, and where the depth to water is not very great, say from 15 to 30 feet. The forms of machinery are very diverse, and there are on the market a considerable number of engines, pumps, and mechanical devices, many of which have been successfully used, while others are still in experimental stages.

The cost of pumping water by engines driven by steam, or by similar machinery, differs with the cost of fuel, the amount of labor involved, and the



WINDMILL PUMPING INTO SOD-LINED RESERVOIR.

depreciation of the plant. It is, as a rule, considerably higher than the amount yearly paid for the maintenance of canals and ditches in the arid region, or the amount paid annually to a canal company for delivering water. It is rarely below \$2 per acre irrigated, and, from this as a minimum, may rise to \$5 or even \$10 an acre. This method of obtaining water will not be profitably employed for general crops, except those, such as rice, where the conditions are such that the industry is impossible without resorting to this means of obtaining water.

In humid and subhumid regions pumping plants are at present more widely used than canals taking water from rivers, because they can be erected by an individual upon his own land without any complications as regards riparian rights or control of the waters. Being compact and under cover, the machinery can be kept from deterioration and in readiness for use in times of emergency, supplementing the deficient rainfall. Where windmills have been utilized and it has been found by experience that the wind is unreliable, the irrigators frequently resort to gasoline engines to keep the pumps running during calm days.