CHAPTER VIII.

PUMPING WATER.

It has previously been stated that the greater portion of water used in irrigation is diverted by gravity from flowing streams. While this is true as regards bulk of water, as regards value it may be said that some of the most important sources of supply are utilized through pumping. In ancient times, especially in Egypt and India, where labor had little value and the conditions for divert-

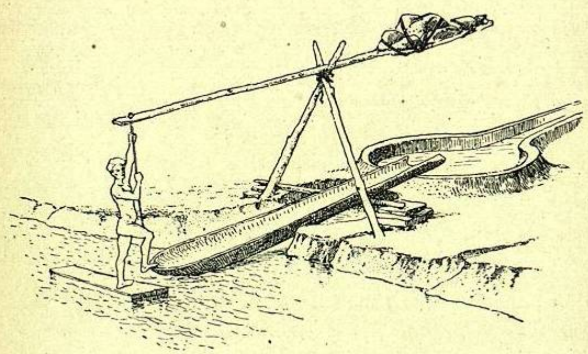


FIG. 81. — The doon, or tilting trough.

ing water by gravity were not favorable, pumping by hand or by animal power was largely practised.

The accompanying illustration shows a crude device, a tilting trough known as a doon. This is pivoted near its centre, and is counterbalanced by rock in such way that one end of the doon can be pressed into the water, the weight of the rock then lifting this end, elevating it sufficiently to throw the water into a ditch.

PUMPING BY HAND OR ANIMAL POWER.

Another view (Fig. 82) is of a series of well-sweeps, or shadoofs, as still used in Egypt, this

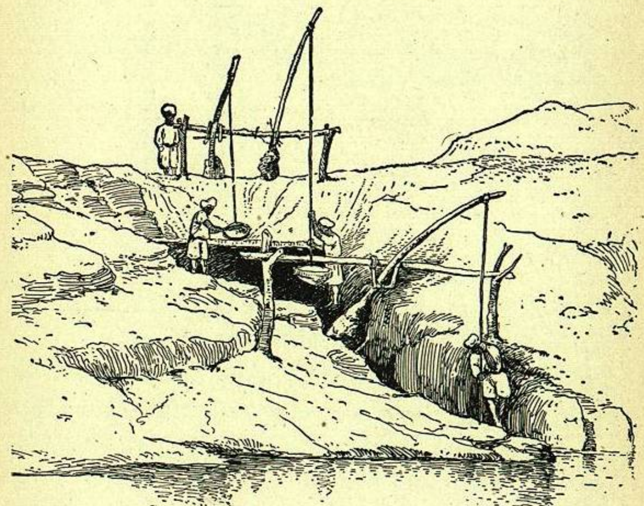


FIG. 82. — Series of shadoofs as used in Egypt.

device being also employed in modified forms in many countries. By means of it water is raised from 5 to 10 feet or more. As shown in the view, a series of shadoofs are arranged, to avoid greater lifts, the water being raised first to one level and then to the next, and so on until the top of the bank is reached. With these well-sweeps the workman uses his weight to depress the bucket into the water, whence it is lifted largely by the counterweight, the bucket being swung over and emptied when it reaches the proper level.

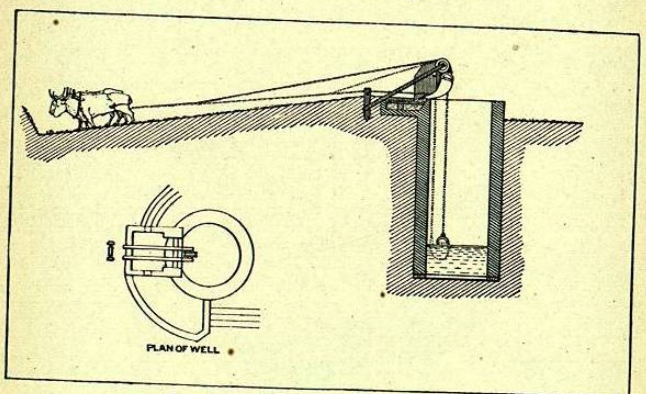


FIG. 83.—A mot, operated by oxen.

Animal power is used in many forms, either in directly pulling up a bucket or skin full of water, as shown in Fig. 83, or in operating some form of pump. The device shown is known as a mot, and consists of a rope passing over a pulley and down into a well, to the lower end there being attached a receptacle for the water. The animals, walking away from the well, usually down an incline, draw

the bucket to the top, where it is emptied. The animals then walk backward to the well and repeat the operation.

In modern times these devices have been improved upon, although some of them are still utilized in crude form by pioneers in the arid region. The well-sweep has in general been replaced by the windlass, which raises water in a

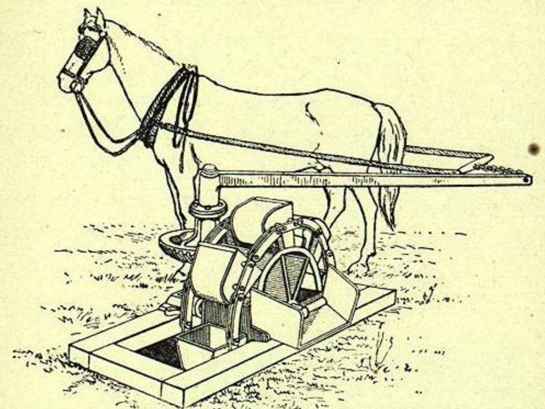


FIG. 84.—Horse-power for lifting water.

bucket, as shown in Fig. 75. With ordinary farm wells of this kind irrigation is impracticable, other than the watering of a few trees or plats of vegetables; but the beginnings of irrigation on many a farm in the subhumid region may be traced to successful experiments with water raised in this laborious manner.

The next step in pumping water under pioneer conditions has frequently been the utilization of horse-power. The accompanying figure (84) shows a simple device, by which a horse walking in a circle causes a series of buckets to be lifted from the well, drawing up water sufficient for several acres. The possibility of irrigation in this way is limited largely by the depth to water and the number of animals available.

USE OF WATER-WHEELS.

The force of flowing water has been frequently employed to bring water up to the level of the irrigable land. The bucket wheel has been utilized from the earliest historical times to the pres-

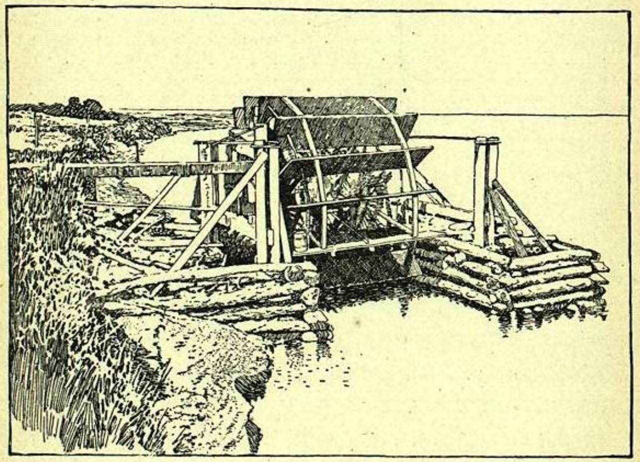


FIG. 85.—Current wheel lifting water.

ent. This consists of a paddle-wheel with a series of buckets arranged around the rim in such form that when the wheel revolves by the force of the current, the buckets are filled, raised to the top, and emptied into a trough, which conducts the water into the irrigating ditches. Wheels of this kind are to be seen along most of the swift-flowing rivers of the West, as shown in Pl. XLI, some of them being as much as 30 feet in diameter.

Where there is sufficient fall in a stream to develop water-power, this can be used by means of various standard forms of water-wheels, such as the turbine, these in turn operating pumping engines. Such devices are employed occasionally to obviate the necessity of building expensive lines of canal, the power of a stream being used to pump the water to the top of a high bank, which otherwise could be surmounted only by many miles of canal, with costly flumes and tunnels.

With small amounts of water descending precipitously and giving a head of several hundred feet, various forms of impulse water-wheel, as shown by Fig. 86, have been employed. This device develops great power for a small amount of water, and can be used to actuate various forms of pump to bring water, either from underground or from surface sources, up to the land which it is desired to moisten.

The increase of irrigated areas in many parts of the United States is being brought about by the facilities for pumping afforded by the development of water-powers and the transmission of the energy by electrical means. The regulation of the stream by storage reservoirs for the purpose of supplying water to the fields frequently creates conditions favorable for producing power for operating water-

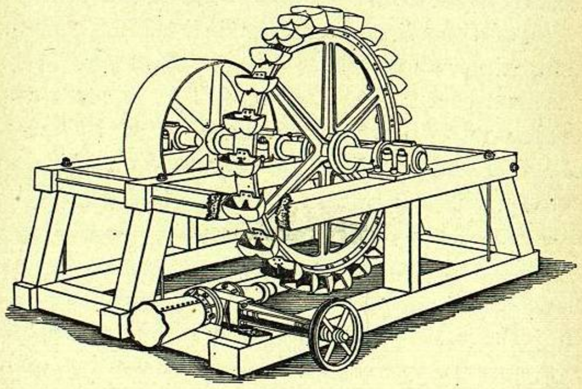
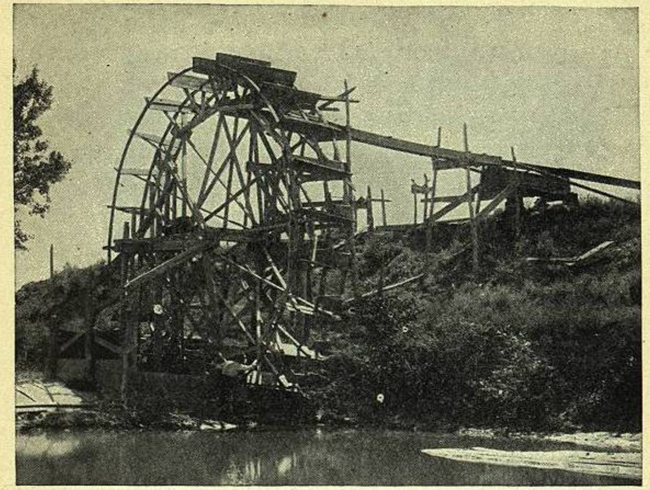
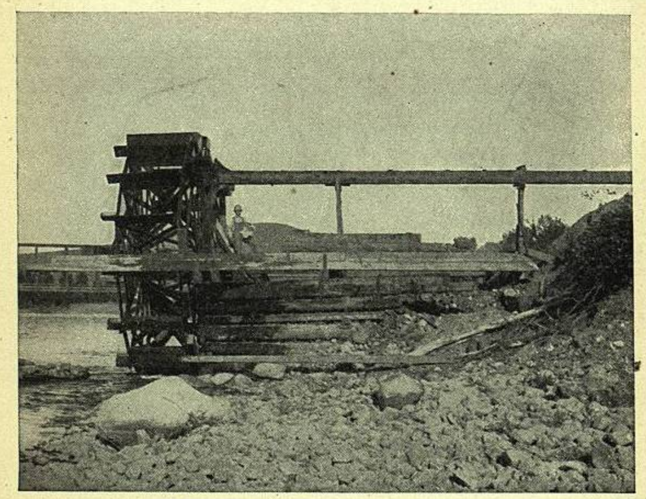


FIG. 86.—Impulse water-wheel.

wheels of one kind or another. These points are, however, usually remote from centres of population and possible markets for the power, and the works built here would be valueless were it not for electrical transmission. There is an awakening of agricultural and industrial activity following each improvement in electrical transmission.

Up to about 1890 there was a rapid decrease in the relative importance of water-powers in the United States; but this has been checked by the





CURRENT WHEELS LIFTING WATER.

practical application of methods of conveying the power by wire, some of these being on a large scale. In this respect the West has led in certain features, largely because of the great expense of fuel there and the fact that development has not been hampered by vested rights to the use of the rivers. Throughout the East, in New England especially, water-powers have been utilized to a notable extent, and the vested rights which have resulted have served to retard changes or improvements. The costly structures and machinery already erected have not been adaptable to new requirements, and often it has been found cheaper to abandon important powers rather than incur the expense of extinguishing various claims and remodelling existing factories.

The advantages of water-power over other sources of energy are, however, so decided that it is apparent that, with improved methods of operation, important falls or rapids will soon be utilized. As a rule it is cheaper than steam-power, for the water costs nothing and the expense of maintenance of hydraulic machinery and of superintendence is small. The annual cost of power consists almost entirely of interest charges on the original investment.

In the United States there are many large rivers and innumerable small creeks descending with rapid fall from the mountains in regions where fuel is expensive. There water-power must always have great importance in industrial development. By combining the power transmitted from a number of small streams distributed over one or more counties, it is possible to bring together at the seaboard or at centres of population an amount of power comparable to that had from some of the great rivers.

In past decades water-power has been employed only in the immediate neighborhood of a natural fall; and where distributed to different manufacturing establishments, this has been rendered possible by dividing the water and allowing it to flow to the various water-wheels located in the factory buildings. This has necessitated the crowding of the buildings together, or a large expenditure for conveying the water to a considerable distance. In New England the permanent works for procuring and dividing this water have been among the most expensive in the world, and corporations have been formed for the purpose of controlling a large river and furnishing the water to manufacturing establishments, instead of generating power and then selling it.

An example of this system of dividing water is on the Merrimac River at Lowell and Lawrence, Massachusetts. At the latter place the Essex Company has built an expensive masonry dam, giving a fall of 28 feet and obtaining 10,000 horse-power during working hours. This dam is 900 feet long and 32 feet in height, the cost being estimated as $250,000. From each end of this canals extend down-stream and mills are located along these canals between them and the river. The canal on the north side is a trifle over a mile in length and 100 feet in width at the upper end, and cost approximately the same amount as the dam. The canal on the south side is about 2000 feet long and 60 feet wide, and cost about $150,000. Water is leased or sold to the mills at a certain fixed rate, the Essex Company maintaining the dam and canals and delivering the water at the penstocks of the mills, from which it flows through the wheels and is discharged back into the river. The condition here is typical of that at many other points in New England, and illustrates the form of development where water is distributed to many manufacturing establishments.

In marked contrast to the above conditions are those growing out of the ability to divide the power and transmit it electrically to places distant 100 miles or more. Here it is no longer necessary to crowd the manufacturing establishments together, but they may be scattered widely over the country, at points where material and labor can be had to best advantage. The power of the falling water can be transformed into electrical energy in a single establishment, from which wires radiate in all directions; or if the water-power is diffused in a number of small streams, each of little importance alone, several plants can be erected and the power concentrated by lines leading to one large factory. This facility for transmitting power has revolutionized many industries, and attention is now given to small water-powers which in times past have been neglected or abandoned as useless.

A third step in progress is made where many sources of power are brought together into one system, and this branches out to localities where power is needed. Each water-power becomes a feeder to a main trunk line, and this line divides to numerous establishments. Such is the condition in Southern California, where a number of generating stations have been erected in various canyons, and the electric wires, converging toward Los Angeles, make possible numerous industries in the vicinity of the city and drive many small irrigating pumps. The arrangement is carried to an extent such that a manufacturing establishment, like a cement mill, may take power during the daytime, when it is in least demand for light, and later return an equivalent by turning in the energy developed by its steam engines.

All of these economies resulting from the utilization of forces otherwise lost have interest in a consideration of the extent to which the arid lands can be redeemed by irrigation, as they are part of the general system of turning to beneficial use the resources now going to waste. Cheap power means ability to pump water, and water supply in turn makes possible an extension of

irrigation, and this is the principal step toward more homes and a settled population.

WINDMILLS.

The most important and widely distributed source of power for pumping water is wind. Over the broad valleys and plains of the arid region the wind blows without ceasing for days and weeks, carrying away the dry leaves, and even at times sweeping up the loose soil. In many localities there are, at depths of 20 to 50 feet or more beneath the surface, pervious beds of sand or gravel filled with waters by the infiltration of rainfall or by percolation from stream channels.

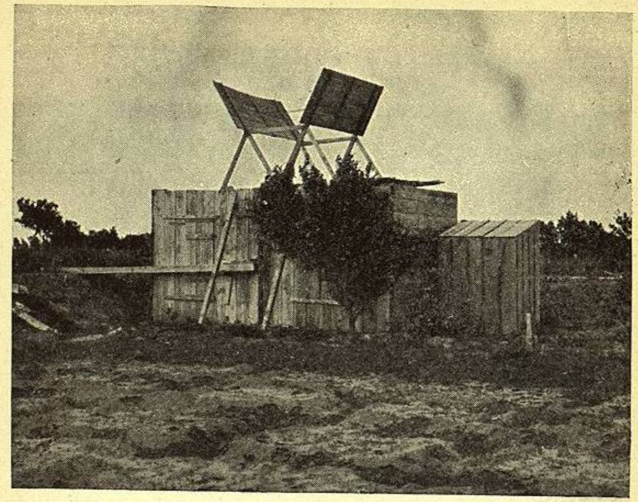
It is a comparatively simple and inexpensive operation to sink a well into this water and erect a windmill, attaching this to a suitable pump. The machinery, once provided, is operated day and night by the ever present wind, bringing to the surface a small but continuous supply of water. This small stream, if turned out on the soil, would flow a short distance and then disappear into the thirsty ground, so that irrigation directly from a windmill is usually impracticable.

To overcome this difficulty it has been found necessary to provide small storage reservoirs or tanks, built of earth, wood, or iron, to hold the water until it has accumulated to a volume sufficient to permit a stream of considerable size being taken out for irrigation. Such a stream flowing rapidly over the surface will extend to a distance and cover an area which would seem impossible with the small flow delivered by the pump.

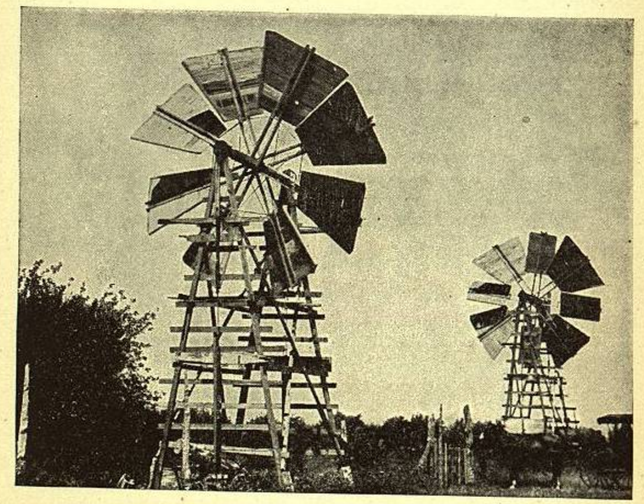
The windmills employed in irrigation are of all kinds, from the highest type of the machinist's art down to the crude home-made devices. The latter are not to be despised, as many of them are highly effective, and at least they have enabled settlers to procure a small amount of water and to obtain a foothold upon the soil, by which ultimately they may be able to obtain funds to procure better implements.

The accompanying Pl. XLII shows a number of these home-made devices, some of them being in the form of turbine wheels, and others, known as the "Jumbo," consisting of horizontal paddle-wheels so arranged that the wind sweeping over the top of the structure strikes the exposed sails and causes the wheel to revolve. On each end of the axis of this wheel are attached the pump rods, which move up and down as the wheel revolves.

Such home-made mills are, of course, of low efficiency as regards the proportion of power utilized. But since the force of the wind is practically limitless, the mechanical efficiency of the device is of little consequence, provided it does the work required. The material for these mills costs from $5 to $20. They are easily repaired and will serve for many years. Such machines are, of course, not comparable, as far as workman-



A. JUMBO TYPE OF HOME-MADE WINDMILLS.



B. BATTLE-AXE TYPE OF HOME-MADE WINDMILLS.

ship is concerned, with those made by manufacturers of implements; but the cheapness of the device has enabled many a settler, discouraged in the attempt to farm without irrigation, to obtain a water supply and successfully raise a vegetable garden sufficient to support his family, and also to put up a small amount of forage for his cattle.

In building these mills pieces of old mowing machines or reapers have been used for axles, bearings, and connections. The sails have been made of pieces of dry-goods boxes and old lumber around the farm, and the whole machinery stiffened and held in place by bale wire or other waste material found in quantities around the houses of men who have attempted to make a living upon the plains. Thousands of settlers have pushed westward from the humid into the subhumid portions bordering the arid region, and in years of abundant rainfall have been able to raise one or two crops. With the changing cycles of moisture, these regions becoming dry, the pioneers have lost their crops year after year, and have been compelled by starvation either to leave the country or to change their methods of farming. Under these circumstances, discouraged, without capital, some of the more ingenious and persistent settlers have been able to dig wells, build windmills, and irrigate a small patch of ground, and, gradually adapting their methods to the climate, have improved upon their conditions and made comfortable and perma-