UNIVERSITY OF ARIZONA AGRICULTURAL EXPERIMENT STATION

TIMELY HINTS FOR FARMERS

No. 95

June 12, 1912

WINDMILLS FOR IRRIGATION PUMPING

(Revised April 5, 1916)

Windmills in Arizona are one of the commonest features of the landscape, and one of the most pleasing. In some sections of the State every homestead requires a windmill to complete its equipment, and to the cattlemen windmills are indispensable. It is often asked to what extent they can be used for irrigation pumping. Is the possible acreage large enough to justify the expenditure? And are the uncertain winds sufficiently reliable to mature the crops? As in other matters of like nature the answers depend upon the attendant conditions. Occasionally windmill irrigators have been disappointed in their efforts and thousands of dollars worth of crops, sometimes nearly ready for the market, have withered and died because the winds did not blow at the right time. Yet in some parts of the State a large amount of produce, particularly garden stuff, is irrigated successfully with the aid of windmills, and it is believed that a fairly good brief can be written in the windmill's defense.

THE POWER OF THE WIND

The commonly used measure of the wind is the number of miles that it travels, or the number of miles of wind that pass by a place, say, in twenty-four hours or in a month. This is called the "wind movement" and is obtained by means of a registering anemometer. The wind movement varies greatly, being least in narrow sheltered valleys and greatest on elevated broad valleys or mesas like the Sulphur Spring Valley and in the vicinity of Holbrook. In Tucson, the wind travel is found to be 55 per cent greater at the University of Arizona than on Main street, and 81 per cent greater than at Phoenix. The wind travel at Douglas for the month of April, 1912, was 1.9 times as much as at Phoenix. The hourly wind movement in miles is, of course, the average hourly velocity.

The power of the wind, however, is not measured directly by the velocity, but by the cube of the velocity. Thus a wind blowing 10 miles per hour has eight times as much power as a 5-mile wind. The average power of the wind is therefore seven times as great at Douglas as at Phoenix. As an illustration of the varying power of the wind, a rancher on the Sabino Creek after several years trial with a 14-foot windmill states that it is not capable of irrigating more than one acre, while an irrigator near Whitewater in the Sulphur Spring Valley who had six 12-foot mills pumping into one central reservoir finds that he can keep 20 acres of alfalfa well irrigated. In each case the lift is about 25 feet.

Even in a single locality the wind power is variable, and care must be taken in deciding upon the site for a windmill. It should be placed at a distance from obstructions such as trees and buildings and preferably on the prevailing windward side. The tower should be as high as possible, since the force of the wind is greatly decreased close to the ground.

The amount of wind blowing across a section of land—that is, one mile in width—and extending upward 100 feet into the air, and blowing 14 miles per hour, has a theoretic energy of 10,000 horsepower! Is it any wonder that the rancher is opposed to seeing all of the wind-power go to waste?

RELIABILITY OF THE WIND

The records of wind movement show considerable difference in the amount of wind in different months, but the wind for any month is approximately the same on succeeding years. In any locality, therefore, the experience of one or two years will enable an observant rancher to know in advance how much ground it is safe to plant.

Wherever windmills are much used, it is customary to build reservoirs close by. Occasionally they cover half an acre; usually they are much smaller. For house service and cattle watering they serve as storage to provide for periods of calm weather. For irrigation uses they are too small to be of importance as storage, but they serve as accumulators of water, perhaps for several days, and when they are filled the water can be drawn out and applied to the fields in a few hours. Thus they save the irrigator's time and they secure an irrigating "head" which can be gotten over the ground as desired. It is not desirable to build large reservoirs, as the loss by evaporation and seepage is then of greater moment than the gain in other directions.

Fortunately the months of greatest wind movement are the spring and early summer months, which include the best growing season. In order to take advantage of the high winds of early spring, the garden irrigator should borrow from the dry-farmer the method of water storage in the soil. During the season before seed is planted, heavy irrigations can be given, preferably in deep furrows, and after each division of the garden is thus treated, the furrows should be covered by cultivation to prevent the escape of the moisture. If the soil is loamy and deep and retentive, 15 to 20 inches depth of water can be advantageously stored in this way. If the soil is shallow and underlain by porous gravels, such irrigations are a waste of time and water.

There are two conditions in which windmills are especially adapted for irrigation pumping First, for the house and garden lot, where no other pumping plant is available and where the depth to groundwater is not excessive. Very often the windmill is required for house service, and since that service does not work the mill to more than a fraction of its capacity, it can be utilized the rest of the time watering a garden or an alfalfa patch for poultry with no additional investment. In one instance on record a windmill lifting water 90 feet furnished the water supply for a house and for irrigating 87 orchard trees and 32 other miscellaneous plants. The second condition in which the windmill is adapted for irrigation service is to provide a supplementary water supply to help out dry-farmed crops. There are large areas in Arizona where dry-farming unaided is almost, though not quite, successful, provided judicious selection of crops is made. The experiments of this Station have shown that in such cases a small amount of supplementary irrigation increases the yield out of proportion to the small amount of water applied, even so small an amount as three or four inches depth making the difference between crop failure and profit (Timely Hint No. 94, Ariz. Exp. Sta.). Over a considerable area which promises to be utilized in this manner the valley fill is of such a character that it is impossible to develop a well at one place which yields sufficient water for a centrifugal pump, yet the slow constant draught of a windmill pump can be supplied. Both conditions presuppose that the prevailing winds are strong.

If the windmill is used to irrigate garden crops such as tomatoes, which need irrigation every few days, it is desirable to purchase a small gasoline engine of one or two horsepower and connect it to the pump rods by belt or gearing. It is then available for use when the wind does not blow.

TYPES OF WINDMILLS

The relative advantages of direct-stroke and back-geared windmills are often debated. In the theory of the windmill it is proven that the efficiency of the wheel increases with the speed of revolution. However, the experimental data, which is very limited in amount, indicate that the best efficiencies are obtained at speeds which are not at all excessive. As an approximate rule, it may be stated that the peripheral speed of the wheel—that is, the velocity of the ends of the sails, should at least equal the velocity of the wind and should preferably be somewhat greater.

As stated before, the power of the wind varies with the cube of the velocity. The power of windmills is found by experiment to increase nearly but not quite so fast as the cube. In a 16-mile wind a 12-foot Aermotor windmill was found to have seven and a half times as much power as in an 8-mile wind. A good 12-foot steel mill should deliver about a fifth of a horsepower in a 10-mile wind and one and a quarter horsepower in a 20-mile wind. The amount of water which can be pumped during gentle winds is insignificant for irrigation purposes. In the Sulphur Spring Valley and elsewhere where the winds are strong, windmills should be loaded and set to take full advantage of 15 to 30-mile winds. Many mills are adjusted to turn out of the wind at unnecessarily low velocities, but a good mill will take care of itself and will suffer no injury in a 30-mile wind. Windmill wrecks are caused usually not by high winds but by lack of lubrication.

From the foregoing premises, and remembering that the practicable speed limit of cylinder pumps is under 40 strokes a minute, it follows that the peripheral velocity of the wind wheel should be about 20 miles an hour when the pump speed is 30 strokes in a minute. An 18-foot mill revolving 31 times a minute has a peripheral velocity of 20 miles an hour, and hence it should be direct-connected, as should a larger windmill. But mills smaller than 18 feet in diameter should be back-geared, for it is better to increase the wheel velocity than to decrease it.

It is true that there is a considerable loss of power in gearing. On the other hand, since the direct stroke presupposes a smaller pump cylinder and a shorter and quicker stroke, there must be more loss of power in the stopping and starting of the water column.

Windmills are built commonly of wood or galvanized steel. Steel mills are to be preferred for many reasons. Metal sails are easily warped to the proper shape, presenting a greater angle of weather on the inner ends than on the outer ends of the sails; the supporting strips behind wooden sails offer serious obstruction to the passage of the wind; steel construction is not affected by the severe dry climate of Arizona, while wood checks and splits, the bolts get loose in June or the bolt heads are drawn into the wood after the rainy season begins, and the sails or outer ends of the sails become broken off and lost.

The mechanical features of construction should be examined by a purchaser. It is of little use to read advertising circulars, for in many instances at least, they overdraw the merits of the mill in most flagrant manner. But the windmill has become so common (single manufacturers are turning out 20,000 mills a year) that each make has established a reputation in every community, and a little inquiry by a customer will elicit information on reliability, cost of repairs, and length of life.

ECONOMICAL SIZE OF WINDMILL

Unlike all other type of prime movers, the weight and cost of windmills increase with the size faster than does the power which they yield. The power varies as the square of the diameter of the mill wheel, while the weight should vary as the cube of the diameter, in order to give equal rigidity and security to all sizes. Thus, a 20-foot mill weighs seven times as much as a 10-foot mill, and costs seven times as much, yet it has less than four times as much power. The windmills on the market increase in weight somewhat less than as the cube, but the larger sizes are built too light probably, and experience shows that they are more often wrecked by high winds or "twisters" than are small mills.

The tables published by windmill manufacturers, purporting to show the power of the different sizes in varying wind velocities are based on false assumptions and are very erroneous. The power of small mills in strong winds is not overstated, but the power developed in light winds and particularly the power of large mills, in all winds, is grossly exaggerated.

The depth of water in the well, or the pumping lift, should influence the size of mill. Shallow depth to water and poor supplies favor the use of small mills, and more of them, possibly a battery of mills discharging into one tank. Generally it will be found advisable to install 8 or 10-foot mills on 25-foot lift, 12-foot mills on 50-foot lift, and 12 or 14-foot mills on 100-foot lift.

The towers may be of galvanized steel, or of timber if it is available at considerably less cost than the steel. If steel is used, the tower should be three-posted; wood towers will be better framed if four posts are used.

PUMPS

As a rule, windmill installations in Arizona are made, at least in part, to provide water service for houses. In order to maintain a constant supply at all times small pump cylinders are used, thus permitting the windmill to run in light breezes. For irrigation pumping larger cylinders should be employed. Ordinarily it will be best for a purchaser to stipulate that the speed of the mill wheel in a brisk gale shall be between 50 and 60 per cent of the speed when detached from the pump—that is, unloaded—and then to allow the windmill manufacturers to order the size of the cylinder. After it is installed, tests should be made, and if the speed in a brisk gale does not conform to the above rule, the stroke of the cylinder should be changed. During the high winds of February, March, and April, the stroke should be lengthened. For example, a 12-foot mill may have a 12-inch stroke in the spring and an 8 or 10-inch stroke during the summer and fall.

The stroke should be about twice the diameter of the cylinder for 25-foot lift and the ratio of stroke to diameter should increase as the lift increases. The cylinder should be of brass or brass lined. The discharge pipe should not be smaller than the pump cylinder. Hard-wood pumps rod are preferable to pipe rods, and the rod couplings should be heavy forged straps with copper rivets and with the shoulders turned hard together.

This Timely Hint can not be closed better than by reiterating the familiar injunction to keep moving machinery oiled. Even though the agent makes the claim that the windmill needs attention only once a month, it is only fair to the mill to climb the tower *once each week* and see that the oiling mechanism is in good order and feeding oil just right Note also at the same time that all bolts are tight and that the bearings are held with the proper tension.

G. E. P SMITH.