Windmills—Old and New.

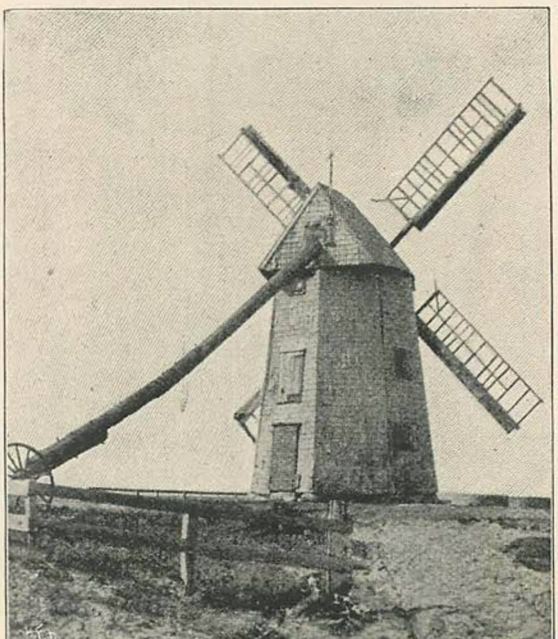
By Philip Laidlaw.

It is not certain when and where the power of the wind was first used to turn millstones and to drive machinery. There were probably no efficient windmills before the Christian Era. Gibbon speaks of the Crusaders as the importers of windmills from the dry country of Asia Minor, where, he thinks, they were first invented. One of the first references to them is in the writings of an old Bohemian chronicler, who mentions that in the year 718 a water-mill was built in his country. "Before that time," he goes on to say, "all the mills in Bohemia were windmills set upon the summits of hills."

But these machines came into general use in Western Europe about the beginning of the twelfth century. The charters granted to convents now began to include permission to erect windmills. Shortly afterwards these structures had become so common that the Pope issued a special edict, compelling them to pay tithes to the Church. The question as to the ownership of the wind often raised conflicts between the landowners and the clergy. An example is related in the annals of an old monk. "Since our monastery," he says, "had no cornmill, they resolved to build one. When the lord of the land heard this, he did everything in his power to prevent it, saying that the wind in Zealand belonged to him, and that no one might build a mill there without his consent. The matter was, therefore, referred to the Bishop of Utrecht, who replied in a violent passion that no one had power over the wind in his diocese but himself and the Church at Utrecht, and immediately granted full power, by letters patent dated 1391, to the convent to build for themselves and their successors a good windmill, wherever they might choose."

Although these machines were for centuries the most important sources of mechanical energy, they were, during most of that time, of very rude and primitive construction. The wind blows from every quarter, but it was long before windmills were adapted to work with any breeze but that one towards which their sails were permanently fixed. The first advance was made when the mill was floated on a pond or canal, so that it could be turned by means of poles and ropes until the arms of the mill were facing the wind which happened to blow.

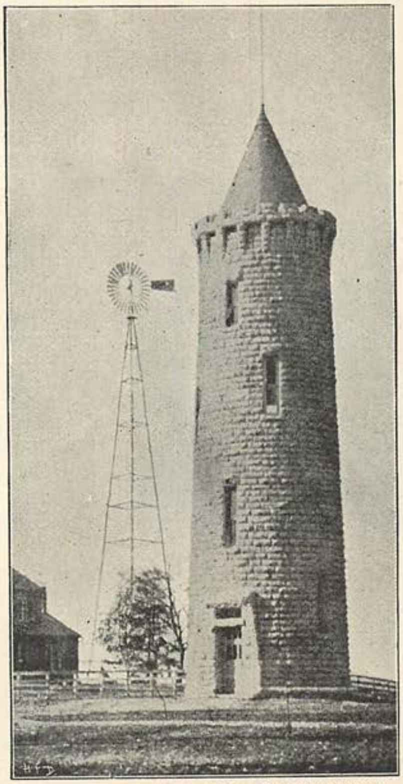
Later, in Germany, the whole mill was set upon a stout upright post, and was dragged round by means of ropes, to suit the direction of the wind. Then, in Holland, which is the country of windmills, a fixed tower was introduced in the middle of the sixteenth century. A movable cap or dome, carrying the axle of the sails, was set upon the top of the tower, upon which it was free to revolve by means of rollers. The dome was turned to the required direction by means of a long pole such as that shown in our first illustration.



AN OLD POLE-WINDMILL, BUILT IN 1746.

Sir William Cubitt, whose ingenuity first converted the windmill into an entirely automatic machine, invented, at the beginning of the present century, the little windmill or "tail-wheel" which is situated behind the great sails. This mechanism turns the dome so that the sails always face the wind, however frequently and abruptly the latter may change. The same inventor devised a simple and effective method of reefing the sails, so as to preserve them from damage, and to keep the speed of the mill comparatively uniform, during great irregularities in the force of the wind. Each of the four sails is made of a series of shutters, carried transversely on the arm, or "whip," which is from 30ft. to 50ft. long. These shutters are hinged like the slats in a Venetian blind; the force of the wind tends to open them and so to diminish the surface of the sail, while a system of weights and levers, working from the interior of the mill through the hollow shaft of the sails, tends to close the shutters.

The massive, old-fashioned windmills were made largely of wood and brick; it was the advent of the iron age that made possible the lighter, more powerful, and less expensive modern machines. The latter, which originated in America, are made in many sizes and follow a variety of types. They are rapidly spreading over the world, and are being applied to all kinds of work. Few people in this country have any conception of the magnitude of the windmill industry. Over 100,000 are turned out every year in the United States alone. They are used to pump water for the supply of railways, villages, farms, and private houses, to irrigate dry land, and to drain marshes. They drive mills, saws, and agricultural machinery, and are being used with increasing success for generating electricity for purposes of lighting and supplying power to motors. But these cheap and useful machines are not yet so well known in this country as to make a description needless.



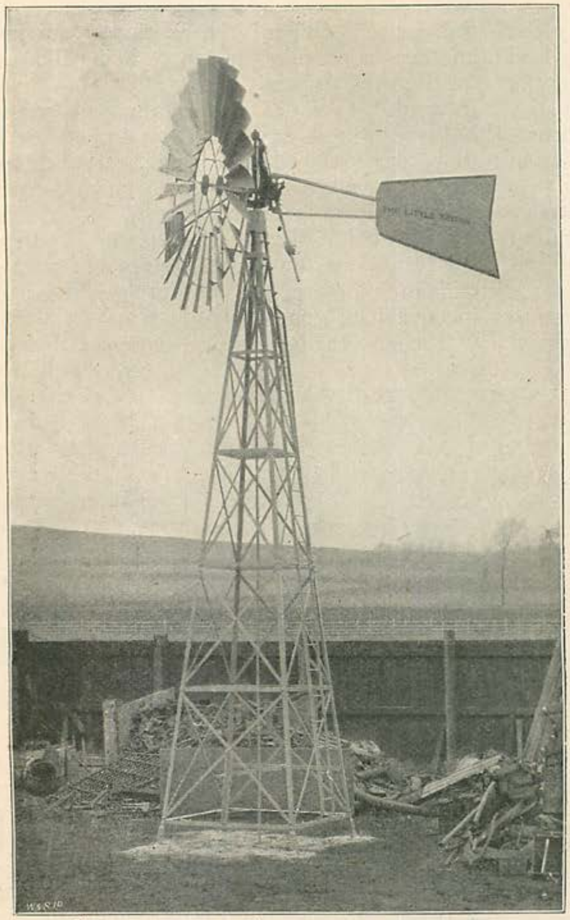
TWELVE-FOOT STEEL MILL ON NINETY-FOOT TOWER.

A light and sometimes very high skeleton tower, of wood or steel, carries the wheel which does duty as a sail. This is a disc, from ten to sixty or more feet in diameter; it consists of many blades which radiate from the centre, and are set as closely to one another as possible, due space being allowed for the wind to pass through after it has done its work. It is as if the four sails of the old type of mill had been multiplied until they completely filled a circle. It is plain that this wheel presents a much larger surface to the wind than was the case in the old mill. In the larger wheels there are two, three, or more concentric circles of blades, otherwise each slat would be of inconvenient length.

The wheel is never quite vertical; its face is always turned slightly upwards. The reason for this is that the wind does not blow parallel with the surface of the earth, but always blows somewhat downwards, owing to the friction of its lowest layers with the earth.

The smaller wheels, from eight to twenty feet in diameter, are usually built of steel, and are principally used for pumping water. The wheel is kept facing the wind by means of a fin or rudder projecting behind it, and the axle works the pump-rod up and down once in every revolution, by means of a crank. These small wheels are protected from violent winds by a simple mechanism which automatically turns the edge of the wheel instead of its face to the wind, whenever the latter becomes so strong as to endanger the structure. Two of our illustrations represent these small machines. One, set on an immensely high tower, pumps water into a tank in the granite tower beside it. The other, the "Little Briton," is, as its name implies, built in this country, and is largely used for pumping.

The larger wheels are usually "geared"; that is to say, the revolution of the axle is communicated to a vertical shaft by means of cogged wheels. In such cases the simple rudder is not sufficient to keep the wind-wheel in the right direction, because the cogged-wheel of the axle tends to "creep



"THE LITTLE BRITON"—SMALL STEEL PUMPING MILL.

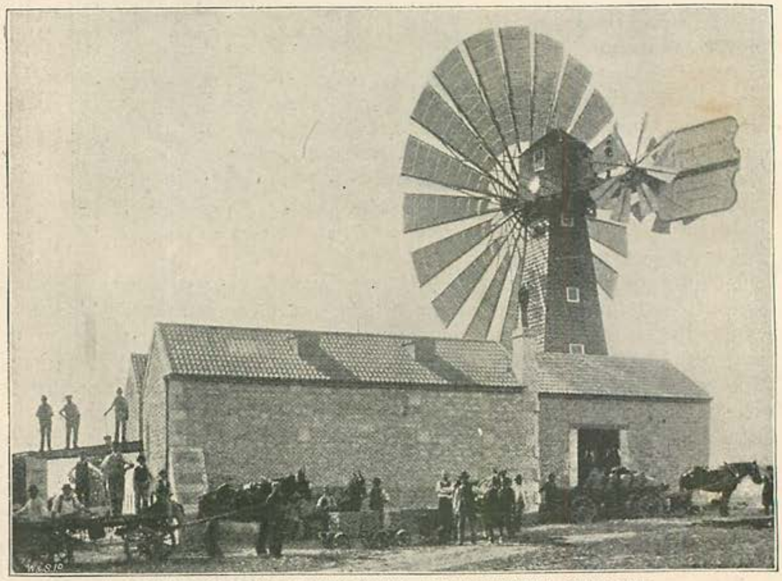
on the frame of the wheel, so that the blades, when the wheel is reefed, present their ends alone to the wind, an arrangement which gives the mill a peculiar ragged appearance when the wind is very strong, but which is very rapid and sensitive in action. One of the photographs shows a wheel working with a power equal to from ten to twenty horse-power, driving the machinery of a mill.

The large wheels used in this country are almost all of the Simplex type. In this machine, which was invented by the windmill engineer, Mr. John Titt, every blade is hinged at its two ends, and the wheel is reefed by the blades turning their edges to the wind. The reefing is effected automatically when the wind becomes too strong, and the same result may be attained by means of a hand lever, so that the machine may be slowed or stopped when desired. Some of our illustrations show this wind engine, as used for pumping water in various ways, and for generating electricity and driving machinery.

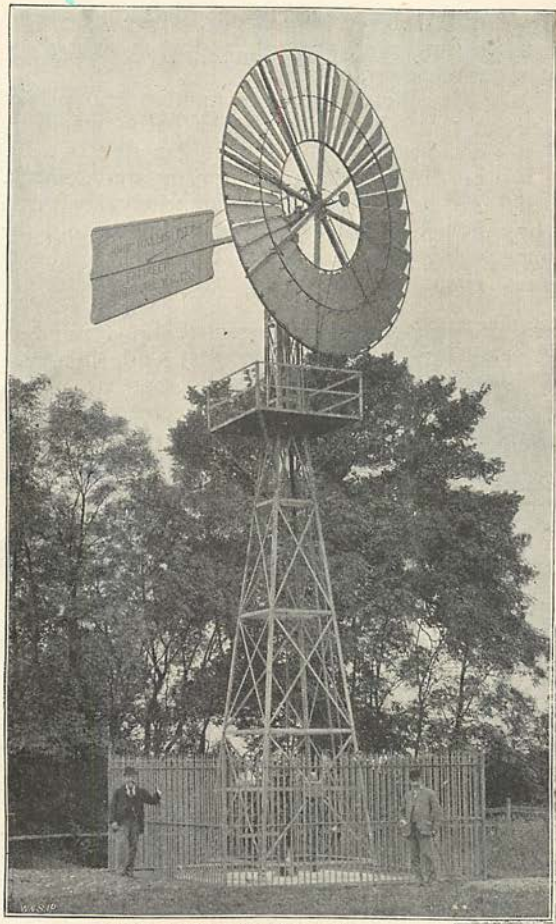
These engines, of which thousands are in use all over the world, have practically solved the question put forward by Lord Kelvin, in his address, "On the Sources of Energy in Nature Available to Man for the

round" on that of the vertical shaft, so as to draw the sail out of the wind. A tail-wheel is therefore employed, making it quite impossible for the sail to move except when the wind shifts.

Some of our illustrations represent the larger mills. The Halladay wheels, which are much used in America, have blades which are fastened together in sections. These sections are hinged



THIRTY-SIX-FOOT HALLADAY WHEEL, DRIVING ROLLER GRIST MILL.

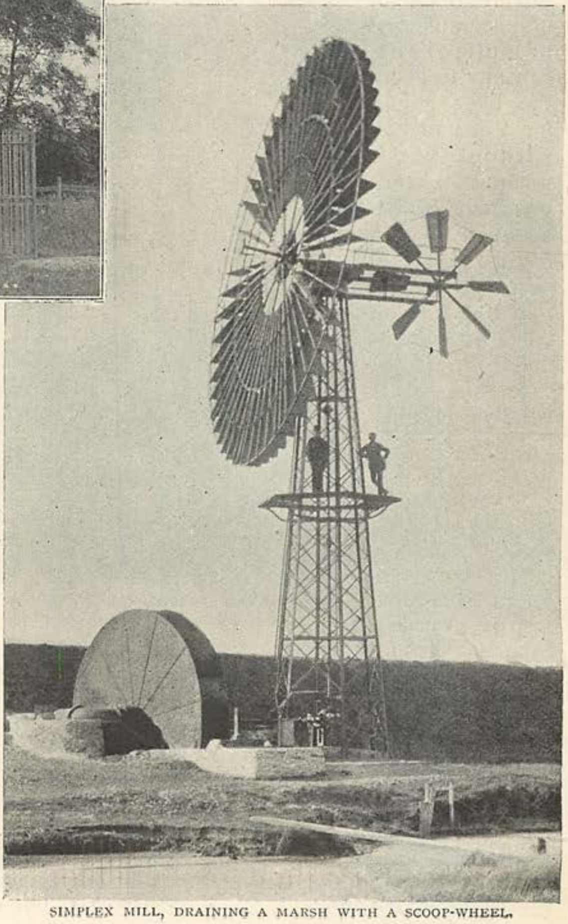


SMALL SIMPLEX PUMPING MILL.

Production of Mechanical Effect," seventeen years ago.

"When we look," he said, "at the register of British shipping, and see 40,000 vessels, of which about 10,000 are steamers and 30,000 sailing ships, and when we consider how vast an absolute amount of horse-power is developed by the engines of those steamers, and how considerable a proportion it forms of the whole horse-power taken from coal annually in the whole world; and when we consider the sailing ships of other nations which must be reckoned in the account, and throw in the little item of windmills, we find that even in the present days of steam ascendency, old-fashioned wind still supplies a large part of the energy used by man. The subterranean coal stores of the world are becoming exhausted, surely and not slowly, and the price of coal is upward bound. When the coal is all burned, or long before it is all burned—when there is so little of it left, and the mines from which that little is to be extracted are so distant and deep and hot, that its price to the consumer is greatly higher than at present — it is most probable that windmills, or wind motors in some form, will again be in the ascendant, and wind will do man's work on land at least in proportion comparable to its present doing of work at sea. Even now it is not chimerical to think of wind superseding coal in some places for a very important part of its duty—that of giving light. Indeed, now that we have dynamos and Faure's accumulator, the little want, to let the thing be done, is cheap windmills."

It was, doubtless, largely owing to Lord Kelvin's advocacy of wind-power



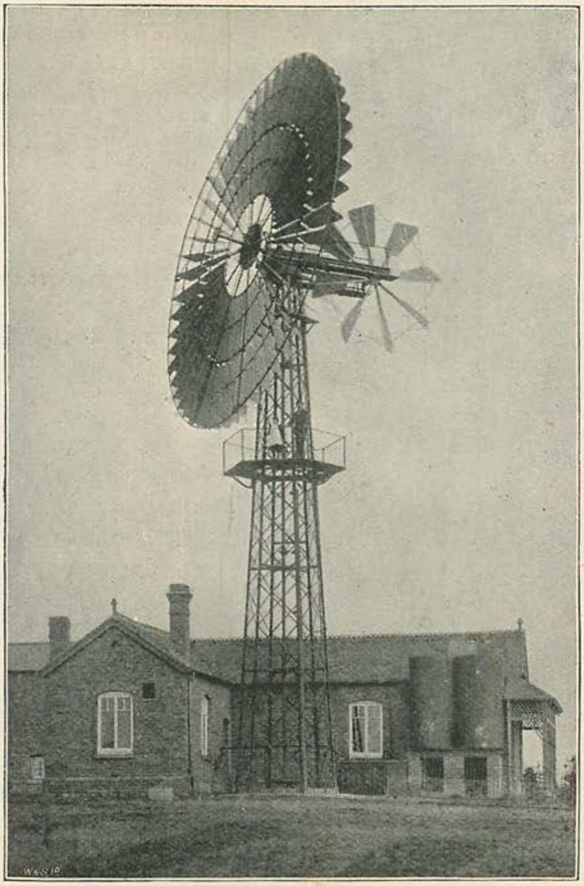
SIMPLEX MILL, DRAINING A MARSH WITH A SCOOP-WHEEL.

that the matter was so vigorously and successfully taken up. Every year since 1881 has seen new improvements in these machines, greater power and greater cheapness, until, at present, the application of wind-power to the production of electricity has proved itself an assured economic success.

In 1887 the French Government decided to light a large lighthouse on the coast by means of a windmill. The machine was successful in its object. Two dynamos, one of four and the other of sixteen horse-power, were used in light and strong winds respectively, the substitution of one for the other being effected by means of an automatic arrangement. A system of accumulators of sufficient capacity to keep the light going for three nights without wind was put in, and was found to be adequate.

In the same year, Mr. Brush, the well-known electrician, erected, near his city house, a wind-wheel 56ft. in diameter, to drive a twenty-five horse-power dynamo. The installation consists of over 350 incandescent lamps, varying from ten to fifty candle-power, as well as two arc-lamps and several motors. The whole system is absolutely automatic, and has run for years without giving any trouble.

Lieutenant Lewis gives an account of another American electric plant which was driven for three years by steam, after which the engine was replaced by a windmill. Every item of expense having been taken into account, and the two methods having been carefully compared, it was found that each lamp cost annually, when lighted by steam-power, 17s. 4d., and when lighted by wind-power, only 8s.



THIRTY-FIVE-FOOT MILL, DRIVING TEN-HORSE-POWER DYNAMO.

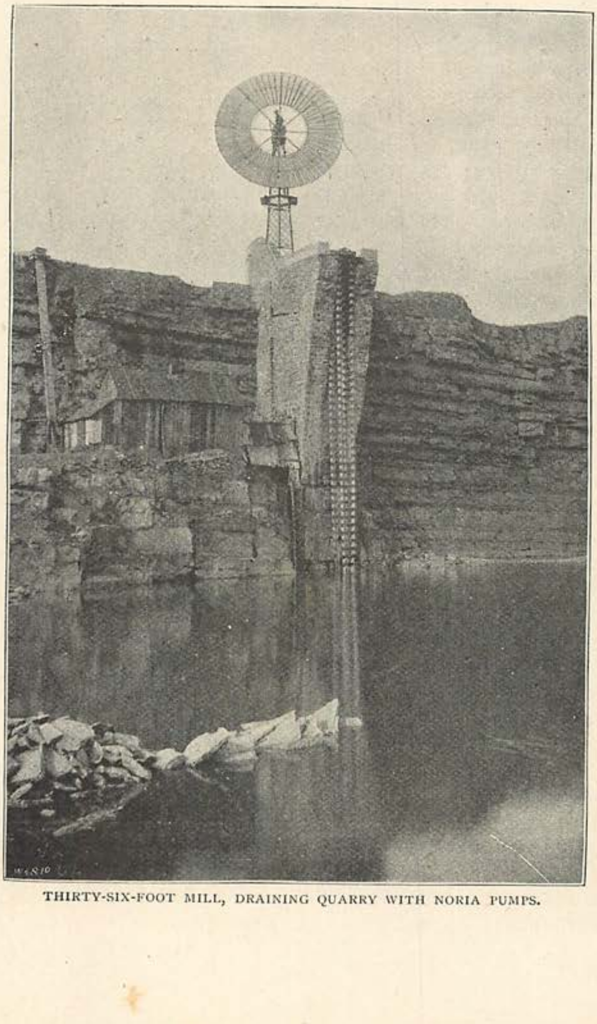
It is not necessary to multiply examples of a fact which has already been sufficiently demonstrated not only in America, but also in Britain, France, Germany, and Austria. An engineer in charge of an installation driven by one of Titt's Simplex windmills told the writer that he considered a further economy might be effected by setting the wheel to pump water during the very gentle breezes that are insufficient to drive the dynamo, thus storing up energy against the time of calm otherwise than by accumulators, or in addition to them. Mr. Rankin Kennedy has suggested the compression of air in steel chambers for the same purpose, and other experiments have been made in which the windmill was made to raise sand, which was allowed to fall upon a wheel when energy was needed. But it is probable that the development of storage batteries will continue to add largely to their efficiency while diminishing their expense, and that these additional methods of holding power in reserve, while necessarily cumbersome, would also be in the end more costly than the simple accumulator.

It is usually said that provision must be made for three days of calm. That is to say, if the mill is used for pumping water supplies, the reserve tank must be large enough to hold all the water that is required in three days; if it drives a dynamo, the accumulators must have a similar capacity. This provision is certainly, under most circumstances, sufficient, especially if the wheel is capable of running with light winds of under ten miles an hour. And there are places where there are very rarely, or never, three days together without a good supply of wind at ten miles an hour. But in less favourable situations there are, two or three times in the year, calms of this nature lasting from four to eight or even twelve days at a time. Thus, from an examination of the daily records of wind-power at Greenwich Observatory, over a period of five successive years, it appears that there were repeatedly more than three days together without a ten-mile wind. This occurred thirteen times in the five years; most of the calms lasting four or five days, but three of them reaching seven days, and one of them eleven. From a study of Falmouth Observatory records over a similar period, it appears that a windmill, situated at that place, would not once have experienced such a calm as to make the three days' reserve insufficient during the five successive years.

Passing from the exceptions to the rule, we find that the wind blows at speeds exceeding sixteen miles an hour for an average of from eight to ten hours in the day, according to the situation, and that an average of from six to seven hours more are occupied by winds of from ten to sixteen miles an hour. The following figures, calculated from the records of Falmouth Observatory, represent the number of hours, in one year, during which the wind blew at the speeds indicated :—

6 and 7	miles an hour,	769 hours.
8 ,, 9	,,	816 ,,
10 ,, 11	,,	1228 ,,
12 ,, 13	,,	814 ,,
14 ,, 15	,,	724 ,,
16 ,, 17	,,	635 ,,
18 ,, 19	,,	568 ,,
20 ,, 21	,,	525 ,,
22 to 24	,,	609 ,,
25 and upwards		1334 ,,

There is, therefore, abundance of wind, even if we neglect all winds below ten miles an hour. There is no danger of a windmill standing idle. And we believe that if the enormous store of energy that lies in the wind were realized, this method of obtaining power would be more largely made use of. Windmills require no fuel; there is no labour connected with them, except that of occasionally filling the oil-cups. Their first cost is by no means great. A 35ft. wheel, for instance, which has driven a ten-horse-power dynamo for the last four years, at no greater expense than the interest on first cost and depreciation, say, altogether, 10 per cent., cost the owner, with its tower, only £320. Undoubtedly, windmills have a great future before them, and Lord Kelvin's forecast has already begun to be realized.



THIRTY-SIX-FOOT MILL, DRAINING QUARRY WITH NORIA PUMPS.

[We are indebted to the U.S. Wind Engine and Pump Company for photographs of American machines, and to Mr. Titt, of Warminster, for our illustrations of British windmills.]