EXPERIENCE WITH JACOBS WIND-DRIVEN ELECTRIC

GENERATING PLANT, 1931-1957

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This report outlines the engineering, construction, performance, electric output, and different uses of the Jacobs wind electric 2500- to 3000-watt plant, thousands of which were installed in many parts of the world between 1931 and 1957.

Early engineering started on this wind-operated electric generating plant in 1925. After several years of testing different types of windmills, the three-blade aeroplane type of propeller was found to be far superior in power output. By means of a flyball-governor-operated, variable pitch speed control, the maximum speed of the propeller was accurately and easily controlled, to prevent excessive speeds in high winds and storms. The three-blade propeller was found to be necessary (as compared to the two-blade type) to prevent excessive vibration whenever the shift of the wind direction required the plant to change its facing direction on the tower.

The periods of vibration which occurred on the two-blade propeller, every time the tail vane shifted, to follow the changes in wind direction, were found to be caused by the fact that the two-blade propeller, when in a vertical position, offers no centrifugal force resistance to the horizontal movement of the tail vane in following changes in wind direction. However, when the two-blade propeller is in the horizontal position, its maximum centrifugal force is applied to resist horizontal movement of the tail vane; thus the tail vane is forced to follow wind direction changes by a series of jerks, causing considerable serious vibration to the plant.

The three-blade propeller was developed by us in 1927 to correct this condition. When in operation, the three-blade propeller creates a steady centrifugal force resistance, against which the tail vane reacts with a constant pressure and produces a smooth shifting horizontal movement of the plant facing direction. The centrifugal force generated by the very light aeroplane spruce-wood blades, when operating at 225 rpm is 550 pounds each, making a force of over 1600 pounds of gyroscopic resistance force to the horizontal vane movement for the three blades. But this resistance is in the form of an even pressure or resistance to horizontal movement, whereas the 1100 pounds of gyroscopic resistance force of the two-blade propeller to the vane movement is applied and then eliminated twice during each revolution.

A propeller diameter of 15 feet was found to produce ample power for electric generator operation to develop 400 to 500 kilowatt-hours per month, based on the available winds in most areas of the states in the western half of the United States. This required 10 to 20 mph winds for 2 or 3 days per week. A specially designed six-pole battery charging type shunt generator was developed to operate at a speed range from 125 to 225 rpm for direct connection to the governor hub of the propeller. It was designed so that its load factor would exactly parallel the power output curve of the wind-driven propeller when operating in the 7 to 20 mph range that it was felt to produce the most hours of wind per month. Wind plants that require higher than 20 mph winds to deliver their rated output will find too many areas where there are too many days with winds below that speed each month, and thus their effective average monthly output in many areas is below expectations. The generator weighs 440 pounds with a 9-inch-diameter armature with a 9-inch core length. The 60 pounds of wire on the field poles gave maximum efficiency with a drain of less than 100 watts for field coil operation. The generator output is 2500 watts at 32 volts, and, for the 110-volt generator, it is rated at 3000 watts.

Our experience with plants installed in many parts of Alaska, Canada, Finland, northwestern United States, and a number of special installations such as the plant we have installed for the joint operated United States and United Kingdom weather station at Eureka, in the Arctic Circle, and with the Byrd Expedition at Little America has shown that aluminum painted (copper edged) spruce-wood propellers have considerably less trouble with frost and ice formation than when they are varnished or when other type coatings are used.

Generators located on high-steel towers are subject to considerable static discharge from the armature through the ball or roller bearings, and excessive charges from nearby lightning will often arc through a bearing and weld spots on the balls and race, causing it to break up soon. We found the revolving propellers collected discharges into the direct connected armature and the lightning pick-up effect of the propellers was frequent and of considerable intensity. To correct this, we installed dual sets of heavy grounding brushes on the armature shaft which completely eliminated any trouble from this cause. With the additional use of a large capacity oil-filled condenser connected across the generator brushes and frame, we practically eliminated any damage to the generators from lightning, so much so that, with high grade ample insulation used throughout the generator and the grounding brushes and condensers, we gave an unconditional 5-year guarantee with every generator against burn-out from any cause and have built many thousands during the past 20 years using this construction without any replacements ever being required because of lightning damage or burn-out from any cause.

The price received at the factory for our 2500-watt, 32-volt plant was $490, less the cost of a suitable tower and batteries, which could often be secured in the country or area to which the plant was shipped. We supplied a 21 000-watt-hour glass cell lead-acid type of storage battery with a 10-year guarantee, for which we received $365. A fifty-foot self-supporting steel tower was supplied for $175, making a total cost for the plant of $1025. This is about $400 per kilowatt as the manufacturing cost of the plant. Shipping and installation costs are additional. Installation cost requires only the labor of two men for two days and a small amount of cement to put into the anchor holes when the tower is built. No special equipment or training is necessary. We have shipped hundreds of plants to most countries with not a single request for additional information to enable them to erect the plant. Regular installation and operating instructions are prepared and sent with each plant.

Operating and maintenance costs of this plant are largely limited to the replacement of the storage battery which, on a 10-year basis, is about $36 per year; from records kept of more than 1000 plants over a 10-year period, the maintenance cost of repairs was less than $5 per year. Some of the owners of our plants bought the Edison type battery and after 20 years are still using the same battery. New batteries of this type are quite expensive, but these owners bought second-hand batteries which still gave them 20 years of service.

Special generators designed for the cathodic protection of underground steel pipelines were developed by us in 1936. These generators were wound for an external circuit resistance of 1/10 ohm or higher. The generators produced 10 volts at 100 amperes and were straight shunt wound. When connected to the pipelines in any normal wind, they maintained a pipe-to-soil potential of 3/10 of a volt pipe negative. Due to the action of the current, the pipe maintained a fair degree of protection through calm wind periods. Hundreds of our plants are protecting many miles of pipelines in North and South America and in Arabia. Some of these plants have been in service since 1937.

DISCUSSION

Q: Can you tell me the present state of this design? You say you are no longer manufacturing wind generators, but are the designs available?

A: Well, I closed the plant and sold the machinery. I still have the company, but the engineering I do is a different type of engineering now.

Q: Are these designs available if another company is interested in producing it?

A: Frankly, it's been 18 to 20 years since I last produced wind generators, and I haven't made much effort to keep them. I'm busy with environmental work, developing a system for cleaning up coastal canals and waters (I have patented and developed a system for that), so I have dropped out of the wind electric business. Now, there are a lot of old plants still running here and there around the country, but no new ones. I no longer have the plans, blueprints, or information on them. I didn't keep them.

Q: Would you have any guess as to what these units would cost today in per kilowatt?

A: They would be about twice what they were when we quit building them.

Q: That's a complete system?
A: That's the plant, tower, and suitable storage battery.

Q: We had earlier a very interesting discussion on the question of electric plants. It would be of interest if you could comment on the operation of such gear.
A: Early in the thirties, about 1931 or 1932, I made a series of tests, and we put a special grounding brush on the generators. We had found that the airplane spruce propellers with the copper leading ends and the static pickup, out in wind and sand and from certain atmospheric conditions, created a static buildup in the armature, which would jump across to the main frame through the ball bearings and would wreck and damage the bearings.

And then I discovered in 1932, that by putting a set of heavy grounding brushes on the big armature shaft, which is 2 inches in diameter, that eliminated that completely. After that no bearings ever went bad and there was no more static buildup.