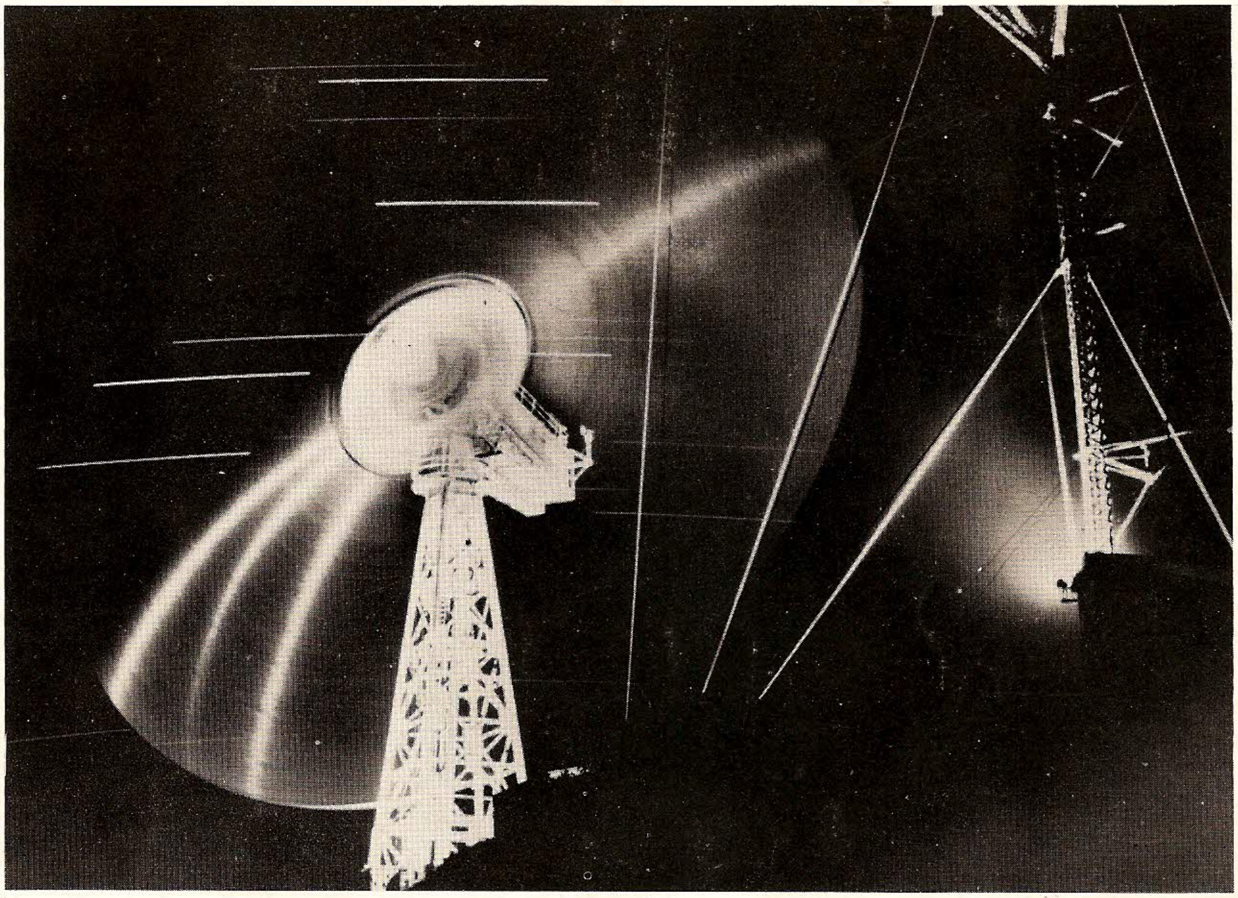
Property of S. D. Dornbirer.

The Smith-Putnam Wind Turbine

Reprinted from Volume 1 No. 3 "Turbine Topics" June, 1943

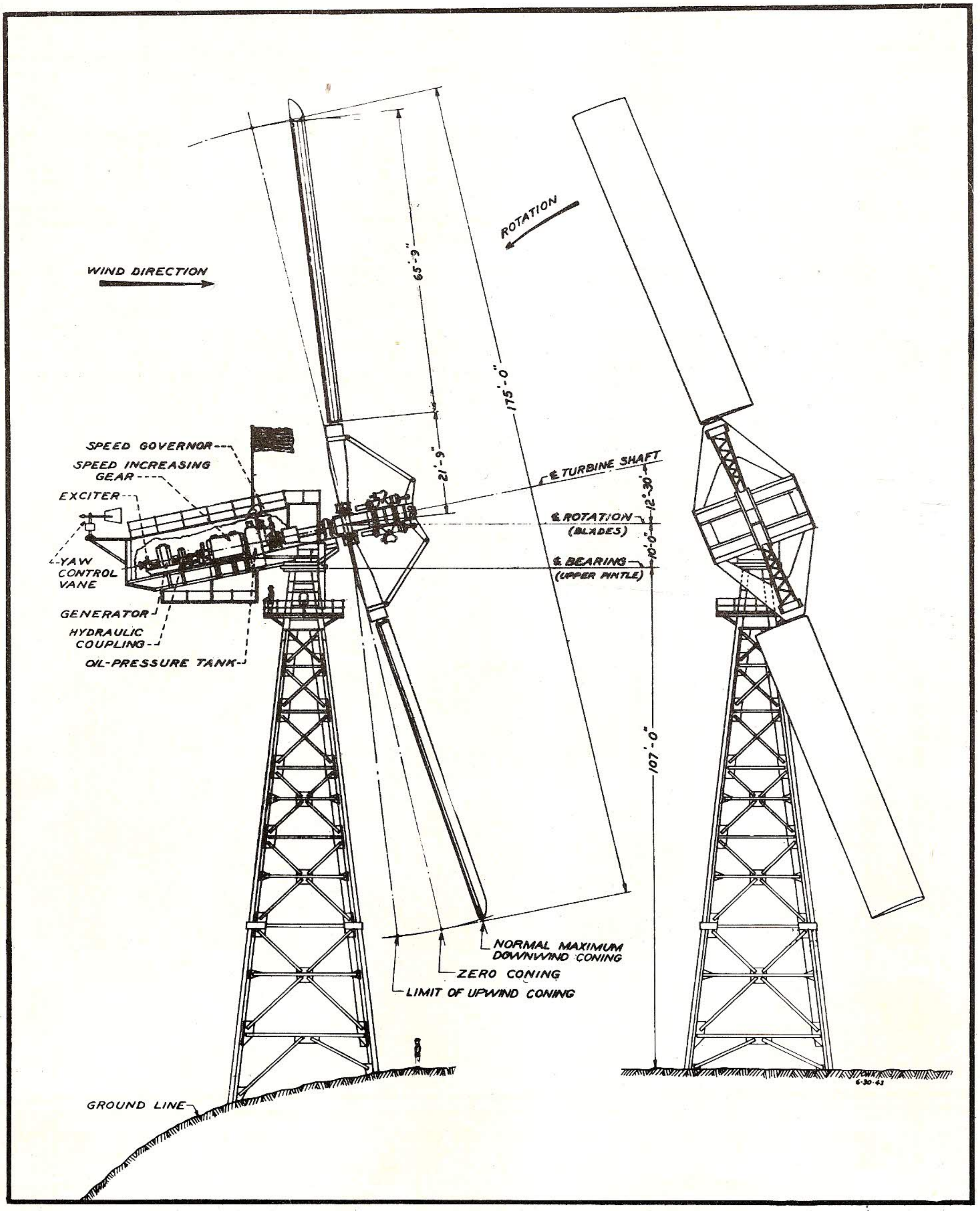


"Night Wind"

S. MORGAN SMITH COMPANY
YORK, PENNSYLVANIA

Printed in U. S. A.

Bulletin No. 145


WIND DIRECTION
ROTATION
65'-9"
175'-0"
21'-9"
SPEED GOVERNOR
SPEED INCREASING GEAR
EXCITER
YAW CONTROL VANE
GENERATOR
HYDRAULIC COUPLING
OIL-PRESSURE TANK
℄ TURBINE SHAFT
℄ ROTATION (BLADES)
℄ BEARING (UPPER PINTLE)
12°-30'
10'-0"
107'-0"
NORMAL MAXIMUM DOWNWIND CONING
ZERO CONING
LIMIT OF UPWIND CONING
GROUND LINE

THE SMITH-PUTNAM WIND TURBINE . . .
A Step Forward In Aero-Electric Power Research

By Grant H. Voaden
Asst. Chief Engineer of the Project

Our company, always in the lead in hydro-electric developments, has been experimenting for the past three years on a new type of unit—an aero-electric unit. Just as a hydro-electric unit consists of a hydraulic turbine driving a generator, so an aero-electric unit is comprised of a wind turbine and a generator.

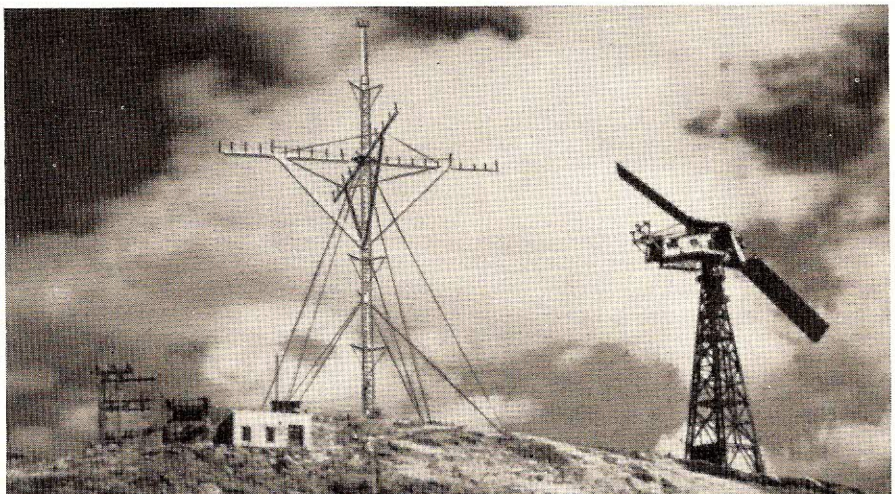
While some of the experimenting done in the early stages was on small scale wooden models made by our pattern shop, it was necessary to have a full scale unit of large dimensions in order to determine whether the project was feasible from a commercial standpoint. For this purpose the building of such a unit was undertaken and on October 19, 1941, for the first time in history an aero-electric unit was synchronized with, was connected to and delivered power to a commercial, alternating current power system. The photograph on the cover shows the unit in operation at night, the stars appearing as horizontal streaks because of the earth's rotation during the time of exposure. This experimental unit is located on the top of a bare mountain known as Grandpa's Knob, near Rutland, Vermont, and is now owned and operated by the Central Vermont Public Service Corporation.

The inventor of the wind turbine, P. C. Putnam, a Boston engineer, now in our country's service, proposed this project to the Management of our company late in the year 1939. After considerable preliminary study by some of our engineers, aided by consultants such as Dr. Theodore von Karman, Director, Guggenheim Aeronautics Laboratory, California Institute of Technology, Dr. S. Petterssen, Aerology Expert of Massachusetts Institute of Technology, now connected with the Norwegian Air Force in England, Dr. John B. Wilbur, Professor of Civil Engineering at M. I. T., and others, the company decided to take up the project. It further decided that the units should be known as Smith-Putnam Wind Turbines and that a test unit should be built of 1,000 K. W. rated capacity, and a blade spread tip to tip of 175 ft.

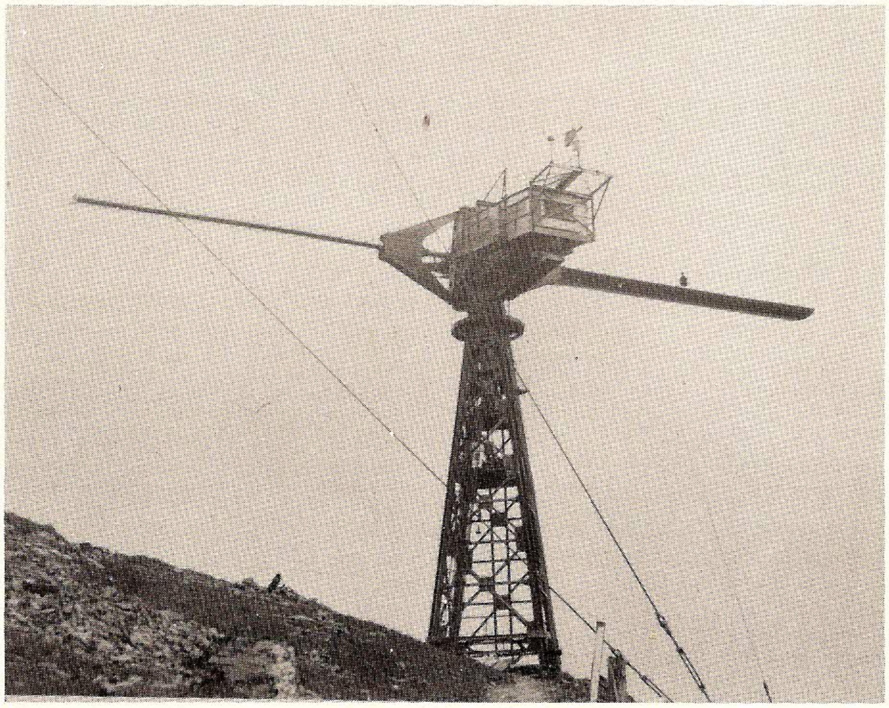
The fundamental basis of the company's interest was the fact that wind power can be used as an auxiliary to water power. Wind power by itself is not prime power; that is, it is not available all the time. A wind of about 20 M.P.H.* is required before any appreciable amount of usable power can be developed. Since sometimes the wind velocity is below this figure there must be other sources of power available to supply the full demand. However, if aero-electric units are added to an existing power system supplied by hydro-electric units or steam driven units or both, then whenever there is sufficient wind a certain number of hydro or steam units can be idled or shut down thereby allowing water to be stored above the dam or coal to be saved.

In the early spring of 1940 Dr. Wilbur accepted the position of

* This figure can be reduced on future units, depending on the wind regime at the site for which the turbines are built.

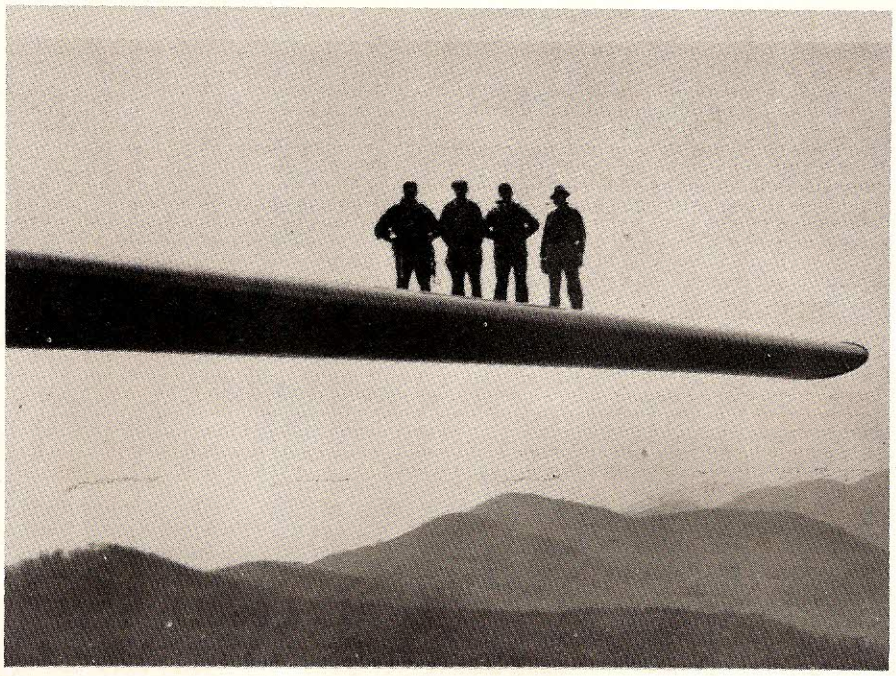


Smith-Putnam Wind Turbine installation on Grandpa's Knob near Rutland, Vt., for Central Vermont Public Service Corp. Tower height, 110 ft., weight 125 tons. Blades 175 ft. tip to tip, speed at tip 263 ft. per second. Weight aloft 240 tons. Mast for anemometers in center to measure wind velocity. Concrete control house, transformers and transmission line to Rutland. Capacity 1,000 K. W.



This is the way the Wind Turbine looks coming up the path from the control house. How would you like to be up there with "Rosie" Rozell?

Chief Engineer of the Project and an engineering force was organized under his direction. Due to the large amount of work in our own plant, the need for speed due to a number of conditions, and the specialized nature of the various phases of the project, it was necessary to have the design and construction of the unit proceed at the same time, and to have the work done by outside concerns. The design and building of practically all the machinery mounted at the top of the tower, with the exception of the blades themselves, was by The Wellman Engineering Company of Cleveland, Ohio. For a few months a staff of over 150 engineers and designers were working full time on the drawings alone. The blades, which are of stainless steel and shaped like the wings of a bomber, were designed and constructed by Budd Manufacturing Company, Philadelphia. The tower on which the turbine proper is mounted and the anemometer mast as well were fabricated of structural steel and were erected at the site by the American Bridge Company of Ambridge, Pa. The generator and all of the switchgear were designed and furnished by the General Electric Co. Published on preceding page is a photo of the complete aero-electric test unit installation on Grandpa's Knob. You see the turbine itself mounted on a structural steel tower 110 ft. high, the concrete control house containing switchboards and instruments for remote control and observation, the transformers and poles for the power line, all of which comprise the station proper. The skeleton-like structure in the center supports anemometers to measure wind velocity and would not be necessary in a purely commercial installation. It is a significant feature from the economic standpoint that the above principal component parts do comprise the entire installation, whereas in a hydro-electric plant it is necessary in addition to have a large dam and power house with expensive auxiliary equipment such as penstocks, head gates, valves, cranes, etc. Then too, wind turbines have the advantage that the land which a battery of say 20 units would occupy would be of little value for other purposes, whereas the land area flooded by a dam is usually quite extensive and sometimes of relatively high value.



These men have just completed a thorough inspection of the stainless steel blade skin.

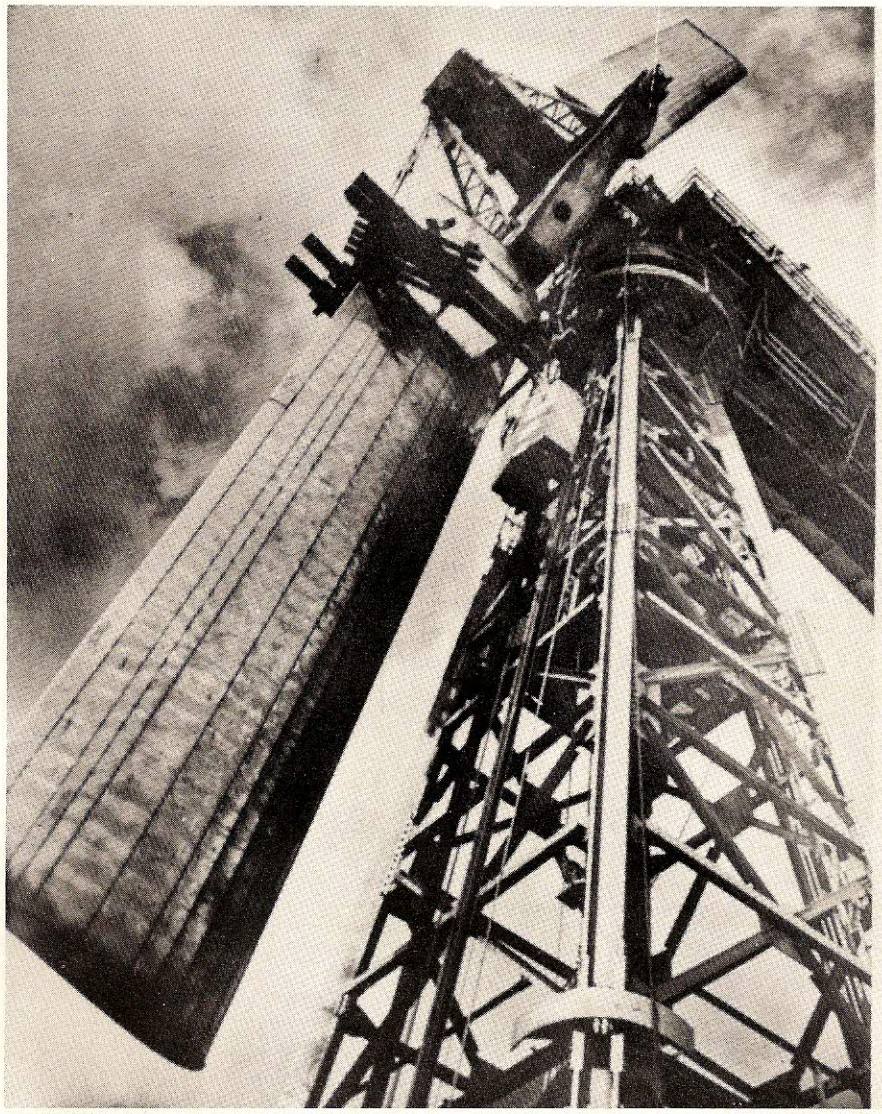
The turbine proper, which is mounted on the tower, is swung about a vertical shaft by a hydraulic motor and gearing in accordance with changes in wind direction so that the turbine shaft is always in line with the wind direction and the blades downwind of the tower. This motion is called "yawing." The rotation of the turbine about its main shaft axis is right-hand when looking at the turbine with one's back to the wind.

The pitch of the blades themselves, which are only two in number, is changed automatically by a mechanism similar to that on a Kaplan turbine to maintain practically constant speed of rotation regardless of wind velocity. Up to about 18 M.P.H., however, the wind is not high enough to make the turbine rotate at full speed. When that velocity is exceeded the generator is connected to the system and as the wind velocity further increases the turbine gives more and more power without any change in blade pitch until at 30 M.P.H. it has reached the 1,000 K.W. rating of the generator. Beyond this velocity the blades are pitched automatically in response to a Woodward governor to keep from overspeeding and overloading the unit.

Another motion of the turbine is "coning." The blades can move up and downwind pivoting on hinges at the hub under restraint of a damping mechanism. This is to provide some "give" to the mechanism in severe gusts of wind; that is, when the wind either increases or decreases suddenly.

The generator is mounted aloft at the upwind end of the pintle girder and operates at 600 R.P.M., 2,400 volts, 60 cycles, being driven through gears which step up the turbine speed from 28.7 R.P.M. Interposed between these gears and the generator is a hydraulic coupling, similar in principle to a "fluid drive"; its

Left to Right: C. J. Wilcox, P. C. Putnam, the inventor, G. A. Jessop, B. E. Smith, Llewellyn Evans, W. P. B., S. D. Dornbirer, J. B. Wilbur, C. L. Avery, Woodward Governor Co., M. G. Dow, Central Vermont Public Service Corp., M. J. Holley, Jr.



Wind Turbine with blades "Feathered." From ground to tip of upper blade in this position is about 205 ft.

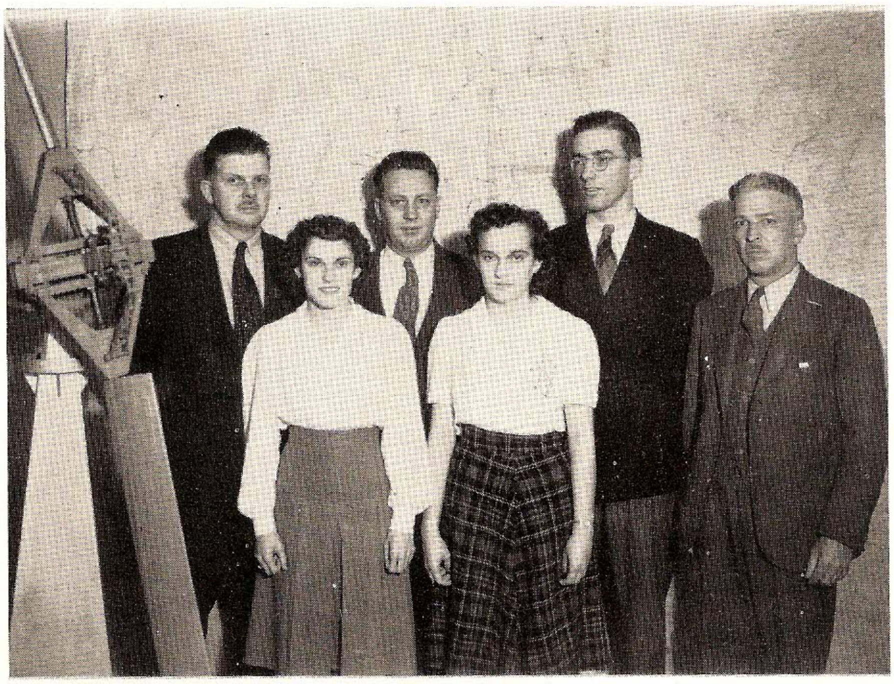
Dr. J. B. Wilbur, Chief Engineer of the Project; Grant H. Voaden, Asst. Chief Engineer of the Project; George A. Jessop, Chief Engineer of the S. Morgan Smith Co.

purpose being to allow a certain amount of "slip" or difference in speed between the high speed side of the gears and the generator itself. At zero load this slip is negligible and the two halves of the coupling rotate at the same speed, but as the load on the generator is increased it is necessary to rotate the driving half coupling faster and faster to overcome the slip until at 1,000 K.W. output its speed is 625 R.P.M. while the generator speed is still 600 R.P.M. While this represents a loss it is necessary for two reasons: primarily to provide means for the loading and unloading of the unit by changing the speed adjustment of the governor and, secondly, to provide a cushion between the turbine and generator to take up shocks due to extremely severe gusts which frequently occur and which otherwise would cause the generator to be thrown off the line due to overload.

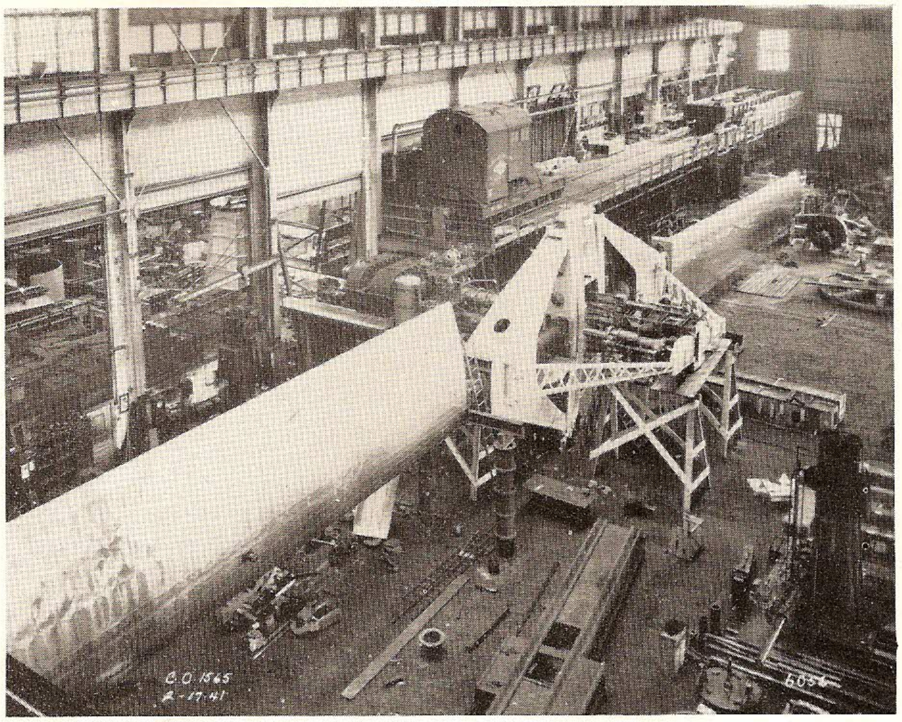
The normal control of the unit is completely automatic, even to the phasing with the system, and it functions without attendance. Manual control is also provided. The unit can be operated completely from the control house several hundred feet from the base of the tower and partially from aloft. Manual control is particularly desirable on this first unit for testing purposes.

This project involves a great many fields of engineering knowledge and endeavor; for example, aerology, aerodynamics, mechanics, structural and electrical engineering, to name only a few. Also in the production of these units every type of worker will find a job—pattern makers, boiler makers, welders, pipe fitters, machinists, electricians and mechanics—all are needed. Some of the pictures on these pages illustrate the different types of shop work that are involved in the manufacture of a wind turbine. It is confidently expected that some day—and it may not be so long—many more wind turbines will be built right here in our own plant and built from drawings made by our own designers.

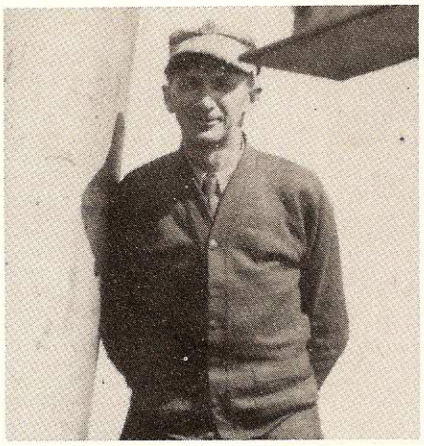
As was naturally to be expected in a new machine of such magnitude involving so many novel features, frequent troubles developed which were eventually overcome in the two years since erection was first started. However, the unit has proven itself fundamentally sound and practical. Mechanically it is as satisfactory as



The Rutland Office and Field Crew: Stanton D. Dornbirer, Supt. of Erection; Ella Taranovich; Carl J. Wilcox, Office Manager and Test Engineer; Mary Skaza; Myle J. Holley, Jr., Test Engineer; Arthur H. Cheney, Test Engineer.



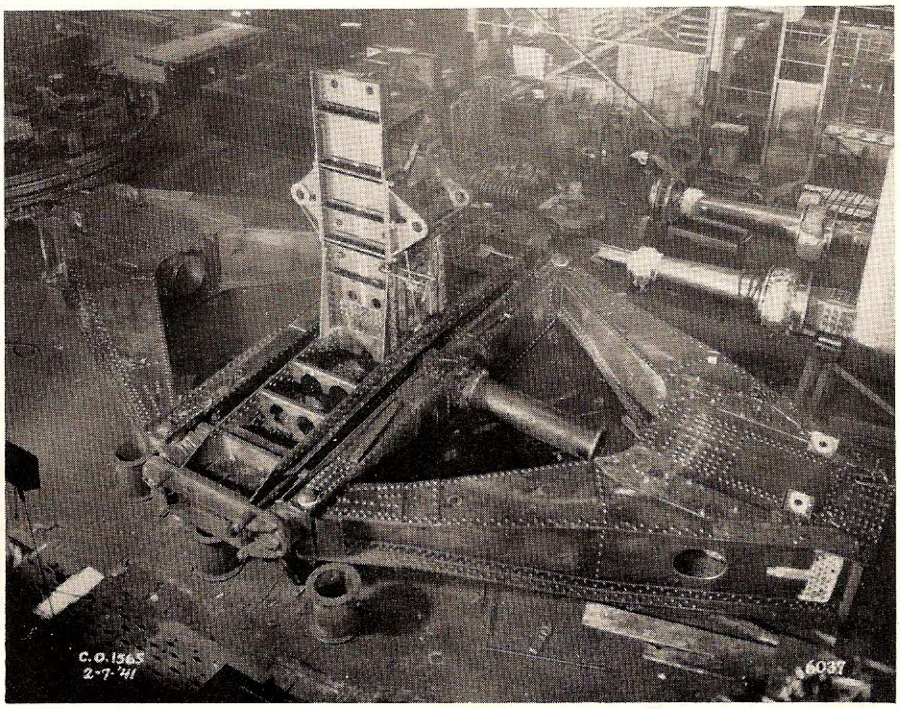
Shop assembly nearing completion in Wellman Engineering Shop, stainless steel blades in position to give maximum power. Note provisions for "coning" of blades up and downwind in gusts, and cylinders and struts for damping the motion.



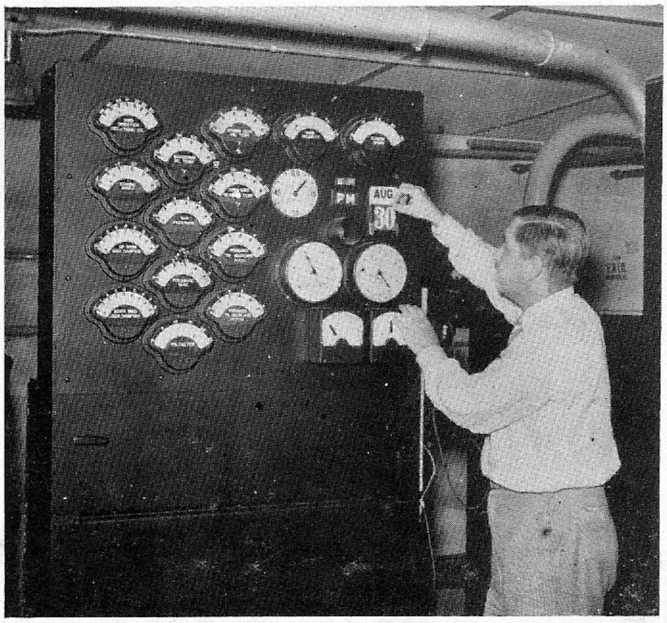
Ernest Stump, Machinery Erection Foreman.

Harold S. Perry, Steel Work Erection Foreman.

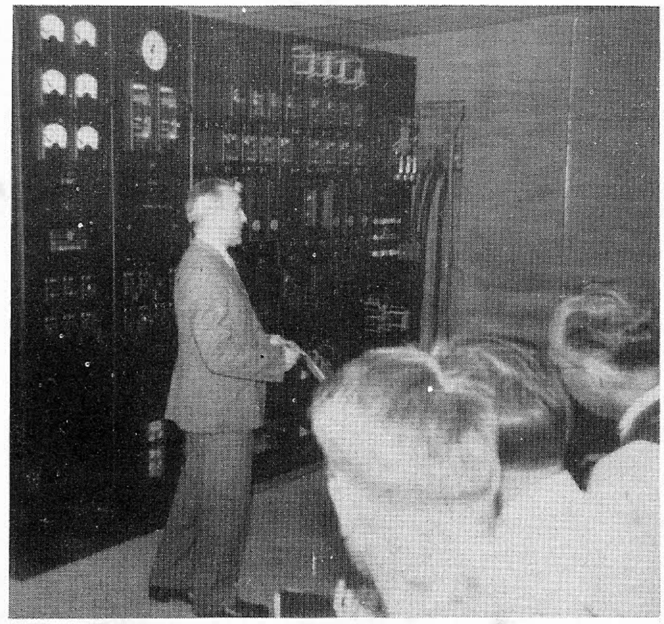
could be expected with an entirely new design having no basis of past experience. Structurally and electrically there has been practically no trouble with the unit. Aerodynamically the unit has lived up to expectations and the output it gives at all wind velocities checks very closely with the model tests made in the wind tunnel. The knowledge gained during the process of bringing this unit to a state of successful operation will enable us to design a production unit which should not only be much improved mechanically, but also be capable of producing power on an economically competitive basis in areas with suitable wind regimes.



Assembly of tailpiece, hub, A-frame and torque tubes (for pitching the blades). Production units will have welded construction, not riveted.



Instrument Panel

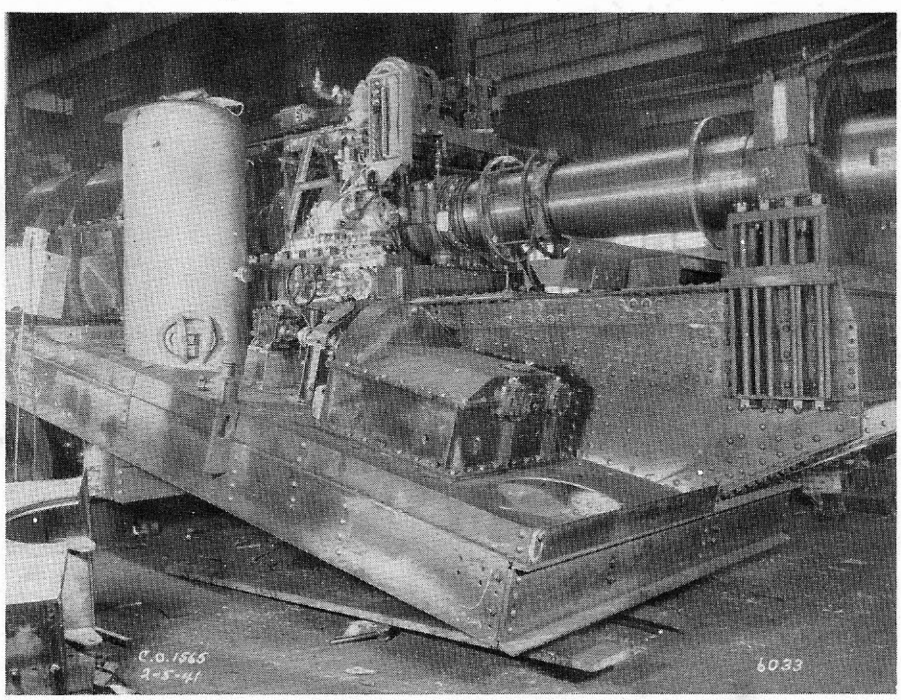


Switchboard

The views above taken inside the control house show on the left the instrument panel which is special for the test unit, and on the right the switchboard.

The eighteen instruments on the test panel indicate the functioning of various parts of the unit, which itself is several hundred yards away, and also the wind velocity at a point approximately on the center line of the turbine and fifty feet upwind of the blades. A few of the indications are blade angle, governor speed adjustment, generator output, turbine speed, coning angle, various oil pressures and temperatures. These instruments not only allow the operators and test engineers to know what the unit is doing even though they are on the ground and several hundred feet from the tower, but also provide a means for recording simultaneously all conditions of a test. This is done by an electrically driven motion picture camera which takes pictures of the entire panel continuously whenever the unit is in operation. These films are later projected on a screen and the readings of the various instruments tabulated and test computations made. An elaborate instrument panel like this would not be required on a production unit.

From the switchboard, whenever there is sufficient wind, the unit can be manually started, brought up to speed, phased with the system and loaded. Conversely, of course, the unit can be stopped. Normally, however, all this is done automatically as a function of wind velocity, and the numerous relays, etc., mounted to the right on the larger panel are for this purpose. A 125-volt storage battery provides the basic power for these controls. The view on the right also shows W. A. Bagley, Switchgear Expert of the General Electric Co., New England District, conducting an Operators' Instruction Class.



Partial shop assembly showing turbine shaft and outboard roller bearing, oil head, Woodward governor and pump, pressure tank, hydraulic motor and yaw gears all mounted on pintle girder and platform which is mounted on and swings about the top of the tower.