

Inspection of the blades indicated no reason for the noise previously referred to. One possible explanation is that there may have been enough play at the blade-hub interface to have allowed the blade to shift back and forth during rotation. The gearbox oil was changed to a Mobil Synthetic (SHC 629) 90W oil.

The Grumman was reinstalled on August 16. The pitch control system was checked out and seemed to operate properly. However, four days later the pitch control system would not respond to manual controls, nor would it operate properly under automatic control. After correspondence with Grumman the problem was determined to be in the pitch control slipping assembly. Two of the power transmission brushes were burned out, possibly caused by a malfunctioning limit switch in the pitching servo.

It was decided by Grumman and Rocky Flats, to replace this machine with a newer model of the same type for the following reasons:

- (1) This machine was the first one made, a prototype, with many typical prototype problems.
- (2) New innovations incorporated in the more recently manufactured Windstreams made this one obsolete.

The Windstream has been removed from the test site and is being returned to Grumman.

(5) Jacobs

Rated power	-	3.0 KW @ 9.8 m/sec
diameter	-	4.1 meters (13.6 feet)
Blades	-	Three-twisted, tapered, fiberglass covered wood
Orientation	-	Upwind rotor

Control - Centrifugal blade pitch and
manual tail feather
Test location - 2.6

The reconditioned Jacobs was erected February 18, 1977. Final electrical hook-up was completed two days later and was operated without load for a short time.

On February 22, during a wind storm averaging 38 mph and peaking to 52 mph, one blade on the Jacobs came off its shaft. One of the tail rails was also slightly bent. The Jacobs was operating under no load at the time of the failure. The sequence of events appeared to have been as follows: The knuckle-joint rod on one of the blades, which both holds the blade and allows it to rotate between the run and feather modes, had pulled out of its hub socket. The rod is held in the socket with an allen set screw with only a friction hold. The rod was subsequently found to be manufactured of extremely hard steel compared to the allen set screw. The blade then flew away from the hub with enough centrifugal force to overextend the blade retention spring. The spring remained distended and the blade remained attached to the hub via this spring. The excess vibration caused by the loose blade may have caused a link in the tail chain to break. It was found that the tail stop chain had been improperly installed on the wrong side of the chain yoke. (Installation directions do not state the side which should be used.) This incorrect installation may have caused the tail rail to bend. The exact cause cannot be determined. The tower casting broke either during the high vibration period or after the tail chain broke, which caused the tail to fold very fast. One of the tail rails was also slightly bent. North Wind Power Company representatives participated in March in the analysis of the failed components and supplied replacement parts. The Jacobs was reinstalled on tower 2.6 on May 4, 1977. With a wind of 15 mph, the machine would produce only 6 volts. The Jacobs was removed

from the tower after investigation showed that the field had an open circuit due to a defective solder joint. Repairs were completed and the machine was reinstalled on May 18. Additional work was required to modify the wiring on the machine so that the voltage regulator would function properly. The system was checked when winds were sufficient on May 26.

On June 23, the hub and rotor assembly rotated off the machine. The blades were a total loss, but the hub appeared undamaged. The rotor was turning at less than 100 rpm prior to the incident. On June 29, inspection of the inside of the hub shaft showed that the woodruff key groove had not been bored deep enough in the hub and there was a distinct mark at the end of the key groove. As the hub nut was tightened, it locked the hub against the woodruff key and not against the tapered generator shaft. A new hub and three blades arrived on July 21. The new hub was an exact duplicate of the first hub. A call to Northwind confirmed that the key way in the hub was not deep enough. A new key way was bored from front to back in the hub, approximately 30° away from original key way. The hub and blades were placed on the Jacobs on July 26. On July 27, the control box was removed for repairs. The field circuit was not being controlled properly, and a failed transistor was replaced. On July 28, the control box voltage regulator section was inoperative. A blown fuse was replaced, but the control box would operate only in the "Regulator Off" mode. In this mode, the field is shorted to the negative terminal, which puts on the full field and the generator will put out 200 volts or more). The control box was removed again for repairs.

A new control box was purchased from North Wind and installed on September 20. It was found that the voltage was regulated properly whenever the machine is loaded. If no load is applied a high voltage is developed. The Jacobs has been operating continuously since the correction of this last problem.

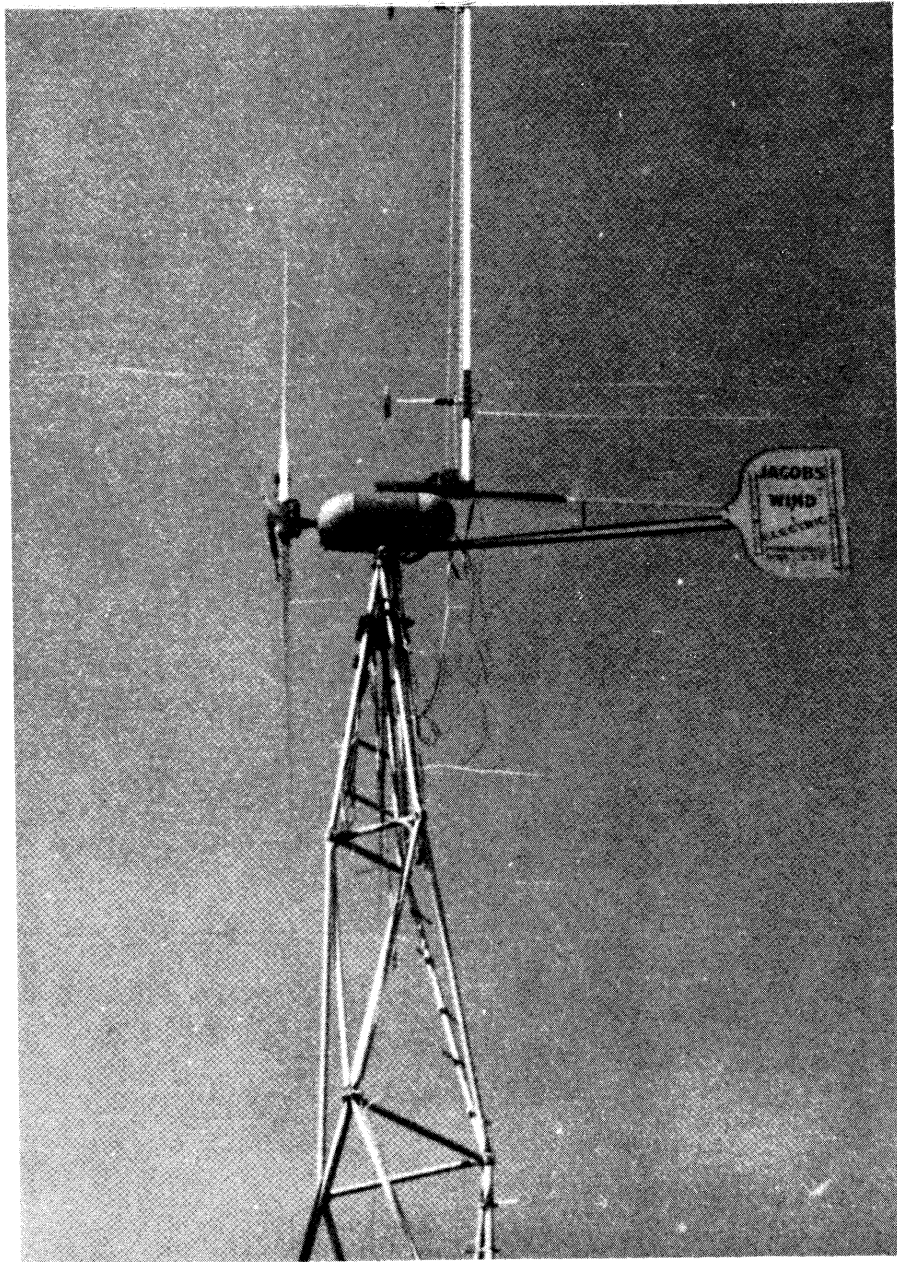


FIGURE 1

Instrumented Jacobs with a Single
Anemometer Boom

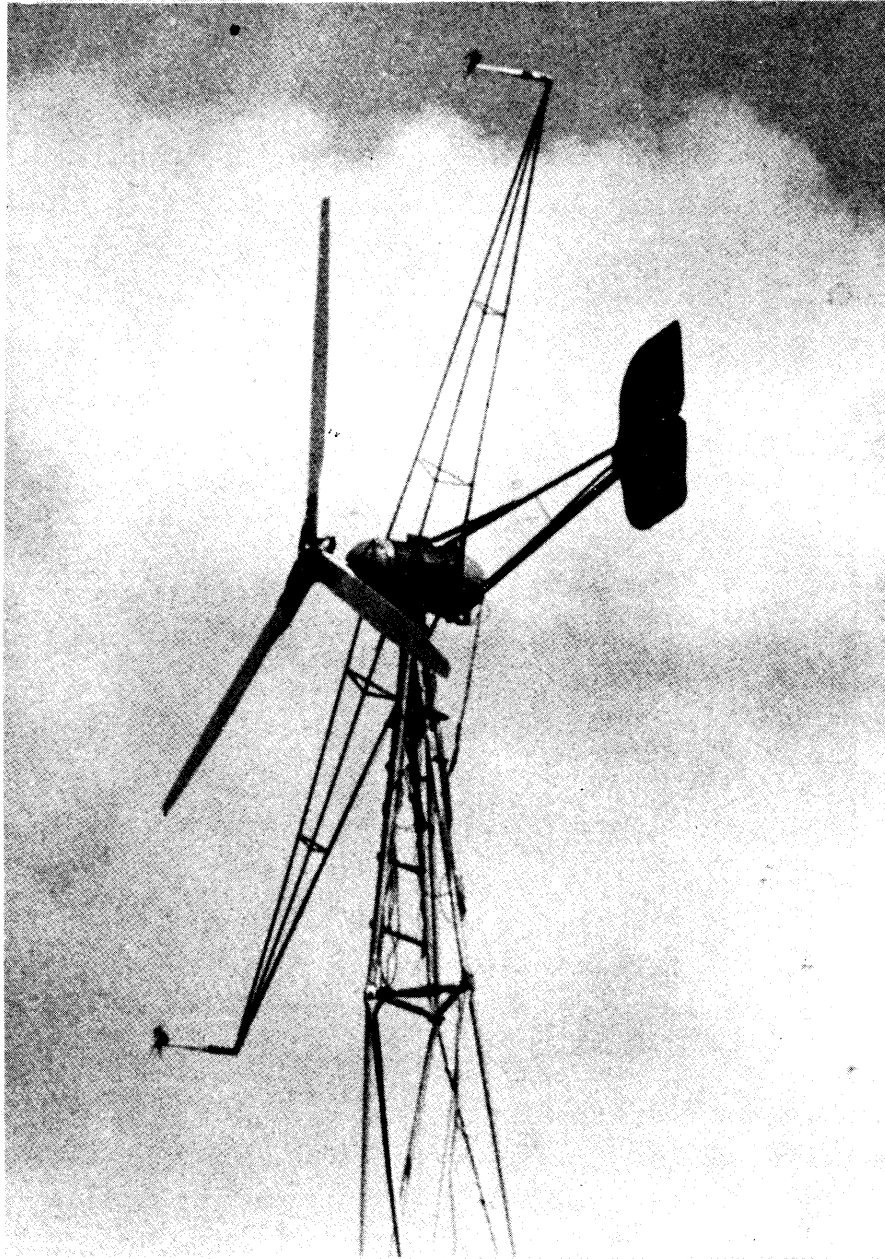


FIGURE 2

Instrumented Jacobs with a Twin
Anemometer Boom