Manual on

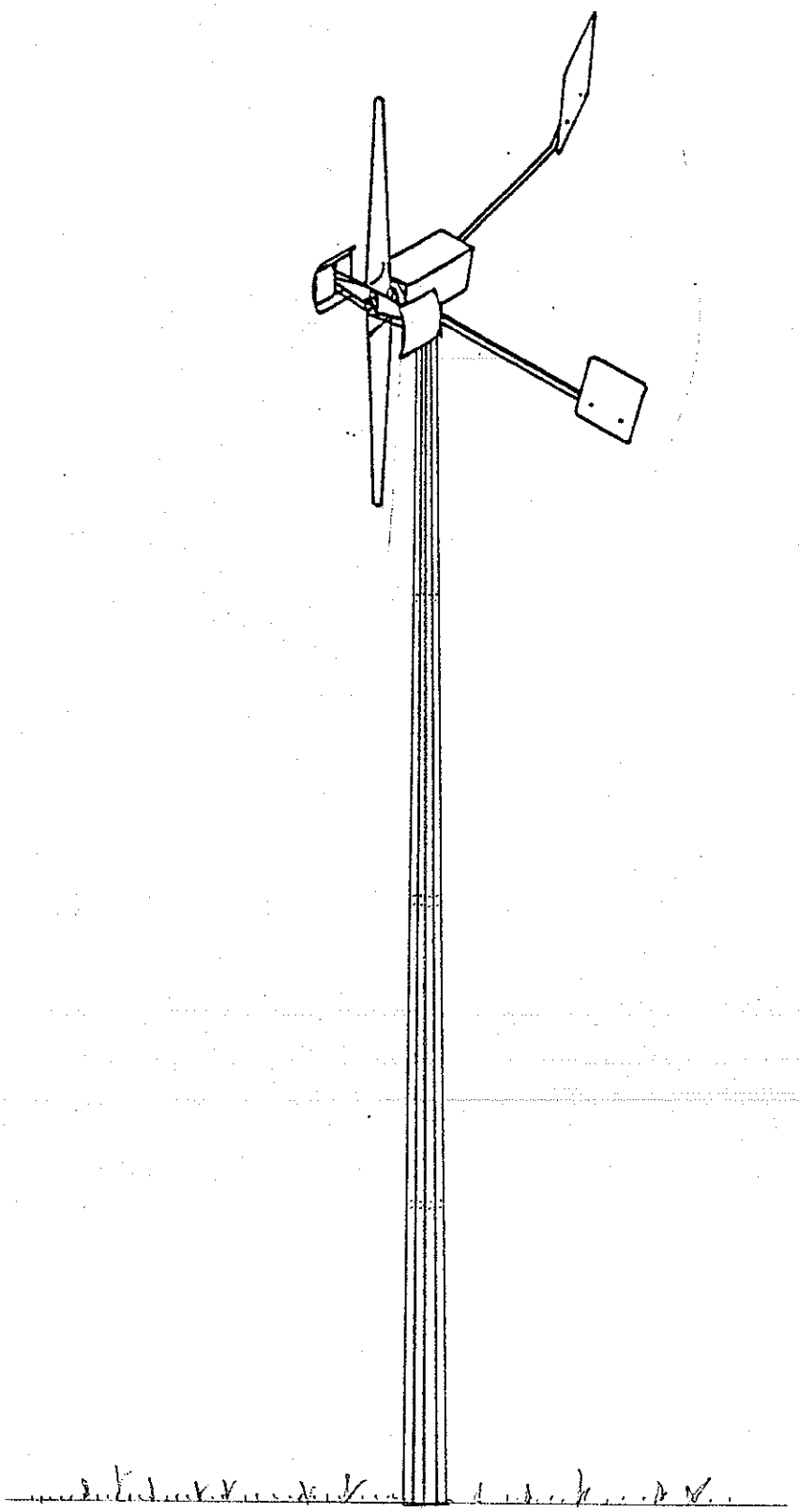
FC 4000 Wind Motor

by

Lars Yde and Carsten Gylding

February, 1993

FC 4000 WindMotor



CONTENTS

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FC 4000 WIND MOTOR

The FC 4000 wind motor is a small windturbine which generates 1.5 kW of electrical energy at a rated wind speed of 10 m/s. The wind turbine is developed at Folkecenter for Renewable Energy for application under low and medium wind regimes. It has a wide range of applications such as grinding, water pumping or battery charging etc., and it is delivered with the necessary equipment to erect the windturbine.

1. Description of parts

The FC 4000 windturbine consists of the following main parts:

1. Nacel
2. Permanenet Magnetic Generator
3. Rotor (blades)
4. Airbrake
5. Yawing system (tail and side vane)
6. Tower

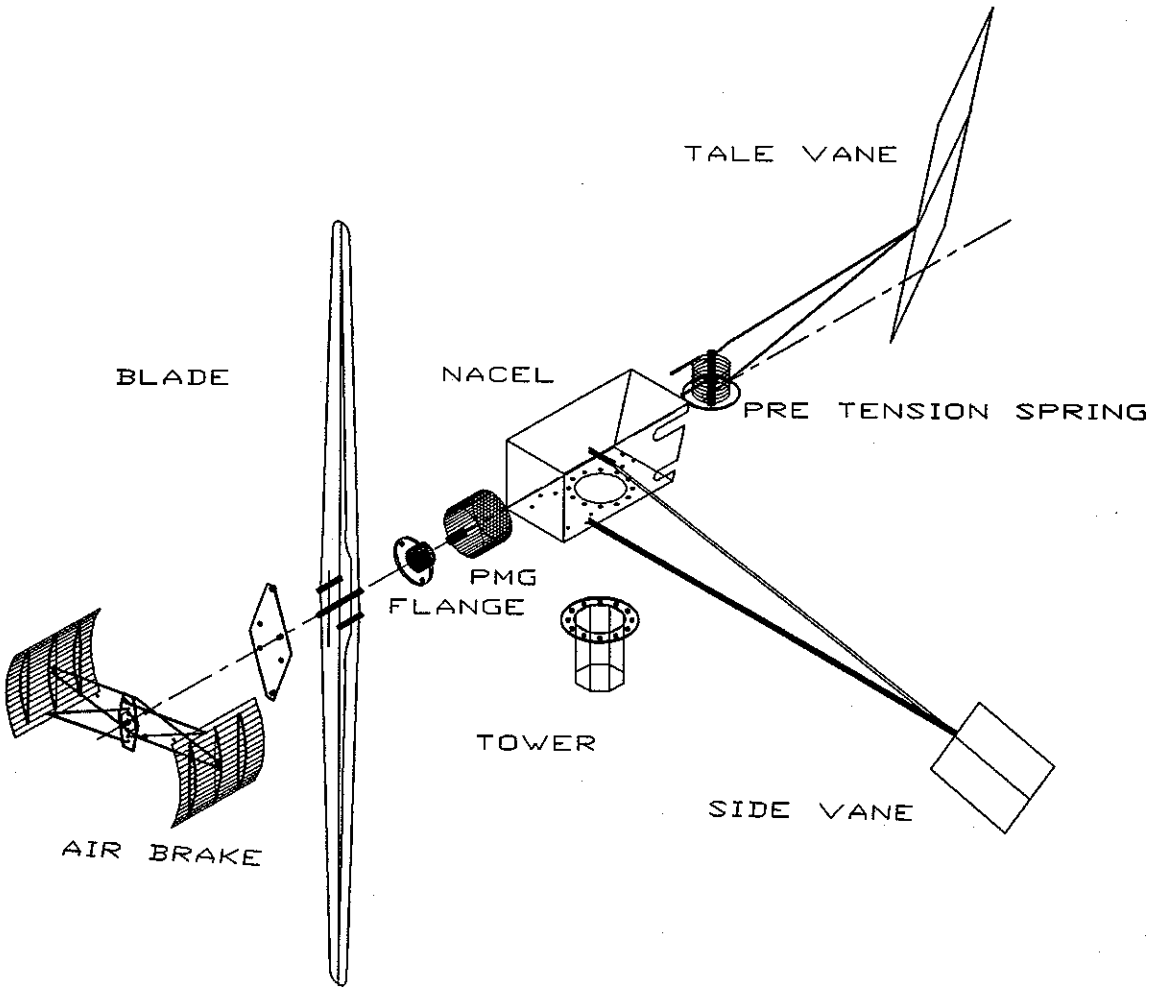


Fig. no. 1

1.1 Nacel

The nacel is the housing for the generator and is fitted to the tower by a roller bearing that allows the nacel to rotate freely, when yawing in the direction of the wind is necessary. The side vane is attached on the right side of the nacel, the tail vane at the rear end of the nacel.

1.2 Permanent Magnetic generator

The permanent magnetic generator is the main component of the nacel. The simple and reliable permanent magnetic generator starts generating electricity at low speed. The slowly rotating generator is coupled directly to the rotor of the wind turbine with the help of a flange. Due to the fact that there is no gear box in the wind turbine, it has a high efficiency, a long lifetime and is close to maintenance free. The PMG is a 14 pole generator producing 1.5 kW of 3 x 220 V and 50 Hz at the speed 428 rpm.

1.3 Rotor

The rotor of the wind motor consists of two wodden or fibre-glass one beam blades. The rotor is fixed on the generator shaft with the help of a hubflange.

1.4 Airbrake

The airbrake is attached in front of the rotor and its function is to limit the speed to approximately 430 rpm. It consists of two curved plates that are connected to a centre plate. The way the airbrake is attached to the rotor allows the plates to turn, hence a considerable drag is created. When the centri-fugal force exceeds the pre-tension of the springs, the plates will start turning, and thus reduce the speed of the rotor. (See fig. no. 2)

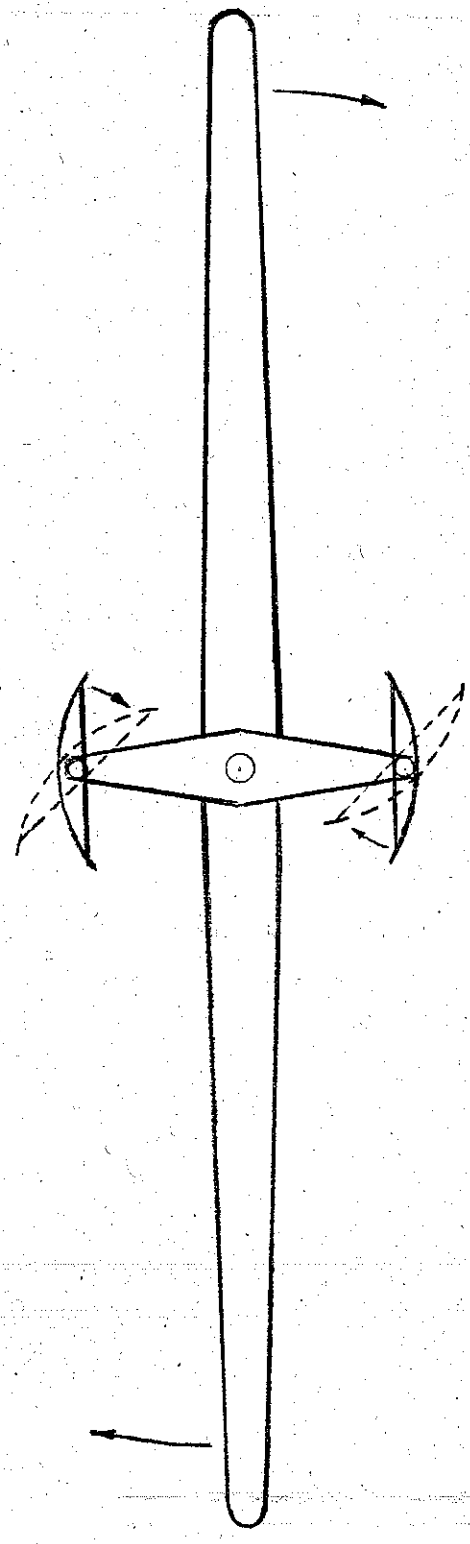


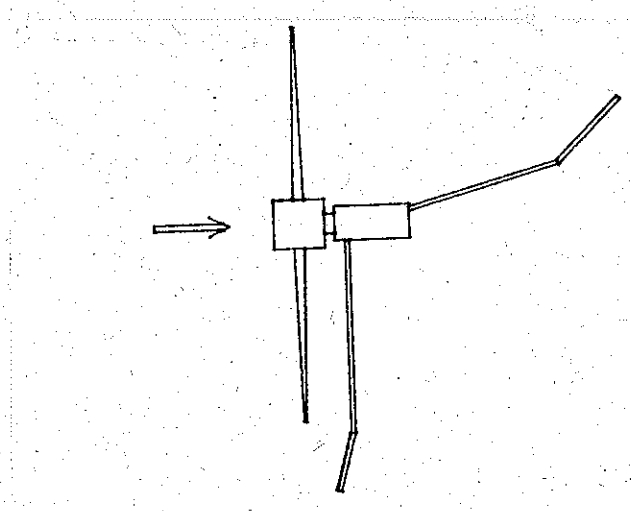
Fig. no. 2: FC 4000 airbrake. The activated position is shown with dotted lines. The two 0.5 m x 0.5 m plates are producing a big drag in this position.

1.5 Yawing System

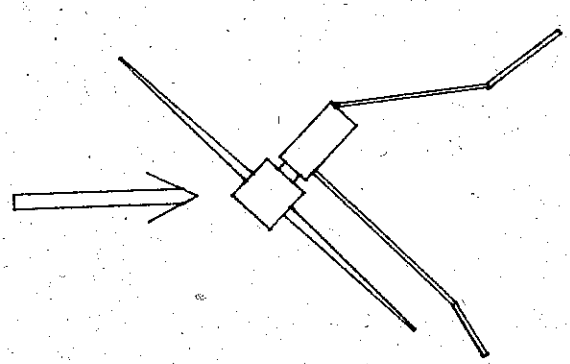
The function of the yawing system is to keep the rotor perpendicular to the wind direction and to move the rotor out of the wind at high wind speeds. The yawing system consists of a tail vane and a side vane.

1.5.1 Tail vane

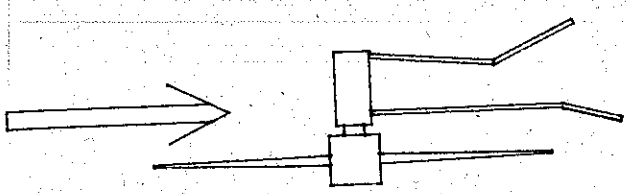
The tail vane is attached to the rear side of the nacel by a pre-tensioned spring. If the wind speed increases to more than 10 m/s, the force on the tail vane will exceed the pre-tension in the spring and the side vane starts to move closer to the tail vane, i.e., the side vane will move parallel to the wind direction. At wind speeds higher than 15 m/s, the side vane is almost parallel to the wind direction. At this stage the rotor is out of the wind direction and is rotating very slowly; thus it is safe.
(See fig. 3)



Light wind



Medium wind



Strong wind or

handbrake activated

Fig. no. 3: FC 4000 yawing system. Top view.

1.6. Tower

The tower is made of 5 mm plate formed to an octagonal conical pipe. The tower is made out of four separate sections that are bolted together. At the bottom of the tower, a base plate is welded on. A similar plate is found on top of the concrete foundation. The two plates are to be bolted together by 8 M16 bolts.

2. Windturbine security functions

There are two primary safety mechanisms in the FC 4000, the airbrake and the yawing system.

The airbrake is activated when the rotor speed exceeds 430 rpm, and it limits the speed to about 470 rpm, even if the FC 4000 is running without generator load. (See fig. no. 2)

The second safety mechanism consists of the yawing system. At light and medium winds the rotor is at a right angle to the wind direction, while the yawing system in strong winds will turn the rotor parallel to the wind direction. (See fig. no. 3)

As a secondary safety system the FC 4000 is equiped with a manual brake. The brake is activated by a winch at the bottom of the tower. When the brake is activated the rotor will position itself parallel to the wind.

3. Performance

The FC 4000 is an efficient windturbine, the power generated in the mainshaft is up to 42% of the power of the wind passing by the rotor area. The generator efficiency is also very high, up to 94%. The power loss in the cable from the windmill is insignificant due to high generator voltage.

Production rates

Mean wind speed	Annual production
3 m/s	1016 kWh
4 m/s	2369 kWh
5 m/s	3881 kWh
6 m/s	5245 kWh

Wind speeds

Cut in:	3 m/s
Rated:	10 m/s
Cut out:	15 m/s
Survival:	45 m/s

In fig. no. 4 the performance is shown when the FC 4000 is used with a centrifugal pump, and in fig. no. 5 the performance for grain grinding is shown. Near the maximum the airbrake is occasionally active. From wind speeds around 9 m/s the yawing safety mechanism is active, causing the output to decrease drastically at wind speeds above 11 m/sec.

POWER CURVE FOR WATERPUMPING (MEASURED)

9,5 m pumping height

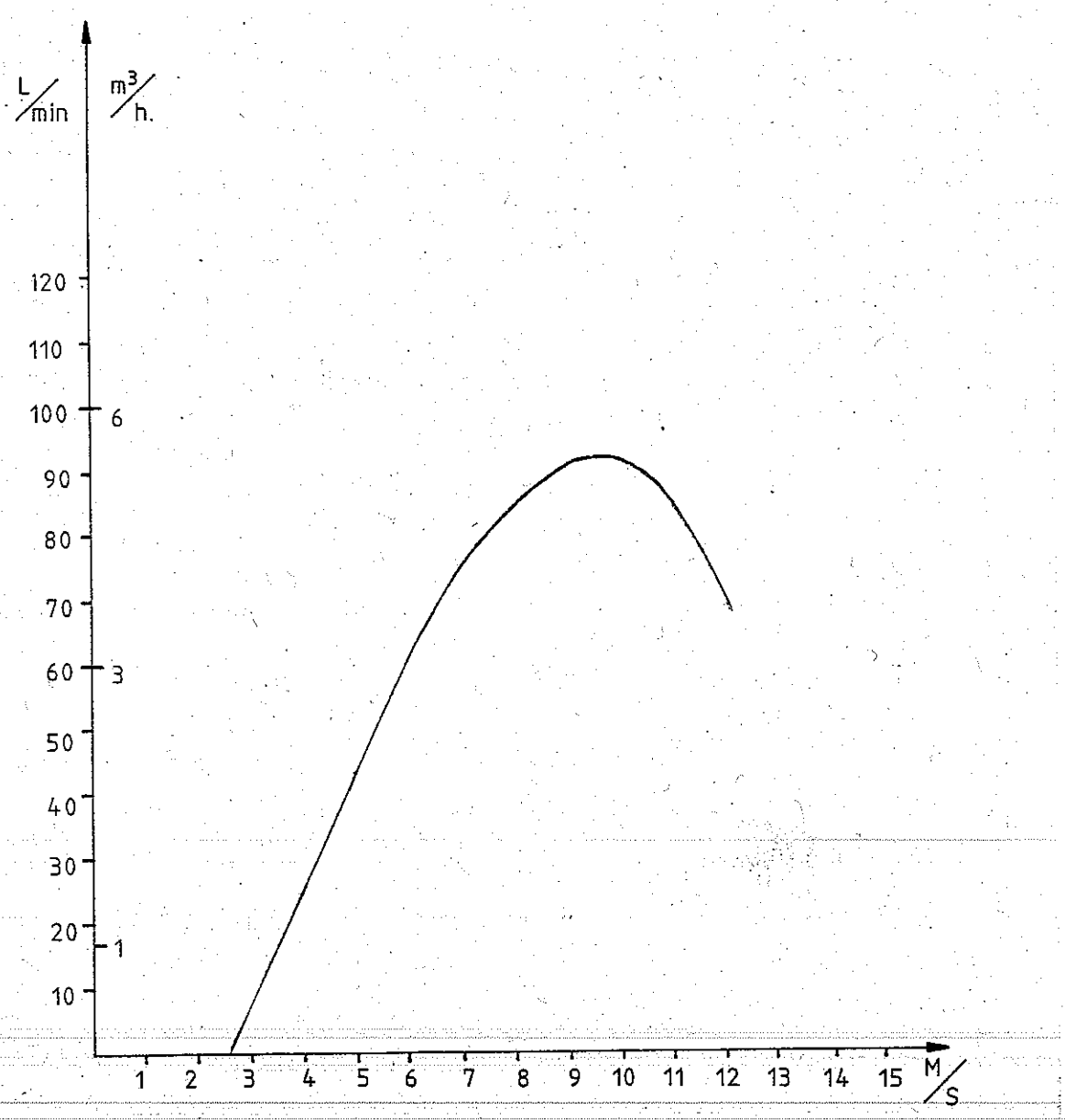


Fig. no. 4.

POWER CURVE FOR GRAIN GRINDING (MEASURED)

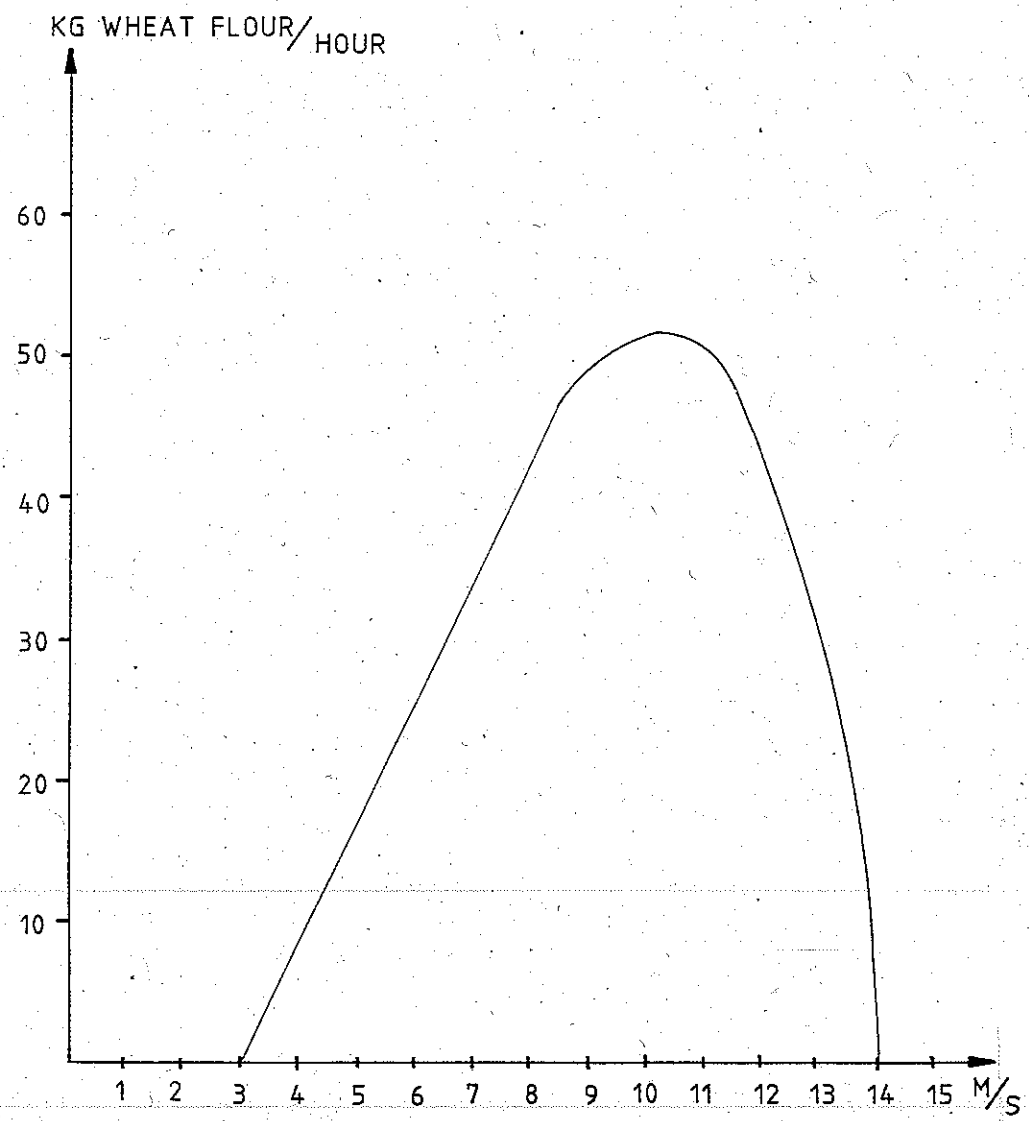
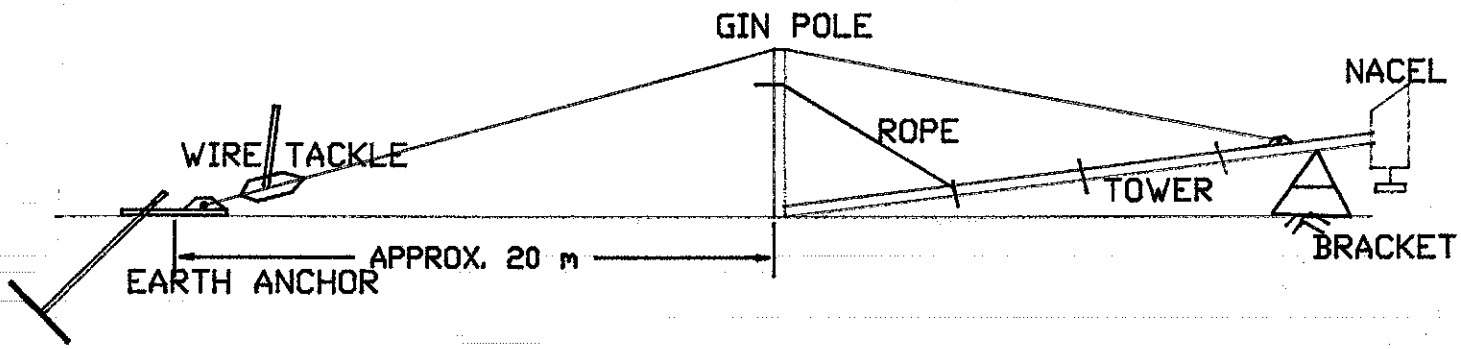


Fig no. 5.

4. Installation

In order to erect the FC 4000 tower the following materials are required:

1) Wire tackle with 35 m wire
2) Earth anchor plate for wire tackle
3) Earth anchor stay for wire tackle
4) Earth plate for wire tackle
5) Gin pole



PROCEDURE FOR ERECTING THE TOWER

Fig. no. 6

4.1 Foundation

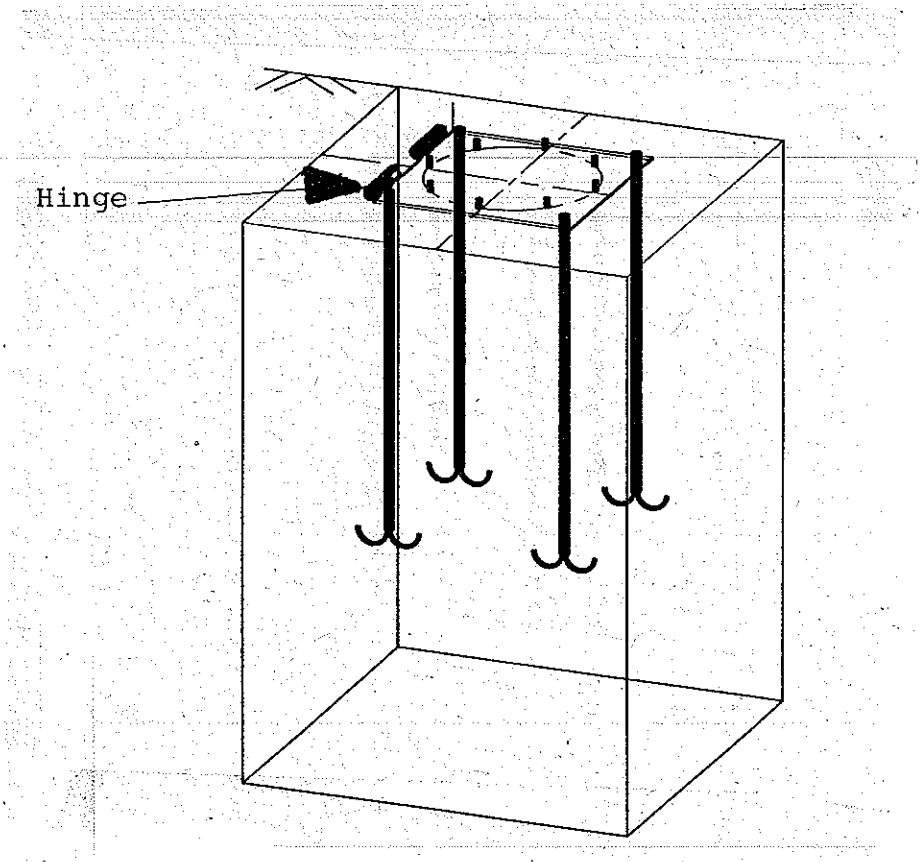


Fig. no. 7

For the foundation a pit 1.2 m x 1.2 m x 1.7 m is dug in the ground. The eight threaded rods with anchor plates at the end are fixed to the foundation plate with nuts on both sides of the plate. (The drawings show four of them). Supported by two 1.5 m long laths, the foundation plate is placed over the centre of the pit. The plate must be horizontal and the hinge which is used to erect and lower the windturbine must turn in the desired direction. Make sure that there are no houses or trees or power lines or similar obstructions in the path of the turbine when it is erected and lowered on the hinge. Fill the pit with concrete upto 0.15 m below the plate and let the con-

crete harden partly. Remove the laths and adjust the nuts so that the plate is exactly level, then fill with concrete under and upto the edges of the plate.

The tower can be assembled when the concrete is hardened. The 25 mm hinge axle is pushed into the hinge sleeves of the foundation plate and the tower base plate. The two lowest tower sections are aligned and blocked up around 0.1 m. The sections are pushed together so that it is possible to fix the eight short 12 mm bolts. The 12 mm bolts are tightened to 8.1 kpm. The two remaining sections are assembled correspondingly.

A gin pole is attached vertically to the tower foundation plate in order to support the tower while it is being erected.

4.2 Earth Anchor for wire tackle

Approximately 20 meters from the turbine foundation the earth anchor for the wire drive must be buried, leaving the stay with the hole above the ground surface.

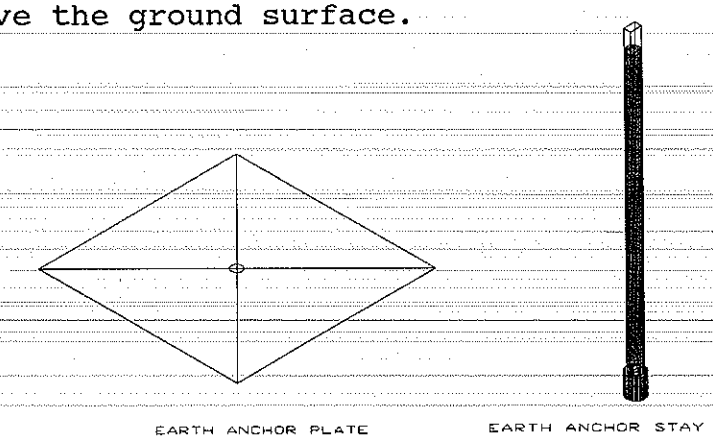


Fig. no. 8

Check the distance with the driving wire which is fastened in the eyelet below the top of the tower and then led up over the gin pole. A rope or wire attaches the gin pole to the tower thus keeping the pole in control should the wire slip during construction.

Precaution should be taken that the wire tackle is accurately aligned with the tower otherwise the gin pole will be unevenly loaded. Before erecting, check with a string fastened to the top of the tower in order to find the right place for the earth anchor.

Erect the tower without the nacel with the help of the wire tackle. (To get used to the procedure). The tower is then lowered down, the top resting on a bracket approximately 1 m above the ground.

4.3 Nacel

The machine house is mounted on the upper flange of the tower with M16 bolts (the bolts from inside the nacel and the nuts from below) and are moment tightened to 20 kpm.

The hand brake wire and the generator cable are pushed through the tower from the top and led out at the openings near the bottom. In the nacel the hand brake wire is led through the curved pipe and a wire lock is put around it, to ensure that it will not fall while the tower is being erected.

The tower with the nacel is lifted approximately half a meter from the bracket on which it is resting and a weight of approximately 50 kg is hung on the nacel in order to test the earth anchor, wire tackle and gin pole before erecting the tower. A person will be fine for this purpose.

The tower and the nacel is then erected and lowered again.

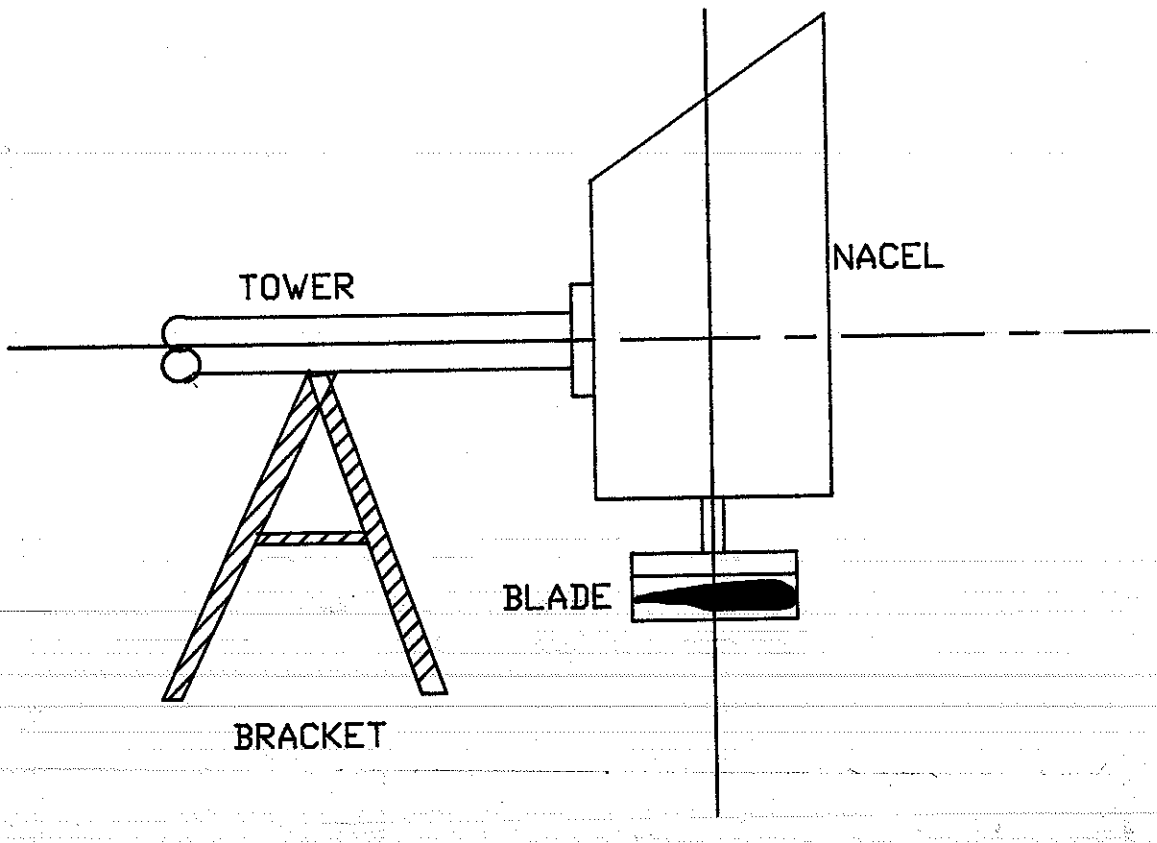


Fig. no. 10

Now the rotor is mounted on the hubflange keeping the most curved side towards the nacel. Use two of the four M16 screw bars and nuts to secure the rotor.

4.5 Air Brake

The air brake and the rotor balancing plate are mounted according to the numbers on the different parts, with the remaining 2 screw bars. Unscrew the 2 nuts that were used to secure the rotor, remount the screw bars, and moment tigthen all 4 nuts to 9 kpm.

4.6 Side vane

The side vane is mounted on the right side of the nacel. (Viewing it from the front.) The side vane plate is mounted with M 12 bolts and moment tightened to 8 kpm.

4.7 Tail vane

The tail vane is mounted with eight 12 mm bolts in the two bearing houses and is moment tightened to 8 kpm. While doing this, be sure that the long spring arm is resting against the inner side of the nacel and the tail beam against the left side of the nacel. The spring must be pre-tensioned, which is achieved when the tail vane stop is attached.

4.8 Hand brake wire

The hand brake wire is put through the holes in the tail beam and the blade spring. Two wire locks are then mounted at the

end of the wire. The other end of the wire is fastened to the winch with two wire locks at the bottom of the tower.

5. Final erecting procedure

The complete windturbine is now ready to be erected for the last and final time. The base plate and the foundation plate must be secured with nuts that are moment tightened to 8 kpm.