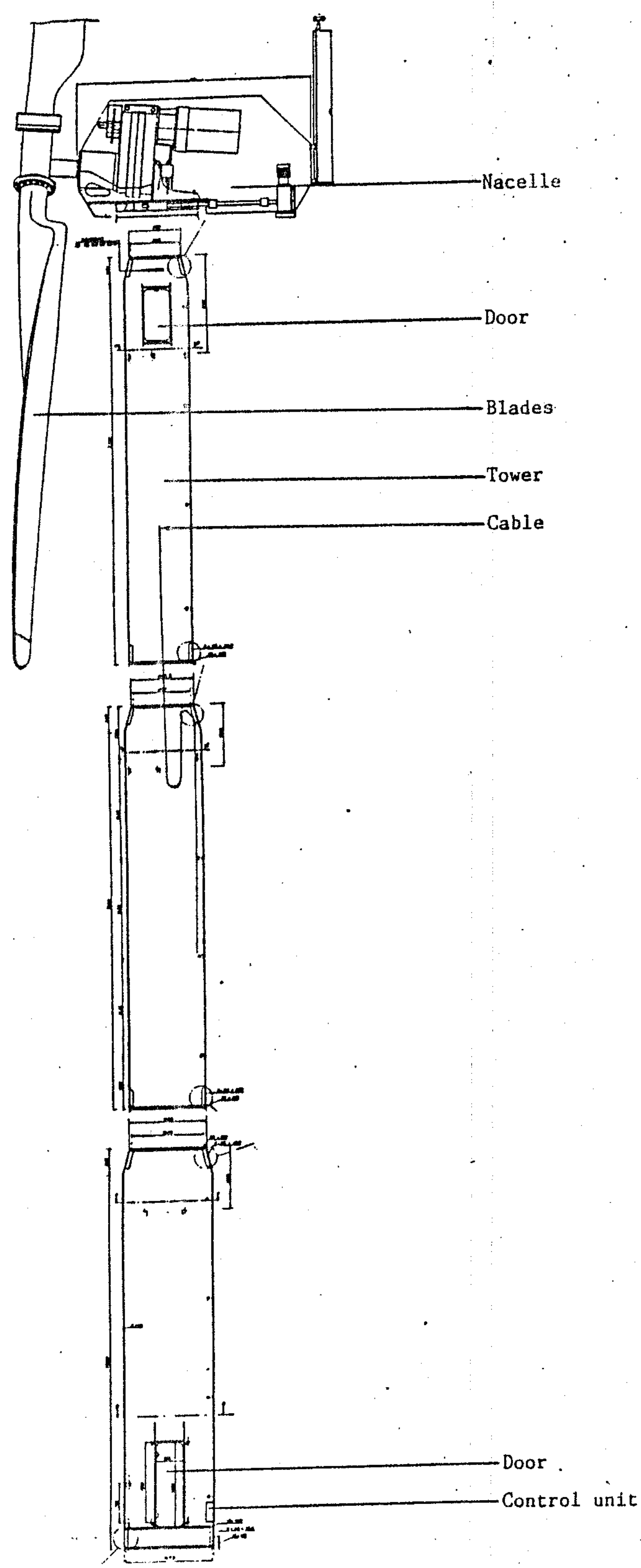
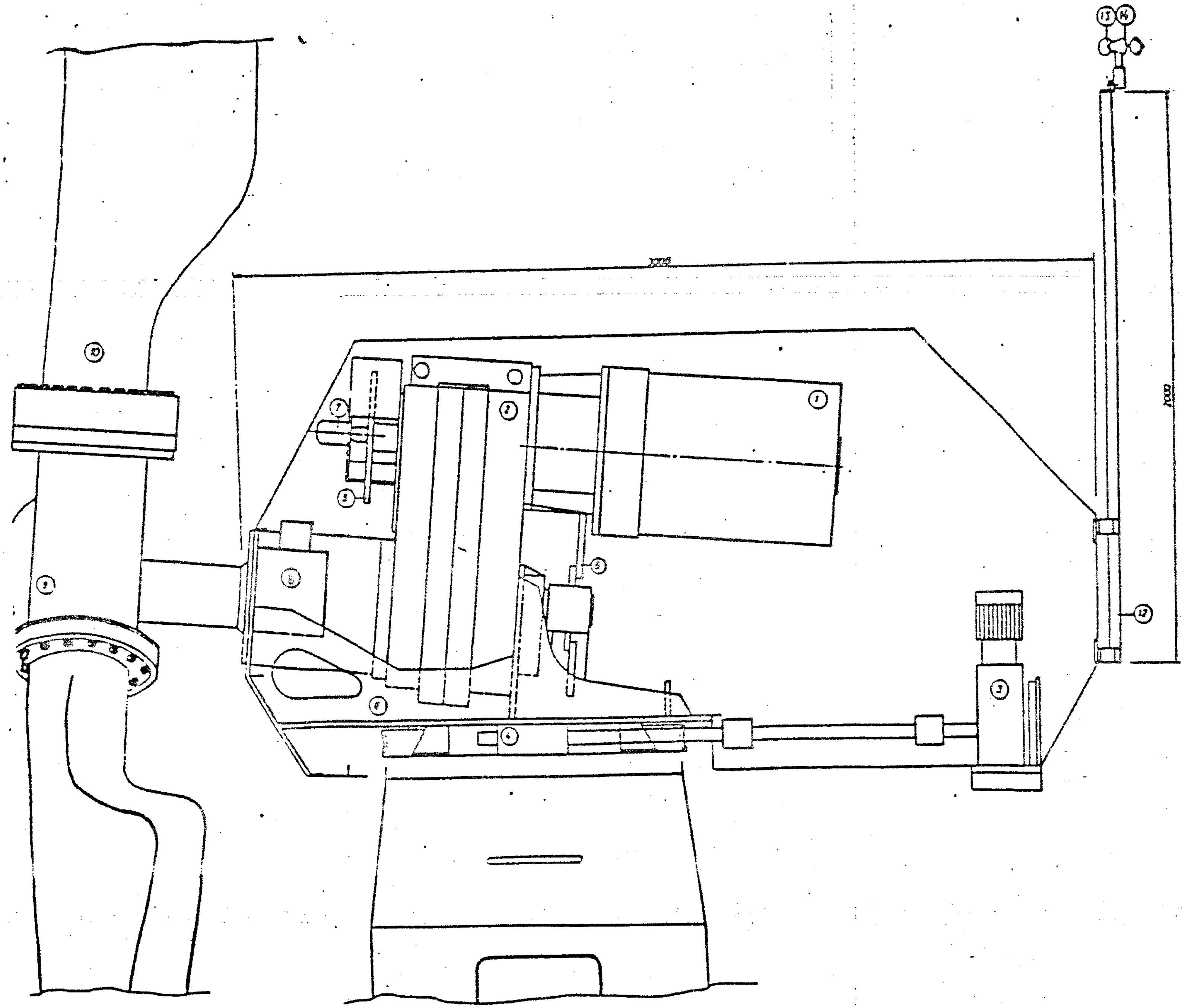
THE D 110 WINDTURBINE

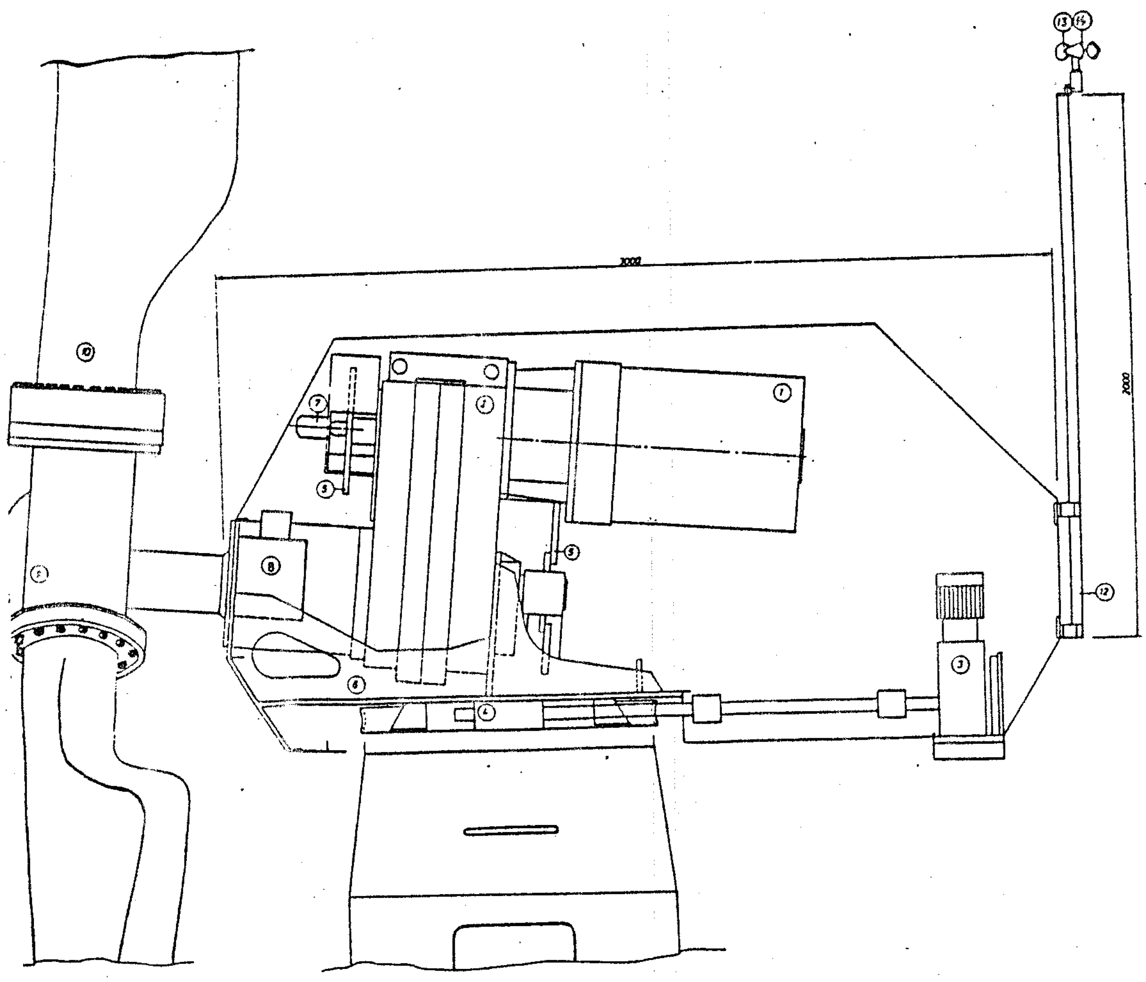


12. Stand for anemometer
13. Anemometer
14. Windvane



NACELLE DETAILS

1. Generator
2. Gearbox
3. Yaw-motor
4. Yaw-system
5. Main brake
6. Bedplate
7. Brake pump
8. Hydraulic brake unit
9. Hub
10. Blades
11. Tower
12. Stand for anemometer
13. Anemometer
14. Windvane



DESIGN.

Our engineers have based our design on well known principles with 3 fixed pitch, up-wind blades with stall regulation, asynchronous generator and electrical yawing. All rotating components are well protected by a housing made of steel plate.

DANISH WINDPOWER turbines are available with a lattice mast as well as a tube tower. All components exposed to weather are hot dip galvanized after processing and welding.

Apart from the blade tip brakes which are activated in case of run-away - the system incorporates a dual brake system one of which has a graduated effect.
The generator is with dual winding thus omitting complicated and effect wasting V-belt.

A number of features are incorporated in the DANISH WINDPOWER machines. This applies particularly to gear, yawing system and brake system.

In co-operation with a large gear factory an integrated gear system consisting of main shaft, main bearings, gear, brake taps and generator suspension was built up as one compact factory-made unit. And compact as it is, it is easily mounted and requires relatively small space in the nacelle. The gear is provided with pressure lubrication.

This specially developed gear for wind turbines was constructed in both larger and smaller variants to be used for larger and smaller types of the present wind turbine design.

The construction leaves ample room in the nacelle for inspection and maintenance of the machinery under all weather conditions. The closed nacelle protects effectively the vital machinery components against weather exposure.

Tower.

LATTICE MAST:

The lattice mast is made of angle and U-iron bolted together into a very sturdy construction.

The lattice mast is provided with an external ladder. Parallel to the ladder is a lifeline with safety catch.

In the top section the cable can twist for the first 3 metres (10 ft) below the nacelle from where it is brought down to the control panel at ground level. The cables are fastened in the corner of the tower.

TUBE TOWER:

The tube tower is made in sections of 7.8 metres (26 ft) bolted together from the inside.

Cables are connected in the same manner as on the tube tower.

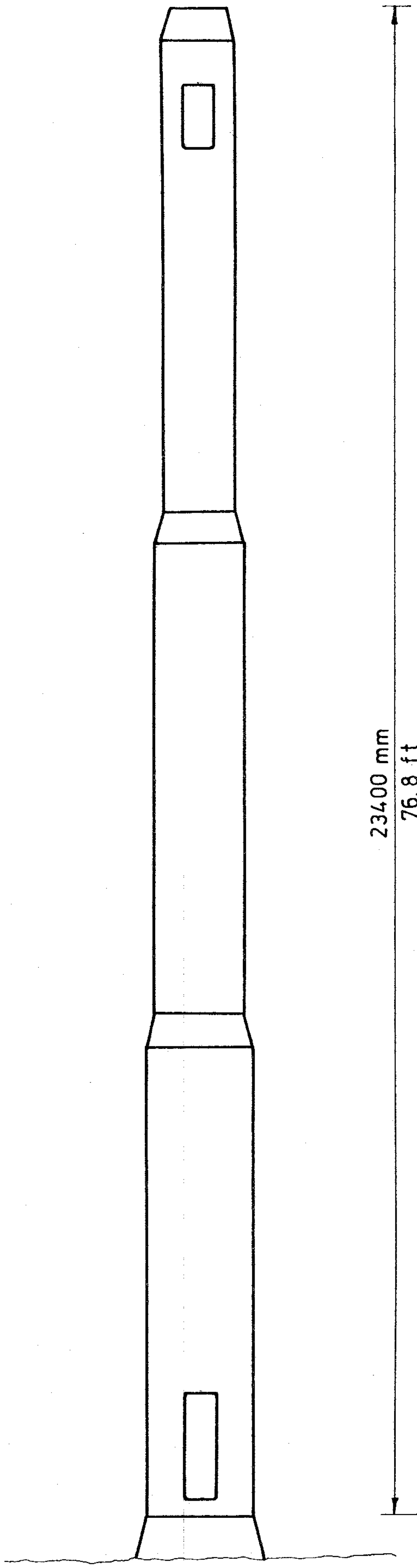
Tube tower as well as lattice tower are hot galvanized after welding.

FOUNDATION:

The foundation must be calculated individually for each place of erection with due regard to the soil conditions in question, to be examined by drill samples.

TUBE TOWER FOR 110 KW TURBINE

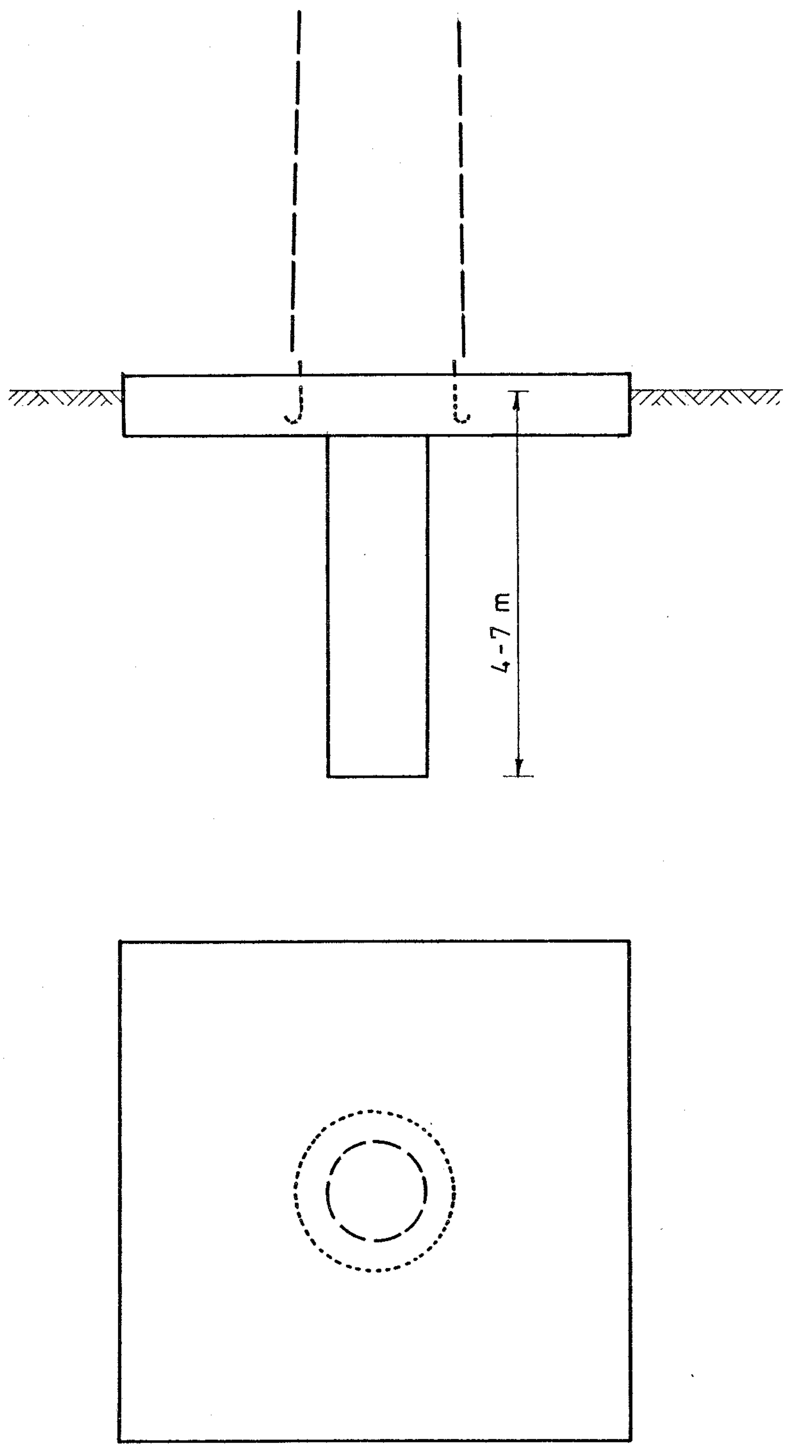
Dimensions and moments



Moment: 2135 kNm

FOUNDATION FOR 110 KW TURBINE

Tube tower



MAIN DATA FOR THE 75 KW WIND TURBINE

Performance:

Rated output	75 kW	
Rated wind speed	18 m/sec	40 mph
Max. output	85 kW	
Max. output at wind speed	22 m/sec	49 mph
Cut-in wind speed	4 m/sec	9 mph
Cut-out wind speed	30 m/sec	69 mph
Survival wind speed	66 m/sec	150 mph
Height above ground at which wind was recorded	m	ft
Est. annual production at sea level 223,000 kWh at	8 m/sec	18 mph
Est. annual production at sea level 151,000 kWh at	6 m/sec	13.2 mph

Rotor:

Overspeed control	Taco relay/blade tip brakes	
Rotor rpm	55 rpm	
Rotor diameter	15.3 m	50 ft
Rotor swept area	184 sqm	1980 sqft
No. of blades	3	
Manufacture of blades	Aerostar	
Blade profile	NACA 44 series	
Blade construction	Fibre glass reinforced polyester	
Pitch control	Fixed pitch	
Blade twist	8.4 degrees	

Generator:

Manufacture	Brown Boveri (BBC)	
Type	Induction, three-phase	6/8 pole
RPM	1200/900 rpm	
Voltage	3 x 480 volts	
Rating	75 kW	
Frequency	60 Hz	
Power factor	0,90	

Tower:

Total height	23.5 m	77 ft
Hub height	24 m	78,7 ft
Type	Lattice or tubular	

Transmission:

Gearbox manufacture	Kumera
Gearbox type	SCM 2315
Gearbox ratio	1:22.5
Gearbox rating	165 kW

Weights: (approx.)

Tower lattice	5,300 kg	11,700 lbs
Tower Tube	6,500 kg	14,300 lbs
Nacelle	5,800 kg	12,700 lbs
Rotor	1,700 kg	3,750 lbs
Total weight lattice tower	12,800 kg	28,000 lbs
Total weight tube tower	14,000 kg	30,800 lbs

MAIN DATA FOR THE 110 KW WIND TURBINE

Performance:

Rated output	110 kW	
Rated wind speed	15 m/sec	34 mph
Max. output	115 kW	
Max. output at wind speed	18 m/sec	40 mph
Cut-in wind speed	4 m/sec	9 mph
Cut-out wind speed	30 m/sec	67 mph
Survival wind speed	66 m/sec	150 mph
Height above ground at which wind was recorded	m	ft
Est. annual production at sea level 349,000 kWh at	8 m/sec	18 mph
Est. annual production at sea level 215,000 kWh at	6 m/sec	13,2 mph

Rotor:

Overspeed control	Taco relay/blade tip brakes	
Rotor rpm	45 rpm	
Rotor diameter	19.2 m	63 ft
Rotor swept area	289 sqm	3115 sqft
No. of blades	3	
Manufacture of blades	Aerostar	
Blade profile	NACA 44 series	
Blade construction	Fibre glass reinforced polyester	
Pitch control	Fixed pitch	
Blade twist	16 degrees	

Generator:

Manufacture	Brown Boveri (BBC)	
Type	Induction, three-phase	6/8 pole
RPM	1200/900 rpm	
Voltage	3 x 480 volts	
Rating	110 kW	
Frequency	60 Hz	
Power factor	0.905	

Tower:

Total height	23.5 m	77 ft
Hub height	24 m	78.7 ft
Type	Lattice or tubular	

Transmission:

Gearbox manufacture	Kumera
Gearbox type	SMC 2320
Gearbox ratio	1:27
Gearbox rating	180 kW

Weights: (approx.)

Tower lattice	6,400 kg	14,100 lbs
Tower Tube	8,200 kg	18,000 lbs
Nacelle	6,300 kg	13,800 lbs
Rotor	2,600 kg	5,700 lbs
Total weight lattice tower	15,300 kg	33.600 lbs
Total weight tube tower	17,100 kg	37,500 lbs

MAIN GEAR BOX - GENERATOR:

The gear is supplied with pressure lubrication and a filtering system to extend time between oil changes to a maximum and to increase life time of gear. The lubrication pump is fitted on the gear and flow of oil is continuously monitored. A dual hydraulic pump for the brakes is mounted on the frontal outgoing shaft.

The generator is mounted on a flange which is part of the gear unit. The flange is standard IEC. Between gear and generator is an elastic coupling.

The generator is a two-speed 6/8 poled generator meaning there are no V-belts to be aligned or replaced.

The electrical switch from low generator speed to high speed or reverse is controlled by a specially developed electric monitoring system providing a smooth change-over at cut-in of generator. The generator is ventilated with exhaust at the rear end of the nacelle.

Main shaft, main bearings, gear, generator suspension, shaft for slow brake and shaft for generator brake are all part of the gear unit.

The use of this gear unit simplifies assembly as there are only two supporting points for the rotary machine.

The gear unit is similar to a type which has been in use for many year for paper machines, stirring devices etc. All bearings are spherical roller gearings. Main shaft diameter is 240 mm (9.5 inch.) and it is supported by two main bearings of which the rear main bearing absorbs the axial thrust.

Gear-wheels on the main shaft are specially ground in a way that even heavy deflection of the shaft cannot cause pitting, i.e. metallic seizing/friction between gear-wheels.

Gear-wheels are made with an especially low-noise tooth profile and all gear-wheels are cut, hardened and ground on advanced machinery.

The gear casing is of cast iron. Welded parts are annealed before processing.

The use of industrially assembled units ensures that all adjustments are made during factory assembly.

KUMERA OY, Finland.

Kumera is one of the leading power transmission manufacturers in Europe and located in Finland.

Kumera has a fairly broad product range, which includes helical and bevel gear units, worm gear units, geared motors, shaft-mounted gear units, marine gear units, drive axles for off-road vehicles, shaft couplings, and electrical motors. Their subsidiary in Norway, Norgear A/S, is the Norwegian leader in power transmissions for marine applications. Norgear also makes jacking systems for aluminium smelters. Another subsidiary is Peiron oy in Kokemæki, Finland. Peiron is a foundry which produces iron and steel castings. Their cumex couplings are also made at Peiron. In Zurich, Switzerland they have a sales office, Kumera AG, which handles a large volume of european sales.. Altogether Kumera has about 400 employees and a annual turnover of approx. 100 million Finn Mark (US $ 16 million)

YAWING SYSTEM:

The yawing system is a very sturdy construction featuring a worm gear instead of cheaper systems using toothed gear.

The yawing system consists of the following parts:

1. External yaw ring bolted to tower.
2. Internal yaw ring bolted to nacelle.
3. Friction shoes, acting as friction brakes.
4. Worm with gear motor.

The external yaw ring is wormed on the outside and has an inner conical shape. The top side serves as slide face for friction shoes.

The internal yaw ring is conical on the outside and slides up towards the external yaw ring.

Friction shoes are made of square pipes, slide shoes are made of nylon and clamping bolts. The friction shoes carry the fully load of the nacelle and press the conical faces of external and internal rings against each other. A frictional force between tower and nacelle is thus established which serves to keep the nacelle steady without jolting movements under all normal operational conditions. This method therefore always secures yawing at full momentum.

The worm is operated by a two-stage worm reduction gear motor with a hollow shaft.

SAFETY SYSTEMS AND BRAKES.

Stall regulated wind turbines should be provided with 2 brake systems of which one must be based on air forces. The mechanical brake must be of the fail-safe type.

The wind turbines are provided with air brakes in blade tips and 2 mechanical brakes at main shafts and generator shafts respectively. Brakes are operated by 2 independent hydraulic circuits.

Both hydraulic brakes are activated simultaneously in every brake situation, whenever it is a normal stop or a stop because of failure.

1) Each blade tip is provided with rotary air brakes that are activated by centrifugal force at overspeeds.

2) The brake on the rotor shaft is made to absorb the flywheel effect and a smaller part of the driving power - in all approximately 40 percent of the necessary brake force. It further operates as a parking brake.

   The brake is a disc brake with 2 calibers. The calibers are made of cast iron and are operated by a hydraulic station.

3) By way of a special valve system the brake on the generator shaft has a graduated braking effect.
   At braking signal the brake is activated to full power which drops to zero concurrently with the rotor revolutions. Thus the violent effects are eliminated which a non-graduated brake asserts during the final phase of braking where it still operates with full braking power. This brake is also a disc brake with 1 caliber, activated by oil pressure from a hydraulic pump that is operated by a special shaft on the gear box.

HYDRAULIC SYSTEM

Disc brake on main shaft

The hydraulic system operating the calibers is built up around a pumping station and a valve block.
At start-up of the wind turbine, voltage is applied to the magnetic valve which closes the feed-back flow.

During braking, the current to the magnetic valve is cut off whereby pressure is generated in the braking system and the wind turbine brakes.
The system is further provided with suction filter, non-return valve, and manometer.

Brake on generator shaft

The disc brake on the power shaft is activated by a hydraulic system based on a valve block and a pump, operated by the wind turbine via the power shaft.

At start, voltage is applied to magnetic valve which opens and admits free oil flow into circuit through the system without applying pressure on the braking caliber.

During braking the valve is closed by electricity-cut-off whereby an immediate pressure is built-up in the caliber. The brake pressure force is determined by an adjustable escape valve. An adjustable throttle valve provides for the brake pressure to drop concurrently with the drop of the wind turbine's revolutions. The system includes oil container with suction filter and manometer.

Brakes are activated (emergency stop):
Manually by pressing button (at ground level or in nacelle).

If the brake pads are worn, the wind turbine cannot re-start.

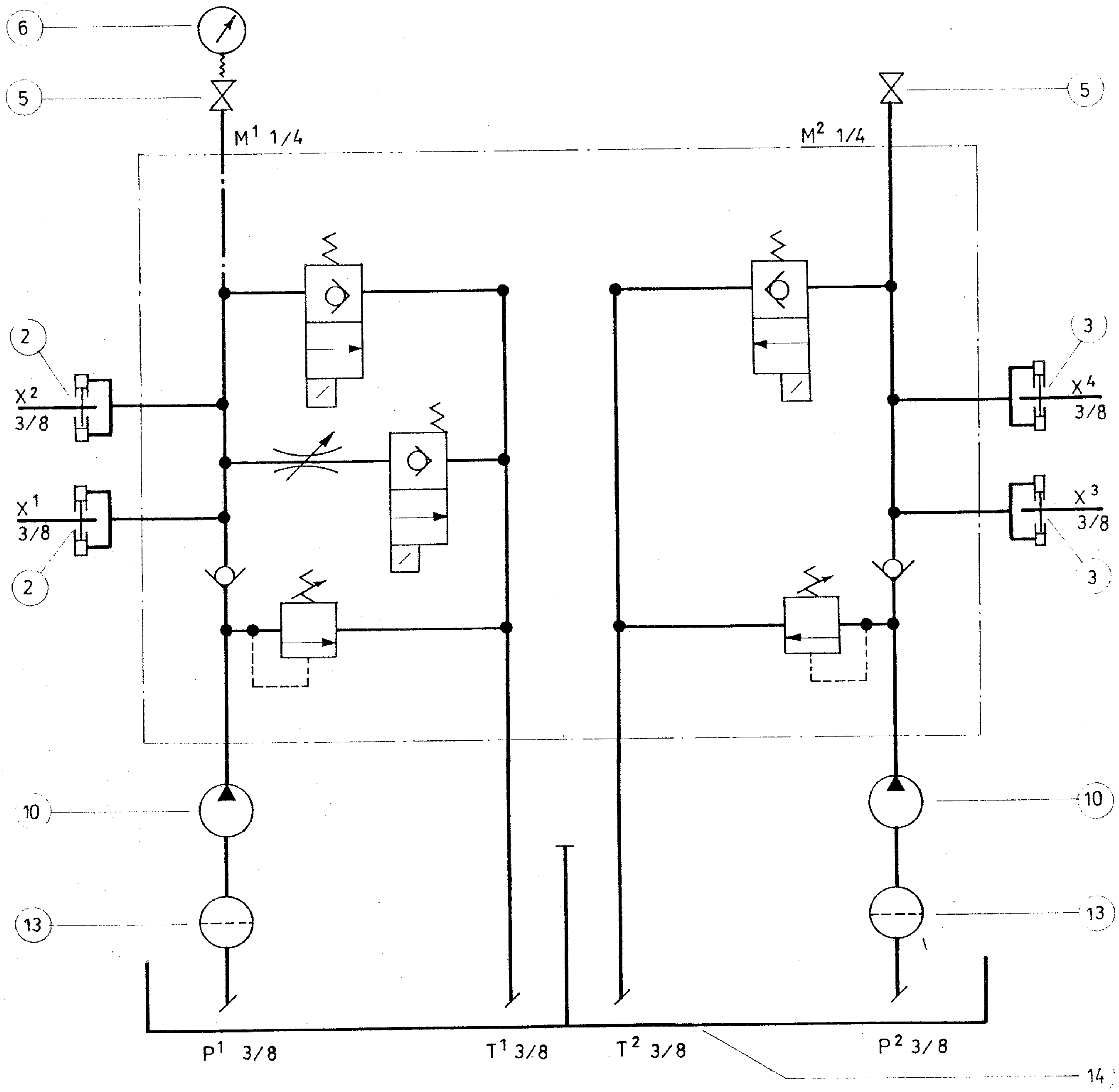
Apart from above, a number of other warning devices are described in the section on control.

Pos	Nos.	Description	Type no.
1.	1.	Magnet valve	DGV4-3-2B-U-x-10-S300
2.	1.	Brake calipers Brembo	20.2846.30
3.	2.	- - -	20.2802.30
4.	1.	Needle valve, adjustable	ELN 25 S
5.	4.	Stop valve	GI 1486 1/4"
6.	2.	Manometer	G 63 - 160
7.	1.	Safety valve	VLP 4858
8.	1.	- - Sterling	A5A25N + 1-0080A
9.	2.	One-way valve	KV10-L
10.	1.	Dual pump	1/ISP 1.2 N
10a	1	Coupling, Sitex	3.5/28 25 mm
11.	2	Vacuummeter, optional	G 63 - -1
12.	2.	Suction filter	FBO-FL 50/3
13.	1.	Reservoir	10 L.
13a.	1.	Filling	1380-40
13b.	1.	Fluid level indicator	1315
	10 liters	Hydraulic fluid	ESSO MUTO HP 32

HYDRAULIC SYSTEM

GRADUATED BRAKE

MAIN BRAKE



BASE PLATE/CHASSIS

The base plate is a welded chassis frame for the machinery which is bolted within a plate area of 60 x 50 inch. This means considerable concentration of forces to be absorbed by the base plate.

Forces from base plate to tower are transmitted by means of the internal yaw ring as well as 4 friction shoes.

Base plate with front plate and consoles support the gear via two suspensions.

Rear console absorbs axial and radial forces and fixes the gear position to front plate.

On the base plate is also a console for the main brake.

The nacelle is in two parts of which the lower part is bolted to the base plate. The top part is hinged. A platform is mounted to the nacelle side.

ERECTION, START-UP, SERVICE AND MAINTENANCE.

Erection and start-up:

The wind turbines will arrive on site in standard shipping containers - in principle one complete machine in one container, usually a 40 ft container.

Well ahead of the arrival of the container the necessary flanges or templates and bolts will be shipped enabling foundations to be poured in due time to prevent delay in erection.

The following estimate can be used as a guideline for planning purposes:

	man/hours	crane/hours
Un-loading container	6	2
Assembly of lattice tower	16	4
Assembly of tube tower	9	3
Assembly of rotor with nacelle	9	3
Assembly of nacelle to tower	6	2
Erection of total machine	6	2
Connection of electronics	5	
Connection of electrics	4	
Test running	3	

Usually our engineers will be supervising the installation and the start-up.

A working team will consist of 4 or 5 persons as follows:

1 mechanical engineer
1 electronic engineer
2 skilled workers and
1 crane operator.

This crew will usually be able to assemble and erect 1 machine per day provided that the team can work continuously with the assembly of several machines at a time. Furthermore the foundation and cable work must be ready and the components must be unloaded and ready for assembly. The team has at it's disposal a truck including necessary tools, excluding air compressor and crane.

Service and maintenance:

Estimated annual service and maintenance on the machines:
The total time consumption per machine/year will be 25-40 hours.
The total costs of service and maintenance as well as monitoring including labor, parts, etc. (direct or indirect) will be 2-4% of capital cost of wind turbines.

Service organization:

The service organization is based at the headquarter in Tehachapi, California from where the main service team is operating. The service organization is constantly undergoing development in order to cope with increasing demands in new areas of operation.

Personnel:

The service personnel are qualified engineers and technicians who have undergone comprehensive training at our factory and service facilities.

Equipment:

Each service team has at it's disposal fully equipped cars and trucks containing welding equipment, light machines, electric tools and other hand tools, winches as well as a stock of spare parts.
This will secure that any break-down or service will result in minimum of down-time for the machines.

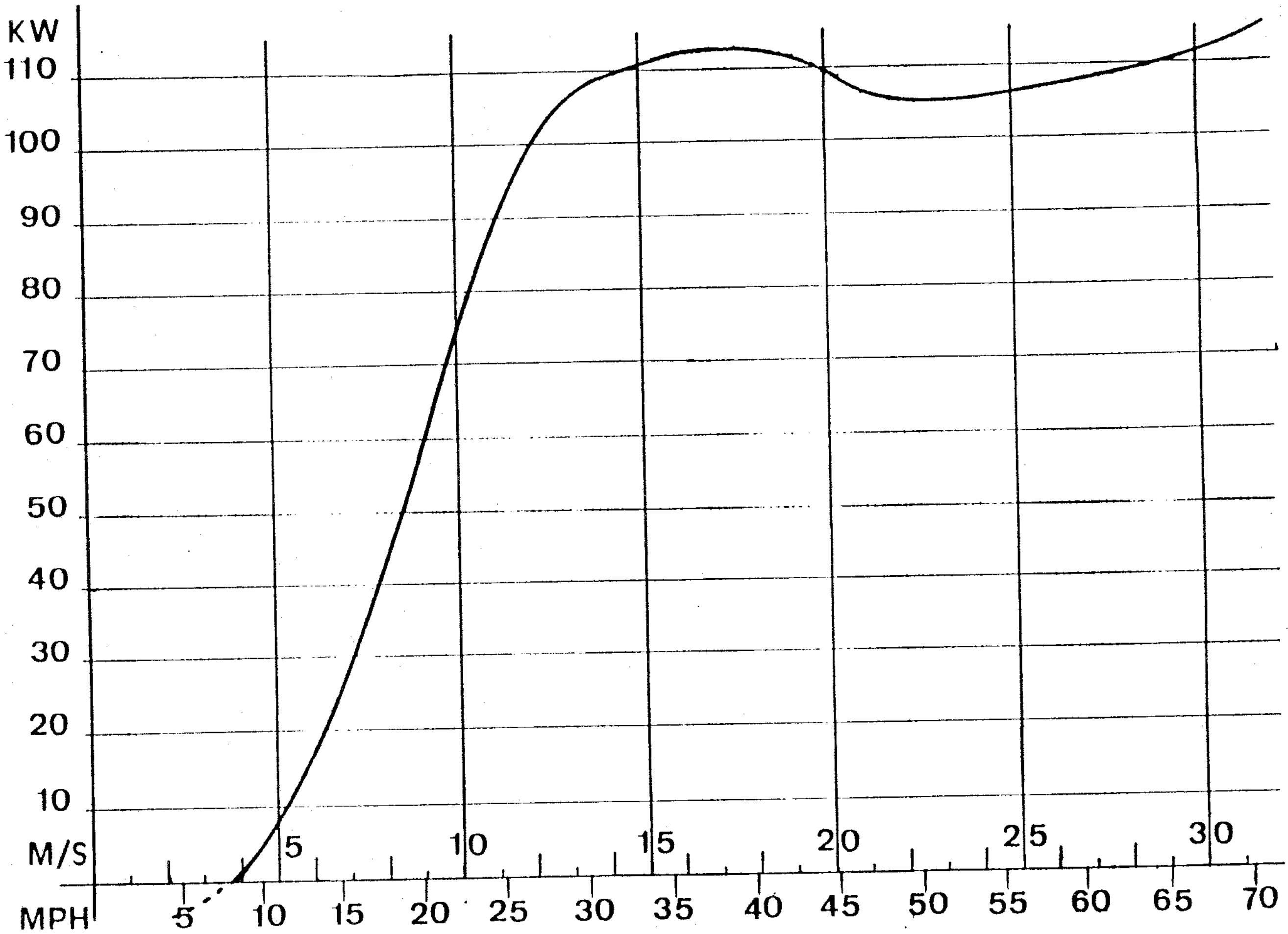
Spare parts:

Additional to the spare parts with the service team a main spare part stock is available at the headquarters in Tehachapi. This is further supplemented by the factory in Denmark as well as our sub-suppliers.

Service from sub-suppliers:

The suppliers of the main components like gearboxes, generators control system and blades have similar facilities in the US.
Together with our general 5-year guarantee from sub-suppliers this will secure a 100 per cent follow-up after-sales service.

110 KW WIND TURBINE

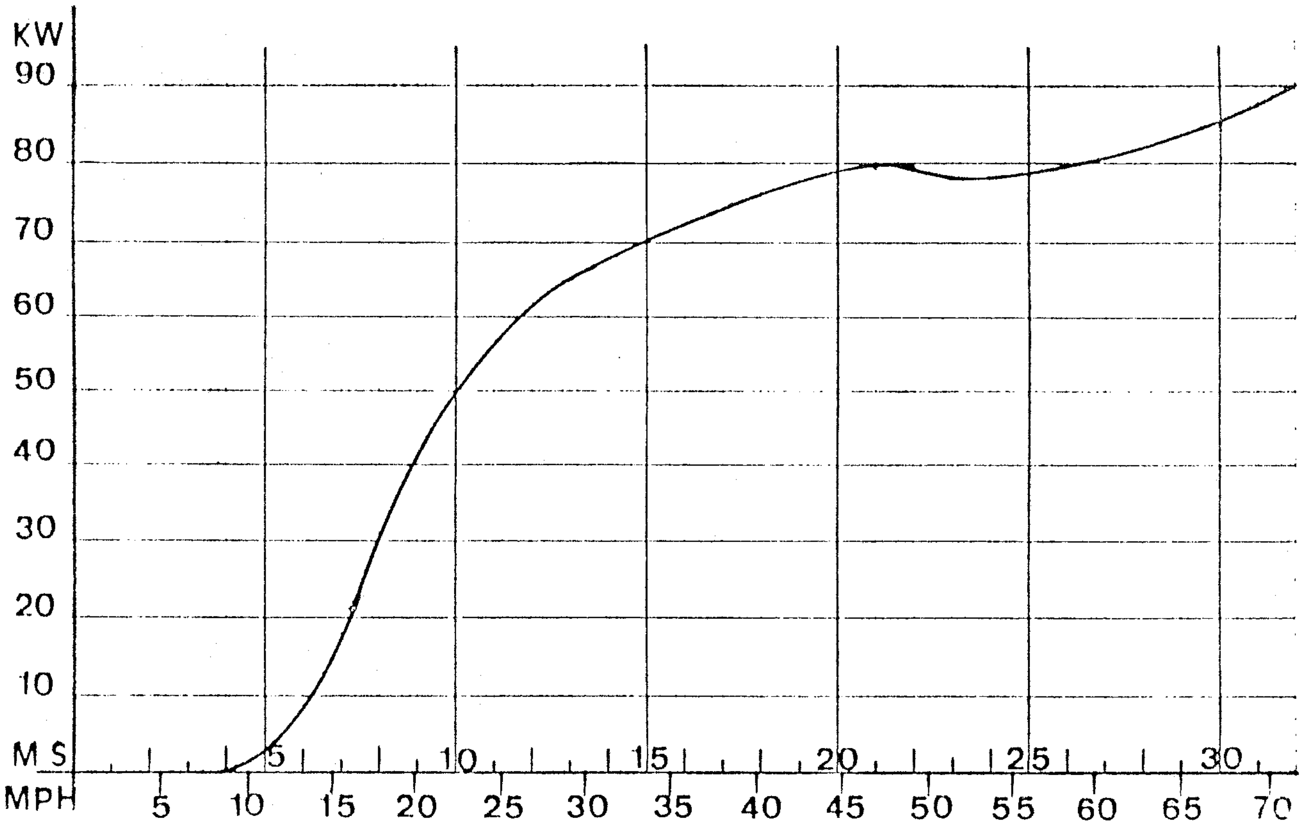


POWERCURVE

Calculated for standard atmospheric conditions at sea level

45 r.p.m.

75 KW WIND TURBINE



POWERCURVE

Calculated for standard atmospheric conditions at sea level