

Vertical Axis Wind Turbines  
With a Capacity of More Than 40 MW

# Vertical Axis

## Wind Turbines With a Capacity of More Than 40 MW



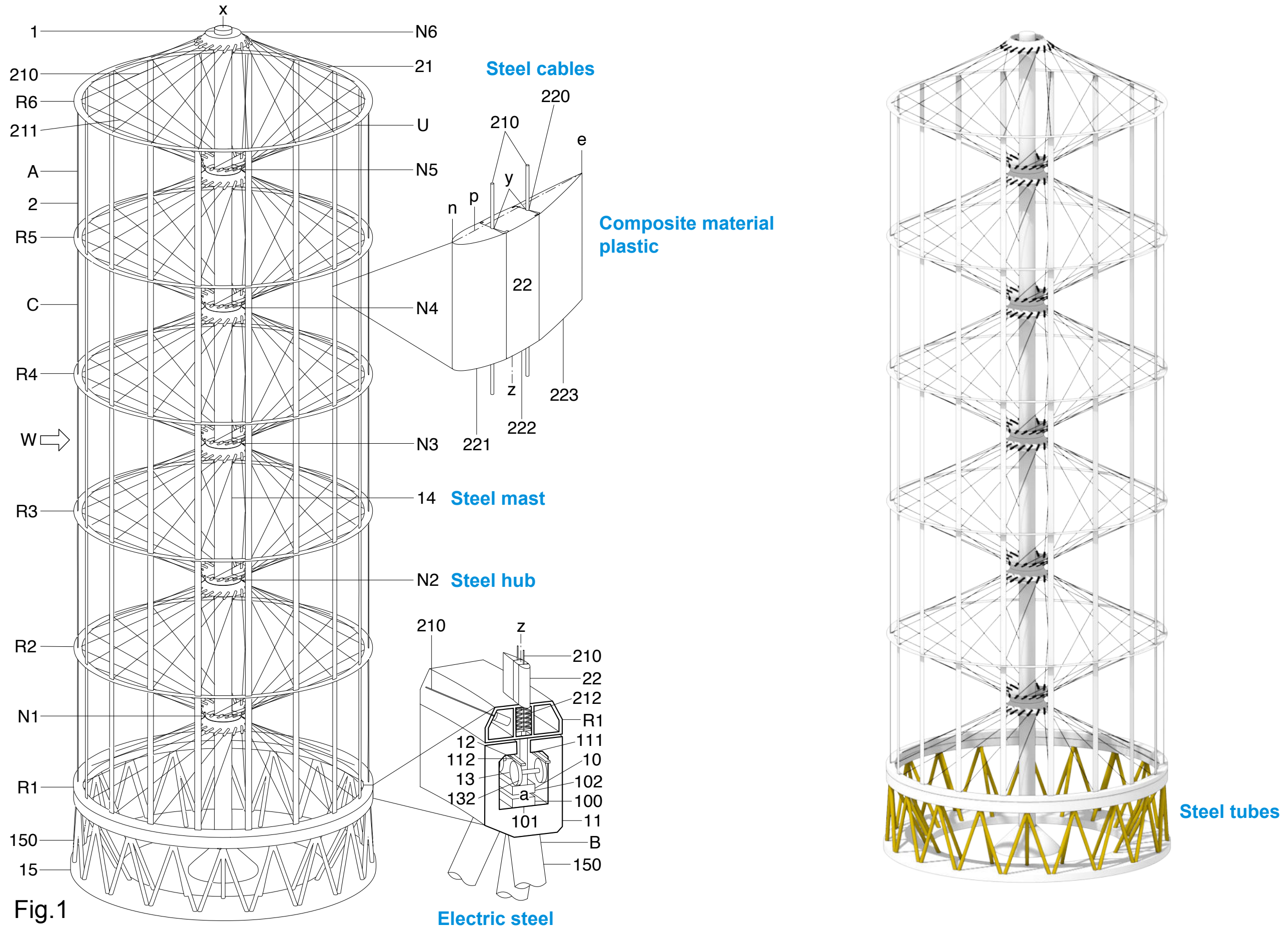
### Content

Different Designs of VAWTs  
(Pages 3 to 29)

Comparison to State of the Art Turbine  
(Pages 29 to 30)



... introducing a rotating cable-stayed mast as a VAWT ...



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... the asymmetrical airfoil produces a third more lift than a symmetrical airfoil ...

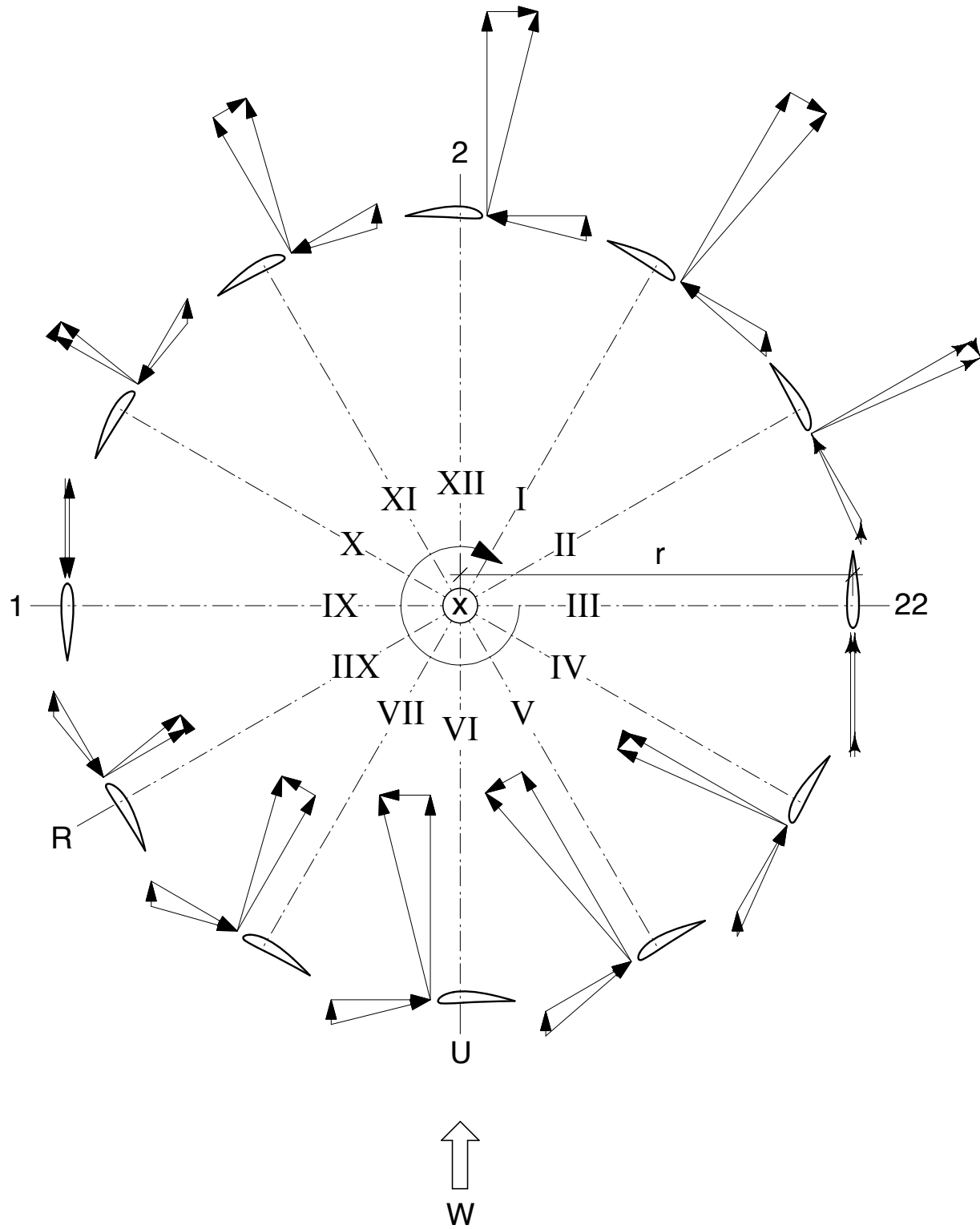


Fig.3 **Beaufort-Scala 4 - 6**

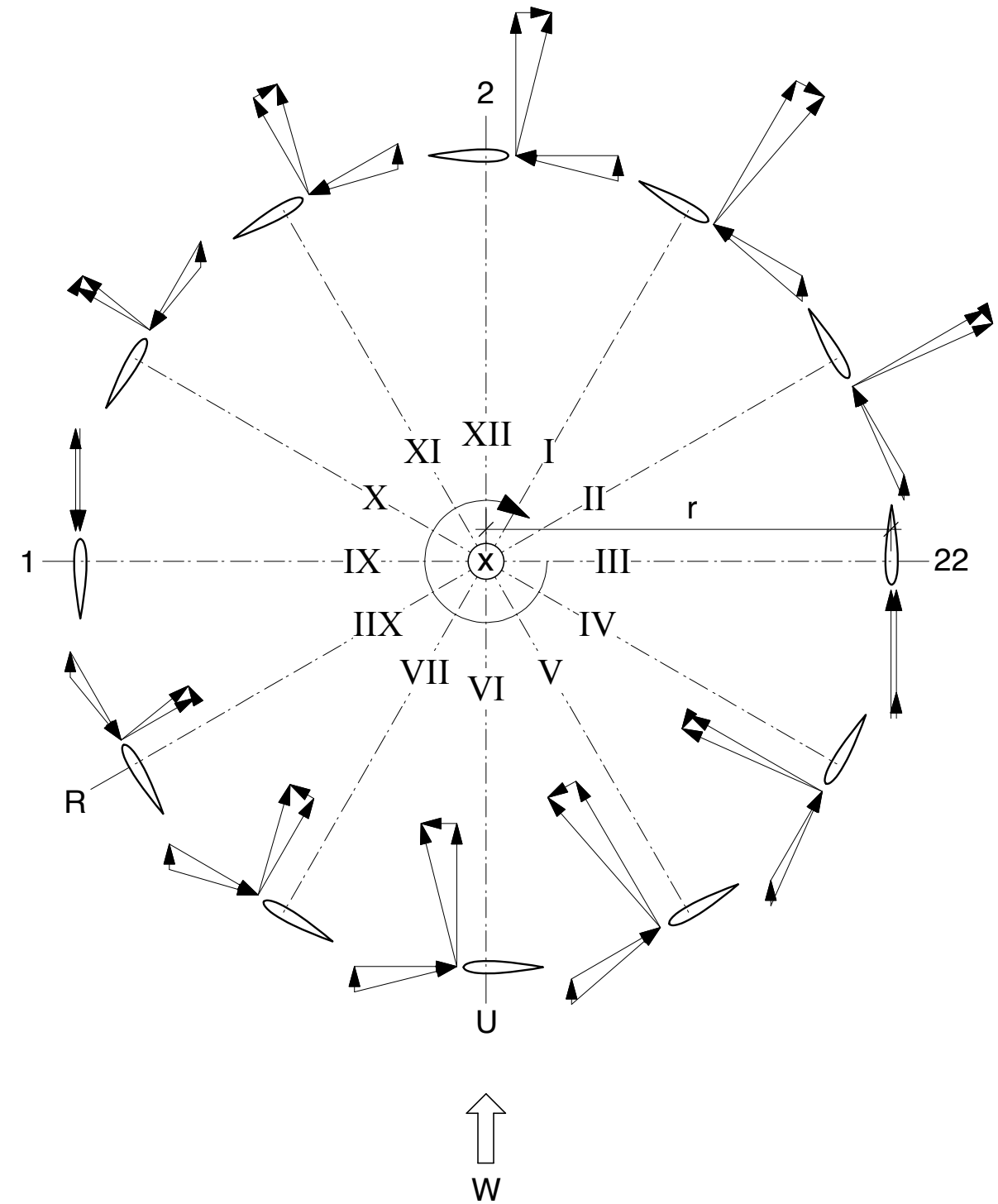
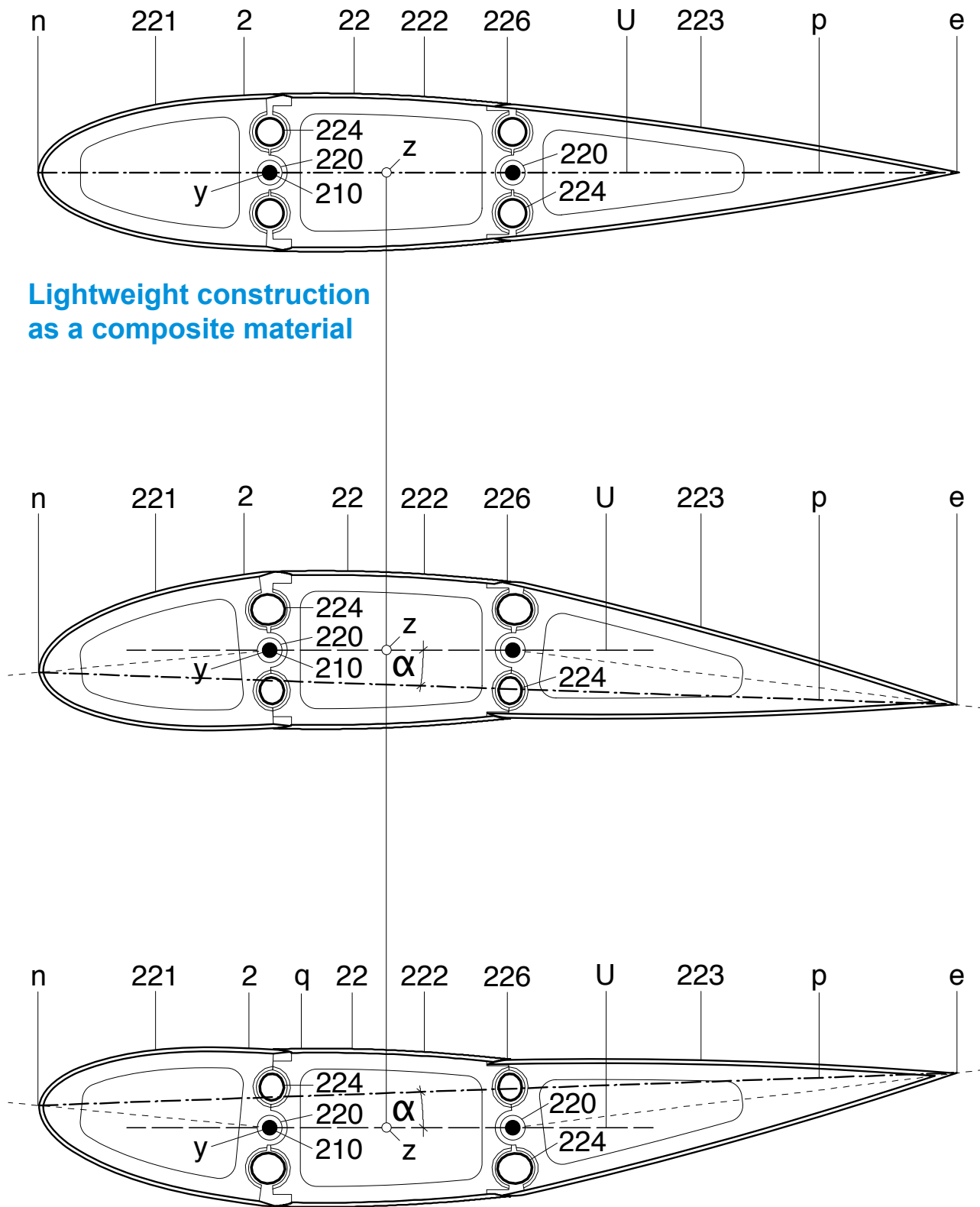


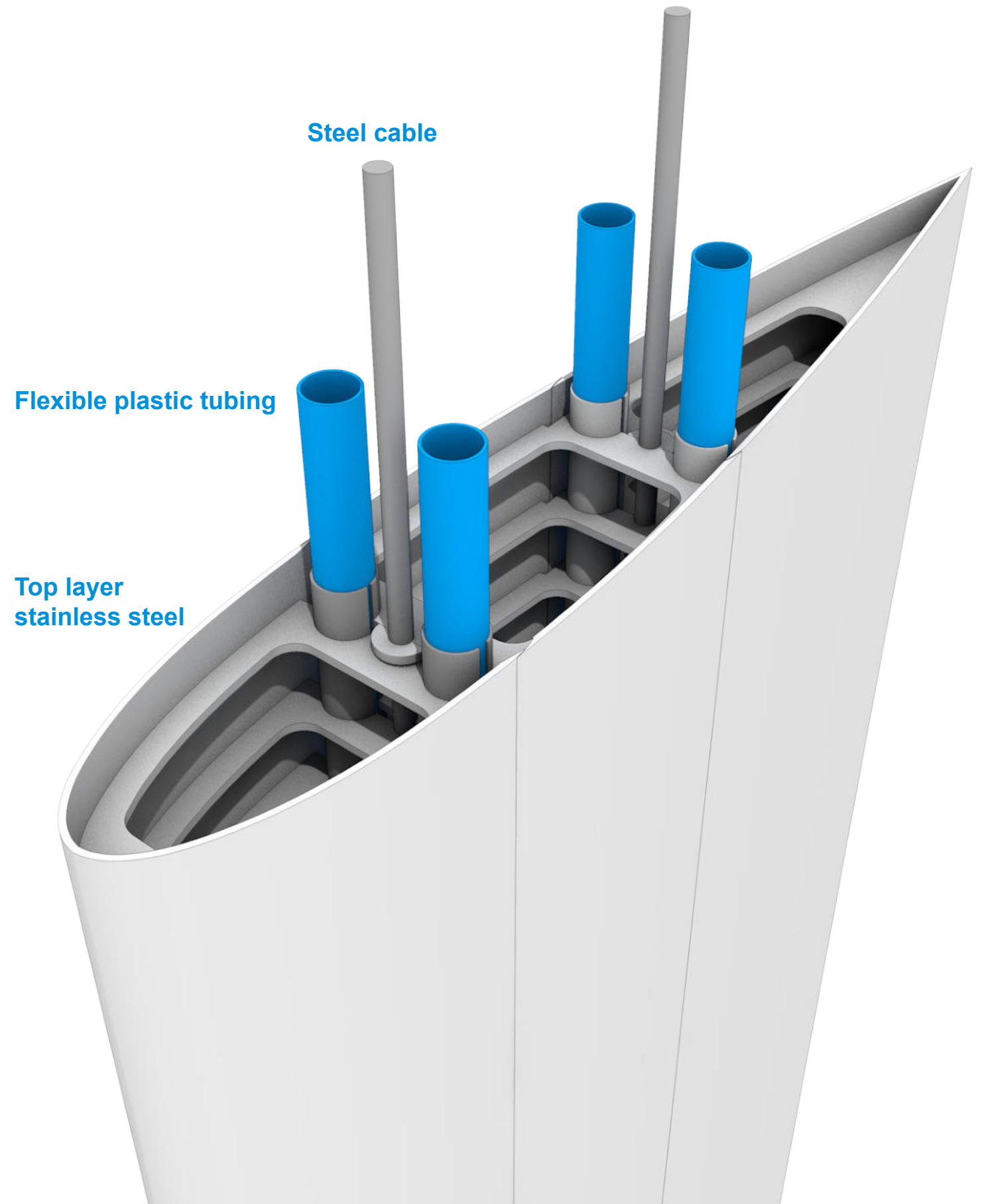
Fig.4 **Beaufort-Scala 7 - 9**



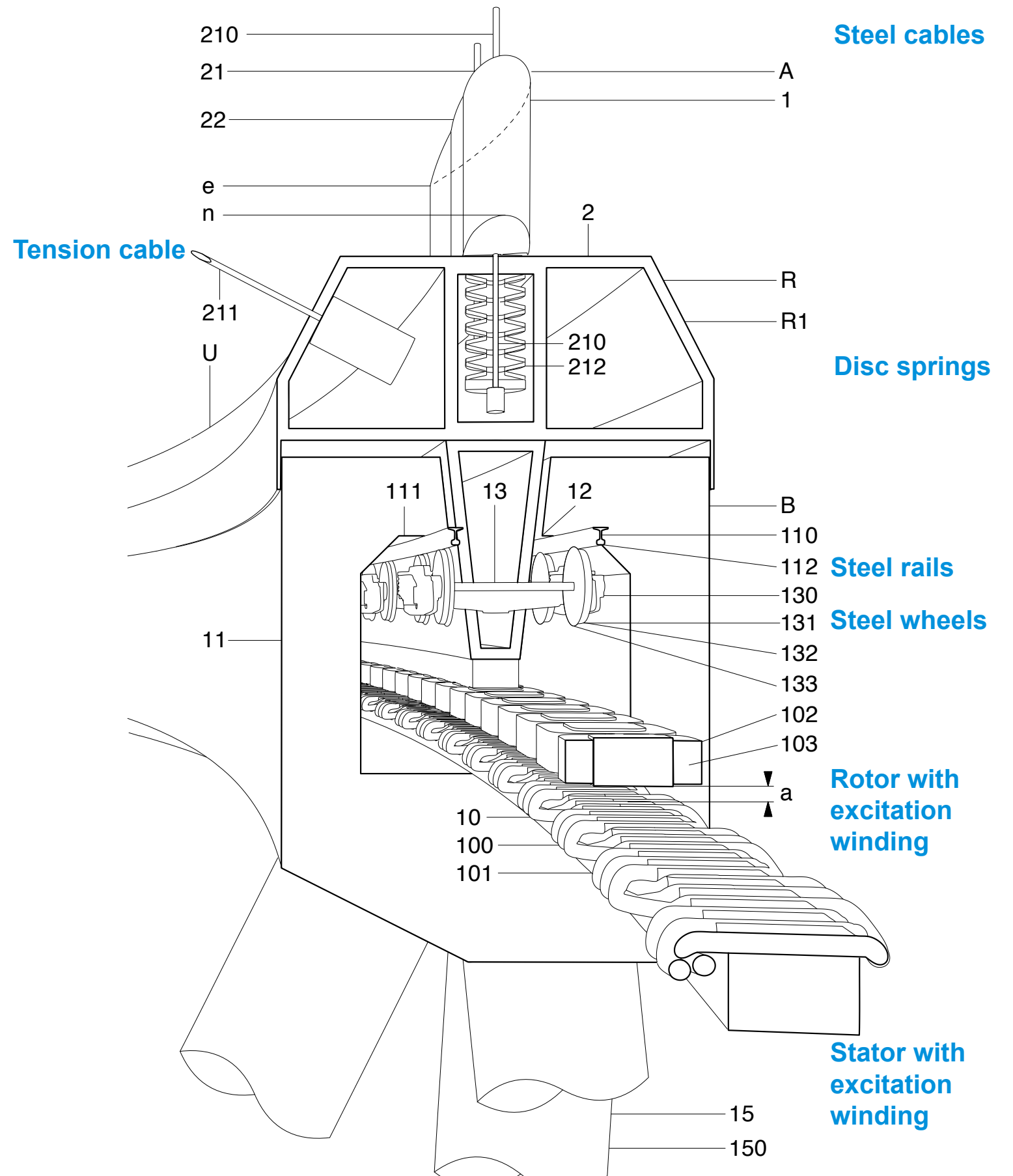
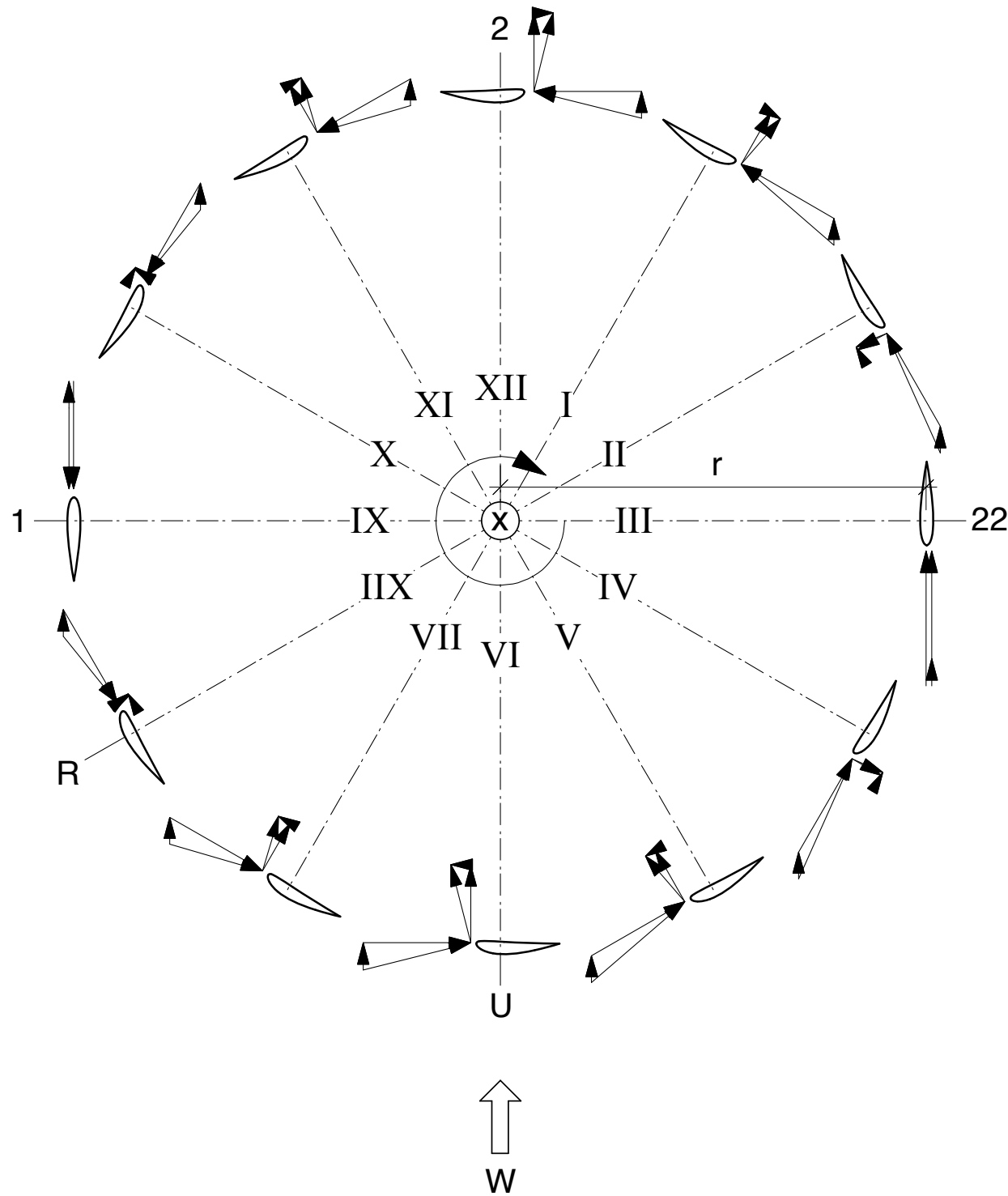
... four inflatable tubes are used as pneumatic actuators to move the suction side of the variable blade profile...



Lightweight construction as a composite material



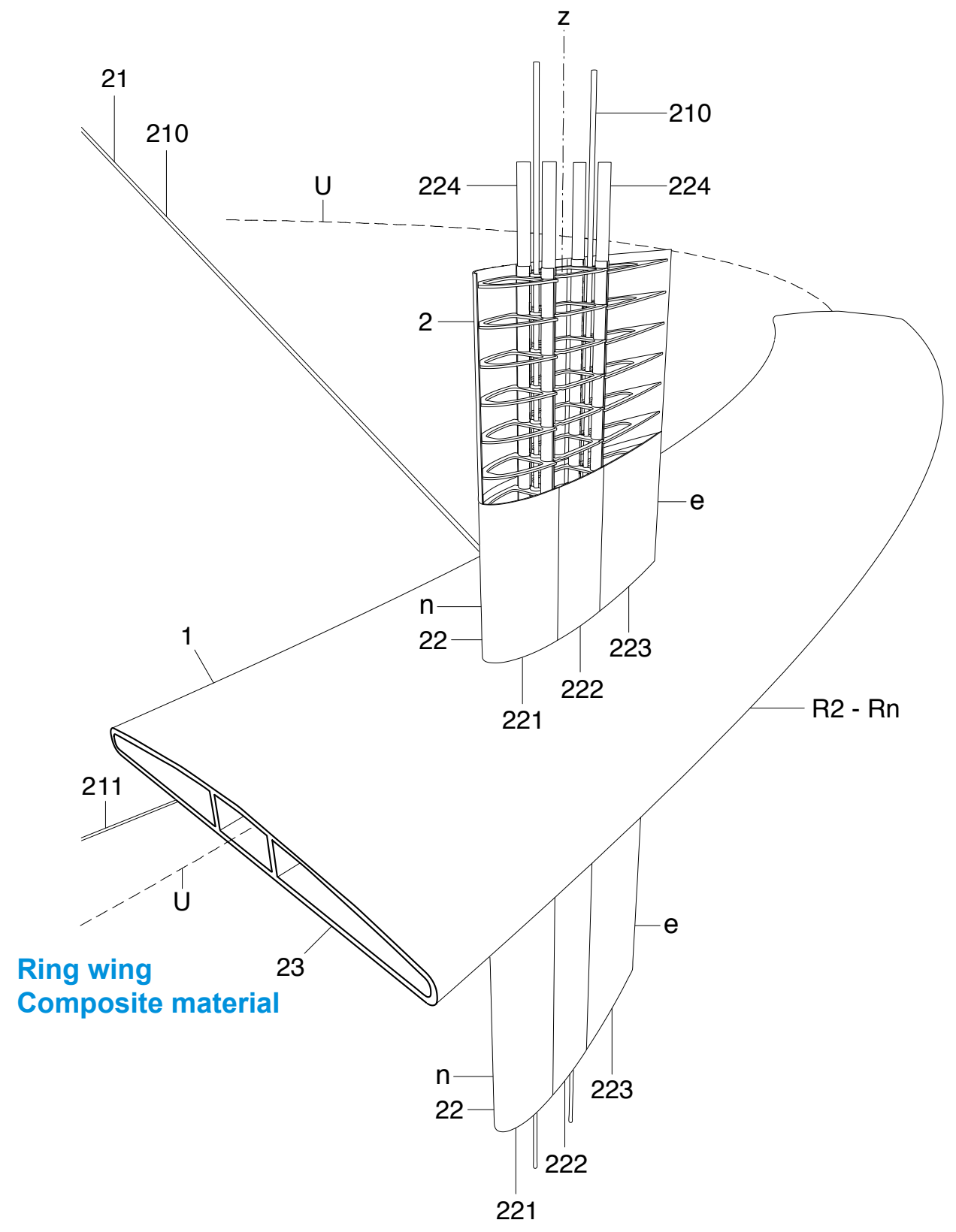
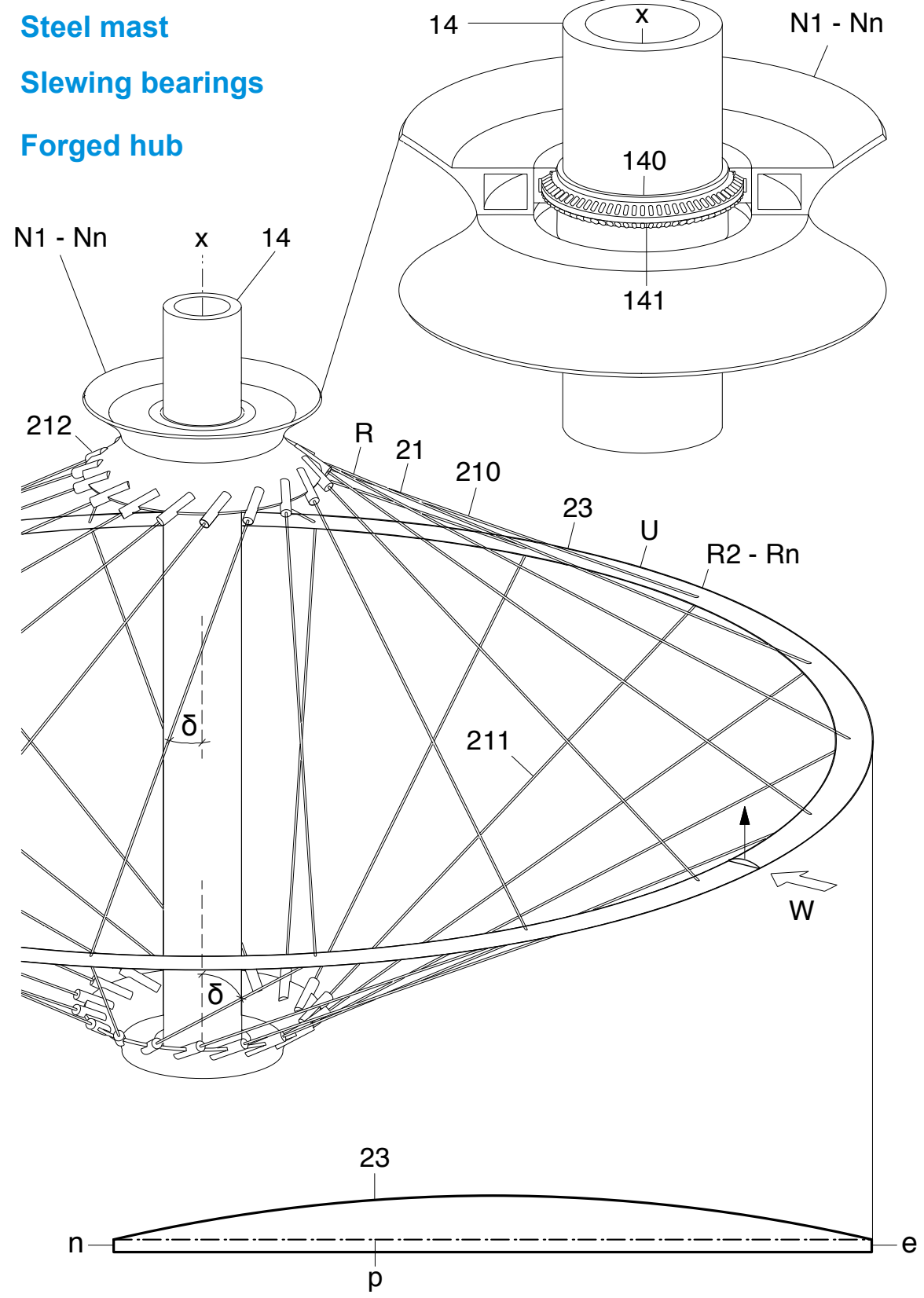
... reversing the orientation of the profile brings the turbine to a standstill ...



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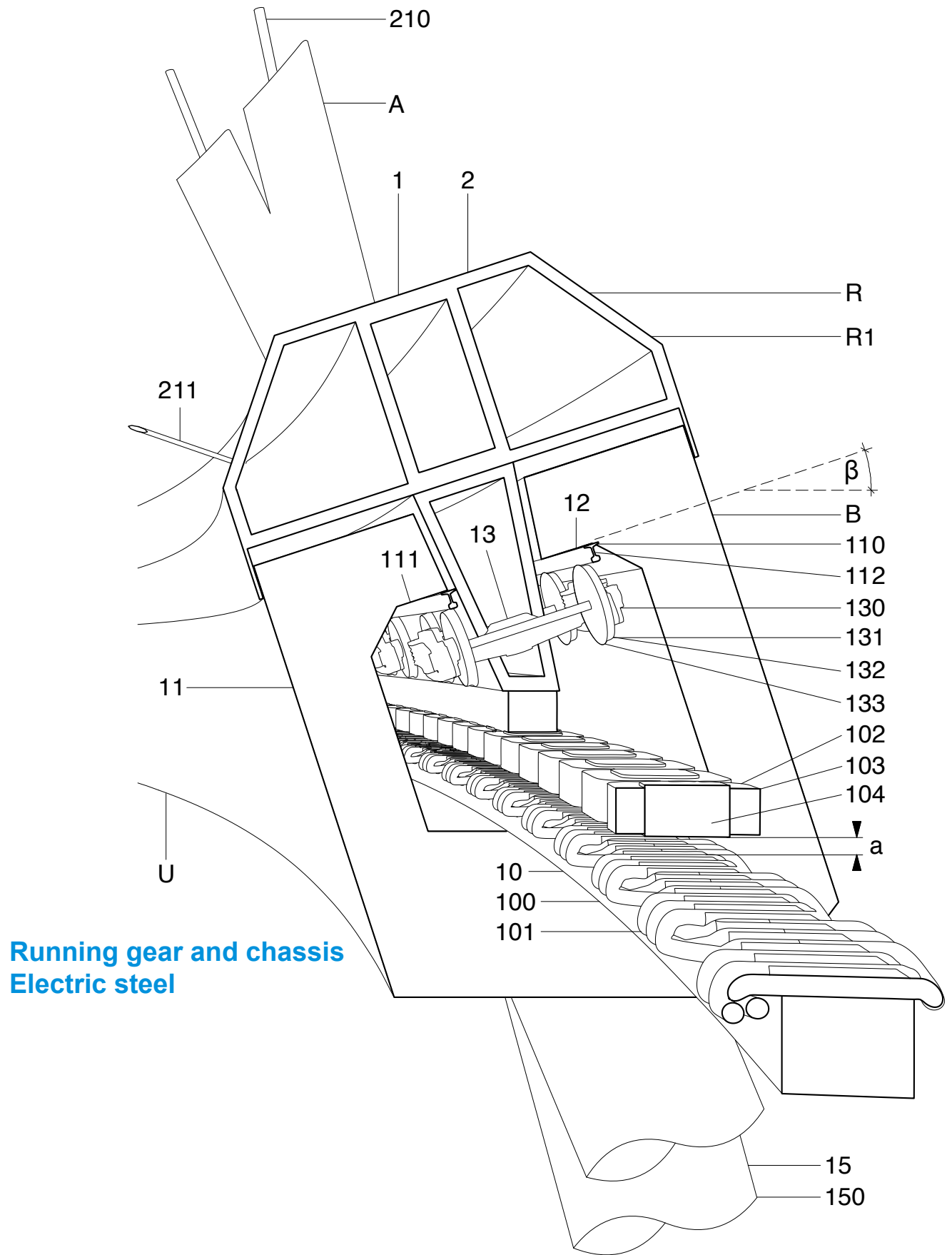
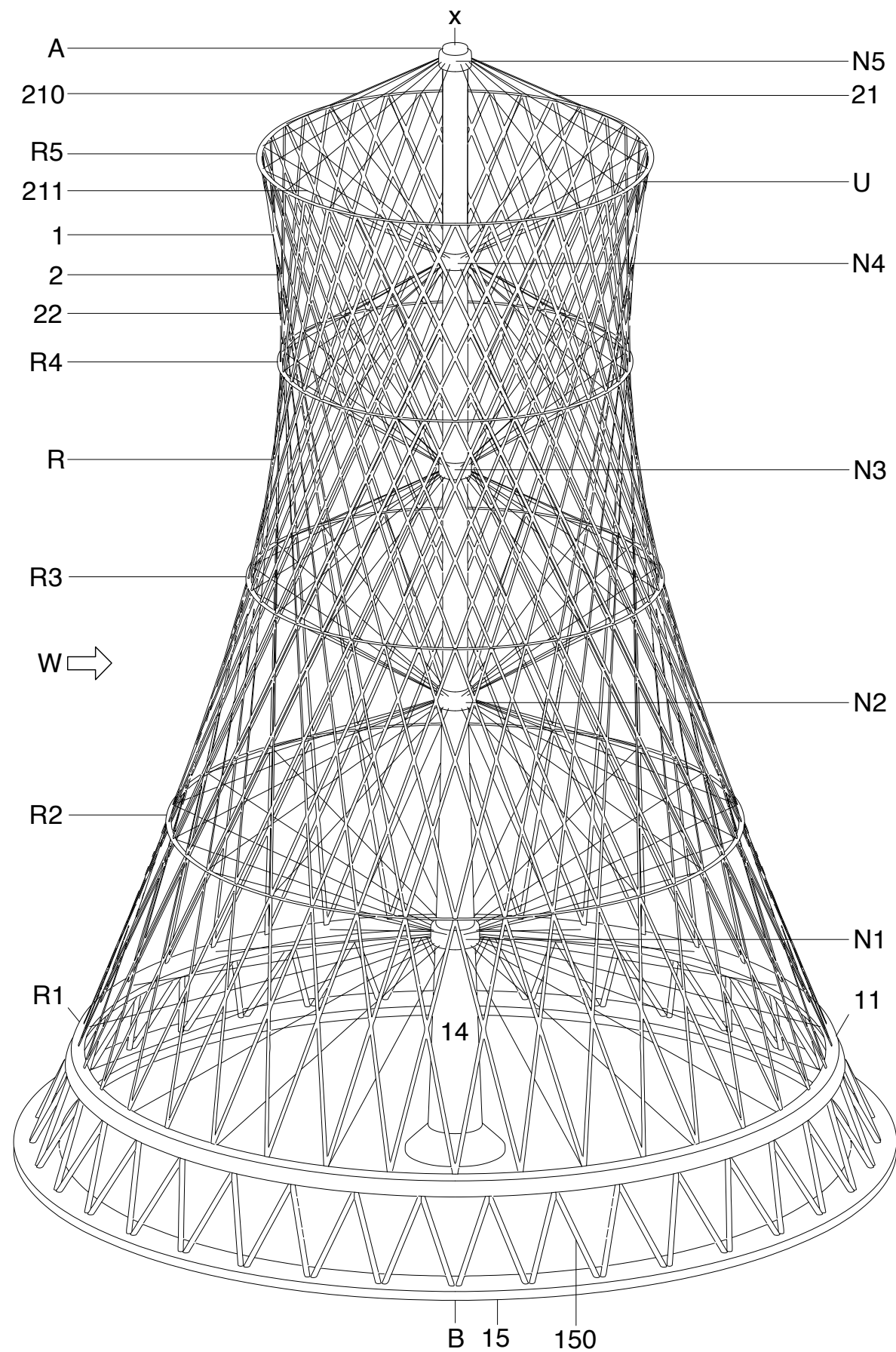


... the cable-stayed structure is suspended from a fixed central mast which is stabilised by horizontal spoked wheels ...



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... a hyperbolic cable-stayed shell is introduced as a hybrid rotor ...

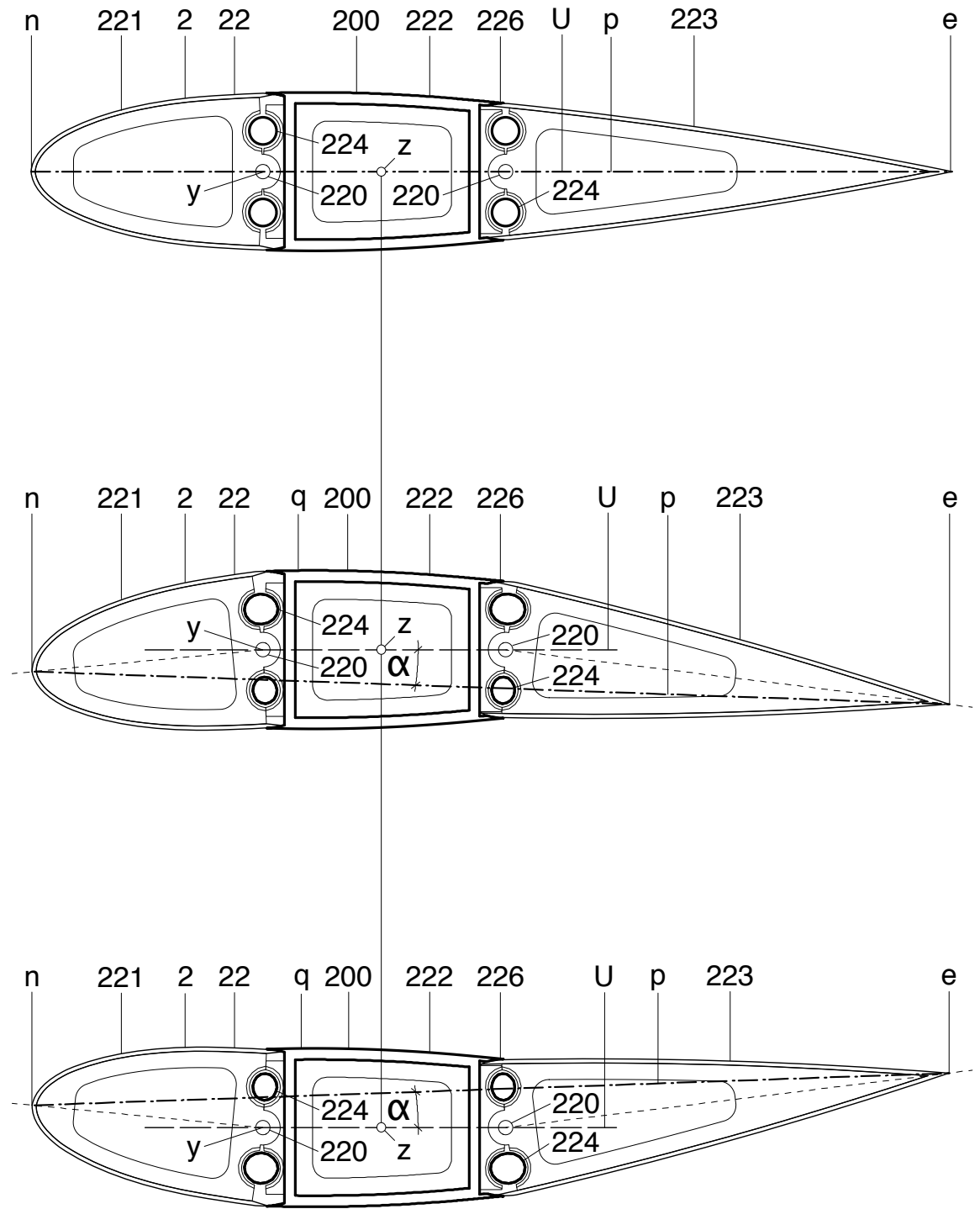
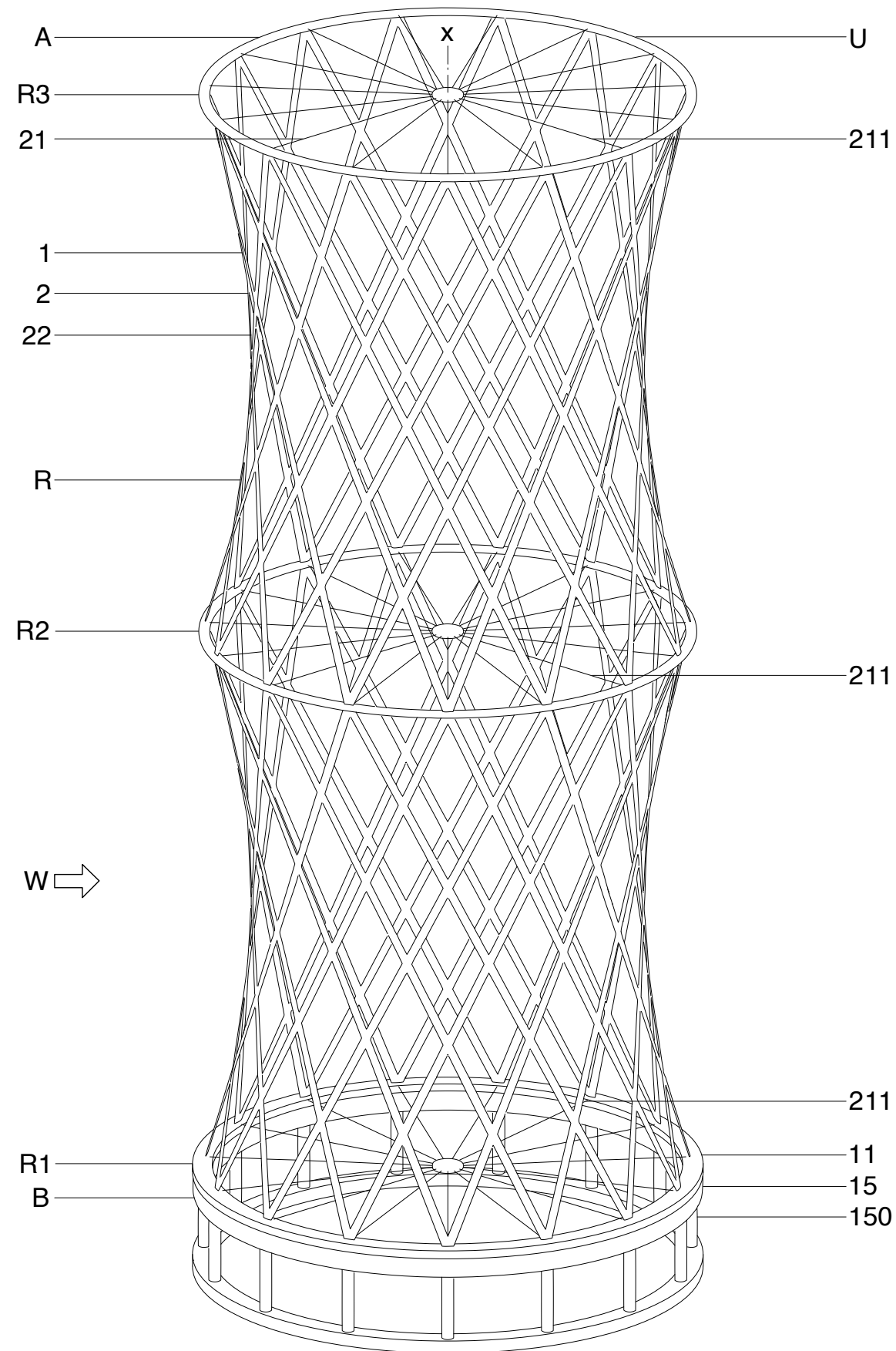


Running gear and chassis  
Electric steel

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... introducing of a hyperbolic self-supporting lattice shell structure ...

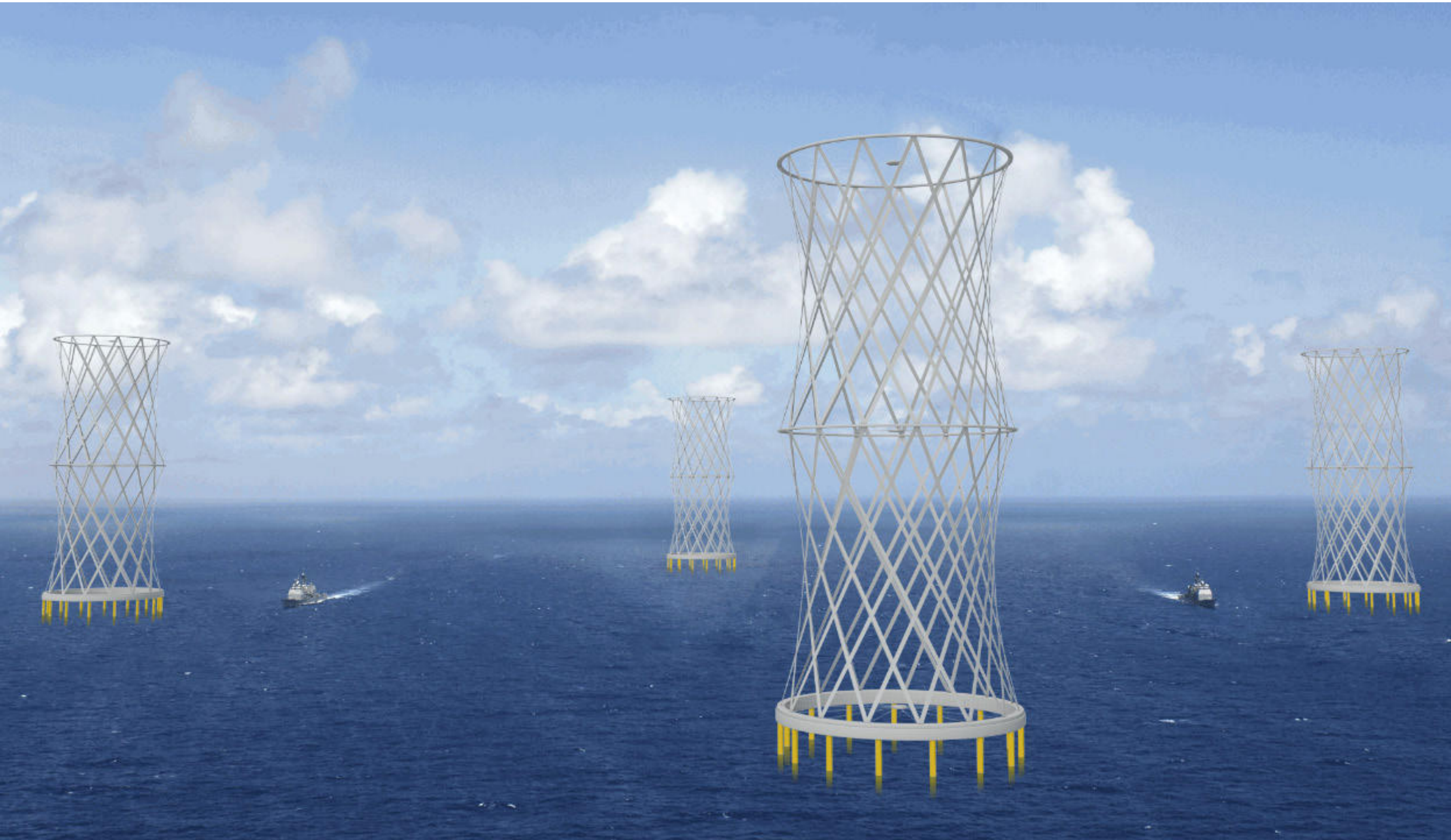


Middle wing segment as load bearing profile

Fig.12



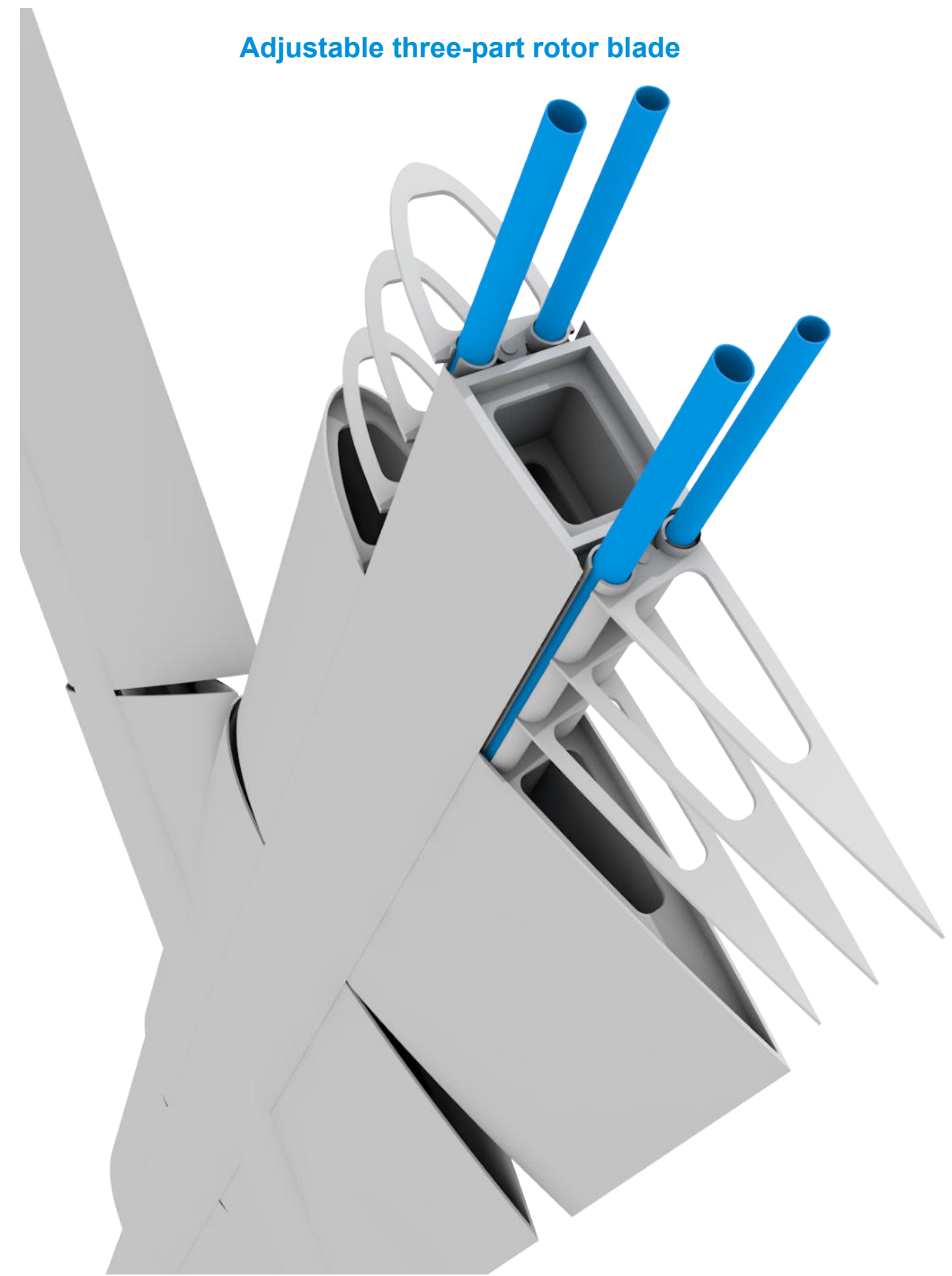
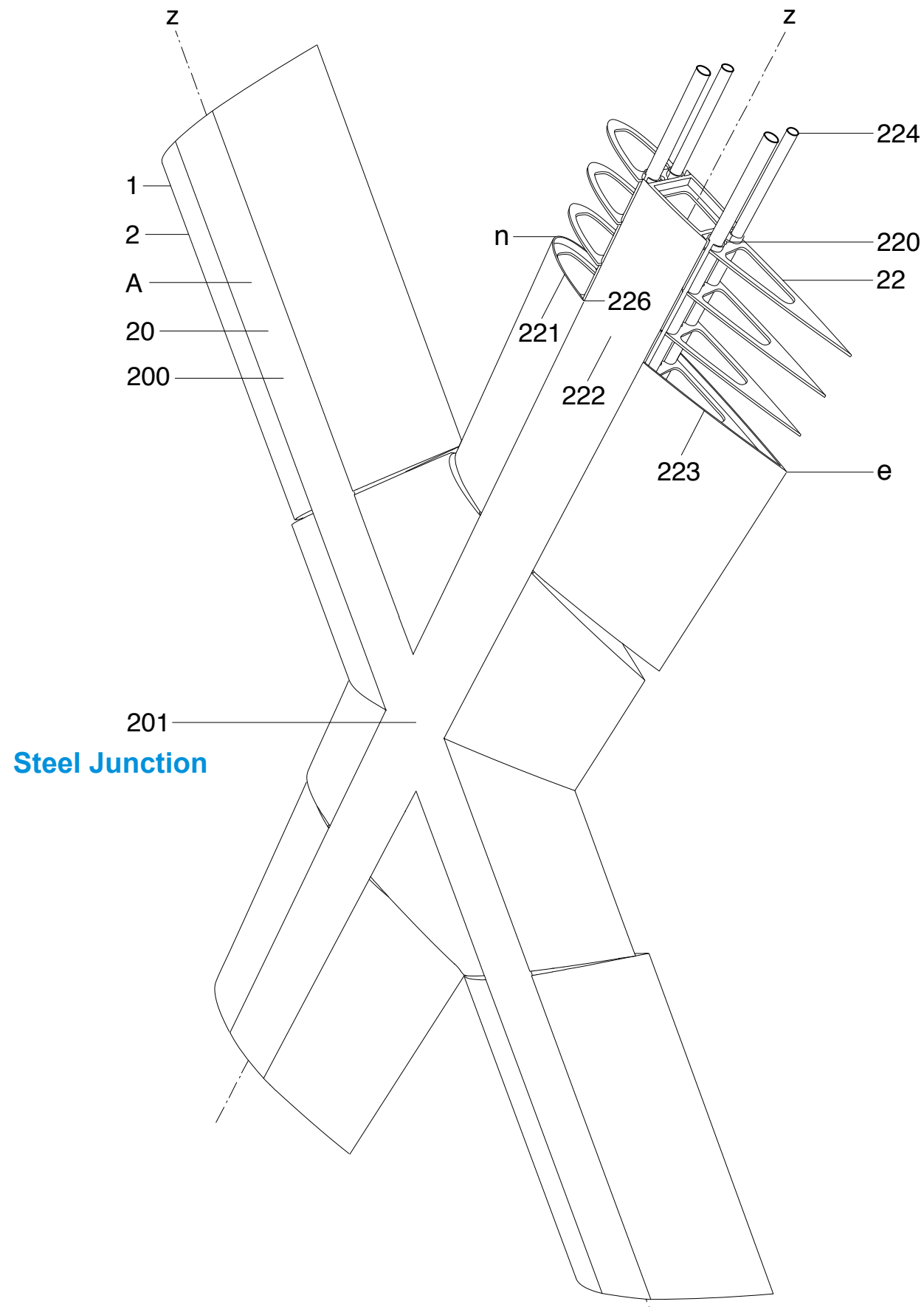
... and there is one more advantage : VAWTs can be arranged much more densely than HAWTs and support each other so that considerably more energy can be harvested from a given surface area ...



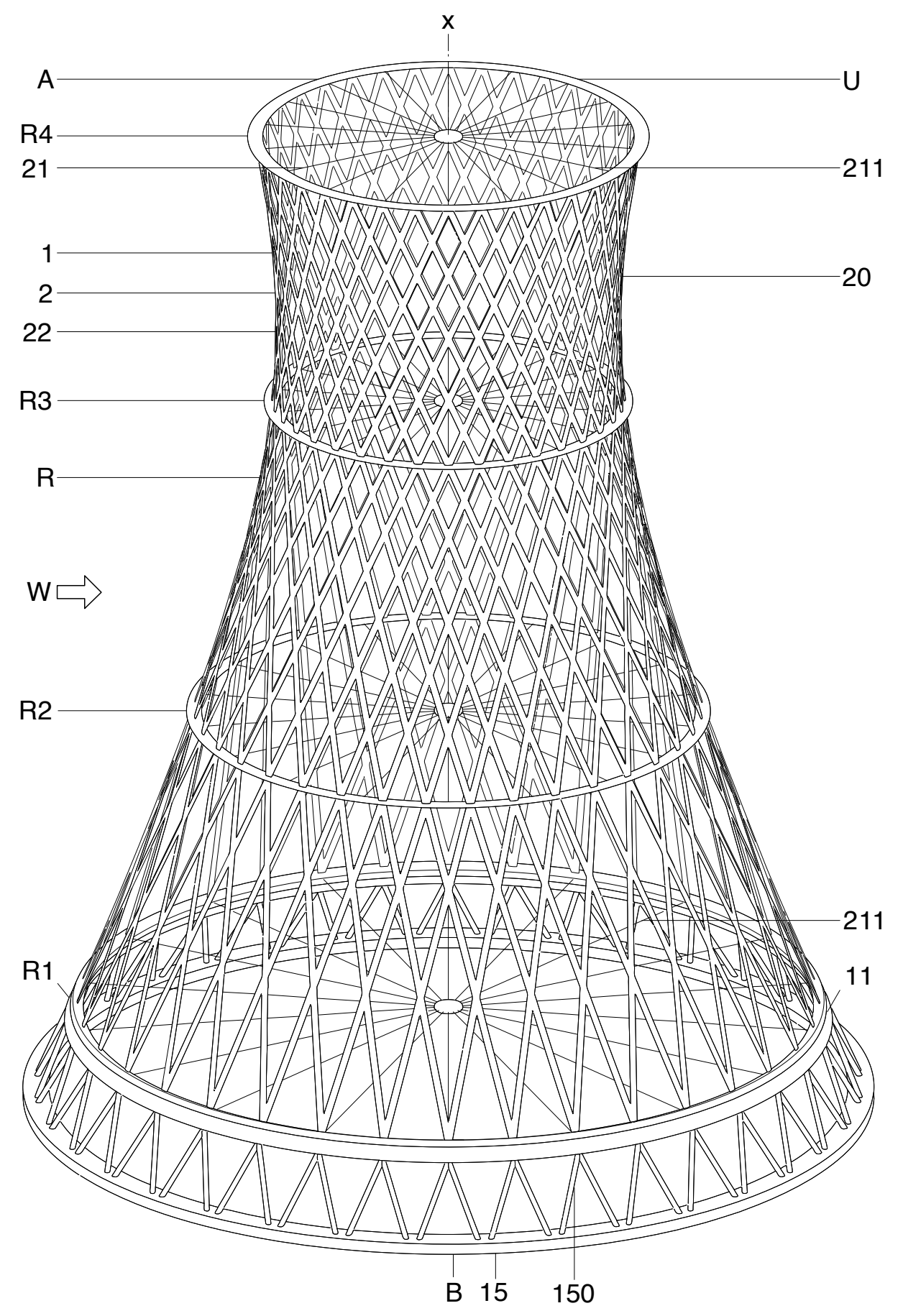
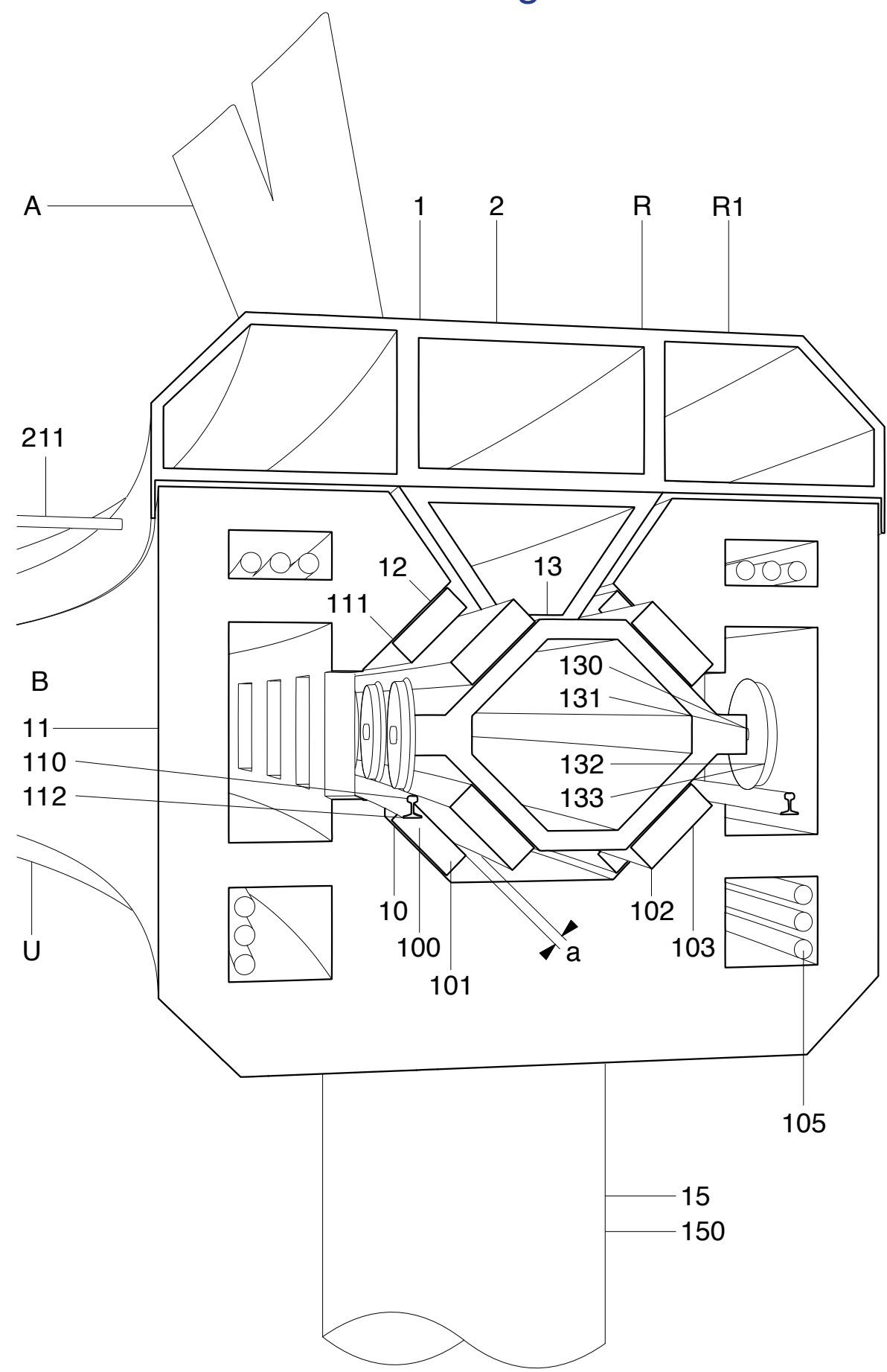
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... in which the centre section of the wing profile is the load-bearing section and reveals a box girder ...



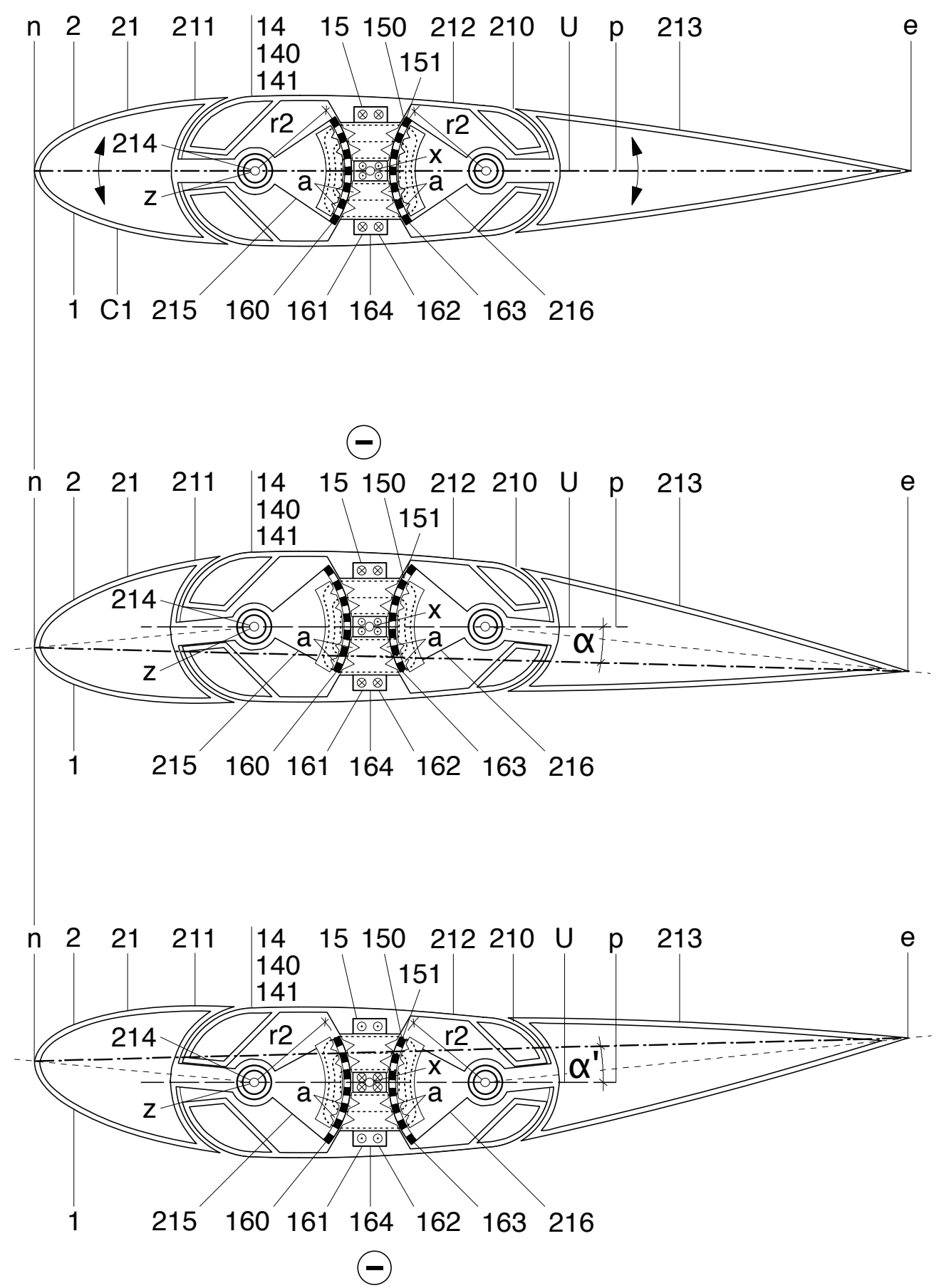
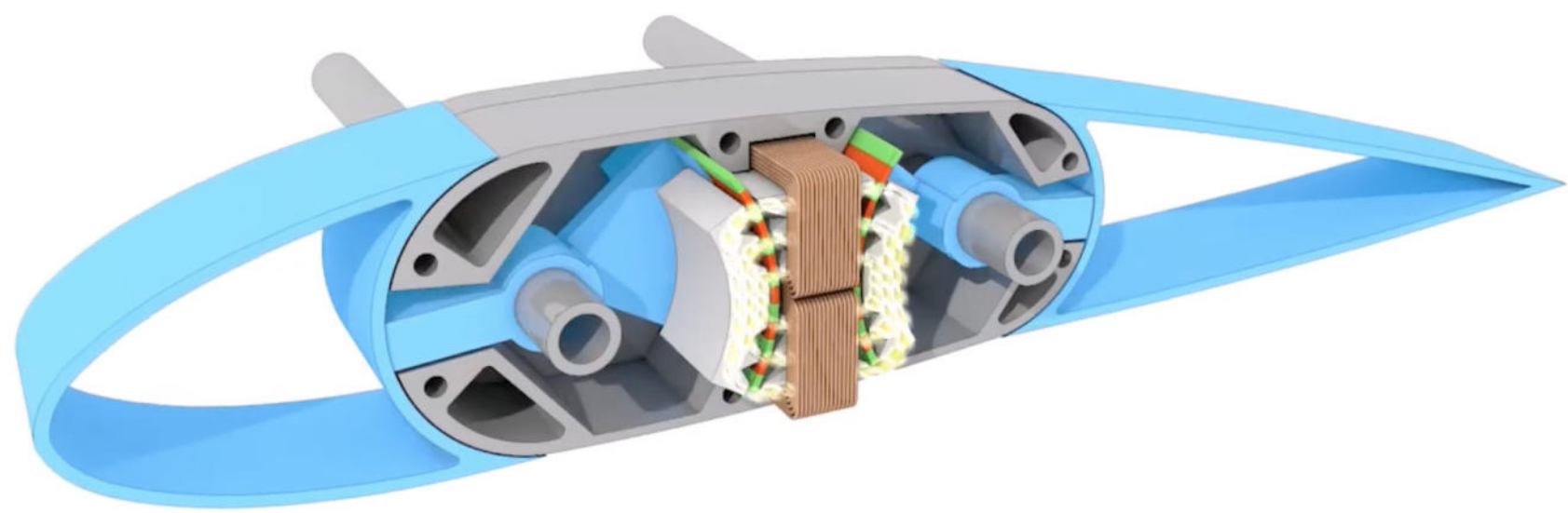
... a combination of four motor-generators will make it possible to activate the magnetic tension on the windward side and the magnetic levitation on the leeward side to counteract the tilting moment ...



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... the use of a fully electric actuator allows a contactless connection between the three sections of the blade ...



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... fast load changes with a frequency of 20 Hz can be achieved ...

Sektional wirksamer Antrieb  
 max. 1350N  
 11mm Hub in 3,2ms

Verstellzeiten

Windrad  
 D=3m  
 191 U/min  
 3,18 U/s  
 314 ms/U  
 0,87 ms/°

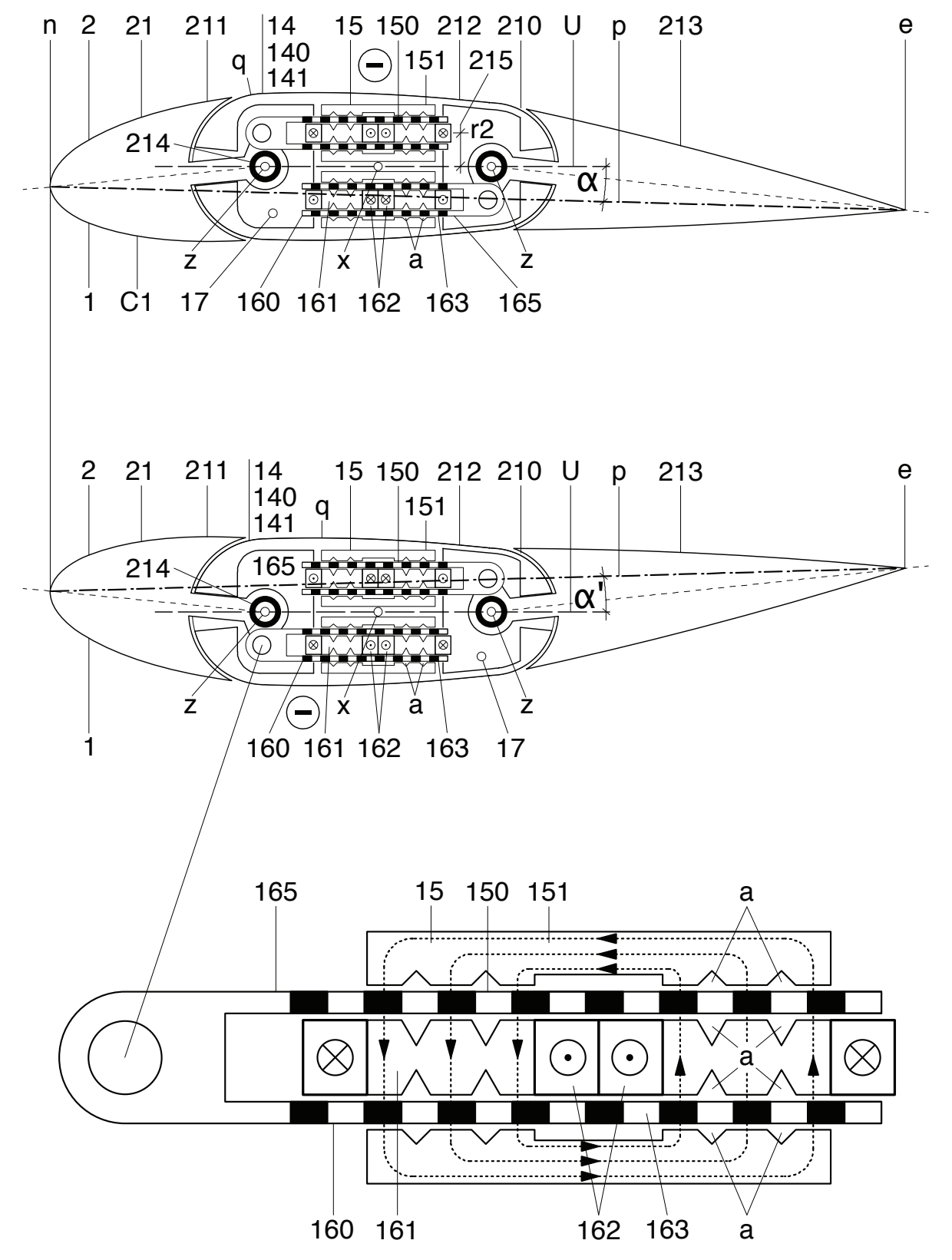
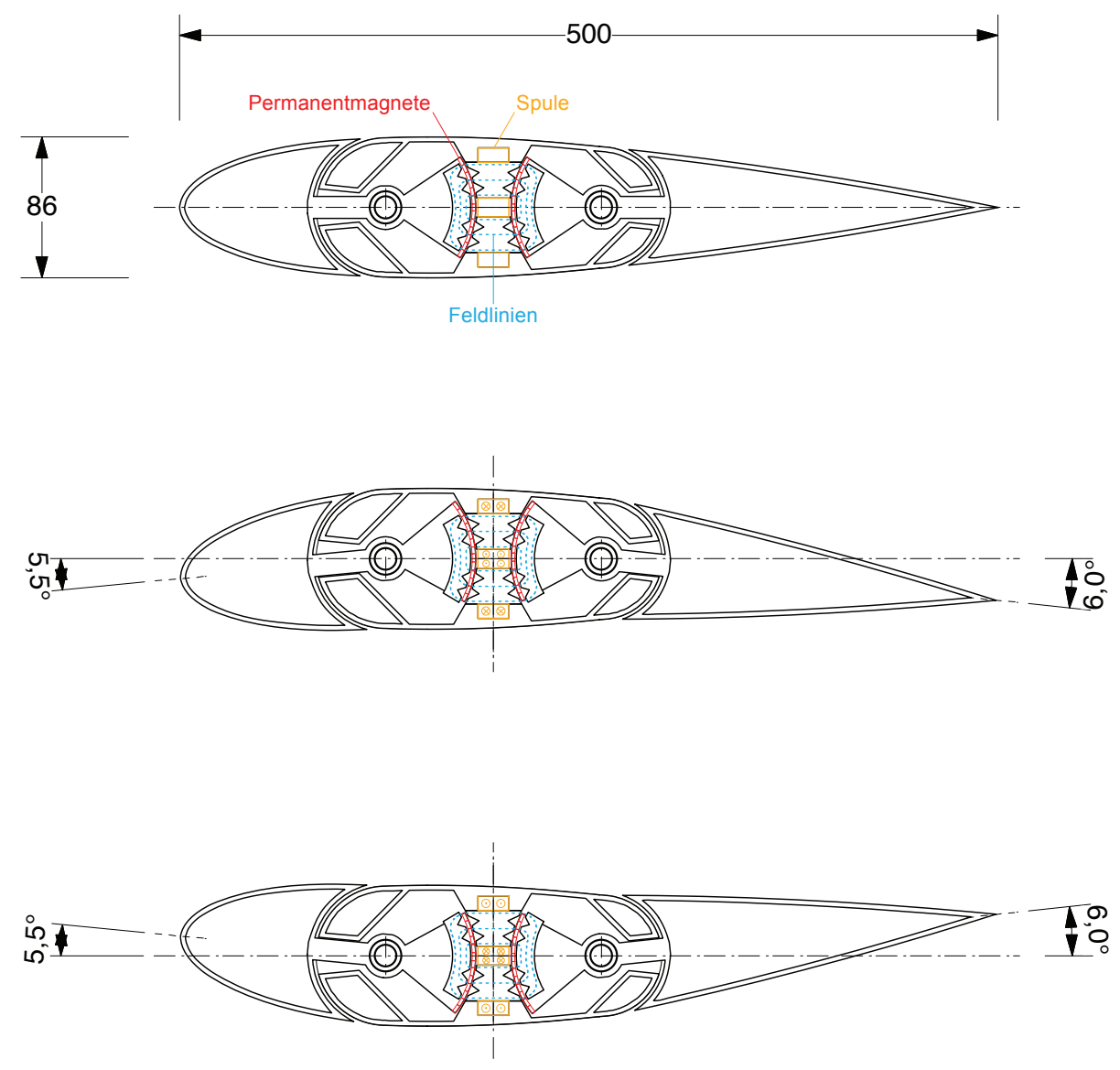
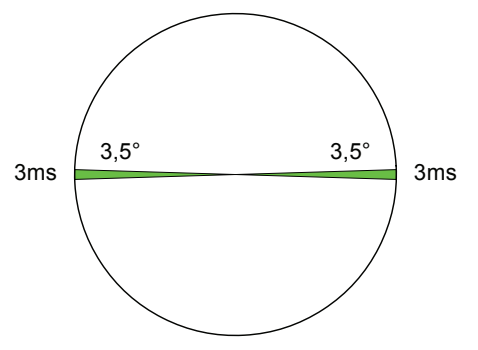
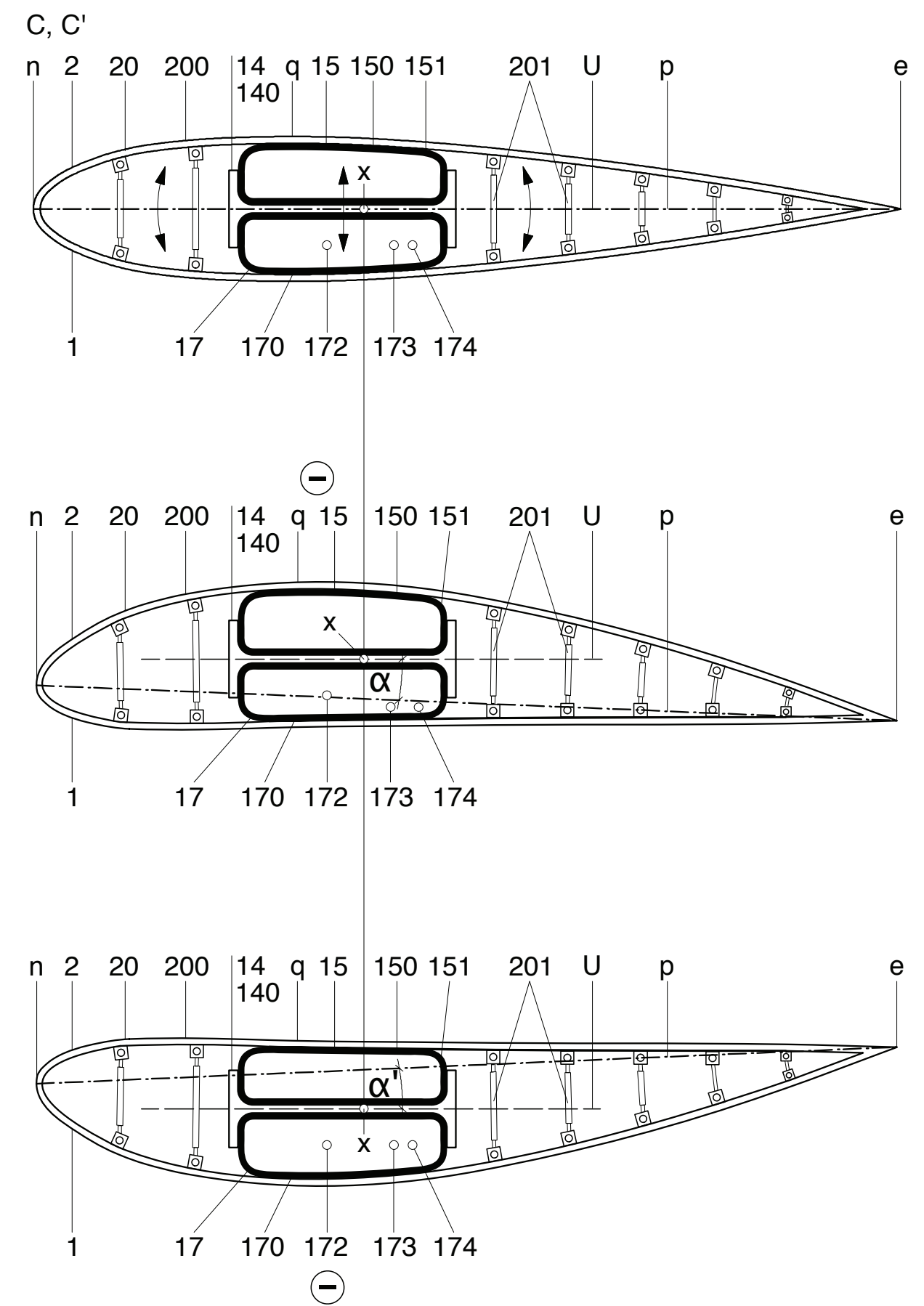
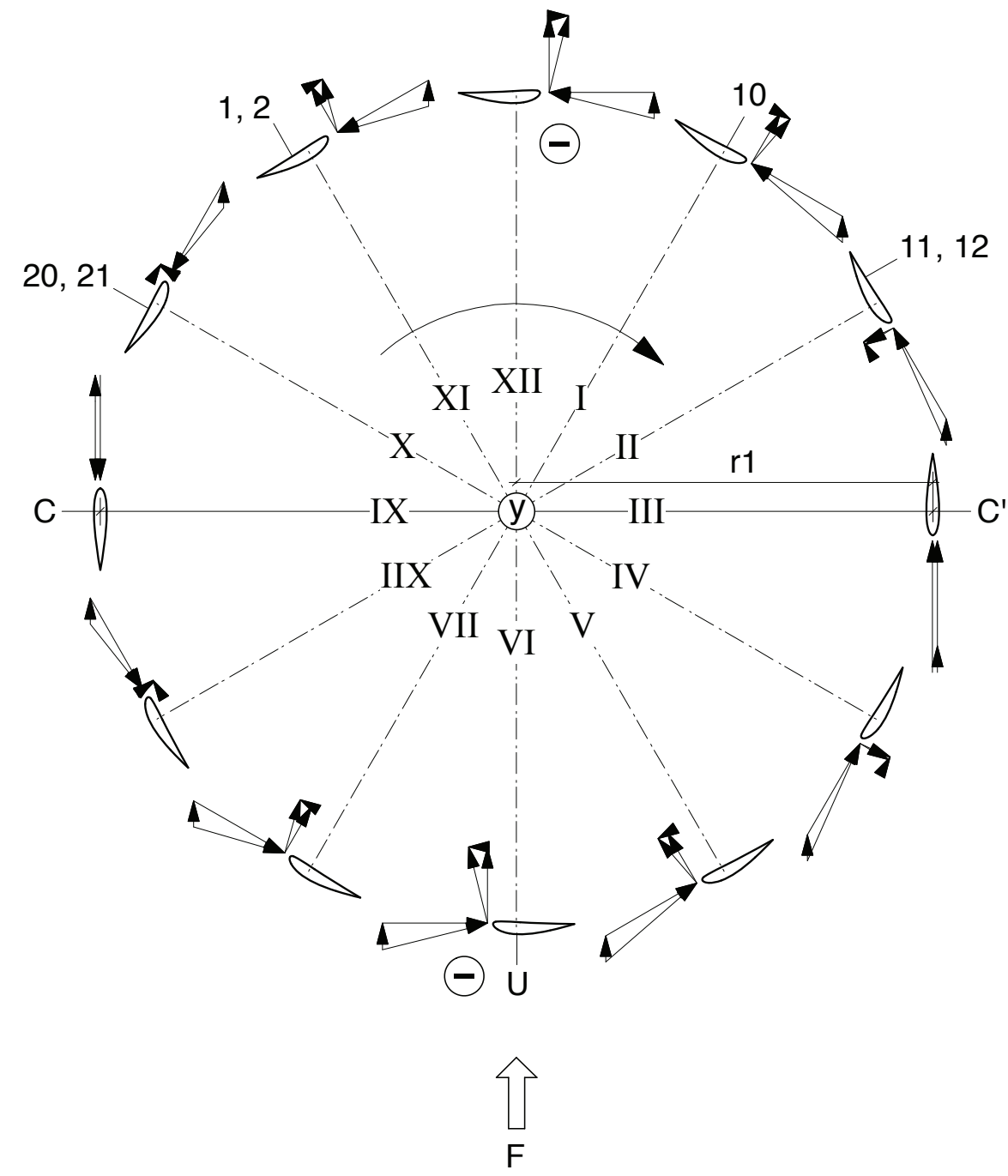


Fig.12

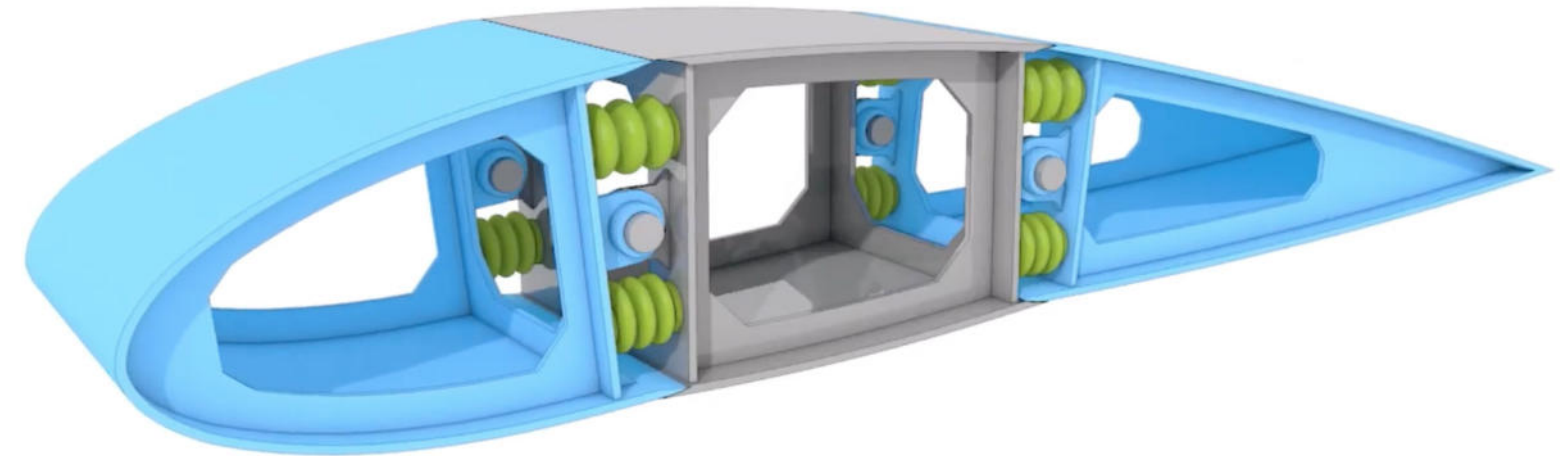
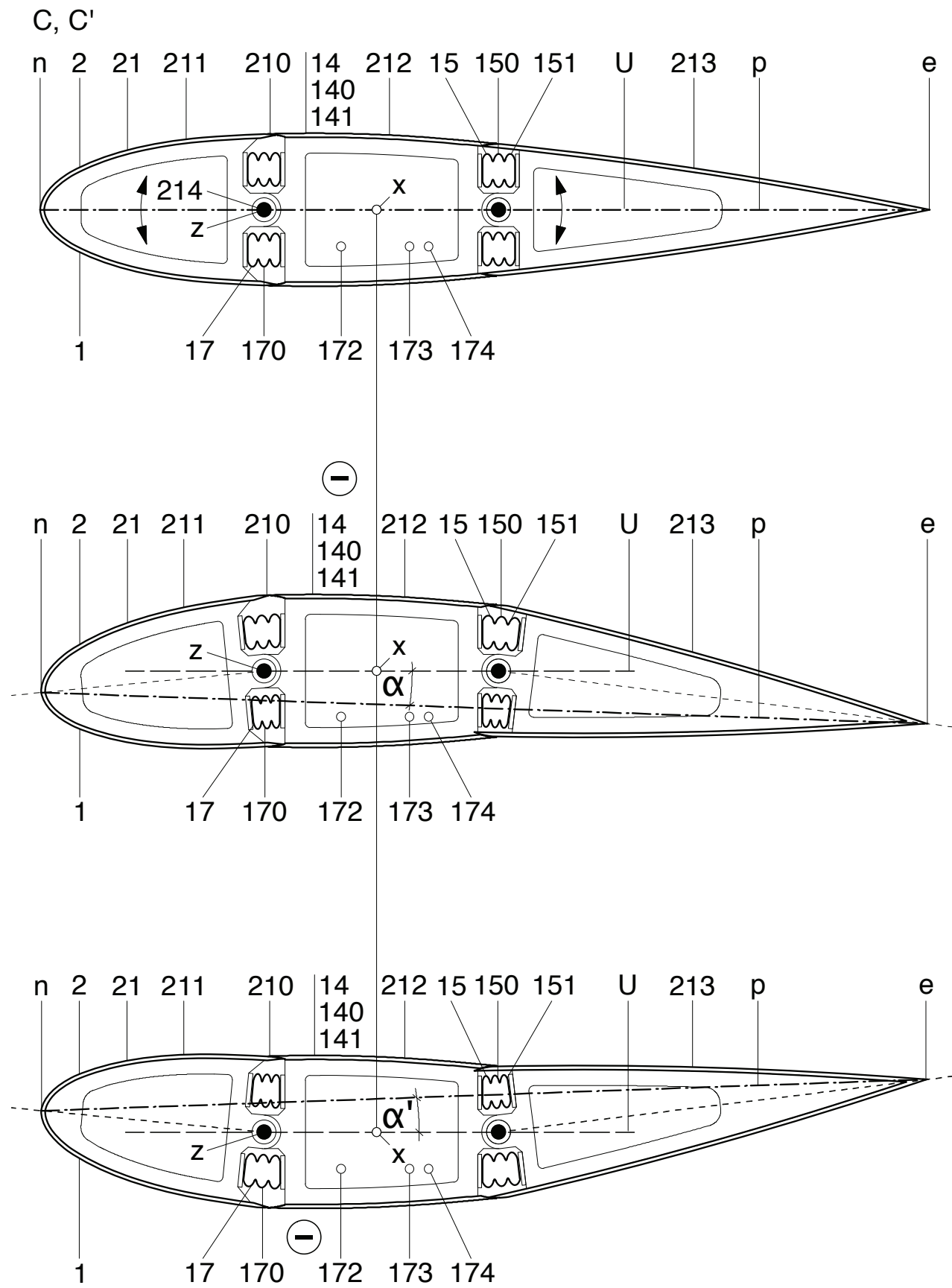
... the introduction of a variable blade profile with a flexible but torsionally rigid outer skin activated by two internal pneumatic cushions, the loadbearing structure acting as a rigid counter-bearing...



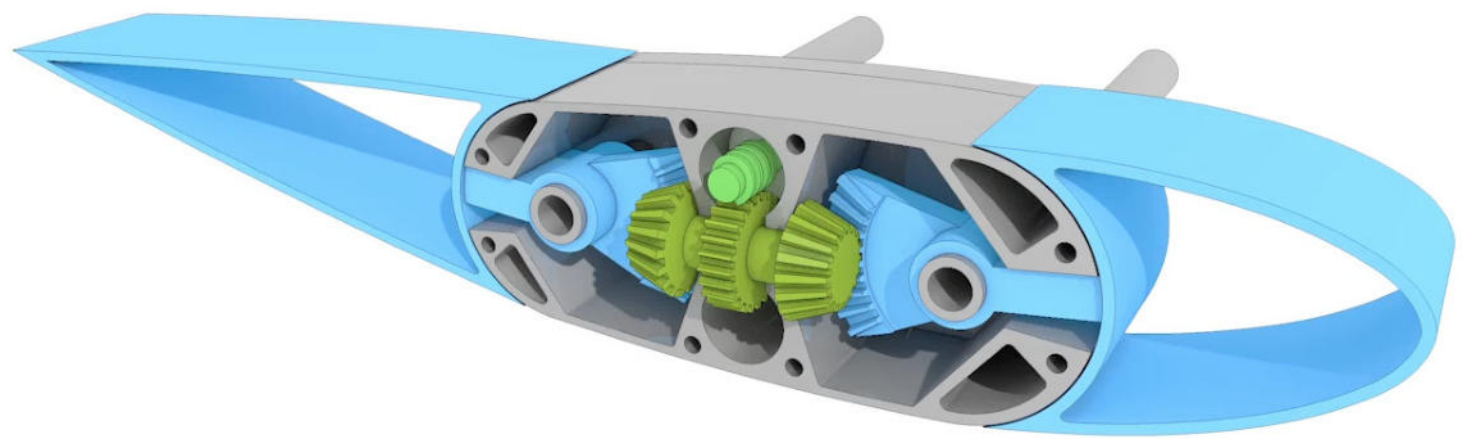
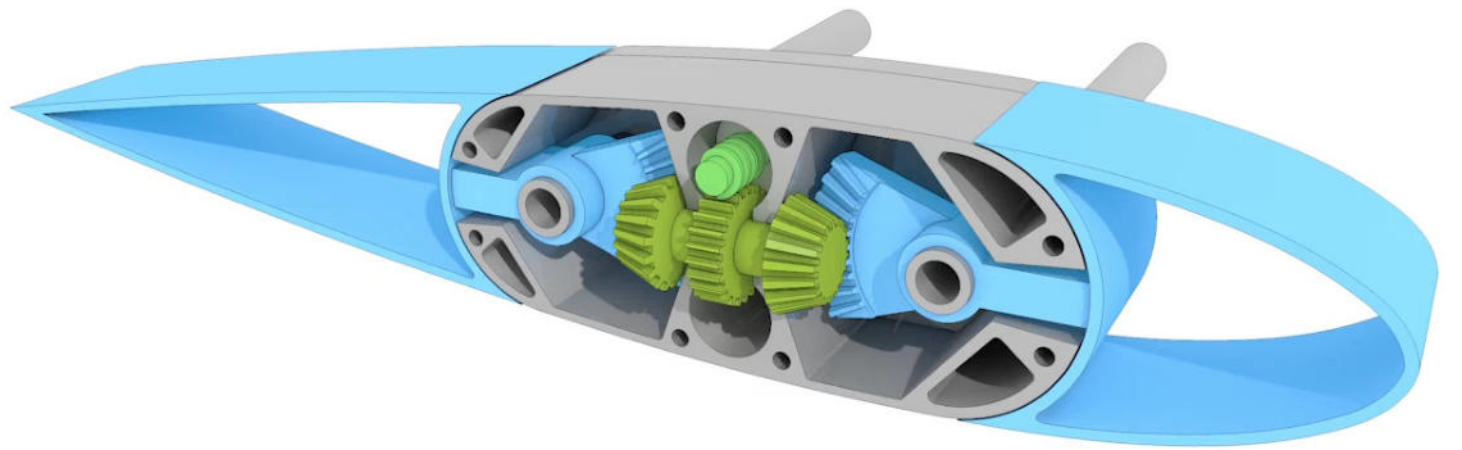
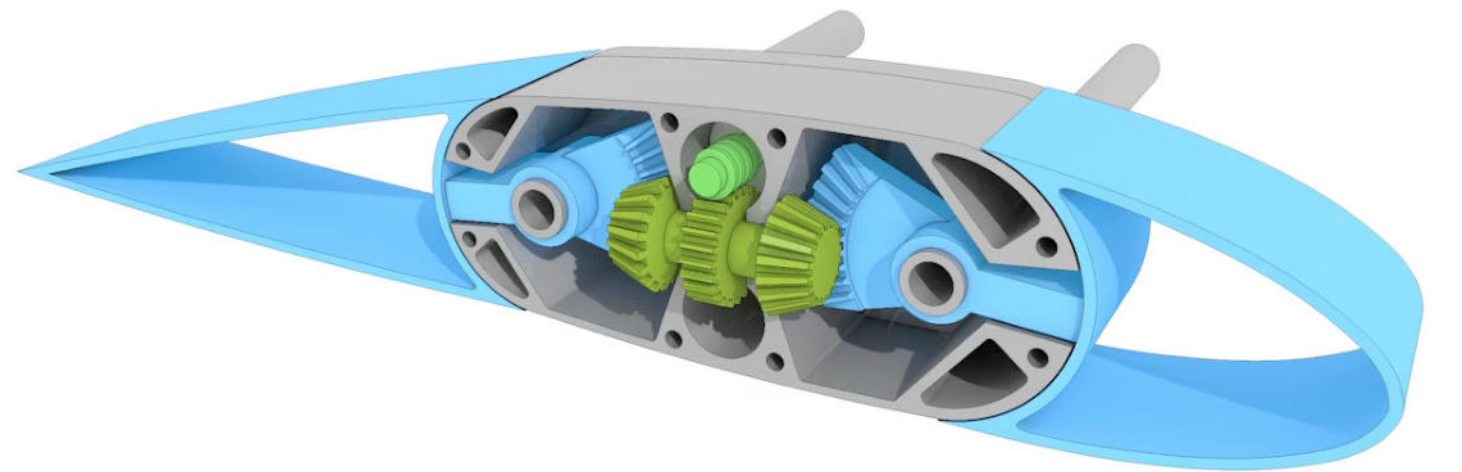
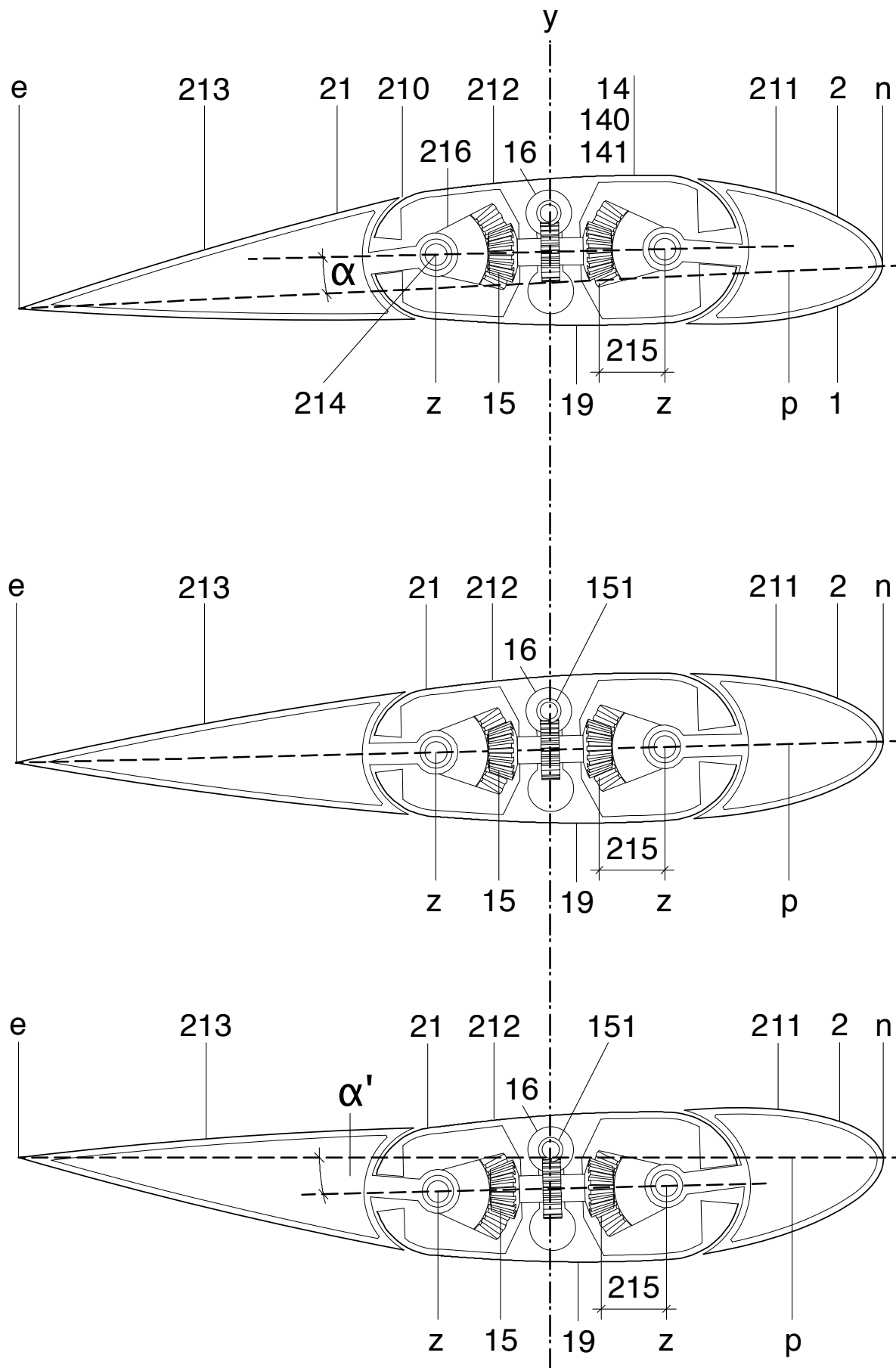
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... introducing pneumatic muscles as actuators in a three-section variable wing profile ...



... a stop-rest gear for the actuators allows a transmission ratio of 1:20 and is energy saving as the profile is fixed in both windward and leeward rotation ...



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... the giant wind turbine will be a landmark - a revolving restaurant on the central mast would be an extra attraction ...



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... the integration of this giant wind turbine into the skyline of Dubai shows harmony with the urban environment ...



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... filigree, rotating, lightweight tubes project into the atmosphere to harvest the kinetic energy of the wind ...



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... these giant wind power plants will create a vertical current out of the conversion out of the inflow, and will have a positive impact on local climate by evaporating sea water contributing to the formation of clouds...



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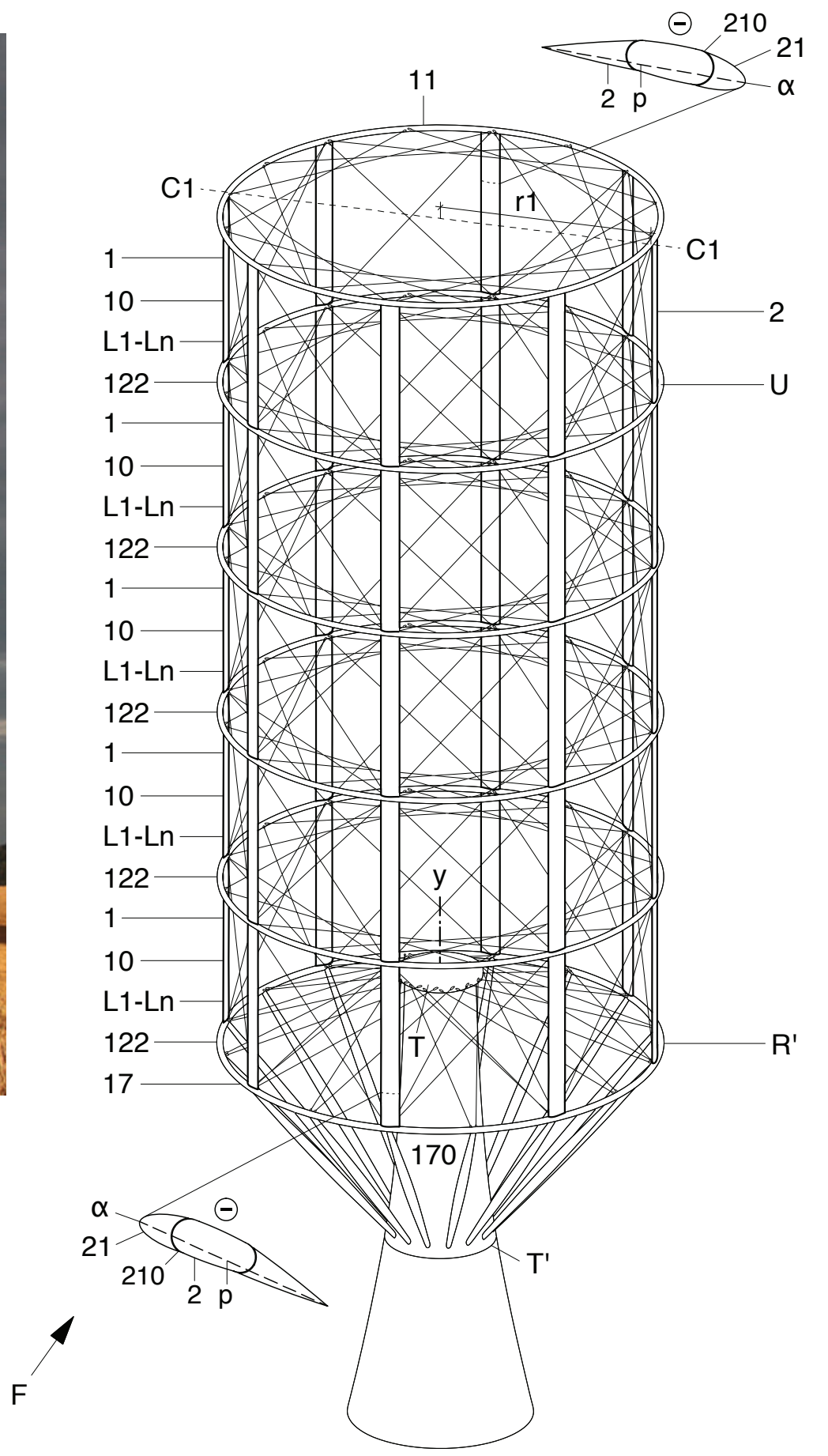
... outperforming a state-of-the-art turbine by producing three times more energy than Enercon E126 with a power to weight ratio of 313 t/MW



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... introducing a base-integrated power plant ...



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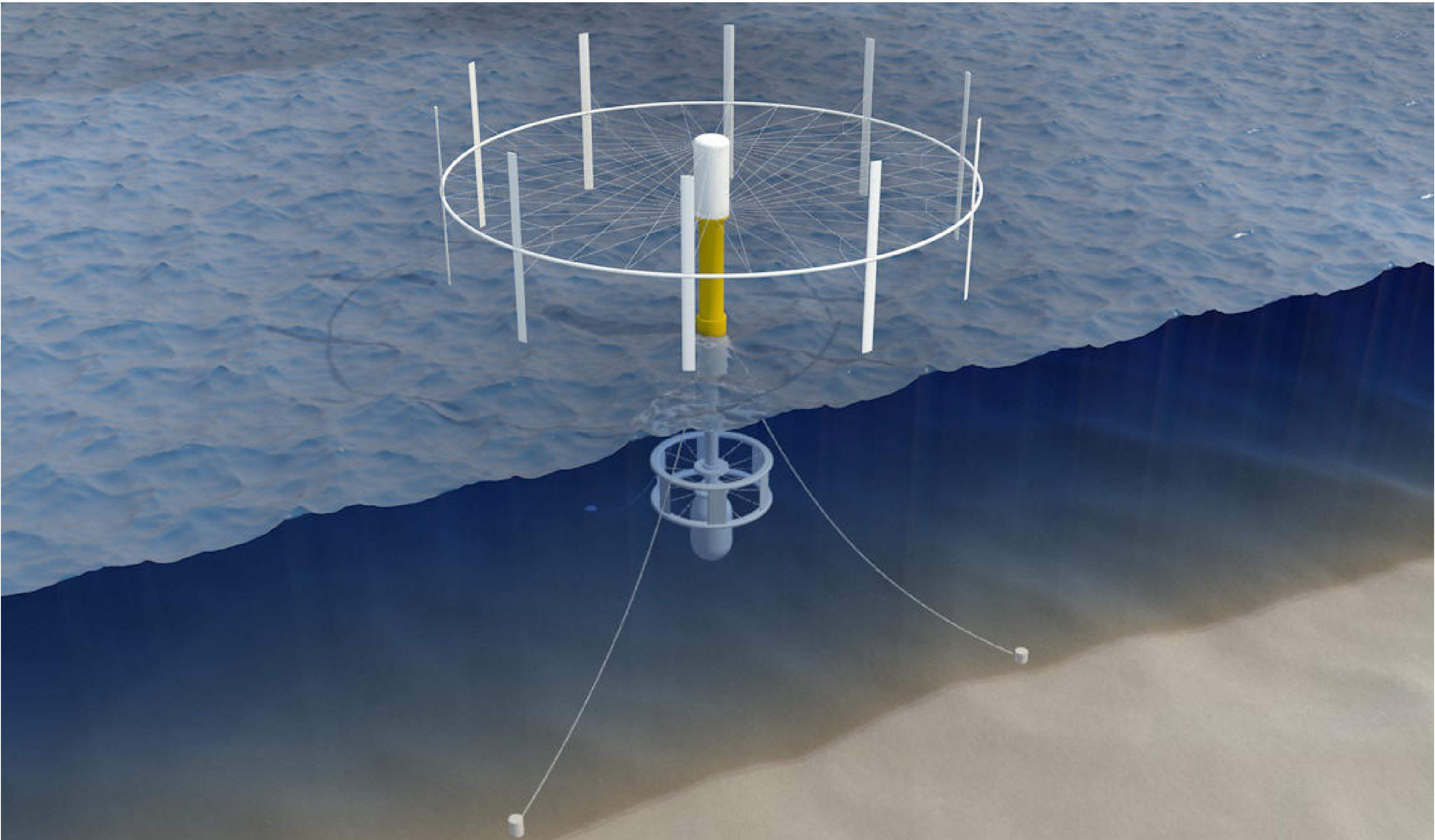
... two wind turbines, each 300m in diameter, in front of the Oeresund Bridge revealing rotor blades, that are cantilevered 50m up and 50m down from the outer compression ring, which serves as a walkway for maintenance ...



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... the Gyro turbine combines a submerged water turbine with a 300m diameter wind turbine - together the two turbines will deliver up to 50 MW ...



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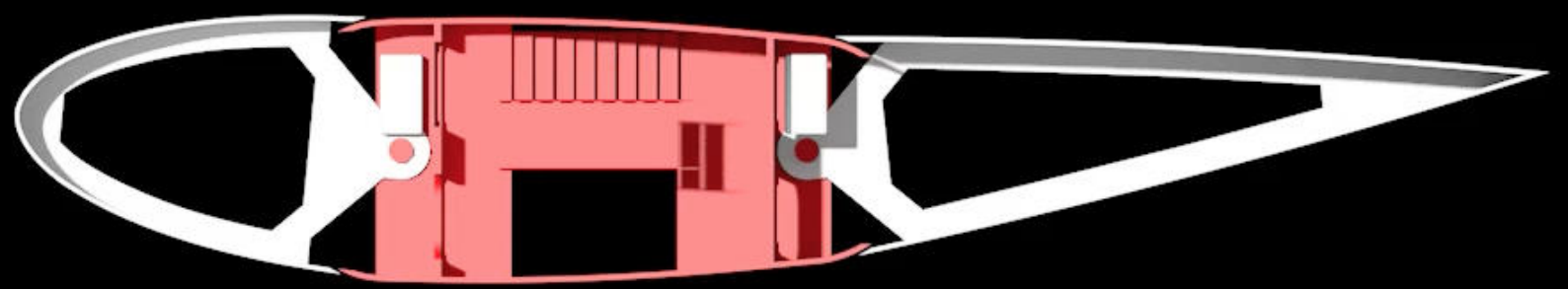
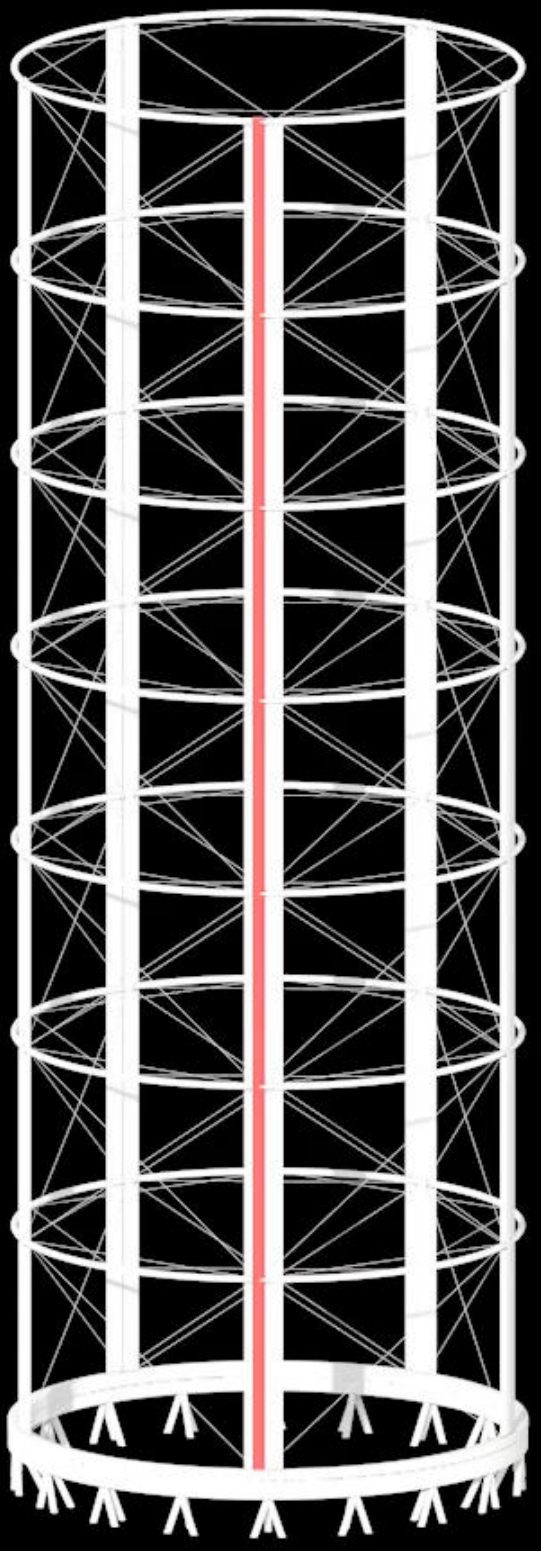
... three huge towers rotate in the bay of Osaka in front of the Akashi-Kaikyo suspension bridge ...



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... the middle section of the three-part rotor blade is made of steel and houses a staircase and an elevator shaft for maintenance access ...





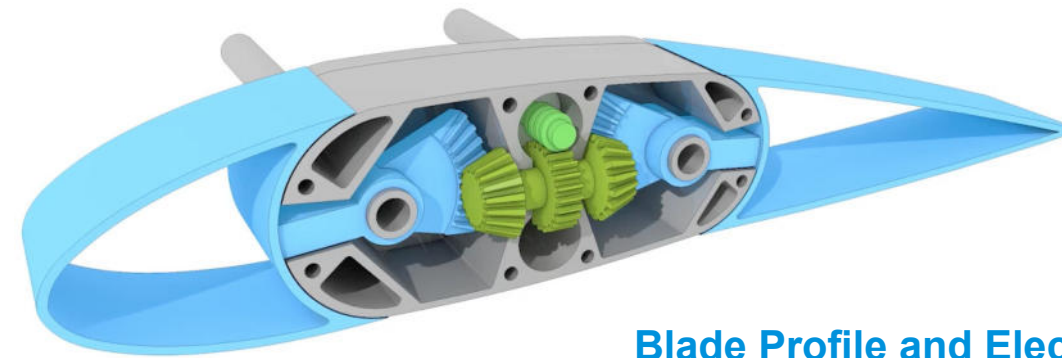
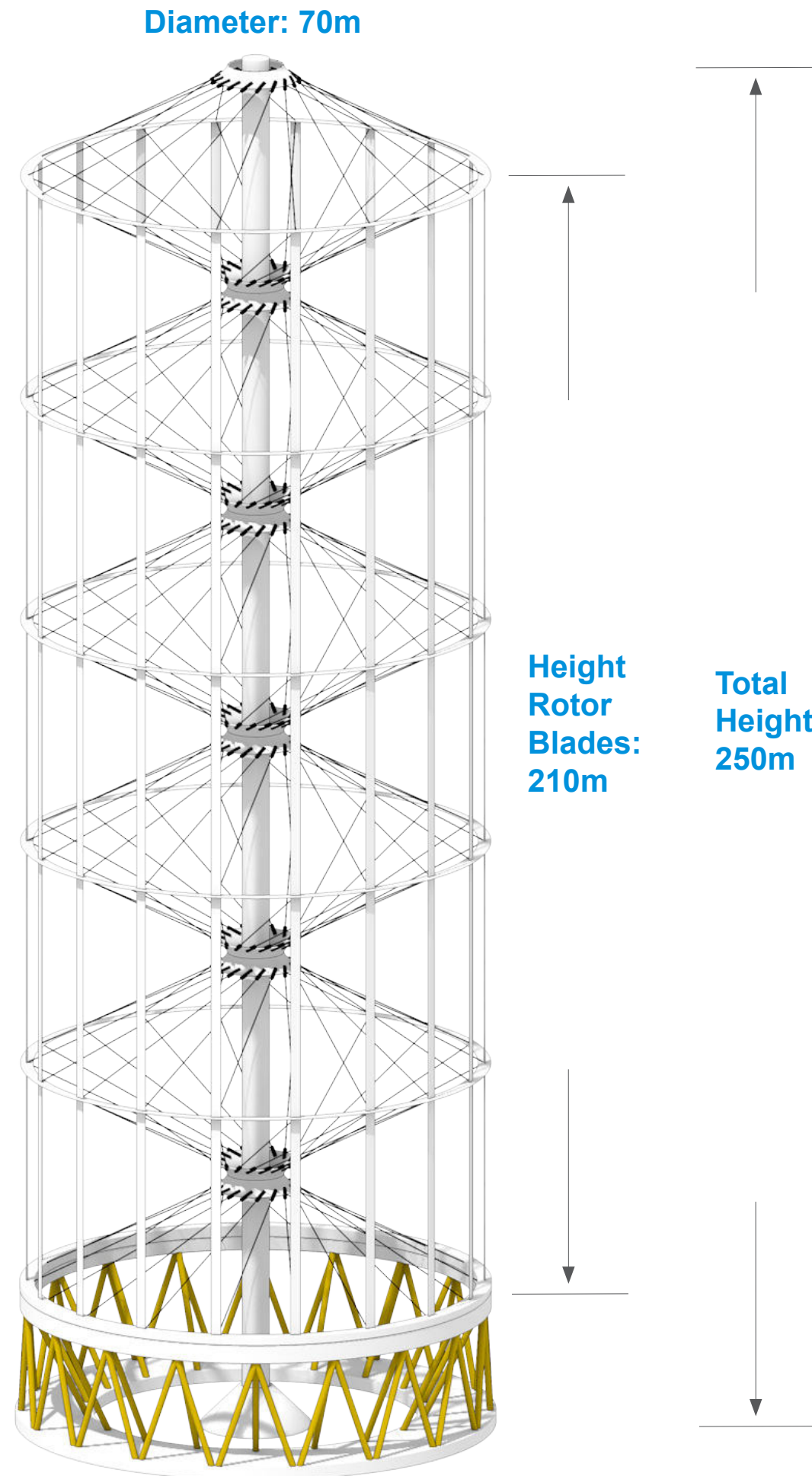
... on the west coast of Tuscany, this filigree cable-stayed tower rises 600 metres into the blue sky ...



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## Capacity 210m Gigatube



**Blade Profile and Electric Actuators**

### Power according to Betz:

$$P = 16/27 * \rho / 2 * A * v^3$$

Air Density  
Inflow Area  
Wind Speed

$\rho = 1,2\text{kg/m}^3$   
 $A = 70\text{m} * 210\text{m} = 14.700\text{m}^2$   
 $v = 12\text{m/s}$

$$P = 16/27 * 1,2\text{kg/m}^3 / 2 * 14.700\text{m}^2 * (12\text{m/s})^3$$

$$P = 9,0 \text{ MW}$$

### Weight Comparison 210m Gigatube / Enercon E-126

	210m Gigatube	Enercon E-126
Mast	595 t	2.800 t
Generator Housing	909 t	120 t
Generator	348 t	220 t
Rotor Blades	324 t	320 t
Steel Cables	640 t	
<b>Total Weight</b>	<b>2.816 t</b>	<b>3.460 t</b>
<b>Power</b>	<b>9,0 MW</b>	<b>3 MW</b>
<b>Power to Weight Ratio</b>	<b>313t/MW</b>	<b>1153t/MW</b>

**(3,7 times better than Enercon E126)**

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... together with industrial partners, the RES Institute is also working on rotorcraft - specifically on a two-seater air taxi. In this project electric actuators have already been studied and a flow simulation has been carried out which impressively demonstrated the airworthiness and manoeuvrability of these new aircrafts.

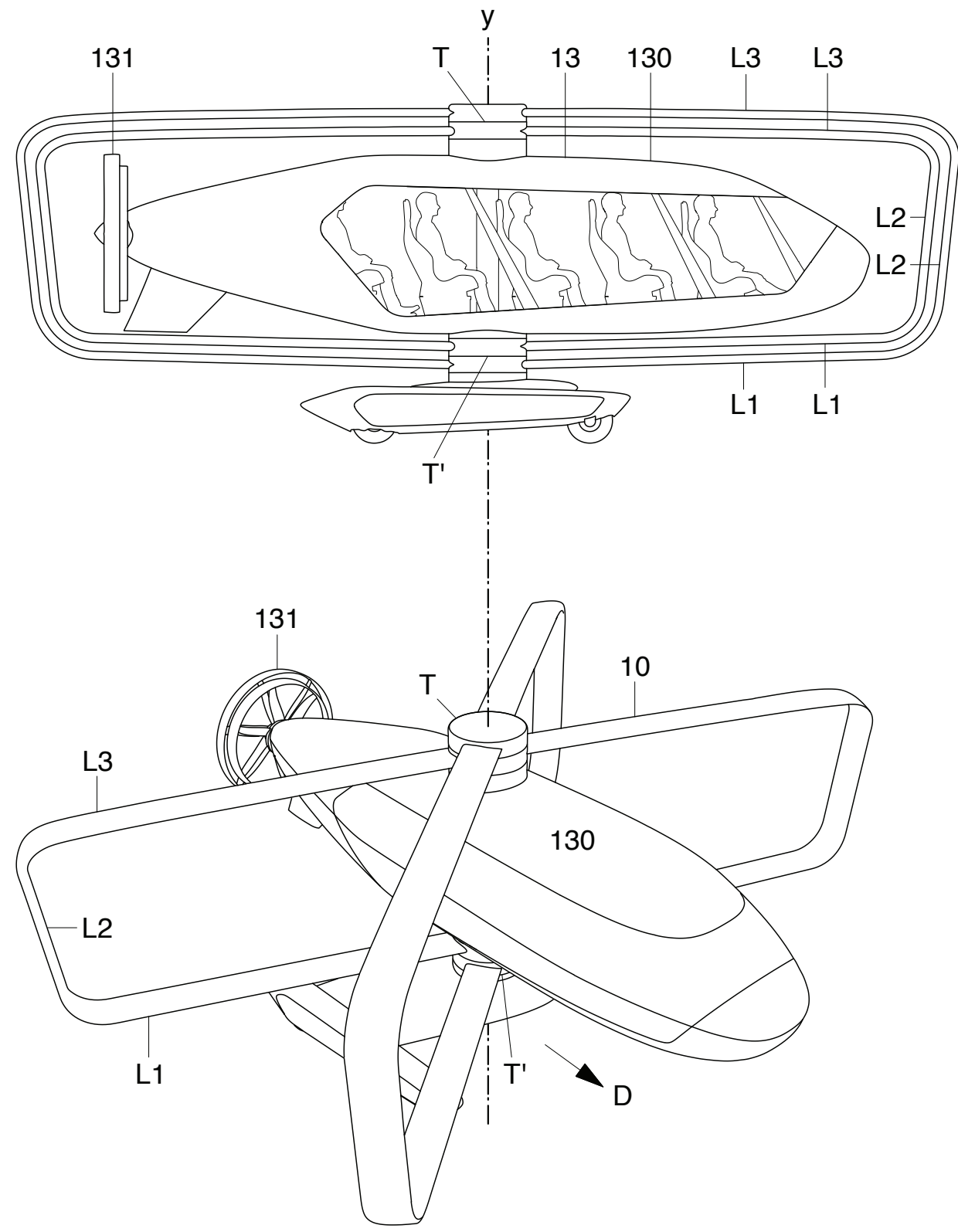
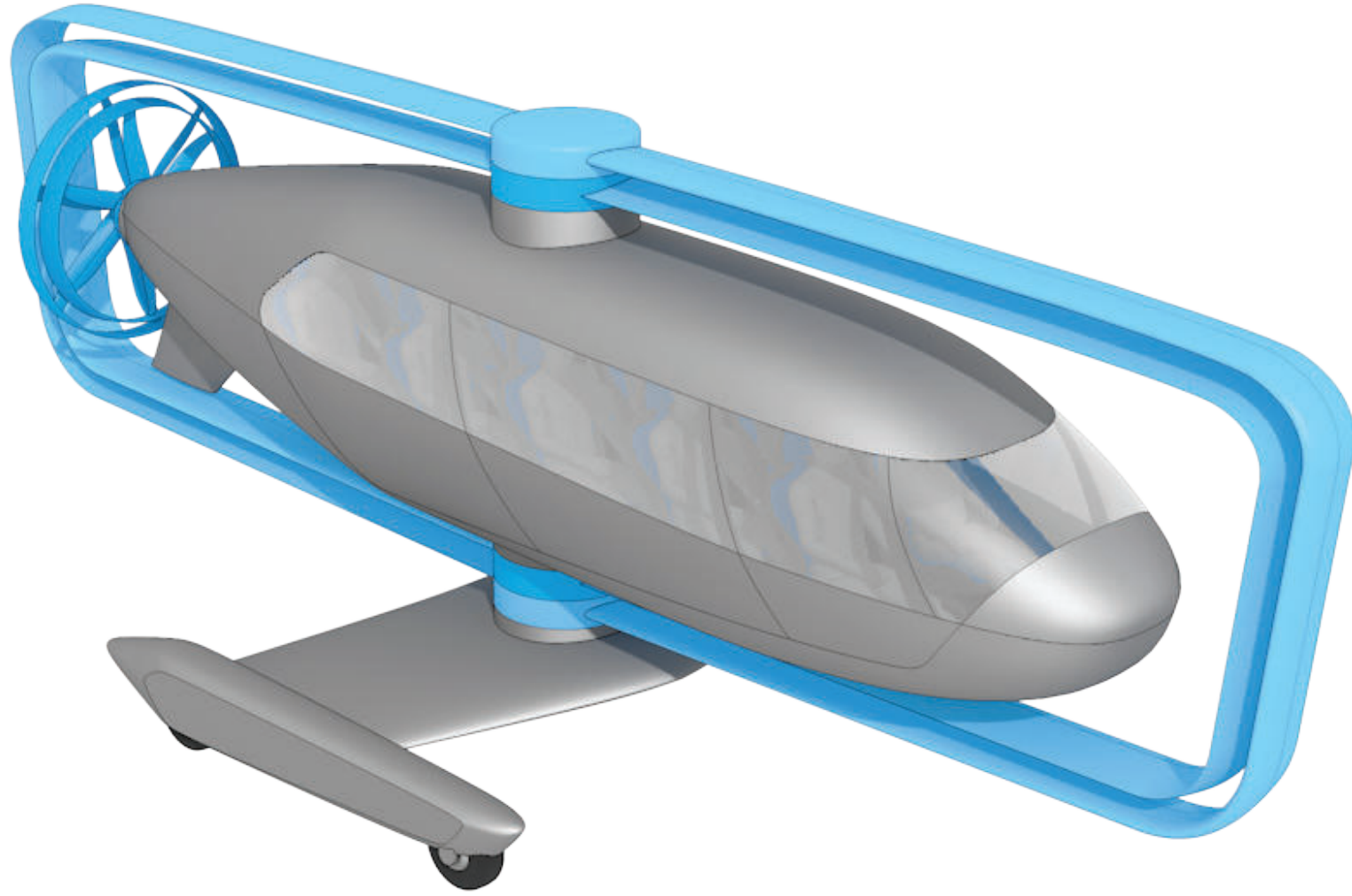


Fig.23

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