Airbine™ Renewable Energy Systems (ARES) - Airborne Wind Turbine (AWT)

Peter Lobner, 11 January 2023

1. Introduction

Lynn Potter founded Airbine™ Renewable Energy Systems (https://airbine.com) in 2010 in Barstow, CA, and patented and trademarked her buoyant Airborne Wind Turbine (AWT) concept with the goal of commercializing this unique system for generating renewable electric power from high altitude winds.

Potter describes the Airbine™ as follows, “Our type of AWT is aerostat-based so that it is held up in the air all the time, (an aerostat is like a helium balloon on a string). An Airbine™ array is made up of individual lighter-than-air platforms, these platforms are called modules. Each module contains one or more electricity-producing wind turbines. Modules are stacked, (with proper spacing in between to reduce turbulence) so that they perform like stacked kites. Stacked kites are many kites on a single or multiple strings. Think of Airbine™ as a ‘Wind Farm On A String’.”…….“AWTs are more efficient (than terrestrial wind turbines) in the production of electricity. AWTs place the turbines where the wind is strong and continuous, 1,000 to 30,000 feet (305 to 9,144 meters) above ground level. One of the biggest problems with ground-based wind turbines is finding a location with sufficient wind to be able to produce consistent energy….. Airbine™ arrays are located (far above ground) where the wind is (more) powerful and consistent 24/7.”

An Airbine™ power generator is expected to be inexpensive to build and operate and can be set up quickly to deliver electric power, even in remote areas. Other applications for an Airbine™ buoyant stacked kite include: (1) telecommunications relay platform, (2) Earth observation or surveillance platform, and, in the longer term, (3) a high-altitude launch platform that could reduce the cost of near-space and orbital flight.

2. The Airbine™ Patents

The basic design and operation of an Airbine™ are described in US Patents US7786610B2 and US2008/0290665A1, both entitled "Funneled wind turbine aircraft" and granted to Lynn Potter in 2010. An Airbine™ is an unmanned, tethered, non-rigid, lighter-than-air (LTA) vehicle carrying one or more wind funnels that capture ambient airflow and accelerates it into a wind turbine to generate electricity, which is delivered via the tether to a ground station that is connected to a terrestrial electric power distribution system.

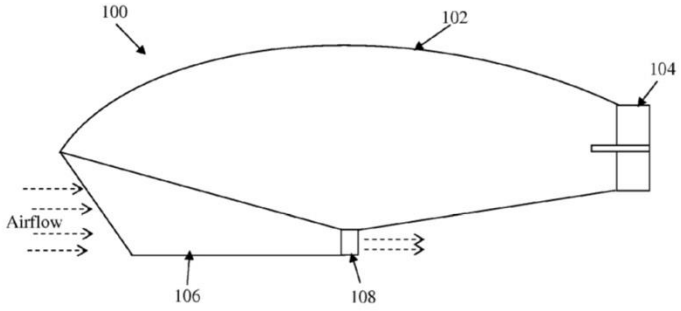


Fig. 1. Side view

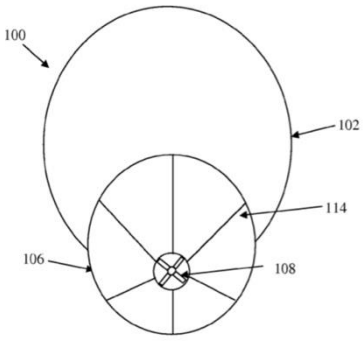


Fig 3. Front view

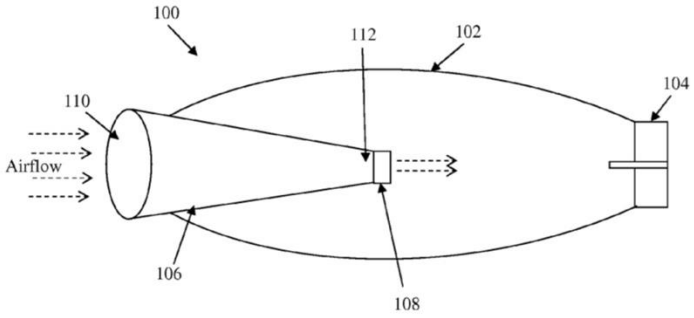


Fig. 2. Bottom view

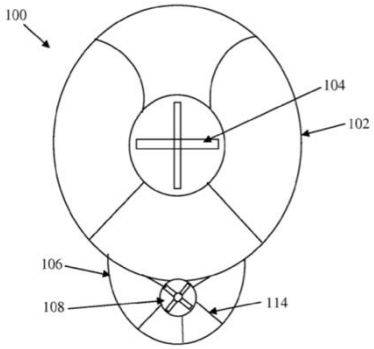


Fig. 4. Stern view

Legend: *The Airbine™ platform (100) consists of a buoyant envelope (102), with cruciform tail-mounted stabilizing / control surfaces (104), supporting an air turbine assembly, which is designed as a funnel, with one or more large air inlets (110), a tapered wind funnel section that accelerates the air flow (106), and a smaller air outlet (112) that directs air into an attached air turbine (108) that generates electricity and discharges air to the ambient atmosphere.*

General arrangement of one embodiment of an Airbine™ platform. Source: Patent US7786610B2

The air funnel enables use of smaller, higher-speed, fixed turbines, with a simple support structure, smaller bearings, and lighter-weight gearbox. The funnel is made of lightweight, flexible material. Ribs (battens) around the air inlet (110) and along the sides (114) may be used to structurally stabilize the wind funnel.

A tethered Airbine™ platform is naturally blown downwind from its launch point. The tether connection to the platform is forward of its center-of-gravity, ensuring that the platform faces into the prevailing wind. A movable rudder (104) provides additional yaw control.

Helium or hydrogen may be used as the lifting gas. The gas envelope has an air ballonet for controlling envelope pressure and for making small changes to buoyancy to help, along with the tether winch, to maintain the LTA vehicle at a desired altitude through daily cycles of heating, cooling and atmospheric pressure changes.

Pitch (angle-of-attack) control to optimize airflow into the wind funnel can be implemented with fore and aft winches on the platform that adjust the lengths of control cables attached to the tether. The elevator control surfaces (104) at the tail also can be used for adjusting pitch and altitude.

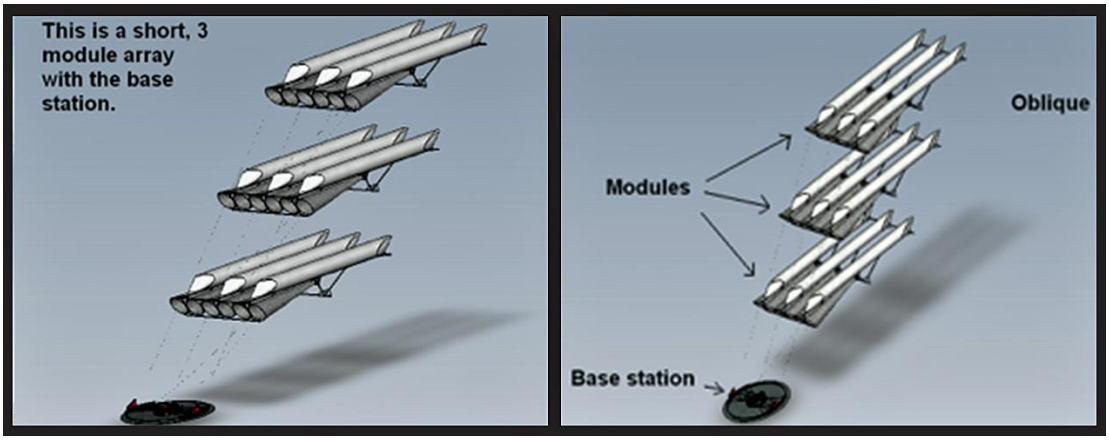
3. Concept of operation for an Airbine™

An individual Airbine™ platform is designed to be connected to fore and aft transverse rigid truss frameworks that join one or more other platforms to form a module, which would be one layer in a stacked kite formation. Tethers connect on the forward framework, ensuring that the installed Airbine™ platforms face into the prevailing wind. The rudder and elevator control surfaces (104) on each of the Airbine™ platforms provides additional yaw and pitch control for the module when operated collectively.

The layers in the stacked kite formation would be spaced apart sufficiently by the tether to enable the platforms in each layer to operate efficiently, without interference from the platforms stacked above and below. The deployed altitude of the Airbine™ stacked kite formation is determined by the length of the tether, wind conditions and buoyancy of the Airbine™ platforms.

Rendering showing the general arrangement of an Airbine™ module comprised of three platforms, each with two air funnels. Note the rigid transverse truss framework connecting the three platforms at their front and back, and the three tethers connected to the front truss framework. Source: ARES

Airbine™ modules can be scaled into larger power generating systems by adding tiers to the stacked kite configuration, within the mechanical and electrical limits of the tether system, and up to the buoyancy limit (pressure altitude) of an Airbine™ module. Following its precedent with other high-altitude tethered aerostats, the Federal Aviation Administration (FAA) likely will set a restricted airspace zone around each AWT. Warning lights would be placed on the AWTs and along the tether.



General arrangement of a 3-tier Airbine™ AWT.

Rendering of a many-tier Airbine™ AWT. Source, both graphics: ARES

Rendering of a many-tier Airbine™ AWT, viewed from above. Source: ARES

The ability to operate a large aerostat system on a very long tether has been demonstrated operationally since 1978 by the Lockheed Martin / ILC Dover / TCOM Tethered Aerostat Radar System (TARS), 12 units of which have been built and operated by several U.S agencies, including Customs and Border Protection, the Air Force, the Army and the Coast Guard. The Federation of American Scientists (FAS) has reported the following design details of TARS aerostats and tether system:

TARS aerostat. Source: Defense Logistics Agency

Parameter	**TARS**
Aerostat volume	Three sizes, from 275,000 ft^3 (7,787 m^3), about the same size of the current Goodyear Blimp (a Zeppelin NT), to 625,000 ft^3 (17,698 m^3)
Aerostat payload	1,200 lbs (544 kg) to 3,400 lbs (1,542 kg)
Length of tether	25,000 feet (7,620 m)
Tether max breaking strength	26,000 lb (11,793 kg)
Aerostat operational ceiling	15,000 ft (4,572 m)
Power source	Some models use a power tether, some carry an airborne generator and fuel.

TARS is a single-aerostat, single-tether system that is quite different than the multi-platform, multi-tether airborne wind turbine system being developed by ARES. Nonetheless, TARS has demonstrated over a period of decades the feasibility and safety of operating large aerostat systems on long tethers in appropriately restricted airspace.

4. Current status

As of January 2023, the Airbine™ platform is in an early stage of development.

5. For more information

Patents

- US7786610B2, “Funneled wind turbine aircraft,” Inventor: Lynn Potter, Filed 21 May 2008, Granted 31 August 2010: https://patents.google.com/patent/US7786610
- US US2008/0290665A1, “Funneled wind turbine aircraft,” Inventor: Lynn Potter, Filed 21 May 2008, Granted 31 August 2010: https://patents.google.com/patent/US8864064B2/en

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