Solomon Andrews - *Aereon & Aereon 2*

Peter Lobner, updated 10 March 2022

1. Introduction

In the early-1860s, Dr. Solomon Andrews invented and flew a directionally maneuverable, hydrogen-filled airship named *Aereon,* which used variable buoyancy and airflow around the gas envelope to provide propulsion for a manned airship without an engine. The same principles of alternating between buoyant ascent and semi-buoyant descent under the influence of gravity have been applied in several modern variable buoyancy propulsion aircraft.

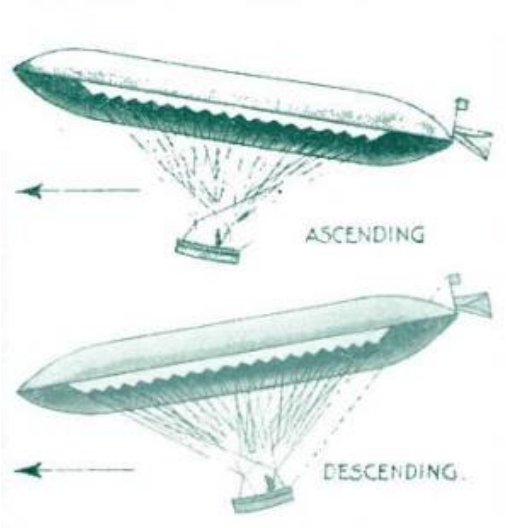
Solomon Andrews circa 1840 by Robert Cornelius. Source: Wikipedia

2. *Aereon*

Andrews' original *Aereon* airship consisted of three side-by-side, cigar-shaped balloons, each measuring 80 feet (24.4 meters) long and 13 feet (4 meters) wide, with seven internal cells made of linseed oil-varnished linen containing the hydrogen lifting gas. The three balloons formed a 39 feet (11.9 meters) wide envelope with a fixed-volume of 26,000 cubic feet (736 cubic meters). A 12 foot (3.7 meter) long open gondola (or "car," or "basket") for the crew and ballast was suspended 16 feet (4.9 meters) below the envelope. A network of adjustable suspension ropes allowed the crew to change the inclination of the envelope in flight. *Aereon* could lift 600 pounds (272 kg), including the pilot and ballast. This was sufficient to carry the pilot and up to three passengers.

The variable buoyancy *Aereon* airship was operated as follows:

- Buoyancy of the airship was controlled dropping some sand ballast to become more buoyant or by venting some hydrogen lifting gas to become less buoyant.
- The angle-of-attack (pitch angle) of the gas envelope was controlled by moving the center of gravity of the gondola (i.e., by moving people in the gondola fore and aft as needed).
- Propulsive force was generated by alternating between positive buoyancy (lighter-than-air) flight and negative buoyancy (heavier-than-air) flight, and by coordinating the pitch angle of the gas envelope.
    - During a buoyant ascent, the pitch angle was adjusted to as much as 15 degrees up. Airflow along the top surface of the envelope moved from bow to stern, helping to drive the airship forward. The airship could continue to ascend until it reaches its "pressure altitude" where the decreasing atmospheric air density reduces airship buoyancy from positive to neutral.
    - During a semi-buoyant descent under the influence of gravity, the pitch angle was adjusted to as much as 15 degrees down. Airflow along the bottom surface of the envelope moved from bow to stern and continued to drive the airship forward.



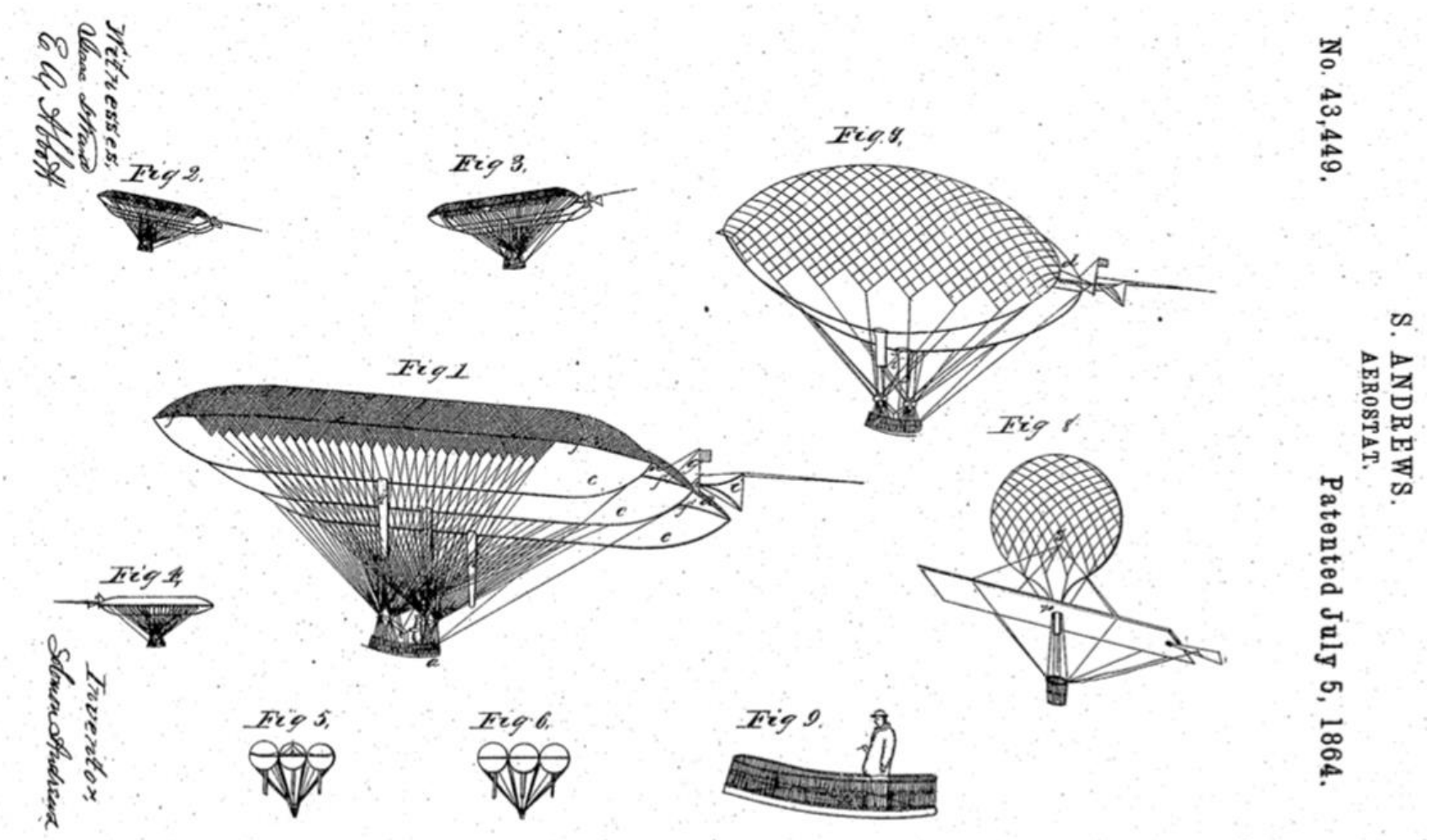
Source: Popular Science Monthly, January 1932

- Direction was controlled by a rudder at the stern of the airship. With sufficient authority from the rudder, the Aereon could point into the wind and maintain an upwind course.
- The cycles of buoyant ascent and semi-buoyant descent under the influence of gravity could continue until lack of ballast precluded another ascent.

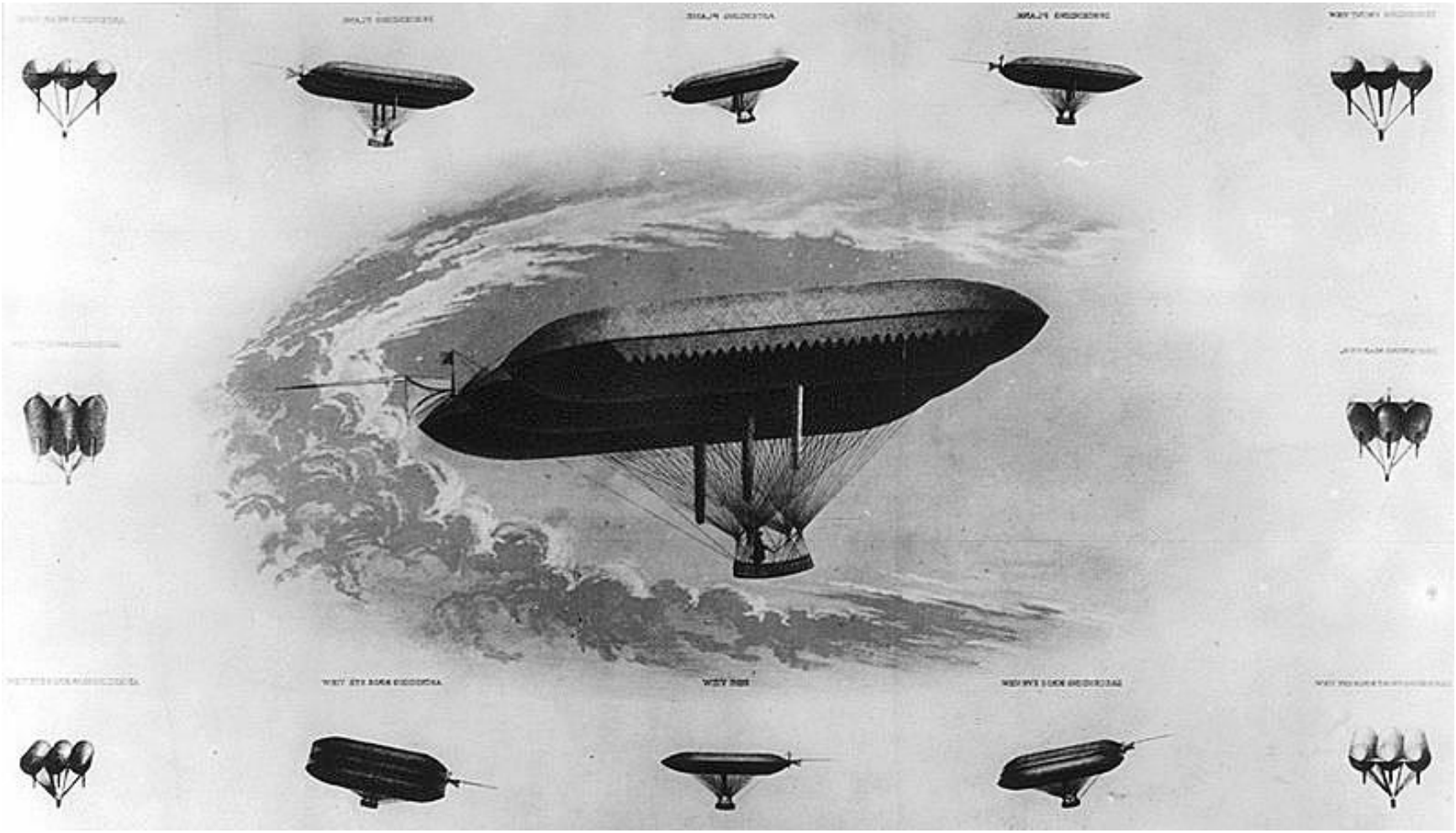
Andrews first flew *Aereon* over Perth Amboy, NJ on 1 June 1863. He made at least three more flights with *Aereon*, including his second flight in July and his last flight on 4 September 1863. With *Aereon*, he demonstrated the ability to fly in any direction, including against the wind, make broad 360-degree turns, and navigate back to and land at his starting point.

Iver Cooper, writing for the Grantville Gazette in 2012, remarked that Andrews was not entirely satisfied with the design. A key issue was that *Aereon* was only balanced when it was full of lifting gas. This limited its maximum altitude in comparison to conventional balloons of the day, which, at launch, were inflated to 50 – 75% capacity, providing space for the lifting gas to expand as the balloon gained altitude. Andrews wanted an airship that could reach an altitude that was above the range of bullets.

On 5 July 1864, the US Patent Office granted Patent # 43,449 to Solomon Andrews for his invention of a balloon that was capable of directed flight and could even be flown against the wind. *Aereon* was very similar to the airship in patent Figure 1.



A variety of variable buoyancy airship configurations are described in Solomon Andrews' 1864 patent. Source: Patent US43449A

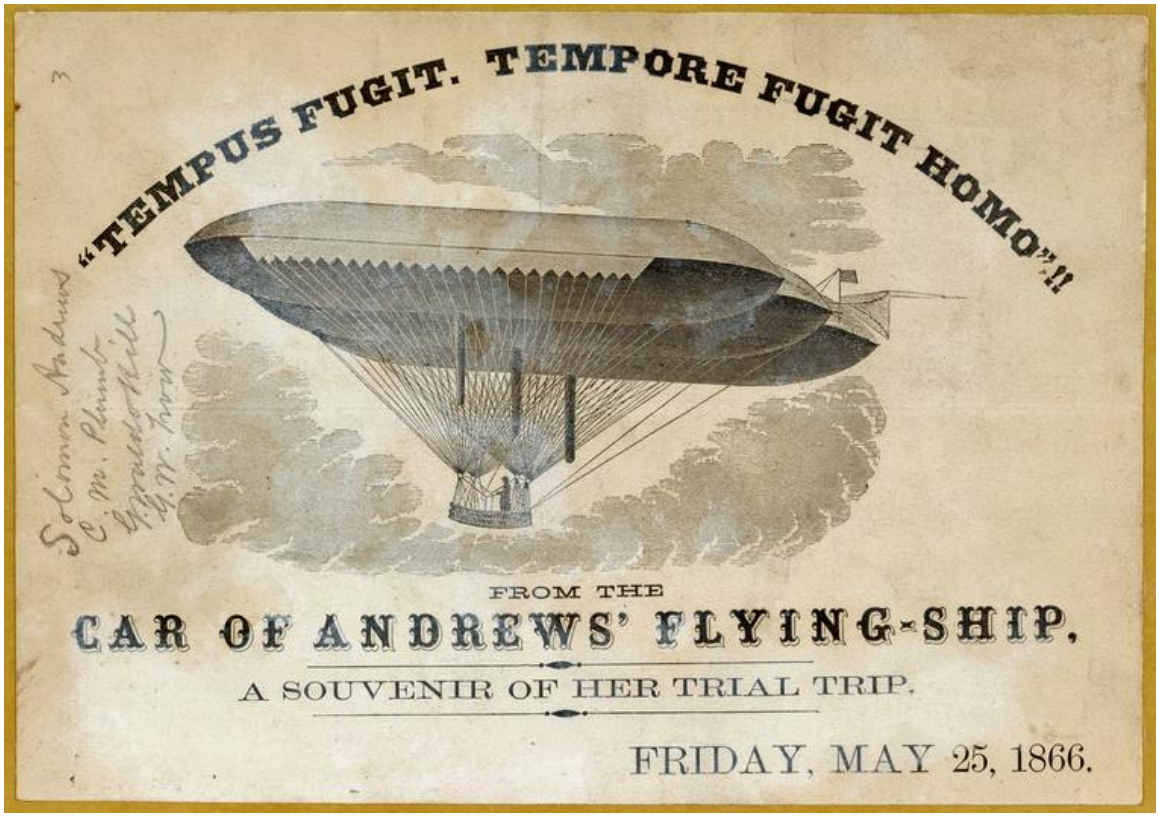


Lithograph of Solomon Andrews' first airship Aereon.
Source: United States Library of Congress's Prints and Photographs division, digital ID cph.3b01438.

3. *Aereon 2*

Andrews' second airship, *Aereon 2*, had a different gas envelope design, described as "a flattened lemon, sharply pointed at both ends." *Aereon 2* also used a different, variable volume approach for controlling buoyancy. This approach used a complex set of ropes and pulleys to squeeze or release external pressure on the hydrogen gasbags, thereby changing their volume and how much air was being displaced.

Aereon 2 flew twice over New York City, first on 25 May and again on 5 June 1866. On the first flight, Andrews launched from lower Manhattan and is reported to have flown *Aereon 2* up Fifth Avenue and thrown commemorative cards to onlookers below. As shown below, these cards had an image of *Aeron*, not *Aereon 2*.



9-3/4" x 6-3/4" commemorative card printed on mid-weight stock. Source: Skinner Auctioneers

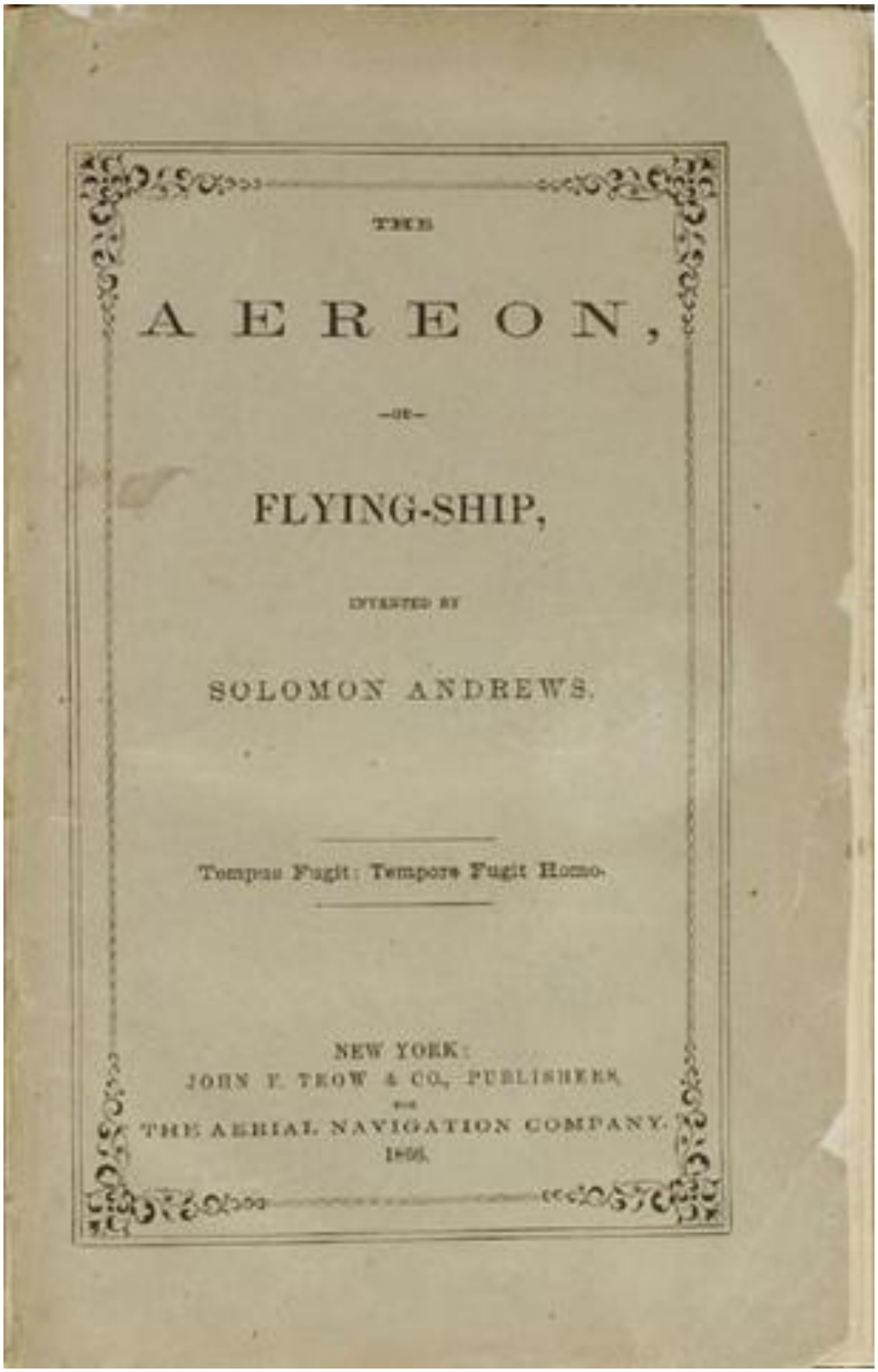
Iver Cooper provided more details about these two Aereon 2 flights.

- After flying up Fifth Avenue, the first flight of *Aereon 2* continued north to Harlem, then across the East River, and finally landed in Astoria, Queens, 25 minutes after launching. The airship reached a maximum altitude of 2,000 ft (610 m) on this flight. Lessons learned from the first flight were that: (1) the rudder was too small and could not hold the airship on a course heading into the wind, and (2) the gondola was not long enough to allow the center of gravity to be shifted enough during flight to get the gas envelope to the desired high pitch angles.
- For the second flight, *Aereon 2* had a larger rudder. During the flight, the crew encountered several mechanical problems that resulted in a temporary loss of flight control. After regaining control, the crew flew on to a safe landing in Brookville, Long Island, about 90 minutes and 30 miles (48.3 km) from the launching point on Manhattan. On this flight, the airship reached a maximum altitude of 6,000 ft (1,829 m). Lessons learned from the second flight were: (1) Andrews estimated that *Aereon 2* needed a 50 foot (15.2 m) long gondola to allow hime to increase his control over center of gravity, and (2) “two lateral wing-shaped appendages” should be added to the airship.

The second flight on *Aereon 2* was Solomon Andrews last flight.

4. The Aerial Navigation Company

Andrews organized the Aerial Navigation Company, which was chartered in November 1865 for “the transportation of passengers, merchandise and other matter from place to place.” The firm intended to build commercial airships and establish regular airship service between New York and Philadelphia. During the post-Civil War economic crisis, many banks failed and Aerial Navigation Co. went bankrupt, ending the plans for the first commercial passenger and freight air service in the world.



Prospectus for The Aerial Navigation Company.
Source: Worthpoint

5. Solomon Andrews' legacy

Variable buoyancy propulsion was not demonstrated again for almost 140 years, when, in the early 2000s, New Mexico State University conducted an indoor test flight of their subscale, unmanned Advanced High-Altitude Aerobody (AHAB) variable buoyancy propulsion airship. Almost two decades later, in 2019, the UK Phoenix team demonstrated variable buoyancy propulsion during an indoor test flight of their Phoenix subscale, unmanned airship. In contrast to these two modern-era test flights, Solomon Andrews flew *Aereon* and its successor, *Aereon 2*, from 1863 to 1866, and demonstrated the ability to fly with passengers against the wind, covering considerable distances in an intended direction and landing safely.

In addition, with *Aereon 2*, Andrews made the first practical demonstration of the use of variable volume to control airship buoyancy. About 100 years later, Russian airship designer David Bimbat implemented variable volume control in the mid-1960s on his Ural 2 and Ural-3 airships and in the designs of many subsequent "ballastless" airships. More recently, the French airship manufacturer Voliris was awarded a patent in 2015 for their design of an airship with a "controlled variable profile."

Clearly Solomon Andrews was ahead of his time.

6. For additional information

- Rare Pioneering Aviation Pamphlet, Aereon, Aerial Navigation Co, 1866; https://www.worthpoint.com/worthopedia/1866-pioneering-aviation-pamphlet-111762012
- Whitman, Roger B., "He Flew an Airship Before the Wrights Were Born," Popular Science Monthly, Vol. 120, No. 1, pp. 15 – 18, January 1932; https://books.google.com/books?id=3icDAAAAMBAJ&printsec=frontcover&rview=1&lr=#v=onepage&q&f=false
- Cooper, Iver P., "Airship Propulsion, Part Four: The Aereon," Grantville Gazette, 14 October 2012: https://grantvillegazette.com/article/publish-541/

- Racine EAA Chapter 838 newsletter, *Contact*, Volume XXIV Issue 10, October 2013, pp. 7 - 8, Sean's Corner, "Aereon – 1864 to Today"; https://eaa838.org/wp-content/uploads/2013/03/EAA-Chapter-838-October-2013-Newsletter.pdf

Patent

- US43449A, "Improvement in aerostats," Inventor: Solomon Andrews, Application granted 5 July 1864: https://patents.google.com/patent/US43449

Other *Modern Airships* articles

- *Modern Airships - Part 1*: https://lynceans.org/all-posts/modern-airships-part-1/
    - Voliris – variable volume airships
- *Modern Airships - Part 2*: https://lynceans.org/all-posts/modern-airships-part-2/
    - David Bimbat & Ural OKBD - variable volume airships
    - Hunt Aviation – Gravity plane
    - New Mexico State University – AHAB
    - Phoenix - VB propelled airship
    - Walden LTAS - VB propelled airships
- *Modern Airships - Part 3*: https://lynceans.org/all-posts/modern-airships-part-3/