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Chapter 6

New Observations on Reaction-Propelled Manned Aircraft Concepts, ca. 1670–1900, A Survey: Part I (1670–1869)*

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Abstract

Konstantin Tsiolkovsky and Robert H. Goddard are renowned names in the history of astronautics; from the late 19th to early 20th centuries, they developed the earliest known concepts of rocket-propelled unmanned and manned spacecraft.[1]

Nonetheless, the earlier history of the potential use of the rocket, or reaction propulsion, for propelling manned aircraft for terrestrial use is not so well documented in the literature. Apart from a few papers at International Astronautical Federation (IAF) congresses, such as one in 1971 by Ramon Carreras on the 1872 concept of a rocket-propelled aircraft by Frederico Gomez Arias, Jules Duhem's *Histoire des origines du vol a réaction* (*History of the Origins of Reactive Flight*) is a main source of study on this topic. However, Duhem's book is now out of date and several other pioneers in this area have come to light since these works appeared.

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In addition to the above-mentioned works, the authors have drawn material from other sources not previously examined fully, especially patents, in order to present several hitherto unknown pioneers of reactive flight. Although not definitive, this survey includes the most significant pioneers and others who are of unique interest, and thus offers new details and perspectives.

Part II of this paper, covering the years 1870–1900, was presented at the Forty-Ninth History Symposium of the International Academy of Astronautics, 26–30 September 2015, Jerusalem, Israel.

Unsubstantiated Early Attempts at Rocket Propulsion

It needs first be mentioned that many texts on the history of rocketry include accounts of two early attempts at "reaction-propelled" manned craft, both featuring the use of rockets. But although frequently presented as factual, neither of these stories can be substantiated.

One of these accounts is the story of Wan Hu (also spelled Wan Hoo), a minor Chinese civil servant who, around 1500 CE, allegedly attempted to fly into the sky on a chair, to the back of which were affixed some 47 gunpowder-type rockets. At a prearranged signal, the fuses of the rockets were ignited, only to make Wan Hu disappear in cloud of smoke. In other words, his experiment apparently failed, resulting in an explosion that killed him.

Yet, although a crater on the far side of the Moon is named in Wan Hu's honor (9.8° S, 138.8° W), the late eminent Sinologist Dr. Joseph Needham calls the Wan Hu accounts "dubious stories...and we suspect that he is a myth invented probably during or after the Chinoiserie period."[2]

Equally unsubstantiated is the story of Turkish experimenter Legari Hassan Çelebi. According to Evliya Çelebi (1611–1682), the Ottoman Turkish traveler who journeyed throughout the Ottoman Empire for over 40 years, in 1633 Legari Hassan Çelebi (apparently no relation) supposedly flew in a multi-winged gunpowder rocket near the Topkapi Palace in Constantinople. Legari is alleged to have ascended up to about 300 m (984 ft), then landed safely in the water (in the Bosphorus Strait).

But there is no evidence for the Legari Hassan Çelebi story beyond Evliya Çelebi's account. Therefore, both the accounts of Wan Hoo and Legari Hassan Çelebi should be considered legendary or, at best, perhaps semi-legendary, rather than factual.[3]

Seventeenth Century: Honoré Fabri (1670)

In 1670, less than 40 years after the possibly legendary flight of Çelebi, the Jesuit Honoré Fabri (1607–1688), the French theologian, mathematician, and physicist, became the first to make a scientific proposal for human flight by means of a reaction-propelled device, according to Duhem. His idea was a form of pump tube that ejected compressed air, as described in Fabri's *Physica id est scientia rerum corporearum* (*This is the natural science of the physical world*) (1669–1671).[4]

Figure 6–1: Portrait, Honoré Fabri. Credit: Frank H. Winter collection.

The relevant passage, from Vol. I, p. 154 of *Physica*, was translated from the Latin into French by Duhem and is now partly given here in English for the first time as follows:

> [If] we could...make a large container in the form of a tube and there(in) compress a quantity of air, fusing the bottom, it would be able to raise up, not only the tube, but also a load of more or less the same weight associated with it. Accordingly, if we adjusted (fitted) this tube with a rudder, an ejection control and a suspended seat for a man, it would be possible to fly with safety through the air, the control operating as it should; what is more, while the air would escape from the bottom, it would not be difficult to store [more] above, by means of a compression pump and a tank similarly fitted to the tube. Thus we could we go in the air for hours.[5]

Duhem offers further explanations and discussion of the significance of Fabri's concept in two chapters of his work, but there is no evidence that Fabri ever attempted to construct the device.[6]

Eighteenth Century:
J. Montgolfier, Miollan and Janinet (1783–1784), and Devenell (1784)

After Fabri's 1670 concept, more than a century passed before the first known proposal for applying "jet propulsion" to balloons was made. This was followed soon after by the earliest attempted use of reaction propulsion, also for balloons.

On 4 June 1783 the French brothers Étienne (1745–1799) and Joseph Montgolfier (1740–1810) made the world's first public demonstration of an unmanned balloon. On 15 October, Étienne became the first human to lift off the Earth in a tethered flight. But during the same month, Joseph had already presented a "mémoire" to the Academy of Lyon in which he explained:

> We have sought power [with] the same fire which serves to keep the vessel aloft. The first which presented itself to our imagination is the power of reaction which can be applied without any mechanism, and without any expense; it consists solely in one or more opening[s] in the vessel [the balloon] on the side opposite to that in which one wishes to be conveyed.

According to the late aviation historian Charles H. Gibbs-Smith, "This is the first technical statement in history on the subject of the jet propulsion of aircraft."[7]

However, it is alleged that in the same year (1783), a writer in the British newspaper the *Morning Post* more directly suggested the directional control of balloons by *rocket*. Unfortunately, we do not have an exact citation. It is therefore possible that this unknown Englishman may have preceded the Montgofiers in conceiving of reaction propulsion, specifically by a rocket, for a lighter-than-air craft.

Not long after, on 11 July 1784, two Frenchmen, the Abotté (abbot) Miollan and Jean-François Janinet[8] (1752–1814), assisted by a mechanic named Bredin, attempted to launch a steerable balloon. Comparable to the suggestion made by Joseph Montgolfier, the balloon had large holes in its sides, each with a moveable valve.

Tickets were sold to the event and the ascent was made at the Luxembourg Gardens in Paris before many spectators. According to Rynin's account, a "strong draft induced by the hole in the side caused the balloon to catch fire while being filled, and it was burnt." This version also agrees with the newspaper account the next day, in the *Journal de Paris* of 12 July 1784, as translated in *The Romance of Ballooning*.[9] However, Miller merely says the day was a hot one and the balloon could not gain sufficient buoyancy to lift.[10] Still another account, as reported by Gillispie and others, relates that the crowd became so impatient to see the balloon ascend they angrily attacked it, tearing it to shreds and setting it afire. Miollan and Janinet escaped unharmed but their experiment never took place. This version, whether it was true or not, was the most popular one during that period and led to many published satirical engravings and even songs.[11]

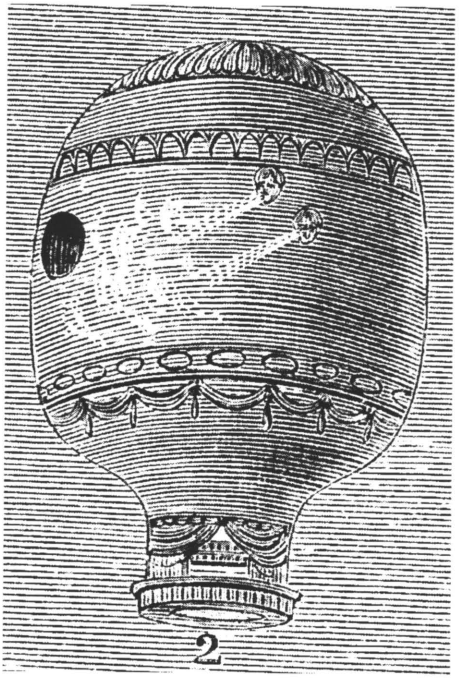


Figure 6–2: 19th Century depiction of Miollan-Janinet balloon, 1794.
Credit: Frank H. Winter collection.

A decade later, in 1794, Robert Deverell (1760–1841), in *Alter et Idem—A New Review*, described at length his "A Project for Directing an Air Balloon by the Explosive Force of Rockets." He may well have been the same author of the earlier piece on this same topic in the *Morning Post*.[12]

1830s: Anonymous (1831)

Following Deverell's proposal, there is once again a long gap before we hear of any other reaction-propelled concepts. When the Industrial Revolution came into full swing in the 19th century, there appeared a multitude of concepts, including patents, for "flying machines" of every description. Many utilized reaction propulsion.

One of the earliest of this period was by an anonymous inventor who, in 1831, described and depicted his novel concept in an eight-page pamphlet, *Dalla Scoperta della dirizione del globo aerostatico* (*On the Discovery of the Direction of an Aerosttatic Balloon*).[13] Printed by one Molinari, this work was sold by the Library of Milesi at the Ponte di Mosie (the Bridge of Moses) in Venice. Although the author of the pamphlet is anonymous, the Library of Congress and Italian science journalist Giovanni Caprara attribute the authorship to one Giambattista Toselli of Mantua. However, the latter attribution may be very easily dismissed as Giambattista Toselli, who became a later aviation pioneer, lived from 1821–1879, which would have made him ten years old in 1831.[14]

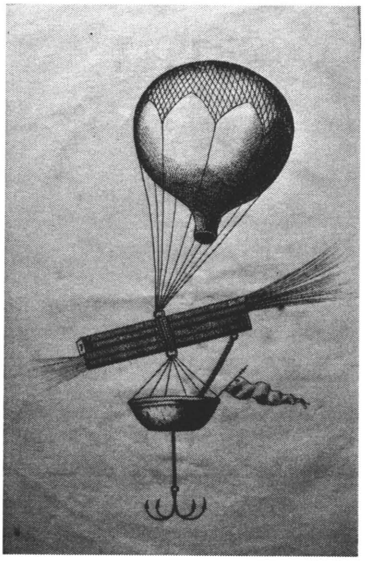


Figure 6–3: Anonymous concept of a "Rocket-Propelled Balloon," from *Scoperta*, 1831, in the Rare Book Room, Library of Congress. Credit: Photo by Frank H. Winter.

Nonetheless, the author's idea, as shown in an accompanying drawing, is very simple: two bundles of long, large firework-type rockets (not Congreve types as mentioned by Caprara) are secured horizontally to the top of the gondola of a manned balloon. A pair or more of these rockets faced one way; the same number of rockets faced the opposite direction. Thus, when the aeronaut wished to travel in one direction, he fired off the bundle facing the opposite direction, and vice versa to go the other way.[15]

However, the text itself presents somewhat of a mystery.[16] In the first instance, it offers a very complex and convoluted explanation of the physics involved. Secondly, the author unaccountably uses the term "tubo" (tube) in referring to the rockets, whereas the Italian word "razzi" (rocket) would be expected. It is therefore possible that this quaint pamphlet was a sarcastic or lampoon treatment of a very simple idea but written in an overdone style characteristic of a more elaborate and almost fanciful "flying machine" concept of the day.

1840s: Anonymous (1841), Phillips (1842, 1868), Jir (1843), Selligue (circa 1844), Siemens (1847) and Tretesski (1849)

One of the oddest concepts for reactive flight during this period is found in the anonymously-authored booklet, *The Great Steam Duck or, a Concise Description of a Most Unusual and Extraordinary Invention for Aerial Navigation.* Published in Louisville, Kentucky in 1841, this piece was actually a satire, by someone calling himself "a member of the L.L.B.B." (the "Louisville Literary Brass Band"), of a plan by Richard Ogelsby Davidson (born 1807) of his eagle-shaped, crank-operated man-powered winged aircraft. This concept had appeared in the same year in the booklet, *A Description of the Aerostat* (New York, 1841) as well as in Davidson's earlier pamphlet, *Disclosure of the Discovery and Invention* (Saint Louis, Missouri, 1840).[17]

In the satire, "the Great Steam Duck" is literally a steam-powered duck-shaped balloon 15 ft (4.6 m) long "from beak to tail" and worked on the principle of an ornithopter (an aircraft that flies by flapping its wings). The steam was to be generated by the burning of coal or wood in the "engine room." But additional propulsion by "puffs of steam" was provided by a "escape-pipe" leading from the boilers then passing underneath the bottom of the craft and finally "out of a small hole under the tail or rudder," thereby imparting "an additional impetus to the Aërostat [*sic*], [with] every puff." This craft was thus partly reaction-propelled.[18]

On 4 January of the same year, a remarkable British patent, No. 8771, was granted to one Charles Golightly for "Motive Power." It is remarkable not for what it covered but because it literally said nothing: where the text of the patent should have appeared, there is no text at all except for the words, "No specification enrolled."

Yet, from circa 1828 to circa 1849 there appeared a series of widely circulated, popular lithographs depicting, in a humorous and cartoon-fashion, different versions of the image of a man, whose name is usually given as Charles Golightly, straddling a reaction-propelled cylindrical steam-powered flying craft.

This interesting case has been studied closely by Winter whose conclusion is that Mr. Golightly may have been a real person, perhaps a man who worked in the British Patent Office, who was simply poking fun at the use of his name for this fanciful flying machine. If this was the case, it may have been easy for him to take out such a patent and to completely disregard the need for a textual specification.[19]

Whatever its origins, the Golightly caricature subsequently became a kind of iconic figure in the history of rocketry and even spaceflight. The image came to personify both the progress and promise of human flight by rocket by the 19th century, or in the age of steam (i.e., the Industrial Revolution). Popular rocketry historian Willy Ley featured a Golightly drawing in his *Rockets, Missiles, and Space Travel* that went through many editions. Earlier, the Verein für Raumschiffahrt (the VfR, better known as the Society for Spaceflight) included a version of the caricature in their journal *Die Rakete* for 15 March 1928 in an article, also probably by Ley, who was then the VfR's Vice-President. In the 15 August 1929 issue of the VfR's journal, *Die Rakete*, there is also a notice about a set of a dozen glass plate slides members could purchase covering rocketry history, including one of the "Apparat Golightly" ("Golightly apparatus").[20]

A year after the Golightly patent, in 1842, the Englishman W. H. Phillips, whom we now identify as the engineer William Henry Phillips, actually built and successfully flew a 2 lb (0.9 kg) powered metal model of a kind of helicopter, in which the pressure from the combustion of potassium nitrate, charcoal and gypsum (or steam according to some accounts) was expelled from the rotor tips. The model, according to a contemporary report, "rose to a considerable height and travelled a long distance horizontally until it touched the ground again."[21]

Figure 6–4: Cartoon (1860) of 1842 reaction-propelled helicopter of W. H. Phillips. Credit: *Scientific American*, Vol. III, 8 November 1860, p. 165.

Scientific American's 8 November 1860 issue ran a cartoon caricature of Phillips' craft, depicting a man in a full-sized version of the machine with two rotor blades. The cartoon appeared with others to illustrate the article, "Flying Machines of the Future."[22] [See Figure 6–4]. A replica of it was also exhibited many years later at the 1868 Exhibition held at the Crystal Palace in London by the Aeronautical Society.[23]

Although very simple and merely an unmanned model, Phillips' achievement is remarkable in its own right for being the earliest known workable rocket-powered helicopter and for that matter, one of the earliest known successful reaction-propelled flying craft.[24] Phillips went so far as to establish his own company, the Aerial Courier Company, for his "Aerodiphros" ("Aerial Carriage"), as he called it, in which he intended to carry passengers and luggage.[25] A prospectus for the company, located at 41 Bloomsbury Square, London, according to the London Post Office Directory for 1844, was also published but these efforts did not lead anywhere.

Many years after his experiment, in 1868, Phillips read a paper titled, "On Aërial [*sic*] Locomotion by Machinery, with Gaseous Buoyancy," before the Aeronautical Society of Great Britain, in which he considered using another of his inventions, the "Phillips Fire Annihilator"[26] (a high-pressure fire extinguisher),[27] as a small, light-weight power source for aerial locomotion on the "reaction principle."

At the First Exhibition of the Aeronautical Society of Great Britain, held at London's Crystal Palace from 25 June to 4 July 1868, Phillips exhibited a "working model" capable of "raising and sustaining itself in the air for several minutes." This "worked by a power evolved by the combustion of materials similar to those used in the original Fire Annihilator" and was submitted in competition for the Society's prize of £100 for the lightest "motive power engine" for its potential application to flying. However, there is no indication that he tried it out on a flying version.[28]

In 1843, Russian newspapers publicized a concept by Emil Jir (also given as Emil Zhir) for a steerable balloon using compressed air, in which the reaction force was not the primary means of propulsion, but only intended to raise or lower the balloon to find the "most favorable winds." The air was to be furnished by a hand-operated compressor.[29]

French engineer Alexander François Selligue (1784–1845) suggested, around 1844, the continuous explosion of hydrogen and gaseous carbide in a metal tube at the rear of his flying vessel. This concept is noteworthy as it may well be the earliest known suggestion of hydrogen as one of the propellants in a reaction-propelled manned flying craft.[30]

Selligue took out a patent for the application of shale oil for direct illumination and, in 1838, another for "the employment of mineral oils for lighting." He was, therefore, very knowledgeable about gases: in fact, he is known for introducing "water gas" into the technology of early gas lighting.[31] But his idea for "Gas Motive Power," as he wrote in a report to the French Academy of Sciences, could actually be applied to "every description of machinery," besides flying machines."[32]

In 1845, the German-Swiss chemist Christian Friedrich Schönbein (1799–1868) discovered gun-cotton which consisted of cotton saturated in nitroglycerin. This new and powerful lightweight combustible explosive offered considerable advances over the weaker, though centuries-old, gunpowder. As a projectile propellant, it produced about six times the gas generation of an equal volume of gunpowder although with less smoke and less heating.

Gun-cotton thus opened up several possibilities. In a house party on 12 November 1846, according to one German diarist at the time, Professor Christian Gottfried Ehrenberg (1794–1876), the German naturalist and geologist was present when the conversation turned to gun-cotton. "Ehrenberg," explained the diarist,

> was highly excited about the discovery and declared that it would [even] exert an enormous influence on the development of aviation and that we would soon come to the point where we are able to propel airships vertically as well as horizontally by means of rockets.[33]

Although Ehrenberg is not known to have gone further with his speculative talk in the party, at about the very same time, Werner Siemens (1816–1892), the German inventor and future great industrialist, may have considered an idea along the same lines.[34] Ley says Siemens "drew a sketch of such a plane and had it published [at some time between 1845 and 1855]" but he surmised that "because he [Siemens] was then holding an army commission he did not use his name but labeled the sketch 'a proposal coming from an officer.'"[35]

We can now identify exactly where and when this concept was published. It is the well-illustrated article (including diagrams) titled "Eine Flugmaschine vermittelst Schiessbaumwolle" ("A Flying Machine by Means of Gun-cotton") appearing in the *Leipziger Illustrierte Zeitung* (*The Leipzig Illustrated Journal*) for 30 January 1847 and indeed, as Ley says, the author merely labels it, "Vorschlag eines offiziers" ("[A] Proposal from an Officer").[36]

Von Siemens does not mention this invention in his later work, *Personal Recollections of Werner von Siemens*.[37] Rather, he only spoke about "flying machines" in general and observed: "The inventors always begin at the wrong end, and invent flying mechanisms without having the power for moving them [as opposed to muscle-powered vehicles]." He also noted that with power, such machines were entirely feasible, but he did not explain why he never built his own. It may be that he became far more interested in the commercial aspects of electrical engineering, starting with his invention of the pointer telegraph (using letters rather than the Morse code) and later went on to build the first dynamo.[38]

Nevertheless, his own flying machine as described and depicted in the *Leipziger Illustrierte Zeitung*—if this was in fact Siemens' own idea—was a huge ornithopter powered by the reactive force of gases produced by elaborately "controlled" bursts of gun-cotton explosions. It is also noteworthy that this concept is probably the earliest known reaction-propelled flying machine using a more powerful solid "propellant" other than gunpowder. [Figure 6–5]

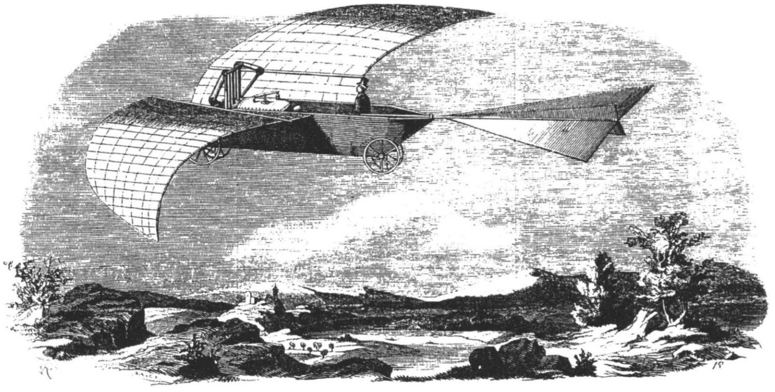


Figure 6–5: 1847 Concept of reaction-propelled ornithopter, allegedly by Werner Siemens. Credit: *Leipziger Illustrierte Zeitung*, Band 8, 30 January 1847, p. 76.

In the meantime, the *Illustrated London News* of 6 June 1846 lampooned the pyrotechnist known as Il Joel Diavolo of London's Vauxhall Gardens where elaborate firework shows were presented, in proposing to make an ascent in a giant rocket. The satirical piece included a rare cartoon and said sarcastically that, "he will be carried to the Moon."[39] There is no evidence that Diavolo went through with his plan of trying out a rocket ascent, although it is possible that he had been influenced by the French pyrotechnist Claude-Fortuné Ruggieri (circa 1776–1841). Beginning in 1806, Ruggieri reportedly sent live animals up in rockets that were recovered by parachute. He even fired a sheep to a height of 600 ft (183 m), safely recovering it by parachute.[40]

According to Dollfus, the practice of sending up small live animals by rockets goes back even earlier and was practiced throughout the 18th century.[41]

In any case, Diavolo's idea was merely intended to be a one-time stunt, and not true, sustainable reaction propulsion.

Nonetheless, about 1830, according to Ley[42] (or 1848, according to Dollfus et al.),[43] Ruggieri is said (like Diavolo) to have been able to make a rocket large enough to lift a man and that the ascent was to take place at the Champ de Mars in Paris. However, the story continues, the volunteer turned out to be a small boy so that the police intervened and prohibited the flight. Ley adds that that boy turned out to be Wilfrid de Fonvielle (1824–1914) who later became a noted balloonist.

However, there are problems with this version of the story. Ruggieri died in 1841 and thus could not have made the attempt in 1848, while de Fonvielle would have been six in 1830, although 24 in 1848. In any case, de Fonvielle makes it pretty clear in his own words that he was not the "volunteer" in question. Reminiscing on his own career in the book *Travels in the Air* edited by James Glaisher in 1871, he says:

> I was bold enough to publish [in the journal *Presse Scientifique* of 1866] a few articles on aerial navigation, and I solicited rich amateurs of extraordinary adventures to come forward with the francs necessary to enable me to repeat the experiment which Ruggieri had made upon a sheep. I declared that I was ready to be shot up in a [huge] sky-rocket provided that its projectile power [lifting power, or today, thrust] were carefully calculated and that it were provided with a parachute. But it was all in vain; no capitalist presented himself.[44]

Therefore, it is possible that the date of 1848 for the alleged Ruggieri attempt, as ascribed by Dollfus and others, may have actually been derived from the approximate time of the proposal by Diavolo.

At the close of the decade, in 1849, the Russian military engineer Captain (later Lieutenant-General) I. (Iustin, or Justin) I. Tretesski or Treteskii (1821–1895),[45] produced a sizeable manuscript of some 208 pages, titled *O sposobakh upravlyat aerostatami* (*On Methods of Guiding Aerostats*). This work was presented to the Commander-in-Chief of the Independent Caucasus Corps, Prince Mikhail Vorontsev, in Tiflis. In it, Treteskii offered three airship designs: one propelled by gunpowder exhaust gases; and the others propelled by either steam or compressed air. Steering was managed by the ships being fitted with jet nozzles aimed at different directions; each nozzle was connected to a main power source.

However, a military study committee judged that Tretesski's ideas were "infeasible." It should also be pointed out that the nozzles of his flying machines were probably not de Laval types that were developed much later by the Swedish engineer Gustav de Laval (1845–1913) about 1890.[46]

1850s: Nye (1852), Konstantinov (1856), Maffiote (1858), Bouquet De La Grye (circa 1858), and Quartermain (1859, 1863)

In England, in 1852, James Nye published a more modest work of 21 pages, *Thoughts on Aerial Travelling and on the Best Means of Propelling Balloons*. Nye described and depicted a huge, 337 ft (102.7 m) long, passenger-carrying type dirigible, propelled by a number of three-pounder (1.36 kg) Congreve (gunpowder) war rockets (minus their warheads) fired successively at the aft end; the rockets were attached to a wheel then, as the wheel rotated in the right position, they were ignited. Steering was by firing individual rockets.[47] [Figure 6–6]

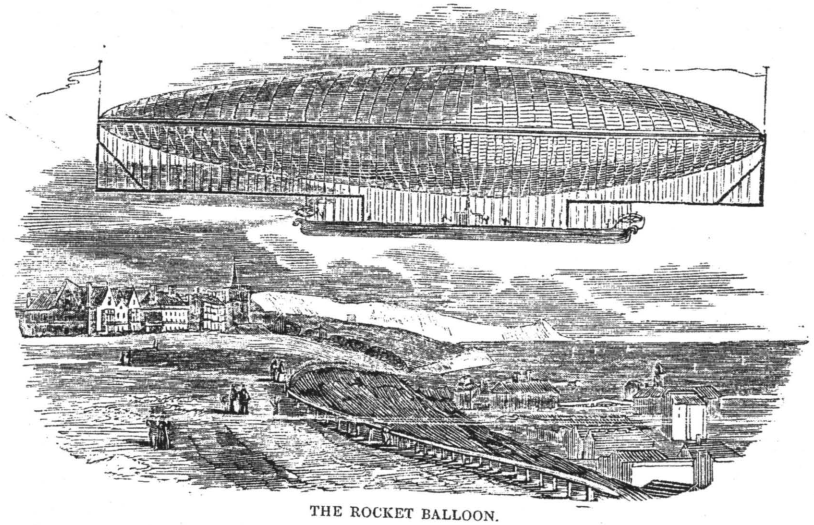


Figure 6–6: "Rocket Balloon" of James Nye, 1852 concept. From James Nye, *Thoughts on Aerial Travelling...* (London, 1852).

Nye also calculated that the three-pounder (then, the lightest Congreve rocket in service) was "sufficiently satisfactory" to power and sustain his "Rocket Balloon." Heavier caliber rockets, he said, were deemed "too powerful," although in truth, neither thrusts nor burning durations were then generally known but flight times and ranges were certainly established for given calibers. Nye also calculated that 5,000–6,000 lb (2,268–2,722 kg) of such lighter rockets were "enough...for a voyage of more than ten hours...and 200 miles [322 km]" distance, or, 20 mph (32 km/h).

Few other details are offered, although an interesting lengthy letter of criticism of Nye's concept appeared in the *Mechanics Magazine* the following year.

Among other things, it was pointed out that the cost of such a voyage would have been extraordinary, amounting to "at least £300," then, a very considerable amount.[48]

Ironically, just four years after Nye, Konstantin I. Konstantinov (circa 1817–1871), the great Russian pioneer of gunpowder-type war rockets in his own country, also wrote a pamphlet investigating the use of these kinds of war rockets for use in aeronautics. This was his *Vozdukhoplavanie* (*Aeronautics*), published in 1856.

Konstantinov was far more scientific than other military rocket practitioners of the day and built a special dynamometer for determining the "force," or lifting weight of rockets, and also obtained their burning times. He thus found through his experiments that these forces were only developed for very brief durations of about 2.7 seconds, and therefore concluded: "It is clear that the moving force of the rockets...is unfit for transport of large masses during long times, for considerable distances." Strangely, however, he also found that the human muscle was a more sustained force and therefore "more suitable than rockets" for achieving human flight.[49]

Yet while Konstantinov's scientific rocketry experiments were then unknown outside his country, standard gunpowder rockets were still considered from time to time as potential sources of power for manned flying machines.

On 14 February 1858, the Spanish inventor Pedro Maffiote (1826–1870) reported to the editor of the *Revista de Obras Públicas* (*Journal of Public Works*) of Madrid that he had built and tested a model rocket aircraft of bamboo and paper, with a three-ft span (0.9 m) oval-shaped wing and single vertical stabilizer (fin) above the wing. The gunpowder was contained in an iron tube below the wing for a total weight of over 2 ounces (56.7 grams). The model flew from 7.5–13 ft/s (2.3–4 m/s). Maffiote gave thought to building a "larger model...but it will still be difficult to discover a chemical compound more effective than [gun]powder...unlike the rocket built these days." However, he still hoped "that some wealthy...person will support this field of research."[50]

About 1858, according to the later recollections of Jean Jacques Anatole Bouquet de la Grye (1827–1909),[51] "I had started studying [i.e., looking toward building] an aviation apparatus, but at that time we only had a steam engine which weighed 100 kg [220 lb] empty." He says he also used rockets to experimentally propel a "special model aircraft." "Learning from the relative success that I got," he continued, "Mr. Arnaud, the Director of the Hippodrome in Paris, offered me 40,000 francs, a considerable sum at that time, for me to sit on a chariot of fire flying before the Empress of France, but I declined this flattering offer."[52]

This is another of several stories that cropped up in the 19th century about near-flights or actual attempted flights in a rocket, like those of Claude-Fortuné Ruggieri and Joel Diavolo in the 1830s and 1840s. They are of general historical and human interest, but unfortunately they are usually not well documented nor offer any technical details.

Still another booklet appeared about this time, *The Expansive Force of Gun-Powder as a Motive Power and a Description of the Engine and Car Suitable for its Application to Air Navigation* (London, 1859), of 12 pages, by William Quartermain. Quartermain also wrote *The Air Navigated by Man upon the Principles Adopted by the Creator for Sustaining all Flying Animals* (London, 1860). The former title suggests that Quartermain earlier thought of, or experimented with, rocket or reaction propulsion for its potential adaptation to a manned flying machine. However, according to the Royal Aeronautical Society Library, it appears that this work no longer extant.[53]

According to Chanute, in 1868 Quatermain exhibited "an explosive engine for aerial purposes...in which the motive power was derived from the gases generated from a species of rocket composition."* But in September 1890, Chanute continues, Quartermain (also given as Quartermaine) then wrote a letter to the journal *The Engineer* (London) "in which he stated that he had abandoned his attempts to procure a light and energetic motor from hydrocarbon matter, in favor of man's weight and muscular power."[54] It should be added that, so far as we know, neither the engines of W. H. Phillips nor Quartermain, as displayed at the 1868 Exhibition, are extant.

1860s: Anonymous (1860), Coignard (1860), Kinsella (1862), De Louvrié (1863, 1865), Sokovnin (1866), Bowman (1866), Telescheff (1867), Butler and Edwards (1867), and Abbruzzo (1868)

The previously mentioned article "Flying Machines in the Future" appearing in the *Scientific American* for 18 September 1860, also contained an idea submitted by an unknown editor of that journal. "The simplest...of all conceivable flying machines," the editor explained,

> would be a cylinder blowing out gas in the rear, and driving along on the principle of the rocket. Carbonic acid [carbon dioxide] may be liquefied, and at a temperature of 150° [F, or 65.5° C], it exerts a pressure of 1,9496 lb to the square inch [9,651.6 sq cm].

* This was at the First Exhibition of the Aeronautical Society of Great Britain, mentioned above.

The editor continued that if a cylinder was filled with this liquid and contained "an opening" at the lower end of "an inch [2.54 cm] square," the cylinder (when heated) "would carry a man" with a surplus of power to carry "the weight of the machine." Accompanying this suggestion is another cartoon, although it is portrayed in a humorous vein, showing a man flying by straddling a jet-propelled carbon dioxide cylinder, greatly reminiscent of the Golightly caricatures.[55]

On 3 May 1860, there appeared British patent No. 1114 by Michael Henry, although it was "communicated [i.e., originated] from abroad" (from France) by the "artist" Louis Coignard, apparently the landscape painter Louis Coignard (1812–1880). This patent was for "Improvements in the Mode and Apparatus for Propelling, Turning and Changing the Direction of Ships, Balloons, and Other Bodies." Henry was merely serving, in this case, as Coignard's British patent agent.

This patent is especially interesting because it describes and depicts a form of reaction (or jet) propulsion with reference to ships and that this propulsion was applicable to the propulsion of balloons and (other) aerial vessels, but no details are offered on the aeronautical application.

Nonetheless, this is indicative that there may have been undoubtedly many similar patents in different countries, where the inventor primarily had ships in mind, but with aeronautical applications for reaction propulsion as secondary applications.[56]

In 1862, Arthur Kinsella of Cascades, in the county of Skamania, Territory of Washington (later, Washington state), in the United States, was granted patent No. 35453 of 3 June 1862 for an "Improvement in Aerial Machines" that consisted of a "rocket-shaped balloon" that was also "propelled in the same manner as a rocket." A steam engine operated on compressed hydrogen and drove fan-wheels, which expelled air through tubes "and the whole machine is thereby propelled similar to a rocket." A steering wheel connected to a rudder was used to steer the machine.[57] [Figure 6–7]

Interestingly, this same patent and concept were also featured in the *Scientific American* for 29 August 1863. The inventor, says the article, was confident his project would "revolutionize the present method of 'communicating between distant points' and 'completely annihilate time and space.'" Furthermore, Kinsella also posted an ad in the same issue advertising "The Washington Aerial Navigation Company" which he had established to start an aerial service "around the globe in an easterly direction" and also carry "mail to the chief city of each state." The ad offered stock in the company, which was to commence operations upon acquiring an anticipated capital of $100,000. Customers could also build the same machine under license "for pleasure." Needless to say, Kinsella failed to initiate the world's commercial transport by a rocket flying machine, as well as the first city by city mail service via the same rocket craft.[58]

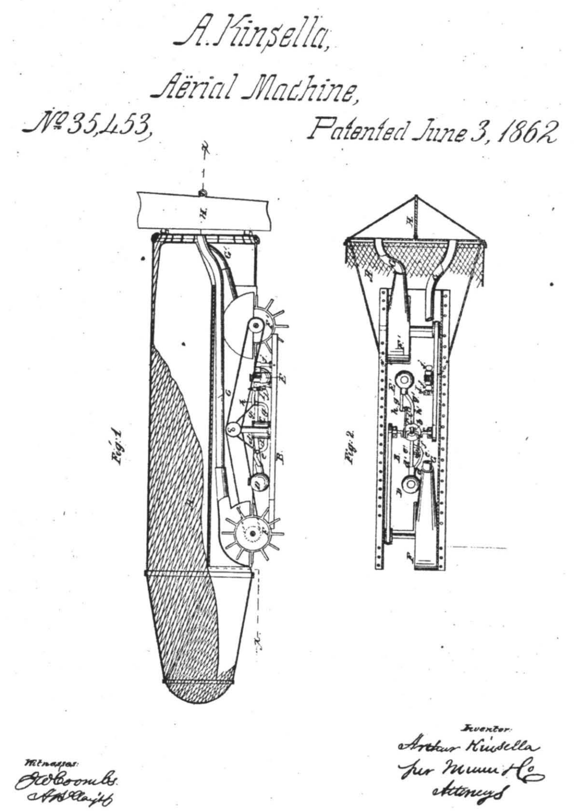


Figure 6–7: U.S. patent to Arthur Kinsella, 1862.
Credit: U.S. Patent No. 35453 of 3 June 1862.

Also in 1863, noted French civil engineer Français Charles de Louvrié, or de Louvré (1821–1894), patented a propeller-driven airship called the *Aeronavia,* or *Aéronave,* with a compressed air motor. In 1865 he took out a second patent for a redesigned version, without propeller, as a reaction-propelled craft. Since fuel is injected into his machine, it is often regarded as the first *patented* jet type aircraft. The propellant was "a hydrocarbon, or better, vaporized petroleum oil" that was ejected through two rear pipes.[59]

The craft also had a canopy-type wing, mounted above a four-wheeled cart that supported the motor. Gibbs-Smith calls de Louvrié's concept "the world's first mature design for a jet-propelled aeroplane"[60] and Duhem devotes an entire chapter and part of another to de Louvrié's concept.[61]

Scientific American.

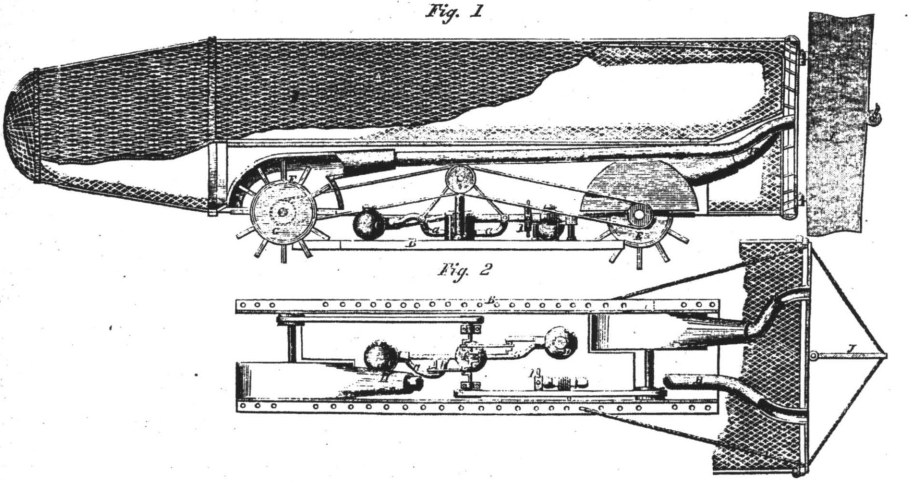
A WEEKLY JOURNAL OF PRACTICAL INFORMATION IN ART, SCIENCE, MECHANICS, CHEMISTRY AND MANUFACTURES.

VOL. IX—NO. 9. (NEW SERIES.) | NEW YORK, AUGUST 29, 1863. | SINGLE COPIES SIX CENTS. $3 PER ANNUM—IN ADVANCE.

Improved Flying Machine.

When mankind are able to travel through the air in any direction, it will be due to the ingenuity of inventors in overcoming natural objects. What these obstacles are, most intelligent persons already know. The idea of soaring above the heads of the multitude, and of traversing the trackless wastes of the atmosphere, is so fascinating, both to the inventor and the enthusiast, that it is no wonder that each should anticipate the pleasures to be derived from it, and ponder upon its advantages as well. From Roger Bacon, a philosopher of the year 1300, down to experimentalists of the present day, each and all have been busy in devising plans and machinery wherewith to sail through the air as swiftly and as safely as birds. Some theorists (for as yet the art of travelling in balloons is practically a theory, to speak paradoxically), are content with merely inflating a sphere, and allowing it to be borne by currents of air, which they maintain exist at certain altitudes, and which blow as the Gulf stream flows—in one direction, at certain seasons of the year. Other persons, however, not content with this method of aerial progression, fitted their balloons with machinery, which, acting on fans or vanes, inclined at certain angles with the side or at the stern of the balloon, was intended to impel the same through the air at a rate of speed impossible to achieve on land. At the present writing we cannot recall any instance, on indisputable authority, where such contrivances have succeeded.

The failures, however, may have been owing to defective apparatus, or a want of scientific knowledge; without which the most sanguine æronant must inevitably fail. The aerial car herewith illustrated, is not, strictly speaking, a balloon; but is an elongated conoidal cylinder, A, having machinery for its operation and propulsion through the air, contained in a car, B, in the lower part of the cylinder. The frame of the cylinder itself is constructed of split rattan, woven in the same manner as a chair bottom, and having the ends of the rattans joined in a rope which runs fore and aft the machine. Outside of this frame there is a covering of silk, as in other balloons. On the platform, B, is placed the propelling machinery, which consists of a cylinder fitted up in all respects similar to a steam engine, having a piston which reciprocates up and down, through the medium of the valves contained in pipes, a. This engine is to be driven by compressed hydrogen gas, generated for the purpose in the vessel, C. The gas is exhausted into the condenser, D, after it has passed through the engine and moved the piston. This engine drives the fan wheels, E, contained in either end of the balloon, the fans of which are set in gas-tight drums, G, filled with hydrogen gas; the whole being driven through belts or other agents suitable for the purpose. The office of these fans, as the reader has doubtless discovered ere this, is to forcibly expel air through the tubes, H H, to the rear of the balloon, and in this manner propel it through the air, in the same way that a rocket travels; indeed it will be seen that this is the idea upon which the inventor has worked, the form of the machine being similar to that of the projectile mentioned. A steering wheel, I, is connected to a rudder, J, at the stern, and it is claimed that by this means the direction of the machine can be altered at will. Fig. 2, is a plan view of the engine, generator, condenser, &c., in which similar letters refer to like parts. The inventor's plans with reference to his scheme are very fully set forth in our advertising columns. It will be seen, on referring thereto, that he proposes to revolutionize the present method of communicating between distant points; and to completely annihilate time and space. If he accomplishes a tithe of what he expects to, he will be a benefactor of his race. This aerial machine was patented through the Scientific American Patent Agency, on June 3, 1862, by Arthur Kinsella, of Cascades, Washington Territory; further information respecting it can be had by addressing him at that place.



KINSELLA'S PATENT AERIAL CAR.

New Rifled Gun.

It is claimed that the Ferris gun, a newly invented weapon, gave a speed of 2,200 feet per second to its shot, as measured by the electrobalist at West Point. The gun was tried in the presence of numerous officers of high standing in the army. The highest velocity ever obtained before was with a Parrott gun, the speed of the projectile from which was 1,800 feet per second. The Ferris gun obtained its high velocity from the quantity of powder burned in it, which is, in a $1\frac{3}{4}$-inch bore, 24 ounces, while the shot weighs 40 ounces—rather more than half the weight of the shot. At this rate the 100-pounder would require 60 pounds of powder, and the 200-pounder nearly 100 pounds—a fearful charge, certainly.

PROPOSAL TO THE GOVERNMENT.—Horatio Ames, of Falls Village, Conn., proposes to make for the Government fifty 800-pound rifled cannon, to carry a 100-pound charge of powder; price of the weapon $1 per pound. The guns are intended to be nearly 10 inches bore, and weigh 30,000 pounds a-piece. They are intended to stand 1,000 rounds without bursting. We presume there are a great many forges willing to make such guns on similar terms.

Figure 6–8: Kinsella flying machine featured in *Scientific American*, 1863. Credit: *Scientific American*, Vol. IX, 29 August 1863, p. 129.

On 10 May and 29 December 1866, Richard Boyman Boyman [*sic*] of Stockwell, Surrey, England, took out two British patents (Nos. 1497 and 3262, respectively), for "further improvements" in propelling vessels by reaction, based on his experiments on "intermittent reaction," in which steam reaction propulsion could be applicable for propulsion on land, sea, and air. Here was thus another example, like Coignard, of recognizing that reaction propulsion was suitable for multiple purposes, including manned flight.[62]

Also in 1866, Russian Vice-Admiral Nikolai Mikhailovich Sokovnin (1811–1894) published his pamphlet, *Vozdushnyi korabl'* (*The Airship*) (Saint Petersburg), in which he emphatically states: "An aircraft must fly by some such principle as that of rocket flight." Yet, he suggested compressed "atmospheric" air rather than the gases of gunpowder (or other propellant). The air could be forced into pipes from the atmosphere (as in a modern jet aircraft) or carried in ready compressed air bottles. The Admiral calculated that a velocity of 29.5 ft/s (9 m/s) was possible for his very large dirigible type airship.[63]

In the following year, Sokovnin's compatriot, retired Captain of the Imperial Russian Artillery Nicholas Telescheff (1828–1895),[64] then living in Paris, proposed his own jet-propelled flying machine that is considered more of a precursor of a jet aircraft. This was part of his overall work towards the design of a very large (120 passenger), complex ornithopter for which he had already taken out patents in England and France from 1864, although a commission of the Russian Academy of Sciences had rejected it and inferred it was a dream![65]

His 1866 version included an onboard air-generator and an internal combustion engine. He also designed, in 1867, a reaction-propelled monoplane with cylindrical fuselage and delta wings described by Duhem as "remarkable for that era."[66] The propulsion was produced by a combustible liquid that was vaporized, compressed, mixed with air, then ignited and expelled.

The Englishmen James William Butler and Edmund Edwards were granted patent No. 2115 on 19 July 1867 for a fully vertical swept-back delta winged steam-reaction monoplane they coined the "Steam Dart."[67] The prominent delta wing is the most interesting of several features of this "multiple patent," according to Gibbs-Smith, who also calls it a "remarkable and prophetic patent."[68] The propulsion was either by steam, compressed air, or inflammable gas "issuing from a pipe" and "two jets may be used...to effect steering."

Another interesting feature is that the motive power was placed in a car and capable of being moved forward and back so as to shift to the center of gravity to correspond with the varying angles of flight. The team of Butler and Edwards additionally proposed a biplane delta flying machine with a pusher propeller rotated by angled jet pipes at their tips (as in the ancient Greek steam-powered aeolipile of Heron of Alexandria (circa 10–70 CE). However, as with almost all 19th century reaction-propelled concepts, there is no evidence that either of these projects ever were built.[69]

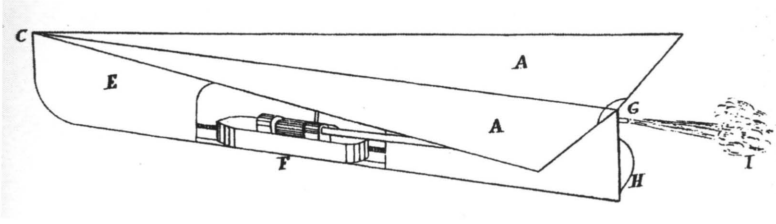


Figure 6–9: 1867 concept of James W. Butler and Edmund Edwards.
Credit: British Patent No. 2115 of 19 July 1867.

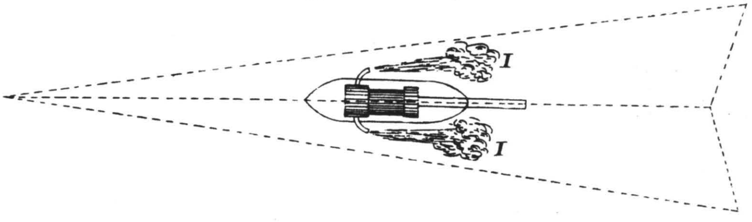


Figure 6–10: 1867 concept of two "jet" version of their flying machine.
Credit: British Patent No. 2115 of 19 July 1867.

Almost a year after the first Butler and Edwards patent, one Onofrio Abruzzo of St. Margherita, in Sicily, Italy, was granted U.S. patent No. 80,107 of 21 July 1868 for an "Improvement in Aerial Cars." The concept is comparable to Kinsella's "aerial machine" in that it was at least a partly rocket-shaped balloon and was likewise propelled internally by a rocket or series of rockets; wings were also attached.[70] [Figure 6–11]

In fact, the craft had a mixed propulsion system including a propeller driven by steam or "any suitable power" while in its rocket propulsion mode, a "war rocket" was to be placed in a "rocket-chamber" consisting of a "tube with a breech plug" at its rear for insertion of the rocket.

Most interesting, the chamber was "mounted on pivots and has free motion horizontally to guide the balloon, and therefore [also] performs the functions of the rudder or tiller." Thus, this is perhaps the earliest known use of pivoting or gimballing of a rocket, or associated with a rocket. "More than one rocket-chamber may be employed," the inventor added, "and they [can] be arranged at various angles to each other, so as to communicate with each other and...as one rocket is ignited and discharged the next one will follow."

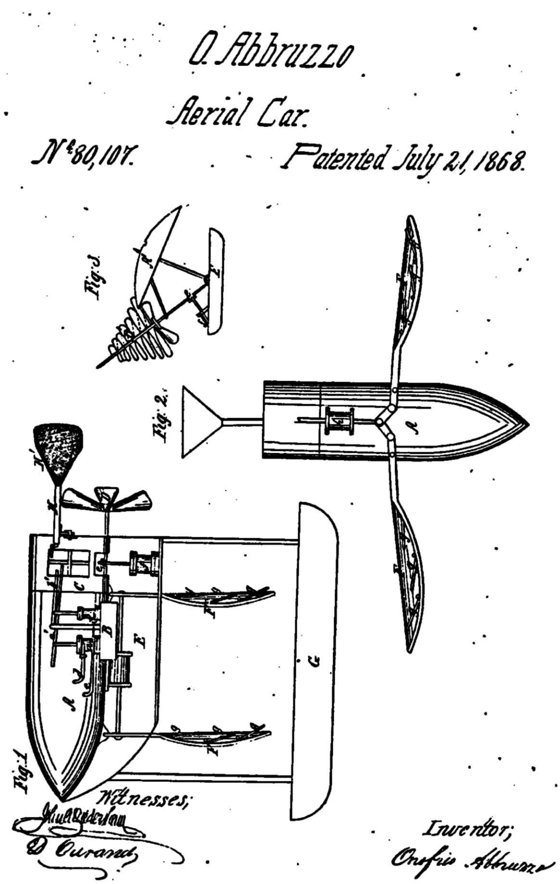


Figure 6–11: 1868 U.S. patent of Onofrio Abruzzo.
Credit: U.S. Patent No. 80,107 of 21 July 1868.

Another feature was a kind of conical shield at the forward end of the chamber to "prevent the fire of the rocket [sparks or exhaust] from reaching the other parts of the balloon." Beneath the propulsion systems was a "car or boat" for the passengers and crew, with baggage carried in an additional suspended car if necessary.

We thus conclude Part 1 of our survey. Again, Part 2 covers the period from 1870 to 1900, which is a particularly rich period for ideas and projects related to reaction-propelled flying machines. This is perhaps not surprising, as this phase of the Industrial Revolution witnessed among its most dynamic advances in a number of relevant technologies and science, consequently inspiring more sophisticated reaction-propulsion ideas.

In this treatment, we will include the work of the aviation pioneers Frederico Gomez Arias, James J. Pennington, Sergei S. Nezhdanovsky, Fyodor

Geshvend, Nikolai Ivanavich Kibaltchich, Russell Thayer, A. V. Eval'd, Thomas Giffiths, Nicholas Petersen, Sumter B. Battey, Edmund Pynchon, A. Fedorov, William W. McEwen, and others.

Part 2 likewise sums up overall general trends and significances in our coverage and their relevance to the work of the earliest pioneers of astronautics appearing from the late 19th to early 20th centuries, primarily Tsiolkovsky and Goddard.

Preliminary Conclusions

We now make a preliminary analysis of the first part of our treatment.

(1) The proponents of the above ideas and/or experiments on manned flight by reaction propulsion were international in scope.

(2) The various proponents seem to be disparate: they have almost no apparent linkage or connection with each other. More is said on this point below.

(3) Patents during the 19th century were primitive by our standards. Patentees were not necessarily required to "prove" their concepts, with the exception of the U.S. in which "working" miniature patent models were required from 1790 to 1880, especially since it was then recognized that most inventors were ordinary people without technological or legal training and it was often difficult for them to adequately describe the novel features of an invention using words and diagrams. Nevertheless, the early U.S. patent model system does not seem to have been well enforced and not all patentees submitted models.

(4) In general, it appears that most, if not all of the proponents, did not fully understand the principle of reaction propulsion. Moreover, the principle of the physics of reactive motion was poorly understood in general during those years. Lack of space in this paper does not permit treatment on the history of theories of reaction propulsion, or rocket motion, and it is treated elsewhere. It is enough to state that up to the close of the 19th century, there were two main schools of thought on rocket motion (and hence, reaction propulsion).[71]

One school of thought had it that the rocket needed air to "push against," and this was the predominant view up to the end of the 19th century and even into the early 20th century. However, it was the other theory that turned out to be the "correct" one, being now well proven and accepted today. This is Newton's Third Law of Motion, which succinctly explains that: "For every action there is an equal and opposite reaction."

(5) While the occasional proposed use, from the 17th to 19th centuries, of a large, but ordinary gunpowder rocket (either the war type or a firework type of sky rocket) as one method of achieving manned flight might seem foolhardy and

"quaint" by our standards, it is important to recognize that these were, in fact, the *only* rockets then available. Moreover, the basic level of rocket technology had changed very little over the centuries since the apparent origin of the rocket in China during the Sung Dynasty (960–1279 CE), as shown by a number of historical studies on this subject.

However, by the mid-19th century there were the beginnings of efforts to make rockets more uniform in their performance, through such Industrial Revolution technological advances as the hydraulic (steam) compression of gunpowder into metallic rocket bodies for Hale and other war rockets. Likewise, there were the beginnings, by such pioneers as Konstantinov cited above, of attempts to more scientifically determine rocket force and other aspects of rocket dynamics.

(6) It is also interesting to note that during the 19th century, we start to see a recognition that reaction propulsion, as used on water for ships, could also potentially be applied to manned aircraft as well, as noted by the examples of the 1860 and 1866 patents of Coignard and Boyman, briefly discussed above. More examples of this trend will be seen in Part 2 of this paper, along with the recognition that reaction propulsion might eventually be considered for flight into space.

(7) It is particularly important to observe that from the mid-19th century, we also begin to see examples of the recognition that *liquid* combustibles might be applied to generating rapidly expanding gases for producing "exhaust" streams to enable reaction propulsion, compared with earlier choices of the burning of solid combustibles, or ordinary steam, to produce exhaust streams.

(8) In general, we see that the earliest proponents of reaction-propelled aircraft from the 17th to 19th centuries hardly paid any attention to the scientific design of the exits or orifices of their reaction propelled flying machines. As will be seen in Part 2, it was not until circa 1888–1890 that Gustaf de Laval, briefly mentioned above, invented and developed the de Laval nozzle for use in steam turbines, and this advance was not immediately adapted to the propulsion of reactive flying machines. It was not fully adapted to the rocket, so far as we know, until circa 1913 with the work of the American rocket pioneer Goddard.

Finally, we return to point (2) above, about the apparent lack connections or linear progressions between any of the earliest pioneers of reaction propulsion flight. However, some of the British pioneers, notably Phillips, Quartermain, Butler, and Edwards, later became fellow members of the Aeronautical Society of Great Britain. Founded in 1866, this was the world's first organization devoted to the mutual study, development, and promotion of manned "flying machines," or aircraft.[72]

Hence, by the late 1860s, Phillips and his colleagues were starting to *share* their ideas about reaction propulsion and other possible modes of achieving manned flight. Furthermore, we see their discussions published in the proceedings of the Society and even the beginnings of exhibits of their "engines" to more fully describe their concepts. It is unfortunate that examples of these early models illustrating the first pioneering steps towards reaction propulsion for manned flight no longer exist.

References and Notes

[1] It should be noted that, as Hermann Oberth's 1923 classic work, *Die Rakete zu den Planetenräumen* (*By Rocket into Planetary Space*) appeared somewhat later, this pioneer falls into a different time frame and phase in the history of rocketry and astronautics.

[2] An artistic period in the West from the mid-to-late 17th century until the mid-18th century, reflecting Chinese artistic influences.

[3] Frank H. Winter, "Who First Flew in a Rocket?," *Journal of the British Interplanetary Society*, Vol. 45 (July 1992), p. 275–276, provides more on both accounts.

[4] Jules Duhem, *Histoire des origines du vol a réaction* (Nouvelle Éditions Latines: Paris, 1959), pp. 4, 49, 52, 295.

[5] Duhem, ibid., pp. 53–54.

[6] Duhem, ibid., pp. 49–57, 59–70, ff.

[7] Charles Harvard Gibbs-Smith, *Aviation An Historical Survey* (Her Majesty's Stationary Office: London, 1970), pp. 19–20.

[8] Jean-François Janinet (1752–1814) was an engraver and printer.

[9] N. A. Rynin, *Interplanetary Flight and Communication* (Israeli Program for Scientific Translations: Jerusalem, 1971), NASA TT T-643, Vol. 4, p. 28; *The Romance of Ballooning—The Story of the Early Aeronauts* (A Studio Book—The Viking Press: New York, 1971), p. 47.

[10] Ron Miller, *The Dream Machines—An Illustrated History of the Spaceship in Art, Science and Literature* (Krieger Publishing Co.: Malabar, Florida, 1993), p. 32.

[11] Charles Coulston Gillispie, *The Montgolfier Brothers and the Invention of Aviation 1783–1784* (Princeton University Press: Princeton, New Jersey, 1983), pp. 997–998.

[12] Duhem, p. 102; Robert Devenell, "A Project for Directing an Air Balloon by the Explosive Force of Rockets," *Alter et Idem—A New Review, No. 1 for a Summer Month in 1794*, pp. 11–18.

[13] Anon., *Dalla Scoperta della dirizione del globo aerostatico* (*On the Discovery of the Direction of an Aerostatic Balloon*) (Molinari: Venice, 1831).

[14] Giovanni Caprara, *Storia italiana dello spazio: Visionari, scienziati e conquiste dal XIV* (Bompiani: Milan, 2012), n.p.; http://www.italianstamps.it/jsite/pdf/VOLANTI-Notize_chronoligia_e_F.

[15] G. B. [G. Boffito], "Ai margini della storia," *Rivista Aeronautica* (Rome), Anno IV, July 1928, p. 211; Rynin, op. cit., Vol. 4, p. 29.

[16] We are indebted to Julia and Michael Ciancone for translating a large part of this rare work into English.

[17] Miller, op. cit, p. 41; Everett Franklin Bleiler, *Science-Fiction, the Early Years* (Kent State University Press: Kent, Ohio, 1990), pp. 596–597; Faith K. Pizor, "The Great Steam Duck," *Technology and Culture*, Vol. 9, January 1968, pp. 86–89.

[18] Miller, p. 41; *The Great Steam Duck or a Concise Description of a Most Unusual and Extraordinary Invention for Aerial Navigation* (Henkle, Logan & Co.: Louisville, Kentucky, 1841), pp. 11, 18–19.

[19] Frank H. Winter, "The Golightly Mystery," *Journal of the British Interplanetary Society-Pioneering Space*, Vol. 34, April 1996, pp. 170–176.

[20] Willy Ley, *Rockets, Missiles, and Space Travel* (The Viking Press: New York, 1958), pp. 86, 88; [probably Willy Ley], "Raketen mit Flüssig Treibstoffen im Jahrhundert," *Die Rakete*, 2 Jahrg., 15 March 1928, p. 45; "Diapositive zur Raumschiffahrt, 3 Jahrg., Heft 8, 15 August 1929, p. 104. Golightly is also mentioned in Willy Ley, "Vom ersten Raketentier," in *Die Rakete*, 3 Jahrg., November–December 1929, p. 21.

[21] Gibbs-Smith, op. cit., pp. 4, 28, 40; Ley, 1958 op. cit., pp. 87–88.

[22] "Flying Machines of the Future," *Scientific American*, Vol. III, 8 November 1860, p. 165.

[23] Royal Aeronautical Society of Great Britain, *Third Annual Report of the Aeronautical Society of Great Britain* (Henry S. Richardson: Greenwich, 1868), pp. 5, 9–10, 53–54.

[24] The ancient Greek Archytas of Tarentum is alleged to flown a wooden dove about 400 BCE that some believe to have been propelled by a jet of steam but this has never been verified.

[25] Deborah Colville, "From *Aerodiphros* to Painless Dentistry: Bloomsbury's Notable Inventors," http://www.ucl.ac.uk/bloomsbury-project/articles/events/conference2009/colville.pdf.

[26] "Phillips Fire Annihilator," *Illustrated London News*, Vol. 15, 8 September 1849, p. 172; "The Fire Annihilator—An Old Invention," *Scientific American*, Vol. VII, 1 November 1851, p. 53; "Philips Fire Annihilator," *To-Day: A Boston Literary Journal* (Boston, Massachusetts), Vol. II (1852), pp. 87–88.

[27] The Annihilator used a slow-burning gun-powder to produce carbon dioxide spray upon fires.

[28] Royal Aeronautical Society of Great Britain, op. cit.

[29] Miller, op. cit., pp. 41–42; Rynin, op. cit., Vol. 4, p. 29.

[30] Miller, op. cit., p. 42; Rynin, op. cit., Vol. 4, p. 29.

[31] "Water gas" was so called because water in the form of steam is decomposed and its hydrogen, mixed with carbonic oxide gas, is mingled with a heavier carbon gas.

[32] "Gas Motive Power," *The Civil Engineer and Architect's Journal*, Vol. 11, April 1848, p. 128.

[33] Bernhard Lepsius, *Lili Parthey, Tagebücher aus der Berliner Biedermeirzeit* (Koehler & Amelang; Leipzig, 1928 and Berlin edition, 1926), quoted by Ley, in *Rockets, Missiles*, pp. 86–87.

[34] Later honored with nobility, he became known as von Siemens in 1888.

[35] Ley, ibid., p. 87.

[36] [possibly Werner Siemens], "Eine Flugmaschine vermittelst Schiessbaumwolle," *Leipziger Illustrierte Zeitung* (Leipzig). Band 8, 30 January 1847, pp. 76–77.

[37] Werner von Siemens, *Personal Recollections of Werner von Siemens*, translated by W. C. Coupland (Asher & Co.: London, 1893), pp. 327–328.

[38] In October 1847, Siemens had already founded his electrical company, Siemens & Halske AG., that was to become internationally famous.

[39] "A Word or Two on Vauxhall," *Illustrated London News*, Vol. VIII, 6 June 1846, p. 370.

[40] Miller, op. cit., pp. 38, 42.

[41] Letter, Charles Dollfus to Frank H. Winter, 20 March 1963, in "Claude Ruggieri" file, National Air and Space Museum.

[42] Ley, op. cit., p. 85.

[43] Winter, "Who First Flew." op. cit., p. 277; Dollfus letter, op. cit.

[44] James Glaisher, ed., *Travels in the Air* (Richard Bentley & Sons: London, 1871), pp. 234–237.

[45] His name has been given incorrectly by others as Nicholas Tretesski.

[46] Miller, op. cit., p. 42; Rynin, op. cit., pp. 29–30; V. N. Sokol'skii, *Russian Solid-Fuel Rockets* (Israeli Program for Scientific Translations: Jerusalem, 1967), NASA TT F-415, pp. 100–102, 107.

[47] James Nye, *Thoughts on Aerial Travelling and on the Best Means of Propelling Balloons* (Edward T. Whitefield: London, 1852, pp. 14–15.

[48] "Aerial Travelling," *The Mechanics Magazine* (London), Vol. LIX (1853), pp. 167–168.

[49] Colonel [Konstantin I.] Konstantinov, *Vozdukho-plavanie* (Tipografia Imperatorskoi Akademia Naukii: St. Petersburg [Russia], 1856), pp. 99–101.

[50] Ramón Carreras, "F. Gomez Arias' Rocket Vehicle Project," in R. Cargill Hall, editor, *History of Rocketry and Astronautics*, AAS History Series, Vol. 7, Part 1 (Published by Univelt, Inc. for the American Astronautical Society: San Diego, 1986), pp. 77–178; Miller, op. cit., p. 45; Duhem, op. cit., 60, 143–165, 182, 218, 221, 229, plates 23–24, with lengthy explanations.

[51] French astronomer and hydrographer, and member of the French Academy of Sciences.

[52] Raoul Marquis [pseudonym for Henri de Graffigny], *Irons-nous dans la lune?* (Éditions Spes: Paris, 1932), p. 149.

[53] Duhem, op. cit., p. 132; E-mail from Brian Riddle, Chief Librarian, National Aerospace Library, UK, to Frank H. Winter, 19 March 2013.

[54] Octave Chanute, *Progress in Flying Machines* (M. N. Forney: New York, 1899), pp. 16–17.

[55] "Flying Machines," loc. cit.

[56] Michael Henry (communicated by Louis Coignard of Paris, "artist"), British Patent No. 1114 of 3 May 1860 for "Improvements in the Mode and Apparatus for Propelling, Turning and Changing the Direction of Ships, Balloons, and Other Bodies"; Duhem, op. cit., p. 131.

[57] U.S. Patent No. 35,453 of 3 June 1862 to Arthur Kinsella for "Improvement in Aerial Machines."

[58] "Improved Flying Machine," *Scientific American*, Vol. IX, 29 August 1863, p. 129.

[59] Miller, op. cit., p. 46; Michael J. H. Taylor, *The Aerospace Chronology* (Tri-Service Press: London, 1989), p. 15; Chanute, op. cit., pp. 94–95.

[60] Gibbs-Smith, p. 38.

[61] Duhem, op. cit., pp. 173–238.

[62] Richard Boyman Boyman, British patent No.'s 1497 and 3262 of 10 May and 29 December 1866, respectively, for "Improvements in Propelling Vessels by the Reaction of Water" and "Improvements in Applying Jets of Steam by Action and Reaction, to Propel Vessels and Aërial [*sic*] Conveyances"; Duhem, pp, 118, 120–122, 208.

[63] Sokol'skii, op. cit., pp. 101, 107; Rynin, op. cit., Vol. IV, pp. 31–33; "Sokovnin, Nikolai Mikhailovich," in *Great Soviet Encyclopedia* (McMillan, Inc.: New York, 1980), Vol. 24, p. 285; Duhem, op. cit., pp. 57, 202, Plate 31.

[64] Also given as Nicolas de Telescheff or Nicolas de Teleshev or de Teleshov.

[65] Miller, op. cit., p. 54; Gibbs-Smith, op. cit., pp. 35, 38; "An 1867 'Jet,'" *Flight*, (London), Vol. 77, 3 June 1960, p. 777; Duhem, op. cit., pp. 57, 122, 165–167, 174.

[66] Duhem, op. cit., pp. 165–167.

[67] British Patent No. 2115 of 19 July 1867 to J. W. Butler and E. Edwards for "Aërial [*sic*] machines."

[68] Gibbs-Smith, op. cit., pp. 37–38.

[69] Duhem, op. cit., pp. 168–169; Rynin, op. cit., Vol. IV, p. 33.

[70] U.S. Patent No. 80,107 of 15 July 1868 to Onofrio Abbruzzo for an "Improvement in Aerial Cars."

[71] For a summary of 19th century scientific inquiries regarding the explanation of rocket motion, see, Frank H. Winter, *The Golden Age of Rocketry—Congreve and Hale War Rockets of the Nineteenth Century* (Smithsonian Institution Press: Washington, D.C., 1990), pp. 225–227.

[72] In 1918, the name was changed to the Royal Aeronautical Society, which still exists today as a leading multidisciplinary professional institution dedicated to the global aerospace community.