FALL 2018

Flapping Wings

THE ORNITHOPTER SOCIETY NEWSLETTER

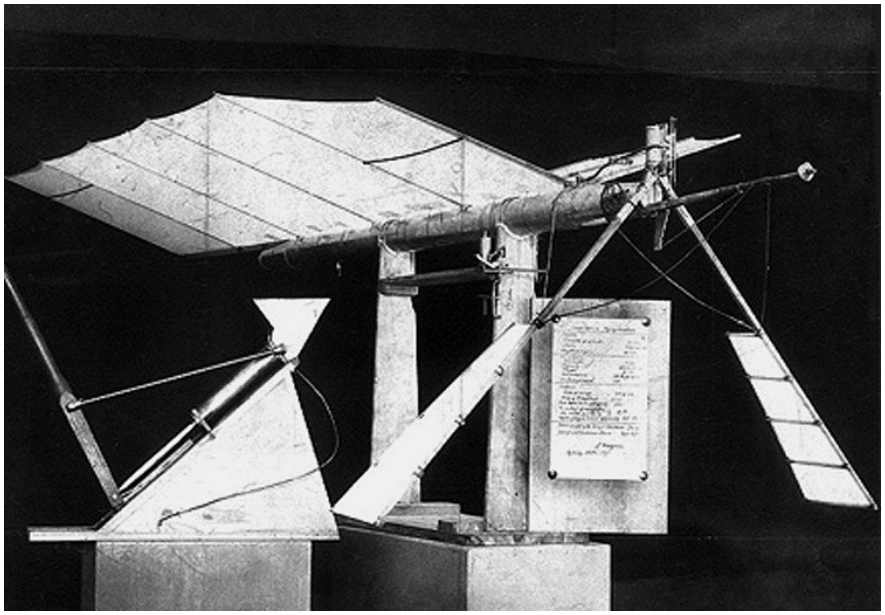
Steam Powered Ornithopters

by Nathan Chronister

One feature that distinguishes flapping wing flight from other areas of endeavor is that we are trying to do something really amazing that has little or no practical benefit. It is within that same spirit that I decided to devote an article to contemplating the subject of steam-powered ornithopters.

The lost technology of steam power has taken on a certain mystique. A steam-era aesthetic has often been romanticized in films such as Hugo and The Golden Compass. In fact, it was the animated film, directed by Hayao Miyazaki, Howl's Moving Castle, that got me thinking about steam-powered ornithopters again and eventually led me up to writing this article.

Howl's Moving Castle depicts a steam-powered world that seems to have gone in a slightly different direction from our actual reality. One notable difference is that all of the flying machines are some type of ornithopter. In the larger aircraft, there are multiple pairs of flapping wings. Most of the ornithopters in the film have relatively small, rapidly beating wings, which intersects with the real history of ornithopters in the age of steam.



Lawrence Hargrave c 1890 built ornithopters some of which were powered by steam.

> I am under no illusions about the nature of steam power related to flight. It cannot compete with a modern engine in any practical way, but from an interest point of view it has no equal! — Geoff Wolfe

Lawrence Hargrave of Australia was one of the pioneers of aviation. He studied fixed wings, in the form of kites, and he also studied flapping wings. He built several ornithopters from 1887 through 1892. Some were powered by rubber band, while others used steam or compressed air. One of these ornithopters weighed 2 kg and flew more than 100 meters. It is housed at the National Air and Space Museum in Washington.

Hargrave designed his ornithopters to have small flapping wings, quite similar to those in the film. The reduced size of the flapping wings offered one advantage. The steam engine could drive the small wings directly, without any need for gear reduc-

A steam-powered ornithopter depicted in the film, Howl's Moving Castle.

tion. This attractive concept was later used in the engine powered ornithopters of Alexander Lippisch, and in the first successful manned ornithopter, built by Adalbert Schmid and flown in 1942. When seen in their historical context, Miyazaki's fanciful flying machines don't seem quite as far off from reality.

Steam quickly fell out of favor for ornithopters, but a small group of hobbyists has been keeping steam alive in other types of vehicles.

Steam Flight

Geoff Wolfe has developed a steam-powered model airplane. Called the Comet Too, it is based on David Parker's earlier design called the Comet, published in 1967. Geoff has built his own engine and boiler for the Comet Too.

There are two types of boilers for steam engines. The conventional boiler holds a volume of water, which is then heated up until it boils. The other type is called a "flash" boiler. In the flash boiler, water is pumped from a tank into a coiled tube which is kept at a very high temperature. The water boils rapidly as it passes through the tube. Sometimes you will see this referred to as a monotube boiler.

Conventional boilers must undergo pressure testing and must have a pressure safety valve. Since there is no water pump (and associated control mechanism) the conventional boiler is simpler and more reliable than a flash boiler. On the other hand, flash boilers can produce hotter steam and higher pressures. They offer a higher power to weight ratio, making them a strong candidate for use in an ornithopter or any aircraft.

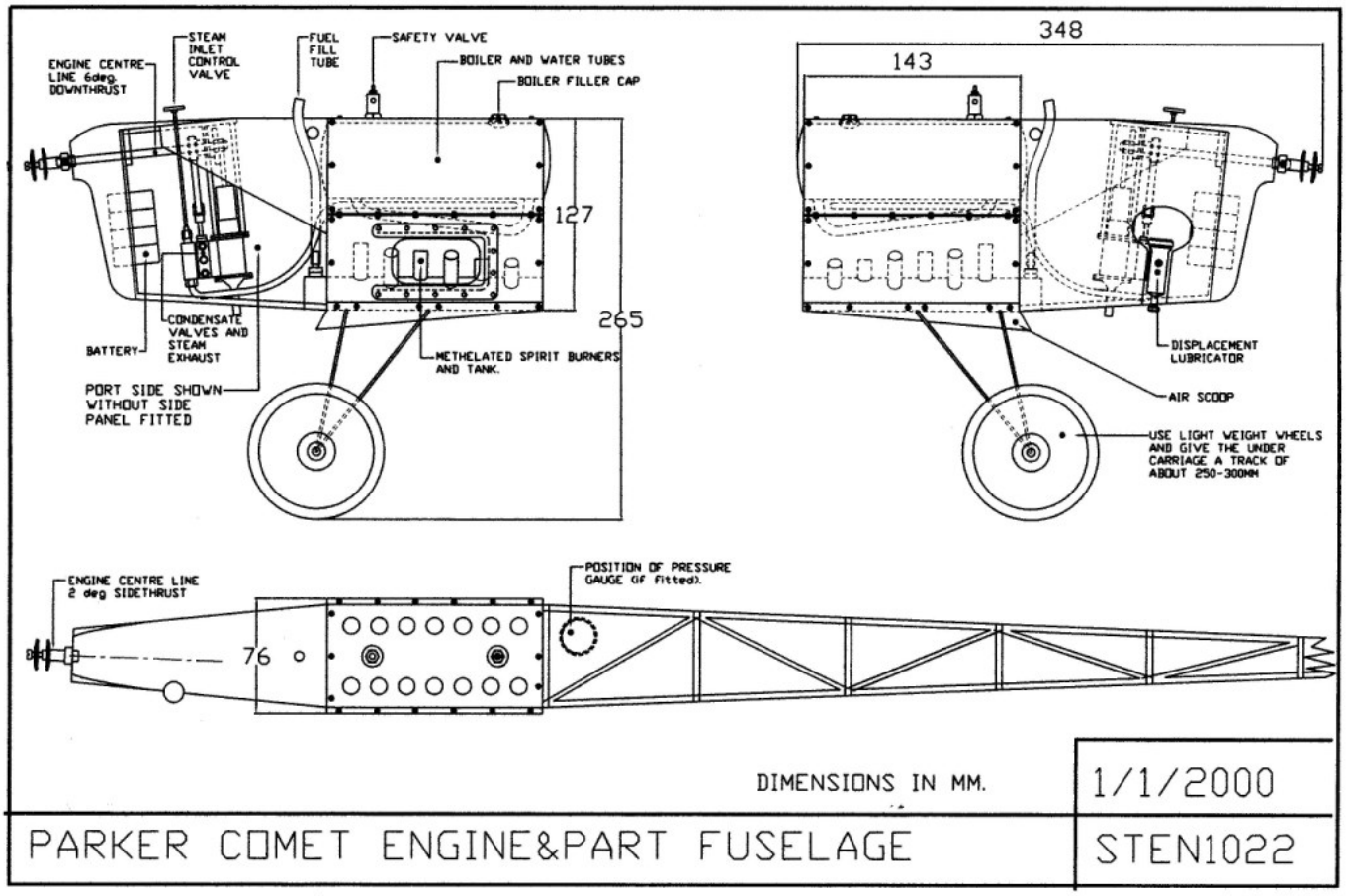
Steam Racing Boats

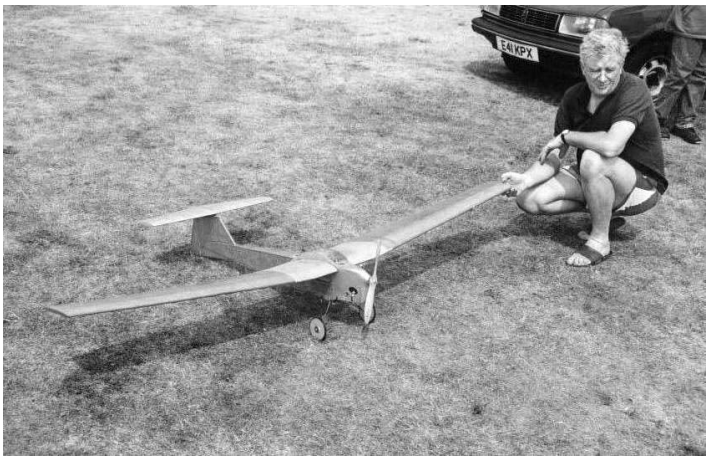
Although very few people seem to be working on steam powered aircraft, those working on steam powered boats have enjoyed a larger community of enthusiasts. One example is the steam powered hydroplane competitions that are held in the UK. These are large model boats that run on a tether and reach incredibly high speeds. Speeds can exceed 130 mph, which is comparable to their internal combustion counterparts. The high performance and state of development of these models suggests that they might provide insights into the design of a steam ornithopter.

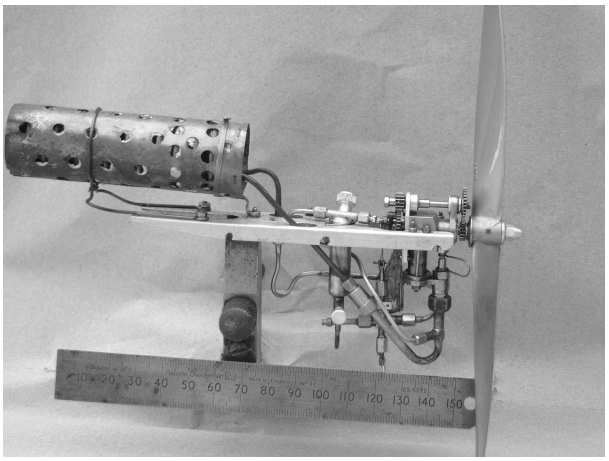
The hydroplanes typically use a flash boiler. A blowtorch provides the heat to boil the water. The torch can be fueled with butane or liquid fuels such as naphtha. A metal heat shield encases the boiler and helps prevent heat from escaping. The flash boiler in a hydroplane can use water from the environment, whereas an aircraft would need to carry enough water on board for a brief flight. Notice that the boiler is much larger than the steam engine itself.. The small engine achieves a high power output by running more cycles per minute. The speed and the power output are comparable to an internal combustion engine of the same size.

Steam Turbines

Some of the steam hydroplanes have used steam turbines instead of piston engines. A turbine can operate more efficiently than a piston, but only when running at very high speeds. Turbines are great for turning a boat propeller at high RPM. But steam turbines never quite caught on







Geoff Wolfe constructed the Comet Too based on an earlier steam airplane design by David Parker. Wolfe designed his own engine, and he has replaced the conventional boiler with a flash boiler of his own design. After much effort, he has gotten some great flights with the steam powered airplane.

in locomotives. The capability of operating over a wide range of speeds allowed the traditional piston steam engine to hold its advantage.

Steam turbines might be an option for ornithopters. Like the steam hydroplanes, the ornithopter can run at a constant speed. However, the steam turbine will require a lot of gear reduction, which adds weight. A typical turbine speed of 100,000 RPM would require a reduction ratio about 200:1 to flap the wings.

Should we use an engine running at high speed, geared down to flap the wings, or use a larger cylinder that can drive the wings directly? Although the modern, high output engines are simply more powerful, the older, slower type has a certain aesthetic quality, which might be what motivated us to consider a steam ornithopter in the first place.

History has shown that a direct-drive system can work. Hargrave's small wings solution was a bit of a compromise. It increased the power, but lost some of the appeal. But in the 1930s, Vincenz Chalupsky used a direct drive system to flap full sized wings, using compressed air. There have also been a few air-powered toy ornithopters that linked the piston directly to the wings. The direct drive arrangement would not be the most efficient way to build a steam powered ornithopter, but it just might be the most satisfying.

Model steam engines are available commercially. These models use conventional boilers heated by alcohol lamps, solid fuel pellets, or electric heaters. They are good for learning how steam engines work or simply demonstrating the concept. I bought one of these models, a steam tractor from Mamod, and while it was entirely fascinating to operate, it didn't seem powerful.

I suspect none of the commercially available engines has a high enough power to weight ratio to fly any type of aircraft. There might be other options. For example, I considered using an air-powered die grinder or a tiny dental handpiece turbine. Eventually, though, you will probably have to build your own steam engine for the ornithopter.

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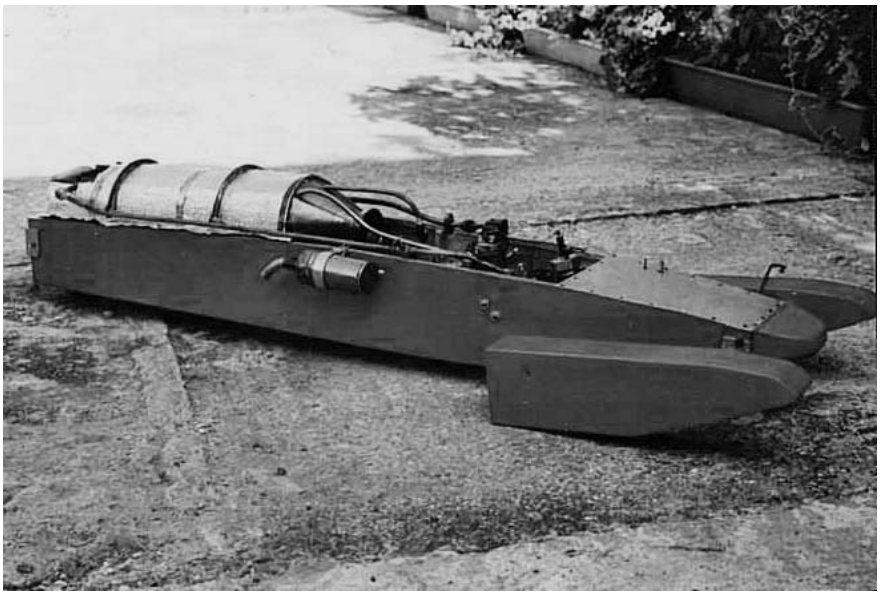


A steam hydroplane constructed by John Benson shows that the boiler is much larger than the engine.

Bob Kirtley launches his tethered steam powered hydroplane.

Flappers Book

Society member Terrence Murphy has published a fantastic book that reveals much of the lost early history of ornithopters.

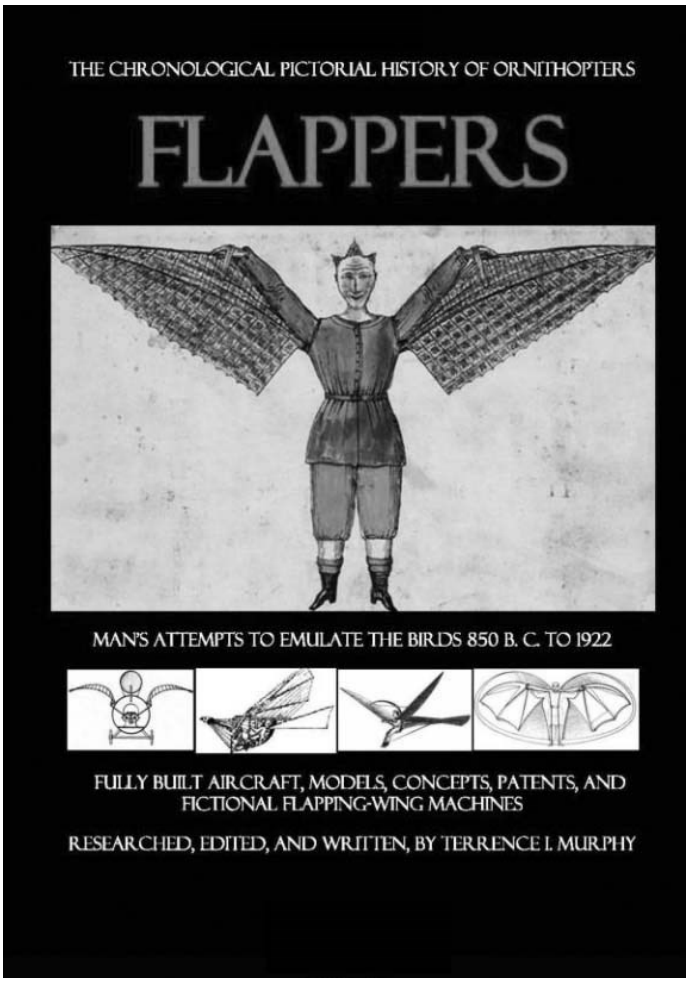
Unlike my own efforts, which have virtually ignored the great many unsuccessful attempts at manned ornithopters, that is the main focus of Murphy's book. Therefore he has created a vast and informative resource that fills in a lot of space that the previous Ornithopter Society publications did not even touch.

Murphy's book is a very unique publication that everyone interested in flapping wing flight ought to have at least one copy of.

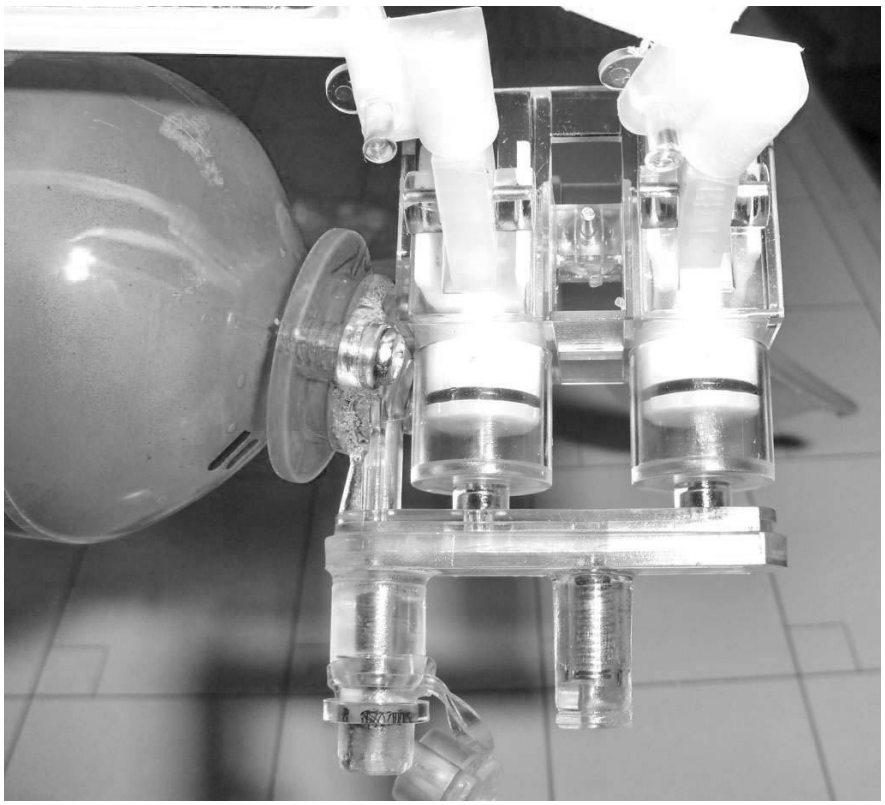
Some of the machines, like the Dubois ornithopter shown here, look like pretty credible efforts. Others are a little less realistic. But I am certain that anyone interested in building a manned ornithopter, or even an unmanned scale-like model ornithopter with kind of a vintagy feel, would get plenty of ideas and inspiration by sifting through the pages of this fascinating volume.

So now you can discover the history of ornithopters from an entirely new perspective. The book is available on Amazon. Just go to amazon.com and type "flappers by terrence murphy" into the search.

Dubois ornithopter from Terrence Murphy's new book, Flappers.



The steam tractor from Mamod is one example of a ready-built model steam engine.



The Skybugz ornithopter from Aerodavinci, designed by Ilho Yang, demonstrated that pistons can be used in a direct drive fashion to flap the wings.

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First off, there are some great books on how to do this. The book, *Making Simple Model Steam Engines,* by Stan Bray, is a good first step in learning the art of building your own model steam engines and boilers. Some of the projects in the book can be built using only hand tools. As you progress in your designs, it will be very helpful to use a lathe, and you may find yourself learning a lot of other new techniques.

Even though I started off by saying the steam powered ornithopter would have no practical benefit, the opportunity to advance your knowledge and cultivate new skills over this years-long process is something that would have unquestionable value.

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