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Flapping Wings

THE ORNITHOPTER SOCIETY NEWSLETTER

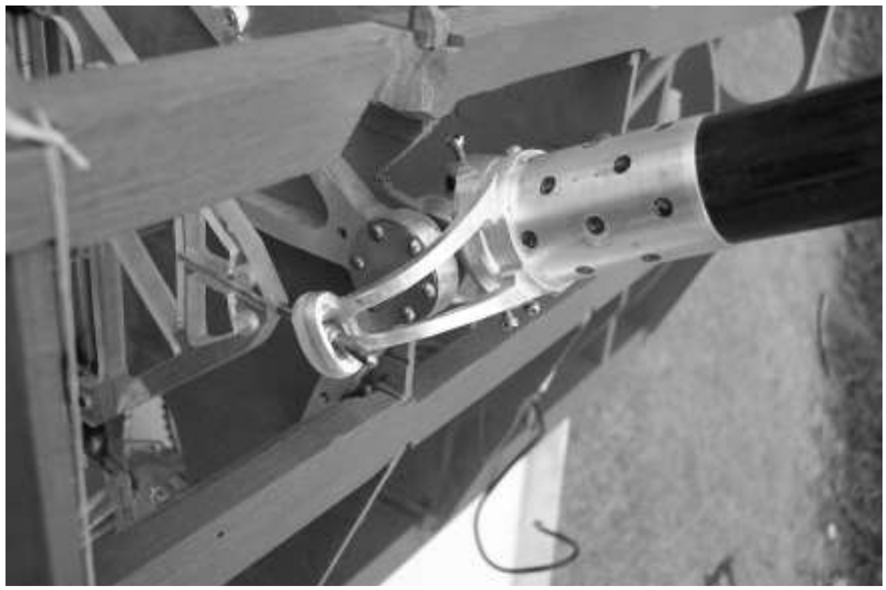
Francis Reynolds Iron Bird

by Nathan Chronister

When I first learned about the ornithopter work of Francis Reynolds back in the 1990s, I thought it was just another of many engine-powered ornithopter attempts being made around that time. But a few years ago, Reynolds was getting out of ornithopters to focus on more important global issues. At that time, he entrusted his “Iron Bird” ornithopter prototype to my care. It was only upon being able to see and inspect the intricate mechanism, with my own eyes, that I began to understand that Reynolds was onto a brilliant discovery.

The Iron Bird, as he called it, is not an ornithopter that was intended to fly. And it’s not made of iron. Instead, the Iron Bird is a heavy wooden framework upon which Reynolds was developing the mechanism for the ornithopter. All of the components mounted on that framework are the same ones that would be used in the actual aircraft. And except for building the final airframe, he already had the mechanism developed and refined to a very high degree of perfection.

The proposed ornithopter called the RC Gull was planned to have an enormous 16 foot wingspan. It would have airfoiled, double-surface wings, and it would be powered by a large internal combustion engine. But what’s really impressive is in the details. Most ornithopters use a flexible membrane wing to achieve the correct angle of the wing, for the upstroke and the downstroke. A few ornithopters have used an active mechanism to drive this twisting of the wings. But Reynold has found a way to control the *amount* of wing twist on the fly. That opens up a whole world of possibilities.



A portion of Francis Reynolds unique flapping mechanism, ahead of his time.

Shortly after receiving the Iron Bird, I was at one of the electric RC aircraft flying meets. While there, I saw some RC sailplanes going through maneuvers. People build a type of RC sailplane called “hotliners”. They are so efficient that they can go into a lightning-fast dive, and then climb back almost to the original height using just the momentum from the dive. Inspiration came when I realized that Reynolds could bring the same blazing performance to flapping wings.
By zeroing out the wing twist, the Reynolds mechanism would allow gliding performance comparable to fixed-wing aircraft. It can safely glide when the engine stops. What’s more, by reducing the wing twist while the wings are flapping, you could make blistering power-on dives. It’s like an adjustable pitch propeller where you can increase the pitch when flying at higher speeds.

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At the other end of the spectrum, Reynolds could increase the wing twist, allowing the ornithopter to fly really slow or hover. If you could do that, you would really amaze people and demonstrate that ornithopters can play at the same level as those planes with rotating propellers.

The wing twist can also be controlled differentially, between the left and right wings. This allows it to be used for steering. Not only differential thrust, but also an aileron type of steering effect has been implemented in the design.

Reynolds didn't want his ornithopter to sit in a box. It would be a sad loss to the ornithopter community for this brilliant device to be deprived of its ultimate completion. I have the Iron Bird mechanism, the wing spars, some wing cross sections, and other related materials that would enable a skilled ornithopterist to step in where Reynolds left off and bring the RC Gull into reality. The large size of the model and its advanced features make it a plausible starting point for a manned ornithopter.

I am looking for one qualified and highly motivated person who would like to take over the project. I am going to be selective about this. It must be someone with the appropriate skills and motivation, who is also willing to share the progress and results with the society, and credit Reynolds in any publicity of the project. If you might be that person, let's talk.

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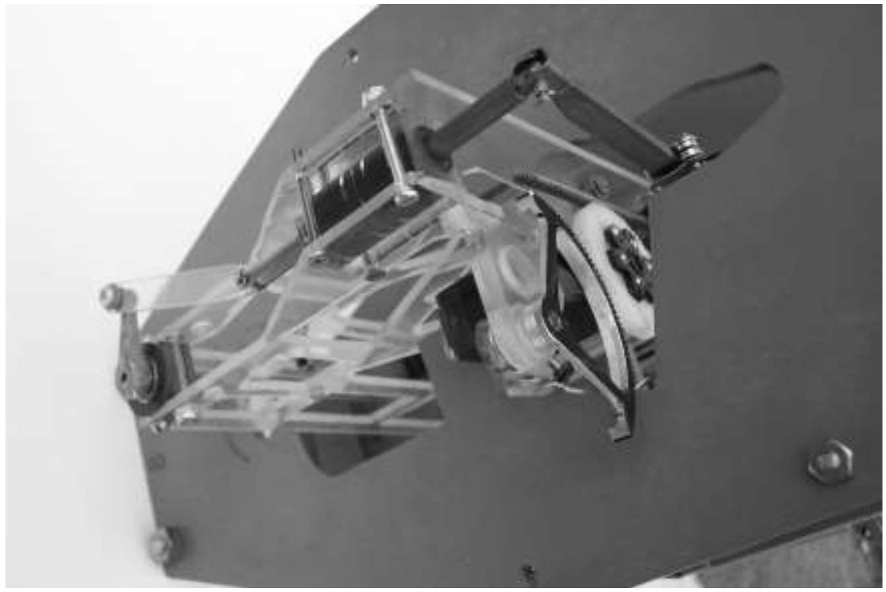
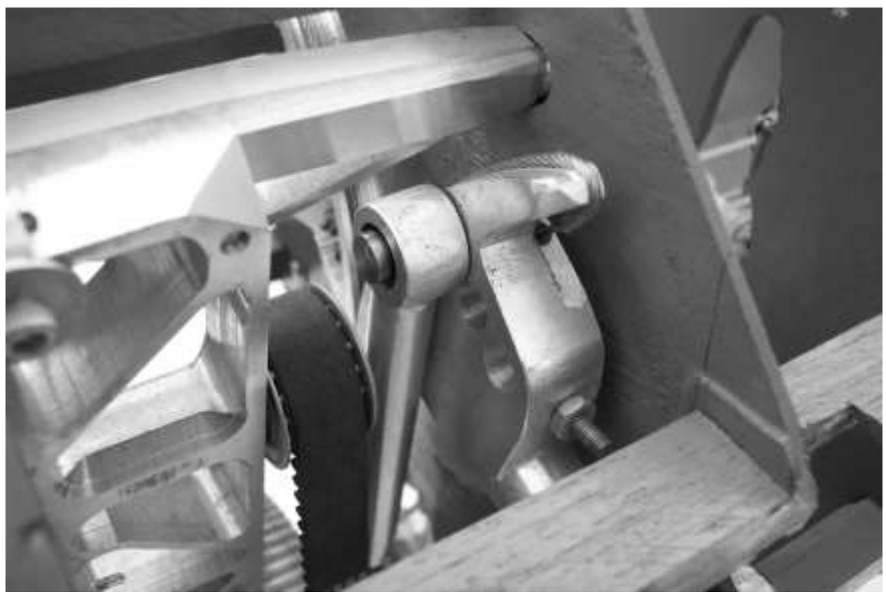


Part of the mechanism for controlling the torsion of the wings.



A view of the core flapping mechanism in the Reynolds ornithopter.

To Vee, or not to Vee?

That is the question – about the fact that bird tails have no rudders and how that applies to ornithopters. Okay, I agree, whether or not a bird's tail can really be called a "Vee" is up for grabs. And, too, there are birds that have other tail arrangements like long trailing feathers, and/or trailing feet. But what *is* obvious: the common bird tail does not have a vertical fin. So, those few tail feathers must perform the pitch function of a horizontal stabilizer, plus maybe the yaw control of a rudder, too.

The Vee-tail alternative for rudder and elevator (Tee) never really caught on with airplanes. Oh sure, there is the Beechcraft Bonanza, Lazair ultralight, and a few others, but mostly the Vee is seen in the realm of birds. Modern aircraft opt for the Tee-tail arrangement: stabilizer /elevator plus rudder, but they have lots of power to spare and aren't trying to be bird like anyway. Pterosaurs relied mainly on long tails, tails with vanes on the end, or nothing at all. Their vanes may have been muscle controlled, or not – information is sketchy. And through the ages bats seemed to get by with nothing tailing behind.

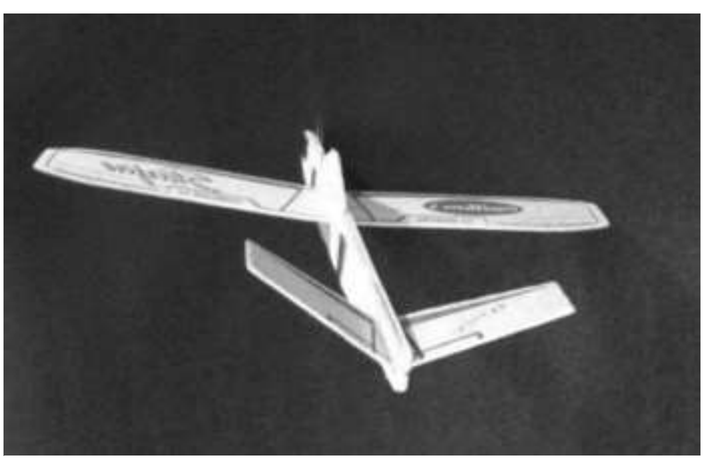
Of course in ornithopter design less drag and weight is a plus. So, from that point of view the obvious advantages of the Vee-tail would be a reduction in surface area (drag) and less mass. However, the NACA (National Advisory Committee for Aeronautics) says, not so: It takes as much surface area (hence weight/drag) as Tee-tails to obtain the control needed for flight. Well, not always believing what I read, I set out to do some experimenting.

Dusting off my trusty Guillow glider and first eliminating the rudder, but retaining the flat elevator, I tossed it into the air. It took a quick dive to the right. Then flailed over to the left too. Not exactly stable flight – as expected.

Next I fabricated a range of Vee-tails: 15 degrees from horizontal, 30, 45 and 60. I simply cut flat Guillow elevators and formed them to the test angles. Both Bonanza and Lazair use 30 degrees successfully. (Note, however, that early on, due to fatal mid-air breakups during extreme stress, Beechcraft issued an Airworthiness Directive to plane owners.) I also tried my new Vee-tails with and without the added rudder area. Keep in mind that these tests were performed free flight, i.e., without controlling flaps.

Here are the test results, which probably agree with what you are thinking:

- 60 degree Vee: some instability, may require elevator
- 45 degree Vee: stable flight
- 30 degree Vee: stable flight as expected,
- 15, or less, degree Vee: requires vertical fin. I found that the fin



Guillow glider modified with 30 degree Vee.

The tail of a bird.

could be quite small compared to stock Guillow. Also, for a given rectangular shape, height was more effective than width in providing stability.

- Vees flipped up-side-down (see Lazair): no difference from right-side-up.

- Lastly, I did not see any difference in performance between the stock areas provided by Guillow and Vees with areas enlarged (that is, equal in area to elevator plus rudder a la NACA).

So, perhaps a small, skinny, vertical fin would be necessary for a Vee-tail on an ornithopter. As elevators, the 30 degree Vees worked fine. Now, if one might have to add an elevator

Beechcraft Bonanza

Lazair ultralight

to Vees greater than 45 degrees, I ask, what then would be the point of having a Vee? Also, the up-side-down Lazair Vee's orientation seems nearer the look of the bird's tail.

Terrance McDonald added a goose head to this commercial toy RC ornithopter.

Want to get involved?

We could use some help recruiting new members! My vision for the Ornithopter Society is that everyone who's doing significant work with ornithopters should be a member. As we move toward that goal, the benefits of the society will increase, and we will have more activities to take part in, such as contests and flying events. If you're willing to reach out to potential new members (and some former members too) please send me an email so I can get you set up.

Nathan Chronister

All of this investigation was brought on by this thought: perhaps the absence of a vertical fin means the bird's tail is indicating some additional function(s) besides gliding stability. Look at landing for instance. The landing process of a bird is quite observable, and is photographed often. You can often clearly see the tail feathers spread, tilting down to form a brake, acting in unison with the wings, parachute-like, adding much needed low-speed lift for a safe landing.

And, too, perhaps the tail aids during take off. The sudden motion and commotion of the flapping obscures detailed photographic views of the process, but close examination

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