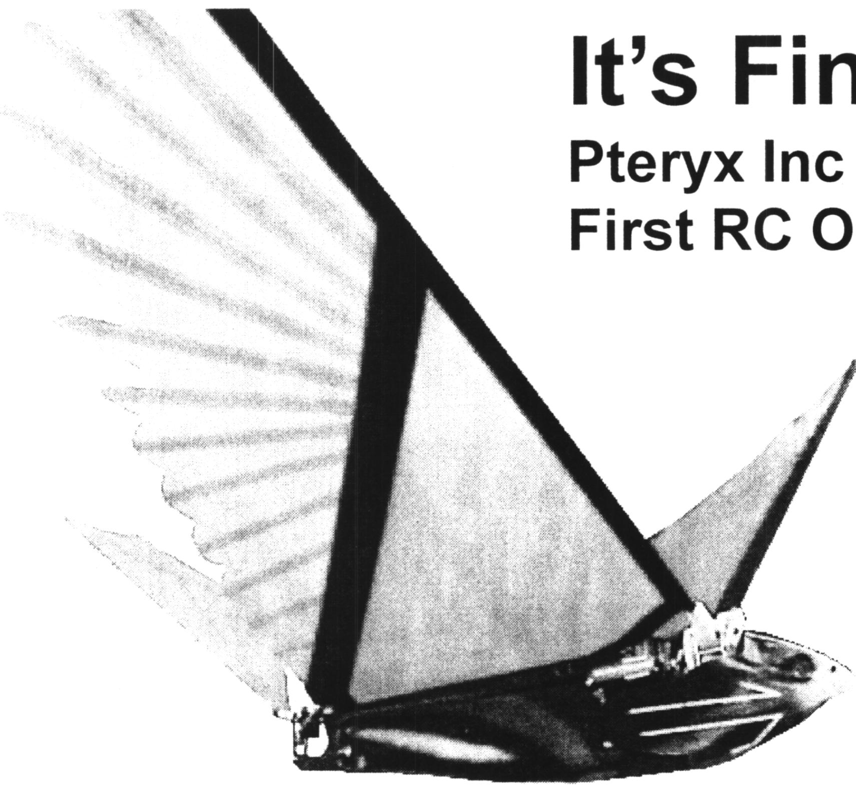
FALL 1999

Flapping Wings

THE ORNITHOPTER SOCIETY NEWSLETTER



It's Finally Here!

Pteryx Inc Launches The First RC Ornithopter Kit

This fall, visitors at the National Model and Hobby Show in Chicago were stunned by the first public appearance of a long awaited radio controlled ornithopter kit. Sean Kinkade of Pteryx Inc has been developing the kit since the successful flight of his VT1 prototype in 1997.

Skybird, the new kit, has several improvements over Sean's earlier successful ornithopters. The precision CNC mechanism, made at Sean's own facility in Florida, has been refined for maximum reliability and performance. The wing design has also been improved over the Spencer-type wing Sean began with. The kit wings include performance enhancing features as well as a slotted wingtip resembling feathers. Sean said the feathers are for looks and have little effect on performance.

A new control system gives the RC pilot authoritative control over the aircraft. One channel controls the throttle of the powerful 0.15 RC car engine. The other two channels control the pitch and tilt of a triangular tail, which directs the flight of the ornithopter without resorting to ugly hinged surfaces. The kit features an automatic gliding system that engages

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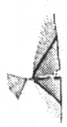
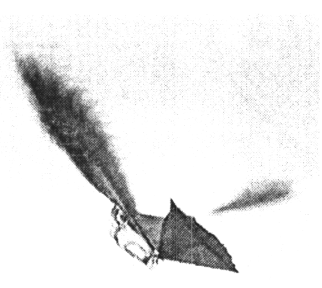
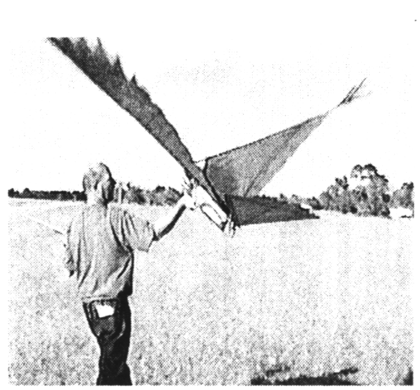


Pteryx Skybird is the first RC ornithopter available as a kit.





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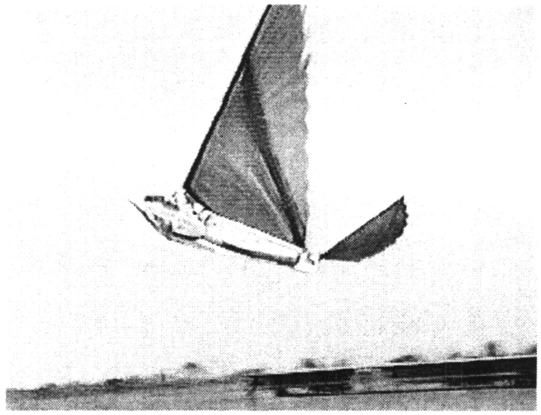
when the engine is idle. Flapping can be resumed in mid flight just by increasing the throttle.

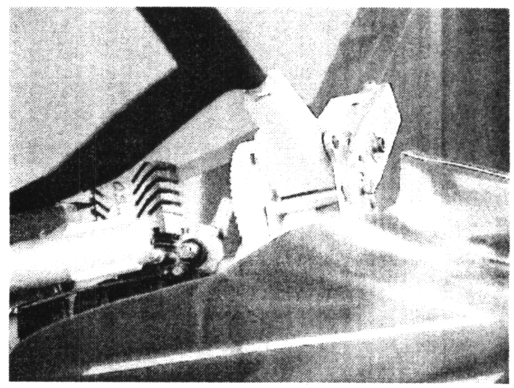
Sean said his goal in developing this kit was not to get it on the market as soon as possible, but to ensure that the quality of the kit would equal or surpass that of other RC products. Having some skill in marketing as well as being a brilliant engineer, Sean knows that an RC ornithopter kit will not succeed on uniqueness alone. It must also be a great-flying, hassle-free aircraft. For that reason, Pteryx is offering the ornithopter as an ARF (almost ready to fly) kit, with the most difficult assembly steps already completed.

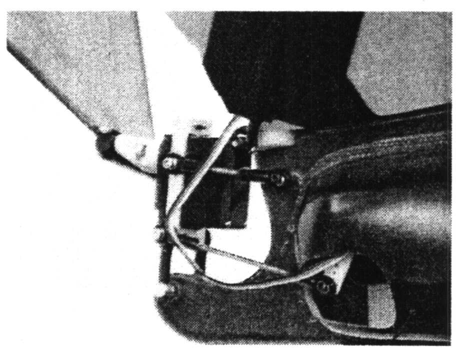
Skybird has a 2.4 meter wing span and ultra light construction. The huge wing area and weight of only about 2 kg allow slow glides and safe landings on grass. Yet it is also a stable, powerful flier that can tolerate moderately windy flying conditions.

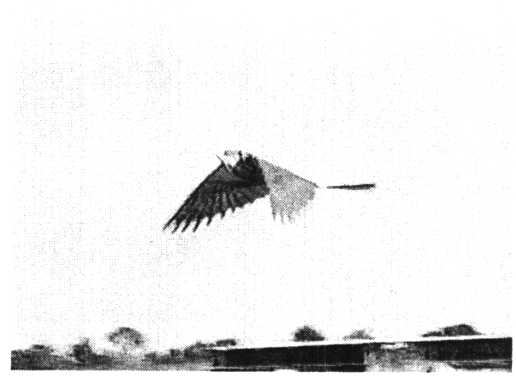
The kit is priced in the same range as good RC helicopters. You shouldn't expect a piece of custom built, precision engineered machinery like this to be cheap. But while an RC helicopter will get you a lot of attention at the flying field, this thing will stop traffic and get you on the local news. It's also a lot easier to fly, with controls similar to an airplane. Sean has made several demonstration flights since the trade show in Chicago, wowing audiences each time.

If you are interested in purchasing a Skybird ornithopter kit, contact Pteryx Inc for information on prices and options. You can call (407) 310-3554 or E mail thopter@earthlink.net. Pteryx Inc will have a web site at www.pteryxinc.com. The web site will include video clips demonstrating various features of the ornithopter. For information by regular mail, write to Pteryx Inc, 569 Timber Wolf Trail, Apopka FL 32712.









What *Is* That Thing?

As we struggle to draw public attention to ornithopters in a world where most people don't even know what the word "ornithopter" means, it has become all too apparent that even we who fly them can't agree on a definition. This article is an attempt to shed some light on the subject and to suggest appropriate ways of denoting various types of ornithopter. Why is this important? Because someone, somewhere, in the next few years, is going to fly the first successful manned ornithopter. Once that news is splattered across the front page of every newspaper in the world, there will be nothing we can do to correct any misunderstandings. It will be like Neil Armstrong forever being misquoted as saying "That's one small step for man". This is something that must be worked out *now*.

The first, and perhaps most important, issue concerns the misapplication of the word "full scale" to describe manned ornithopters. We've all been guilty of this at one time or another, but I say it needs to stop. In what sense is a manned ornithopter "full scale"? Aspects of its design may have been tested in an earlier RC model, but not all RC ornithopters are intended as models of a proposed manned vehicle. Since ornithopters are based (at least loosely) on the technology of bird flight, rather than scaled down from a manned vehicle the way model airplanes are, any ornithopter that is within the size range of birds must be regarded as "full scale". Likewise, terms like "miniature" or "scale" do not apply to unmanned ornithopters. Ornithopters from Tim Bird on up to Sean Kinkade's Skybird are not models of a proposed manned vehicle, but full scale emulations of the flapping flyers in nature. Therefore, it is inappropriate to speak of the proposed "manned" ornithopter as being "full scale".

Those of you who are developing micro air vehicles for the US government should readily agree. If ornithopters find their only commercial application not as manned vehicles, but as tiny unmanned devices, does it make sense to use the term "full scale" for the less significant, manned, aircraft? With billions of birds and insects already in practical service, isn't it obvious that an ornithopter is an ornithopter even if it is small? I suggest, therefore, that manned ornithopters should be referred to as just that, "manned ornithopters", rather than something as linguistically inappropriate as "full scale ornithopters".

Further, why misrepresent the heritage of flapping flight by denying full-size status to the creatures that gave us this crazy idea in the first place? Every time you use the words "full scale" to describe a manned ornithopter, you are reminding your reader of the history of birdmen leaping from bridges and flapping along the ground in ridiculous (and ridiculed) contraptions you'd do better not to associate yourself with. Much better not to contrast your work from the time-honored success that nature has had with flapping flight.

Many readers may be uncomfortable using the term "manned" in our politically correct society. What if the pilot of the first manned ornithopter turns out to be a woman? Jim Theis had some good, gender-neutral suggestions for what to call various manned and unmanned types:

· Piloted ornithopter: an ornithopter controlled in flight (flown) by an on-board, human pilot.

· Remotely piloted ornithopter: an ornithopter flown by a human pilot not on board the ornithopter.

· Robot piloted ornithopter: flown by an on-board computer.

· Remote robot piloted ornithopter: flown by a computer that is not on-board.

· Human powered ornithopter: a piloted ornithopter powered exclusively by an on-board human or humans.

"We could continue", Jim wrote, "but the chances of a robot piloted, human powered ornithopter any time soon seem remote, at least to me." He chose the word "robot" over the more descriptive term, "autonomous", in an effort to more effectively communicate with a general public (including press, grandparents, and kids) that is unfamiliar with such terms. "We don't want to put people off, sending them to the techno-nerd dictionary to understand what a person said after landing the first piloted ornithopter (do we?) or in any other way imply that ornithopters are weird or require super terminology to describe. Robots are generally portrayed in the popular media as computer controlled, recognizable things. In the public imagination robots still move around and look like something familiar: a dog (Dr Who), person (Data), or friend (R2-D2). Why not a friendly robot that moves around with wings? If I designed one I'd name *her* Tinkerbell."

Another issue is what to call a machine that is propelled by flappers but gets a substantial amount of lift from fixed wings. One might go to the dictionary on this one, but really it is we ornithopterists who should inform Webster and not the other way around. Besides, if you do check with dictionaries, you will find that they don't all agree. Some say an ornithopter is held aloft and propelled by flapping wings, whereas others only say that it is propelled by flapping wings.

Let's consider the first definition. An ornithopter is an aircraft that derives its propulsion and lift from flapping wings. All of its lift? Surely not,

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since nearly all ornithopters (like birds) get some lift from fixed lifting surfaces such as the stabilizer, struts, or fuselage. So the question before us is, "How much lift must come from the flappers for a given machine to qualify as an ornithopter?" Do you have an answer?

For the sake of argument, let's say that at least half of the lift must come from the flappers. 50 percent. Is it easy to determine whether a particular machine is an ornithopter now?

First of all, one should be aware that lift is not determined solely by wing area. If an ornithopter has a big flapping wing in the back and a small fixed wing in the front, the fixed wing might end up carrying most of the weight. It depends on the balance point location rather than the relative areas of the two surfaces. So you need to know the balance point to figure out if something is an ornithopter.

Now let's consider the case of a "tip flapper", in which the flappers are located at the ends of a fixed wing. In this case, both the flappers and the fixed wing are the same distance from the balance point. The incidence of the flappers, rather than their area, determines their share of the load. In many cases, free flight ornithopters of this type have the flappers angled downward so they produce very little lift. In radio controlled ornithopters, the incidence could be controlled so that the flapper's share of the load would vary during a single flight. In other words, a flick of the transmitter stick could transform your fully-fledged ornithopter into a mere tip flapper, mid-flight.

Further, even some of nature's flying machines might not meet the fifty percent requirement. Beetles have sizable fixed wings in addition to their flapping ones. Among birds, the tail, especially in takeoff and landing maneuvers, provides some lift. And birds glide. OK, we all agree that an ornithopter that can glide is still an ornithopter. But what if an ornithopter alternates between flapping and gliding to achieve the same effect as tip flapping? The accipiters, or bird hawks, are noted for their use of this technique. Nature is no purist when it comes to flapping flight.

Perhaps the greatest flaw in the definition used above is that it relies on some arbitrary percentage to separate ornithopters from non-ornithopters. It is possible, under that definition, for two nearly identical machines to be classed one as an ornithopter (having 50 percent of its lift from fixed wings) and the other as a non-ornithopter (51 percent). We have a cultural bias toward fifty percent. It's right in the middle. It coincides with our concepts "majority" and "most". However, we might just as well use any other percentage, 30 or 87, and the result would be the same: an artificially imposed dividing line. We can avoid such awkward cutoffs by using a more vague definition, some thing like "an ornithopter gets a lot of its lift from the flappers", but that isn't really a definition at all. It leaves the matter totally open to interpretation. Clearly, then, the definition of an ornithopter must rely on qualitative distinctions, not quantitative parameters like the amount of load carried by flappers.

The alternative is to define ornithopter as an aircraft propelled by flapping wings or fins. Not just wings, because a wing is sometimes defined as "one of the chief supporting planes of an airplane". The word "chief" was intended to separate wings from stabilizers, but it also gets us back where we were before. Our definition must explicitly include flapping *fins* to avoid lapsing back into the whole quantitative quandary. Some find it distasteful to include airplanes with small flapping propellers within our definition of ornithopters, but it is an inevitable inclusion if we are to avoiding imposing an artificial dividing line where no natural one exists.

What if the first on-board human piloted ornithopter uses a pair of small flapping fins? Would we want to call that an ornithopter? I suggest that we should. Rather than trying to boil continuous variation all down to black and white, I suggest that we need to grow a little and accept the more difficult, yet more powerful, notion of some ornithopters getting more of their lift from the flapping parts than others do.

We could say, for example, that ornithopters like James DeLaurier's Mr Bill were advancements over Spencer's Orniplane partly because they derived more of their lift from the flappers. It makes sense, I think, to recognize that the amount of lift contributed by the flappers is something that varies over a range. We can strive to increase the amount of lift generated by the flappers and give due credit to those, like DeLaurier, who have advanced this effort.

As part of my own efforts to encourage increased lift from the flappers, a few years ago I was part of an attempt to reform the USA's indoor contest rules to prohibit the use of so-called fixed-lift machines. Also involved was Bob Meuser, the author of the existing rules. His original intent was to exclude fixed-lift ornithopters, but he hadn't foreseen the current canard designs, which get most of their lift from the so-called stabilizer. Our task was heroic, in that we were constantly foiled by the lack of any natural distinction between fixed-lift and flapper-lift ornithopters. In retrospect, even those terms should have been abandoned.

Contest rules should not define aircraft types, but they can influence how technology evolves. Wanting to get away from rules that favor a particular type of ornithopter, I decided to offer a new ornithopter postal contest. It is open to all indoor ornithopters but has a separate category for designs that don't have the usual front stabilizer or fixed center section.

Where To Get It

A few years back, Patrick Deshaye came up with the idea of using polyethylene foam sheeting to build a flexible, thick-airfoil wing for ornithopters. An outer wrap of foam sealed with soldering iron heat at the trailing edge provides a nice airfoil that is torsionally compliant. Albert Kempf recently used a similar foam wing made of Depron with great success. I've gotten together a collection of foam sheeting from things I've gotten in the mail, but you can also buy the stuff in huge rolls.

Ship It sells the "foam wrap" in varying thicknesses and widths. Thicknesses are 1/32, 1/16, 1/8, and 1/4 inches. Widths range from 6 to 72 inches for huge rolls that will set you back more than 100 US dollars. You might find the stuff in smaller quantities at a shipping and packaging business near you, but beware of the variety that is perforated every 12 inches.

Order from Ship It, 3600 Eagle Way, Twinsburg OH 44087-2380 USA, www.shipitcatalog.com, 1-800-481-3600. Ship It also sells cardboard boxes in over 600 sizes, for example 28 by 24 by 6 inches for transporting your indoor ornithopters.

So Dark A Nature

Recently I read Steven Vogel's new book "Cats' Paws and Catapults" which compares engineered mechanisms with those found in nature. It is an interesting book that, by pointing out differences between engineered and evolved ways of doing things and the strengths and weaknesses of each, indirectly suggests a design philosophy for ornithopters; this is true even though flapping flight is not much addressed. The author's knowledge is wide-ranging, as exemplified by two quotes selected for his book:

The only difference I can see between machines and natural objects is that the workings of machines are mostly carried out by apparatus large enough to be readily perceptible by the senses (as is required to make their manufacture humanly possible), whereas natural processes almost always depend on parts so small that they utterly elude our senses.

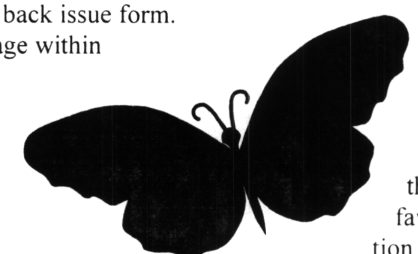
— *René Descartes*

I fear... that the whole of this subject is of so dark a nature as to be more usefully investigated by experiment than by reasoning...

— *Sir George Cayley*

A History Of Ornithopters

Leonard Opdycke's excellent publication World War 1 Aero included, in issue #159, a detailed history of ornithopters with an emphasis on early and manned designs. The richly illustrated article is still available in photocopy back issue form. $12 includes postage within the USA. Write to WW1 Aero at 15 Crescent Road, Poughkeepsie NY 12601 USA.



Entomopter Rises

Nathan Chronister in July produced a tiny, electric-powered entomopter that climbed vertically in tethered flight. The machine, using a Kenway motor on 7.2 volts, weighed 8 grams. Although the tether interfered with attempts at stable hovering, the entomopter climbed vertically to the end of the tether. No further work is planned at this time because there was insufficient power to carry an onboard battery.

Spring Storage

In the previous issue, I quoted Octave Chanute's estimate of rubber energy storage at 600 foot pounds per pound. Dick Quermann wrote to tell me that a more accurate figure is 3078 foot pounds per pound, according to Jim O'Reilly on the 1993 NFFS symposium. This is far better than steel springs at 95.3 (from Engineering Materials Hnadbook, CL Mantell, 1958). On the other hand, steel springs return a higher percentage of the energy put into them, making them useful in applications like Joss Levy's CO_2-powered ornithopter. Springs stored energy during part of the flapping cycle to allow a constant motor speed.

The Butterfly Effect

Indoor ornithopters fly in circles, right? Recent research by Jack Windig and Soren Nylin, reported in *Proceedings of the Royal Society*, show that male speckled wood butterflies, which fly in circles to drive off rivals, tend to be asymmetrical. The researchers believe that asymmetry has been favored by natural selection because it improves performance in this all-important territorial behavior. Indoor ornithopters, since they too fly in circles, might likewise gain a slight advantage from asymmetry. On the other hand, ornithopters fly in much wider circles than these butterflies and often reverse the direction of their turn as the motor runs down. The optimum amount of asymmetry might therefore be very slight, and its benefits negligible. Female speckled woods are symmetrical, as would be expected of creatures that don't have a preferred turning direction.

Letters

I have been in contact with the producers of air motors similar to the one in the Air Hog. I believe these motors have potential for ornithopter propulsion. I will be in a position to obtain several of these motors for development of ornithopter propulsion and am seeking co-conspirators. If you have an interest in applying an air powered motor to an ornithopter please E mail me at emailaoa@juno.com. It does not have to be a flying ornithopter; developing a power train suitable for ornithopter use is a worthwhile project. If ideas are lacking, no problem; projects are available for those with project desires.

Here is a summary of three reports that I pulled from my files. They may be of interest to some in the group. More available on request.

— *Grant Smith*

Pseudo-Ornithopter Propulsion. Grant Smith, 1972.

Abstract: It is possible to simulate ornithopter operation in a rigid lightweight airframe by vertically shifting the operator's center of gravity while the aircraft follows a cyclic flight path. This creates a relative motion between the aircraft center of gravity and the wing surface which allows a propulsive work input to the system without the weight and complexity of jointed wings or pedal-propeller dives. A simplified mathematical model is presented which allows performance estimates based on assumed pilot input. Indications are that pseudo-ornithopter propulsion may be a suitable method for propelling a powered aircraft. It can allow a reduction in the weight and complexity of the aircraft while providing a large effective propulsive area coupled with low drag while coasting. It may provide an effective means of man-power assist as well as dynamic breaking in a light single place aircraft

A Study of the Mechanics of Flapping Wings. DS Betteridge and RD Archer, 1973. University of New South Wales, Sydney.

Summary: A method for analysis of flapping wing flight using lifting-line theory and actuator disk theory is proposed for prediction of aerodynamic loads, propulsive efficiencies, and optimum lift distributions.

Introduction: Athough many qualitative studies were made of flapping-wing flight in the late 19th century, for example by Marey and Lilienthal, the first attempt at a quantitative study appears to have been made by Walker (1925, 1927). He assumed a constant velocity up-and-down stroke in a plane normal to the translational velocity. The angle of attack was assumed constant during each half-cycle, but differed during the up and down strokes. Allowance was made for wing twist by dividing the wing into three sections, each of which had a constant angle of attack. The wing section was assumed to have time-independent static (quasi-static) properties.

The next approximate theory was developed by von Holst and Kuchemann (1930, 1945), who replaced the flapping wing with a plunging wing, quasi-static conditions again being assumed. For the first time, allowance was made for the effect of induced drag.

In 1941, Garrick considered the propulsive forces acting on a wing-flap combination undergoing several modes of oscillation He dealt only with the two dimensional case, but introduced the effects of unsteadiness and calculated the propulsive efficiencies of a plunging and translating wing. The only other theory appears to be that of Osborne (1951), in which the forces acting on an oscillating wing element were determined, the integral over the span being replaced by what he termed "shrewdly chosen averages". Allowance was made for the lift-induced velocity, using the momentum theory developed for propellers (Glauert, 1935). However, no attempt was made to estimate the instantaneous forces acting on the wing.

A detailed treatment of the theories of the above references can be found in Weis-Fogh and Jensen's experimental study of locust flight.

The Technological Prospects for Flapping-Wing Propusion of Ultralight Gliders. J Wolf, 1974. Aviation Institute, Warsaw, Poland.

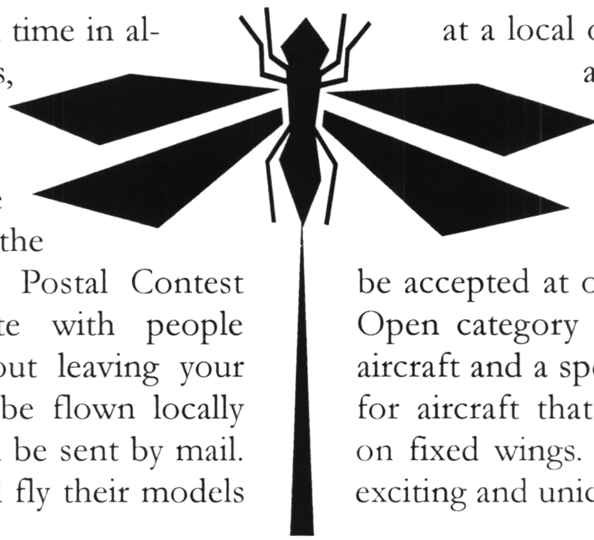
Abstract: The subjects of consideration are basic mechanical and aerodynamic problems of oscillating-wing propulsion for a man-powered hang glider. This propulsion requires elastic suspension of the pilot. The drive is transmitted from the pilot's legs to a stiff-wing structure by a trapeze device. This simple type of propulsion may reach extreme efficiency if appropriate longitudinal control is provided. Translational motion oscillating wings are shown to have many advantages over swinging, bird-like wings. Morphology analysis and value engineering have confirmed the soundness of this type of propulsion.

My team and I are designing an ornithopter. My team consists of aviation designers. Some results of our research are given at the web site ancom.w3.kiev.ua.

I research this problem and have an article "Bionics in Aviation" which was printed in journal *General Aviation* (see my web site). Some of my articles are printed in a Ukrainian magazine. Now I am looking for a sponsor or partner with whom I can build the first functioning [manned] ornithopter.

— *Igor Azaryev*

MILLENNIUM
INTERNATIONAL ORNITHOPTER POSTAL CONTEST



This year, for the first time in almost two decades, builders of flapping-wing aircraft will have an opportunity to compete internationally. In fact, the Millennium Ornithopter Postal Contest allows you to compete with people around the world without leaving your own town. Entries will be flown locally and their flight times will be sent by mail. Typically, contestants will fly their models at a local or national indoor contest and have the local contest director sign the entry form to verify the flight times, but other forms of evidence may be accepted at our discretion. There is an Open category for any flapper-propelled aircraft and a special Flapper Lift category for aircraft that meet certain restrictions on fixed wings. We wish you luck in this exciting and unique competition.

GENERAL RULES

• There is no entry fee.
• Each entry must include:
1. Entry form, completed and signed. The local contest director's signature is required unless the contestant provides other proof of flight duration (e.g., videotape) deemed suitable by OS postal contest director Nathan Chronister.
2. A scale 3-view drawing or clear 3-view photos of the model, with pertinent dimensions of model and motor.
• All entries must comply with the Design Requirements.
• The OS contest director has final authority to decide on compliance with rules.
• Flights must be made in the year 2000 and entries *received* by 15 Feb 2001. Send to Nathan Chronister, PO Box 376, Arkville NY 12406 USA.

SECTION 1: TO BE COMPLETED BY CONTESTANT

Name: ______________________________
Address: ____
Name and date of local event: ____
Organization sponsoring local event: ______________________________
Name of local contest director: ______________________________

□ Category A (open) □ Category B (flapper lift)

SECTION 2: TO BE COMPLETED BY LOCAL CONTEST DIRECTOR

I certify that the contestant named above flew an ornithopter (flapping-wing aircraft) for a duration of ____ minutes and ____ seconds, and that the same ornithopter met the Design Requirements below. Signature: __________________________ Date: ________

DESIGN REQUIREMENTS

• An eligible model is propelled solely by flapping wings or small flapping fins.
• Models must be flown indoors and launched by hand within two meters of the floor.
• Power must be provided by a rubber motor.
• If the entry is for *Category B*, the following *additional requirements* must be met:
  • All non-flapping lifting or stabilizer surfaces must be aft of the rear motor hook. This applies to stabilizers, fixed wings, fixed portions of flapping wings, fuselage structures that could produce significant lift, etc.
  • All wings must have the same flapping rate and roughly the same range of motion.

THE ORNITHOPTER SOCIETY

Industrial Evolution
PO Box 376
Arkville NY 12406 USA

Ornithopter Society Membership Info

Join the Ornithopter Society or renew your membership: Dues are $12 per year in the USA. Dues outside the USA are $17 US per year. Payable to *Industrial Evolution.*

Get published: Nathan Chronister, editor of *Flapping Wings*, invites you to send your articles and photos to be published in this newsletter. Send your material to the address above or E mail it to evolution@catskill.net.

www.catskill.net/evolution/flight