Flapper Facts

Newsletter of the Ornithopter Modelers' Society

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How to Join OMS: Join now by sending $9 ($14 outside the USA) to the address above. Payment should be made to "Nathan Chronister." Renewal dues are the same.

Twenty Minutes Plus!

He's done it again! Roy White has set another record for indoor ornithopter duration (Cat. 4). On 2 September 1995, one of his models flew for 21 minutes and 44 seconds. This is the first record flight to exceed 20 minutes.

Ornithopter Plans

Frank Zaic recently sent me a copy of the Model Aero Publications book index. This index lists the contents of each of the books he sells, and several of those books contain plans for ornithopters! If you would like a copy of the index, send $1.25 to:

Model Aeronautic Publications
Box 135
Northridge, CA 91328

Apparently, you have to buy an entire book to get a single ornithopter plan, but you'll also be getting dozens of other plans for every conceivable form of model aircraft. The plans are from 1934 through 1965, so the ornithopter designs are probably fairly robust. The prices include US postage.

Discussion Forum

I've created an E-mail list for ornithopterists. To post a message, include the word "OMSLIST" in the subject and send it to chronstr@bucknell.edu. To receive messages from the group, send me your E-mail address.

Membrane Wings James DeLaurier

Last year, we performed wind-tunnel tests on a "Tim Bird". It was mounted on a support which allowed the lift and thrust to be measured. The wing flapping was actuated with an electric motor, which certainly gave a smoother sinusoidal motion than that from the usual rubber band. We observed that the wing does generate significant lift in addition to the vectored thrust component. That is, my notion that all the lift is vectored thrust was wrong. However, the lift is very dependent on flapping frequency as well as angle of attack. (This frequency dependence was not observed for our "Mr. Bill" type wings.)

Also, I don't think that the camber always, necessarily, reverses between upstroke and downstroke as I had sketched. When I was looking at some slow-motion footage of Spencer's motorized Penaud flyers (his "Seagulls"), it was clear that the wings maintained a positive camber throughout the flapping cycle. [Ed.: Could this be due to a limp membrane edge?]

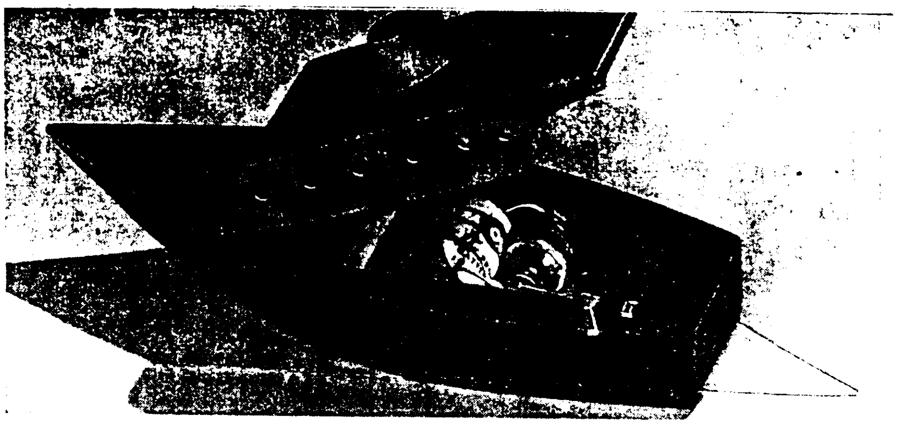
However, I do maintain that the classical Penaud flyer, with its aft CG, does the following:

1. Relies greatly on tail lift for balancing weight.
2. Obtains significant lift from vectored thrust.

By the way, the Tim Bird was modified in various ways:

1. Flat carbon battens were added to give chordwise stiffness.
2. Cambered ribs were added.
3. The wings were hinged to flap in a birdlike manner.

None of these modifications were an improvement over the basic membrane design.



The Model Boat That Flips to Go

By Roy L. Clough Jr.

THIS boat model is guaranteed to drive kibitzers crazy as it sits there in the water. It has no propeller, no paddle wheels, no hidden jet pump, not even a rudder. Yet, when you close a switch mounted on the deck, away it goes, kicking up a wake.

There's no mystery about the basic power source—an electric motor and a dry cell. But how is the thrust applied?

After everybody has had a guess, let them in on the secret. It swims like a whale or porpoise. But its horizonal flipper is transparent plastic, invisible in the water. The flipper is quite efficient, too, and drives the boat about as fast as a conventional propeller.

The boat goes together easily. Cut the sides, transom, and spreader bulkhead from 1/16" sheet balsa. Cement the sides together at the stem, bend them over the bulkhead, and secure to the transom with pins and rubber bands. Even up the symmetry and cement on 3"-wide planks for bottom and deck. Cut these pieces a trifle oversize and sand them flush after the glue sets.

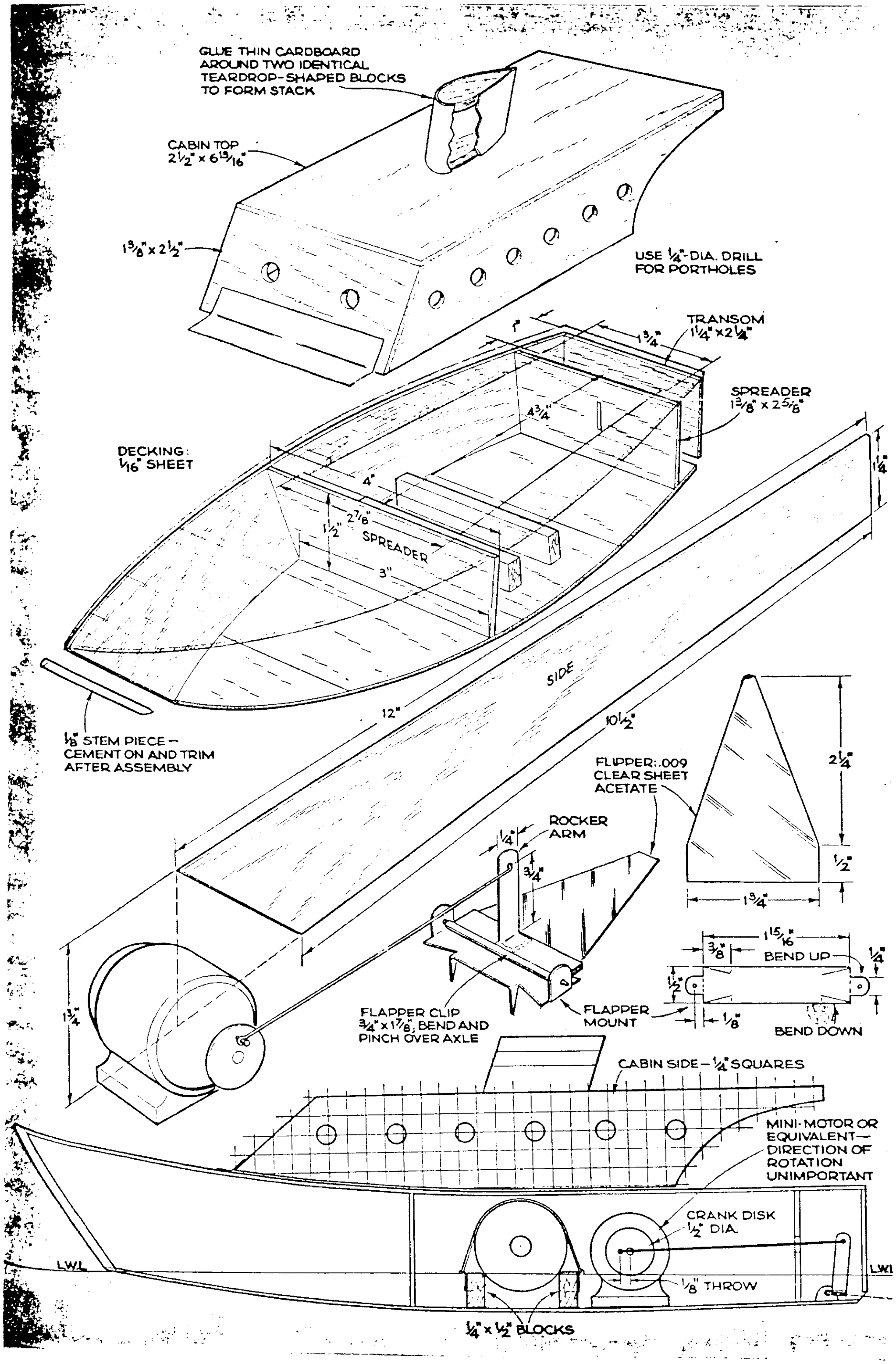
Cut the four cabin parts from 1/8" sheet. After assembly, hinge the front to the decking with cloth tape. Dope the entire job inside and out with at least two coats.

The driving mechanism is tin-can stock and 1/32" music wire. It consists of a flipper clip pivoting in a mount, and (soldered to the clip) a rocker arm, driven by a connecting rod from a crank disk on the motor. Exact dimensions are not critical as long as the mechanism works freely. Keep the slot in the back of the boat as small as is consistent with smooth operation of the flipper. The rocker holder has teeth that are pushed through the boat bottom and clinched.

Make the connecting rod a bit long. Solder the crank disk to the motor shaft, taking care not to overheat the motor. After cementing the motor to the floor, rotate the shaft so the crank throw is in the maximum forward position, and tilt the rocker arm to its limit of forward travel. Bend the connecting rod at the proper spot to hold this position and slide it into the hole in the rocker arm. Cut the rear bulkhead to size from 1/16" balsa and make the vertical slot just large enough to let the connecting rod play without binding.

Solder a couple of pigtails to a D cell; one wire goes directly to the motor, the other has a slide or knife switch inserted. Polarity and direction of rotation are unimportant. A rubber band fastened between two hooks bent fr[illegible] music wire keeps the cell in its cradle.

The boat can be made to circle in either direction by twisting the tip of the flipper to produce a side thrust.


GLUE THIN CARDBOARD AROUND TWO IDENTICAL TEARDROP-SHAPED BLOCKS TO FORM STACK
CABIN TOP 2½" x 6 13/16"
1 3/8" x 2½"
USE ¼"-DIA. DRILL FOR PORTHOLES
TRANSOM 1¼" x 2¼"
1"
1¾"
SPREADER 1 3/8" x 2 5/8"
4¾"
DECKING: 1/16" SHEET
4"
2 7/8"
1½"
SPREADER
3"
1¼"
SIDE
12"
10½"
1/8" STEM PIECE—CEMENT ON AND TRIM AFTER ASSEMBLY
FLIPPER: .009 CLEAR SHEET ACETATE
2¼"
½"
1¾"
ROCKER ARM
¼"
¾"
1 15/16"
3/8"
BEND UP
¼"
½"
1/8"
BEND DOWN
FLAPPER CLIP ¾" x 1 7/8", BEND AND PINCH OVER AXLE
FLAPPER MOUNT
1¾"
CABIN SIDE—¼" SQUARES
MINI-MOTOR OR EQUIVALENT—DIRECTION OF ROTATION UNIMPORTANT
CRANK DISK ½" DIA.
1/8" THROW
LWL
¼" x ½" BLOCKS

Design Manual and Backissues

The revised *Ornithopter Design Manual* and the bibliography are not available yet, and I expect that they will be substantially delayed. I just don't have time to work on them right now. The *Flapper Facts* backissues 1983 through 1995 are available for $25 ($33 overseas).

Letter from Roy Clough

An ornithopter should be defined as a flying machine that gets at least 60% of its lift and 95% of its propulsion from flapping wings. 100% of either is not practical or possible. A wide fuselage and even "legal" stabilizing surfaces may contribute to lift in some flight regimes. A simple, enforceable rule could be to evaluate the planview of the machine, corrected for dihedral angle if used. If 60% flaps, then it is an ornithopter. [Ed.: There's that pesky area equals lift fallacy, again!] I say 60% so that a fixed center section can be taken out of the remaining 40%. Designers should not be deprived of the fixed center section often needed to support the mechanism. It may not prove possible to leave this center section uncovered or open for several reasons; covering may be a structural part and even if it is not, leaving an array of thrashing arms and levers open to the slipstream imposes a pointless, even "unfair" drag penalty.

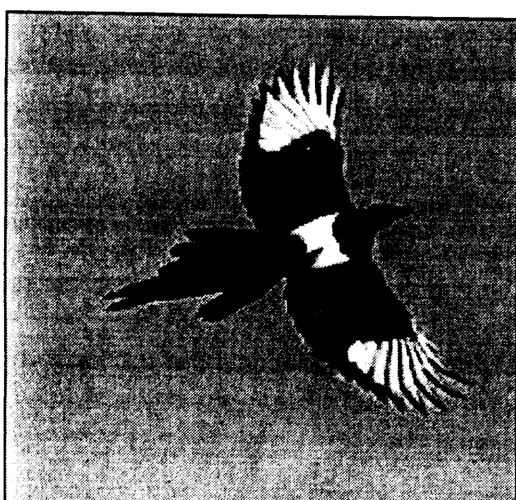
Create a separate sub-category of non-competing machines which may have substantially fixed lifting surfaces and derive their propulsion from flapping stub wings or fins, oscillating propellers and various "rowing" propulsion schemes. Call this category something like "FWAPS", that is, Fixed Wing Alternative Propulsion Systems. This would be more fair to true ornithopters. Otherwise they may eventually have to compete against soaring gliders fitted with "kicker" propulsion systems. By all means include FWAPS in the newsletter.

Incidentally, there is a natural precedent for ornithoptering with fixed wing area. Coleoptera. Locally we have a big "Junebug" beetle that flies around with wing sheaths extended like fixed wings. It is one of the best arguments for motorcycle helmets with face shields that I have ever run into.

[Ed.: Birds too can use fixed-wing lift during flapping flight. The birds alternate rapidly between flapping and gliding, combining fixed and flapping surfaces temporally rather than spatially to achieve the same effect. A recent article addressed the use of this practice at various flight speeds: Neuromuscular control and kinematics of intermittent flight in budgerigars (*Melopsittacus undulatus*). Tobalske, Bret W.; Dial, Kenneth P. Journal of Experimental Biology. Feb 1994, v187, p1-18.]

Mike Palrang Indoor Info

In response to your request in issue #13 for info on ornithopters at the '95 Nats: The flapper I flew was a Frank Kieser "Fancy Girl" built from the plans that appeared in the NFFS publication "Winning Indoor Designs '87-'89". As you probably know the upper & lower wings are 180° out of phase & the right & left wings are approximately 90° out of phase on his design. My plane is overweight at 1.78 grams. Larry Coslick's and Roy White's planes weigh about 800 mg. My 12:07 flight used a 13.5" loop of .081" wide Tan II rubber wound to 1670 turns and backed-off 110 turns to a launch torque of 0.48 oz.-in. It got about 130' high 4:30 into the flight and landed with 92 turns and 0.12 oz.-in. left in the motor.



Flapping Wings!

The Ornithopter Home Page

Check out the main ornithopter site on the World Wide Web! Before it's gone!

New, unpublished info on designing ornithopters!

Info on swimming machines!

Newly revised!

Photos and video clips!

http://www.bucknell.edu/~chronstr/orn.html

AMA Rules Proposal

Letter from T. R. Quermann

In issue #7 of *Flapper Facts*, the issue of the inadequacy of the current AMA ornithopter rules was discussed. An approach to a revised rule was suggested and reader response solicited. Since then Nathan Chronister and I have exchanged numerous letters trying to devise a simple, fair, effective rule to insure that the flapping wing carries most of the load. [Ed.: In typical canard indoor models, the center of mass is located very close to the stabilizer, so the stabilizer must contribute more lift than the larger, flapping wings.] My original suggestion based on centers of lift was obviously impractical because the determination of where the center of lift is located was left to the contest director.

In order to avoid this problem, Nathan suggested the use of extreme forward and rearward points on the surfaces. Making some assumptions concerning typical aspect ratios, etc., some simple calculations indicated that such a rule could indeed put most of the load on the wing. However, it also encouraged distorted configurations seeking to exploit the fact that the center of lift does not lie on the extreme fore or aft point on a surface. It also penalizes common configurations involving swept surfaces.

Since any rule using secondary characteristics to control a critical parameter is likely to be either unnecessarily restrictive or vulnerable to circumvention, I believe that more effort should be made to figure a way to measure the critical parameter. For the ornithopter the critical parameter is the location of the centers of lift of the surfaces.

Clearly, an exact determination of these centers is far beyond the capabilities of any model builder or contest director. Fortunately, a few simplifying assumptions lead to a very easy method for approximating the center of lift. By writing the rule around "centers of lift" and defining the "centers of lift" as the points determined by the approximation, a reasonably sound practical result should be attainable.

The approximation method assumes the following:

1. The center of lift of a rectangular surface is at the 1/4 chord point.
2. If the surface is divided into a large number of equal span segments by lines parallel to the direction of flight, each segment produces a lift proportional to its mean chord.

In order to determine the "center of lift" of a surface, one first makes a cardboard pattern of the projection of the surface on a horizontal plane. This pattern is then bisected by cutting along a line connecting the midpoints of all chordwise lines parallel to the direction of flight. The projection of the "center of lift" is *defined* as being located at the center of gravity of the forward half of the bisected pattern. [Ed.: The accuracy of the approximation is not too important, as long as it excludes models with too much stabilizer lift.]

To simplify the contest director's job, it is suggested that each contestant determine the "centers of lift" of his model's surfaces and mark the allowable extreme for the model center of gravity location on the model. If, when suspended at this point, the stabilizer end goes down, the model fails, period.

Putting all this together, I offer the following proposal for a new free flight ornithopter rule. The format is taken from the more recent AMA rules. I sincerely hope that anyone who is offended by my efforts would use their background and intellect to write a better rule. You certainly can't believe that the present rule should be retained. To those who might object that the rule is too long, too detailed, too complicated, etc., I suggest that you read the AMA rules for Easy B, Bostonian, and Manhattan Cabin. One might note that the least popular event, helicopter, has the shortest rule.

17 Ornithopter. For event 210.

17.1 General. All rules applying to FF Indoor Rubber, with the exceptions noted below, shall apply.

17.2 Characteristics.

17.2.1 An ornithopter derives its chief support and sole propulsion from its wings.

17.2.2 All wings shall be driven in a flapping or reciprocating manner to achieve propulsion.

17.2.2.1 At least 90% of the area of each wing shall be driven.

17.2.2.2 All wings shall have the same approximate degree and rate of motion.

17.2.3 A single horizontal stabilizing surface is permitted.

17.2.3.1 The projected area of the stabilizer shall not exceed 40% of the total projected area of the wings.

17.2.4 A side view of the model in level flight must display a clearly visible indelible mark positioned as follows on a structural member such as a motor stick.

17.2.4.1 Vertical lift lines shall be drawn thru the "centers of lift" of all wings and the stabilizer.

17.2.4.2 A vertical line shall be drawn twice as far from the stabilizer lift line as it is from the most remote wing lift line. This line shall pass thru the indelible mark.

17.2.4.3 The fore and aft balance point for the model must be on the wingward side of the vertical line thru the indelible mark.

17.2.4.4 The minimum distance from a wing lift line to the stabilizer lift line shall be greater than the maximum wing chord.

17.2.5 The "center of lift" of a surface shall be determined from a cardboard pattern of the projected surface on a horizontal plane.

17.2.5.1 For wings, the pattern shall depict both halves in their mid-downstroke position, even though this may never occur simultaneously in actual flight.

17.2.5.2 The pattern shall be bisected by cutting along a line thru the midpoints of all chord lines parallel to the line of flight.

17.2.5.3 The center of gravity of the forward half of the bisected pattern shall be determined. By definition, this point shall be coincident with the projection of the "center of lift" of the surface.

17.2.6 All flights shall be hand launched. Twenty seconds will define an official flight.

Letter from Walter Erbach

It would appear as though the rule proposer has never been an indoor contest director. Would you like to process someone else's very delicate models under contest pressure, pushing a yard stick against those delicate surfaces to ascertain whether the ships entered are legitimate? Then mark the locations on the stick for CG boundaries? Next, how will you accurately establish the CG location with minute air drifts and tiny puffs of wind causing the model to dance constantly? Build a big shroud? I'm not talking about the obviously acceptable case but the one where the CG is at one of your marked boundaries and a fellow, itching to make an official AMA protest, is watching your every move. How do you justify all this to those builders whose ships have CGs well away from the middle of the motor stick so that changes of motor cross section or length change the CG location?...

Your rules proposal states that an ornithopter derives its *sole* propulsion from *flapping* wings. Isn't any flight which terminates in a glide automatically invalid since propulsion is being provided by weight, not by wing flapping? As a contest director, you could get hit by a surly competitor's protest should he lose to such a flight. As a CD I've been there.

After you write a proposal you must shed all of your personal feelings about it; looking at it as though you've never seen it before. Is your proposal clear, is it easily understood, is it written so that it cannot be misunderstood? (Ah, ha, the builder says to himself, I just found a loophole.) Does it accomplish what it purports to do, might it force the contest director into rule interpretation? All that isn't easy. Another illustration: The original set of rules for a proposed Easy B event was written by a group of builders from one of our largest and oldest indoor/free flight clubs. The rules were reviewed by the club and submitted to the AMA. With all this, the proposed rules were so bad that dozens of builders wrote letters of complaint and protest!...

Elsewhere you suggest comparing average wing and stab chords. Ever try to determine accurately an average chord? Detailed and cumbersome rules [Ed.: or procedures] serve only to drive builders from an event.

Letter from Nathan Chronister

The cardboard pattern idea wasn't mine. Although I would like to see a rule that somehow restricts the amount of lift that can be provided by the stabilizer, I also tend to agree with Erbach that complex methods of insuring this should be avoided. As described by Quermann, and in earlier issues of *Flapper Facts*, I suggested using extreme points on the surfaces, rather than centers of lift, to insure the necessary lift distribution. While the idea seemed simple enough to me, Erbach objected that the idea was difficult to explain and that even the act of comparing the center of mass location to the points on the wing and stab would be impractical.

There are approximately three options, then. One is to use estimated centers of lift as Quermann suggests. Another is to use a less direct, but simpler, method, such as my idea based on extreme points. Finally, we could abandon our pursuit of a stabilizer lift restriction altogether, falling back on the existing method which regulates fixed wing area rather than lift contribution. [To reiterate a central theme, even a small stabilizer can contribute the majority of a model's lift.]

I would like to hear from anyone who has an opinion on these issues. Which of the three alternatives, or other alternatives, do you think is best, considering the practical difficulties involved in each?

Quick Ornithopter Nathan Chronister

In this issue you'll find plans for a small ornithopter I built a few years ago. The basic design philosophy is that it takes a minimum of time to build. However, this is not a good model for beginners because it is extremely fussy and difficult to get any kind of good flight out of it. It is, in other words, an interesting challenge. The main problems you will encounter are:

1. Shaping the crank in such a way that it doesn't catch on the needle.
2. Trimming it correctly. It needs a large tail, probably about 50% larger than shown in the plans, though everything else is to scale.
3. It probably still won't fly very well, though I believe I got "level flight" out of it once.

It only takes about 15 minutes to build, so maybe you can give it a try and let me know if your luck is better than mine.

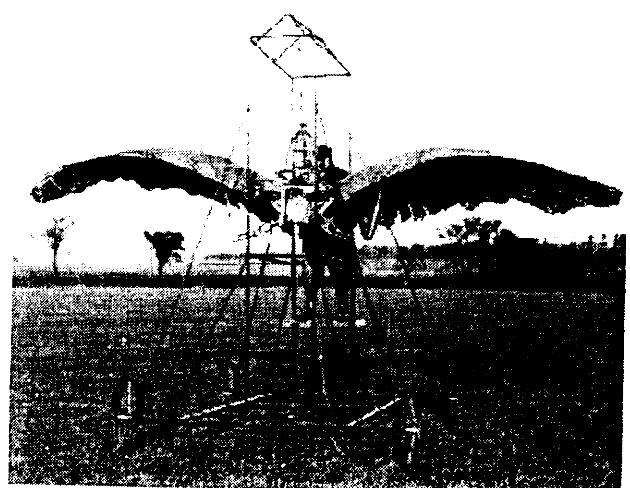
Frost Ornithopter

The following is an excerpt from the World Wide Web pages of the Science Museum, London (http://www.nmsi.ac.uk/Welcome.html).

Edward Purkis Frost, a Cambridgeshire squire and magistrate, made flapping-wing machines (ornithopters) of willow, silk and feathers. The wing action of the ornithopter was intended to mimic that of a crow, separating to allow air to pass through on the upstroke, and closing again for the downbeat.

As President of the Royal Aeronautical Society (1908-11), Frost witnessed the triumph of the conventional aeroplane over the ornithopter.

The left wing of a Frost ornithopter is displayed in the Museum. The whole unit was unearthed in woods by a pack of hounds in 1925 and is too delicate to be displayed complete.



Edward Frost's 1904 Ornithopter

It was intended to run along a track so that forward speed would contribute to the lift. The wings beat at 100 strokes a minute. On test, suspended by a rope from a tree, the whole machine was said to rise about 0.6 m (2 ft) at each stroke, looking 'like a gigantic bird trying to fly'. A spring balance showed a lift of 36-72 kg (80-160 lb) on a downstroke. However, the machine weighed 105 kg (232 lb) so clearly could not have flown.

Quick Ornithopter

by Nathan Chronister

actual size