oms flapper facts
SPRING 1993

## From the Editor

I would like to thank everyone who has sent in information and plans for the newsletter. In this issue, you will find plans for a rubber-powered model sent in by George Benson. I have also received plans for another early ornithopter which will appear in the next issue. I would like very much to publish some more recent designs capable of better performance, so if you have any, *please* send them in.

Readers who would like to get their hands on a whole bunch of plans, along with a wide variety of articles on how to design and build ornithopters, can now get a copy of *Flapper Facts: 1983 - 1990 Back-issues* . The set is about 130 pages long and includes plans or drawings for about 30 different rubber-powered ornithopters. There is also information of interest to those of us who think ornithopters should be big and noisy.

There is other good news too! The *Ornithopter Design Manual* is now available as a photocopy of the original. 22 pages, illustrated, and very useful to anyone who designs rubber-powered ornithopters.

To cover copying and postage, please send $8 for the back-issues or $2 for the design manual. Checks and money orders must be written out to Nathan Chronister.

### Membership dues

Dues, including subscription to *Flapper Facts* , are $4 per year or $7 per two years (overseas, $6 per year). Checks and money orders must be written out to Nathan Chronister.

## News

### New Record

On February 12 of this year, Roy White set a new Cat I record of 6:22. Send your news of records and other accomplishments to *Flapper Facts* . Don't keep your talents a secret!

### OMS Elections

In the mid 1980s, OMS sponsored a number of postal contests and became a chapter of the AMA. By resuming such activities as the postal contest, OMS can encourage further growth of ornithopter modeling. For example, it may be interesting to see the results of a sport-scale ornithopter postal contest, since this would certainly encourage a lot of new, creative design ideas without the difficulties of gas or electric power. As Patrick Deshaye wrote in an early issue of this newsletter, ornithopter modeling is an exercise in "applied freethinking," and the scale ornithopter creates new opportunities for this.

These things are more than I can do alone, however, so it is necessary to resume another OMS tradition, that of electing officers. Positions elected will be president, VP, treasurer, and newsletter editor. If you have a strong interest in promoting the ornithopter hobby, please consider running for one of these positions.

If you are interested, please submit a brief statement of your qualifications and general goals for OMS (1/4 page double-spaced, or shorter) by June 15. It will appear in the next issue of *Flapper Facts* .

# Flashback
## 1942 attempt at gas power used unusual wing design

In the early 1930's, when Miles VandeGrift began working with ornithopters, rubber-powered flappers were roughly similar to today's. They were monoplanes, but the membrane wing was the same then as it is now. When it is forced through the air, such a membrane forms a cambered shape which has an acceptable lift / drag ratio. However, such a wing differs from that of an airplane or bird, and performance would be improved significantly if a more efficient airfoil could be used in ornithopters.

Wing cross-sections of various flying entities


Miles set out to do just this. He designed a special mechanism which could vary the incidence of the wings while flapping them, just as the incidence of a membrane changes as the wing oscillates. This concept, called **rigid panel variable incidence,** was soon tested in a rubber-powered model. This ornithopter did not climb, but it produced enough lift to demonstrate the potential of the concept.

Robert Knutson, assisted by Miles, followed up with a gas-powered ornithopter using the same concept. Envisioned as a model for a proposed human-carrying flapper, it had a span of 10 feet and was powered by a Super Cyke engine. Power transmission was accomplished by a rubber sewing machine belt followed by several stages of gears. Because radio control was not available, a mechanical autopilot mechanism was developed, but this was not used because the hysteresis lag was too great. The wings could be locked into a dihedral position with the correct angle of incidence for gliding, and the model glided very well. Powered flight, however, was not successful. According to Robert, this may have been due to the fact that most of the wing stroke was far above the horizontal, causing a severe nose-down tenancy due to the thrust line being too far above the center of mass.

Miles also proposed the use of separate wingtip airfoils, analogous to the pinion feathers of an eagle, under separate variable incidence control. His calculations indicated that power requirements would be low. He also recognized the potential use of ornithopters as low speed reconnaissance aircraft. Since the propeller makes most of an airplane's noise, an ornithopter with a highly muffled engine would be far quieter than an airplane.

Non-membranous wings of various types have been used in many of the largest ornithopters. Maule's human-powered flapper, described in the previous issue, had rigid wings. Ornithopters flown recently by MacCready and Harris / DeLaurier used flexible wings with airplanelike cross-sections. While these may offer substantially improved efficiency, they are more difficult to design and build than conventional model airplane wings. The rigid panel concept allows the use of ordinary built-up wings and therefore may be more practical for use in model ornithopters.

## More info

on Harris and DeLaurier was requested by some of you. Therefore, I am listing several articles on this ornithopter as well as on Paul MacCready's ornithopter. You might be able to find these articles in your library. This is just a sample of the many articles which have been published.

**Harris / DeLaurier:**

*Discover* April 1992 p20
*The New York Times* May 31, 1992 v141 pF12
*Popular Mechanics* Jan 1993
*Popular Science* March 1992 p20

**MacCready:**

*Design News* Aug 18, 1986
*Engineering and Science* Nov 1985
*National Geographic* vol.170, pp138-139 July 1986
(has an article with indoor ornithopters too)
*Smithsonian* vol.16, pp72-81

The MacCready ornithopter is featured in the IMAX film *On the Wing* and both of these ornithopters have appeared on TV.

## Question & Answer

Do you have questions about ornithopters? This column is your chance to get them answered. Send in a question, and I'll either answer it or try to find someone who can. Anyone who has a different or more complete answer is encouraged to send that in, too! Our first question comes from Robert B. Dance.

Q: Do you have any information on using electric power for an ornithopter? I am an artist and would like to try a butterfly with these mechanisms.

A: Flapping mechanisms for electric ornithopters are the same as those for any other ornithopter except that a large gear reduction is required. (See plans in this issue for a typical flapping mechanism, although there are many types.) My own electric ornithopter uses an HLH731 gear train from Hobby Lobby, (615) 373-1444. The output shaft can be bent to form a crankshaft which pushes the wings up and down. It is also possible to build your own gear reducer from gears found in appliances, VCRs, lawn sprinklers, etc. The reduction ratio should equal the load speed of the motor divided by the required flapping rate, which is roughly 300/minute if you have a very light wing loading. Thus, a 15000 RPM motor requires a reduction of roughly 50:1. It is very important to use a powerful enough motor, one which is made especially for aircraft use. The HLH731 gear train comes with a 4 watt motor, which I replaced with a 20 watt model airplane motor of the same weight. There are a few tailless flappers in the back-issues which might help you design a butterfly, though some real ones have tails. A tandem configuration would also be suitable, and it might offer good pitch stability. Unlike other biplane and tandem ornithopters, all four wings would have about the same timing in order to immitate a real butterfly.

## Exchanging information

Information on ornithopters is hard to find, but there actually is some out there. A goal of OMS has always been to help its members find information, and one way of doing this is by listing what is available from various members. Here's how it works:

If you have any magazine articles, plans, or other information which might be of interest to others, you may send a list of these items to *Flapper Facts* . The list will then appear in the newsletter along with your address. Members who are interested in what you have will then send you money for copying and postage.

P.J. Ernst Sr. has volunteered to get the ball rolling with a list of old *Model Airplane News* articles about ornithopters and some ornithopter patents. He can be reached at 5 Carmen Lane, Alexandria, KY 41001.

*Model Airplane News*
Jan 1941 E. Lidgard "Flapper"
July 1943 R. Horak "The Flapper"
Oct 1943 W.F. Tyler "Flapperoo"
July 1955 P. Schoenky "Flapping Wings"
Oct 1956 Bell "Flutterer"
May 1957 L.H. Conover "Lil Iggle"
Nov 1968 A. Rogers "Ornithopter"
Apr 1972 K.B. Johnson"Flip flop the Ornithop"

Patents
234,947 Breary 1880
980,840 Rozboril 1911
1,758,178 Slinn 1930
1,907,887 Spencer 1933
2,182,406 Ogsbury 1939
2,321,977 Boatwright 1943
2,859,553 Spencer 1958

I would like to offer, from my own files, magazine articles on the following topics. I would prefer to receive any plans or unusual articles you have in exchange for these, but an SASE and a few stamps are OK instead.

Paul MacCready's pterosaur replica, article with mechanism and tech. info.
Harris&DeLaurier ornithopter.
Entomopters, machines which imitate insect flight using small, rapidly beating wings.
Animal flight - name the animal and specifics.
Frank Kieser's Free Flight Symposium articles on linkage design (also found in back-issues).

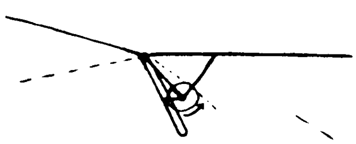
I would also like to discuss design ideas (tried or untried) or other ornithopter topics with anyone interested. Call (914) 687-4911 or write to me at the address on the back cover.

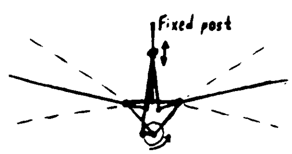
# Design Ideas

Earlier this month, I got a surprise phone call from Larry Burks, who was in the area. We got together and discussed ornithopter design ideas. Since the 1970s, Larry has been building all different kinds of rubber-powered ornithopters as well as a few internal combustion and electric ones.

Larry built his first successful ornithopter with no knowledge of other ornithopters that existed at the time. Since then he has been experimenting with different flapping mechanisms, some of which are pictured in schematic below. Some of his smaller flappers are monoplanes in which only one of the two wings is moved by the crank; the reaction force causes the whole fuselage and "fixed" wing to move in the opposite direction, with the result that both wings actually flap. The mechanism provides more force on the downstroke than on the upstroke, for greater net lift. [A competing idea is that of using rubber bands to assist the downstroke. This method slows the upstroke, which is undesirable according to Larry. -ed.] Another model has two beating wings whose actions are synchronized by the use of a sliding bar mechanism.

Single-wing flapping mechanism

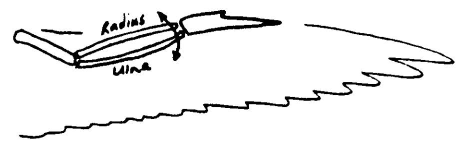





Synchronized flapping mechanism

Larry has also built some very large rubber-powered ornithopters which are over four feet in span. Large outdoor flappers have been around for over 100 years and sound like an interesting project. Or, as Larry describes, they sound like a jet landing. A loud, unusual noise produced by one of his larger flappers is attributed to air rushing over the trailing edge of the wing membrane, and degradation of the membrane edge supports this explanation. Larry proposes the use of a different wing structure which will be better-suited to large ornithopters. It imitates the pivot joint found in birds' wings and in the human forearm. This joint consists of the radius and ulna, which move around each other to produce a twisting, rather than bending, movement. The wing of a typical ornithopter cannot twist; only by having a loose membrane can it achieve the varied angles of incidence required for flapping flight.

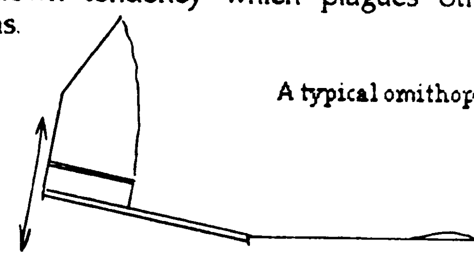
Bird wing showing pivot joint



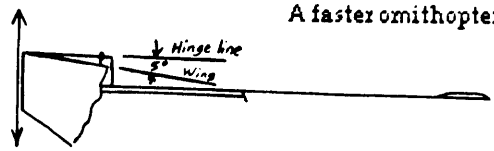


Ornithopter wing with pivot joint

Larry has tried different angles between the wing rib and the wing hinge line. By setting the wing rib at an angle of 5 degrees down, the flight speed is increased to a more bird-like value, while if it is angled "up" instead, the ornithopter will nearly hover. The faster flapper also has less of the nose-down tendency which plagues other designs.



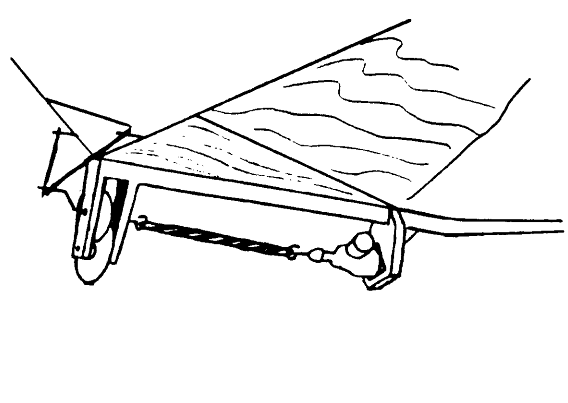
A typical ornithopter




A faster ornithopter

Biplanes have been the record-holding indoor ornithopters for a while now, but Larry wants to make them fly even better. His work hasn't focused on indoor models, however. He has found that by having a large vertical spacing between the wings (see photo), it is possible for both wings to spend the entire cycle close to the horizontal position, providing maximum lift. These models are also very stable. Larry favors the use of a flapping mechanism which is 180 degrees out of phase, rather than 90 degrees out as in many biplane flappers. This means that while one pair of wings is moving down, the other is always moving up, so that the net lift is always the same and there is no "bob" in the flight path. Another advantage of the 180-out mechanism is that it allows the wings to get though the transition between one stroke and the next as quickly as possible (perhaps at some cost to flight duration). Since the load on the crank drops to zero when it goes through the dead-center area, it speeds up when the wing is at this point in the cycle.

A problem with gas and electric ornithopters, as well as with 90-out flappers, is that the motor cannot accelerate fast enough when the crank moves through this position, and the wings spend too much time in the turnaround between strokes. (Also, the engine may quit due to speed fluctuations.) To solve this problem, Larry proposes that a rubber band be connected between the engine and the reduction gearing. This smooths out the motor RPM and has the additional advantage of allowing the engine to be started without a clutch. It should be easy to start before the rubber band winds up and begins to provide resistance. [Instead, the rubber band could be placed between the gear reducer and the flapping mechanism, thus protecting the gears from damage in the case of wings striking the ground, etc. -ed.]



Gas ornithopter with rubber band for smoother running

As an intermediate stage in the development of such an ornithopter, the rubber motor alone could be used for power. A rubber band with the same torque as the gas engine would be used, and it would be used in combination with a gear reducer.

Larry has been building a type of ornithopter he calls "flutterbugs". In contrast to the usual flapping angle of 40 or more degrees, Larry has been using flapping angles of about 20 degrees, and some of his large rubber-powered models kick up dirt when they take off.

In these models, the wing is always nearly horizontal, so lift is maximized. Also, since the crank radius is shorter in relation to the wing, with a given rubber motor the aerodynamic forces on the wing (and thrust) are greater. The motor will also unwind faster, but it can now be replaced by a thinner motor which might extend duration beyond that of a high-angle flapper.

There are two problems with the flutterbug which might be less important than its advantages. One is that the wing spar must change directions more often, requiring more energy. The other is that the membrane will go limp more often during the turnaround at the end of each stroke. This effect can be offset by using a tighter membrane on a pivot-jointed wing, or by using a narrower wing. Larry points out that swifts, which are among the fastest and most efficient of birds, use a lower flapping angle than other birds.

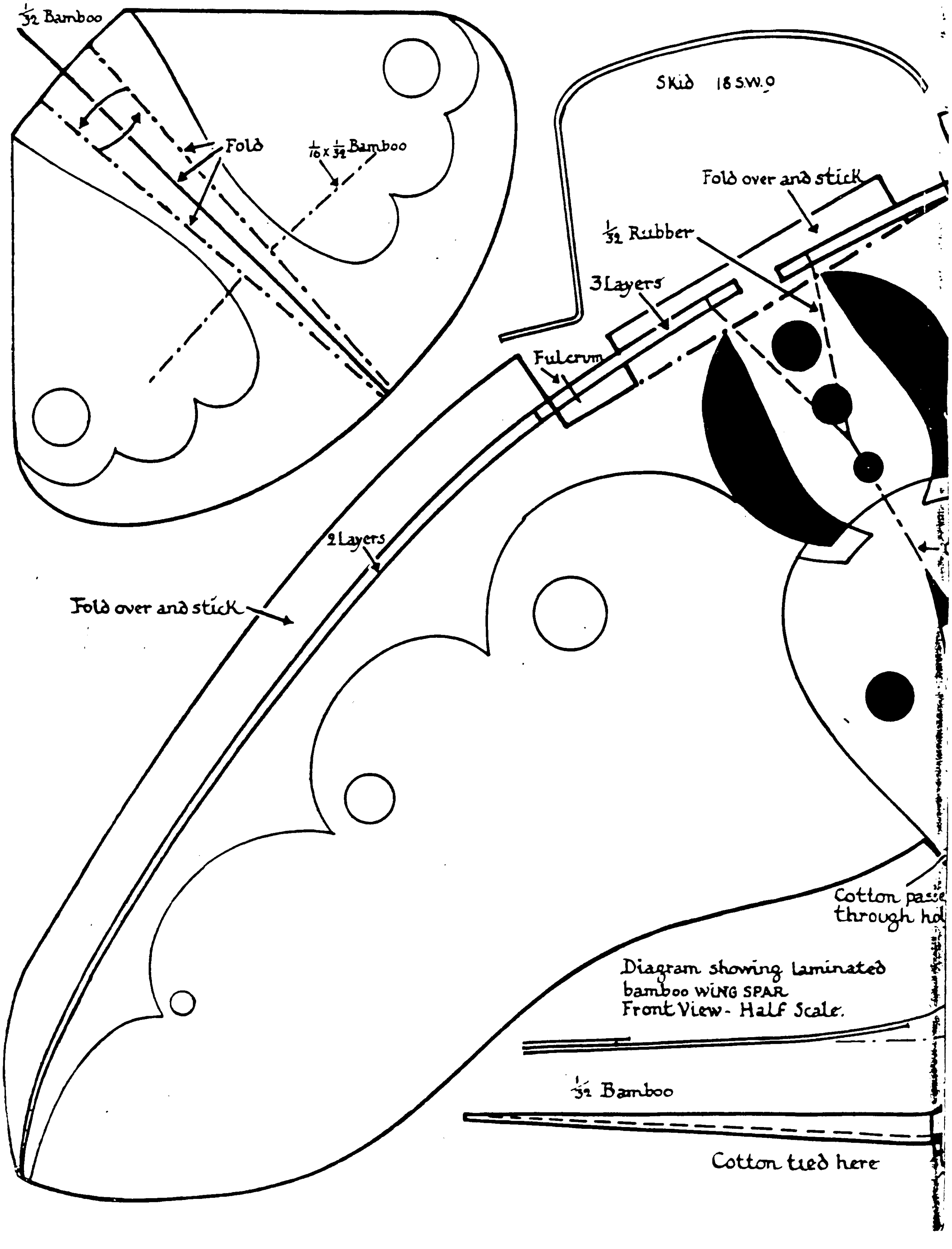
## AMA Nationals/ United States Indoor Championships

will take place on June 3, 4, 5, and 6, at East Tennessee State University in Johnson City, TN. An ornithopter event is planned for June 3. For more information, write to:

USIC
198 Manhattan Avenue
Hawthorne, NY 10532

### Next Issue:

Building your first ornithopter.
Plans. Electric ornithopter News.



1/32 Bamboo
Fold
1/10 x 1/32 Bamboo
Skid 18 S.W.G
Fold over and stick
1/32 Rubber
3 Layers
Fulcrum
2 Layers
Fold over and stick
Cotton passe
through hol
Diagram showing laminated
bamboo WING SPAR
Front View - Half Scale.
1/32 Bamboo
Cotton tied here

# Flapper Plans

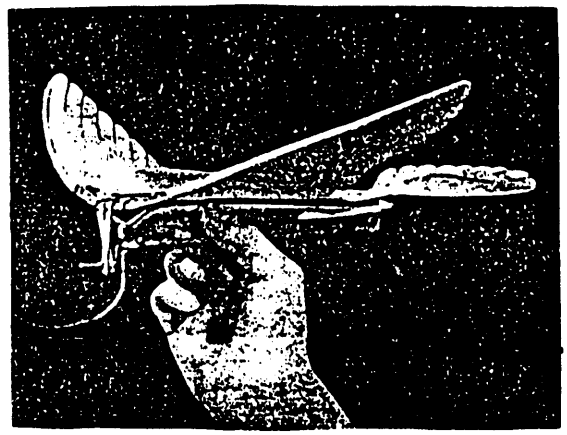
George Benson Writes:

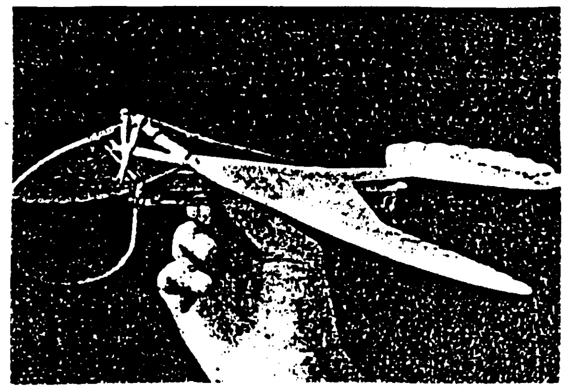
To help with materials to add to the newsletter, I enclose a plan from the October 1940 *Aeromodeller*. The editor recently was very helpful in unearthing it from the archives and sending a copy. I built one in 1941 (aged 14) and remember it traversing our small English living room. It did not flap, but in a frenzied manner it quivered, shook and vibrated madly, but still in level flight. I have started another one to see if 50 years of life's experiences will help attain better performance.

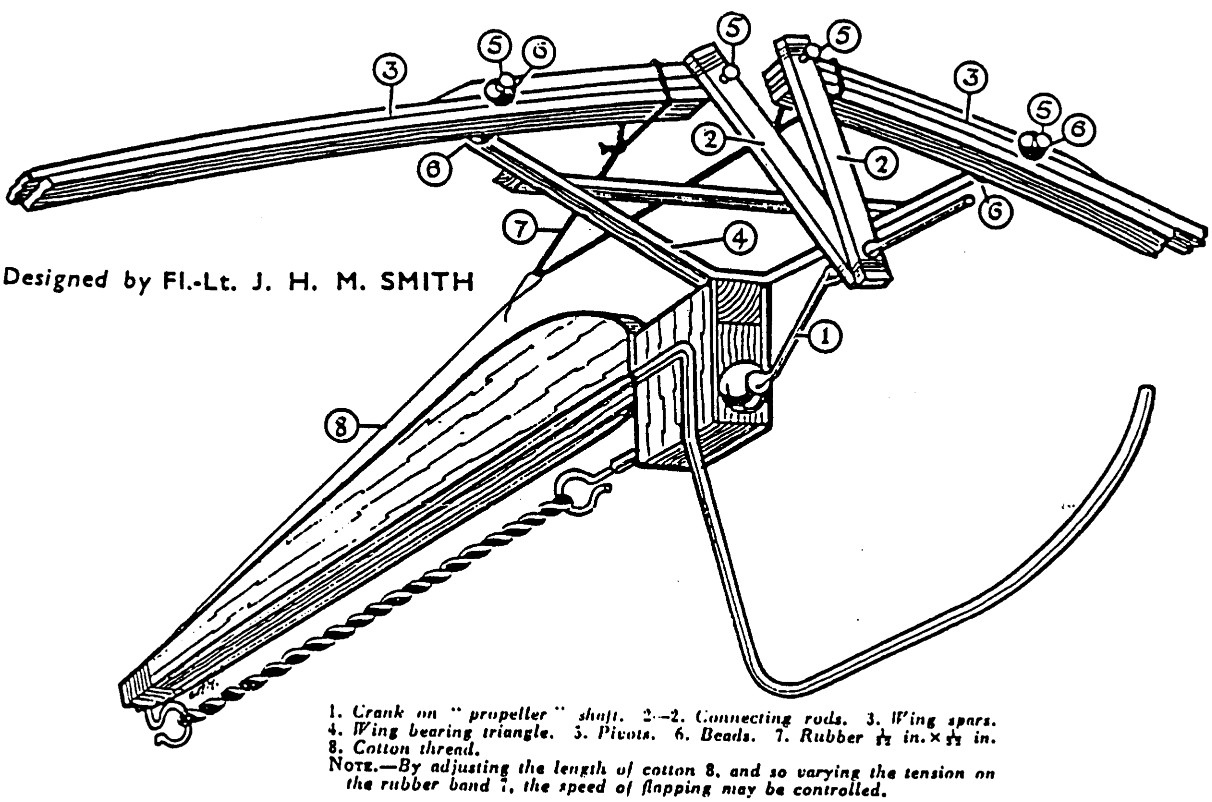
Incidentally, *The Aeromodeller* will feature an article in the June 1993 issue on "Theory Behind Ornithopters," and in the July issue will feature ornithopter plans on "a magnificent double ornithopter that will do over 60 secs. regularly."

*Aeromodeller* available by subscription from USA distributor:

Wise Owl Worldwide Publications
4314 West 238th Street
Torrance, CA 90505
(213) 375-6258



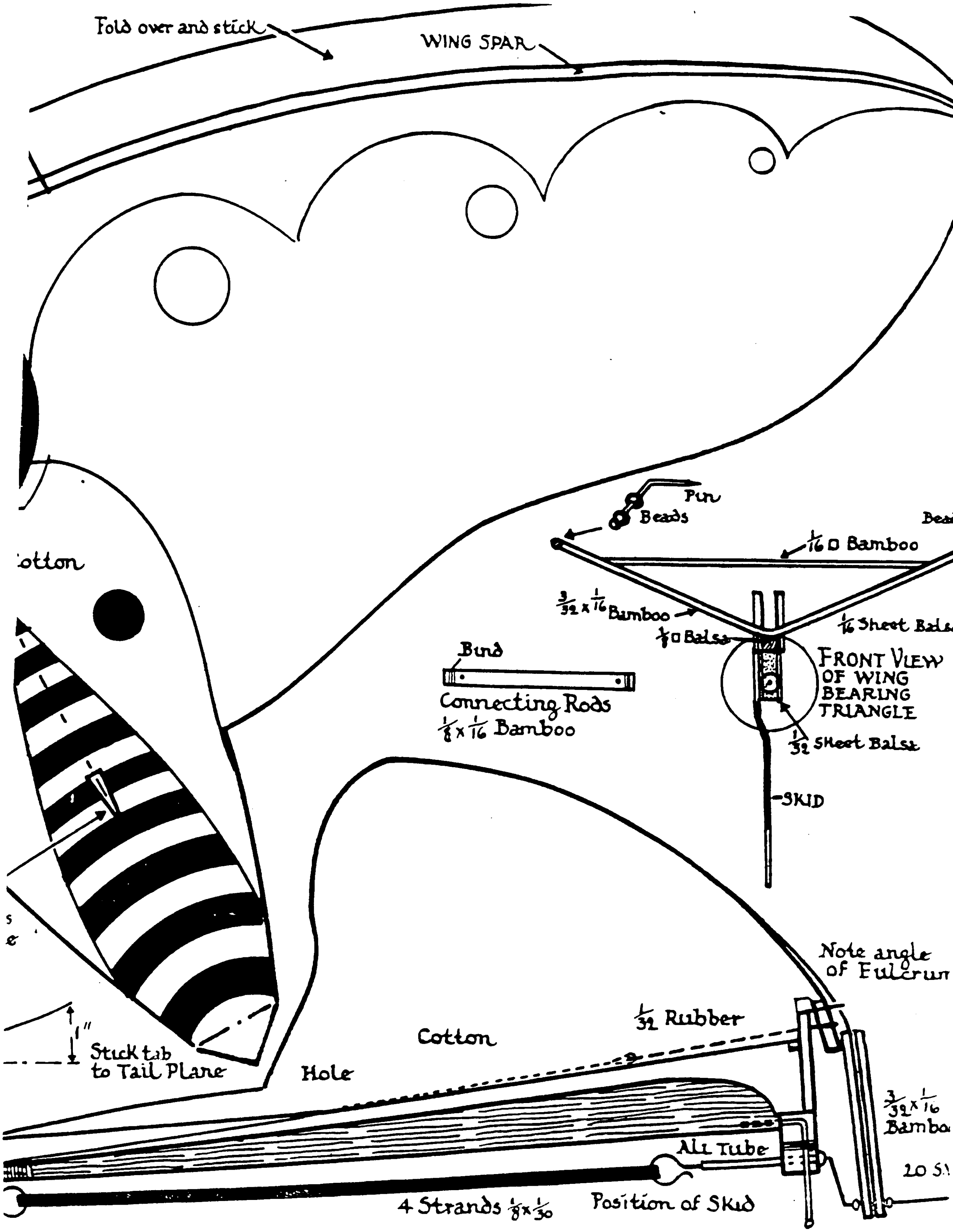





*Designed by* Fl.-Lt. J. H. M. SMITH

*1. Crank on "propeller" shaft. 2–2. Connecting rods. 3. Wing spars. 4. Wing bearing triangle. 5. Pivots. 6. Beads. 7. Rubber $\frac{1}{32}$ in. × $\frac{1}{32}$ in. 8. Cotton thread.*

NOTE.—*By adjusting the length of cotton 8, and so varying the tension on the rubber band 7, the speed of flapping may be controlled.*



Fold over and stick
WING SPAR
Pin
Beads
1/16 □ Bamboo
3/32 x 1/16 Bamboo
1/8 □ Balsa
1/16 Sheet Balsa
FRONT VIEW OF WING BEARING TRIANGLE
1/32 Sheet Balsa
SKID
Bind
Connecting Rods 1/8 x 1/16 Bamboo
Cotton
Stick tab to Tail Plane
1"
Hole
Cotton
1/32 Rubber
Note angle of Fulcrum
3/32 x 1/16 Bamboo
Ali Tube
4 Strands 1/8 x 1/30
Position of Skid

## Send me your photos!

Below:
Larry Burks and two views of one of his electric ornithopters. Although the model was underpowered, this configuration is probably very efficient.

Right:
1. Miles VandeGrift and ornithopter model. 1941 - 1942.
2. A view of the model with its wings all the way up.
3 A picture of the engine and part of the drive system in the lowest position.