OMS flapper facts

WINTER 1993

From the Editor

Response to the comeback issue of *Flapper Facts* was very encouraging. I received many letters which were useful in planning the newsletter as well as very interesting to read. It is a delight to learn what other members are working on, and you will find some of their projects described in this issue.

An important fact which your letters and the survey brought to my attention is that many OMS members haven't yet built an ornithopter. In response to this, I am developing a very simple beginners' model, but unfortunately it was not ready in time for this issue. In its place, I'm including a kit review which should be of interest.

Articles

Those of you who saw the previous issue will notice the improvements made possible by increased member input. Please send any photos, construction tips, articles, ideas, or news you have. I promise to find space in the newsletter for everything I receive.

Membership dues

Dues, including subscription to *Flapper Facts* , are now $4 per year or $7 per two years. Overseas members must pay $6 per year due to higher postage. (This small increase in prices will cover expansion of the newsletter) Make checks payable to Nathan Chronister.

NOTICE!

A mark in this box indicates that it's time to renew your membership. This will be your last issue if you do not. ☐

Lost: One Silver Mechanical Bird

by Warren Williams

I wound its rubber motor tightly, bringing the bird to life. The launch was smooth after freeing its wings to move in a birdlike manner. With its double wings it moved swiftly toward the sky. Flying in a tight right-hand circle, it didn't take long to find a thermal. Rising rapidly, it drifted and flew toward a flock of young seagulls riding lazily on the same hot thermal. The gulls were following each others' tails in a clockwise direction as my bird entered their airspace. This strange mechanical bird took them by surprise, and they broke formation and began to follow. Round and round they went; each gull seemed to be inspecting this strange flapping machine. In the distance I was able to see one gull attack, pecking away at the stabilizer. Now the position of the sun reflecting off the metallic wings was like sending a distress signal to us on the ground. My bird, as if having a brain, began to outdistance the gulls by climbing higher into the atmosphere. Looking up, I could see my bird disappearing into the sky, and after a few minutes I was convinced it was lost and out of sight.

Reward offered for a slightly used *silver biplane ornithopter*, with several holes on its tail, carrying a loop of deteriorated, weather-checked 1982 Pirelli rubber. If found I promise to install a dethermalizer and a new loop of rubber.

News

Ken Johnson

has built 169 ornithopters since 1968, has held indoor records in cat.I, II, and III, and has received national publicity for his flappers. He has also built and flown models of dragonflies, butterflies, a chicken, and Dracula. This raises the interesting idea of building "scale ornithopters" using animals as prototypes. Paul MacCready and Nathan Chronister have also flown scale ornithopters.

George Tornkuist

has built a unique ornithopter which notably simplifies the flapping mechanism. The model has a tandem wing configuration in which the aft wing is rigidly attached to the fuselage. The front wing is moved by a single pushrod; like a seesaw, one side goes up while the other goes down. The reaction force causes the fuselage and aft wing to move in the opposite direction, so both wings flap equally.

Nathan Chronister

has built a successful electric ornithopter. This monoplane is powered by a 20 watt motor and was made from readily available parts. In its first successful configuration it weighed about 4 ounces and had a span of 4 feet. It first achieved sustained level flight from hand launch in January 1993. Efforts are underway to improve efficiency, and plans will be available after this is complete.

Dan Garfinkel

is working on an .049 biplane ornithopter and would like to share information with other OMS members. He writes:

"I have been a member of OMS almost from the beginning. I have sent in photos, drawings, ideas, whatever I could do to help.

"Now I would like to put some questions to our membership. Has anyone done enough experimentation to have come up with firm answers, or even rough ideas about the following, concerning biplane ornithopters:

- Optimum flapping angles for top and bottom wings and between wings?
- Vertical spacing between wings: has anyone tried a vertical spacing of one or two inches?
- Optimum stabilizer and rudder area as a percentage of wing area?
- Balance point as a percentage of wing chord from leading edge of wing?
- Incidence angles of wing and stabilizer?
- Span /chord ratios for wing and stab?
- Membrane type wings compared to rigid, built-up wings?
- Material used for membrane? Airfoil?
- Wing loading?
- Optimum flapping rate?
- How to lock wings into optimum gliding position?
- Types of power transmission from engine to wing linkage? I am using friction drive to gears and will explain in detail to anyone interested.

"I would very much like to discuss any or all of the above, or any other things concerning ornithopters. I will answer all letters as quickly as possible.

Dan Garfinkel
P.O. Box 835
La Porte, TX 77572

Any information you can give Dan will be greatly appreciated, and he will certainly share with you the results of his work.

Harry Geyer

asks, "Do the present day flappers really represent what an ornithopter should be? - a vestigial wing area in the form of a small center section and the oscillating outer panels for propulsion? Do the outer panels lift?"

The outer panels do contribute net lift. Harry's other questions are very interesting because our ornithopters are much less efficient than birds. It would be very worthwhile to investigate different and more complex wing designs, either built-up wings as Dan suggests, or wings with a joint in the middle as in birds, in an attempt to improve performance.

The main purpose of *Flapper Facts* is to facilitate the sharing of information between members. Please feel free to use it as Dan and Harry have to seek information as well as to show others what you know.

Fossilized Flappers

On the outside of my window, attached with suction cups, there is a small bird feeder. As I begin to write this article, a starling arrives to steal a bit of peanut. The calorie or so contained in the morsel will provide energy for several minutes of flight. As the bird glides in, its tail is moved distinctly downward, causing the bird to pitch upward and slow its approach. The wings flutter to prevent a stall and to contribute lift at this low speed. The landing gear is extended, and the bird thumps onto the feeder.

Some readers may suspect a typo in the above paragraph, but in fact the starling, like other birds and bats, does lower its tail during a landing approach. The pitch is actually controlled by the wings, which are actively moved forward or backward to maintain the correct orientation. The tail, while it is not needed for control, does provide extra lift during the approach. Some birds and bats have practically no tails at all, and neither did an entire order of extinct flying reptiles, the pterosaurs.

Thus, many of nature's fliers cannot serve as prototypes for scale ornithopters. At least not without on-board electronics which can perform some of the same control functions as the brain of a flying animal.

Paul MacCready, who also built the first successful human and solar-powered airplanes, has built just such an ornithopter. This machine was built for the IMAX film *On the Wing* shown at the National Air and Space Museum, which relates biological to technological flight. It is a detailed 1/2 scale model of the pterosaur *Quetzalcoatlus northropi* which lived in Texas about 65 million years ago.

The wings of pterosaurs were relatively similar to those of small model ornithopters. They consisted of a spar formed from the bones and other tissue of the arms and elongated fourth finger (they had only four), with a membrane which contained stiffening fibers. Due to these fibers it probably behaved something like the paper used in the membranes of model ornithopters, rather than the more elastic membranes of bats which do not extend as far as their rigid supports. (See "A functional analysis of flying and walking in pterosaurs" by Kevin Padian in the journal *Paleobiology,* 9(3), 1983, pp 218-239)

To make up for its lack of a tail and its instability, the model used a computer-controlled forward rudder (its head), it moved the wings forward and backward to control pitch, and it spread its claws to create drag during turns. Power was provided by two 1 hp cobalt electric motors, and an elastic energy-return system reduced the load on the motor. The wings used a reinforced membrane and had a better cross-section than simpler model ornithopters. Total weight was about 40 pounds, and total span was 18 feet, half that of the original flying reptile.

While the pterosaur was under development, some 1 and 2 meter flapping models were flown, in addition to various gliders for testing the control systems. The 1/2 scale flapping pterosaur solved the control problems, but did not achieve climbing flight as was intended (see*Technology Review* vol. 92, p8 Aug/Sept 1989 article on Harris & DeLaurier).

A purpose of the pterosaur project was to show a creature from the past as museums do, but to make it seem as alive as a zoo specimen. To this end, project combined the efforts of engineers and paleontologists very effectively.

The pterosaur replica costed $500,000. It may not be possible for underfunded RC modelers to build tailless ornithopters at the present time, but many birds have tails large enough to act as stabilizers. Since the nuances (nuisances) of bird landing approaches are for now beyond the scope of any ornithopter project anyway, it seems like a replica of a bird, whether RC or rubber powered, would be an interesting project.

More information:

Science News vol. 128 p247 Oct. 19,1985
Flying vol.112, pp 82-83 Feb 1985
Time vol.126, p58 July 22, 1985
National Geographic vol.170, pp138-139 July 1986
(has an article with indoor ornithopters too)
Smithsonian vol.16, pp72-81
National Geographic World vol.128, pp32-36 April 1986
Earth Science vol.38, p5 Winter 1985
Sierra vol.71, p10 March/April 1986
Popular Science vol. 228, pp78-79, 124
Science 86 vol.7, p26-35 April 1986

History part 2:

Early gas-powered ornithopters

No one will ever know when the first gas-powered ornithopter was flown. Early attempts were lightly publicized and tend to escape historical attention. A few sources here and there report stray success stories, and in this article I have compiled as many as I have found.

A number of sources report amazing and perhaps misleading claims. For example, a 1930s Italian ornithopter weighing 50lb was powered by a 0.5 hp air motor. Even real birds require more power than this.

Other reports, however, provide more information and appear more plausible. An account of Harry D. Graulich's 1935-36 work clearly states that the model "successfully flew." This one had a span of 16 feet, and its 4-cylinder engine must have had abundant power. The flight took place in Walden, New York, and was tethered (since RC was not available).

I have found two references to flying engine-powered ornithopters in Russia. If, as it seems, these both refer to the same aircraft, it was built by Victor Toporov, first flown in 1960, and powered by a motorcycle engine. It only went a few meters into the air, perhaps because it relied on ground effect, or perhaps because the pilot was being cautious. My sources (see below) are not clear as to whether the craft was manned. It had four twisting-airfoil wings in tandem.

In the 1960s, the gas-powered flapper was developed nearly to the point of kit production by aircraft designer P. H. Spencer. He built and flew models ranging from .02 to .15 engine size, and may have flown larger models up to 8 feet in span. Some of these were monoplanes with simple membrane wings, while others used fixed wings with flapping tips. Spencer also designed a rubber-powered bird sold around 1960, the patent for which contains some clever ideas but no hints about his gas-powered designs.

Human muscle

Many human-powered ornithopters have been built, and some have glided successfully. The success of human-powered airplanes is proof that the human-powered ornithopter is possible (birds require less power for their weight than airplanes, other things being equal), but great improvements in efficiency must first be made.

One of these aircraft was built by Emiel Hartman of England, in 1959. Its wings used very large simulated feathers. It was towed into the air and pedals were used in flapping the wings, or in failing to do so.

In 1944, an ornithopter glider powered only by arm muscle was built by Belford D. Maule. The craft weighed 385 lb, had a 54 ft span and was 30 ft long. The wings moved through a 32 inch arc and the ailerons were moved in synchrony with the wings, presumably being lowered for the upstroke and raised for the downstroke. Maule claims to have achieved sustained climbing flight after a tow launch on Nov. 18, 1944. The day of the flight was said to be cold and lacking in thermals, but it seems impossible for such a large craft to fly on so little power.

There is, however, something to be learned from Maule's design. If an ornithopter has very little power available and can glide well, it is best off with a very shallow arc. This allows some thrust to be produced without loss of lift. The same trend is seen among birds, in comparing a pigeon to a gull.

Maule planned a follow-up to his original glider, but as is often the case with promised ornithopter sequels, only the first attempt can be found in the literature. Much has been lost in the shadows of the past, but with the well-publicized successes of MacCready and Harris/DeLaurier, the ornithopter finally seems to have found a permanent place in history.

Bibliography:

Hertz, Louis H. *The Complete Book of Model Aircraft, Spacecraft, and Rockets* .

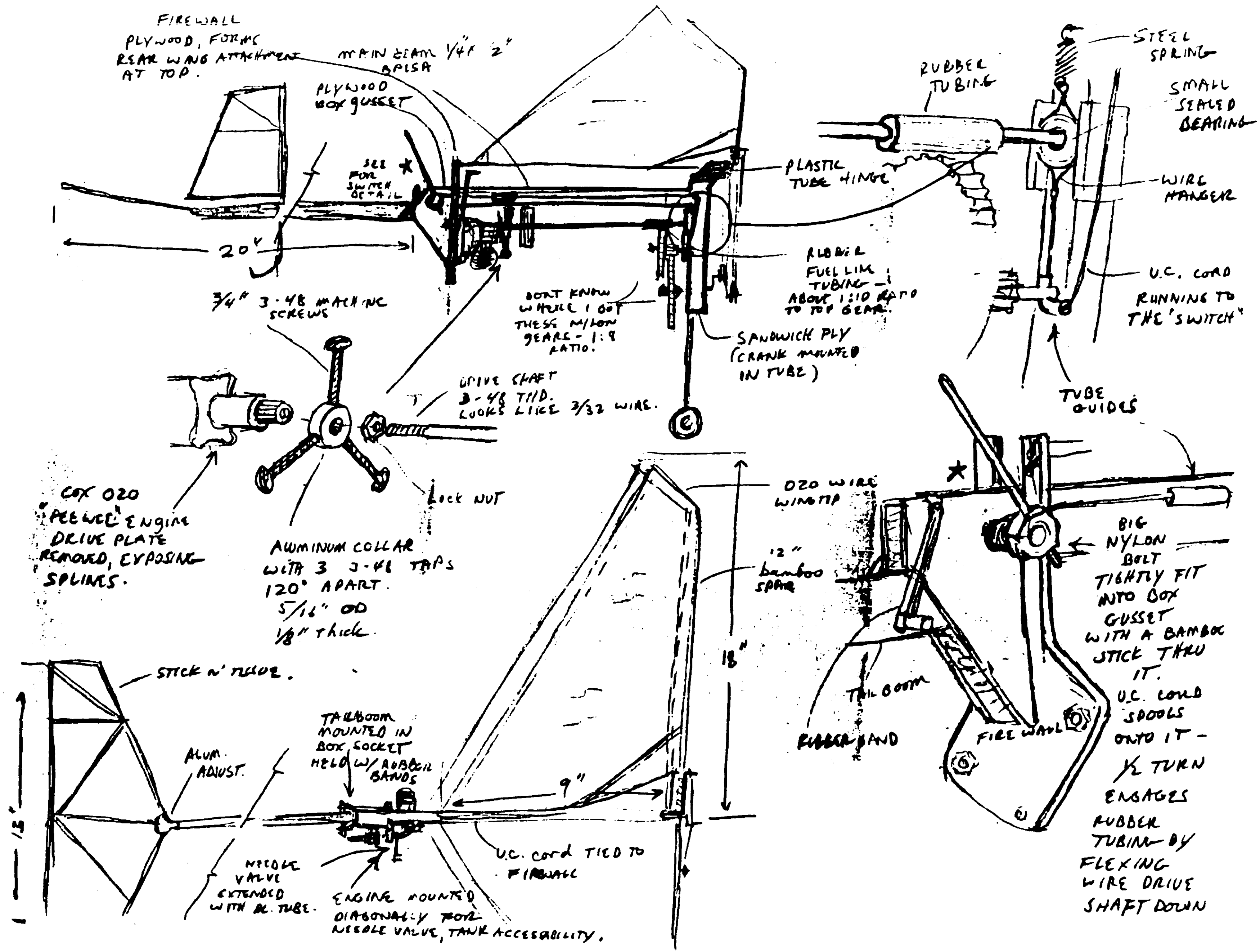
The Illustrated London News Oct. 31, 1959 563

"Maule's Ornithopter Glider" *Aero Digest* , Mar. 15, 1945

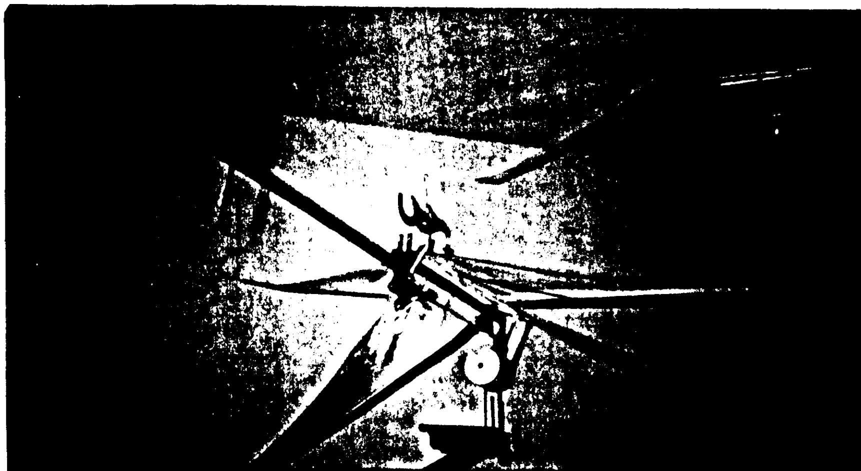
McGraw Hill Encyclopedia of Science and Technology "Ornithopter"

Shevelyov, Alexander. "Homemade Aircraft" *Soviet Life* , Feb. 1988

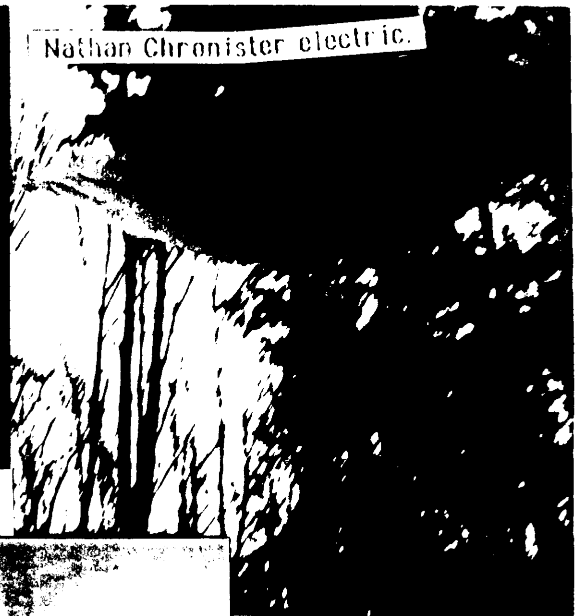
Additional information provided by Jeremy Harris



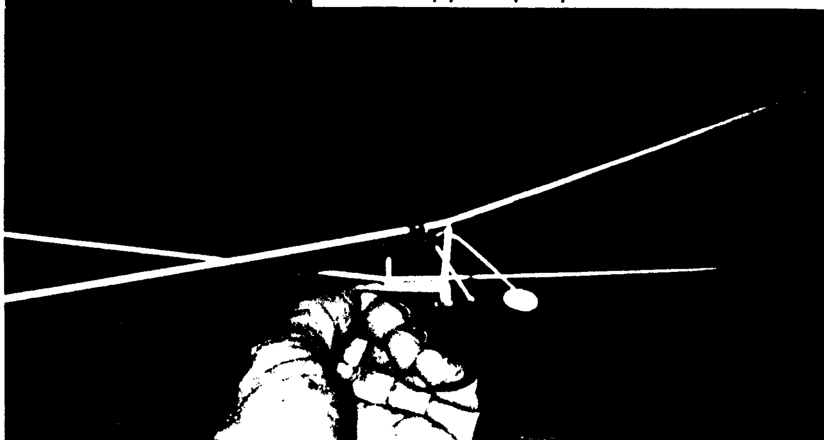
FIREWALL
PLYWOOD, FORMS REAR WING ATTACHMENT AT TOP.
MAIN BEAM 1/4" x 2" BALSA
PLYWOOD BOX GUSSET
SEE ★ FOR SWITCH DETAIL
20"
RUBBER TUBING
STEEL SPRING
SMALL SEALED BEARING
PLASTIC TUBE HINGE
WIRE HANGER
RUBBER FUEL LINE TUBING - ABOUT 1:10 RATIO TO TOP GEAR.
U.C. CORD RUNNING TO THE "SWITCH"
DON'T KNOW WHERE I GOT THESE NYLON GEARS - 1:8 RATIO.
SANDWICH PLY (CRANK MOUNTED IN TUBE)
3/4" 3-48 MACHINE SCREWS
DRIVE SHAFT 3-48 THD. LOOKS LIKE 3/32 WIRE.
TUBE GUIDES
COX 020 "PEE WEE" ENGINE DRIVE PLATE REMOVED, EXPOSING SPLINES.
LOCK NUT
ALUMINUM COLLAR WITH 3 3-48 TAPS 120° APART. 5/16" OD 1/8" Thick
020 WIRE WINGTIP
12" bamboo spar
18"
BIG NYLON BOLT TIGHTLY FIT INTO BOX GUSSET WITH A BAMBOO STICK THRU IT.
U.C. CORD SPOOLS ONTO IT - 1/2 TURN ENGAGES RUBBER TUBING BY FLEXING WIRE DRIVE SHAFT DOWN
TAILBOOM
RUBBER BAND
FIREWALL
STICK N' TISSUE.
ALUM. ADJUST.
TAILBOOM MOUNTED IN BOX SOCKET HELD W/ RUBBER BANDS
9"
U.C. cord TIED TO FIREWALL
NEEDLE VALVE EXTENDED WITH AL. TUBE.
ENGINE MOUNTED DIAGONALLY FOR NEEDLE VALVE, TANK ACCESSIBILITY.



Patrick Deshaye's gas ornithopter with flapper-propelled model above it.



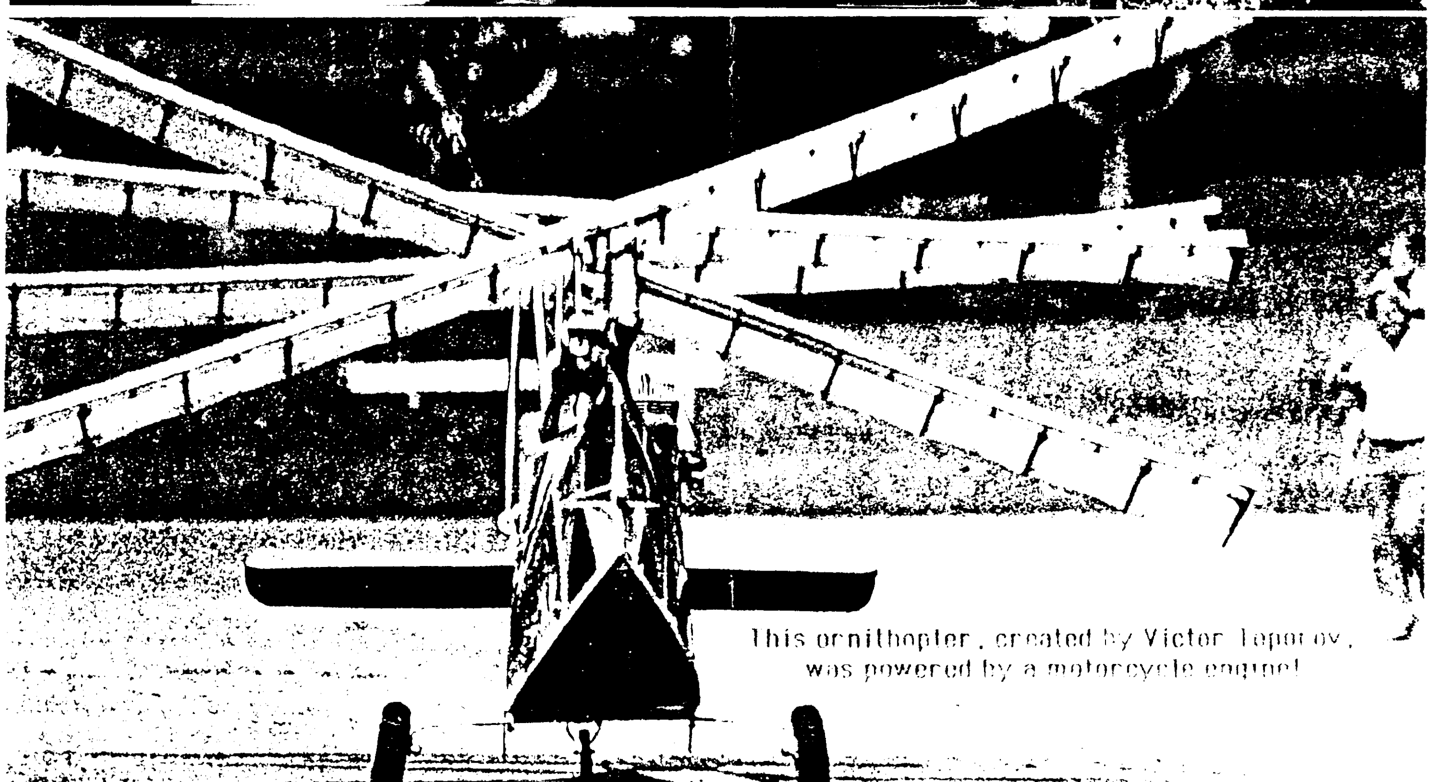
Nathan Chronister electric.



George Tornkuist has built a unique tandem-wing ornithopter, seen in front view.

Patrick's model about to land.

P. H. Spencer launches a gas ornithopter.



This ornithopter, created by Victor Toporov, was powered by a motorcycle engine!

Kit review
The Flapping Flyer from Indoor Model Supply

There is a rubber - powered ornithopter kit available which makes a great first ornithopter or a reliable model for the more experienced. The Flapping Flyer can be flown outdoors in the absence of wind. It is a monoplane with a 24 inch span, and it reaches a height of 25 feet. It will fly for 90 seconds, which is longer than most ornithopters even if it isn't record material.

I decided to build a Flapping Flyer because, although I had experimented with ornithopters for a number of years, I still did not have anything capable of much duration. The Flapping Flyer answers this need and is very consistent.

Building the kit is not too difficult and I did it in one weekend. The plans are very thorough, and although they seem to have a few errors, none of these is a problem. Previous model-building experience is a must, but previous ornithopter experience is not.

A few things should be kept in mind when building the Flapping Flyer. CA glues will do everything they can to get into the moving parts, of which there are many, so be careful. Also note that the fin is below the stabilizer unlike in most airplanes, and that it's easy to ignore the tail's orientation when attaching it to the motor stick. Attaching the wing assembly to the motor stick involves a series of struts. Getting these to line up might be tricky but the use of white glue in this step allows you time to work with it. Overall, the Flapping Flyer is a great kit, and I enjoyed building it. Hopefully, information on this kit will encourage some of the OMS members who haven't built an ornithopter to give it a try.

The Flapping Flyer is available from Indoor Model Supply, Box 5311, Salem, Oregon 97304, phone 503-370-6350. Costs $8.95 plus $3.50 s&h.

If you want to try building a simpler model, and if you don't mind working from plans instead of a kit, try the 19" Manta Ray Ornithopter, item BH-125, from Peck-Polymers, Box 710399, Santee, CA 92072-0399, phone 619-448-1818. $1.80 for plans, $3.00 s&h.

Fly a gas ornithopter!
Patrick Deshaye's .020 - powered flapper

Patrick Deshaye, who founded OMS in late 1983, had some success with an .020 powered ornithopter in summer 1991. Unlike most previous gas flappers, this one is simple and inexpensive, and it is the only one for which any detailed construction information is available. It is hoped that an experienced modeler could build a flapper similar to Mr. Deshaye's from these sketches, although some enterprise will be required, for example in locating suitable gears. His letter provides more information:

"[The model] once climbed to about 12 ft altitude from a ground launch, flying for 10-15 seconds (I have an eyewitness) before the engine quit. Cox .020 engines are notoriously balky and the machine kept bouncing out of trim so I don't have any truly convincing in-flight pictures. This design does have some advantages which could be applied to .049 power, especially the 3-spoke flywheel which can be used with a spring-starter, and which creates enough air disturbance to cool the engine. The rubber-tubing friction drive allows enough 'slip' to keep the engine running, while the step-up in torque via the reduction gearing provides great force at the crankshaft, enough to twist a nylon thrust bearing in two!"

"I am working very lackadaisically on an .049-powered flapper similar in layout to the .020, but with a planetary idler gear / clutch arrangement made of RC car gear parts."

A gear ratio of about 80:1 produces the torque necessary for wing flapping and is one of the greatest obstacles to building engine-powered ornithopters. The clutch is the other. Both of these require special parts which must be either custom made or cleverly borrowed from existing appliances or models. Patrick has found some workable solutions to the gearing and clutch problems which we hope will be of use to others.

Next Issue

Rubber plans, more news of gas-powered ornithopters, plus ... anything you send in!