Flapper Facts

Newsletter of the Ornithopter Modelers' Society

Fall 1997

Editor/Publisher: Nathan Chronister, PO Box 376
Arkville, NY 12406 USA
Membership dues, payable to the editor:
New members: $14 for one year ($21 outside USA)
Renewal: $9 per year ($14 outside USA)

Electric Ornithopter Flies!

Joss Levy

Enclosed is a picture of my new electric free-flight model, my first attempt at electric flight. It is the same size as my CO_2 model [which had a span of 79 cm and was described in the Spring 94 and Fall 95 issues], and I have taken a break from my still unfinished radio model to built it. It has turned out underpowered, so I am now modifying it to take a bigger motor and battery. I'll send fuller details and more pictures when the model is finished and flown. (30 September 1996)

Thank you for another issue of my favorite newsletter... I'll also take this opportunity to update you on my efforts with my electric model, although real success now seems further away than ever. I think I told you that I was going to try using wings covered with a stretchy material. This I did. I used polyethylene food wrap film, but found that it still stiffened up the framework quite considerably and also wrinkled up badly when the wings were twisted. The model in flight seemed just as underpowered as before, so I gave up these wings and tried something new again.

My next wings each had a passive rear spar in addition to the powered front spar, parallel ribs, and a series of overlapping scales which are free to slide past each other. I used a membrane covering just for the tip section because this allows the tip to become negatively cambered on the upstroke. Only the outermost rib and the root ribs were rigidly attached to the front spar; the others being hinged to it. The rear spar is rigidly attached to all ribs except at the root where it is hinged. These wings were pre-twisted like my previous wings, the twist being of a helical pitch nature, and the magnitude of the twist being such that the wings become untwisted in gliding flight.

These wings maintain a beautifully smooth and wrinkle-free surface when twisted or flexed up or down, but are also heavier than any of my previous wings. With the new wings fitted, the flying performance was definitely improved; not dramatically, but back up to the standard of my (much lighter) CO_2 model, i.e. achieving a gentle climb. However, it still seems like the model requires about twice as much power as would be needed for an equivalent fixed wing aeroplane model.

A video recording of the model in flight, played back in slow motion, seems to show that the wings do not twist as expected. The upstroke looks just fine. The downstroke starts off looking good, but the wings gradually untwist. It would appear that the wings are initially twisted by inertial force at the start of the downstroke, but that the aerodynamic forces are insufficient to maintain this twist when the inertial force has gone.

I then tried a series of modifications to overcome this problem although in each case there was no improvement in performance. These were: (1) breaking the joint between the outermost rib and the front spar, hinging it and adding a spring (the flexibility of the spring being in addition to the flexibility of the spar), so increasing the torsional flexibility of the wings by 60%.; (2) adding counterbalance weights ahead of the wings to eliminate the inertial twisting moments; (3) adding leading edge slats so that, given that the wings weren't twisting correctly, at least they wouldn't stall; (4) making the twisting action mechanically assisted — in this case using a cable and pulley system to pull up the rear spar during the downstroke without affecting the upstroke, but here I think the extra weight and drag outweighed any improvement in aerodynamic efficiency. The photo shows the wings with mod's (1) and (4) in place.

I'm just starting on a new model which will have an improved wing-twisting mechanism (with no external cables). I've no reason to expect a dramatic improvement in performance, but I have no other ideas to try.

Incidentally, I think I've found a better way to make the spars. [Previously, he had used wooden spars covered with unidirectional fiberglass cloth.] I got some 2 mm dia. Fibreglass rods from a kite shop, tapered them to a semicircular section at one end and joined two together for each spar to give a figure-of-eight section at the root changing to a circular section at the tip. Advantages: does away with the wooden core, which may be prone to taking a permanent twist, and quicker to make. Disadvantages: messes up your razor plane, and the splinters really penetrate your hands.

I enclose a picture of my partly constructed big model. Unfortunately I cannot now complete it until the wing efficiency problem is solved. If I manage to do this, I will of course send you full details for Flapper Facts. (28 July 1997)

Wham-O Bird

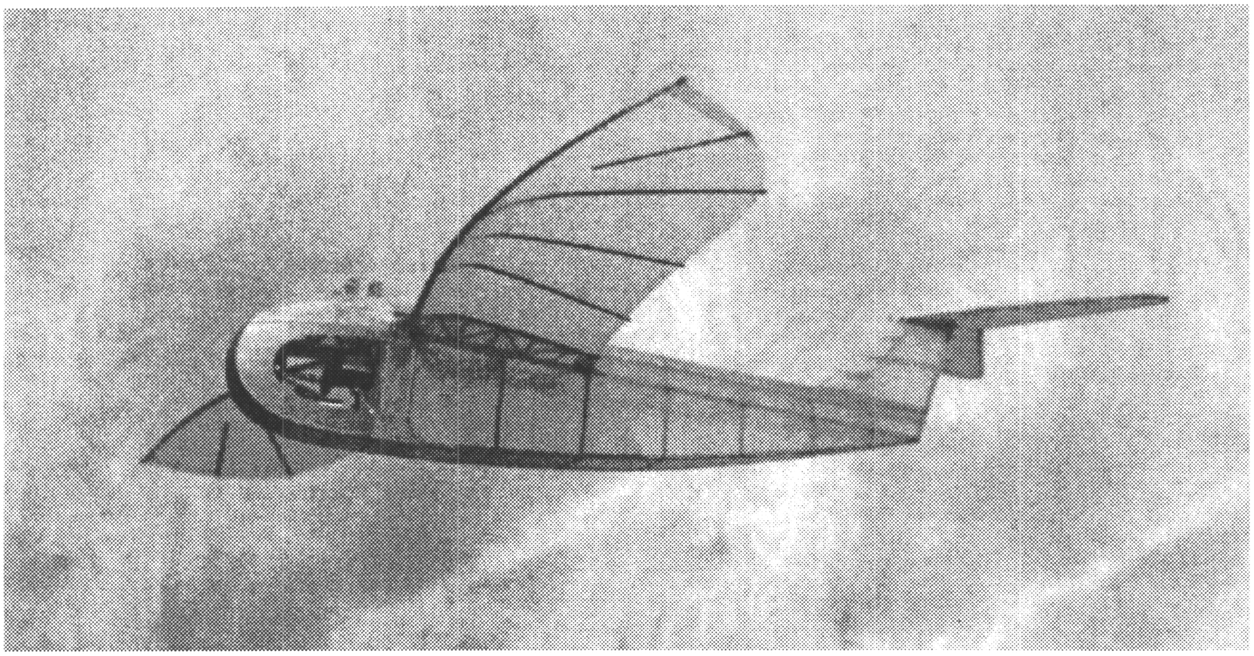
Guy Foster writes:

"I am looking for an original Wham-O ornithopter made in 1958. I believe it was called the Wham-O Bird."

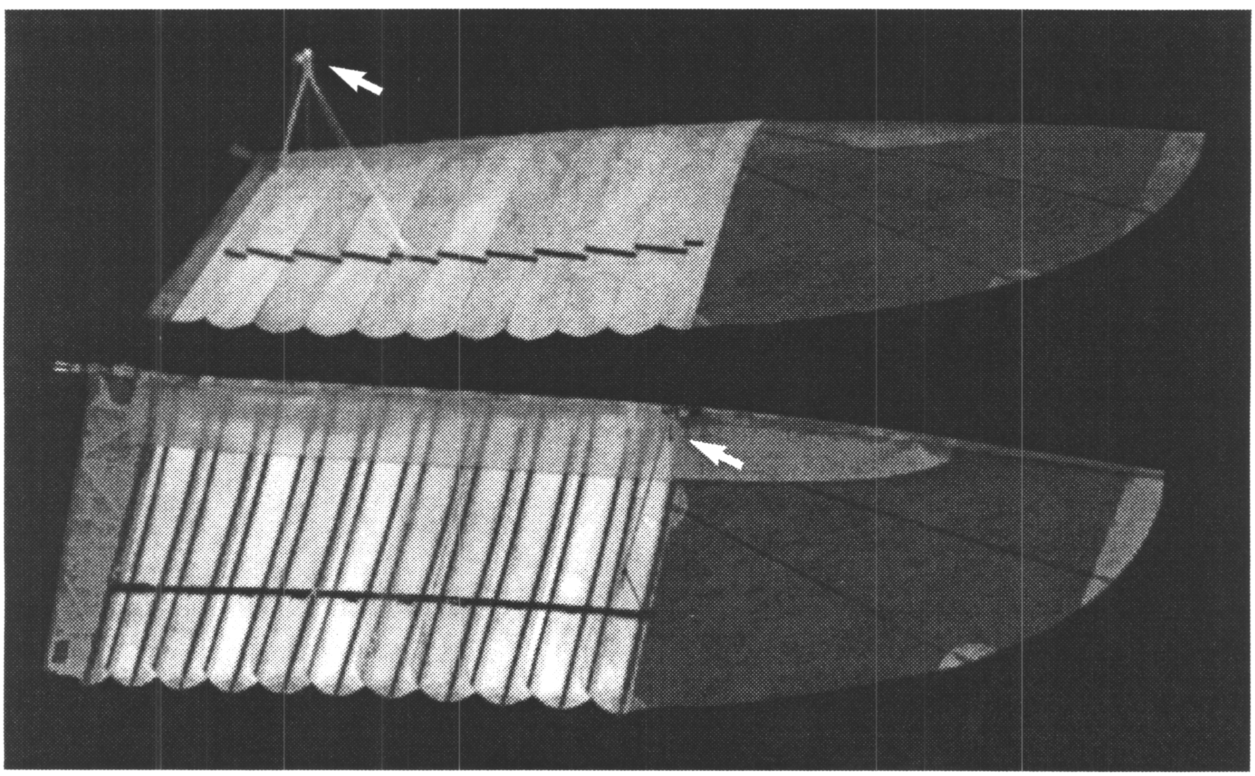
"I saved all summer for one, working for a nickel a day as water-boy on my grandfather's cotton farm. I was four years old then. They cost $3.00, which was a fortune back then. Well, I finally got it, wound it up and watched it flap and fly way out into the cow pasture where a cow abruptly stepped on it."

"I was very sad, as a four year old boy would be. My grandparents were too poor to buy me another one and that was the last one in the store I believe. I always hoped to get another one some day. Do you know of any? An original in the box would fulfill a dream. Thanks, Guy Foster, PO Box 74572, Metairie, LA 70033-4572."

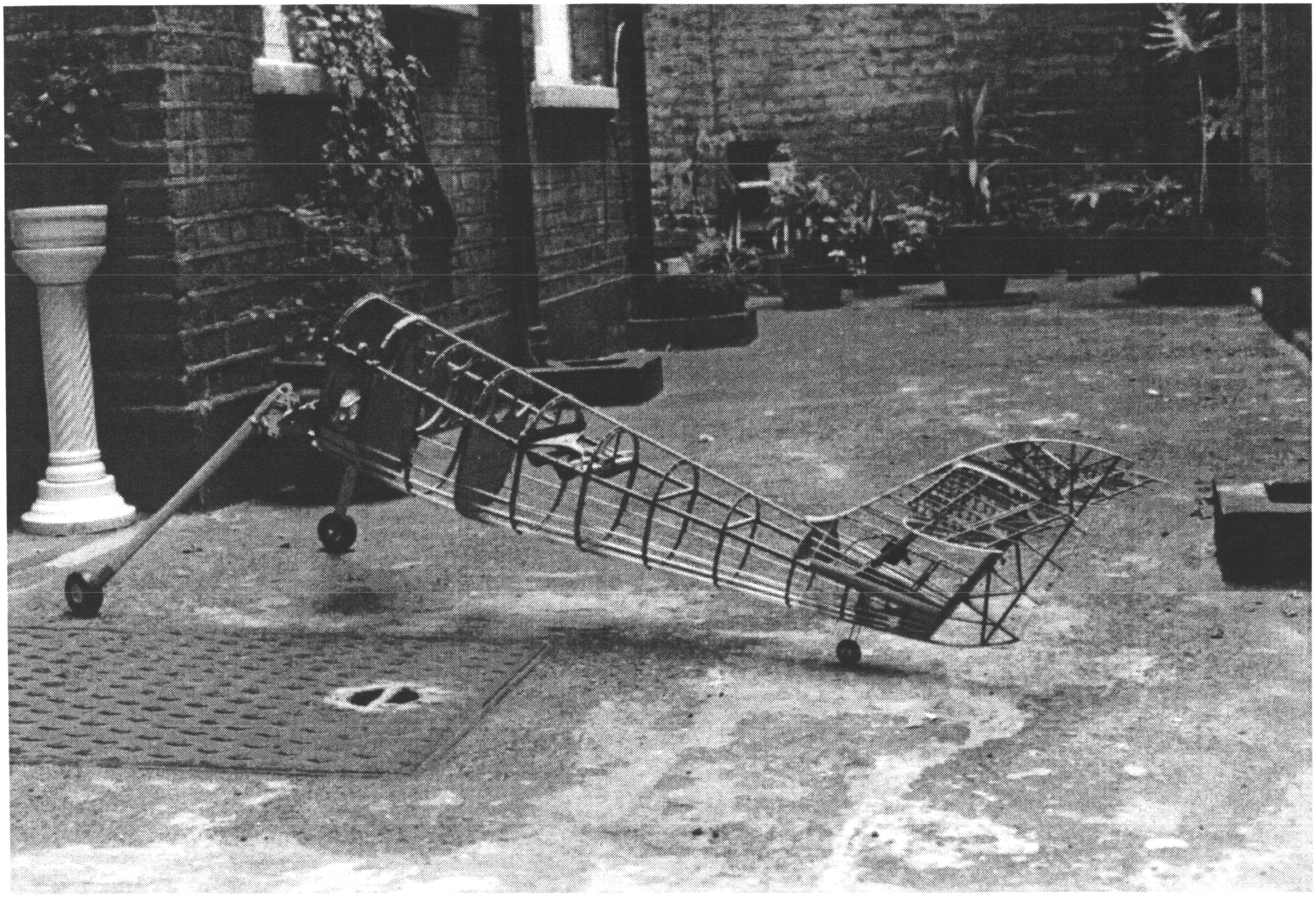
Next Issue!
Kiselev — Tatlin — Toporov
MANNED ORNITHOPTERS IN RUSSIA



Joss Levy's electric ornithopter before installation of a more powerful motor.



A wing design used with the electric ornithopter. Right wing shows cable and pulley to assist downstroke wing twisting. Left wing shows spring to increase torsional flexibility instead of having the ribs directly attached to the spar.



Joss Levy's unfinished RC ornithopter.

The Chalupsky Compressed-Air Ornithopter

(Translated from Deutscher Sportflieger, June 1938)

Flapping-wing aircraft models have already appeared several times in Deutscher Sportflieger, e.g. the Pause-Ornithopter in issue 2 of the 1936 volume, Goedecker's ornithopters in issue 10 of 1936, and Brunner's ornithopter in issues 6 and 9 of 1937. All of these models had one thing in common: a rubber motor provided the power.

In this column, I'd like to talk about an interesting flapping-wing model which uses a compressed-air motor to power it. The man who built the model is an old hand: Chalupsky has been interested in the solution to this problem for a couple of decades now. He writes to me that "after lots of consideration and numerous experiments, which lasted a full 18 years, the task was completed, and on 16 July 1930, my first mechanical birds took flight."

Between 1930 and 1937, Chalupsky built many more models, with total weights ranging from 3 to 4.5 kilograms. He has the following to say about his development work:

"I realized from the start that the twisted rubber cord and bent axle construction, and all the disadvantages associated with this design, could not provide an appropriate motor for even the smallest [manned] ornithopter; therefore I constructed only compressed-air motors, with valve or slide-valve timing. Both can be readily adapted to the requirements of each craft's wing design. Birdlike flight demands a special motor, one which moves the wings with a similar 'feel' to the motion that only real muscles can produce. That's why I construct compressed-air motors which create a pulsing or oscillating motion, which allow the wings to swing freely, and which don't restrict the momentum of the wings. The wing joints are not damaged by the powerful shocks when the direction of the wing motion changes, since air redirected from the slide-valves creates a cushion under the piston at the appropriate moment. The use of compressed-air motors allows much larger and heavier aircraft."

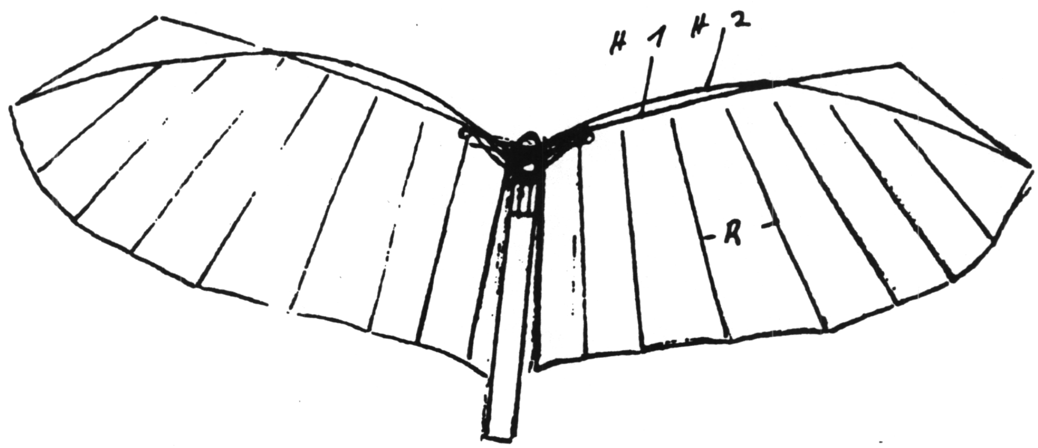
"My ornithopters weren't developed overnight, not by any means. There were two main obstacles to overcome. First, there was some doubt as to whether simple wings, consisting entirely of fabric stretched over a frame in the style of bats' or insects' wings, could provide satisfactory results; second, there were difficulties with stability. Some nature observers believe that birds' flight is actually labile, and that stability is only maintained through the constant attention of the flying creature. If this were the case, the goal of unmanned mechanical aircraft would be unattainable, since any such craft would fall straight to earth. In 1912, I constructed a helicopter with two pairs of wings which flapped up and down. This model was presented before the Austrian Association of Flight Technicians (Osterreichischer Flugtechnischer Verein) in 1912, and received first prize. The model was activated three times and took off every time. In this way, it was proven that the flap-valve theory was in fact wrong, and that a one-piece, stretched-fabric wing could be a functional aerodynamic organ. Next came

Chalupsky Ornithopter

H1. Longitudinal wing girder, a torsion-resistant pine dowel.

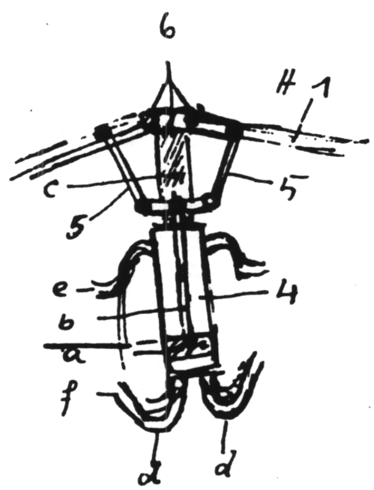
H2. Hollow, elastic girder. Passively controls reversal of wing direction.

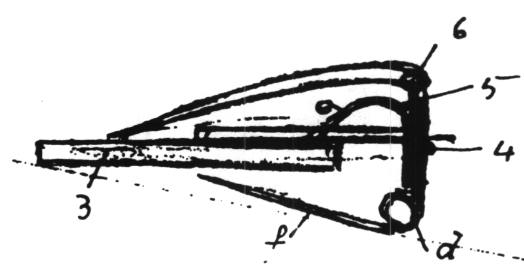
R. Ribs made of very bendable material.



Compressed-Air Motor

3. Container for compressed air or carbon dioxide at 15 to 20 atmospheres.
4. Vertically oriented compressed-air motor cylinder, 2.8 cm diameter.
   a. piston (moves up and down)
   b. piston shaft with direct hinged connection to H1
   c. wing supports with hinge sockets for H1
   d. outgoing conduits, curved in such a way as to simultaneously serve as supports
   e. ingoing conduit
   f. outgoing conduit
5. Connecting rods.
6. Hinge attachments between wing support (c) and longitudinal wing girder (H1).





the question of stability. My current models have only one pair of wings, and no other means of stabilization, not even a tail surface. The tail surface is unnecessary: in some cases it serves merely as ballast, as long as the craft is not carrying a pilot, and even in birds, it plays only a secondary role, as Lilienthal has correctly observed. The secret of stability in birds' flight can be found in the shape or curvature of the wings."

The craft built upon these insights — the 1937 model — is constructed as follows: The major components of the ornithopter are a couple of wings, a small motor, and a container for compressed gas. The compressed-air motor which provides back-and-forth motion has a single cylinder with a slide-valve, as in a steam engine. The piston is 28 mm in diameter; the piston shaft is connected directly to the wings by way of a hinge. The wings have a 70-degree range of motion.

The container, made of strong 0.5 mm steel, holds 2.5 liters of gas; it has been tested under 45 atmospheres of water pressure and can withstand gas pressures of up to 30 atmospheres. It can be filled with compressed air or carbon dioxide directly from the standard large steel cylinders. Since the expansion of the compressed gas during motor operation causes rapid cooling of all parts through which the gas flows, soon leading to the formation of frost on the slide-valves, the container may only be filled to a pressure of 30 atmospheres on very hot days (at a temperature of 25 °C). At lower temperatures, a lower filling pressure of 15 to 20 atmospheres is necessary, so that the slide-valves do not freeze up during flight. Using compressed air, it is possible to conduct flight tests even on a cool day, whereas carbon dioxide, as a much more elastic gas, requires summery temperatures; this doubles the amount of time needed for an experiment.

Along the conduit between gas container and slide-valve is placed a reducing valve, which lowers the high pressure of the gas to about 10 atmospheres for use in the motor; this requires the reducing valve to work steadily for some 30 seconds. The motor builds up nearly 1/15 horsepower. Since the load of carbon dioxide at 30 atmospheres weighs 0.3 kg and the aircraft with empty container weighs 2.8 kg, the net weight of the aircraft is 3.2 kg.

The organ of flight is a pair of wings, 1 m long and 50 cm wide, built from wood and hollow shafts. Each wing has two supports: one is stiff and strong, the other elastic and bendable. Each wing has 9 ribs. The covering is made of canvas. The wings weigh 1 kg in total; thus about one-third of the total weight is in the wings.

The model is a stable one. The center of gravity is located under the middle line of the craft, and a bit behind the middle of the wing supports. The model is started by hand. In the first few seconds, it drops down like a bird leaving the top of a column; it then climbs upwards at a slant to a height of 15 to 20 m. The landing occurs at low forward velocity, and is usually not too hard, because the wing surfaces function like a parachute after the motor has shut off.

[Editor's note: There exists an old newsreel film of Chalupsky's ornithopters in flight. The unusual wing design probably accounts for their tailless stability.]

Flapping FISH

Nathan Chronister

Since I moved to New York's Catskill Mountains earlier this year, I have been teaching environmental education with a focus on water resources. Much of my time has been spent alongside or in streams, teaching children about the creatures that live there. These mountain streams, with their crystal-clear water, stony bottoms, and quiet pools, provided the inspiration for my latest flapper project. Watching the trout and other fish that lurk in the pools, I decided to build one of my own. Flapping fin propulsion was successfully used to power a free-swimming, RC submersible on 8 October, 1997. Constructed in the shape of a fish, the model used its tail fin for both propulsion and steering. Pectoral fins allowed the model to dive and surface.

The 46 cm fish was powered by a Speed 400 motor and a 1400 mah nicad battery. A 25 to 1 worm gear reduction, turning a crank, drove the main tail-flapping motion. A thin brass tail boom provided a degree of flexibility and elasticity so the flapping foil had a suitable angle of attack for propulsion.

The entire motor and gearbox assembly was mounted on rails allowing it to be moved fore and aft by a servo. This mechanical mixer allowed the thrust to be redirected for steering. A problem with this steering system is that when the drive motor is turned off, the tail usually doesn't stop in a neutral position. However, this fact can be turned to advantage: By pulsing the thruster, then letting the model drift only if the stopping tail position is favorable, smaller-radius turns are possible. Otherwise, the model had a large turning radius because the range of motion of the tail was small.

The drive and control pushrods exited the hull through rubber pushrod seals available from the RC suppliers. The diving plane was operated by a servo located in the nose. The pushrod seal and steering arm were concealed in a flooded compartment in the lower half of the nose; this arrangement reduced drag without increasing buoyancy. Control characteristics were favorable; it was not difficult to have the model swim all over the place at a constant depth, yet it could dive and surface rapidly.

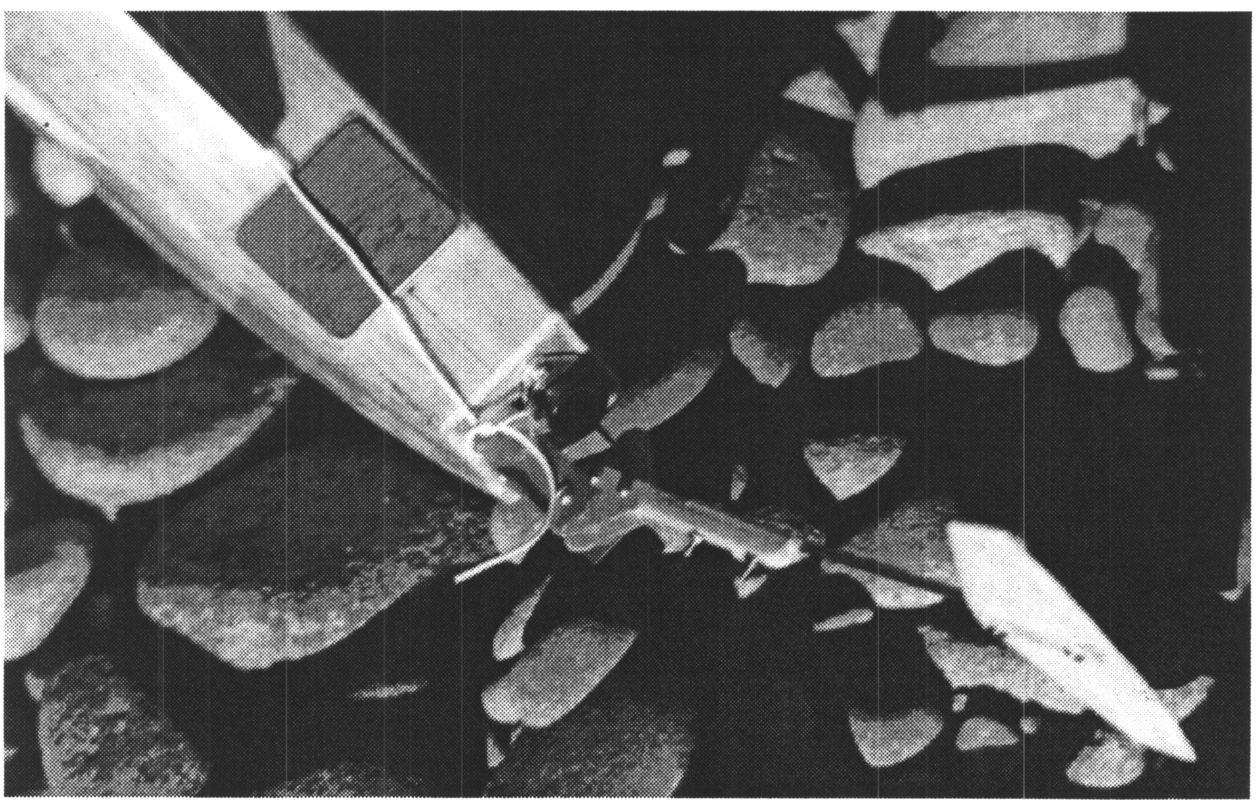
The model, which had a volume of about 950 ml, was weighted for slight positive buoyancy. This was a safety feature, ensuring that the model would surface if the battery died. If it had been desirable for the fish to be able to sit underwater without forward motion, it could have been weighted for neutral buoyancy. However, there is a danger of the model getting caught on the bottom; even with positive buoyancy, on one occasion the fins plowed into some silt on the bottom of the stream, requiring manual intervention before the model could surface.

Balsa wood construction was not ideal for a fish, but a few coats of epoxy kept the water out. Only a little moisture was found, and that may have been condensation. A removable hatch, held on by rubber cement, allowed access to the charging jack and power switch.

The gearbox used in this model was not suitable for the amount of power that was available. For that reason, I never went beyond about 1/4 throttle. The swimming speed was slow at that power level, but not slow enough to make it boring. In fact, it was probably faster than real fish usually swim. Speed might have been increased by fine-tuning the size of the fin and the flexibility and length of the tail; I also considered using a floppy tail hinge instead of the elastic tail. I didn't get a chance to try these modifications before the gearbox wore out.

Except for the need to minimize volume and maximize weight, swimming machines have a lot in common with ornithopters. The mechanisms are extremely familiar. Also, like ornithopters, flapping-fin water craft offer unlimited room for exploration in areas of configuration, efficiency, and control. A whole variety of swimming configurations exist in nature: Some fish, along with turtles and penguins, use their pectoral fins for propulsion, and a few even use the dorsal fin. Then there are ducks, rays, sperms, etc. (Hertel's *Structure, Form, Movement* examines a variety of swimming things.) As for efficiency, I think I heard a little trout laughing as it swam within sight of my mechanical fish. As with birds, the real thing is capable of much more subtle and complex motions than our crude imitations. Typically, a fish passes a sinusoidal wave along its body which builds as it progresses toward the caudal fin. My *jointed* fish approximated that motion about as well as a Tim Bird replicates the avian flight stroke. Real fish can also flap their fins in various complicated ways to maneuver delicately in close spaces. And of course, they have the ability to shoot off in any direction instantaneously. But in a way, fish are easier to imitate than birds: I was able to build a successful 3-channel RC fish on the first try and without any prior experience with simpler models.

RC fish and, below, close-up view showing tail mechanism and access hatch.



Rundlauf Now Available

Felix Scharstein

Wolfgang Send, my companion, works in Göttingen at the DLR (Deutsche Forschungsanstalt für Luft und Raumfahrt). His subject is aeroelastics. His work has to do with the problem of big planes, like the new Airbus, that they must not start flapping their wings. He also collaborates with zoologists in Göttingen and Köln. The main interest circles around the physics of flapping flight, the needed power, and the effectiveness with changing parameters. We are working together now for maybe four years, and I, as a precision mechanic, try to build models and our research apparatus.

We started with rubber-band-models in the tradition of Erich von Holst, a professor in biology who started flapping flight research in the 1940s. You didn't mention him in your flapping history, so maybe he's not very well-known in the States. [See Winter 97 issue and photo this issue.] Maybe also interesting is the fact that the Tim Bird is based on v. Holst's models, as I know from Karl Herzog, a still living, very friendly old man in Tübingen who built a lot of E. v. Holst's models. He told me that he had sold one of his models to the later Tim Bird producing company who used his model as an example of how to build an ornithopter. The very thankful company sent him a big box with lots of Tims as his fee. Two of the photos show our rubber-band-model in flight; the best flights were about 25 meters when we were faced with the problem that we couldn't get any data about the flight.

In the last year we have developed our "Rundlauf," an instrument for flapping flight research. [Editor: It appears to be a rotating boom.] The idea is to measure propulsion, lift, electrical power needed, flying speed, flapping amplitude, and flapping frequency. Now we are also able to connect our Rundlauf with the PC so we have a very good possibility to compare real flight data with theoretical models and, more to my part of our research, to develop better wings. Very proud of our success, we founded a little company, "Aniprop," and at the moment we are trying to sell the Rundlauf to museums and universities. It's an absolutely needed instrument for every serious flapper too!

I was very surprised to see that there are really lots of people in the States building flapping models, and I'm looking forward for news and contacts. Of course I want to be a member of the OMS.

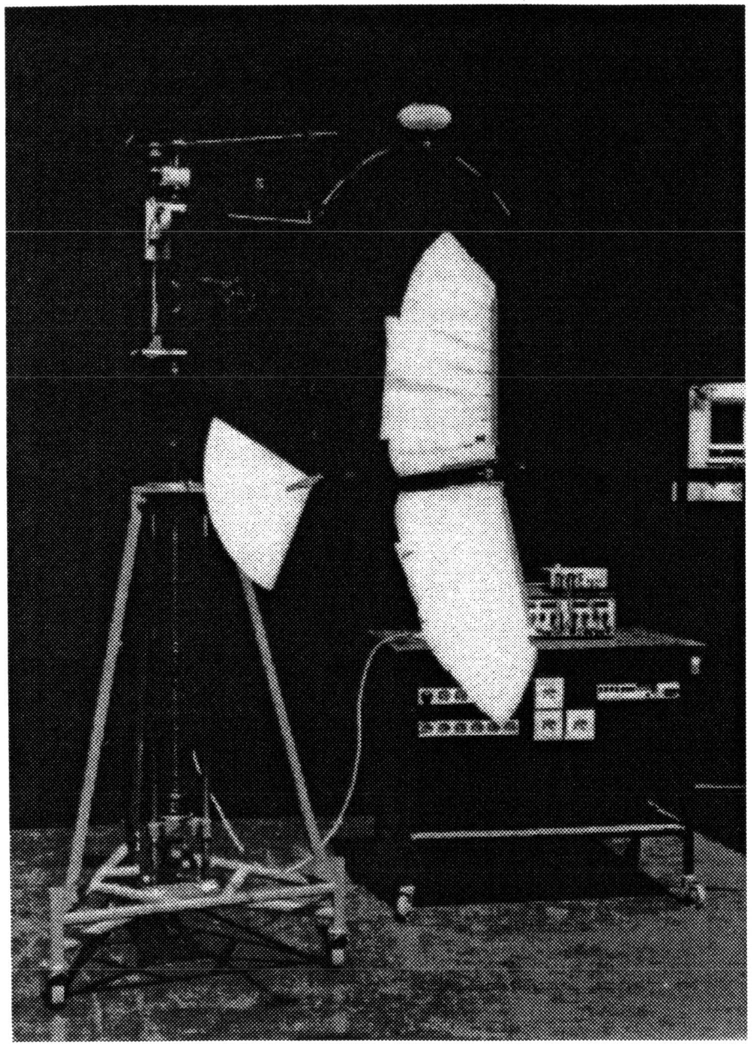
Felix Scharstein
Großbüllesheimerstr 71
53881 Euskirchen
Germany

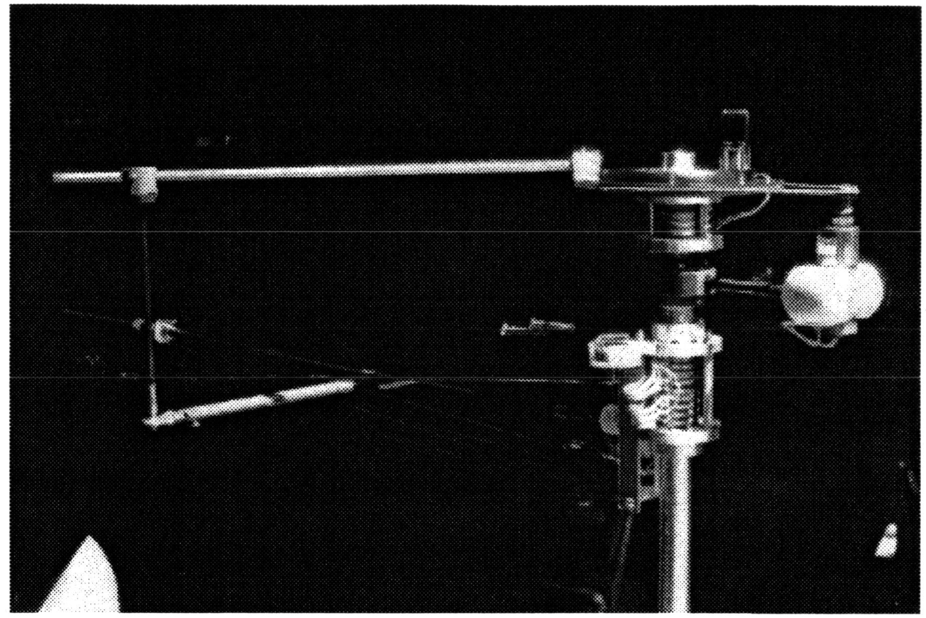
Bat Ornithopter

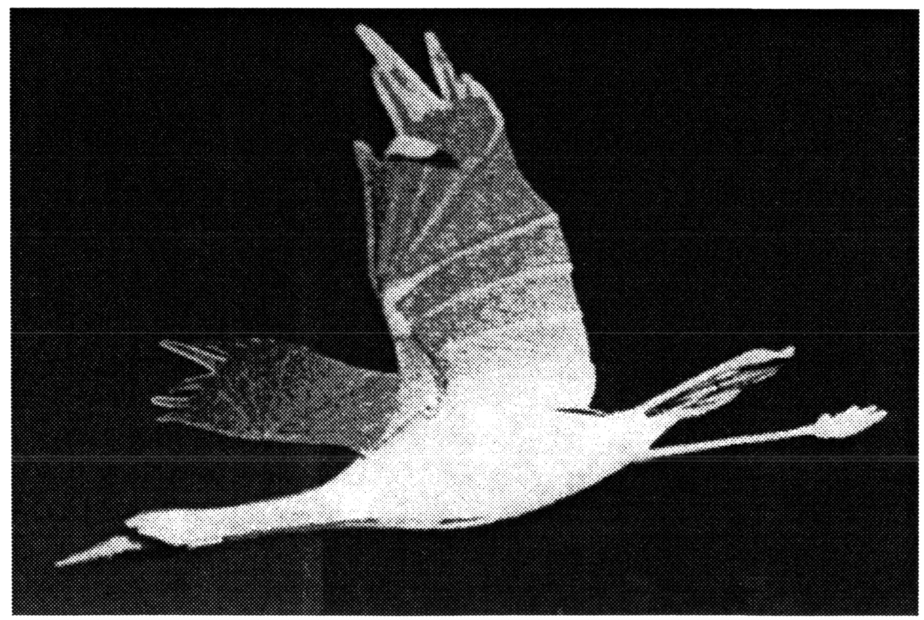
One of our correspondents recently told me about an interesting ornithopter plan he remembered seeing in an old model airplane magazine.

Ivan Williams said the plans appeared some time from 1982 to 1987 and depicted a very batlike model, not merely one with batlike wings as in the Ken Johnson Birdie design from Model Builder. It may have been rubber or electric powered.

If you know anything about this article, please contact the editor so it can be listed in the next issue.







Rundlauf, an ornithopter testing apparatus, with a test model in place. The model is electric-powered and appears to have artificial feather wings.
Upper right: Detail of Rundlauf.
Lower right: Erich von Holst crane.

Electric Wing Testing

Nathan Chronister

My latest series of electric ornithopter flights began last fall. With the goal of developing an electric RC model, I wanted a way to try out different wing designs. However, I knew tests with rubber models would not give applicable results due to their rapid upstroke. A biplane rubber model could have been used, but I didn't want to make four wings for every test! I was left with the option of building a reliable free-flight electric model, and drawing on my previous experience with a successful but less reliable model, I was able to do so. The new model, unlike its predecessor, flapped its entire wing area.

The model provides another data point in determining how much power is needed to fly an electric ornithopter. I used a Speed 300 motor and four 110 mah cells. Weighing 162 grams (5.7 oz.) and having a motor power output of about 30 watts, the model had a power to weight ratio of 185 watts/kg. The motor was geared 72 to 1 to drive wings that were each 56 cm long.

The best flights achieved a gentle, circling climb, and the model remained airborne until the wings had stopped flapping. Many of the wing designs, however, were incapable of level flight. It should be understood that the effects of these modifications might depend on variables, such as spar flexibility, CG location, and flapping amplitude, that were held constant during these tests. The results do not necessarily apply to all ornithopters.

Beneficial Modifications

Triangular planform
- Increases upstroke lift by providing more lifting area near the wing root.

Pre-tensioned spar
- Beneficial, at least with the very flexible spar and large (60 degree) amplitude used here. Tension was supplied by the membrane itself, or by a trailing edge cord which increased wing camber.

Detrimental Modifications

Spencer-type wing brace
- Performance might have improved with a less rigid brace. Caused shoulder joint to break in crashes.

Pre-twisted wings
- Caused stability problems; performance could not be compared.

Downstroke assisted by rubber bands
- Clear reduction in performance.

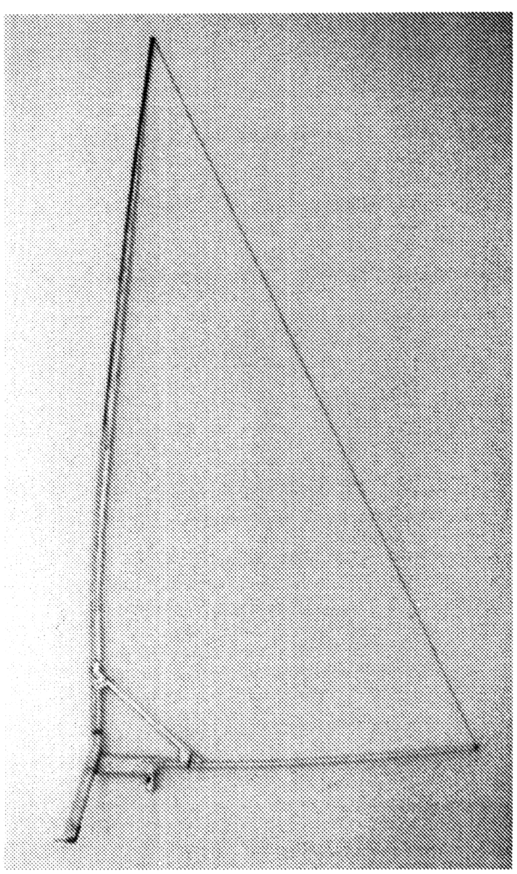
The final series of flights was an attempt to fly the model with radio control. A 7-cell pack was used for increased power, and the model was flown in both 2 and 3 channel versions. Control was by throttle, differential wing tension, and (in the 3 channel version) elevator. The first problem I faced was that the receiver with built-in ESC kept sensing an overcurrent. Once I understood the problem, I solved it by decreasing the crank radius. The model was very difficult to control because it tended to dive and turn right as power was increased. The turn was caused by asymmetric wing flapping; this is also why rubber models often turn the opposite way when wound backward. The diving tendency is poorly understood, but Jim DeLaurier said it might have something to do with downstroke stalling in part of the wing.

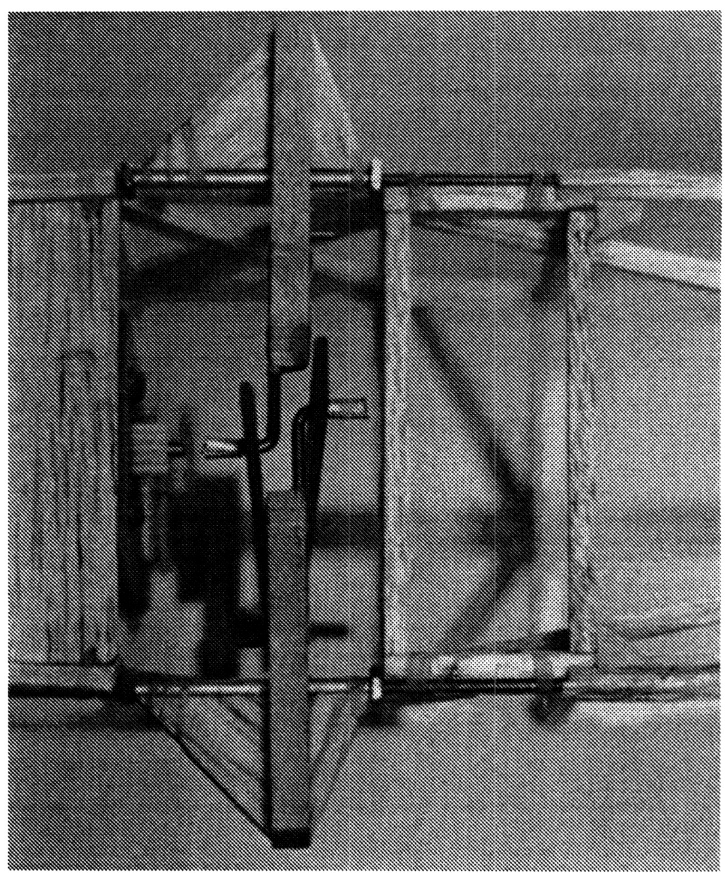
On its best flight (with 2 channel control), the ornithopter maintained its altitude for about 150 feet before I failed to correct for the turn, at which point it turned sharply to the right and crashed. The gearbox from this ornithopter is being transplanted to a new design. Unlike the previous model, it has overlapping wing levers to reduce the power-dependent right turn.

Other Projects

Last fall, I achieved semi-stable hovering flight with two ornithopters: a monoplane with horizontal stroke and a biplane with vertical stroke. Both models could climb by expending huge amounts of power. Both tended to swing back and forth rather than hovering on a point, but stabilizing tendencies were evident.

I also built an electric model driven by a cam. The mechanism was light and low in friction, with ball-bearing cam followers on both sides of the cam. The followers were mounted directly on a rod connecting the left and right wing levers; the right wing lever pointed up and the left wing lever pointed down. This mechanism ran smoothly, but the followers slipped off and mangled the cam before a flight attempt could be made.





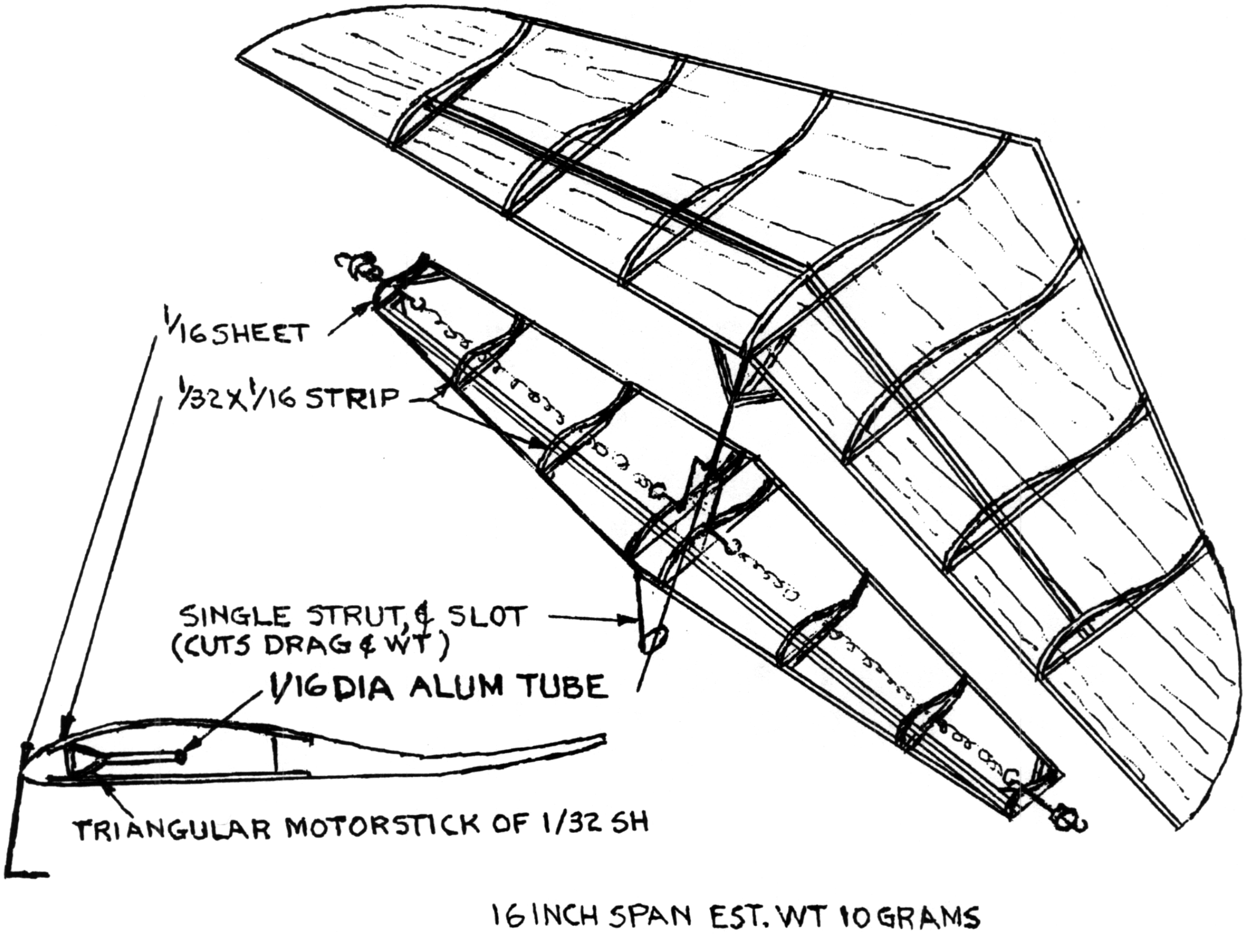
Nathan Chronister's wing design with triangular planform and tensioning cable. Another cable, adjustable, pulled the root rib down and against the fuselage. Flapping mechanism with overlapping wing levers for more symmetric flapping.

Whatever it is, it Won't Go Away!

Sid Davidson writes:

"I am sending my latest project. I was fascinated by Chaulet's design but didn't like the weight of 50 grams. I tried to reduce drag and weight by enclosing the motor, making the spar of the wing part of the motor stick and eliminating a strut. Also notice that the tips of the main wing flap like an ornithopter. I will send more information if I get it to work. I have been using light tissue up until now. However, if I knew where to get the very light plastic and what glue to apply it with it would help me a great deal. You don't have to write me; if you could publish it in the paper I would appreciate it."

Sid, thanks for the drawing of your "latest project." The Indoor Model Supply catalog lists several varieties of plastic covering and the cements to use with them. Send two bucks to Box 5311, Salem, OR 97304 for a catalog. These items are available in Europe from Sam's Models, The Chapel, Sandon, Buntingford, Herts SG9 0QJ, England.



Sid Davidson's project based on a design by Georges Chaulet. See Spring 97 issue.

Toward Birdlike Flight

(Translated from Flug-Und Modelltechnik, September 1996)

Fred Ludwig from Chemnitz has already made himself and his flying saurians known at several Inter-Ex meetings, where his demo flights consistently serve as a high point of the activities, while consistently winning awards as well. His saurians already fly perfectly, turn their heads and move their wings in flight, and make various noises. Mr. Ludwig could easily be satisfied with that. He is always certain to receive plenty of invitations to flight exhibitions, and certain to receive applause at each one.

But he is not a show-flyer — he is a researcher and model-builder. Flapping-wing propulsion is the single goal he has set for himself. He has since built five such models, the lightest of these (600 g), astonishingly, was not the furthest-flying. His current ornithopter has a 2100 mm wingspan, weighs 1260 g, and flaps its wings three times a second; the motor is an AP 29 reduced by a ratio of 100:1 (50:1 toothed belt, 2:1 chain transmission). In Ostrach, Fred predicted that his model would only fly a few meters at first, or rather, just make little hops. Which is exactly what Ludwig's bird did, until it kicked into full flight mode, described a large arc, cleared the fence easily and landed in the coffee tent. The damage was slight, the success great. His third model in Ostrach, an all-wing aircraft, looks truly unspectacular, and only an expert would notice the absence of one vital part: the rudder assembly or winglets. Being particularly interested in "nature in flight," Fred Ludwig is disturbed by the popular use of rudder assemblies on aircraft built to resemble birds. A new kind of steering mechanism is built into his all-wing craft: in addition to the usual RC controls, namely a combined control for aileron and elevator, this model also features a weather vane, with a sensor which reports any sudden wind gusts to an electronic system which, in turn, translates the information into servo commands. [OMS member Steve Morris has flown a similar craft.] This spreads the ailerons, which then provide air resistance. Not only does this principle provide a steering mechanism very similar to that of birds, it also allows the construction of all-wing aircraft with significantly lower air resistance — and therefore, significantly more efficient performance. The smooth turning and consistent straightaway flight of his craft, which Ludwig has dubbed the "Board," are impressive indeed. We hope to have more to report soon.

Wanted: Indoor Photos

The lack of representation for indoor ornithopters in this newsletter is not the result of editorial preference. Rather, it's because I never receive submissions from indoor modelers.

I would like to increase representation of indoor ornithopter modeling in the newsletter, web site, and other OMS publications. Please send sharp color or black-and-white photos, either prints or slides.

Also, plans for indoor *duration* models would be greatly appreciated. Designs that use a lot of fixed-wing lift are welcome. If you don't have time to draw plans, send me the model (even your old, damaged ones) and I'll draw it myself.