Flapper Facts

Newsletter of the Ornithopter Modelers' Society

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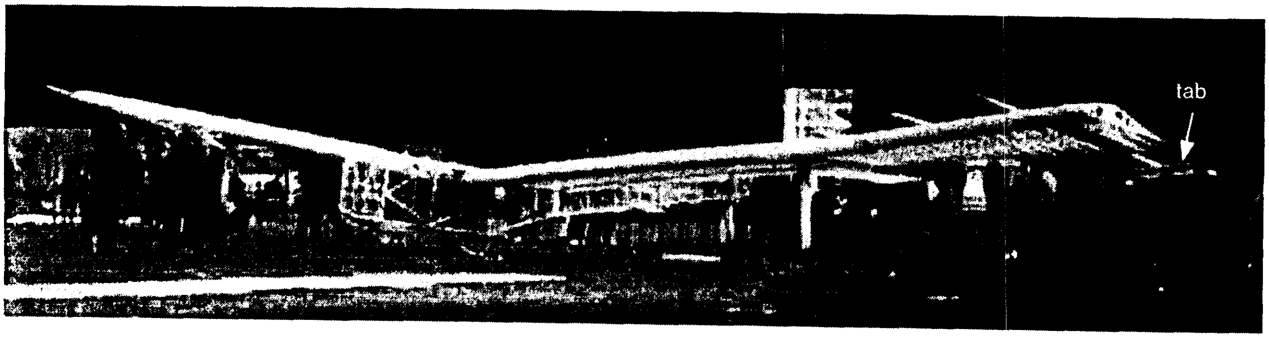
Karura Kazuho Kawai [edited]

Named after a great mythical bird, the Karura ornithopter spans 28 meters, is 9 meters long, and weighs 36 kg. The wings have a rectangular planform and a modified Lissaman 7669 airfoil. The wings are constructed with inner fixed wings and outer flapping wings. They flap down with wire and flap up naturally by the pressure difference between the sides of wing. A tab projecting from the trailing edge helps to twist the wings during flapping.

A pilot in the cockpit makes power with an ordinary rowing motion. The seat system is similar to the sliding rigger of a racing boat, and it reduces pitching with pilot action. The slider and the hand lever are connected to a wire and the pilot makes power with arms and legs.

The beams of the inner wings are made of CFPR, and the beams of the outer wings are made of wood. The body is made of wood.

The flapping cycle period is from 2 to 3 seconds. In flapping, the aircraft has an up-and-down pitching movement, so to maintain the correct attitude the tail is automatically controlled with a gyroscope.

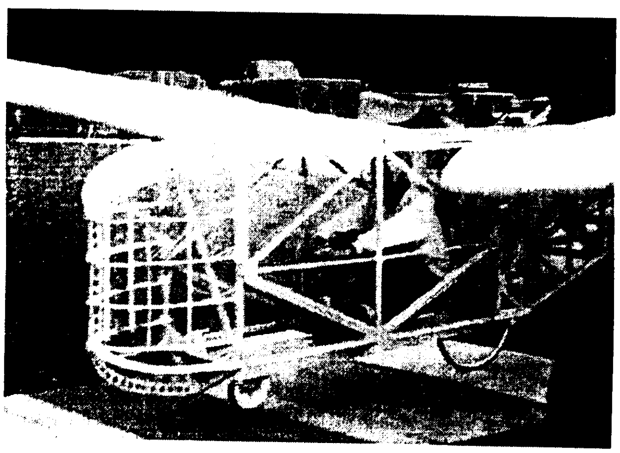


The group responsible for the Karura ornithopter is known as the Silver Shooting Stars. Here is the history of the group:

- 5th May 1993. The human powered ornithopter project team Silver Shooting Stars was united. There are 60 members consisting mainly of OBs of the Kyoto University birdman team. The head designer is Masashi Harada. The president was Akiko Mori. (Now, the president is Kazuho Kawai.)
- The construction started at 6th July in three groups:
  1. Tokyo group (The group head: Masashi Harada): Construction of cockpit and main design in NAL.
  2. Shiga group (The group head: Yasunori Todo): Construction of tail and body in Masataka Shintani's house.
  3. Kyoto group (The group head: Kazuho Kawai): Construction of wings in Kazuho Kawai's house.
- From 10th September, all parts were transported to Yoshida dormitory in Kyoto University. The members of Kyoto University birdman team joined us for

construction.

- On 21st November, all parts were transported to Kakamigahara City in Gifu prefecture. The construction took place at Kakamigahara Aerospace museum.
- On 12th December, construction was finished. The period of construction was 8000 hours. Before test, the aircraft was partially broken by a spectator.
- On 19th December, a nonflapping aviation flight test by human powered launching was conducted. At takeoff, the right flapping wing twisted in the wrong direction and broke. The aircraft rushed into a ground loop and was badly broken.
- After the test, the air craft was transported to Uji campus of Kyoto University, and transported again to Kawai's house. Last construction work was at Uji campus and now the construction is suspended.



In 1994, two papers were published in Human-Powered Flight International Symposium in Seattle, USA.

Now, a 1/8-scale model of Karura is under construction at Harada's house. We are studying the theory of flapping.

You can learn more about Karura by visiting its well-illustrated website:

http://web.kyoto-inet.or.jp/people/kazuho/index-e.htm

This article is borrowed from the website with permission, but there are many pictures on the web that were not included here, including a diagram of the flapping mechanism.

Letters

From Mike Palrang:

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 N.F.F.S. 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.

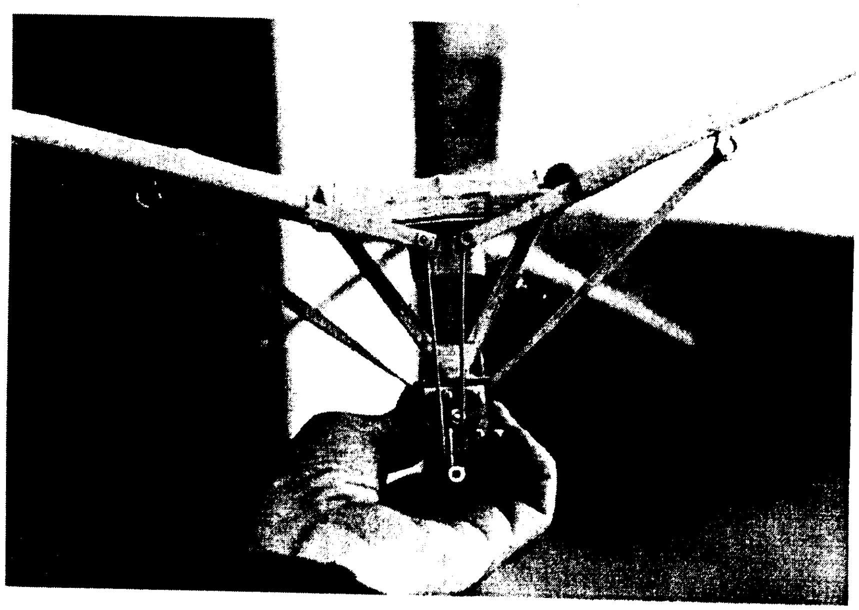
From Brandon Wald:

I am building a 9′ ornithopter of a pterodactyl. I have a friend that is building a 17′ ornithopter that is to resemble a bird.

From Steve Morris:

I thought I would give the list a try by mentioning an ornithopter I built this year. Hobby Lobby sells an RS-280 electric motor with a lightweight 100:1 brass gear reduction mounted to it for only $15.00. I purchased one because it looked like a reasonable powerplant for a 3.5 ft span electric ornithopter. I built a balsa model with a planform that sweeps forward about 20° for the first half of the semi-span and then aft 20° for the remainder (i.e. like a seagull in top view). The outer panels are a single-surface cambered airfoil with ribs attached to a thin LE spar. The whole wing is designed to naturally twist under airloads to keep the local airfoil sections at close to their ideal angle of attack. I covered the wings with Japanese tissue. The flapper mechanism is the standard single crank with connecting rods to each wing. The wings are springloaded to store energy on the upstroke and use it on the downstroke. The fuselage has an inverted V-tail at the back for stability. I power the model

A recent electric ornithopter by Steve Morris



with a 4-Cell 110 mah battery pack. This produces a flapping frequency of roughly 1.5 Hz with a total angular stroke of 50°.

My first flights were attempted with a 40° flapping stroke and the model would not climb, but flights from a hill resulted in 30 seconds of level flight before hitting a tree. I increased the flapping stroke to 50° by extending the crank arm radius, but this resulted in an average wing dihedral that was slightly negative. I tried flying it any way and it climbed initially, but it lacked spiral stability due to the wings being "down" more than "up". It circled back and spiral dived into the ground after about 5 seconds. My gear train was damaged, so I ordered several more motors from Hobby Lobby and hope to build a new version of this model soon.

* * * *

I have been continuing my experiments with a 40 inch span electric powered ornithopter. My initial approach was to use membrane style wings. These consisted of a torsionally flexible leading edge with ribs attached to it and a single surface covering of tissue. The twisting deformation of the wing causes the covering to nonlinearly stiffen the wing, which limits the amount of twist obtainable. This problem can be avoided by using an elastic membrane, but I have not been able to find a light enough elastic material to do this.

I decided to take a different approach and build a wing with "feathers". I built these feathers using a tapered spruce spar that is bent to the desired camber shape. Additional spruce supports are glued 90° to the feather's main spar to support the covering material which is Litespan, a thin Tyvek-like material. The main spar must lie close to the feather's leading edge as the feathers are radially rotated into the spanwise direction near the wing tip. I drew a wing planform with 10 feathers arranged so that they overlap just like a bird's, i.e. each feather's LE lies on top of the next outboard feather's TE. The feather spars attach to a torsionally flexible leading edge and a fairing covers over the LE. The wing is very light and strong. When I flap the wing the twisting deformation is nearly linear and on the upstroke the feathers unseal from each other to allow more deformation and unloading of the wingtips on the upstroke. I hope to build a new ornithopter using these feathers soon.

My feathers meet the leading edge spar at different angles depending on how close to the wing tip the feather is. Each joint is a scarf joint (i.e., cut to match the LE angle) and is glued with a 1/64 ply reinforcing gusset. The leading edge torsional stiffness controls most of the wing's twisting deformation. My leading edge is a tapered piece of spruce with a rectangular cross section. I'm considering adding carbon fiber spar caps to increase the bending strength and I don't think this will affect the torsional stiffness much. The entire wing was built using cyanoacrylate glue including the attachment of the Litespan to the spruce spars of the feathers.

From Charles Pell, replying to Morris:

I like your design. The CF caps will do exactly what you say; you might think of the loading asymmetries due to gravity, and run the CF helical in one handedness only to increase the torsional stiffness on the downstroke, leaving the spar much more torsionally compliant on the upstroke to reduce that negative vertical component.

Torsional compliance (usually LEs) show up in all creatures using flapping foils for locomotion in a fluid (air/water). The crude formula,

$$Kdv > Kl >> T$$

seems to describe the basic requirements for wing stiffness in a flapping creature, where Kdv = the flexural stiffness in the dorsoventral direction (resists bending during flapping up and down), Kl = the flexural stiffness in the dorsoventral direction (resists bending due to fore and aft loads), and T = the torsional stiffness of the spar. T you are having fun with now. Kdv everyone plays with as well. The "stealth factor" is Kl, which controls how the thrust generated by the wings gets transmitted to the body/fuselage. Kl can be controlled in two basic ways: by the flexural stiffness of the wing spar itself, and by the stiffness of the main bearing where the spar pivots (or deforms, or flexes, depending on your design). Most people just use a fairly stiff spar and make sure that their spar pivots are beefy to take the moments produced in the forward direction by the wings (thrust).

Note that a spar of tubular cross section tends to be the stiffest, torsionally, as well as being pretty stiff in bending. (Steven Vogel recently published papers on "Twist-to-Bend Ratios" that all builders might find useful.) The most torsionally compliant beams (spars) are those with decidedly noncircular cross sections, especially things like triangles, X-shapes, and C-shapes. My favorite spar design uses a tube that possesses a lengthwise slit that runs from 1/3 of the way out a spar from the flapping joint to the end. This makes for a spar that is stiff in bending while being torsionally compliant where it counts. [This is similar to the structure of a feather shaft.] The "cheap trick" aspect is that the slit is on the TE of the spar, and the wing surface area material runs into that slit, attached to an internal anchor inside the tube. The spar can then be faired to the wing surface; in fact, I use faired spars with TE slits to do the job in one step.

From Bob Eskridge:

A good friend of mine about 10 years ago has dropped out of sight, and I'm thinking you might help me find him. His name is Jim Thies, and he used to live in Boca Raton, Florida, but now there's no listing for him there. I think of you because he may be a member of your ornithopter group. He accomplished more than anyone else I know in the way of flapping flight. He designed and built a gasoline engine powered man-carrying ornithopter and had made brief experimental flights in it before the accident which left him a paraplegic in a wheel chair. On a takeoff attempt from the grounds of the West Palm Beach Polo Club one wing struck a light pole and spun the craft around and into the ground, leaving Jim with a broken back and paralyzed from the waist down. He had worked as a design engineer with a firm in Boca Raton manufacturing high speed turbines which were powered with compressed air and used in such applications as dental drills and metal cutting and grinding tools. Being very inventive, he was busy working on proposals for an improved wheel chair, finding the one he was using deficient in many respects, when last I heard about him. I wonder if any of the members of OMS might know of his whereabouts, and whether you might ask about it in the next newsletter?

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Thanks for your response of 2/6/96 to my message, same date. Have since talked to another friend who saw the Jim Thies ornithopter flying. He elaborated thus: the plane was set up as a test bed, and was initially powered with a Soarmaster engine and prop unit for stability and control tests before changing to the anticipated wing-flapping mode, and it was performing very well in this conventional mode. Jim was about ready to convert to the ornithopter mode when the accident curtailed further efforts. Additional detail suggests there was an enclosed fuselage shaped like a bird's body and wings with a somewhat scalloped trailing edge, and empennage very like a bird's tail feathers with no vertical fin or rudder. The pilot lay prone in the fuselage, facing forward, with a control bar below him which moved aileron-like devices in the wing for roll control but also for glide path control when used together. The tail could "wiggle" up and down and also warp left and right for directional control. It seems that all these unusual control modes had proved out and were working well, so there was a major achievement in getting that far. The accident occurred at dusk when a wing struck not a light pole but a 2" galvanized pipe which had been set up to support a loud-speaker system, almost invisible under those lighting conditions. We are still searching for a magazine article which had photos of the "bird" so that perhaps you can share it with your readers.

From Sean Kinkade:

I have another model in the works. This

one consists of a helicopter boom fuse. The engine is rear mounted with a drive wire going to a gearbox up front. The drive wire goes through the boom like an RC helicopter's tail rotor drive. It has a 4-stage spur gear reduction (230 to 1!), homemade gearbox, TD .051 powered. I'm Hell bent on getting a 1/2 A orni to fly!! The rear mounted engine should surely help c.g. problems cause this is another membrane wing bird. Pat Deshaye had an 020 bird with a similar arrangement. This will be the first time I take the super high reduction approach. As I recall, my bird of October '93 had around a 120 to 1 ratio and would flap briskly until launched when the flapping frequency slowed considerably. That was OS .10 powered but I hope to have enough power from the TD now that I have a Lite Machines heatsink head and 30% nitro fuel! I want a super slow flapping bird with extra low wing loading. Much like a scaled up version of the toy ornithopter of my childhood. I think it was made by Hasbro. It was not the Whamo! bird. It had hardened music wire for wing spars and flew much slower and longer than the Tim Bird. I bought a Tim Bird shortly after breaking my Hasbro bird and remember being disappointed with it because it didn't float around like the other. That was around 1970. I wish I could find out about that old toy thopter. I'd be interested in buying the tooling if it still exists and remarket it. Anyway, it's a smooth flying, slow flapping bird I'm after now. I'll keep you posted.

* * * *

I went to the super high gear reduction on my new ornithopter as an experiment into large slow flapping wings. So far I have noticed that for the first time there is no audible fluctuation in engine frequency while running the system. Granted, the wings are not covered yet but I have held the model by the wing spars while running it and the weight of the fuselage/gearbox bobbing up and down doesn't sag the engine much.

Yesterday I completed an elaborate servo mixing system for the tail. Very birdlike!! The tail is triangular like the Tim Bird model and has a gimbal type system that pitches the tail from side to side as well as up and down. I machined the main components from Delrin plastic. The tail spars are AFC carbon kite spars. I also designed a unique rocking servo tray to provide mechanical mixing for the tail. Conventional V-tail mixers did not provide enough throw for my liking so I built this custom unit.

I've ordered a new 1/2 oz. polyester fabric to cover the wings with. When it arrives I'll only be days away from flight tests. As usual, the beast has become rather heavy and this concerns me. At least I know that the .049 can be removed and a Tee Dee .09 can be installed in its place if need be. The drawback is there is no Lite Machines .09 heatsink and it is a difficult part to have to machine.

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I have patiently been making advancements with my .049 ornithopter. I have it mounted to a sawhorse and after throwing a rod in my engine I decided to lower the 350 to 1 ratio. The 7 foot wings flapped effortlessly but slowly, and the engine raced with no audible fluctuation. The reduction proved too great and did not load the engine enough. The new ratio is 229 to 1 and so far looks GREAT! The engine sounds right and the wings flap at about 1.5 hertz. These are big thick wings and the thrust produced is quite good.

I intended to solve the ratio and heat problems prior to installing the radio. Glide tests (safely onto my trampoline) show good lift but a tendency to stall which I think is because the bird's tail heavy. Even so, it glides better than the Tim Bird without power. Under power I think this model will fly. Flame outs may prove disastrous however but I'm not worried about that at this point. The weight of the radio in the nose should help prevent stalling anyway. Eventually I will install a Light Machines clutch. I'll keep posting updates.

* * * *

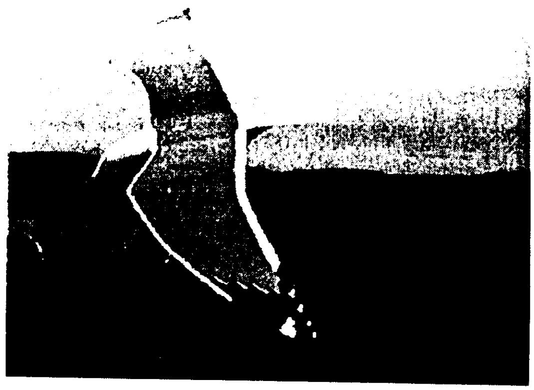
[Kinkade now writes about another model, inspired by Spencer's Seagull.] My gear ratio in

Stiffness and Weight of Sport Kite Spars Simo Salanne

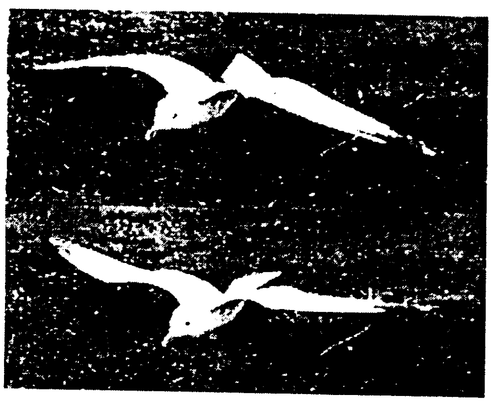
S = Based on measurements by Simo Salanne L = Based on measurements by David Lord M = Based on manufacturers data

Spar Type	Short Name	Relative Stiff.	.... Weight	Scale Fact.	Weight g/m	Outer Diam mm	Rem
Reference spar: Glassforms K75	K75	1.00	1.00	1.00	33	8.7	S/L
AFC 1580	AFC1580	0.20	0.33	0.67	11	4.0	S
AFC 1700	AFC1700	0.26	0.37	0.71	12	4.3	L
Clearwater 187-2	CW187-2	0.29	0.28	0.73	9	5.5	L
AFC 1800	AFC1800	0.32	0.46	0.75	15	4.5	L
Clearwater 202-2	CW202-2	0.34	0.31	0.76	10	5.9	L
Beman Ultralite 13	BeULT13	0.38	0.36	0.78	12	5.0	M
AFC 1880	AFC1880	0.38	0.45	0.79	15	4.8	L
AFC 1960	AFC1960	0.45	0.49	0.82	16	5.0	L
Beman Ultralite 14	BeULT14	0.47	0.36	0.83	12	5.5	M
Beman Light 13	BeL13	0.47	0.48	0.83	16	5.0	M
Vlieger-Op Exel RCF 5	RCF5	0.49	0.45	0.84	15	4.9	M
Glassforms Prospar PS-15-278	PS278	0.57	0.63	0.87	21	7.1	M
AFC 2100	AFC2100	0.58	0.60	0.87	20	5.3	L
Clearwater 250-2	CW250-2	0.60	0.41	0.88	14	7.1	L
Advantage 250/2	ADV/2	0.60	0.49	0.88	16	7.3	L
Beman 5.5 mm (arrow shaft)	Bem5.5	0.64	0.52	0.89	18	5.5	S
Beman Ultralite 15	BeULT15	0.64	0.39	0.90	13	5.9	M
Beman Light 14	BeL14	0.69	0.54	0.91	18	5.5	M
Beman Pro-Competition 14	BePRO14	0.69	0.54	0.91	18	5.5	M
AFC 2200	AFC2200	0.70	0.66	0.91	22	5.6	L
Vlieger-Op Exel RCF 6 Strong	RCF6S	0.70	0.96	0.92	32	5.9	S
Beman Strong 14	BeSTR14	0.75	0.66	0.93	22	5.5	M
Beman Ultralite 16	BeULT16	0.82	0.42	0.95	14	6.3	M
Glassforms Procomp CP-15-278	CP278	0.84	0.54	0.96	18	7.1	M
AFC 2300	AFC2300	0.84	0.69	0.96	23	5.8	L
Vlieger-Op Exel RCF 6	RCF6	0.85	0.66	0.96	22	5.9	S
Beman Light 15	BeL15	0.90	0.63	0.97	21	5.9	M
Beman Strong 15	BeSTR15	0.96	0.69	0.99	23	5.9	S
SkyShark IIIP (1994)	IIIP	1.00	0.41	1.00	14	7.1	L
AFC 2400	AFC2400	1.00	0.76	1.00	25	6.1	L
Clearwater 250-3	CW250-3	1.06	0.57	1.02	19	6.9	L
Advantage 250/3	ADV/3	1.06	0.75	1.02	25	7.7	L
SkyShark VP (1994)	VP	1.11	0.49	1.03	16	7.1	L
Glassforms Prospar PS-16-306	PS306	1.11	0.88	1.03	29	7.8	L
Clearwater 315-2	CW315-2	1.17	0.51	1.04	17	8.8	L
Beman Strong 16	BeSTR16	1.22	0.77	1.05	26	6.3	M
Beman Light 16	BeL16	1.23	0.75	1.05	25	6.3	M
AFC 2540	AFC2540	1.26	0.88	1.06	30	6.5	L
Vlieger-Op Exel RCF 6 Ultra	RCF6U	1.26	0.51	1.06	17	5.9	S
Clearwater 280-3	CW283	1.35	0.70	1.08	23	8.3	L
Beman Pro-Competition 15	BePRO15	1.41	0.69	1.09	23	5.9	M
Clearwater 250-4	CW254	1.42	0.85	1.09	29	7.9	L
Advantage 250/4	ADV/4	1.42	0.93	1.09	31	8.1	L
Glassforms Procomp CP-16-309	CP309	1.43	0.76	1.09	25	7.8	L
Glassforms Prospar PS-19-352	PS352	1.54	0.98	1.11	33	8.9	L
Vlieger-Op Exel RCF 7	RCF7	1.61	0.78	1.13	26	6.9	M
Clearwater 315-3	CW315-3	1.86	0.76	1.17	25	9.1	L
Glassforms Procomp CP-19-352	CP352	2.00	0.86	1.19	29	8.9	L
Phoenix/CarboFlex 8	CFlx8	2.10	0.93	1.20	31	8.0	S
SkyShark VIIP (1994)	VIIP	2.11	0.80	1.21	27	8.4	L
Vlieger-Op Exel RCF 8	RCF8	2.17	0.96	1.21	32	7.9	S
Beman Pro-Competition 16	BePRO16	2.20	0.84	1.22	28	6.3	M
Vlieger-Op Exel RCF 8 Strong	RCF8S	2.56	1.09	1.27	37	7.9	M
Vlieger-Op Exel RCF 9	RCF9	3.08	1.05	1.33	35	8.9	M
Clearwater 385-3	CW385-3	3.25	0.78	1.34	26	10.9	L
Vlieger-Op Exel RCF 9 Strong	RCF9S	3.79	1.26	1.40	42	8.9	M
Vlieger-Op Exel RCF 10	RCF10	4.73	1.20	1.47	40	9.9	M
Vlieger-Op Exel RCF 10 Strong	RCF10S	5.42	1.53	1.53	51	9.9	M
Vlieger-Op Exel RCF 11	RCF11	5.75	1.35	1.55	45	10.0	M

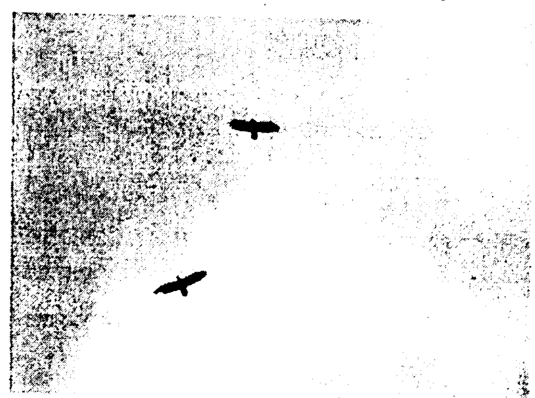
Robert Hoey's bird gliders



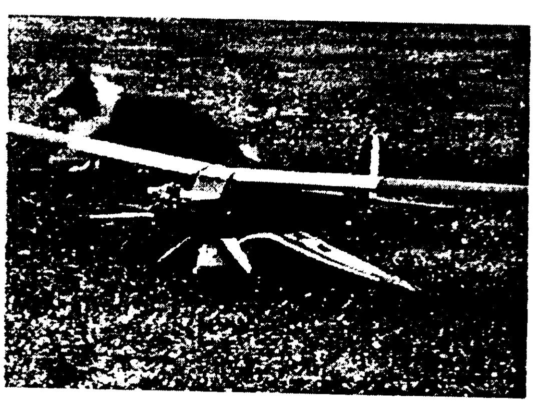
This seagull model is very realistic even close-up, but the Monocote gleam of Hoey's turkey vulture gives it away. Like the real thing, it rocks back and forth in flight.



The tail is moved in a birdlike manner to serve elevator and rudder functions. The wings have adjustable dihedral.



Which one is the real raven? Hoey has cleverly included (or not) some missing feathers.



Hoey has a little sheltie that likes to chase the launch plane.

this model is 85 to 1, higher than Spencer's but lower than any I've ever built. It should generate about 4 flaps per second.

I will try to keep this thing as light as I can but I do build sturdy mechanics and use ball bearings throughout, plus mine will have a clutch, pull start, and radio. If it flies it will be user friendly unlike most ornithopters. Gears are from my gear supplier, the gearbox will be CNC machined by a machinist I subcontract, I'll have the Icarex sail wing sewn with spar sleeves like a stunt kite. In fact, this will be very much like a stunt kite in construction except it will have a fiberglass body and mechanics. I have shown the Spencer video to the fiberglass expert here in Orlando. He sees what I'm up to and can make really nice bodies in the future. (He makes the canopies for the X-cell helicopters from Miniature Aircraft.)

* * * *

Well, I just got the Thunder Tiger .12. The model is the Pro-12BZX. It's rated at 0.56 brake horsepower at 29000 rpm. This would give me 5.68 hertz flapping! Wow, that may be too fast.

The engine looks real nice with a big black heatsink head and I just LOVE that pull starter! No more fooling with electric starters! I hate lugging all that equipment around. I may even convert this engine to a Davis Diesel to eliminate the need for the glow head battery. That way it's just turn the radio on, tug, and fly. I believe that a marketed gas powered ornithopter will only succeed if it's made reliable and easy to fly. A major part of the easy element is starting and launching.

My OS .15 muffler fits right on to the .12. This engine looks right for the size of the gears I'm using. The spur gears I'm using are 24 pitch, 1/4 face delrin gears. The pinion gears are made of steel. This time I did it right. I start with extruded pinion wire and machine it down to 1/4 inch for the shank portion. It's so nice not to have to worry about roll pins, etc. The shank and pinion teeth are one piece. I doubled the face width on the output gear by doubling two gears together on a splined shaft. This gave me a 24 pitch 1/2 inch face output gear. I hope it holds up. Your Flapper Facts article on Spence mentioned that he used steel spur gears in his seagulls. I am trying plastic gears due to their economy... plus metal gears can generate radio "noise".

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My output crank pin is attached directly to the gear disc so failure will occur if the gear teeth strip. This arrangement works well and eliminates the problems so common with transmitting torque from the gear through a shaft to a crank. My first two stages attach to the shafts but the load is lower on them than the output.

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I have the .049 thopter completely built, covered with Icarex, and bench tested. Even with the lower ratio of 230 to 1 the engine over-revved and kept throwing rods. I "solved" this problem by slowing the engine down! Instead of a Tee Dee cylinder I used a Medallion .049 cylinder in its place. It has two small slit exhaust ports on each side instead of one larger port on each side. This slowed the engine down enough to prevent self destruction but still flaps the big wings with authority.

My mechanical mixer for the tail control proved to be too heavy for my liking so I've postponed any flight tests until I can afford a new radio with electronic mixing. So for now, the big bionic bat hangs on the wall in my bedroom.

It just so happens that I received the Spencer films right around the time I was completing the .049 thopter. His free-flight seagulls flew well. REAL well. Since his wing design looked ridiculously simple, I got off on a new tangent to produce a model utilizing his modified high aspect Rogalloesque wing. It has been my intention for years to manufacture an off the shelf RC ornithopter. I could see a model being priced in the range that modelers can afford due to Spence's inexpensive membrane wing design. The major manufacturing expense will be the engine and transmission but I believe that will be manageable too.

For now, my prototype under construction uses my own unique gear reduction mechanism and the Thunder Tiger .12 car engine previously mentioned. The fuselage is balsa and ply with carbon tube wing spars. It has a triangular tilting and pitching tail but if that does not work well it will be changed to a V-tail.

From James DeLaurier:

I have several German articles from the 1930s on a Czech modeler, V. Chalupsky, who flew compressed-air tailless ornithopters. These look like the basic Pénaud-type membrane-wing flapper, except that the body is a long cylinder for the compressed air. Also, the wings appear to have some sort of rib structure, and a broad, low aspect-ratio, planform (somewhat like a Lilienthal glider).

The span looks to be approximately 5 ft. Also there are several in-flight photos. I recall seeing a brief clip on TV several years ago of an overdressed gentleman pumping up his tailless ornithopter and releasing it for a stable successful flight of a few seconds. No information was given, but in retrospect I think this was Mr. Chalupsky.

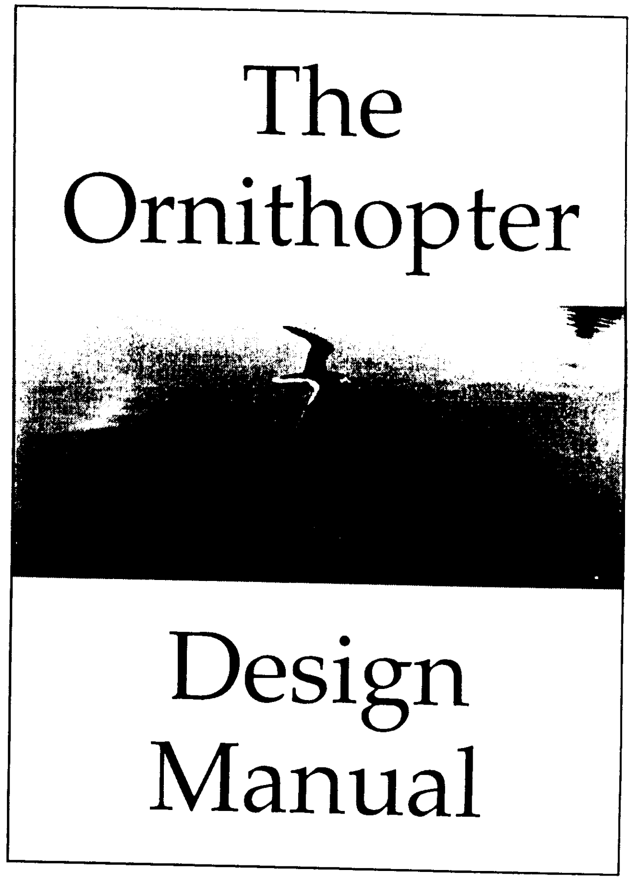
By the way, these articles were provided to me by Mr. Horst Händler of Germany (a friend of Horst Rabiger).

Back Issues

For those who don't already know, here's how you can get a copy of the Flapper Facts Back Issues. One spiral-bound volume contains all the issues through 1995, totaling 296 pages. I'll throw in the Winter and Spring 1996 issues too if you request them. Send $25 (outside the USA, $33) to Nathan Chronister, 20 Crum Elbow Rd. Apt. 1E, Hyde Park, NY 12538 USA.

Next Issue

I don't really have anything planned for the next issue. Please keep sending in all those great articles and pictures, so you'll be assured of getting an interesting newsletter in return! For some reason it's always more interesting when it contains your OWN article! Starting now, please observe 1 inch margins on all sides. Otherwise I'll have to crop and reduce.



The Ornithopter Design Manual

Completely rewritten, the third edition of the Design Manual reflects the great advances in ornithopter theory and practice of the last ten years. A lengthy section on engine-powered and electric ornithopters has been added. 52 full-size pages, clearly illustrated with drawings and photographs.

Contents:

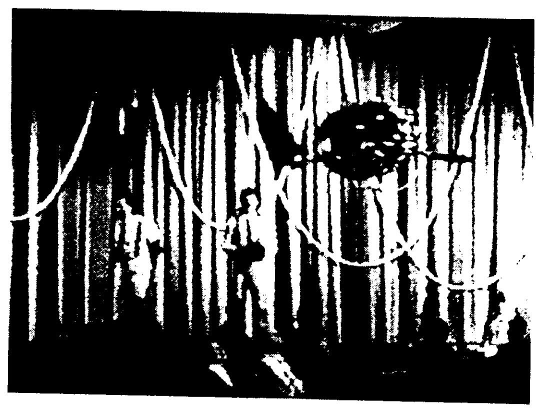
Introduction
Building and Flying Ornithopters
Membrane Wing Aerodynamics
Advanced Wing Designs
Engine-Powered Ornithopters
Supplies/Suggested Reading

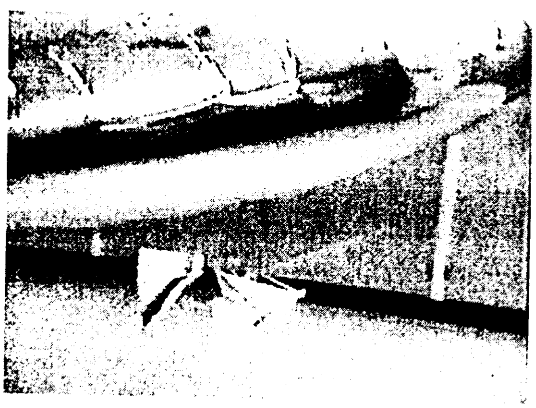
To obtain a copy, please send $6 (outside the USA, $8) to Nathan Chronister, 20 Crum Elbow Rd. Apt. 1E, Hyde Park, NY 12538 USA.

Mike Dodd's ornithopter blimps

A while back, Mike Dodd sent me a videotape of some ornithopter blimps he has been flying. Free-flight blimps are typically a little heavier than air to insure they will return to the ground when the power runs out. Although the helium lift eliminates any need for good performance from the flappers, ornithopter blimps fly faster if they have efficient propulsion. The flapping blimp is perhaps a good way to experiment with wing designs without having to worry about stability, crashes, and other difficulties.

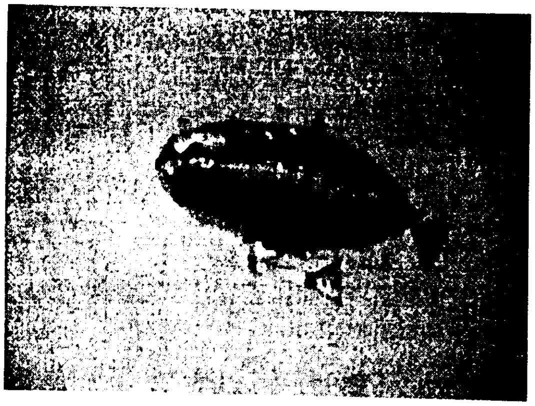
The first picture shows a fat mylar goldfish that is propelled by its pectoral fins. A larger, radio-controlled version was propelled partially by its pectoral fins





and had a powerful caudal fin as well. The tail was used both for steering and propulsion. Evidently the tail was powered by a servo. Dodd sold this machine to comedian Jim Stafford who used it in his twice-daily show in Branson, Missouri.

Some other models built by Dodd use more unusual flapping devices. Apparently in an attempt to prevent the fuselage from bobbing up and down, he has used a pair of opposed, horizontally flapping vertical fins in several of his models. Two rubber-powered blimps were used in an experiment to see whether the fins should flap at their base (like a rudder) or at the end of a long boom (like a fly swatter). Although both models were



capable of propulsion, the fly swatter type seemed to do a little better. Dodd also flew an electric version of this model. These models with opposed flapping fins give an unusual impression in flight. They don't quite look like fish, but they do look rather organic.

The obvious follow-up to Dodd's work would be an ornithopter deriving its lift from a fixed wing rather than from a balloon, using a flapping tail rather than the usual shoulder-hinged thruster for propulsion. A model along those lines appeared in one of the older issues of *Flapper Facts*. It had a flapping fin located beneath the fixed wing. John White has also been doing some work with flapping tails, but he uses them in combination with flapping wings.

Steve Morris Tim Bird conversion

Another video was sent in by Steve Morris. He modified a Tim Bird ornithopter by giving it aeroelastic, ribbed wings of greatly increased span. The swept outer portion of the wing increases the amount of twisting, as Morris demonstrates in the picture on the right. The wings have a single-surface tissue paper covering. With all these modifications, the Tim Bird turned in flights of about 30 seconds. One can also increase Tim's flight duration simply by using oversized membrane wings.

110 Sunset Drive
Cocoa Beach, FL
32931
August 25, 1995

Dear Nathan,

Enclosed is a copy of the drive I will use when I turn my attention to an electric ornithopter. There's nothing new in it, just the integration of several old ideas to fit a new need. I'm by profession reluctant to disclose something I've not yet built because there are always some surprises lurking, but the lead-screw drive has been around as long as metal-working lathes have, and in this design there's almost nothing to fabricate. The rest is purchased, so the risk is minimal.

This drive gives us a separation of choices; we choose the travel of the nut to get our "gear" reduction and then select the ratio of the bell-crank arms to get the desired length of stroke of the flapper links, and go back and forth until we have the best combination possible as indicated by the actual flights. We are not stuck with the initial choice. This design permits the kind of experimental activity we ornithopterists thrive on.

Reduction:

With a 20-thread/inch screw, if we want one flapper cycle to take place with 40 turns of the motor, a 40:1 reduction, we will use a 1" travel of the nut, 20 turns each way, for a 40-turn nut travel cycle. For a reduction of 50:1 we use a nut travel of 1.25", etc. We can fine tune the reduction to less than one thread at a time with the toggle reversing screws.

Connecting Rod Stroke:

If the nut stroke is 1" and you want an output stroke of 1.5", make the ratio of the arms of the bell-crank 1.5:1, etc. This drive eliminates the flapper phase shifts that are unavoidable with the usual crank drive.

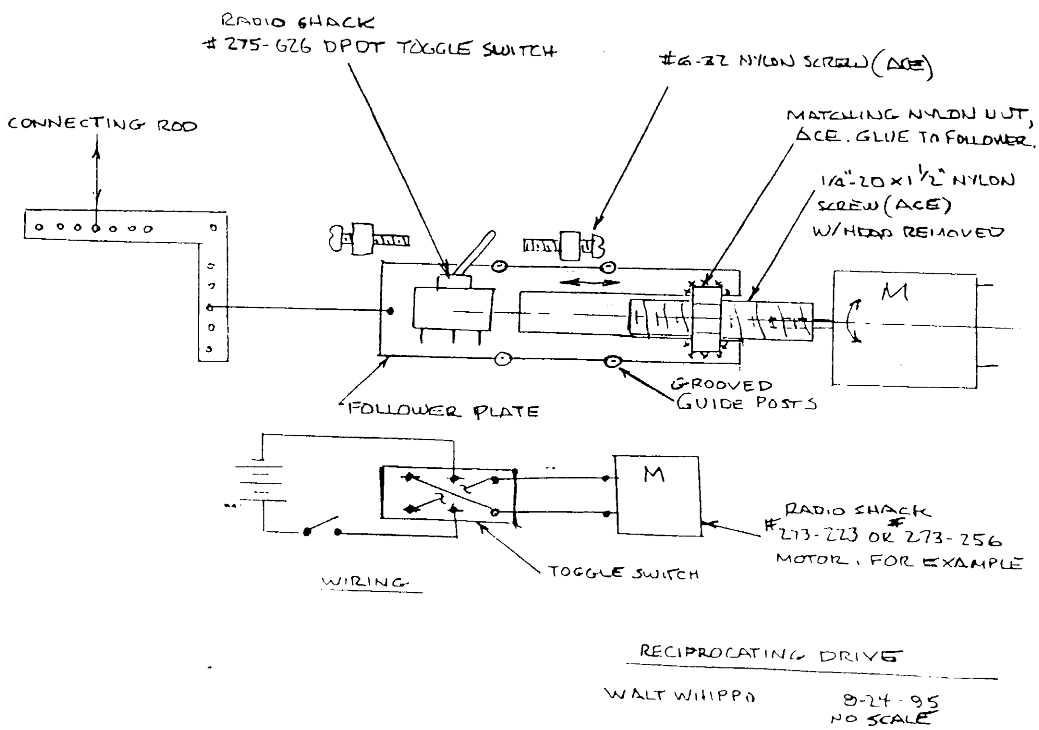
Power:

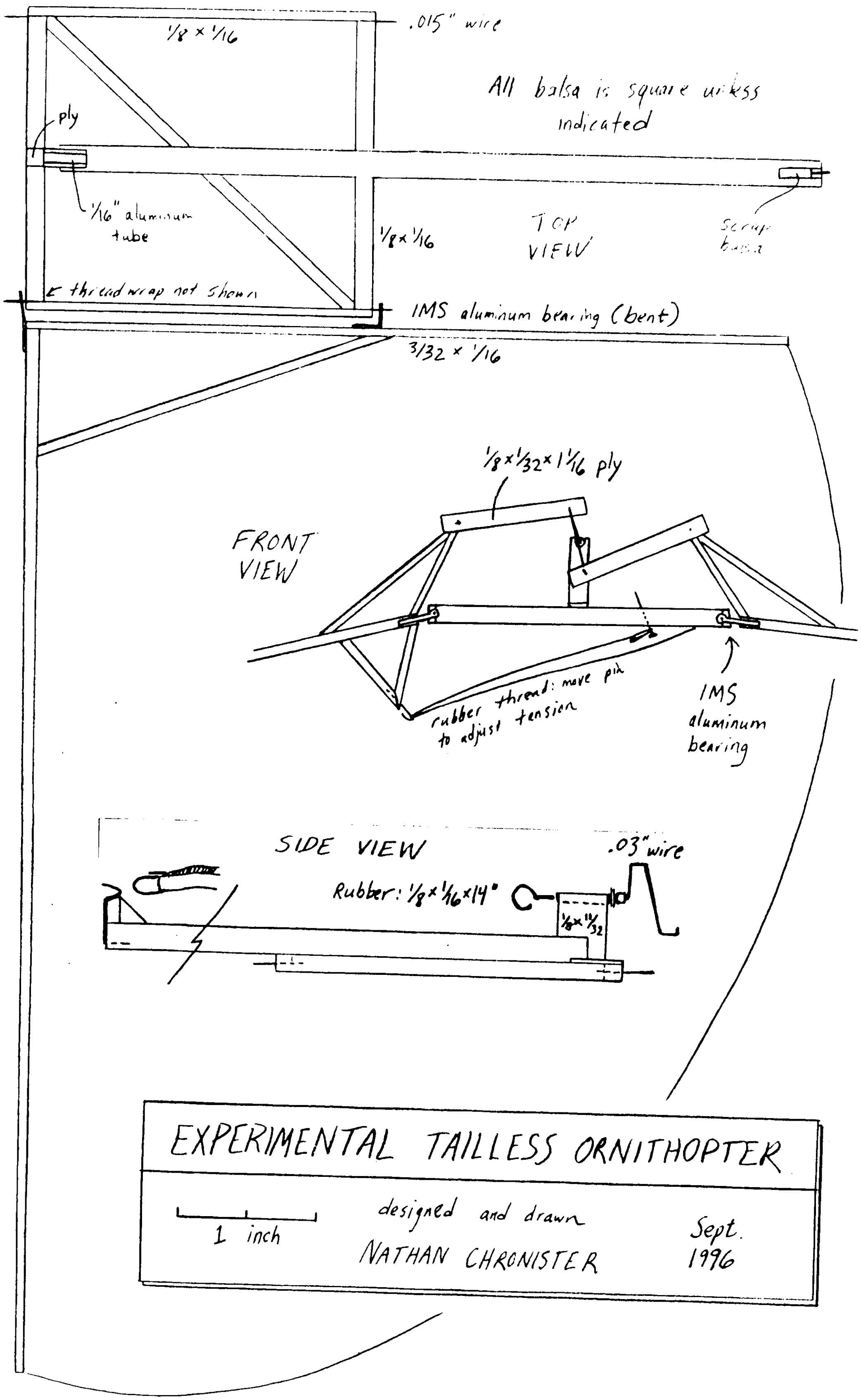
The only other choice you have to make is the power input. The suggested motors are low-cost, so I don't mind abusing them. The smaller one, 273-223, is rated at 3 volts, and I don't hesitate to drive it with a 9-volt rechargeable battery, also from Radio Shack. This battery, consisting of 6 nicad cells, actually measures 7.2 volts (doesn't anybody tell the truth any more?). For the 273-256 motor, rated at 18 volts max., I would try 3 "9-volt" batteries for an actual 21.6 volts. This motor can happily draw 2 amps and give you about 40 watts of initial power, if you adjust the drive train (shorten or lengthen the nut stroke, change the bell-crank ratio, or both) until you get that current reading. When the switch is reversed the motor becomes a generator bucking the battery, which brakes it to a stop almost instantly for a quick turn-around.

Well, I think I've given you something to play with. I'm sorry I'm not advanced enough in my learning phase to use this drive right now; I'm still a raw beginner in ornithopters. I'm building wing variations for the Free Bird, which is the most satisfying outdoor ornithopter I've built so far. I'll be comparing several configurations, aspect ratios, structures, strokes, airfoils, etc., so I will have some experience when I get to the Big Electric Bird I'm looking forward to.

I have an engine-powered variation of this drive in mind also and I'll share that with you soon if you don't beat me to it.

Walt Whippo





EXPERIMENTAL TAILLESS ORNITHOPTER

1 inch

designed and drawn
NATHAN CHRONISTER

Sept.
1996

New Photos of P. H. Spencer's Orniplane and Seagull