SUMMER 2017

Flapping Wings

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She's Got Leg Feathers!

The use of 3D modeling to understand aerodynamics of early flight

by Savannah Peters, supervised by Dr. TA Dececchi with the assistance of Dr. Rival and Kaley Sheppard in the hydrology lab at Queens University, Kingston, Ontario.

Powered flight is a major locomotor novelty that has only occurred three times in the 500+ million-year history of vertebrates: in birds, bats and the extinct pterosaurs.

Cretaceous paraves and aves, thought to bridge the dinosaur-bird gap, while present in the fossil record, are rarely preserved with perfect feather arrangement. Recently a series of taxa have been discovered possessing long feathers not only on their forelimbs but on their hind limbs as well. It is most likely that these early birds had ground-dwelling ancestors who eventually took to the air, and there are several theories as to how this occurred. These interpretations raise questions on the origin and function of the hind wing.

Here we present work seeking to test the aerodynamic implications of having a set of feathers on the hind limb to better understand how flight first appeared in the ancestors of modern birds. 3D-printed models were created for two key taxa (Microraptor and Archaeopteryx) along this transition and incorporating mechanisms to permit a flapping flight stroke to mimic how these organisms likely flew. [A motor/gearbox and ESC were donated under the Ornithopter Society grant program. *Thank you for your support!*]

The models were then run in Queen's Optical Towing Tank to examine the effects of drag and vortex shedding in our models based on the addition and variation in dimensions of the hind limb feathers. After errors in printing and several issues with the bodies, we were able to test one, stationary model of Microraptor, which revealed that the hind leg did add lift. We hope to continue this study, improve the bodies to allow flapping, and continue to work on improving the 3D printed model.

This work is a major step forward in testing the hypothesis about the adaptive nature of this unique feature and helps better understand how and when flight first arose in the lineage leading to birds.

Microraptor fossil showing elongated feathers on the front and hind limbs.

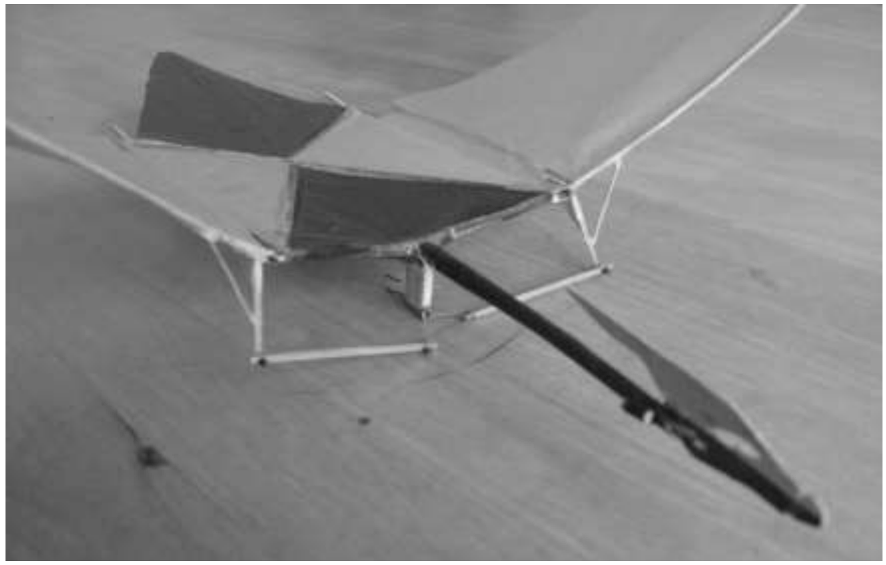
Pterothopter Plan

by Colin Taylor

The Pterothopter is a unique rubber-band-powered ornithopter. The fundamental design feature is that the wing hinges are skewed nose-up about 8 degrees. This gives the wing some fore and aft motion as it flaps. That helps keep the body level and reduces drag. Test models have all flown well under power, and they glide quite well too, but they tend to zoom and stall as the motor runs down. Putting some ballast up front helps, and putting it at the end of a long lever saves weight. That is what led to the pterosaur configuration.

Make the wing spars from split and shaved cane or bamboo. They are as thin as you dare, to save weight: 1/16 inch at the root and 1/32 at the tip, bent by warming on a soldering iron. The drooped tips are best achieved after assembly. Don't set fire to the kitchen!

Make the centre section spar from three pieces of 1/8 balsa. Then construct the centre section *upside down* on the plan to ensure the hinge pins are parallel and correctly oriented when the centre section is fitted to the motor stick. The wing hinges are made from rolled paper tube on a pin or carbon rod mounted in 1/64 ply tabs. While the centre section is still on the plan, add the gussets, hinges, and the wing spars. The wing ultimately has 10 degrees of



Pterothopter design by Colin Taylor.

mean dihedral. So, with the wing spars flat on the board, add the actuating levers with 10 degrees of inward tilt and 10-15 degrees of forward tilt. (One lever needs more forward tilt than the other). Reinforce with two plies of tissue where the tabs attach to the centre section and the paper tubes and levers attach to the wing gusset.

The motor stick is hollow and made from a sandwich of 1/32 balsa. Make the crank and bearing tube from 25 SWG wire and brass tube with two washers. Attach the crank tube and rear hook with epoxy and reinforce with three plies of tissue. Note that the wing hinges and the crank bearing are *not parallel* so there is some lost motion in the mechanism and it will only work if there is slight play in the pushrods. When finally attaching the centre section to the motor stick, make sure the pins on the ends of the levers align with the corresponding parts of the crank and that there is no interference between the crank and the pushrods. The pushrod retainers are from plastic insulation.

Make the hind legs and tail on the plan and attach to the motor stick with the correct incidence. The head and neck is a push-fit using 1/32 cane. The covering is Japanese tissue attached with Pritt dry adhesive. The wing tissue joins the centre section at the rib with the wing fully down. To allow for the fore and aft motion of the wing, the tissue is creased inboard of the rib.

The motor is made from two loops of tan rubber 24 x 1/8. The loops are threaded through two small wire rings and the motor is wound on the bench and then transferred to the model. Tricky! 250 turns gives about 40 secs of flight indoors. To make the model turn, add a tiny bit of weight to a wingtip. If it zooms and stalls, add weight to the nose.

Project Firebolt

by Michael Jensen

Nathan has asked me to write a short piece for this newsletter. He has very kindly sent me the Iron Bird [developed by Francis Reynolds and described in the previous issue] so that I can study it, with the objective of eventually giving my own vehicle a means of propulsion via flapping wings.

My project is a rather ambitious one. An aeroplane controlled like a surf-board. A flying surf-board. Most people I show it or describe it to decide to call it a hover-board. Except it doesn't look like a surf-board anymore.

The design evolved to the point where the fuselage began looking more and more like a bird, and then I realized that handles for the pilot to hold (or not), could be introduced as spikes. I was already thinking about dragons, but the spikes definitely solidified the design. I am now in assembly, attaching the spars to the central fuselage section, using the reality of that process to assist me in finalizing the design. Hence small changes to the design are being made on a constant basis. I fully expect the vehicle to be completed and fly within a few months.

Currently I am building a 3/4 scale model, 24 feet wide. The full size version should lift somebody about half my weight flying at around 10 m/s, or somebody my weight at 15 m/s. It's an amateur construction, mostly wood and glue. I have an undergrad in physics, and a research-based masters in mechanical. I've taken courses in aerodynamics and flight mechanics, and have modelled this vehicle in

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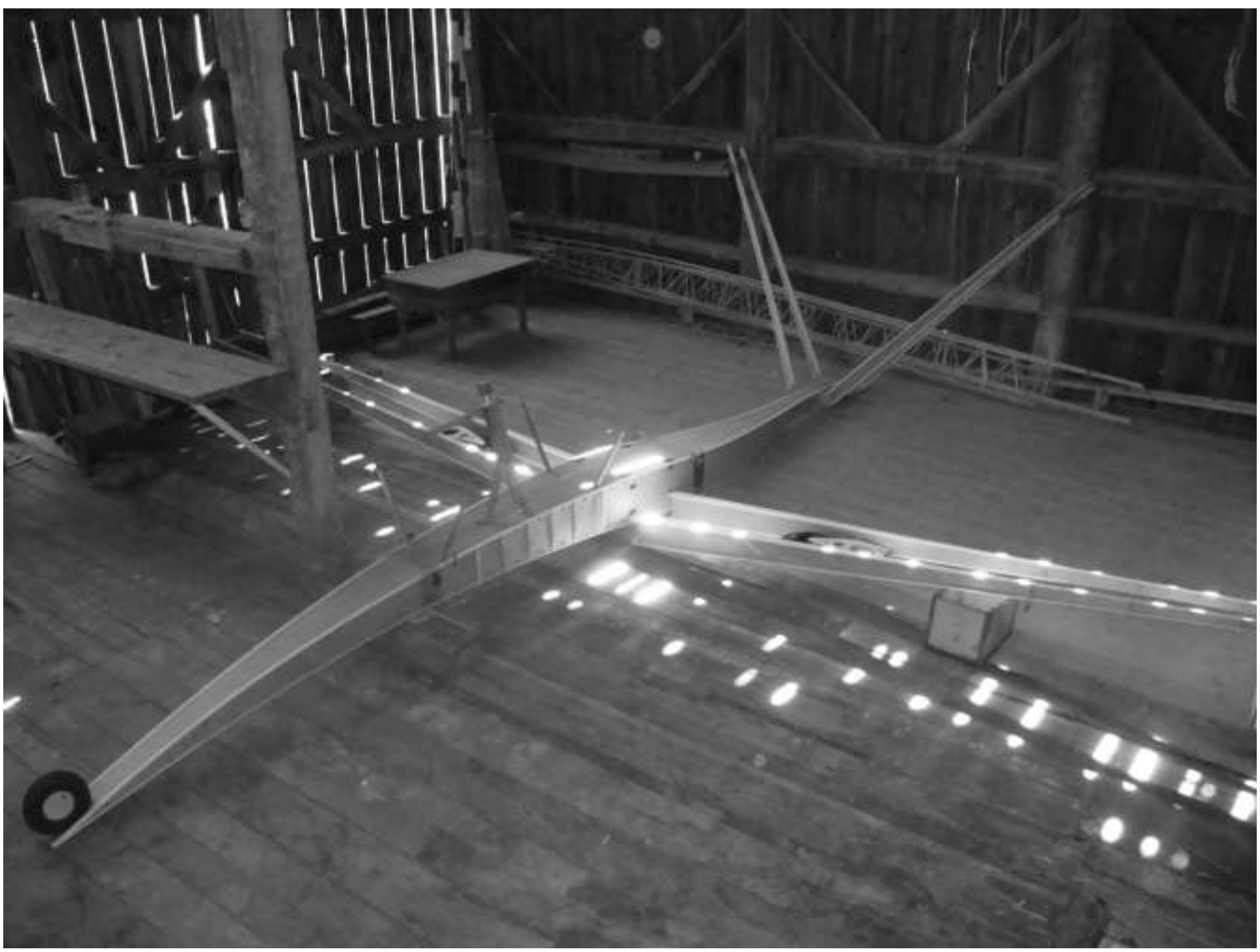


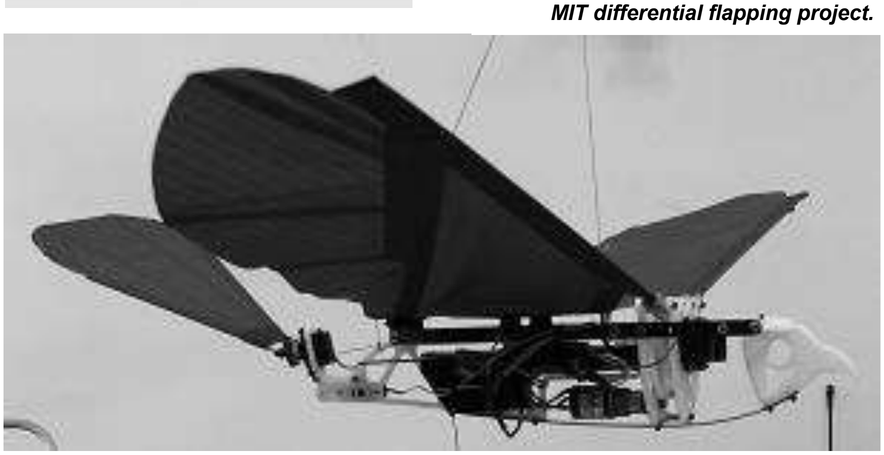
Bat Bot

Researchers at Caltech and the University of Illinois have teamed up again to develop the “Bat Bot”, a self-contained bat robot with soft, articulated wings. The platform aims to study the flight specialization of bats, including their versatile dynamic wing conformations, as well as more than 40 active and passive joints.

Differential

A project at MIT involving Rick Cory, Zach Jackowski, Gui Cavalcanti, and Russ Tedrake has produced an ornithopter with differential amplitude flapping. This mechanism allows for quick turning and agile maneuvering. The ornithopter made a brief successful flight, despite some stability issues. It appears that the differential flapping mechanism does not always maintain the correct “average dihedral” during flapping. The design used a brushless motor to power the wing flapping, two servos to control the flapping amplitude (one for each wing), and two servos to move the tail.

MIT differential flapping project.



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XFLR5. So I'm not an engineer, not yet, but I know enough that I feel quite confident! There remains to do, of course, extensive testing.

If anybody out there thinks this all sounds fabulously exciting — think of the flight scenes from *How to Train your Dragon 2* — I would be very interested in hearing from you! Have you heard of the X-prizes? The purpose of an X-prize is to find, quickly and anywhere in the world in a really cost-effective fashion, the people you really want to work on projects with. I think of this as my own X-prize. Once it flies, I'll be posting videos of it online, and inviting participation in the project! So consider this something of a pre-call to the select audience of the most awesome, the Ornithopter Society!

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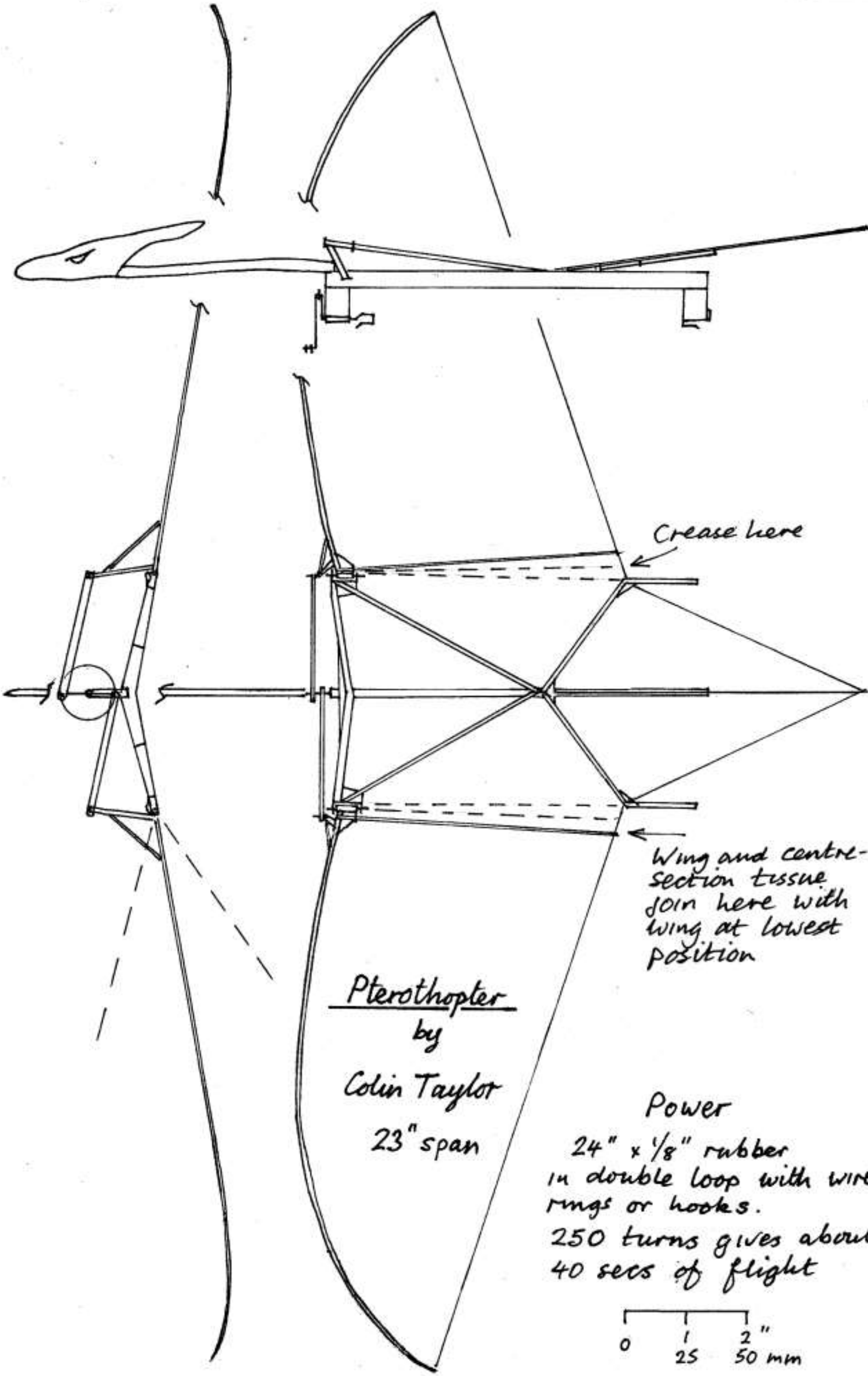
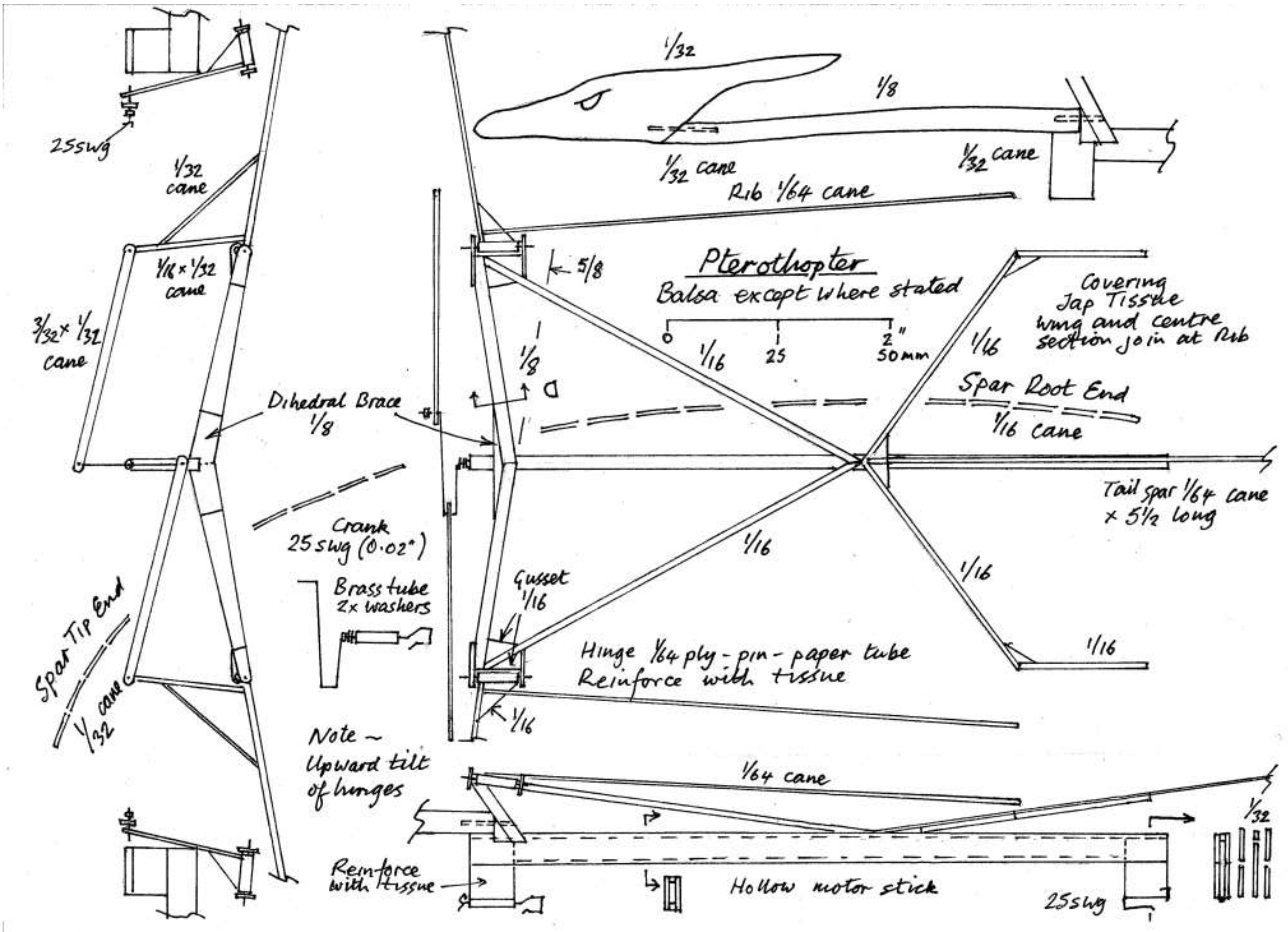

Crease here
Wing and centre-section tissue join here with wing at lowest position
Pterothopter
by
Colin Taylor
23" span
Power
24" x 1/8" rubber in double loop with wire rings or hooks.
250 turns gives about 40 secs of flight
0 1 2"
25 50 mm


Pterothopter
Balsa except where stated
0
25
2" 50mm
Covering Jap Tissue
wing and centre section join at Rib
Spar Root End
1/16 cane
Tail spar 1/64 cane × 5½ long
Rib 1/64 cane
1/32
1/8
1/32 cane
1/32 cane
5/8
1/8
1/16
1/16
1/16
1/16
1/16
Gusset 1/16
1/16
Hinge 1/64 ply - pin - paper tube
Reinforce with tissue
1/64 cane
Hollow motor stick
Reinforce with tissue
25swg
1/32
Note ~ Upward tilt of hinges
Crank 25 swg (0·02")
Brass tube 2x washers
Dihedral Brace 1/8
25swg
1/32 cane
1/16 × 1/32 cane
3/32 × 1/32 cane
Spar Tip End
1/32 cane