Flapper Facts

Newsletter of the Ornithopter Modelers' Society

Winter 1997

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Announcements

Before you become too engrossed in reading this issue of Flapper Facts, I'd like to call your attention to my new address (above). Keep an eye out for further changes, because I am currently working on a one-year internship with Americorps and will be moving again at the end of December.

The OMS web site has moved also. OMS founder Patrick Deshaye has kindly offered a home for the page until I get back on line. The new address is http://www.earthlink.net/~pazuzu/orn.html. If you're wondering what Pazuzu is, you can check out Patrick's home page (by leaving out the orn.html) and find out all about it. Another web site that may be of interest is http://www.aero.kyushu-u.ac.jp/ornithopter/homeorni.html. Reportedly, they have some animations based on computer models of dynamic stall (i.e., stalling of an ornithopter wing).

A lot of people have expressed interest in the current whereabouts of Jim Theis. Well, I'm happy to announce that he recently joined OMS and can be reached at 475 1st Ave, Zumbrota, MN 55992. Thanks to those who helped track him down and those who sent copies of his articles!

As always, I'm in need of plans and ready-to-print articles for Flapper Facts. I'd especially like to see some plans for indoor models! The increased margins on this and future issues will allow you to collect your Flapper Facts in a 3-ring binder, so please provide margins on any full-size plans you send.

Folding Wings are Here!

Remember the recent folding-wing ornithopter contest in which only one person managed to build a successful entry? Well, just to demonstrate the rapid evolution of ornithopter technology, we now publish plans for 3 successful designs in a single issue! It is ironic that two of these are oldies, but those who believe in progress will not be disappointed when they see the plans for the one recent variable-span design.

Before describing that model, I'd like to comment on the two older designs. One is by Theo Landes. The unusual mechanism produces a backward folding at the shoulder joint during the upstroke, resulting in a reduction of wing area at the "soufflet". The photos seem to show some folding of the outer panel, but no mechanism for this is apparent in the drawings. We might learn more from the accompanying article, but it's in French. (If you would like to translate this or other articles from French or

German, to English, please let me know and I'll send them your way.)

The other design comes from Erich von Holst. Patrick Deshaye and I have been discussing von Holst's unusual designs and Patrick thinks they must be very efficient because they reportedly fly very well despite being heavy. We'd like to hear how they work if you decide to build one, which we think you should. Horst Handler sent pictures of his von Holst replicas (see Fall 1995 issue) but gave no description of their flight.

Finally, we come to the simplest, yet most advanced (in my humble opinion), folding-wing ornithopter of them all, VS1. The distinctive feature of this model is that the wing folding joint is very birdlike; it is located near the middle of the wing, not at the shoulder as in the Landes design, and it folds fore and aft instead of up and down like von Holst's and many other designs.

The difficult problem of how to contract the wing without ruining its aerodynamics has been solved by resolving the wing into two separate plates which overlap when the wing is folded. The overlap is not very tidy, but the model flies and climbs despite this flaw. To eliminate the problem, it would be necessary to use a larger number of plates, which is how birds solve the same problem. Notice that the split par in the inner portion of the wing offers a large amount of torsional flexibility, so the outer panel and nonfolding rib can adapt to the upstroke and downstroke pitch requirements. By bending the two portions of the spar in opposite directions, you can give the spar a built-in twist which increases the wing pitch during the upstroke and makes the pitch less negative during the downstroke.

The folding mechanism, like the panel system, is imperfect but effective. As the wing nears its downward extreme, the flexor cable (made of sewing thread) becomes taut and folds the wing. In the late part of the upstroke, the extensor cable acts in a similar way to re-extend the wing. Midstroke, the cables are slack and we rely on Newton's first law to keep the panels where they belong. If you cut one of the cables, you'll see that the wings don't quickly extend or contract on their own. The normal folding action is too fast to see unless you hold the model up to a window, backlit, and view it from the top or bottom. The limit cable simply prevents over-extension of the wings, and must be adjusted to meet this requirement. To adjust the other cables, move the wing to its extreme position and pull the cable tight, but not too tight. Notice that the flexor cable passes through a cut-out in the wing tissue. Reinforce this and other tissue stress areas.

Real birds have their own version of this system. They extend their wings in the later part of the upstroke, as in this design, but they don't fold their wings until the beginning of the upstroke, not in the late downstroke as in this design. It wouldn't be very difficult to do it the bird way, but it would require getting into the flapping mechanism. The flexor cable could be driven from the crank with any desired phasing. However, I'm not sure it would be worth the effort. VS1 flies almost as well as the stock Tim Bid, and the appearance in flight wouldn't be changed much by the above refinement.

How birdlike does VS1 appear in flight?

Since it is rubber-powered, the upstroke is so fast that the folding makes little difference in the overall visual impression. However, the use of this design in an electric or biplane model would yield a much more birdlike motion, with an upstroke slow enough to see.

The inevitable asymmetries of construction and Tim Bird's asymmetric flapping action will prevent this model from flying straight with the flat Tim Bird tail. If it doesn't fly straight, it won't maintain its altitude. I solved this problem by constructing a very light V-tail using the original tail joint, bamboo, and tissue. VS1's longitudinal stability is somewhat power-dependent; you can fly it short distances with only a vertical stabilizer if the CG is right, but the ever-decreasing output of the motor eventually results in a stall. Notice that with too much power, the tailless model nose dives.

I think this model is a great step toward more accurate imitation of the avian flight stroke, for never have the overall movements of a bird's wing been so faithfully duplicated. However, in many of the details there is much room for development. The most obvious need is for a more aerodynamically efficient panel system, but it will be difficult to accomplish this without excessive friction. The previously mentioned change in the timing of wing folding is another step. Finally, one might wish to experiment with more complicated wing skeletons, incorporating an elbow and carpal joint in addition to the wrist joint. Of course there are also the quantitative refinements that can be made to any model: getting just the right amount of wing area or wing twist, just the right angle for the wrist joint folding, etc. If you enjoy the many complicated challenges offered by ornithopter modeling, folding-wing models are for you.

Toward the Full-Size Ornithopter

G. Chaulet

Innumerable articles have been written about the possibility of building and flying a man-powered ornithopter. We all have seen the sketches drawn by Leonardo da Vinci at the beginning of the 16th century.

Before the Wrights, numerous inventors have proposed flapping machines which were supposed to take off and move in the third dimension. This was achieved only by small rubber-driven artificial birds. [Editor's note: Actually, other power sources were also successfully used in ornithopter models in the 19th century.] The man who had the genial idea to use a rubber band to provide energy was the French Alphonse Penaud. We modelers owe much to this inventor.

After the successful aeroplane and helicopter developments, the human engine appeared to be perfectly unuseful. Nevertheless, a bright demonstration of the muscular possibilities has been illustrated by [Paul MacCready's] Gossamer machines. And this may have given some impulse to the idea of making some form of human-powered ornithopter. The idea is quite simple: that we can do as well as birds, and also that what has been done with an airplane can be done with flapping wings. The last issue of Flapper Facts reports the efforts of the Japanese toward such craft.

Now let's think SERIOUSLY. Motorized airplane models have been flying for a century or so. Engined RC ornithopters are just starting. Full size planes have been flying for 93 years. There are no full-size ornithopters flying yet.

This means that we are facing a problem which is terribly difficult to solve. Now, when you have something very hard to do, what is the best approach? Use the most efficient means, or the least appropriate? If we have to cross the Atlantic swimming, shall we have the help of an air-filled lifebuoy, or a big piece of lead?

Around 1936, the problem of the helicopter was as difficult to solve as is by now the ornithopter problem. Louis Breguet, who had flown a primitive helicopter (the first one) in 1907, resumed his work. Did he choose a pair of calves to power his rotorcraft? No! As he was not completely stupid, he rather used a 350 HP engine. And his helicopter flew. No doubt that fitted with a human engine, the helicopter would still be on the ground.

Now if somebody wishes to fly with an ornithopter, he has to use the best components, but also an appropriate engine. That is, something which will provide at least 200 HP. Trying to fly AT THE SAME TIME an ornithopter and a muscular machine is pure craziness.

Tailless Plans

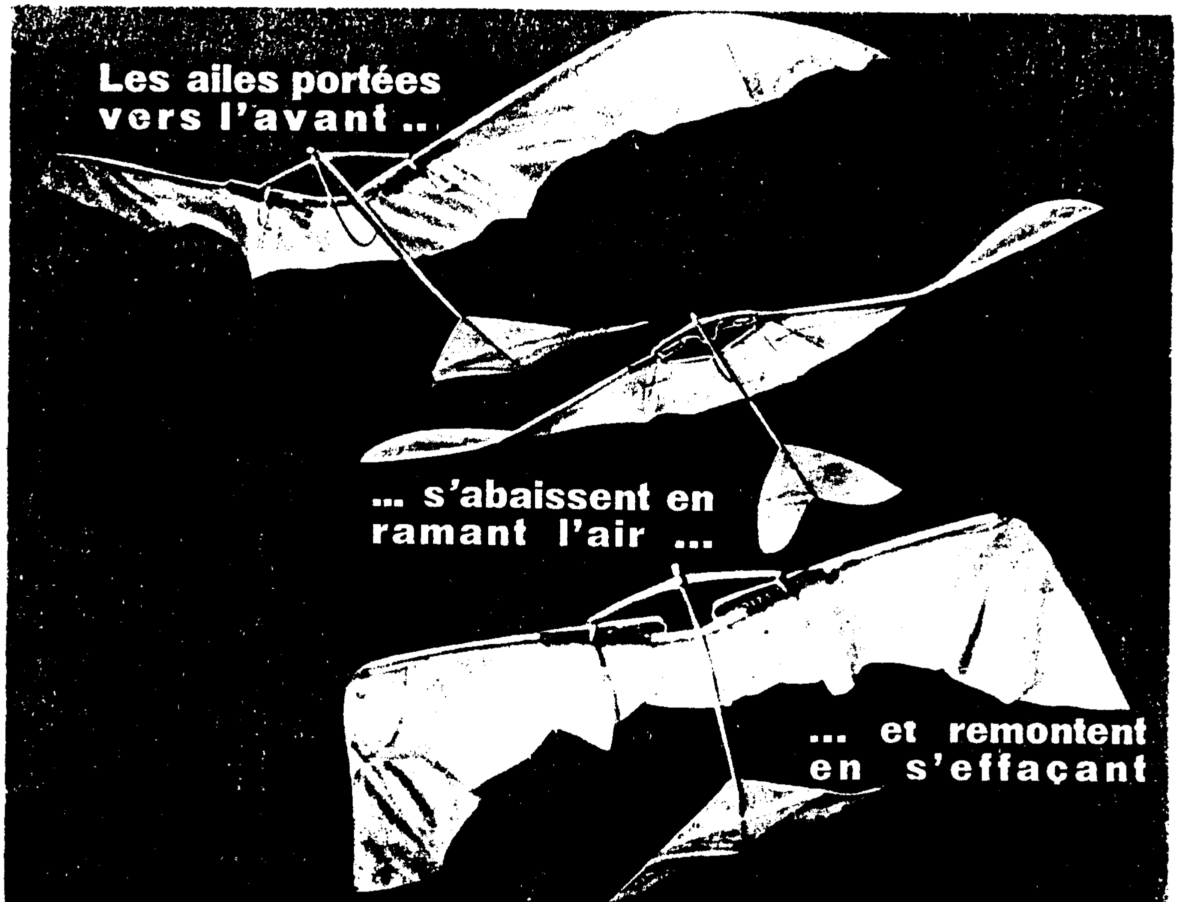
In this issue are plans for two tailless ornithopters. One is a biplane by Sid Davidson, and the other is a Tim Bird conversion by the editor.

Sid Davidson's Tailless Biplane

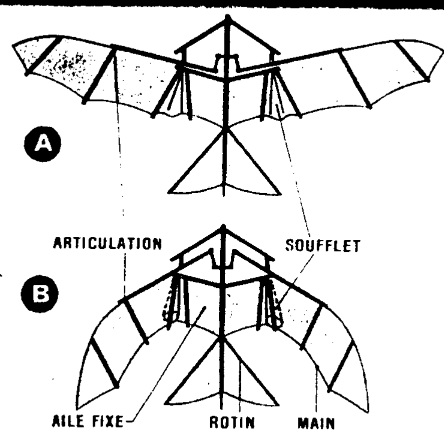
This model derives its stability from a center section that has a reflexed trailing edge. This is adjusted in much the same way as a tail boom. Davidson says it is important to adjust the center of gravity so that it is exactly below the center of lift or the model will not fly. The swept-back wings help locate the center of lift above the CG. The plans show a thin rubber strand to assist the downstroke; this should be beneficial, but it has not been tested. Davidson recommends: "Please, no beginners should try this ornithopter, and only the experimentally inclined, as it is a pain in the [butt] to adjust."

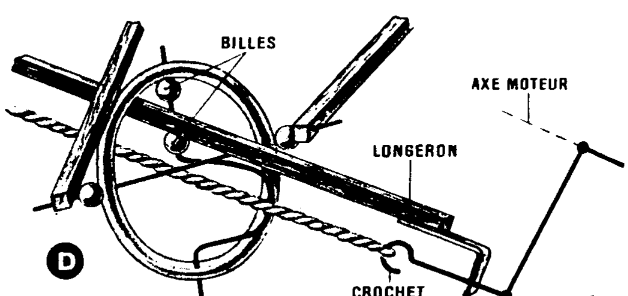
Tailless Tim

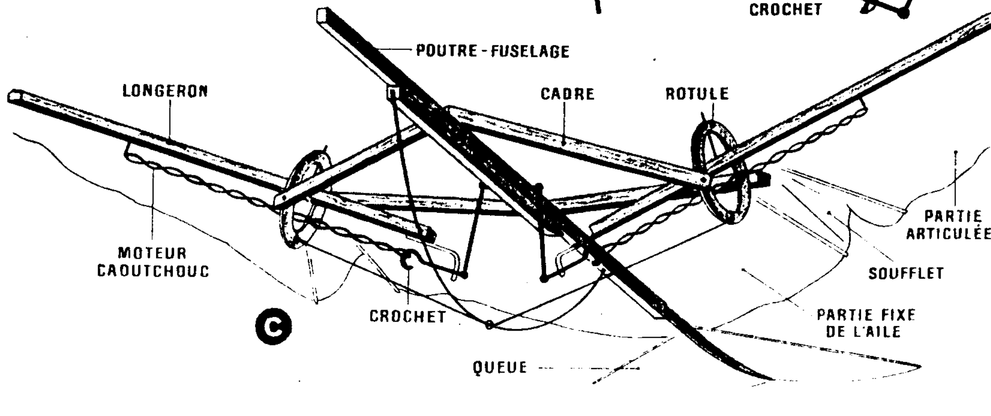
Somewhat less painful is the simple Tim Bird conversion for tailless flight, although it isn't fully tailless because it requires a vertical fin. The secret lies in the downward-curved spar, which gives the wing a built-in twist. That is, the average pitch is higher in the outer portion of the wing than in the inner portion. Somehow this allows the model to fly without a tail. It might also improve the rate of climb (when used with a V-tail), but it's hard to tell so I'll leave that to your own judgment. I curved the spar by splitting it down the middle and then gluing it back together with the curve held in. Instead, one might boil the spar in water for a while, mount it on a curved surface, and then bake it dry. Try to match the curvature shown on the plans, but it is more important that the two wings match each other.



LA MOUETTE DE M. THÉO LANDES : A et B représentent les positions extrêmes des ailes, en avant et en arrière. C donne une vue perspective de la carcasse et du mécanisme : les longerons, entraînés par la détorsion des caoutchoucs, tournent autour de leur rotule respective comme des rames autour de leur tolet. On voit en D le détail d'une rotule.







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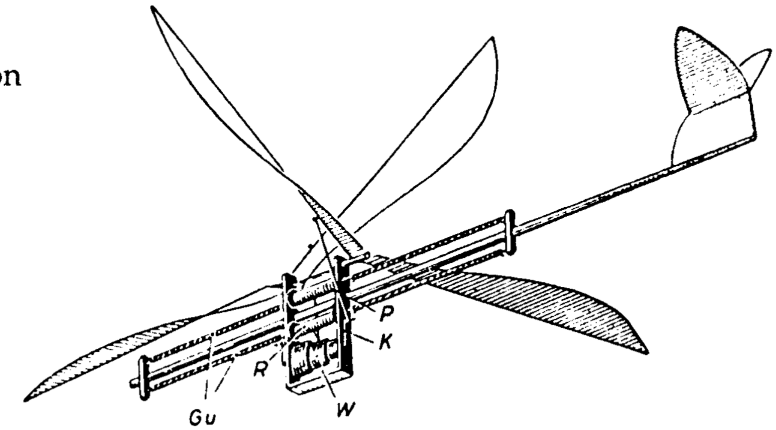


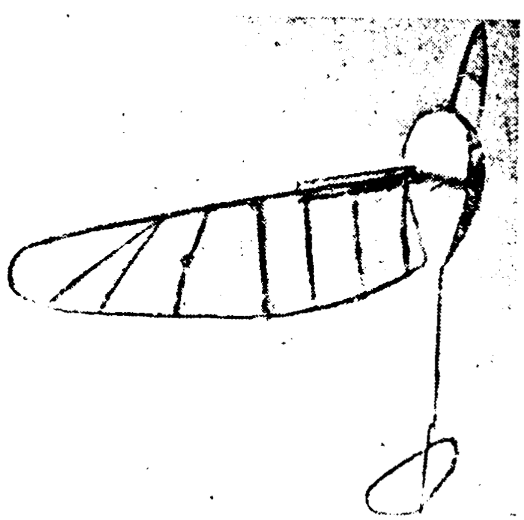
Fig. 10.—Dragonfly and its mode of power. Gu = rubber motor. R = thread roll. W = stepped roll plate. K = Crank. P = connecting rod. This is the Eric V. Holst design.

Ornithopters of E. v. Holst

Dr. Erich von Holst studied for many years the flight of insects and swallows. In 1939 he built a model insect to prove his observations. The model had a span of 35 cm. and the low weight of 7 grams. The model was constructed from straws, sewing silk and tissue paper.

In spite of the small rubber motor a height of 2 metres and a duration of 44 seconds was obtained.

In 1940 von Holst built a Dragonfly (Fig. 10). The model had a span of 53 cm., a length of 48 cm. and an A.U.W. of 12 grams. As the dragonfly the model had two pairs of wings, which are turned during the flapping motion. Both wings which have dihedral are on a common axis. Motive power is supplied by a rubber motor which drives the wings via a system of rollers and threads. Through the thread system the one wing goes up while the wing behind goes down. On the other side the action is reversed.



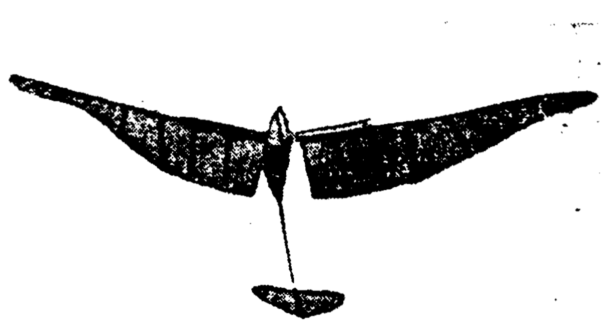


Fig. 11.—The "Buzzard" in a climb and Fig. 12 above, in horizontal flight, see Figs. 13, 14 for more detail.

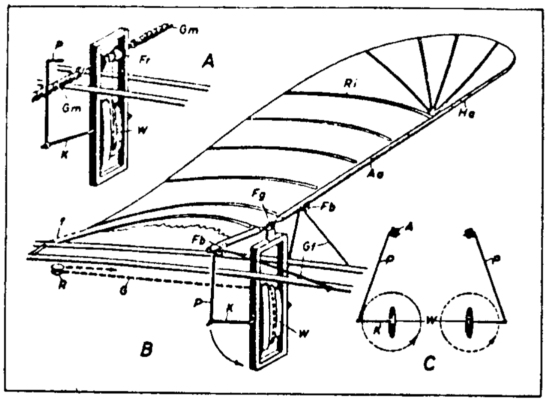


Fig. 13.—Driving mechanism with rubber motor as developed by Prof. E. v. Holst.

E. von Holst's Buzzard (Fig. 11) had an overall length of 45 cm., a span of 97 cm. and a weight of 24 grams. Two stiong rubber motors, one in front of the wings and one behind the wings powered the model. The slinking angle is approximately 45° (Fig. 12).

The most interesting part of E. von Holst's models is the drive mechanism (Fig. 13). The heart of the mechanism (Fig. 13A) is a thread drive, which consists of a stepped or conical foimed reel (Fr) and a stepped eccentric rollplate (W). Because of the eccentricity the downbeat takes place with a larger force than the upbeat. When turning the rollplate (W) by hand the thread is unrolled from the reel (Fr) and onto the plate (W) and at the same time the rubber motor (Gm) is wound up. As soon as the rollplate (W) is released the reel (Fr) is turned by the rubber motor and the thread winds back. The rollplate (W) drives the cranks (K) which in turn drive the connecting rods (P) to the wing halves.

Later von Holst simplified the mechanism, as used on the Swan (Fig. 13B). Here a long rubber strand was led over several rollers (R) in the fuselage. The stretched (not wound) rubber band was taken round the various diameter steps of the rollplate (W). When only slightly stretched the band was brought round the larger diameter and as the tension increased round the smaller diameter. In Fig. 13B the direction of rotation of the cranks (K) is shown.

Fig. 13C shows the section of the connecting rods on the fixing point (A) where small brackets (F6) make the connections. The rubber strands G_t fixed to F_b on the one hand and to hooks on the fuselage on the other half to make the downbeat stronger than the upbeat, as they are stretched both forward and outwards. Only one rib (Ri) is fixed to the L.E., all other ribs are only fixed to the L.E. through the covering. The T.E. of the innermost rib is fixed to the fuselage. Hence the inner wing part is not completely free to follow the action of the L.E. Once flapping, the outer part of the L.E. transmits its action via rib (Ri) onto the outer wing, while the inner wing is kept back. Hence a twist is developed across the span.

Throughout the construction emphasis should be laid upon precision.

Building Instructions for the Buzzard (Fig. 14)

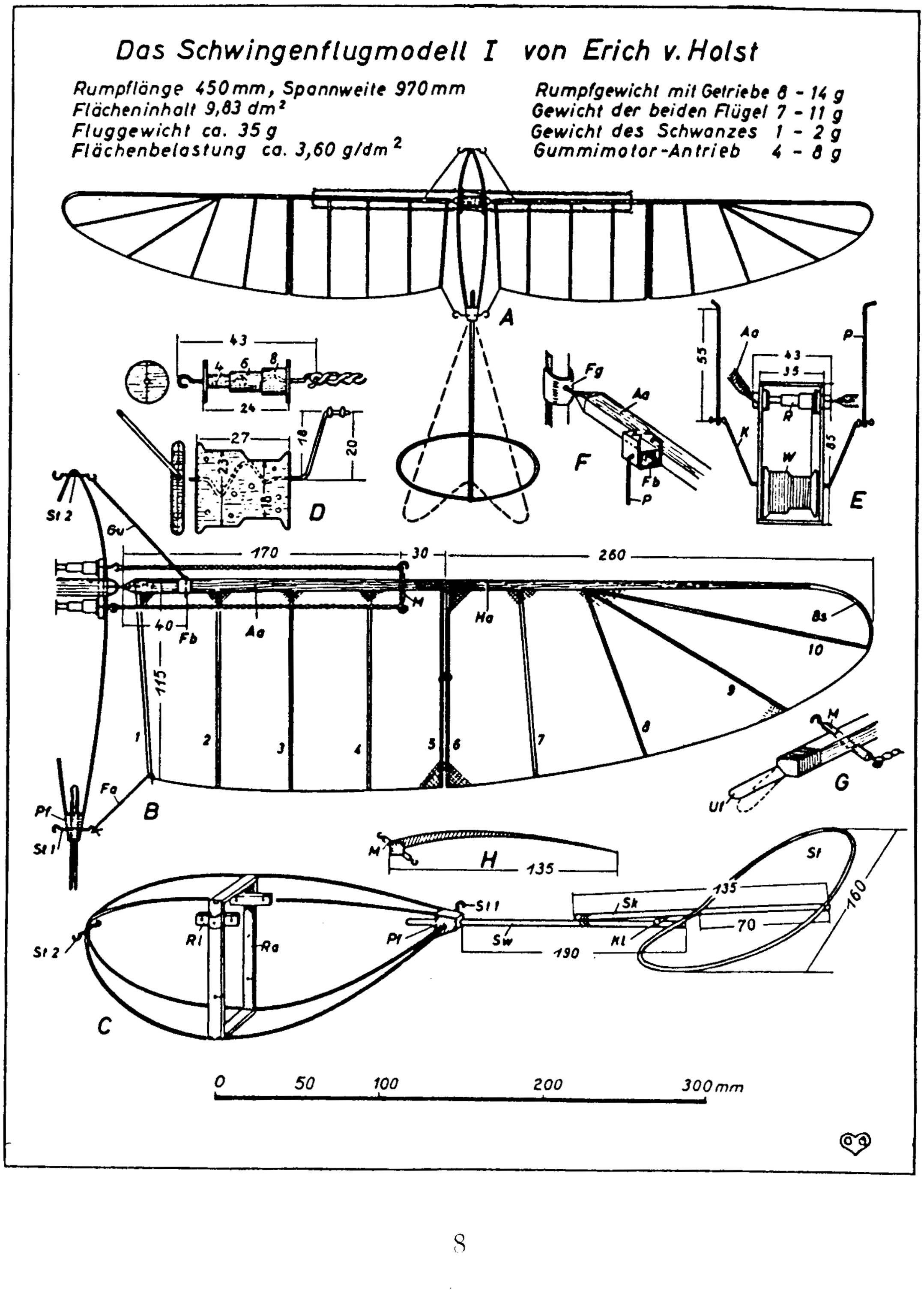
The construction starts with the main former (Ra) of the fuselage, from 7 x 2 balsa. The bearings (R1) for the thread end are made from the same material and cemented at the top of the former on the inside. The two thread reels (Fig. E) have 0·5 mm. dia. piano wire shafts, while the rollplate has one of 1·25 mm. dia. As can be seen in Fig. D the shafts are in both instances zig-zagged inside to prevent any danger of turning and hence the reels and plate are best laminated during their construction of hard balsa. The ends are both reels and the rollplates are reinforced with 0·3.

The rollers and rollplate are pushed into the bearings (R1) which have slits at the top to allow this. After positioning, the slits are filled in with cement

(Araldite or UHU-hart), the rollers and rollplate freed after the cement is dry, and a bearing of properly hardened cement is achieved.

The rest of the fuselage consists of 0·8 mm. bamboo, both ends stuck into small balsa blocks. Sw is made of balsa and Sk from a straw which is bound and cemented to Sw. A small piece of balsa (K1) is pushed between Sw and Sk and fixed with a small rubber band. This allows the angle of incidence of the

Fig. 14.—The "Buzzard" by Eric v. Holst with original German text as published in "Mechanikus" magazine; all dimensions in millimetres.



tailplane Sf to be varied by repositioning of K1. The tailplane outline consists of bent grass or pampas grass, which is formed into an ellipse and cemented to Sk.

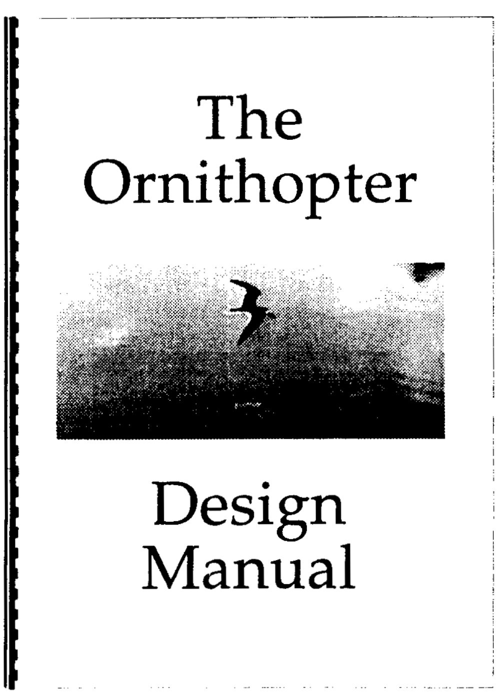
The fuselage and tailplane are covered with Japanese tissue. The wing (Fig. B) has a square spar, which acts as both L.E. and main spar. This is made from balsa and tapered towards the tip. It consists of two parts (Aa) the arm and (Ha) the hand part. Both parts are connected by a 2 mm. wide, 0·25 mm. thick watch spring strip (Uf).

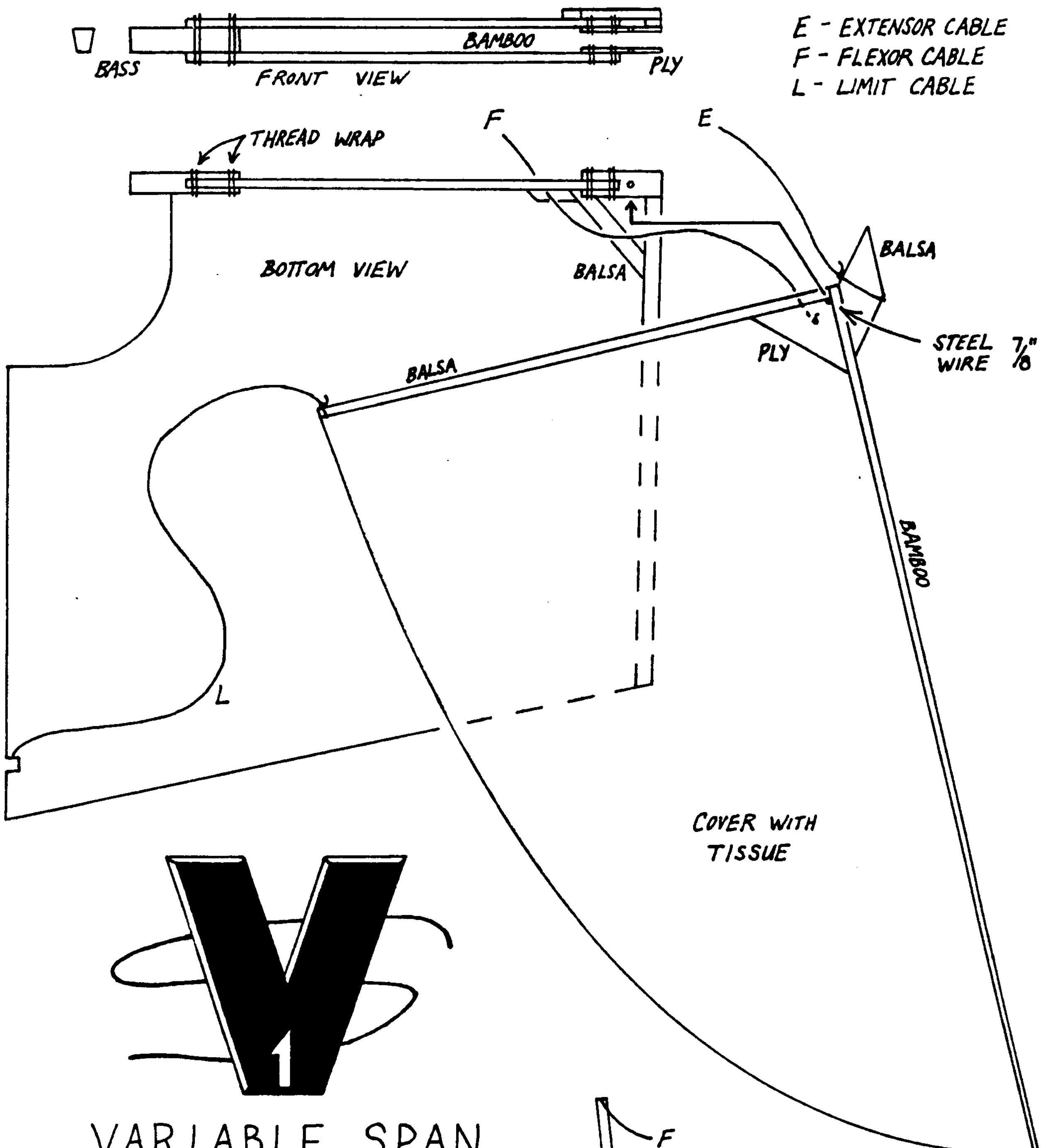
At the shoulder joint the spar is sharpened to a point (Fig. F) and a small piece of piano wire cemented in. This connects into the bearing Fg which is made from tinplate.

The hooks for the rubber motors are fixed to a piece of balsa (M) which runs diagonally from the lower rear surface of the spar to the upper front surface of the spar. The connecting rods (P) are fixed to the spar through a U shaped bearing (Fb) (Fig. F).

The wing ribs 1 to 10, with the exception of 5 and 6, consist of thin bamboo or straw strips and are fixed to the L.E. only by thin gauze strips.

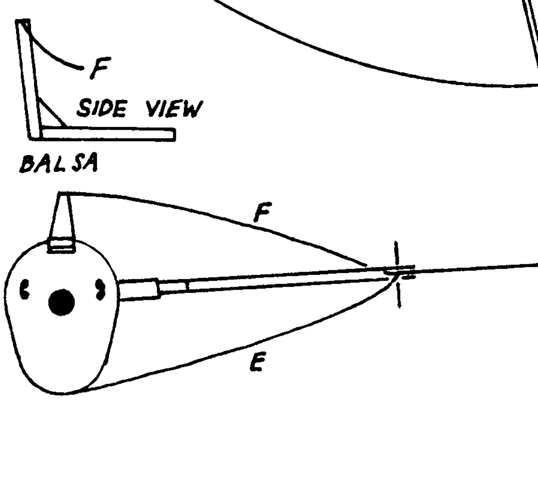
Rib 5 is a 2 mm. thick spruce one cemented to the end of the cross main spar. Rib 6 is also cemented to the L.E. but consists only of a strip of bamboo. Ribs 5 and 6 are fixed together by small S hooks. As the wing will not obtain its proper outline until it is covered with Jap tissue the construction is best done on a jig. After fixing the finished wing to the fuselage it is finally fixed by a rubber band (Gu) between the fuselage nose (St 2) and (Fb) and a thread (Fa) between the trailing edge and (Pf) through hooks (St 1).



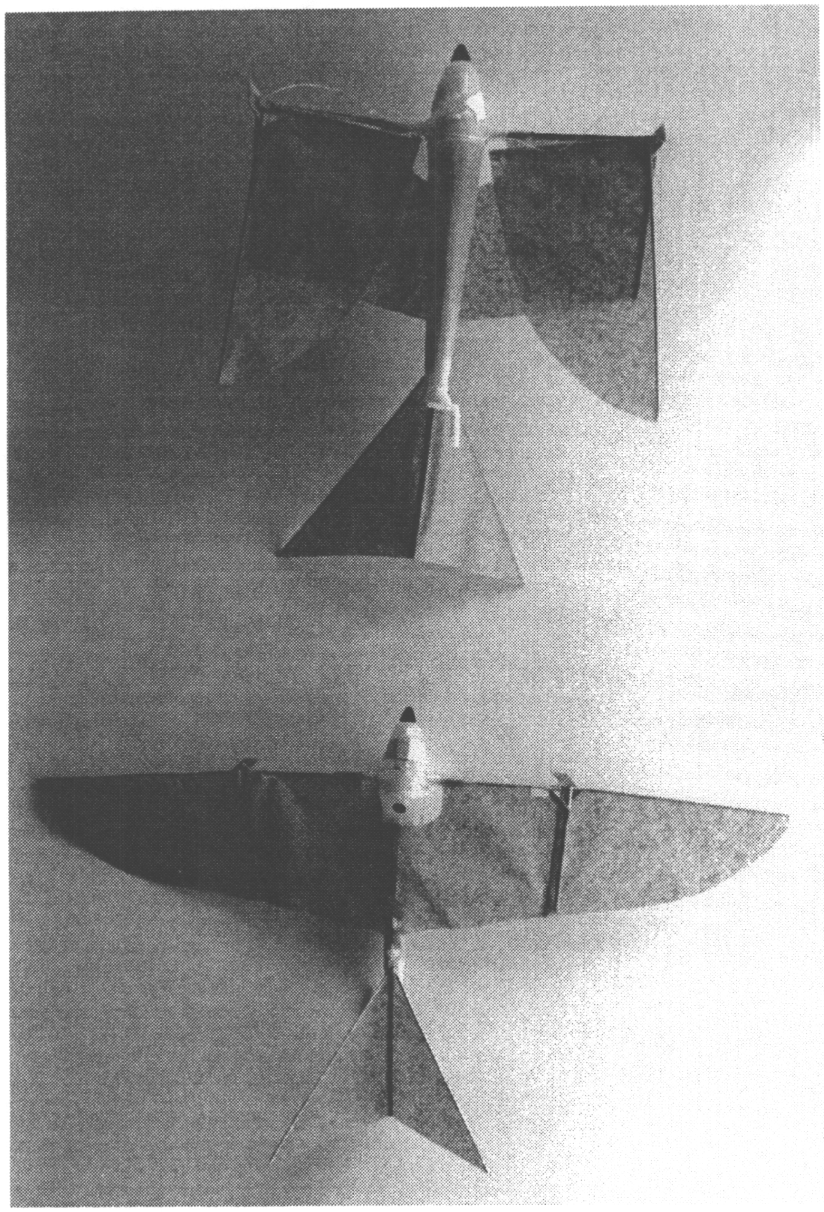


VARIABLE SPAN ORNITHOPTER

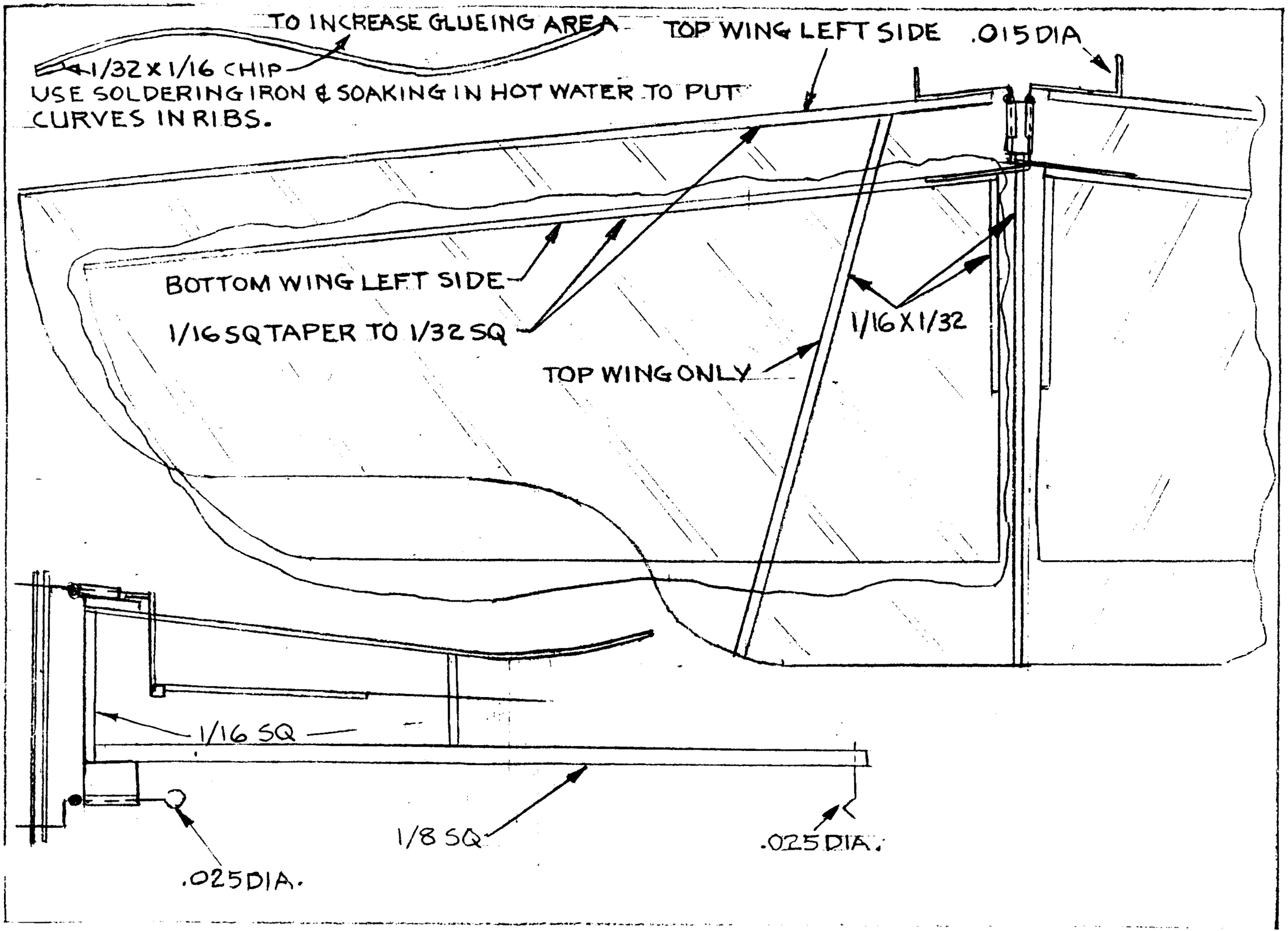
BY
NATHAN
CHRONISTER

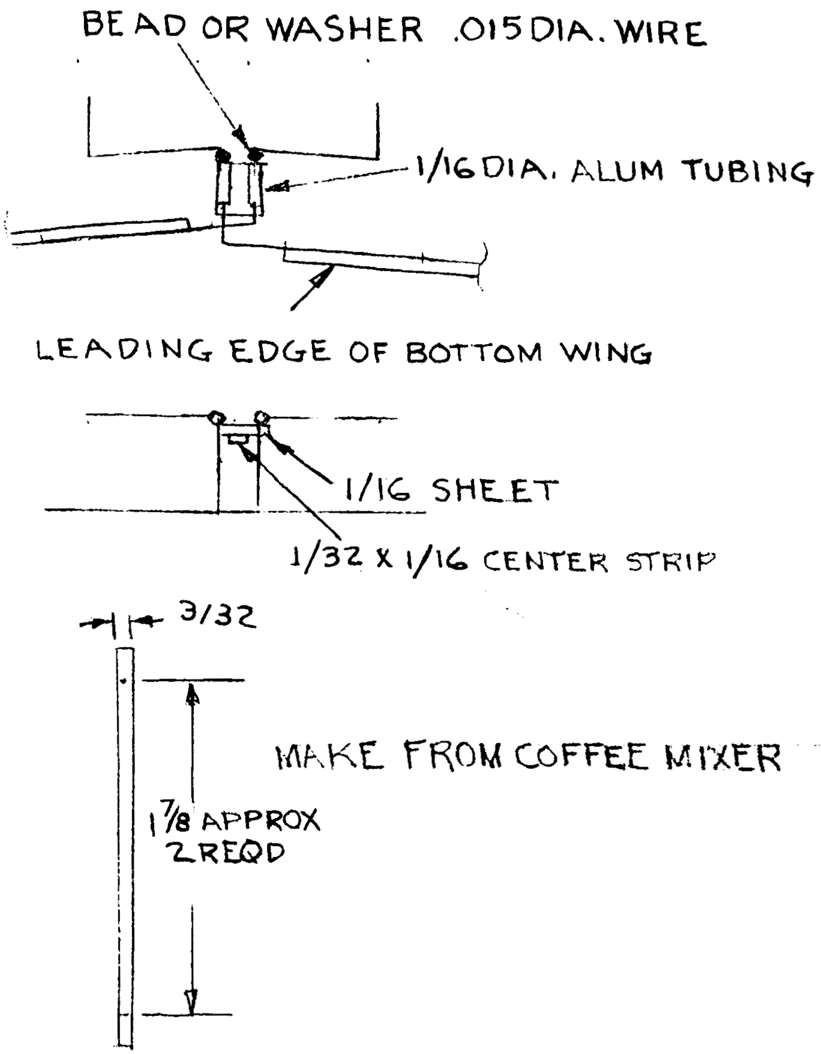


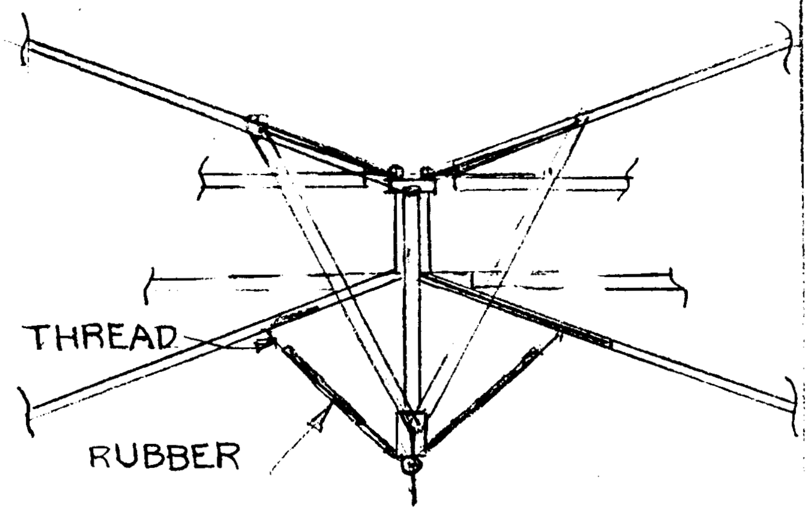
VS1 Variable Span Ornithopter



Two views showing wings folded and extended

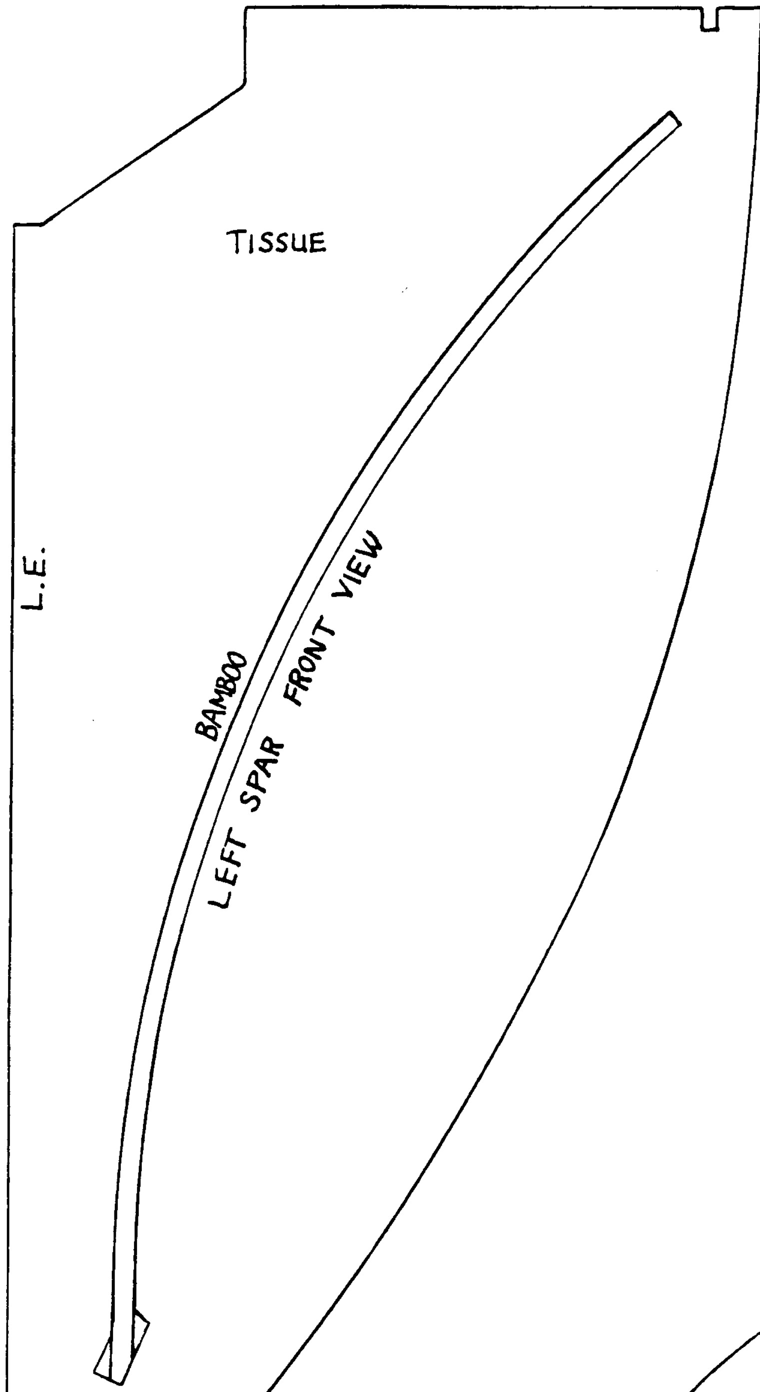

TO INCREASE GLUEING AREA
1/32 X 1/16 CHIP
USE SOLDERING IRON & SOAKING IN HOT WATER TO PUT CURVES IN RIBS.
TOP WING LEFT SIDE
.015 DIA
BOTTOM WING LEFT SIDE
1/16 SQ TAPER TO 1/32 SQ
1/16 X 1/32
TOP WING ONLY
1/16 SQ
1/8 SQ
.025 DIA.
.025 DIA.





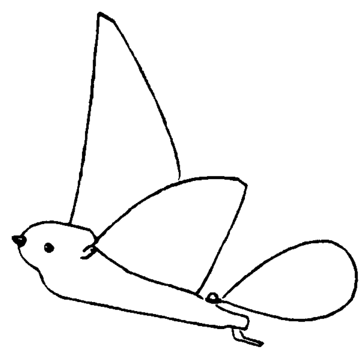
Tailless Biplane

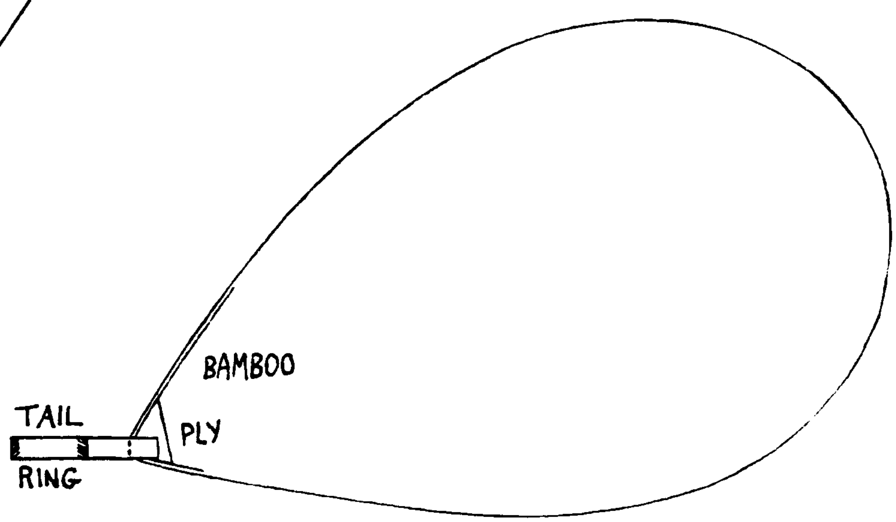
Sid Davidson



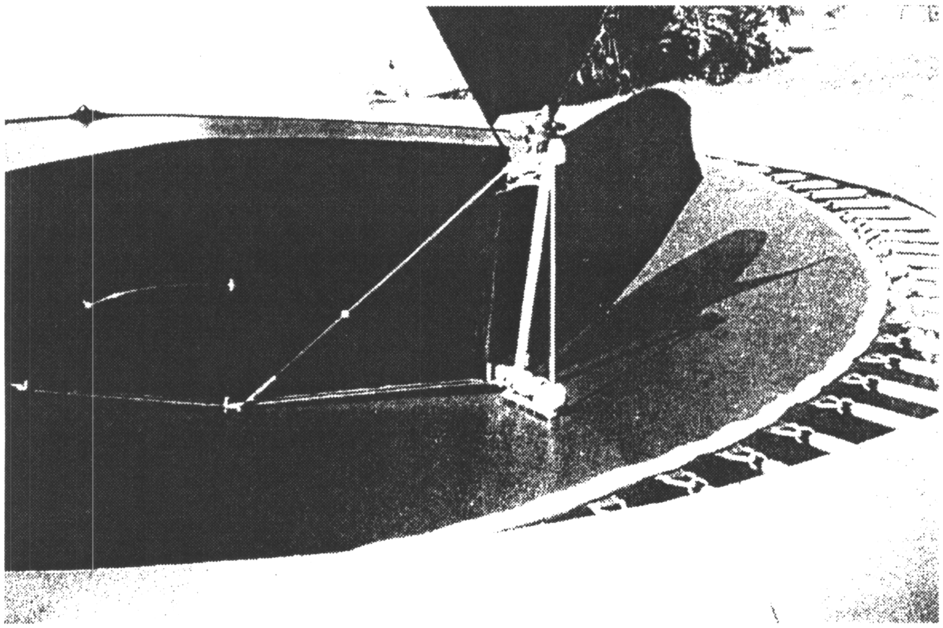
TAILLESS TIM

Nathan Chronister

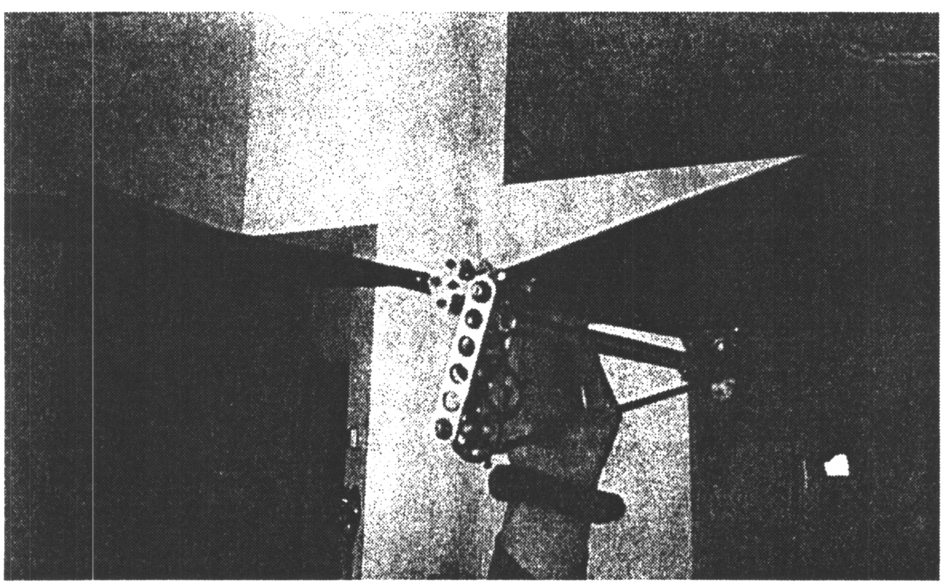




Sean Kinkade .049 Ornithopter
(See Fall 1996 issue for description)

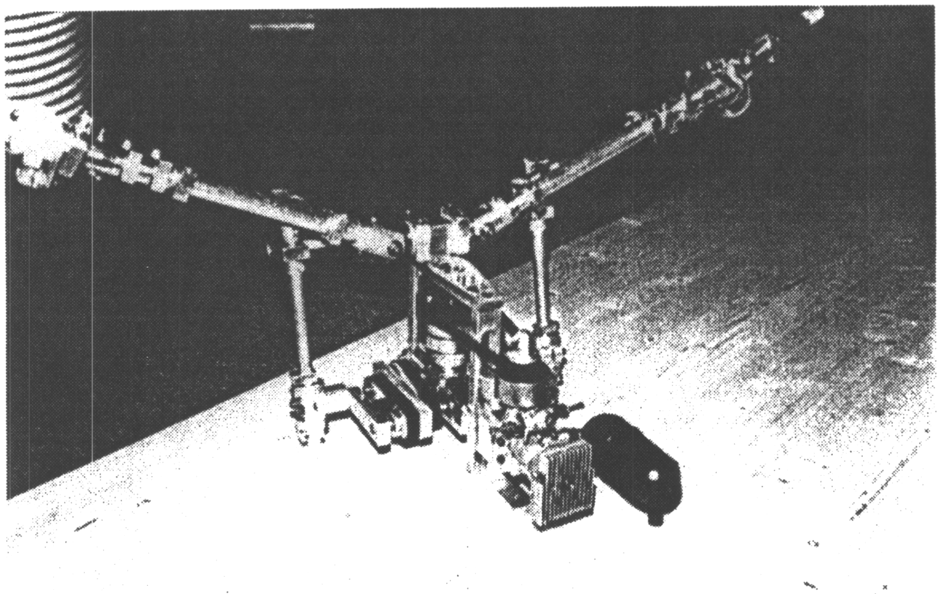


Trampoline used for glide tests

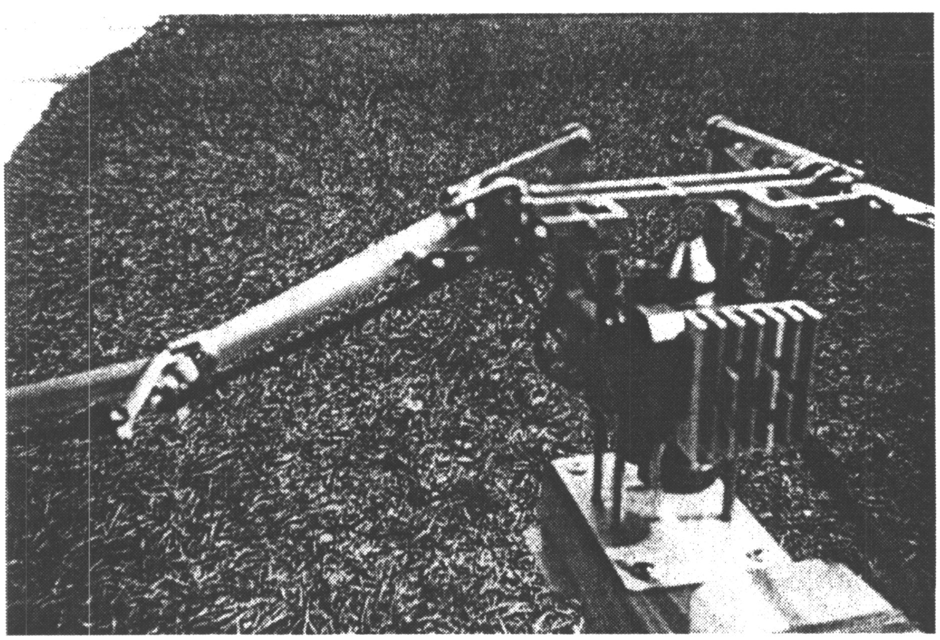


A view of the flapping mechanism

Sean Kinkade Mechanisms



1988 model using planetary levers



1994 model with articulated wings