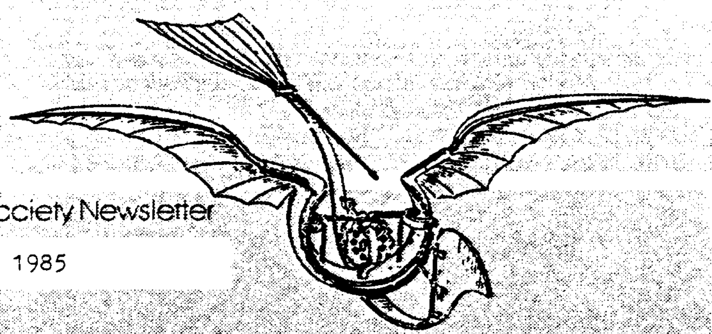
Ornithopter Modeler Society Newsletter

WINTER 1985



flapper facts

Volume II Number I — Pat Deshaye, Editor

WHAT'S HAPPENING... ANYWAY?

It is difficult to list or even summarize the ways in which our club has progressed, and still more difficult to believe it has all transpired in less than one year. It is clear that the paperwork is underway to make us a "Special Interest Group" affiliated with the AMA, all thanks to the tireless efforts of Frank Kieser, probably the most enthusiastic and efficient president any club could have. A quick look at the roster shows not only an increase in membership, but that we now have officers for managing everything. Rules are being amended by and for our members. A design manual for ornithopters is projected for publication during 1985 and an OMS-sponsored postal contest is planned for the same year. Perhaps most exciting, one of our members has blasted the tailbooms off every goddamn flapping thing in the whole cosmic fike!!! I don't want to play anymore...

True, Pat

WINTER MYSTERY FLAPPERPET '85

On the next page please find all of the hard documentation yet available on Al Rohrbaugh's legendary flapper. The isometric drawing of the 24" span model was pirated from Al's AMA record entry forms, submitted by Bob Meuser. Al has since sent me the same drawing but with only two dimensions given: a new overall span of 26" and new length of 20". As the model size increases, so apparently does its duration; not at all what flapper builders have come to expect.

As to the design, it is a biplane with a White/Parham style 90 degree phased crank. Please reread "A Brief Review of Biplane Ornithopters," Summer '84 issue. The configuration features a fixed centersection and "Bibitte"-style linkage arrangement. Al has used a very high flapping/fixed surface ratio, but has still outdone any flapper propulsion model to date. We all want more details, but because the machine is still evolving and Al perhaps wants to squeeze every drop of duration from this devonian device, final plans may be a while in coming. I'm hoping that the Facts will receive some detailed plans for the next issue. For now, here are some performance notes:

"Al Rohrbaugh has demolished the ornithopter records this year. He has a 'biplane?' design, that is, two wings on each side, but the wings don't flap together. when the upper wings are about 1/4 of the way down, the lower wings start up, squeezing the air backwards. The times are incredible:

cat. IV	7:51	5/19/84	Akron
cat. III	8:17	6/30/84	W. Baden
cat. IV	8:49	7/22/84	Akron
cat. IV	10:25	9/1/84	Akron
cat. II	6:05	9/29/84	Chanute AFB

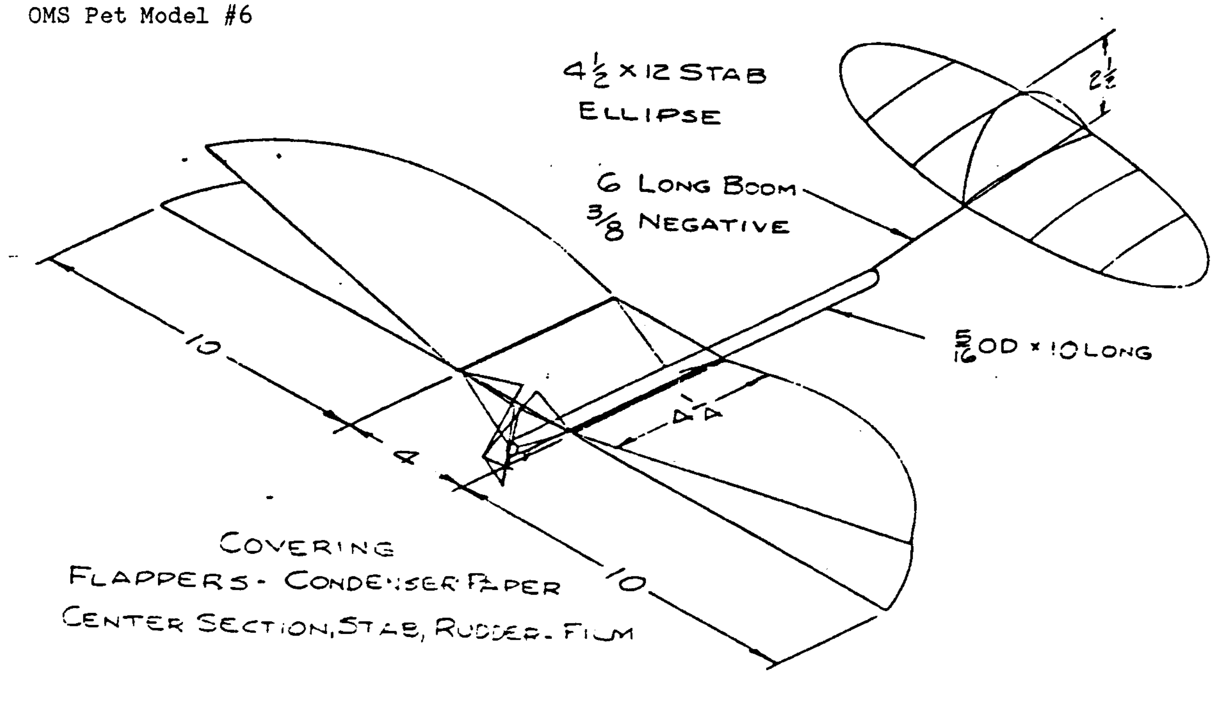
Al is trying to talk <u>Model Aviation</u> into an article." --Rick Doig 10/4/84

"... We were doing quite well with our birds, but then Indiana Al showed up and we'd have done better to fly the model boxes! Don't know if I can describe it- ETHEREAL. It seems to float through the air effortlessly-2.8 flaps per second. Workmanship is immaculate. Time was 8:17. We have his flights on video tape and just beautiful. When the wings flap, they appear to be changing bottom and top positions. Hell of amodel. Don't know about low ceilings--didn't see it bump and wonder what it's recovery would be. But it flaps so slow that it probably wouldn't present a problem.

Hope to hear from your soon. Roy + Shirley White
[7/30/84]

P.S. At W.B., we did 4:52 to break Walt Ehrbachs record, but it didn't mean a thing against Indiana Al's 8:17.

OMS Pet Model #6



TIME - 7 MIN. 51.2 SECS.
AKRON MAY 19, 1984

ORNITHOPTER
AL ROHRBAUGH

GETTING TECHNICAL

Please read part I of F. Kieser's analysis of ornithopter drive mechanisms. This is perhaps the first time engineering analyses have been applied to ornithopters, whereas there are reams of such studies applied to Nordics, Wakes and even lowly Pennyplanes. Part II will appear in the next issue.

EVIL DESIGNS

On these pages you will see, presented very graphically, some of the most perverted and obscene constructions ever to defile the air:

1) Phil Watson's "Gossamer Gnat," a teensy-weensy multiwinged bugger which climbs like a rocket.

2) The "KAMO-3," a monoplane canard design submitted by Warren Williams. Warren picked this one up during a trip to Japan, to see the World F1D Champs in Nagoya. Haven't got the faintest idea who designed it or what it can do, but it certainly looks like a pretty model, even if it does fly bassackwards.

3) Months ago, Reg Parham submitted some antique (1938-39) *Flying Aces* plans for a tailless ornithopter designed by Alan Orthof. Reg writes:

"The machine, apart from the motorstick, was constructed of bamboo. The drive operating the flapping arms was ingenious in that there was a single connecting rod to one arm whilst the other arm was extended to slide through a hole in a little adaptor on the first arm's spindle. The fin was useless but the model did fly with a maximum duration of twenty seconds. Possibly being the only tissue available at the time, its colour was black and I used to fly the model at night around a lamp post outside my parent's home. I thought nothing of this because, being a little impetuous in those days, often test flew my creations in the street. However, with the flapper I inadvertently gained local notoriety as one who had a tame bat and could be dealing with the occult. Seriously, the model's flight pattern, as one would expect, was erratic and lived up to its designer's claim to be a stunting ornithopter."

DO YOU KNOW THE RULES?

Bob Meuser has been active in revising and clarifying a few ambiguities and unintentional restrictions which were written into the letter of the present rule. It is very difficult to invent a rule, as this depends to a large extent on defining the ornithopter. Most agree that this is an area that the OMS should reach a consensus, or at least a compromise on. Reprinted here are the current proposed revision to the AMA ornithopter rule:

FF-86-9—Change model specifications for Ornithopters. This proposes to allow horizontal stabilizing surfaces to be located in places other than at the extreme front or rear of the model, as long as they are at least ¼-wingspan away from the wing. This would be accomplished by revising the sentence in par. 5.6 which addresses the horizontal stabilizing surfaces ("Horizontal . . . 50% of the total wing area.") to read as follows: "No part of the horizontal stabilizing surface(s) shall be within a horizontal distance of one-fourth the wingspan from any part of a wing, and the total projected area of such surfaces shll not exceed 50% of the total wing area." Robert B. Meuser (Oakland, CA) states that the intent of the present rule was to permit canard models to compete, but the rule is too restrictive, inasmuch as it requires the stabilizer to be too far forward, which results in the necessity to add nose weight to the model to get it to balance correctly. Either that, or a swept-back stabilizer is needed. He states that either of these alternatives is too extreme, and that the proposed rule would allow the stabilizer of a canard to be moved rearward—but not so close to the wing that it would function more like a fixed wing (p. 8, par. 5.6). **Note:** This proposal has also been submitted to the Indoor Contest Board, where it is identified as IND-86-22.

FF-86-10—Multi-wing Ornithopter rules clarification. This proposes to clarify the existing rule concerning multi-wing Ornithopters so that "biplanes" having one wing which flaps very little are not allowed. This would be accomplished by revising par. 5.6 of the AMA rule book so that the sentence dealing with multi-wing models ("If the model has more than one wing . . .") is changed to read as follows: "If the model has more than one wing, these restrictions apply independently to each wing, and the wings shall be substantially identical in size, shape, relative areas of fixed and flapping parts, and degree of flapping motion." Robert B. Meuser (Oakland, CA) says that under the present rules, a modeler could build an Ornithopter biplane with substantially identical wings, except that one would flap by the normal amount while the other flapped very little. This would mean that, in effect, the wing with little flap would be a fixed wing, which is contrary to the intent of the rules (p. 8, par. 5.6). **Note:** This proposal has also been submitted to the Indoor Contest Board, where it is identified as IND-86-23.

THE DESIGN OF ORNITHOPTER LINKAGES - PART I

A vital part of any ornithopter design is the linkage that connects the power source to the flapping wings. All too often, we arrive at a linkage configuration only after several trial and error layouts and sometimes we never do get exactly the arrangement we are after. Then after a design is selected, the only comparative evaluation we have is to build and flight test the craft. Part I of this article will present a systematic method of arriving at exact dimensions for a linkage either by layout or analytically. Then in part II we will describe a method of comparative evaluation of different linkage configurations by computer.

Most ornithopter linkage designs are what is known in classical mechanics as a four bar linkage consisting of a continuously rotating input crank and an oscillating output arm (the wing) that is driven by the connecting rod. The fourth bar is the frame that supports the two pivots. For ornithopters, the four bar may be sub-divided into two types as shown in figures 1(A) and 1(B). For type one, the connecting rod is outboard of the wing pivot and for type two, inboard. Figure 1(C) defines the variables for the input and output data.

The sequence for designing a linkage by drafting board layout is as follows:

1. select and lay out the crank center (X0,Y0), the wing pivot (X1,Y1) and strike the wing radius arm (R1)
2. lay out the maximum wing down and wing up lines through the wing pivot (X1,Y1)
3. select a wing offset angle (A4) and lay out through the wing pivot to the arc of the wing radius arm for both wing down and wing up. The intersection is X2,Y2 and X3,Y3
4. Lay out a line from X2,Y2 through X0,Y0 and from X3,Y3 through X0,Y0
5. The crank radius (R0) is one half the difference in the length from X2,Y2 to X0,Y0 and from X3,Y3 to X0,Y0
6. A circle may now be drawn for the crank radius and the points X4,Y4 and X5,Y5 located as the crank end of the connecting rod giving the connecting rod length.
7. The connecting rod length may also be determined as one half the sum of X2,Y2 to X0,Y0 and X3,Y3 to X0,Y0

The thing to watch is that tha angles between the wing radius arm and the connecting rod (A8&A9) are neither too acute or obtuse. This can be controlled by changing the wing offset angle (A4). With a little practice, no more than one or two iterations should be required.

So much for the graphical solution. We could solve graphically and plot intermediate wing angles, but this is a tedious job so let us turn to the analytical and computere solutions. The advantages of the computer solution are speed and accuracy so that more data can be obtained from which to make a comparative evaluation of different linkages. The equations and four computer programs which have been developed to analyze the linkage will give the following outputs in chart and graph form:

1. The solution of linkage dimensional parameters for any given wing excursion and pivot locations.
2. The solution of wing angular position and velocity versus crank angular position.
3. A relative value of crank load versus crank angular position.
4. A relative value of the roll, vertical and horizontal forces on the body due to the wing flapping motion versus crank angular position.

The complete set of equations will be given for the first item only since it is the only one that can be readily done with a calculator. The results of the computer programs for the other three items will be presented in part II.

The first program is called "TRIAL". It gives the first approximation of a design for a selected crank center, wing center, wing radius and wing maximum up angle and down angle. The solution is based on a design condition as shown in figure 1(D), in which the ends of the connecting rod for both the maximum wing up angle and down angle lie in the same straight line. This condition results in a design in which the crank positions are 180 degrees apart for the maximum up and down angles of the wing so that the wing motion most closely follows a true sine curve. The key to this configuration is to determine the exact wing offset angle (A4). The following equations calculate the required crank radius, wing offset angle and connecting rod length as well as the resulting crank position for maximum wing up and down:

$$AT=A2-A1$$
$$R0=R1*SIN(AT/2)$$
$$D0=((X1-X0)^2+(Y1-Y0)^2)^{1/2}$$
$$L0=(D0^2-(R1*COS(AT/2))^2)^{1/2}$$
$$A5=TAN^{-1}((X1-X0)/(Y1-Y0))$$
$$A6=TAN^{-1}(R1*COS(AT/2)/L0)$$
$$A4=A2+A5+A6-(AT/2)$$
$$A7=A5+A6$$

A computer print out of input and output data from a typical design is shown in figure 2.

Now that we know one set of linkage parameters for the most efficient design from a mechanics standpoint, we may, for other design reasons wish to vary some of the parameters. The first option is to vary one or more of the input assumptions and rerun the "TRIAL" program. The only other option is to maintain the same input parameters and utilize a wing offset angle other than the one that gives the straight line connecting rod alignment. For this we have the second program called "WINGO". If we know the wing offset angle we want, this program may be used without first going through the "TRIAL" program.

A typical design to be calculated by "WINGO" would be as shown in figure 1(A) or 1(B). This program requires the inputs of crank center, wing hinge center, wing radius, wing full down and up angles and the new wing offset angle. From these inputs the program calculates the required crank radius, and connecting rod length and the resulting crank angles at wing full up and down and the angle between the connecting rod and wing radius at full up and down. This last item is calculated so that we may avoid a design that is near or past the lock-up point. The equations used in this program are as follows:

$X2=X1+R1*COS(A1-A4)$, $Y2=Y1+R1*SIN(A1-A4)$

$L1=(X2^{2}+Y2^{2})^{1/2}$

$X3=X1+R1*COS(A1-A4+AT)$, $Y3=Y1+R1*SIN(A1-A4+AT)$

$L2=(X3^{2}+Y3^{2})^{1/2}$

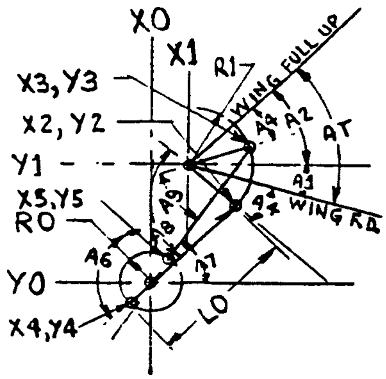
$L0=(L1+L2)/2$, $R0=L0-L1$

$A7=TAN^{-1}(Y3/X3)$, $A8=A6+A4-A1-PI$, $A9=A7+A4-A2$

A8 & A9 MUST BE >15 DEG., <165 DEG., TO AVOID LOCK-UP

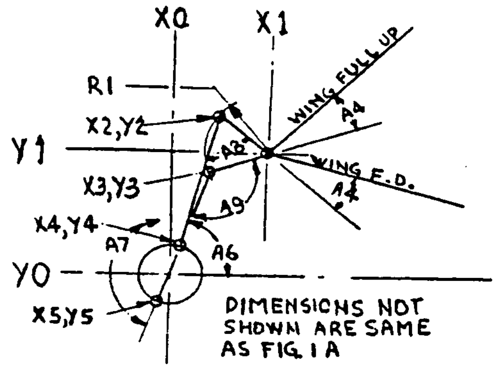
A computer print out of input and output data from this program are shown in figure 3.

After the above analysis, we should have a workable mechanical design. With a computer, this whole process can be iterated several times in a matter of only a few minutes with great dimensional precision. If we were doing a drawing board layout of the design, this is probably as far as we would take it. However, two additional programs have been developed to make a comparative analysis of the performance of different linkages. The first program calculates wing angles and wing angular velocity as a function of crank angle. This can be done for any desired crank angle increment. From this data, the second program then combines any set of two or four wings and calculates and plots relative values of crank load and the roll, vertical and horizontal forces due to the wing flapping as a function of crank angle. The assumptions on which these programs are based and comparative evaluation of several different linkages together with sample plots of the data will be the subject for the next part of this article.



TYPE I LINKAGE
CONECTING ROD OUTBOARD
OF WING PIVOT

FIG. 1(A)



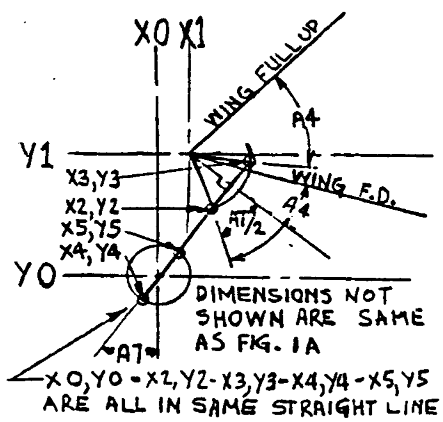
TYPE II LINKAGE
CONNECTING ROD INBOARD
OF WING PIVOT

FIG. 1(B)

X0,Y0 - CRANK CENTER
X1,Y1 - WING PIVOT CENTER
X2,Y2 - UPPER END CONROD-W.D.
X3,Y3 - UPPER END CONROD-W.U.
X4,Y4 - LOWER END CONROD-W.D.
X5,Y5 - LOWER END CONROD-W.U.
R0 - CRANK RADIUS
L0 - CONNECTING ROD LENGTH
A1 - WING FULL DOWN ANGLE
A2 - WING FULL UP ANGLE
A4 - WING OFFSET ANGLE
A6 - CRANK ANGLE - W.D.
A7 - CRANK ANGLE - W.U.
A8 - W.D. WING RADIUS ARM TO CONROD
A9 - W.U. WING RADIUS ARM TO CONROD
AT - TOTAL WING DEFLECTION

DEFINITION OF VARIABLES

FIG. 1(C)

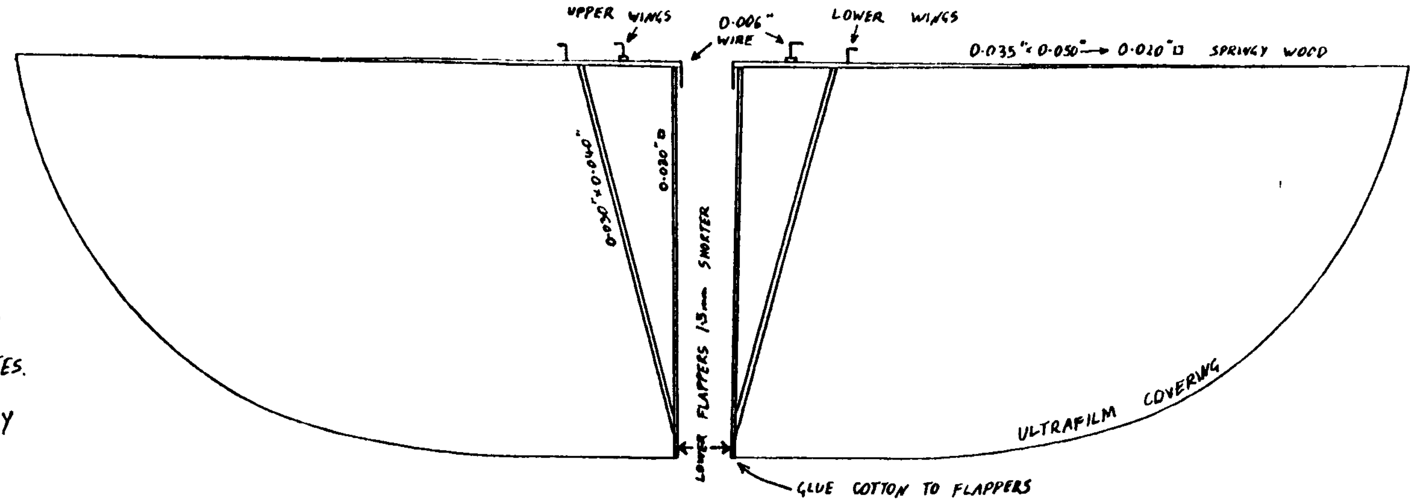


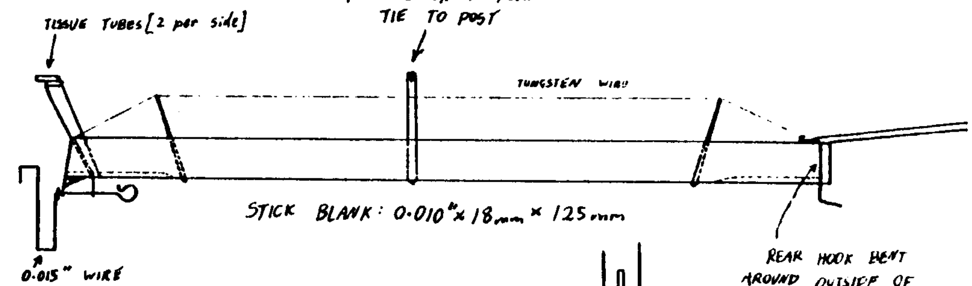
TYPE I
SYMMETRICAL LINKAGE

FIG. 1(D)

THREE PROTOTYPES BUILT, ALL WITH STARTLING CLIMB RATES.

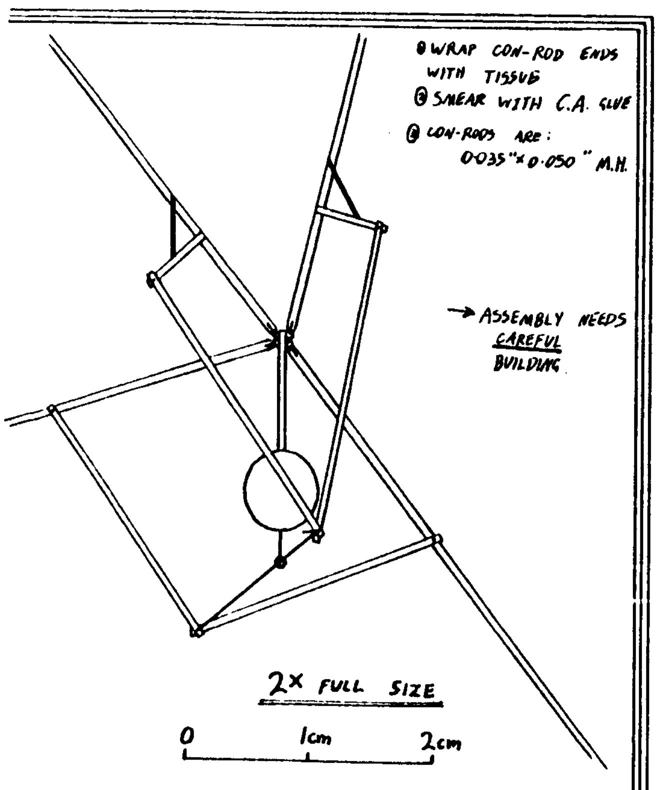
→ TRIM CAREFULLY





FULL SIZE

0 1cm 2cm 3cm

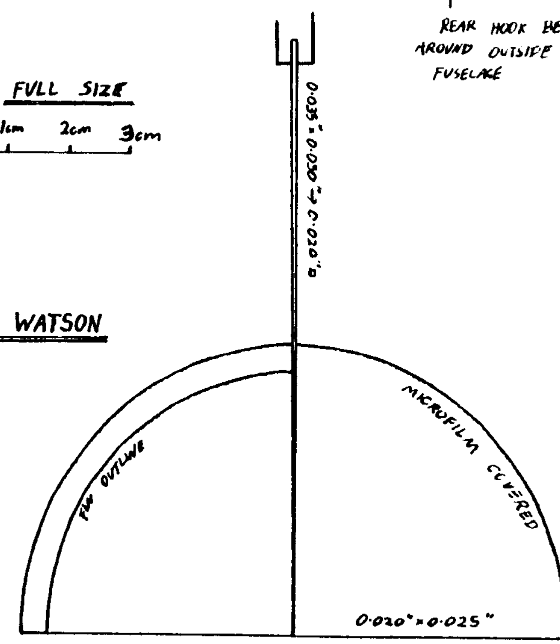


COSSAMER GNAT

DESIGN, DRAWING BY PHILIP WATSON

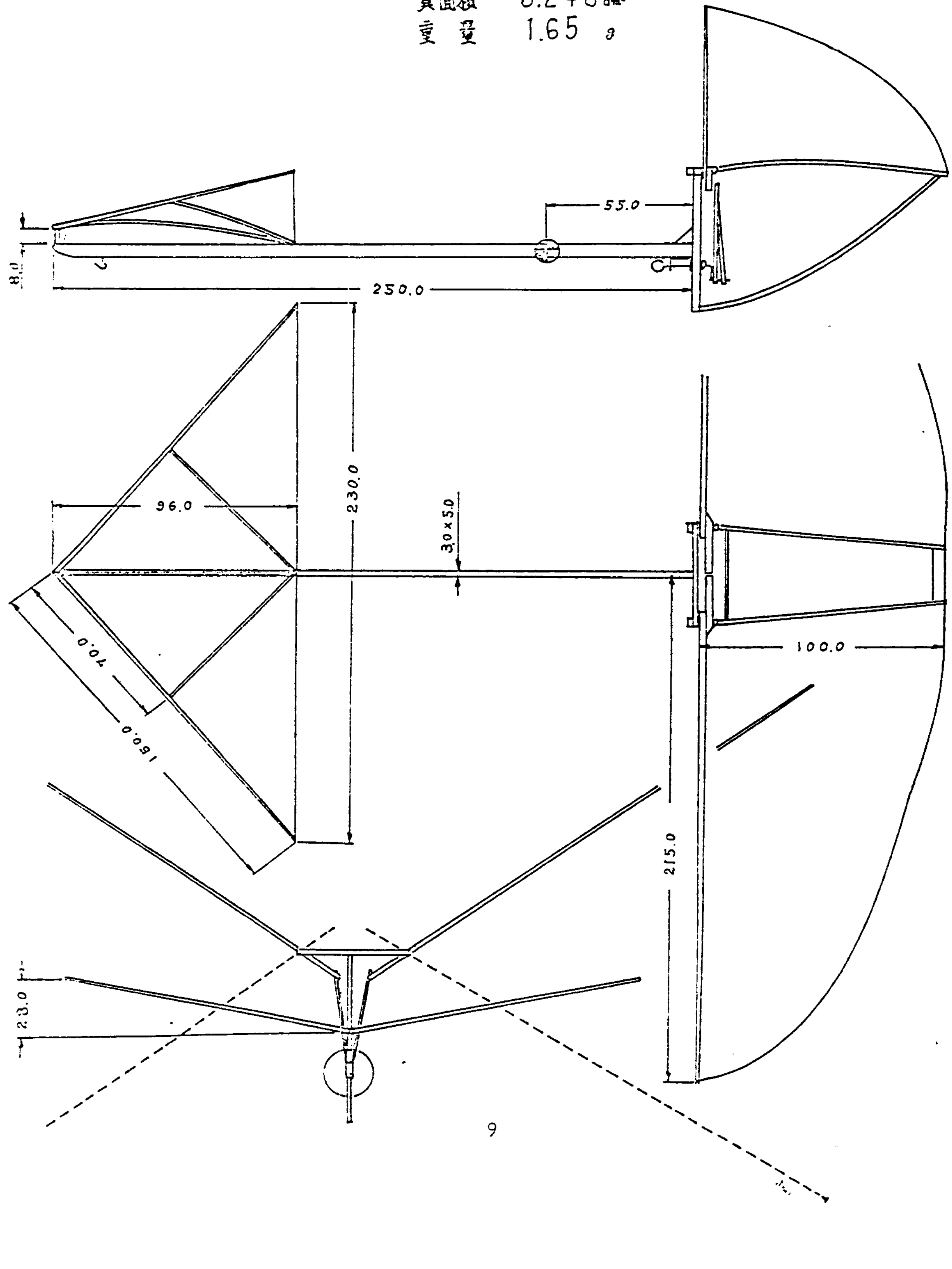
WEIGHT : 0·3 gm

FLY ON 0·35gm RUBBER

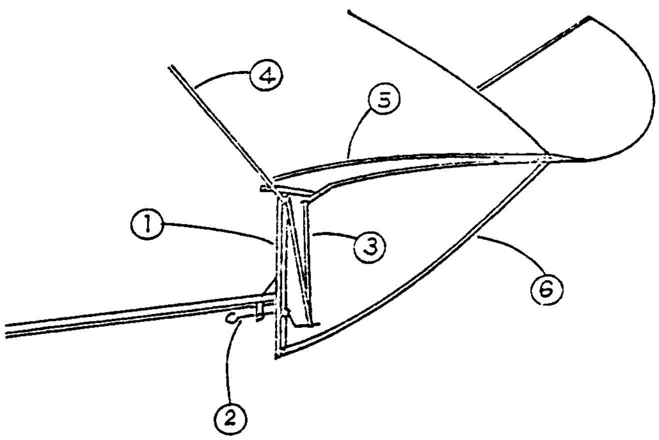


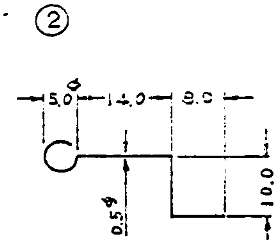
カモ型はばたき機　KAMO-3

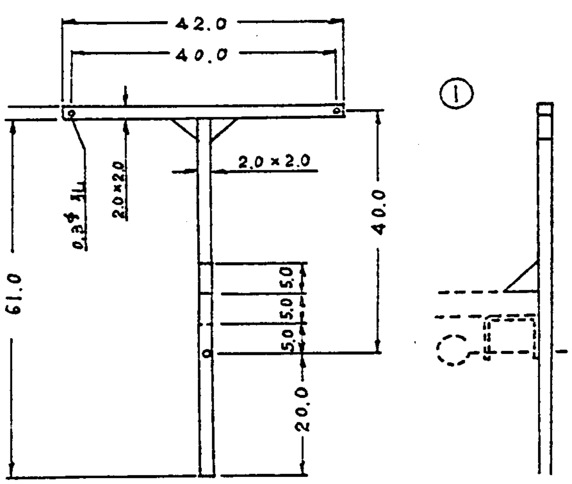
全長　350.0 mm
全巾　430.0 〃
翼面積　3.248 dm²
重量　1.65 g

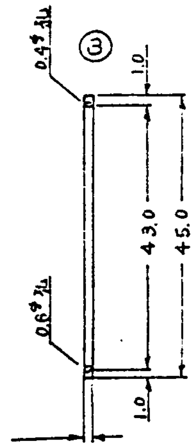


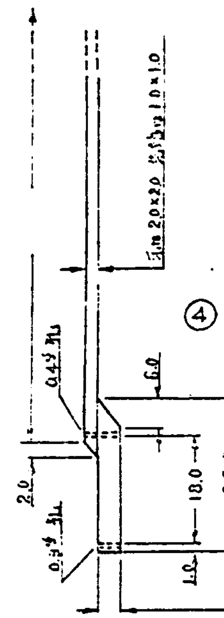
カモ型はばたき機　KAMO-3

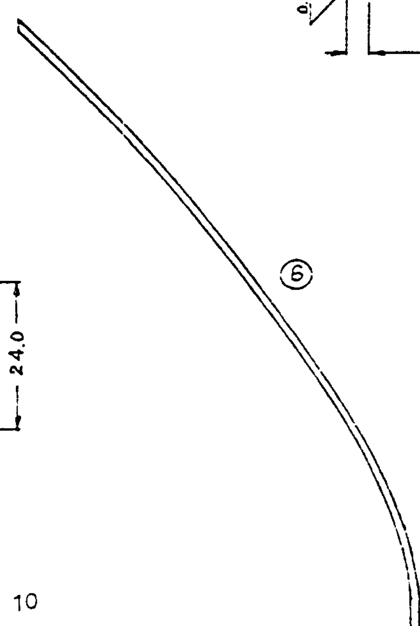


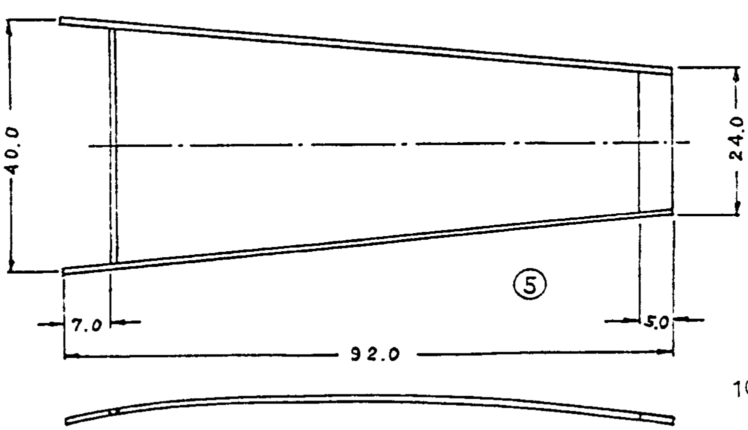


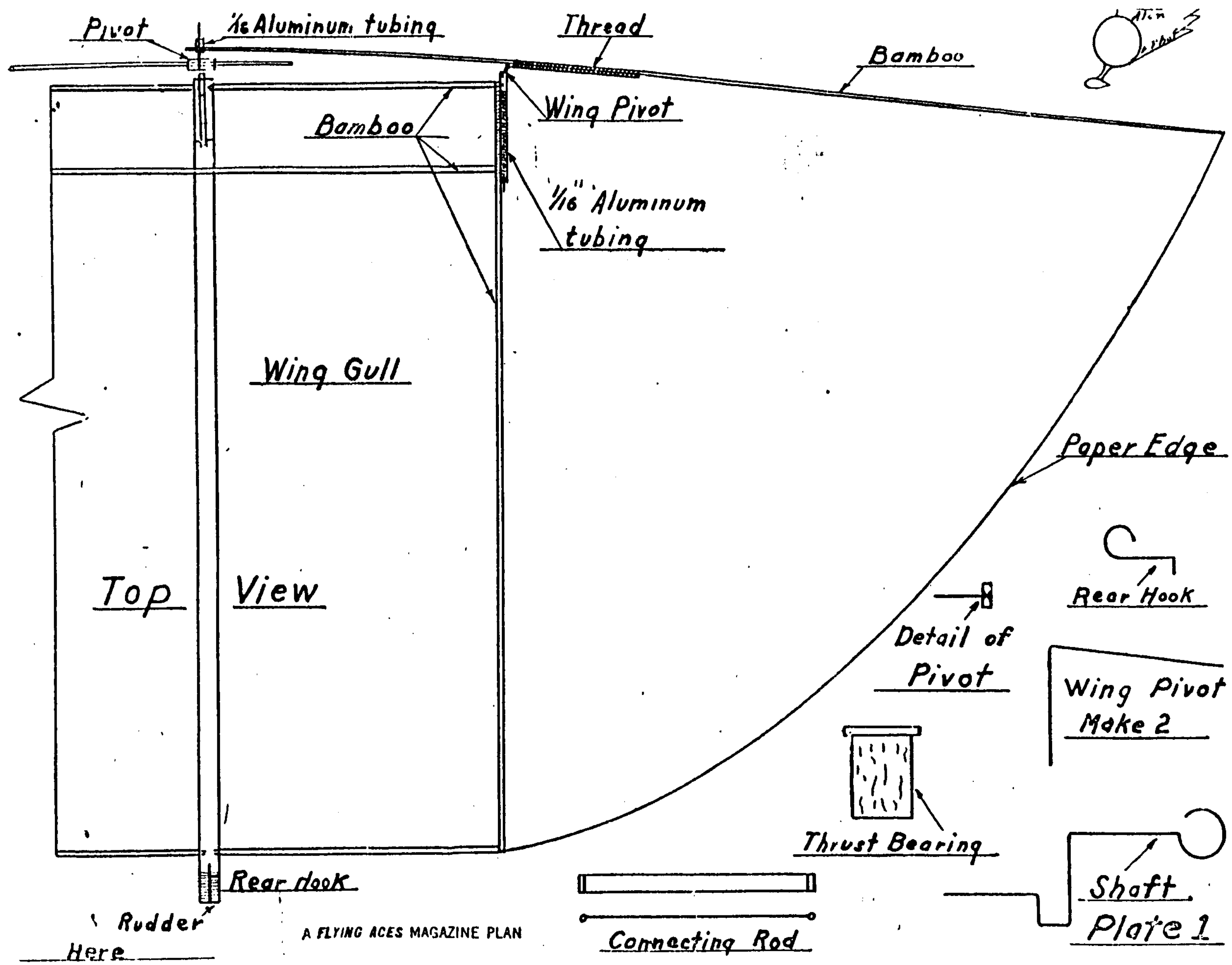


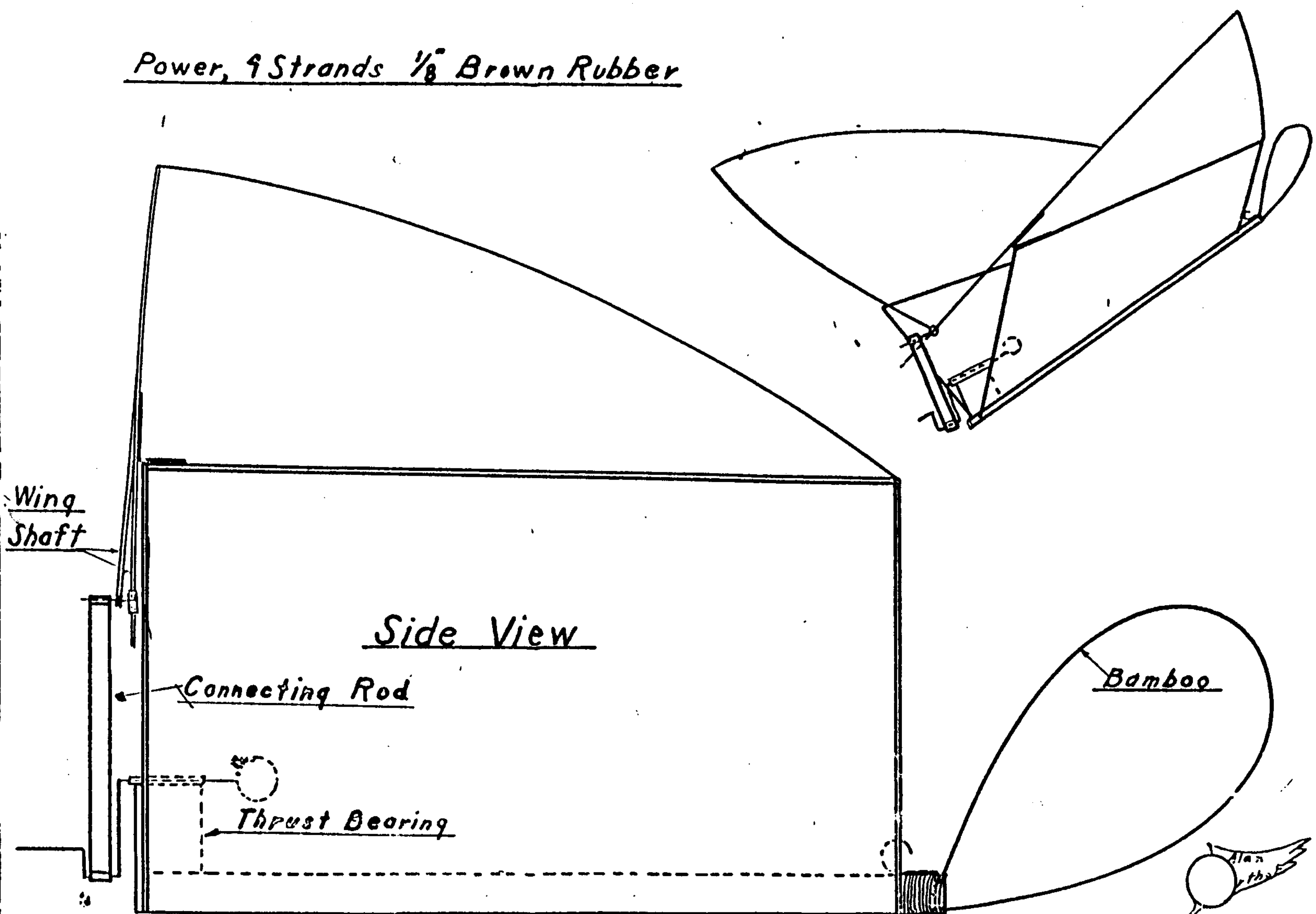









Pivot
1/16 Aluminum tubing
Thread
Bamboo
Wing Pivot
Bamboo
1/16" Aluminum tubing
Wing Gull
Paper Edge
Top View
Rear Hook
Detail of Pivot
Wing Pivot Make 2
Thrust Bearing
Rear Hook
Rudder Here
A FLYING ACES MAGAZINE PLAN
Connecting Rod
Shaft
Plate 1



A FLYING ACES MAGAZINE PLAN

Plate 2