## Chapter XII

# A Flapping-Wing Model

HERE is something new for the aero modellist—a simple yet very successful flapping-wing model which really does fly. It is of the Slinn pattern such as is popular in America. This little model flies most steadily and realistically; its duration is not large—from 12 to 15 seconds—but it flies most spectacularly and it is fascinating to watch it in the air. The mechanism is of the simplest character, and is made entirely of bent wire of which full constructional details are given in the illustrations. It is of 17 in. span, and the length of the motor rod is 8⅝ in., the motive power being provided by 4 strands of $\frac{3}{16}$ in. $\times \frac{1}{32}$ in. elastic. The mainplane is of paper, and the motor rod of spruce. I have made the drawings so complete that I do not think a lengthy description is necessary in order to enable the reader to make it. The wire should be piano wire of 18-gauge throughout. It will be noticed that the crank has a winding handle formed on it, the bearings being provided by two washers soldered to the wing supports.

### THE ARTICULATING RODS

These are attached in the manner shown in detail 4, whilst the bearings

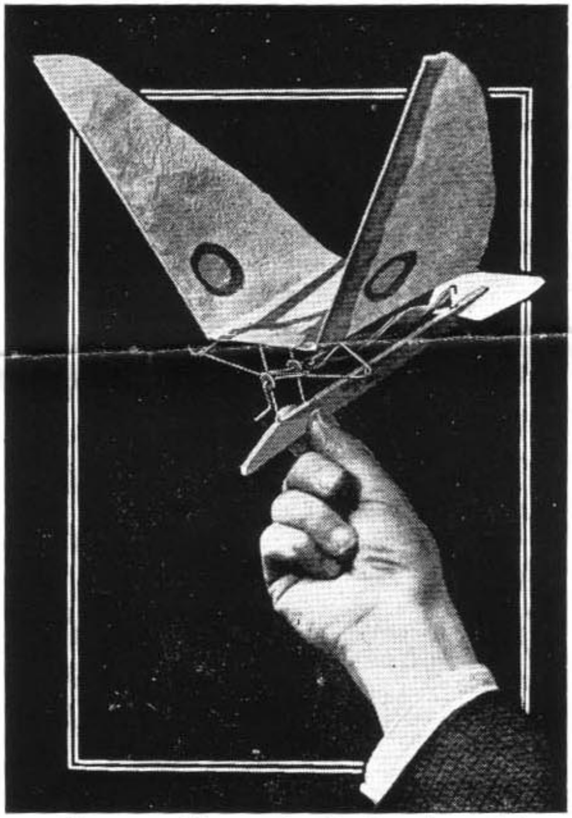


FIG. 232.—The complete flapping-wing model.

are shown in detail 3. Detail 5 is, of course, the rear hook for the elastic, whilst detail 1 shows how the wing supports are attached to the tin-plate wing mounting. The two limbs marked L, which are, of course, made of wire, form the hinge to the wing, whilst J indicates the wire leading edges to which the wing is attached; the paper wing is stitched over this, the rear or trailing edges of the wing being quite flexible. Details of the wings are given on page 148.

I shall be glad to receive details and photographs of any successful flapping wing model which has been built by readers.

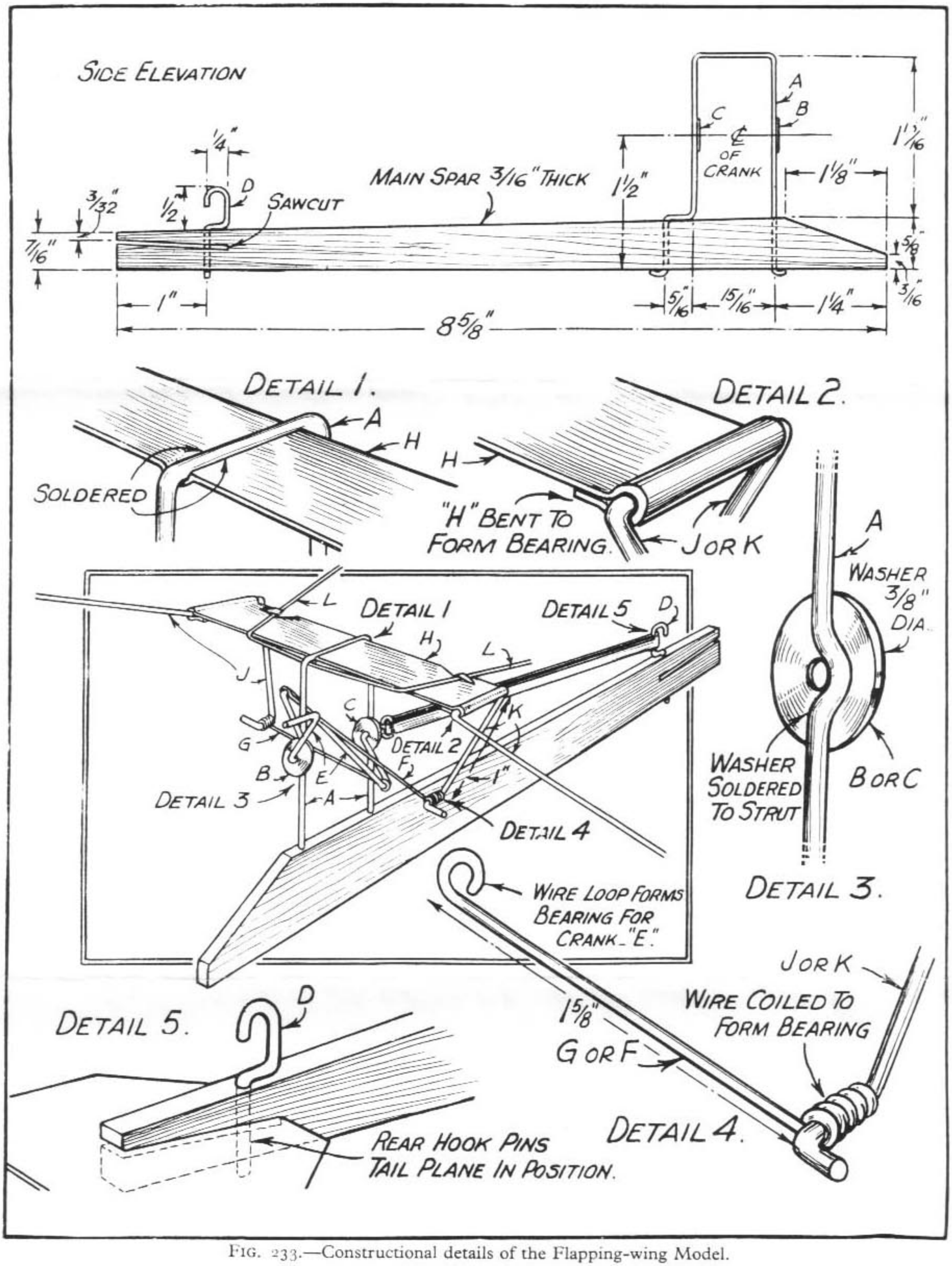



FIG. 233.—Constructional details of the Flapping-wing Model.

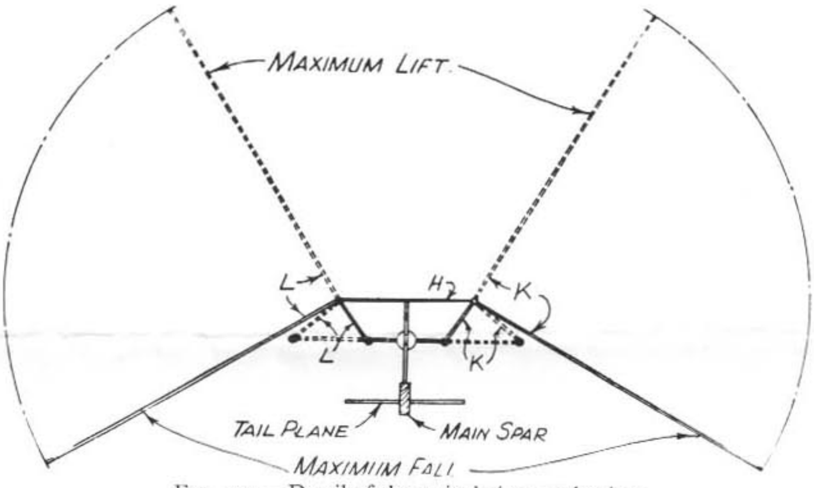


FIG. 234.—Detail of the articulating mechanism.

One of the chief difficulties encountered with this type of model is to get the model to climb. Usually, they fly at the height at which they are launched, but this one does climb, and the best length of flight obtained at the present (with the model illustrated) is 80 yards. Generally speaking, a flapping wing model requires a stronger down-stroke than up-stroke, and a rate of wing articulation of 80 strokes a minute at least.

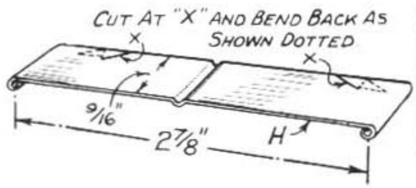


FIG. 235.—The wing anchorage and hinges. They are made from 22-gauge tinplate.

There are, of course, other means of articulating the wings, and in larger models it may be necessary to use reduction gearing in order to obtain sufficiently powerful wing strokes. Although very little experiment has been conducted with wing-flapping models a few experimenters have obtained successful results, although I cannot trace that any such models have been built powered with a petrol or a compressed-air engine. Some very neat flapping-wing models were sold in this country (of French manufacture) before the War. No full-size machine on flapping wing lines has yet made a successful flight. I shall be interested to hear from any readers of this book who have built successful models of this type, and to publish details of their machines in "Practical Mechanics."

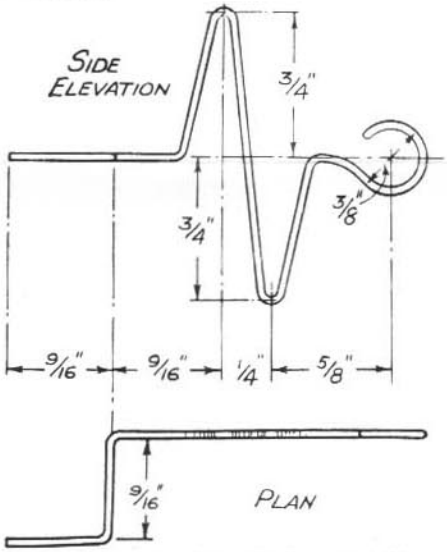


FIG. 236.—The articulating crank with combined winding handle.

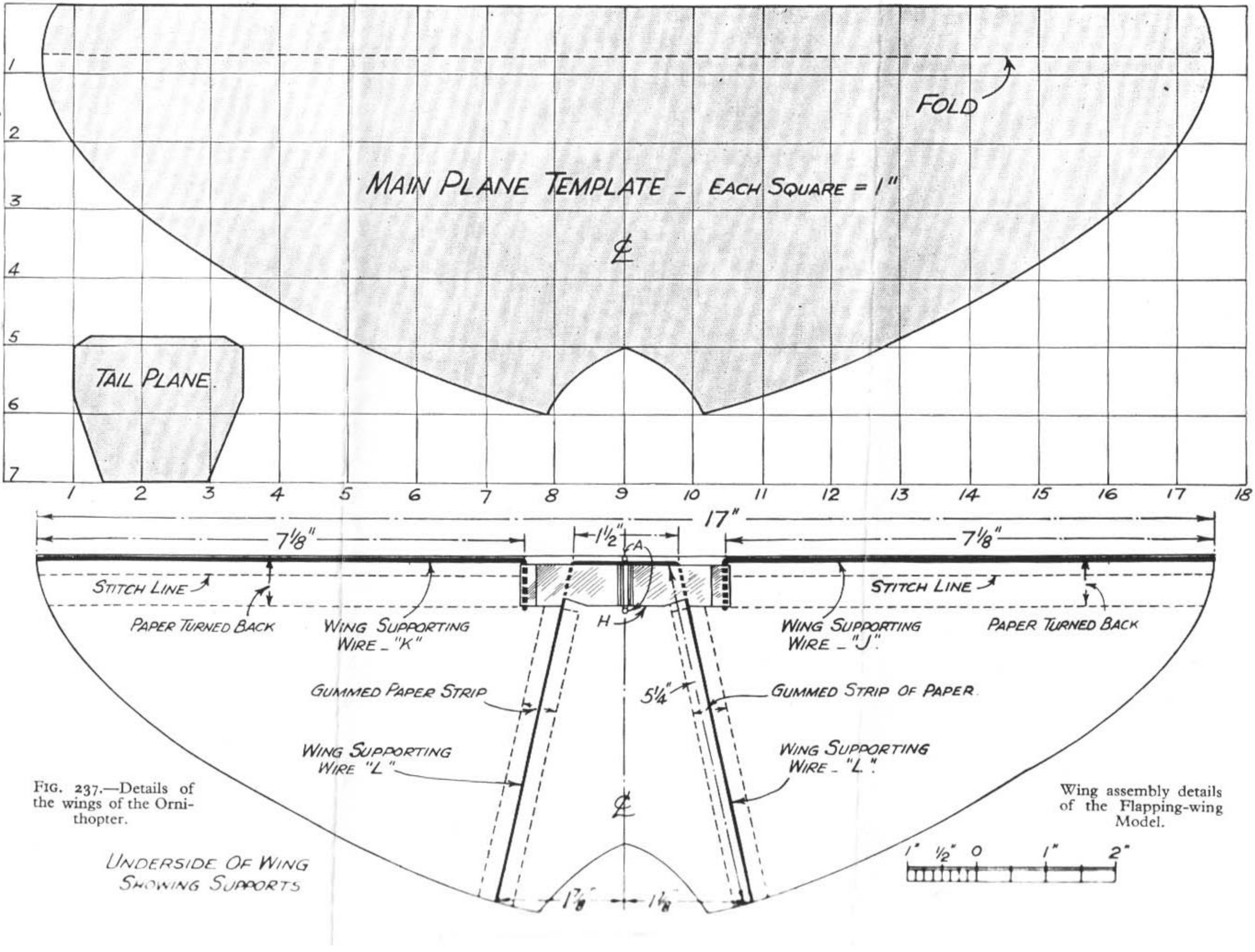
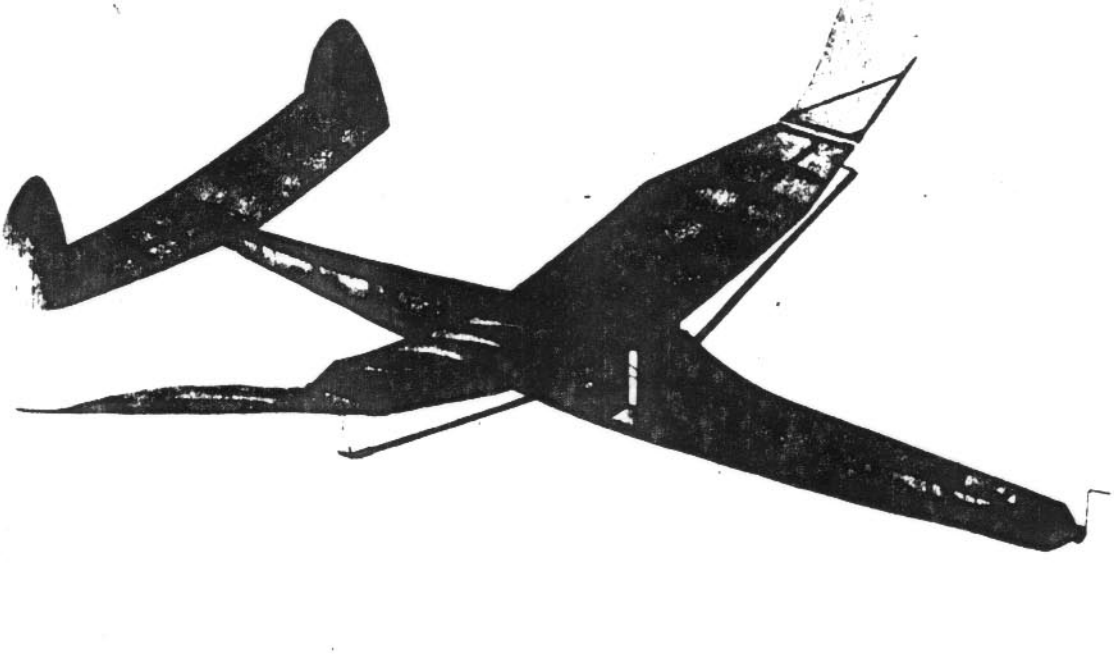



Fig. 237.—Details of the wings of the Ornithopter.

Wing assembly details of the Flapping-wing Model.

# The Flapper

from Model Airplane News, July 1943



## Junior and Senior Record Holder Ornithopter

*by* **ROBERT HORAK**

AFTER designing and building several ornithopters following the general indoor trend of design, I reached the conclusion that indoor types were not adaptable for outdoor flying. I then set about trying to develop an ornithopter which would turn in successful outdoor flights. After trying various ideas and different aerodynamic setups I finally arrived at the following conclusions:

1. It must have a large stationary surface with a high lift airfoil set at a high angle of incidence.
2. It must be extremely light but strong in the right places.
3. It must be streamlined in order to permit fast flights. Speed is essential since lift increases with the square of the velocity. In other words, a model producing 5 oz. of lift at 5 mph. will produce 25 oz. of lift at only 10 mph.
4. It must have sufficient flap area to obtain the very necessary forward speed.

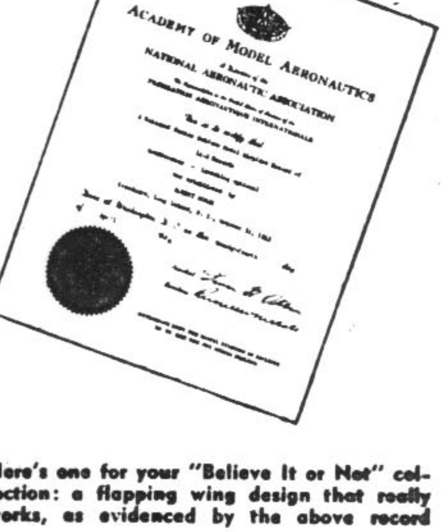
I designed the model presented here with these ideas in mind. The model presently holds both Junior and Senior National Records.

Read the article carefully, studying plans until all details of construction are clear. Lightness should be paramount throughout the entire model. Select materials indicated. Original model only weighed 1-1/2 oz.

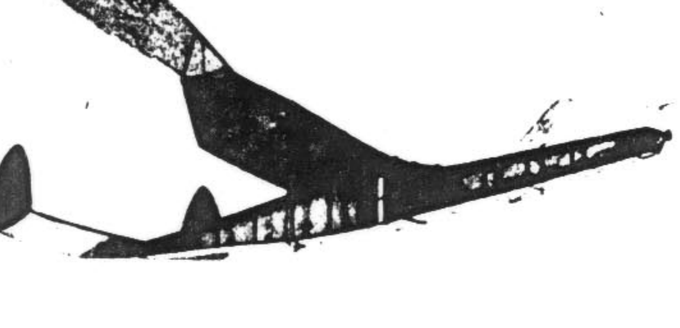
FUSELAGE—Select four pieces of 3/32 sq. medium hard balsa for the longerons. Pin longerons in position placing pins on either side of the wood and not through it as this weakens the structure. Next select a length of soft 3/32 sq. stock. This is to be used for the crossbraces and uprights. Finish one side of the body and let it dry thoroughly; then place a piece of wax paper over it and build the second side directly over the first. After both halves are dry, remove them from the plan. Cement the rear of the fuselage together and insert the crossbraces starting with Station No. 6. Stations No. 7 and No. 8 are cut from 3/32 medium sheet. Do not glue No. 7 in place until the crank arm is bent. Bend the crank arm from .050 wire to the shape shown, being sure to put the tubing in place. Before bending the hook, solder the washer in position and insert the wire through Former No. 7. After this is done the hook may be bent and the Former cemented in place. Fill in the nose with 1/16 sheet, carve the noseblock to shape and re-cement the body joints from Station No. 7 forward. The original model used "quarter grained" wood exclusively due to its superior strength/weight ratio.

WING—The wing is built in one piece and the dihedral is "cracked" in later. The first step is to cut 9 ribs from soft 1/20 sheet. After they are cut out, select a length of soft 1/8 x 3/8 for the trailing edge and a piece of 3/32 sq. for the leading edge. Place them in position and

(*Turn to page 52*)




**Here's one for your "Believe It or Not" collection: a flapping wing design that really works, as evidenced by the above record**



# The Flapper

(*Continued from page* 31)

apply cement. When the wing is dry remove the structure from the plan. Next cement the 1/4 lengths of aluminum tubing for the hinges in the places indicated.

The moving flaps are made next. Select a length of 1/16 wire and bend to proper shape. Then construct the small wooden triangles. Install them with cement and bind with wire. Then bend fitting "A," cement and bind into place. Note the differences in dimensions and be sure to make one right- and one left-hand flap. Next bind and glue tubing as indicated on the plan. Cut out the paper outline and cement it to the wire. The connecting rods are 9-3/16 long and made from 1/8 x 1/4 sanded to a streamlined section.

STABILIZER—To build the stabilizer select a length of 1/8 x 1/4 soft stock for the trailing edge, taper it and pin in place. Then obtain a length of 3/32 sq. and some 1/20 sheet. Cut the ribs and place on plan, locate the leading edge, assemble and cement entire structure at once. When dry remove it from the plan and sand smooth. Pinpoint the rudder outline on 1/32 sheet. Cut and sand smooth. Two are required.

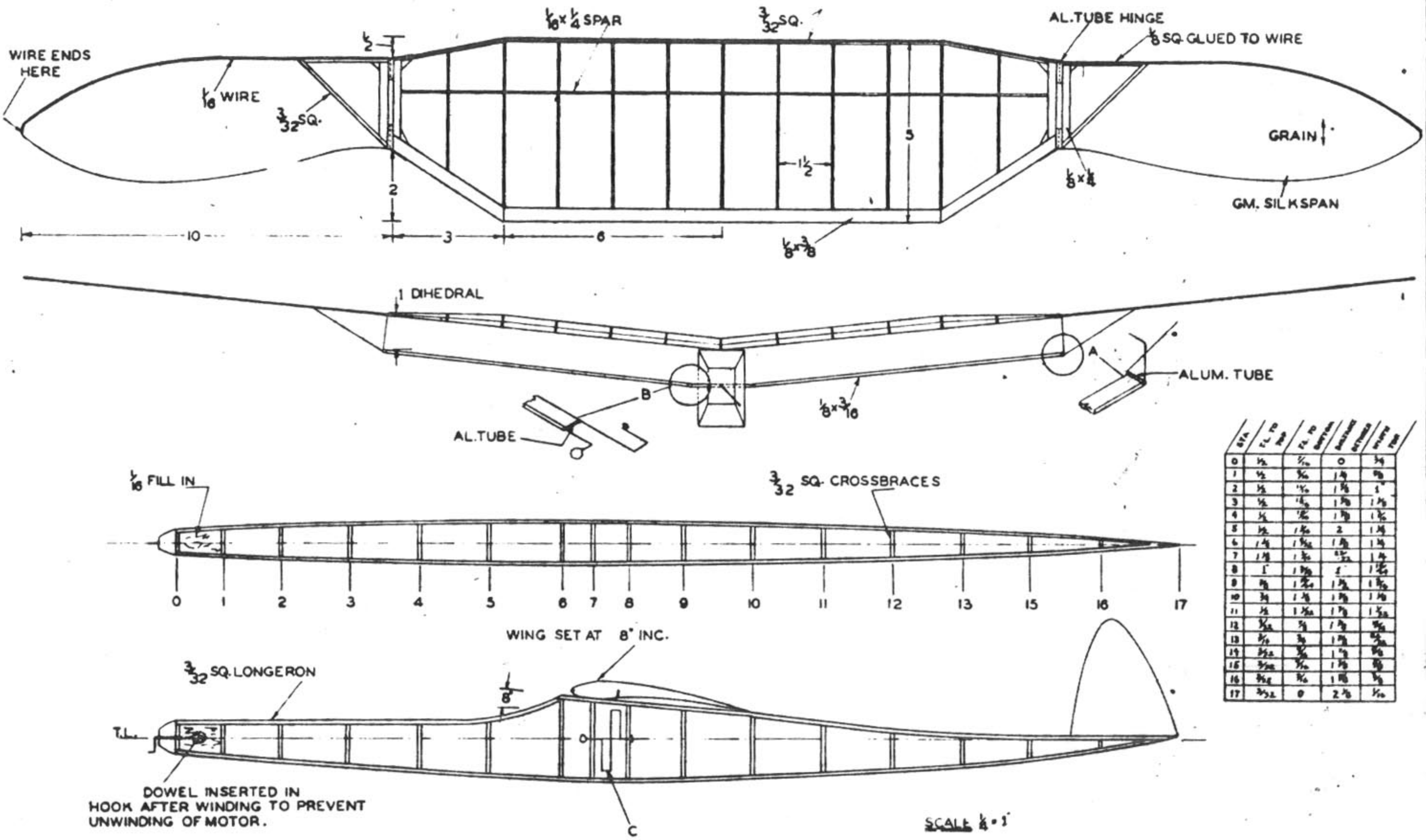
MOTOR—Power is supplied by four loops of well lubricated 3/16 flat brown rubber. Each loop is 11" long.

COVERING—The original model was covered with red tissue and given two coats of dope. Regarding the wing, cover the lower camber first, then the upper camber. Make certain the grain of the tissue runs spanwise. Cover the stabilizer same manner as the wing. The fuselage is covered with the grain running lengthwise. The rudders are not covered or doped as the latter will warp them.

FLYING—The model should balance 1/3 of the wing chord back from the leading edge. First glide the model and adjust for a slightly nose-heavy glide using the horizontal tail surfaces for adjustments. When the glide is satisfactory, wind up the motor (either way will work) and launch with a gentle push into the wind. If the model is built according to the plans presented, it should fly right off your building board. Incidentally, for a little fun try towhooks on the side of the fuselage; tow it up and then watch it really pile up time.

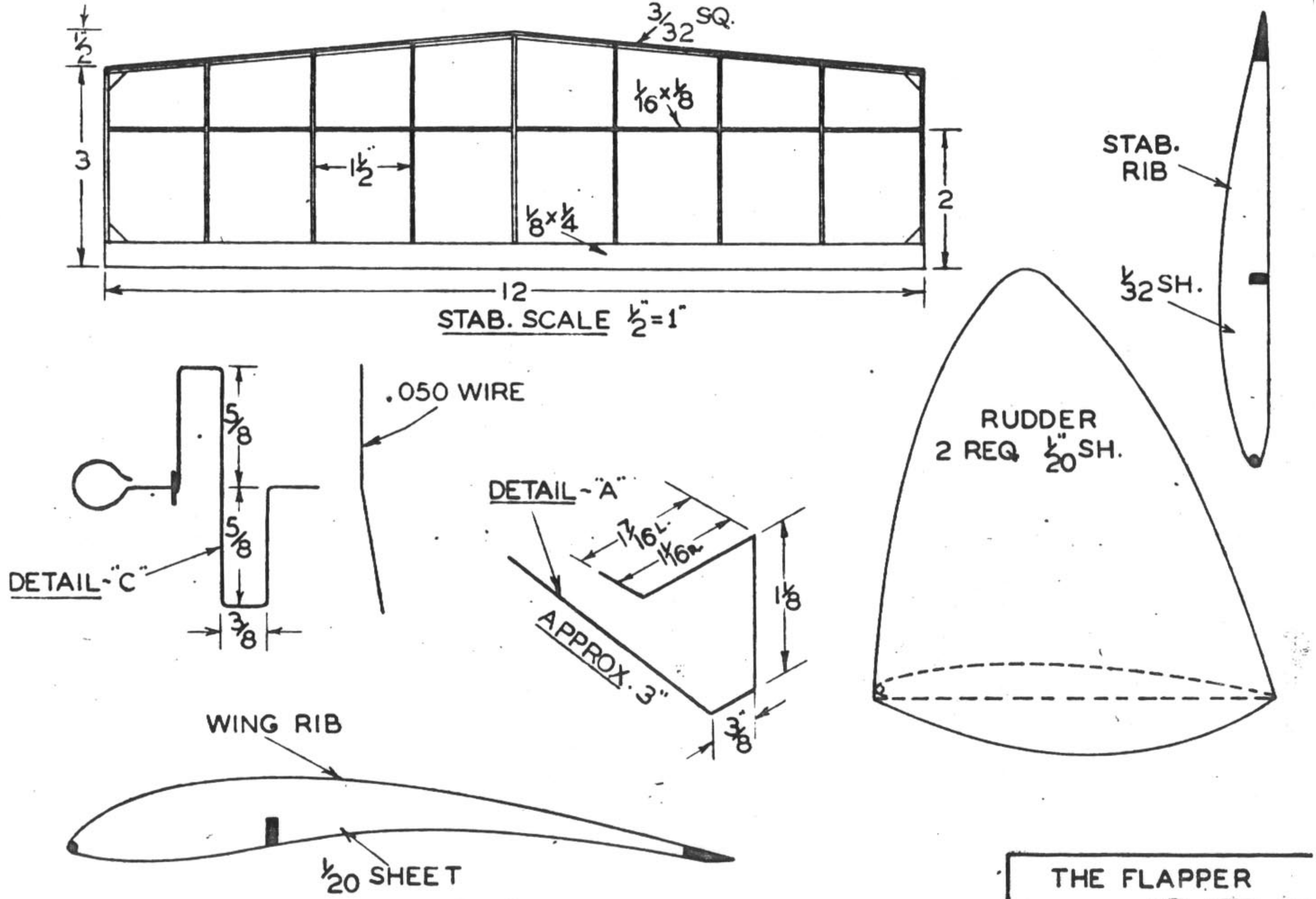
## BILL OF MATERIALS

7 lengths 3/32 sq. medium hard
12"—1/8 x 1/4 soft
12"—1/8 x 1/16 medium
20"—1/8 x 3/8 soft
20"—1/16 x 1/4 hard
20"—1/8 x 1/4 medium
1/32 x 3 x 4 soft (2 required)
1/16 wire
.050 wire
1 1/2 sheets red tissue
White G. M. Silkspan
Aluminum tube 6 x 3/32

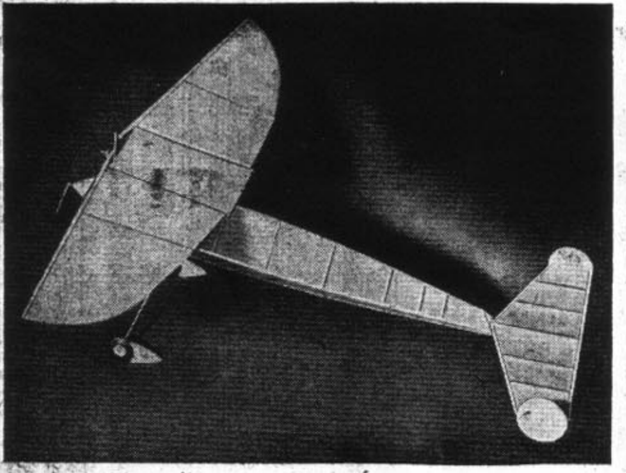


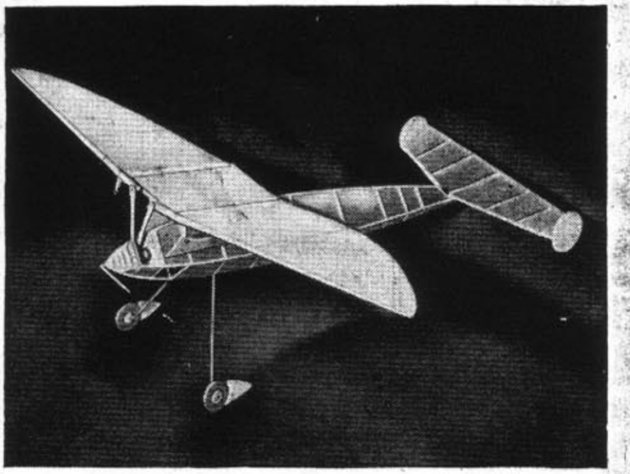

| STA | T.L. TO TOP | T.L. TO BOTTOM | DISTANCE BETWEEN | WIDTH TOP |
|---|---|---|---|---|
| 0 | 1/2 | 5/16 | 0 | 3/4 |
| 1 | 1/2 | 5/16 | 1 1/4 | [illegible] |
| 2 | 1/2 | 11/16 | 1 3/8 | 1 |
| 3 | 1/2 | 14/16 | 1 [illegible] | 1 1/8 |
| 4 | 1/2 | 15/16 | 1 [illegible] | 1 1/8 |
| 5 | 1/2 | 1 1/16 | 2 | 1 1/4 |
| 6 | 1 1/4 | 1 3/32 | 1 [illegible] | 1 1/4 |
| 7 | 1 1/8 | 1 3/16 | [illegible] | 1 1/4 |
| 8 | 1" | 1 [illegible] | [illegible] | 1 [illegible] |
| 9 | [illegible] | 1 [illegible] | 1 [illegible] | 1 [illegible] |
| 10 | 3/4 | 1 1/8 | 1 [illegible] | 1 [illegible] |
| 11 | 1/2 | 1 3/32 | 1 [illegible] | 1 [illegible] |
| 12 | 5/32 | 5/8 | 1 [illegible] | [illegible] |
| 13 | 3/16 | 3/4 | 1 [illegible] | [illegible] |
| 14 | 3/32 | [illegible] | 1 [illegible] | [illegible] |
| 15 | 3/32 | 5/16 | 1 [illegible] | [illegible] |
| 16 | 3/32 | 3/16 | 1 [illegible] | [illegible] |
| 17 | 3/32 | 0 | 2 1/8 | 1/16 |

— THE FLAPPER —
NATIONAL RECORD HOLDER
DESIGNED BY – ART HORAK
PROP SPINNERS CL.




THE FLAPPER
PLATE 2





# "FLAPPEROO"

**An extraordinary design created for experimental flying**

*by* **WILBUR F. TYLER**

IT'S a lulu! It's a wow! We mean the Flapperoo—a real honest-to-goodness cabin ornithopter that will flap its way off the ground, right into your model building musts—and you will enjoy working on this unique model, as presented by MODEL AIRPLANE NEWS.

The rubber driven ornithopter model is not exactly new, for about 1870 Alphonse Penaud, the French scientist, built and successfully flew a flapping wing device, actuated with rubber bands in tension. Except for the fact that bird flight could be partly imitated, Penaud quickly abandoned the ornithopter, having proved that man could not sustain himself in the air by beating a pair of wings.

The internal combustion engine has changed our scheme of living in many ways, but the ornithopter is still impractical as a means of aerial transportation.

However, modelers have been quick to realize the possibilities of the "wing flapper" and endurance times of over five minutes have been recorded with the simple stick type ornithopter.

It's not difficult and it's lots of fun to build these distinctively different models. So start the ball rolling towards new modeling thrills by making the Flapperoo cabin ornithopter. It's a rugged little job, as well as a neat dependable flier.

Look over the plan carefully so that you will have a general idea of the construction and then begin work on the fuselage. Scale up the drawing onto your working surface. The 1/16" square longeron strips are pinned to the outline, and in no time at all, crosspieces are glued into place and one panel is completed. Complete the second panel in like manner. Then finish the fuselage structure by cementing the remaining crosspieces into place. Elastic bands are very useful in keeping the sides from springing apart during this operation.

To make the removable rear plug, add a second set of crosspieces to the fuselage at the point where the rear plug is to be cut off. When the cement has dried cut between the twin set of braces. This will leave a smooth-fitting detachable fuselage section. Add the solid balsa plug with rear hook, already attached. Be sure to cement strips of balsa to the rear plug so that when it butts onto the fuselage it won't twist under power, or drop out when the motor has unwound. Select the topside of the fuselage when set on edge, and finish work on the rear plug by cutting and recementing the top longeron to follow the contour found on the plan.

Cover the bottom of the first fuselage nose-bay with 1/16" sheet balsa. The two pieces are cut to fit snugly between the uprights and then are cemented into place.

While this is drying commence building up the nose of the model with 3/32" soft sheet balsa. Each layer is precoated and then cemented together so that the grain of the wood lies in alternate perpendicular layers. For best results use clamps or the jaws of a vice to hold the layers firmly, until dry.

Having located those missing pliers, consult the front view of the drawing for the proper shape of the landing gear attachment to the fuselage. The "V" bend makes for a simple strong fastening. Use .018 music wire for the landing gear.

The axles are not completely bent until the balsa wheels have been finished. Otherwise, pushing-wheel-around-square-corner-trouble may arise.

Wheels are cut from medium hard 1/8" sheet, and washers, either model-shop variety or home-made brand cut from dural, are glued to either side of the wheels to prevent wire from cutting through the balsa.

Complete the wire bending, remembering that patience is a virtue. Add wheel fairings for that racy appearance, carved from 3/32" sheet balsa.

Return to the now dry nose block and tack it to the front of the fuselage with a few drops of cement. Whittle and sandpaper it to the fuselage contour.

Cut through the upper longeron, just behind the nose block, for one bay (see drawing). Next cut and fit a piece of 3/32" balsa sheet, preferably laminated to the right thickness, to the square opening. This bulkhead will take the rubber motor tension, therefore care should be taken in its construction. Do not glue it into place, yet.

Drill a hole through the center of the nose block and on through the laminated bulkhead. Remove the bulkhead and nose block, then cement washers to each of the four sides, large enough to allow a .024" diameter wire to revolve freely.

The drive shaft is bent from music wire .024" in diameter. Bend the round hook first, and make certain that the shaft is threaded through the bulkhead, before bending the crank. Follow dimensions as closely as possible.

At this stage the drive shaft should require one more bending operation, while the thrust bulkhead is situated between the rubber hook and the crank.

Heat up the soldering iron and solder the thrust washer to the shaft. Take care not to burn your fingers or the bulkhead with droplets of liquid solder.

If you haven't done so, make the two pine connecting rods and slide them on to the drive shaft.

Manipulate the bulkhead into place; slide the nose block over the front of the shaft; align the whole assembly so that nothing binds when the drive shaft is revolved, and cement the bulkhead and nose block into place. Apply several coats of cement in thin layers in order to make the joint as solid as possible. Bend a right angle on the front of the shaft. This completes the nose assembly.

*(Continued on page 47)*

## "Flapperoo"

*(Continued from page 21)*

The zippy looking centersection struts are cut from 3/32" sheet balsa. Use the front view on the plan for getting the right height. The streamline emblem, cut out of the struts, adds to the model's appearance. Round the leading and trailing edges and sandpaper the struts smooth.

Consult the plans often while constructing the centersection and the flapping outer wings. Note that the leading edge spar tapers in two planes. Bamboo is used on the trailing edge, to give flexibility required for the success of this type model.

Make sure that you make one right and one left outer wing panel. We almost didn't on our first ship.

The stabilizer is built up from strips 1/16" x 3/32". A flat airfoil is used, since this relatively inefficient section was found to give best results.

Rudders are circular in shape. Cut them from 1/32" sheet balsa and round the edges over. They are butted onto the end ribs of the stabilizer with cement.

Cover the fuselage, centersection, outer flapping wing panels and the top of the stabilizer with an outdoor grade of tissue. Fuselage covering may be water-sprayed and then lightly doped.

Make the fittings for the wing from piano (music) wire, washers and thin strips of dural. Assemble the wing, striving for wing panels that will move freely.

Rig the wing to the fuselage by first cementing the cabane struts to the centersection. They should line-up when viewed from the side. Then before the cement has dried, pull the struts inward so that they approximate the front view position on the plan.

Push the connecting rods, one through each of the pins projecting beyond the front spar of the flapping panels, and by spreading or pulling the cabane struts together, find the position—cut and try—which will produce the best action. Apply cement liberally, gluing the struts to the fuselage.

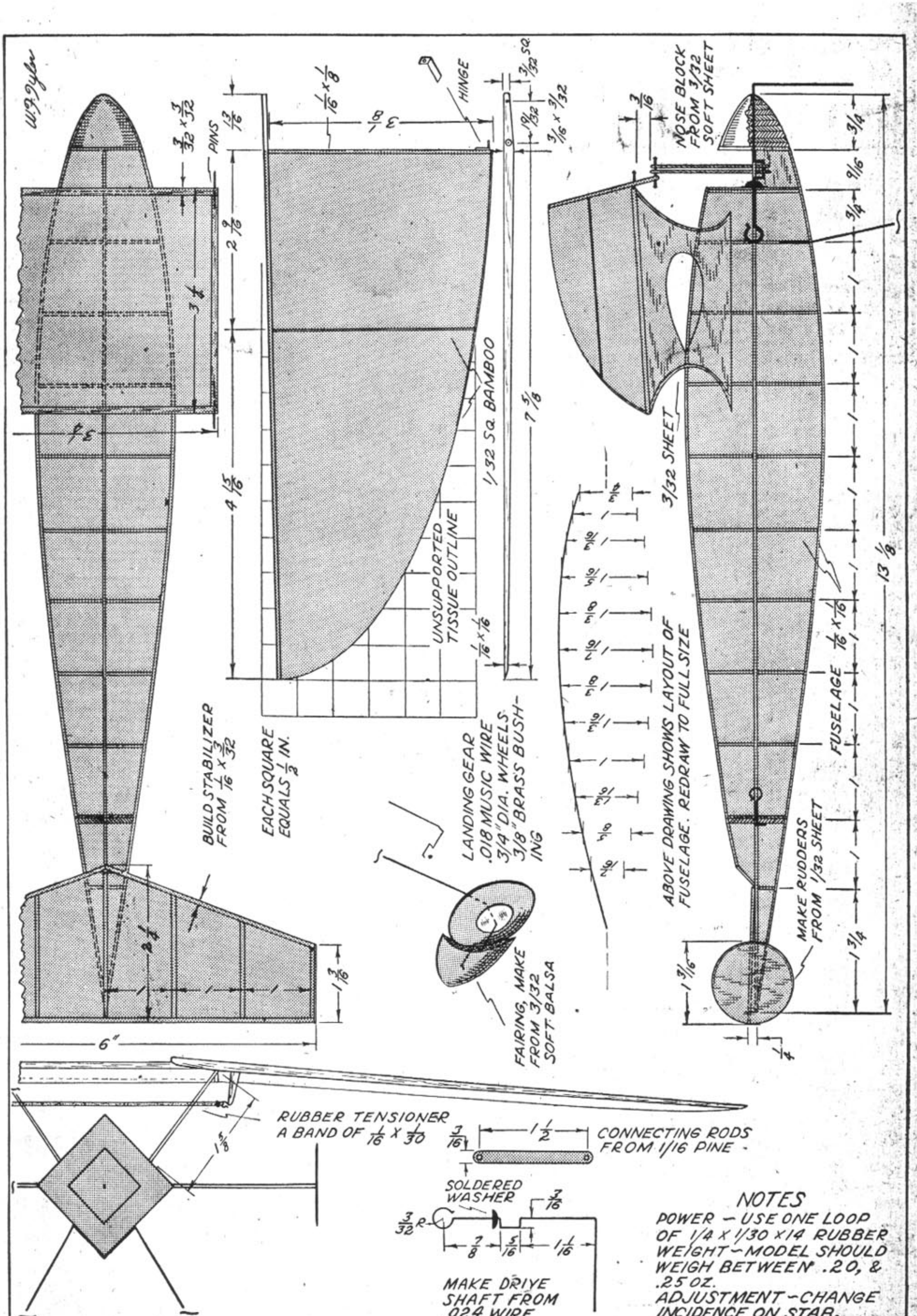


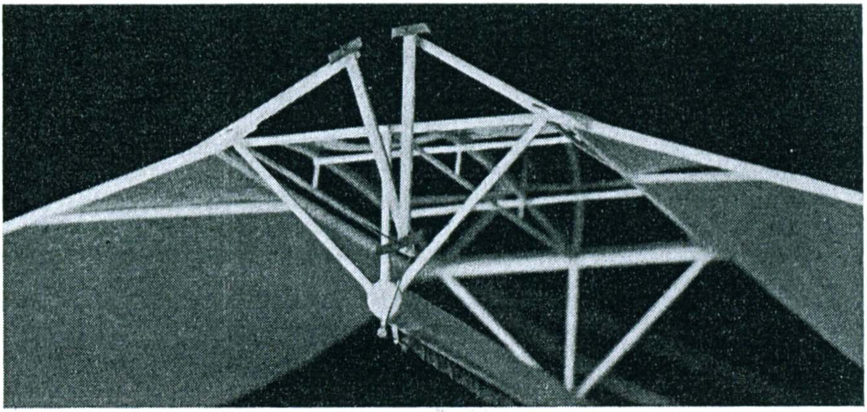
The rubber tensioner for the "flappers" makes for a smoother stroke, by carrying the crank past the top and bottom dead centers. The tension should not be too tight, otherwise it will absorb too much power.

Use a fairly tight loop of 3/16" brown rubber for testing. It was found that the tail surfaces provided the best means for adjustment; merely increase or decrease the angle of incidence.

When you are satisfied with the performance on hand winds, take out ye trusty winder and crank in a few hundred turns. Set the model down on its landing gear—watch it suddenly become alive, give healthy beats with its wings, pick up speed—and then climb upwards for a thrilling takeoff.

Oh! In case we didn't mention it before, it makes no difference which way you wind up the Flapperoo. It always works!


HINGE
1/16 x 1/8
3/32 SQ
3/16 x 3/32
NOSE BLOCK FROM 3/32 SOFT SHEET
PINS
3/32 x 3/32
1/32 SQ. BAMBOO
UNSUPPORTED TISSUE OUTLINE
3/32 SHEET
BUILD STABILIZER FROM 1/16 x 3/32
EACH SQUARE EQUALS 1/2 IN.
LANDING GEAR .018 MUSIC WIRE 3/4" DIA. WHEELS 3/8" BRASS BUSHING
ABOVE DRAWING SHOWS LAYOUT OF FUSELAGE. REDRAW TO FULL SIZE
FUSELAGE 1/16 x 1/16
MAKE RUDDERS FROM 1/32 SHEET
FAIRING, MAKE FROM 3/32 SOFT BALSA
6"
RUBBER TENSIONER A BAND OF 1/16 X 1/30
CONNECTING RODS FROM 1/16 PINE -
SOLDERED WASHER
MAKE DRIYE SHAFT FROM .024 WIRE
NOTES
POWER — USE ONE LOOP OF 1/4 X 1/30 X 14 RUBBER
WEIGHT — MODEL SHOULD WEIGH BETWEEN .20, & .25 OZ.
ADJUSTMENT — CHANGE INCIDENCE ON STAB.



# MODEL ORNITHOPTERS

*By* R. H. Parham

MANY of the early experimenters in the field of Aeronautics endeavoured to produce flying machines which could achieve flight by flapping wings. These aircraft, whether in the full size or model form, were unsuccessful for the following reasons:

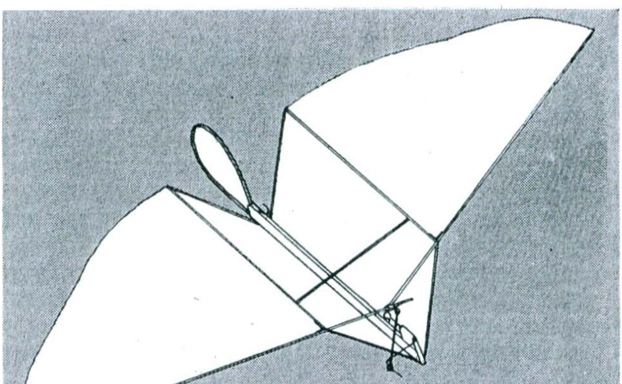
(*a*) The lack of suitable lightweight power plants.

(*b*) The extremely inefficient and complex mechanisms used to simulate the action of birds wings.

(*c*) Lack of knowledge of stability.

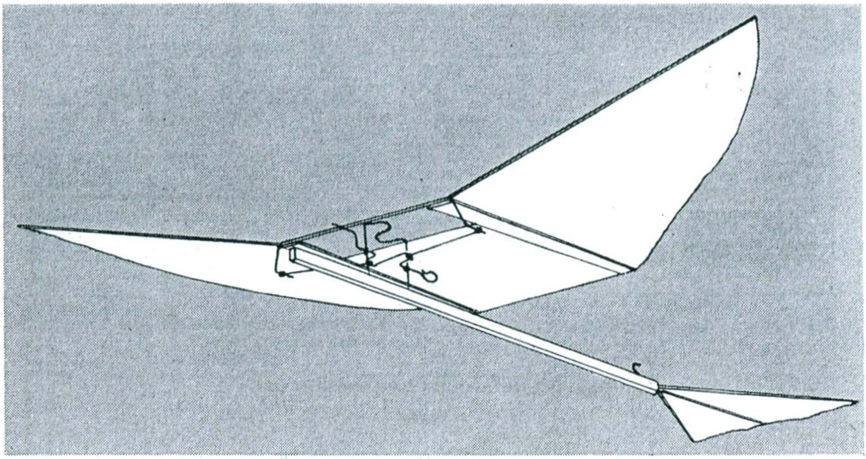
The modern model ornithopter has a light efficient power unit in the form of a rubber motor. Its wing structure and operating mechanism are the simplest possible, while both lateral and longitudinal stability are obtained by standard methods.

An early "flapper" was constructed in 1937 to plans published in an American model journal by Salem Barrack. The design was the result of three years' experimental work and soaring flight of over sixty seconds duration were claimed. Fig. 1 illustrates the layout, which is considered by the writer to have



*Left:* Fig. 2. The tailless ornithopter design by Orthop and Ledman, developed by Parham in this country to equal the then British record of 20 seconds.

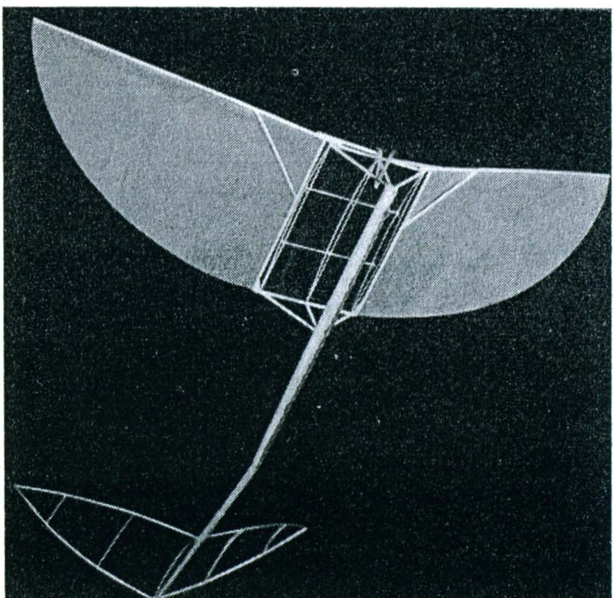
*Heading:* Details of the flapping mechanism on R. H. Parham's latest ornithopter design, "Flippin' Kid," a drawing of which appears on page 109.



set the modern trend in ornithopter design.

During 1939 another type of ornithopter was produced from plans published by the American modellers Alan Orthop and Joseph Ledman. This remarkable tailless design, shown in Fig. 2, had an overall length of 9 inches and a wingspan of 12 inches. It consisted of a balsa motor stick, a vee type centre section, tissue covered, with flapping wing assemblies similar to those on the previous model. The flapping mechanism comprised a rubber driven crank operating the wing spar extensions via a connecting rod. All structural parts, including the fin outline, were of bamboo and the motor was hand wound by the crankshaft extension.

This model had an excellent performance and equalled the existing British record of 20 seconds whilst being flown around a lamp post on a dark



*Above:* Fig. 1. Salem Barrack's 1937 design. In spite of claims for flights of 60 seconds, Parham was unable to achieve more than 6 secs. with his version. It set the modern design trend in design however. Size was: span 15 in., motor stock 12 in.

*Right:* A view of Parham's 44-second model "Flippin' Kid."

winter's evening. Its flight pattern was erratic, principally due to the lack of a stabiliser, but it could climb rapidly to about twelve to fifteen feet before descending slowly to earth. The small fin proved relatively ineffective and the machine flew as well without it.

Recently interest in ornithopters was revived and it was decided to concentrate upon an indoor design on the basis that it would be simple to develop, easy to construct and possibly give satisfying durations. This decision was fully justified, the model presented here being the fourth of a series and is remarkably successful. It has flown in a normal size lounge for over 30 seconds, has a best duration to date of 44 seconds, and its flight pattern can be changed readily from a straight course to a tight tailchasing spiral of less than four feet in diameter.

*Design*

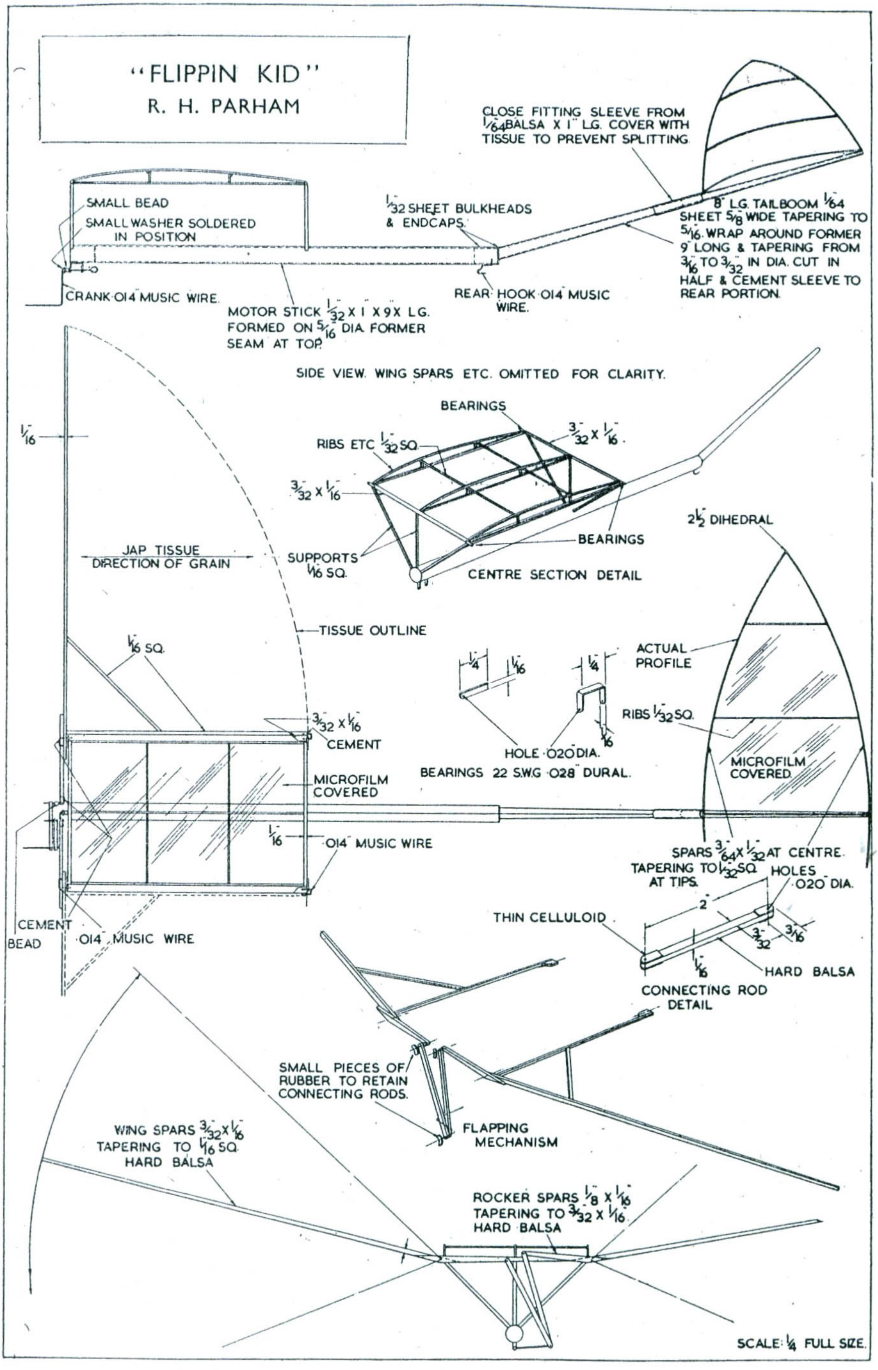
Simplicity is the keynote, and the basic layout follows the successful American school of thought headed by Parnell Schoenky. The wingflapping mechanism consists of a simple crankshaft operating wing spar extensions through connecting rods. As the wings flap, the covering assumes its own natural section and propels the machine forward in a similar manner to a boat when sculled from the stern with a single oar. Lift and climbing flight is attributed to the use of the stabiliser set at a negative incidence of between 15 and 20 degrees. This gives the model the necessary "nose up" attitude to present a positive angle of attack to the mainplanes at all positions of flap. A unique feature of the design is the use of the dihedralled tailplane. This is mounted on its own sleeve and can be rotated axially about the tailboom. When tilted a few degrees anticlockwise looking towards the nose, the model will circle to the right, and vice versa. This appears to resemble the form of control used by birds when turning in flight.

*Construction*

This follows normal indoor practice and little comment is necessary. Use firm straight grained wood for all spars and quarter-grained stock for the motor stick and wing ribs. Microfilm covering is added to the centre section after it is mounted on the motor stick and to the tailplane before cracking the spars and cementing to the correct dihedral. The wing panels are easily cut from jap tissue using a sharp razor blade and a card template. Holes in bearings, and connecting rods, are best made by using a .020-in. dia. twist drill held in a pin chuck which is rotated between the fingers. In the final assembly, check for free operation of all moving parts and only lightly cement the tailboom in position.

*Trimming*

As no torque problems are involved, this is very easy. With the tailplane in the neutral position, string a loop of lubricated rubber between the hooks, apply about fifty turns via the crank and carefully launch in a slight "nose up" attitude allowing the model to fly from the hands. A slow undulating powered glide should result, but if this is not so, *e.g.*, the glide is steep, increase the negative incidence of the tailplane by recementing the boom. Having settled the glide add more turns and the machine should begin to climb. When this condition is obtained, firmly cement the tailboom in position. The time has now arrived to experiment with tilting the tailplane, to produce circling flights. For duration attempts, the motor can be stretch-wound from the rear in the usual indoor manner. Performance will tend to fall off after a large number of flights due to excessive stretch of the tissue wing panels. They should therefore be replaced when necessary.


"FLIPPIN KID"
R. H. PARHAM
CLOSE FITTING SLEEVE FROM 1/64 BALSA X 1" LG. COVER WITH TISSUE TO PREVENT SPLITTING.
SMALL BEAD
SMALL WASHER SOLDERED IN POSITION
1/32 SHEET BULKHEADS & ENDCAPS.
8" LG. TAILBOOM 1/64 SHEET 5/8 WIDE TAPERING TO 5/16. WRAP AROUND FORMER 9" LONG & TAPERING FROM 3/16 TO 3/32 IN DIA. CUT IN HALF & CEMENT SLEEVE TO REAR PORTION.
CRANK ·014" MUSIC WIRE.
REAR HOOK ·014" MUSIC WIRE.
MOTOR STICK 1/32 X 1 X 9 X LG. FORMED ON 5/16 DIA. FORMER SEAM AT TOP.
SIDE VIEW. WING SPARS ETC. OMITTED FOR CLARITY.
BEARINGS
RIBS ETC 1/32 SQ.
3/32 X 1/16
3/32 X 1/16
1/16
BEARINGS
2 1/2" DIHEDRAL
JAP TISSUE DIRECTION OF GRAIN
SUPPORTS 1/16 SQ.
CENTRE SECTION DETAIL
TISSUE OUTLINE
1/16 SQ.
ACTUAL PROFILE
1/4
1/16
1/4
3/32 X 1/16
CEMENT
RIBS 1/32 SQ.
1/16
HOLE ·020" DIA.
MICROFILM COVERED
BEARINGS 22 S.W.G. ·028" DURAL.
MICROFILM COVERED.
1/16
·014" MUSIC WIRE
SPARS 3/64 X 1/32 AT CENTRE. TAPERING TO 1/32 SQ. AT TIPS.
HOLES ·020 DIA.
2"
CEMENT
BEAD
·014" MUSIC WIRE
THIN CELLULOID
3/32
3/16
1/16
HARD BALSA
CONNECTING ROD DETAIL
SMALL PIECES OF RUBBER TO RETAIN CONNECTING RODS.
FLAPPING MECHANISM
WING SPARS 3/32 X 1/16 TAPERING TO 1/16 SQ. HARD BALSA
ROCKER SPARS 1/8 X 1/16 TAPERING TO 3/32 X 1/16. HARD BALSA
SCALE: 1/4 FULL SIZE.