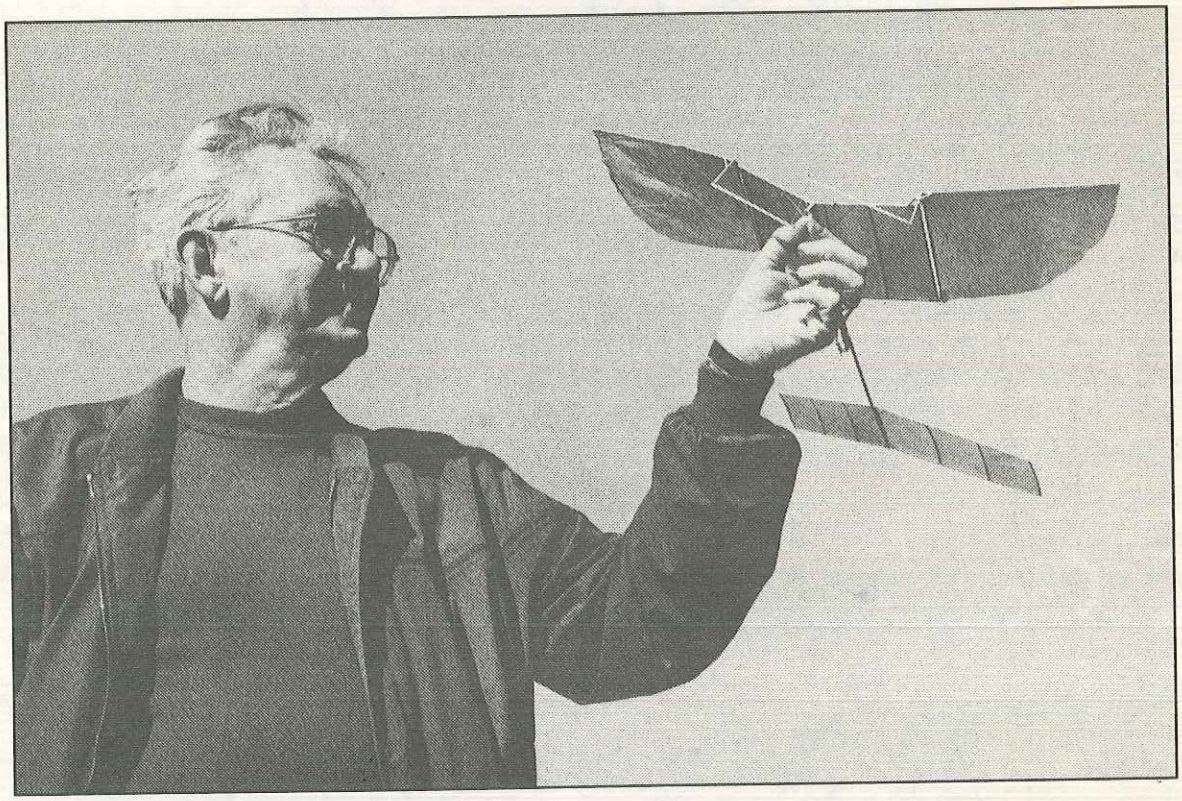
THE FLIP-FLOP ORNITHOP

■ BY KEN JOHNSON/PHOTOS BY WARREN WILLIAMS

Ready for something *really* different? Try this outdoor ornithopter, an outstanding performer from a recognized expert in the field of flapping-wing flight.



After building a lengthy series of successful indoor ornithopters, our author decided to try his hand at an outdoor model, with excellent results. Not difficult to build, the text walks you through the construction step by step and the plans are clearly detailed in all areas. You need to build one.

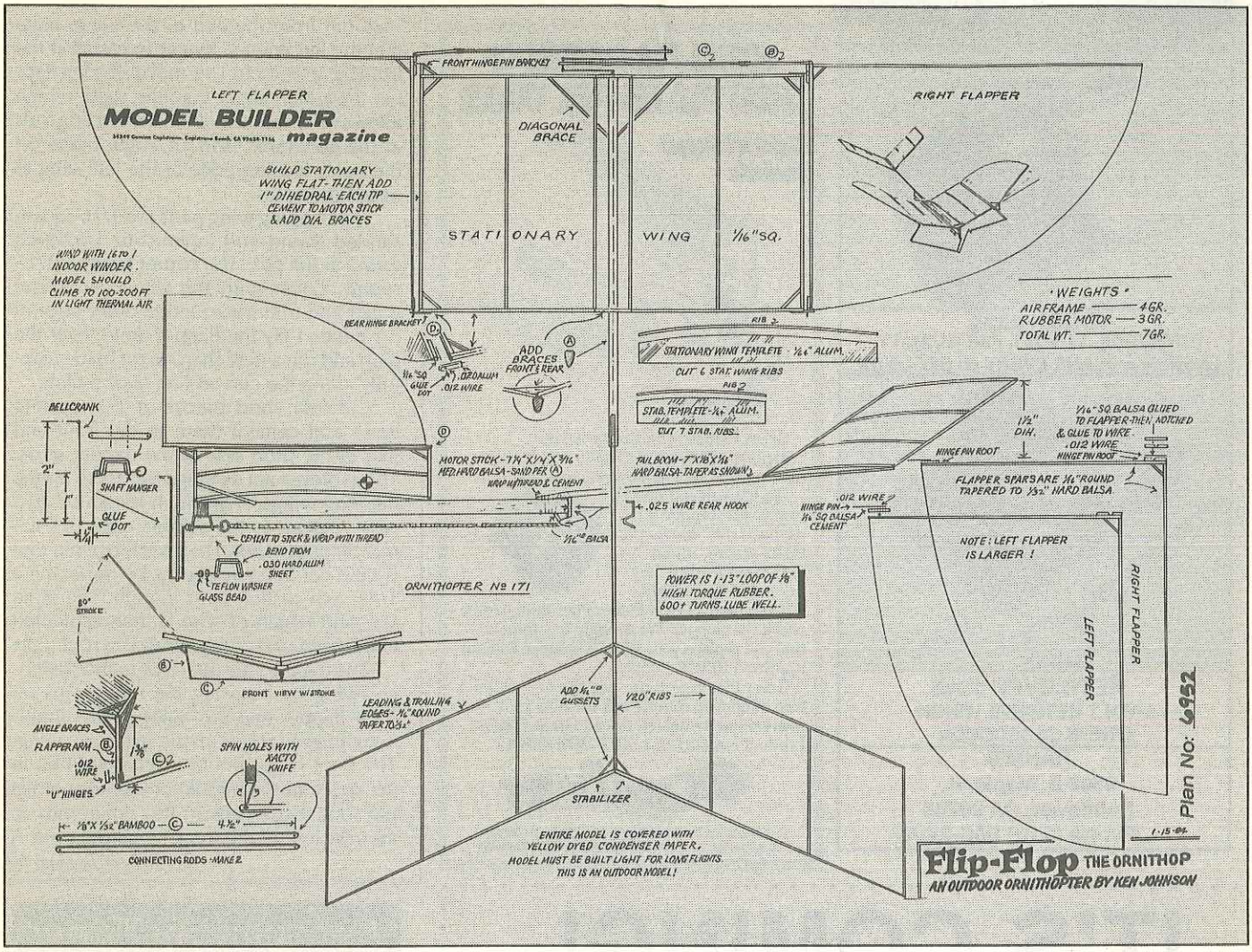
My introduction to ornithopters took place around 1965. I saw an article in one of the model magazines featuring a nice looking model, with a square stick-and-tissue fuselage and a high mounted wing.

I built the model but was somewhat disappointed with the performance. (In retrospect, my model may have been a tad heavy.) It sat for years on a shelf in my model room. Every time I looked at it, I longed for an outdoor flapper that would really fly.

My interest in ornithopters didn't wane. Many indoor flappers have come off my building board over the years. Finally, I decided to give outdoor another try. Using a one-design model I developed for the indoor group in Santa Monica, California, I updated the design to outdoor standards. Knowing that ornithopters *must* be light, I covered it in condenser paper. The performance on this model has been good and many flights of over 3 minutes have been clocked.

The "Flip-Flop" name was inspired by an article in *Esquire* magazine. In 1972, while living in Ohio, I contacted the

6952 1 OF 4



people at *Esquire* after reading about someone's efforts with full-size man-carrying ornithopters. They asked me to come to New York to demonstrate my model flappers for them. The ensuing article on my "Wingfoot" model was published in the April, 1973 issue of *Esquire*. The editor, Tom Farrell, titled the article "Flip-Flop the Ornithop." I liked the title so much, I decided to use the name for my outdoor model.

Although this model looks like an indoor flapper, it's designed to be flown outdoors. Choose the wood carefully. Hard and medium-hard balsa and bamboo are correct for this plane.

The ornithopter should be flown in very light or no wind conditions. It will fly best in thermal air. It should be wound with a 16:1 or 20:1 indoor style winder. Launch the flapper into the wind with the nose slightly raised and with a very slight push.

CONSTRUCTION

Start with the motor stick, a piece of 3/16x1/4 balsa. Round the corners on the top edge, then taper the sides of the stick toward a point at the center of the bottom. Fashion the shaft hanger from .030 hard aluminum sheet. Drill a .025-inch hole at both ends about 1/16-inch in from the ends. The holes can be punched into the aluminum with a sewing needle. Be sure to dress the metal around the holes so that it's smooth. I use a jeweler's flat file for this.

Now make the two right-angle bends in the shaft hanger. The end pieces should be 1/4-inch long. Cement the shaft hanger to the bottom of the front end of the motor stick. Be sure to wrap thread around the hanger and motor stick and cement well.

The rear motor hook is made from .025 wire. Cement it onto the back end of the motor stick. Add the two pieces of 1/16 square balsa to strengthen the hook. Cement the tailboom to the top of the motor stick before wrapping the motor hook/tailboom joint with thread and gluing. The tailboom is made from hard balsa, tapered to 1/16-inch square at the rear. Cement the tailboom to the motor stick with the rear end elevated 3/4-inch, then wrap the joint with thread and cement.

Build the stationary center portion of the wing over the plan. Cut through the leading and trailing edges at the center and cement in the two 1/16 balsa braces to strengthen the center. Put in 1 inch of dihedral under each tip of the stationary wing.

Cement the stationary wing to the motor stick at the very front, then add the 1/16 square balsa diagonal braces from the motor stick to the leading edge of the wing. Note that the leading and trailing edges of the wing should be notched down into the motor stick and glued. Don't forget to add the 1/16 square balsa corner braces at the wingtips.

The stationary wing can now be covered with dyed condenser paper (I chose yellow as it has good visibility against a bright blue sky), starting with the narrow center section and adding the two outer panels. Make the four aluminum hinge brackets (.020 sheet aluminum) with a .015-inch hole drilled or punched through near the end of each piece. Cement these onto the tips of the leading and trailing edges of the fixed wing. The holes should be located 1/16-

2 OF 4

inch out from the end of the wing. Note that the left wing is longer in chord at the front by 3/16-inch. This makes the left flapper 3/16-inch larger than the right, which allows for clearance of the connecting rods at the bellcrank. Add an angle brace on the outer leading edge of the left wing to accomplish this.

The flapping wing parts are 1/16 square sanded round and tapered to 1/32-inch round at the tips. The corner brace is 1/16 round. Cover with the same condenser paper and trim the rounded outer edge of the paper. I lay the flapper down over the plan and run a new sharp razor blade carefully along the curved line on the plan.

Cut four short pieces of 1/16 square balsa and cement them to the front and rear of the short side of the flapper spars. These pieces act as hinge pin roots for the flapping wings. A 5/8-inch length of .015 wire is glued to the outside edge of each rear hinge pin root. The front hinge pin root is now cut into two pieces by removing a 1/16-inch section at its middle. The same size and length of wire is then cemented to the front part of this hinge pin root only.

The flappers are attached to the stationary wing by inserting the hinge pins on each flapper into the holes in the aluminum hinge brackets on the stationary wing. The front hinge pin bracket should be in the space in the middle of the front hinge pin root. Now cement the hinge pins to the rear half of the front hinge pin root. A

continued on page 80

3 OF 4

ADVERTISER INDEX

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ORNITHOP *cont. from page 62*

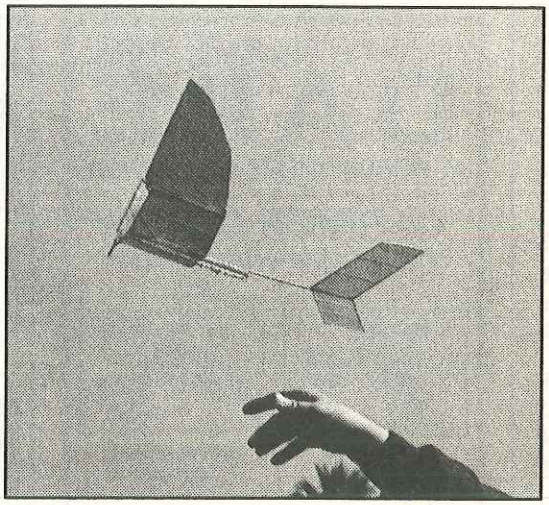
small dot of cement should be placed at the tip of the rear hinge pin.

The flapper arms are 1/16 round balsa, 1-3/8 inches long. The flapper arms are attached vertically at a right angle to the front flapper spar. Each is angled out slightly from the vertical so that it is in line with the bellcrank. A small piece of .015 wire is bent in a U shape (make one for each side). Cement one side of the U to the end of the flapper arm (on the backside of the arm). The front side of the U is left open so that the connecting rod will slide over it.

On each of the flapping wings, be sure to cement the two 1/16 round angle braces that support the flapper arms. These 1/2-inch long gussets are cut to a 45-degree angle at each end.

The bellcrank is formed from .025 music wire. A round loop is bent at the rear, then the wire is passed through the two holes in the shaft hanger. Slide a Teflon washer, then a small glass bead onto the shaft. Make a 90-degree bend in the shaft. The distance from the glass bead to the first bend is 1 inch. Measure out 1/4-inch and make a return bend. The return distance measures 2 inches. One more 90-degree bend is made. Measure out 5/16-inch and cut the wire.

Make the two connecting rods from bamboo barbecue skewers from the local supermarket. When working with bamboo, I find that scraping works better than sanding. A single-edge razor blade or small X-Acto knife is good for this. A small pointed X-Acto is used to "spin" the hole at each end of the two connecting rods.



And away she goes! Build it light for best performance. Prototype model was covered with condenser paper dyed yellow for good visibility.

Slide the bellcrank wire through the hole at one end of the rod. Work it carefully around the right-angle bends and into position on the crank (on the first end bend). Put a small dot of cement at the corners of the right-angle bends so the connecting rod will not slide out of position. Attach the other connecting rod to the crank at the other position and put a dot of cement at the bend. A final dot of cement will hold the outer connecting rod onto the shaft.

Test the flappers to see that they work freely and that the stroke measures about 80 degrees. Make sure that the connecting rods do not bind on the bellcrank.

The stabilizer is built flat over the plan. Cut the stab at the center and cement in 1-1/2 inches of dihedral at each tip. Cover and attach to the end of the tailboom.

FLYING

Attach a 13-inch loop of 1/8-inch lubed rubber. Note the position of the CG; it should be 1-1/4 inches forward of the trailing edge of the stationary wing. Put in only a few winds on the motor, to test the smoothness of the linkage. If everything looks good, you're ready to fly. Start with 300 winds and work up from there.

I've found that an ornithopter can be wound either clockwise or counterclockwise. If the model has difficulty at launch you may wish to try winding the motor in the other direction, as the torque force will then be reversed.

Good luck with your Flip-Flop. Let me know how it flies for you. My address is 16728 Bermuda St., Granada Hills, CA 91344. *MB*

4 OF 4