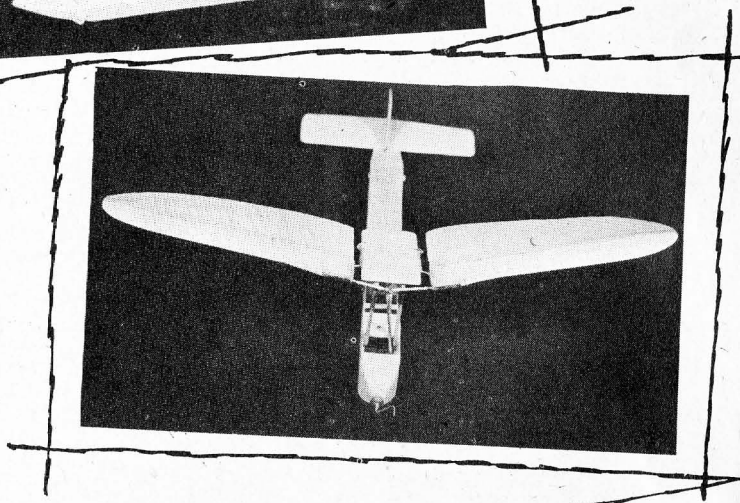
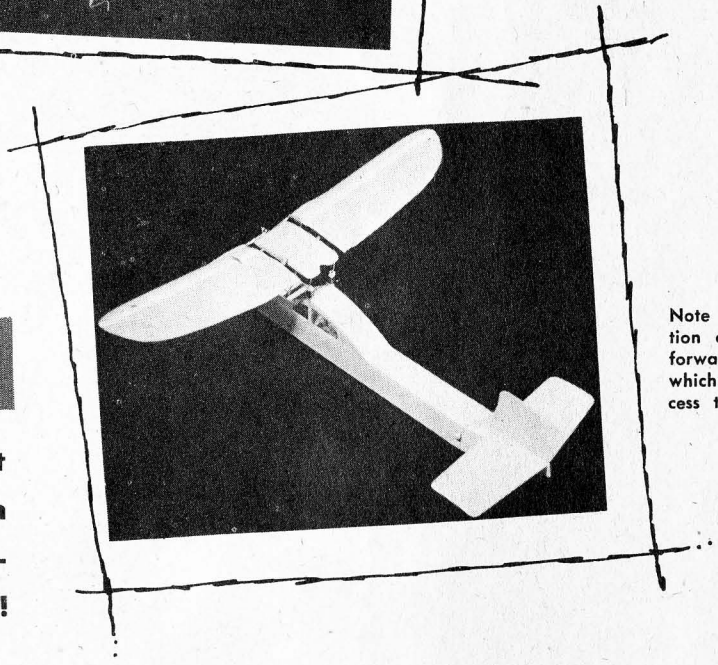
This side view clearly shows the alignment guide posts, "Angle-Of-Attack-Changer" curved guide wires and connecting rod, pivot posts, and the two wing connecting rods (looking l. to r.)



Looking down at the front of the Flapper you can see how the wing panels are attached to the connecting rods and "Angle Of Attack Changer."



Note the break-away section of the fuselage, just forward of the rudder, which opens to provide access to the rubber motor.

FM FLAPPER

Want a model plane that flies like a bird? Then here you are — a simple-to-construct ornithopter!

BY PAUL E. DEL GATTO

● Ever since we began designing model planes, we've wanted to develop a flapping-wing model (ornithopter) that would be more practical structurally and look less like the weird contraptions we'd seen on flying fields.

Our first few attempts failed miserably, and for a long while we completely forget about the whole idea. Then, about a year ago we again attempted the project, and taking up where we stopped, worked out what we felt was a more efficient flapping mechanism.

Its final evolution was similar in many respects to the standard type of mechanism in general use, with several very important additions; most important being the "Angle of Attack Changer." The idea behind this was to use a more rigid wing frame.

In doing this we were aware that, with the standard type of mechanism, lift and thrust were achieved through the use of a highly flexible wing, made up of a thin leading edge which was lightly braced, with the remainder of the wing pattern made up of tissue paper. When the wing would flap on the up-stroke the trailing edge would be depressed downward, which would in effect raise the angle of attack of the wing; when the wing would flap on the down-stroke the trailing edge would be pushed upwards, which in effect decreased the angle of attack of the wing. Our "Angle of Attack Changer" is designed to do some of the work that originally had to be done by an extremely flexible wing.

The wing we used can be truly considered as being semi-rigid and capable of supporting a useful load even when the wings are not flapping. The leading edge we used, is very rigid for a

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model this size, and also symmetrically shaped to blend in with the main wing pattern. The main wing materials we experimented with were gas silkspan, bamboo paper, drafting paper, one to two-ply strathmore (available in any art supply store), and 1/32" sheet balsa. The sheet balsa and the strathmore proved to be too rigid for such a small model. However, we were able to make some short flights with the one-ply strathmore. To us, this indicated that if a larger model were constructed the structure could be made even more practical, but for this model best results were achieved with the more flexible grades of paper.

Experimenting with different wing pattern outlines we also concluded that variations in the pattern shape affects the extent of the efficiency obtained.

We also tried different flap ranges up to as much as 90°, and different ranges in the angle of attack up to the 20° range we have right now. After many combinations we concluded that, for the rate of flapping we could achieve, a 50° to 60° flap range combined with the 20° angle of attack range would be a good combination.

The basic structure of the "FM Flapper" is very simple and can be completed very quickly. Plans are full-size!

FUSELAGE: Construct the 1/16" square main fuselage frame, then the rear fuselage frame to which the tail assembly is mounted. Note that the top view of the main fuselage frame is the same as the main fuselage frame shown in the side view.

Having completed the frames, cut out the 1/32" sheet balsa sides, top and bottom—except for the top section forward of the cabin—and cement the sheets to the frame.

TAIL: The tail assembly is cut from 1/32" medium sheet balsa. The proper curvature is obtained by cementing it to two stab-mount ribs located on the top edges of the rear fuselage frame.

WING: The wing construction, while fundamentally simple, does require that care be exercised in hinging the wing panels together. Use sizes of wire and tubing as close as possible to the specifications noted on the plan.

Begin by cutting and shaping the wing leading edge. Bend the wing braces and ribs to shape from 1/32" diameter wire. Then cement them in the positions indicated and lightly bind and solder them where they join.

The connecting rod bearings are bent from .049" diameter wire and bound and cemented to the ⅛" diameter dowel fasteners. When the assemblies have dried, recess the leading-edge section of each wing panel slightly, and cement them to the leading edges.

The wing hangers are bent from .040" diameter wire and cemented in the position indicated on the plan.

The center section is shaped from a piece of 3/16" medium sheet balsa, as shown in the wing plan and side view. To the center section you then cement the hanger bearings on the side, as shown.

The next and final phase is to make the shaft and connecting rod assemblies and have them functioning smoothly.

Begin by cementing the pivot and guide posts to the insides of the 1/32" sheet-balsa sides. Then make the wire pivots and alignment guides, binding and cementing them to the posts.

Bend the angle-of-attack changer and alignment track wire to shape and cement them to the bottom of the center section as shown. Next, cement the pivot bearings to the center section leading edge, aligning them so that the wings pivot freely in the guides without binding.

The three connecting rods are made from 1/16" inside diameter thin aluminum tubing with the ends flattened out and drilled to receive the shaft, connecting-rod bearings, and angle-of-attack changer.

The nose block is shaped from a block of medium balsa and hollowed out. Then cement a small face washer to the outside face of the nose block. To the inside edge of the hollowed-out area, cement a hard piece of 1/16" sheet balsa, and cement another small face washer to the sheet-balsa face.

The crankshaft is bent from 1/16" diameter wire. Beginning from the nose end, complete that portion of the shaft which passes through the nose block. Insert the partially finished shaft into the nose block, adding another face washer and ball-bearing washer to the outside shaft end. The outside face washer is then soldered to the shaft. Then a small washer is cemented to the inside, up against the face washer there. By doing tnis, the position of the crankshaft is locked.

Finish bending the crankshaft, and while in the process add connecting rods and the necessary small washers to complete the assembly. When the most desirable positions for the connecting rods have been determined through temporary assembling, solder the washers to the crankshaft, allowing for free but restricted movement of the connecting rods fore and aft. After this has been done, solder the retaining washers to the connecting rod bearings and the angle of attack changer, thus completing the basic assembly.

FINAL ASSEMBLY: Cut the two wing patterns out of one of the materials recommended and fasten to the leading edge and wire rib with a Scotch tape seam. Then add the remaining details such as the 1/32" sheet balsa to the forward top section of the fuselage and the thin celluloid windows.

Hinge the tail section and make the .040" diameter winder hook which fastens on to the rubber-motor dowel post as shown in the Winder Sketch.

Do not dope the surfaces of this model as it will add unnecessary weight.

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The section on the bottom of the fuselage below the shaft hook should be left open or hinged for easy installation and removal of the rubber motor.

Ten to twelve strands of T-56 ⅛" flat brown or its equivalent, is the power range recommended for this model. The completed model should weigh slightly over one ounce. Ours weighed approximately 1.3 ounces, but the changes we incorporated into the plan should reduce the all-up weight as much as a quarter of an ounce.

FLYING: Flying the model requires no special skills. However, there is one thing to watch for, and that is if the model is flying at too high an angle of attack. This would be an indication that the model is stalling. If this occurs, it may be trimmed out by warping the trailing edge of the stabilizer down.

Do not add ballast to the nose as the added weight will reduce performance.

The importance of minimizing vibration and friction cannot be overemphasized, as these are perhaps the greatest drawbacks in making a successful ornithopter; so be certain that all bearing parts are well lubricated and function freely.

BILL OF MATERIALS
(Balsa unless otherwise specified)

2—1/32" x 3" x 36" (medium) ..... Fuselage sides, top and bottom; stab; fin
3—1/16" x 1/16" x 36" (medium) ..... Fuselage frame

1/32", .040", 1/16" inside diameter aluminum tubing; 1/32", .040", .049", 1/16" diameter wire; three 3/8" diameter face washers; assorted small brass washers; 1/16", 1/8", 3/16" sheet balsa; gas Silkspan, bamboo paper or drafting paper; 1/16" x 3/16" hard balsa; Scotch tape; fabric hinge; cement; solder; 10' T-56 1/8" flat brown rubber; 1/8" and 5/32" diameter dowel; thread.