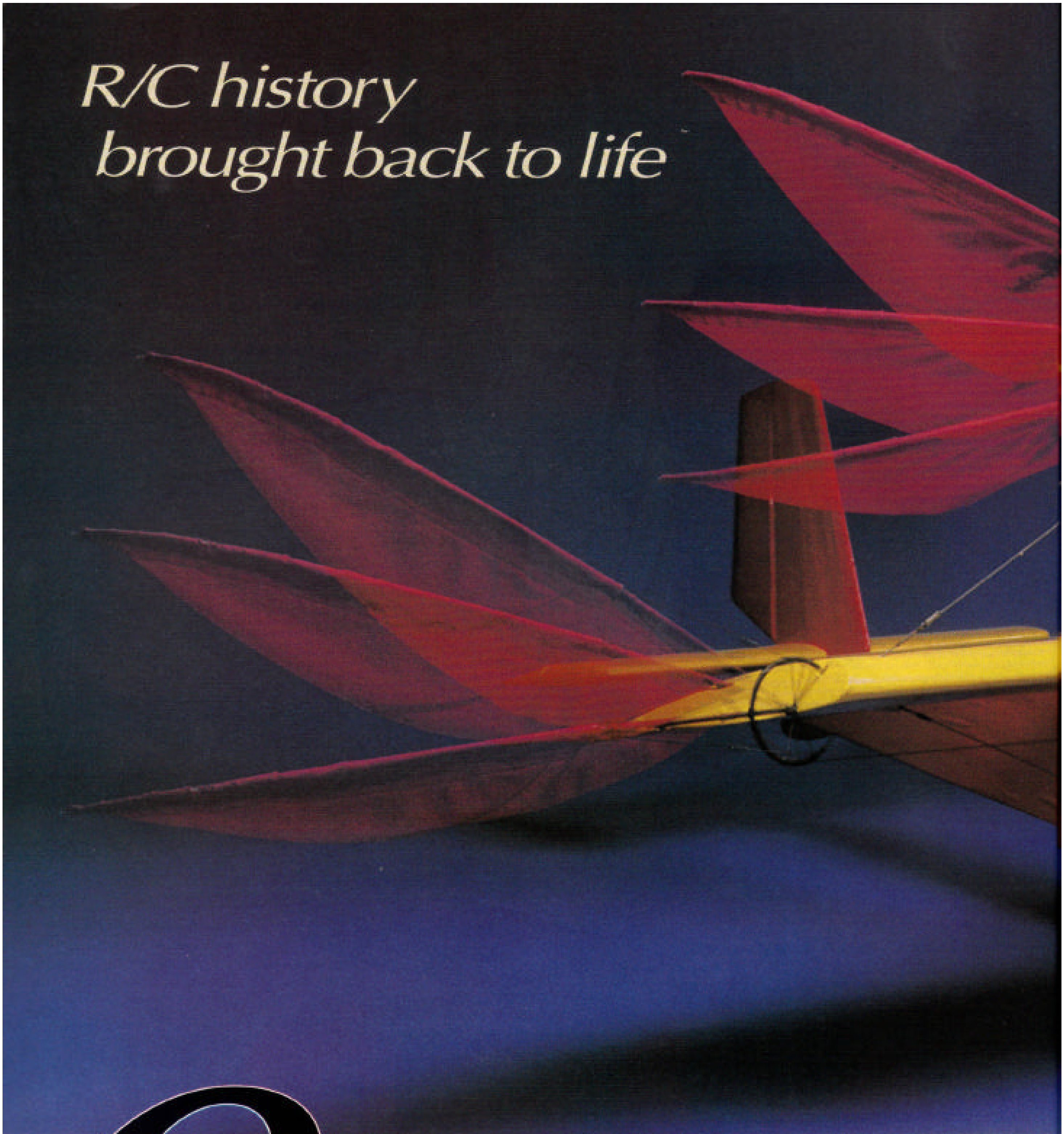



# SPENCER'S Ornithopter

*by Faye Stilley*

SOME MEN BUILD an aircraft, get in and go flying. That's the kind of man Percival H. Spencer was. Born in 1897—before men were flying—he made his dream come true in 1911 when he built and flew a biplane hang glider. Three years later, while still in high school, he rebuilt a wrecked version of a Curtiss flying boat and taught himself to fly. That was the beginning of a long career of designing, building and flying aircraft. Spencer is best known for the Spencer-Larsen amphibian, the Seabee and the Spencer Aircar amphibian.

Spencer wanted to build a man-carrying ornithopter. In the early 1930s, he built and flew

several rubber-band-powered models and, in 1934, he patented one. That same year, he built a gasoline-powered biplane ornithopter that, unfortunately, did not have enough power to fly. In 1956, he patented an improved version of the rubber-powered ornithopter called "Wam-O-Bird" and sold thousands. In the late '50s, he built a series of Seagulls powered by model airplane engines. They flew free-flight, but were tethered. Wanting to unleash his Seagulls, Spencer approached Jack Stephenson, an avid R/C flyer, and asked, "Can the Seagulls be converted to R/C control?" Jack decided that the relays in his R/C models could not withstand the bouncing caused by the flapping wings, and he suggested a biplane version with opposing flappers to cancel out the bouncing motion. Spencer agreed immediately. After all, he had built a biplane ornithopter back in 1934. Spencer and Stephenson collaborated for several months, and in June 1961, the R/C prototype model was completed and flying. Unfortunately, Spencer died before he could complete the development of the man-carrying version.

## SPECIFICATIONS

**Wingspan:** 90.7 in.

**Length:** 52 in.

**Weight:** 7.5 lb.

**Power:** .35 2-stroke

**Construction:** balsa and ply

**Covering:** silk and dope

*Percival Spencer holds the 70-inch-span, free-flight prototype of the ornithopter.*

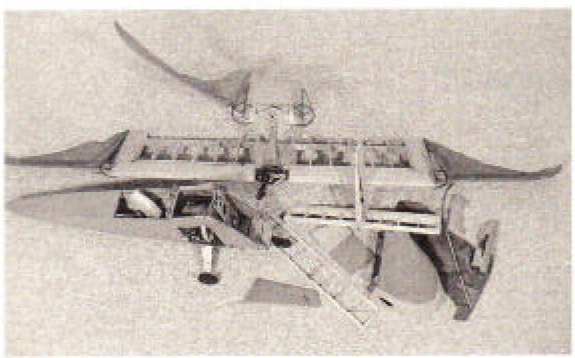
### RESTORATION PROJECT

Jack Stephenson believes that the Spencer Orniplane model was the first successful R/C ornithopter and the only one ever to take off from the ground. Thirty-five years later, I was asked to restore the model to display in the New England Air Museum. I agreed because I thought it would be a lot of fun and educational, too.

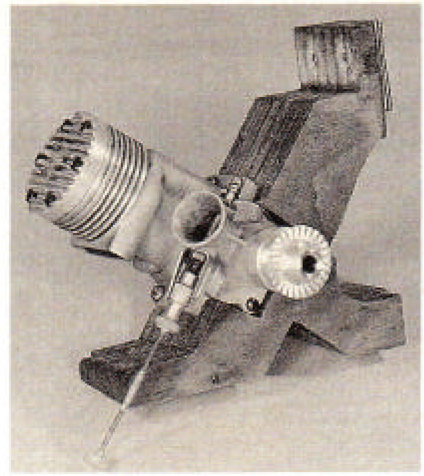
The surviving parts were covered with decades of dust, soaked in oil and came replete with several generations of spider webs and carcasses. I admit that I had second thoughts about what I had agreed to do, but they quickly disappeared when I began to examine the pile more closely. I was fascinated with the ingenuity that went into this unusual bird. There were no hobby shop "goodies" here. Virtually every part—wood and metal—was handmade. My mission was to restore it to original. It would be much easier to build one today because of all the available parts, accessories and materials; I hope that some clever modelers will take the challenge and build 1999 versions.

### THE ENGINE

Spencer's design called for the engine to be installed within the fuselage. It needed to be cooled by air and also be accessible for starting and adjustment. Most important, it had to line up perfectly with a gearbox that would transfer power to the flappers. He came up with something that looks more like some sort of modern art than it does an engine mount. As odd as it looks, it met all the requirements. One "leg" was bolted to the side of the fuselage and the other to the bottom. The engine is a Torpedo 35.



*Left: this is what was left of the prototype model when it arrived at my door.*



*One "leg" of the mount is bolted to the side of the fuselage and the other to the bottom. The engine is a Torpedo 35.*

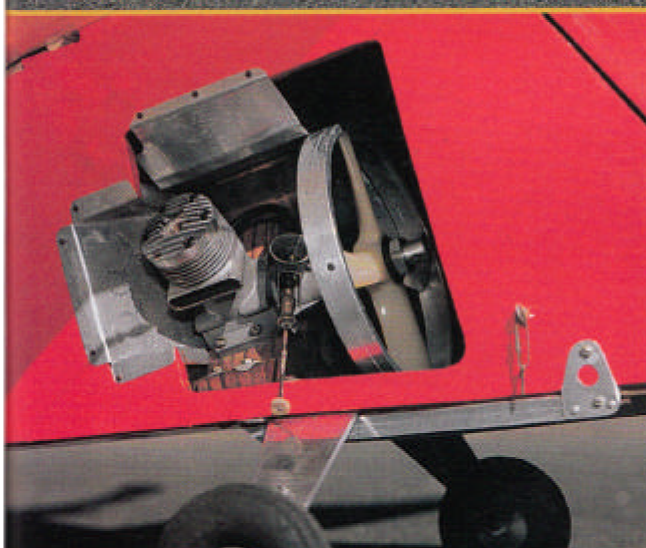
COLOR PHOTOS BY WALTER SIDAS, B/W PHOTOS BY DAVE STILLEY

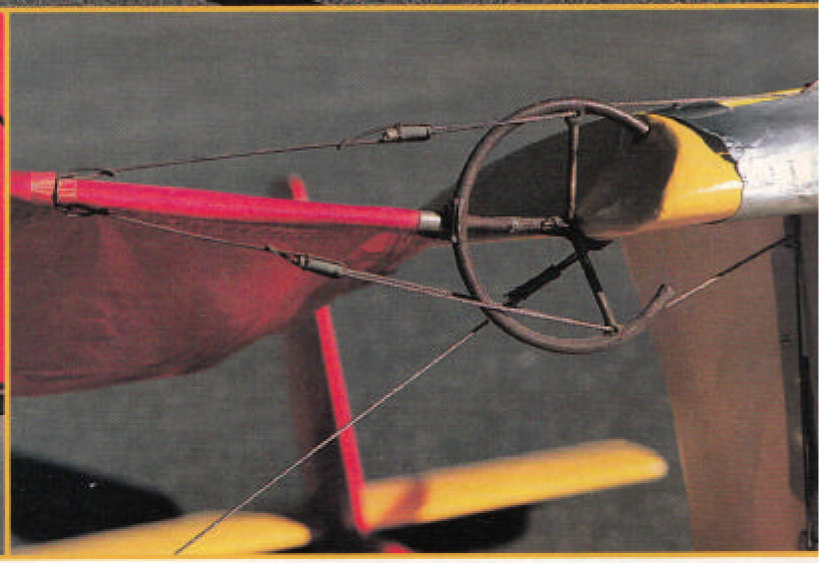
For engine installation, two 12x4 nylon propellers were cut down and fitted together to form a fan. An aluminum ring was attached around them to complete the fan/flywheel. Lightening holes drilled in the ring helped to balance the assembly. The flywheel protrudes outside the fuselage to facilitate hand-starting, and the cylinder head and needle valve are accessible from outside the fuselage. A shroud encircles the engine to force air over it, and a baffle behind the engine directs the air back out of the engine compartment. An inlet hole above the gearbox allows air in through the forward bulkhead.

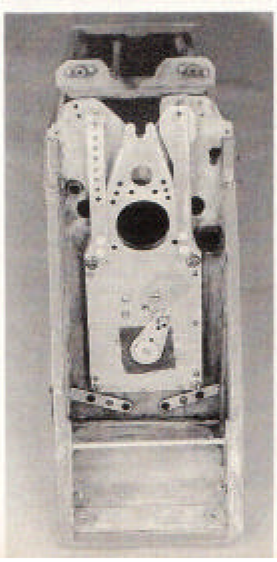
### SETTING THE GEARS AND PULLEYS

After experimenting with several gear ratios, I chose to use 30.5:1. With the engine running at about 12,000rpm, the flappers cycle about $6\frac{1}{2}$ times a second. I used a simple, two-stage gear setup with an 8-tooth pinion driving a 56-tooth gear for the first stage and an 11-tooth pinion driving a 49-tooth output gear for the second stage. I drilled and riveted slabs of nylon material to the gearbox covers to serve as gear shaft bushings.

The upper tower section shown in the photos contains the main drive pulley and idler pulleys, which guide the drive cables to the flappers. The large pulley attached to the lower center of the tower is the main drive pulley. It drives the lower wing flappers with cables connected directly to it. It also drives the upper wing



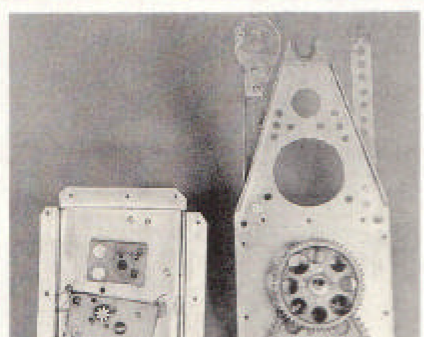




***The output side of the gearbox and the lower end of the tower section, which is permanently attached to the wing assembly. The output arm (crankshaft) is connected to the main drive pulley on the upper tower section with a long conrod. The large round hole above the crankshaft is an air duct to the engine compartment.***

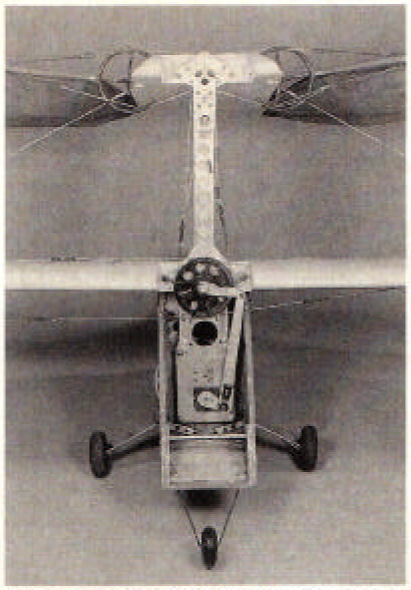
flappers with cables routed to them over idler pulleys in the upper section of the tower.

The large, spoked pulleys are attached to the upper wing flappers. Spencer made the flapper pulleys from tubing, which was slotted to form a pulley-type rim. The flapper pulleys on the lower wing are the same as those on the upper wing. The cables from the flapper pulleys connect directly to the main drive pulley. They travel straight to the drive pulley on one side and cross on the other side. This cable arrangement pulls the left and right flappers up or down in unison.

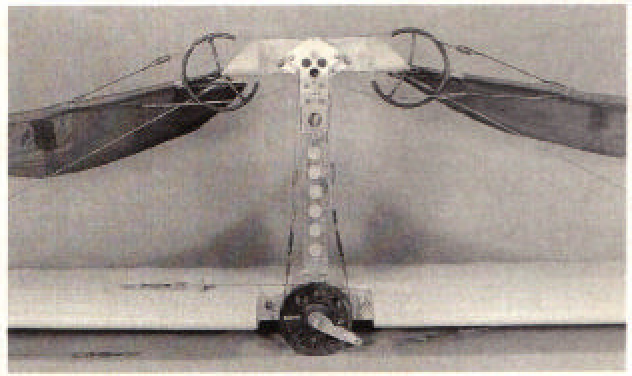


***The open gearbox.***

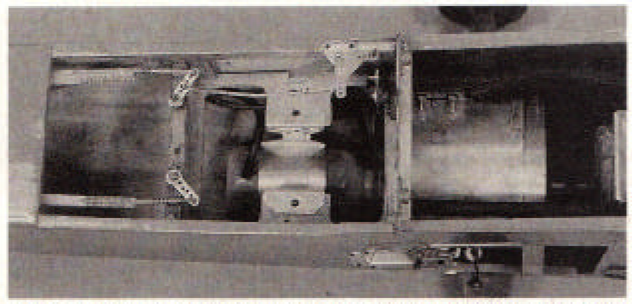
When the power train is assembled, the crankshaft arm rotates and pumps the conrod—and in turn, the main drive pulley—up and down, much like a piston. The oscillating motion of the main drive pulley on the drive cables controls the direction and distance of the flappers' travel. If you have read this far, I'd guess that you have come up with some other creative way to transfer power from the engine out to the flappers. Figure 1 illustrates how Spencer hooked up the cables.



***The complete power train with the conrod in place.***



***The upper tower section contains the main drive pulley and idler pulleys, which guide the drive cables to the flappers.***



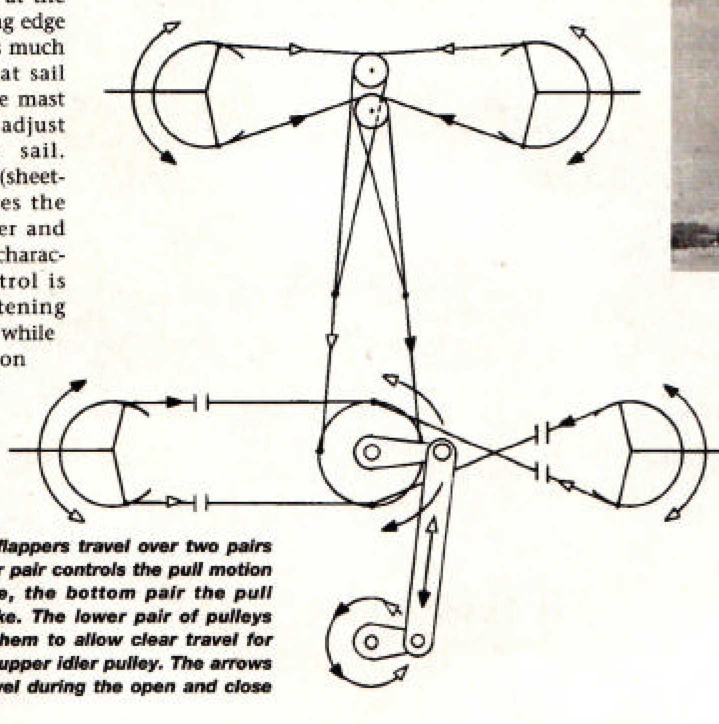
***The aileron control cable is linked to the rudder pushrod idler arm to provide coupling. An idler arm is used to adjust rudder throw. The nylon bellcrank is the only prefabricated part, besides the wheels, on the entire aircraft. It is linked to a second idler arm, which in turn is connected to the aileron control cable and the rudder servo. The fuel tank is suspended by aluminum brackets.***

### THE FLAPPERS

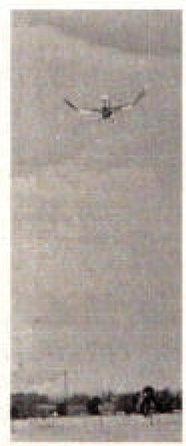
The flappers are made of rip-stop nylon. In some ways similar to the wings of a bird, they create lift and thrust by flapping. The amount of curvature in the fabric across the span determines the amount of lift and thrust generated. The darts in the flapper limit the maximum curvature. There are many other factors involved in the effectiveness of a sail (flapper); however, this very simple design proved itself effective enough to propel the Orniplane. Adjusting the tension of a sail changes its performance. There were no provisions made to adjust flapper tension in flight except for "aileron" control.

The root rib (metal rod) on the main wing flappers is hinged at the connection to the leading edge (aluminum tube). It acts much like the boom of a boat sail that is connected to the mast and can be moved to adjust the tension of the sail. Tightening the flapper (sheeting in the sail) changes the curvature of the flapper and therefore its lift/thrust characteristics. Aileron control is accomplished by tightening the flapper on one side while loosening the flapper on the other side. The movable root rib is connected to a cable that runs through the wing to the other root rib. The oblong metal loop limits the travel of the root rib and therefore, the maximum curvature of the flapper.

The complete wing assembly with the main drive pulley and all the cabling installed is connected to the fuselage by four wing bolts and to the output crankshaft by the conrod. After the aileron cable and two guy wires have been connected, it is ready to fly.



***The cables to the upper flappers travel over two pairs of idler pulleys. The upper pair controls the pull motion for the flapper upstroke, the bottom pair the pull motion for the downstroke. The lower pair of pulleys have a spacer between them to allow clear travel for the cable traveling to the upper idler pulley. The arrows show the direction of travel during the open and close power strokes.***



### IN THE AIR

It stretches the imagination to picture this thing flying when the only means of propulsion is the flappers. It did fly; there is a video to prove it. It is sad that the development of such a unique aircraft stopped because of Spencer's health. Perhaps some creative modeler can pick up where Spencer left off and create a modern ornithopter.

If you have any interest in creating such an aircraft, Jack Stephenson is eager to help. He believes that a ¼-scale Piper Cub kit could easily be used as the base aircraft, using the fuselage, tail group and much of the wing. He has sources for many of the unique parts as well as a ton of ideas as to how the aircraft can be built more easily and be a more efficient flyer. He even has some plans. Contact him at 22 Hook Rd., RFD 4, Gilford, NH 03246; (603) 293-7016. ✦