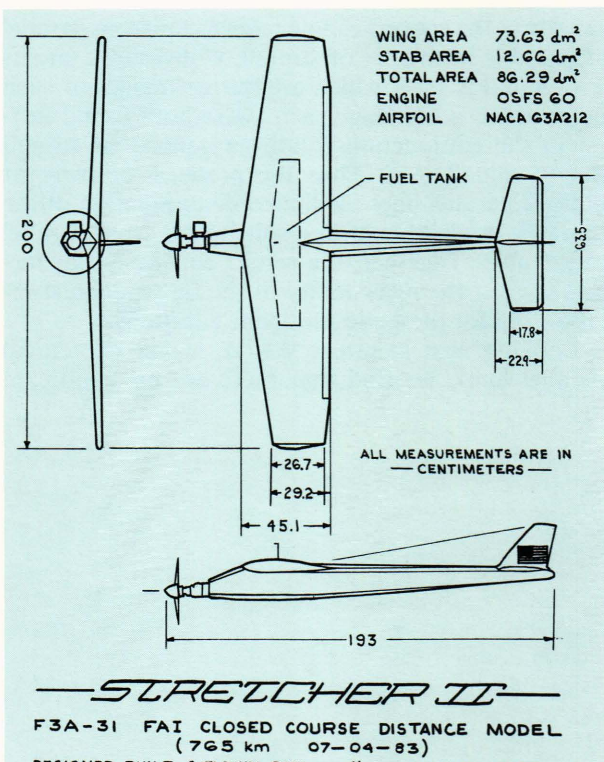
MAYNARD L. HILL

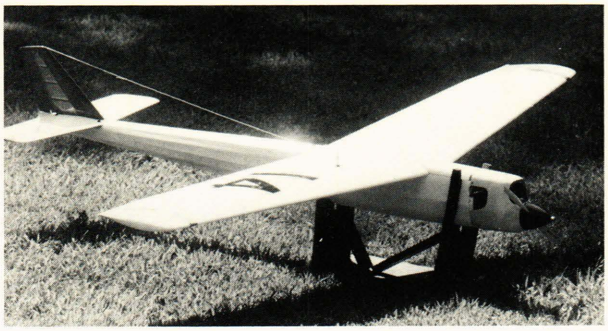
A CLOSED COURSE DISTANCE RECORD FOR POWERED RADIO-CONTROLLED AEROMODELS

On Sunday, July 3, 1983, we gathered at a horse pasture near Sunshine, Md., for a flight session to measure fuel consumption and flight speed of a specialized radio-controlled aeromodel. We had been testing for more than a year and this was about the fortieth session. We had already made four unsuccessful attempts to break the Federation Aeronautique Internationale world record of 740 kilometers for radio-controlled models in closed course distance—a record set in 1979 by two Soviet modelers, Y. Saslavski and A. Smolentsev. We had totally destroyed four models in crashes and had experienced three other crashes in which the damage was major but repairable.

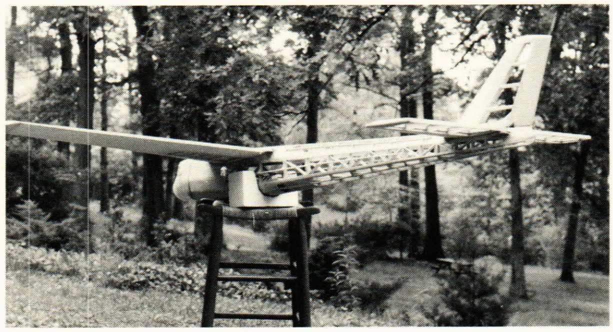
For the closed course distance record, two pylons are set up 500 meters apart, and a credit of 1 km is accrued for each circuit completed during a nonstop flight. The combination of tight turns and straight legs generates some special design and performance problems. If the model is small, aerodynamically clean, and speedy, the airflow over the wing or propeller can become messy in the turns, and the model can stall out or slow down horrendously during each turn. If you make the model big and slow, pilot fatigue will set in before the necessary number of laps can be completed. (The rules require that one man must fly the model.) By this fifth model, I had settled on a 77-inch-span bird called Stretcher II. A previous Stretcher had set a closed course distance record (189 miles) and cross-country distance record (184 miles) back in 1965. Stretcher II uses a 0.61 cubic inch displacement, four-cycle, hobby engine converted to use a capacitance discharge spark-ignition system. Four pounds of gasoline-based fuel are carried in a wing tank and fed to a float chamber down near the carburetor. A hand-carved, 14 inch narrow-bladed propeller provides the best compromise for the big variation in drag on straight flight versus drag during turns. Hewitt Phillips of NASA/Langley, helped design the propeller with his

American flags flew on the pylons marking the 1 km closed course while Stretcher II, in the foreground, dipped her wings in salute 1530 times between 9:02 AM and 6:17 PM on the Fourth of July, 1983. Part of the crew that worked to set a new record of 765 kilometers proudly displays the spirit of the day. Left to right: John Patton, Doug Harper, George Pickrell, Maynard Hill, Mel Newcomer, Charlie Calvert, Harry Gratten, Jack Anglin. (Photo by M. O. Chance.)





The first model of a series of five that were built for this effort had a cowled engine and a foam-fiberglassed wing. It flew very well but the structure was too heavy to allow sufficient fuel for a record unless it were to be flown slowly for 15 to 16 hours. The strain of flying a precise course is a problem for the pilot, so new lighter weight models were built to provide the fuel capacity for speeds that would produce a record in 9 to 10 hours. The model could lift more weight, but the rules limit gross takeoff weight to 11.02 pounds. Thus, the only way to increase fuel capacity is to cut down on structural weight.



This photo of model No. 1 before covering shows the balsa bridge truss structure in the fuselage. The elevator servo is mounted aft at the tail. No rudder is used. Control is by ailerons and elevator only.

superb computer program. Very early in the project, he came amazingly close to defining the optimum pitch and blade shapes. Another friend had put the turn and straight-leg drag problem on his home computer, but the answers did not help much because the computer had no way to deal with the reality of turbulence in actual flights.

Several notebooks were filled with data about fuel consumption versus horsepower during many weekends of testing on a homemade dynamometer. However, static ground testing alone was not enough. To determine engine behavior as a function of air speed, I strapped the engine onto a ski rack on top of my car. A baby bottle full of fuel was tied to the right rearview mirror; a fuel pump located in the back seat put pressure through the nipple to lift the fuel up into the float chamber. I would start the model engine, jump behind the wheel, and drive on an Interstate highway for 30 minutes at constant speed. An optical tachometer was mounted inside the windshield. During a quick stop at an interchange, I would read how much fuel was used, refill the bottle, and drive away again at a new speed. Only once was I stopped by a state policeman, when I was in the midst of a 75 mile per hour run. He agreed that it was decent of me to pick a highway with little traffic, but that didn't cut down the fine. He suggested that if I really had to do this, perhaps it would be possible to arrange for an escort. I burned up a lot of gas in my car over a period of several months to obtain the necessary data. Interestingly enough, four-cycle model engines are so quiet that other drivers on the road did not hear the engine above the road noise. Also, the propeller was essentially invisible. Only a few people looked at me oddly. This was summertime, and I think they were wondering what kind of funny skis I had strapped on top.

The data from the car tests helped quantify how propellers of various pitches and diameters would af-

Fuel consumption tests in a simulated flight environment were done by mounting the engine on a ski rack on the roof of the author's car. The fuel is contained in an 8-ounce baby bottle tied to the rearview mirror. A pressure pump in the back seat of the car forced the fuel into a float chamber mounted behind the engine. The spark system and batteries were also contained on the engine mount. Reading the bouncing fuel level from the driver's seat was impossible, so constant speed runs of about 30 minutes were made and fuel level readings were taken at the start and stop of each run. Steadiness of engine rpm could be checked via an optical tachometer mounted against the inside of the windshield.

fect horsepower, engine speed, and fuel consumption in the air. The optimum combination produced 0.33 horsepower and used 1.03 pounds of fuel per horsepower per hour at the maximum cruise speed of 59 miles per hour.

However, those steady-state tests still didn't spell out the whole story. The only way we could get truly representative fuel consumption figures was to go out to Mr. Butts' farm, put a man with a radio at each pylon, and fly around the course for an hour or two to measure the time per lap and total fuel consumption. Around and around we'd go, counting, timing, and weighing, again and again. We had to do the tests fully loaded, at midweight, and at nearly empty weight with a family of propeller pitches and diameters. (The model weighs 6.9 pounds empty and 10.9 full.) For each data point, an hour-long flight was necessary to average out all the variations in pilot technique, turbulence, thermals, wind, etc. It was tedious work. Some crashes happened because I was so preoccupied with the measurement process that I forgot to fly the airplane properly.

By July 3 we had some good data and growing confidence. I announced to the practice crew, "Today we will put 8 ounces of fuel in this machine. The engine will run 66 minutes and we will make 88 laps." I often made those kinds of predictions to try to inspire confidence in the crew. They stuck with me even when I was missing the mark by a factor of 2, but this time the engine stopped at 66 minutes and 1 second and we had gone 87.5 laps. John Patton said, "Maynard, I think you're ready! Why don't we celebrate the 4th by taking that record away from those Russians?"

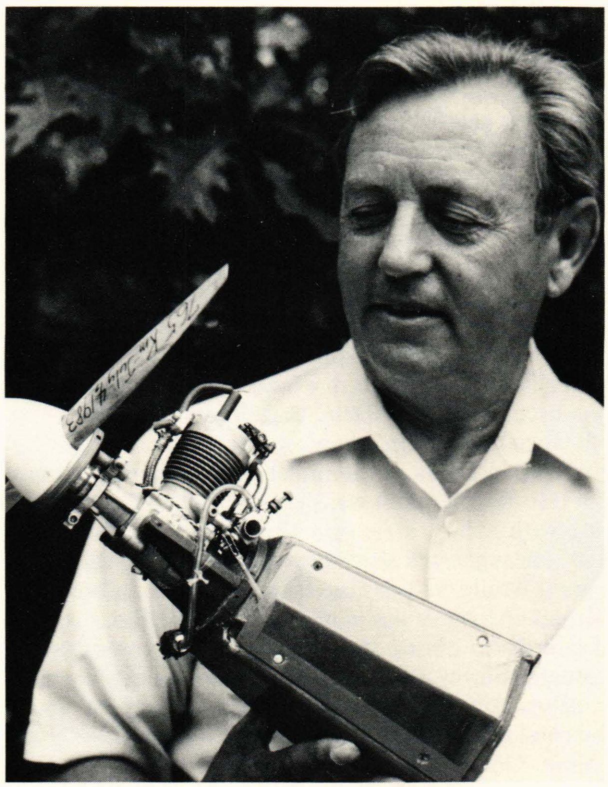
I was reluctant for many reasons: It takes a big crew for an official attempt. The airplane we were flying had been repaired and was 8 ounces heavier than a new one. I was out of spares. Very hot weather was predicted, with possible thunderstorms. And I wasn't psyched up. But then we calculated that even with the 8 ounces of extra weight we would have plenty of fuel. That psyched me up right quick, and so we struck a deal: if an adequate crew could be rounded up, we would go ahead.

At 9:02 AM on the Fourth of July 1983, Stretcher II was hand-launched, after being certified for an official Federation Aeronautique Internationale attempt: not over 11.023 pounds (5 kilograms) at launch, engine no bigger than 10 cubic centimeters (0.61 cubic inch), and with some area and wing loading restrictions. The temperature was already up to 80°F, the sky was clear, and there was no wind. Climb-out was smooth, although not spectacular. In fact, if you don't throw the model hard into the air, it sinks to the ground before the prop "unstalls" and bites into the air to provide enough thrust for climb.

Then the tedium began. I would fly straight for about 15 seconds, and a ham radio receiver nearby would roar "Turn now!" Round we would go for a 180° turn in 4 to 5 seconds. Then another 15 seconds of straight flight and another roar of "Turn now!" Again and again, all day long I would hear it. No one said anything else to me because my brain was busy concentrating on flying a precise course. Every time I talked, I would lose a couple of seconds on that lap.

I turned on the electrostatic wing leveler at about the tenth lap, and then things seemed to smooth out

The OSFS60 engine, shown here, is clean and in good shape after hundreds of hours of running. A hand-carved, narrow-blade propeller 14 inches in diameter with a 10-inch pitch was used. The engine turns 5600 rpm static and 6700 in the air. The tubular object at 11 o'clock behind the spinner is a magnetic pick-up for the capacitance discharge spark ignition system that was adapted to the engine. The device at the far end of the fuel tubing is a homemade filter of 200-mesh screen and chemical filter paper. The fuel must be kept extremely clean to prevent blockage of the tiny metering orifice. The odd-looking spark plug is a homemade adaptation containing a 10-kiloohm resistor potted in a piece of arrow shaft tubing for the purpose of eliminating radio frequency interference.



This well-focused photo of the engine with the author in the background was made by Walt Good. The engine is mounted horizontally. The cowling caused unsteady airflow around the carburetor and was not used for the record flight.

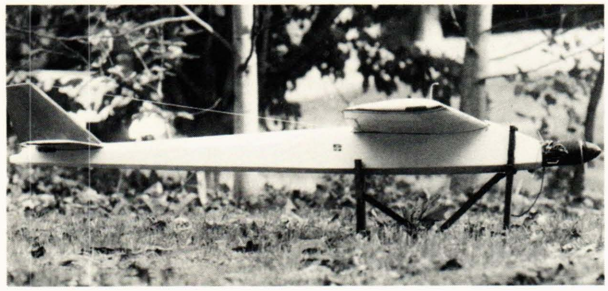
(see my companion article in this issue). We were right on at 43.5 seconds per lap at full fuel load. Later, when the fuel tank was nearly empty, this lap time would decrease to about 41 seconds. We passed the 100 lap mark at 10:17 AM—still right on. By now I was comfortably ensconced in a chaise longue in the shade of an umbrella, with umbilicals to an automobile battery and a 5 watt amplifier for the transmitter. (Five hundred meters is an eye-straining distance, and, in some previous work, I've concluded that if you're straining your eyes, the servos are usually twitching and drawing extra current because of low signal strength from standard 250 milliwatt transmitters.)

We were nearing 350 laps around 1:00 PM when I realized that the turn radius was getting pretty big; with hard-over aileron commands, the airplane would bank only 10°. That is something I'd felt before with electrostatic autopilots when thunderstorms start to build up within about 2 miles of the flying site. Usually, the observation serves as a warning that it would be a good idea to go home. There was a big black cloud behind me. The sky was clear above the site, but it wouldn't be for long.

The explanation for the flattened turns is given in detail in my other article in this issue. Briefly, the reason is that as a thunderstorm approaches, the atmospheric electric field, which is usually about 150 volts/meter (positive upwards), often rises to 1000 to 2000 volts/meter. The signals coming in from the wing sensors increase by a factor of 10 to 20, and a hard-over command from the transmitter is balanced out by the feedback loop so that the airplane banks only a couple of degrees. The airplane becomes so stable that you can hardly turn it. And if a big black cloud comes within a kilometer or so, the electric field can reverse polarity and build up to 10,000 to 40,000 volts/meter, and the airplane will want to fly upside down. I shut down the stabilizer and prayed for no rain.

The storm coasted by about 1 mile to the southeast. Enough rain fell between 2:00 and 2:20 PM to make us put the transmitter in a plastic bag. A wind of about 15 miles per hour blew parallel to the course for about an hour. Lap time sank back to about 47 to 48 seconds, and the upwind legs seemed interminable. But our luck held, and at 3:15 PM the wind went dead calm again. The sky was still overcast, with thunder several miles away. I couldn't resist the urge to find out what was happening to the atmospheric electric field, and I switched on the electrostatic stabilizer. Zaroom—the airplane went hard over into a 90° bank before I could flip off the stabilizer. As I suspected, the electric field was severely distorted.

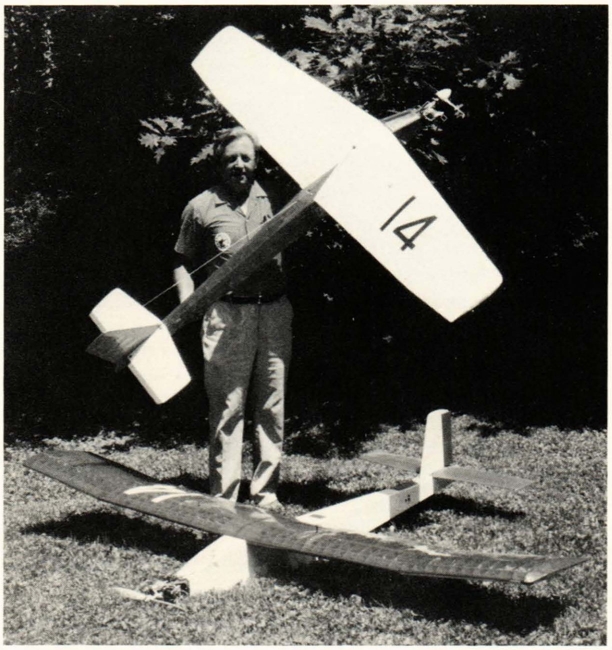
We had a peaceful time of it for the next two hours, and we passed the 700 lap mark at about 5:30 PM. I had a mild headache, but otherwise felt good. Only 64 laps more to go! (The Federation Aeronautique Internationale office said the record was 740 laps; the Soviets said it was 749. We didn't know which one to believe, but, to be sure, our goal was to go at least 764 laps, 2% more than 749 circuits—2% being the margin by which an existing record must be exceeded in order that the new record be recognized.)



Models 2, 3, 4, and 5 had longer and sleeker fuselages with a small circular cowling. The wings were lightweight, built up of balsa ribs. The airfoil was a laminar NACA 63A212, which caused some problems in tight turns. The model would slow down excessively when it jumped out of the "drag bucket" at high lift. Some trailing edge separation occurred also that caused excess drag. The problem was mitigated by using more power and by limiting the bank angle when the model was fully loaded.

Then, about 5:45 PM, I peeked over my left shoulder. There was another ominous cloud, darker and bigger than the last one! Thunder, too! I climbed from the normal 100 feet up to about 300 feet as a safety factor. I kept flying and peeking, flying and peeking. The storm was coming directly toward us. It was going to hit in about 5 minutes. We had 15 laps still to go for the record. At 756 laps, the cloud let loose with its fury. There wasn't much rain, but there was a strong wind with tremendous turbulence. I had done this kind of thing before with sturdy, powerful models, but a lot was at stake here, with a more frail machine. The first three or four laps really scared me. They were full of bumps and upsets, and each lap was taking well over a minute. But then I realized that this wasn't much different from what we sometimes do with relatively fragile slow-flying gliders in blasting winter winds on the mountainsides near Cumberland, Md. "Just steer and we'll make it," my mind whispered to me. In order to fly up and down the course, I had to crab into the wind at an angle of 45°. Since the model flies at 59 miles per hour, the average wind must have been about 41 miles per hour straight across the course. The sky grew darker and there was thunder. Somebody yelled, "Hey—you might get hit by lightning." I responded with, "I couldn't think of a better way to go!" I've studied thunderstorms enough to judge this one to have its lightning more than 2 miles away. The threat was minimal, and I wasn't about to stop three laps short of the record.

We made it to 764, the required number of laps. The gale was still blowing. I remembered that the crew for a duration record (set in 1981)[1] expressed a little disappointment when I quit at 20 hours instead of going for a full 24 hour day. They knew this airplane had enough fuel for 1000 laps. So jokingly, I asked, "Should we keep going for the 1000 laps?" The response is unprintable. Seven hundred sixty-five laps! That was enough. I dove the model from 300 feet to the ground in about 10 seconds and chopped the en-



Stretcher II with New Faithful (in the foreground), which set the current radio-controlled model duration record of 20 hours and 51 seconds on September 21, 1981. Both models used the OSFS60 four-cycle engine.

gine 10 feet off the ground. We landed with no damage, not even a broken prop (something that happens often). The landing spot was 180 feet from the launch point, well within the 1640 feet (500 meters) required by the rules.

We had done it! I threw the transmitter in the air like a midshipman's hat at graduation. The crew and I jumped all over each other. The wind stopped for our celebration. A little rain fell and champagne poured down! Mr Butts, the owner of the farm, joined us. He is a healthy septuagenarian, owns and flies an Aeronca Chief, and is as fine a Maryland gentleman as you'll ever find. He'd seen all our failures during the past year. This time, he came to cheer.

We had used American flags to mark the pylons in honor of Independence Day, and were waving them happily when a tractor-drawn haywagon with 50 subteenage children pulled up in front of us. The children had been watching from an adjacent summer camp and had come over to sing "America the Beautiful" to help us celebrate. Their rendition was magnificent! I'm sure I was not the only one in the crew who was choked with tears. This was the best Fourth of July picnic I've ever been to! The food was terrible—one dried-out ham and cheese sandwich. But the aerial fireworks were spectacular. Approximately one million, eight hundred sixty-six thousand consecutive explosions in the engine produced a truly revolutionary celebration!

(Editor's note: Maynard Hill has held 16 world's records for radio-controlled aeromodels and currently holds five: altitude, powered airplane, 26,990 feet; altitude, powered seaplane, 18,950 feet; duration, 20 hours 51 seconds; cross-country distance, powered airplane, 283 miles; and the record described in this article, closed course distance, powered airplane, 765 circuits (475 miles).)

REFERENCE

[1]M. L. Hill, "World Endurance for Radio Controlled Aeromodels," *Johns Hopkins APL Tech. Dig.* 3, 81-89 (1982).