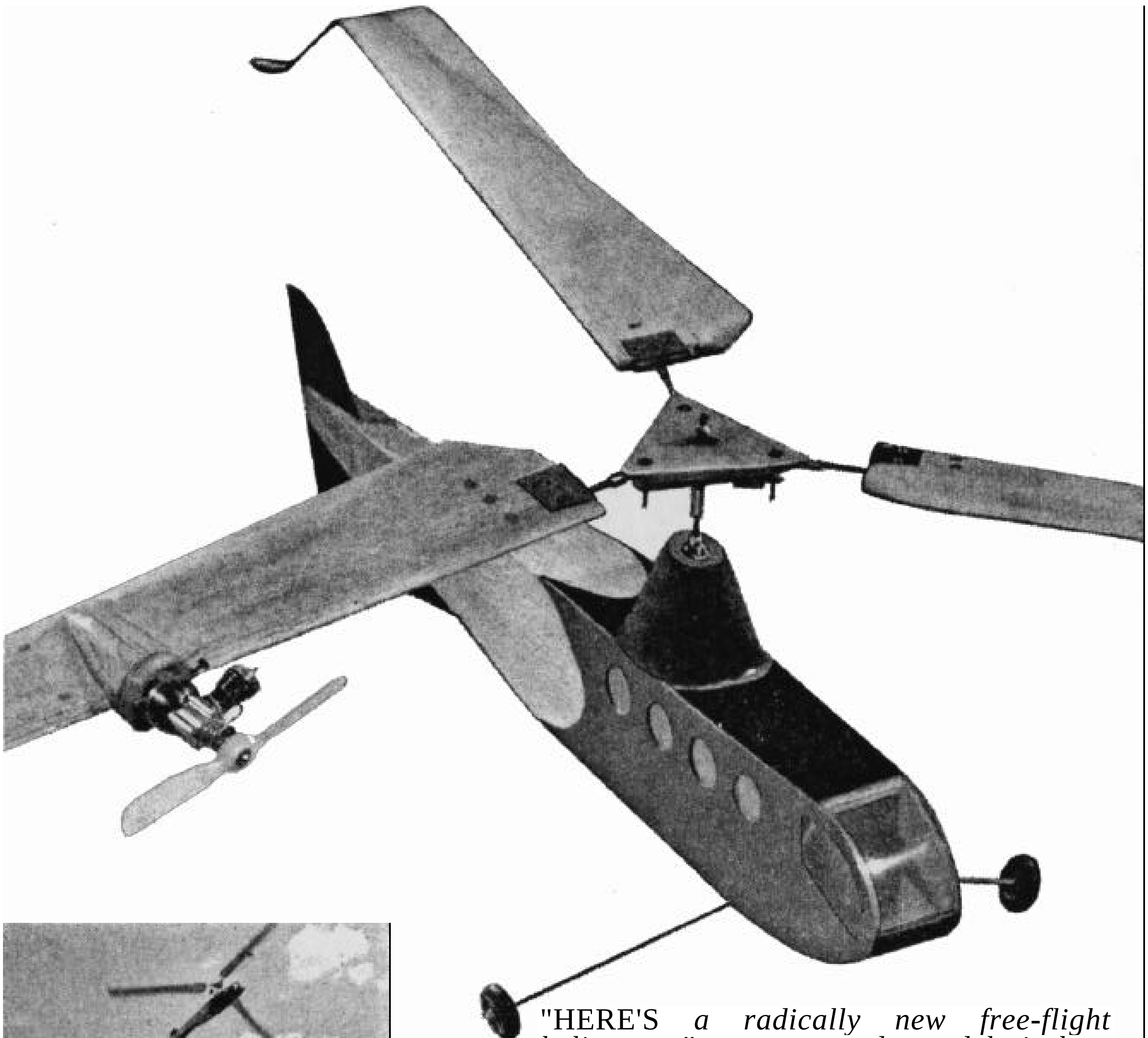
Build it… and watch it soar 1,000 feet in the sky:

New Model Helicopter:

By Roy L. Clough Jr.

EVER since the first helicopter got off the ground, model-makers have been trying to design a miniature version that would do the same. Here's one of the first model-helicopter designs to succeed really well.

Its secret? Most early models were such complicated contraptions that they sometimes worked-but more often didn't. The new one is ingeniously simple in construction, yet makes

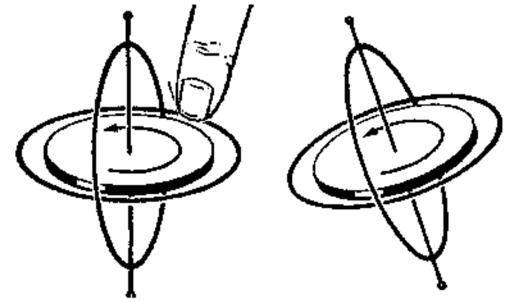


"HERE'S *a radically new free-flight helicopter,"* says noted model-airplane *authority Howard G. McEntee, shown at left flight-testing the model for* POPULAR SCIENCE. *"Its ingenious engine-on-rotor-blade design is the first such I know of. It gives the model a stable, soaring flight, uncomplicated by the many problems that have plagued other copter designers for so long."*

Why It Flies

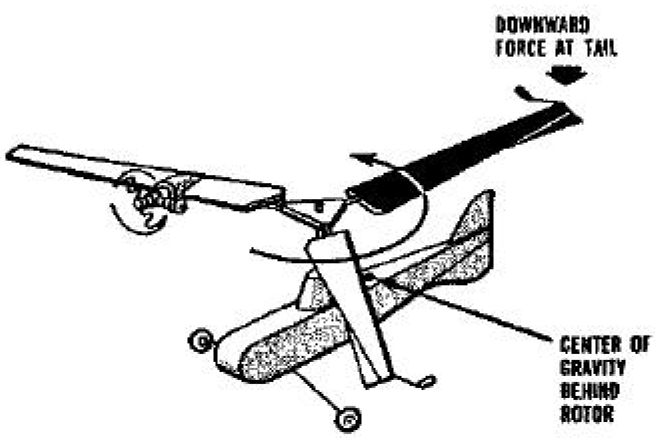
use of half a dozen complex principles of flight. The result is a fascinating study of aerodynamic problems that have plagued designers of both real and model copters for years.

The power plant is a glow-plug engine.

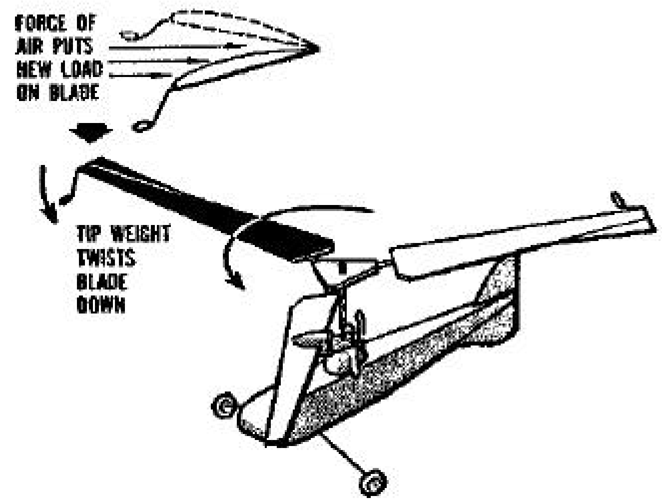


1 Poke at the rim of a spinning gyroscope and it immediately tilts. But not where you touch it—instead at point 90 degrees *past* where you touch it. Scientists call this "precession." In the PS helicopter, the whirling rotor acts like a horizontal gyroscope and the propeller blade a vertical gyroscope.

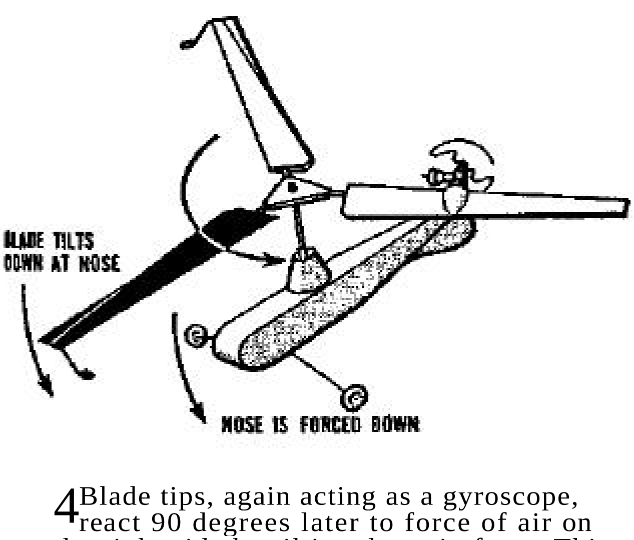
How the rotor works in flight



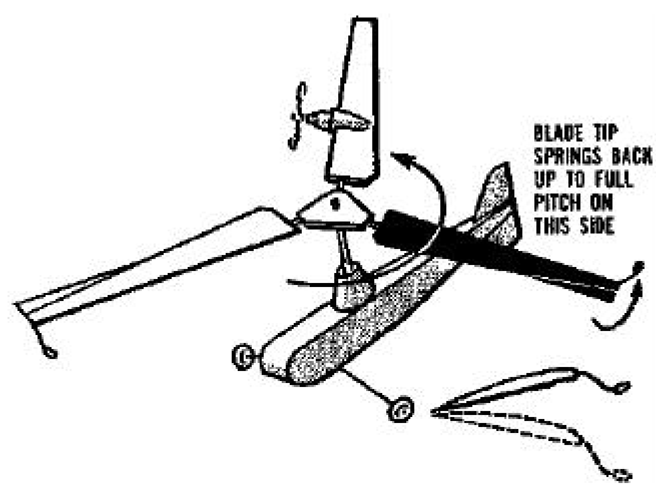
2 To keep a copter level, rotor blades must decrease pitch on forward stroke to balance reduced lift of rearward stroke—called "cyclic pitch." This is done by weighting the model tail-heavy so it pulls down on the blades at the rear—like pushing on rim of a gyroscope.



3 Whirling blade-tip weights react 90 degrees later to the force at the tail by twisting blades down on copter's right side. This reduces lift as blades advance into the wind. At same time, air pressure against the down-tilted blades exerts a new force on the rotor.



4 Blade tips, again acting as a gyroscope, react 90 degrees later to force of air on the right side by tilting down in front. This tips the nose down so the copter, while tail-heavy, tilts forward for straight-ahead flight.



5 Blades spring back up on left side to take full bite of air. Since lift is less on rearward stroke away from the wind, the full-pitched blades now balance reduced-pitch blades on opposite side, and the copter flies level.

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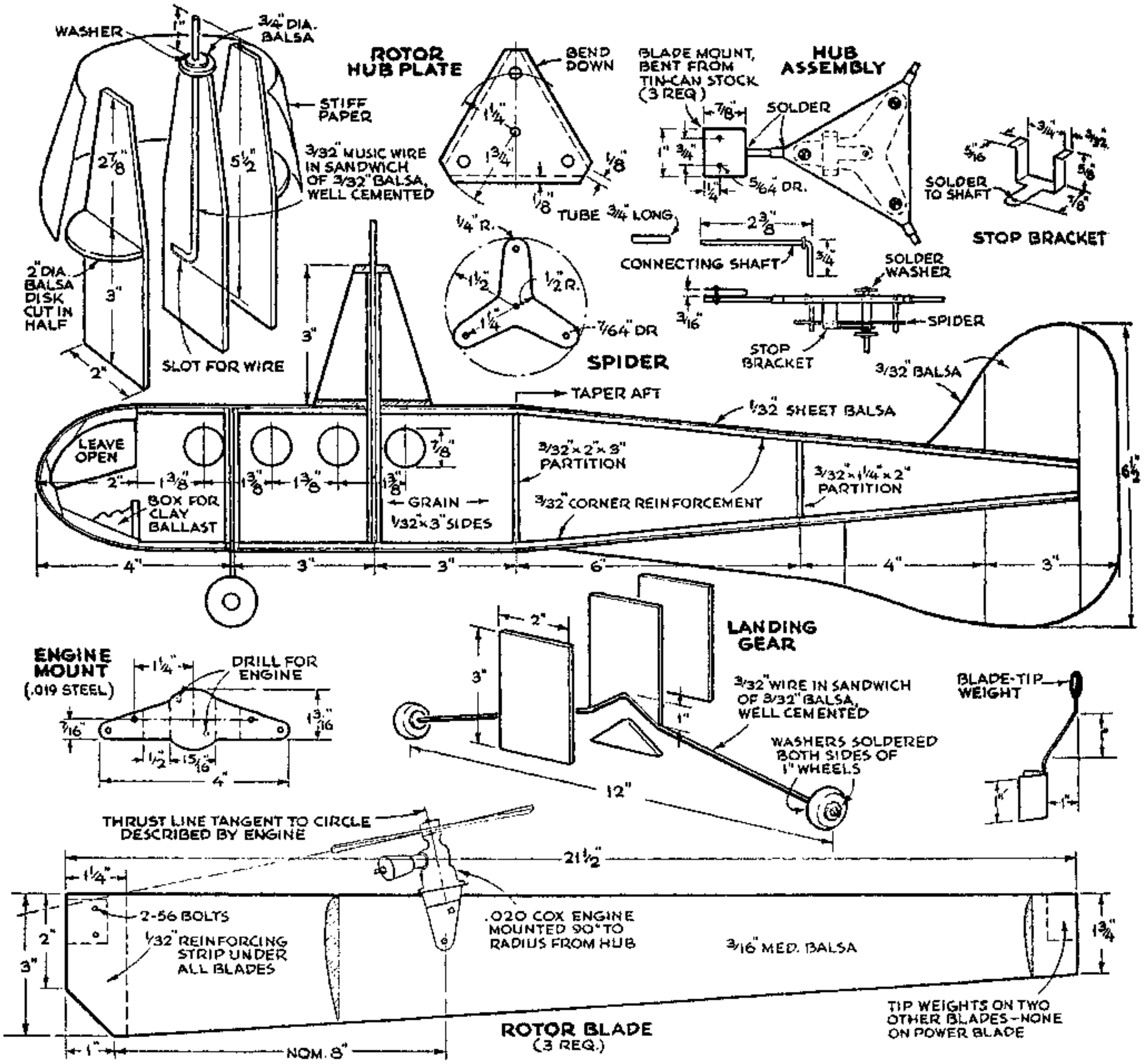
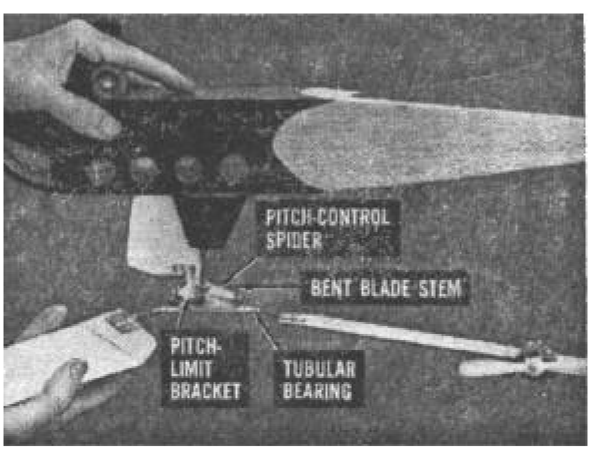
How you can build the gas-model helicopter





Underside of rotor hub shows how spider forces two non-powered blades to tilt at the same angle as powered blade. Wire blade stems are bent at right angles to engage holes in spider plate. Solder parts with hub held flat, upside down, to insure uniform alignment of the blades.

like that used in most model planes. But instead of being mounted inside the fuselage, the engine is attached directly to one of the copter's three rotor blades. In most conventional copters, both real and model, the engine drives the rotor from a central shaft. In turning the rotor forward, it "braces its feet" against the fuselage and also pushes backward. This backward torque keeps attempting to spin the fuselage in the opposite direction from the rotor.

In full-size copters, torque must be offset by a separate stabilizing tail rotor or other special devices to keep the craft flying straight. In the model shown here, the blade-mounted engine *pulls* the rotor around instead of pushing it. It creates no torque and thus needs nothing to counteract it.

The model is a whopper, too—nearly 4' across the rotor tips. Yet, despite its size, it's so efficient that it flies on a tiny .020 Cox engine—one of the smallest made. Designed for free flight, it has hit altitudes of 1,000 feet on two minutes of fuel, giving it a rate of climb of 500 feet a minute. Earlier models have required much bigger engines to achieve the same lifting power.

How the model flies. The three rotor blades are pivoted loosely at the hub, leaving them free to tilt up or down like the elevator on an airplane. The blades are also linked together at the hub by a bell-crank mechanism so that whatever one blade does, the other two do likewise. Unlike a conventional helicopter, however, no special controls are needed to tilt the blades up or down for takeoff or landing, or to provide complicated changes, known as cyclic pitch, during flight. They're automatic.

The trick is based on the fact that the whirling rotor and the spinning propeller

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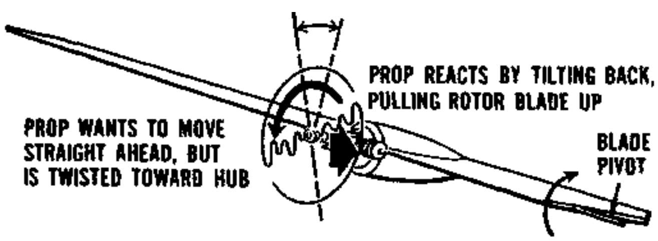
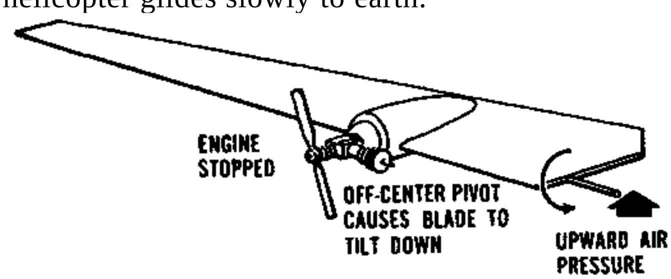
How the model climbs



Whirling propeller acts like a gyroscope in the same way as the rotor, but this time in a vertical plane. It reacts at 90 degrees to the sideward twist on it by tilting upward. This tilts up the rotor blade (and the other two blades linked to it), giving the helicopter lift for climbing.

How the model lands

When the engine quits, the upward gyroscopic twist on the rotor blades also stops, and they pivot freely. Upward air pressure on the trailing edges forces the blades to tilt down, and the helicopter glides slowly to earth.



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attached to the rotor both act like gyroscopes. As the drawings show, a gyroscope reacts to a force placed on it by tilting at 90 degrees, or *sideways,* to the original point of force. This is used in several ways to provide stable flight.

The upward gyroscopic twist of the propeller tilts the rotor blades up to give the copter lift for taking off and climbing. A similar gyroscopic reaction is given to the rotor by weighting the copter tail-heavy. This causes weights fastened to the leading edges of the blades to twist the blades downward and reduce lift as they advance into the air stream—just like the cyclic-pitch mechanism on big copters.

An additional gyroscopic reaction in the rotor forces it to tilt downward at the nose to keep the model flying forward. Earlier attempts to make a model copter fly forward by simply weighting it nose-heavy proved disastrous. The rotor, pulled down at the front, reacted like a gyroscope and flipped over, on its side, sending the craft crashing to the ground upside down.

Earlier models had another fault: Blade pitch was fixed at an upward angle for climbing. To provide the downward pitch for landing, the rotor had to come to a stop, then reverse its direction. This time lag caused the copter to drop a long distance before the reversed rotor got up enough speed to break its fall. In the new design, the pivoted rotor blades continue to turn in the *same* direction, but automatically tilt downward when the engine stops to let the model glide gently to earth.

Only the rotor is tricky, the copter's fuselage is a simple sheet-balsa job. But the rotor, the heart of the craft, must be carefully balanced to provide correct blade pitch and avoid vibration. The blade-tip weights are blobs of solder, each equal to the weight of three nickels. They are used only on the two non-powered blades as the engine supplies the weight on the third blade. After the weights are mounted, gradually shave off bits of solder until the rotor remains balanced in any position. Weight the fuselage with clay until it balances at a point 1/2" *behind* the rotor's axis. This will make the ship slightly tail-heavy as required for proper flight.

Blade pitch is controlled by a spider-shaped plate on the underside of the hub. This works like a three-way bell crank. When the plate is twisted by the stem on the power blade, it in turn twists the stems on the other two blades to a like angle. The U-shaped stop bracket should limit the plate's movement to provide a maximum of 12 degrees upward blade pitch for climbing. Downward or negative pitch should be set as shallow as possible for a slow, leisurely descent.

Note that the engine is mounted at an angle on the rotor blade, rather than straight-ahead. This puts its thrust line at a tangent to its circle of rotation. If it pointed straight ahead, it would exert a side thrust on the rotor as it whirled around. Note, too, that it is turned partially on its side, with its cylinder tilted inward toward the rotor hub. This puts its fuel reservoir in line with centrifugal force so the gravity feed will continue to operate even though the engine is being slung around sideways by the rotor.

The engine must also be tilted slightly downward to minimize the force of its slipstream. The slipstream tends to turn the copter's fuselage to the right, but is offset by the rotor's downwash and bearing friction, which tend to swing the fuselage to the left.

The engine can be mounted on the metal bracket shown in the construction drawing or, for a neater appearance, can be faired into the rotor blade with a shaped balsa block, as shown in the photos. If a larger engine than the .020 Cox is used, it will require additional counter weighting of the rotor blades. In this case, add the extra weight to the tips of the blades themselves, *not* to the tip weights, which must remain the same.

Flight-testing the copter. An ROG (rise-off-ground) takeoff is slower but safer at the start since you can see what's happening. When all adjustments are perfect, you can go to the faster hand-launch.

Begin with a 6"-diarneter, 3"-pitch plastic prop and trim it a little at a time until the engine reaches maximum r.p.m. Hold the ship by the tail until the rotor gains speed, and duck out of the way. The model should rise slowly, then tuck its nose down and climb in a right-hand spiral of 20' to 30' in diameter. During trials and on windy days, let some of the fuel flow/ through before letting go—or you may wish the copter didn't fly so well. •