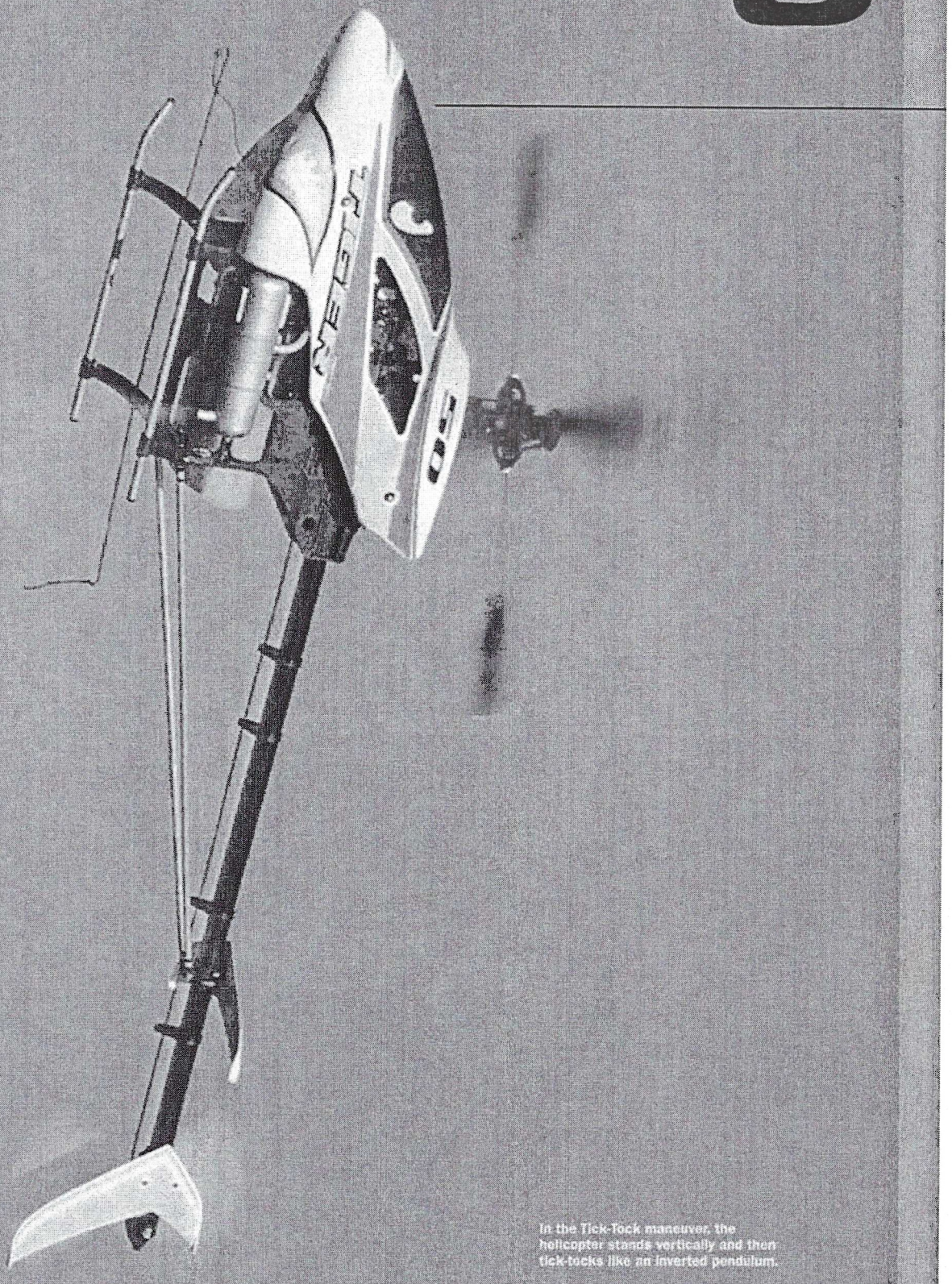
James Wang | **ROTO**

Getting



In the Tick-Tock maneuver, the helicopter stands vertically and then tick-tocks like an inverted pendulum.

Started
in 3-D Helicopter Flying

In previous issues, we have taken readers to the Extreme Flight Championships in Ohio, the 3D Masters competition in England, and the International Radio Controlled Helicopter Association (IRCHA) Jamboree in Indiana. This month, I will discuss how to get started flying remote-control (R/C) helicopters, how to progress into 3-D flying, and how to become as good as those 3-D competition pilots. Once we have illuminated the path, then all it takes is plenty of practice — and that is the fun part! Three-dimensional flying is fun because there is no limit to what an R/C helicopter can do; it is all up to your creativity. Even the world's best 3-D pilots are constantly improving and brainstorming new maneuvers.

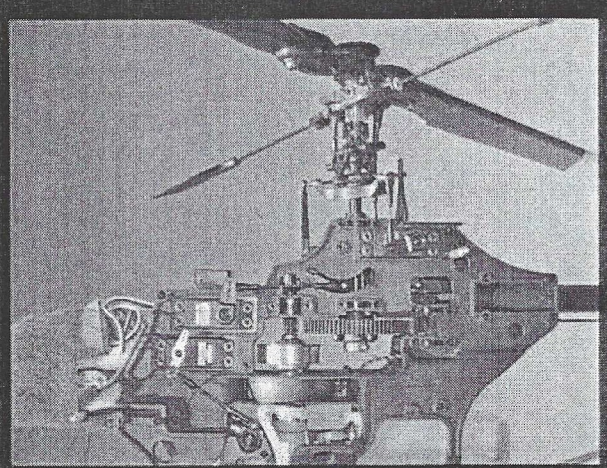
Ten years ago, no one was performing a Tick-Tock, but now this maneuver has become routine. In the Tick-Tock maneuver, the helicopter's nose is pointed up or down in a completely vertical orientation, and then the pilot pumps the fore/aft cyclic control to oscillate the helicopter like an inverted pendulum. To prevent the helicopter from falling out of the sky, the pilot also pumps the collective pitch to generate positive or negative thrust at the correct moment. Nowadays, a good pilot can Tick-Tock a helicopter and translate the helicopter sideways at the same time: from a top view, it looks like the helicopter is tap dancing in a circular pattern.

How long does it take to become reasonably good at fly a 3-D helicopter? Assuming you practice at least twice a week, it will take about two to four months for you to become proficient at hovering. Then, it will take another two to four months for you to become comfortable in forward flight. In total, after one year, most average pilots should be able to loop and roll and do gentle airplane-type maneuvers with their helicopter. After another year, you should be doing some decent 3-D flying. I have seen many young people who, after only six months of flying, were able to perform incredible anti-gravity routines. In general, it takes about 300 flights or 15 gallons of fuel to become comfortable at doing basic 3-D maneuvers.

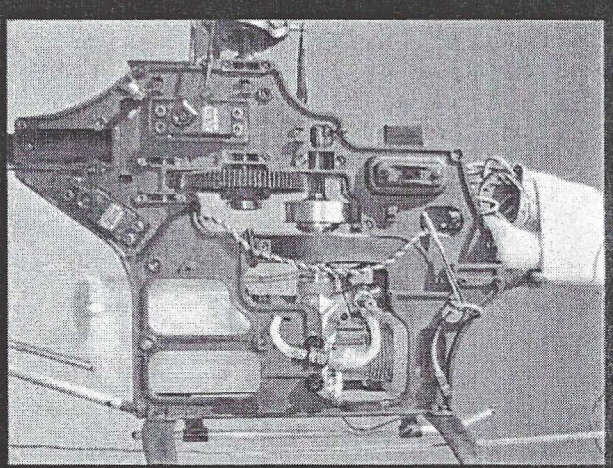
The use of computer flight simulator will help tremendously, and watching videos of top pilots will provide inspiration. The 2003 and 2004 Extreme Flight Championships (XFC) DVDs from SKS video are excellent, and I highly recommend ordering them from www.sksvideo.com. They are very well filmed. The 2004 3D Masters video from England is also excellent, and is available from www.curtisyoungblood.com. At the latter Web site, you can also find excellent 3-D training tapes, which are produced by the World Champion pilot Curtis Youngblood.

The Road from Hover to 3-D

Here is a sequence of maneuvers to learn. Start with hovering first. Always practice hovers with the tail rotor facing you, because then moving the transmitter stick left will cause the helicopter to go left, and moving the stick right will cause the model to move right. Wait until you are completely comfortable with a maneuver, and then move on to the next lesson. The next step is to learn to hover the helicopter with its side facing you. Eventually, you need to become comfortable hovering the helicopter with either the left or right side facing you. Finally, learn to hover with the helicopter's nose facing you. This is challenging, because the controls will appear reversed; left becomes right, and right becomes left. Learn to be comfortable hovering at different altitudes and with wind from different directions.



Here, we see the throttle control servo and two of the three servos needed for controlling the swash plate. Notice how well engineered all the components are in this new helicopter.



The right side of the Tiger 50 shows that the servos and radio switch are all bolted directly to the plastic side frames. I think it is faster to build R/C helicopters than airplanes, and no glue is required.

Begin slow-speed, forward-flight training by doing a hovering figure 8 with the helicopter in front of you. From the top view, the helicopter is moving in a figure 8 pattern, but keep the helicopter tail pointing at you all the time. After a few flights, slowly swing the nose around so the helicopter starts to fly forward in a "slow" figure 8 pattern. Practice this with the helicopter at a height of about 15 ft. Learn to fly the helicopter slowly, and importantly under control. Note it is actually more challenging to fly a helicopter slowly. In high-speed forward flight, a helicopter flies very much like an airplane, and you can actually take your hands off the control sticks for few seconds. One mistake frequently made by beginners is to over-control the helicopter in hover and forward flight and cause it to get into a "pilot induced oscillation." Sometimes, it is better to just let the helicopter settle down naturally without pilot input.

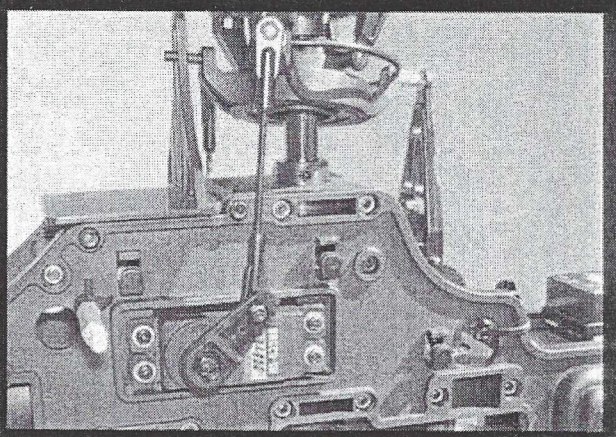
Keep practicing the figure 8, eventually making it bigger and bigger and faster and faster. Next, learn to fly an oval circuit with the helicopter in front of you at an altitude of about 100 ft. Learn to fly smoothly, and always learn to pilot the model going in either direction. Soon, you will be ready to fly it through loops and rolls. The next milestone is to learn the inverted hover maneuver with the helicopter at an altitude of about 300 ft. Again, you must learn to hover the helicopter inverted with the nose pointing in any direction. Once you have mastered "switchless" (without the controls be reversed) inverted hovering, then you have passed the first test for 3-D flying. The rest of 3-D flying is just combining different movements to form a maneuver.

Choosing a Helicopter Size

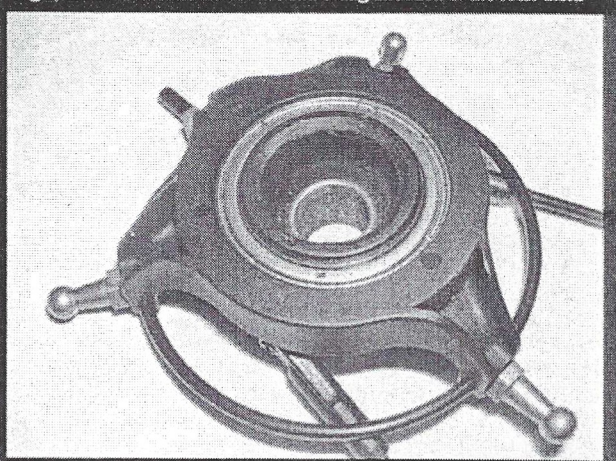
Rather than learning in a vacuum by oneself, it is much safer to seek the help of an experienced R/C helicopter pilot. Such an expert can help check over your machine to make sure it is safe, and can then teach you the control functions and supervise you while you practice. Experienced pilots are usually more than happy to provide free help. Just be sure to thank the pilot by buying him/her lunch or bringing him/her some soda to show your appreciation each time. He can help save you from many unnecessary crashes and speed up your schooling.

It is possible to learn to fly with electric- or glow-engine-powered R/C helicopters. Modern electric helicopters are quite powerful and can fly more than 10 minutes on one battery charge. Our sister magazine, Quiet Flyer, frequently contains articles on what's new and how to set up electric helicopters. Today, let me use engine-powered helicopters as an example. A good trainer model is one that uses a 30- or 50-size glow engine. Popular 30-size engines include the OS 32 SXH, the OS 37 SXH, the Thunder Tiger Pro 39H, the Enya 35H, the Weston UK 36H, the Hirobo 36H, and the Webra 35H. The "32" in "OS 32" means that its engine piston has 0.32 cubic inch of displacement, which is equivalent to about 5.5 cc. Usually, the bigger the displacement, the more power, but it also depends on the engine quality. Popular 50-size engines include the OS 50 SXH, the OS 50 SXH Hyperhead, the Thunder Tiger Pro 50H, the Enya 50H, and the Weston UK 50H. A 50-size engine has about 8.5 cc of displacement. Note that these engines have an "H" behind their names because they are helicopter engines. A helicopter engine is constructed similarly to its airplane counterpart, except that it has a bigger heat sink head to help dissipate heat. Airplane engines do not need big heat sinks because they have propellers to cool them. Helicopter engines also have different air-fuel mixture designs in their carburetors because they spend most of their time in the 50% throttle position. A helicopter carburetor must provide a smooth mid range for hovering, as well as a reliable idle and a powerful top end. This is demanding on carburetor designers. You'll be interested to know that most modern helicopter engines all work quite well, because Darwinism has weeded out the bad ones!

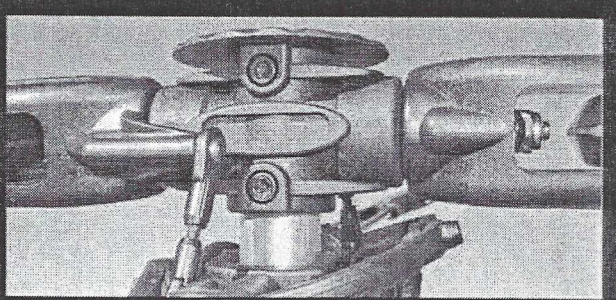
Most 30- and 50-size helicopters use injection-molded plastic for some of the structures, and are therefore inexpensive. They typically range from $300 to $450 because they are physically smaller than 60- and 90-size helicopters, which are used by experienced 3-D pilots. These R/C helicopters are not toys, and



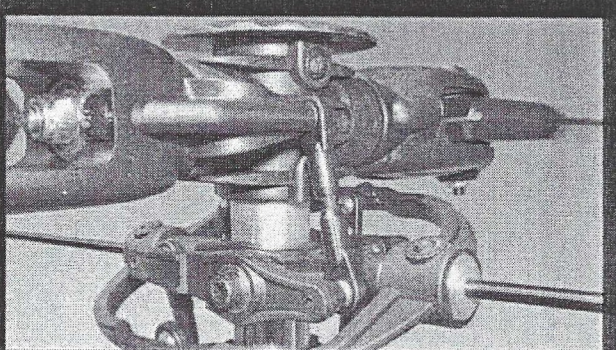
Here is the third servo that connects to the swash plate. The swash plate is the black disk on top; it controls the main rotor blade pitch angle, and in turn controls the lift and tilting direction of the rotor disk.



This is the bottom side of a swash plate. Notice that these parts have been CAD designed and CNC machined.



The side view of the Tiger 50 main rotor head shows that ball links can handle large G forces. It is amazing that modelers have used these little links on R/C model helicopters for more than 30 years now.



The swash plate controls the Bell-Hiller mixing arm (the little horizontal arm shown here), and the plastic mixing arm controls the blade grip through the ball link linkage.

helicopters of any size can still cause serious injury, so treat them with respect. In the past, we have shown many pictures of the popular Raptor 30/50, Hirobo Evo 30/50, and JR Venture 30/50 helicopters. These come in two versions: a shorter tail boom version for using 30-size engines, and a stretched tail boom version for using 50-size motors. This month, let's make it more refreshing by using a "new kid on the block" helicopter as our example. Let's use the brand-new Tiger 50 from Audacity Models.

Equipment Needed

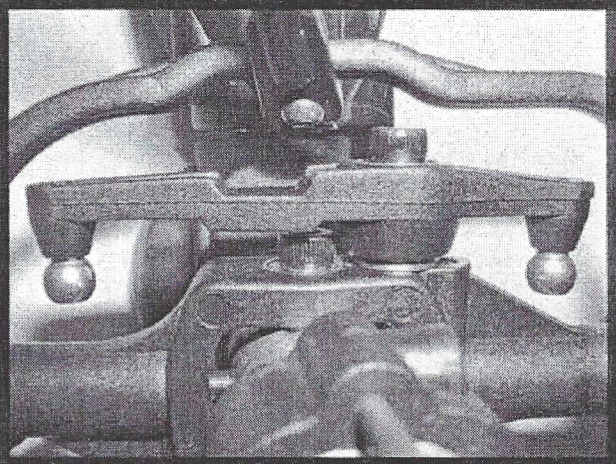
The Tiger 50 is distributed in the U.S. by Audacity Models in Orlando, Florida (www.audacitymodels.com). This new model was released in Fall 2004. The price is $299 for the almost-ready-to-fly (ARF) version and $284 for the kit version, so they are the least expensive 50-size models on the market. These are not low-ball mail order prices, either—they are everyday hobby shop prices. In the ARF version, the helicopter mechanics come assembled, saving the modeler about 15 hours in building time. For beginners, this can be very nice, especially when the factory assembles the ARF properly. I checked out an ARF Tiger 50, and it was built well. I have also used it for 3-D flight, and nothing has fallen out of the sky yet! Modelers who enjoy mechanical tasks may want to build the kit themselves, however.

Usually, ARF helicopters are only available in the 30- and 50-size range. Century Products offers the Hawk 30 and Falcon 46 in ARF or kit form. Horizon/JR offers the Venture 30/50 in ARF form only. Thunder Tiger offers the Raptor 30 in ARF or kit form, and the Raptor 50 in kit form only. The Hirobo® Evo 30 and 50 are in kit form only. Besides the Thunder Tiger Raptor 60 and the Graupner Uni-Star, there are no other companies in the world that make ARF 60- and 90-size helicopters.

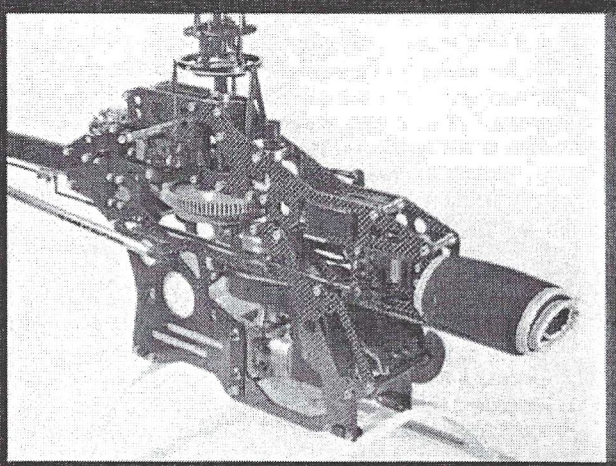
To complement the helicopter kit and engine, we also have a muffler, a rate gyro, five servos, a receiver, a 1000-mAh or larger receiver battery pack, and a helicopter transmitter. Most modern transmitters with six or more channels (the Airtronics RD6000 and RD8000, the JR 662, the JR 8103, the JR 9-channel, the Hitec Eclipse 7, the Hitec Optic 6, and Futaba 8-channels) all include built-in software for airplanes, gliders, and helicopters.

Another reason to start with a 30/50-size model is that the aerodynamic load on the control system is low, so it is not necessary to get expensive servos. For example, on the Tiger 50, I use the inexpensive Hitec HS-635 analog servos, which only cost around $40 apiece. But this servo has a ball-bearing-supported output shaft, 0.18-second speed for 60-degree travel, 69 in.-oz of torque, and—most important of all—zero deadband (slop) in gears' mesh. For helicopters, it is important the servo gears do not have freeplay; otherwise, the control response will feel sloppy. The HS-635 and many other newer Hitec servos use a new glass-filled nylon material, called Karbonite, which lasts longer than metal gears and gives zero freeplay at the output shaft. Their new, more expensive HS-6575 servo with Karbonite gears is what I use on 60- and 90-size helicopters because it has even more torque and faster speed. In general, when picking a servo for a 30- to 50-size helicopter, anything with over 60 in.-oz of torque and a travel speed faster than 0.2 second for 60 degrees is sufficient for sport flying. There are cheap servos that cost $12 apiece; they are inadequate for flight control, but are fine for throttle control.

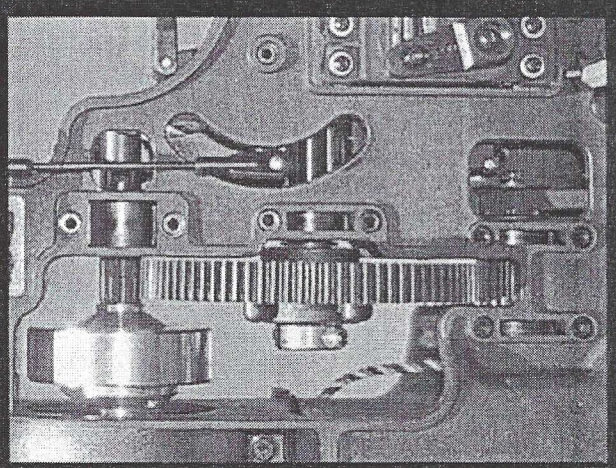
I recommend investing some money and getting a reasonably good gyro. The best "bang for the buck" are the Futaba GY-401 and the JR-500. These gyros cost about $150 each, but they will work from learning to hover, up to doing full 3-D maneuvers. Gyros that cost under $100 just do not perform well. Futaba® and JR® both make high-quality, high-speed servos that are dedicated for gyro use, and I recommend them. If you want to save money, the Hitec HS-525BB at $30 is a good choice because at 0.17 second, it is fast enough for learning purposes. Alternatively, the Hitec HS-6965 is a "cream-of-the-crop" servo that has a 0.09-second travel speed, but costs $90. Beginners may not feel the difference between servos, but experienced pilots can.



This is the bottom view of the Bell-Hiller mixing arm. Its job is to mix (combine) the swash plate controls with the flybar controls to the main rotor blade. Again, notice the high-quality engineering involved.



This model uses expensive carbon graphite sheets for side frame material. Carbon is lightweight and strong. This is a carbon frame conversion kit from ZeroG Products in Hawaii. It is a gorgeous $300 aftermarket upgrade for the plastic Raptor 30/50 helicopters. The Tiger 50 layout looks similar to this model; however, the Tiger frames are plastic, so the entire kit is priced at only $300.



The drive train on the Tiger 50 represents typical 30/50-size helicopters. The engine and clutch drive an aluminum clutch bell. The pinion on the clutch bell turns a big plastic main gear. The main gear drives another pinion, which has a pulley above that turns a long rubber belt to drive the tail rotor. It is quite a complex mechanism, but is engineered for durability and relatively long life.

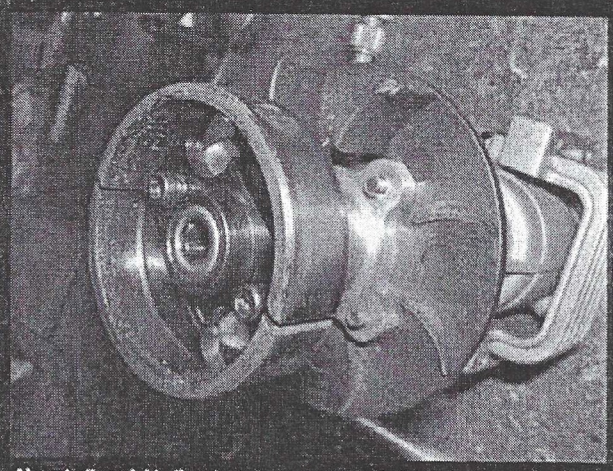
Building Your First Helicopter

All helicopter kits on the market now come with decent instruction manuals. So, when starting that first helicopter, follow the manual word by word on building the mechanics, installing the radio, and setting up the linkages, and you cannot go wrong. The main reason some beginners have problems getting their helicopters flying properly is because something was not assembled or set up properly. We can't blame the beginners, because they have never assembled helicopters before and it takes some mechanical dexterity. That is why you must read and re-read the instructions, double checking the assembly until you are confident you did everything correctly. Treat it as if you are packing your parachute for the first time. Take the finished model to an experienced helicopter pilot, or ask the folks at the hobby shop if they know some reliable helicopter pilots. Have one check it over as if he/she is inspecting his/her own parachute.

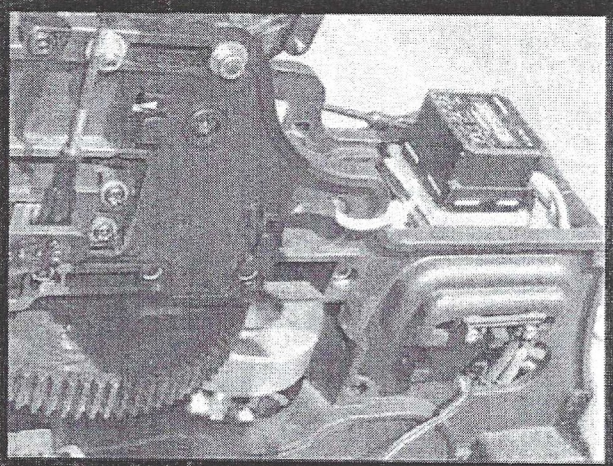
It is very challenging to design an R/C helicopter that can be suitable for beginners and for aggressive 3-D flight. The requirements are vastly different. Beginners want a stable platform where the helicopter will try to restore itself to level flight if there are perturbations, and the controls should be gentle and gradual. On the other hand, expert 3 D pilots want machines that can react instantaneously to their command. An expert wants a neutral helicopter, and the helicopter can maintain the position of the last command. In the last 10 years, R/C helicopter designers have learned a lot from designs of the 1970s and 1980s, and have made modern R/C helicopters very adaptive. Newer R/C helicopters all have a limited range of adjustability for the pilot to set up the model to have more stability or more controllability. For example, the Tiger 50 is designed with the beginner in mind, because in the stock format, it is very stable and easy to handle. However, if the modeler makes few changes to the mechanics and the radio program, then the same helicopter can become more agile and responsive enough to become a 3-D trainer. The Tiger 50 will never compete in speed and performance with a Fury, Raptor 90 SE, or Hirobo X-Spec, but those three $900 helicopters are three times more expensive than that $299 plastic helicopter. Inexpensive plastic helicopters like the Tiger 50, the Raptor 30/50, the Evo 30/50, the Venture 30/50, and the Hawk 30 can perform 90% of the 3-D maneuvers that the big and expensive machines can, but they just don't do them as quickly or as powerfully. However, these plastic helicopters are great for practicing new maneuvers or just having fun.

Example: How to Tune the Model

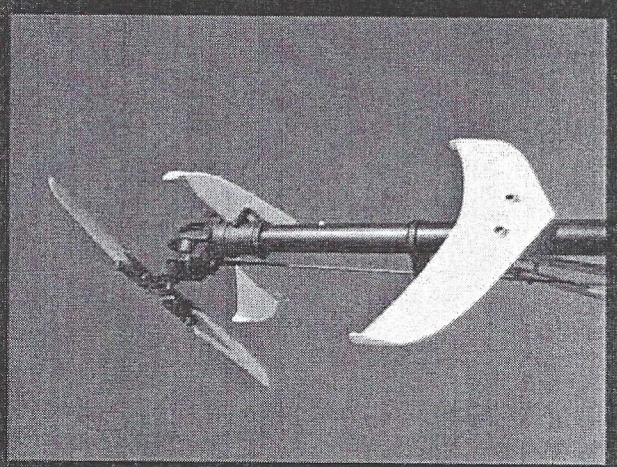
Now, let's use the Tiger 50 as an example on how to "tune" a plastic helicopter to change it from a tame beginner machine into a more agile 3-D practice machine. The first step is to increase the rotor speed. When learning hovering and forward flight, the main rotor speed should be around 1500 rpm. For 3-D flying, we need to dial it up a few notches and get the rotor speed whirling at 1750 to 1850 rpm. Fast rotor speed means faster pitching and rolling response. Next, we need to use lighter control paddles. The Hiller paddles at the tip of the flybar serve two purposes: to provide stability, and to help control the main rotor blade angle for steering. By using lighter paddles, the stabilizing effect from the paddle is reduced. Then, we must maximize the swashplate tilt angle to what is mechanically allowable. Next, we want to make sure we use the right holes on the mixing arms and bellcranks. The Tiger 50 washout arms have two holes, and we need to use the hole that is farther out so that when the swashplate tilts, the flybar paddle will deflect a greater angle. Almost all plastic helicopters on the market allow this. The Tiger 50 kit also includes two little bushings to extend control ball 3 mm further out on the swashplate. This will increase the main rotor blade angle change when the swashplate tilts.



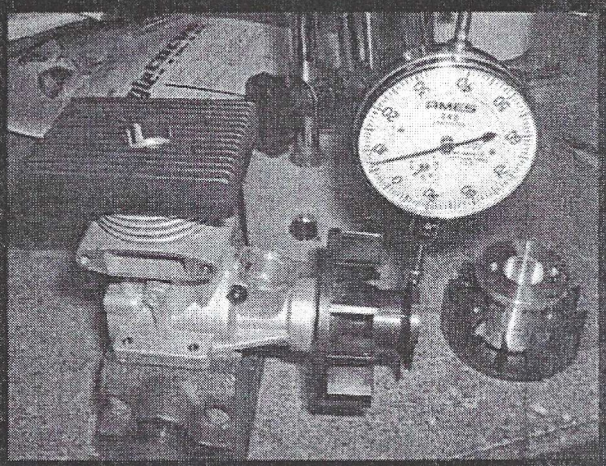
Almost all model helicopters use a centrifugal clutch design similar to that shown on the Tiger 50. When the engine rpm reaches about 2000, the clutch shoes spread out and grab the clutch bell. (The clutch bell is not shown here.)



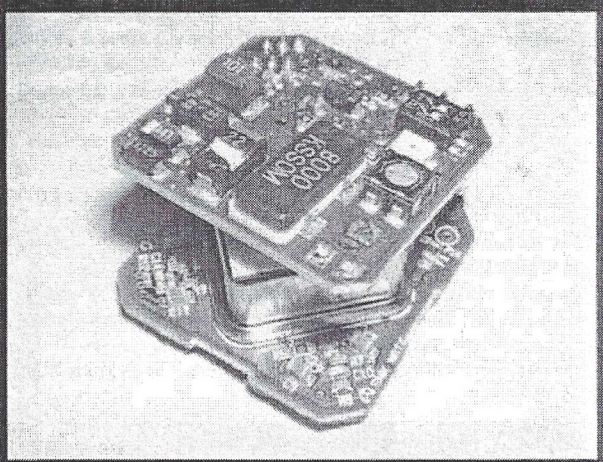
The Futaba GY-401 gyro and the receiver switch can be seen here mounted in the frame to the top and right.



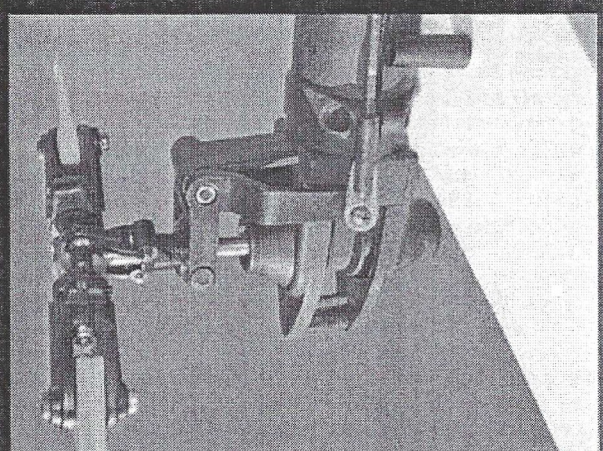
The tail fins provide a weathervane effect to help stabilize the helicopter in forward flight. For extreme 3-D flying, pilots usually use fins with big holes to get rid of the stabilizing weathervane effect.



The modeler should use a dial indicator to check if the fan hub is mounted concentric to the engine crankshaft. It is wise to take you time when performing these tasks in order to get a quality job when you are finished. It will save you money in the end.



This is what the inside of a Futaba GY-401 gyro looks like. This tiny device helps to make helicopter yaw control more manageable.



This is the bottom side of the Tiger 50's tail rotor gearbox. We can see the 90-degree bell crank that is used to control the tail rotor blade pitch angle for yaw control, and the rubber belt that drives the tail rotor.

Some helicopters also allow the modeler to change the Bell-Hiller mixing ratio. The Tiger 50 and the Evo 30/50 have this flexibility. For 3-D flying, we want to reduce the Bell-Hiller mixing ratio. For example, the ARF Tiger 50 comes with the Bell-Hiller mixing arm attached to the seesaw at the 100% Bell-Hiller mixing ration location. For 3-D flying, relocate it to the 70% Bell-Hiller mixing ratio point. Lower ratio means the flybar has less feedback effect for stabilizing the model. You have probably started to catch the pattern: For aerobatic flying, we want less stability. That's why a super-duper helicopter designed for advanced 3-D flying may not be the most suitable model for beginners, and a super-stable helicopter is not what an expert wants. But we can make a beginner helicopter more responsive by doing the above-mentioned tricks. With experience, you will learn how to tweak the knobs to change the personalities of your helicopter to suit different flying needs. Because modern plastic helicopters are tunable, experienced flyers frequently also buy inexpensive plastic 30/50-size helicopters to use as beaters.

It need not be expensive to fly R/C helicopters. Just get an inexpensive plastic helicopter and use it to learn hovering, forward flight, and even the basics of 3-D flight. Replacement parts for modern plastic helicopters are very reasonably priced. Their design allows you to tweak one from being very stable to being responsive enough for 3-D flight. A good model can last a long time, and can handle a few crashes along the way. In future issues of this magazine, I will go over radio setups and how to perform different 3-D maneuvers.

Start practicing! ✈

References

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