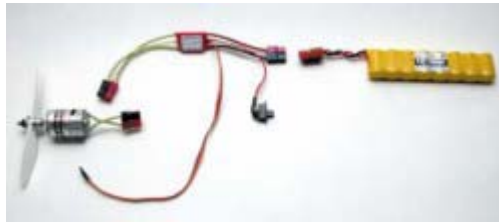


## **Introduction to Electrical Power** **By Bob Aberle**

**AT THIS POINT** this series will begin to split off into the specialty areas of model aviation. Radio Control (RC), as noted in the past few months, takes up the major portion of interest. However, equally important to so many modelers are the non-RC aircraft, such as Free Flight, Control Line, Hand-Launched Gliders, rubber-powered models, and more! As the months go by, this series will "spin off" into all of these fascinating areas.



*The three basic components of model-aircraft electric power system: (L) Speed 400 6-volt winding ferrite motor, (center) Jeti Models JES-110 ESC, (R) eight-cell 1100 mAh NiMH battery pack. New Creations R/C has custom-preinstalled all necessary APP connectors. No soldering is necessary. A plus for beginners!*

From a primary power standpoint, the most popular for model aviation today involves the use of glow-fueled engines. To a lesser degree, but just as important, are the gasoline-fueled engines as employed in the larger models (quarter scale and the like). The third power category is electric, and this has become increasingly popular in recent years because of the many technological improvements in motors and batteries.

Guest-author experts will soon be writing about glow- and gasoline-fueled models. Electric has been my specialty for some years; it is the only power source I use today. Read on in the next few months as I explain electric power and take you through the process of assembling, installing power in, and flying an electric-powered model.



*Speed 400 6-volt winding direct-drive motor. Wires, APP connectors were preinstalled.*

**What is electric?** Electric power uses the energy supplied from batteries to operate motors without the need for "wet" fuels. At the beginning of this series I pointed out

that when you are referring to fuel, the power plant is an "engine." When you are referring to electric power, it is a "motor."

**Why would someone,** especially a beginner, want to try electric power? The two primary advantages of electric power are that it is clean and quiet. It's clean in the sense that you will not end up with fuel residue on your model after each flight. It's also clean because there is no fuel to accidentally spill on the ground and get into the water table. There is a remote chance of that happening, but it is still a big concern in certain areas of our country.



*Direct-drive propeller is mounted on propeller adapter that mounts on motor shaft. New Creations R/C supplies this adapter already mounted to motor shaft. The propeller is a white plastic Gunther 5 x 4.*

Electric power is quiet, as in no noise! Probably the loudest sound you will get from an electric motor is the propeller or air noise, and that isn't much. Quiet operation means that you have the ability to fly in urban areas without disturbing the public. Electric power is so quiet that you can fly at sunrise, in dead air or calm wind conditions, without the fear of waking up neighbors.

There are more subtle advantages associated with electric power. Without a piston and connecting rod pounding away, there is little vibration. This makes it much easier on the radio-system components, which need little isolation or padding to survive.

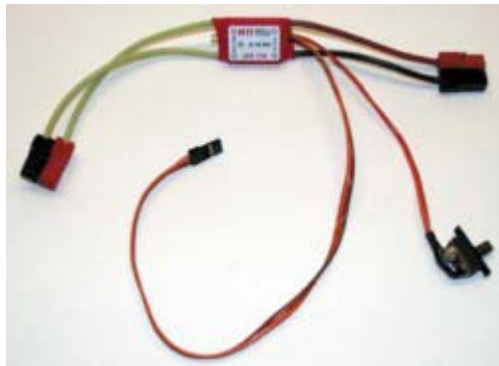
Electric motors are basically turned on by a switch or controller. You don't have to prime and flip a propeller, use a starter motor, or light a glow plug to get your model in flight. This easy starting feature is particularly nice when flying in colder weather. You can sit in your warm car while the battery recharges, then venture outside for the flight. There is never any waiting.



*Red dot on rear of motor casing denotes positive (+) terminal. Red APP connector is placed on positive motor lead wire; black APP connector is on negative lead. Both wires are connected to "motor" lead wires on ESC.*

When you are finished, you just put the aircraft in your vehicle; no cleaning is necessary. With the absence of fuel, you don't have to be concerned about the finish applied to your models. Anything will work!

After hearing these advantages, could there be any disadvantages? Yes! When you apply electricity from the battery to the motor, it will start instantly. If you fail to realize this, you might accidentally connect a battery, have the motor start, and it might hit you or take off across your shop, wrecking everything in its path. Most modern speed controllers have safety features to help with this that I will discuss in a moment.



*Jeti Model 110 ESC with BEC circuit (explained in text). Left pair of wires go to motor; right pair goes to battery pack. Cable with servo-style connector plugs into throttle port on RC receiver. On/off switch at end of remaining cable is mounted on exterior of aircraft's fuselage.*

**Is electric power** better than glow-fuel power? I've used both in the last 50 years (30 for electrics!). I think there will always be a place in our hobby for fueled engines. Modelers love the sound, and they like fueling, starting, and adjusting an engine.

On the other hand, a beginner in modeling has much to learn in a short time. Sometimes the problems with starting and operating a fueled engine can consume most of the available time while attempting to learn to fly. And if not adjusted properly, the engine may stop in flight.

With electric power, the motor always starts and will keep running as long as you have a charge in the battery. Yes, a wire could break or a fuse could blow, but that motor is usually going to keep running in a reliable fashion. As the charge wears down during a flight, the electric-powered aircraft will fly noticeably slower. This is your warning to set up for a landing. For these reasons, electric power is the perfect choice for the beginner in our hobby.



*Jeti Model 110 ESC with BEC circuit (explained in text). Left pair of wires go to motor; right pair goes to battery pack. Cable with servo-style connector plugs into throttle port on RC receiver. On/off switch at end of remaining cable is mounted on exterior of aircraft's fuselage.*

There are many things you have to learn to use electric power. Since this is a beginners' series, my intention is to gradually bring you up to speed. Battery charging is important. Hooking up all of the necessary wiring could prove a problem for some.

My first choice for an electric-powered ARF (Almost Ready-to-Fly) model will not require any soldering. Each power-system component will be what we call "plug and play"; that is, the radio and electric-power-system installations are totally handled with preassembled connectors. An entire electric-power-component package (which I will describe) will be available from Kirk Massey of New Creations R/C.



*An eight-cell 1100 mAh NiMH battery pack with preinstalled APP connectors.*

**What does an** electric power system consist of? The basic components are the motor, the propeller and any adapter that might be required to attach the propeller to the motor shaft, an Electronic Speed Control (ESC) to control the motor throttling, the battery pack to supply the energy, and the charger to charge that battery.

For an electric-powered model you must install the motor, ESC, and battery inside the aircraft and integrate it into your onboard RC system. The radio essentially operates the ESC, which operates the motor's speed in flight.

Your biggest concern at the start with electric power is understanding and correctly charging the battery. A battery that is not fully charged is much like a fueled model with only a partial tank of fuel.



*Global Hobby Distributors' WattAge PF-12 Park Flyer AC/DC Peak Charger. At left is 115VAC power input cable. At right is 12VDC power input cable. In front is pair of output wires with preinstalled APP connectors which attach to battery pack when it is being charged.*

**Motors:** The electric motor itself is of primary importance. There are different types, such as simple ferrite magnet motors; the more sophisticated cobalt (samarium cobalt) magnet motors; and the highly efficient, long-lasting, expensive brushless motors.

After selecting the type of motor, your next concern is to size it so that it is capable of flying a model aircraft of a particular weight. In this case the choice has been made for you. Another consideration is running the motor direct drive (with the propeller attached directly to the motor shaft) or through a gear-reduction drive that can add an advantage to the power output.

Since this is a beginners' article I've selected a basic ferrite motor known in the generic sense as a Speed 400. These come in three different windings designated by voltage. This project will use the 6-volt winding. The motor can be obtained from many sources.

This size motor is capable of flying a model with a total flying weight of roughly 10-18 ounces. It can accomplish this using a direct-drive propeller, so for this first try we will not use a gear-drive assembly. Be advised for the future that a gear drive will allow you to fly heavier-weight models and/or it can extend the flying time of a model flown on direct drive.

My choice of direct drive was to keep it simple and inexpensive. A Speed 400 motor costs approximately \$15. It is a sealed can. When you eventually burn out the brushes, you throw out the motor and buy another!

The motor will have two terminals, and they are polarized (positive and negative). Most have a red dot or mark indicating the positive terminal. For our beginner's package, a wire has already been attached to each terminal. The connectors applied to the wire ends are the popular Anderson Power Pole (APP) variety. There are many popular connectors available, but I felt that the APP were best for this application. These connectors have already been attached for you.

Almost any brushed electric motor will generate some form of electrical noise which could conceivably feed back into the RC system. To suppress this brush noise, one or more bypass capacitors are added. Generally, one capacitor goes from each terminal to the case, which is like a ground connection. In this case, the motor selected has the capacitors installed inside the motor can, so nothing else is necessary.

When you start your motor the first time, the wind created by the propeller should blow toward the rear of the model. If it blows forward, it means that the motor polarity has been reversed and the propeller is turning in the wrong direction. That shouldn't happen in this instance since the work has been done for you. Be advised for the future that if the propwash blows forward, reverse or swap the motor terminal connections.



*All electric-power-system components are plugged together as they would be inside model's fuselage. ESC cable with servo connector is plugged into RC receiver. Add two more servos for rudder and elevator control, and you have complete power and control system for your model.*

The motor shaft protrudes from the front of the motor. Some direct-drive propellers are simply pressed onto the motor shaft. I'm not in favor of that approach, so I specified the use of a propeller adapter. The adapter is slipped onto the motor shaft. A collet-type device essentially clamps to the motor shaft as you tighten the adapter. I found the adapter already installed on my motor shaft; you might find the same.

Once the adapter is in place, put the propeller on, followed by a propeller washer then the nut. Tighten the nut, and you are set. The propeller of choice for this project is a Gunther 5 x 4 white plastic. You will likely have to drill the center shaft hole somewhat to fit on the adapter shaft. Next month I'll write about how to install this motor on your aircraft.

**The ESC** is probably the heart of the electric power system. The ESC in electric-powered flight takes the place of the throttle (or engine) servo used on a fueled model.

The ESC in this instance weighs roughly 3¼ ounce and has two pairs of wires: a servo-type cable and a cable with a switch on the end, all exiting the case. Two wires, with APP connectors already attached, will plug into the motor wire connectors. Polarity is important, so it is red to red and black to black.



*Cable from ESC plugs into throttle port on RC receiver. It doesn't look it, but connector is plugged into CH3 on this Hitec Electron 6 receiver.*

Two more wires will have APP connectors attached, and they will plug into the battery pack. The third cable has a servo cable connector on the end. That cable is plugged into the throttle port (usually the number-three position) on your RC receiver. The switch will be mounted on the side of the fuselage and must be manually turned on to activate the entire electric power system.

There are all kinds and sizes of ESCs on the hobby market. The one chosen for this project is the Jeti 110. The ESC will be rated for current; in this case it is 11 amps continuous operation. For our application we need 8-9 amps, so there is a margin of safety. If the rating wasn't high enough, you could overheat and possibly burn out the ESC. The rating must also take into account the number of cells in the battery pack. The Jeti 110 can handle six to 10 cells. We will be using an eight-cell battery.

Many small ESCs (such as the Jeti 110) will contain what is called a Battery Eliminator Circuit (BEC). It will permit the main motor battery pack to also power the onboard RC system (receiver and servos) on a shared basis. This saves the weight of an extra airborne battery pack. It is also a convenience because this one battery is recharged for every flight.

In actual practice, the BEC has a special circuit that provides a regulated 5 volts to the RC system via that cable that is plugged into the receiver throttle port. When the battery gets down near 5 volts the circuit cuts off the motor, but it still provides the necessary power to operate the RC system so that you can safely land the model.

Most ESCs with this BEC feature (the Jeti 110 included) will allow you to briefly restart the motor after the first shutdown. You do this by moving the throttle stick on the transmitter all the way to idle, then back up. That resets the ESC and will allow a few more seconds of power so that you can line up on the runway for a safe landing.

Most modern ESCs (including the Jeti 110) employ "smart" circuitry via a microchip, which can add considerably to the safety of electric motor operation. Remember what I wrote earlier: when the battery is attached to the motor, it could start instantly. If you have the throttle stick at full or partial with the entire system plugged in, the motor and propeller could start turning.

The microchip in the ESC will sense anything other than a dead idle position and prevent the motor from starting. To start the motor you must physically move the

transmitter throttle stick down to idle then go back up. The motor will then start, and its speed will be proportional to the control-stick position.

**The Battery:** This is also an important part of the electric power system. Batteries come in all types, sizes, weights, and capacities. The choices are critical to the model's performance. For this project the choice of battery has been made for you; it is a Nickel Metal Hydride type (NiMH) consisting of eight cells made up as a pack. Each cell has a capacity rating of 1100 milliampere-hours (mAh). The nature of these ratings will be explained in later articles.

APP connectors have thoughtfully been attached to the two wire cables. As in the case of the motor connections, the polarity is critical to the system's correct operation. It is always positive to positive and negative to negative. If the color-code convention is followed, it is usually the usual red to red and black to black. However, not everyone uses that color convention.



*Rear of PF-12 showing 115VAC and 12VDC power input cables. This charger allows you to recharge battery packs indoors or at flying field from 12-volt car battery.*

Do not mix up connections between the motor and battery. The connectors going from the ESC to the motor are generally connected once at the time of initial installation and not touched thereafter. Placing a piece of masking tape on each connector can remind you not to touch them until such a time as you transfer the equipment to another aircraft.

Estimating that this direct-drive Speed 400 motor will have a current of 8-9 amps, this particular battery pack should be capable of providing six to seven minutes of electric power at full throttle. In reality you will have much more power than you need; therefore, you will be able to throttle back during a normal training flight.

Throttling back reduces the motor current, and, as a result, increases the flight time. With average throttling back it will be possible to extend your flying times to 10 minutes or so. Owning more than one battery pack will allow you to fly on one while the other is on charge. That will provide you with more flying time and less waiting time.

**Charging:** The last item in the electric power package is the essential battery charger. There are many choices, simple and complex, available at varied prices.

Kirk Massey's favorite for a beginner is the Global (WattAge brand) PF-12 Park Flyer AC/DC peak-detect charger. The key words are "peak detect"!

Some of the simplest battery chargers come with just a rotary-crank type timer. You rotate the timer switch to 15-20 minutes and wait for the timer to run down. The trouble with this is that the charger can't sense the amount of charge already in the battery. This can easily result in overcharging, which can cause excessive heat buildup in the battery. An overheated battery can quickly be ruined.

A peak-detect charger is essentially an automatic charger. All Nickel Cadmium (Ni-Cd) and NiMH batteries have a characteristic where the voltage applied during charging increases until the point of full charge (full capacity) is reached, at which point the voltage peaks then begins to drop off. At the peak, or slightly thereafter, the charge cuts off automatically.



*Never charge a hot battery pack. Use a "cooling device" such as this, consisting of a 3-inch-diameter PVC pipe approximately 12 inches long. Attach RadioShack 12-volt fan on one end. Battery pack is inserted in other end so that air from fan passes over battery, thereby cooling it. In this case the battery is being cooled while it is on charge (battery plugged into charger).*

Since this is a sensing cutoff and not a timed cutoff, only what is necessary to reach full charge is put into the battery. If your battery had residual charge in it, the charge period would be reduced accordingly.

The one thing you must do manually is tell the charger the amount of charge current required. For NiMH batteries it is suggested that you apply a charge current equal to two times the rated capacity of the battery. We refer to this as "2C."

In this case the battery is rated at 1100 mAh (which is the same as saying 1.1 amp per hour). Multiply 2.0 by 1.1 amps, which equals 2.2 amps. This particular Global charger has a maximum charge current of 2.0 amps, so you would set the charger to that maximum current. At that approximate 2C charge rate, a fully depleted NiMH battery pack would take roughly 30 minutes to reach full charge.

Each battery will vary according to the number of cells, the type of the cells, and the capacity rating. You will pick up on this concept as you progress with electric power. For this first choice I've selected a charger that can't overcharge the battery pack because its maximum current of 2.0 amps is close to what this battery requires.

When you purchase this or any charger, it is generally your responsibility to prepare a cable that will allow the charger to connect to your battery pack. Kirk Massey has prepared a cable with APP connectors to attach between the Global charger and our battery pack. Note the output connectors on the front of the Global charger. Press down on each connector, insert the wire, then release. Do that for the positive (red) and negative (black) connectors.

Later you might want to purchase a more sophisticated charger that has a higher current rating or can handle battery packs with more cells. (The Global is capable of handling four to 12 cells.)

There are several fully automatic chargers on the market. When you attach a battery to one for charging, it will sense all of the necessary parameters and set the charger accordingly. The concept involves a computer sensing system and has a menu that must be accessed for regular operation. These chargers work well, but they are more complicated to use than this basic Global unit and they cost much more.

It is typically a good idea to remove the battery pack from the model when charging. Immediately after a flight the battery may be quite warm--even hot. A basic rule is to never charge a hot battery. You should cool it off before attempting to recharge. Putting a hot battery in your soda cooler isn't the right method. It will result in uneven temperatures throughout the pack.

The better approach is to buy a RadioShack 12-volt electric fan (part number 273-243). You can mount it at one end of a length of 3-inch-diameter PVC (polyvinyl chloride) plumbing pipe. Power the fan from your 12-volt car battery. Put your hot battery pack at the other end of the PVC tube. This will allow the air the fan blades generate to pass over the battery pack and cool it. Approximately five minutes in this tube will reduce the temperature to a safe level for charging.

This Global charger can be powered by 115VAC for indoor (shop) use or from 12 volts DC from your car battery. At the field, most of us just raise our car hoods and attach the charger input cables (alligator clips) to the battery terminals.

The polarity is important. Make sure that the red alligator clip goes to the car-battery positive (+) terminal and the black goes to the ground or negative (⊖) terminal. The Global charger has a built-in timer circuit that cuts off the charger after a 90-minute period. If you left the charger unattended and something went wrong, the charger would safely cut off after 11½ hours.



*A 12-volt RadioShack fan is simply epoxied in place at end of PVC tube with the help of a few pieces of scrap wood. Fan draws little power from car battery.*

**That's the full** electric power system. Remember that this article has been prepared as a starting point for a rank beginner who is entering electric flight. There is a shopping list in the accompanying table that you can use to purchase all of the necessary equipment. You can purchase all of the items from Kirk Massey at New Creations R/C, Box 497, Willis TX 77378; Tel.: (936) 856-4630. (Kirk prefers telephone calls to E-mail correspondence.)

You can buy the components on the list from other sources; for simplicity's sake I specified one source and the exact equipment necessary. The addition of the connectors made this a custom order. If you are lucky to live near experienced electric modelers, by all means solicit their help; it can save you a great deal of time. However, the theme of this series is to get you going on your own--with little or no help!

Next month I will start with a basic electric-powered ARF trainer: the AeroCraft Pogo. It was specifically selected to use the electric power equipment I have described and the Hitec Neon three-channel RC system, which I discussed in part two of this series (in the April 2003 Model Aviation, starting on page 54).

I expect to take the Pogo from the kit box to the flying field, which includes final assembly of the model and installation of the electric power and RC system. **MA**