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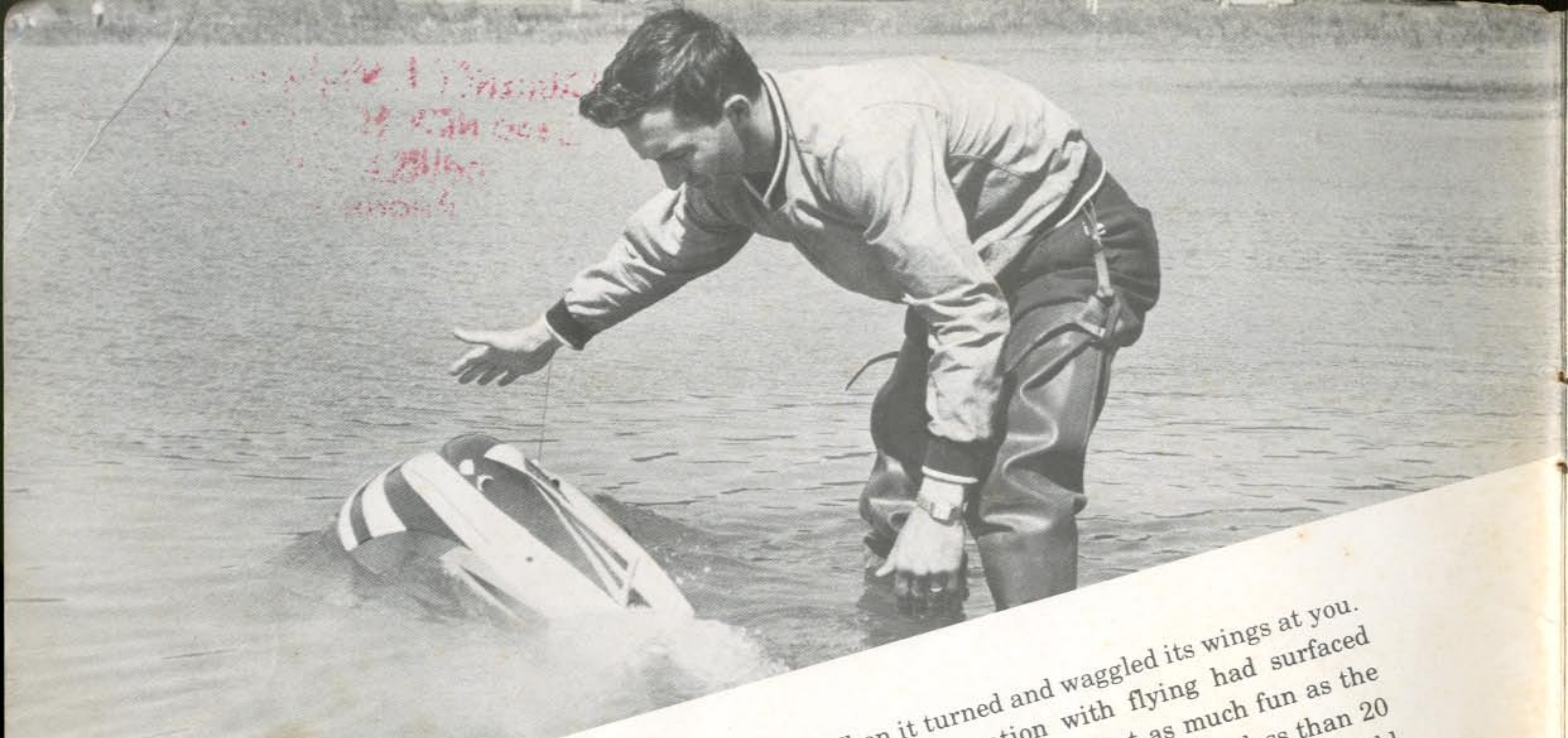
basics of RADIO CONTROL MODELING

By Fred M. Marks
and William Winter



You'd probably seen them many times: guys standing in a field flying their model airplanes around in circles overhead, guys standing in an empty parking lot with little race cars whizzing around. A couple of thin wires connected the model to the man: control wires, of course—they probably served as a tether, too. Then you saw a plane without wires—and it wasn't flying away, out of control.

"Hey, where are the wires?"

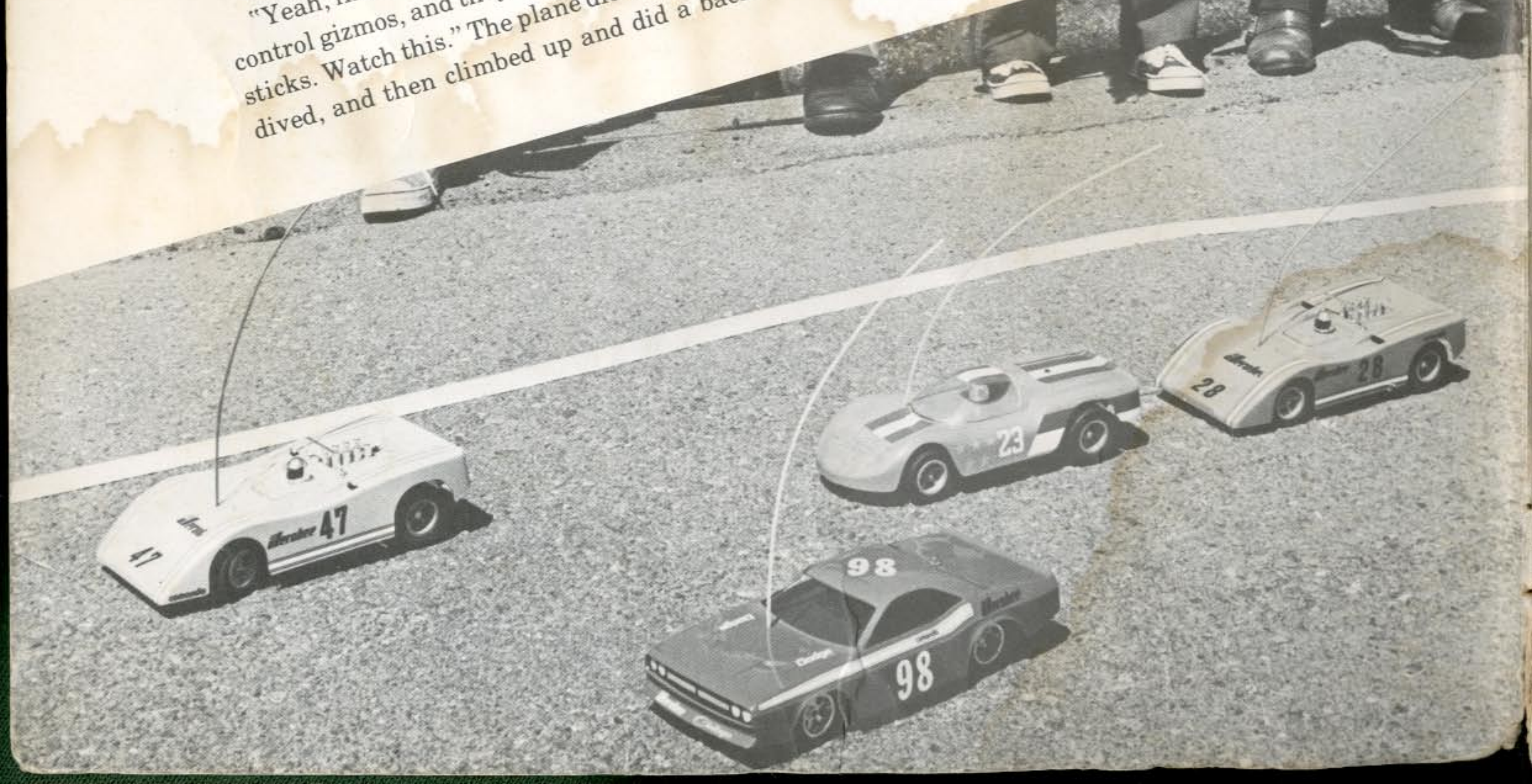
"No wires, man, this is radio."

"Radio?"

"Yeah, inside the plane are a bunch of motors and control gizmos, and they match what I do with these sticks. Watch this." The plane did a neat one-eighty, dived, and then climbed up and did a back somersault. Then it turned and waggled its wings at you.

Your old fascination with flying had surfaced again. This looked like almost as much fun as the real thing, and it would probably cost less than 20 hours of dual time in a Cessna. You'd have to build that model plane. Might be fun to do with the little guy—he'd like that. It could be *more* fun than full-size flying, and she wouldn't worry about you being up there with nothing but the Bernoulli effect holding you up. Bet you could control a boat or a race car with one of those radios, too. Where'd that fellow with the plane go? There he is—"Hey, tell me more about this radio stuff."

"Best thing to do is to go to the hobby shop, and there's this book, see, and . . ."



basics of RADIO CONTROL MODELING

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ON THE COVER is an Antic, a semi-scale model built from a Proctor kit by Don Klapstein. A. L. Schmidt's photos show the model flying, waiting on the runway, and resting on the grass ready for a trip to the workbench. Photos opposite by A. L. Schmidt (above) and Jerobee-Auto World (below); back endpaper photo by A. L. Schmidt.

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The ultimate in airplane modeling is a miniature aircraft, such as this model of a Ford Tri-Motor, that looks and acts like the real one.

I Introduction

WHETHER you're looking for the relaxation of building a model that operates just as the prototype does, or you're ready for the intense competition of a yacht or plane race, radio-control models can provide what you seek. The variety is almost infinite: planes, boats, cars, submarines, dirigibles, tanks, and so on. The hobby is one you can pursue alone or with others; there are many clubs and associations in the hobby.

Our first admonition to the novice is "start simple." The construction time of a model depends directly on its complexity, as does the amount of skill needed to operate it. If any model should be immediately successful, it is your first one. Frustration and discouragement can result from a model that takes too long to build or that is too difficult to operate.

A typical multichannel digital system includes, top left to bottom right, transmitter, battery charger, battery pack, four servos, and receiver.

The usual source of project supplies is a hobby shop. Thousands of hobby shops exist across the country, and it is a rare city that does not have several. Mail-order houses, advertised in the model magazines, carry a more extensive stock than most local hobby shops, but they cannot provide the personal advice and assistance that the hobby shop can. Model magazines are the best source of information about all facets of the hobby, and through their advertisements the magazines constitute a catalog of the available models and supplies.

The hobby shop has another important function: It is a place to meet other modelers. Your first attempt at operating a radio-control model will be much more enjoyable if you have the assistance of an experienced modeler. It is possible to learn how to fly an R/C plane from a book, just as it is possible to learn how to ski from a book; but the help of another person makes learning easier, whether it is R/C [illegible] skiing.

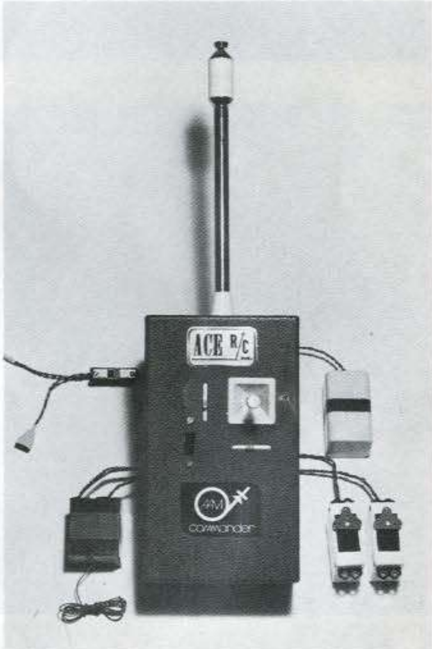
Your first major deci[illegible] eling is whether to build a p[illegible] a car, or something more exotic.

Whether summer or winter, wheels or rotor blades, radio-control modeling provides enjoyment and challenge.

and cars provide a more relaxed environment for learning the fundamentals of radio control than do planes, for the simple reason that boats and cars operate in only two dimensions, not three. Mistakes in controlling boats and cars do not turn your model into kindling wood the way a flying error does.

As you think about the type of model you'd like to build, consider where you will operate it. A plane needs a large open area that is sufficiently isolated so that noise will not annoy anyone. Boats require a lake or a pond; mufflers may be required on power boats. A paved area such as a schoolyard or a parking lot is suitable for cars and other wheeled vehicles.

There are several ways to undertake building a model. The most common way is from a kit. The variety of airplane, boat, and car kits is almost limitless. Many modelers convert toys and display models to R/C operation; other advanced hobbyists build models from scratch, either following instructions in magazine articles or creating an original design.



The pulse proportional control system (above left) is light, simple, and reliable. It can control one function. A two-channel digital proportional system (above right) can be used for cars, boats, gliders, and simple planes.

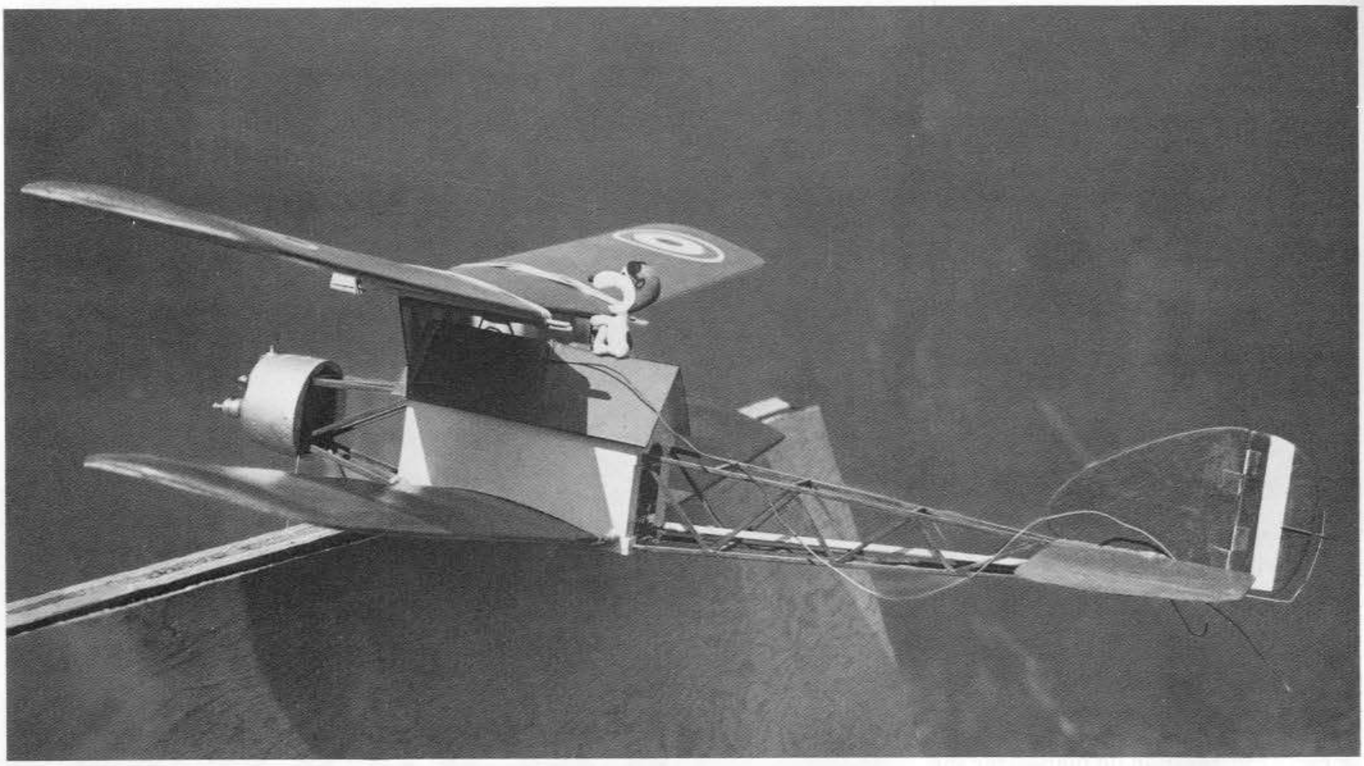
The model and the radio equipment depend on each other. Control systems for boats are different, for instance, from those for airplanes, and control systems vary in the number of channels they use.

A channel is an independent path of information from the transmitter to a control device which performs an independent function on the model. For example, independent control of rudder, elevator, ailerons, and throttle of a plane requires four channels.

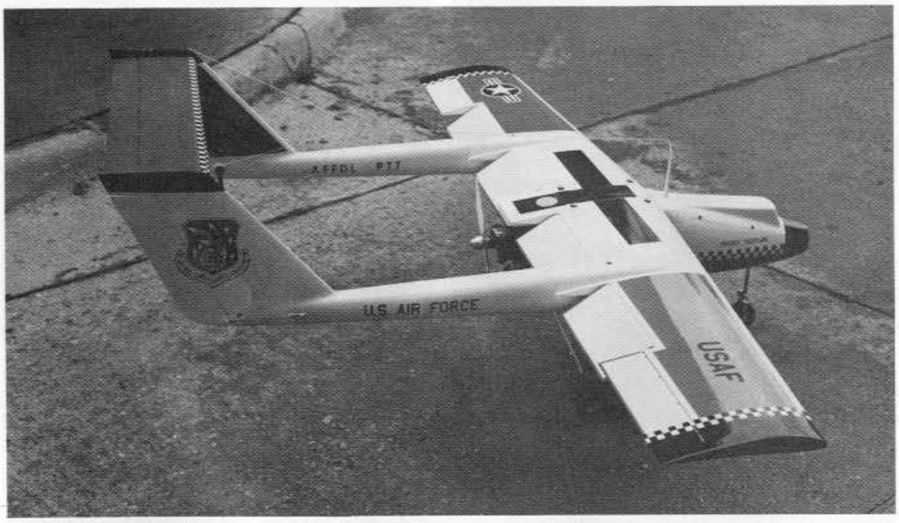
In past, many control systems have been used in the past. Currently 95 per cent of the systems in use are of two types, digital proportional and pulse proportional. The digital system is the more popular of the two. It is quite sophisticated electronically and it performs very well. The pulse system is simpler and lighter in weight. The two systems are equally reliable, so your choice should be based on the application. The term *proportional* refers to continuously variable positioning of controls. Some earlier systems provided essentially all-or-nothing controls.

It is not the purpose of this book to examine the circuitry of the radio system or to explain electronics. The high quality of the radio systems available and the information that accompanies such equipment and that exists in other books and magazines render repetition unnecessary. We will regard the radio system as a black box.

Licensing and understanding of Federal government regulations are prerequisites to operating an R/C model. More than 100,000 persons are licensed by the Federal Communications Commission to operate Class C stations, which are used to control models. The Citizens Radio Service was established in the early 1950's to broaden public use of special portions of the radio spectrum without the need for a code test or a written examination. Before that time only licensed ham operators could enjoy the hobby of operating R/C models.



Is it a doghouse or a Sopwith Camel? Novelty models can be a lot of fun.



R/C models are more than toys, and sometimes they are even more than hobby equipment. The U. S. Air Force uses this model for testing.

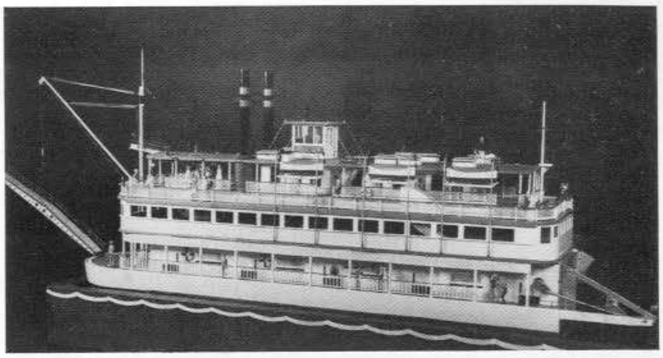
More typical of R/C airplane models is this simple trainer with controllable rudder, elevator, ailerons, and throttle—sometimes called full-house control.

While the advent of the Citizens Radio Service eliminated the requirement for code proficiency and the examination, it did not eliminate the licensing requirement. To obtain a license, first become familiar with Volume VI, Part 95 of the FCC rules and regulations ($1.25 from the Superintendent of Documents, Government Printing Office, Washington, DC 20402). At the same time obtain Form 505, the license application from the Federal Communications Commission, Washington, DC 20544. Mail the completed form and the fee to the FCC, Gettysburg, PA 17325.

The Class C license permits you to operate commercially produced equipment or equipment tuned and certified by a licensed second-class operator. Maximum power allowed is 5 watts; most commercial equipment produces less than 1 watt. Operating radio equipment without a license is a good way to satisfy your curiosity about the interior decor of jails.

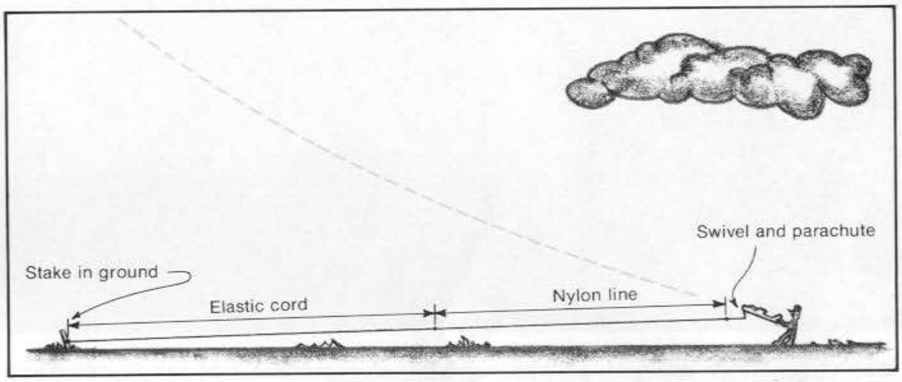
The greatest problem facing R/C hobbyists is that of combining the radio equipment and the vehicle so that all systems work correctly and reliably. Seldom is an R/C vehicle sold as a complete unit. Most often the vehicle and the radio equipment are two separate items, and it is the task of the modeler to integrate the two items. To that task much of this book is addressed.

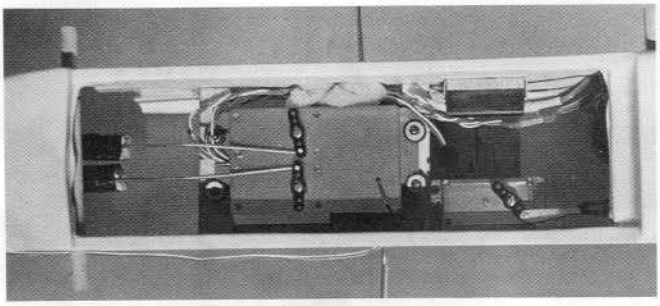
Even small semi-scale models intended for rubber-band power, such as this Guillow Stuka, can be adapted for radio control. The engine is mounted inverted, and the cylinder head is concealed by cowling. The model has two-channel control.



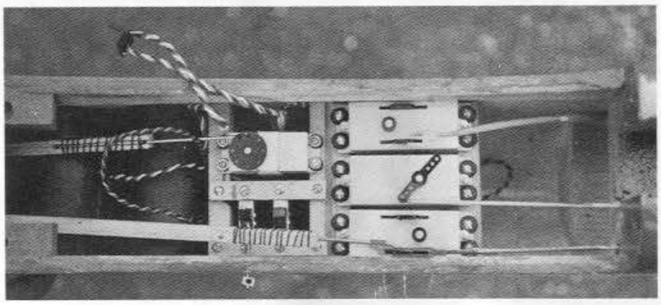
Here's an excursion steamer with animated figures, operating gangplank, and recorded orchestra and whistle. Note the wooden carrying cradle that also serves as a display stand.

An elastic-cord device can furnish the power for launching a glider.

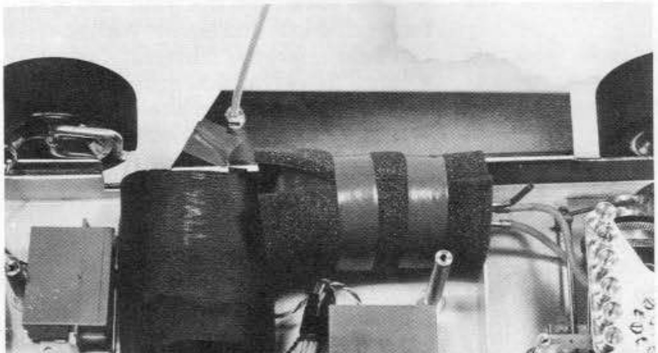




A "brick" system contains the receiver and two servos in a single unit, with some saving in weight.

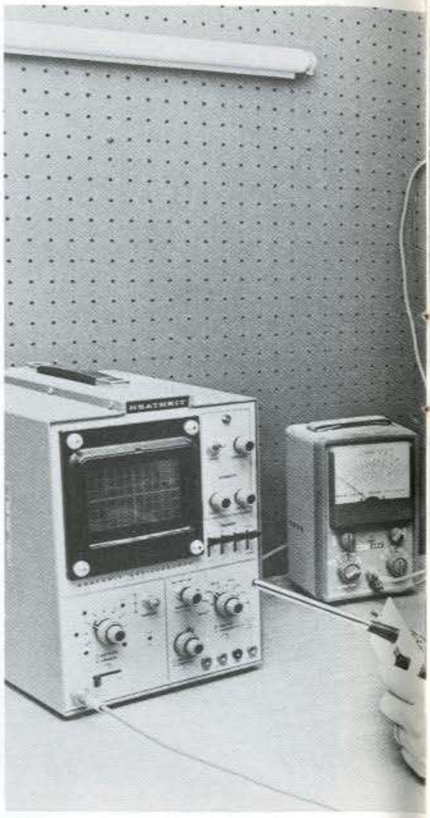


Separate servos are more common. This airplane installation has four servos, two linear and two rotary.



Two-channel control is sufficient for cars—steering and throttle/brake. Receiver and fuel tank are cushioned.

R/C modeling can be out-and-out competition or it can be as simple as a boy and a boat.



(Above) A necessary adjunct to a workbench is tool-storage space, such as a pegboard with hooks. It is best to separate electronics from modelbuilding, either with separate benches or by allocating space on one workbench. (Above right) Author Fred Marks checks a transmitter at his electronics workbench. On the bench are an oscilloscope, a multimeter, and another transmitter. Most modelers will not need this much electronic equipment. (Far right) Good lighting and a place to sit make modelwork much more enjoyable.

2 Tools

THE NOVICE MODELER usually seizes the first convenient work area he can find. Difficulties soon arise if it is an area on which some other purpose or some other member of the household has a prior claim. Everything must be cleaned up and put away when the dining table, for example, is needed for dining. Wood chips and sanding dust in the living-room carpet and glue smears and paint fumes in the kitchen can create domestic friction even faster than a carelessly said "Macaroni again?"

The modeler needs an area that can be devoted exclusively to modelbuilding. It must be habitable, even comfortable. Among the requirements are:

Lighting, such as a twin-lamp overhead fluorescent fixture for general lighting and high-intensity spot lighting for detail work.

Ventilation so that the fumes from paints and cements can be dispersed before they cause headaches (or worse).

Electrical outlets for tools, soldering irons, chargers, and so forth. Outlets at the back of the bench for chargers prevent the nuisance of dangling cords. Outlets at the front of the workbench are preferred for use with power tools and soldering irons, so the cords will stay clear of objects on the bench. Outlets, especially those for power tools, should be grounded to eliminate any shock hazard in a defective tool. (Have an electrician install a branch circuit if you do not know how to do it.)

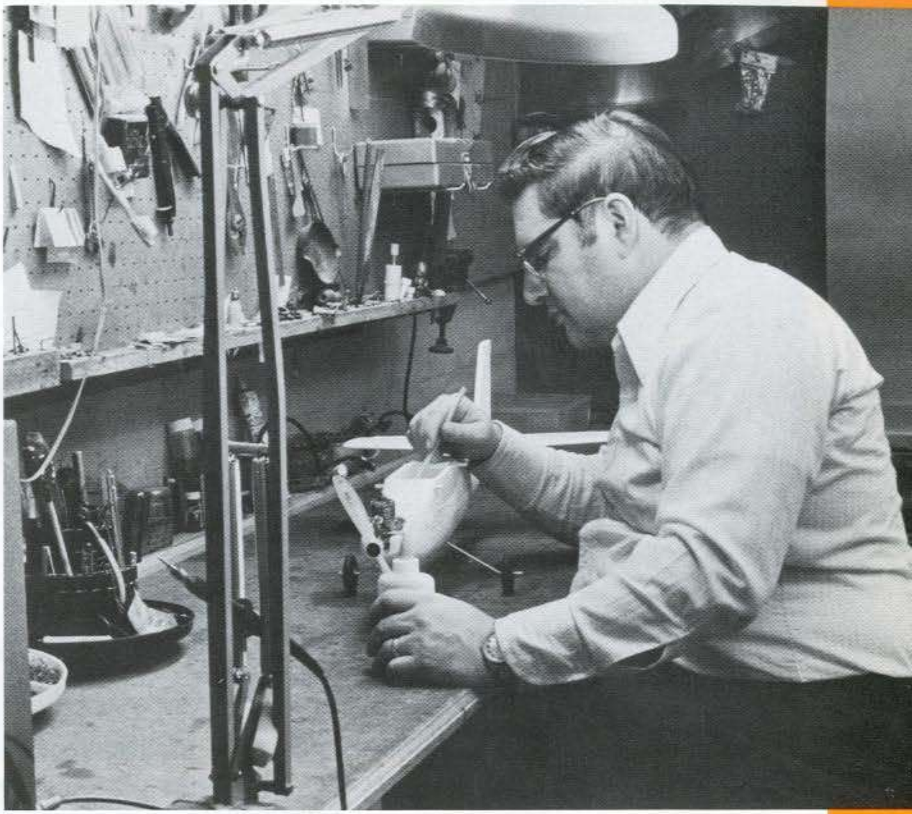
Tool storage space: One of the most convenient places to store tools is on a piece of pegboard, using the various hooks and fixtures available at a hardware store.

Shelves and drawers for small tools and construction materials. Ceiling and wall racks can be used to store models. Shelves under the workbench (but set back from the front) are useful for storing kits and boxes. Wall shelves can hold reference material, including a large loose-leaf notebook to hold all the active instruction sheets.

Small-parts cabinets: It does not take long for an active modeler to accumulate many small parts, such as screws, nuts, washers, needle valves, plugs, sockets, switches, and other fittings. A small cabinet with a dozen or so drawers is inexpensive and soon becomes indispensable.

As you lay out your work space, allot a third or a half to electronics, allowing space for both installation of components and testing of completed vehicles. Equipment such as scopes and meters can rest on shelves at the rear of the workbench. If your work area is large enough, consider having two workbenches, one for modeling and one for electronics.

The workbench itself can be con-



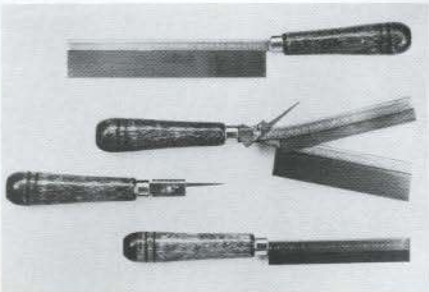
structed from 1 x 4's, with a ¾" plywood or chipboard top. The work surface should be a separate piece that can be replaced when it becomes worn and marred. A luan-mahogany hollow-core door makes an excellent work surface. It does not warp, and it readily accepts pins for holding work in place. The height of the workbench depends primarily on whether you prefer to stand or sit as you work.

Tools: The tools you need for building a model airplane or boat are different from those you would use to build a bookshelf or tune up your car. Here is a discussion of some of the more common modelbuilding tools.

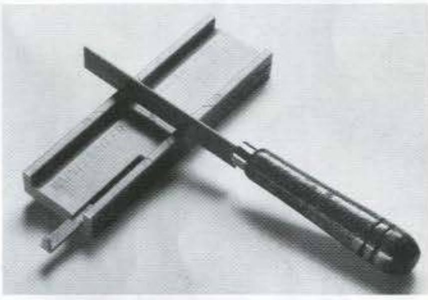
Hammer: A modeler uses a hammer most frequently to drive pins into a work surface to hold parts in position for gluing. Although any hammer is adequate for this purpose, one with a magnetized and slotted head is the handiest. A small hammer with interchangeable heads is useful for the occasional modelbuilding tasks that call for a hammer.

Saws: You can do most of the balsa-cutting work encountered in modelbuilding with a common coping saw. An ordinary carpenter's saw is useful for cutting heavier materials, and a small keyhole saw, such as one that fits into the handle of a modeler's knife, can work in tight corners where even a coping saw would be stymied.

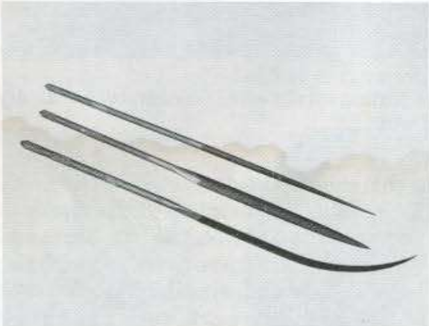
A power jigsaw or band saw can make the cutting of balsa blocks, plywood formers, and other such items easier and more accurate. An inexpensive vibrator-type jigsaw can be used to



Several different types of blades are available for razor saws.



It is almost impossible to "eyeball" a perfectly square cut—use a miter box.



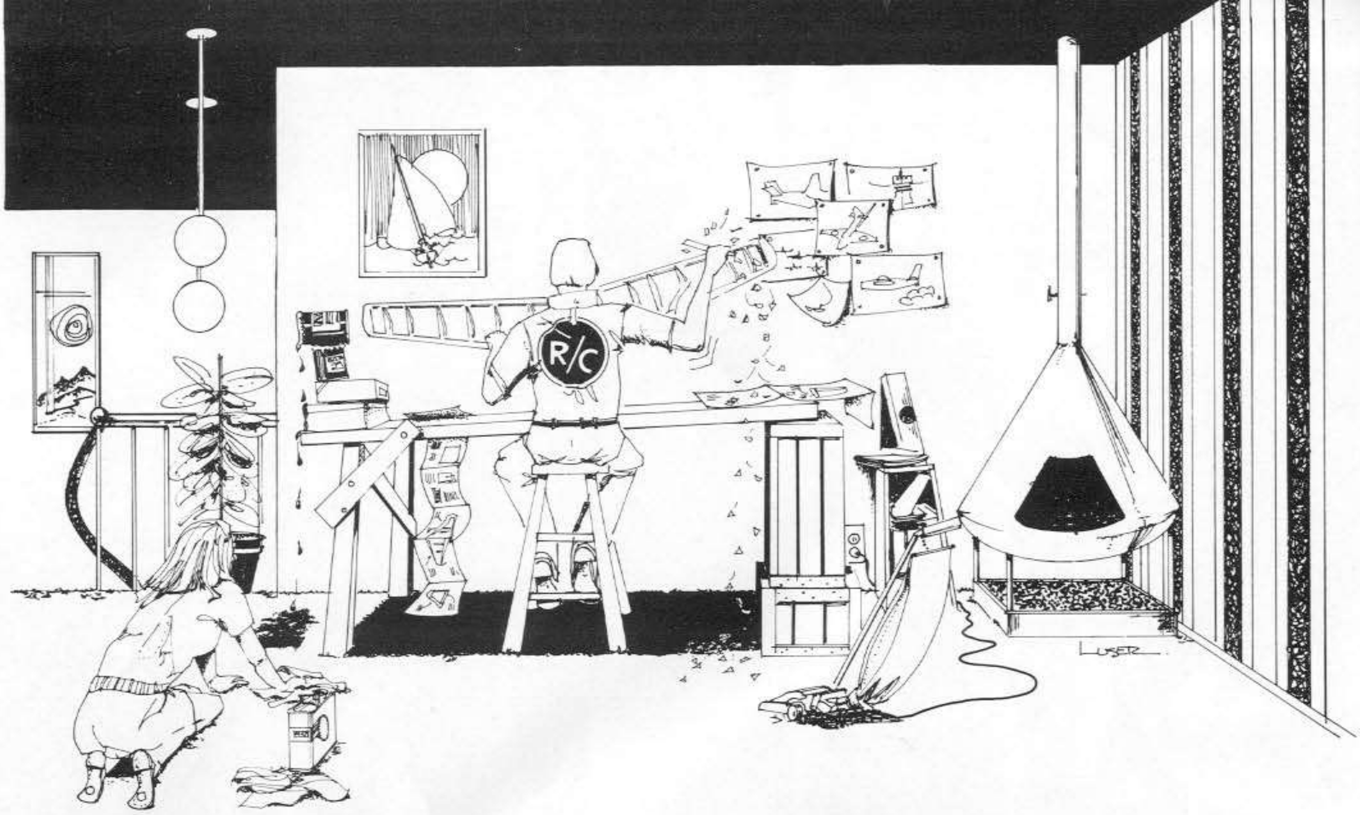
An assortment of small files of several shapes is useful for final shaping of metal, plastic, and wood parts.

A work positioner is almost as good as a third hand for holding small parts.

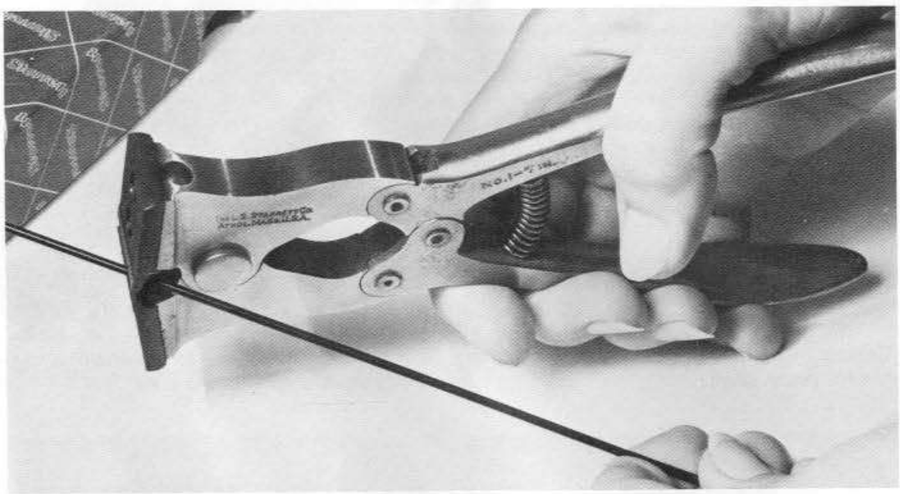
do many of the same cutting jobs. If you do much modelbuilding, you may find that a power saw of some type is not an extravagance.

A common hacksaw is useful for cutting heavy metal, and a razor saw can do lighter, more precise metal-cutting. The razor saw has a thin, rigid, fine-toothed blade. It can be purchased as a separate tool or as a blade for a modeler's knife.

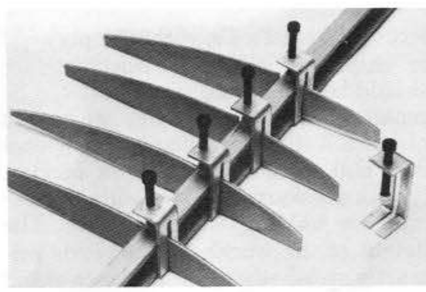
Many modelers cut brass and aluminum tubing by rolling it back and forth beneath a sharp knife or a razor blade (doing the cutting tool no good). A tubing cutter is faster and easier, as is



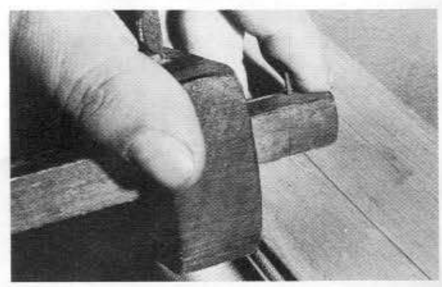
Many beginning modelers take over a part of the house before investing in a workbench. They should have consideration for others.



Special heavy-duty cutters are the best tool for cutting music wire. You can ruin ordinary cutting pliers by using them to cut hard steel wire.



Slotted clamps can be used to hold ribs to a wing spar while the glue sets.



A marking gauge has a number of uses. It is used here to score sheet balsa so a narrow strip can be broken off.

almost any tool designed for a specific purpose when compared to a makeshift tool.

Pliers: Needlenose, duckbill, and roundnose pliers, diagonal cutting pliers, and electrician's pliers all play an active part in almost any modeling project. Slip-joint and locking pliers are useful for holding objects while working on them with other tools. Pliers come in a variety of sizes, too. You should be careful to choose the size appropriate to the job. Pliers that are too small for a task can be damaged by the object they are holding, and nothing can chew up a small object faster than a large pair of locking pliers.

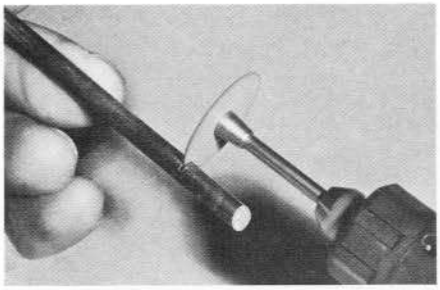
Vises and clamps: A medium-size vise, substantial enough for bending light sheet metal or steel wire up to 5/32" thick, is essential. If the vise is of the type that pivots on its base and locks in different positions, so much the better. A second, smaller vise is desirable for delicate work, such as holding sockets for wiring.

A selection of clamps of various types and sizes is a necessity. A hardware store can provide C-clamps and broad-billed wooden spring clamps. Stationers offer a variety of spring clamps. Spring clothespins have many uses around the workbench.

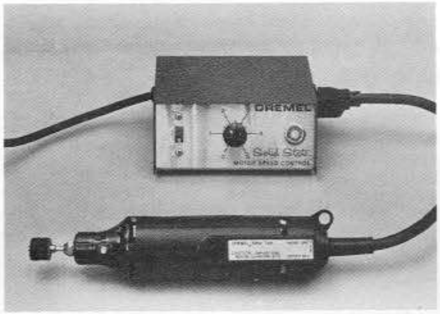
Cutting tools: Modeling involves much cutting of wood of various sizes and textures, and it requires a corresponding diversity of cutting tools.

The single-edge razor blade is an old favorite for cutting thin material. Industrial-type razor blades specifically intended for cutting and available in hardware and paint stores are generally better suited for modelwork than are the shaving-type blades sold in drugstores.

Hobby or modeler's knives, such as X-acto's line, are ideal for delicate and precise work. Generally speaking, such knives have surgical-steel

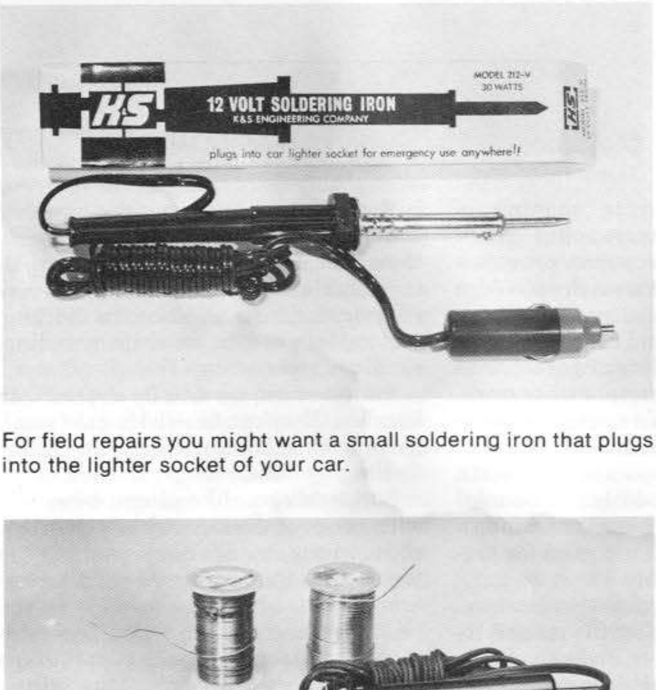


An abrasive wheel in a motor tool can be used to cut music wire. Always wear safety glasses when you work with power grinding or cutting tools.



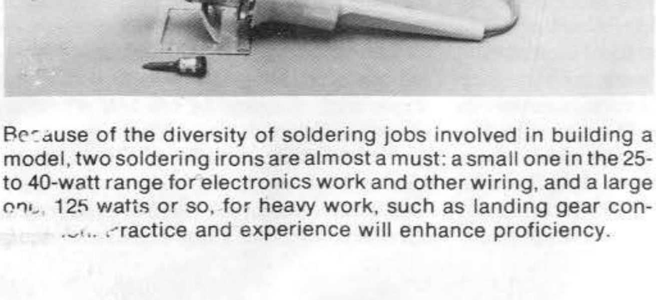
A speed control unit enhances the versatility of a motor tool.

An electric hand tool with its array of burs, grinding wheels, and collets can make many of the tasks in modelbuilding easier and faster.



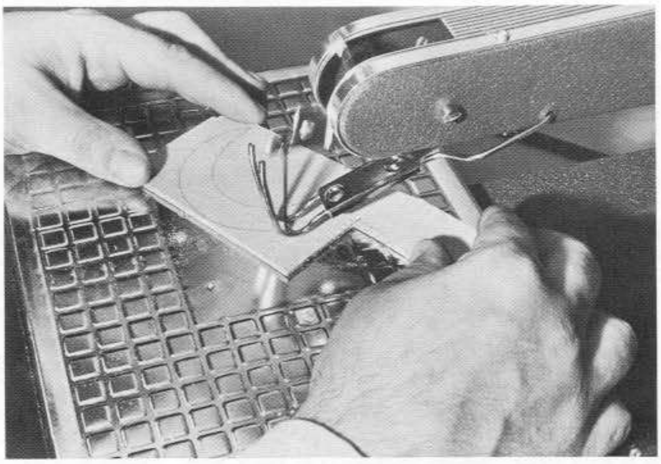
For field repairs you might want a small soldering iron that plugs into the lighter socket of your car.

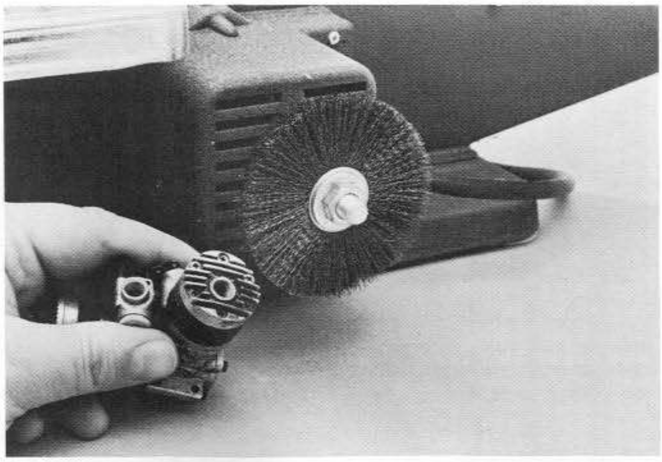
A sealing iron facilitates work with heat-shrinkable and heat-adhesive covering materials.



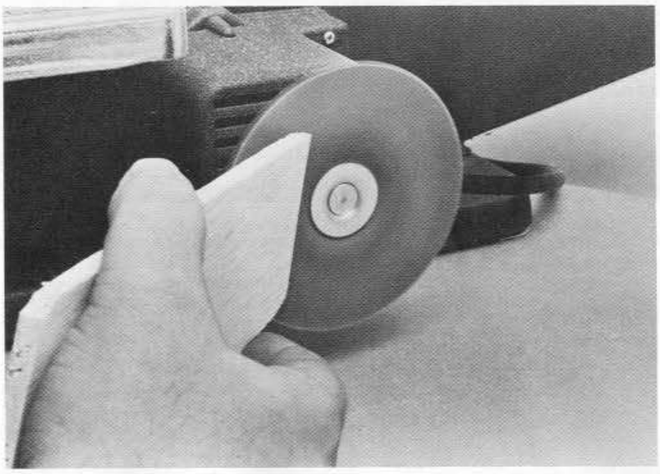
Because of the diversity of soldering jobs involved in building a model, two soldering irons are almost a must: a small one in the 25- to 40-watt range for electronics work and other wiring, and a large one, 125 watts or so, for heavy work, such as landing gear construction. Practice and experience will enhance proficiency.

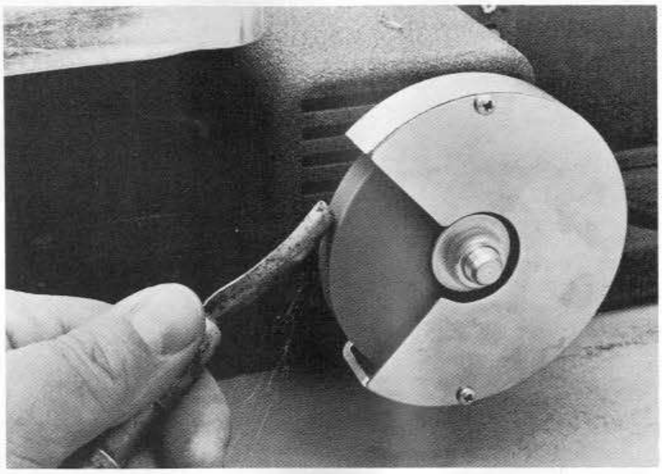
Adjustable jigs are a real help in building a wing. The jig shown here permits complete construction of the framework of a wing while holding everything in alignment.





The Dremel Moto-Shop is a number of tools in one: jigsaw (above left), wire-brush wheel, useful for cleaning crud from an engine (above right), sanding disk (below left), and grinding wheel, for sharpening tools (below right).





which can be inserted into a handle. Many blade styles are available.

For heavier work the Stanley knife is excellent. The large handle makes the knife easy to use, and the blades are sharp enough to cut balsa without crushing the fibers. The blades can be sharpened easily, and replacement blades are inexpensive. To make long cuts, clamp a metal straightedge in place over the material to guide the knife.

Chisels and gouges are excellent for hollowing out small hulls, wingtip blocks, and nose blocks, making slots and grooves, and cutting where other tools can't be used. Millers Falls produces a set of five gouges to handle almost any cutting situation. The tools can be sharpened with a sharpening stone.

Balsa strippers: Non-standard-size strips can be cut from sheet balsa with a balsa stripper, which is essentially an adjustable gauge that holds a knife a set distance from an edge guide. A marking gauge is a similar device which marks a line at a given distance from the edge of a sheet of wood.

Planes: A small plane is superior to a knife for performing such tasks as shaping the leading edge of a wing. The ability of a plane to make a long, even cut facilitates accurate shaping of wood. Hardware stores offer small planes, and hobby shops can provide a miniature plane that uses double-edge razor blades.

Files and rasps find constant use in all phases of modeling. Medium-size files are handy for general utility work. A set of small files of various shapes is useful for delicate work.

Wood files and rasps are well worth having. A round wood file can be used to enlarge holes and round out window corners. Larger rasps are good for preliminary shaping of blocks.

Do not skimp on quality when you buy files. A high-quality file retains its sharpness much longer, and a sharp file cuts faster. A wire file brush can keep your files clean.

Drills: You must have a drill, either hand-powered or electric. An electric drill can be purchased for as little as $10. It will save enough work to repay the investment quickly. A set of high-speed drill bits can be used in working with both wood and metal. One small item worth its price in convenience is a rack for the drill bits. It keeps the bits organized, and it protects them from the abrasion (which would dull them) that would result if they were simply tossed into the toolbox.

A motor tool can bring the ease and convenience of electric power to operations that demand more precision than is possible with a standard full-size electric drill. In addition to drilling, motor tools can be used for grinding, sanding, and cutting.

Pin vises are essentially chucks with handles. They can be used to hold small parts and to hold a twist drill bit for drilling by hand.

Screwdrivers, like pliers, come in a wide range of sizes. Also like pliers, use of the wrong size can damage either the tool or the object it is used on. A screwdriver blade should be as wide as the head of the screw—no wider. Some engines and accessories have Phillips screws (cross-slot) or allen screws (with a hexagonal recess instead of a slot). Ordinary screwdrivers cannot be used for these screws; it is therefore necessary to have sets of Phillips screwdrivers and allen wrenches. Other screwdriver variations sometimes necessary in tight places are the short-shank and long-shank types and the type with fingers to hold a screw in place at the end of the blade.

Nut drivers: A cross between a screwdriver and a wrench, with a screwdriver handle, a long shank, and a socket at the end to fit a nut, a nut driver

A pin vise is used most often to hold very small drill bits for drilling by hand. It can also be used to hold small parts while you work on them.

Many modelers prefer an airbrush or a sprayer to brushes for finishing a model. A wide variety of spray-painting equipment is available.

useful for tightening and loosening nuts. It can function in tight locations where a wrench cannot, and it is faster than a wrench.

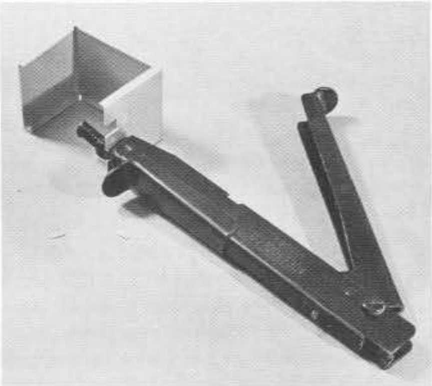
Soldering irons: Two types of soldering irons are useful for R/C modelers. The more frequently used is the soldering pencil. Commonly rated at 25 to 30 watts, the soldering pencil is best for soldering small items, such as electrical components. The tip of the soldering pencil is replaceable; several styles of tips are available. The type of soldering pencil with a female tip (it is hollow and it threads onto the heating element) generally lasts longer and is less likely to seize onto the shaft of the iron.

A 75- or 100-watt soldering gun or soldering iron is preferable for heavier soldering jobs. The soldering gun reaches operating temperature quickly, but the slower-heating soldering iron with its larger tip has a greater heat-transfer area and a greater heat capacity than the soldering gun.

The type of solder is as important as the tool itself. Resin-core solder is mandatory for soldering electronic equipment and wiring. Never, *never* use acid-core solder on electronic gear. (The acid will destroy the wiring.) A spool of 60/40 resin-core solder can be used for soldering wire, brass, and other light metal. Soldering music wire (piano wire) calls for acid-core solder.

The specialist occasionally may need to make solder joints that require more strength than tin-lead solder provides or that need more heat than a soldering iron can give. A small propane torch such as a Bernzomatic provides a large amount of heat at a temperature high enough to melt silver solder.

Wire strippers: The hazard in using a knife to strip insulation from wire is that the wire will be nicked, leading to fractures in the wire. A wire stripper is a cutting tool with a wire-size notch in the cutting edge so the insulation is cut but not the wire. Cheaper wire strippers are adjustable to various wire



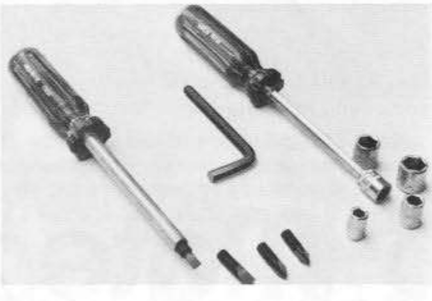
A nibbling tool is useful for cutting away light sheet metal.

sizes; the more expensive ones have several notches corresponding to the different wire sizes. The wire stripper is by far the best tool for stripping insulation from wire.

Sanding tools: Commercial sanding blocks can be purchased in hobby shops and paint and hardware stores. Some secure the sandpaper with a clamp; others, with a wedge. A flat sanding block is a far better sandpaper holder than the human hand and does a better job of sanding a flat surface. Specially shaped sanding tools can sand curved and angled surfaces.

Power sanders: A simple vibrator sander is sufficient for most modeling purposes. An electric vibrating device inside the tool causes the sanding surface to oscillate. Such a tool is not expensive, and it saves a lot of manual labor.

Pins: Pins play such an important part in modelbuilding that they can be considered tools. Pins come in a surprising variety of shapes and sizes. The handiest for modelers are steel pins, which can be picked up with a magnet and which are stronger than brass. T-shaped banker's pins and other paper pins are easier to work with than small-headed common pins.



Nut drivers can be obtained with interchangeable heads and screwdriver blades. The L-shaped tool is an allen wrench.

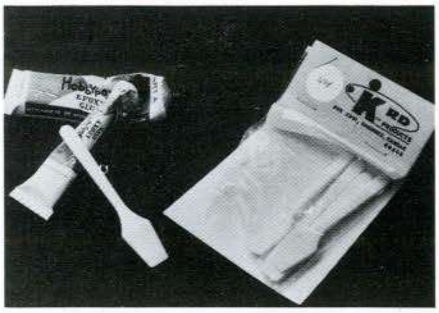
Jigs: A building jig permits rapid, accurate assembly of models. It is relatively expensive, but it permits an entire wing to be assembled, joined at the center, and covered while all the parts are held in proper alignment.

Multipurpose tools: The Dremel Moto-Shop is basically a jigsaw with attachments for sanding, wire-brushing, and grinding plus a flexible drive tool with collet chucks.

Other tools: A sharp-pointed awl can be used to start holes for drills in wood, and a center punch performs the same function in metal. Glue guns can reach into otherwise inaccessible places and speed up work because the glue flows at the push of a plunger. Tweezers are handy for all kinds of work with small parts. Reamers are useful for enlarging holes. Tap and die sets are important in metalwork. Wood screws cut their own threads in wood, but in metal a self-tapping screw requires so much force that the torque on the screw can sometimes shear the screw off or loosen the part being threaded.

How many tools? Models can be built with only razor blades, a couple of screwdrivers, and pliers (the universal wrench). Specialized tools, though, make the work easier and the finished product better. By themselves they don't turn a modeler into a craftsman, but they can aid him in becoming one.

No one adhesive is good for everything, but the multitude of adhesives available provides something for every combination of materials you will encounter.



Plastic spatulas (top) and cheap disposable brushes (middle) are ideal for mixing and applying epoxy. There is no way to clean epoxy from a brush. (Above) Epoxy makes an excellent coating for the inside of an engine compartment.

3 Materials

IN RECENT YEARS both the plastics industry and the aerospace industry have developed new materials and adhesives. The hobby industry has been quick to adopt these new materials. In the past, model airplanes usually were built of balsa wood and celluloid cement, covered with tissue paper, and painted with dope. Now a similar model can also involve the use of white glue, epoxy resins, silicone rubber adhesive, and heat-adhesive plastic sheeting. These are all special materials, each having its own best application. In the discussions that follow, the special purposes and potential problems of each are covered.

Balsa is a lightweight, tropical wood. It is soft, and it is easy to work with. It varies greatly in strength and density, so it must be selected carefully, with an eye to its use in the model. Some sheet balsa, for example, bends readily along the grain; other sheet balsa resists bending and splits instead. For curved parts, such as a leading-edge covering or a rounded pilot house of a boat, the more pliable balsa is preferable. Bending, incidentally, is aided by briefly soaking the wood in hot water.

On the other hand, balsa used for ribs and other structural members must be stiff and hard. Trailing-edge sheeting must be hard enough to resist bending and bowing. Where weight is not a factor and strength is, select harder, stiffer wood.

Thin balsa strips can be cut to width with a single-edge razor blade or a knife. Because it is difficult to make knife cuts that are true in pieces thicker than ¼", use a fine-toothed saw to cut thicker pieces. Use a straightedge to guide the cutting tool, and make several light cuts rather than one heavy cut. For structural shapes, cut the piece slightly oversize and sand it to the correct size.

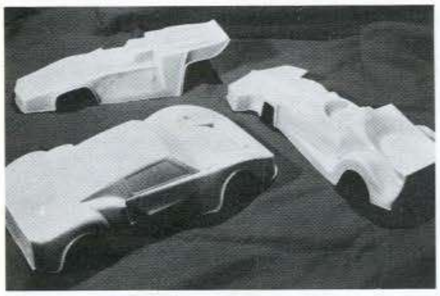
When you work with balsa, protect it from damage. It is easily dented by bumps of dried glue on the bench surface, by a watchband, or even by a shirt button. Always clear the work area and sand the bench surface lightly. Place the piece of balsa on a protective cloth or a foam-rubber pad, especially if the outside of the block has already been shaped.

When you select sheets and strips of balsa, check along the edge for bowing. Balsa can sometimes acquire a slight bend during storage. Sheet balsa pieces to be butt-joined should be chosen for straight edges which fit together evenly. Uneven edges make difficult the construction of fuselage sides and boat hulls.

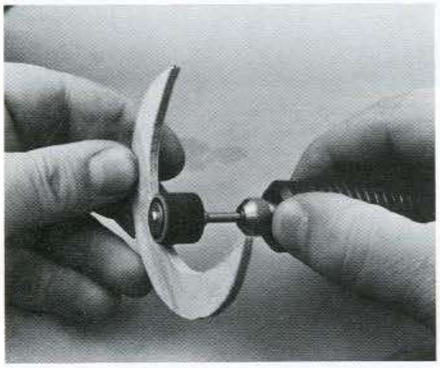
To true up such wood, trim it with a sharp knife, using a steel rule for a guide. Use C-clamps, if necessary, to hold the wood and the guide in position at the edge of the workbench. If the wood is clamped flat on the bench with the portions to be removed hanging over the edge, the excess material can be removed easily with long strokes of a sanding tool.

In constructing such items as fuselage sides from sheets of wood, work so that the surface of the balsa that is next to the workbench becomes the outside surface of the model. This method reduces the amount of sanding needed.

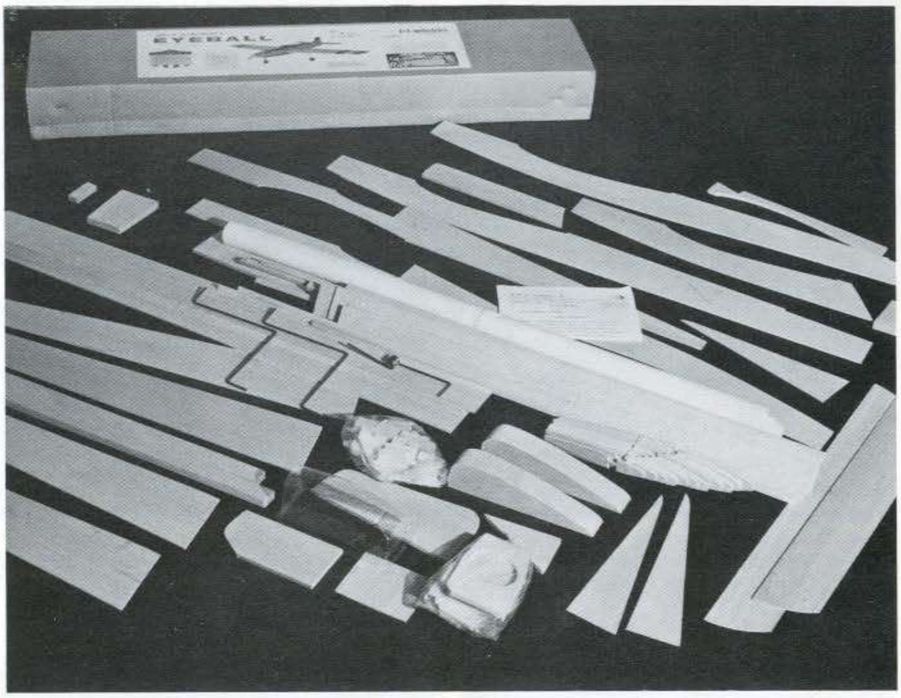
Balsa requires careful sanding. It is such a soft wood that mistakes can happen quickly. A sanding tool with a large surface avoids localized pressure, while sanding with small pieces of paper held in the fingers creates depressions and grooves from fingertip pressure. In addition to commercial sanding tools, yo



The vacuum-forming process is well-suited to making plastic car bodies (above) and airplane parts.



Plywood is often used in airplane models for structural parts. This piece, a fuselage nose ring, is made of five-ply ⅛" plywood.



It's hard to believe that an airplane that actually flies can be built from the typical balsa kit. The only non-wood parts in this kit are the heavy wire landing gear and the clear plastic canopy for the cockpit. Covering material may be paper-, cloth-, or plastic-based.

can use tools made from pieces of plywood, shaped blocks, and dowels with sandpaper contact-cemented to them. Thin strips, such as trailing-edge pieces, should be sanded alternately on both sides, not fully sanded on one side first, to avoid bowing due to compression of the fibers.

If you have a circular saw, you might consider buying balsa planks of specified hardness for cutting into sheets, strips, and blocks of convenient dimensions. Use a fine-toothed blade designed for a soft wood.

Plywood is used for highly stressed parts such as firewalls, engine-mounting bulkheads, nose doublers, landing-gear mount, car chassis, and boat bulkheads. Normal thicknesses are 1/16", 3/32", 1/8", 3/16", and 1/4". Aircraft-grade plywood is preferred because of the quality of the wood, the bonding, and the number of laminations. Cheaper grades are pithy inside and coarse-grained, and they tend to splinter when sawed. Birch plywood and mahogany veneer are commonly used in modeling for reinforcing large balsa areas, rather like doublers, in built-up vehicle and boat superstructures. Large pieces of balsa, plywood, and veneer are best joined with contact cement. Hobby shops carry small pieces of plywood; the larger sizes of plywood and veneer are lumberyard items. When you purchase such material from lumberyard, specify furniture-grade plywood.

Other woods: In non-flying models the weight of hardwood is not an objection. Basswood, for example, has a close, even grain suitable for carving. Maple makes strong motor mounts and engine bearers. Pine is used in aircraft for servo bearers. Laminated pine is good for boat hulls and other types of bodies which are carved to shape. Spruce makes excellent spars for large airplanes. Many of these woods are available at hobby shops.

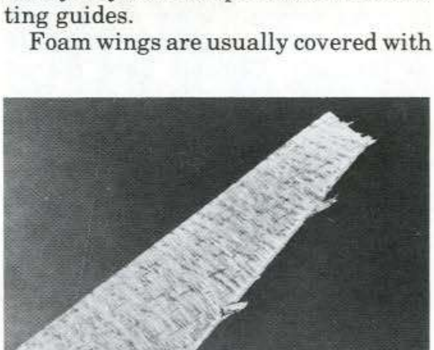
Foamed plastics are being used more and more, both commercially for fuselages, hulls, and even complete models and for original work by modelers who cut shapes from blocks of foamed plastic with a hot-wire tool. The hot-wire tool consists of a length of Nichrome resistance wire stretched between two ends of a bow. Electricity passing through the wire creates heat; a rheostat regulates the amount of electricity. Plywood templates serve as cutting guides.

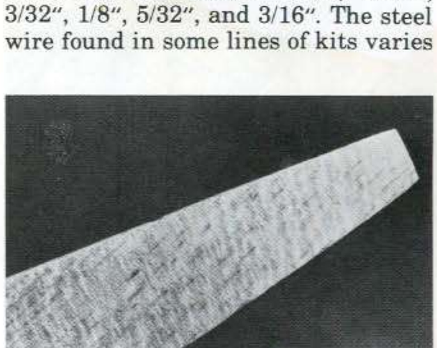
Foam wings are usually covered with thin sheet balsa, plywood, or plastic applied with white glue or a contact cement that is compatible with the plastic. Polystyrene and polyurethane foams are the most commonly used plastics. The latter is the denser and stronger of the two and can be used for moderately large powered airplanes without any need for covering.

Vacuum-formed plastics: A number of commercial models are made by the vacuum-forming process. Similar models are made using polyethylene plastics and rotational molding techniques.

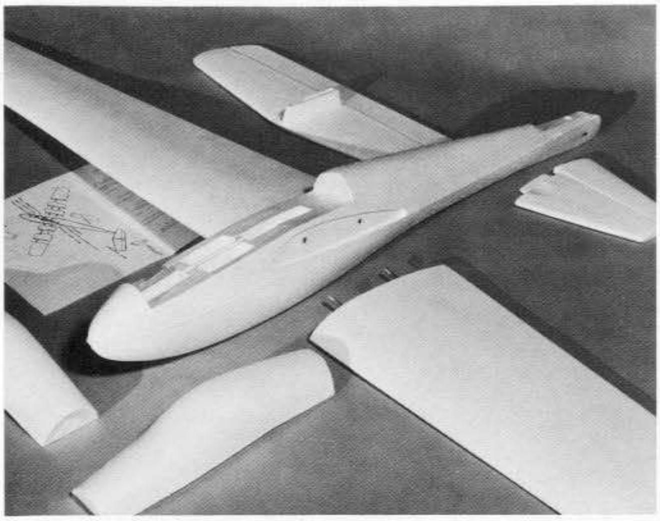
Hardware: Hobby shops carry a large stock of parts and accessories. Whether you are a novice or an old hand, take a look through the parts racks at the hobby shop to see what items can make modeling easier.

Steel wire (also called music wire and piano wire) commonly comes in fractional-inch sizes: 1/32", 1/16", 3/32", 1/8", 5/32", and 3/16". The steel wire found in some lines of kits varies

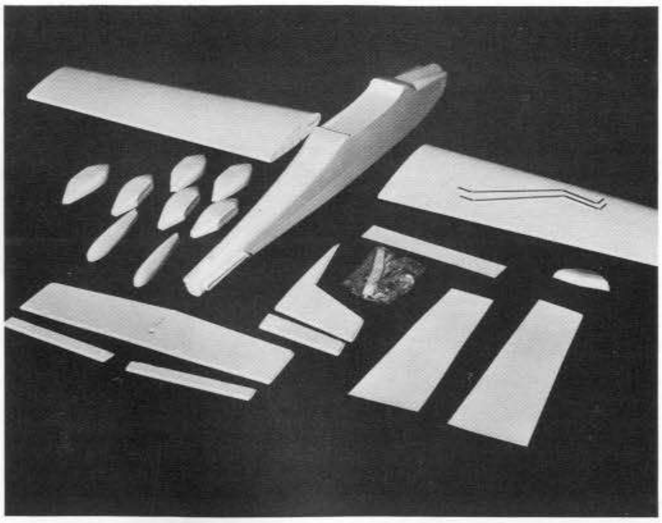




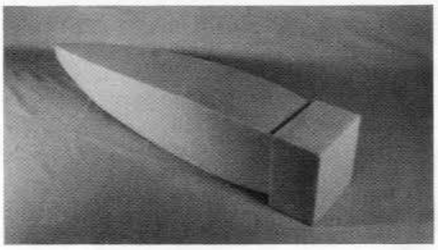
Die-cut balsa parts have "whiskers" (above left) which must be carefully sanded off, leaving a smooth edge (above right).

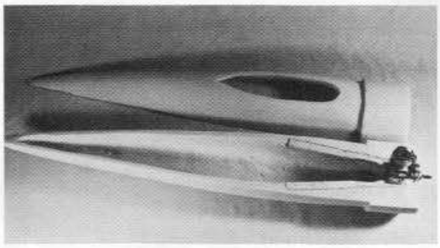


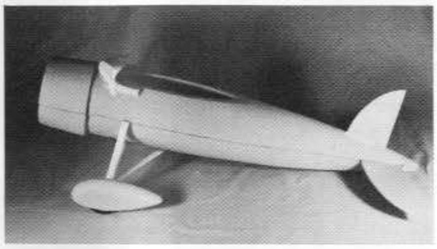
Planes molded completely of polystyrene foam are quickly assembled but are somewhat heavier than planes built from traditional materials such as balsa.



Vacuum-molded ABS plastic makes up most of the structure of the Dee-Bee Cardinal. The wings consist of a foam core covered with a skin of thin plastic.







Polyurethane foam can be used for scratchbuilding models. First the basic shape is blocked out with a saw (above left); then the fuselage is shaped and hollowed (above center); later details are added to the basic body (above right).

in hardness and bending characteristics. You may want to replace such wire with better-quality wire from the hobby shop.

Roundnose pliers can be used to bend small sizes of wire, but thicker pieces must be clamped in a sturdy vise and bent with a hammer. Hard-to-bend parts, such as shock-absorbing nosewheel struts, require a special bending jig. Thin steel wire can be cut with diagonal cutters, but larger sizes should be filed or ground part way through and broken off.

Steel wire is easily soldered. The protective film of oil on the wire must be wiped off and the surface of the wire brightened with fine sandpaper or steel wool. The portion to be soldered should be rubbed with soldering paste and then tinned (melt a bit of solder on it). A hot soldering iron is a must. A 35-watt ¼" chisel-tip soldering pencil is adequate for wire up to ⅛" in diameter; heavier wire requires a larger soldering tool. A joint that will be subjected to heavy stresses, as in a landing gear, should be wrapped with thin wire and then soldered, with solder flowed into the crevices between the wires. The joint can be filed smooth after it has cooled.

Occasionally a washer must be soldered onto a wire to retain a part such as a wheel. Spacing may be required between the part and the washer, or the part may need protection from the heat of the soldering iron. From scrap balsa make a temporary spacer with a hole or a slot in it to fit over the wire. Hold the work so the part and the spacer rest evenly and apply the solder. Remove the spacer when the joint has cooled. If you solder near a bearing, place a drop of oil on the shaft at the bearing to avoid any possibility of solder or flux flowing into the bearing.

Adhesives

Celluloid cements: Years ago modelbuilders dissolved celluloid in acetone to make model cement. Nowadays celluloid cements come in as many grades as gasoline and are formulated as precisely. Cements have characteristics that determine their use. Drying rate—regular, fast, or extra-fast—is one. Compared with most other adhesives, celluloid cements are fast-drying, but those labeled extra-fast are more suitable for quick field repairs than for original construction. Some cements may soften or destroy certain brands of paint or dope.

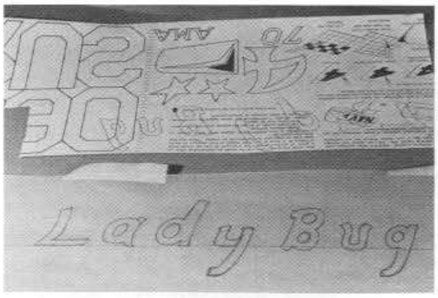
Fuel-proof cements are necessary for motor mounts and engine compartments. Hot-fuel-proof adhesives and finishes do not deteriorate from contact with exhaust gases. Whether fuel-proof or not, though, these materials should not be subjected to prolonged exposure to raw glow fuel. When fuel is spilled, wipe it up immediately.

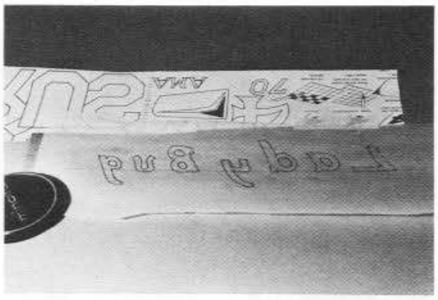
Butyrate cements and dopes are fuel-resistant. Nitrate dopes are impervious to gasoline-oil mixtures and can be protected from glow fuel with a coating of a high-quality fuel-proofer.

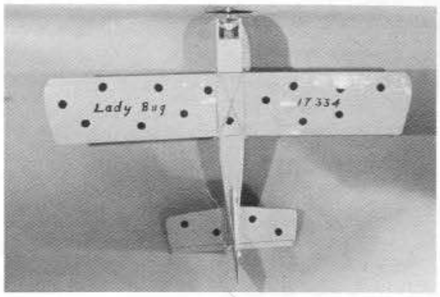
Cement comes in many types and sizes of containers—tubes, bottles, cans; quarts, pints, and smaller sizes. If you purchase a pint or a quart of cement, also buy a can of thinner to replace the solvent that evaporates each time the container of cement is opened. Glue guns and squeeze bottles make the work easier where joints are numerous or inaccessible.

All critical joints made with celluloid cement should be double-glued. Coat both surfaces with cement, allow them to nearly dry, apply more cement, and bring them together under pressure. Thin cement soaks into porous material quickly, resulting in a poor joint if only one application of cement is used.

White glue: More specifically called polyvinyl-resin glue, white glue such as Elmer's Glue-All is water-soluble and slow to set but strong, hard, and colorless when dry. It is best used for hardwood and plywood where strength is required. If you use white glue for laminating sheets of balsa, do not skimp on the pins, clamps, and weights







We named one of our planes Lady Bug and wanted to make our own trim letters. (Above left) We drew the letters on tracing vellum, then reversed the paper (above center) and transferred the lettering to the back of a sheet of Monokote. We cut the letters out and put them in place (above right). Almost any design can be made with adhesive coverings.

that hold the laminations in place while the glue dries. Otherwise the moisture in the glue will cause the balsa to warp. Wipe off any excess glue that oozes from the joints, because when the glue dries it will be difficult to sand smooth.

Epoxy cements are very strong, adhere to almost anything, and are almost completely impervious to chemicals once cured or set. Epoxies come in two parts, resin and hardener, which are mixed as needed to form the cement. Once mixed, the material begins to set, hardening or curing completely in anywhere from 5 minutes to 24 hours, depending on the type of epoxy used. In general, the shorter the curing time, the more brittle the cured adhesive. Epoxies have the advantage of curing through chemical reaction rather than through evaporation of a solvent. Therefore they can be used in sealed areas where neither white glue nor celluloid cement would dry. Epoxies do not penetrate porous materials as well as other adhesives, and they do not hold well on polyethylene or other flexible plastics. For the most part, though, epoxies have enormous gripping power on most materials. The joined parts are virtually welded into a single unit.

The procedure for using epoxy cement is a little different from that for using other adhesives. First squeeze the recommended proportions of resin and hardener onto a clean mixing surface, such as a sheet of paper. Use only as much as needed, because the excess cannot be stored, saved, or put back in the tube. It simply cures and hardens there on the mixing surface. Mix the resin and the hardener with a disposable wood stick or a flexible plastic spatula. Apply the mixture to the surfaces to be joined (which must be clean; metal should be roughened slightly with emery paper). Hold the parts together firmly while the epoxy hardens, because it has no strength until it is cured. If you are using 24-hour epoxy, clamps are handier than fingers. As you work avoid getting epoxy on your fingers, from which it will likely wind up on the model. Epoxy can (and should) be washed off hands and other washable items with soap and water before it hardens fully. Curing of the slower epoxies can be hastened by heat, as from a heat lamp. Be sure that the parts being joined will not be affected by the heat. Epoxy is particularly good as an adhesive for motor mounts and as a coating for engine compartments and other areas where fuel and oils are present. Apply the epoxy coating with an expendable brush.

Polyester resin has been used primarily as an adhesive to hold fiberglass cloth in place on boat models. This use has largely been abandoned because of the brittleness and weight of the resin. The material has more recently been used as a filler and base coat for balsa. Because of its brittleness, resin provides little strength, and must be supplemented with a covering material such as light fiberglass.

Warning: The solvents used in polyester resins are quite toxic and can cause permanent damage to your nervous system. Never use them in a closed room. Good ventilation is required during both the application and the hardening processes.

Covering Materials

Covering materials can include Japanese tissue, Silkspan, silk, and nylon, as well as fiberglass, plastic wrap, and even aluminum foil.

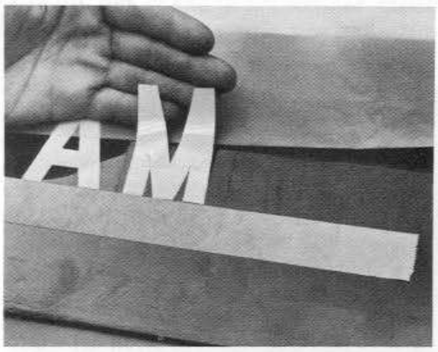
Japanese tissue can be used in single layers on small planes with .01- to .02-size engines. On larger planes two layers can be applied, with their paper grains at right angles. Tissue is applied dry. Dope is used to fasten it to the perimeter of the airframe. The tissue is then sprayed with water, which causes it to shrink tight. Three or four coats of clear dope are applied to seal it.

Silkspan is much tougher and somewhat heavier than tissue. It comes in light and heavy weights, sometimes designated as rubber-model and gas-model grades. Its texture is like that of a tea bag. Silkspan does not tear readily when wet, so it can be applied to the frame either dry or wet. To use it wet, fold the material and dip it into a shallow pan of water. Remove it, set it on a towel for a moment to blot up excess water, and lay the paper over the frame, unfolding it and pulling out any wrinkles. Silkspan is a good choice for covering small planes.

Silk comes in various weights, thicknesses, colors, and variations in quality. Very light silk can be used on any plane with a wingspan up to about 54". Heavier silk is better for larger craft. Silk is also used to seal and strengthen balsa surfaces, such as airplane fuselages and boat hulls.

Silk is punctured easily, even by weeds and twigs, but it is more durable than Silkspan. Some silk has a close weave, requiring less dope to fill; open-weave silk requires more dope and also has a tendency to pull apart when stretched over framework. Avoid silk that has been sized—chemically treated for other purposes. Such silk feels stiff and is more difficult to work with than better grades of silk. The sizing tends to rub off wet or doped silk, and it makes wrinkles and folds more difficult to smooth out.

Like paper and wood, silk has a grain. It tears more easily along the grain than across it. For covering models, silk should be applied with the grain running along the longer dimension of the part—wing tip to wing tip, nose to tail. Silk can be applied wet or dry and can be stretched in any direction around compound curves without wrinkling. It stretches more easily



To apply Mylar numerals and letters, use a piece of masking tape as a guideline. Place a piece of non-stick paper between the letter and the surface to which the letter is to be attached. Slide the paper out of the way little by little as you stick the letter down. Then remove the masking tape.

when wet than when dry. If the silk should wrinkle during preliminary stretching, it can be pulled tighter after first lifting the doped edges by applying a bit more dope to soften the previously applied dope.

Surfaces to be covered with wet material, whether tissue, Silkspan, or silk, should be given a preliminary coat of dope or sanding sealer for protection against the water.

To trim silk neatly, dope the material ¼" or so beyond the frame edge. When it is dry, cut it with a single-edge razor blade. Undoped silk tends to snag when cut.

Nylon is stronger than silk and is available in various weights. It is not an organic material but rather a plastic. It requires more doping than silk to fill the pores. Nylon dries faster than silk, so wet-covering work must be done more quickly. However, nylon can be rewetted as necessary. Nylon is virtually puncture-proof and is well suited to use on larger planes and boats. Although it is heavier than silk and not quite as easy to apply, nylon is not troublesome to work with.

Fiber mixtures such as Silron combine the desirable characteristics of silk and the strength and lower cost of rayon.

Fiberglass cloth is available in a wide variety of weights and weaves. It cannot be used as a covering material over open areas, but it provides strength where it is applied to solidly backed structures. Fiberglass cloth is bonded to the structure with either epoxy or polyester resin to provide great strength, excellent durability, a smooth base for paint, and almost complete imperviousness.

Fiberglass can assume almost any shape over compound curvatures and lends itself well to construction of complete structures such as cowlings, wheel pants, fuselages, and boat hulls. It is possible to mold small parts, not over 6 inches in any dimension, at home. First construct a smooth male mold for the part and cover it with plastic wrap. Then build up layers of light fiberglass cloth and bond them in place with epoxy. The fiberglass and the epoxy are held in place with plastic wrap stretched over the mold.

More advanced molding is done with matched male and female molds. Color and a smooth surface are obtained with a heavy gel coat of resin that contains the color and sometimes metal-flake finishes. The techniques are within the capabilities of a well-equipped home workshop and an experienced modeler.

You can make molds from wood, plaster, or, to duplicate an existing part, silicone rubber. Molds permit easy repetition when several parts must be made. Flanges, mounting blocks, runners, and the like can be epoxied to the

1 Sand all surfaces smooth using No. 100, 200, 320, and 400 dry sandpaper.

2 Apply base coat of resin, lay on cloth, brush resin up through the cloth. Be sure to get all the wrinkles out. After the resin sets, sand smooth without damaging cloth.

3 After trimming, apply a second heavier coat of thinned resin. Sand smooth with No. 400 then No. 600 wet-or-dry paper used wet.

4 Now spray on color, rub to a sheen, and wax, as with lacquers, enamels, and epoxies.

Note: resin or epoxy alone can be used without any covering material. However, the finished model will soon develop cracks and splits along the grain of the wood.

PAINTING, USING FIBERGLASS AND RESIN

basic fiberglass shell so constructed. The area to be epoxied must be free of dirt, dust, and oil, and it should be roughened slightly for good bonding. Other than epoxy, only silicone-rubber adhesives and hot-melt glue adhere to fiberglass shells.

Heat-shrinkable coverings: A number of different covering materials are available. The range of types includes plastic and fabric, adhesive and non-adhesive (and the adhesive types include heat-adhesive and sticky materials), and many different weights and colors. The one characteristic these materials have in common is that they shrink when heat is applied. Thus a smooth, taut covering can be achieved with a heat gun or even with a common household iron.

The plastic materials are excellent for covering framework and open areas, but they are difficult to handle over large sheeted surfaces because air can be trapped underneath, forming a bubble. Such coverings are durable, and they take far less time to apply than any other. One caution: Do not dope any wood that will be covered with a heat-shrinkable material. The heat will cause the dope to blister.

Finishes

Finishes used to be limited to dope. Now the choice includes lacquers, epoxy paints, and synthetic varnishes; plastic covering materials can eliminate completely any need for finishing.

Dope is an excellent finish. It is cheap, and it is easy to apply. Most model dope is of the butyrate type, although nitrate dope, which is less readily available and not fuel-proof, is sometimes used. Nitrate and butyrate dopes are incompatible with each other, and often different brands of the same type of dope are incompatible. Use the same brand of dope throughout a project.

The two weaknesses of dope are shrinking and blushing. Some shrinking is desired to pull covering material smooth and taut, but dope continues to shrink with time. A plasticizer, such as castor oil (3 or 4 drops added to an ounce of dope) can reduce the tendency to shrink. (To create a sheen, add 1 or 2 drops of oil of wintergreen to an ounce of color dope.) Blushing, a whitish discoloration, is the result of moisture from the air being trapped as the dope dries. Blushing is a problem only when the humidity is above 50 per cent or so. Adding a retarder to the dope (up to 10 per cent) slows the drying process and permits moisture to escape.

The number of coats of dope applied depends on the material and finish desired. Where weight is a factor, two or three sealer coats of clear dope suffice on tissue, three or four on Silkspan, and four to six on silk and nylon. The covering material must be well sealed to prevent pinholes in the finish coat of colored dope over wood areas. If the covering material is dyed silk, clear dope alone can be used, thus avoiding the extra weight of the coat of colored dope. Clear dope, though, does not provide as much protection from sun and weather as does colored dope, and an annual coat or two of clear dope may be necessary for models that are old or that have been exposed to a great deal of sunlight.

Dope can be brushed or sprayed. It is available in regular cans and bottles and in spray cans. Spray cans are fine for small models, but for covering large areas, dope in spray cans becomes costly. Inexpensive spray guns can be purchased in hobby shops, paint stores, and hardware stores.

You can purchase dope at hobby shops in hobby-size quantities, but if you build many models or large ones, the aircraft parts supplier at your local airport may be a more economical source. Aircraft dope is much more heavily pigmented than model dope and requires a plasticizer for model use because it shrinks more than model dope.

In ordinary use, two or three coats of dope should be adequate, although some builders may use as many as 12 coats on scale aircraft and boats, sanding between coats and rubbing and waxing the final coat. For spraying, colored dope should be thinned as directed on the can or bottle. For brushing colored dope, add about 10 per cent thinner. Because of the weight buildup, do not spray dope onto any covering that has not been filled with dope, resin, or some other filler.

Occasionally dope will attack the cement in a joint, creating a fillet. The cement can be sealed, once it is thoroughly dry, by brushing epoxy over it, by dry-brushing with dope (brush out most of the dope in the brush onto a scrap surface and paint the model with the remainder in the brush), or by applying many coats of thinned dope, allowing each coat to dry thoroughly.

Good brushes are essential, because dope tends to pull the bristles out of ordinary brushes. Ox-hair brushes have bristles pliable enough to withstand constant use without shedding. Brushes must be cleaned immediately after each use, using dope thinner.

Epoxy paints produce a strong, shiny surface. They are available in hobby shops. Some can be used over any surface or filler; others require compatible base materials. Check the label before you buy. Complete hardening of the paint takes up to 24 hours; some brands dry dust-free in as little as 1 hour. The brands that dry dust-free quickly are to be preferred; otherwise you may produce a shiny, durable surface with the texture of No. 400 sandpaper. Stick to the same brand of epoxy paint, hardener, thinner, and primer for a given job.

Automotive lacquers and enamels produce the most beautiful and professional finishes if carefully used. They have dense pigmentation and cover rapidly, usually with one or two sprayed coats (their advantages are lost if these finishes are brushed). They may be applied over any of the normally used surfaces. They dry dust-free quickly, can be resprayed after only a short interval, take a shine by the use of a retarder in the final coat, and are reasonably light and inexpensive.

Lacquer can be hand-rubbed to a high luster, but glow fuel will attack it, particularly if the lacquer has not been permitted to harden for at least a week. In addition, a plasticizer must be used to prevent cracking. Enamel is fuelproof, but it cannot be hand-rubbed unless a hardener is used. Both lacquer and enamel require well-filled surfaces.

Sealers, fillers, and primers have been mentioned several times already. They are the items most often neglected and the most necessary for a good finish. Sealing means coating the surface with a material that prevents successive applications of paint from sinking into the surface. The most commonly used sealer is dope; epoxy and polyester resin can be used at some cost in weight.

Even after a surface is sealed, it has minute depressions, the result of wood grain or fabric weave. It is a good idea to fill these voids completely before applying finish coats. The simplest surface filler is a homemade mixture of talcum powder and dope mixed to a creamy consistency, about 1 part talcum to 5 parts dope. This mixture can be brushed or rubbed on to fill surface pores, scratches, and small nicks and holes. After each application the surface is sanded with fine sandpaper until the high spots show through. The final coat is left unsanded, a glass-smooth opaque painting base. Commercial sanding sealers are used in the same way.

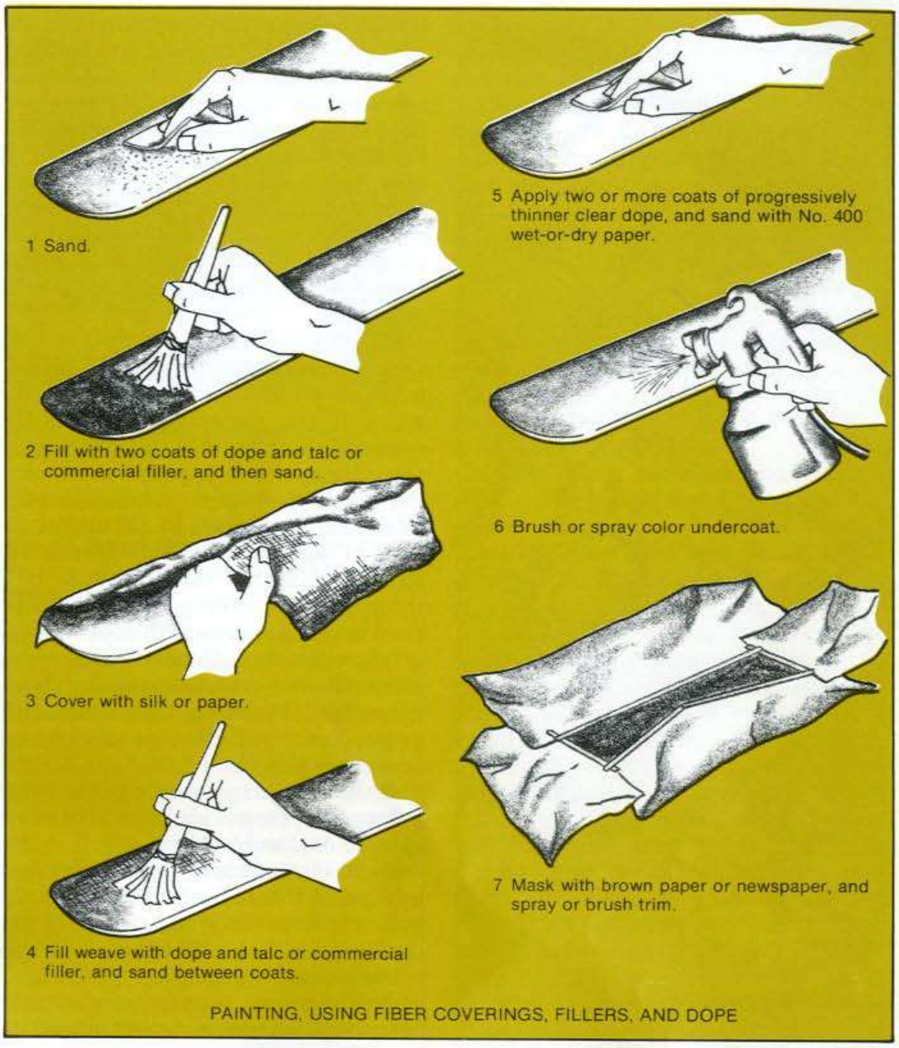
Filler can be applied over paper and silk, usually where those materials have been applied to wood, and to bare wood, such as fuselage sides and boat hulls. The filling of solid surfaces can be hastened by spraying on a coat of automotive primer after a few coats of light filler have been applied. The primer can be wet-sanded almost completely off using No. 200 to No. 400 wet-or-dry sandpaper. The resulting surface is professionally smooth.

The epoxy and polyester finishing processes do all the sealing and filling with about two coats. Again, wet-sanding is the key to an easier job.

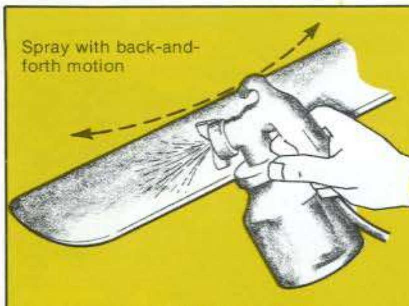
At least a quick, light coat of primer is desirable before applying the final coats of enamel, lacquer, or epoxy, to aid the finish coat in adhering to the surface. Sand the primer coat very lightly before the finish coat is applied, and clean the surface completely of dust with a damp cloth or a tack rag. Then clean the surface with a cleaner such as Prep-Sol to remove all oil, dirt, and fingerprints.

Gaps, cracks, and dents must be filled or the finish will not be complete. The job is best done with materials that are light and that do not crack as they harden. A number of products are available commercially: wood pastes, vinyl spackling compound, epoxies, plastic putty, and so on. Use a product which is compatible with both the base material and the finish.

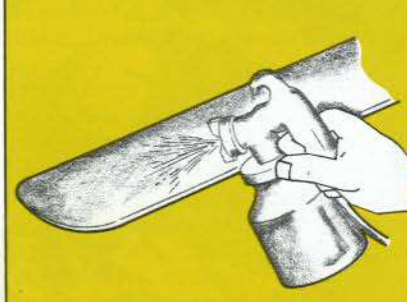
Finishing techniques: Obviously a model will fly with almost any finish that provides protection from fuel, heat, and light. A good finish, though, adds to the visual appeal of the model



PAINTING, USING FIBER COVERINGS, FILLERS, AND DOPE



1 Spray on light coat of primer, then sand back to filler with No. 400 wet-or-dry paper.



2 Spray covering coat of primer, and then sand smooth with No. 400, then No. 600 wet-or-dry paper used wet.

3 Clean surface with Prep-Sol or equivalent.

4 Spray on color.

5 If desired, mask and apply trim with spray gun. After lacquer (or enamel with hardener) sets for at least 1 hour, rub to a sheen with DuPont No. 7 white polish, and wax with carnauba wax. Epoxies require no rubbing.

PAINTING, USING LACQUERS, ENAMELS, AND EPOXIES

and to your pride in it. Finishing techniques depend on both the material of which the model is constructed and the finish. First some general notes on finishing:

● Red, yellow, white, and green are the most visible colors for a plane. The top and the bottom of the wing should be different colors, to help you tell when the plane is inverted during maneuvers and stunts. Black and red look alike, by the way, when viewed against a cloudy sky. If weight is a consideration, choose a dark color rather than white or yellow. It takes a larger quantity of the lighter colors to cover a given surface.

● Multicolor paint schemes are impressive, but for your first attempt keep the paint scheme as simple as possible. For multicolor paint schemes, mask for each color so that only one color is applied to each part of the plane. A considerable amount of extra weight can result from painting the entire plane one color and then masking for the trim color.

● The masking-tape contact area should be no wider than ¼". Use paper in conjunction with the tape for large areas. If you are using dope, seal the edges of the tape with a light coat of clear dope prior to application of color. For acrylic and epoxy paints, use polyester film tape (made by 3M and available at automotive paint stores) instead of masking tape. Because it is thinner than masking tape, there is no need to seal its edges with dope—which is incompatible with acrylic and epoxy paints. Remove masking tape by steadily pulling it back on itself at an acute angle. Never pull the tape straight up, and never jerk it.

● Wet-or-dry sandpaper lasts longer than garnet paper and therefore is more economical.

● Butyrate dope thinner—in fact, any paint thinner—is cheaper by the gallon. Check for it at your local aircraft repair service. The thinner is useful as a cleaning agent.

● The paint, thinner, primer, and retarder for a given project should all be of the same brand to ensure compatibility.

● All finishing should be done in a well-ventilated area, unless you enjoy headaches and nausea.

Plastic foam models can fly without any finish at all, but they appear much better when painted or covered. Painting and covering require different techniques right from the start.

If you plan to paint your model, sand it lightly with No. 400 sandpaper to remove any bumps. Be careful not to sand away any of the natural glossy surface of the plastic in the areas where you are not actually changing the contours of the surface. Removal of the glossy surface makes the foam much more absorbent to paint and varnish. The weight of the extra paint could be a problem with a small, light model. After sanding, you have a choice of several finishes. You can apply one or two light coats of polyurethane gloss varnish, using either a brush or a spray can. If you prefer dope, you must first paint the foam with a mixture of white glue and water to fill the pores and provide a smooth surface. Then paint over the white glue with color dope or spray enamel. Do not let the dope come into contact with any uncoated foam, or the foam may dissolve. A variation on the white-glue-and-dope method is to use white glue and water to apply Silkspan to the entire model and then finish the Silkspan with dope.

Acrylic paints (not to be confused with acrylic lacquers), which are available at art-supply stores, can be applied directly to plastic foam. Acrylics are thinned with water but dry waterproof. They adhere well and do not chip or flake. They can be used straight from the bottle for an opaque finish or thinned with water as a stain. Acrylics dry with a matte finish; polyurethane varnish can be applied to give a glossy finish.

Some spray enamels are suitable for use on foam. Read the label; if you are in doubt, test the paint on a scrap piece of foam or a foam cup. Enamels such as Sig Plastinamel work well if they are not applied too heavily. They dry slowly, so you must use them in a dust-free place. Several thin coats of enamel are better than one thick coat.

Instead of painting a foam plastic model, you can cover it with a self-adhesive plastic material such as Top Cote or Krome Cote. These coverings are lightweight and strong, actually adding strength to the model. Top Cote can be doped or painted, making it unnecessary to keep a stockpile of several colors on hand.

To use Top Cote, sand the foam very smooth (in contrast to the procedure for painting foam). Do a careful job and pay particular attention to obtaining a smooth, evenly rounded leading edge.

To cover a wing cut four sheets of Top Cote or similar material about an inch oversize all around for the top and the bottom of the left and right panels of the wing. Start at the bottom of one side of the wing. Peel off the backing material and apply the Top Cote to the wing, smoothing it lightly with the fingers. If wrinkles occur, lift the material off and reapply it. Make every attempt to smooth the covering with your fingers rather than with an iron. Use heat only for sealing the edges and for a mild shrinking action. Heat sufficient to fully shrink the covering material may melt the foam.

Curl the covering around the leading edge ¼" past the center line. Fold the material over the trailing edge and seal it with an iron. Use a low heat setting, as for rayon. Stretch the material and work it smooth over the wing tip. Seal it, trim the excess, and seal it again on all edges. Repeat the process for the bottom of the other wing and then do the top surfaces. A hair dryer can remove most of the wrinkles, and dope will finish the job.

A couple of sprayed coats of dope or one evenly brushed coat will produce a glossy finish with a weight increase of only a few grams. Krome Cote already is silver in color and needs no pa
Trim can be added with vinyl tape, decals, Trim Monokote, and

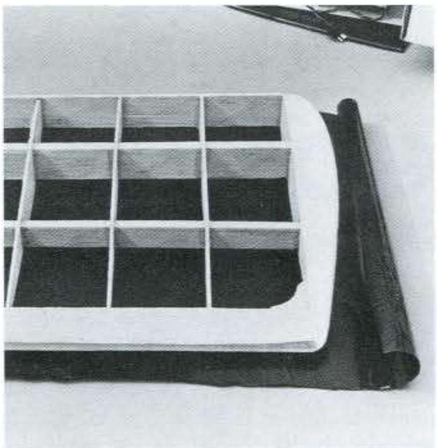
sheets. Trim sheets can be made by doping contrasting colors onto Top Cote and cutting it to shape for use as decals. Vinyl tape works particularly well on the leading edge of the wing, contributing to strength as well as appearance. Do not attempt to use a heat-adhesive or heat-shrinkable covering. The heat required will melt the foam.

Balsa models must be sanded completely with No. 180 sandpaper until the fuselage corners, control-surface edges, and wing tips are properly rounded, the nose is shaped, and all sheeting is smooth and free of gaps. Use vinyl spackling compound or wood filler to fill all the nicks, cracks, and dents. Sand the model as smooth as possible with No. 180 or No. 220 sandpaper. Brush on a heavy coat of dope or sanding sealer to bring up the grain of the wood for easy sanding. Sand again with No. 220 sandpaper until the model is smooth. Brush on a second coat of dope or sealer and sand with No. 400 sandpaper until the model is smooth and glossy. Repeat the process until the wood grain is completely filled.

Apply Silkspan, silk, Silron, or similar material to the framework, using thick, clear dope as the adhesive. Pull out all wrinkles while the material is wet. Stretch the material smooth at one end, dope along the edges, and then smooth and stretch the other end until the material is smooth but not tight. Work the dope through the covering to the wood with your fingers. As the dope dries it will pull the covering material tight. Cover the wing panels, doing first the bottom and then the top, and cover the stabilizer the same way. Always overlap the covering so no bare wood is visible. Cover the fuselage top, bottom, and sides, in that order, and then the control surfaces. Last, trim the edges of the parts with a new, sharp razor blade.

Brush three coats of clear dope thinned 50 per cent over all sheeted surfaces to bond the covering still tighter to the framework and to fill the grain of the covering. Achieving a good fill on open areas is a problem that can be overcome many different ways. One way is to brush thinned dope (2 parts dope, 1 part thinner) onto the area. If a bead or droplet appears, remove it with a tissue. Repeat the process using progressively thinner dope until every pore of the covering is filled. Silkspan and Silron usually seal with two coats; silk requires three or more.

Do not sand anything until the preceding sealing job is done. Let the sealer coats dry overnight. After this, the weave of the covering must be filled. Sand the covering very lightly with No. 400 or No. 600 sandpaper. Use great caution where ribs or edges touch the covering. Fill the weave of the covering by applying several more coats of thinned dope or a commercial sanding



The open egg-crate frame of the wing cannot develop lift, of course, and it must be covered. Among the most common covering materials nowadays are various types of plastic sheeting.

filler, such as those produced by Aerogloss and Sig. Sand lightly between coats and bring the surface to a smooth, glossy look.

Mask the model and apply the necessary coats of colored paint, wet-sanding between coats with No. 400 wet-or-dry paper. If you intend to rub the finish with rubbing compound, apply at least one additional final coat. Allow the paint to dry at least 24 hours before you apply masking tape over it.

After the color coats have dried at least several hours and preferably overnight, wet-sand the entire model with No. 600 wet-or-dry paper to remove the ridges caused by the masking tape. Set the model aside for at least 72 hours if you are going to rub the finish. Wait at least overnight before you fly the model even if you are not going to rub the finish. Raw fuel attacks incompletely cured finishes.

You can obtain a high-gloss finish by rubbing the entire surface with automotive rubbing compound such as Du Pont white rubbing compound. Use a dampened soft cloth dipped into the compound to rub out the finish. Cover a small area just as you would when polishing a car. Use moderate pressure and allow the compound time to work. Always polish in one direction, preferably from front to back. Polish lightly over ribs to avoid rubbing through the finish. A final rub with Brasso polish followed by a waxing gives a lasting luster.

Balsa models also can be covered with heat-adhesive plastic. The material offers the lightest finish, and it is available in a wide range of colors.

Plastic has a few drawbacks. It does not provide as much strength as a fabric covering. Compound curves, nooks, and crannies are hard to cover without wrinkling the material. Fuel travels under the plastic if its edges are left unsealed; a thin line of polyurethane varnish over the seam remedies this difficulty. It is difficult to cover large areas without trapping air bubbles; pricking the plastic with a pin as it is heated allows the air to escape.

To cover a balsa model with plastic, first sand the framework thoroughly with No. 180 wet-or-dry sandpaper. Fill all chinks, cracks, and splits. Do not apply dope to the framework; the dope will blister when heat is applied to attach the covering. Resand with progressively finer sandpaper up to No. 400. Carefully remove all sanding dust with a tack rag before covering the model. The dust prevents the plastic from adhering.

The tools you need are a razor blade, a pair of scissors, and an old electric iron or a heat gun such as that sold by Top Flite. Useful but not essential is a sealing iron, like those used for sealing plastic bags.

Because the covering can be peeled off and reused, you can practice working with the material right on the model itself. Start with a wing panel. Cut a piece of covering that is about 2" larger than the panel outline. Remove the backing, place the covering over the framework, and smooth it out as well as you can. Work around the panel with the iron and "tack" the material down every 3 or 4 inches, smoothing it and pulling out as many wrinkles as you can. It takes some practice. (You will have to determine the iron temperature yourself. Use as low a temperature as possible. An iron that is too hot will melt through the plastic. There will be some temporary discoloration as the iron is applied to the plastic.)

Work around the periphery of the frame and seal the covering down tight. Lap the excess material around the edges and seal it. Work carefully where there are compound curves, such as at the wing tip. Be patient—every wrinkle can be taken out. Trim the excess with a razor blade. Cover the other surface of the same panel. This time no excess need be cut. Cut just enough material to extend beyond the edges. Seal all the edges with the iron, and then run the iron close to the surface but not touching it, to shrink the material. Use a damp cloth or a glove to press the covering to the wood as you heat it to ensure adhesion. If you use a heat gun to shrink the material, proceed carefully and avoid using excessive heat. You can use lacquer thinner or dope thinner to remove any adhesive that oozes out.

Use sticky or wet adhesive film such as Monokote Trim to trim the model. Trim items and decorations are available as decals, dry transfers, and adhesive-backed plastic. They should be sealed around the edges with polyurethane varnish; decals and dry transfers should be protected completely with varnish.

4 Radio equipment

ONLY TWO radio-control systems are recommended—digital proportional control and pulse proportional control. More than 90 per cent of the R/C equipment purchased today is digital. There are numerous manufacturers of digital proportional sets; there is only one manufacturer of pulse proportional equipment, Ace Radio Control. The pulse system is noted for its simplicity and light weight. In addition to digital and pulse there are a number of systems that were used in the past. Even though secondhand equipment can be purchased, these systems are not recommended because service for the equipment is not readily available.

Except for small, light models or for use as a second system after the initial learning period, the pulse system is not recommended over digital systems. It offers just one proportional control, usually rudder. The digital set, on the other hand, can be obtained for control of up to eight functions.

Selection of a system for purchase can be an enjoyable process or a frustrating one, as can be the selection and purchase of any item which comes in a wide range of models. The typical modeler usually bases his choice on planned use, cost, advertisements (all of which are identically laudatory), reviews in magazines, and, most often, recommendations by other R/C modelers. Too much of the last can confuse rather than clarify.

A few general comments about commercial equipment are in order. Only a few years ago there were a number of different systems available. Most required the modeler to construct a wiring harness and integrate various components—receiver, servos, and batteries. Under such circumstances reliability was a problem. Reliability improved with the development of complete digital systems, which required only that the modeler install the equipment in the model.

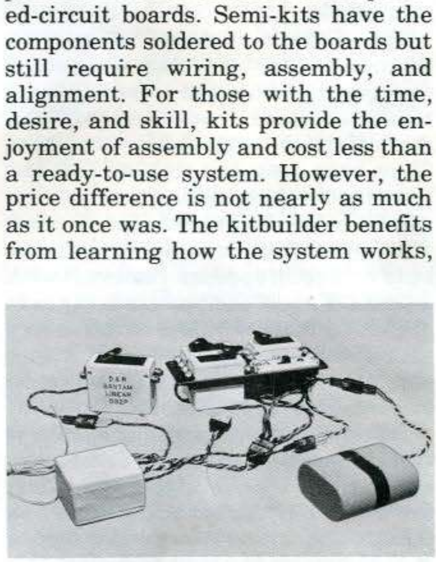
Every brand of R/C system manufactured today is virtually trouble-free and takes advantage of such advanced electronic devices as integrated circuits. Each system is warranted by the manufacturer, usually for 90 days. Service is available from the manufacturer—in some cases at regional repair centers. Further, the universal use of the digital concept permits these sets to be repaired by competent R/C technicians. This is not to say that any TV repairman can fix the set; the job requires a person who understands R/C systems. A modeler can purchase almost any set advertised in the model magazines with the assurance that the set will function as promised.

A visit to a local flying field may reveal that a large number of flyers use the equipment of one manufacturer, while at a different field the equipment of another manufacturer predominates. There are several reasons for this. The most common is that a certain brand is the one recommended by preceding flyers. Sets that have not performed well will have a poor reputation. The influence of a top flyer or a noted contest winner is often recognized at the local level.

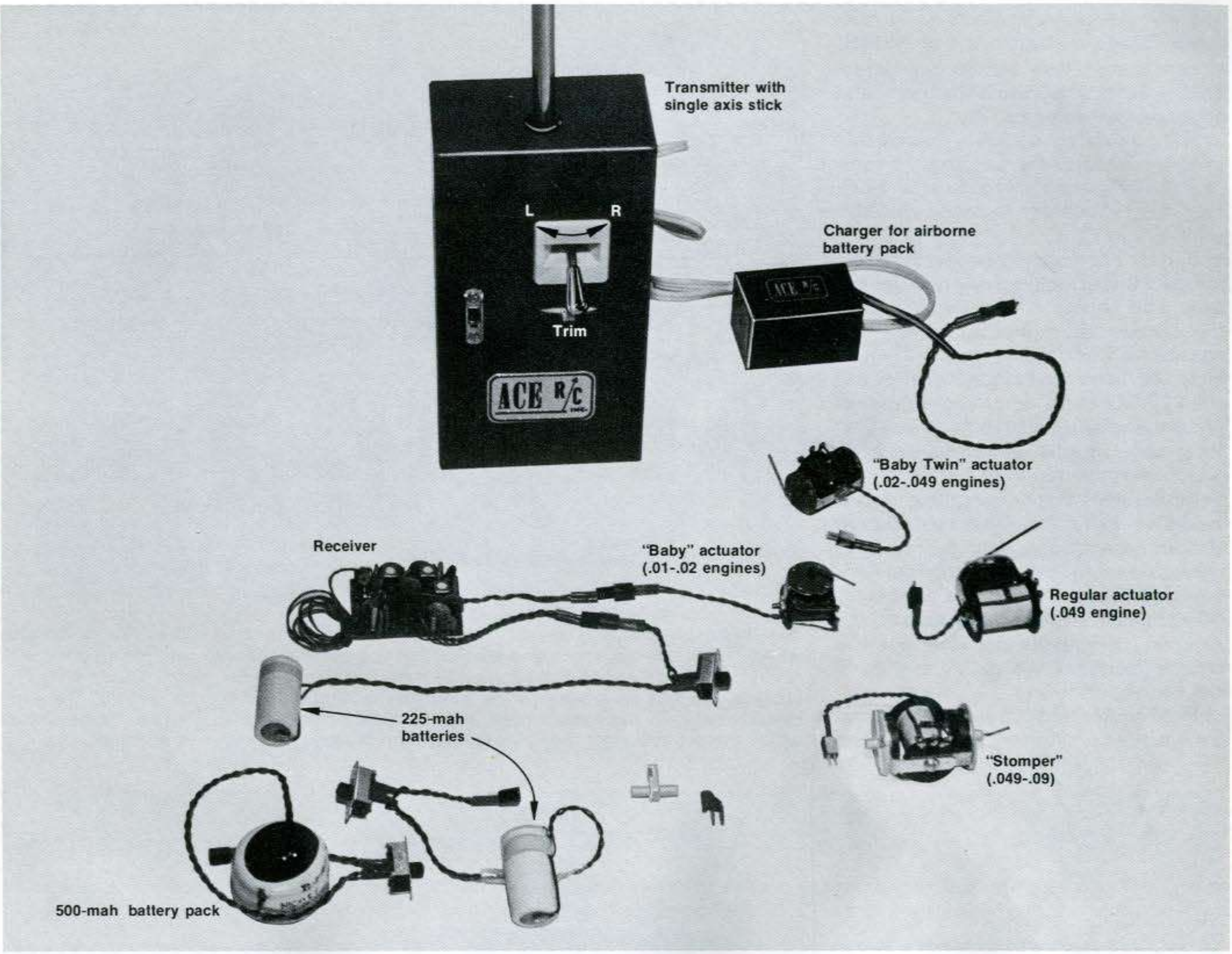
More important is the availability of service locally from a factory representative or a qualified R/C system service man. It is annoying and time-consuming to ship a set from one end of the country to the other for repairs.

You may elect to construct a radio system from a kit or a semi-kit. A full kit is one in which all parts of the system must be assembled and the components must be soldered to the printed-circuit boards. Semi-kits have the components soldered to the boards but still require wiring, assembly, and alignment. For those with the time, desire, and skill, kits provide the enjoyment of assembly and cost less than a ready-to-use system. However, the price difference is not nearly as much as it once was. The kitbuilder benefits from learning how the system works,

A typical R/C set includes transmitter (this one has two two-axis control sticks plus two small control wheels below the sticks), four servos, airborne battery pack, receiver, and off-on switch. This particular detachable, telescoping antenna has a screw base.



The airborne portion of a digital set designed by author Fred Marks illustrates the use of plastic labeling tape to mark the plug-and-socket connectors.



The Ace R/C pulse system offers actuators in a wide range of size and output power for airplanes of various types.

and he may learn how to service it himself. Kits for radio-control systems are currently available from Ace R/C, Heathkit, and Royal Electronics.

In conducting reviews of many sets for *American Aircraft Modeler* over the past few years one of the authors has found that most sets perform satisfactorily and that for the beginning R/C modeler no specific brand need be recommended over another. It is unwise to continually change brands on whim or with the idea that another brand performs a bit more precisely. Few flyers or car drivers can detect a 10 per cent difference in servo resolution.

System selection: For general use with model planes, boats, cars, helicopters, and most other models, your first set should be a four- to eight-channel digital set with four servos. You need not use all the servos at first. You can add them as you progress. If you know for certain that you are going to operate only a boat, a car, or a glider and will not need more than two channels, you can save money by buying a two-channel set. A new two-channel digital set can be purchased for about half the price of a new four- or five-channel set. Most complete R/C systems include everything needed for operation, such as batteries, battery charger, transmitter, receiver, and four servos. The advertised prices for systems having four or more channels are for a full system with four servos, no matter how many more channels the set may have. Servos for channels beyond four cost between $20 and $40, depending on whether they are in kit or ready-to-use form.

A four- or five-channel set permits the modeler to operate a car with two or three channels, a power boat with two channels, a sailboat with two or three channels, or an airplane with aileron, elevator, rudder, and throttle controls—called full-house control. Channels beyond four generally are used to control retractable landing gear, landing flaps, and special features.

You have a choice of three frequency bands: 27 megahertz (MHz), 50-54 MHz, and 72 MHz. These are also referred to as the 11-meter, 6-meter, and 4-meter bands, respectively. There are restrictions. All modelers may use the five 27-MHz citizen band channels. Only those holding a valid amateur

FREQUENCIES AND FLAG COLORS

MHz	Color
26.995	Brown
27.045	Red
27.095	Orange
27.145	Yellow
27.195	Green
53.1#	Black and brown
53.2#	Black and red
53.3#	Black and orange
53.4#	Black and yellow
53.5#	Black and green
72.080*	White and brown
72.160	White and blue
72.240*	White and red
72.320	White and violet
72.400*	White and orange
72.960	White and yellow
75.640*	White and green

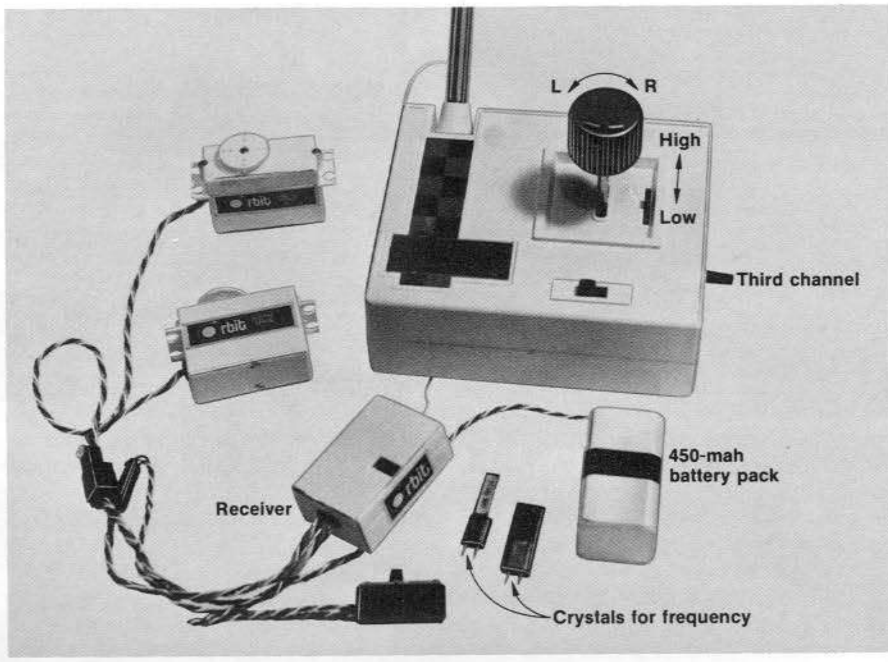
* These frequencies are for aircraft only.
# These frequencies require an amateur operator's license.
Frequencies in the 27-MHz band may be subject to interference from illegal citizen's band operations.

radio license may use the 50- to 54-MHz band. There are seven 72- to 76-MHz channels shared by airplane modelers and those who operate boats, cars, and other surface vehicles.

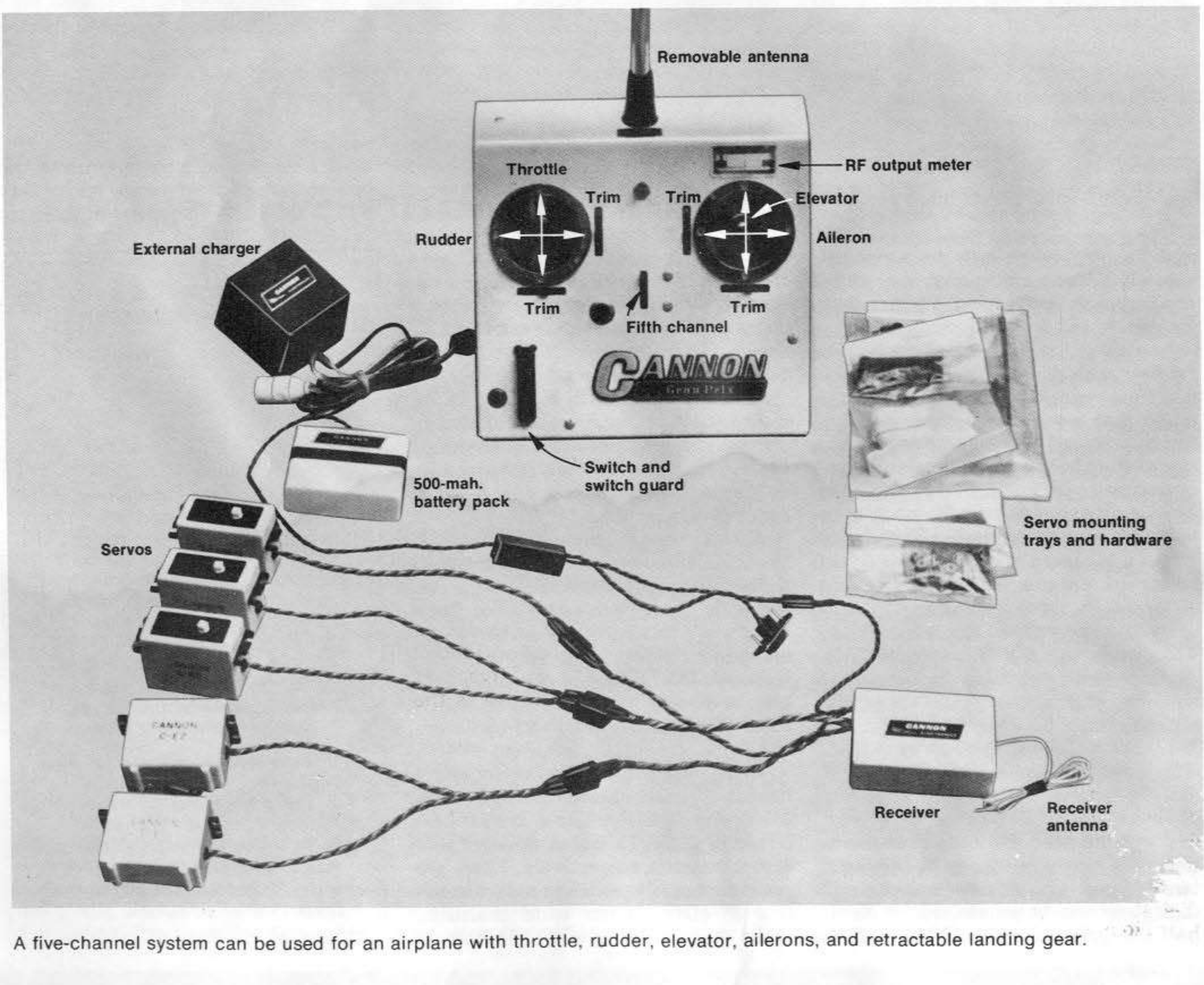
Many modelers attach a colored flag to their transmitter antenna to indicate the frequency they are using. Such flags are mandatory at many club flying fields.

If there are many flyers in your area, notice which frequencies are used the most and choose one of the less-used frequencies. In suburban areas the chance for interference on the 27-MHz band is greater, and many modelers use the 72-MHz band. A number of manufacturers offer a frequency-change feature and, in one instance, modules which permit changing bands at the field. Before flying or operating an R/C model, check for any other operators in the area—within 1 or 2 miles. Your operation might cause another person's model to crash or vice versa. Listen for other model airplanes; also turn on the receiver in your model (but not the transmitter) and watch for motion of the control surfaces.

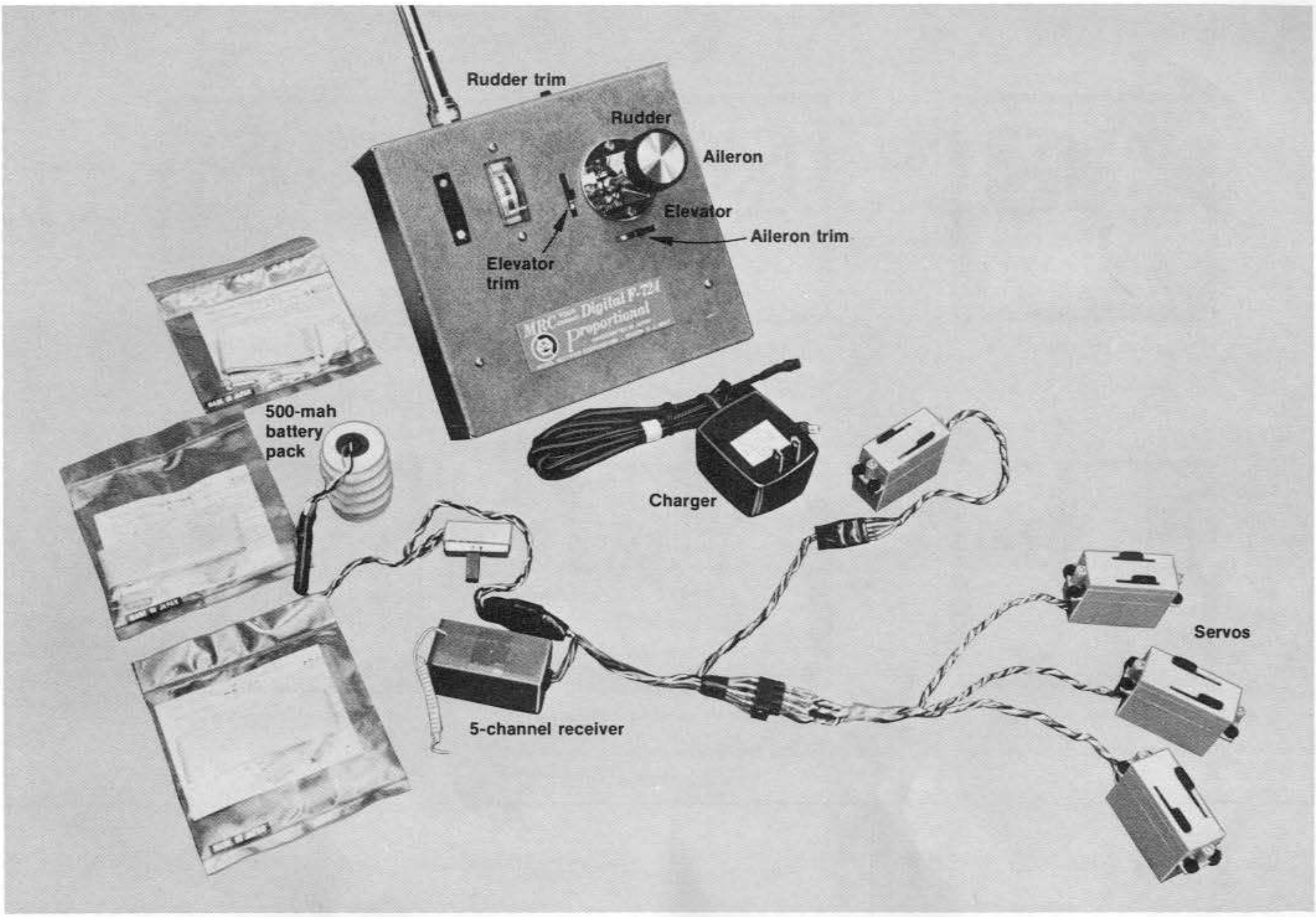
Used equipment can save you money. Two suggestions: First, don't buy from



This three-channel set is designed especially for cars. One channel controls the throttle with forward-and-back movement of the stick; a second channel controls steering with rotary motion of the knob at the top of the stick. The third channel, which could be used for shifting gears, is controlled by the lever on the right side of the transmitter. The extra crystals between the battery pack and the receiver are for changing the frequency on which the set operates; they permit operation on any frequency in one band.



A five-channel system can be used for an airplane with throttle, rudder, elevator, ailerons, and retractable landing gear.



A single stick can control elevator (forward and back), ailerons (left and right), and throttle (rotary motion of the knob).

someone you don't know unless a friend recommends a given set. Second, insist on an actual demonstration of the set in the chosen operation over several flights or runs. Don't accept a boat or car demonstration if the set is to be used in an airplane, because boats and cars require far less range. A used set can be put into like-new condition by the manufacturer. The reconditioning process may involve replacement of worn potentiometers, servo motors, and gears. It's best to get an estimate of the cost of reconditioning before you have the work undertaken.

Applications: Some applications need fewer than four channels. For a car, three channels suffice for throttle, steering, and shifting gears. Clutch and brake actions are usually automatic with throttle retardation via a centrifugal clutch. An engine-powered boat usually needs only two channels—for throttle and rudder—while an electrically powered boat may require only control of rudder, motor speed, and motor direction. A glider can be flown with a two-channel set for rudder and elevator only, although a more advanced model may use ailerons or spoilers in addition. A sailboat can be operated by two- or three-channel sets depending on the need for trim of a jib. A four-channel set can be used for these applications at an increase in cost over a two- or three-channel set.

Transmitter configurations: The most popular transmitter configuration for four or more channels is the two-stick type. It has two control sticks protruding from the face of the transmitter. The transmitter is usually held in both hands with the thumbs resting on top of the sticks. The sticks may be moved up or down and left or right, independently.

The two-stick Mode II configuration is recommended because of its popularity. If you ask an experienced modeler to help you check out a plane, chances are that he will be a Mode II flyer. Asking a Mode II flyer to check out and instruct on a Mode I set is like asking him to pat his stomach, rub his head, reverse every five cycles, and balance a pencil on his nose at the same time. If, however, you know a Mode I flyer who is willing to help you, Mode I is the better choice.

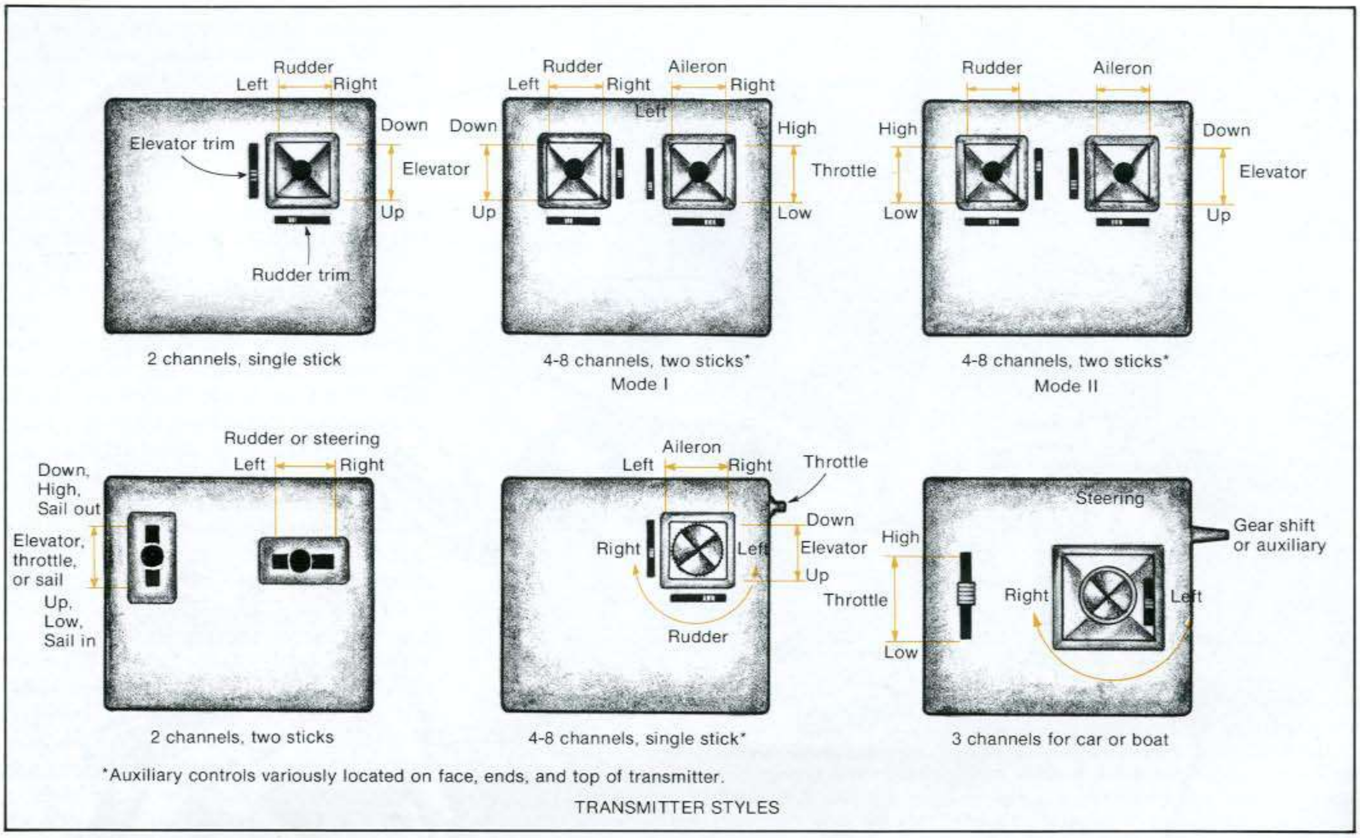
Mode II places the primary controls, elevator and aileron, under the dominant right thumb. (It is possible to modify a set for left-hand operation.) It is more difficult, though, to precisely control aileron and elevator when they are on the same stick. Perhaps the best basis for a choice between Mode I and Mode II is the popularity of one mode or the other in the area that you live in.

The third major configuration for a four-channel set is the single-stick type. Here rudder (for an airplane) is controlled by twisting a knob at the top of a two-axis stick. Thus pitch, roll, and yaw (nose up or down, wing tips up or down, and nose right or left, respectively) are all controlled by one hand. Choice of this configuration is simply a matter of personal preference. The single-stick transmitter is cradled in the left arm, and the fourth channel is controlled by a finger of the left hand.

Placement of trim and auxiliary channel levers varies among manufacturers. The two-stick sets almost always have the controls placed immediately adjacent to the stick assembly for ease of operation.

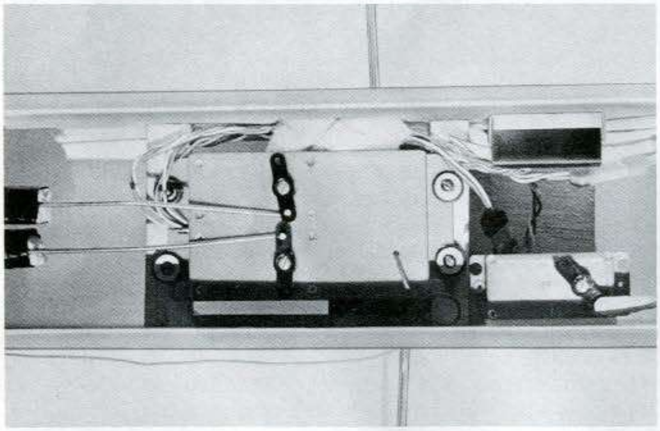
Special configurations: Boat and car modelers may prefer the use of a control wheel for steering and a lever for sail or throttle trim. Some car transmitters have a pistol-grip handle with a squeeze trigger for throttle control. Some sets provide separate single-axis sticks for throttle or sail trim and steering, with any third function on a separate lever. These special configurations are not recommended for control of planes.

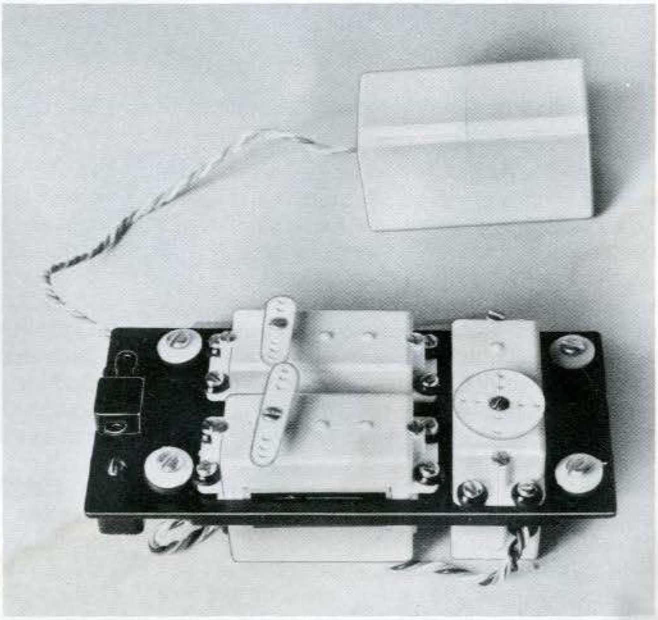
Receiver and servo configuration: There are few major variations in re-



*Auxiliary controls variously located on face, ends, and top of transmitter.

TRANSMITTER STYLES





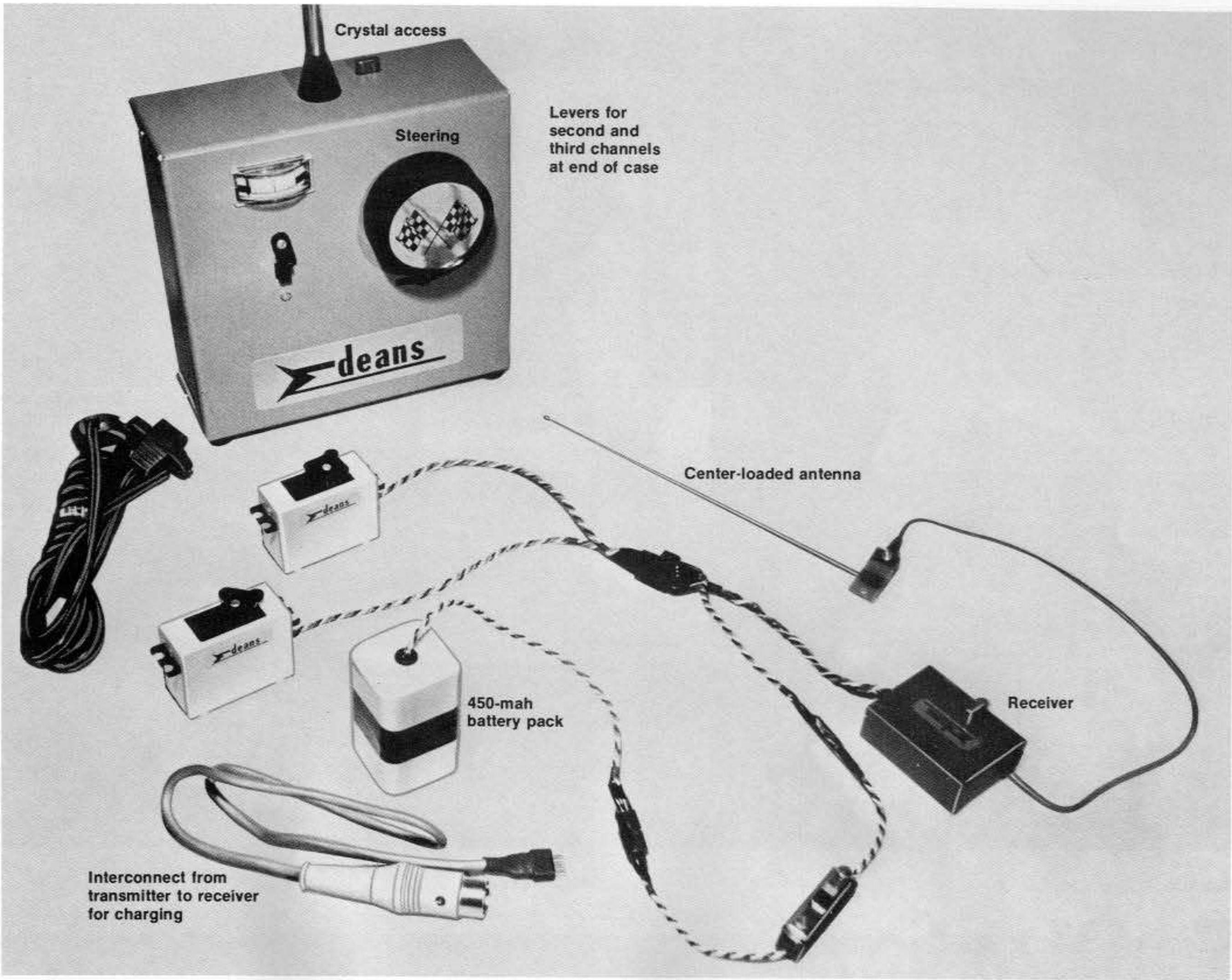
(Above) This brick-style system contains two servos and a receiver/decoder in the large central unit. A third, external (outside the brick) servo is connected to the brick with a plug-and-socket connector. (Right) A servo-mounting tray makes the task of installing servos easier. The rubber grommets isolate the servos from vibration from the engine. All three of the servos shown in this photograph are of the rotary output type.

ceiver configuration. Most receivers are a separate unit with connection to the servos and the battery pack through cables. The only major departure from this is the "brick" type set with the receiver and one or two servos mounted in a single plastic case. The brick has the advantage of ready installation and interchangeability between models, although servo mounting systems permit essentially the same flexibility. The drawback of the brick is that failure of any one component puts the entire system out of use for the repair period. The most common use of brick-type receivers is in gliders.

The other variation is in the wiring. Some sets use individual connectors and cables for each channel; others use one or more plug blocks sharing a common cable; and a third type places all connections at a master block-type connector mounted directly on the receiver board. All work well. The multiple plug blocks transmit less vibration to the receiver.

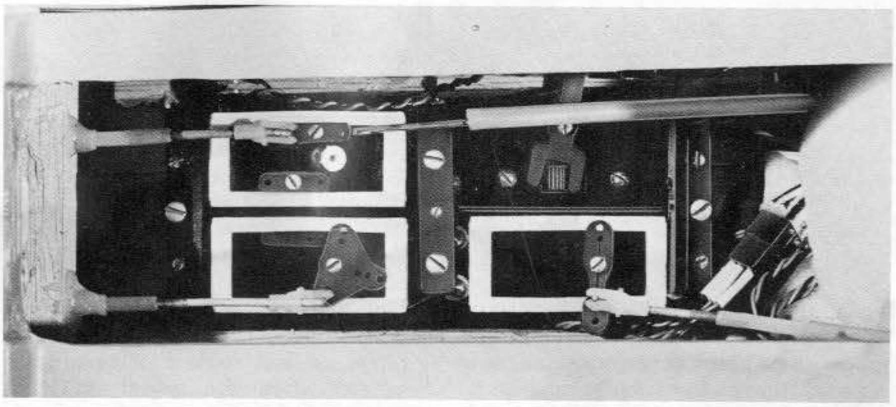
The battery pack used most often for powering the receiver and servos is a flat or rectangular one containing four 450- to 500-milliampere-hour (mah) nickel-cadmium cells. Variations from this include half-size (and half-weight) 225- to 250-mah cells, a heavy-duty 800-mah pack and a cylindrical pack made up of 500-mah button-style cells. All work well and can be selected for their shape. The only exception is that the small 200- to 250-mah packs should not be used to operate a receiver with more than two servos for anything but brief periods. Small battery packs lack capacity for long periods of heavy operation.

Servos come in a range of sizes, styles, and output configurations. Th



A large steering knob plus two levers on the side of the case control the three servos of this system designed for cars.

choice is largely a matter of individual preference. Some servos have only rotary output, others have only linear output, and yet others have both kinds of output at some sacrifice in size. Linear servos offer direct push-pull action with no side-to-side motion of the pushrods. Rotary-output servos are usually the smallest but their output is non-linear. The pushrod motion is sinusoidal, a function of the sine of the angle through which the output shaft turns. At 45 degrees of rotation, for example, only 70 per cent of the differential motion available at 0 degrees is applied to the pushrod. However, the output thrust is increased by the inverse amount, an advantage in moving heavy control loads at extreme deflection. Many modelers prefer the flexibility of dual-output servos, even though they are larger.

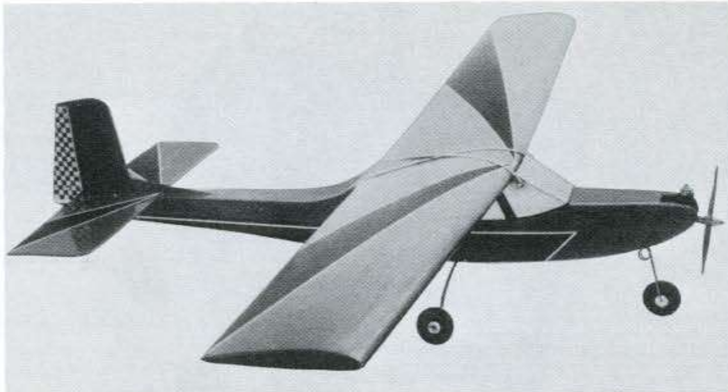


The upper servo in this photo is of the linear-output type; the other two produce rotary output. The output arm of the servo on the right has been trimmed to provide clearance for the keeper at the end of the pushrod. In addition, trimming makes the arm somewhat flexible, in case servo travel is more than the controlled device requires. This flexibility will prevent the servo from stalling, which could cause a high battery drain.

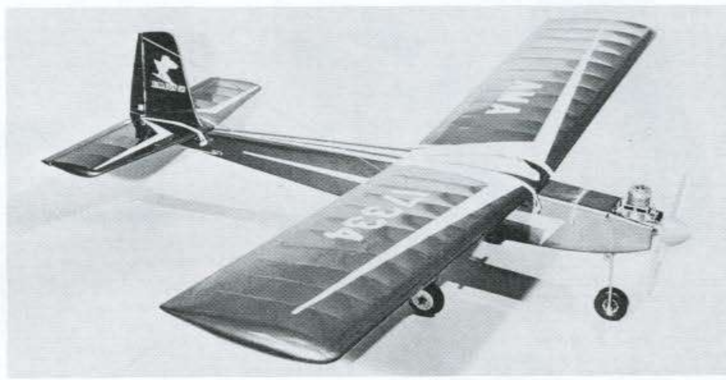
Accessories: Servo-mounting trays have largely become standard with manufactured systems, and they are the recommended mounting method. Their use is illustrated later for specific model installations.

Many sets have recently adopted the use of a flight-training or buddy-box configuration as standard circuitry. This arrangement permits an instructor to connect his transmitter to that of the trainee and assume control if necessary. Different brands of sets are not designed to interconnect in this manner; connection is possible only with the same brand and only if both sets are so equipped. This factor could well determine the final selection of a brand of equipment if a local club or flyer has a matching set and is willing to be an instructor.

2-T



Dick's Dream



Falcon 56

5 Airplanes

THE BEGINNER'S first quandary usually occurs in the hobby shop, where he is faced by what seems like hundreds of airplane kits. "Which one should I buy? How do I put it together? How do I make it fly?" he asks. This chapter describes a number of typical models—some simple, some complex, some in-between. They are arranged in a progression that a new modeler might follow as he gains experience and, in a sense, outgrows the simpler models.

Choosing a plane: Some R/C modelers live where experienced help is available from others; other beginners must go it alone. The approach for each is different. The ideal model for the lone wolf is one that is nearly indestructible, has a minimum of control functions, and can be repaired or replaced quickly and easily. Indestructibility is best achieved by a small model with low mass and a ½A engine—.049-cubic-inch displacement or less. Control simplicity means control of only the rudder or possibly rudder and elevator. Control simplicity also means fewer pushrods, easier construction, and less confusion when you learn to fly. The most important trait of a true beginner's model is its ability to fly with no control input. In other words, it should be a free-flight model which the controls only displace from free flight.

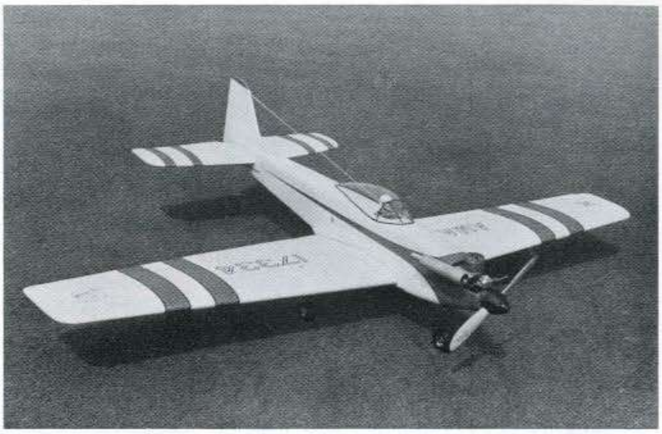
There is but one reason for these qualifications. A bugaboo for most beginners is that control of turning is reversed when the model is flying toward you. Flying away presents no problem—moving the control stick to the right gives a right turn. As you complete that first beautiful one-eighty, though, the situation reverses. Moving the control stick to your right moves the plane to your left. This can create some confusion for the novice flyer, who may not be able to recover both his senses and his control of the plane before the crunching noises occur. If the model is capable of free flight, the novice can take his hands off the controls long enough to remember that he must imagine himself sitting in the cockpit. Then, too, a simple, rugged model can survive a crash with only minor damage. As the novice's flying skill improves, he can progress to a more complex plane.

What of the modeler who has help from friends who are experienced R/C flyers? He can start a step or two farther along, with anything from a small multi-control model to a full-house .60-powered trainer. We recommend a .15- to .30-powered trainer, which will enable him to proceed on his own fairly quickly.

These recommendations are compatible with the advice in Chapter 4 that the beginner purchase a four-channel system. Only those controls that are needed are installed. In fact, a novice might want to use a plane for rudder and elevator control and then for rudder, elevator, and throttle control, simply adding throttle control when he is ready for it.

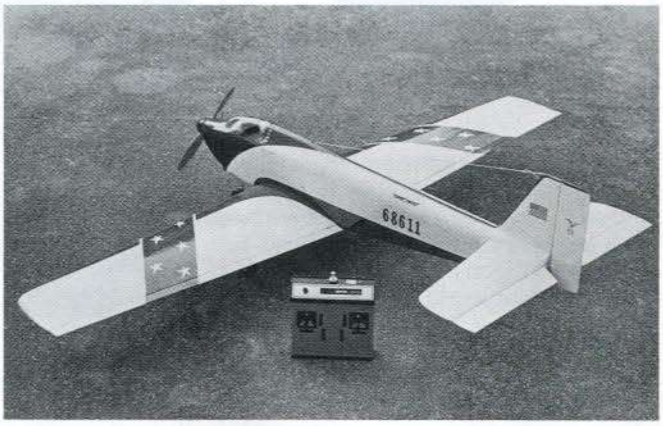
Eight models were chosen to

Ranger 42

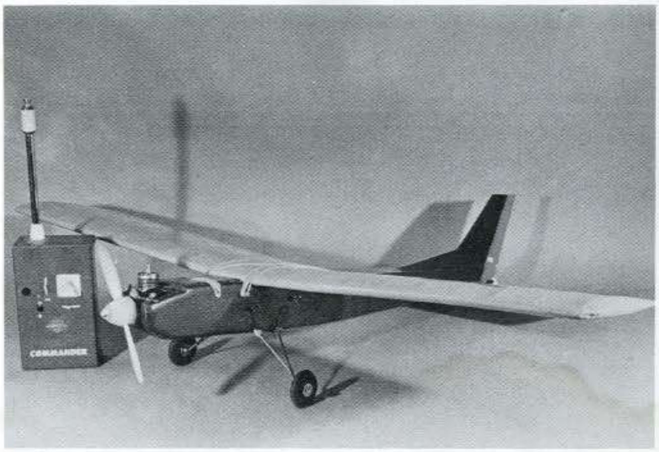


Tiger Tail

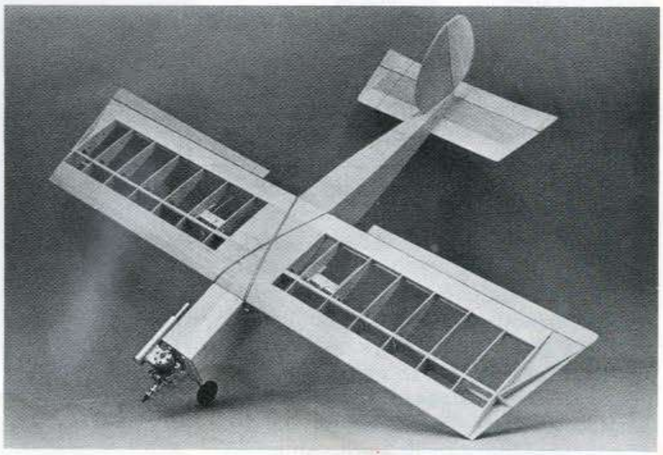
Skywagon



Komet



Flexible Flyer



Sweet Stik

sent a typical progression for an R/C modeler. Our choice of one model over another does not necessarily mean it is better or worse than another model. The choice was mostly a matter of convenience. Also, because manufacturers change and upgrade their products, a particular model may be discontinued, altered, or replaced.

The first model, a small plane called Dick's Dream, represents the class of small, simple, rugged models that can be flown with rudder control alone. It is powered by an .02 engine. The second is the 2-T, which is similar in construction but designed for controlled elevator and throttle. It is powered by an .049 engine.

The third model is the Ranger 42, a .10-powered model with controlled elevator, rudder, and throttle. This model is an example of molded-plastic-foam construction.

The fourth model, the Falcon 56, has probably been in existence longer than any other trainer model. It illustrates all-balsa built-up construction, power by an engine of .19- to .30-cubic-inch displacement, and control of at least rudder, elevator, and engine.

The fifth plane is the Sweet Stik, an advanced trainer or sport-flying model. It illustrates installation of aileron control.

The sixth model, the Skywagon, illustrates vacuum-formed plastic construction. It is an intermediate trainer designed for full-house control—rudder, elevator, ailerons, and throttle—and a .30 to .45 engine.

The Komet is in the class of sport and competition models. It illustrates construction which involves bonding balsa, cardboard, or plastic skins to molded or shaped foam-plastic cores. It also illustrates more advanced finishing methods and installation of full-house controls.

The eighth kit is an advanced model, the Tiger Tail, a .60-powered competition model with retractable landing gear.

In addition to the eight kit models, construction of a model designed by author Fred Marks is presented to show the techniques of building a model airplane from scratch.

It is not our intent to give a detailed description of the step-by-step construction of each model, but rather to illustrate the construction techniques involved and to show alternate installations. First, though, a few notes common to all the models.

The initial order of business for any model is to study the plans thoroughly until you understand every step of construction. You should be able to visualize everything that must be done. Next examine the kit and identify all the parts, so you won't, for example, cut fuselage bulkheads out of material intended for wing spars. Watch for pieces that may not match in weight and hardness. Leading-edge pieces, for example, should not be heavy and hard for one wing and soft and light for the other. Also note the assembly sequence.

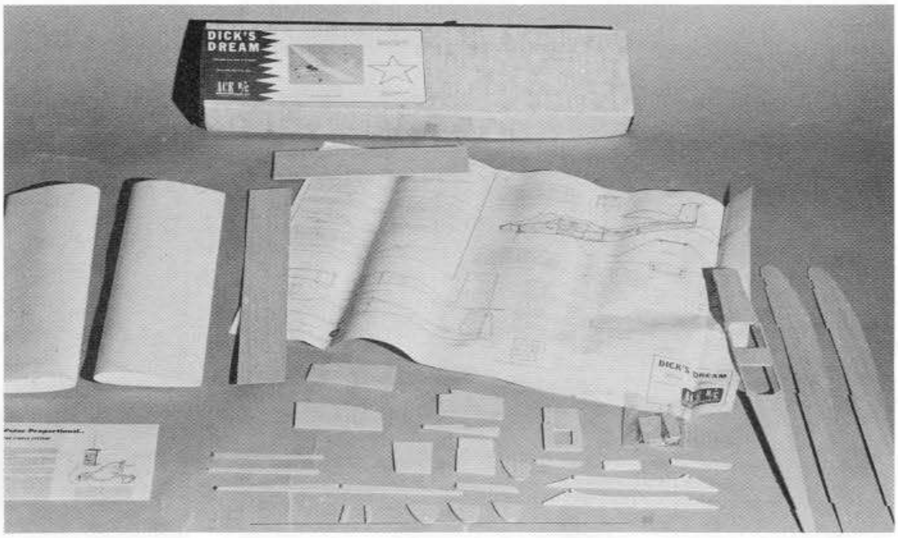
Dick's Dream

Dick's Dream is a tiny model designed to fly with an .01- or .02-cubic-inch engine such as those produced by L. M. Cox. The model is a good one for a beginner who works alone, or for the modeler who has limited flying space or a limited budget. It is almost impossible to damage if it is flown over moderately deep grass, such as a pasture. (However, very tall grass can conceal a model surprisingly well once it has landed.)

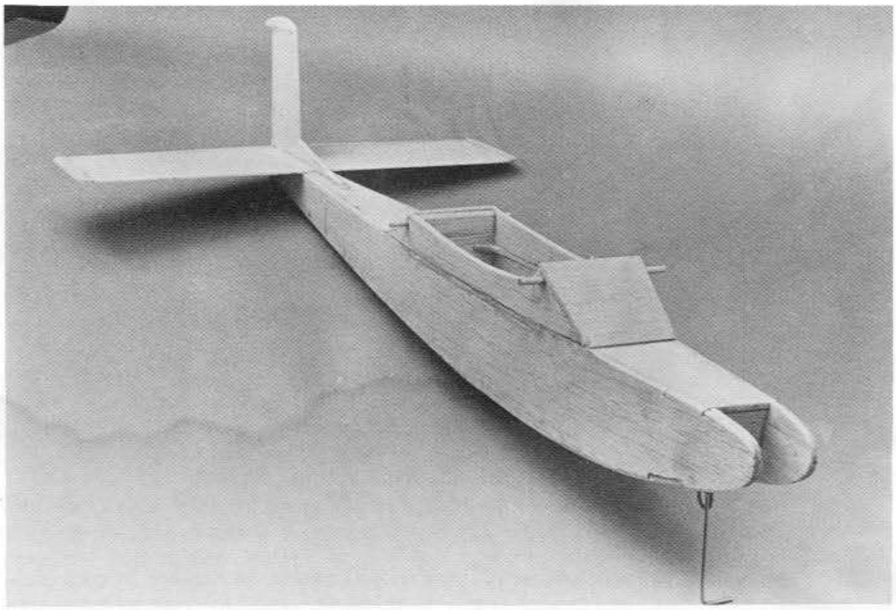
Dick's Dream consists of a set of molded polystyrene-foam wings, which have adequate strength without covering or reinforcement, and balsa and plywood parts for the fuselage and tail assembly. Note that both wing panels are exactly alike and that one must become a right wing and the other a left. The same warning applies to any model. There must be a right wing, a left wing, a right fuselage side, and so on.

Use a sanding block to remove any flash at the trailing edge of the wing panels. Avoid using too much pressure. Several light strokes work better. Carefully round off the leading edge of the wing. Unevenness here can affect flight performance, so don't hurry the job. Then cut the panels to the desired length with a fine-toothed saw such as a razor saw. Be sure the tips are square with the leading edge. Now cut the tips from top to bottom at a 45-degree angle. The angle helps the plane to turn more easily. A light sanding removes any roughness.

As it is difficult to judge small angles correctly, a block for sanding the dihedral angle is well worth the few minutes required to make it. The sanding block is made of wood and is designed to use the edge of the table for a guide. Block the tip up to the correct dihedral angle. Hold the wing panel firmly with



Dick's Dream is a fairly simple kit—balsa fuselage and foam wings. It's a good first plane.

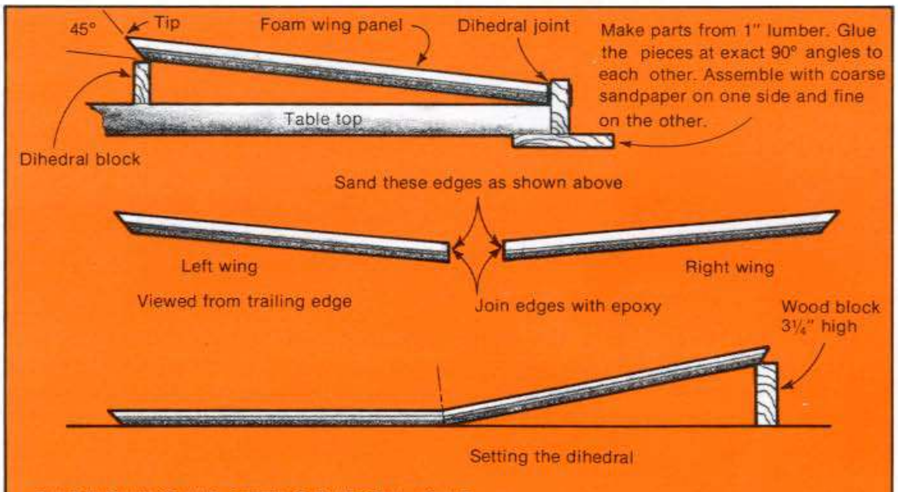


Rubber bands hook over the dowels protruding from the cabin to hold the wings on.

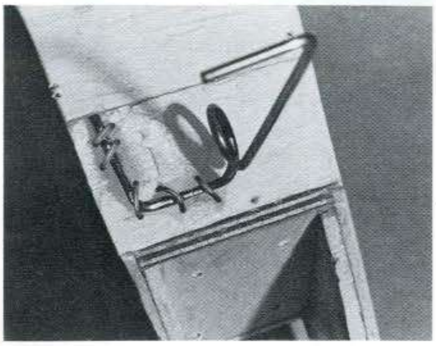
one hand, and with the other hand slide the sanding tool along the edge of the table. Start the work with coarse sandpaper, and finish with fine sandpaper. Take into account the thickness of the table top when you make the sanding tool, so the table edge will not be marred.

Check the wings for a tight fit where they are to be joined and punch several holes about ¼" deep into the ends of the wings with an ice pick or a nail to make a stronger glue joint. Join the wing halves with epoxy.

To keep the wing true while drying, place a weight on one half—the trailing edge must touch the bench—and use a block under the other tip for the correct

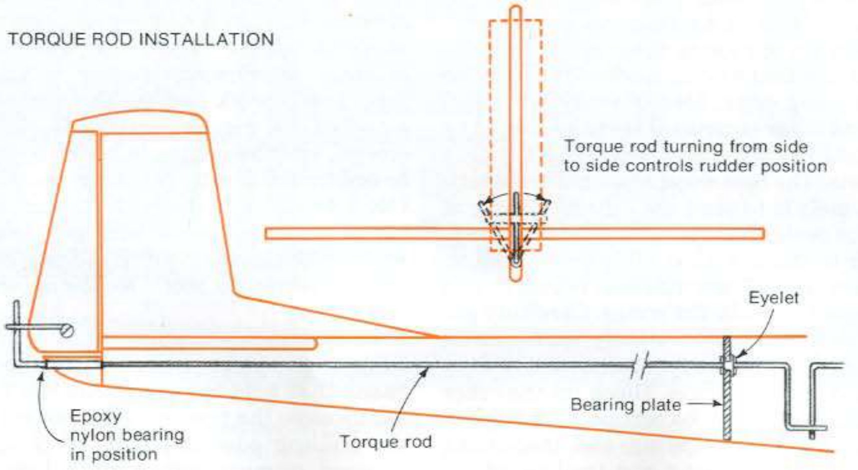


SANDING WING AND SETTING DIHEDRAL JOINT



Use thin wire or thread to lace the landing gear to the fuselage and then add a liberal dose of epoxy. J-bolts or clips are too big to use in small model airplanes.

TORQUE ROD INSTALLATION



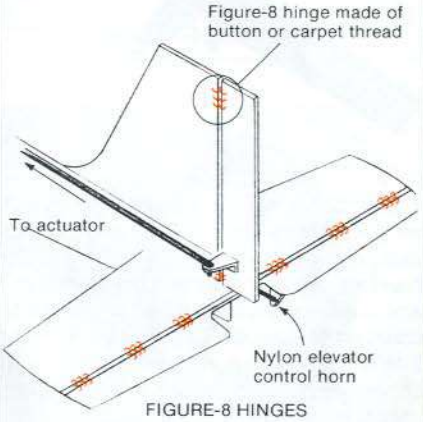
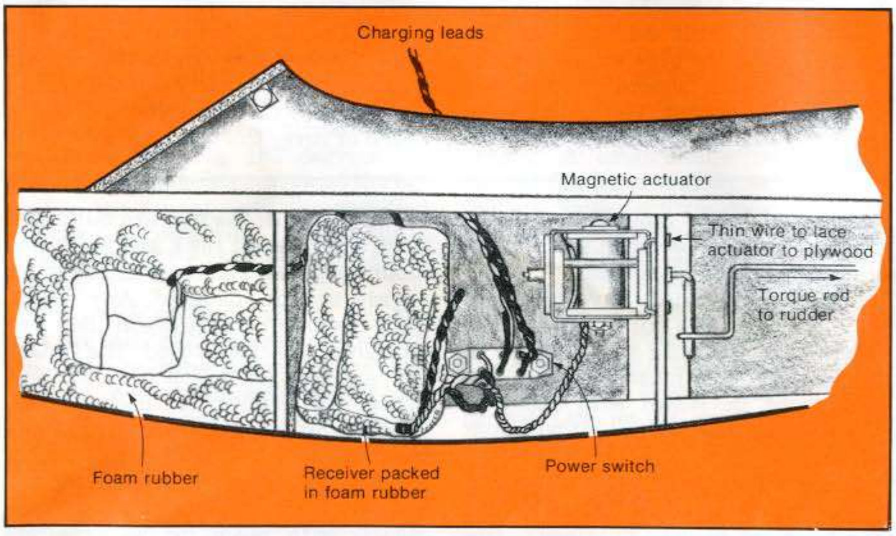


FIGURE-8 HINGES



total dihedral. Measure the distance from the trailing edge to the table. Let the epoxy cure thoroughly.

Follow the painting instructions that come with the model. Don't use any adhesive on the foam wings except epoxy or white glue. Celluloid cements will dissolve the foam and ruin the wings.

If you have some experience in building models, the most difficult task will be that of properly installing the radio equipment. The battery pack must sit in a pocket in the foam rubber as shown. The foam rubber is best installed before the fuselage bottom is put in place. The receiver must be wrapped in foam rubber at least ⅜" thick and placed with the bottom of the printed circuit board toward the forward bulkhead. Tie a knot in the receiver antenna 2½" from the receiver and then insert it through a 1/16" hole drilled in the side of the fuselage. Be sure to place large washers under the screw heads which hold the switch in place on the outside of the fuselage. Although not shown on the plans, wood rails were added to the bottom of the cabin to hold the actuator bulkhead more firmly. The actuator bulkhead is free to move up and down; restrain it by spot cementing at the top on each side. Don't glue the whole assembly in place because it is convenient to be able to remove the switch and slide everything out to use in another model.

The torque rod may be difficult to bend, particularly since this operation is not shown in the instructions. The actuator arm holds the front loop where it belongs, so carefully check the location for the bend at the tail with the arm engaging the torque rod. Then disengage the actuator arm and slip the torque rod back, so that the bend can be made to come out exactly at the rear of the nylon bearing when the actuator arm is engaged. Solder or crimp an eyelet to the pushrod where it will contact the nylon bearing to prevent the pushrod from ramming forward in a collision. The center line of the actuator arm and the center line of the torque rod should be aligned as closely as possible.

The amount of finish applied to .01- and .02-powered models should be minimized. Two coats of dope and talcum to fill plus one coat of color on the balsa parts should suffice. Trim the model with pre-doped colored tissue or use decals or self-adhesive plastic material. Foam wings may be finished with one or two coats of Sears high-gloss polyurethane varnish from a spray can or a light coat of the spray enamel intended for models. Builder Timothy Marks chose not to use paint. He simply decorated the wing of his Dick's Dream with Trim Monokote stars.

Install the engine with small wood screws. Use the smallest, lightest wheels you can find. Fasten the wing on with four rubber bands, and the plane is ready to go. With the exception that one must take the additional time to construct built-up wings, the other similar small models, such as the School Boy, Skampy, Nomad glider, Schoolgirl, and Li'l Roughneck, require exactly the same construction steps.

2-T

The 2-T is built around a set of molded polystyrene-foam wing panels and can be powered by an .049 engine. The fuselage and empennage (tail surfaces) are built up of balsa. The model can be constructed much like Dick's Dream, but it requires careful assembly of the three wing panels in proper alignment.

The dihedral joints may be shaped as shown for Dick's Dream, or they may be cut quite accurately with a table or radial-arm saw. Block the wing tips up to the proper height, cut the angles, and epoxy the pieces together. For a model this size, reinforcement of the wing on the bottom and at the leading edge with filament tape is a must, unless the wing is covered with a heat-adhesive plastic.

For similar models with a built-up wing, pin the structure to the work surface over the plans. Use plastic wrap to protect the plans from glue. Do not use wax paper; the glue dissolves the wax, and the joints are weakened. Model cements such as Ambroid are sufficient for the wing structure in small models. Be sure that such items as leading edges are supported by blocks when they are above the plan; don't depend on them to be straight. Always pin spars down either directly to the board or to blocks; likewise the trailing edge. Ideally every rib, spar, and other structural member should be held in rigid alignment while the glue sets. The best way to join built-up wing panels is to sand the dihedral angle at the center just as is done for foam wings or to cut it with a table or radial-arm saw. Install the dihedral braces in one panel and join the wings. Carefully pin one panel down rigidly using scrap balsa blocks to support it at the leading and trailing edges. Block up the other panel and then be certain that there is no twist by sighting and measuring along the leading and trailing edges. Let the joint dry thoroughly.

The fuselages of most models this size are slabsiders—the sides are flat. They can be built directly over the plans. Use white glue except for the doublers, which should be attached with contact cement. The tail surfaces are most often flat sheet to be sanded to rounded leading and trailing edges. Be sure to check the amount of right thrust in the engine mount. (To compensate for its torque, the engine is often mounted with its axis at angle to the axis of the fuselage.) If it is 5 degrees or more, one side of the fuselage may need to be shorter than the other. Check the plans.

The 2-T, like most .049-powered models, has a flat firewall engine mount. If you use a Medallion, Tee Dee, or other beam-mount engine, a tank mount will work better. The tank is attached to the firewall with wood screws, and the engine is bolted to the beams molded into the tank mount. Use 3-48 machine screws to mount the engine to the beams, and use lockwashers or elastic stop nuts to prevent engine vibration from loosening the screws.

To protect the trailing edge of the wing from nicks where the rubber bands that hold the wing onto the fuselage cross the trailing edge, epoxy to the trailing edge a length of dowel, plywood, or music wire slightly longer than the width of the fuselage.

Models in this category can carry more coats of finish or covering than Dick's Dream. The foam wing can be used without any finish, but it will quickly become dirty. There are a number of techniques you can use to finish or cover the foam wing.

Goldberg Ranger 42

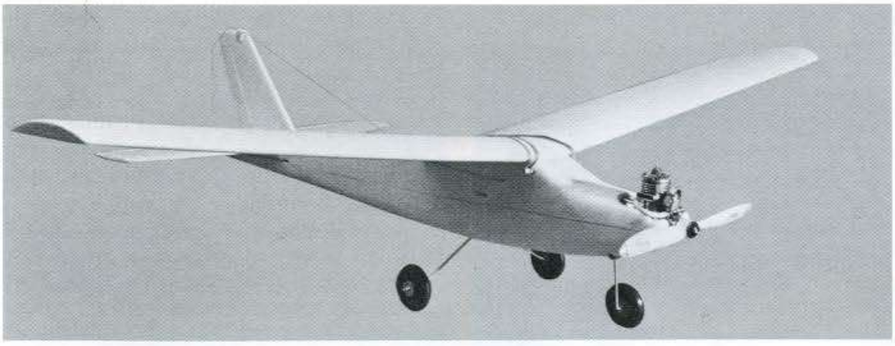
The Goldberg Ranger 42 is a typical plastic-foam model. Such models are molded completely of either polystyrene or polyurethane foam. In most cases very little wood is used. The engine mount, firewall, bulkheads, landing gear mount, servo mounts, and reinforcing spars are usually molded in place. The tasks remaining for the modeler include assembly, installation of equipment, and finishing.

Some foam models have one-piece wing, fuselage, and tail surfaces, while others have the wing and fuselage in two halves which must be joined. The parts must be joined with epoxy or white glue. Other adhesives will melt the foam.

If the wing pieces must be joined, follow the instructions given for the two preceding models. Fuselage halves to be joined must have all bulkheads, floors, and mounts installed before joining. The fuselage must be carefully aligned and held in alignment with tape until the cement sets. If the two halves don't line up, use sandpaper to even up the joint. Any voids can be filled with vinyl spackling compound.

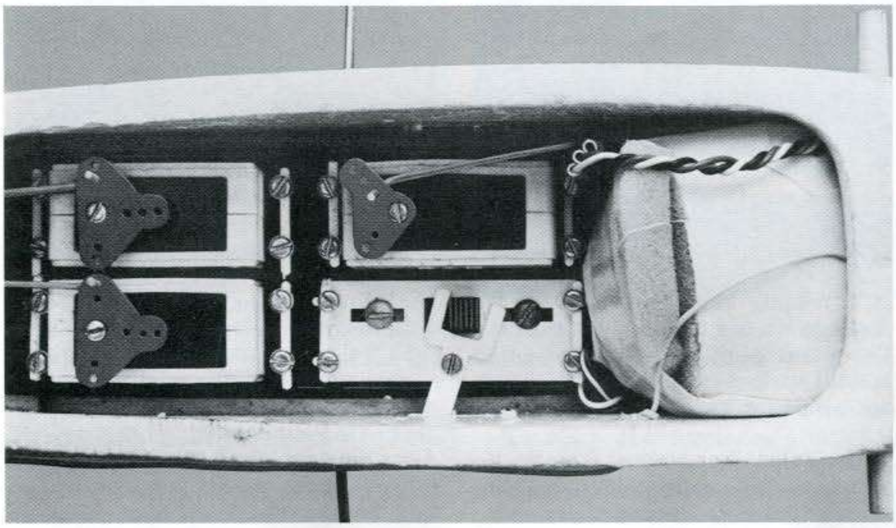
The Goldberg Ranger 42 has a one-piece wing, and its fuselage is already assembled with the forward bulkhead, floor, servo mount rails, and main gear mount in place. You must decide which engine will be installed. Any engine with displacement between .049 and .10 cubic inch can be used. The Golden Bee and the Medallion are both adequate. The Golden Bee uses a radial mount, and the Medallion uses a tank mount.

Although the instructions for the Ranger (and for most other foam models with beam mounts) indicate that the engine should be mounted with blind nuts under the bearers, we prefer the following method. First, epoxy the bearers in place if they are not already installed. Then mount the propeller on the engine, and loosen or remove the glow plug so that the prop can be rotated freely. Place the engine in the bearers and align it at the location shown on the plans. Be sure the

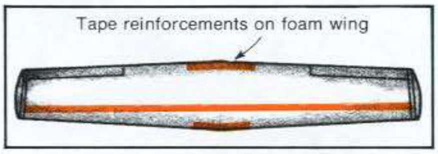


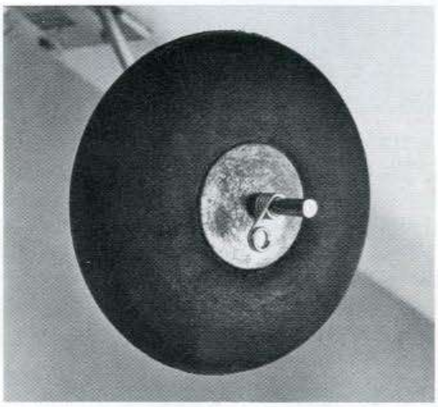
The Ranger 42 can be flown naked, but we think you will prefer the finished version (page 27, top left) which is covered with chrome-finish Mylar.

An .049 engine would be sufficient; here an .09 engine is used for extra power.



The rudder and elevator servos, left, and throttle servo, center; the switch; and the receiver, wrapped in foam, have been installed. The antenna passes through the fuselage side.





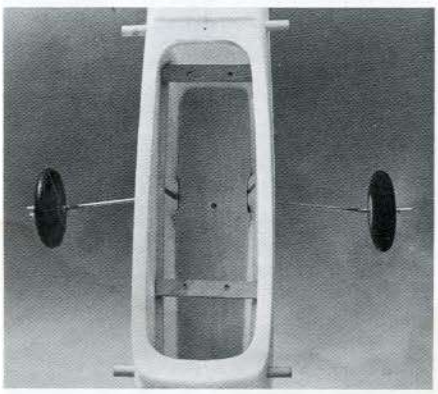
An inexpensive, efficient wheel retainer can easily be wound from wire. It requires no tools, and it will not work loose.

propeller clears the fuselage. Mark and drill a 1/16"-diameter hole at the center of the left rear mount hole. Fasten the engine with a ½"-long No. 4 sheet-metal screw. Align the engine for thrust by measuring from the tip of the prop to a pin set in the vertical stabilizer. Rotate the prop 180 degrees between measurements and twist the engine in the mount until the specified side thrust is obtained. Then carefully mark and drill for the remaining three screws.

Most molded-foam models require that the fuel tank be inserted through the fuselage wing cutout, a troublesome job. We recommend using the Sullivan slant-top tanks for these installations because the foam at the nose is thick and it places the tank rather low, making it desirable to have the fuel tubing exit at the top of the tank. Carefully measure and drill the firewall for the tubes coming from the tank. Bend the brass tubing forward to align as needed to protrude through the holes drilled in the firewall. Thread two pieces of 1/32" or 1/16" music wire through the holes and into the wing compartment. Insert them into the fuel and vent tubes, making sure the wires aren't crossed. Insert the tank in the fuselage until the tubes pass through the bulkhead. Remove the wires and connect the flexible fuel line from the fuel tube to the needle valve.

Hinge the control surfaces next. Mark the hinge locations with a pencil, and cut slots long enough to accept the hinges. A small knife works well. Spread the foam slightly as you make the cut. Smear a little epoxy or white glue on one leaf of the hinges and insert them into the slots on either the fixed or the movable surface. Put them all on one side. Don't have some of the hinges on the fixed surface and some on the movable surface. Be sure that no glue gets into the moving parts of the hinges. Line up the other surface and insert one end hinge slightly. Proceed along the joint, inserting each hinge a little bit. Then go back and push them down a little more. Work slowly and keep going back and forth until all the hinges are completely seated in both the fixed and the movable surfaces.

Set plywood plates into the foam control surfaces and drill them for the control horns. Install the main gear and nose gear. Epoxy the servo mount rails in place and temporarily mount the servos. Make certain that room is left for the receiver and the battery pack.



A view down into the fuselage of the Ranger 42 reveals two servo mount rails. The servo tray is attached to the mount rails with machine screws and blind nuts.

Construct the elevator and rudder pushrods and the throttle linkage. Connect the battery pack, receiver, and servos, and check for proper surface movement and direction of travel. Mount the switch on a plywood plate inside the fuselage. Be sure to use large washers under the heads of the bolts.

After installation checkout, remove the equipment and the engine. Place a short length of surgical rubber tubing between the tank fuel tube and the tank vent tube to seal the tank against dirt. Mix a small batch of epoxy and use it to coat the entire engine compartment, the engine mounts, and the firewall, so that fuel and oil will not penetrate the structure of the plane.

Finishing techniques for foam are discussed in Chapter 3. For a model this size, a plastic material or Silkspan is advisable for strength and crash-resistance. We used Krome Cote except for the windows, which we covered with clear Top Cote. Trim Monokote and decals completed the job.

Molded plastic-foam models generally fly well. They are not very damage-resistant, but they can be repaired easily with epoxy at break points. They are heavier than comparable balsa models and therefore have some flight limitations. They are inexpensive, and replacement components such as wings are generally available.

Foam techniques are not commonly used in larger models because such models need the additional strength that comes from a thin plywood, plastic, or balsa covering.

Some foam models are available in kits for power by engines of up to .45-cubic-inch displacement. These are not normally recommended for the novice.

Falcon 56

The most popular and versatile construction method requires building up a frame of wood and then covering it with silk or a heat-shrinkable plastic covering. The Falcon 56 (with a 56" wingspan) is one of the oldest models using this method. It was originally designed to fly with escapement or reed-type non-proportional equipment and thus had to be stable in flight. There are many similar models in the same class; the S-Ray and the Falcon 56 are both excellent for the novice flyer who has assistance and who wants to build a larger model that can penetrate the wind or carry heavier equipment.

Models in this category have a wingspan between 40 and 60 inches, a wing area of 400 to 550 square inches, and a flying weight of 3 to 5 pounds. They are designed to be powered by .15- to .45-cubic-inch engines. They are of balsa, plywood, and hardwood construction. In most cases the wing is of open construction, as is the horizontal stabilizer of a few of the models. The fuselage usually has a rectangular cross section. Most of the older models of this type use beam mounts for the engines. The different planes are distinguished by the type of wing used and the lengths of the moment arms (the lengths of the nose and the tail). Longer moment arms produce a smoother-handling plane. Their length is, of course, limited by shop and car-trunk space.

The Falcon 56 has a shoulder wing with a moderate amount of dihedral. Its moment arms are relatively long. It is built of balsa, plywood, and hardwood. Both the wing and the horizontal stabilizer are of open construction, with solid leading and trailing edges. The fuselage is a box tapered in at the nose. The main gear is fuselage-mounted, and all surfaces are secured with rubber bands for knock-down transportation.

The Falcon has several features not found on the models discussed previously: built-up construction, steerable nose wheel, and the ability to take off from close-mowed grass.

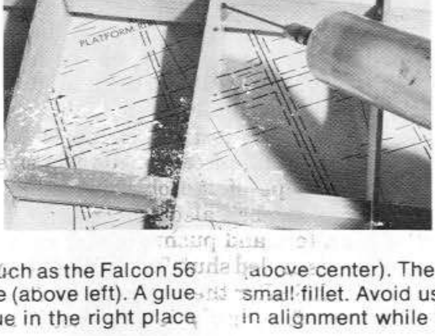
Construct the wings first, and work on the rest of the model while the wings dry. Tape the plans down and pin the trailing edge down solidly. Then space the ribs and pin them in place. (The Falcon ribs have a tab to hold the height; other models may require placing the bottom spar down on blocks before putting the ribs down.) For the Falcon, slide the spars through the center of the ribs after the ribs are pinned down. For the others, block up the spars and the leading edges as required. Add the tip blocks and any dihedral gauges provided. Build the left and right panels using white glue or model cement—white glue is the stronger. Let both wing panels dry thoroughly, at least several hours and preferably overnight.

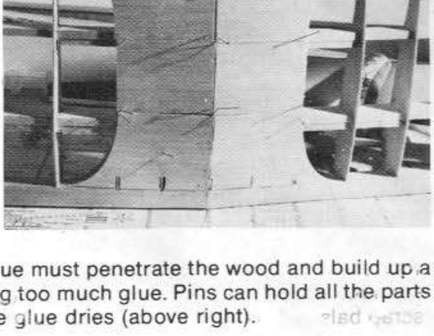
While the wing panels are drying, proceed with the horizontal stabilizer. The stabilizer for the Falcon is constructed in exactly the same manner as the wing. Some models may use a solid horizontal stabilizer; others may have a stabilizer built up of light sheet and strip balsa.

Well-designed fuselages usually have doublers—reinforcements—from the nose to a point aft of the wing. Full-height fuselage sides of 3/32" or 1/8" balsa are used for the doublers —remember to make a left side and a right side. The doublers are best attached to the sides with contact cement. Coat the doubler and the fuselage side with a very thin coat of contact cement. Let both parts dry for at least 15 minutes before joining them. Make certain that the parts are aligned correctly when you join them. Put the fuselage side on a flat surface, line up the doubler, and press it down with heavy hand pressure.

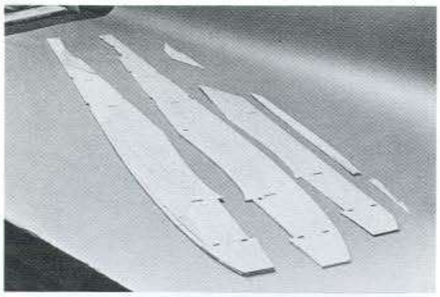
Pre-construct any bulkheads that require joining, lamination, or doubling. Cement pieces of scrap balsa across the grain and set these parts aside to dry. Before you join the sides to the main bulkheads, rule in with a soft pencil the exact locations of all bulkheads. With the doublers in place and all pre-cemented assemblies ready, you can assemble the fuselage.

Check constantly for accurate alignment as you work. Several kinds of

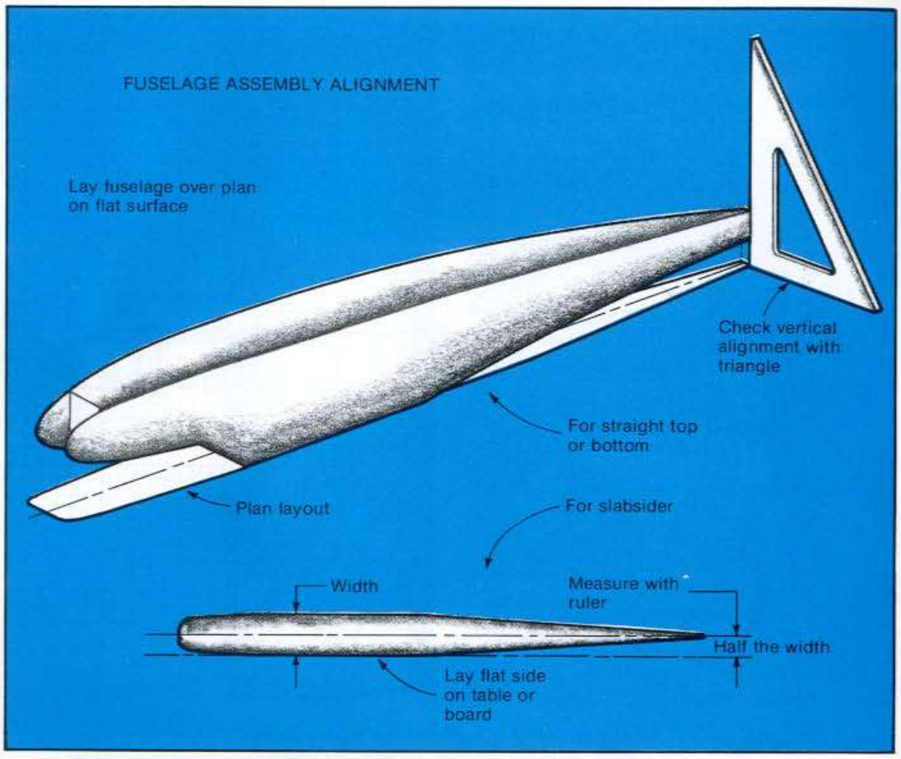




The first step in building the wing of a model such as the Falcon 56 is to tape the plans down on your work surface (above left). A glue gun will help you put the right amount of glue in the right place (above center). The glue must penetrate the wood and build up a small fillet. Avoid using too much glue. Pins can hold all the parts in alignment while the glue dries (above right).



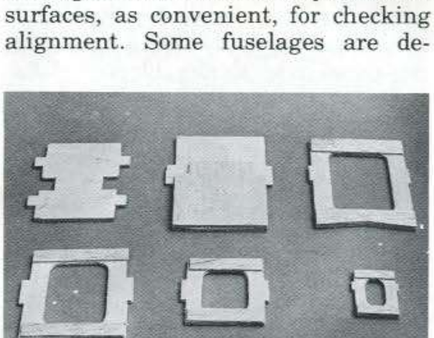
When you apply contact cement to the fuselage sides and the doublers, remember to keep right and left parts separate. Laying out all the parts on the workbench before you start cementing is helpful.



errors can occur as you assemble the fuselage. One is twist: tail surfaces out of line with the wing. Even when the flying surfaces are lined up by shimming during final assembly, the crooked construction is obvious. Twist causes the vertical stabilizer to lean, imparting a tendency to turn.

A less noticeable error is an asymmetrical bend in the fuselage; that is, when the sides are joined at the stern post, the post is not on the center line of the fuselage. This bend throws the stabilizer platform out of line and angles the vertical stabilizer to one side like a permanent rudder. It is easy to err if one side of the fuselage is weaker or thinner than the other. Careless application of the sides to the key bulkheads during assembly can create subsequent alignment problems that cannot be eliminated.

Simple checks during construction prevent these difficulties. The box-type fuselage can be rested on any of its flat surfaces, as convenient, for checking alignment. Some fuselages are designed so that the bottom is flat from nose to tail and therefore can rest on the workbench. Others have a flat top.



The bulkheads and the formers can be strengthened by laminating thin pieces of [illegible] sa across them.

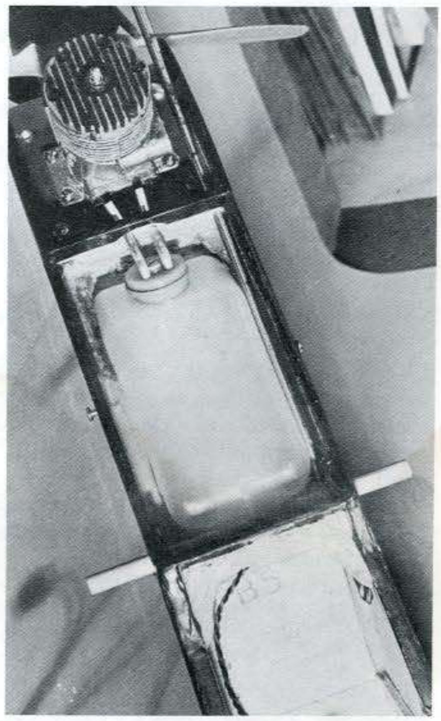
To align the fuselage, attach the sheet balsa sides to the two main fuselage bulkheads. Now stand the body on the top view of the plane. If the sides are not square with the bulkheads, the fuselage will not line up with the plan but will be twisted. Align the sides with the plan before the glue sets by pinning the bulkheads and sides to the bench.

The fuselage sides should be vertical to the bench. Check with a draftsman's triangle or any convenient right-angled object. If the sides are not vertical to the bench, the fuselage will be out of line. If necessary, remove the holding pins while the cement is still wet and reattach the sides to the bulkheads.

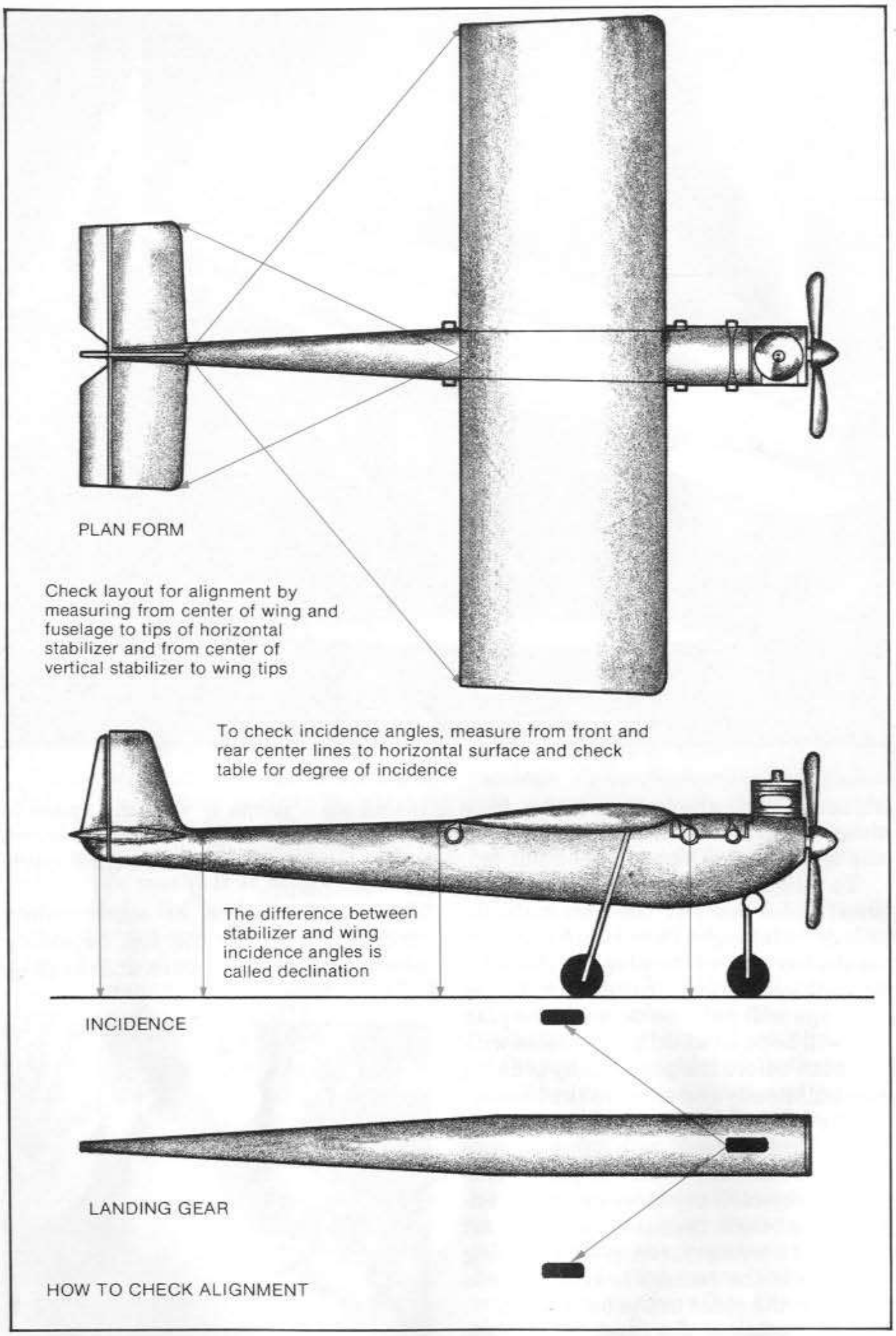
The section of the fuselage through the cabin usually can be aligned and allowed to dry before joining the sides at the rear. Books or some other heavy object can be placed on top of the fuselage to press it firmly against the benchtop, preventing movement while the glue dries. A helpful trick is to attach one piece of bottom sheeting across the fuselage adjacent to one of the main bulkheads, further locking the work against movement.

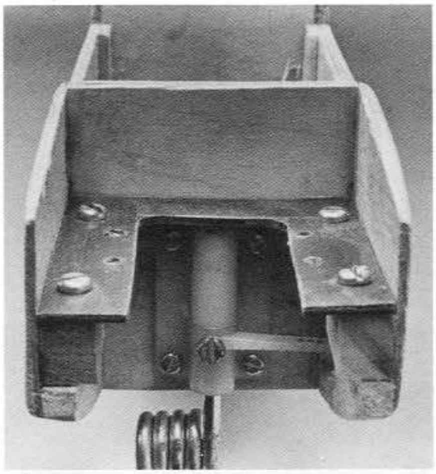
As you build the model, do not forget to provide access hatches for the radio equipment, the fuel tank, and the batteries. The size and the shape of the hatches depend, of course, on the size and the shape of the objects beneath them. Remember also to arrange for the actuators and pushrods before the fuselage is sealed shut. These items can be installed after the basic assembly is done, but frequently it is difficult to insert such items if working space is cramped. You can tell how much access is needed by placing the actual parts over the plan.

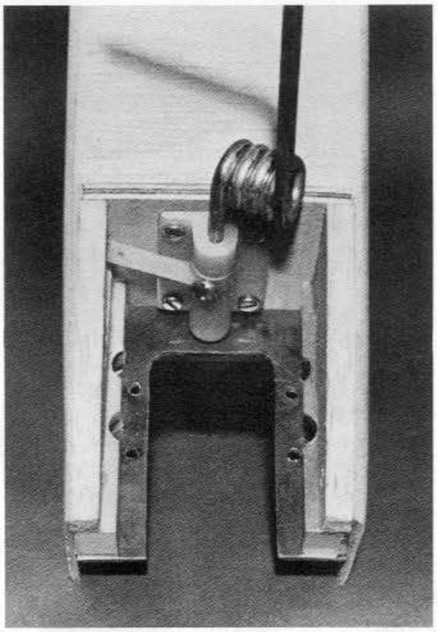
The nose section of some trainer models is open at the top, providing access for the battery pack and the plas-



An extension drill bit, visible to the right of the fuel tank, is handy for drilling holes for the throttle linkage. The fuel tank normally is covered by a hatch held down by rubber bands over the two screws in the side of the fuselage. Fashion a drill bit yourself by grinding a V-edge on a piece of music wire.







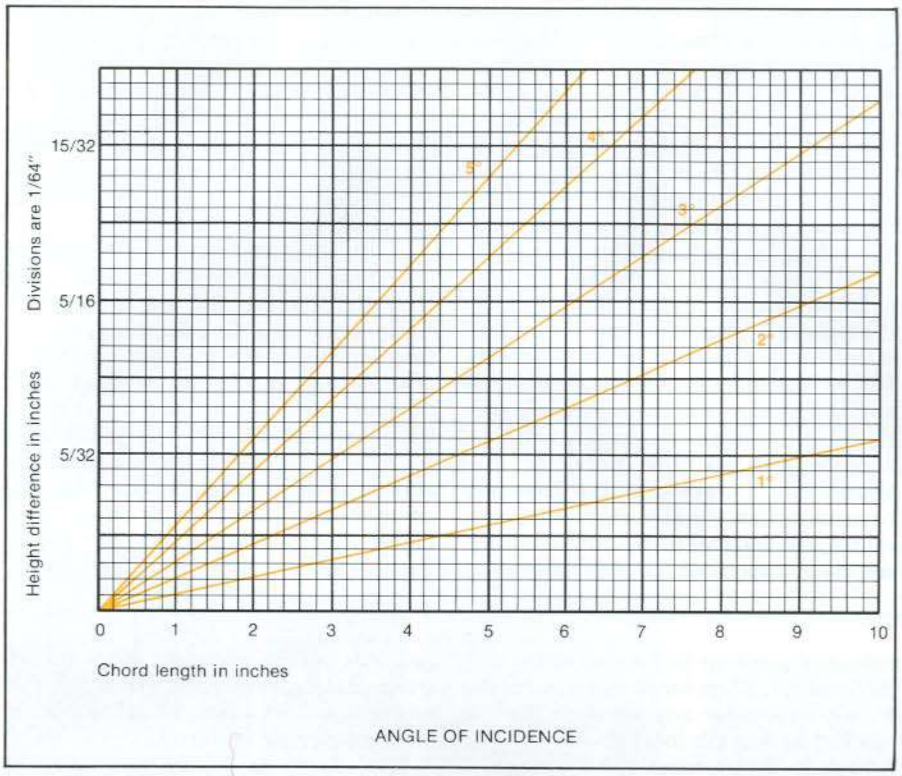
To install the tiller arm for the steerable nosewheel (top), you will have to cut away part of the side block. Note that the side blocks are cut away to clear the engine-mounting nuts also. The engine-mounting plate (above) can be cut from printed-circuit board or 1/8" plywood. Sheet-metal screws are used in the installation shown.

tic-bottle clunk tank (which has a weighted fuel pickup inside). A snug-fitting hatch covers the opening. In some installations the front cabin bulkhead, which is usually plywood, is reinforced and has an access hole in it. This hole allows the fuel tank and batteries to be inserted and removed.

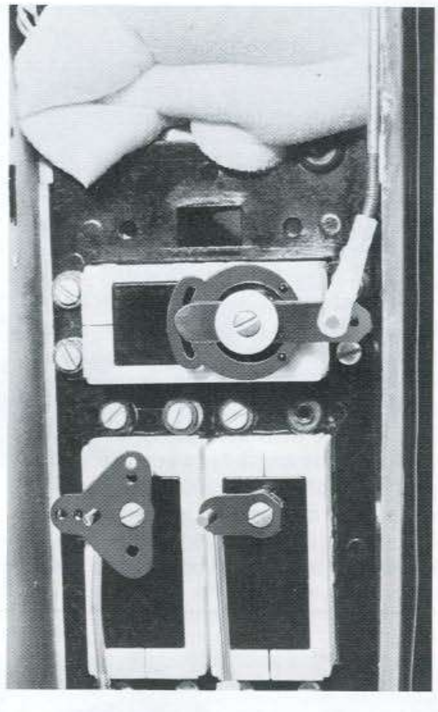
With proportional control systems an engine of up to .35-cubic-inch displacement can be used. This engine requires a fuel tank of 6- to 8-ounce capacity. The larger tank requires a modification to the nose. To make room for the larger tank, cut a new firewall the same shape as the old one but equal in width to the second bulkhead. Cut a new top hatch block and bottom nose sheeting. Assemble them according to the original plans. Make new motor-mount plates the width of the front end. These steps simply widen the front end to the full fuselage width, making the front end roomier and stronger because the sides no longer must bend around the second former. Set the fuselage aside and let the glue dry thoroughly.

Now comes one of the tricky steps—joining the wing panels. The Falcon wing is joined with plywood dihedral braces at the leading and trailing edges, and with heavy balsa joiners on both sides of the main and aft spars. Other models use plywood joiners. First cut the spars and the leading and trailing edges to the proper dihedral angle. This process is aided by spot-cementing dihedral gauges directly to the wing members. The sanding method described for foam wings works well here, but a table or radial arm saw does a quicker and more accurate job. Be sure you can identify left, right, top, and bottom pieces. Cement the joiners to one panel. You must use white glue or epoxy. Let the joiners dry thoroughly before you join the two wing panels. Pin one panel down solidly, blocked just as it was when you built it. Then apply cement to the other halves of the joiners and to the other wing panel. Set the wing panel in place and block it rigidly to the correct dihedral angle—specified in the kit instructions—usually a certain number of inches from the work surface at the tip of the wing. Measure the leading-edge and trailing-edge heights carefully to be sure there is no twist in the wing. A wing-building jig makes the alignment process much easier, by the way.

You can sheet the top of the center section of the wing while the di



This chart converts angle of incidence given in degrees to height difference in inches.



The device on the throttle servo in the Falcon 56 is an override, needed because the range of adjustment of the throttle is much less than the travel of the servo.

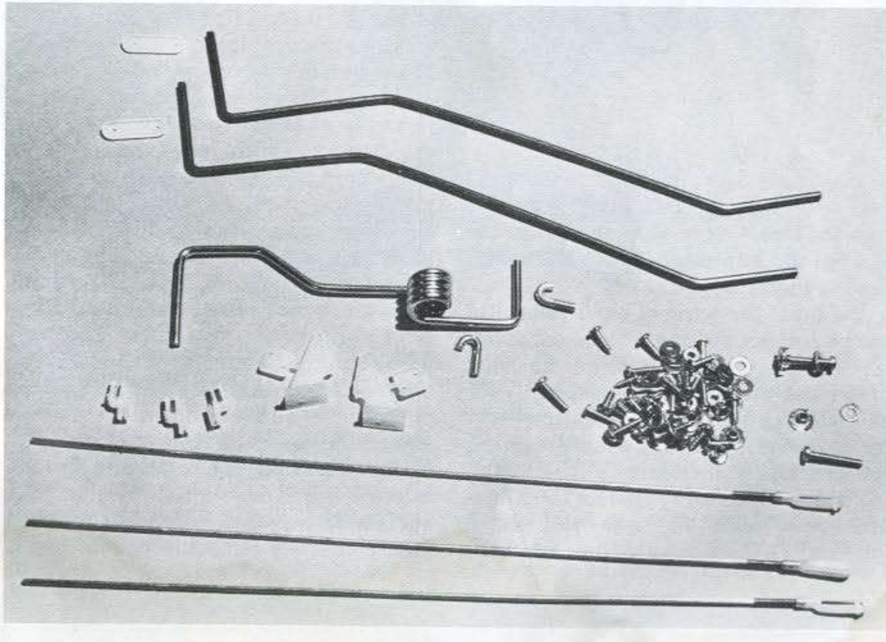
joints set. When all the glued joints are completely dry, complete the rest of the sheeting.

Shape with knife and sandpaper all the hatch blocks, the elevator, the rudder, and any fairings and accessory items. Inset plywood plates for control horns. Join the elevator halves with both halves rigidly pinned down. Any twist between the halves of the elevator will cause the plane to roll. Sand and carve all tip blocks, fuselage corners, and surface sheeting to shape. Fill cracks, joints in the sheeting, and ding marks with filler. Join the vertical and horizontal stabilizers and attach them to the fuselage.

At this point carefully check the alignment of the model. The average modeler becomes lazy here. He assumes that the parts are cut accurately and that he assembled them properly. Besides, he further assumes, you can always trim things out with the controls, right? Wrong! The model can fly with unaligned wings or elevators, but it will not fly well. Maneuvers become almost impossible. For example, if there is a slight twist between the wing and the horizontal stabilizer, an outside loop leads off one way and an inside loop the other—and the problem can not be corrected with ailerons or the rudder.

The tools you need for alignment are a butcher's cord or chalk line, a plastic triangle or a carpenter's square, and a ruler. The ruler should be graduated in ...hs of an inch.

...ck the following alignments with ...fuselage, tail surfaces, and



Hardware for the Falcon 56 includes landing gear, control horns, pushrods, clevises and keepers for the pushrods, J-bolts, machine screws, sheet-metal screws, and washers.

engine mounted as for flight: engine thrust, both horizontal and vertical; wing incidence; horizontal stabilizer incidence; angle between horizontal and vertical stabilizers; angle between wing and horizontal stabilizer; and landing gear. All the measurements are angular. Our tools, however, require that we measure otherwise. If, for example, wing incidence must be 2 degrees and the wing chord is 10", then the height of the leading-edge chord line above the trailing-edge chord line must be determined. The height is the product of the chord length and the sine of the angle of incidence. The chart on this page graphs sines of angles up to 5 degrees. To use the graph, find the chord length along the bottom, read up to the line for the angle of incidence, and then read to the left for the difference in height between the leading edge and the trailing edge.

The first step in checking alignment is to establish the horizontal reference line. Usually the construction plans identify it. If the plans do not identify the line, set up a line which passes through the center line of the firewall and the first few bulkheads. Mark the center line with pins and stretch a piece of cord between them. Block the fuselage up so that the line is parallel to the workbench surface. Attach the wing and the horizontal stabilizer, and adjust each of them to conform to the plan.

The reference lines for the wing and the horizontal stabilizer pass exactly through the center of the leading and trailing edges. These lines can be determined from the plans by measurement. Mark these also with pins.

Check the angle between the vertical and horizontal stabilizers. It must be exactly 90 degrees. If the vertical stabilizer is rigidly attached to the fuselage, sand the horizontal stabilizer mount until the two pieces are at right angles. Then align the wing and horizontal stabilizer by sighting from behind the model to see that the stabilizer tips line up with the same points on the wing. Sand the wing saddle carefully until they do align. Check the alignment by blocking the fuselage until the wing tips are at precisely the same height above the flat surface. Then check the stabilizers for equal height at the tips. If you must make more adjustment, do it at the wing saddle—the horizontal stabilizer is already aligned with the vertical stabilizer. Next, check the angle of incidence of the horizontal stabilizer and sand the mount fore or aft as needed. Recheck the previous roll alignments to make sure they have not been disturbed. Finally, check the horizontal and vertical thrust angles of the engine as described for the Ranger 42. Adjust the thrust lines by shimming the engine at the mounting points.

Install the landing gear and check for main gear run-out. If the model has fixed gear, roll the model across the floor and twist the nose-gear wire for alignment. Steerable nose gear must be aligned after the control equipment is installed.

Install the engine and the control equipment temporarily to make sure they fit. Remove the engine, control equipment, tank, and landing gear before you finish the model. Almost any type of finish can be used on the Falcon 56. One caution—the open areas of the wing and tail surfaces cannot stand much sanding, lest the covering material be worn through at the ribs. We covered our Falcon 56 with Super Monokote, a heat-shrinkable Mylar covering.

Sweet Stik

The Sweet Stik is similar in construction to the Falcon 56, so we shall discuss the installation of ailerons, the use of a building jig, and the use of a radial engine mount.

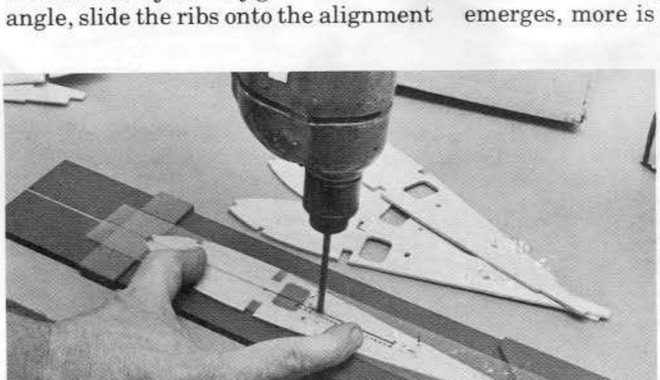
We built the wing of our Sweet Stik on the Adjustojig, one of the most popular commercial jigs. Some builders prefer to construct a jig specifically for a model. A jig requires some time to set up. However, it greatly simplifies wing construction and ensures a true wing.

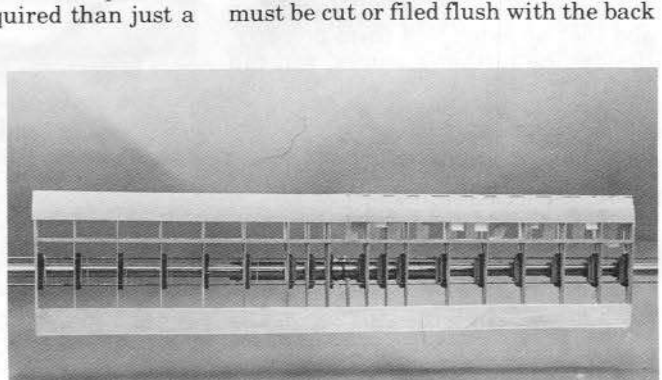
First drill the wing ribs for the alignment rods. Adjust the jig to the dihedral angle, slide the ribs onto the alignment rods, and position and clamp down the rib locators. Then build the wing completely except for any sheeting that is blocked by the rib locators. Be sure to let the glue or cement dry thoroughly before you remove the wing from the jig. Hurrying now would completely negate the effect of the jig.

The aileron linkage and servo mounting are typical of built-up models having inset ailerons rather than strip ailerons. The Sweet Stik has strip ailerons but uses a linkage more commonly found with inset ailerons. Required are two 90-degree bell cranks, a long piece of music wire, transverse pushrods, two short adjustable-link pushrods, plywood servo and bell-crank mounts, and aileron horns. The linkages must move freely and not rub or bind against the structure. The bell-crank mount bolts must be secured against loosening. Lock nuts, Loctite, or silicone-rubber bathtub sealant should be used on the threads. The pushrod between the bell crank and the aileron horn must pass through the surface of the wing. Where the pushrod emerges, more is required than just a hole cut in the covering material. A wood plate serves as a guide for the pushrod and as a firm attaching point for the covering material.

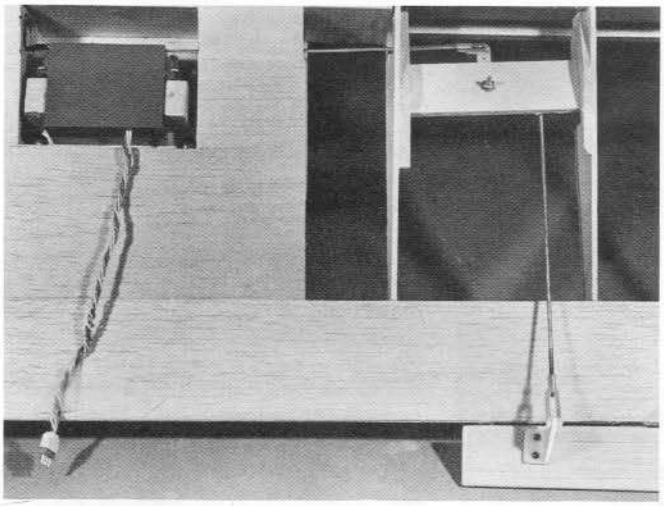
The aileron servo must be mounted crosswise to the fuselage. The linkage that we have used for years between the servo and the pushrod is shown in the photo on p. 37. Bend a short length of soft wire (not music wire) at 90 degrees to engage the output wheel or arm. Roughen the pushrod at the servo location with emery cloth, bind the bent wire to the pushrod with fine tagging wire or copper wire, and solder the wires together. Arrange the servo mount so that the connection can be made and automatically secured by fastening down the servo.

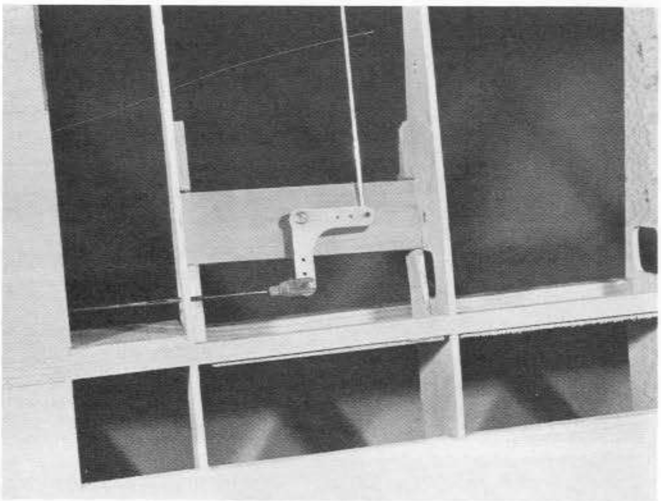
The engine of the Sweet Stik is mounted to the flat firewall on Tee Bar aluminum mounts. Most engine mounts are already drilled for mounting to the firewall, using machine screws into nut plates or blind nuts on the back of the firewall. Any screws or bolts protruding through the nuts into the fuel tank or battery compartments must be cut or filed flush with the back



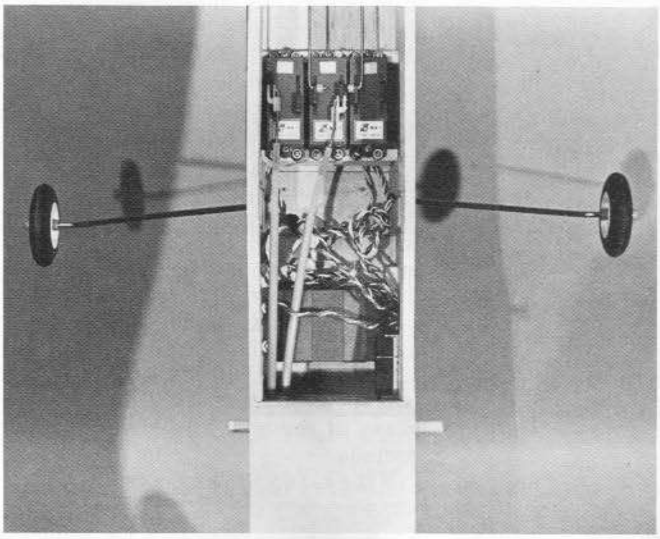


The use of a jig requires that you drill holes in the wing ribs for the rods of the jig. A template (above left) ensures that the holes will be in the same place in all the ribs. The jig (above right) holds the wing in alignment during construction.

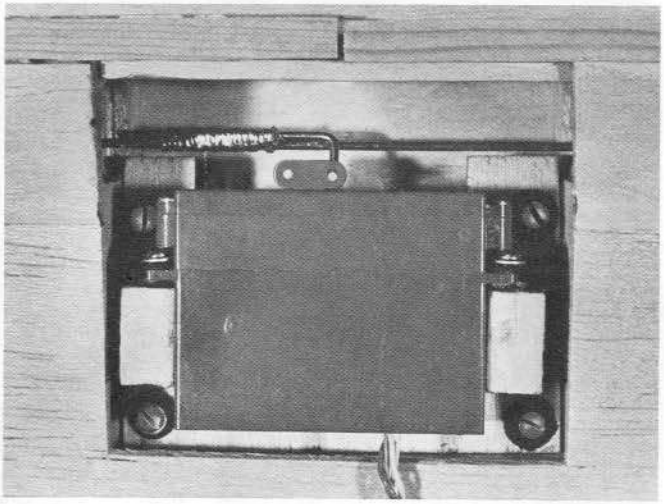




The aileron servo of the Sweet Stik is mounted in the center of the wing (below). Pushrods and bell cranks (above and above left) transmit the motion of the servo to the ailerons. Connecting the aileron servo to the pushrod requires soldering.



The three servos in the fuselage of the Sweet Stik control elevator, rudder and nosewheel, and throttle.



of the nut. Otherwise they could puncture the tank or the battery in a crash. The engine is best attached to the mount with self-tapping screws threaded directly into the holes in the mount.

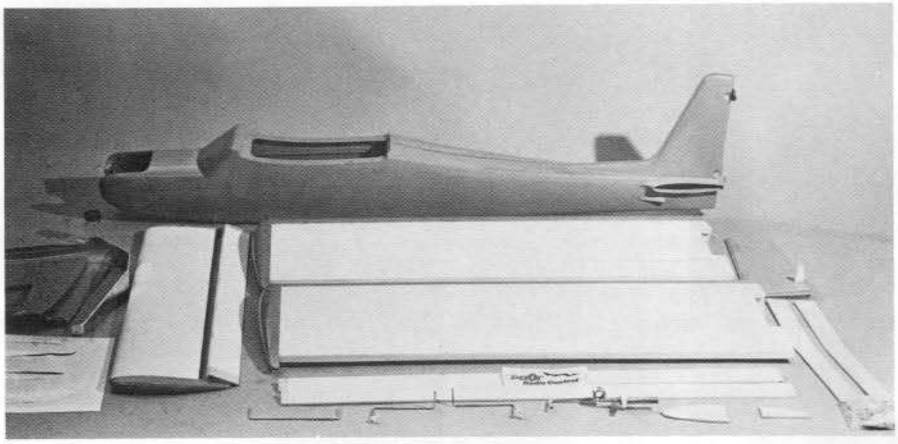
The Sweet Stik is normally equipped with a .45 engine and four channels of control for ailerons, rudder, elevator, and throttle. The nose wheel is steerable from the rudder servo. A fuel tank of 8 to 10 ounces should suffice. It is not a model for the novice who has no help, but with controls set for minimum sensitivity and the center of gravity as far forward as possible (no more than ½" forward of the position shown on the drawings) it is a good trainer for the modeler who has some assistance in learning to fly. For a more experienced flyer it is an excellent intermediate trainer and sport model. Other models available in this category are the Senior Falcon, Mighty Mambo, Little Big Daddy, J-Craft, Tauri, Lancer, Trainermaster, and A-Ray. They all are of built-up wood construction and all use a .30 to .45 engine. A beginner should have help for initial flights with any of these planes.

Pilot Skywagon

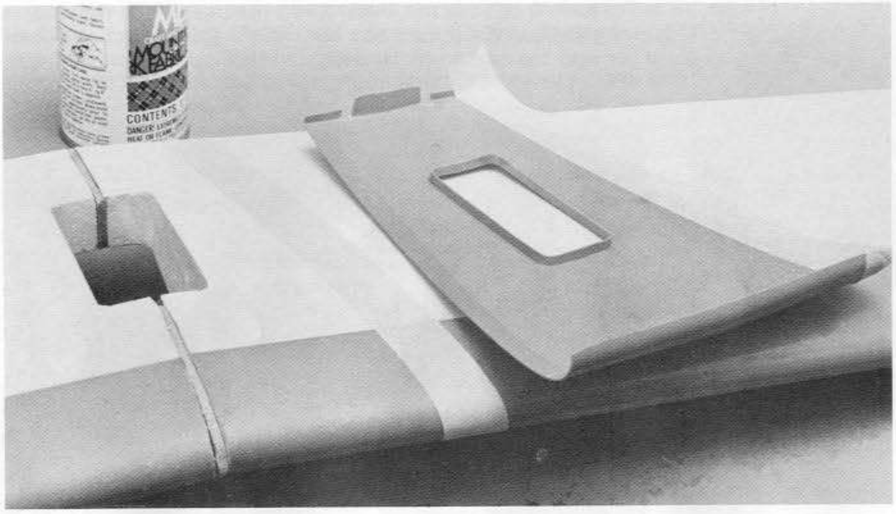
Formed plastic models have entered the scene in the past few years. Most are vacuum-formed of ABS plastic. The va[illegible]-forming technique is simple. A [illegible]ade in the desired shape, sheet plastic is placed on a sealed frame over the mold, a vacuum is applied, and the entire assembly is placed in an oven. The heat softens the plastic, which conforms to the shape of the mold. Upon cooling, the plastic retains the new shape and is trimmed to produce the final component.

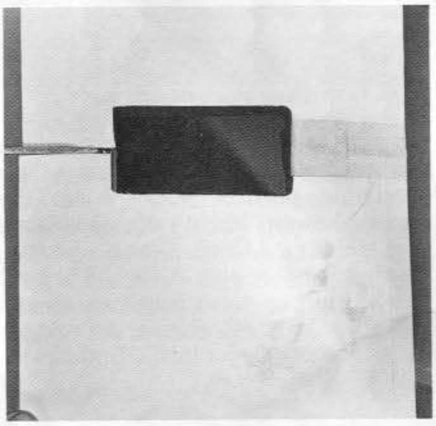
The components are joined with a solvent, methyl ethyl ketone (MEK), which softens the plastic. The parts to be joined are held together while the solvent evaporates, welding the parts into a single unit.

Most plastic models are constructed the same way. A fuselage shell is provided in one piece. Usually the vertical stabilizer is molded as part of the fuselage. The horizontal stabilizer and the wing are foam plastic covered with plastic sheet. The wings must be joined at the center; in some cases so must the horizontal stabilizer. Wing and stabilizer tips must be cemented on. The elevators, rudder, and ailerons come ready to be covered. Strip ailerons are usually used. Accessories include cowlings, wheel pants, fairings, clear canopies, and the like. The basic plastic comes in a wide variety of colors, so there is no need for a finish other than trim.

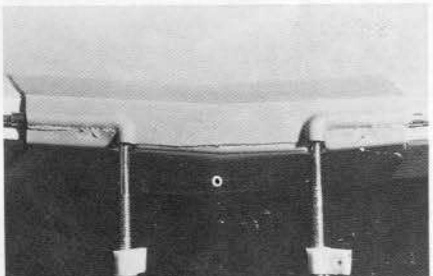


The Skywagon is typical of molded-plastic model airplane kits.





To assemble the wing, coat the halves of the wing and the joiner with epoxy, slide them together, and tape the joint to prevent the epoxy from leaking (left). When the joint is dry, add the reinforcement piece with contact cement (above).



Trim the aileron horn tunnels for a free fit to prevent binding, which would put strain on the servo and drain the battery.

Plastic models have a few shortcomings. They are heavy for their size, and they are not always very durable. On the other hand, they are low in cost. They can be constructed quickly, and they need no finishing. The plastic is impervious to fuel.

The Pilot Skywagon is an intermediate trainer designed for .30- to .45-cubic-inch engines. It is designed for four-channel control: elevator, ailerons, throttle, and rudder, with nose-wheel steering controlled by the rudder servo. Because it is a high-wing airplane, stability and ease of control are excellent. The model is docile and is a good intermediate trainer for the flyer who has some help.

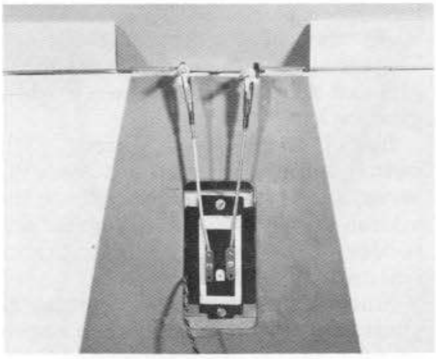
The first task is that of joining wing panels. Partial or full-length spruce spars are usually provided. A slot is already made in the foam core to accept a plywood joiner. Use only epoxy. White glue will not dry, because it will be trapped in dead air at the middle of the joint. Celluloid cement will destroy the foam core. The wing joiner should be a snug fit over the spars, but it must not force them out and make the skin of the wing bulge. Trim the joiner for a smooth fit. Mix a big slug of epoxy and pour some into the joiner slots. Coat the joiner and the exposed foam with epoxy. Don't worry about coating or joining the plastic skin. It can carry no load across such a thin joint. Do not depend on the joint between the two foam cores or even the joint between the spars to carry any load. You must provide some carryover structure.

The Skywagon uses a formed plastic carryover reinforcement which doubles the center section of the wing and provides the necessary strength. To apply the reinforcement, first check the alignment and trim it for fit with the aileron horns in place. It may be necessary to shim and adjust the piece. With the piece held in place, mark its outline on the wing with a pencil or tape. Apply contact cement to the doubler and to the wing to within ¼" of the outline. Then apply the reinforcing piece carefully, checking the alignment as you proceed. There is no way to loosen contact cement. After the reinforcement is in place, brush solvent cement around the edge to bond it to the wing. Rely on capillary action to spread the solvent under the reinforcement, but hold the pieces together until the solvent evaporates. It is important to have solid joints in the area of the aileron horn tunnels.

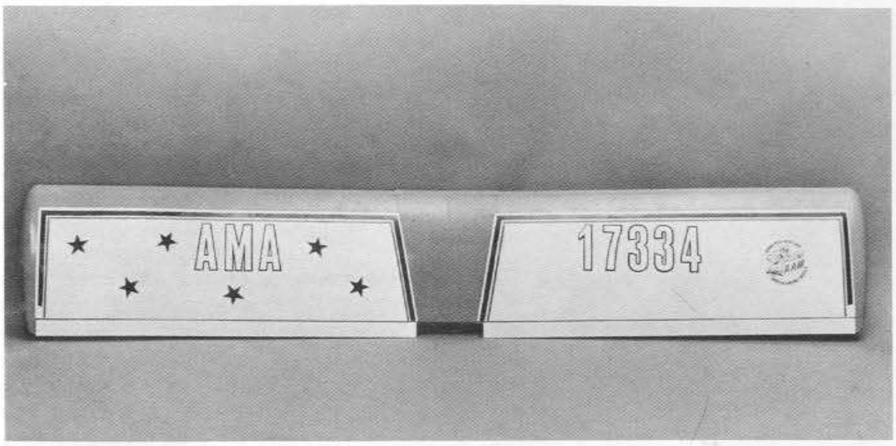
If the kit does not include hinges, you can use any plastic or metal ones. Complete the wing assembly by hinging the ailerons and bonding the tips in place. For a low-wing model, attach the landing gear as described for the Komet in the next section. Epoxy the aileron servo mounts to the foam liner. Use large mounting blocks to form a good-sized bonding area.

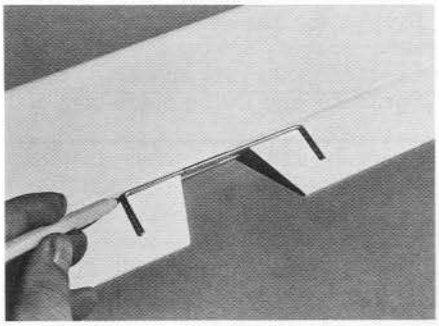
If there is no plastic wing joiner provided with your kit, use the following technique. Join the panels as before, but roughen the plastic wing cover over a strip 2" wide at the center. Smear this area with epoxy and double the area with fiberglass tape. Put enough epoxy on the fiberglass to fill the grain, and feather or taper the epoxy down to the wing surface at the edges.

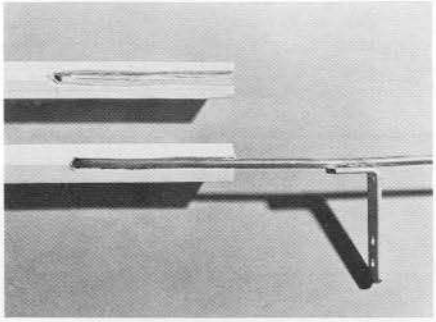
Prepare the horizontal stabilizer by joining the two halves. Determine the position of the elevator crossover tie bar. If the elevator is one piece that must be split, install the crossover bar before splitting the halves apart, to help maintain alignment. If the elevators are already separated, measure the crossover bar position with them taped to the stabilizer. Remove the tape, pin the elevators down rigidly, drill for the crossover bar, cut grooves along the elevator so that the crossover bar can be set flush with the leading edge of the elevator, and assemble the

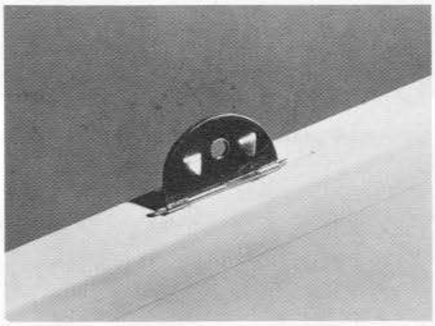


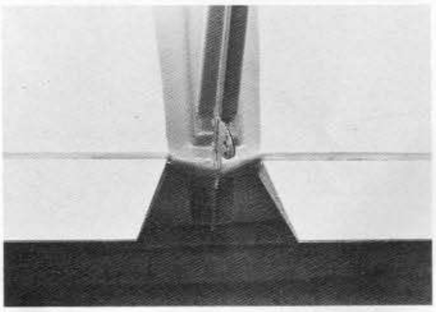
The aileron servo is mounted in a cavity at the center of the wing.

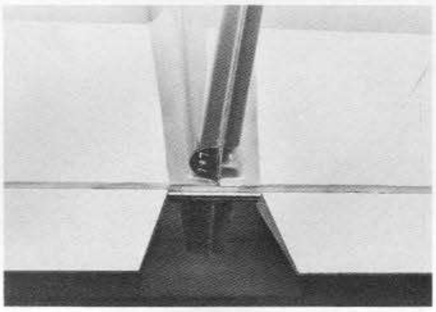












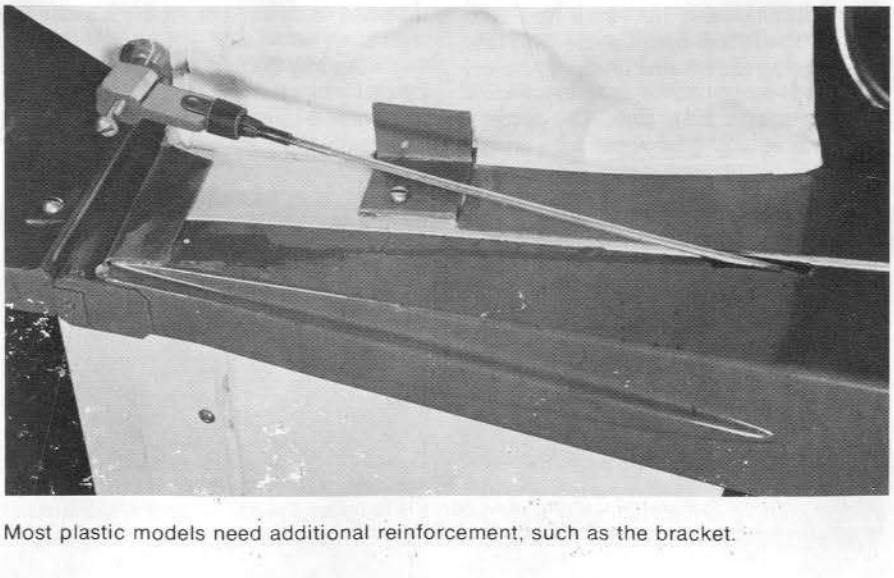
(Top) The completed wing is trimmed with Monokote and decals. (Above, far left) Lay out the elevator parts carefully. Twist in the elevator can result in a plane that will not fly properly. (Above left) Groove the elevator and epoxy the tie rod into the hole. (Above) Pronged metal hinges grip well and need no adhesive. (Far left) To prevent misalignment, the plastic piece at the rear of the fuselage must not be trimmed until the horizontal stabilizer is in place. (Left) Hinging the elevator is easier to do after the stabilizer has been mounted.

elevators and the crossover bar with epoxy. Hinge the elevator to the horizontal stabilizer, and inset a plywood plate for the elevator horn if needed. Cover and finish the elevators, rudder, and ailerons before hinging them if they are made of balsa.

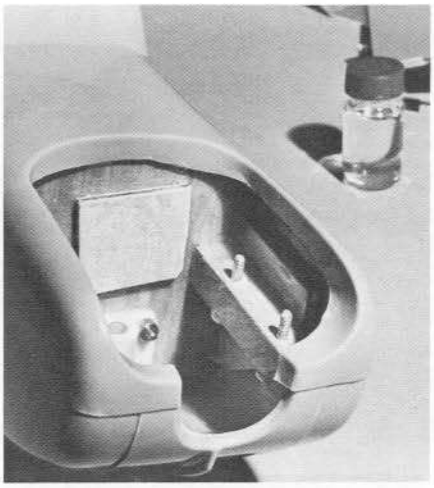
Join the horizontal stabilizer to the fuselage with solvent. If the joint is a poor fit, use clear silicone bathtub sealant instead of solvent.

Fuselage assembly and engine installation are next. One of the weaknesses of a number of plastic models is the use of only a partial firewall, leaving the fuselage open for oil to flow back to the wood parts and equipment. Install the engine and fuel tank with the tubing protruding through the firewall. Fit the throttle control linkage. Use plywood or hard balsa to fill out and complete the bulkhead. The job is easiest if you first cut a cardboard pattern and then use the pattern to cut the wood. Epoxy the plywood or balsa in place. Remove the engine and cap the fuel and vent tubes. Coat all the wood, the engine mounts, and the engine compartment liberally with epoxy, using a disposable brush. Then seal all voids between the firewall, side panels and braces, and the shell of the fuselage with silicone rubber bathtub sealant.

The Skywagon has built-in hardwood engine bearers with bolts set in to accept a linen-phenolic mount plate which must be drilled to accept your engine. Use the general procedure described with the Ranger 42 for engine thrust alignment. The engine must be secured to the plate with machine screws and self-locking nuts or at least with lock washers under ordinary nuts.



Most plastic models need additional reinforcement, such as the bracket.



Seal the hole in the firewall with a piece of plywood, and then drill holes in the firewall for placement of the fuel lines.

For models which have the engine mounted directly to hardwood bearers, drill 3/32" holes and use 3/4" long No. 6 plated-steel sheet-metal screws. It's the simplest and best way to attach the engine.

The main gear of the Skywagon mounts to spruce fuselage stiffeners in the fuselage. We beefed up the arrangement by adding a ⅛" plywood cross plate epoxied to the stiffeners. We found it necessary to add a ⅛" music wire spreader bar to the main gear. Use clips or J-bolts to attach the wire to the aluminum. The nose gear is simply inserted, a retaining screw is set in, and the nose-wheel steering linkage is connected through the bottom of the fuselage.

The plastic fuselage comes already attached to a plywood frame to which the firewall and the first two bulkheads have been cemented. This frame also holds the wing-attachment fittings. The servo mounts are cemented to the plywood side pieces with epoxy, white glue, or hot-melt glue.

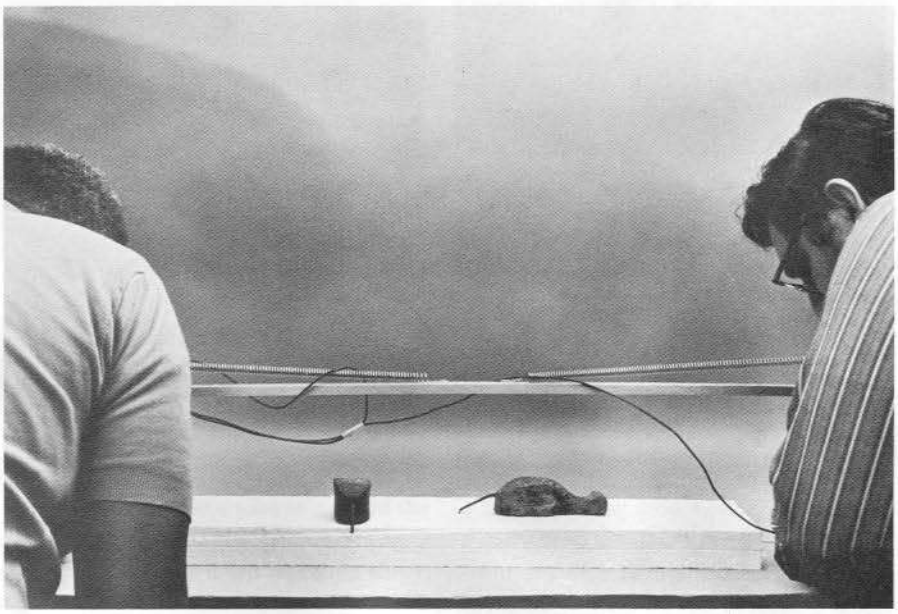
Install the servos, battery pack, switch, and receiver. Mount the wing servo, and install the pushrods to the aileron horns. Install the elevator and rudder pushrods. Set the servos to neutral and adjust the linkages.

Since the plastic model requires no paint, one need not remove the engine or equipment at this point. Instead trim the model with Trim Monokote, the decals provided, or any of the many fuel-proof decals available. Add the wheels, and this model will be ready to fly. Among the other models in the same category are the Dee Bee Alpha, Pilot 177 Cardinal and Gull, Lanier Sprint 25, and Dubro Sportsman 600.

Komet

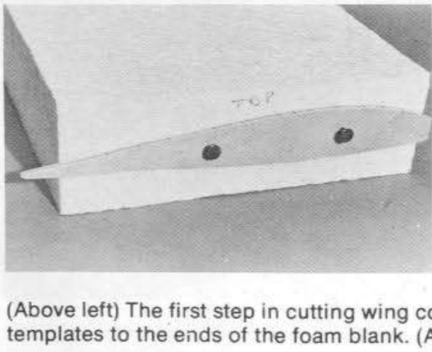
The Komet is a full-house, .60-powered sport and stunt model which illustrates the process of covering foam wings as well as some advanced modeling and finishing techniques. We don't recommend it as a first airplane, but it is a good plane for anyone who has progressed through the Sweet Stik and Skywagon classes of models.

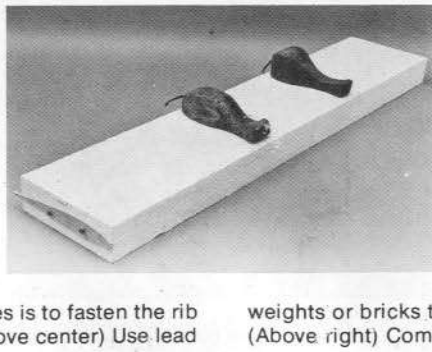
Covered polystyrene-foam wing and stabilizer cores have been popular for some time, particularly in high-performance competition models and in plastic models. These cores may be either molded to shape—they are available for many models—or cut from foam blanks with hot wire and templates. The latter weigh somewhat less. The cutting rig needed is expensive unless you contemplate cutting several cores over a period of time. The cutter is a length of .03" Nichrome wire with a spring-loaded bow to keep the wire taut. A transformer with an output of 18 to 36 volts at 6 amperes provides the current.

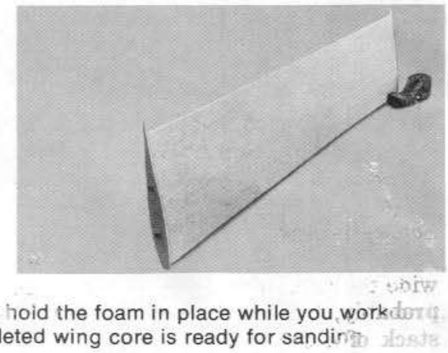


Four hands are a necessity when you cut wing cores from foam plastic.

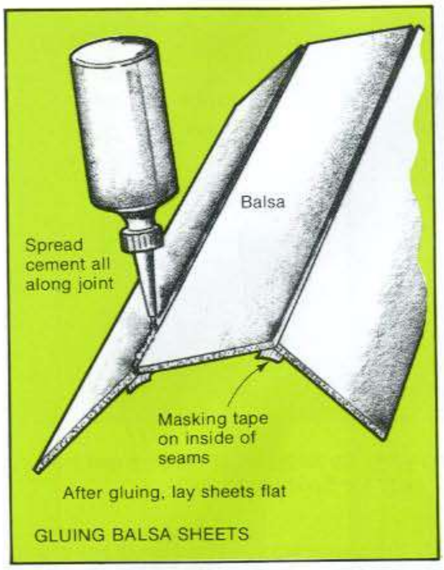
Cut or buy foam blanks approximately the size of the wing. Trim them so they are rectangular for purposes of alignment. Make root and tip airfoil templates from plywood, drill them for locating pins, and attach them to the ends of the foam blank. Their location is determined by the wing sweep, if any, and by any twist between the wing root and tip. The templates should have small run-in and run-out ramps at the starting point.

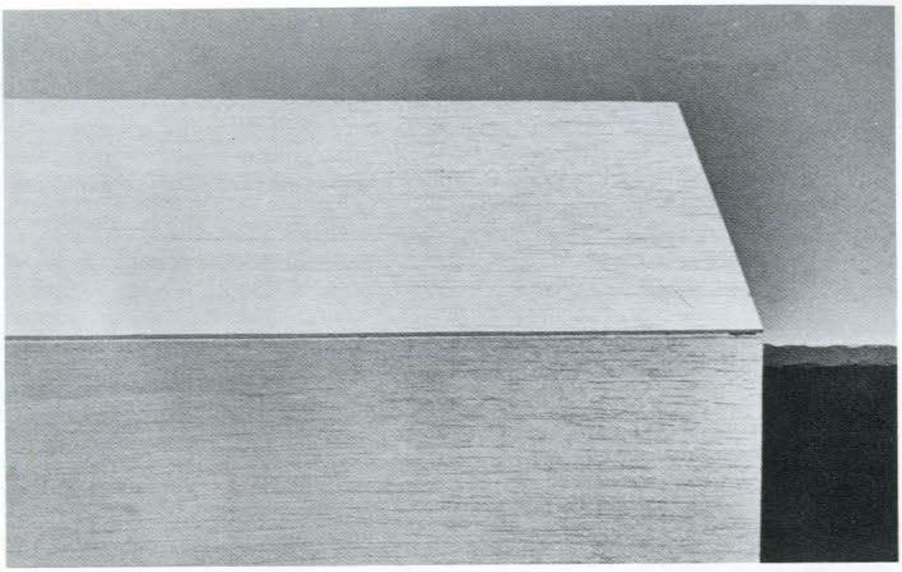


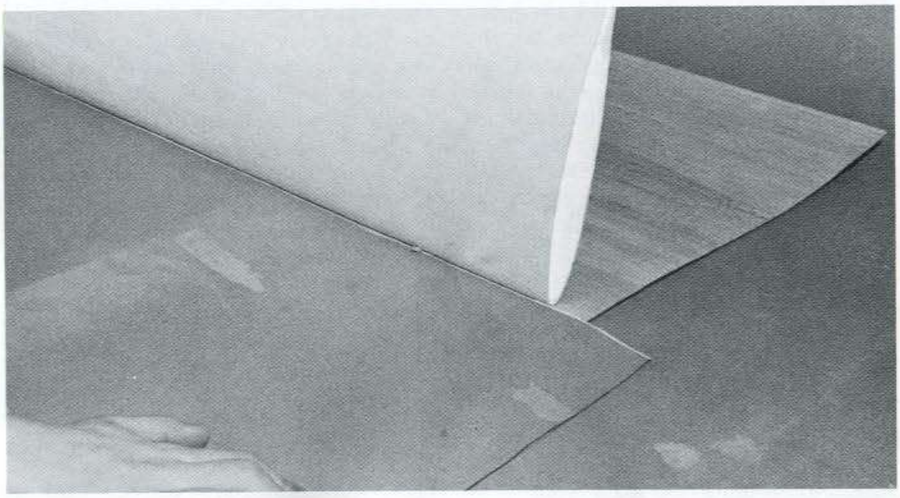




(Above left) The first step in cutting wing cores is to fasten the rib templates to the ends of the foam blank. (Above center) Use lead weights or bricks to hold the foam in place while you work. (Above right) Completed wing core is ready for sanding.







The easiest method for butt-gluing sheets of balsa involves using tape to create a hinged joint (top). Covering a foam wing core with balsa requires patience and skill (above).

Cutting cores is a bit like learning to fly—it takes practice and a good helper. Practice first on scrap, not on your wing blanks. When the wire is at the proper temperature, start moving it evenly through the foam. Moving it too fast will cause the wire to sag and dish the core; moving it too slowly causes rough ridges to be formed. Practice until you and your helper can make a smooth, even cut.

After you have cut the wing cores (or purchased them) locate the landing-gear blocks and any other required wood inserts, such as spars, trailing edges, leading edges, and wing-mount blocks. You can cut slots for these items in homemade cores with a soldering gun and a homemade tool such as that shown below right. Attach the inserts with epoxy, if at all possible. If you must use white glue, allow at least 24 hours drying time before covering the cores.

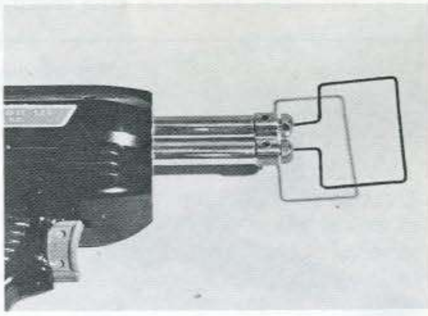
The cores for the Komet are molded to shape with slots cut for the fixed landing-gear blocks and with the leading edge squared off to accept a balsa leading edge. The balsa leading edge is not common; most often the wing covering is simply formed around the leading edge.

Foam cores can be covered with hard poster board, sheet balsa, thin plywood, plastic, Dacron/polyester mat, or fiberglass/epoxy mat. The home builder should stick with balsa or plywood. The last three materials require knowledge of the specific application, structural characteristics, and construction process.

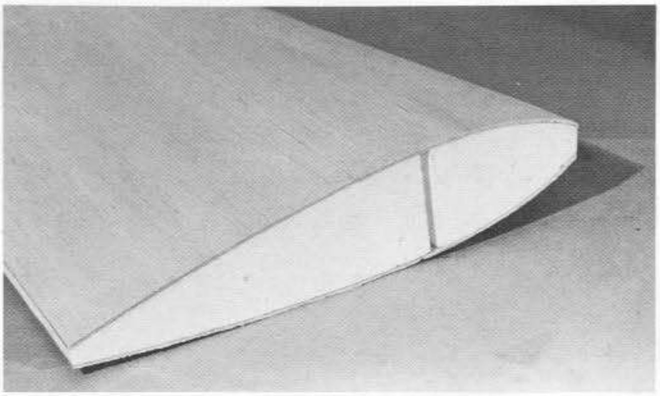
The next step is to prepare the skins for covering the foam-plastic cores. Plywood can be purchased in sheets large enough to use without joining. Some kits provide one-piece balsa skins ready to use; others may provide two ...le pieces that must be joined. More ...ably, though, the kit includes a ... a dozen or so 1/16" or 3/32" sheets of balsa 4" wide and 36" long. From them you must construct two wing skins 24" x 36". The sheets will probably not have straight, nick-free edges, so you must create them.

Stack the sheets and align the ends and edges as best you can. Now run masking tape up over each end to pull the stack together. Drive a large straight pin all the way through the stack at each end so the sheets won't slip. Set up a table or radial-arm saw to rip slightly narrower than the narrowest sheet. Feed the stack of strips through and check to be sure that all the sheets are even on the side just cut. Move the rip fence closer to the blade to cut the narrowest strip, and feed the stack through again, cutting the other side this time. All the strips are now the same width and have straight edges, a necessity if twisted wings are to be avoided. If a saw is not available, you can do a good job by pinning the stack of sheets to the work surface so they are even with the edge, and then sanding them with a long sanding block.

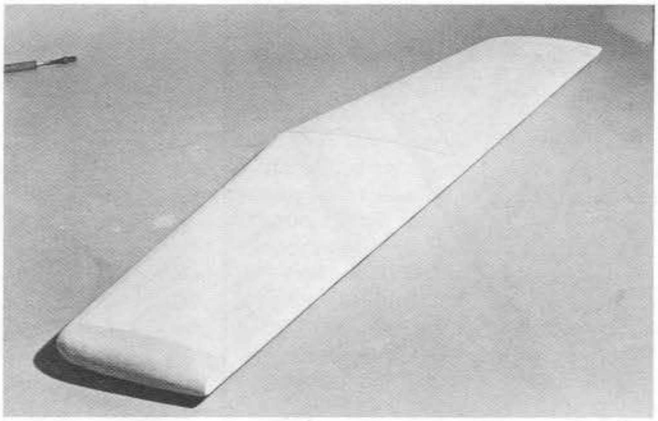
Use Franklin Titebond glue or Ambroid cement to join the sheets. White glue is difficult to sand, and epoxy precludes the use of polyester filler. Select the two softest pieces for the leading edges and set them aside. Take the first two pieces to be joined, butt them tightly and evenly, and tape the entire length of the joint with ¾"- or 1"- wide masking tape. Flip the two sheets over and move them out over the edge of the workbench to hinge open the joint.



You can make a tool for cutting and shaping foam from a soldering gun and No. 16 copper wire bent to any appropriate shape.



The balsa skin has been cemented to the foam wing core, and the wing is ready for the balsa leading and trailing edges to be attached. The slot is for the wing joiner.



Here is the Komet wing after the addition of leading and trailing edges and tip blocks, ready for finishing.

Spread a thin line of cement all the way along the joint, close the joint, apply a few pieces of tape to hold the joint closed. Repeat the procedure for the next joint. Use the soft pieces you set aside for the middle sheet—the fourth of seven, for instance. Proceed until an entire skin for one core is completed. Set it aside on a flat surface to dry and weight it down. After both skins are completed, sand them until they are smooth and even, using a long sanding board or (gently) an orbital sander.

The skins for the wings of the Komet are made up in four pieces because they must be butt-joined to the balsa leading edge rather than wrapped around the leading edge of the foam wing core.

When the skins are complete and all inset blocks and leading edges are in place on the cores, apply the skins to the cores. Sand the cores lightly and use a vacuum cleaner to remove all traces of dust from the cores and the skins. Use a contact cement that will not attack the foam core. Suitable cements are available at hobby shops and hardware stores. With a 1" brush or a spray can, give the entire core and one side of the skins a thin but complete coat of contact cement. Set the cores and skins aside so the cement can dry for 10 to 15 minutes. With a sponge, wet the skin which must wrap around the leading edge. Wet it only on the uncemented surface. Lay out two pieces of brown wrapping paper or waxed paper somewhat wider than the wing chord, and find someone who can lend a hand.

Position the core above the skin with the leading edge centered over the middle of the prewetted center sheet. When you are satisfied with the alignment, press the leading edge of the core down firmly onto the center of the skin. Now place a sheet of paper over the skin next to you so that adhesion cannot take place. Slide the paper right up to the contact line at the leading edge. Now roll the core down toward you until it lies flat on the paper. Don't let the other half of the skin flop around. Lay the other piece of paper over the top half of the wing core, but let a gap of about an inch remain between the paper and the leading-edge bond line. Have your helper hold the core solidly while you begin forcing the skin to adhere to the core, working back from the leading edge. Use thumb pressure for the first inch or two, and run your thumb along the length of the wing from root to tip to make a good bond.

As you work, have your helper rotate the wing core so that it is always solidly against the work surface directly under the chord line where you are applying pressure. Keep sliding the paper back toward the trailing edge. As you move into the flatter area of the wing use the heel of your hand to apply pressure. Use firm pressure, keep the core evenly against the work surface, and avoid twisting or pounding the assembly.

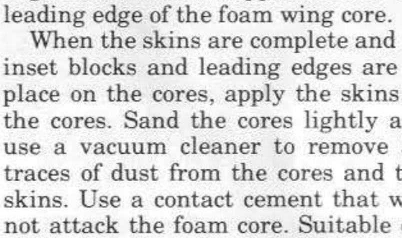
Once half the skin is attached, turn the wing over and attach the other side in the same way. Trim the sheet along the root, tip, and trailing edge. Because a very tight bond between the tip blocks and the end of the wing is necessary, trim the end of the wing, including some of the core, with a table or radial-arm saw. If you can set up the saw to cut the dihedral angle exactly, cut the root of the wing the same way; otherwise use a sharp knife and sandpaper.

Join the two completed wing panels in the way described for the Skywagon. Since there is no plastic joiner, use at least 2"-wide fiberglass tape and epoxy or polyester to strengthen the center joint. Attach the tip blocks, shape the ailerons, hinge them to the trailing edge, and cut out the balsa over the slots in the hardwood landing-gear block.

The landing-gear block is, of course, hidden under the skin. Measure from the plans to find it. If you are in doubt, probe the skin with a pin until you find the block and the slot in it. Place the landing-gear retaining clips over the slot and cut away the balsa under them.

The remainder of the Komet is constructed much like the Falcon 56. One difference is the formed plastic top deck. Attach it with a bead of Ambroid cement—not too much, though, or the plastic will be softened.

A careful check of the alignment of all surfaces is important. We finished our model by applying dope over a covering of Silron.

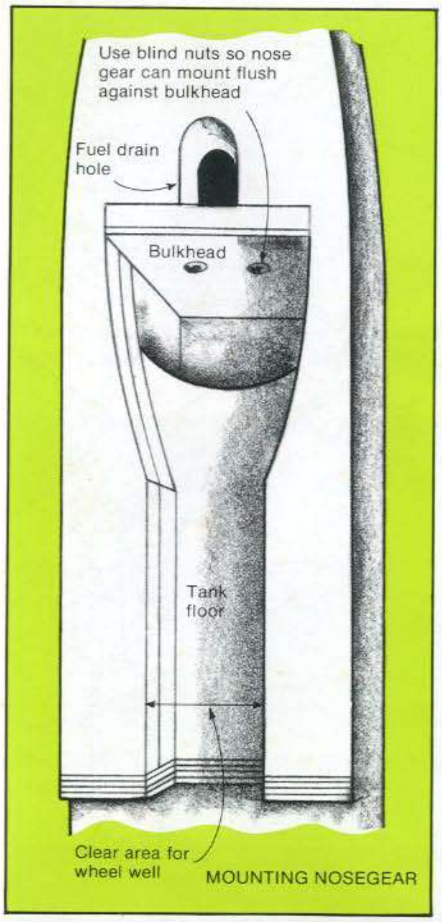


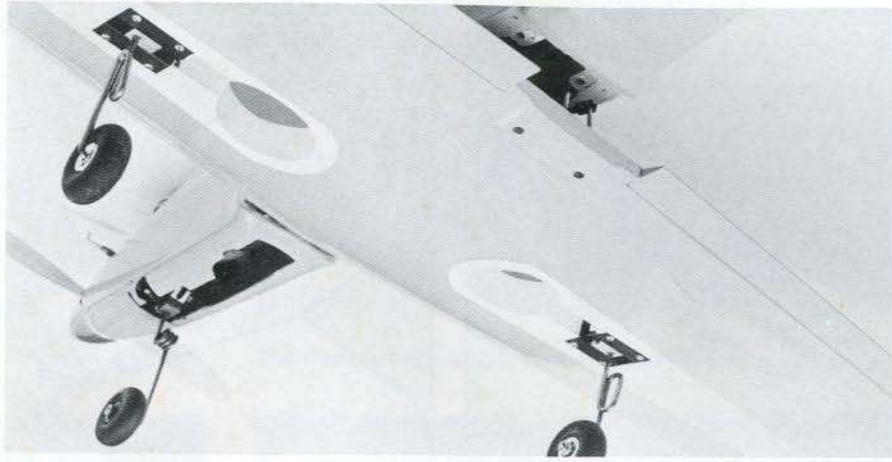
Tiger Tail

There are many manufacturers of retractable landing gears and many types of landing gears: tricycle, conventional, electrically operated, servo-operated, and pneumatically operated. Retractable gear can be controlled by a separate channel, by switches at the extremes of throttle travel, or by a pulse-omission detector. There are far too many types to cover here; we shall describe a few general practices.

To illustrate retractable landing gear we chose the Tiger Tail. It is a full-house competition model which benefits significantly in flight from installation of retractable gear.

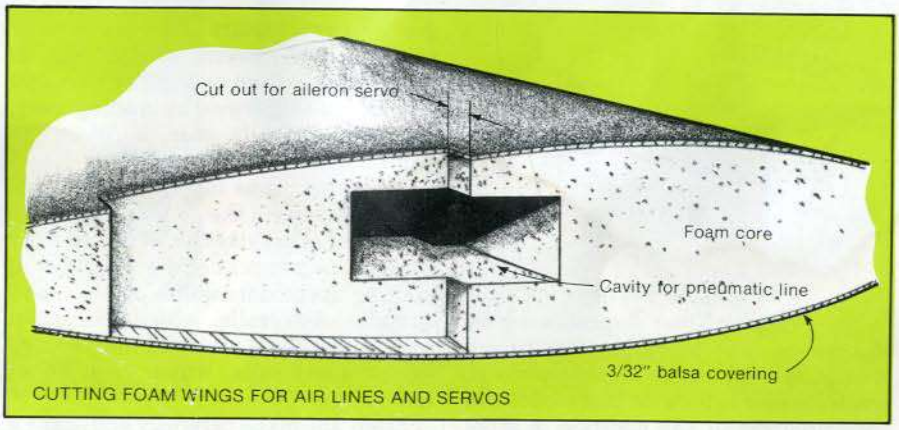
Almost all retracts mount the same way. The nose gear mounts to the firewall and retracts into a hole in the lower nose block. Because of gear length, it is necessary to cut a cavity in the leading edge of the wing. If a non-retract model is being modified, the usual wing-mount dowel must be replaced with two, one on either side, and the structural integrity of the wing





Retractable landing gear reduces air resistance and looks prototypical.

Some retractable landing gears are actuated by pneumatic systems, which are faster and more powerful than servos. The pneumatic system can be triggered by a servo.

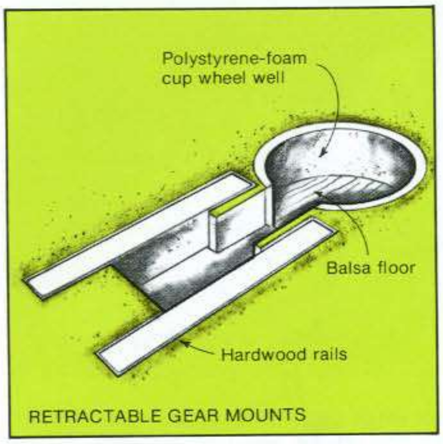


must be ensured by the use of fiberglass tape and epoxy over the wing center joint, with an added layer over the section removed to accept the nose wheel.

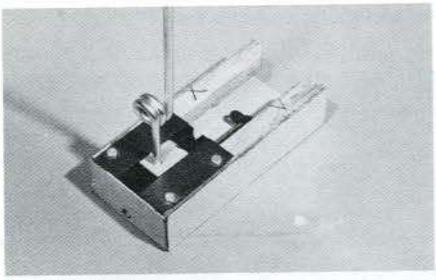
A heavy plywood firewall (preferably ¼" thick) must be used for the nose retract unit. Position the gear and check for proper alignment, both retracted and extended. Remove sufficient material to allow free movement of the steering arm. When you are satisfied with the alignment, mark the mount points, drill 3/64", and use 1/2" No. 4 sheet-metal screws for the quickest, simplest attachment. A little more insurance can be added against eventual loosening by using 4-40 machine screws and blind nuts.

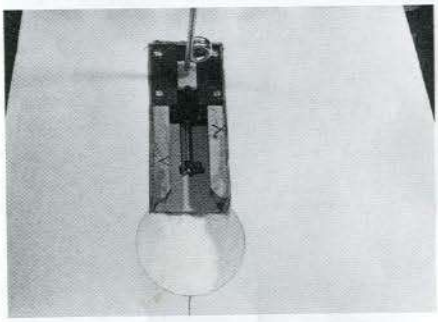
The main gear is mounted in cavities in the foam wing core. You can build mounting rails to cover a span of 4" or more that are attached to the wing skins and the foam core with epoxy. More simply, a plywood box can be built and inset into the wing with shorter mount rails in the box. The wheel well can be edged with sheet balsa or a section of a styrofoam cup. Attach the gear with ½" No. 4 sheet-metal screws. You can also use 4-40 nylon bolts into tapped holes to form a breakaway mount that will prevent structural damage in a hard landing.

The means of actuating the gear determines the kind of linkage needed. For pneumatic systems such as the Romair we used in the Tiger Tail, the pressure tank can be located in the aft fuselage cavity with the filler located on the fuselage side. A servo-actuated shuttle valve to control pressure to the individual gear cylinders is located in the fuselage. Pneumatic lines are led to the nose gear and the main gear. Nosewheel steering is controlled with nylon cord or No. 22 stranded wire. Completely electric gear requires only routing and tunnels for the leads and access to the connectors. Mechanical landing gears actuated by a single servo require a servo thrust of 6 pounds or more and usually 180 degrees of servo travel. The servo is mounted in the wing cavity with the aileron servo. Adjustable linkage connects the landing-gear servo to

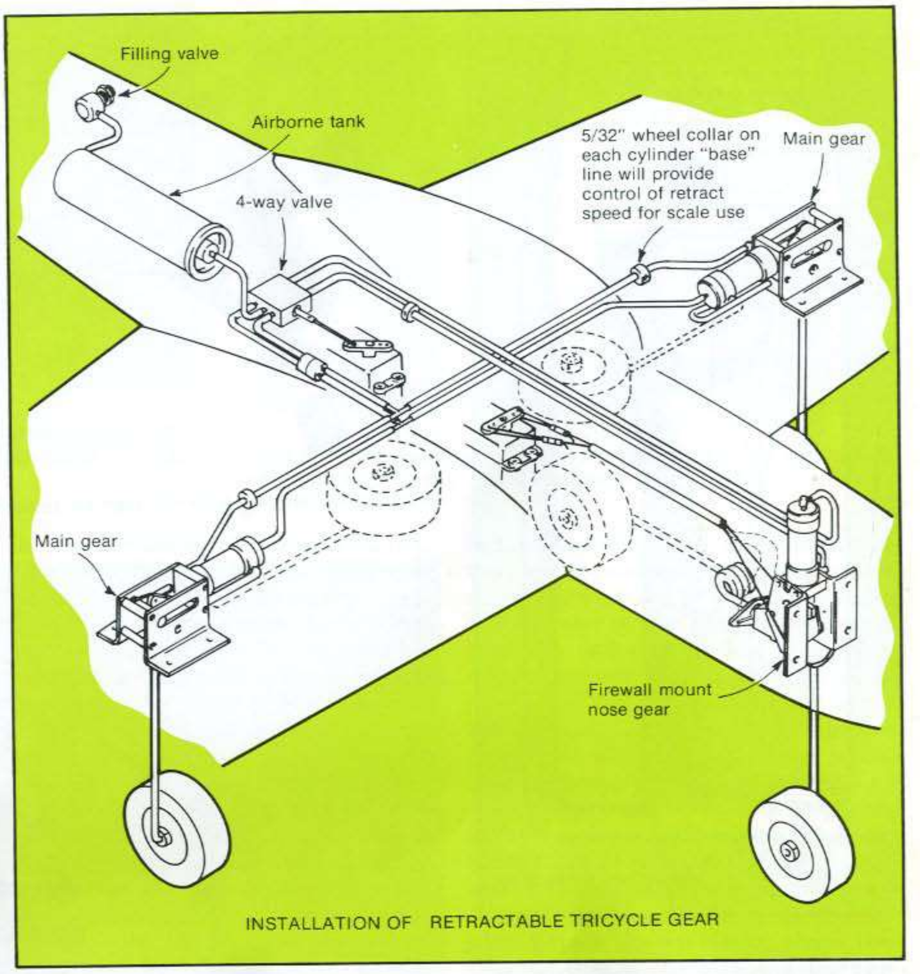


RETRACTABLE GEAR MOUNTS





A small plywood box with hardwood mounting rails simplifies the job of installing retractable landing gear.



INSTALLATION OF RETRACTABLE TRICYCLE GEAR

the mechanical retract gear. Connection to the nose gear is usually complicated by the need to remove the wing. A removable link normally overcomes this problem.

Construction of the Tiger Tail is similar to the construction of the Komet. We chose to use a new finishing technique: lightweight fiberglass cloth attached to everything but the control surfaces with a polyester resin. The control surfaces were filled with polyester resin without cloth. The color coats were acrylic lacquer.

Flexible Flyer

The Flexible Flyer is presented for the person who enjoys building from scratch. In addition, a beginner can teach himself to fly with this model and then progress by the addition of more control and more power.

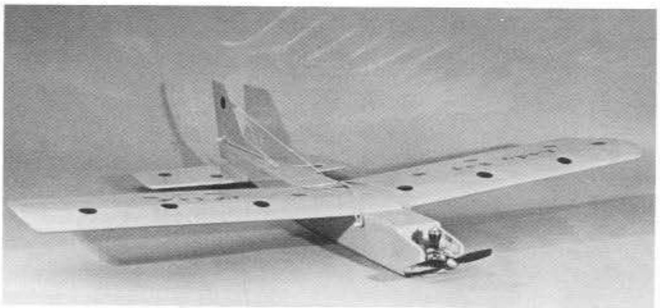
Plans for the model are shown on page 46. Full-size plans are available for the Flexible Flyer model by writing DJT Enterprises, 118 Central Ave., Gaithersburg, MD 20760. The plane is called the Flexible Flyer because it can be flown initially with a good .049 engine, no landing gear, one or two digital channels, or with pulse proportional gear. As you acquire skill it is an easy step to a more powerful engine, such as the Cox Medallion or the Tee Dee .049 engine, and lightweight landing gear. Later full tricycle gear, a .10 or .15 engine, and three channels can be used in the same plane for advanced training. In fact, with the last combination, the center of gravity can be moved back to about 30 per cent of the wing chord, making the model capable of inside and outside loops, rolls, wing-overs, snap rolls, and almost all other maneuvers, except axial rolls, which require ailerons.

Study the plans carefully and make a list of the materials you need. The 39" wingspan requires purchasing 4-foot pieces of balsa; the leftovers can be used for ribs.

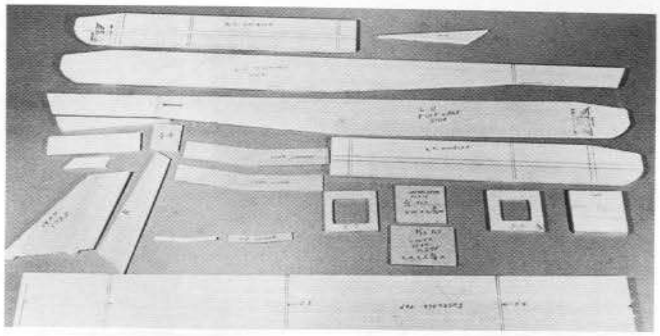
The most tedious construction chore is cutting out the ribs. Use a modeler's knife, a jigsaw, or a band saw. First cut the wing rib pattern from the plan. Then contact-cement it to a piece of 1/16" plywood. Working carefully, cut the rib pattern to shape. It is best not to cut the pattern exactly to the line. Cut a little outside the line and then sand it to the final shape.

Drive two small brads through the plywood pattern so that their points protrude about 1/16". With the balsa sheet lying on a flat surface, press the pattern down so the brads penetrate the balsa and prevent the pattern from slipping while you cut around it with a sharp knife. For the first 18 ribs, ignore the notch at the leading edge of the pattern. This notch is cut only in the four center ribs. Next cut four center ribs from 3/32" balsa. They must be cut to permit the addition of 1/16" sheeting over the center section. It is not necessary to recut the plywood rib pattern; just move it down 1/16" to cut the top line and up 1/16" to cut the bottom line.

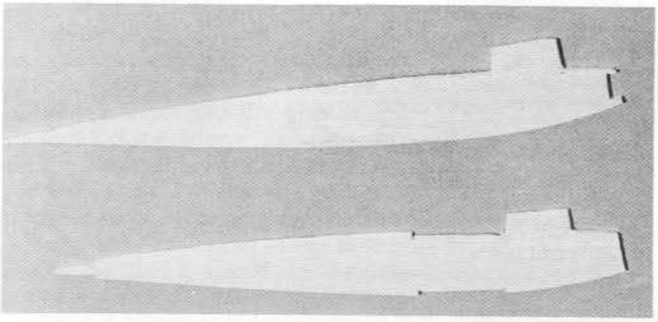
With all the ribs cut and sand... select eight 1/16" x 1" ha... and trailing-edge pieces a ... than the length of the wing



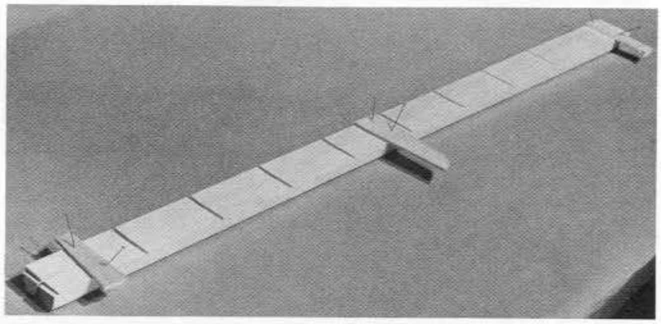
The Flexible Flyer can be built to fly with a small engine and no landing gear or with a large engine and landing gear.



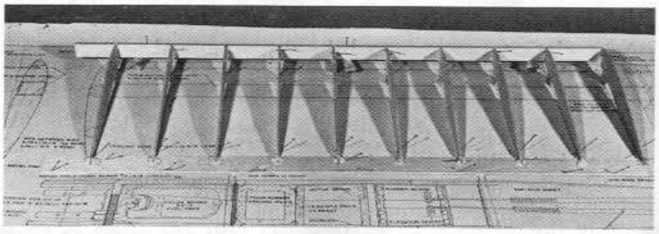
The Flexible Flyer is built fundamentally from a homemade kit.



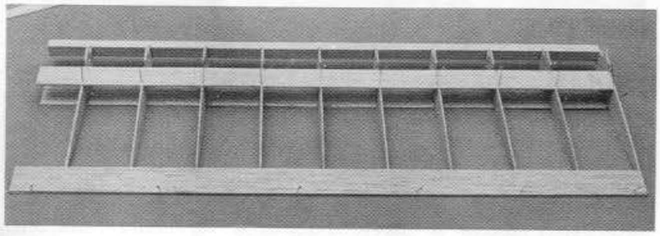
The outer and inner wing ribs, above and below, are cut from 1/16" and 3/32" balsa, respectively.



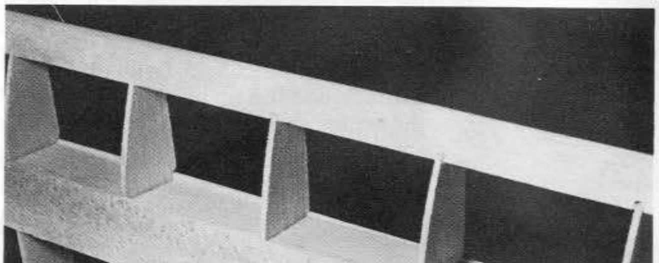
Cut notches in the leading edge of the wing to accommodate the ribs. Do both halves at the same time to ensure symmetry.



Pin down the leading and trailing edges on the plan, and then glue the ribs to them, using pins to hold everything in place.



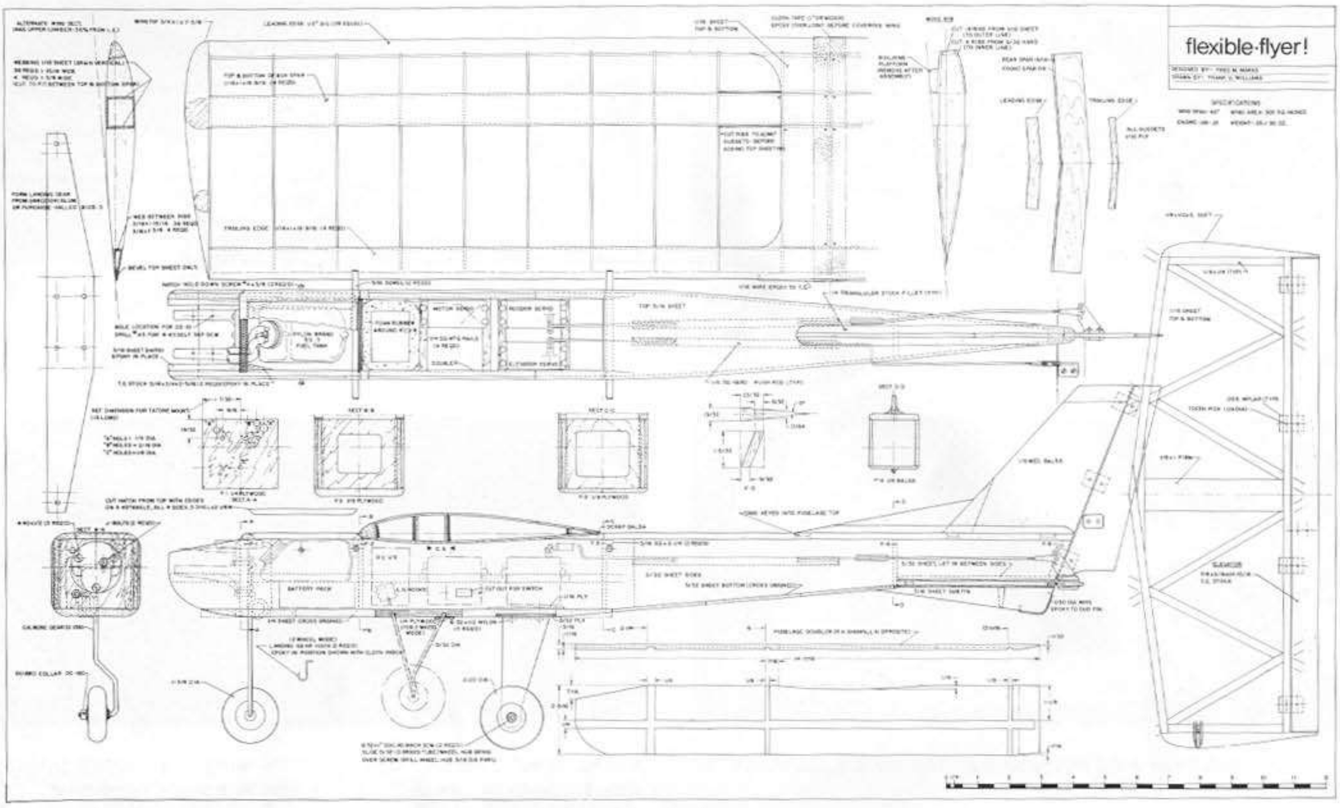
Remove the wing from the plan, turn it over, and glue the bottom spar in place, using pins to hold it while the glue dries.



Add webbing between the ribs and the top and bottom spars to form a box-shaped spar. A precise fit is important for strength.

The joint at the center of the wing requires plywood braces, clamps, and pins. Use white glue or epoxy, not hot-melt glue.

They will be trimmed to size later. Preformed stock is used for the leading edge and need only be cut to the proper length and notched for the ribs. Build each wing panel as follows: Pin down the bottom sheet for the trailing edge. Use a number of pins to hold it down flat. Space nine of the 1/16" ribs along the wing panel and pin them down at the trailing edge so that they are vertical and directly over their location on the plan. Also pin in place the 3/32" rib next to the center rib, but omit the center rib until later. Once all the ribs are pinned down, the pins in the forward part of the trailing edge can be removed. Glue in the top spar. Pin it both front and back, because it must assume the curvature of the wing. Prepare the preformed leading edge by cutting it to length and marking the loca-



tion of the ribs. With a saw cut a notch at each rib location 1/16" deep and 1/16" wide for the nine outer ribs and 3/32" wide for the two inner ribs.

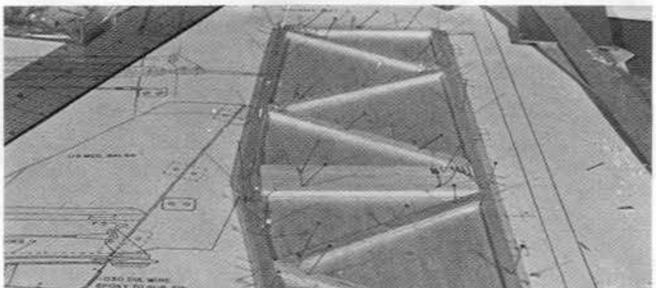
Carefully block up the leading edge so that at least three points are at the same height. Bevel the top trailing-edge sheeting with a plane, a knife, or sandpaper so that it provides about ¼" of surface for bonding to the lower trailing-edge sheet. Glue the beveled sheet in place and pin the entire trailing-edge assembly down at several places to make sure it does not warp. While the wing is pinned down, install the web pieces that go between the top and bottom of the trailing edge. They add tremendously to the strength and warp resistance of the wing.

The easiest way to add the web piece is to cut a strip that fits between the top and bottom sheets and then cut it to fit between the ribs. Glue the pieces in place at each location. Let the wing assembly dry thoroughly before moving it from the board. The bottom spar will be put in place later.

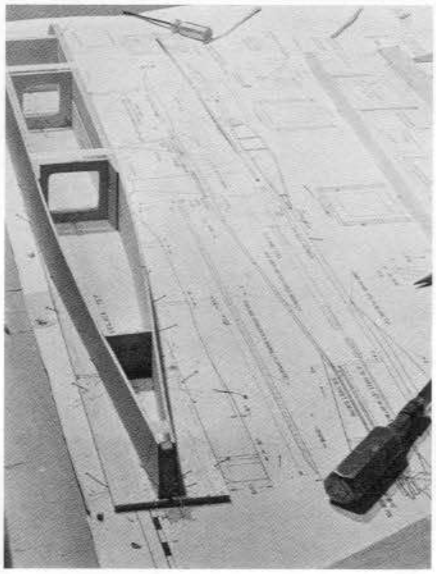
After the wing assembly has dried completely, take out all the pins, carefully remove the wing from the board, and turn the wing over. Pin down the trailing edge, the aft edge of the top spar, and each rib so that the wing is again held in rigid alignment. Glue the bottom spar in place and let it dry thoroughly. While it dries, you can cut the webbing that fits between the spars.

To join the wing panels, cut the 3/32" ribs away from the leading and trailing edges and the spars and set them aside. Fit the dihedral gauges to the leading and trailing edges and the spars. Cut the dihedral angle as described for the 2-T. Cement the plywood joiners to the left panel and let them dry. Remove 1/16" from the four cut lines of each 3/32" rib and cement them in place again, observing the dihedral angle for the first rib. Cement the joiners to the right panel, pin the left panel down solidly, and block up and align the right panel as described in the notes on alignment for the Falcon 56. Cement the ribs in place, add the tip blocks, and glue on the center sheeting. Sand the assembly smooth.

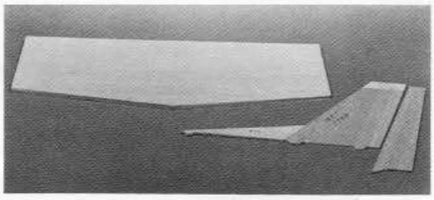
Add sheeting to the center of the wing. The curved edges of the sheeting prevent concentration of stresses.



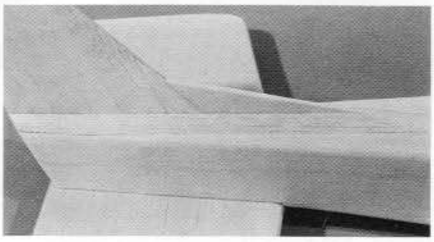
The horizontal stabilizer is simply a frame covered with balsa ... stabilizer is ready for the top sheeting.



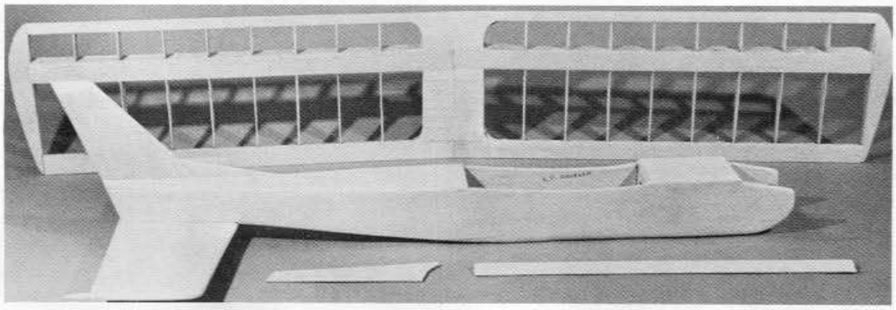
You can mark the position of the bulkheads, the formers, and the sides right on the flat top sheet of the fuselage.



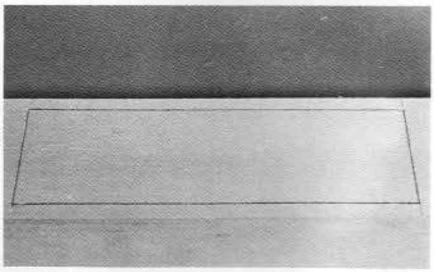
Construction of the vertical and horizontal stabilizers is an easy job.

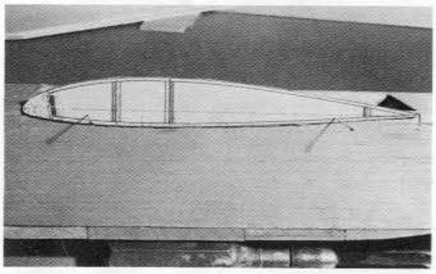


The alignment of the stabilizers is critical. The two filler pieces in the angles between the vertical stabilizer and the top of the fuselage strengthen the vertical stabilizer.



Here are the completed wood parts—fuselage, wing, rudder, and elevator.





Cutting the wing crutch is best done in two steps. First cut a rectangular opening in the top of the fuselage, and then use the rib pattern to cut out the sides.

Construct the stabilizer directly over the plans. Pre-cement and join the vertical stabilizer parts on a flat surface. Laminate the doublers to the fuselage sides. Mark the locations of the firewall and fuselage formers on a single sheet of ¼" soft balsa 3" x 26", using a pencil and a square. Mark the center line of this piece from front to back. Pin the sheet solidly to the work surface over the top view of the fuselage.

Proper alignment of the fuselage is automatic if the fuselage doublers are grooved. Use a table saw or razor saw to cut these grooves. Use a combination square to mark the top sheet where the bulkheads cross. Follow the instructions for the fuselage in the section on the Falcon 56.

Glue the sides and bulkheads F-1, F-2, and F-3 together with white glue. Add the bottom sheet and the landing-gear plates to the assembly, and let it all dry at least an hour. Then pull the fuselage sides together and cement them to F-5, add F-4, and pin the sides rigidly to the top deck. Be sure to center bulkhead F-5 over the center line. Let the fuselage dry overnight.

Turn the fuselage over, pin it down again, and cement the stabilizer in place with the tips blocked to equal heights. While the stabilizer dries, cement the vertical stabilizer and the triangular reinforcements to the fuselage top. Be sure to check for the right angles between the vertical and horizontal stabilizers. Next cut the wing saddle. Use the rib-pattern center line to set the position and mark for cutting. Make the cut in the top of the fuselage with a razor saw, and cut the sides of the fuselage with a knife. It is best to make a horizontal cut first and then trim it on a 5-degree downward slant to match the dihedral angle of the wing. Drill the fuselage sides for the wing dowels and fasten them in place with white glue.

If you use an .049 engine, drill the firewall for the engine back plate and mount the engine with small wood screws. Install the pushrods and the radio equipment to make sure they work properly, but remove them before you paint or cover the model. We covered ours with Monokote.

When you are ready for a more powerful plane, simply replace the Golden Bee with either of the more powerful .049 engines listed earlier. Lead ballast must be added to the front compartment until the model balances at the frontmost center of gravity when using the small engines.

To install landing gear and a larger engine first drill the plywood plate for the main gear and mount the gear with clips or bolts. Remove enough of the lower ¼" sheeting to accept the nose-gear coil. Drill holes for the J-bolts that hold th[illegible] nose gear. The plans show a T[illegible]minum mount which must be drilled to accept the upper J-bolt. The Midwest T-bar mounts need not be drilled, but they do require cutting 3/16" from the upper end of the Goldberg nose gear. Position the engine mount and drill the firewall to accept it. Attach the mount and the engine as described for the Sweet Stik. Cut the hatch from the top block, and drill the firewall for the fuel lines and the throttle linkage. The raw balsa exposed by cutting should be coated with epoxy to prevent it from being soaked by oil. Install the fuel tank and the fuel lines. Add the servo for the third channel, and rebal[illegible] it is best to start [illegible]ity forward and then move it back as you gain confidence in flying.

The Flexible Flyer is quite rugged. One of ours has made more than 300 flights. Another survived a 200-foot vertical dive after the wing bands came off. (We forgot to put on enough; the Flexible Flyer needs six ¼" x 3" rubber bands to hold the wing on.) If the wing should break, remove the covering in the area of the break, realign the wing, and epoxy 1" x 3" fiberglass strips to the spar and the leading and trailing edges. Then re-cover the broken area and refinish it. We made such a repair in half an hour using 5-minute epoxy and Monokote. The model is still flying.

Equipment installation

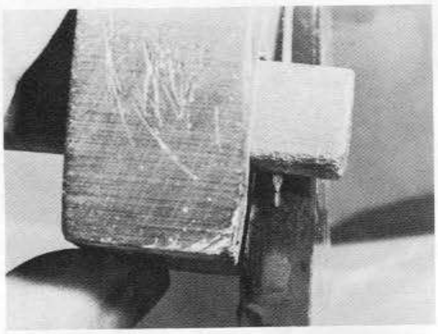
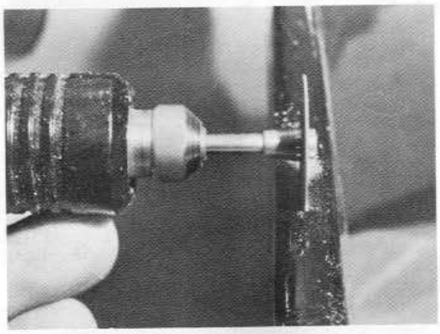
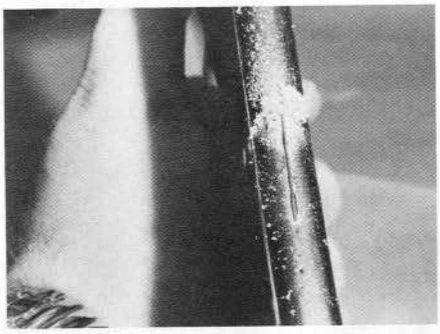
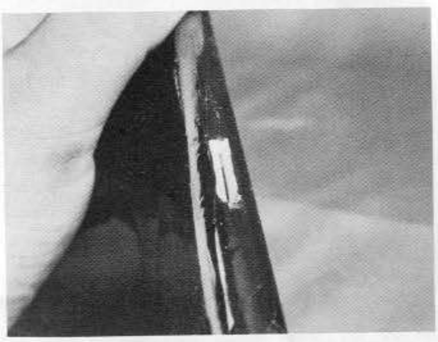
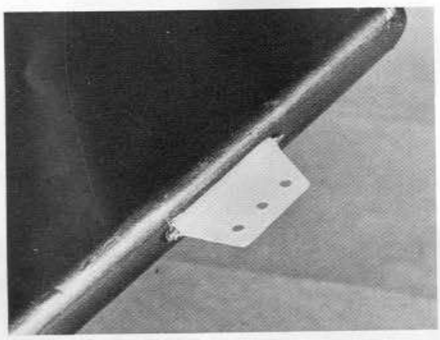
Equipment Installation: Here are some general notes on installation of equipment in model airplanes. The installations shown are typical.

Hinges: We prefer pin hinges for all but the smallest models. Dick's Dream required figure-8 hinges made of control-line cord. This type of hinge is easy to make. First drill or punch small holes opposite each other in the wood. Take a 24" length of cord, coat the tip with glue, and shape the tip into a point. Lace the cord back and forth in a snug figure-8 pattern between the surfaces for several loops. Feed the last turn back through an adjacent hole for a snug fit, clip the cord off, and coat the area around the holes with white glue. The hinge must be snug so the control surface will not flap.

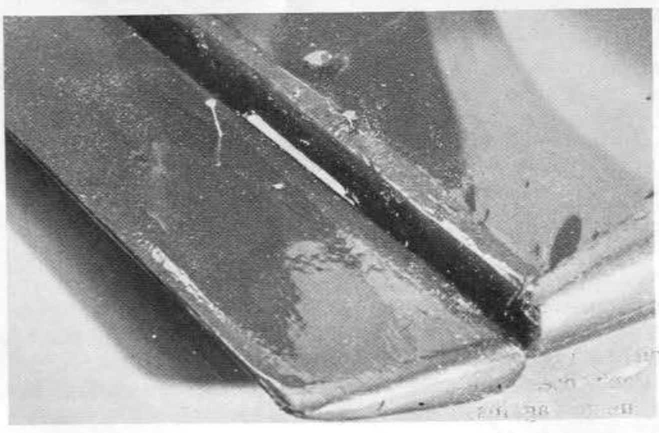
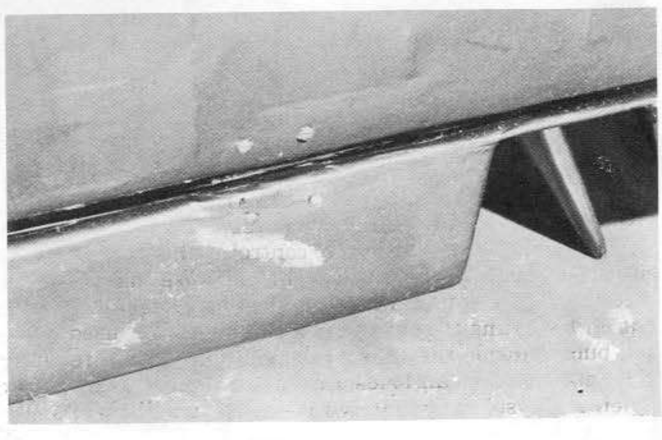
On the 2-T and the Ranger 42 we used polypropylene sheet hinges. To install them, cut slots in opposing edges of the fixed and movable surfaces. Insert the hinges with a tiny amount of glue on the ends. Mate the surfaces and slide the hinges into the slots. Drive pins or toothpicks through the surface and on through the hinges. Snip the pins flush with the surface.

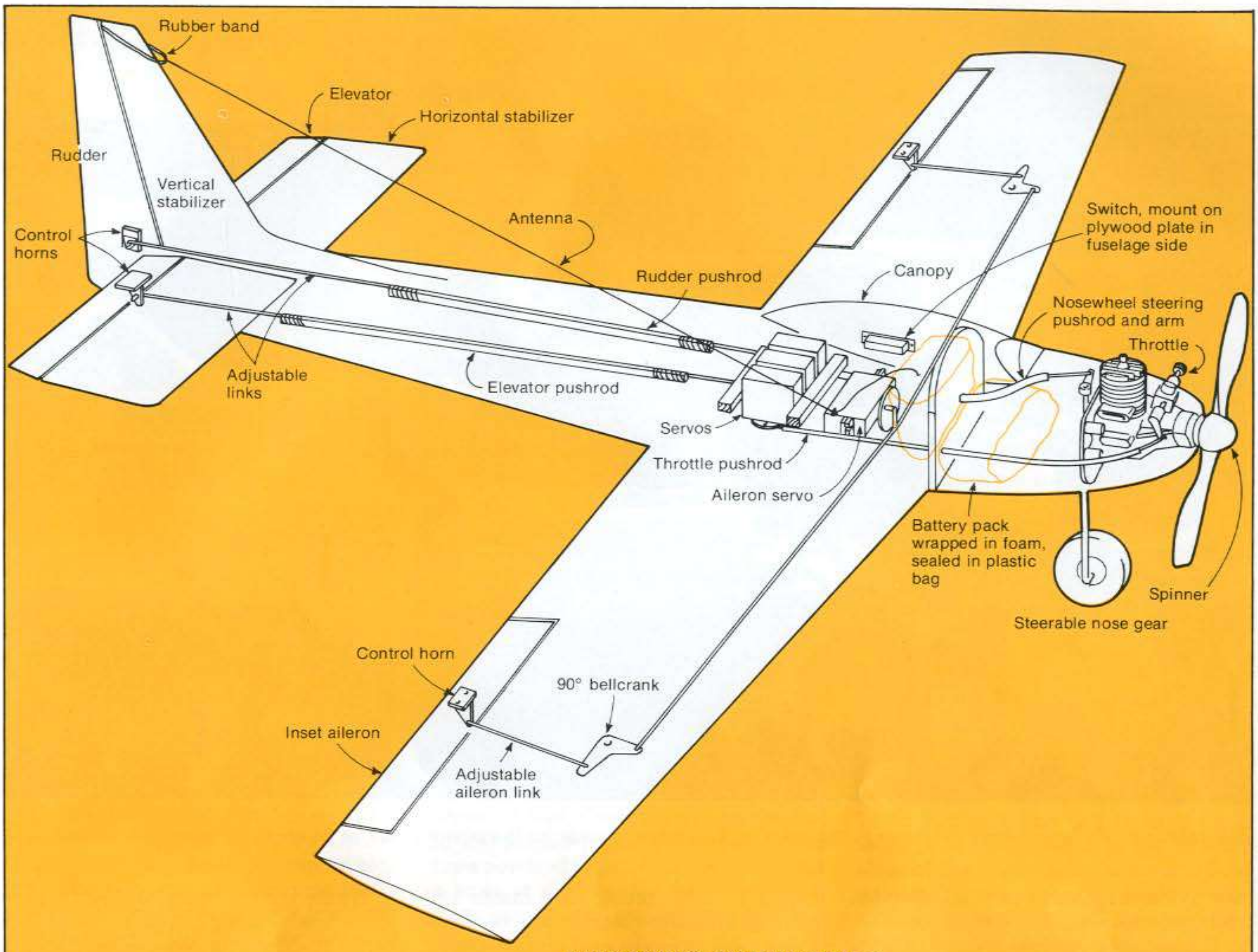
We always use pin hinges on larger planes such as the Falcon 56. The installation procedure is the same as that for the polypropylene sheet hinges. Be sure to use pins to retain the hinges. Do not rely on glue alone.

Occasionally you will see suggestions for making hinges of Monokote. Such hinges do not work as well as commercial hinges, and they are troublesome to make.

To install hinges, mark the location of the slot (above, far left), cut the slot with an abrasive disk in a motor tool (above left and above), cut a recess for the hinge (far left), apply a little epoxy to the leaf of the hinge and slip the leaf into the slot (left), apply another dab of epoxy and slide the movable piece—aileron, elevator, or rudder—onto the other leaf of the hinge (below left), and drive several small pins through the holes in the leaves of the hinges to strengthen the joint (below). Be very careful to keep glue away from the moving parts of the hinge, or you will no longer have a hinge.



BASIC CONTROL SYSTEM INSTALLED

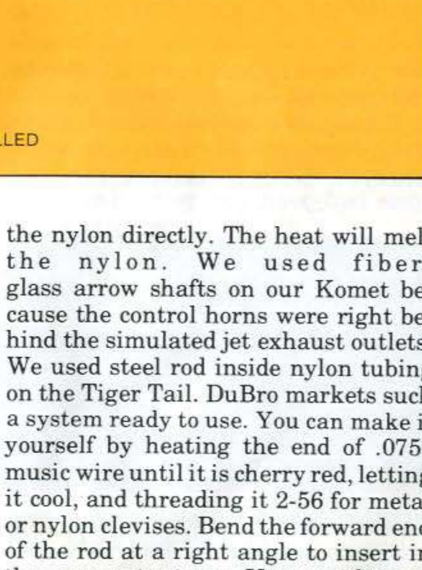
Control horns can be attached to the control surfaces with 2-56 machine screws or sheet-metal screws. The screws are usually provided with the horns. Always use the nylon nut plate that goes on the opposite side of the surface; do not depend on screws into the wood to hold the horn. If at all possible, locate the horn so that the line of holes for the pushrod is directly over the hinge line. Holding the horn in place, mark one hole on the surface. Drill the hole, and mount the horn with one screw through the horn, the surface, and the nut plate. Now mark the second hole after you have aligned the horn, drill the hole, and fasten the horn permanently.

Pushrods must be stiff enough not to buckle, and they must not bind. There are numerous commercial arrangements ranging from nylon rods to simple wood and metal rods. Most commercial systems work well. Don't use flexible cable for connections to control surfaces. Flexible cable is all right for throttle control or nose-wheel steering, but on long runs to control surfaces it can buckle inside the tube as the surfaces move against air loads. Do not use nylon rod systems for aileron connections; too much bind develops in the 90-degree bend to the ailerons. The best arrangement for conventional ailerons is the arrangement shown with the Sweet Stik.

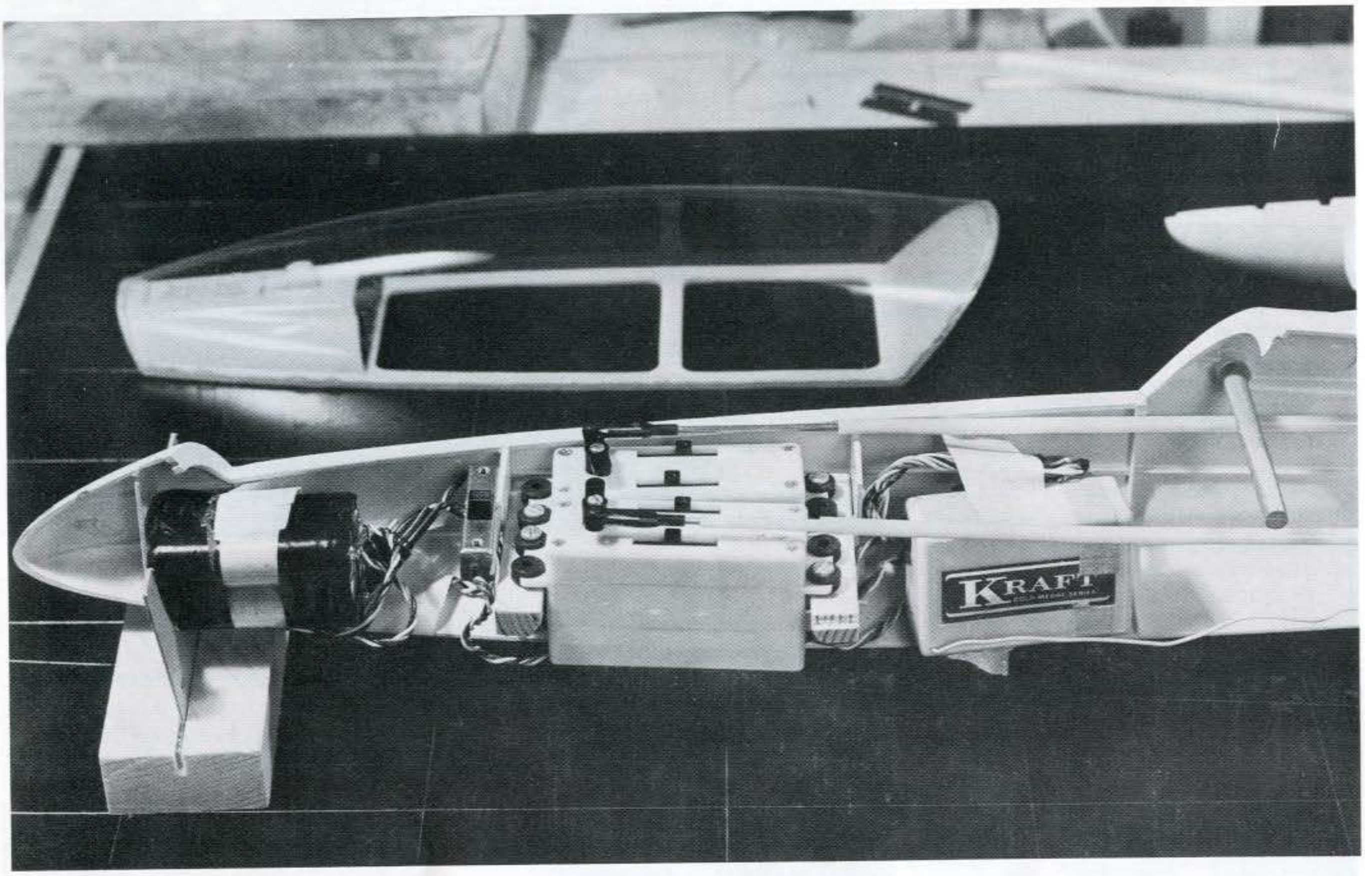
One of the best pushrod arrangements where an absolutely straight run is possible is that of a steel rod inside a nylon tube. Much cheaper and almost as good is a length of hard balsa with threaded links attached. Fiberglass arrow shafts are excellent but at some penalty in weight; birch dowel also works well.

Most of the different types of pushrods are illustrated with the example models. Dick's Dream uses a torque rod for rudder control. The 2-T uses a pushrod made of 3/16" square hard balsa with 3/64" music wire at the front and threaded rod and nylon clevises at the back. Connection of the rods to the wood is easiest if Dacron thread is wrapped around the rod and the wood and then is coated with glue. We used this arrangement for the Ranger 42, Falcon 56, and Sweet Stik.

We used nylon rods on the Sky Wagon, attaching them with hot-melt glue. One caution: Don't press the small tip of a Weller glue gun against the nylon directly. The heat will melt the nylon. We used fiberglass arrow shafts on our Komet because the control horns were right behind the simulated jet exhaust outlets. We used steel rod inside nylon tubing on the Tiger Tail. DuBro markets such a system ready to use. You can make it yourself by heating the end of .075" music wire until it is cherry red, letting it cool, and threading it 2-56 for metal or nylon clevises. Bend the forward end of the rod at a right angle to insert in the servo output arm. Use any of several kinds of retainers to hold it. Install



CONTROL HORN INSTALLATION

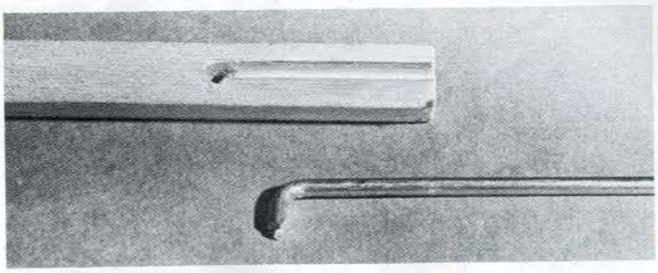


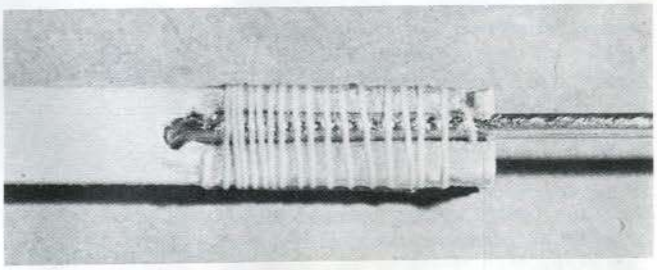
Installation of R/C equipment in gliders is the same as for planes, except for the obvious lack of an engine and a throttle servo.

the nylon sheath as you would a nylon rod, but make sure it is straight.

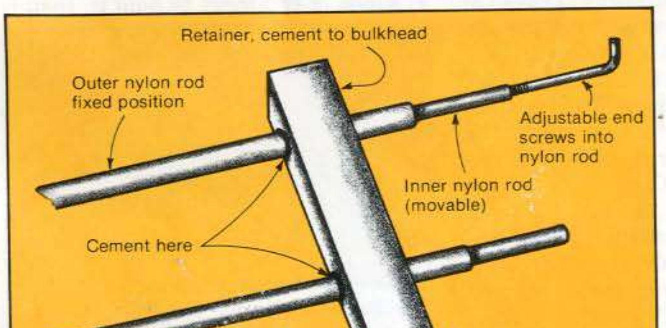
Connections to the throttle and the nose-wheel steering horn are almost always nylon rod, flexible cable inside nylon, or 1/32" music wire inside 1/8" tubing. Metal-to-metal contacts sometimes used to cause radio interference; better receivers have now virtually eliminated the problem.

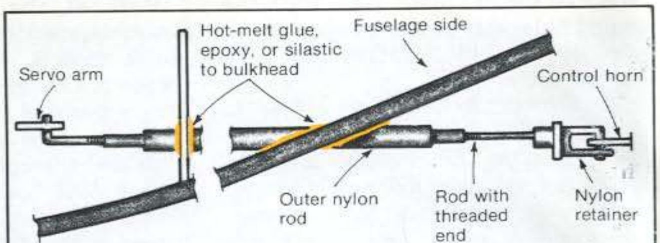
Numerous commercial throttle overrides are available. You can also thin down the throttle servo output arm as illustrated on page 25 and have an equally effective override.



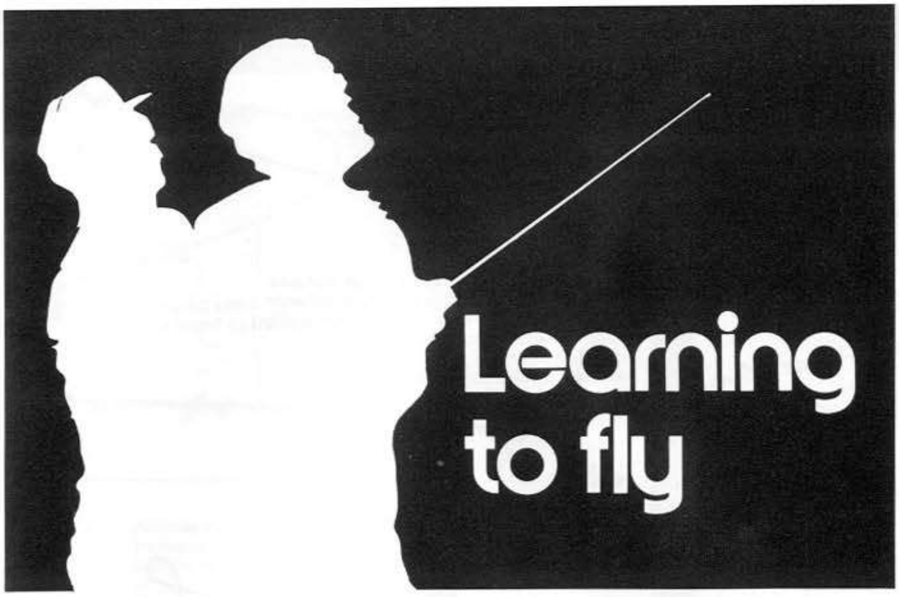


In order to fabricate a metal-to-wood joint in a pushrod, bend the end of the metal rod at a 90-degree angle, cut a groove and drill a hole in the wood, and fasten the parts together with epoxy and a wrapping of thread.





(Left) To anchor nylon control rods, glue a wood retainer to a bulkhead, pass the rods through it, and cement the outer, fixed nylon tube to the retainer. (Above) Use a similar method to form a neat joint where control rods pass through the side of the fuselage.



Learning to fly

One of the authors once had the gratifying experience of helping a novice through his first flight. As the plane came in to a landing a warm smile came over the beginner's face and he said, "I've dreamed my way through that flight a hundred times." One of the best preparations for flying a radio-controlled model is to learn beforehand what to expect.

Let's assume that you have built a Flexible Flyer, 2-T, or Dick's Dream and have installed one channel of control. Further, you are learning to fly alone. The pre-flight checks are first. At home, check the plane for center of gravity, balance, and alignment according to the manufacturer's plans. The center of gravity is shown on the plans and the instructions. Try to balance the plane by supporting it on the tips of your thumbs underneath the wing near the fuselage (not at the wing tips). With your thumbs at the specified center of gravity, notice if the plane tips forward or backward. If the nose dips, move some of the weight toward the rear. You probably can shift some of the R/C gear or the batteries to the rear. If the plane is tail-heavy, move some of the weight forward. Only as a last resort should you add lead or solder to balance the plane, since that adds to the total weight. The balance point of the plane must be at the location specified for the center of gravity before you attempt any glide test.

Look the plane over thoroughly for cracks, breaks, loose nuts, binds in the control linkages, and weak points. Check the radio for freshly charged batteries. Test it for ground range as specified by the manufacturer and for proper response of the rudder to transmitter commands. Make sure you have rubber bands, a fresh glow-plug battery, an extra glow plug, clean wiping rags, and such items as pliers, screwdrivers, glow-plug clip, wrenches, fuel [illegible]er bulb, fast-drying cement or 5-minute epoxy, pins, and scrap balsa for shims.

At the flying field, test-glide the plane. Be sure you have a calm day (wind 5 mph or less). Turn on the transmitter and receiver, and gently launch the plane directly into the wind with the engine not running. Launch it level—neither nose-down nor nose-up—and with enough force to carry it about 75 feet. Correct any aberrations in the plane's performance before you try a powered flight. Make adjustments a little at a time, and adjust only one item, so you can see the result of the change.

The first item of business for the powered flight is to again check the radio ground range. Then start the engine. Check to see that the rudder responds properly to transmitter commands. Launch the plane into the wind, just as you did when you test-glided it. This is the moment of truth.

The plane should start a gentle climb straight out. Allow it to gain some altitude and gently turn it to the right or to the left by moving the transmitter stick slightly. Do not overcontrol—this is a common beginner's mistake. Control in small increments as you are learning. After a while you will be able to anticipate what the plane is going to do and will be able to apply the proper corrections. Continue gentle turns and increase the altitude to 200 or 250 feet. Always keep the plane upwind from you, so that if you make a wrong move, the wind will blow the plane back toward you. If the plane travels downwind, it can fly farther and farther away and perhaps disappear. It is wise to have your name, address, and phone number on a card inside or on the model.

When the engine quits, prepare to land the plane. It won't come crashing down out of the sky immediately, so you have a moment or two to decide what to do. Plan to make your first few landings in tall grass. Do not attempt a landing on pavement until you've had some experience. Circle the plane back toward you (assuming it is upwind, where it should be) until it is about even with you on the downwind leg. Now you can judge the plane's altitude and glide angle. It should be fairly easy to estimate how far downwind to fly the plane before starting the base leg across the wind. Again judge the glide angle, and let the plane lose a bit more altitude if necessary. Now turn the plane upwind into the final approach. Your most important task is keeping the wings level. Later you will be able to adjust the glide angle to make the plane land right at your feet; for now, though, keep the wings level and prepare to do a little walking. It is better to walk a few yards to pick up a whole airplane than to carry home in a bushel basket the pieces of a plane that landed right at your feet.

Occasionally you will find you cannot land into the wind because there is insufficient altitude for turns. In those cases, keep the wings level, land the plane downwind, and start walking.

With a rudder-only plane, a way to lose altitude quickly is to apply full rudder and hold. The airplane will go into a spiral. Neutralize the rudder at 75 or 100 feet, but be prepared for a zoom (a sharp increase in the upward slope of the flight path) and a stall. As soon as the nose comes up, apply rudder again momentarily until the nose stops rising. Neutralize the rudder and your plane will be in level flight again. Timing is critical, and you should attempt a spiral only after you have had some flying experience.

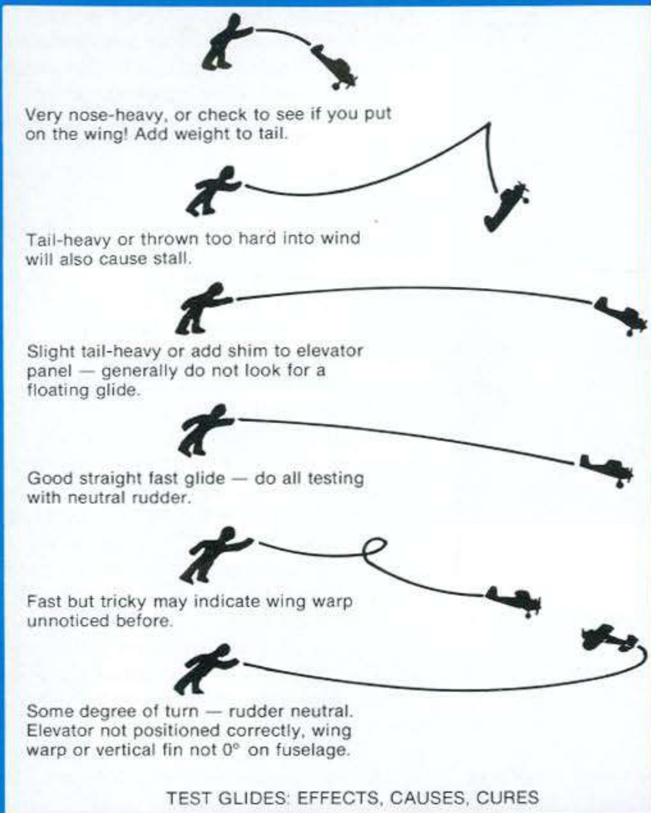
A safer way for a beginner to achieve a rapid descent is to circle the plane and then tighten the circle until the plane loses altitude. To stop the turn and level the wings again, apply opposite rudder briefly.

In general try to anticipate your airplane. As soon as the plane responds to a command, release the control stick. It is better to give several short commands than a long hard blast that must then be countermanded.

After you have gained experience you may want to try a few simple stunts and maneuvers. Stunts, generally speaking, are the result of building up speed. By now you have noticed that your plane will climb, if it is adjusted properly, when no rudder is applied. With a small amount of rudder the plane holds its altitude. Hard rudder held on builds up a spiral dive and increases the speed of the plane.

The speed can be turned into—with a rudder-only airplane—rolls, wing-overs, split-S's, and Immelmann turns. Planes with elevator and throttle controls have a much larger repertoire.

Begin all of these maneuvers with at least 200 feet of altitude. Enter a spiral



Very nose-heavy, or check to see if you put on the wing! Add weight to tail.

Tail-heavy or thrown too hard into wind will also cause stall.

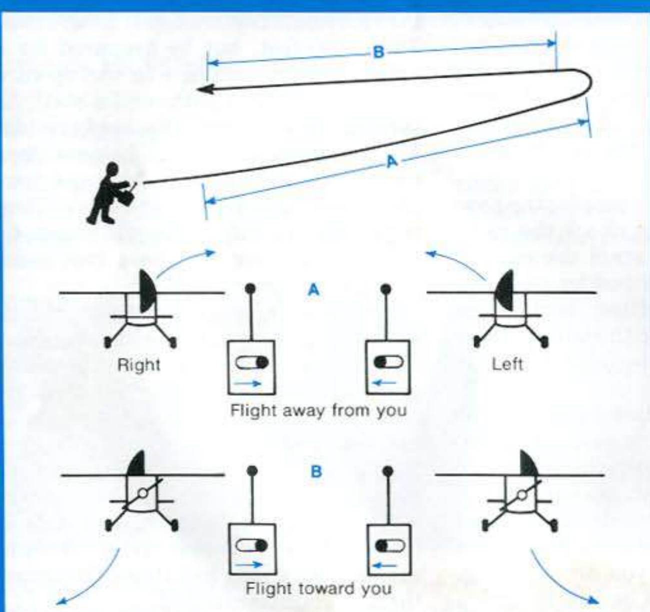
Slight tail-heavy or add shim to elevator panel — generally do not look for a floating glide.

Good straight fast glide — do all testing with neutral rudder.

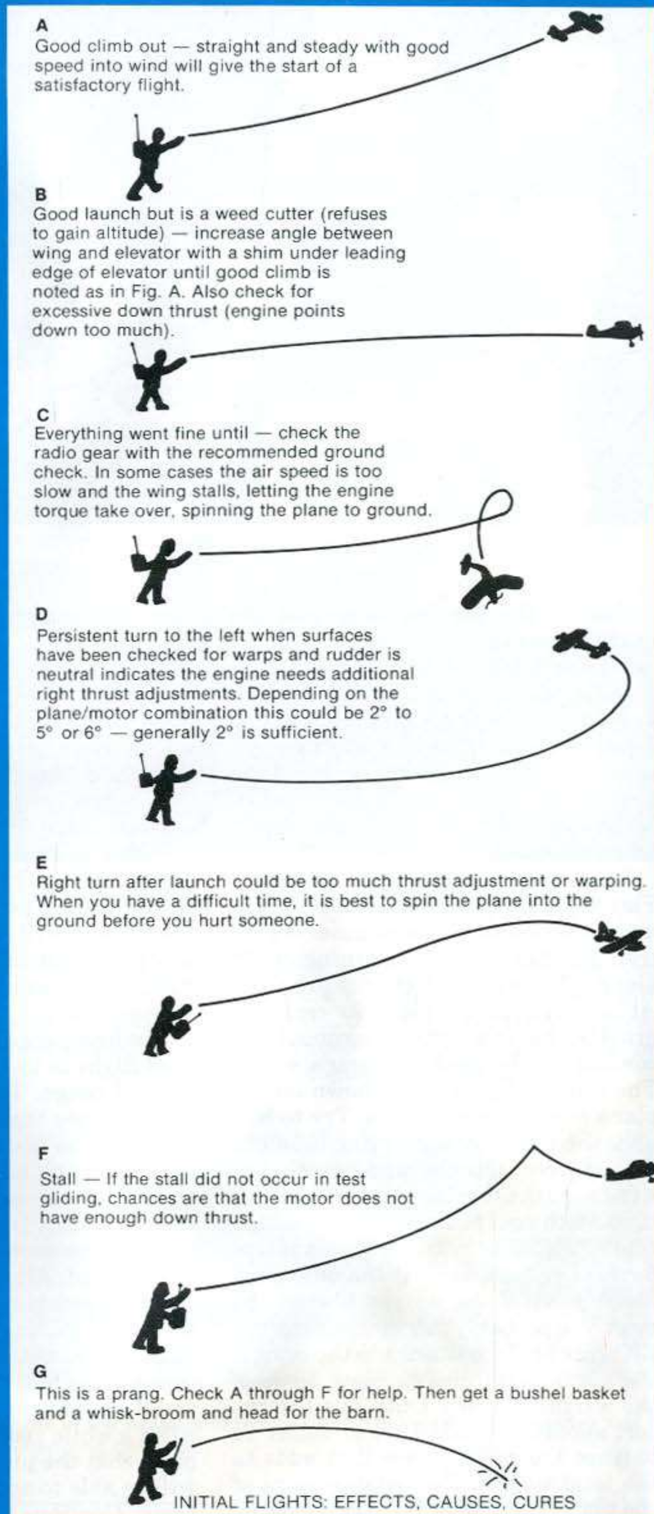
Fast but tricky may indicate wing warp unnoticed before.

Some degree of turn — rudder neutral. Elevator not positioned correctly, wing warp or vertical fin not 0° on fuselage.

TEST GLIDES: EFFECTS, CAUSES, CURES



Push wing up into turn desired with your stick thumb. This is by far the easiest method for remembering.



A
Good climb out — straight and steady with good speed into wind will give the start of a satisfactory flight.

B
Good launch but is a weed cutter (refuses to gain altitude) — increase angle between wing and elevator with a shim under leading edge of elevator until good climb is noted as in Fig. A. Also check for excessive down thrust (engine points down too much).

C
Everything went fine until — check the radio gear with the recommended ground check. In some cases the air speed is too slow and the wing stalls, letting the engine torque take over, spinning the plane to ground.

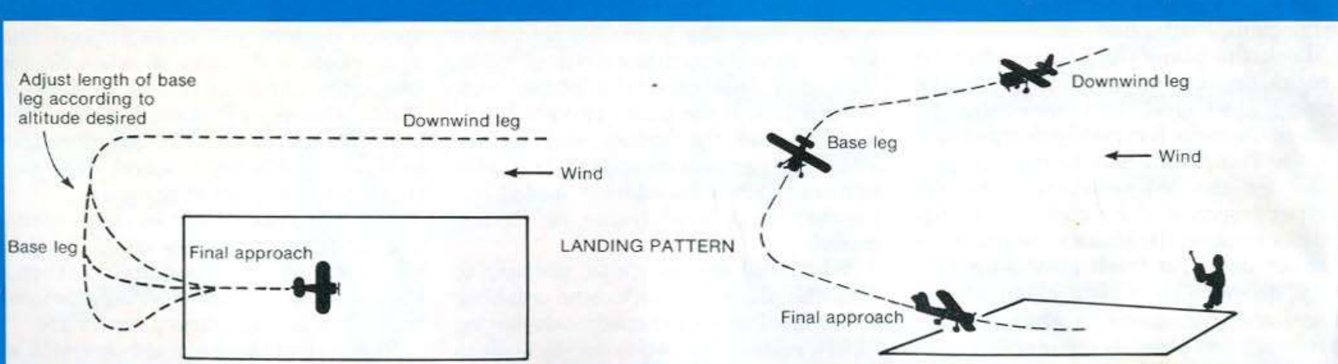
D
Persistent turn to the left when surfaces have been checked for warps and rudder is neutral indicates the engine needs additional right thrust adjustments. Depending on the plane/motor combination this could be 2° to 5° or 6° — generally 2° is sufficient.

E
Right turn after launch could be too much thrust adjustment or warping. When you have a difficult time, it is best to spin the plane into the ground before you hurt someone.

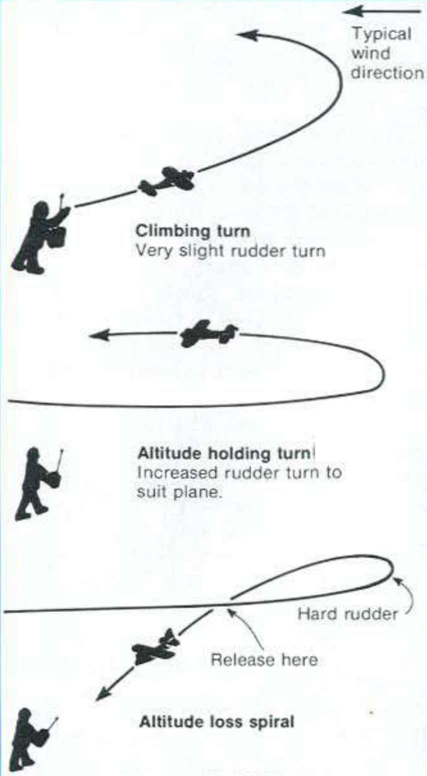
F
Stall — If the stall did not occur in test gliding, chances are that the motor does not have enough down thrust.

G
This is a prang. Check A through F for help. Then get a bushel basket and a whisk-broom and head for the barn.

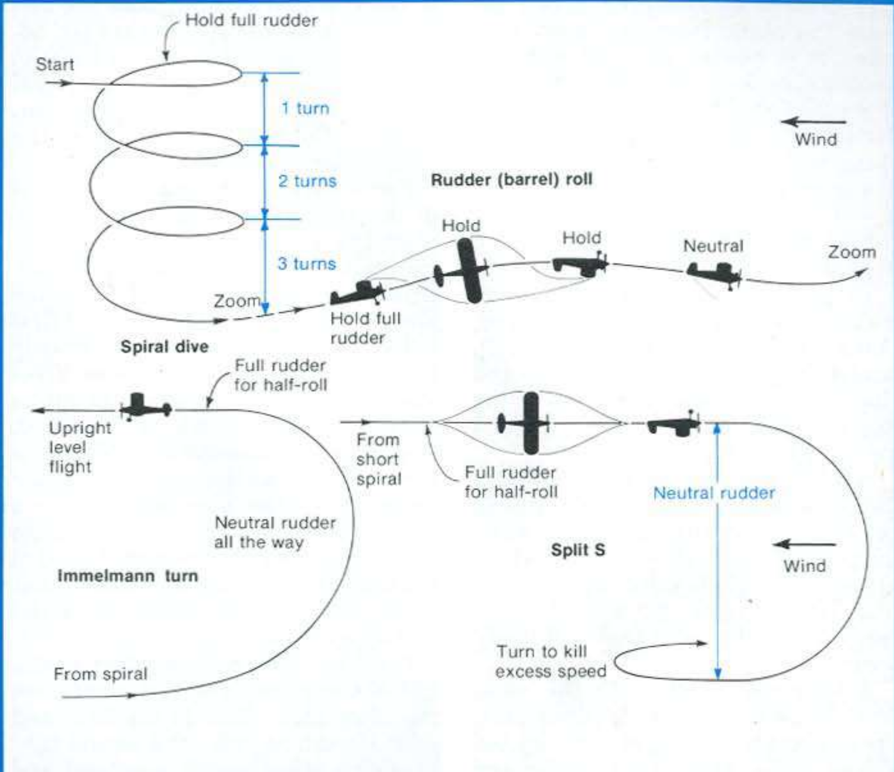
INITIAL FLIGHTS: EFFECTS, CAUSES, CURES



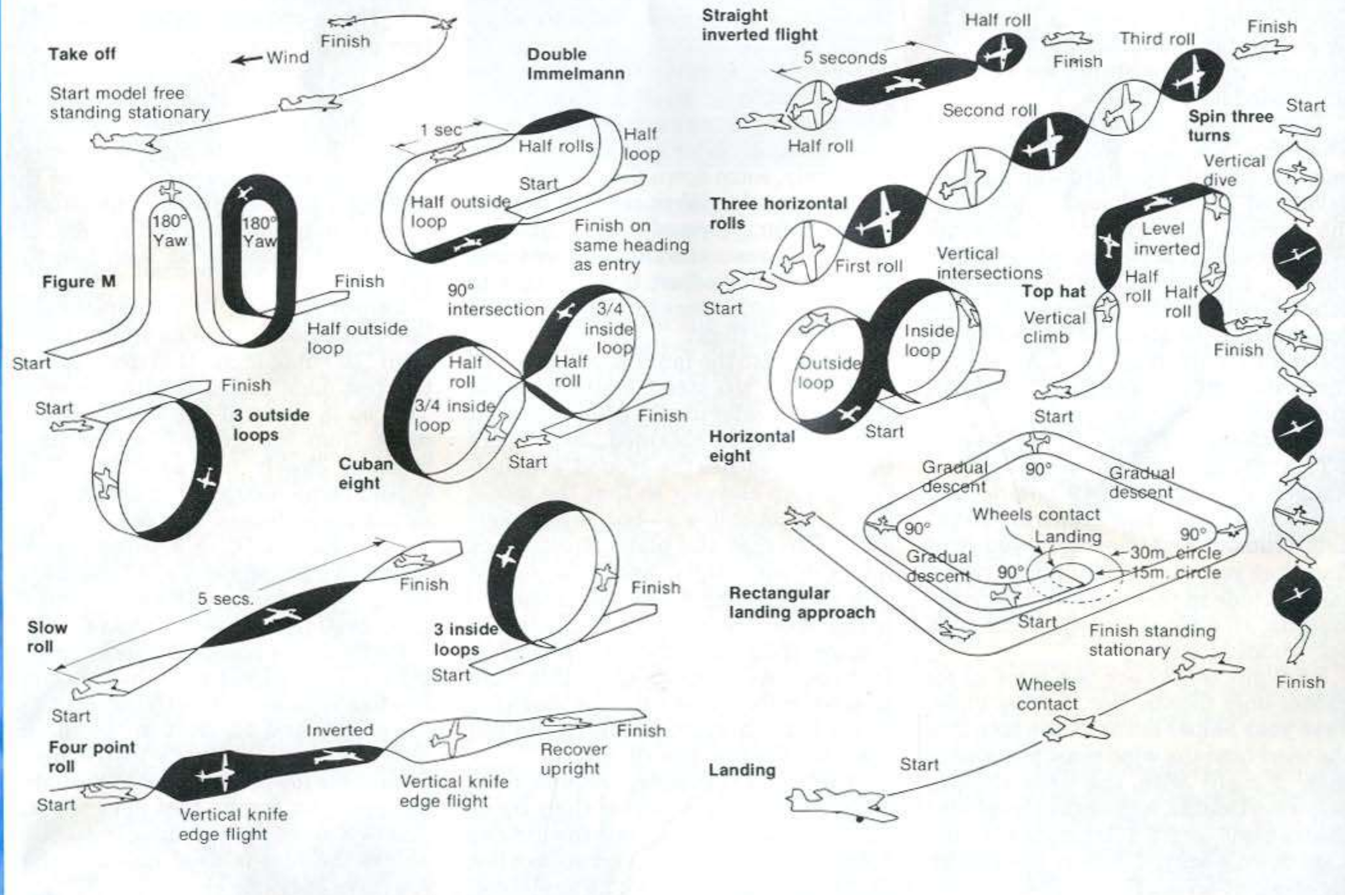
LANDING PATTERN



ALTITUDE CONTROL



STUNTING WITH RUDDER ONLY



F.A.I. AEROBATIC SCHEDULE

dive to build up speed. For a roll, release the plane from the spiral dive when it is headed into the wind by neutralizing the rudder. When the nose of the plane is about 45 degrees above horizontal, apply rudder and hold. The plane will make a horizontal spiral. The spiral or roll may be irregular, but it will be recognizable. Neutralize the rudder when the plane is right side up to resume normal flight.

To perform an Immelmann turn, make a spiral dive to build up speed. Come out of the spiral just as for a roll, but let the plane continue to climb and start an inside loop. At the top of the loop apply full rudder to roll the plane over into level flight.

A split-S requires more altitude than the other maneuvers. Dive and roll as before, but neutralize the rudder when the plane is upside down and the wings are level. The plane will complete half a loop. When it comes out of the loop, be ready to kill the zoom that will likely occur.

A wing-over starts with the usual dive. Allow the zoom to continue until the airplane is pointing straight up and almost stalls. Apply hard rudder and hold until the nose comes over to straight down; then neutralize to recover.

Other stunts, which involve going over the top in an inside loop, can be performed only by altering the trim. Considerable experience is needed to fly an airplane trimmed for these maneuvers, and these stunts are not recommended for beginners.

Takeoffs are beautiful to behold when they are done well. The surface must be smooth and hard—an asphalt pavement is ideal. Place the plane on the surface pointing into the wind. When ready, release the plane (don't push it) and correct any turning tendencies with gentle commands. Easy does it! Once the airplane has sufficient speed it will lift off by itself. Allow it to climb straight out and gain some altitude before beginning a turn.

Two-channel flying: If you have a 2-T, a Flexible Flyer, or possibly a Ranger 42 with an .049 engine and have installed two control channels—rudder and elevator—you will find that you can control pitch, maintain altitude in the turns, and flare the landing, all difficult or impossible with only rudder control.

Preflight checks are the same as for rudder-only flights. For the test glide, have your helper launch the plane into the wind (and the wind must be no more than 5 mph) with the nose slightly below horizontal. Adjust the elevator at the transmitter for a flat glide with the nose down slightly. Adjust the rudder for straight-ahead flight. The elevator and rudder adjustments interact in that any turn tends to produce the effect of down elevator, so keep adjusting at the transmitter until both are correct. When all adjustments are set, adjust the clevises at the control horns to give the same trim—for straight, level flight—with the transmitter trims neutralized. Do not forget to reset the transmitter to neutral before flying.

For powered flight, put enough fuel in the tank for 30 seconds of flying. Start the engine, and make sure the transmitter and receiver are turned on. Direct your helper to launch the plane just as he did for the test glide. At first follow the procedure for rudder-only flying. If the model climbs or dives steeply, adjust the elevator trim until a smooth, steady climb is obtained. Apply a small amount of rudder for a turn. Notice that the nose of the plane drops. Raise the nose with some up elevator. Let the model continue to climb while you become accustomed to the feel of the controls. Remember that if you neutralize the controls, the model will fly by itself.

Until you feel confident of your control of the plane, keep the model two mistakes high. This is the first and most important rule—the second is to keep the model nearly overhead and upwind. If the model is too far away, you will find it difficult to tell whether it responds to commands and even to determine in which direction it is flying. We don't mean you should fly the model only in a circle around yourself, but try to keep it in front of you and up 200 or 300 feet.

When the engine stops, allow the plane to settle into a glide path. Notice whether it assumes a nose-up or nose-down attitude; later remove or add, respectively, some down thrust at the engine mount. In either case, retrim the elevator for powered flight, and remember to reset the transmitter trims to neutral and adjust the linkages to match the deflections introduced by the trims during flight.

To return to the landing procedure, if the glide is too steep, flatten it with some up elevator until a smooth but not floating glide is obtained. Just before the model reaches the ground, gradually apply up elevator so that the model flares for touchdown—but do not overcontrol so that the plane shoots back into the air, stalls, and falls to the ground. Remember, too, to keep the wings level. Essentially the only difference from rudder-only landing is that you can slow the plane and shorten or stretch the glide with the elevator. There is no disgrace in landing in tall grass for the first few flights.

Stunts and maneuvers require more elevator and rudder travel than training does, so move the clevis inward one hole on the control horn and make a few flights to become used to the new sensitivity. For a loop, dive and then hold full up elevator until the plane goes up and over. Just before the bottom of the loop, ease off on the elevator to prevent zooming after the loop. If the plane doesn't come over the top, give full rudder to roll it over and make it fall into level flight.

The next step is the Immelmann turn—a loop with full rudder thrown in just before the top of the loop and then neutralized for level flight.

Wing-overs are pretty sights. From level flight give sharp, full up elevator so that the plane shoots straight up. Neutralize and feed in rudder for a vertical turn. When the nose comes down bring the plane back to level flight with up elevator.

Rolls are easiest when the engine is operating wide open. Start with a shallow dive followed by a slight climb. As the climb progresses feed in full rudder, and the plane will start to roll. As it inverts, feed in down elevator to keep the nose up (the plane is upside-down) while continuing to hold full rudder. As it rolls over, ease off the elevator to prevent a dive as the plane returns to normal position.

Snap rolls are spectacular: a slight dive, a bit of climb, and then full up elevator and full rudder. The sky will look as though it is coming apart, and so will your plane unless there are plenty of fresh rubber bands holding the wing on. Outside maneuvers, such as outside loops and figure-8's, require a more versatile model.

Three-channel flying: The addition of a third channel for throttle enables you to reduce the engine speed for more comfortable cruising and to stop the engine entirely in case of an emergency. The ability to control the speed of the engine allows you to choose the landing time and place. Some stunts, such as snap rolls and wing-overs, are easier and smoother at less than full throttle.

Larger models: It is impractical to test-glide models with an engine larger than .10 cubic inch. Therefore the entire test must be made with power on. The job is easier if the takeoff can be made from the ground, either pavement or closely mowed grass. There should be no nearby obstructions such as buildings, fences, or trees.

The Falcon 56 is a three-channel model. We recommend a .35 engine for flying from grass; a .19 engine will do for takeoff from paved runways.

Perform the preflight checks as you did for Dick's Dream. Do not attempt any hand glides. Before flying, break in the engine and adjust it in accordance with the manufacturer's instructions. Obtain the lowest practical but reliable idle rpm. An engine that idles too fast makes a slow, safe landing impossible unless the fuel is used up—and then you have only one chance.

Be sure to extend the transmitter antenna. Turn on the system: transmitter first and then the receiver. Open the throttle. Have a helper hold the model while you start the engine, until you are proficient enough to hold the model with one hand and start it with the other. Don't forget, by the way, that there is a propeller turning only inches from your face and fingers. Retard the throttle and recheck the idle. The model should sit in the grass and not roll. On pavement you may want to consider a drag brake.

If your plane has a steerable nose wheel, practice taxiing until you are completely familiar with ground handling.

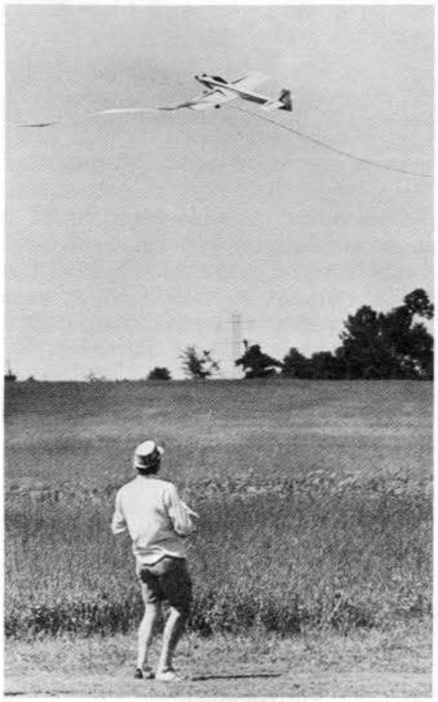
Now you are ready to fly. Fill the tank; it should be full this time, or the engine may fail on takeoff. Adjust the engine for peak, and then back the needle valve off until the engine is just slightly off peak. Pick up the model and hold the nose high. The engine must not slow down or quit. Shake the model up and down—the engine should keep going. Now recheck the idle. When you are satisfied with the adjustments, set the model down with the engine idling. Determine the wind direction, taxi to the downwind end of the field, and head the model into the wind. Have your helper hold the tail of the model, and open the throttle all the way. Check all the controls for full throw, proper direction, and lack of jitter. Make a habit of doing this before every flight. If nothing else, it can prevent you from taking off without turning on the receiver.

When all is ready and the engine is running wide open, signal for release of the model. As it begins to roll, go easy on the steering and just keep the model heading straight. Use up most of the runway as long as the plane is accelerating. If the plane does not accelerate, throttle back rather than lift off into a stall. Recheck the wheels for free roll; if you are on grass, you may need to mow the grass closer. If the plane accelerates as it should, ease in some up elevator until the plane breaks ground. As soon as it lifts off, ease off on the elevator so that only a gradual climb results. Don't hold in the elevator to create a steep climb because a stall or a snap roll may result. If a wing drops, pick it up with the rudder control.

Establish a gradual climbing turn and let the model swing around and come directly overhead. When it is about 200 feet high, throttle back gradually until it holds altitude. For slower flight, throttle back still further and feed in more up elevator to hold level flight. From here on, flying is the same as two-channel flying described earlier.

Adding ailerons: The Skywagon and the Sweet Stik both have ailerons. In the case of the Skywagon, the ailerons are relatively insensitive compared to the rudder, so it is best to minimize the rudder throw. Use the innermost hole on the servo and the outermost hole in the rudder horn for the rudder pushrod. Be certain the rudder and ailerons are exactly centered before flying.

It is difficult to tell when strip ailerons are centered. Set the model on the floor and adjust the main gear until the trailing edges of the wings at the tips immediately in front of the ailerons are exactly the same height from the floor. Check at the inner end of the aileron to see if there is any twist in the ailerons. If there is, try to "average" the setting between the tip and the inner end.



A stunt that is more difficult than it looks is the cutting by the airplane of a ribbon stretched between two poles.

The ailerons on the Sweet Stik are much more sensitive than those on the Skywagon; aileron travel should therefore be minimized. Set the pushrod at the servo in the innermost hole in the servo arm. If your servo has only linear output, you have no choice. Set the pushrod from the servo to the 90-degree bell crank in the outermost hole of the bell crank. Set the link from the bell crank to the aileron horn in the innermost hole, and set the clevis in the outermost hole of the aileron control horn. You must, of course, do all this before the wing is covered. With the servo in place, turn on the receiver and transmitter and check for aileron deflection. Move the aileron-horn linkage to the hole in the 90-degree bell crank that gives a maximum deflection of 3/16" each way at the trailing edge of the aileron. As you become more proficient, move the linkage in a hole on the control horn or out a hole on the servo output arm.

When you step up to ailerons, your left hand is used more, particularly during takeoff and landing. Since the nose wheel is steered by the rudder servo, ground control is a function of the rudder. Ailerons are the primary control in flight.

The method of flying is the same as for three-channel flying. Taxi and practice taking off until the entire operation is second nature to you. Takeoff is the same as with the Falcon 56, except that you must use the ailerons rather than the rudder to keep the wings level.

When you are ready for maneuvers—after several hours of becoming accustomed to the plane—the control throws must be increased. Move the aileron, elevator, and rudder linkages in one hole on their horns. Check the trim and make a few flights until you feel comfortable with the new control settings. The Skywagon can perform inside loops, wing-overs, axial rolls, snap rolls, spins, hammerhead stalls, and (just barely) outside loops. The Sweet Stik can perform almost any maneuver ever devised.

Maneuvers are beyond the training stage and are a matter of skill and practice. Therefore we simply describe a few here that have not been discussed previously.

Outside loops are easier if the model has a symmetrical airfoil, such as the Sweet Stik has. Semi-symmetrical airfoils permit outside loops, but with some difficulty. Start with plenty of altitude, full power, and down elevator. Avoid full-elevator loops initially until you are sure that the model will not snap-roll inadvertently.

Axial rolls require full aileron and full power. As the plane becomes inverted, feed in down elevator as necessary to keep the nose level. Ease off on the elevator as the plane returns to the upright position.

Vertical-8's can be performed with either half—top or bottom—first. For top half first, perform an inside loop. As the model comes down into the bottom of the loop, make a smooth transition into an outside loop. At the end of the outside loop, level off at the same altitude and heading with which the plane entered the maneuver.

For a horizontal-8, perform three-quarters of an inside loop. As the model approaches straight downward flight, make a transition to an outside loop. Do the full 360 degrees of the outside loop and then finish the last quarter of the inside loop.

Spins require considerable altitude. Enter a steep climb and reduce power until the plane stalls. Then give full rudder while holding up elevator. Recovery is made by neutralizing control and applying throttle. One warning —some models may not recover from a spin. None of our example models have that difficulty.

Repairing the airplane

Naturally you worry as you fly the plane that you spent so many hours constructing: Will it crash? It may ease your concern if you take a somewhat fatalistic attitude. It will crash someday, but it can probably be repaired. Repair is no more difficult than construction.

When your model makes what the full-size airlines call a non-routine landing, there are several things to do and several things not to do. First, if you are going to stomp your feet and swear, don't do it near the crash site. You might step on some salvageable pieces. When you reach your model, turn off the radio equipment and unplug the battery pack. Don't turn the propeller until you are sure the engine is not damaged or full of dirt, and don't start ripping the model apart until you've determined whether it is repairable.

Next, look around the scene of the impact for any parts that might have come off the plane. Look at the model to see which parts are missing—such as wheels and hatches—and try to find them. These parts can be salvaged for repairing or rebuilding the model.

Once you have recovered all the bits and pieces, take everything back to your car or your field box. Then—or perhaps after you get home—decide whether to scrap, repair, or rebuild the model.

If you elect to scrap the model, remove the propeller from the engine, taking care not to turn the propeller, and then remove the engine from the plane. Remove the radio equipment, and clean any oil and dirt from the outside of the receiver, battery, and servo cases. Salvage all pushrods, control horns, linkages, other hardware, and anything else that you can reuse. Remember, all those parts either cost money or took time to make. Then build a funeral pyre for the carcass of the model.

Rebuilding is called for if sheets of balsa or parts of the framework have been damaged or are missing. You can rebuild almost any model if you kept the plans after you built it. Remove the engine, the radio, and the hardware, and then carefully remove all parts of the structure that can be salvaged, such as wing tips, flying surfaces, bulkheads, hatches, plywood plates, carved blocks, and unsmashed ribs. Take heart—you built the model from a box of parts. If the damage is not much more than skin-deep or if parts have broken away cleanly and the remainder of the structure is still solid, you can repair the plane without having to remove the engine and the radio. With care and patience you can restore the model to like-new condition.

It is impossible to describe every potential repair you might have to make, but there are certain guidelines that apply to general situations.

The first step in rebuilding and repairing is to remove all oil and dirt from the damaged area. Start by removing the covering from the damaged area, and then remove the oil. We have found that the best solvent for removing oil is a spray-on rug cleaner called Texize K2-R. Spray it on, let it dry to a powder, and then brush off all the powdery residue completely. Two or three applications may be necessary. If the oil cannot be removed, cut away the wood until you reach clean material. Lubricating oil from the engine can penetrate quite deep into the structure of the model.

As you work through the damage, review the sequence in which you remove parts so you will not have to backtrack as you reassemble them. Fastening broken parts together requires jigs, clamps, pins, and an adhesive other than a quick-setting one—it takes time to align the parts and secure them in place.

As you work, think two or three steps ahead and decide whether the next part should be replaced with balsa, plywood, or epoxy filler. Thixotropic epoxies (fluid when stirred but semisolid if left to settle) such as those sold in hardware stores are strong and can be used to fill gaps; however, there must be a framework to carry the load. After you have reassembled the parts, determine whether the repaired structure is strong enough. You may have to add gussets and reinforcements to give added strength, but avoid adding too much weight to the model. Fiberglass cloth attached with epoxy reinforces a repaired joint quite well.

After the structure has been fixed you must restore the surface for refinishing. This is the point where most repair jobs look like repair jobs. There are several fillers you can use to fill break lines and ding marks: Plastic Balsa by Aerogloss, Sig Epoxolite, automotive plastic body filler, epoxy filler, or Microballoons and epoxy. These plus the sanding techniques used during the original construction can create a surface that matches the rest of the model. Remember, by the way, that polyester filler cannot be used over certain epoxies.

A few special cases bear attention. Molded-foam models such as the Ranger 42 can be repaired with epoxy. The joint will be stronger (and heavier) than the original structure. Vacuum-formed plastic wings and stabilizers are difficult to repair because the plastic is so thin. Plastic fuselages can be repaired with gauze, scraps of the original plastic, and solvent-type cement.

Foam-core wings that are covered with plastic, balsa, or plywood can be repaired if the break is a clean one. Realign the pieces and use epoxy to fasten them together. Reinforce the break line just as you reinforced the joint between the halves of the wing during construction (see the description of the Komet). Such repairs must be fully reinforced. Repaired wings should be load-tested to the expected structural load. For example, the Tiger Tail wing must be able to carry a load of about 70 pounds distributed across the wing.

To load-test a wing, set the wing in position on the fuselage. With the model inverted and the fuselage evenly supported, set bags of sand on the wing, spreading them evenly along the wing. Load-testing may reveal hidden breaks in the structure of the wing.

In rebuilding a model it is necessary to make new components to replace those damaged beyond repair. The task is easier if you can recover as many components as possible from the wreck and reconstitute them sufficiently to serve as patterns for the new parts. You can also use the original plans and the techniques described for the Flexible Flyer to transfer rib, bulkhead, and other patterns to new wood.

required parts and reassemble the model just as you did the original kit.

The engine and the radio equipment should receive even more careful attention than the airplane itself—they both cost more. See Chapter 8 for information on engine maintenance and repair.

Before you turn the radio system on, inspect it carefully for physical damage. Clean off any dirt and oil. Unplug all the components and remove the covers from the receiver and the servos. Check for broken wires, damaged switches and connectors, bent or broken components on the receiver and servo boards, scraped insulation, broken printed-circuit boards, broken copper strips on the boards, and damage to the battery pack and battery cells. Check the gears of each servo for damaged teeth.

If you find anything wrong, repair it or have the set serviced by an experienced R/C system repairman. If no repairs appear to be needed, reassemble the components and charge the batteries for the full period recommended by the manufacturer. Plug the power harness into the receiver, but do not connect any servos. Turn the set on and check that no components in the receiver overheat.

Plug in the servos one at a time and check for proper operation. If any servo malfunctions, remove the power, disconnect the servo, and have it repaired. If all the servos work, perform a range check. If the range is significantly less than normal, say 25 per cent or so, have the set serviced. Extremely short range is an almost certain sign that the receiver crystal was broken in the crash—not an uncommon occurrence.

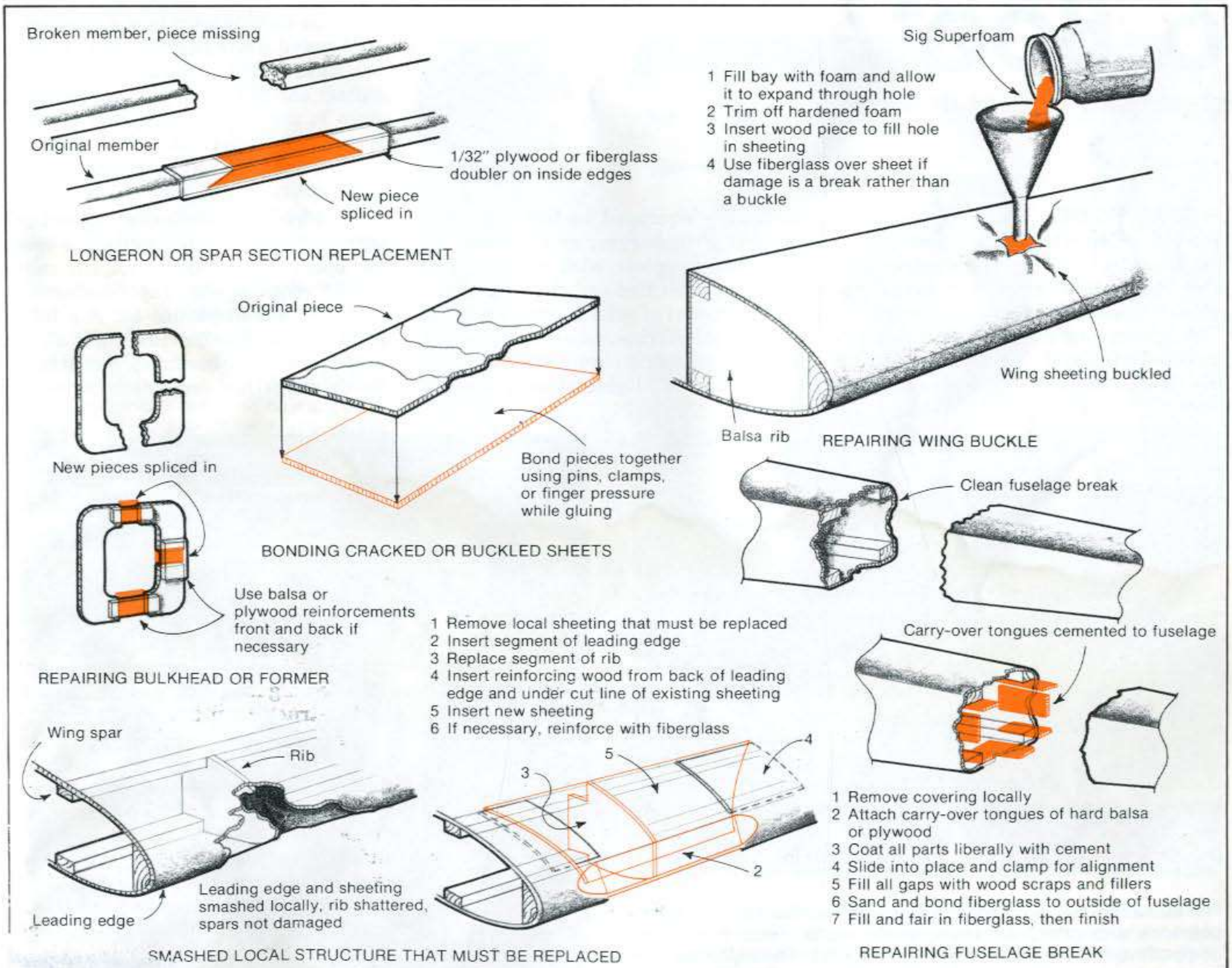
Finally, check the system for battery life. The batteries can suffer damage that can't be detected visually. If you have no equipment for testing the battery, charge the batteries fully and exercise the servos continuously for at least an hour. Then recheck the battery voltage and range-check the system once more.

To check the voltage, charge the batteries for 14 hours. Place a load resistor across the battery pack to yield a current drain of 100 milliamperes. The voltage of a 450-mah battery should not fall below 1.1 volts in less than 3.5 hours. For 800-mah cells, the time is 7 hours; for 225-mah cells, 35-45 minutes.

The most reliable range test is one made in an open area similar to the normal flying site, with the receiver and transmitter antennas fully extended. Most manufacturers specify an operating range for their equipment; most equipment should have a range of at least 400 feet.

You can also determine a reference range for your R/C system when you know the equipment is functioning properly. If you determine the reference range with the antenna collapsed, you reduce the amount of walking required. Deterioration of the reference range by more than 25 per cent is a sure indication of problems that require servicing.

To perform a range check, set the model about 4 feet above the ground (but not on an automobile, whose steel body would affect radio reception), plug in the servos, and then operate the transmitter as you walk away from the model. (Have a friend watch the model.) The point where the servos begin to move erratically determines the limit of operation of your system.



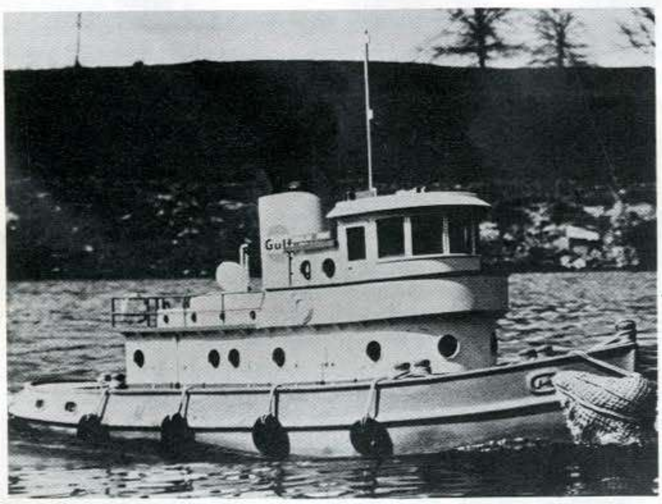
Boating permits a relaxed approach—such as floating a cabin cruiser or a tugboat on a sunny Saturday afternoon—to R/C modeling.

6 Boats

BOAT MODELS can give you some good experience in the fundamentals of radio control and model construction, and they allow a more relaxed approach to operation than do planes.

A boat can be more than an electric-motored runabout or a modified plastic toy. It can be a racing hydroplane, a battleship equipped to fire blanks, a tugboat with barges, or a sternwheel riverboat complete with calliope. Nor do the possibilities end there. You can build a model of an ore boat, an ocean liner, a submarine, or even a rowboat with an operating oarsman.

A boat, being lighter than the medium in which it operates, is buoyant and therefore requires no minimum speed for operation. It does not, in many cases, require the rapid-responding controls that airplanes do. A piloting error with a slow-moving tug is almost meaningless. A boatman has time to think about his commands when his



The authentic-looking model tugboat (above) has a full-scale appearance and offers a relaxing performance pace. If you are competitive-minded, consider sailing (right). The sailboats are headed down the back leg of a course on a pond.

craft comes toward him and a right-rudder command makes the boat move to his left. Sequential controls can be used for auxiliary functions, such as blowing whistles, raising flags, lowering small boats, and turning gun turrets.

The fact that water is much heavier than air is evident in the contrasts between air and marine propellers in diameter, pitch, and blade area. Also, water rudders usually have a portion of their area forward of the hinge line to reduce the force required to turn the rudder. Dynamic balancing of control surfaces is almost never required in airplane models. Control loads are quite high for large or fast boats and for sailboats. Paralleling of servos is common.

Boats can be powered by electric motors or gas engines. For most purposes electric drive is preferable.

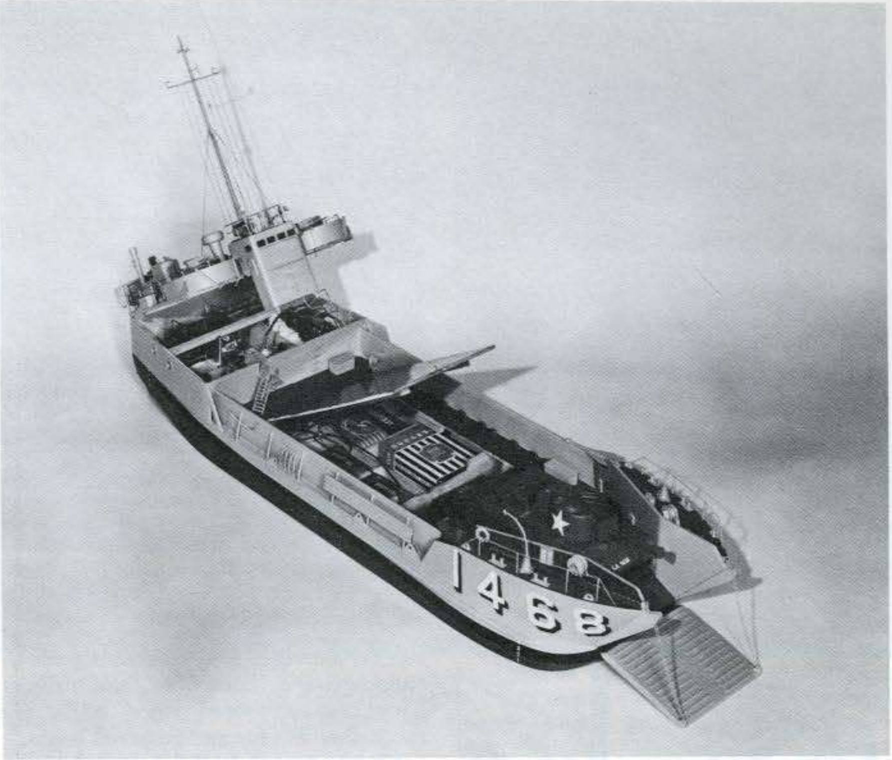
Although a boat propeller is small, it imposes heavy loads on the electric motor that drives it. It can require reduction gearing or multiple motors. High motor loads drain batteries fast, so large batteries, usually the lead-acid type, are necessary. Nickel-cadmium batteries of the size required are expensive as a rule.

Weight: A boat can carry an amazing amount of equipment and a heavy battery load. The Sterling Chris-Craft, for instance, can support 75 pounds. Such a capacity is beyond the weight of even the most elaborate control system. A 4-foot submarine, in addition to being heavily constructed and crammed with equipment, can require 30 pounds of ballast. Sailboats usually have a lead keel.

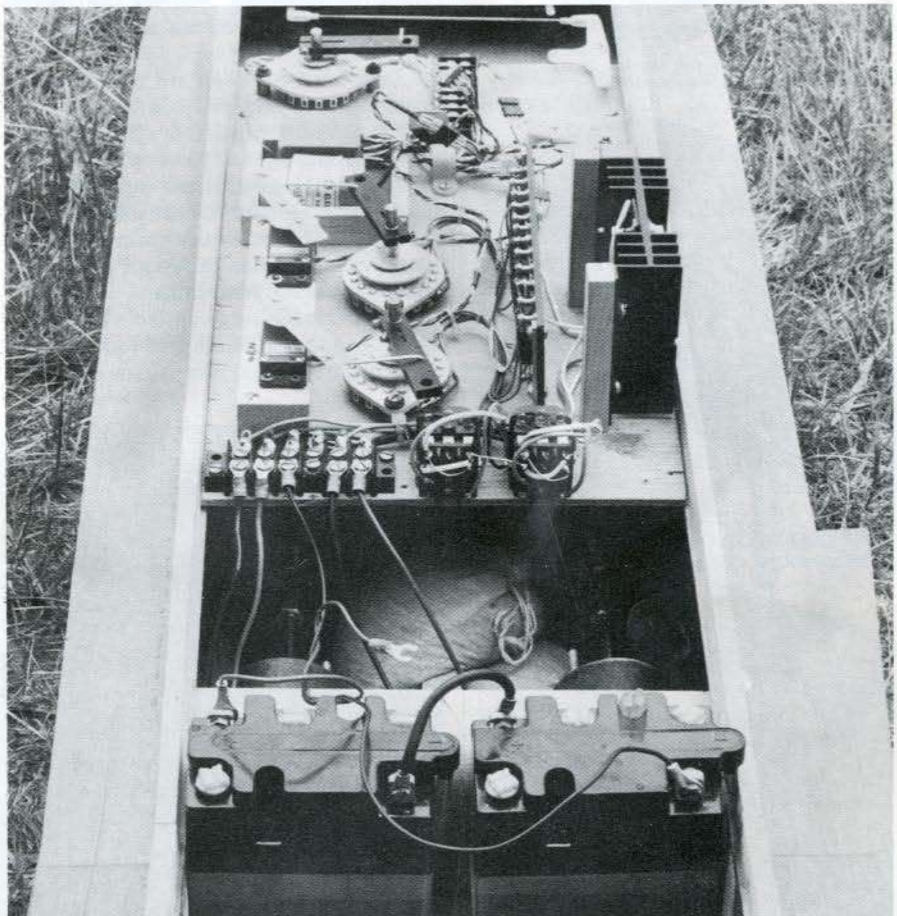
The relative freedom from weight limitations—although weight distribution is important—encourages flexibility in the choice of materials and construction methods. A fiberglass hull is tougher than one made of balsa. Balsa hulls can be protected with fiberglass cloth. Laminations of white pine can be used for larger hulls. Any shape hull can be fleshed out by using any method or combination of methods. The modeler is not compelled to glue together fragile balsa as he usually is with airplanes. Various woods, plywoods, plastics, metals, epoxies, and resins can be used in almost limitless combinations. Large hulls can be carved quickly from plastic foam and covered with protective epoxy or fiberglass or even used as the mold for a fiberglass hull. In the last case the plastic foam can be melted away with heat or a solvent to leave the desired hull shape.

Gas-powered engines require thorough fuel-proofing of the hull inside and out. In addition, gas engines create tremendous vibrational stresses in the structure, the mounting, the radio equipment, and the accessories.

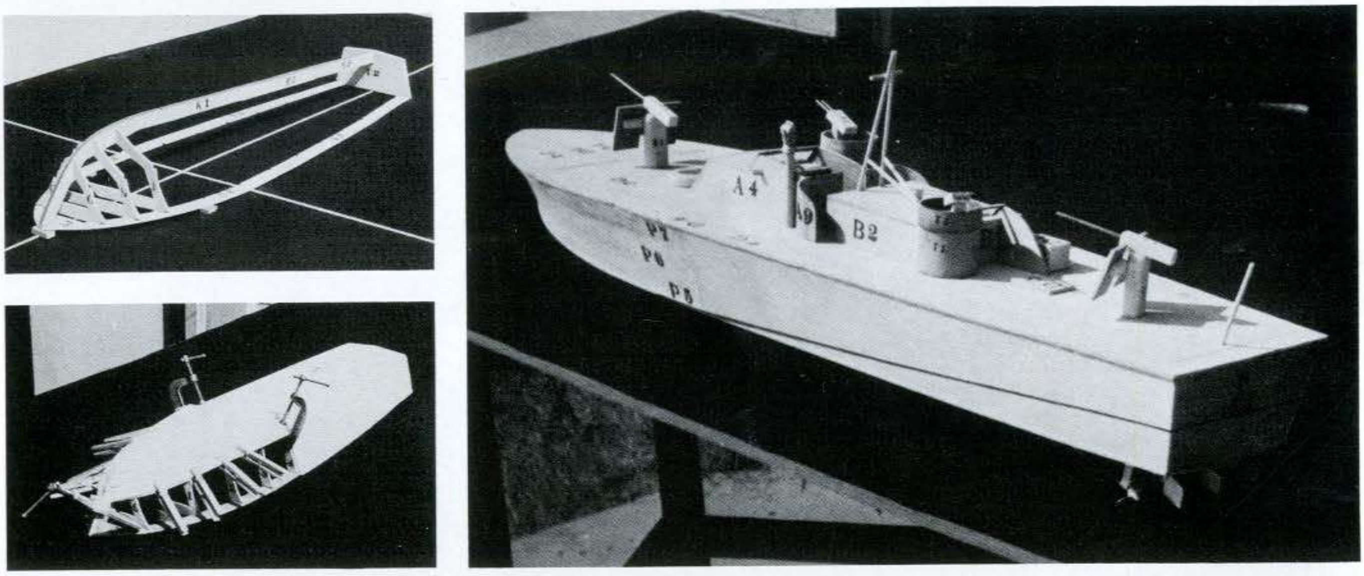
Although a boat cannot fly away, it



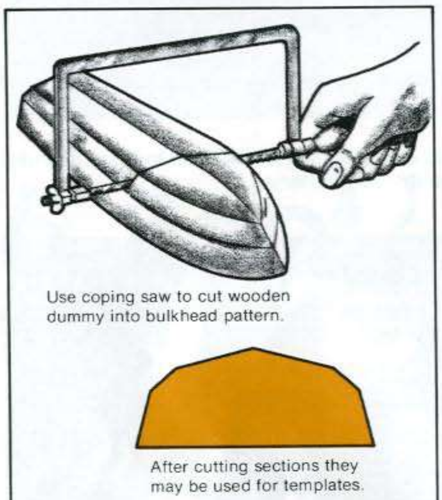
A motorized ramp and a tank are features of this LST. A similar model built today would use smaller rechargeable batteries in place of the dry-cell batteries.



The inside of a tugboat model reveals, from front to back (or bow to stern), a pair of motorcycle batteries, two motorcycle starter motors, bags of ballast, and a sophisticated control system for controlling the speed and direction of the boat. The heat sink, top right, carries the transistors that control motor speed.



The Dumas PT-109 model has a wood frame (above left) to which wood planking is glued (left). Then the details are added (above).



CARVING WOODEN HULL PATTERN

can be damaged if it strikes objects or runs aground. Thus fiberglass hulls or fiberglass-reinforced wood hulls are recommended for gas-powered boats.

Kit or scratch-built? A modeler's involvement in building a boat can range from merely opening a box containing a ready-to-use boat to designing and building the boat. Within that range are kits, kit conversions, and designs in magazine articles.

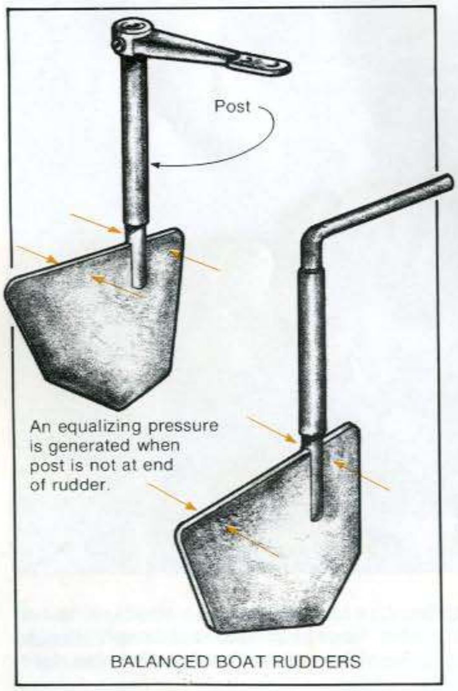
Originals offer an unlimited selection of types and great latitude for detailing. They require drafting skill to develop bulkhead patterns and hull lines. If the vessel is not large, carve a hull or a half-hull to accurate external contours. Saw the mock-up crosswise at intervals, and use the resulting pieces as patterns for templates.

An original design calls for an understanding of materials and construction technique. There are three common methods for constructing boat hulls.

The first is to erect bulkheads, deckside down, on a flat surface, with the framing jigged up as the particular design requires. After framing has been added to tie the structure together, the hull is covered with sheet balsa, thin plywood, or balsa strips. Some flat-bottomed boats can be assembled keel-down in the same manner.

The second method entails carving a hull from wood such as balsa or pine to the external dimensions, and then hollowing it out with gouges. Rest the work on a soft material to prevent denting the surface. For larger hulls, the necessary number of laminations can be glued together. Each lamination must be sawed to the external and internal outline, leaving enough material for shaping and finishing. Use templates to check shaping progress.

The third construction method in-



BALANCED BOAT RUDDERS

Fiberglass is a popular material in model boating. Besides a fiberglass hull, this racer features a fiberglass top deck with a metal flake finish in gel coat.

An excursion steamer offers many possibilities for such operating items as a gangplank, a whistle, and even people dancing on the top deck. The steamer could be powered by a small steam engine. The carrying box is painted blue to simulate water.

volves the use of fiberglass, either fiberglass cloth and resin applied over a wood hull or an all-fiberglass molded hull. Fiberglass is tough, hard, fuelproof, and virtually immune to ordinary damage. When the likelihood exists that several identical hulls will be made, as in a club project, molded construction is faster and better for many types of boats.

Magazine articles: The designs that appear in hobby magazines usually specify a built-up frame of balsa bulkheads, balsa skin or planking, and perhaps lift-off plywood decking with the superstructure attached to it. Some larger projects call for a laminated hull.

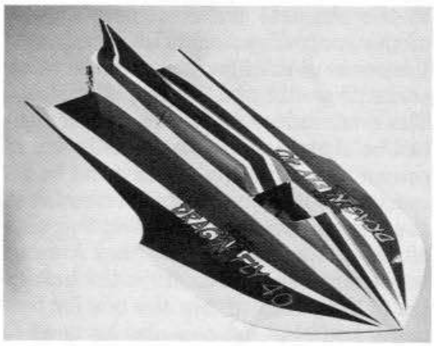
Kits for boats generally require less work than do airplane kits. The average boat modeler would be appalled by the typical balsa airplane kit, which looks like a bad day at a lumberyard.

Before you buy a boat kit, you may want to ask an experienced hobby dealer what he would recommend. He will ask you what kind of boat you would like to make and explain the popular categories in size and price. He will explain control methods, and he will discuss the pros and cons of electric and gas power. He may suggest dividing the project into phases, buying the hull first, then the power plant, and so on. The dealer will, of course, try to match his suggestions to your construction skill and your pocketbook.

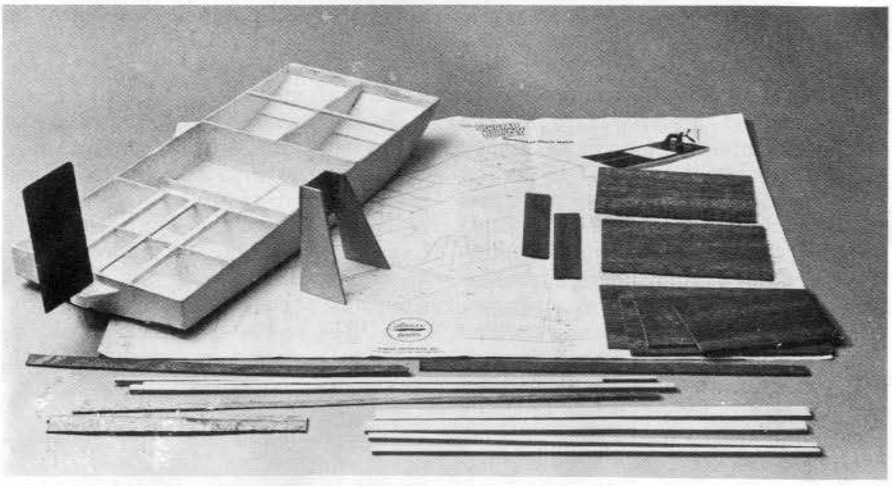
He is likely to categorize the kits as:

- Sailboats.
- Sport boats, such as runabouts and cabin cruisers.
- Commercial and utility boats—freighters, tugs, shrimp boats, and the like.
- Military models.
- Racing hydroplanes.
- Miscellaneous boats, such as air boats and submarines.

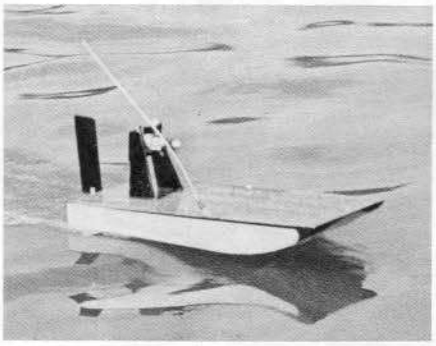
Kit boats for radio control range in length from 18" to more than 48".



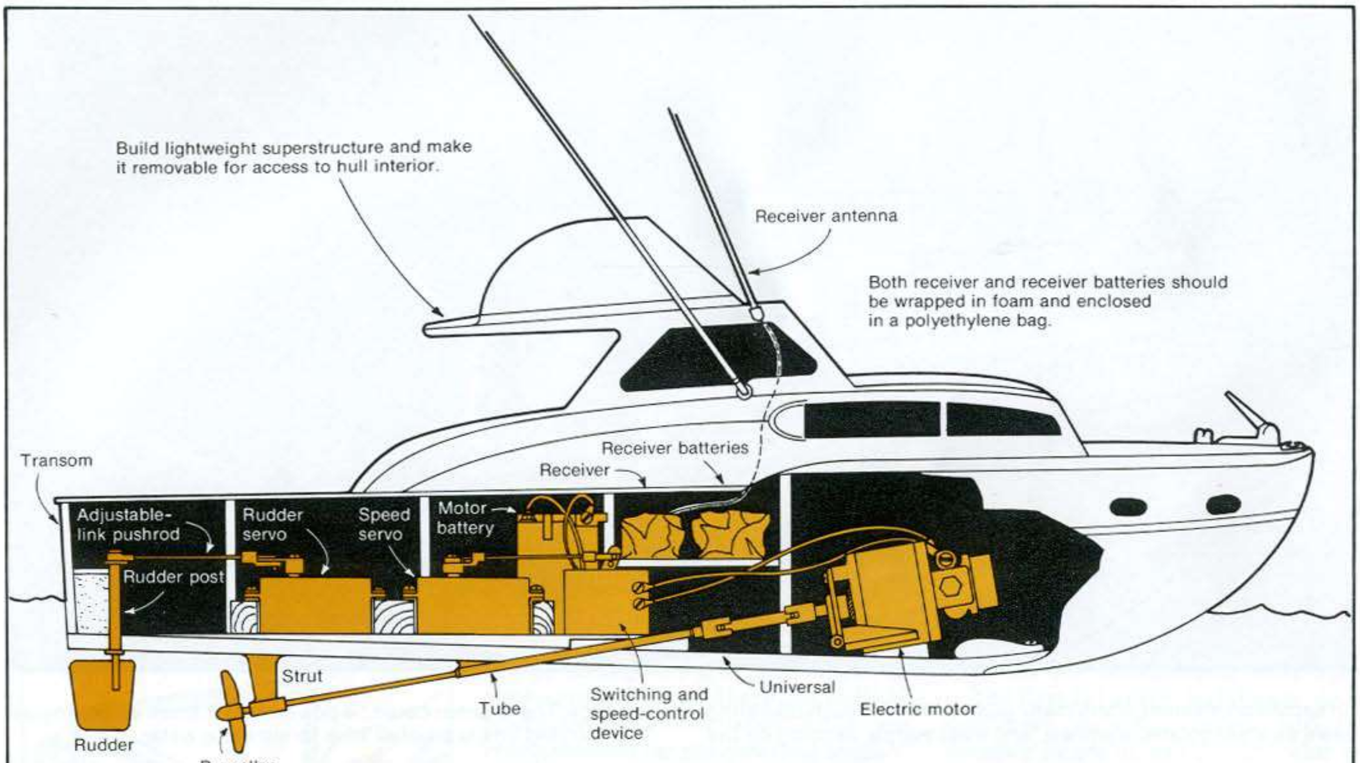
To accentuate the lines of a racing hydroplane, paint on stripes of various colors.



Want to challenge the local marshes? The air boat has a balsa hull, mahogany top deck.



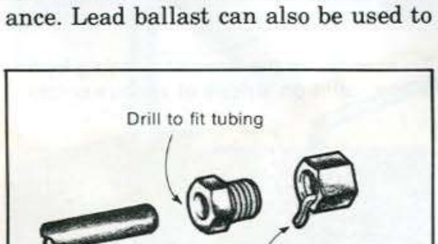
An air boat driven by a propeller on an .049 engine represents a simple project utilizing only one channel of control.



TYPICAL SINGLE-ELECTRIC-POWERED BOAT

Speaking practically, 18" is about the minimum length that will accommodate radio-control gear. Gas power calls for at least a 24" boat, to avoid overpowering the boat.

Placement of components: The layout of the equipment is determined by the physical and electronic aspects of the control system. The location of the power plant depends on the location of the propeller and the propeller shaft. The remainder of the equipment cannot be scattered about the hull where convenient. The equipment must be accessible, and it must be distributed so that its weight does not affect the trim of the boat. The battery box can be made large enough to allow the batteries to be moved within the box for balance. Lead ballast can also be used to trim the boat. The photographs with this chapter illustrate a number of different component layouts.



STUFFING BOX

Operating hardware—propellers, flywheels, shafts, couplings—requires tailoring to fit each specific situation. Most kit instruction sheets and most construction articles in magazines specify the hardware for the particular model.

A sturdy engine mount is important for good engine performance and long life for your boat. Loose mounting causes excessive engine vibration, fuel foaming, and damage to the drive train and the hull. A flywheel is necessary for starting the engine and keeping it running. An airplane propeller acts as a flywheel; a boat propeller does not have enough inertia to function as a flywheel. A collet-type flywheel-locking arrangement is vastly superior to a lock washer and nut.

A front universal joint is required because it is nearly impossible to align the engine and the drive train perfectly. An aft universal joint is necessary only if the shaft angle is too steep or if a steerable strut is used. It is better if you can avoid using an aft universal joint: Components left off a model, to paraphrase Henry Ford, don't give trouble.

The stuffing box provides a bearing surface for the drive shaft and a water seal where the drive shaft passes through the bottom of the hull. You can either use a commercial one or make one. If you simply use a piece of brass tubing, make sure the upper end extends above the water line.

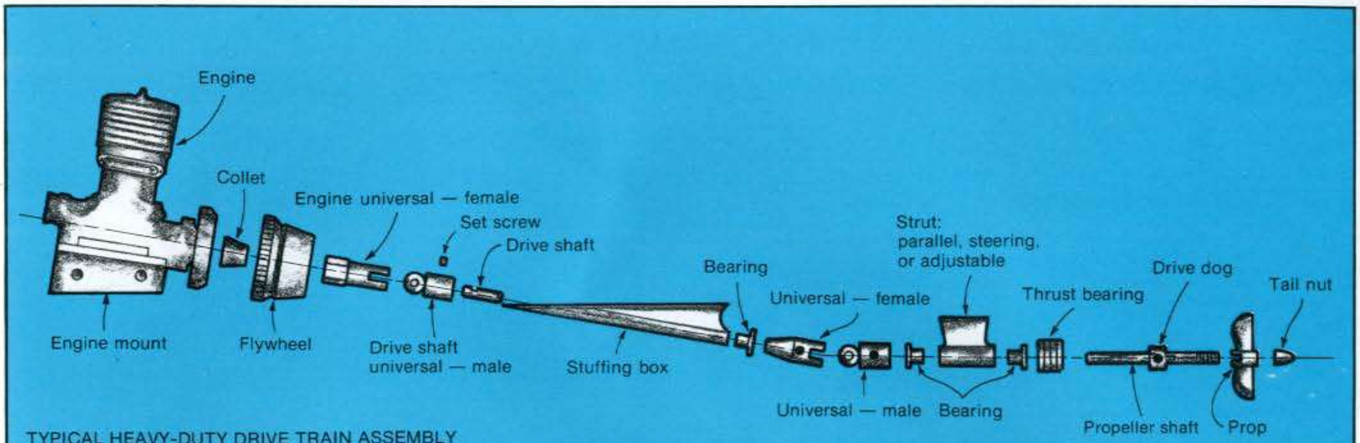
In light-duty installations a sturdy stuffing box and a stiff drive shaft should suffice to prevent whipping of the drive shaft, vibration, and loss of power. Engine-powered models and models with large electric motors need a strut to support the propeller shaft. An adjustable strut eases the task of shaft alignment.

Use high-quality parts, even when a makeshift seems to do the job. Accurate alignment of operating parts is mandatory. Poor alignment of a coupling or a shaft consumes power. With electric drive poor alignment translates into lost thrust, higher current drain, and shorter battery life. Poor alignment with a gas engine causes vibration that can ultimately shake everything apart. Be sure that all parts are lined up perfectly and operate freely.

Not all propellers are alike, even when the pitch and diameter are the same. Sometimes boats which barely move with one prop accelerate to good speed with another.

To determine the propeller diameter for a gas engine, multiply the stroke of the engine by 2 to 2.5 for a two-blade propeller and by 1.6 to 2 for a three-blade propeller. The flywheel should have approximately the same diameter as the propeller, and its thickness should be about one-third of its diameter. Pitch of the propeller should be equal to the diameter or perhaps a little less.

On heavier boats, begin with a smaller diameter and lower pitch to avoid overloading the engine. If the engine is too lightly loaded, increase the propeller diameter. If



TYPICAL HEAVY-DUTY DRIVE TRAIN ASSEMBLY

angle becomes too great for efficiency because of propeller diameter, move the prop back, use an articulated drive, or use a three-blade propeller. If the prop diameter required by the boat is too big for the engine, you must either use a larger engine or install reduction gearing between the engine and the propeller.

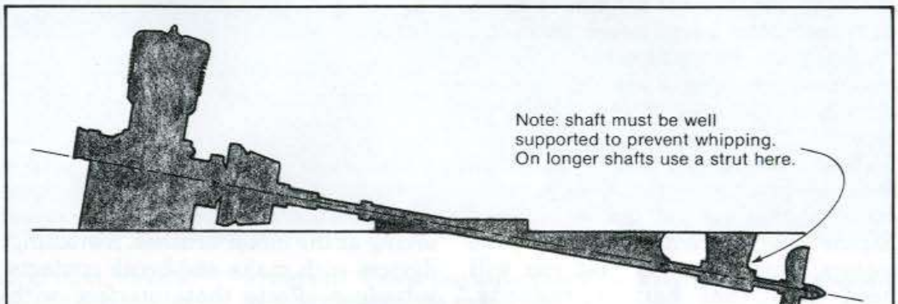
Motor and engine sizes: Electric motors and gas engines come in a wide range of sizes. However, the lower end of the power scale is not too useful for boats, because radio and hardware installations require large boats and hence large engines. Among electric motors the Aristo No. 5, the Decaperm, the Monoperm, and the Pittman 10005 manufactured by Dumas are popular. The Kroker SeaPup, SeaWasp, and SeaRam series are expensive but powerful motors. Small .049 gas engines can be used for light, simple boats, but engines at the high end of the scale—.35, .45, .56, and .60—are in demand for speed and power.

Electric or gas? Each has pros and cons. The electric motor is easy to install. It is vibration-free, and it starts instantly. It is cleaner and quieter than a gas engine, and it can be reversed without complicated gearing. The electric motor, though, requires heavy batteries for power, and it can contribute to radio interference. The batteries require a different charging rate than the batteries that power the receiver and servos.

The gas engine is more appropriate for racing boats and open-top runabouts. A gas-engine installation is lighter than an electric drive. The two biggest problems of a gas engine are vibration and heat.

Gas engine vibration limits the type of radio-control gear: Complicated and dainty gimmickry doesn't operate well when shaken up. Hulls must be sturdy. Wood motor mounts must be epoxied to the hull—ordinary cement will not hold. Use hardwood, nails, and screws as well as cement where appropriate.

[illegible] is possible for small engines running in the open, particularly if a heat sink is used, but water cooling is recommended for most boat applications. Some manufacturers produce water-cooled engines; water jackets are available for some engines. Water cooling requires plumbing, usually a pickup tube right behind the propeller and an exit tube in front of the prop. Thus even when the boat is standing with the motor running, there is forced circulation of cooling water.

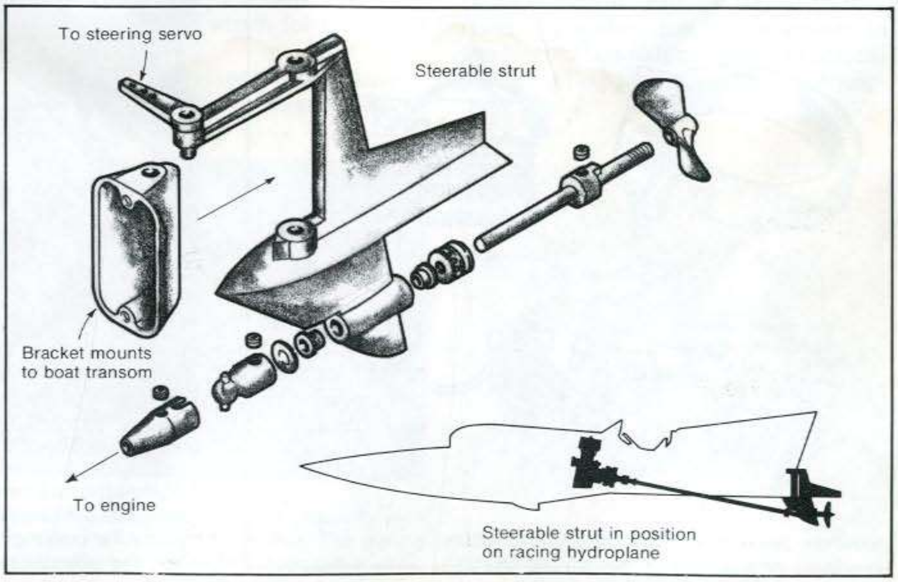


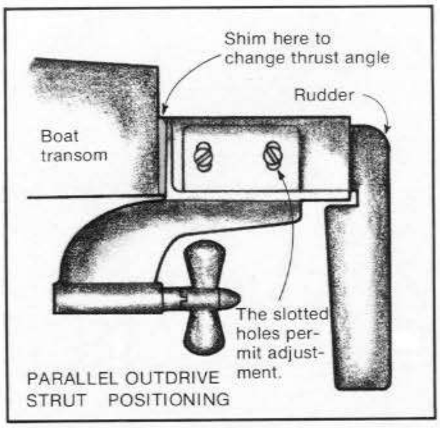
NECESSARY ANGLE OF INSTALLATION

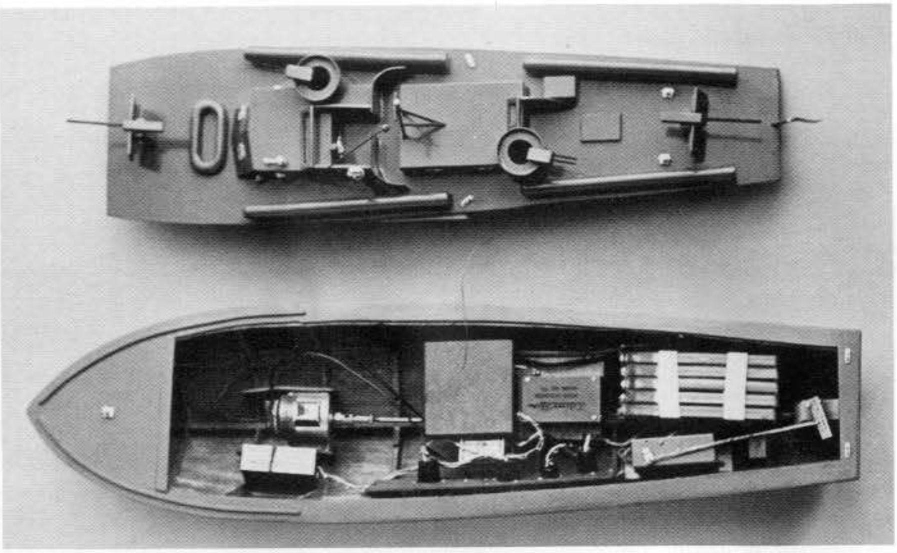
To keep the engine clean and to eliminate noise a muffler is recommended. Several marine accessory and engine manufacturers offer mufflers.

Kit limitations: Manufacturers of boat models often include in their kits hardware of the simplest and cheapest type, such as steel wire for a shaft and brass tubing for a stuffing box. Replacement of the hardware with parts by a manufacturer such as Enya, Octura, Graupner, or Dumas is often a sound investment. The R/C Products Directory, available from Potomac Aviation Publications, contains a complete listing of typical hardware.

Kits are often shown with a gas engine because the manufacturer assumes the customer expects to see a gas engine. In many cases an electric motor







The R/C system of the PT boat includes the motor, forward; plug board for connectors, port; receiver, just aft of midship; and a stack of five batteries and the rudder servo, aft.

is preferable. When electric drive is specified, many large boats are shown with one motor when two or three are required. The manufacturer similarly assumes that customers will be deterred by the cost of the additional motors.

If you dual-power a boat, be sure that the radio-control gear, relays, and switches that control the motors can handle the current drawn by two motors. Remember too that you will need additional battery capacity. Switching devices are designed for specific voltages and currents. Exceeding the specifications can result in damaged switch contacts.

Similarly, wiring should be heavy enough to carry the motor current without overheating. Adding a parallel wire is equivalent to doubling wire size. You can use double-pole relays and switches to divide the load between two sets of contacts.

Useful electrical components can be found in electronics stores and the model railroad departments of hobby shops.

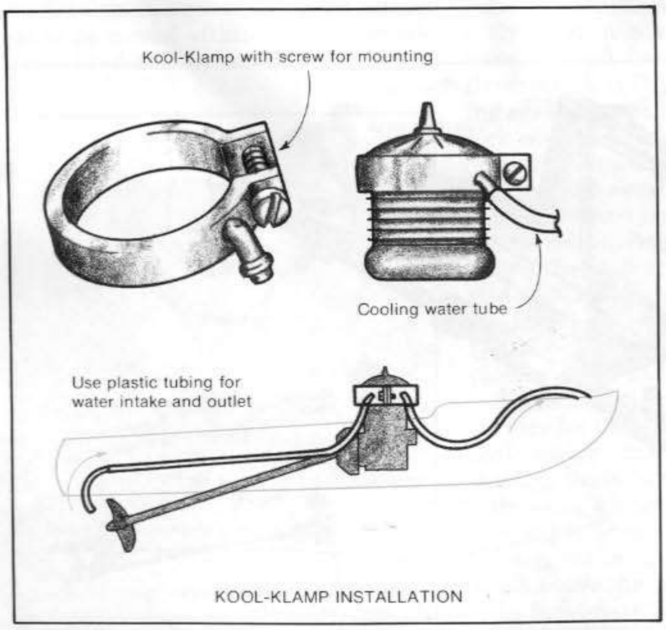
Electrical noise is a far greater problem in a boat than it is in an airplane, especially with electric drive. Drive motors draw far more current than servo motors, and there is much more arcing at the motor brushes. Switching devices with make-and-break contacts introduce effects that interfere with radio reception. Compact installations can bring system components into close proximity, increasing the effects of noise.

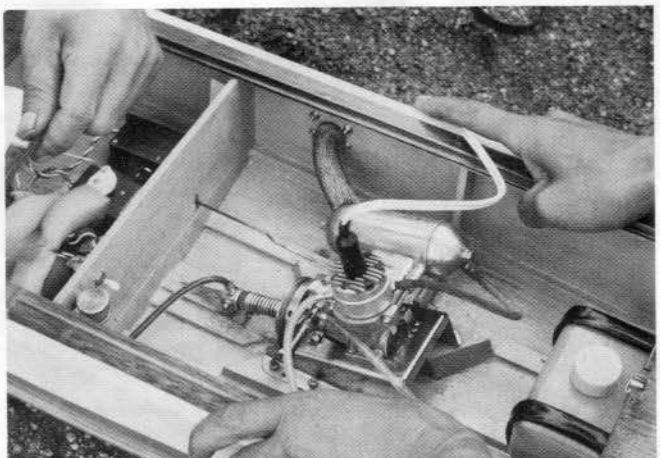
The receiver must be kept as far from electric motors as possible. The antenna should be taken up through the deck close to the receiver. It should never be carried back through the hull near other wiring and electrical components. Avoid metal-to-metal linkages by the use of nylon clevises and control horns.

Suppress any device that sparks by installing appropriate resistors, capacitors, and diodes across the terminals. Relay contacts can be protected by wiring a .01-mfd. ceramic capacitor and a 10-ohm, ½-watt carbon resistor in series between the relay frame and the contact.

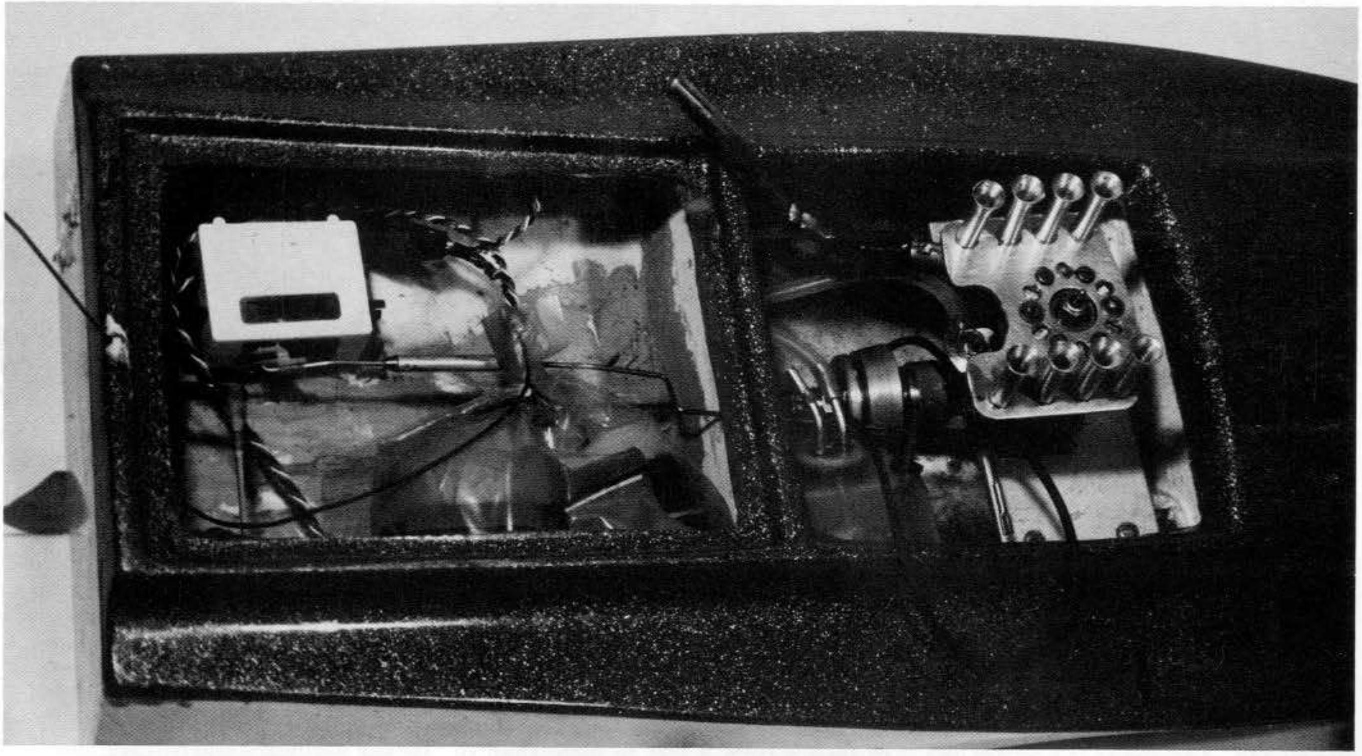
Which control system? Rudder-only control might be acceptable in the smallest, simplest boat, but once the novelty wore off, such a boat would not be rewarding. Therefore the simplest controls that can be considered practical are rudder and motor control—reverse and stop-start—or engine throttle. To these controls can be added various auxiliary control functions and speed control for the motor.

From the standpoint of economy, the electric boat operator can still find used reed equipment that may be preferable to digital proportional sets for applications not requiring proportional control. Reed servos have considerably more thrust but are slower than proportional servos. Pulse proportional con-





Engines that are carried within the hull or other enclosed area and cannot be air cooled require a water-cooling jacket on the cylinder head. After cooling the engine, water passes through the muffler to keep the exhaust temperature down.



A typical racing-boat installation includes, left to right, throttle servo, radio gear sealed in a plastic bag, fuel tank, and engine with a heat sink. Everything except the engine compartment is covered by a hatch when the model is in operation.

trol is little used for boats except for small airboats. Feedback proportional control is necessary for operating fast gas-powered boats. The precision and rapid response of proportional control recommend it over other systems.

For operating boats with a number of features that can be controlled with a simple on-off switch, sequencing can be achieved by the use of printed-circuit switch plates. Electric motor control is possible with slide-type rheostats for speed and mechanical switches for forward, reverse, and stop. They are easily adapted to actuation by digital servos.

The choice of transmitter is not a crucial one. Special boat transmitters are available, but most model boaters use any single- or dual-stick transmitter available.

Boats can easily carry the extra weight of older, heavier R/C equipment; boaters therefore can take advantage of secondhand equipment, sticking to name brands such as EK (Logictrol), Kraft, Orbit, and Heathkit for assurance of service. Avoid, however, the complicated and unreliable sequencing equipment of a few years back. Some of it is still on hobbyshop shelves, but it is not a good buy.

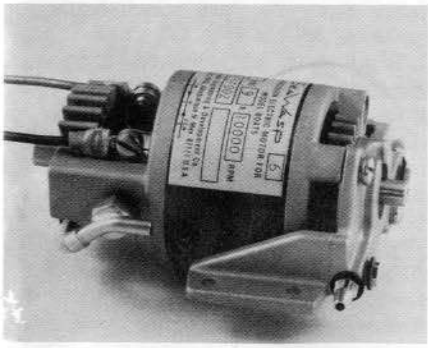
Sailboats are to boating as gliders are to flying: no noisy motors, no oversize batteries, just the wind for propulsion and maneuvering. The most enjoyable form of sailboating is racing. Skill is important in competition because boats being raced are usually equal. Sailboats require almost as much skill to operate as airplanes.

An R/C model yacht has three essentials: the hull and the sails, the radio equipment, and a winch for trimming the sails.

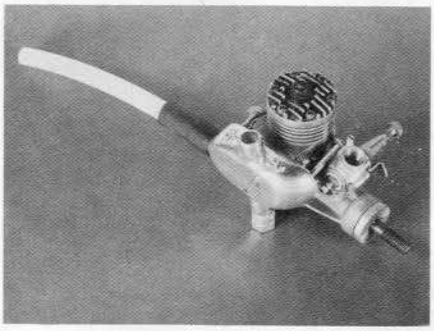
The radio equipment is the same as that used in model airplanes. For a sailboat you will need a set with two channels; three-channel control is preferable. One channel is used for controlling the sails, and the second for rudder control. Many skippers use a third channel for trimming the jib.

Before you buy radio control equipment, check with other R/C boaters in your area so you do not duplicate their radio frequencies if possible. Some radio gear is capable of switching frequency. In a regatta it is inevitable that many people will be using the same frequency. For that reason, races are run in heats.

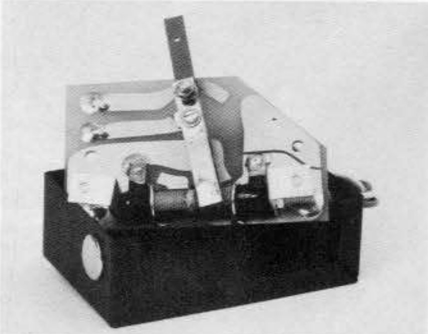
The radio receiver and the servos are mounted on a platform inside the hull of the yacht. They should be an inch or two above the floor of the hull away from any water that might collect in the bilge. Most skippers rely on careful boat-building technique to keep equipment dry.



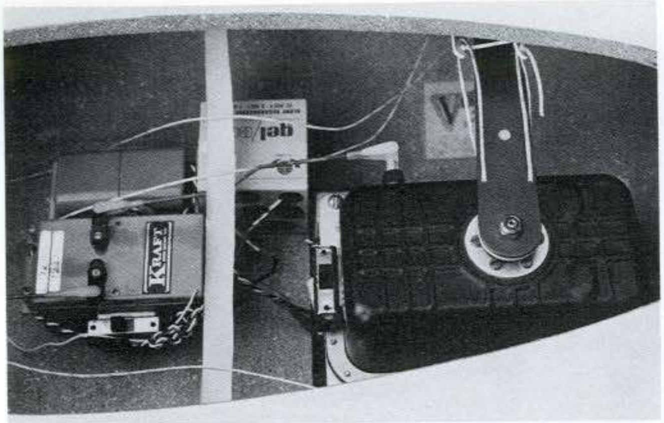
The Sea Wasp motor is approximately 2" in [illegible] and 3" in length.



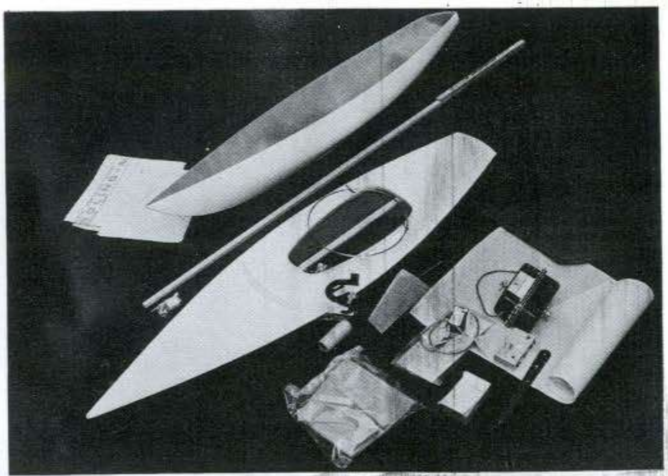
A general purpose exhaust collector will quiet a small engine somewhat. The piping carries the oily exhaust overboard.



The Dumas control unit gives variable speed and forward, reverse, and stop.



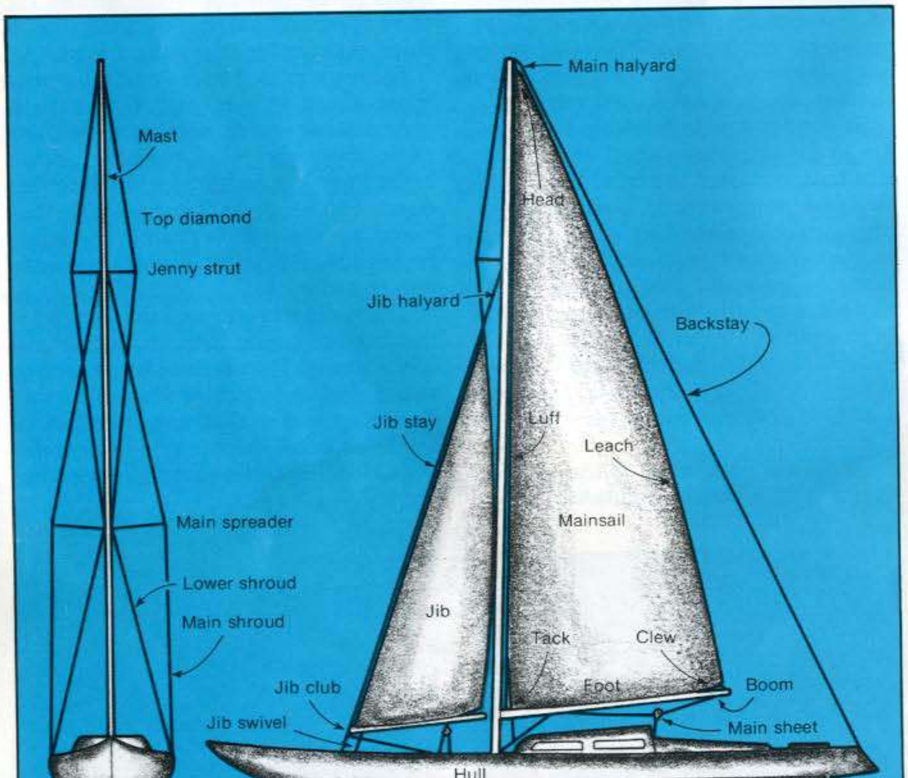
The heart of a radio-control sailboat is the sail winch, at the right in the photo. The sail winch transmits the force of the wind on the sails to the hull of the boat. This installation is shown aboard a Soling-M model sailboat.



The Soling-M sailboat as it appears in kit form: Included are fiberglass hull, built-up deck, and superstructure.

The sail-sheeting winch positions the yacht's sails. Strong fishing line, called sheets for this purpose, leads from the winch to the two sail booms. The sail-sheeting system must be able to set and hold the sails in any position, from all the way in—parallel to the center line of the boat—to all the way out—at right angles to the center line. The winch must withstand the force of the wind blowing against the sails; in fact, the winch transmits the force of the wind to the hull. The winch should be able to pull in a 10-pound load for a distance of 20 inches in 5 to 10 seconds. You can build your own sail winch—many modelers do—or buy one.

The third and most obvious essential is the yacht itself. Model yachts range in length from 3 feet to more than 6 feet. Mast height is usually equal to the length of the boat plus a few inches. The mast and sails are removable, making the yacht easy to transport. About two-thirds of the R/C yachts in use today are kit products; the remainder are scratchbuilt. The most common construction materials are fiberglass for the hull, fiberglass or mahogany plywood for the deck, stainless-steel wire for the rigging, spruce for the spars, Dacron for the sails, and brass for the hardware and fittings.



Construction of a model yacht begins with a stand. Without a stand, rigging the boat is almost impossible. To the fiberglass hull must be added the rudder shaft log, rudder thwart, keel brace, floor brace, sail mounting and control system, floor, mast riser, and deck beam. Polyester resin is the best material for attaching these items. Deck, cabin, and railing complete the craft. All wood parts may be finished with varnish, epoxy, or polyester. The last step is the addition of the keel weight—12 to 14 pounds of lead.

Most sails are made of 2¼-ounce (per square yard) Dacron sewn with nylon thread. Dacron does not stretch or mildew, but it may crease as a result of rough handling. Avoid getting oily stains on Dacron—they are almost impossible to remove.

The radio equipment is best installed on permanent mount rails or in a waterproof box. Double-faced polyurethane servo-mount tape can be used, though, since there is no vibration that would shake the parts loose. The mounting system should be sturdy, because the servo and winch loads are quite heavy.

Rigging: With the boat on the stand, install the centerboard and the rudder if they are not already in place. Hook the jib swivel into its pad eye, step the mast (insert it in the socket), attach the backstay, taking up any slack, and fasten the shrouds to their turnbuckles. Tighten the main shrouds just enough to take out the slack, and adjust the turnbuckles to center the mast over the hull. Check the centering by sighting from some distance ahead or astern. Adjust the jibstay, if necessary, [illegible] the mast is perpendicular [illegible] terline or perhaps raked a little aft. Tighten the lower shrouds enough to take any lateral curvature out of the mast. Check this by heeling the boat over and sighting down the mast or by sighting from astern and using the backstay as a reference. The lower shrouds are also used together with the backstay to control fore-and-aft curvature of the mast. Try to get the mast as straight as possible.

Make sure that all the mainsail hooks are attached to the jack wire. Attach the jib tensioner lines and the main and jib sheets. Secure the radio antenna to the mast, turn on the transmitter and receiver, and run the sheets in all the way. The main should be sheeted down tight. Adjust the main and jib halyards so that the sail luffs neither sag nor are so tight that wrinkles are thrown into the sails. Check the complete control system for proper operation, adjust the jib trim to about the middle of its range, run the sheets out about halfway, secure the cabin and aft hatches, and launch the boat.

Sailing: Most public libraries have at least one good book on sailing. Such books are quite helpful for learning general principles.

Here is a good way to acquaint yourself with the sailing behavior of your model. Put the boat on a beam reach. Adjust the sheets until the mainsail is just filled and not luffing (flapping or shaking). Luffing of the sails is an indication that wind is being wasted. On the other hand, if the sails are too tight, the boat will heel excessively and lose speed. Keep a bit of weather helm (turn the rudder toward the windward side) to prevent the boat from rounding up into the wind. Raking the mast forward produces the same effect.

Now try a close reach, perhaps 60 degrees off the wind, sheeting in as necessary. If you are successful, sheet in all the way and see how high you can point the boat to windward without losing speed. Come about onto the opposite tack, continuing the turn until the sails fill. Now try some jib-trim adjustments. As you head up into the wind with the main sheeted down tight, trim the jib so it starts to luff just before the main does.

Now bear off gradually onto a broad reach, letting the sails out to take advantage of the wind. Watch for luffing at the top of the main. The broad reach is the fastest point of sailing; in a strong wind you will see the boat start to plane. Now turn so the wind is dead astern and let the sails out all the way.

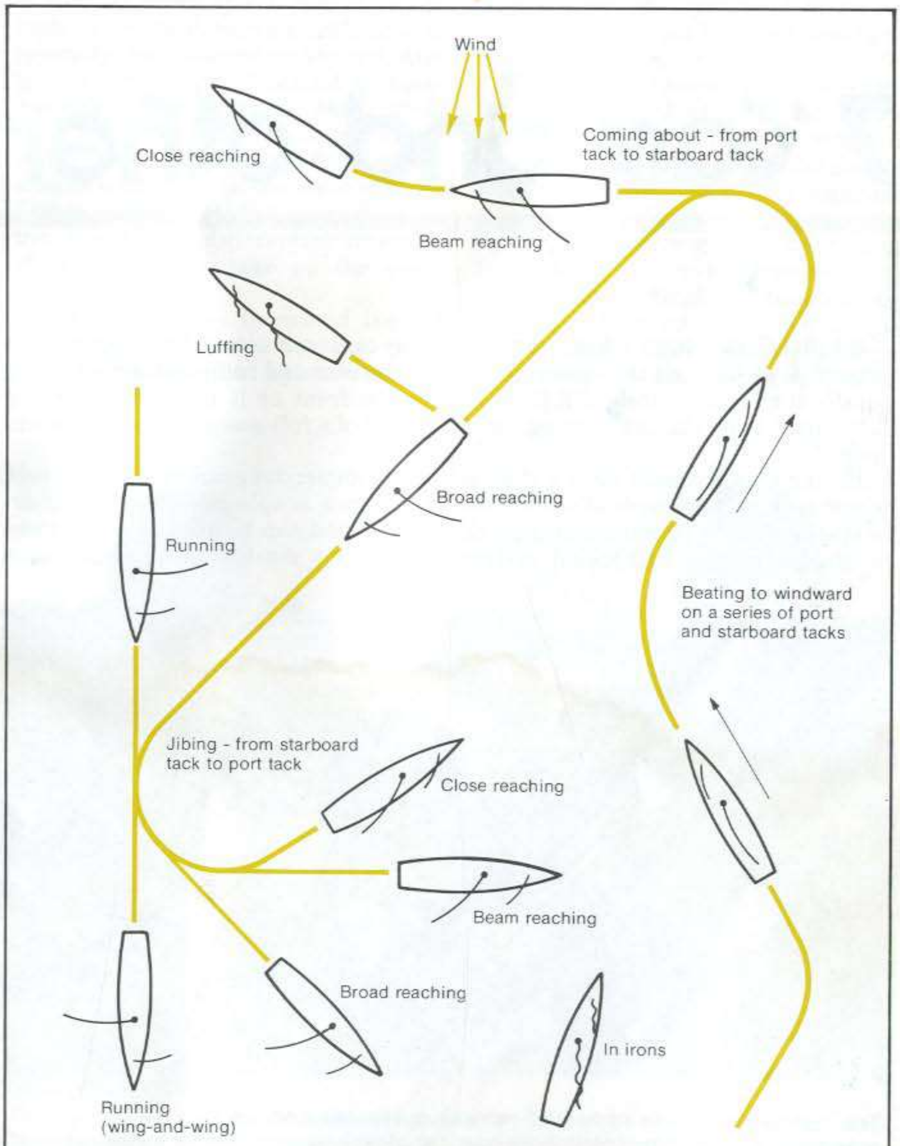
The main objective in running before the wind is to get as much sail area exposed to the wind as possible. To get the jib out of the lee of the main and into position where it will do some good, [illegible] ets in about one-third and [illegible] e side the main is on, just far enough to cause the main to jibe to the opposite side. Now resume your course, sheeting out all the way. With luck the jib will remain where it is and the boat will be running wing-and-wing. Tightening the jib tensioner may help achieve the wing-and-wing configuration.

At this point bring the boat back in so you can check the rigging for slack shrouds and lines and loose knots and also see if any water has been shipped. Adjust the rudder trim if necessary.

Strong winds call for a somewhat different technique. When you bring the boat about, do so smartly—the boat will not coast as far into the wind. The sails will work best if they are as flat as possible, so tighten the main and jib halyards and outhauls. Tighten the boom vang to flatten the main and keep the boom from hiking up on a run. In strong winds the boat will heel way over. Unless the cabin is watertight, some water will be shipped; sponge it out occasionally. Heeling is not dangerous—the boat cannot capsize—but it reduces the effectiveness of the sails and the rudder. Sailing into the wind will be more difficult, and you may have to slack off on the sheets to get adequate maneuverability.

Sailing in light airs can be frustrating or a genuine challenge to your seamanship. Make your turns smoothly, adding helm gradually through the turn to reduce rudder drag. The boat will have little momentum to carry it through, so don't prolong the turns unnecessarily. Be sure to continue the turn far enough to fill the sails on the new tack. You will need more draft in the sails, so slack off the boom vang and the sail halyards and outhauls. If the wind dies entirely and the boat is becalmed, run the sheets out about halfway and wait for the next puff of air before you decide to swim for the boat.

Whatever the propulsion method—sail, steam, electricity, or gas—radio-controlled boats provide hours of enjoyment and relaxation.



POINTS OF SAILING

Hardly anything detracts from the scale appearance of this Mercedes Grand Prix racer. Note the fine detail in the radiator grille and the wire wheels with their knock-off hubs and Michelin tires.

7 Cars and other models

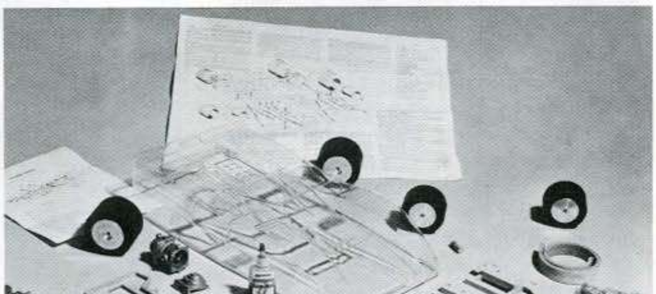
RADIO-CONTROL CARS offer a great deal of fun, and they provide lessons in the fundamentals of R/C. They fall into two classes—racing and sport.

Racing cars are built upon a chassis which may be homemade of aluminum or steel or may be a commercial casting or stamping. The suspension system may consist of a straight unsprung axle at the rear and rudimentary springing at the front or it may be a working model of a full-size automobile suspension.

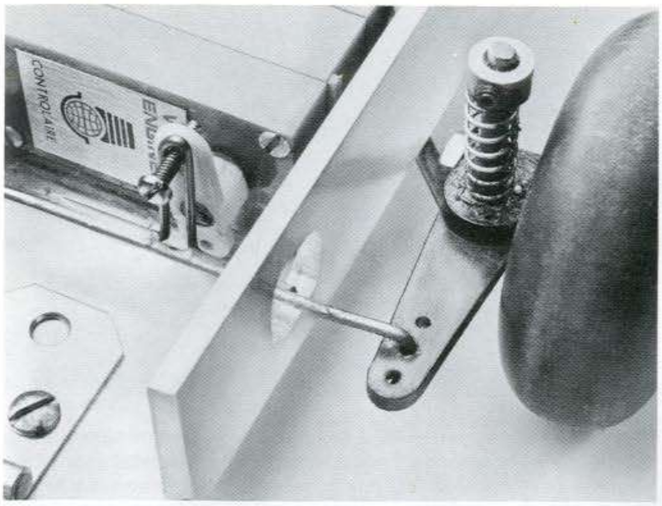
A commercial gearbox, a timing belt, or even a simple pinion and gear arrangement can be used as a transmission. The most exotic transmission used nowadays is a variable-ratio belt drive. Whatever the transmission, a clutch is a necessity for the same reason as in a full-size car. Most models use a centrifugal clutch.

Brakes are desirable on a racing car. The true racing driver must be able to brake when going into turns to permit the proper "drift" before accelerating

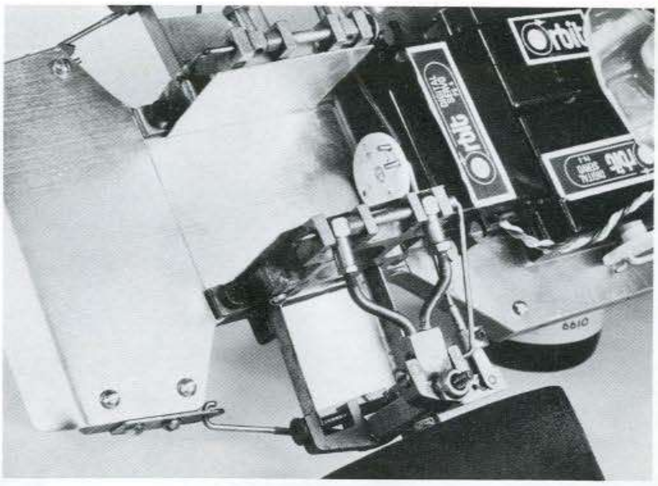
The mechanism of this homebuilt car was assembled from an assortment of commercial parts. Note how a single servo controls the throttle through a pushrod and a bell crank, and the brake through a heavier pushrod angling across the chassis.



A typical race-car kit has a molded plastic body ready for details and paint and a number of precision-machined parts that are bolted together to form the chassis of the car.



This simple steering mechanism and front suspension uses commercial parts and a tie rod made of music wire.



More complex than the mechanism at the left is this independent front suspension with torsion springing. The parts duplicate the front suspension of a full-size car.

out of the turn. Brakes are almost invariably connected to the throttle servo so that they can be applied as the throttle is retarded.

Model cars, like planes, have air-cooled engines. Heat sinks should be bolted to the cylinder head and placed where the air stream created by the motion of the car will cool them. Prolonged idling with the car stopped can lead to an overheated engine.

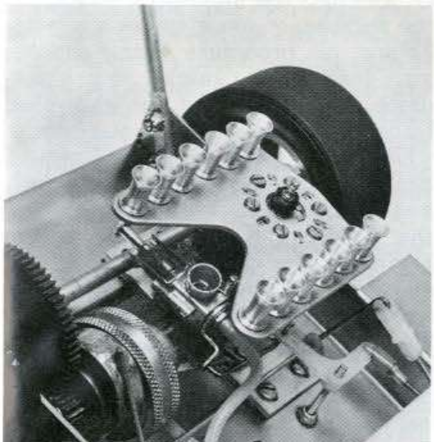
A muffler for the engine is usually necessary to reduce noise and, with an extension, to pipe exhaust away from the radio equipment.

Almost any digital proportional radio system can be used to control a car. Unless a multi-speed transmission is used, only two channels are needed: throttle-brake and steering. Since size and weight are not critical factors, the use of the newest miniaturized R/C equipment is not necessary. You can purchase used equipment. As you become more proficient at operating the car, you may want a more precise steering servo. It isn't necessary to purchase a complete new R/C system; you can adapt a new servo to the existing system.

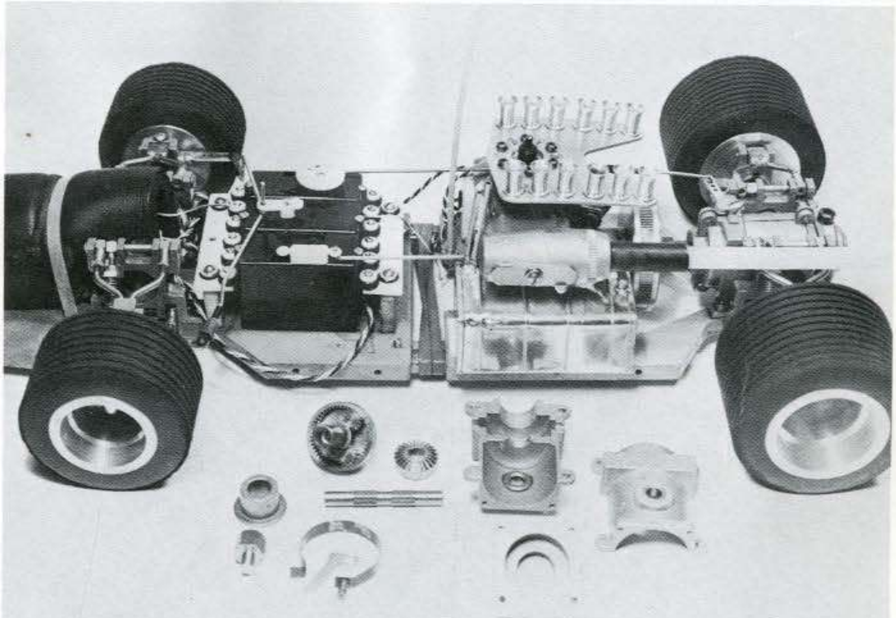
Throttle-servo speed should be as high as practical. Servo transit time is typically .5 to .9 second end-to-end. Any transit time above .7 second is unacceptable to most drivers. Many modelers cut servo transit time in half by using linkages that permit full throttle motion with just half the servo motion. Either a spring-loaded connection to the throttle or differential linkages must be used to take up the overtravel.

The easiest way to extend the receiver antenna above the car is to mount a section of ⅛" nylon tubing so that the antenna wire may be threaded up through the tubing and secured at the top. The full 36" of antenna length is not needed because cars rarely move very far from the operator. The excess antenna length can be coiled loosely at the receiver.

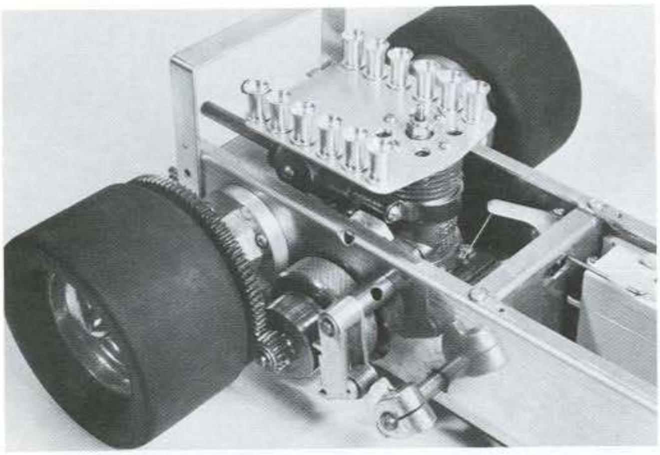
The R/C equipment must be cushioned against vibration. A car transmits considerable vibration to servos. A servo that has been used in a car should never be used in a plane. The standard mounting method—cushioning the servo with rubber grommets—is best for cushioning servos. However, because of the difficulty of constructing mounts and the convenience of simply using double-faced mounting tape, most modelers use the latter. Double-



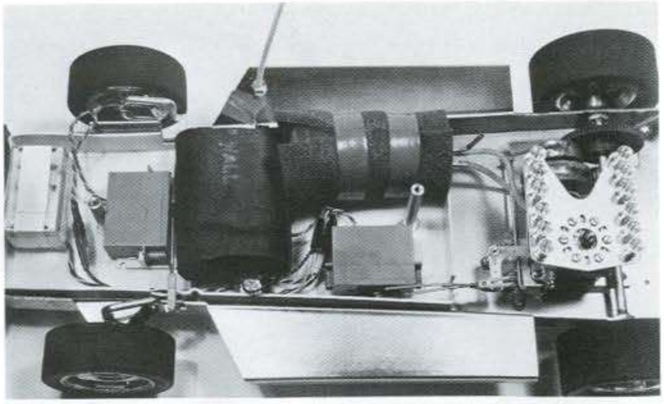
A heat sink—this one has simulated exhaust pipes—is needed to provide adequate cooling for the engine of a race car.



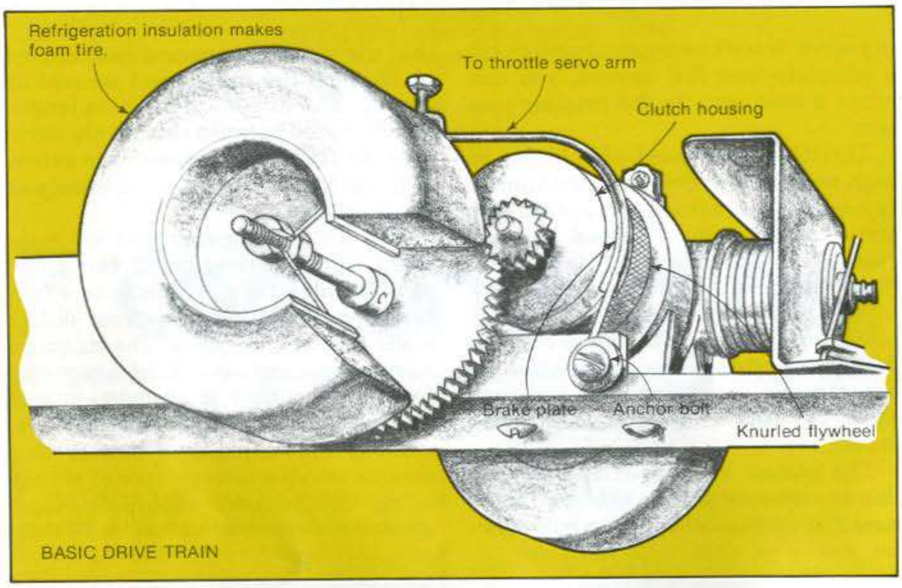
This full-fledged race car, shown without its body, has independent suspension, a two-speed planetary transmission, and three servos that control throttle, steering, and transmission. The nearest servo controls the throttle; the center servo, the steering; and the far servo, the transmission. A second transmission is shown disassembled in the foreground.

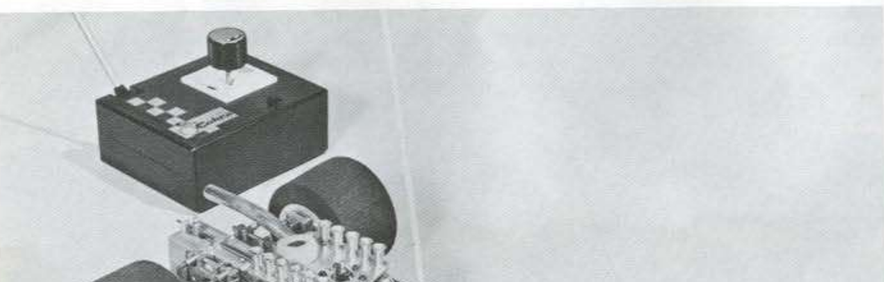


A sophisticated type of brake uses a servo-actuated cam, which presses a brake shoe against the flywheel. The gear-and-pinion drive is typical of gas-engine-powered cars.



Most race cars have plenty of room on the flat aluminum chassis for all the components. This is a two-channel installation. One channel controls steering; the other, the throttle and the brake. Two pushrods enable one servo to control both the throttle and the brake. The receiver and fuel tank are cushioned.





No. 13, built by an unsuperstitious modeler, is an Indianapolis-type racer that has independent suspension and a two-speed transmission.

faced mounting tape must be at least ⅛" thick to protect the servos properly. The receiver and the servo pack should not be solidly mounted but rather should be loosely wrapped in foam rubber. Since there is no way to eliminate the pounding that the gears in a steering servo take, periodic replacement of the gears is necessary. Keep a spare set of gears on hand rather than wait for a failure.

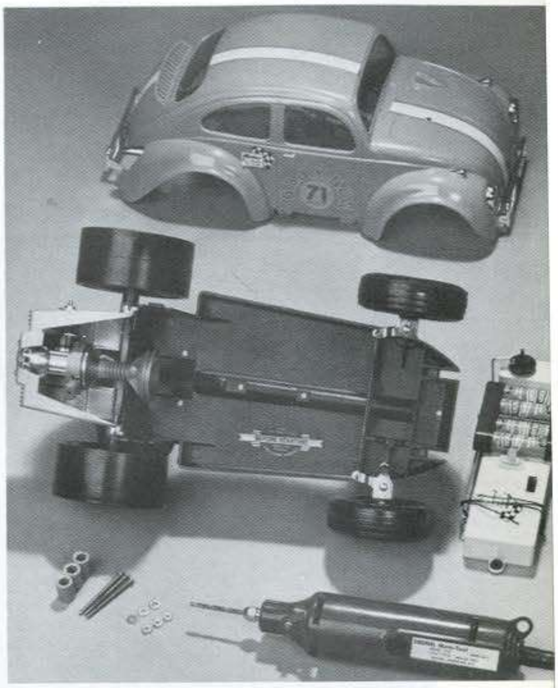
The fuel tank of an R/C car usually is a simple clunk tank: a polyethylene bottle with a pickup that can follow centrifugal force with the fuel. Sophisticated sump tanks that prevent the loss of fuel flow under acceleration and that eliminate foaming sometimes are used.

You can exercise considerable creativity when styling, constructing, and finishing the body shell. Formed plastic and fiberglass are by far the most popular materials. Fuel-proof finishes must be used.

Except for a few cars that have a pull starter, engine-powered cars must be started by spinning the flywheel rapidly. You may use an electric starter for the purpose, or you may use a bicycle. Follow this procedure: Prime the engine through the intake with a few drops of fuel. Connect the glow-plug leads. Bring the starter or the bicycle wheel up to speed. Hold the flywheel against the starter or the bicycle wheel, and as the engine begins firing, open the needle valve until the engine begins to run. Take the car off the starter, and adjust the engine for smooth running. Don't let it over-rev. Throttle the engine back to idle, set the car on the ground with a little forward motion, and take control with the radio.

A number of small plastic models that are driven by either electric motors or small gas engines are easily adapted to radio control. Installation of the radio equipment usually involves adapting the steering

A body kit can be a pair of molded fiberglass shells, to which you add details and paint.



This model VW has a rear engine, just like the prototype—only one cylinder, though.

the model to radio control with a servo.

Modification of some plastic shelf models for electric power and radio control is practical. Gas engines are not recommended for these cars because of the relative fragility of the plastic and its susceptibility to attack by glow fuel. The maximum speed of these cars is not great; if it were, the front-end parts would have to be reinforced to withstand collisions. Magnetic actuators and pulse proportional control are adequate for operating small electric-powered cars.

R/C systems can be adapted to other kits and to automotive designs of your own. Auto magazines are excellent sources of car outline drawings.

Hobby shops carry an extensive line of electric motors and gears. It is not difficult to build your own metal gearbox. Most cars and trucks can be adapted for steering using a servo. Differentials which permit drive wheels to turn at different speeds are seldom necessary. One-wheel drives are customary because of the difficulty of constructing a differential and the lack of any great need for one.

Boat control systems can be adapted for controlling cars quite easily, because of the similarity of operation between boats and cars.

Miscellaneous models: Although most radio-control enthusiasts admire exotic projects—anything other than airplanes, boats, and cars—relatively few modelers have the courage, it seems, to tackle a model such as a submarine or a helicopter. Many people think that such a project requires an electronic and mechanical genius. Ac[illegible] such models are more com-

The flywheel of a car protrudes through the bottom of the chassis, so you can use either an electric starter or the rear tire of an overturned bicycle to start the engine.

Flying a model helicopter is a form of recreation that demands the utmost in concentration.

plicated or time-consuming to build than a multi-channel airplane or racing boat. A project can be as complex as the builder wishes, and an exotic model need not be elaborate or complex.

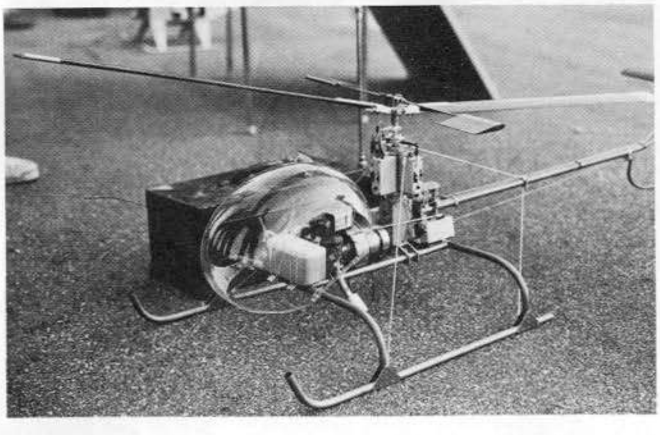
Helicopters: Although R/C cars, boats, and planes now are commonplace, only recently have R/C model helicopters become a reality. There were a number of obstacles preventing the operation of R/C helicopters. One was the practical problem of constructing light, strong, and reliable mechanical parts. Another problem was that no one really knew how to fly a model helicopter.

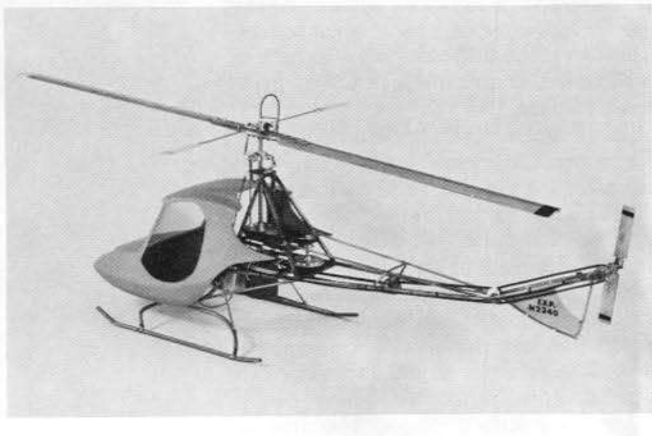
A number of commercial kits are available for helicopters. Because of the amount of machine work and precision involved, the kits are expensive. The cheapest helicopter kit costs around $100 and has some performance limitations; others cost up to $400. Helicopter kits are almost exact scale models of their full-size counterparts. The machinery of the helicopter must perform the same functions and therefore it must be much the same, but reduced in size. Helicopters have, as a minimum, throttle control, two-axis cyclic-pitch control (for left-right and forward-reverse), and yaw control. The most recent kits also have controls for collective pitch. In most models throttle and collective pitch are coupled.

The heart of any helicopter is its transmission. The transmission reduces the engine-output speed from 10,000 rpm or so to about 1000 rpm. It provides a power takeoff for the tail rotor. It carries the entire load of the helicopter. The most efficient transmission is a geared unit, although timing belts have been used successfully.

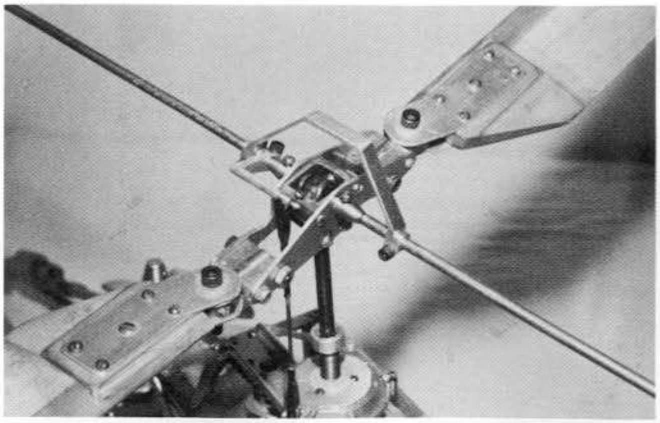
The engine usually is coupled to the transmission through a centrifugal clutch. The engine is started with an electric starter, in the manner described for boats. The engine must be cooled by a shrouded fan.

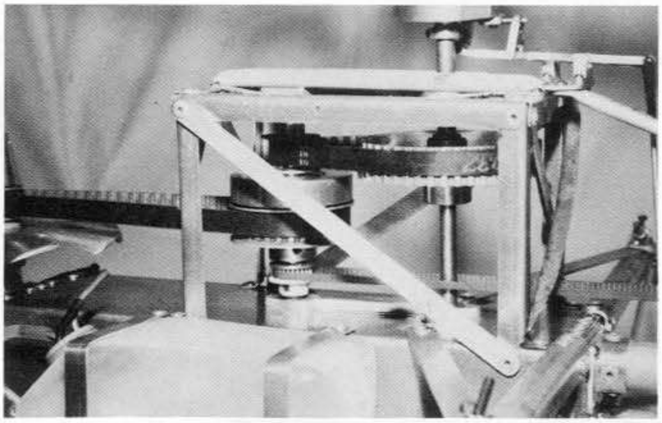
The rotor head poses a difficult engineering and construction task. It carries the main rotor blades, the swash



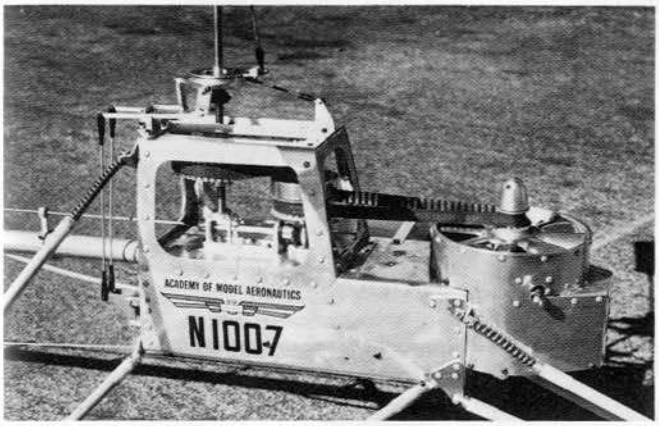


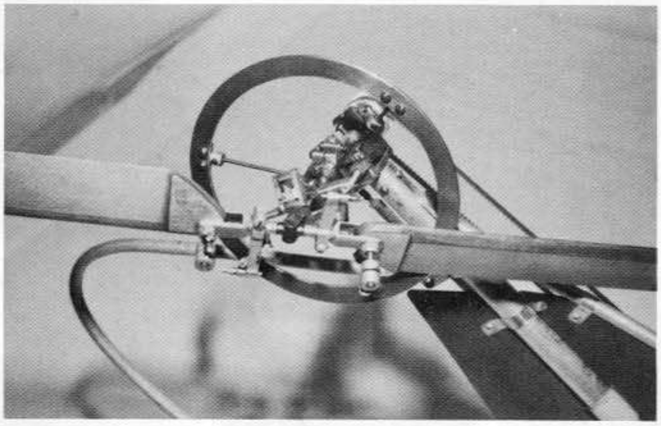
A plastic bubble canopy transforms a simple tubing framework into an almost real-appearing helicopter; a molded fiberglass cockpit performs the same function. The belt drive to the is reminiscent of an old-fashioned dentist's drill.





Simplicity is relative in a helicopter—even a simple rotor head (above) is complex. Timing belts (above right) are usually used to drive the rotors of a helicopter. A shrouded cooling fan and sprung landing gear (below left) are essential. A variable-pitch tail rotor (below) is necessary to control yaw—turning to the left and the right—in a model helicopter.





plates, and the linkages that control the rotor blades. The hub assembly must transmit all flight loads into the drive shaft. The hub is subjected to vibration and cyclic loading. The rotor blades usually are constructed of a composite of hardwood, balsa, metal, and fiberglass.

The tail boom supports the tail rotor and its drive shaft. As long as it performs this function, the structure of the tail boom can be as simple as desired.

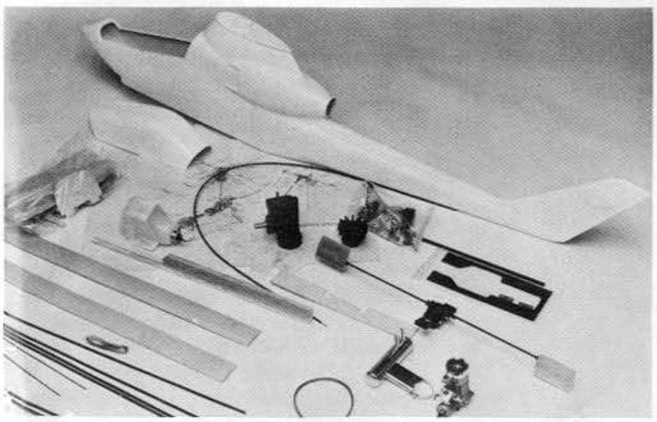
Flying a helicopter is much more difficult than flying a plane. Several hours of practice are needed to master each step in sequence. As with full-size craft, there is almost no correlation in flying technique between planes and helicopters. Learning to fly a helicopter is easier if you have experienced help.

The question of what kind of transmitter to use still has not been answered. Early helicopter modelers had no choice but to adapt existing dual-stick and single-stick transmitters. Special stick configurations have been tried, such as two three-axis sticks. Cyclic pitch is controlled by the right stick, and yaw (tail-rotor pitch) is controlled by the knob on top of the left stick. Throttle is controlled by the left stick and collective pitch is coupled to the throttle.

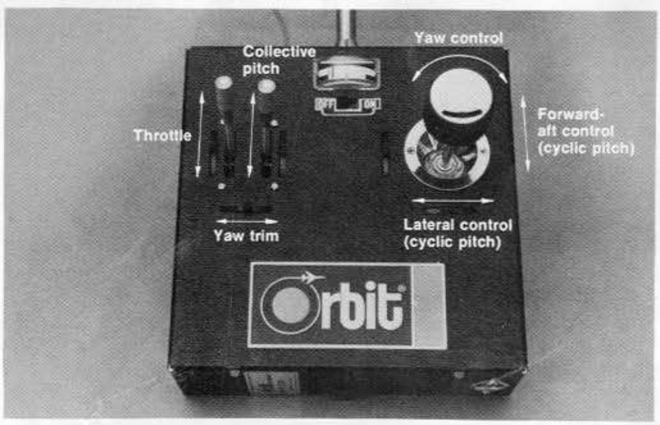
The helicopter is not a beginner's project; the challenge of building and flying one should satisfy even the most ambitious modeler.

Tracked vehicles such as tanks and bulldozers are popular projects for modelers who want something out of the ordinary. Most commonly, toys are used and adapted to radio control. Very few tracked-vehicle models are built from scratch.

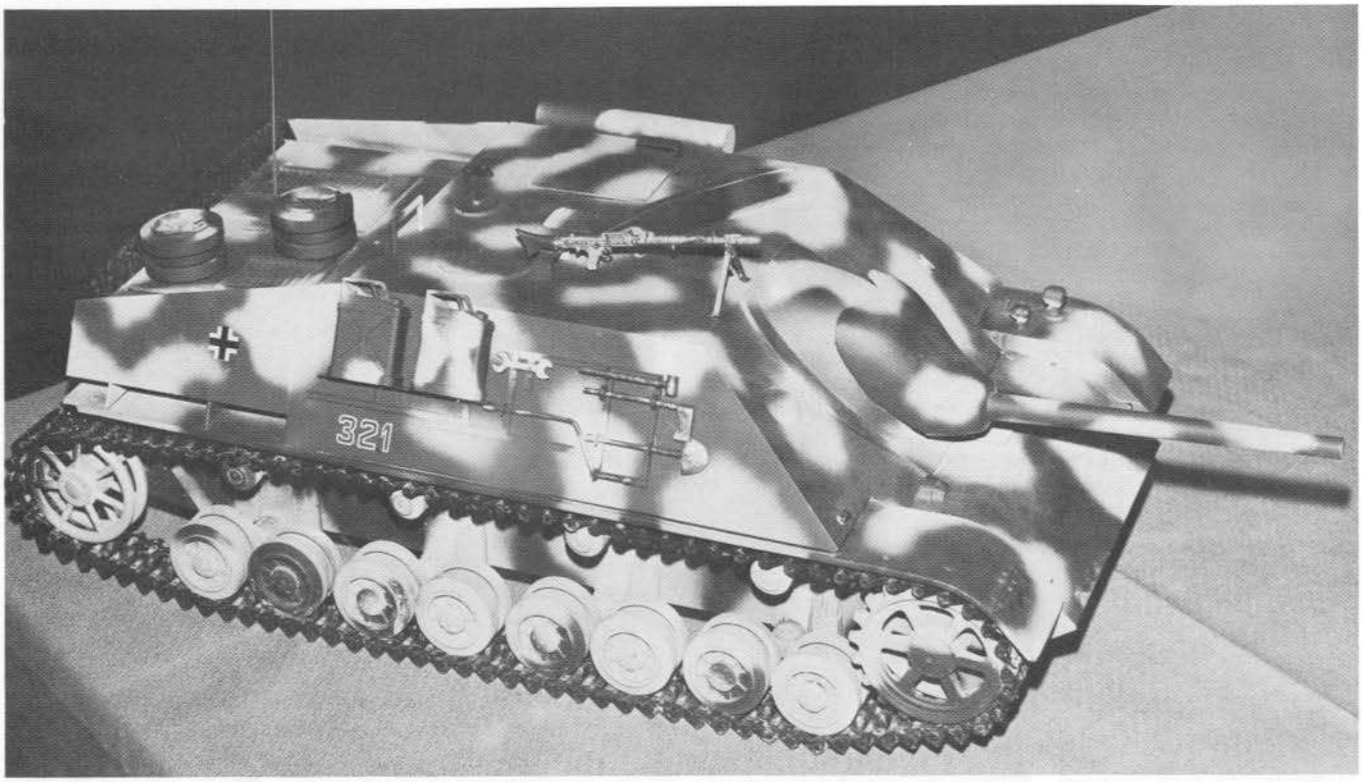
The secret of the propulsion system



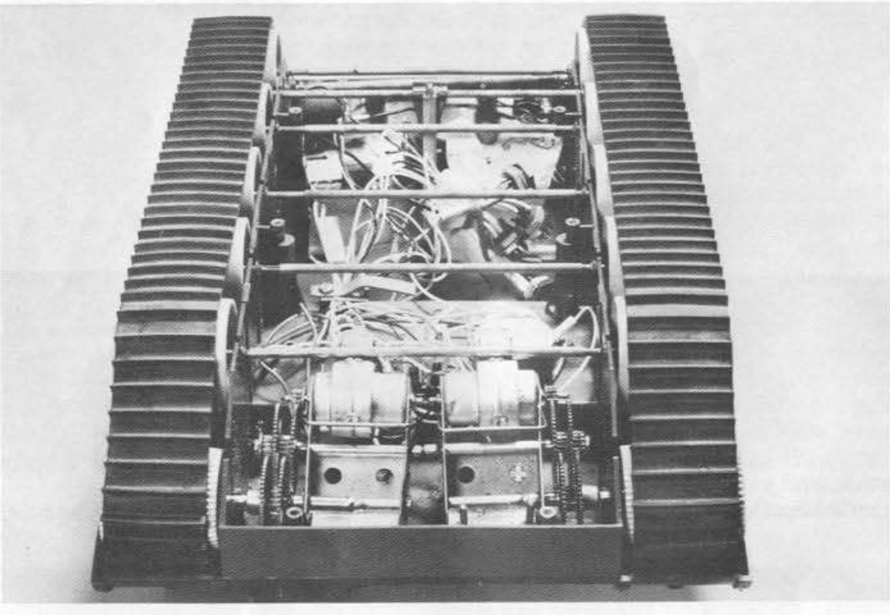
...ess shell of this helicopter kit belies the fact that there is ...x to do before the craft will fly.



The two sticks on the left control throttle and collective pitch; the stick on the right controls yaw and cyclic pitch.



Working tanks can be converted from toys and plastic shelf models. Twin-electric-motor drive (below) permits independent operation of the treads on each side of the tank.



It may not be as fast as a full-size jeep, but it gets better mileage—and it's more fun.

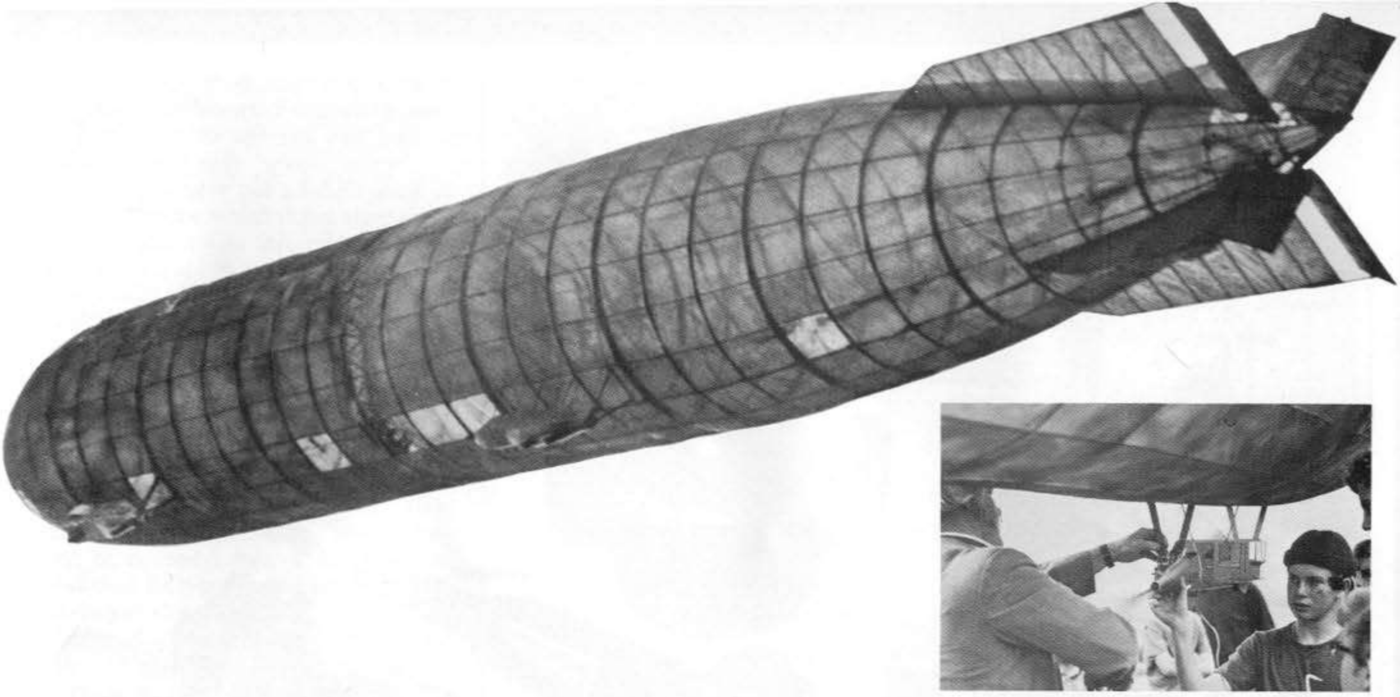
for tracked vehicles is that the drive axle must be divided, with each half of the axle operated by its own electric motor. Tracked vehicles share a few problems with boats. Because of the proximity of the receiver to the motors, arc suppression is required if digital equipment is used. You may even need to install higher-quality motors than those provided with the model.

Submarines are not necessarily complicated, but they call for special operating techniques. Versatile operation can be achieved with single-channel control. Multichannel equipment provides a finer degree of function control.

Model submarines usually do not submerge completely. Normal operation calls for periscope-depth running, which is achieved by ballasting and trimming the vessel so its deck is barely above the surface of the water when at rest. The vessel maintains this attitude at low speed; with more speed the nose inclines downward until the deck is under water. Water ballasting is not required. The submarine is trimmed with the controls to maintain depth—a ticklish operation. Controlled diving planes are more sensitive for their size on a model than on the prototype. Since negative buoyancy is not quite encountered, any control failure or stopping of the engine causes the craft to surface.

The receiver antenna is never under water; thus control is uninterrupted. True underwater control is possible with electro-acoustic transmission, which is too complex to describe here.

Another method of making a sub run deep is cam programming. In



A Zeppelin heading for Lakehurst? No, it's a model of a dirigible. The photo at the right gives an idea of the size of the model.

plest form the cam is driven by a spring escapement or clockwork to operate controls mechanically. The cam can be a printed-circuit disk, as on some servos, with contact fingers that work as switches in the circuits to one or more control motors. Some toy subs (and cars) have employed cam programming. With cam programming the sub is not under radio control while it is submerged. Radio operates the craft on the surface and controls the beginning of the dive. Under water the radio control ceases, and the cam, which can be interchangeable for different programs, takes the boat through simple maneuvers such as turns. Forward speed alone can maintain underwater trim, or forward speed plus cam control. The one danger is a cam failure. You can avoid this danger by placing the cam under the control of a clockwork timer that disconnects the cam after a certain length of time or shuts off the motor, if forward speed is the factor that maintains underwater running.

Submarine models are normally 3 to 4½ feet long. For the smaller ones, the tight space for R/C equipment and the heavy batteries result in the need for very little ballasting. Larger subs may need lead ballasting up to a gross weight of perhaps 35 pounds. Anything larger than that will require more power than inexpensive motors can provide.

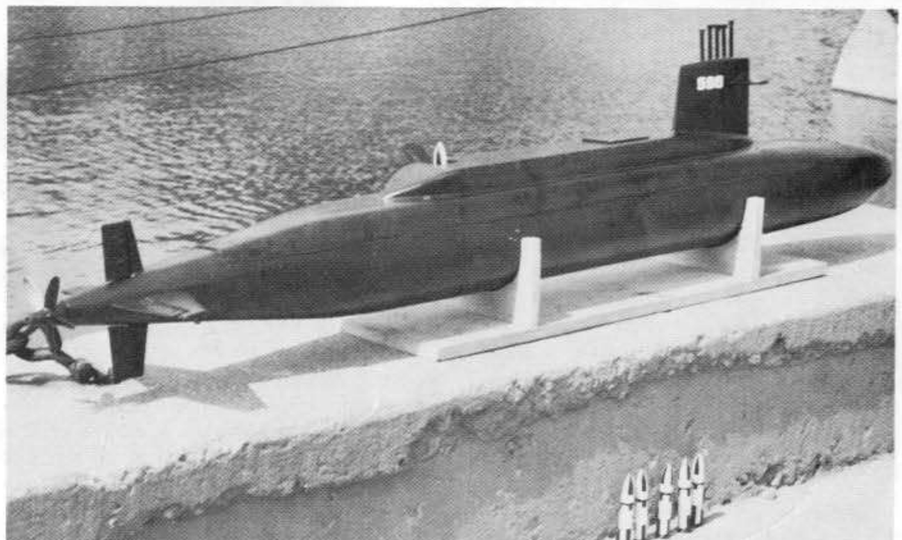
The hull of the submarine can be constructed of fiberglass or laminated wood. Shaft holes are best located and aligned before the external shaping is completed. Careful sealing between the removable deck and the hull is essential. The seal normally consists of greased rubber tubing and stripping. [illegible] the grease you use is compatible with the gasket material. Because the bolts and nuts which hold the deck on and pull it into place put a strain on the hull, firm anchoring arrangements for the hardware are imperative.

Although a simple sub is not much more complicated to construct than a boat, its ballasting is more critical for operation, and its control is more demanding of practiced procedures. Twin-electric-motor drive and ample battery capacity are as essential in a sub as they are in an ordinary boat; also essential are adequately rated electrical components and the suppression of electrical noise.

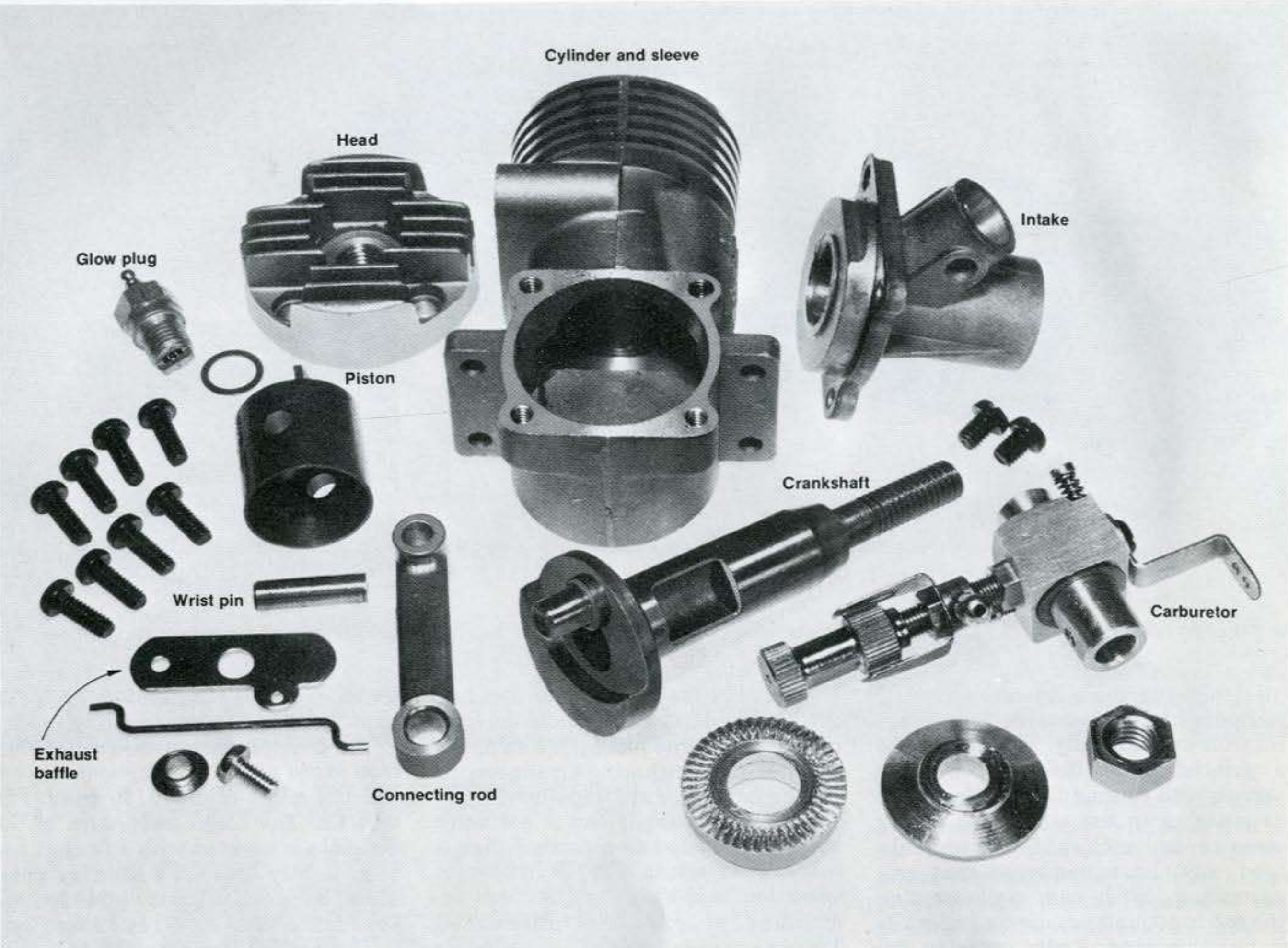
Other models can be adapted for radio control, such as fully operating clamshell cranes. The major tasks are interfacing servos with control switches for electric motors and adequately suppressing electrical noise.

The dirigible constructed by Dr. Harmon Ward uses three channels to control the angle of climb, steering, and throttle. The balsa framework of the dirigible is covered with silk that has been lightly sprayed with gray dope. Mylar bags inside the dirigible contain the helium. The model is 25 feet long and requires a special trailer for transport. The helium for an afternoon of flying costs about $25.

There are, doubtless, projects even more exotic than a 25-foot-long dirigible or a missile-launching submarine. Whatever they are, though, the basic control system is the same reliable radio-control gear. The sky (or the lake bottom) is the limit.



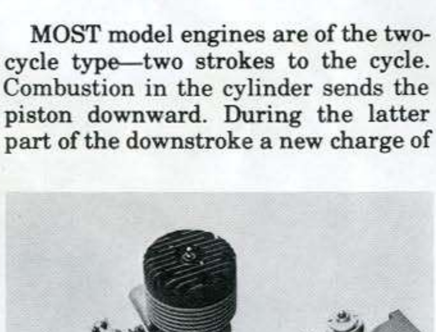
Some model submarines fire dummy missles. The cradle is handy for carrying the model.



Seeing the parts of a gas engine helps you to understand how the engine works. Note the hollow crankshaft that serves as a valve.

8 Engines

MOST model engines are of the two-cycle type—two strokes to the cycle. Combustion in the cylinder sends the piston downward. During the latter part of the downstroke a new charge of fuel and air enters the cylinder, sweeping the exhaust gases out. The upstroke compresses the fuel-air mixture in the cylinder. The mixture ignites as the piston reaches the top of the cylinder.



Engines differ in size: left, a .60-cubic-inch engine; right, an .049 engine.

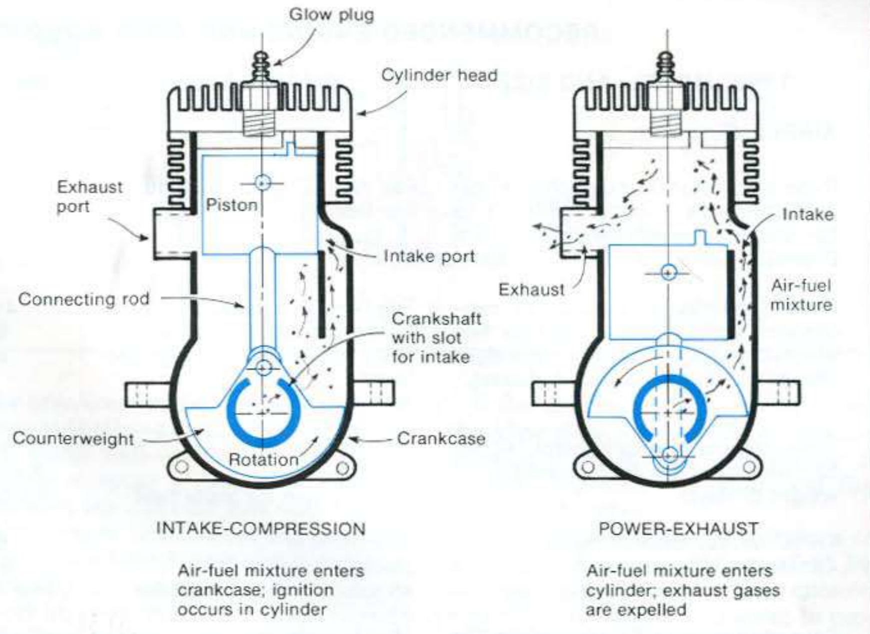
You need to know how a typical two-cycle model engine works to understand why a specific one-yours—doesn't. The diagram on page 77 shows a typical model engine. The engine has three valves, or more accurately one valve and two ports. The intake and exhaust ports are opposite each other in the cylinder wall, and the intake valve is an opening in the hollow crankshaft. The crankcase is sealed except for the two ports and the hollow crankshaft.

Let's follow the action of the engine through a cycle. As the piston rises, it closes the two ports in the cylinder wall and seals the crankcase. A vacuum is created in the crankcase. As the piston nears top dead center, the hole in the crankshaft passes beneath the carburetor. Because of the vacuum in the crankcase, air is drawn in through the venturi of the carburetor. The reduced pressure in the venturi causes fuel to be drawn through the holes in the spray bar and mixed with the air, and the fuel-air mixture is sucked into the crankcase. As the piston starts downward, propelled by the combustion of the fuel-air charge from the previous cycle, it creates a positive pressure in the crankcase, because the crankshaft has turned and the shaft valve has closed. The piston descends past the two ports. Exhaust gases escape while the charge from the crankcase is forced into the cylinder. A baffle on the top of the piston forces the fresh charge upward to clear out or scavenge the exhaust gases. The piston starts upward and begins another cycle.

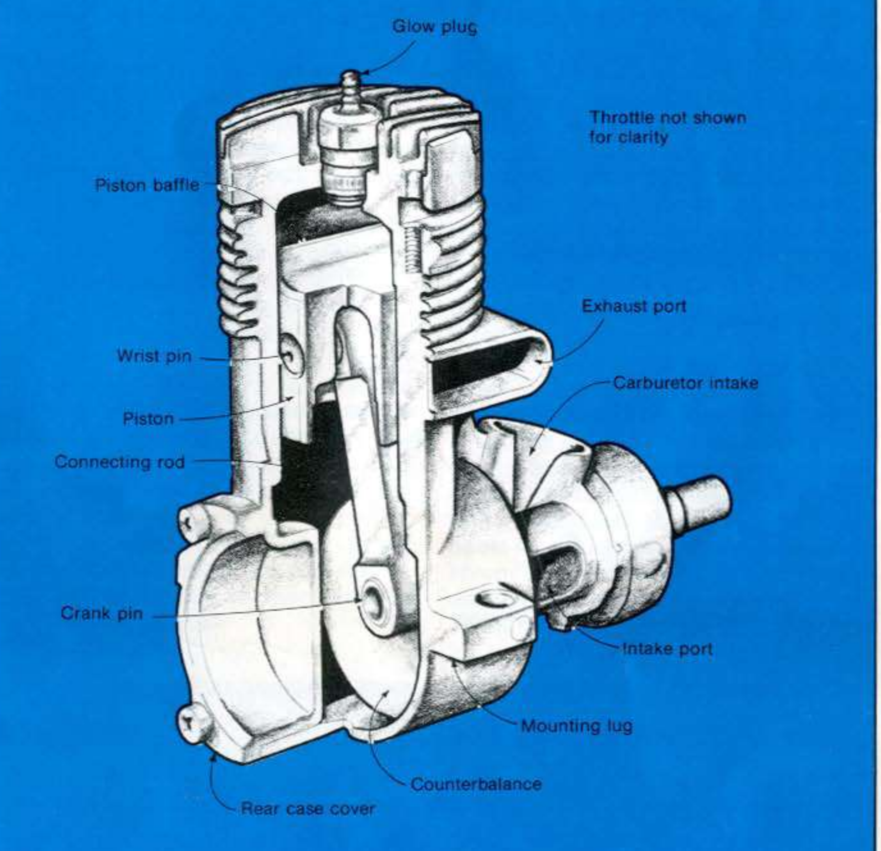
The glow plug is not a spark plug. It has a coil of wire which is hot enough to ignite the charge in the cylinder. Initially the coil is heated by connecting a battery (1.2 to 1.5 volts) to the electrode of the plug and a point on the engine. Once the engine is started the heat of combustion is sufficient to keep the coil hot, and the battery can be disconnected.

The intake valve can be of several types: the opening in the hollow crankshaft described above; a rotating disk between the crankcase and the carburetor; or a reed valve, a disk of thin metal that flutters in and out with the pressure in the crankcase.

Carburetor design also varies. The spray bar may be absent, replaced by several holes spaced around the periphery of the venturi. Some engines have a throttle combined with the carburetor; in many cases the throttle is connected to an exhaust baffle that serves to further regulate the speed of the engine. Other engines may have jet tubes that can be adjusted with a needle valve instead of spray bars.



ROTARY VALVE, TWO-CYCLE ENGINE



TYPICAL ENGINE CONSTRUCTION

Selecting an engine

The size and type of your model determines the engine size. See the table on page 78.

Engine size is critical with airplanes. A plane with too small an engine will not fly; a plane with too large an engine will be uncontrollable. The situation is not so exacting with boats and cars, but too large an engine causes control problems.

Among small engines, the Cox Pee Wee and .049-size reed-valve engines such as the Babe Bee and the Golden Bee are easier to start and adjust than the Medallion and Tee Dee engines but are less powerful and somewhat less durable.

The choice of engines of .09-cubic-inch-displacement size (CID) and larger is much broader. Larger engines should be purchased with a throttle, even though you may not plan to use the throttle initially.

For airplanes, the engines shown in the table can be used as is or with a muffler. The propeller serves as a flywheel, and the motion of the plane provides sufficient air for cooling the engine. For boat application, a flywheel, a water jacket for the cylinder head (for cooling), and an exhaust stack are necessary. A car requires a flywheel, a heat sink, a muffler, and an exhaust pipe.

Breaking in the engine

There have long been arguments and questions about the need for breaking in an engine. Most experts and manufacturers agree that an engine needs to be broken in.

First partly disassemble the engine to remove any chips of metal and other foreign material remaining from the manufacturing process. Remove at least the back cover, the cylinder head, and the prop driver; if you can take the engine apart completely without special tools, do so. Clean all the parts with

RECOMMENDED ENGINE AND PROP SIZES FOR R/C MODELS

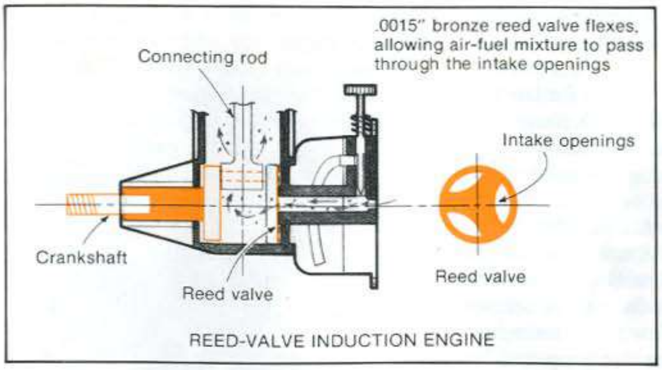
TYPE, MODEL, AND SIZE	ENGINE SIZE	PROP SIZE	COMMENTS
AIRPLANES			
Pulse proportional or one-channel digital control, 24" to 36" wingspan, 8- to 12-ounce total weight (example: Dick's Dream).	Pee Wee .01 or .02 minimum Tee Dee .01 or .02 maximum	.01-.02: 3 x 1¼ .01-.02: 4½ x 2	Break-in, use stock prop. Break-in, cut to 4" diameter.
Pulse proportional or one- or two-channel digital control, 36" to 60" wingspan, about 1 pound total weight (Ranger 42, 2-T, or powered gliders).	Tee Dee .02 minimum Golden Bee .049 nominal Tee Dee .049-.051 for high performance .09 or .10 absolute maximum	4½ x 2 6 x 3 6 x 3 7 x 4	Where torque is a problem with small engines, go to a lower pitch.
Three-channel digital control, 42" to 52" wingspan, up to 3 pounds total weight (S-Ray).	.15 minimum .19-.23 nominal .29 maximum for grass field	8 x 4 8 x 6 (9 x 4) 9 x 6 (10 x 6)	
Three- or four-channel digital control, 46" to 60" wingspan, up to 4 pounds total weight (Falcon 56, Sig Kadet).	.19 minimum .29-.35 nominal .45 maximum for grass field	8 x 6 9 x 6 (10 x 6) 10 x 6 (11 x 6)	
Four-channel digital control, 60" to 72" wingspan, up to 6 pounds total weight (Senior Falcon, RCM Trainer).	.45-.51 minimum .60 maximum for grass field	10 x 6 (11 x 6) 11 x 7 (12 x 6)	On heavy or large models such as the Senior Falcon, use 11" x 6" or 12" x 6" narrow-blade "Power-Prop."
BOATS			
Air boats up to 18" long by 8" wide.	.049	6 x 3	
Air boats up to 30" long by 12" wide.	.19	8 x 3 (8 x 4)	
Cruisers up to 18" long with an 8" beam.	.10	1 x 1	
Cruisers up to 24" long with a 10" beam.	.15-.19	See table on page 81 for marine propeller sizes.	
Cruisers up to 36" long with a 12" beam.	.19 minimum .45 maximum		
Hydroplanes up to 24" long.	.19		
Hydroplanes up to 36" long.	.29-.35		
Hydroplanes up to 48" long.	.45 (.60 or O&R marine engine for full racing)		
CARS			
Small sports cars and 1/12 scale models.	.049	Not applicable.	
Stock, sport, and Indianapolis-type cars.	.19-.23		
Drag racing and large miscellaneous models.	.29-.35 maximum unless water cooled		

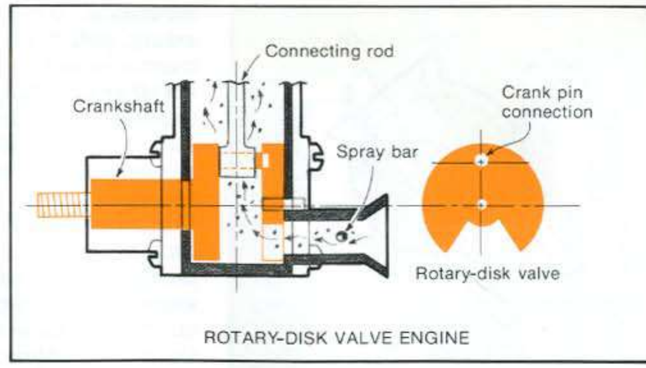
Note: The propeller sizes shown are based on the use of muffled engines. Where two sizes are shown, the one in parentheses will probably overload a muffled engine. Unless the engine will reach and sustain nominal speed without loading or overheating, the prop specified in parentheses should not be used.

alcohol, oil them sparingly with a light machine oil, and reassemble the engine.

It is not a good idea to break in the engine for long periods of time on the workbench, because the load on the engine and the cooling of the engine are quite different from what they will be in the model. However, you should make the first two or three starts and short test runs at the bench for convenience in learning to start the engine. Even if you plan to use the engine in a car or a boat, test it with an airplane propeller to provide adequate cooling.

The fuel used during break-in should contain at least 25 per cent lubricant, and part of that lubricant should be castor oil. If you don't know the composition of the fuel, add 1 ounce of castor oil to a quart of the fuel. Never use a





fuel that is more than 15 per cent nitromethane for break-in. Commercial sport-flying fuel is usually about 10 to 15 per cent nitromethane.

Read the manufacturer's instructions before you break in the engine. If they differ greatly from these instructions, remember that the warranty on the engine requires that you follow the manufacturer's instructions. Even if the manufacturer says no break-in is needed, the break-in will improve the performance of the engine.

For the first few runs, avoid using a muffler if possible, because of the added back pressure and heat. Earplugs may help you to stay in the vicinity of the engine. The break-in can take place with the engine either in the model or on a test stand.

Fill the fuel tank and start the engine. Open the high-speed needle valve about five or six turns. Choke the engine by placing a finger over the carburetor intake and flipping the propeller counterclockwise two or three times. Fuel should flow through the fuel lines from the tank to the carburetor (unless there is an air leak in the fuel line) and not siphon back to the tank when you stop turning the prop (which it will do if the tank is mounted too low).

Next heat the glow plug by connecting one lead of a 1.2- to 1.5-volt battery to the electrode of the plug and the other lead to some point on the engine. You can check the glow plug by removing it from the engine and connecting it to the battery. The coil should glow bright orange. If it is dull orange or red or dark, check the battery and the plug.

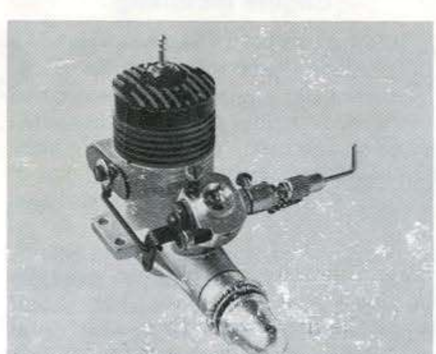
The propeller should be mounted so that the blades are positioned at two o'clock and eight o'clock, viewed from the front, when the piston begins to come up against compression. There are two reasons for this. First, it's the most comfortable position for starting (left-handers may disagree—they may want to experiment to find a better position for the blades), and second, if your plane should come in for a dead-stick landing (no power), the prop is somewhat protected.

With the fuel visible in the feed line, choke the engine for three more flips of the prop to place an atomized charge in the crankcase and the cylinder. Use a primer bottle—an old nasal-spray bottle works well—or an old hypodermic needle to spray a drop or two of fuel through the exhaust port onto the top of the piston. Grasp the propeller firmly and slowly force it over. If the engine is properly primed and the glow plug is working, you will feel a slight kick as top dead center is passed. Rotate the prop on around until the piston comes up against compression and then flip it sharply.

The engine may start to run with a rich "four-cycle" sound—blubbery and somewhat rough. It may pop once. It may run for a short burst and then quit. It may not fire at all.

A new engine almost never starts the first time. If it pops once but doesn't keep running, continue flipping the propeller for a dozen times or so. If the engine pops each time but does not start, lower the piston until the exhaust port is open and blow sharply into it to clear out the excess fuel. Chances are that the engine will start with the next flip of the propeller. If not, you may have to reprime the cylinder.

If the engine runs for a moment and then stops, reprime and try again. If it repeats and still will not run for more than a few seconds, open the needle valve another turn and choke the engine for three turns of the propeller. Check the fuel line for air leaks and the needle-valve assembly for any dirt or congealed castor oil in the fuel that might be clogging it.

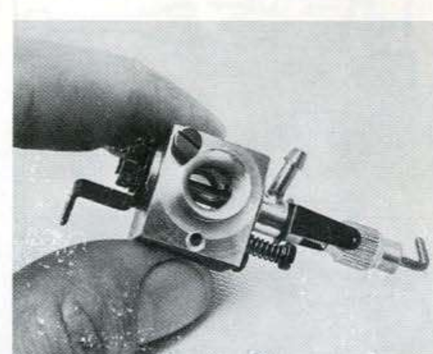

On many engines the throttle and the exhaust baffle work together to control speed.

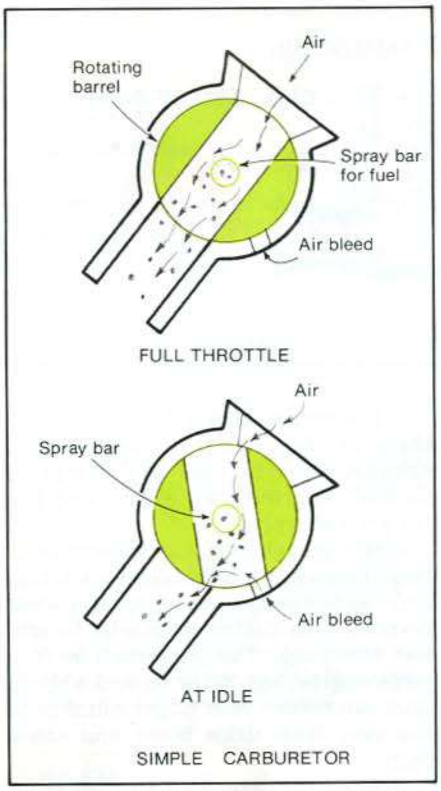
If the engine doesn't fire at all, check the glow plug, and then blow into the exhaust port, in case the engine is flooded. Reprime, try again, and flip the prop sharply.

Many modelers out of deference to their fingers use a "chicken stick" for flipping the prop over—a piece of wood covered with rubber or plastic to protect the prop. The combination of a large engine, say .60 or so, and a sharp prop can reduce your finger count or at the very least draw blood and cause pain.

Break-in procedures are different for engines with piston rings and engines with lapped pistons—first the engine with rings. If it starts running rich, as indicated by a lot of oil in the exhaust and a blubbery sound, screw the high-speed needle valve in, leaning the mixture (more air, less fuel) just enough so the engine will continue running when the battery is disconnected from the glow plug. If the engine slows down, reconnect the battery and lean the mixture an eighth of a turn at a time until the engine just holds speed. Do not lean it out any further now—never lean out an engine to a "two-cycle" peak—a smooth, high-pitched sound—during the early part of the break-in.

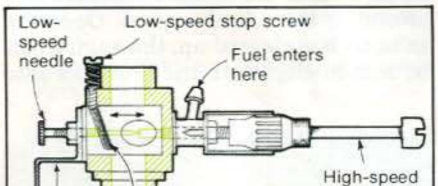
During the first few minutes of running, the engine will emit a rather dark, oily exhaust as the moving parts mate with each other. The dark exhaust should last no longer than the second or third tank of fuel. Once the exhaust has cleared up, the engine can be leaned slightly until it breaks into


Visible inside the venturi of this carburetor is the spray bar. Throttle arm is at the left.



a clear, smooth two-cycle sound. Back the needle valve off until the engine sound starts varying between two-cycle and four-cycle sound. If all is well, the engine should be able to run for 5 or 6 minutes without slowing. If the engine does slow down, back the needle valve off so that the engine runs with a four-cycle sound. When the engine is able to run through a tank of fuel without slowing or requiring adjustment of the needle valve, it is ready for use.

Engines without piston rings require additional bench running. Run the first one or two tanks of fuel through without leaning out to a two-cycle sound at any time. As the second or third tank progresses, lean the engine out to a two-cycle briefly and then richen it immediately. When the tank is nearly empty, pull the fuel line from the carburetor inlet to stop the engine abruptly rather than let it run lean for the few seconds it would pull air through the fuel line. After about six runs on the bench the engine can be operated in the model.



For break-in do not use a propeller larger than the one you intend to use for flight, because it will overload the engine. If the engine cannot be leaned out during the next few runs, switch to the next smaller diameter prop and let the engine run faster but still with the rich mixture setting.

In some small engines varnish may tend to build up, keeping them from running at full power. A half ounce of Hoppe's gun cleaner or one of the commercial small-engine cleaners added to each pint of fuel will prevent varnish from forming during break-in.

Once the engine is running properly, you may fly the plane, drive the car, or operate the boat. Don't lean the engine out to a peak, though, until you have run at least a gallon of fuel through it. If during a flight or a run you hear the engine speed up into a continuous two-cycle, throttle back immediately, land the plane or stop the car or boat, and reset the needle valve for a richer mixture. As each tank of fuel is consumed, you will probably need to lean the mixture about one click of the ratchet on the needle valve to maintain the same speed as on the previous run. By the end of the first gallon of fuel or so, the situation should be stable.

Two-cycle model engines depend completely on the oil in the fuel for lubrication and for some cooling. A rich fuel-air mixture provides plenty of oil for lubrication; thus the emphasis on a rich mixture during break-in.

The break-in period never really ends. One excessively lean run can damage an engine and shorten its life. Except for all-out competition, you seldom need to run an engine at a full screaming two-cycle on the ground, but the engine should break into a two-cycle during airplane maneuvers or a high-speed boat or car run.

Engine mounting

It is impossible to balance a one-cylinder engine perfectly, and the vibration from the engine can be amplified by poor mounting. A poorly mounted engine—or an unbalanced propeller—can lead to fatigue failure of the model and damage to the R/C system.

There are two types of engine mountings, radial and beam. A radially mounted engine is screwed or bolted directly to a flat plywood firewall or, in some cases, to a flat aluminum plate that is bolted to the firewall. Radial mounting works well for .049 and smaller engines. A sturdy ⅛-inch

A Perry carburetor and a closed-chamber muffler have been installed on this .19 engine. At the lower left is the propeller shaft.

plywood firewall will retain ½-inch-long No. 2 wood or sheet-metal screws for .049 or smaller engines.

There are several different methods by which an engine can be beam-mounted. Allen screws are recommended to fasten the engine down, because they can be tightened much more securely than ordinary machine screws. If you use ordinary slotted-head screws, though, choose fillister-head screws rather than round-head screws. The extra thickness at the edge of the head provides much more area for the screwdriver to bear against. Elastic stop nuts work much more positively than washers and ordinary nuts, and they are recommended over blind nuts in locations where they can be reached easily. For attaching engines or a breakaway plate to plastic mounts or hardwood beams, steel sheet-metal screws work well and are cheap. A thin rubber washer under the engine-mount lug helps maintain tension on the mount bolts to prevent loosening of the

This rear-rotary engine is equipped with a Kool Klamp water jacket and a flywheel to adapt the engine for marine use.

bolts. Check extruded and cast aluminum mounts for taper on the mounting surfaces that can cause unwanted thrust misalignment. Washers can be used to compensate for the taper.

Boat engines mount in much the same way as airplane engines. Car installations require that the engine be mounted in the metal chassis, using allen screws, rubber washers, and lock nuts.

Propellers

The table on page 78 provides most of the information you need for selecting a propeller. Once the engine is broken in and you know it can get the model off the ground or through the water, you can experiment to determine what is the optimum propeller.

The basic rule is that the prop must not overload the engine while the model is held stationary. If the engine cannot be made to reach its normal peak speed, as determined by sound, or if it overheats, use a propeller of lower diameter or pitch.

You may want to experiment with propellers of the next higher and next lower pitch than the one recommended. A lower pitch might be necessary to get a plane out of rough grass; a higher pitch might be needed to make a light, clean aircraft maneuver crisply.

For boats, use nylon props until you find one that works best. Then you may want to buy a copper-beryllium propeller, more durable but more expensive than nylon.

Most airplane propellers are wood, by far the best and safest material. Wood props are more expensive than nylon ones. Nylon propellers survive crashes better than wood ones, but they are susceptible to fatigue from flexing. Flexure can be seen while the engine is running, but never stand in front of the propeller. The tips of the prop describe a blur path about half an inch wide.

There are certain precautions to follow with nylon propellers. Do not use nylon props on any engine larger than .45 CID or on a .45 engine that will be run in excess of 12,000 rpm. Avoid using nylon in weather colder than 40 degrees Fahrenheit, except on .049-inch displacement and smaller engines.

Balance nylon props carefully, because they are more dense than wood and can develop more stress and vibration than do wood propellers if out of balance. For engines larger than .051, temper nylon propellers. Support the prop on a cookie sheet so the blades do not touch anything. Bake the prop at 225 degrees for 30 to 40 minutes. Turn off the oven, open the door slightly, and let the prop and the oven cool to room temperature.

You can color a nylon prop by boiling it in water with Rit dye; you must temper it afterwards. Because nylon does fatigue, replace the propeller after about 50 flights as a safety precaution.

Airplane propellers must be carefully balanced. Balancers are available commercially, or you can make one. Balance the prop by sanding material from the front of the heavy end of the blade.

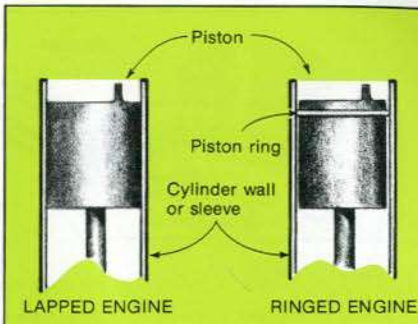
Three- and four-blade props, other than the small ones used on .051 and smaller engines, are not as efficient as a good two-blade prop. Most of those seen in photos are for scale effect only.

Fuels

Glow-plug engines require a fuel that can be ignited without the need for a spark. The most commonly used mixture includes methyl alcohol (methanol), nitromethane, and castor oil or a synthetic lubricant, usually some substance derived from ethylene glycol.

Some fuels contain additives, such as nitrobenzene, also called oil of mirbane, which is used as an anti-detonant. Detonation, explosion of the fuel and air in the cylinder, can be caused by insufficient cooling of the engine, temperature and humidity, or engine intake timing. The effect of nitrobenzene can be heard best on a hot summer day. An engine will seem to run normally except for a crackling sound; add some nitrobenzene to the fuel (2 or 3 ounces to a gallon of fuel) and the crackling will subside.

Most commercial fuels consist of about 25 per cent lubricant, 5 to 15 per cent nitromethane, and the balance methanol and small amounts of additive.



LAPPED ENGINE: Has no rings; seal is achieved by close fit between piston and cylinder

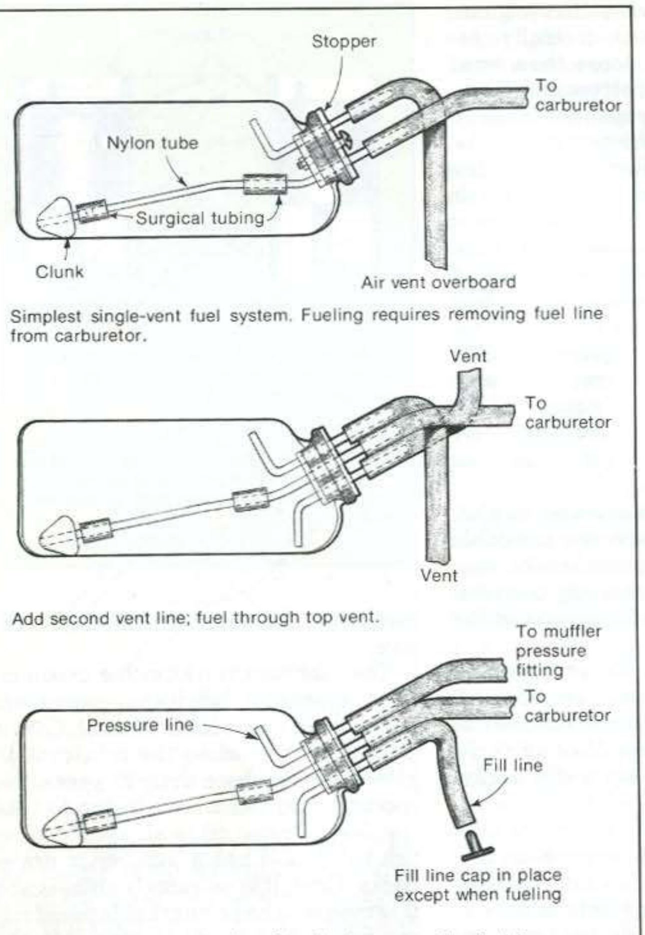
RINGED ENGINE: Has more space between piston and cylinder wall; seal is achieved by spring pressure of piston ring on cylinder wall

The lubricant can be either castor oil or a synthetic lubricant—petroleum oils will not mix with methanol. Castor oil has been used as the lubricant in glow fuels for more than 20 years, but recently synthetics have begun to take its place. Castor oil is an excellent lubricant, but it has a number of drawbacks. First, it is extremely viscous and it is messy. It has remarkable penetrating power and tends to soak into the structure of the model faster than synthetics. (Pity those poor World War I pilots who flew for hours at a time behind radial engines that used castor oil for lubrication—and breathing its fumes has the same effect as taking it internally.) Second, the viscosity of castor oil in cold weather makes starting the engine difficult unless the fuel is kept warm. Third, in small engines and in large engines that are idling, castor oil forms varnish, a brown gunk that increases piston drag, on the cylinder wall and the piston. To remove varnish, put an ounce per gallon of Lubricin in the fuel, use a like amount of detergent such as Peak Power or Hoppe's gun cleaner, or take the engine apart, clean it with steel wool and detergent, oil it, and reassemble it.

MARINE PROPELLER SIZES

Engine Size	Speed Prop Dia. x Pitch	Power Prop Dia. x Pitch
.15	1.378" x 1.92"	
.19-.29	1.574" x 2.20"	1.574" x 1.88"
.35-.40	1.771" x 2.48"	1.771" x 2.12"
.45-.56	1.968" x 2.76"	1.968" x 2.36"
.60	2.165" x 3.03"	2.165" x 2.59"
.65	2.362" x 3.31"	
.71-.80	2.559" x 3.86"	
1.40	2.775" x 3.86"	2.775" x 3.30"

Fiberglass-nylon engine mounts are available for any size engine.

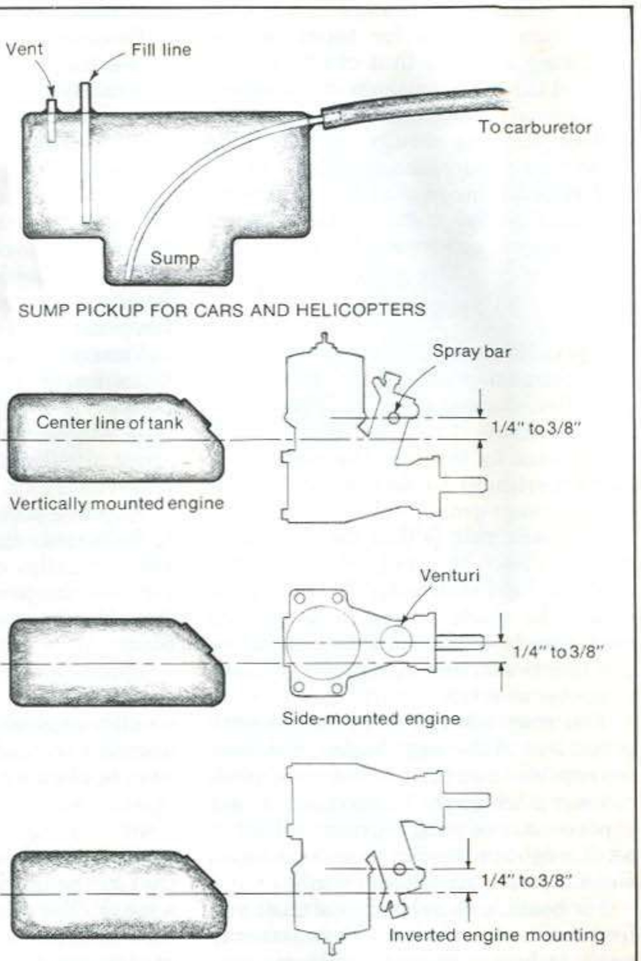


Simplest single-vent fuel system. Fueling requires removing fuel line from carburetor.

Add second vent line; fuel through top vent.

Using exhaust pressurization of tank to insure positive fuel flow

FUEL LINE INSTALLATIONS



SUMP PICKUP FOR CARS AND HELICOPTERS

TYPICAL FUEL TANK INSTALLATIONS

Synthetic lubricants avoid the problems associated with castor oil, but they have their own weaknesses. Castor oil retains its film strength to a temperature of about 700 degrees, while synthetics begin to break down at about 400 degrees. The temperature of the cylinder head of a model engine is about 350 degrees during normal operation, but it can double under conditions of overloading, lean mixture, or inadequate cooling. Some fuel mixtures contain both synthetic lubricants and castor oil; some may contain Lubricin N-1, a high-film-strength additive.

This .61 engine—large as model engines go—has been modified with a Perry carburetor and a flow-through muffler.

Remember, too, the precautions in the section on breaking in the engine. It's not necessary to run the engine with a big plume of oil belching from the exhaust, but remember that a high-pitched, screaming two-cycle is hard on the engine.

When you price that first gallon of fuel, you may decide to mix your own to lower the cost. The ingredients are easier to find in some areas than in others. Speed shops can provide nitromethane and methanol; chemical supply houses can furnish castor oil, nitromethane, and various additives; and chemical and lubricant firms may be able to supply the other items. The author has used the following mixture:

	Per cent	Ounces per gallon
Baker AA castor oil	25	32
Nitromethane	5	6½
Methanol	67½	86½
Nitrobenzene	2½	3

You can add small quantities of Hoppe's gun cleaner or Peak Power detergent to the complete mix.

Because of the cost of castor oil this mixture is no longer competitive in cost with commercial fuels. Here is a mixture that uses synthetic lubricant:

	Per cent	Ounces per gallon
Baker AA castor oil	5	6½
Synthetic lubricant	16	20½
Lubricin N-1	1	1
Nitromethane	8	10
Methanol	70	90

Because of shipping regulations, nitromethane is usually diluted about 2 to 1 with methanol, so consider, for example, each ounce of diluted nitromethane as 1/3 ounce of nitromethane and 2/3 ounce of methanol, and revise the quantity of straight methanol accordingly. Pure nitromethane is dangerous to handle, and the diluted material is preferable. Be as careful with nitromethane as you would be with gasoline.

Fuels should be mixed in a well-ventilated area. Do not mix fuels in your basement. Enough vapor could accumulate so that the furnace or the water heater could ignite it.

Cleanliness is essential.

mixing and handling of fuels. Use milk filters or laboratory filters and clean utensils. Store the fuel in tightly sealed metal or plastic containers. Never store fuel in glass containers.

The author has experienced no difficulty finding the ingredients mentioned in the Washington, D. C. area. In some areas commercial fuel may be easier or cheaper than home brew, particularly if you have to go to several sources of supply for the ingredients.

Fuel systems

Some small .049 engines have an integral tank mount that makes the fuel system self-contained. Other engines, though, require a fuel system that consists of a tank, a feed line, a pickup line, and vent lines.

Molded polyethylene tanks are used almost universally; metal tanks tend to rust or corrode. Polyethylene tanks come in many shapes, sizes, and brand names; base your choice on the shape needed for your installation, the size, and the price.

Match the size of the tank to your engine to give an average run time of 10 to 12 minutes. A longer run, unless you operate alone, is not fair to the other people on your frequency. Further, a tank that is too large can cause fuel feed problems as the fuel depth changes during the run. Recommended maximum tank sizes are:

Engine	Tank
.60	12 oz.
.45-.50	8 oz.
.29-.40	6 oz.
.19	4 oz.
.10	2 oz.

The fuel lines and the fuel pickup probably cause more annoyance than any other part of the model unless they are properly installed. The flexible fuel line can be clear polyvinyl chloride plastic, which hardens quickly in use, surgical tubing, which eventually becomes gummy and dissolves, or silicone rubber, which breaks under severe strain or a shear load. All in all, silicone rubber is best, but it may be difficult to find in sizes to fit the small engines.

Instructions for most commercial tanks show a length of flexible tubing from the outlet tube back to the fuel pickup or "clunk." The clunk is free to move up, down, and sideways to follow the fuel as it sloshes back and forth during turns and inverted flight. A hard landing is apt to force the clunk to the front end of the tank, kinking and doubling the fuel line back upon itself.

A better way to connect the clunk to the outlet tube is with a section of stiff nylon tubing, with short lengths of silicone rubber [illegible] connecting the clunk to th[illegible] tubing and the nylon [illegible] outlet tube. The clunk should be free to move from side to side, and when the tank is held vertically the clunk should clear the end of the tank by ¼ inch.

Generally speaking, nylon tubing is best for all fuel lines that need not be flexible. Use non-serrated ⅛-inch nylon-tubing pushrods, heated and shaped as necessary.

Because of the vibration which causes fuel to foam, most boats and cars use a sump tank; so do helicopters, because of the absolute necessity to keep fuel flowing to the engine.

Except for exhaust-pressurized tanks, the center line of the tank should be ¼ to ⅜ inch below the level of the spray bar or the center of the venturi—see the illustration on page 82. With the tank higher or lower, fuel will tend to siphon toward the engine or back into the tank.

There are several good practices to follow in laying out fuel lines. Keep all lines as short as practical. Avoid kinking and pinching the lines. Never mount the tank rigidly, but always wrap it in a thin layer of foam rubber to prevent foaming caused by vibration. Always use a filter in the fuel line from your fuel pump to the tank—filters on the model between the tank and the engine cause more trouble than they prevent. If you use surgical tubing, replace it frequently.

Mufflers

To rework Robert Frost's line, good mufflers make good neighbors. People who live near your flying field or your racetrack will be more kindly disposed toward your activities if your engines are muffled.

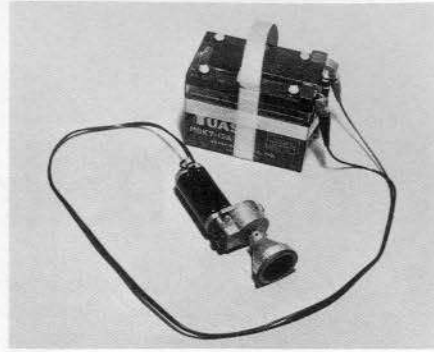
Mufflers, of course, detract from engine performance, reducing output by 300 or 400 rpm. (This is not a deterrent to competition if everyone must use a muffler.) In general, use the muffler recommended by the manufacturer of the engine or, if the manufacturer makes no recommendation, use a flow-through type. Always use as large a muffler as the engine is designed to accept.

A muffler creates back pressure in the cylinder, raising the temperature of the cylinder. Resist the temptation to tweak the needle valve a bit to pick up the rpm's lost in the muffler: The cylinder temperature will rise even further, and the engine will be ruined. Even more than before, it is important to keep the fuel-air mixture rich.

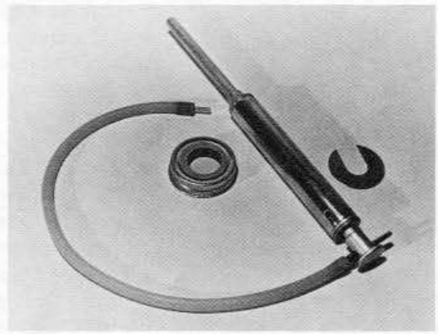
Accessories

There are a number of accessories that make working with an engine somewhat easier. Already mentioned is the "chicken stick," a length of ½-inch dowel covered with plastic garden hose, for turning the propeller when starting the engine. A glow-plug clip such as the Kwik-Klip is handy for connecting the battery to the glow plug. Push-on connectors don't seem to work as well. An electric starter is a necessity for boats and cars and is handy for airplanes. The author recalls many blisters from using a pull cord to start engines. A fuel pump and a fuel container are a good investment, particularly if you use large engines. A four-way wrench for glow plugs and prop nuts is a necessity. A drawstring bag is useful for slipping over the engine to protect it when the model is not in use.

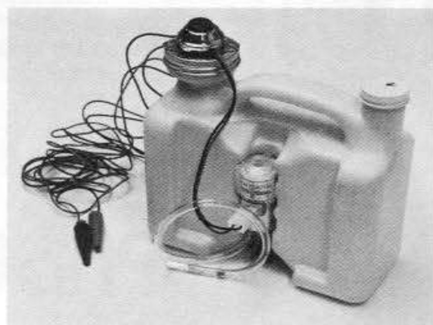
The model engine is a masterfully designed precision piece of equipment. When properly broken in and cared for and given the right fuel it can furnish years of service and trouble-free operation.



An electric starter takes the work out of starting an engine. The cone-shaped piece fits over the prop spinner.



A manual fuel pump is simple and reliable, but it cannot remove fuel from the tank at the end of an operating session.



A reversible electric fuel pump, shown tucked into the notch of the plastic fuel container, is a useful accessory.

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Fred M. Marks

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