How to Design and Build Flying Models

Keith Laumer

August 28, 2015

Contents

List of Figures

Foreword(s), preface

Foreword to the British Edition by Ron Moulton, Managing Editor, Aeromodeller:

All that my good friend Bill Winter has written in his introduction to the original American edition of this book has equal application in Europe. Just as in the U.S.A. the hobby and model shops of Britain support a very keen following for the admirable pursuit of aeromodelling. There is also a distinct need for this purposeful book with its skilful approach to the problems of the self-taught enthusiast.

Keith Laumer spent several years in London, and his gifted talent for breaking the most obvious point of instruction down to simple understandable terms was quickly appreciated by readers of Aeromodeller. Keith contributed a complete beginner course of model designs ranging from a solid balsa wood glider to a three foot span acrobatic control-line model, which are still among the most popular full-size plans available. * [See list on page 211]

In so doing, this quiet American made a deep impression on the established model fraternity in Britain. He introduced some more of that "know-how" for which his fellow countrymen are famous and the characteristic line of his designs became accepted as new shapes among hitherto traditional outlines. But it was not a "one-way" trade, and the dozen chapters which follow serve to illustrate how much Keith Laumer's association with British aero-modellers stimulated his own appreciation of what was needed in this book.

In fact, Keith may well have written his piece on "Getting aloft" or "Rebuilding a wreck" after a weekend at a London model flying club field instead at his home in Florida.

Apart from vital references, little is changed in this edition from the original American. Modellers have a universal understanding which permits them to follow that a "ship" is an aeroplane, a "shop" is a workshop, "gas" is petrol and "endurance" means duration. To alter these expressions would diminish the atmosphere Keith has created[FFFD?]that of the maestro imparting his wisdom with not a word wasted on the way.

Read on - and enjoy this introduction to the satisfaction of craftsmanship, the companionship of the flying field, the excitement of experiment and the challenge of competition.

R. Moulton

Foreword by WILLIAM WINTER Publisher, American Aircraft Modeler:
For several generations, the building (and flying) of model airplanes has been a most popular hobby with the American boy. Almost from the time of the Wright brothers' first flight at Kitty Hawk, model airplane clubs, manufacturers of kits and supplies, and even books about this scientific hobby have existed. A great many books have been published but, unfortunately, progress has been so swift up to now, that virtually all of these books are as outdated as the trolley car. Now that hobby shops number in the thousands, and model airplane items are found in countless stores of many kinds, the need is greater than ever for a truly useful book to help the beginner get started and to assist the active hobbyist improve his skills.
How to Design and Build Flying Models is such a book.
The listing of chapters indicates a rare perception of the problems besetting the would-be modeler. A bewildering variety of models attract: ready-to-fly plastic items, built-up balsa-wood designs, gliders, powered planes, free-flying jobs, types that fly captive on the end of control wires, even radio-control miniature aircraft (for the "graduate" hobbyist) capable of any stunt known to full-scale designs. Where should one begin in this wonderland? Chapter 1, "What Shall I Build?" points the way. Other chapters develop the picture most logically: Materials; Engines, Accessories and Gimmicks; Equipping the Shop; then follow precise discussions about Building Your Model, Covering and Finishing, Getting Aloft, and so on.
This book does more than update the techniques of this hobby-sport. Showing a sensitive awareness of what the hobby really is all about, it goes beyond the basic areas of information with badly needed pointers, as for example, the chapter "Rebuilding a Wreck." Everyone knows that any flying machine, especially a fragile model airplane, will be damaged on occasion. But who has ever told us how to repair, or to make good as new again, a broken aircraft? Experts take this for granted; why not share this knowledge with the tyro? This Mr. Laumer has done.
Or what book ever considered how to make a landing gear retractable? Many modern big planes retract or fold-in their landing gears. Many a builder of flying scale-type models has wondered how this feature can be introduced in his handiwork. The author shows many ways in which this can be done.
Having accomplished its task of providing a comprehensive run-down of a complex hobby, this book soars to still greater heights. Roughly speaking, flying models fall into two categories: free-flight and control-line. Special chapters detail attractive sport projects in both these areas.
Nor was the author content to rest upon the how-to-do-it aspects of the hobby. His well-rounded analysis of the field is capped by the chapter "Designing Your Own." The great failing of the hobby, as it is practiced by millions of men, boys (and girls!) today, is the withering away of resourceful initiative, a natural result of the trend to prefabrication, ready-to-use items, and things that require little or no basic know-how.
The modern hobby overlaps more and more with the toy field. If model planes are to remain more than toys, keeping traditional values of training and worthwhile accomplishment, it becomes highly important to understand why and how a plane flies. For a model-plane builder not to have this understanding would be like a doctor lacking the ability to diagnose his patients' complaints. Unthinkable!
Assisting the builder who would know why, and how, a lengthy index and glossary renders an invaluable assist.
W. Winter

Preface by Keith Laumer:

In the ten years since the publication of the first edition of this book the world has changed more than it has in any decade since the dawn of history. Social orders have toppled; regimes have risen and fallen; international balances have swung; man has reached the moon. But interest in modeling among people of all ages and nationalities and political persuasions has continued unabated. Black and white, old and young, male and female modelers continue to whittle balsa and tease cranky engines to life, to rise at dawn to gather at the flying field, to labor far into the night over the newest project. The field of international model competition is one of the few in which Soviets and Americans have engaged in friendly rivalry, unmarred by accusations of foul play.

There have been changes in modeling, of course. Rocketry has lured away a few devotees more interested in brute power and outer space than in the delicate balances of airborne flight. Radio control equipment has become increasingly sophisticated, efficient, and inexpensive. And the plastics industry has contributed marvels in new materials.

But the basic urge to create a graceful structure capable of winging off into the high blue sky on its own power remains unchanged. The satisfactions of craftsmanship, the companionships of the flying field, the excitement of experimentation, and the challenge of competition still intrigue the active mind.

Youngsters who read the first edition when it appeared have now completed high school and college, and have gone on to found careers in many fields - including aeronautics and space research. Who knows what wonders will be seen - and performed - by those who now greet the second edition? Perhaps future editions will include chapters on "How to Fly in a Null-G Field," or "Modeling on the Moon." But whatever changes take place in man's habitat, wherever he explores in the universe, the urges that made him build and fly will go with him.

Brooksville, Florida KEITH LAUMER 1970

Note from Minze Zwerver:
Before you see the results to recreate a book I have never touched or had the privilige to read until I discovered it in HTML format a while back. Unfortunately I didn't enjoy reading it like that. So I set out to reformat the book from the HTML pages. It's missing some words, as did the HTML version. Also some pictures that are referenced in the text are missing. Further more I updated the references to images used in the book, but I kept the original scanned numbers. I let tex do the bookkeeping on the references. This presented me with a new problem : giving a title of description to the images used in the book. Some are missing or just plain wrong.
If you have comments or info that might be helpfull, please send to ysblokje@gmail.com and I will use it to better the recreation.
Minze Zwerver, 28 August 2015

Chapter 1

What shall I build?

Just to show you we're really going to begin at the beginning, let's start by talking about what a flying model is. Don't make the mistake of thinking a model plane is just a toy "real" one; it's a small flying machine in its own right, based on aerodynamic laws as real as those that govern the functioning of a giant jet transport.
A flying model is a miniature structure capable of supporting itself in stable flight by the action of its surfaces against the air. This can include everything from a folded paper dart to a complex multi-engined R/C scale job. Some models are gliders[FFFD?]throw 'em and they ride smoothly around in the air until they touch the ground. Others have power-driven propellers which rotate, pulling the model forward. The resulting flow of air over the wing lifts the ship from the ground, and the balance of weight, drag, lift, and thrust and the pressure of air against the flying surfaces maintain it in stable climbing flight. When power cuts, there is a readjustment of forces, a new stable balance is struck - and the model glides down. Jet-powered jobs are pushed forward by a stream of high-speed gases ejected toward the rear, but in any case, the power is incidental; the plane flies on its wing, stabilized by its tail surfaces.

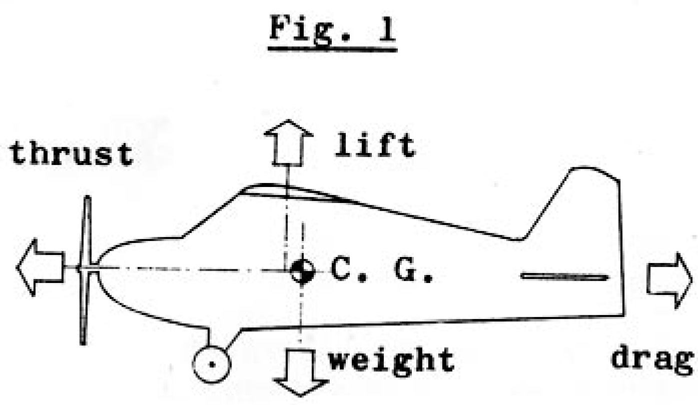


Figure 1.1: Basic aerodynamic definitions

Free-flight models fly without control other than inherent stability and trim. A control-line model lifts itself and flies, too, but tethering lines are substituted for inherent stability[FFFD?]with the gain of vertical maneuverability enabling the flyer to enjoy the thrills of high-speed and aerial stunts at close range.
Almost every kind of model can be built either as a high-performance contest model, or as a simpler, tamer sport model. The former are generally more difficult to build,

trickier to adjust for flight, more fragile, and except for C/L, likelier to get lost. These ships are for the scientific-minded, the competition fans. The average builder usually has more fun with ships that are content to take off, fly well but not fantastically, and glide in to a good landing; rugged ships with neat lines and dependable performance. Even the contest-bound modeler will feel more secure if he learns about flying with sport jobs before turning loose a timed, dethermalized, superpowered VTO free-flight with a rocket climb and a floating glide. As in most activities, it's a good idea to work your way up gradually to the advanced stages; so before plunging ahead into a project, let's look over the field and see what's available.

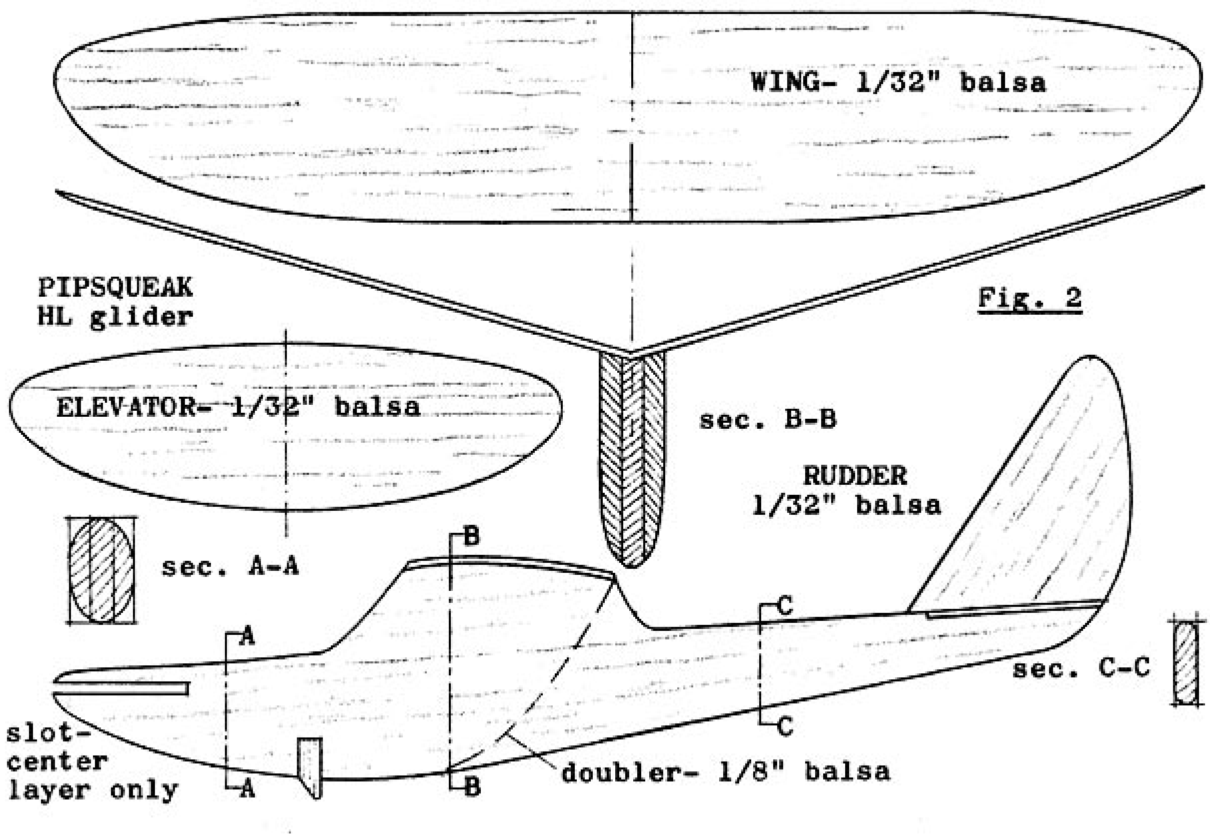


Figure 1.2: Pipsqueak HL glider.

Considering first those models which fly without power (gliders and sailplanes), the simplest are the small hand-launched jobs, usually built from sheet balsa and devoid of non-essentials. These ships can be made as small as three to four inches in span or as large as two feet, and are perfectly capable of gliding right out of sight in a thermal, just as big contest models sometimes do. A good size to begin with is a 7-inch wing span, with wing and tail surfaces cut from 1/32" sheet balsa, and fuselage from 1/8". If you're tired of reading already, you can stop now and build Pipsqueak from the full-size plans shown in Fig. 1.2. (In fact, it wouldn't hurt to build two, in case one lands on the roof.) You can learn a lot about flying and adjusting a model from a small glider like this, either in a spirit of scientific inquiry or just for the heck of it.
With the possible exception of R/C models, all flying models are essentially gliders; an

engine is merely one method of hauling the model into the air. Contest models which achieve flights of many minutes are generally limited to a motor run of no more than ten or twenty seconds.

For gliders between 18-inch and 30-inch span, the addition of ribs to the wing and sometimes the elaboration of the fuselage into a box structure is advisable, for greater strength and improved performance. The ribs supply camber to the wing and increase its rigidity, while the box fuselage gives increased support to the wing and tail. This kind of glider can be sanded and doped to a slick finish without fear of warping, thus increasing the efficiency of the model by reducing friction with the air.

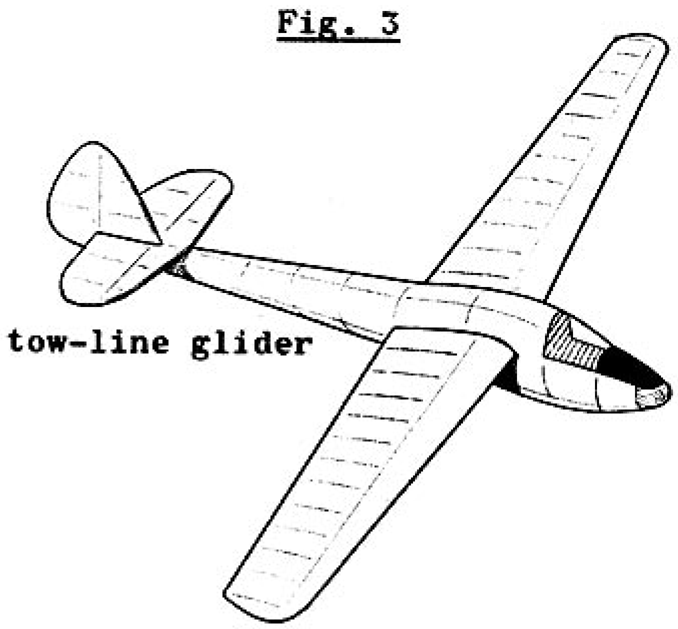


Figure 1.3: Towline glider.

Larger gliders, such as the Nordic type (usually of sailplane configuration, with very high aspect-ratio-the ratio of wing span to chord-as shown in-Fig. 1.2), are nearly always built up and tissue-covered, for lightness. A well-designed covered frame is very strong for its weight, but of course it can't equal the rugged-ness of the all-balsa jobs, and must be launched with more care; an all-out heave-ho might leave the wings behind. For this reason, a towline is the usual mode of launching these ships. A hook is installed on the lower side of the model just in front of the center of balance, placed so that the line will drop free when the pull is relaxed. The towline is made of heavy linen thread, light fishline, or string swiped from the kitchen drawer, of a length equal to the height you hope the model will reach before releasing (not over about 50 feet at first) and with a bit of rag tied to the end to help you find it after use. By trotting into a slight breeze, you gently tow the model to a good height, and then relax and watch it float around upstairs.

For the advanced model glider pilot, the addition of a radio-control unit adds the final touch. A radio-controlled glider is capable of staying aloft for a long time by riding air currents, and in areas where conditions are favorable for soaring, R/C gliders are very popular.

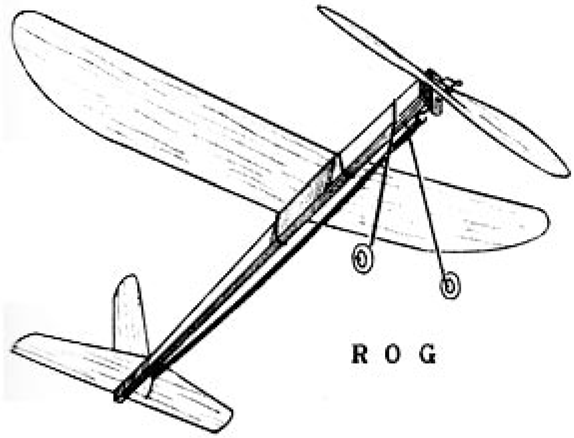
An alternate method of launching either type of glider is the use of a rubber cord, stretched out and released. The length of the cord and the extent to which it is stretched determine the violence of the launch. For small models, try this: Attach a 4-foot length of 1/8" flat rubber to a post one foot high; tie an 8-foot length of string to the rubber, and attach a small wire loop to the end of the string. This is engaged in a hook under the model, the rubber is stretched out as far as you dare - and let 'er go! By varying the angle of launch, the length of the rubber and string, the vigor of the send-off and the trim of the model (nose-heavy for a long fast curve, regular balance for loops and snap-rolls), you can do almost any acrobatic in the book, even with - especially with - a tiny 6-inch glider.

Keith Laumer photo, courtesy *Flying Models*
Take-off! A F/F model with butterfly tail

Figure 1.4: Keith Laumer Photo [model shown is 'V-Girl'].

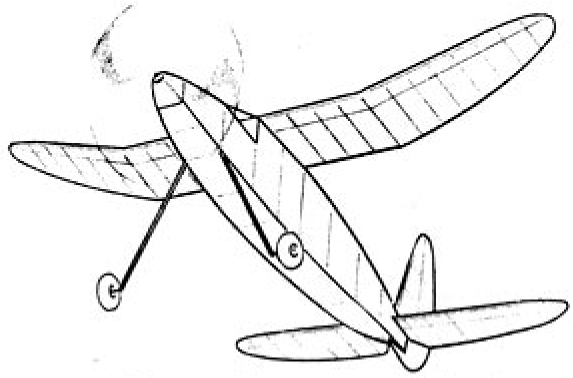
The time comes in the life of every glider pilot when he wants to try a powered model. The transition is easy, particularly if you start with rubber power, employing construction similar to non-powered ships. It is a mistake to think of rubber power as a feeble makeshift, as anyone knows who has ever ducked as a big Open event job[FFFD?]carrying several dozen strands of tough rubber wound to a thousand or so turns-whizzed past. But it is a versatile form of power, applicable to very small and simple models as well as to highly sophisticated endurance ships; and best of all, anyone can operate it with very little practice.
All-balsa ROG (rise-off-ground) models like the one in Fig. 1.5, of 12-18-inch span, are excellent first projects. They can be bought ready-built or put together in an hour or two, cost very little, are extremely rugged - and a good model of this type can easily climb 200 feet in the air and stay up several minutes, flight after flight. Experience gained in operating a simple ROG is good training for flying more complicated types.

Fig. 4



R O G

Fig. 5



rubber endurance model

Figure 1.5: ROG / Rubber endurance model.

The performance of your ROG can be improved by using tissue-covered built-up flying surfaces. The resultant model is more fragile than an all-wood job, but is correspondingly lighter and has a better glide.

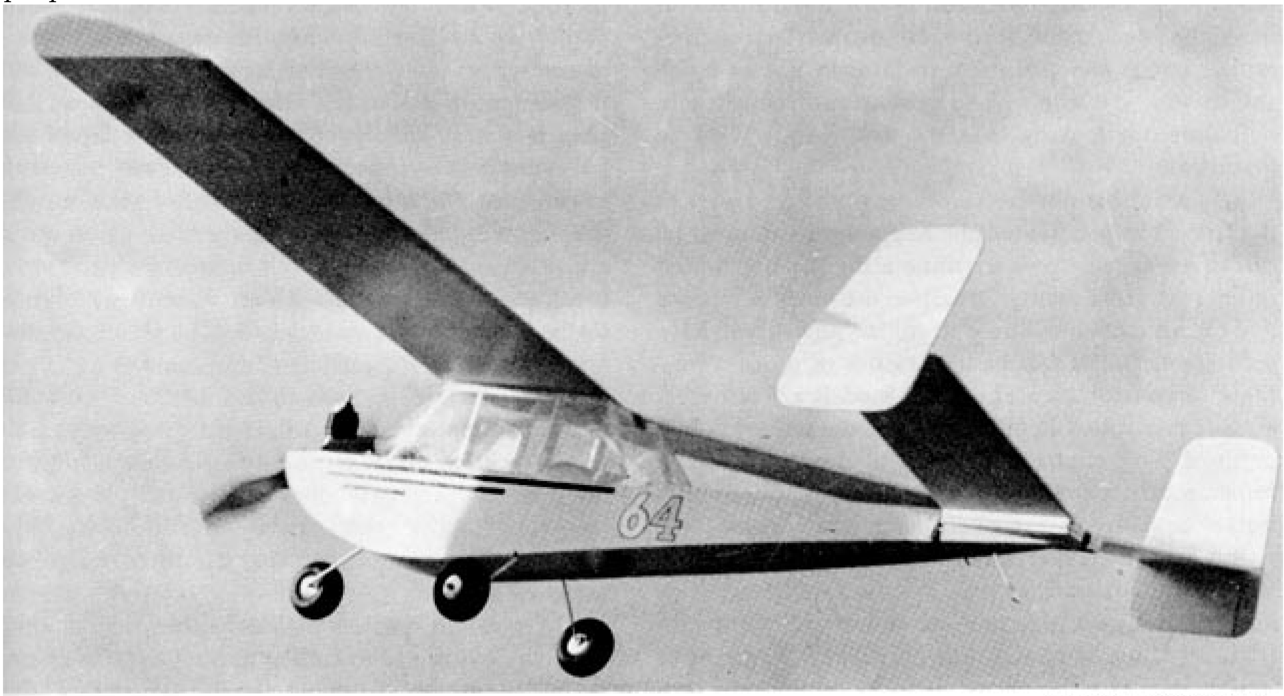
The ultimate development of the basic ROG idea is the wholly built-up endurance model (fig. 1.5), having the rubber completely enclosed within a fuselage, and with a precise airfoil formed by closely spaced ribs and multiple stringers. A model of this kind, with its graceful lines, its tight-doped tissue covering, its feather-light weight, and its hand-carved propeller, is a thing of real functional beauty and has been known to inspire small boys and tired businessmen alike to go home and try a hand at modeling.

Construction of these ships is simple and straightforward. Fuselages are usually of box type, and wings and tail generally have constant chord and thus identical ribs, simplifying cutting-out. Machine-cut props are available and work well, for those who don't like to whittle. Conventionally, many of these designs include a "pilot's" compartment with windows; these are called "cabin" models. Those without cabins are "stick" models.

For the modeler with a taste for more realism, the semi-scale sport model is the logical compromise between looks and performance, with the added bonus of simplicity and ruggedness. A semi-scale model has proportions similar to those of man-carrying airplanes, and carries a full complement of cabin windows or open cockpits, wheel pants, fancy paint jobs, etc., all of which add to the joy of watching the little ship flying around overhead. Since these accessories slightly reduce aerodynamic efficiency and add weight, semi-scale models are usually not capable of getting lost out of sight as easily as the pure endurance model, a deficiency which many modelers are willing to forgive.

The fanciest version of rubber power is the scale model, a true replica of a full-sized airplane, on which the perfectionist can lavish the ultimate degree of detail, down to instrument faces, wire rigging, and doors that open and shut, preferably not in flight. The more practical builder usually controls the passion for scale in the interest of practicality, and modifies things sufficiently so that the model will fly well and survive landings. A little added dihedral, a slight increase in rudder area, a modest relocation of the landing gear detract little from the looks of the plane, and help a great deal in action.

It is sometimes possible to select a prototype which is perfectly adapted to pilotless flight, but in most cases some modification is called for to achieve inherent stability. In every case it will be necessary to use a special large-size propeller, and if take-off from the ground is to be achieved, this usually means lengthening the landing gear to provide prop clearance.



A F/F sport model banks off in a climbing turn Keith Laumer photo

Up to now, things have been comparatively quiet, with only the soft whirring of large blades beating the air, impelled by the silent resilience of twisted rubber. When we turn to internal combustion, things are different. These are two types of miniature "gas" engine made especially for model aircraft, both equally loud. This detracts little from the enthusiasm of model builders, many of whom like to start up engines on the bench and run them wide open just to enjoy the scream. We won't be so profligate of power, and will start out looking over the field with a view to getting aloft.

All the rubber-powered types we considered were of the free-flight persuasion; the happy owner does all he can in advance to predetermine a flight pattern, and lets her go; from then on it's up to the built-in settings and the air currents. But with engine power, you have a choice between two basic varieties of model: free-flight or control-line. The latter models are tethered, and are controlled in flight through the tethering line or lines. This control is limited to the up-and-down dimension, since of course the flight path is circular, but a complete pattern of stunts is possible.

But before getting further into control line, let's first take a look at free flight. Within this category are a number of model types which are quite different from anything we have seen in rubber power. The most elementary job, using a small 1/2 A power plant, is the profile fuselage, solid-wing model. Since engines pack considerably more wallop than rubber, a comparatively massive solid fuselage is practical, and of course no provision need be made for housing a long rubber motor. A simple F/F trainer built along these lines is almost indestructible, and can be flown with long motor runs without fear of a flyaway; when the engine cuts, the model will make a fast glide-in without lingering aloft to look for thermals. The profile approach enables the designer to incorporate interesting lines in the model without difficulty, and especially in very small models, to achieve a very neat appearance.

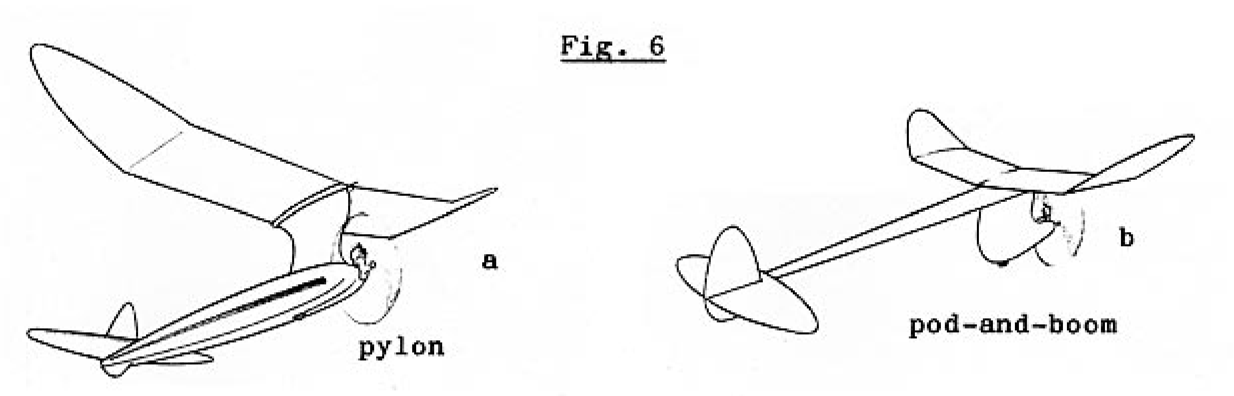


Figure 1.6: Pylon / Pod-And-Boom

Less attractive perhaps, but a better flyer, is the pylon configuration (Fig. 1.6). Here a slender balsa box is adorned up front with a vertical fin rising from the upper surface, providing a mounting platform for the wing above the turbulent slip-stream from the propeller, as well as other aerodynamic advantages.
The pod-and-boom model is another very practical type employing a solid unit as a mounting for engine, L.G., and wing, and with a slender boom extending rearward for the tail (Fig. 1.6). These ships can be very light, and if carefully built, can turn in contest performance in spite of all-wood construction.
However, the most practical strength-weight ratio is obtained with a fabric-covered frame. Pylon models sometimes use tissue-covered wings, as do pod-and-boom jobs; but the technique lends itself best to fully built-up frameworks, similar to the box and cabin models of the rubber categories, and more elaborate types. The engine-powered versions differ chiefly in having shorter noses, due to the concentrated weight of the engine. Also, the greater weight-carrying capability of an engine enables the modeler to build more solid, sturdier airframes, and incidentally to indulge in a bit more fanciful design. A little planking, some soft balsa fillets, color dope, all add to the looks of a free-flight sport job, without sacrificing satisfactory performance.
Many sport models are semi-scale, having the approximate lines of a piloted craft, with a cowled ogine, clear plastic canopy or windows, rubber-tired aluminum wheels, decal trim and numerals, etc. This kind of ship provides more year-round fun for the average modeler than either an ungainly looking contest-type ship with a penchant for disappearing behind a distant cloud or a fully scale ship with its flight limitations and its habit of dropping pitot tubes and dummy exhaust sticks in a routine rough landing. Although kit manufacturers tend to ignore this type, the model builders' magazines supply a steady stream of excellent sport designs along with the latest contest winners.
This is not to discourage the scale enthusiast; for the builder who wants realism, nothing can compare with true scale, complete in every detail; and unlike the case of rubber-powered models, few concessions to flight requirements are needed if the plane is wisely selected. Low-winged ships are dubious free-flight projects and multi-engined jobs are, for all practical purposes, out (except for three-engined ships like the Ford Trimotor, where only the center engine runs, the other two being dummies). But there are plenty of light planes, home-builts, WW I jobs, etc., which can be built and flown with complete success, and undeniably these are the most eye-catching of all models.

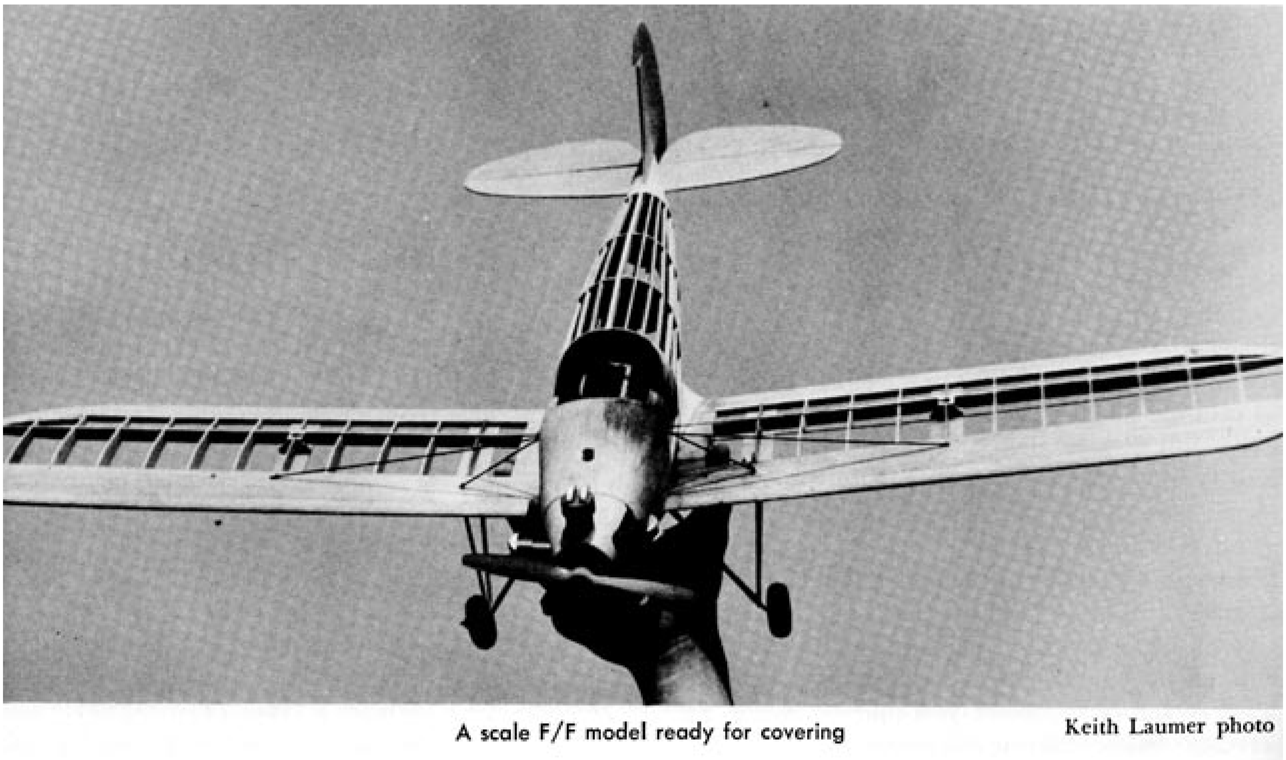


Figure 1.7: Keith Laumer Photo [model unknown. Looks like a Kinner Sportster]

The advent of the control-line model opened up a whole new realm of flying model types. These models employ movable elevator surfaces, controllable by the flyer who holds a handle to which lines are attached which in turn operate the flippers, giving up-and-down control (Fig. 1.8).
With C/L, it became possible for the first time to perform stunts, attain terrific speeds (over 160 mph), engage in aerial combat, all in a small flying area. And in the scale department, multi-engined and unstable low-wing airplanes which had previously been the exclusive domain of the solid-model whittler now impressively took to the air, engines roaring, landing gears folding, lights flashing, in an amazing simulation of the flight of manned craft. Die-hard free-flight men, of course, denounce this development as the end of science in aeromodeling, little better than the twirling of a weight at the end of a string. Anything, they argue, would fly on lines.
This is a prejudiced viewpoint. Every C/L designer has had the deflating experience of trying out a new ship and discovering that, as in the full-scale airplane industry, some ideas which look good on paper just won't fly. The thing which arouses the disdain of the no-strings faction is the elimination of lateral stability as a factor in the performance of a C/L model, due to the confining lines which permit the ship to fly only in a circle (actually, a hemisphere) around the man holding the control handle. However, the skill needed to maintain the model in level flight (no problem with free flight) more than makes up for this, and success depends as much on the flyer as on the model. While anyone can quickly learn to fly a stable C/L model in gentle circles, it is a skill which must be acquired, and the C/L flyer can advance into steadily more complex models, capable of more and more spectacular flight - and correspondingly more demanding of piloting skill.
The inexperienced modeler should start in control line with a specially designed trainer.

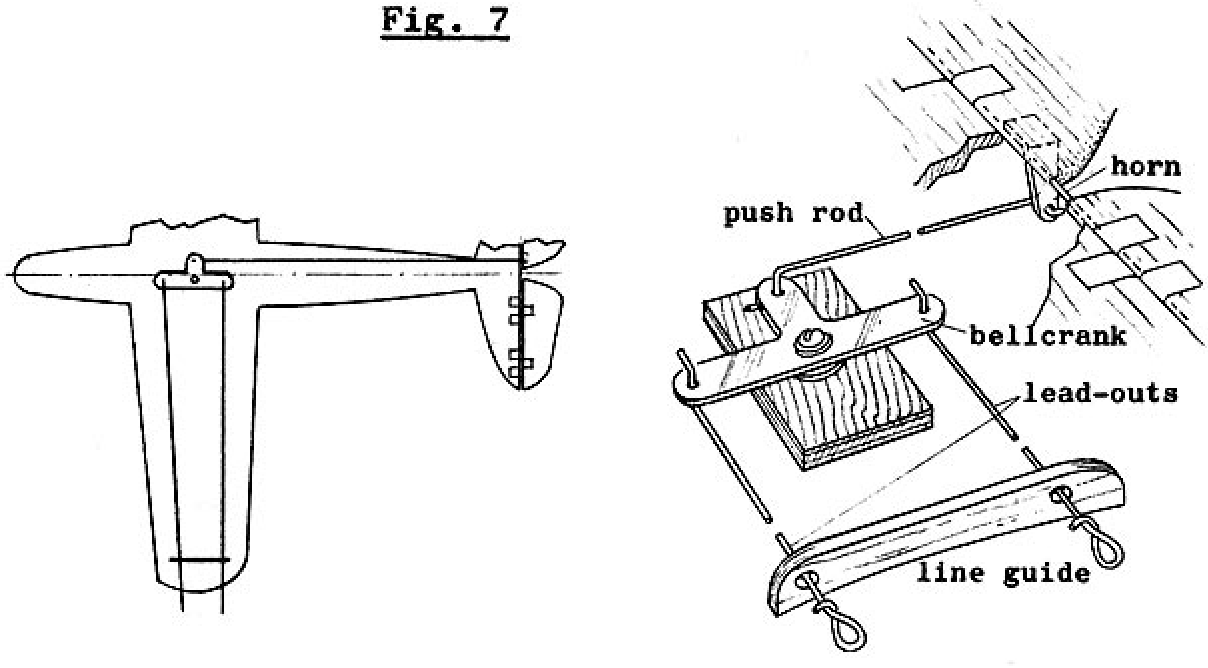


Figure 1.8: C/L controls

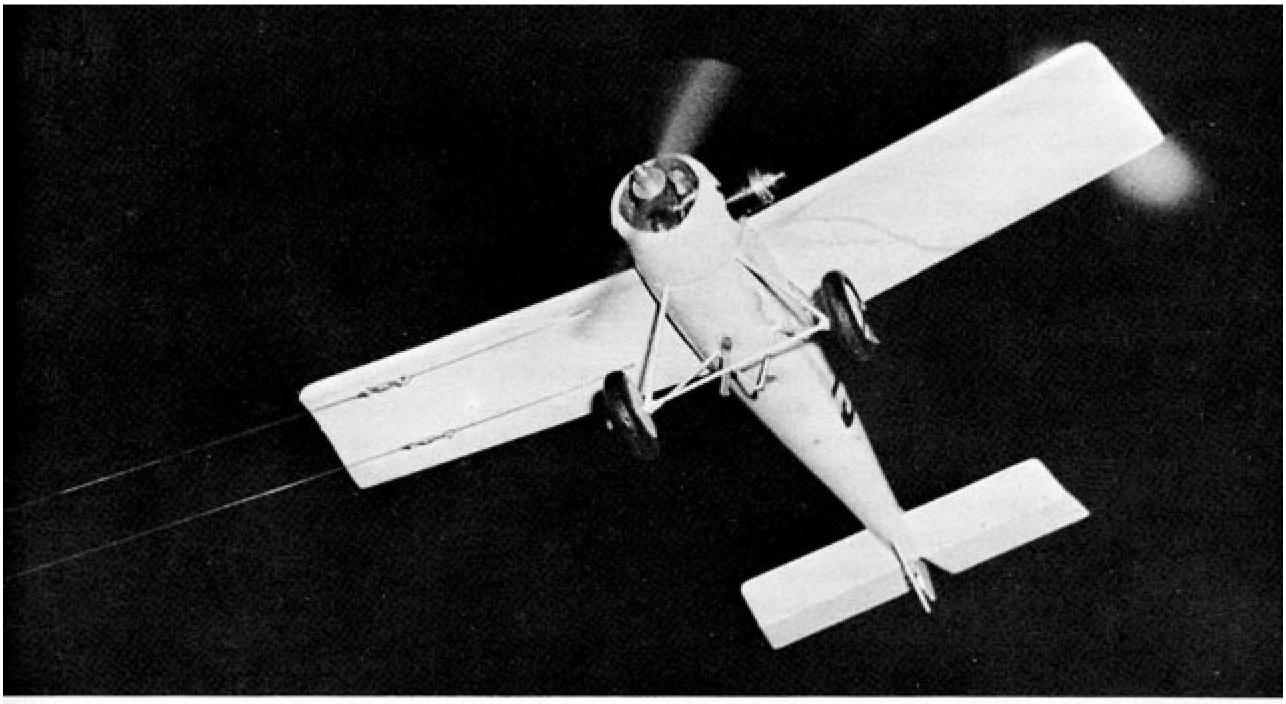
These models are solidly built of hardwood and solid balsa, have limited control movement and built-in stability, and are underpowered. They can be (and are) repeatedly dived into the ground, clobbered on take-off, brought in to fatal landings - and go right on flying. (The use of concrete runways during this phase of the learning process is not recommended.) By the time the rugged trainer has been battered into a state which precludes any further hope of repair, it is time to step up to a higher-performance ship, having more looks, capable of fancier tricks, and requiring a bit more in the way of trained reflexes on the part of the flyer.

Sport models can be tamed for early flights by setting controls for shorter travel (and less chance for spectacular pilot error) or by using a smaller engine than the ship is designed for; putting the propeller on backwards reduces its efficiency, and helps to slow the model down. After the feel of the new plane has been absorbed, set everything for peak performance and start in on loops, wing-overs, figure eights, and other stunts. With an engine howling and a responsive ship pulling on the lines, there is some real excitement as you feel your way into that first up-and-over!

The C/L model is probably at its best in the stunt category. A high-performance stunt job features a large wing, usually of symmetrical airfoil (it spends as much time flying inverted as right side up), a short fuselage, immense elevators with wide travel, a big power plant, and sometimes flaps linked to the controls for even faster response.

A special type of stunt job, usually lacking landing gear and other external refinements, is the combat model, specially built to seek sudden death in the air. Streamers of tissue paper are attached to the rear of the combat ship, and two flyers take the field together, flying in the same circle. The stated object is merely to cut the other ship's streamer, but in the natural course of events, mid-air collisions, vicious attack dives that don't pull out in time, and other catastrophes make combat a short, fast life for a model. But to a combat man, the spectacle of a darting shark-nosed ship coming over and down,

engine screaming, to rake an opponent end-to-end in a lightning pass, then whip up in a cloud of balsa chips to race defiantly around the cleared circle, flaunting an untouched streamer as the other flyer fights to bring his shattered plane in to a dead-stick crash landing[FFFD?]this is living!
A more peaceful version of two-to-a-circle flying is the team race, for which special models are flown. These ships are generally semi-scale types, with landing gears, cowled engines, cockpits and colorful paint jobs. Pilots and ground crews work in close co-operation to keep the model in the air with the engine turning up at maximum rpm, with pit stops for re-fueling or trouble-shooting handled as snappily as at any race track.
Scale and semi-scale models are excellent C/L projects, since with a flyer at the controls, practically any ship can be flown, regardless of inherent stability problems. Weight is less critical than in free-flight, since relatively immense engines can be used to pull the ship into the air by brute force. Fully operating, retracting landing gears, flaps, and lights can be installed, as well as bomb-drops, rocket-launchers, crop-dusters, etc. In this category of model, the designer and builder have a free hand to add gadgets and try out ideas.
While single-engined ships are simpler to build and fly, the lure of the multi-engined job is one that no modeler should ignore. The sound of two engines running in synchronization at 20,000 rpm is alone worth the trouble, and it's a thrilling sight when a twin-engined scale model moves off down the runway and lifts into smooth fast flight.



Flying a C/L scale model at night Dick Stouffer photo

Figure 1.9: Dick Stouffer Photo - Flying a CL scale model at night

C/L scale ships are longer-lived than their F/F brethren, not being so subject to the vagaries of air currents, and it is practical to lavish even more time on their construction and detailing, with reasonable hope of a long life. Since sheet balsa planking can be used wherever needed without fear of weight problems, beautiful and realistic finishes are more readily gotten, and best of all - your C/L job won't ungratefully fly away.

During the last few years, radio-control equipment for modelers has developed rapidly. Today there are numerous dependable outfits available at reasonable cost, which can be installed and operated successfully by any modeler.

Transmitters and receivers are smaller and less delicate, and installation and wiring have been simplified so that some sets need merely to be placed in the model and plugged in. The builder must, of course, construct the movable control surfaces and link them to an escapement, but this is hardly more complicated than installing controls on a C/L model.

The basic R/C ship employs rudder-only control; this is enough for the flyer to have to think about, the first time in the air. The ship is trimmed for a climbing turn, and the radio impulse is used to turn the rudder strongly in the direction opposite to the built-in turn. By holding the rudder over briefly, the ship can be turned in the desired direction. Holding the rudder hard over brings it around in a tight downward spiral; by snapping the ship out of such a dive, a neat loop can be executed.

After you've become proficient with rudder-only, you can step up to elevator also, and add engine speed control, ailerons, etc. For more than three or four different controls, depending on the escapement used, a multi-channel or other more complex radio installation is necessary. Of course, with increasing complexity comes increasing trouble shooting, and since a skilled flyer can perform every maneuver in the book with rudder-only, it is advisable to stay with simple equipment for a long apprenticeship.

R/C ships are actually a specialized form of free-flight model, generally being of extra-solid construction with massive balsa-block nose sections to reduce engine vibration, heavy-duty landing gears to help cushion the receiver against landing shock, and low-slung stabilizers to simplify installation of rudder controls and increase ease of assembly.

R/C ships are underpowered as models go, and have rather sluggish flight characteristics, owing to high weight and low power. Controls are of fail-safe type, and in the event the flyer loses control, the ship merely free-flights until fuel is exhausted. For this reason it is a good idea not to take on more than five or ten minutes' fuel at most. The range of the average receiver is about a mile, though much longer range can be reached under favorable conditions, but it is wise to keep the model close, and not too high - just in case.

Scale R/C models are very popular, and with the low-power, high-weight formula, they can be built with plenty of scale detail and perform well.

In the pursuit of more and different power plants for models, and in keeping with the jet age, the manufacturers have not only raised the internal-combustion engine to a high level of perfection, but have also made available to the modeler a whole range of jet engines which make possible true-scale powered models of the latest fighter planes.

Chemical jets are small and not particularly powerful, but are quite practical, easy to operate, and perfectly safe. In addition to being used in scale models, they have proved to be satisfactory glider launchers for those who don't like throwing things and who like to hear a soft hissing noise while their model whizzes around the yard.

An alternate solution to the scale-jet problem is the ducted fan. An engine fitted with a short multi-blade prop is mounted inside the fuselage of the model, and expels air out the rear through a carefully proportioned duct. Engine cooling is a problem here, as well as access to the engine for starting; but the fan does work.

The big brothers of the chemical jets are the large liquid-fuel (paraffin) jet engines which operate exactly like the full-size ones, giving off preliminary belches of black smoke and balls of flame, then bursting into an earth-shaking roar. Jet C/L models can turn in speeds approaching 200 mph, and their builders explain that the red heat of the engine while running is not due to friction with the air, but is normal to this type of power. The heat problem places some severe limitations on design for jets, since the engine must either be mounted clear of the model or well insulated to avoid setting the whole project afire. A tankful of fuel is good for several seconds of flight of a violence which must be seen to be appreciated. This type of engine is recommended to those who like: (a) trying to start engines, (b) loud noises, (c) short flights with bad landings, and (d) to be different.

Of course the urge to be different has led modelers to explore many avenues of flight other than the normal configurations and power arrangements. The ornithopter, or wing-flapping model, has its devotees, and while it may never replace the bird, it is an interesting novelty. The canard, or tail-first model, is one of the oldest (the twin pusher of the prehistoric era of modeling was a canard), and is still going strong in some quarters. The main advantage of a canard is that the propeller is in the rear and thus less likely to suffer in a crash; this is a less valuable feature today than in the era when crashes were more frequent and propellers more expensive.

The Delanne configuration, employing two widely staggered wings in place of the usual wing and stabilizer, has been very successfully used on full-scale aircraft, and works well on models. But, except for experimentation, there's not much point in going to all that extra work. Besides, the flight adjustments of a Deland are unfamiliar to modelers, which makes it difficult to test such a ship without destroying it in the process.

The same is true of the helicopter, but in view of the many outstanding advantages of this approach to flight, modelers keep trying. It took the professional aeronautical engineers many decades to solve the problems of stable flight with a manned helicopter, but modelers have persevered in their attempts to build inherently stable choppers - and have succeeded. The sensation caused among the bystanders when the model goes churning its way straight up into the blue is said to be one of the chief rewards of the experimenter.

There are plenty more types: flying wings, amphibians, sea-planes. The ROW (rise-off-water) is a regular contest category, and you can fit floats like those shown in Fig. 1.10 to most land-plane models for water operation. Models with pusher engines mounted above the cabin, or with outlandish configuration, sometimes fly beautifully. Try 'em all and see.

You can buy construction kits for all the kinds of models mentioned above, and then some. A kit usually contains a clearly printed full-size plan with printed instructions, and all the necessary balsa wood, plywood, tissue, wire, and special fittings to build the model. Kits do not contain dope, cement, engines, or accessories, fuel tanks or tubing; usually kit wheels are of poor quality, and you'll have to buy a set separately. Nowadays (darn it) kit components are increasingly prefabricated, with all parts die-cut or pre-shaped. Since die-cutting produces ragged, splintered edges, and the preshaping of balsa blocks is often inaccurate, with the result that parts don't always fit properly, pre-fab kits in general have brought about lower-quality workmanship. On the other hand, lazy hobbyists who wouldn't go to the trouble to build a model from scratch are enabled to go on flying.

The fact that many kit manufacturers and builders alike seem to overlook is that it's fun to build a model-why have a factory do it for you? You can still get kits that require building rather than mere assembly, of course, and enjoy the pleasures of craftsmanship. You'll learn and pave the way for designing your own.

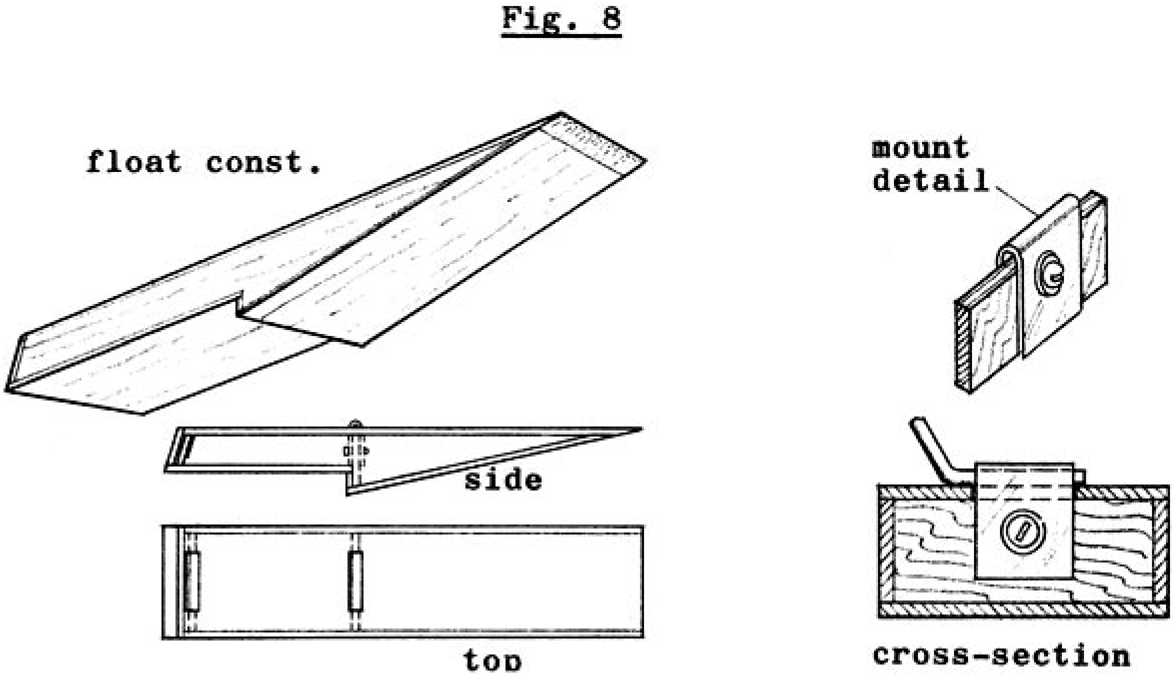


Figure 1.10:

In considering what to build, don't overlook the model-plane magazines. UK modelers are fortunate in having three first-class monthly publications devoted to the sport, each edited by an experienced, active model-builder.*
These publications are filled with modeling news, scale details, pictures, and articles on every phase of modeling. Even the ads are interesting, containing frequent announcements of new products. There are three or four new model designs in each issue, complete with plans and instructions. If you run out of ideas, just check the mags. In selecting a model be sure to pick something suited to your experience and facilities. A large free-flight model adorning the bedroom ceiling for want of a flying field can be a source of great frustration. Bogging down in scale detail when what you want to do is fly can be equally discouraging. Start off on something that fits your situation, and don't forget that after you gain a little experience, the only limit on the types you can build is the breadth of your own imagination.
* 1. Aeromodeller; PO Box 35, Bridge Street, Hemel Herapstead, Herts HP1 1EE. 2. Radio Control Models & Electronics (at same address as Aeromodeller). 3. Radio Modeller, 64 Wellington Road, Hampton Hill, Middlesex, TW12 1JT.

Chapter 2

Materials for modelers

The model builder of today is lucky: no need for him to crouch over a candle flame, heating and bending hand-split bamboo strips to form wing tips, or to pare shavings from basswood spars in an effort to lighten a ship powered by sliced inner tube. Old Christmas wrappings are no longer pressed into service as covering material, nor is it necessary to purloin the isinglass from the side-curtains on the flivver to make a windshield. Modern flying fans have at their fingertips - or at least, at the nearest hobby shop - a wealth of superior materials, precisely manufactured and reasonably priced. You won't get the most out of modeling until you know the materials that are available, and what you can do with them.

First, there's balsa wood. It's light, tough, flexible, easily cut and sanded. It takes a smooth finish and holds tight when glued. Moistened, it becomes pliable, and it sets again when dry. And it comes in a wide range of hardnesses and stock sizes.

You'll find balsa sheets in standard widths of 2, 3, and 4 inches, with wider sizes available by special order. Three-inch is the most widely used size; why pay a premium for wider sheets when it is a simple matter to edge-cement to build up whatever width is needed?

Standard lengths are 24 and 36 inches, the latter being most popular. Thicknesses ordinarily available are: 1/32", 1/16", 3/32", 1/8", 3/16, 1/4", and 1/2".

The 1/32" sheet balsa is used for planking, and for ribs and cap strips for small models. It also makes good wings for small gliders and ROG's. Always select hard, straight-grained wood in this thickness.

The 1/16" balsa, commonly called "sixteenth," is used for almost every portion of model structures, including ribs and formers, planking, spars in small models and built-up spars in larger ships, tail surfaces in smaller models, wings for gliders and ROG's, etc. When used for planking, medium 1/16" with straight grain is best; for ribs and formers, medium to hard wood is appropriate, and here's where you can use up the irregular-grained material. Rock-hard 1/16" balsa is fine for spars, keels, and other long stress-bearing members.

The 1/8" sheet balsa is used for much the same purposes as 1/16", but for larger models. It also can be used for fairings, fillets, and filling, since it has sufficient thickness to allow sanding to curved shapes without cutting through.

The thicker sheet sizes are mainly used for building up cowlings, fairings, and other compound curves, or for structural parts on very large ships. Pick the softer grades in thick balsa; the parts made from it are usually non - stress bearing and you need a saw to cut hard material over 1/8" thick.

Balsa strips come in the same lengths and thickness as sheets, and in varying widths. The standard sizes are: 1/16" square, mainly used for fuselage longerons and spacers and as stringers and spars, on small rubber-powered models; 1/16" x 1/8", useful as stringers for larger rubber jobs and small engine-powered ships; 3/32" square, frames for medium-sized rubber and "gas" models; 1/8" square, fuselage frames for large rubber models such as the Wakefield types, and for medium-to-large engine jobs; 1/8" x 1/4", for stress-bearing fuselage members in 1/8" square frames, wing spars for 1/2 A free-flight wings, trailing edges for small rubber models, and fuselages for small stick-fuselage ROG's. The 1/16" square and 1/4" square sizes can be used to build up sturdy box fuselages for large gas models or shaped to form leading edges for small-to-medium wings. All the strip sizes from 1/16" up are used as strip planking on models of appropriate size.

Strip balsa should be individually selected for the purpose for which it is to be used. Pick very hard material for spars and stringers, and medium for leading edges, planking, etc. Very soft strips are useful chiefly for chewing on while pondering the next project or discussing the flaws in the other fellow's model. The hardness oF a strip can easily be determined by pinching its end, in much the same fashion as one selects bananas. Soft balsa squashes flat; medium balsa gives reluctantly; hard balsa makes a depression in the fingers. Be careful to test strips (and sheets) only at the end so as not to ruin the piece if it is softer than you expected.

Balsa blocks can be had in almost any size up to about 2 x 4 inches and up to 3-foot lengths. These should almost invariably be of the softest grade, as they are used to form curved portions of a structure such as the fuselage front end. It is not only hard to carve a tough block, but the added weight of hard wood is undesirable. Styrofoam blocks are sometimes used as a substitute for balsa. When reinforced with a balsa spar or planking, it is strong and lighter than a conventional structure but requires special care in shaping and finishing.

Special formed sections can be purchased also, such as rounded and hollowed leading-edge sections for larger power models, and beveled trailing edges in several sizes.

You can make extremely tough light-weight load-bearing members (particularly wing spars, fuselage keels, etc.) by laminating balsa with other materials. Two pieces of hard 1/16" sheet balsa with a piece of celluloid cemented between them have at least twice the strength of the balsa alone, with little increase in weight. Tough brown paper is another excellent laminating material, and is easy to use since it can be obtained in the form of gummed tape, ready for application. Silk and nylon can be used between thin balsa layers, or applied to the outside, as on landing-gear fairings and scale wing-struts.

Solid or laminated hardwoods (in modeling, all woods other than balsa are hardwoods), either plywood or veneer, are indispensable materials, used for firewalls, bulkheads to which landing gears or wing mountings are attached, spar reinforcements, etc. Plywood, consisting of at least three layers of wood with the grain alternating at right angles, is obtainable in thicknesses of 1/32" and up. The more layers the plywood has, the tougher it is. A good 1/8" plywood will have about five laminations; this is tough enough for a firewall on even the largest model, if properly supported. Light-weight, three-ply mahogany or other relatively soft wood, from 1/16" to 3/16" thick is easily worked and strong enough for most applications. Four-or five-ply birch is stronger and heavier, and should be used where heavy shocks are taken, as on a landing-gear bulkhead in an R/C job. Hobby shops and most lumber yards carry plywoods and veneers in useful thin sheets. Veneers generally have only one layer of 1/28" thick hardwood, such as walnut, applied to a core of basswood or poplar. This material is subject to warping, and is both heavier and weaker than plywood, but it can be used successfully if not too much is expected of it.

Bamboo, once a standard modeler's material, has faded from the scene in recent years; however, it is still a light, tough wood, which has the virtue of splitting easily into extremely narrow strips for small stringers. It is a flexible wood, which can be curved sharply without breaking, and makes excellent wing struts, since it will give and spring back in a hard landing, unlike balsa or hardwood when trimmed to a small cross-section.

Tough hardwoods, such as oak, ash, and hickory, are useful in modeling chiefly as motor mounts for beam-mounted engines. Softer or brittle hardwoods like mahogany or fir won't last. A lemonwood bow stave, purchased from an archery supply house, will make a vast number of really indestructible motor mounts at small cost.

Model builders' cement is the universal adhesive for assembling balsa parts (as well as repairing broken dishes, loose shoe-soles and other errata, which the modeler must accept gracefully as the price of family indulgence of his aeronautical noises, stinks, and stains). In addition to regular fast-drying cement, extra-fast cement is also available for quick field repairs. Fuelproof glue for use with glow-plug engines is also obtainable in several speeds. Also fuelproof, and incredibly strong, is epoxy glue, which will bond anything to anything. It requires a modest extra effort in mixing a resin and a hardener, but impatient modelers have even been known to epoxy an engine direct to a firewall.

Ordinary mucilage is useful to the modeler in covering, since it dries slowly and is sticky from the word go, unlike cement, which sometimes refuses to hold the paper in place, right up to the moment it hardens.

For joining hardwood parts, as when motor mounts are glued against plywood bulkheads, a glue such as Weldwood is best. White liquid polyphenyl resin glues are also acceptable for this purpose, and while not as strong, they dry more quickly and are easier to use. You can strengthen cemented joints with crinoline.

Metals are joined with solder (all except aluminum); a plain solder used with an acid-type flux is most satisfactory, except in electrical work; here resin-core solder should be used.

After a frame has been built, it is usually necessary to cover it. For this purpose, various grades of paper are commonly used. Japanese tissue, which comes in many colors, is feather-light, tough, and long-lasting. It is used for the smallest built-up ROG models and other rubber jobs, and for small F/F ships.

A heavier paper called Silkspan, available in several weights, is very widely used for covering power models from about 30-inch span up to the largest sizes. A still heavier paper made from bamboo can be used for extra-large ships, or where great strength is needed, as on R/C models.

The plastics industry has contributed a number of new covering materials, including Monokote, a self-adhesive film with a plasticized finish, requiring no doping for a high gloss. This is an exceedingly tough covering, and can be heat-shrunk to a taut surface equal in appearance to a hand-rubbed 20-coat paint job. It comes in a variety of colors. A similar product is Shrink-Tight, available only in white, but of even greater strength. In fact, the process of heat-shrinking must be done with care or the structure will collapse under the pressures created. Any of the above may be applied over sheet balsa planking for an improved finish.

Silk and nylon are more expensive, trickier to apply, and require more dope for sealing, but have the advantages of tremendous strength and very long life, as well as good looks.

Some models are wholly or partially covered with balsa wood, particularly where a smooth surface is desired for the sake of scale appearance or where extra stiffness and rigidity is needed. Sheet balsa is used for flat or simply curved surfaces, and strip balsa for compound curves.

Open areas such as cabin windows are usually covered with sheet plastic or celluloid. These materials can be purchased in all thicknesses from paper-thin to board-thick, and are very strong and durable. Some plastics such as celluloid are soluble in model cement; these are easy to glue. Others are impervious to cement, and so are difficult to attach, but have the advantage of not being susceptible to damage from cement, dope fumes, or overflow. Model shops carry small-sized sheets; large sheets can be bought at lumber yards and paint stores.

Microfilm is a special covering material used for the most delicate and fragile of all models, the indoor endurance job. It is a liquid which is poured over a pan of water to form a thin film, which is then lifted on a wire loop and applied to a spider-light frame.

For the finishing of models, the special light-weight paint known as "dope" is universally used. The term, which includes regular dope and several types of fuel-proof dope, clear and in dozens of colors, is a lacquer which dries quickly to a glossy surface, forming a tough film which helps consolidate the structure and adds to its strength. For the special fuelproof dopes, special thinners are required, and the different types cannot be mixed. Paint in spray cans is available in exotic colors such as Tahitian Orange and Candy Oriental Purple; it is more expensive but easier to apply than the brush-on product. The builder who has a high rate of production will find it economical to purchase pint or quart cans of red, yellow, blue, black, white, and silver dopes and mix his own colors. Regular dope is cheaper, and can be fuel-proofed by a coat of a clear material such as Humbrol fuelproofer.

Epoxy paints are also available, requiring mixing before application. Two coats of epoxy equal several dozen coats of ordinary dope, but the penalty is paid in the form of extra weight. Still, epoxy makes an impressive finish for models where high performance isn't vital.

A fifty-fifty mixture of dope and cement (be sure to use the same type to be certain they'll mix) makes an excellent material for coating a frame before covering, for added strength. It can also be used to dope a loose section of paper covering which has resisted the shrinking effects of water and plain dope.

On wood surfaces, a filler should be used before doping to fill the open pores. A good filler can be made by adding talcum powder or cornstarch to clear dope. Lacquer-base auto body putty can be thinned and applied with a brush when a hard metallic surface is needed, as on a scale model of a metal-surfaced ship. Again, be sure to use a dope which will not dissolve the filler, or bubbling will occur.

After a model is fully doped, added decorative touches can be achieved by the use of decals. Standard designs such as military insignia can be had at a hobby shop; the modeler can make his own designs by using sheet decal material in various colors. Numerals, scallops, stripes, etc., can be drawn on the back of the decal material and cut out, then transferred to the model. Clear dope or fuelproofer should be painted over the decal to seal it to the surface and prevent fuel damage.

For forming cowlings, wheel pants, fillets, etc., there are several useful materials. Carve a wooden form, dope and wax it, and over it build up fiberglass or papier-mache, which can be sanded to exact shape when dry. Fiberglass can also be molded over a wire screen form for large shapes. Some modelers form whole fuselages, especially for C/L ships in this way.

If trim is to be painted on the ship, either by brush or spray, masking tape can be used to good advantage to cover the areas which are not to receive paint. If a light coat of clear dope is applied over the edges of the tape, seepage under the tape will be prevented. Tape should be carefully stripped after the paint is dry to prevent damage to the covering or finish.

Rubber is one of the modeler's most useful materials. Flat rubber from an old inner tube can be used to cushion engine mounts and L.G. installations. Sponge rubber serves to absorb vibration around a radio installation. Rubber bands of all sizes are a must for holding knock-off flying surfaces in place, actuating various mechanisms, etc. And, of course, rubber is an important power source for models.

Flight rubber for motive power comes in flat strips approximately 1/32" thick, in widths of 1/16", 1/8", 3/16" and 1/4". A model may carry from one strand of the smallest size to several dozen of the largest. Rubber should be stored in total darkness when not in use, preferably in a tight tin can, and sprinkled with talcum to help keep it in condition. When installed in a model, lubricate it with glycerin, liquid soap, or special rubber lube to cut down friction.

The same rubber is used in many R/C jobs to operate the escapement.

To power your engines, you can get commercial fuels tailored to each particular power plant. There are 1/2 A fuels, speed fuels, fuels for engines with piston rings, glow fuels, and diesel fuels. You can get it in 1/2-pint cans or 55-gallon drums, depending on how much you fly. Or you can make your own by mixing (for glow engines) castor oil and alcohol, 1:2; (for diesels) ether, kerosene, and mineral oil, 1:1:1. Test your mixture in your engine and vary it until you get the best results. Commercial fuels contain potent additives which make them hotter and easier-starting; but for sport flying, home-brew is fine - and cheap.

Plastic tubing for fuel lines comes in several sizes and also makes good bushings, spacers, insulators, etc.

For making accessories and fittings for model planes, everything from empty tin cans to burned-out flashlight bulbs is useful. The practiced modeler never lets a good defunct alarm clock get away, or a dead radio chassis. Such odd-and-end materials can be grouped under several headings, along with standard modelers' items.

A basic material is wire, which appears in a multitude of forms. Tough, springy, steel piano wire is sold by hobby shops in several diameters, in 3-foot lengths. The 1/32" piano wire is used for propeller shafts (prop hooks) and landing gears for small rubber models, lead-out wires for C/L jobs of all sizes, tail skids, wing hold-down hooks, etc. It is easily bent to various
shapes, and adds little weight, but is not stiff enough for C/L pushrods or landing gears for any but the smallest craft. The 3/64" piano wire makes an excellent pushrod for small C/L models, and wing hold-downs, etc., for big ships. The 1/16" size is widely used for L.G. struts for 1/2 A sport models, pushrods in bigger ships, shafts for all sorts of installed mechanisms, and many other things. The 3/32" wire makes a sturdy L.G. for medium-sized, powered ships, and 1/8" is super tough (and heavy) for the big ones. Fisherman's leader wire is useful for small items, on all kinds of models.

Softer wires are also useful. Fine copper wire is used to wrap joints to be soldered; a larger size can be bent into tiny circles and pounded flat to make small washers; soft paper-clip stock can be bent to form such items as pendulum arms and other lightly stressed mechanisms. Insulation slipped from heavy wire doubles as fuel tubing, or can be cut in short sections as spacers in various gadgets. Fine steel wire or stranded cable is used for control lines for heavy ships. Number 30 linen thread does fine for the small ones.

Metal tubing, of brass, aluminum, or copper, is another basic gadgeteer's item. Brass tubing makes good bushings for folding landing gears and other operating parts, as well as outlets for special homemade fuel tanks. Exhaust stacks of soft aluminum tubing help keep engines clean and quiet, and keep dirt out of the ports. Special tools for reaching hard-to-get-to spots can be improvised from tubing, and a sharpened length of the right size is an excellent hole-cutter.

Sheet metal often comes in handy. Aluminum sheet, being light and easy to cut, is most useful, and makes motor mounts, L.G. retaining plates, and special fittings of all sorts, including gear boxes. Brass is heavier but has the advantage of soldering easily, and is used, along with tin-can stock, for making fuel tanks, engine mounting-nut retainers, etc. Extra-strong dural can be used for "Cessna-type" landing gears and other load-bearing items.

Sheet lead is a useful form of the metal commonly used as weight to trim a model for flight or as a pendulum bob.

Gears salvaged from clockwork mechanisms are indispensable for putting together fascinating things like retractable landing gear installations and other automatic or semi-automatic devices. Springs of all kinds are also useful here as well as on shock-absorbing L.G.'s.

Never throw away a small nut, bolt, or washer. A small can or jar filled with these odds and ends will be one of the most used items in the modeler's shop, for mounting engines, landing gears, gear boxes, etc. In fact, any small metal object should be saved in a gadget box; old cartridge cases, empty aluminum cigar containers, ball-point pen cartridges - all of them come in handy at one time or another. Many items manufactured for other uses have been taken over by the modeler for his own purposes. Fish-line swivels work fine to clip models on to control lines; sandpaper makes realistic scale wing-walks; tiny oiler cups made for heavy machines make good fuel filler-caps with automatically closing covers; glass beads are dandy thrust bearings for dinky rubber models; dress snaps hold down cowlings. A modeler soon develops an alert eye for spotting the potentially useful.

The real key to resourcefulness in modeling is a little of everything. A piece of stiff cardboard for patterns; white paper for fillets; gauze or crinoline for hinges; a scrap of tracing cloth for reinforcements, a piece of inner tube for shock absorption; formica, felt, wire screen, all have their moments. The bottom taken from an old kitchen strainer makes a perfect radiator bug screen for a scale job; a toy aluminum pot makes a metal engine cowling; and imitation rubies and emeralds become scale navigation lights. It is up to the modeler to accumulate a trove against the hour of need.

Chapter 3

Engines, accessories, and gimmicks

Model shops stock plenty of hardware for model building. Some of these items replace handmade components, improve flying, or make possible new and fancy gadgets, while others fill needs we didn't even know we had. By knowing what's available and making use thereof, you can save work, build better ships, and spice up your flying with a few extras.

The basic accessory is the internal-combustion model-plane engine, still called a "gas" engine as a hangover from the days of the gasoline-fueled ignition engine. The simpler glow and diesel engines have almost completely supplanted ignition today, except for occasional use in R/C or C/L jobs where a high degree of engine control is desirable. For ordinary flying, the advantage of a timer lever which can be advanced or retarded to control engine speed precisely is not enough to offset the heavy and unreliable ignition system of coil, condenser, batteries, etc., which must be carried by the plane.

An alcohol-base fuel is used with a glow plug, while diesels burn an ether mixture. The diesel has the possible disadvantage of requiring two adjustments rather than a needle valve adjustment alone, as on glow engines. Although the diesel engine is favored in most of the world, U.S. modelers seem to prefer glow; however, an increasing number of foreign-made diesels are now being imported.

Aside from its simplicity, the average glow engine is (maybe) a little easier to start than the average diesel; but all engines are so easy-starting now that this point is not too important. Diesels are generally more heavily built than glow engines, but they will swing a heavier prop - though in general at a lower speed. But rpm in excess of 10,000 is commonplace with any modern engine, and nobody really needs more, unless he plans on entering speed competition. Glow engines seem less subject to vibration, but diesels require no batteries (which run down) or glow plugs (which burn out). Some manufacturers turn out both a diesel and a glow version of their engines, so you can try both in the same plane. Mountings, tanks, and accessories are about the same for both varieties, but don't get the fuels mixed up.

Model engines are exceedingly simple and efficient machines with only three moving parts: a piston, a connecting rod, and a crankshaft. Most of them are two-cycle engines and draw fuel into the combustion chamber, fire, and expel exhaust solely by the up-and-down movement of the piston in the cylinder. Fuel flow is regulated by a spray bar and needle-valve assembly, which can be adjusted to mix more or less air with the fuel for a rich or lean mixture. Diesels also have an adjustable counter-piston opposing the power piston, enabling the flyer to vary compression to fit conditions, such as different props, temperatures, fuels, etc., and to control speed.

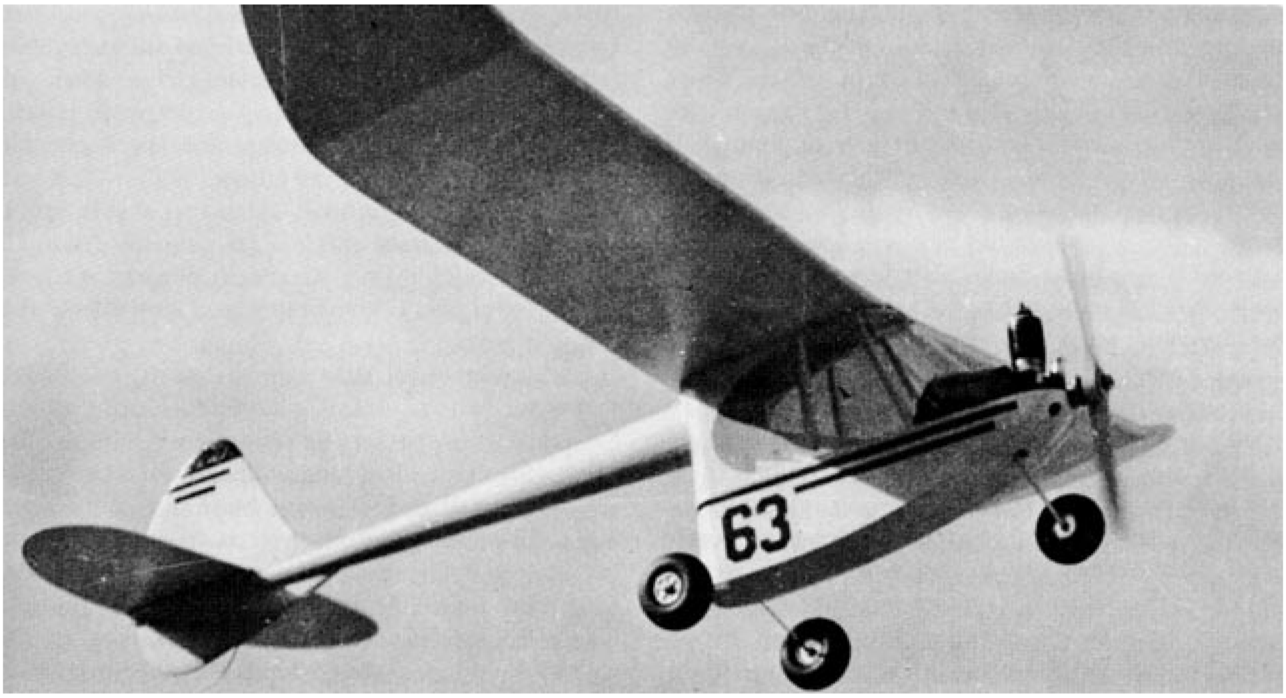


Figure 3.1: A pod-and-boom job with tricycle landing gear.A pod-and-boom job with tricycle landing gear.

Glow plug engines are fired by a glowing platinum filament, which is heated for starting by a 1-1/2 volt battery, after which the heat of combustion keeps it hot. Diesels fire on compression alone.

When you get a new engine, you should first read the starting instructions carefully, even if you've had experience with engines before. Sometimes there's a trick or two which will save you a lot of cranking. After you've briefed yourself, set the engine up in a test stand for break-in. Usually you can make a test mount by notching out a piece of 1" hardwood for beam mounts, or by drilling a board or piece of metal for radial mounting. Clamp the mount to a bench, or hold in a vise. Don't hold the engine in a vise directly; you can easily warp it or even crack the crankcase casting that way. Put the recommended-size prop on the shaft, and tighten the nut down well. If there isn't a fuel tank on the engine, you'll have to buy or make a separate one and set it up at the level of the needle valve, and connect it to the engine with transparent tubing. Fill the tank using a pump can, eye-dropper, or a hypodermic syringe until fuel comes out of the overflow. Put a finger over the engine air intake (choking) and flip over the prop until fuel fills the line; then stop, or you'll flood the engine.

Set the needle valve at the position recommended, usually about three turns open. If you have no instructions, you can gauge the approximate setting by opening it just far enough so that fuel comes readily through the line when you choke the engine and flip the prop. Recommended setting for the compression screw on a diesel is usually supplied too; if not, try it with the setting as is. If that's no good, set the piston at the top of its stroke, and screw the lever down until the counter-piston touches the piston. (Be careful - don't force it.) Then open the screw a turn.

Up to this point, glow and diesel procedure are about the same; now the differences start. For glow, connect the battery leads; tap the connection against the plug to be sure you're getting a spark as it touches, or look in the exhaust port for a glow. A hot plug will light up the interior of the engine like a dim light bulb. The glow of a cold-type plug is barely discernible, but it will work where recommended.

When you're sure you have fire, use your eye-dropper or hypo to place a drop or two of fuel in the cylinder (priming) through the exhaust port. Now turn the prop over once to be sure you don't have too much fuel in the chamber, resulting in blockage. If it turns over O.K., start flipping the prop. Snap it over with a quick flip, and keep your finger moving on out of the line of action of the prop. The engine should fire after a few flips. If it merely pops, keep flipping. If it continues to pop but won't catch, close the needle valve a half turn and go on flipping. If it pops a couple of times and then no more, prime it again and flip the prop some more. If after two or three primes it's still popping without firing a burst or running, open the needle valve a half turn, and continue.

Soon, you'll be rewarded by at least a ragged burst. You have to listen carefully at this point in order to decide what to do next. If the burst starts relatively slowly, runs up the scale and cuts abruptly - whaaap! - it's too lean; open the needle valve another half turn. If it runs unevenly - slowing down and petering out - it's too rich; close half a turn. Sometimes, if an engine is too tight, it will fire a long tight burst, and run down, sounding rich. It's hard to tell every time which is which, but a few minutes of flipping and firing will loosen up a tight engine enough to run. Put a few drops of fuel on the head after firing; if it boils away furiously, it's probably overheated.

Once the engine fires and keeps running, start closing the needle valve slowly; the engine should pick up speed. It's almost never necessary to open the N.V. after starting; a too-lean engine won't keep running, unless it's well broken in; then it may four-cycle, running with a ragged, flat barking sound.

If the engine quits as you lean it, open to the starting setting and try again. It may be heating as it speeds up, and seizing. Be careful not to run a new engine wide open for the first few minutes. Sometimes it helps to add a little of the proper oil (castor for glow - mineral for diesel) to the fuel on the first few runs. Disconnect the power leads as soon as the engine is running smoothly - not before - to save batteries. Be careful not to let the leads cross - your battery will be dead in short order!

Diesels depend much more on the compression setting for starting than on the needle-valve adjustment. After setting the N.V. somewhere near the proper spot as outlined above for glow, prime the engine and start flipping. If the prop meets stiff resistance as it goes over, slack off the compression until it flips over easily. Don't overdo it; you should feel a definite bounce as the piston passes center and is pushed down. If you set the prop on dead center, with the piston at the top of the stroke, then barely nudge the prop tip, it should snap over by itself.

If the engine fires weakly and dies out, you probably need more compression; tighten it down a quarter turn and try again. If it fires, but instead of running, starts rocking back and forth - a weird trick typical of long-stroke diesels - slack off the compression, or close the needle valve a bit. Rich and lean conditions sound much the same as with glow engines, except that the diesel is more tolerant; and remember that excessive compression can sound like a lean mixture, while inadequate compression has symptoms similar to a rich mixture. Actually, the two adjustments must strike a balance; the higher the compression, the leaner the N.V. setting required, and vice versa. You can run a diesel very slowly by backing off compression and opening the N.V. Keep flipping and adjusting until you get a start, then tighten down the compression lever for smooth running, leaning the N.V. if necessary.

Sometimes a new diesel, after starting, will begin to heat up and slow down. In this case, let off on the compression, a little at a time, until it settles down. Opening the N.V. will have the same effect on diesel or glow.

Many engines of either type will run equally well in either direction; this is a very handy feature since you can use regular props to power a pusher, or use counter-rotating props on a twin-engined job to balance torque. But be sure to note which way your prop is turning before launching a model; a backward flight can be very embarrassing.

Rather than change running settings, you can stop a running engine by dropping a rag over the prop, pulling the fuel line off the spray bar, pinching the fuel line, or by sticking a knuckle in the prop blades. The latter method has been thoroughly tested by modelers, and is not recommended, though it's more painful than dangerous. Don't crank engines with loose cuffs hanging down; the effect can be gripping indeed. And keep out of the line of fire of any flying prop blades; they very rarely come off - but they could!

Always test-run an engine before installing it in a model. It's a lot easier to tinker with on the bench, and it's always discouraging to get out in the field with a cowled-in engine before discovering that for some reason it won't go. Although manufacturers test engines and guarantee them, occasionally you'll get a defective one. Don't fret; take it back and get a new one for it. But don't assume you've got troubles until you're sure.

Some engines are reluctant to start the first time. Get someone wth modeling experience to help you, if necessary. After a run-in, it will be a lot easier. After running, it will usually be necessary to open the needle valve on a glow engine, or to slack off compression on a diesel, for the next start. Be sure you know these settings, and once you've determined them, don't lose them.

Engines come in a wide range of sizes, with displacements starting at 1/100 of a cubic inch (.010) and ranging up to .60 cubic inch. By far the most popular engines, and the most numerous, are the 1/2 A (also designated AA) engines of .049 cu. in. or less. These will fly free-flight models up to three feet in span with ease, and will handle control-line jobs of about half that span satisfactorily. To gauge the correct engine size for a given model, you can figure that the recommended prop length should be about one-sixth of the span for a free-flight model.

Engines may be either beam or radial mounted; some have fittings for both. Beam mounts are a little more trouble to build, but they're stronger and more rigid. It's a good idea to use bolts with washers, lock washers, and nuts, rather than wood screws, since the latter can be loosened by use or hard knocks, and there's no way to retighten them satisfactorily, though a piece of wood stuffed into an enlarged screw hole will help in an emergency. Sometimes wood screws can be helpful when changing engines in the field, or if a mounting nut comes loose.

There are a lot of accessories you can buy for engines. You can get a muffler to keep the noise down to a low roar; in fact, in some areas this is now required by law. To extend the length of the propeller shaft, or to mount a spinner, special union prop nuts can be had. Spinners, which serve to streamline the front of a model and carry out fuselage lines, are manufactured in many sizes and shapes, from plastics and aluminum. Special fittings for speed control, marine operation, etc., are also available. You can even buy a conversion unit which will enable you to mount two or more engines in tandem, driving a single propeller through a system of gears, or, contrarily, equipment for driving two propellers with a single engine.

Fuel tanks of all sizes can be had in specialized shapes for various uses. Rigid-type fuel tanks usually have three tubes projecting from them. One is a filler tube, which extends through almost to the bottom of the tank, so that fuel won't pour out in inverted flight. The overflow tube projects from the bottom; inside, it extends nearly to the top of the tank so as to release air as the tank is filled, and to indicate filling by overflowing. The fuel feed tube to the engine projects at right angles to the other two and is placed to pick up the last drop of fuel - if the tank is mounted in the proper position. C/L jobs usually use a wedge or other non-rectangular shape, designed to feed fuel to the engine as the model circles. This type tank must be mounted with the pick-up line to the outside of the circle. A clunk or bottle-type tank with a weighted fuel pick-up helps do the same job in R/C ships. Unless an integral tank is included with the engine, free-flight models usually use a small rectangular tank, either in conjunction with a timer or containing a metered amount of fuel, to control engine run. To insure a steady flow of fuel with a stunt job, or where several engines are fed from a single tank, bladder-type pressure tanks with regulators are used.

To harness the power of the model plane engine, a propeller is necessary. Various hardwood and plastic propellers are made in a complete range of sizes and pitches for all engines. Nylon propellers are the most satisfactory for most uses - although they have a tendency to disintegrate at the extremely high tip-velocity attained by the bigger racing engines. For speed competition, mylar props are superior. Wooden props are fine, but brittle. Be careful when drilling the mounting hole on a nylon prop to a larger size to fit a big shaft; with a power drill the bit may grab in the tough nylon and shatter the prop (and your composure).

Prop sizes are given in inches, representing the length, followed by a figure indicating the pitch. Be sure to observe the manufacturer's recommendation as to the size prop to use with your engine. A prop with a pitch equal to half its diameter or less is a low-pitch prop. Longer, low-pitch props are used for free-flight; short, high-pitch props are for C/L only. Multi-blade props are made, mostly, for use on scale jobs; these should be a little shorter than a two-bladed prop for the same engine. A diesel generally requires one size larger prop than a glow engine of the same displacement. Always keep your props in balance by sanding a bit off one end or the other, as needed; if a blade receives more than a minor chip, discard it, or trim it down to a smaller size to eliminate the flaw. Lopsided props cause fast engine wear. When mounting the prop on the engine, take care to set it so that it rests horizontally when the engine stops, to save damage in landings.

You can get extra use from broken wood props, by matching up halves and trimming them at an angle through the mounting hole so that each part has half of the hole (Fig. 3.2). Cement them together with the holes in alignment, and the pressure of the prop washer when tightened up on the engine will hold them firmly in place.

To keep those models rolling, you can equip their undercarriages with wheels of any desired size, in a choice of materials and styles. Small rubber models usually use hardwood wheels, or light-weight inflatable air wheels with wooden hubs. Engine-powered jobs usually carry aluminum-hub wheels with rubber tires; these can be solid, semi-pneumatic (hollow), or fully pneumatic air wheels. They also come with doughnut tires or slim streamlined ones for contest jobs. You can even get perfect replicas of full-scale aircraft wheels for scale models.

When mounting wheels, be sure the axle holes are roomy enough for free rotation. Drill them out to a larger size if necessary. Plastic or metal wheel collars for retaining wheels may be used in place of solder; this is simple and allows wheels to be removed easily

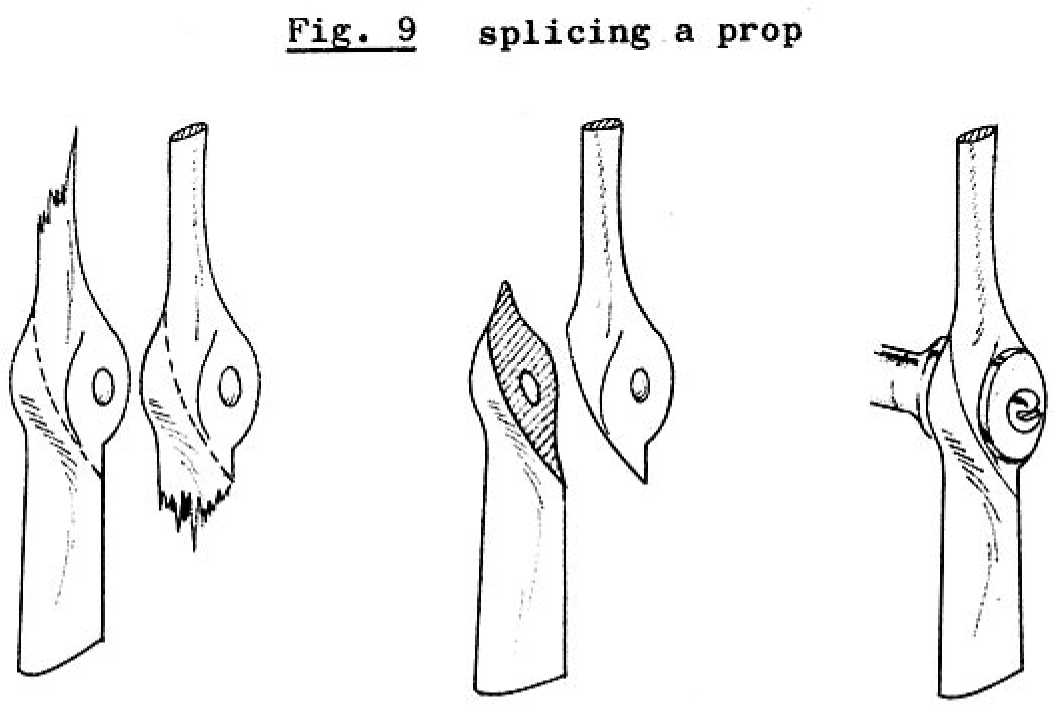


Figure 3.2: Splicing a prop.

if necessary. Collars are heavier and less secure than solder and on small models are unattractively large. Still, you don't need a soldering iron to use them, and they're fine for temporary field use if a soldered retainer comes loose a long way from the workbench. They can also be used for other purposes, such as retaining a pendulum or securing a C/L push-rod.

For control-line models, hobby shops offer a complete line of fittings. The heart of the control system is the bellcrank. These are made in a number of sizes, and are equipped with bearings, mounting bolts, washers, etc. Elevator horns, to link the pushrod to the movable surface, come in several types and sizes, as do hinges. There are also special eyelets to line the holes through which the lines emerge from the fuselage, retainers for use in keeping lead-out wires secure in the bellcrank, guides for lead-out wires, etc. You can get a gadget to hold your C/L ship in position while you scramble for the lines, and pull the trigger to release it. And how about an outside-the-circle control handle and lines, so you can sit down and fly the ship from the shade of a tree without having to rotate - a boon to vertiginous modelers.

To dress up the external appearance of your ship, there are clear plastic canopies in various sizes, miniature pilots' heads so your plane doesn't have to fly around unoccupied, colorful decals, and other items. Look over a display and you'll see lots of useful items. Of course, some of these are mere luxuries, which you can either improvise yourself, or fly without very satisfactorily. Some gadgets haven't gotten to the manufacturing stage yet - like power panels for starting multi-engined jobs, enabling you to dial juice to each engine in turn. When you get around to installing operating mechanisms in your ships, you'll be pleased to find small electric motors available, which turn up several thousand rpm, on 1-1/2 to 6 volts. You can get battery holders for any number of batteries of

any standard size.
Many of the accessories mentioned above you can make yourself if you prefer, for reasons of convenience or economy. Use sheet aluminum to form such fittings as battery boxes, motor mounts, and bellcranks. Follow the construction of the manufactured item to be sure it will work. You can make up battery leads by using a length of old two-wire electric cord and soldering fittings onto the ends. Make an extension needle valve by soldering a length of coil spring to the needle valve, and add a knob at the tip to turn with. Spinners can be turned on the lathe or in a drill press from aluminum, wood, or plastic.
You can make a canopy by heating a thermoplastic like plexiglass in the oven, then pulling it over a carved form while it cools (Fig. 3.3). Tanks are easy to make from tin-can stock or shim brass. Cut a rectangle to form the body of the tank and solder the ends to form a hollow square, oval, wedge, or whatever you have in mind. Then add a plate to each end and trim off the excess. Drill three holes and install the filler, overflow, and feed tubes. Bevel the ends of the tubes, and extend them all the way through to the opposite side. Place the filler on top, the overflow on the bottom, and the feed line in front (Fig. 3.4). Check the tank for leaks by closing two openings and sucking the air out; if your tongue sticks to the tube and comes away with a pop, it's tight. If not, start looking for the leak and plug it with solder.

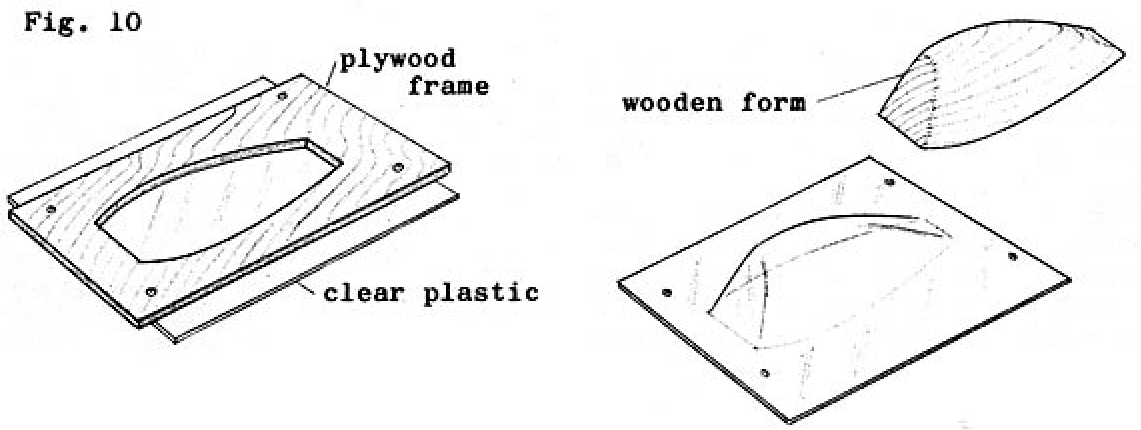


Figure 3.3:

Without question, the ultimate in accessory equipment for model planes is a radio control installation. For a long time, radio control was the private domain of a few electronic experts. Equipment was complex, heavy, and unreliable, and the necessary licenses were hedged about with elaborate and unrealistic requirements. Not so long ago you had to know Morse code to get a permit to operate your R/C model.
Today all this is changed. Receivers have grown feather-light - so small they can be carried in models of the smallest size, powered by 1/2 A engines. Instead of a maze of wiring, a simple plug-in connector is supplied. Ingenious escapements permit up to four different controls from a simple single-channel radio. And along with all the improvements, the price has dropped steadily. R/C flying constitutes a whole field of modeling in itself, and before going into it, you should devote some time to study of a good recent book dealing exclusively with the subject. Developments in the field have been so

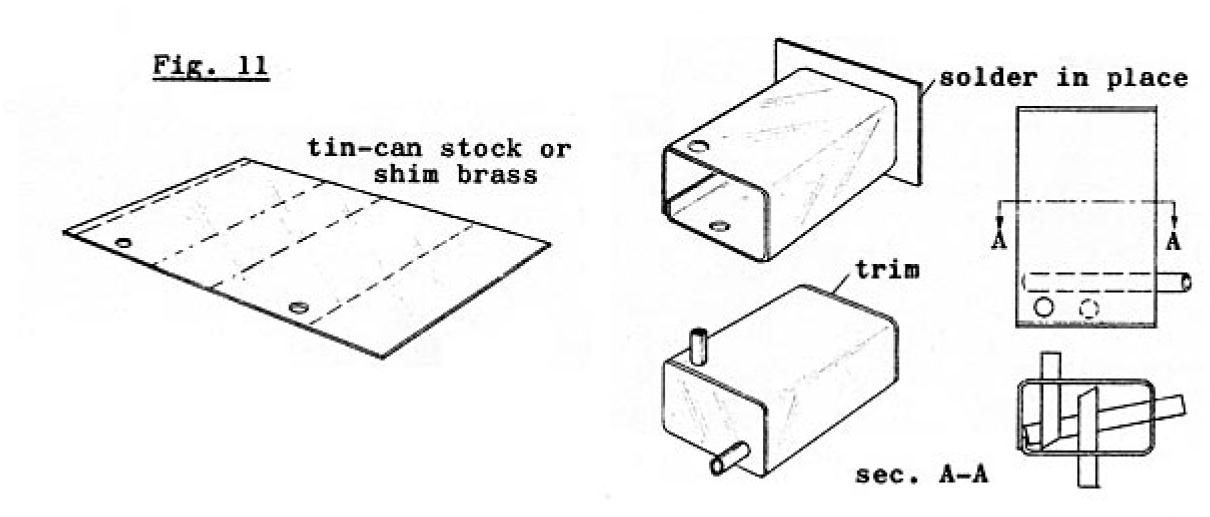


Figure 3.4:

rapid that a book over a year old would be obsolete now.

Once you have a model performing smoothly, flight after flight, you may get the urge to liven things up with a gadget or two. Some of the mechanical marvels you can install in your ship will add to its performance - like retracting landing gear, operable wing flaps, or lights for night flying, all of which are covered in a separate chapter. Other gimmicks are just for fun. You use a third line for C/L or a timer with F/F for delayed action operations, and rubber, springs, or gravity for power.

For example, it's easy to rig up a device to drop "bombs" (consisting of cornstarch or similar material in tissue-paper bags) which make a satisfactory cloud of dust when they hit. Simply build a chute from balsa, or use a stiff paper tube with a cover at the bottom which can be opened to drop one bomb at a time. You can practice precision bombing by marking a target on the ground.

Another way of using cornstarch is to let it feed out through a small hole in the bottom of the container, to lay a smoke trail. This idea can even help you find a wandering F/F job; just follow the white line. An air scoop to pressurize the starch compartment will insure a steady flow. You can also lay a trail using a smoke bomb made especially for model use.

A small glider, or even a big one, can easily be clamped under the fuselage of a powered model and released in flight; or try towing a glider behind the mother ship with a towline. It will release automatically when the motor cuts and the pull on the line is relaxed.

The experimental-minded builder can try some interesting mid-air tests by arranging for a slow-flying biplane to shed a wing aloft - or a fast job can sprout an extra wing when the motor cuts for a safe glide-in. This isn't as tough as it may sound. The extra wing can be made from sheet balsa, sanded to an airfoil section, and can be folded alongside the fuselage, clamped flat under the regular wing (or on top of it), or fitted inside the wing to emerge from the tips, being snapped into place by a rubber band when the release acts.

Try an ejection seat in a C/L fighter. Blow the canopy in mid-flight and kick the balsa pilot free - and don't forget his parachute, made of the lightest nylon or covering tissue. Try it out as a surprise on a combat ship. When you lose your streamer - bail out! It'll

be worth losing to catch audience reaction! The parachute idea can be used with a F/F job, to liven up a flight; as the model circles overhead, a trap door opens in the side or bottom, and the chute blossoms below. Very effective!
Not everything that is carried has to be dropped. Try fitting a small light-weight camera into the fuselage of a F/F model, and use the timer to trip the shutter, making a nice aerial shot of the flying field. Or put the camera in a C/L job, and practice aerial photography; see if you can catch another model flying in the same circle.

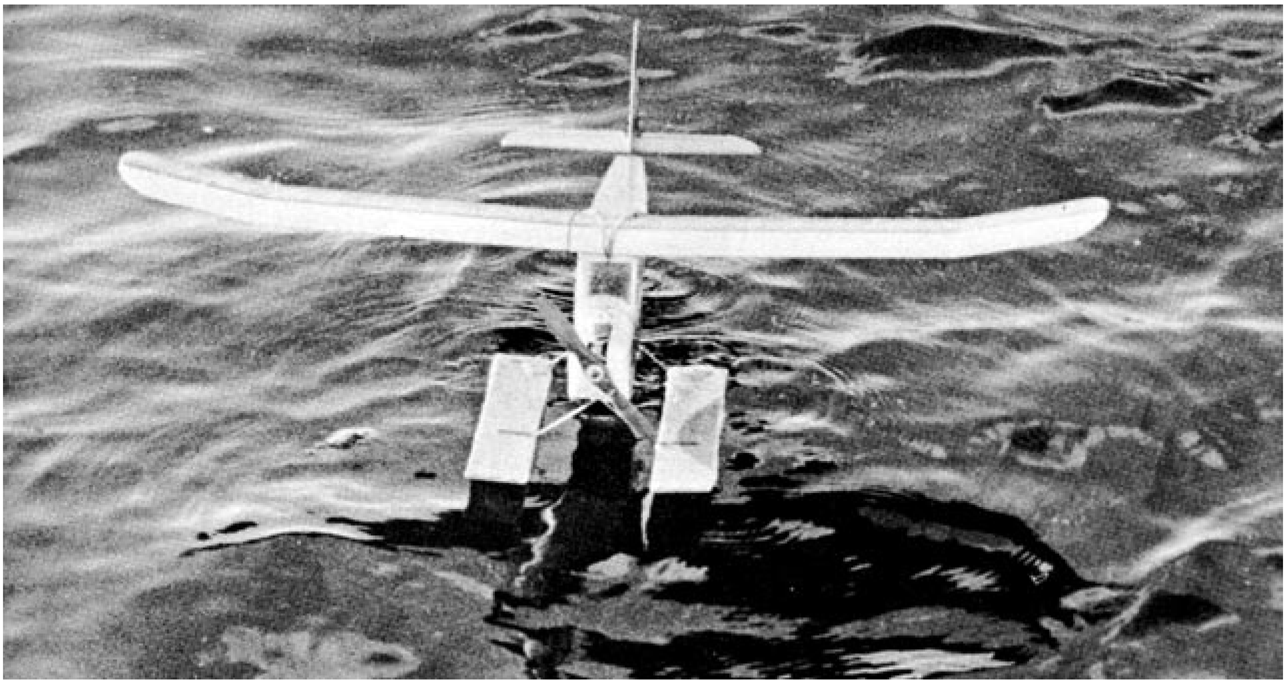


Figure 3.5: A semi-scale pendulum control model fitted with floats.A semi-scale pendulum control model fitted with floats.

If you want to see some real action, fit a reliable F/F ship with an acrobatic sequence attachment. Rig up a movable control surface, along the lines of an R/C rudder or ruddervator; however, instead of actuating it by a radio impulse, trip the gimmick with a timer. Use a small spring motor from a toy, or gear down a few strands of rubber to produce a slow rotation; mount an eccentric on the rotating shaft, with the operating arm for the surface held against it. The shape of the eccentric will determine the movement of the controls. Use a timer (or third line for C/L) to trip the device. When released, the movable surface (or surfaces) will cycle to put the ship through a stunt pattern. For example, a movable elevator could be first held half-down for two or three seconds to put the ship in a steep dive, then full-up to bring her up and over in a loop, then back to neutral to continue straight and level. If you have a big field, a steady-flying model and no wind, you can gas up and enjoy long motor runs with your acrobatic ship.
A very practical installation you can use in sport and scale F/F jobs is pendulum control - and the idea is also applicable to R/C in conjunction with radio-operated controls. A pendulum, consisting of a lead weight at the end of an arm, is suspended near the G.G. of the model. The upper extension of the arm operates the control (Fig. 3.6). For elevator, a setup identical with C/L can be used substituting a fore-and-aft swinging pendulum for the bellcrank. A side-mounted pendulum can operate rudder and/or

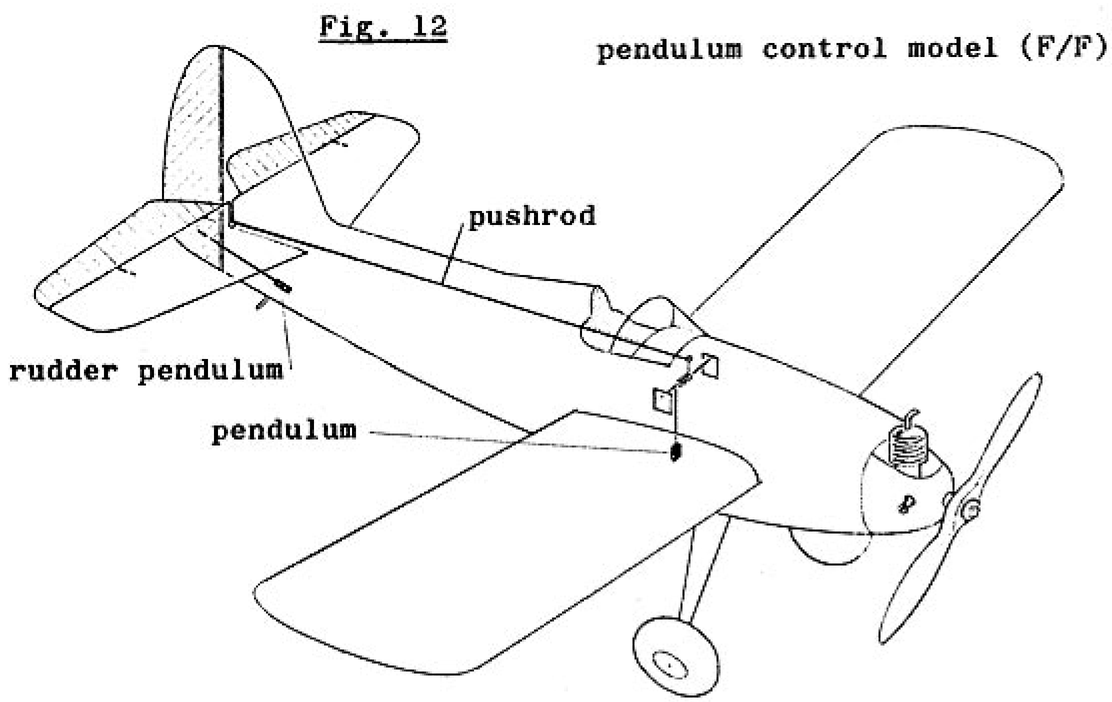


Figure 3.6: Pendulum control model.

ailerons - or try a universal joint for complete control. Always mount the pendulums so that controls are at neutral when the model sits level, in flight attitude. Be sure that all joints work freely, or disaster's bound to strike.
When using a pendulum, trim the model with the controls locked, then unlock and test. Nose dives are the result of a too-light pendulum; a fluttery motion of the tail means tail-heavy trim. Be careful on launch not to heave too hard or you'll swing back the pendulum and dive in!
These are only a few of the weird ideas possible to the modeler with a yen for the unexpected; with a little thought you can dream up even wackier ideas to amaze your friends. And remember - you don't have to be crazy to be a model builder - but it helps!

Chapter 4

Equipping your shop

Housekeepers habitually object to glue stains on the dining room table and balsa chips in the rug, so it behooves the peace-loving modeler to find a space of his own for building.

You don't need an elaborate shop; the scene of your labors can be a corner of the kitchen table, a cleared space in the attic or cellar, or an empty garage - or maybe a workbench and a few shelves set up in your bedroom. In each case, the essentials remain the same. You must have a work surface of some sort and tools to perform the basic operations. You can add what you desire to the basic list to make modeling easier and enable you to tackle more complicated projects.

A perfectly flat work surface is a must, so since sticking pins into a table-top is hard work, procure a piece of 1/2" or 5/8" fir plywood, 12 x 36 inches in size, and a piece of 1/2" Celotex of the same dimensions. Glue the two pieces together with wood glue, weight them down on a flat surface until dry, and you have a work-board on which you can build anything up to six feet frames during assembly or for doping, and the ply. wood side is for cutting. It's handy to have a small piece of 1/4" plywood handy-about 6 inches square-to cut on when the soft side of the board is up.

The next indispensable item is an ordinary single-edged razor blade. This is the best tool yet devised for cutting sheet balsa, and has the virtue of being cheap and easily procured. Double-edged blades can also be used for some purposes, such as trimming excess paper from a covered frame. These blades should be broken in two along the center to make two pieces to avoid sliced fingers. For carving and hollowing blocks, and for cutting thick or hard material, specially made modelers' knives can be very useful. A small pocket knife with very sharp blades is handy for such jobs as shaping leading edges or other long pieces where long shavings are removed.

When you get the pieces cut out, it's necessary to hold them in position for assembly. Brass or steel straight pins, the slimmer the better, are used to lay out fuselage side frames and wing leading and trailing edges and other assemblies built directly over the plan. They can also serve to hold balsa blocks or planking in place on a structure while the glue dries. It's not a good idea to try to pin through slender longerons and stringers, particularly at points of stress, as it weakens or splits the wood. Rubber bands can be used to hold frames together where pins are impractical, and spring clothespins are also useful, especially if the ends are notched or shaped for special purposes. Sometimes the expanding action of the handle end of the clothespin will hold down an awkward interior joint.

A coping saw makes life more beautiful for the modeler faced with a piece of plywood or hardwood requiring cutting. Use a fine blade and clamp the plywood to the board with a C clamp, or in a vise. A short length of hacksaw blade is a sturdy tool for straight cuts; wrap the end with tape to avoid scraped fingers.

A pair of slip-joint pliers is necessary for bending wire parts such as landing gears. Wire can be cut by bending back and forth, but a pair of diagonal or end cutters makes it easier. Only the best quality of cutters are worth the modeler's attention; piano wire is hard.

A small hand drill with bits from 1/16" to 1/4" is extremely useful for drilling out wheels to fit L.G. wire, making holes for motor mounting bolts, fuel lines, etc. You can bend a hook, chuck it in the drill, and use it to wind rubber motors in a hurry. Very small holes can be cut using a piece of piano wire of the proper size as a bit with the business end sharpened to a chisel tip. Larger holes through soft material are neatly cut by a length of brass tubing with the end sharpened and notched like a saw. A pencil with the eraser removed provides a 1/4" cutter.

For getting into confined spaces, a pair of tweezers is very useful; for heavier work in close quarters, needle-nosed pliers are handy. They can also be used to bend tight curves in wire. Here again only the best quality is good enough for work with piano wire.

Model builders cut a lot of paper, and scissors are faster than a razor blade. Don't use the ladies' sewing scissors - get a cheap pair for yourself.

For sandpaper make a sanding block 3/4" x 2" x 4". Cut a slot along one side to tuck the sandpaper into, and slightly round the working face to avoid having the edge dig in unexpectedly. This is very helpful in sanding out planked surfaces, etc. Hand-held sandpaper is better for cutting down curved portions such as cowlings and fairings.

Sandpaper itself is one of the modeler's most useful accessories. Don't bother with flint paper, the common yellowish kind which soon wears out; supply yourself with garnet or aluminum oxide paper. You can dust it off and use it over and over. It's sold by lumber yards, hardware stores, and auto supply houses, and an occasional enlightened model shop. Garnet paper is a bright reddish brown, and aluminum oxide paper comes in various shades of tan and brown, with a salt-and-pepper look. All are labeled on the back. Get one sheet each of three or four grades from 6/0 to 3 and try them out. Get a few fingernail emery boards from a drugstore, too. You'll soon develop your own preferences. The difference between crude-looking models and showpieces is largely in the amount of sanding done.

If you're building power models, you should have a small adjustable crescent wrench for tightening prop nuts and mounting motors. One or two screwdrivers with small tips and long shafts are needed for tightening down mounting bolts and assembling gadgets.

A small tack hammer for tapping out metal parts like aluminum landing-gear retainers should be on hand, along with a small pair of tin snips or heavy scissors (your own) for cutting thin sheet aluminum or tin-can stock. A hack saw is useful for cutting heavier metals, plastics, etc.

For trimming up and finishing metal parts, and for some fine cutting of hardwood, a small triangular file and an auto ignition file are very helpful. When you start building fancy items like gear boxes, you'll want a set of small taps and dies for cutting threads.

A typewriter key brush or an old toothbrush is excellent for cleaning up engines and brushing dirt from landing gears which have seen service. Keep a pint jar with a wide top on hand for washing engines in kerosene after underground landings.

You'll need a few paintbrushes for doping and trimming. A flat sign-painter's brush, 1/2 to 1 inch wide is a good basic brush for laying on dope. A camel's hair (or better still, red sable) brush does a beautiful job, and will last a long time if carefully cleaned in thinner after each use. Small round brushes (No. 3) do a good job of making fine lines when required. Cheap brushes don't last and they shed hair at the most embarrassing moments. This is one of the few items, along with cutters and needle-nosed pliers, which should be bought in the best possible quality. Of course, a spray outfit will make the job of finishing models much easier, and will turn out a superior job, but you'll still need brushes for finishing and touching up.

A small whetstone or grinding wheel keeps blades sharp for clean easy cutting. Use 3-in-1 oil on a hard Arkansas stone for putting a razor edge on your pocket knife. The oil will come in handy for lubricating things, too.

The modeler inevitably needs to do at least a little drawing and laying out of parts, and a ruler and compass should be on hand for this. A tape measure will help in laying out new control lines, checking wing spans, measuring out rubber motors, etc., and doesn't cost much. And don't forget a Stillson (pipe) wrench for getting the tops off neglected dope bottles.

In addition to hand tools, the modeler can add a number of power tools to his arsenal with a resultant improvement in efficiency. A small jig saw makes cutting out of parts painless and requires little space or expense. A band saw does a fast job of cutting out ribs and other duplicate parts in stacks, and of roughing out thick balsa blocks, as well as routine parts cutting. A six-inch table saw will produce spars of any desired size from sheet balsa, and will also cut beveled trailing edges from balsa or hardwood. Special cutting heads can be attached to shape curved leading edges.

With a lathe you can produce your own hardwood wheels, thrust buttons for rubber power, balsa fuselages, and other parts. You can put a high polish on aluminum propeller spinners and wheels with a cloth buffing wheel mounted on a lathe or a simple mandrel, and you can use the other end of the mandrel shaft for a small wire-brush wheel, which is very efficient for cleaning and smoothing items like solder joints.

A disc sander is an easy-to-make attachment for the same mandrel. Cut a disc of 3/4" plywood and cement a piece of coarse sandpaper to it. Make the center hole a close fit on the shaft to avoid off-center vibration. Use the sander for cutting down roughly shaped cowlings, etc.

A hand-held power drill can give the modeler most of the advantages of power for small jobs. There are attachments available for everything from sawing to spraying paint. You can even drill holes with it.

A soldering iron or fast-acting soldering gun, with flux and solder, makes it possible for the builder to put together a stronger model. Landing gear joints can be wrapped with copper wire and soldered, and wheels can be retained with a drop of solder on the end of the axle. Soldered mounting nuts will stay put, and you can't build really solid gadgets for dropping cornstarch bombs on gadgetless skeptics without doing some soldering. Of course, all wiring for electric lights, R/C installations, etc., must be soldered.

Probably the most useful single power tool is the drill press. In addition to drill bits, you can fit anything into the chuck, from disc and drum sanders to wire brushes. Special routing and cutting attachments can be added to extend the field of action of the drill press. You can run a bolt through a piece of wood or aluminum, tighten down a nut, chuck it in the machine, and turn out lathe work. By putting an old automobile engine valve in the chuck, you can lower the quill (power off) and apply terrific pressure for fitting together press-fit parts like bushings in wheels.

You'll need a place to put your workboard and storage space for your tools and supplies. If space is strictly limited, it's O.K. to pack the smaller items in a cardboard carton and lean the board in a corner when not in use; but it's a lot better if you can manage at least 3'6" x 5' of floor space for a permanent work table and a little wall area for a small shelf. Fig. 4.1 shows a simple workbench you can build at very small cost to fit this space. If you have more room you can extend the length up to five feet; more table space is unnecessary even for giant models. The wall shelf shown in Fig. 4.2 will store your glue, dope, balsa, etc., where you can get at them easily.

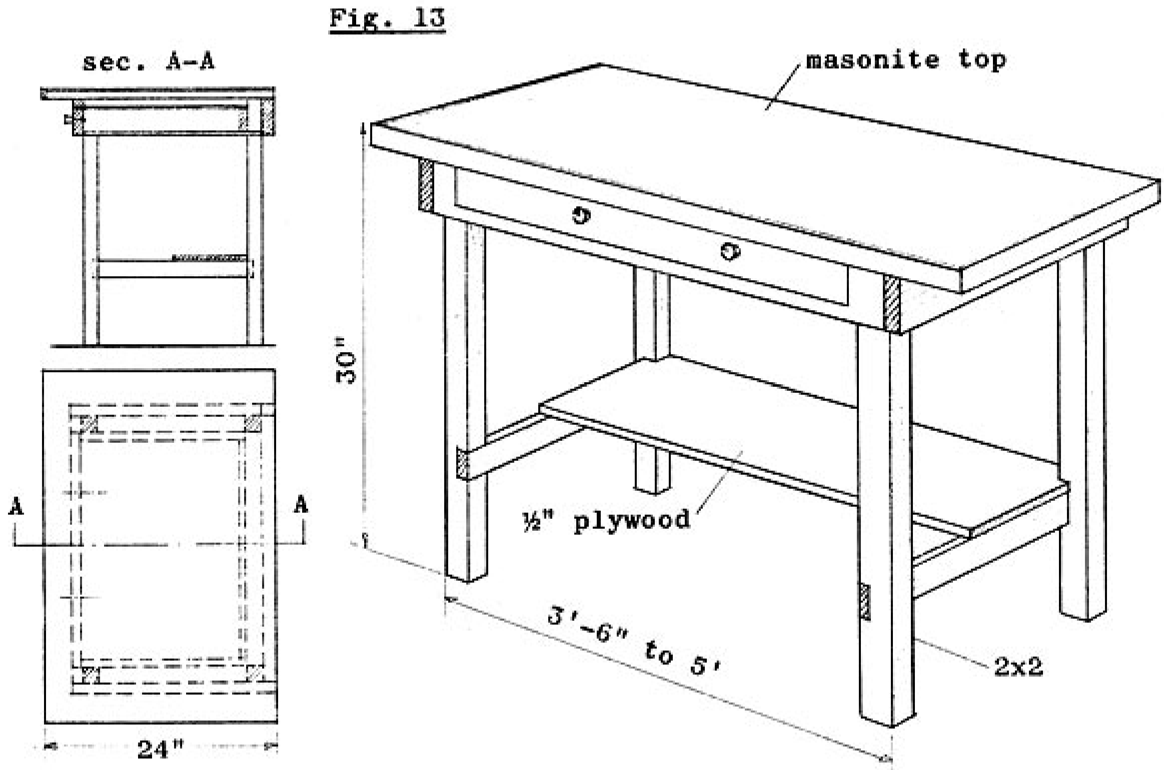


Figure 4.1:

For scaling up plans and sketching your own designs, you'll need a drawing board. Make one from a piece of flat 1/2" plywood, 21" x 31" and surface it with 1/8" tempered masonite. Be sure the board is squared up and that the left edge in particular is perfectly straight. You can buy a 30" T square, or make one, using masonite for the ruling edge. It is best to buy your triangles, one 45[FFFD?] and one 30-60[FFFD?], of clear plastic. With this simple equipment you can design almost anything.

An adjustable lamp which can be clamped onto the workbench is a great help. Use a 100-watt bulb to shed real light on the subject. A small postal scale will enable you to be very scientific about the weights of things - a necessity if you plan to enter competition. For R/C modeling, a voltammeter is a must.

A filing cabinet for your plans and magazines is very helpful, once you pass the toss-'em-under-the-bench stage. Don't ever throw away a plan, even if you're not interested in building it at the moment. A good plan library is indispensable to the enterprising modeler.

Engines should be tested and run out of doors, or at least in a well-ventilated space where a little spattered oil and a lot of noise won't matter. You should have an adjustable test stand for beam-mounted engines and a metal frame with various holes

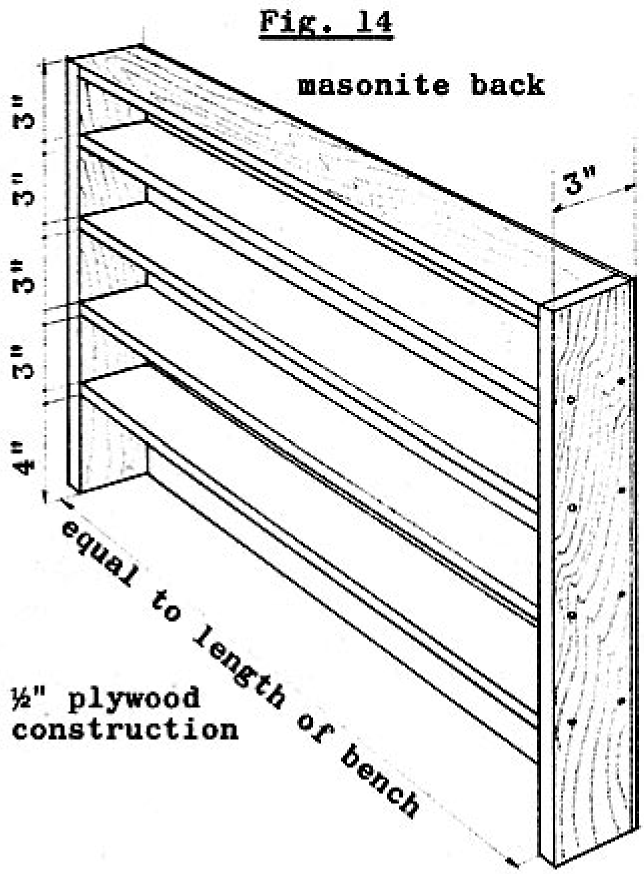


Figure 4.2:

for radial-mounted power plants. A powered starter is a helpful item for breaking in engines or running them with small props for high speed. These can be purchased or built, using an auto-starter motor, driving a short length of water hose; press it against the spinner and push the button. Tachometers are available for checking rpm, and can be a real aid to getting the most from an engine. You can build a static thrust tester by mounting the engine on the lower end of a board (a 1x4 will do) about 18 inches long, suspended from its upper end so that it swings freely. By noting the angle the board assumes when the engine is running, you can compare different props, fuels, etc.

To save batteries used for starting glow engines, an old radio transformer can be altered, by cutting a few of the windings, to produce 1-1/2 volts. Ask a radio repairman to find one and fix it up for you.

And just to be sure you have a permanent record of your projects, make a camera a part of your modeler's equipment. Take pix of new models before testing - just in case. Get shots while starting, launching, and in the air. Even spectacular crack-ups make interesting shots - consoling thought, isn't it? You can sell your best pictures to the model magazines, which are always happy to see what we modelers are up to.

As you develop your own working habits, you'll discover tools you can't do without - and maybe some you don't use at all. Keep your eyes open for new items, and exercise your ingenuity in discovering new applications for things. Remember - there are few tools that a modeler can't find a use for.

THE TOOLS AND EQUIPMENT YOU NEED
Minimum:
Workboard, single-edge razor blades, straight pins, sandpaper, slip-joint pliers, flat paint brush 1/2 to 1"
Plus, if you build engine-powered models: screwdriver, hand drill and bits, coping saw, adjustable wrench.
Average:
The above, plus: Workbench and shelves, pocket knife, sanding block, tack hammer, diagonal pliers (cutters), needle-nose pliers, scissors, vise, hack saw, files (triangular, flat) whetstone, ruler and compass, small C clamps, type brush, paintbrushes - flat and round, oilcan, soldering iron, batteries or transformer, workbench light, drawing board and T square.
Deluxe:
The above, plus: Tin snips, grinding wheel, Stillson (pipe) wrench 12", taps and dies 1/32"-1/4", tubing cutter, tape measure, jig or band saw, 6" table saw, mandrel with 1-HP motor (for: sanding disc, buffing wheel, wire brush), power hand drill with attachments, small lathe, engine test stand, vise, tachometer, scale (postal), voltammeter, filing cabinet, engine starter, static thrust tester, camera.

Chapter 5

Building your model

Research shows that, in order to be a model builder, one thing is essential; you must build models! If you're starting off with a kit or magazine plan, you'll have an easier time following the drawings if you already know the basic methods for converting raw materials into airplanes; and a kit model can often be improved by adding a trick or two of your own. When you design your own ships, you'll want to have a variety of techniques at your command; so let's look over the standard building methods used for various types of model.

Simple gliders and ROG models are usually assembled from sheet balsa. If you are not building from a kit in which parts are die-cut, transfer your patterns for wing, tail assembly, and other parts to sheet balsa of the correct thickness. Select the proper grade of wood for each part, and fit the patterns to the wood using the straight edge of the sheet where convenient; cutting a piece from the center of a sheet is wasteful. To transfer patterns, trace them on plain paper, fit the paper to the wood, then lift the edge and slip carbon paper underneath.

Always lay out parts with the grain running the long way of the pattern, unless it happens to be a piece you intend to bend; balsa bends parallel to the grain (Fig. 5.1).

Fig. 15

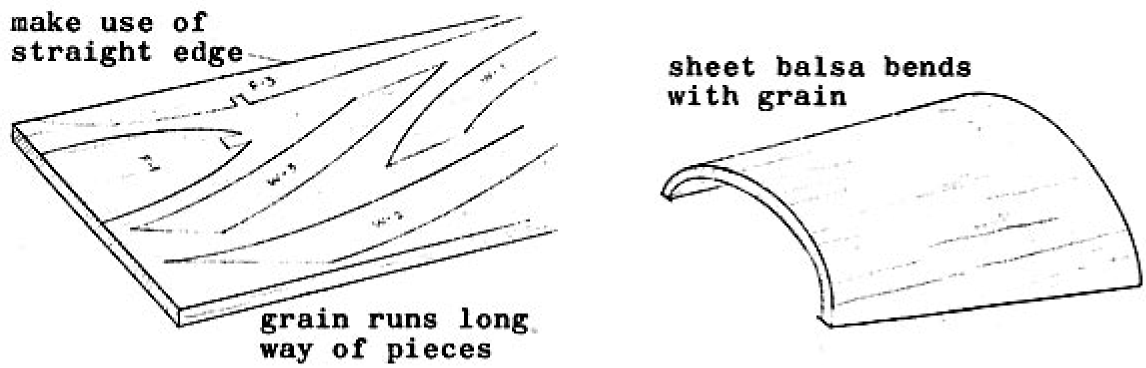


Figure 5.1:

Cut out the parts with a razor blade, being careful to hold the blade perpendicular to the wood, not at a slant. If the wood is tough, make two or three light passes rather

than trying to dig through with one; it's
both easier and neater. Cut outside the lines and sand away the excess to insure accuracy. Do your cutting on your workboard - the hardwood surface of the dining room table is tough on razor blades!

With the parts cut out, sand all leading edges to a rounded shape for streamlining; be careful not to round an edge which is to be cemented against another piece.

When assembling parts, use only a little cement, smoothly applied. For extra strength in important joints, double-cement by coating the parts and allowing the cement to dry, then cement again and join.

Some larger models employ a solid balsa profile fuselage, cut from thick sheet balsa; or a hollowed-block body, made by lightly cementing two blocks, carving to shape, separating and hollowing, then re-cementing. These are specialized types; more advanced models usually employ built-up construction, in which a framework is assembled and covered with tissue or other material. This produces a lighter and stronger structure, and makes possible interesting and realistic contours and efficient airfoils.

The box fuselage is versatile and simple to build accurately. The two sides of the fuselage are built over the plan (or sometimes cut from sheet balsa) and joined together by spacers, formers, or bulkheads. Cover the plan with waxed paper before starting assembly of the first side. Select the toughest balsa for the longerons and stringers and lay them out on the plan, holding them in place with straight pins (Fig. 5.2a); then cut and add the spacers, using cut-offs and medium wood unsuited for longerons. Careful cutting of the ends of the spacers for a good fit will increase the strength of the model. Make two of each piece as you go along, using the same strip (or strips of equal hardness) to insure perfectly matched sides. Place the extra pieces near their proper positions to save confusion. Use just a bead of cement on each end of the spacer, settle it firmly in place level with the longerons, and hold it there with pins if necessary. Don't stick the pins through the wood; put them alongside (Fig. 5.2b). Wipe off excess cement as you go.

When the first side is complete, leave it in place and build the second one directly above it. Be careful not to make your joints too juicy, especially on the underside, or you'll encounter difficulty in separating the sides afterward.

Allow half an hour for the cement to set hard, then pull the pins and remove the two sides from the plan very carefully. They will stick together, so leave them joined until you've sanded them carefully along the outline and on both faces, using a sanding block and fine sandpaper. Then use a razor blade to separate them.

If the two sides are to be joined by spacers of strip balsa, cement a pair of spacers to one of the sides, on the surface which was against the other when built (this leaves the sanded side out). Usually it's best to start at the widest point of the fuselage. When the two spacers have set (be sure they're straight), lay the side flat on the board and attach the other side; block up the rear so that the sides are parallel, or at an angle, as the plan top view indicates. Allow a few minutes to set up, then carefully draw the ends of the sides in to the proper distance (usually touching), and join (Fig. 5.2c). Don't use too much cement; it may soften the glue holding the side frames together and let things get out of control. The rest of the spacers can be added next. Hold the sides together with rubber bands wherever needed while drying.

If bulkheads are used, join the sides on the widest one, then proceed as for spacers. Before adding too much structure, be sure to install any necessary items inside the fuselage, such as L.G. mountings, engine mounting nuts, controls, etc. It's pretty difficult

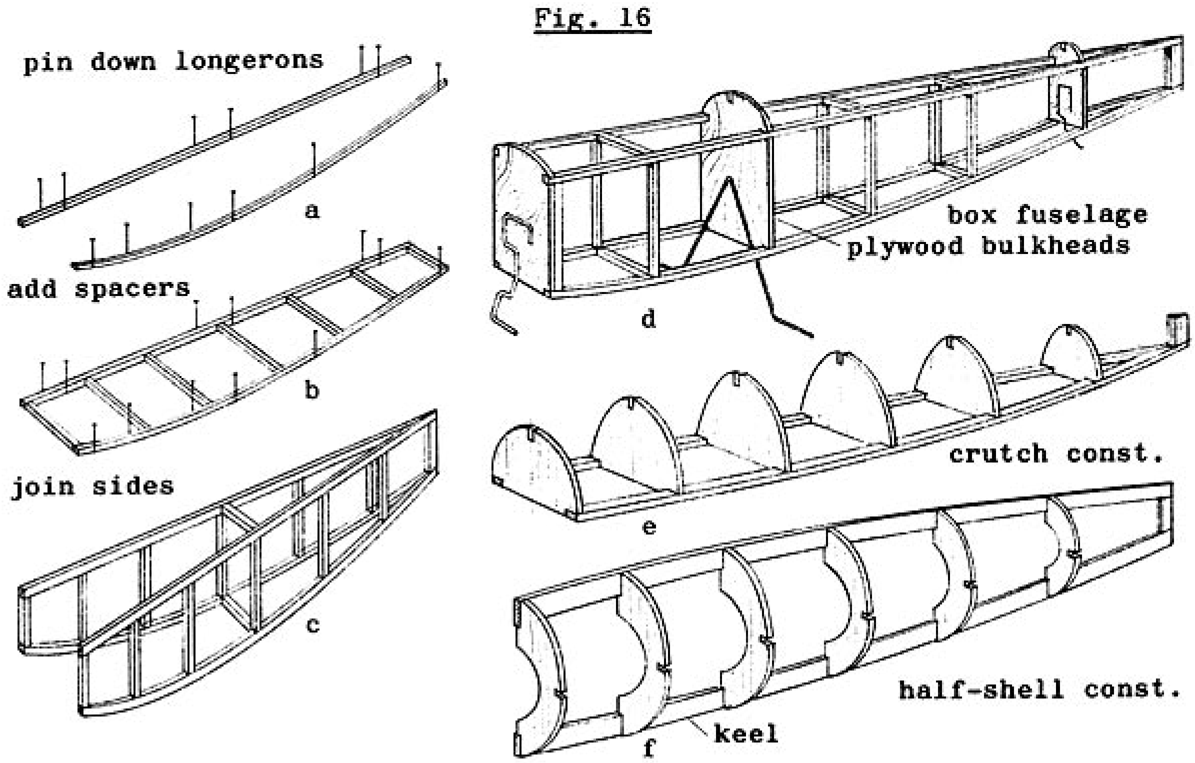


Figure 5.2:

to lace landing gear struts to a bulkhead or drill mounting holes in a firewall after it is built into the model (Fig. 5.2d).

Add any necessary formers to the box only after it has been completed and squared up. Pieces of balsa strip, set diagonally, can be used to straighten out sections that are out of line. When placing stringers, check the notches for alignment, and whittle them a bit if necessary to straighten things out - but don't mistake a crooked fuselage for misaligned notches. Place stringers symmetrically, one on each side to avoid uneven stresses. To help bend a stringer around a deep curve, you can split it parallel to the curve, and cement along the split. This procedure can also be used for longerons; it makes them stronger, and prevents them from pulling the frame out of line.

A variation of the box fuselage is the diamond, where the sides are symmetrical and, after being joined, are turned on one corner so that the longerons become top and bottom keels and side stringers.

Fuselages having a strongly curved cross-section can be built in a number of ways. Crutch construction (Fig. 5.2e) is commonly used on contest-type, free-flight jobs, as it is strong, lends itself to pylon configuration, and gives a very solid engine mounting. The "crutch" consists of two heavy balsa members laid out on the top view of the fuselage and joined by spacers. This assembly represents a horizontal cross-section of the fuselage. Formers are added to it to build up the bottom portion of the body; then it is removed from the plan and the top half is added, plus any full-section bulkheads.

A similar method is the half-shell technique (Fig. 5.2f). Here the top and bottom outlines of the finished fuselage are represented by keels which are pinned to the plan. Bulkheads are split along a vertical center line and one-half of each is cemented in po-

sition. Then the half fuselage is removed from the plane and the other half is added. It is very important with this method to place stringers carefully to retain fuselage alignment. This is a good way to build a complicated scale fuselage, since it enables the designer to use outlines and cross-sections directly as patterns. To avoid cutting bulkheads, a fuselage can be built using a jig, which holds the bulkheads in place while keels, stringers, etc., are cemented.
If the fuselage is to be planked (see Chapter 6), provision for this covering is made by building the framework undersized by the thickness of the finished planking. For tissue covering, be sure the structure provides a smooth and continuous support for the paper. Stringers should project slightly from their notches, and bulkheads and formers should be sanded down between stringers to avoid ridges pushing up through the finished covering. Sand all joints carefully, after they are thoroughly dry.
No matter what kind of fuselage you use, make provision early for installing the power plant. The firewall or motor bearers for an engine have to be tough and solidly anchored - don't try to stick them on as an afterthought, or they're likely to come off the same way. Use fuelproof cement and plenty of it - but in thin layers, not all at once. Drill all necessary holes for mounting bolts and fuel line before installing the mounts, and secure the nuts firmly on the underside of the bearers or the back of the firewall by cementing a piece of hard balsa over them - or better yet, attach a metal plate to the back of the mount and solder the nuts to it (Fig. 5.3). Always attach the nuts with the engine in place, to be absolutely sure they're going to fit.

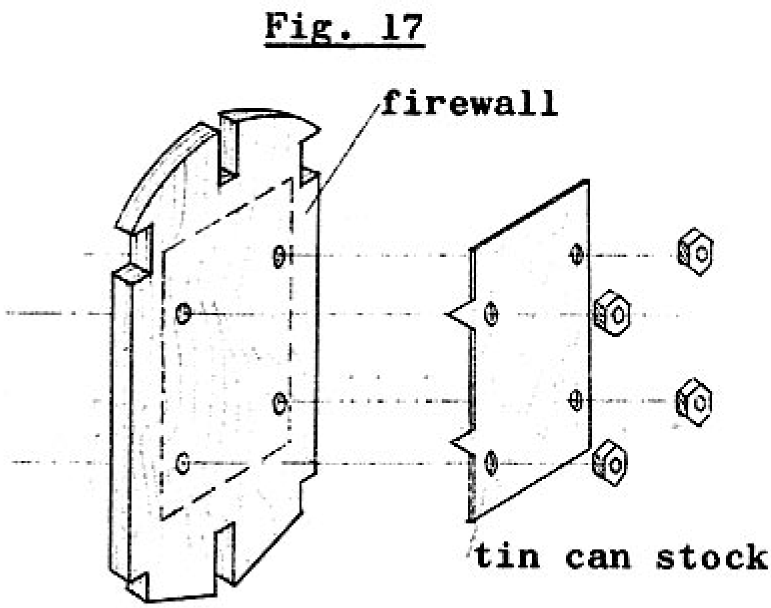


Figure 5.3:

Install the fuel tank early in the game, too, not overlooking the filler and overflow lines. Spend a little time securing the tank in position for proper feeding; a tank that flops around inside the model can cause the engine to cut prematurely and is likely to fool the modeler as to how much fuel is in the tank; after stopping early a couple of times, the tank can bounce into a more favorable position, and keep feeding fuel to your poor old F/F while it churns right on up into the clouds.

If you're using rubber power, get the prop assembly ready first, starting with the prop itself. Machine-cut and plastic props are available, or you can make one yourself. To carve a prop, lay the outlines out on a block (Fig. 5.4) and cut out the blank. Start whittling by shaving off the right-hand corner of the uppermost blade until the top left and lower right edges are roughly joined. Then do the same for the other blade. Now turn it over and repeat. Take care to give the front surfaces of the blades a convex shape, and the backs a flat or a concave form. You can use the same technique to carve gas props in an emergency.

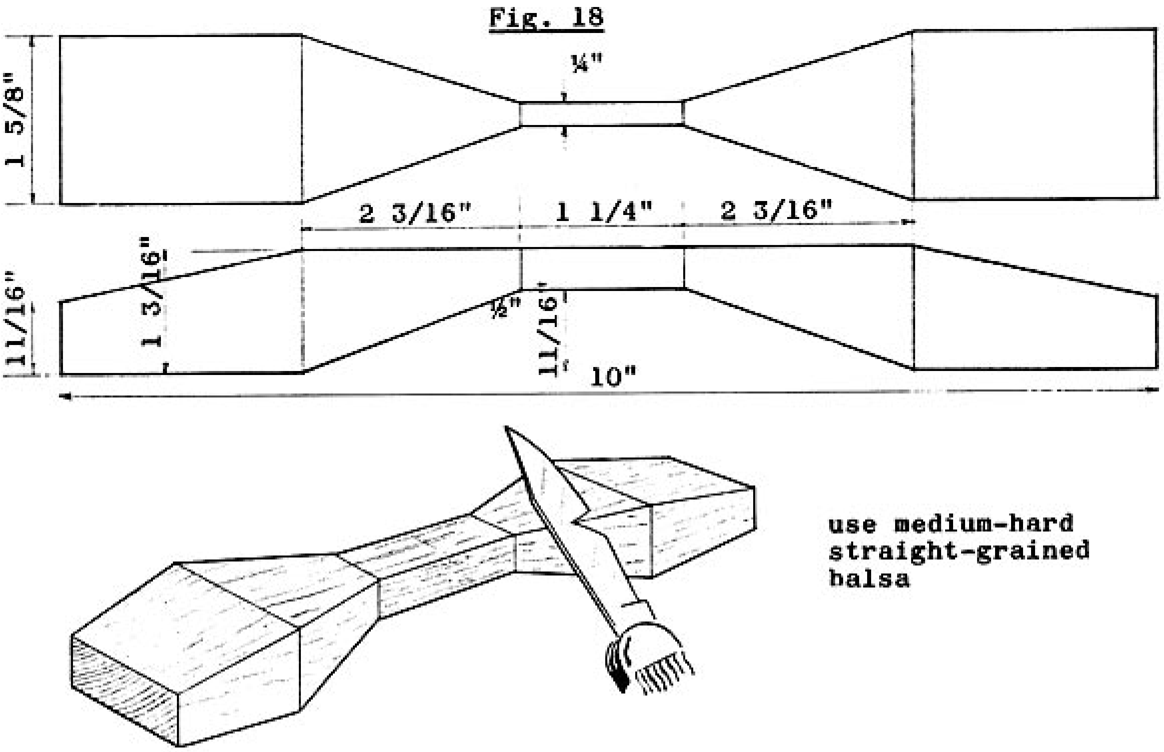


Figure 5.4:

Another method is to cut a stack of balsa strips of the desired length and pin them together with a long pin through the center point. Use eight or ten strips about four times as wide as they are thick to build up the proper thickness. Fan them out widely and coat them with cement; then arrange them so that the tips retain enough overlap to allow shaping.

Sand your prop out carefully, and balance it by resting the two ends of a pin projecting from the center on two narrow strips set on edge; sand the tip which dips. Make the prop shaft from piano wire, and bend the end of the hook back so that it can latdi over the shaft to prevent opening under full turns. Slip the nose block and thrust button over the shaft, add a washer, bead and washer (or a ball-bearing washer) and then the prop. If the prop is to be free-wheeling, install the spring now, then bend the end of the wire at right angles. A pin projecting from the front of the prop stops the shaft from turning freely while pressure is on it; the spring disengages the prop when the rubber has unwound, allowing the prop to free-wheel.

By bending a loop in conjunction with the final bend, you can engage the prop assembly in a winder for fast winding (Fig. 5.5).

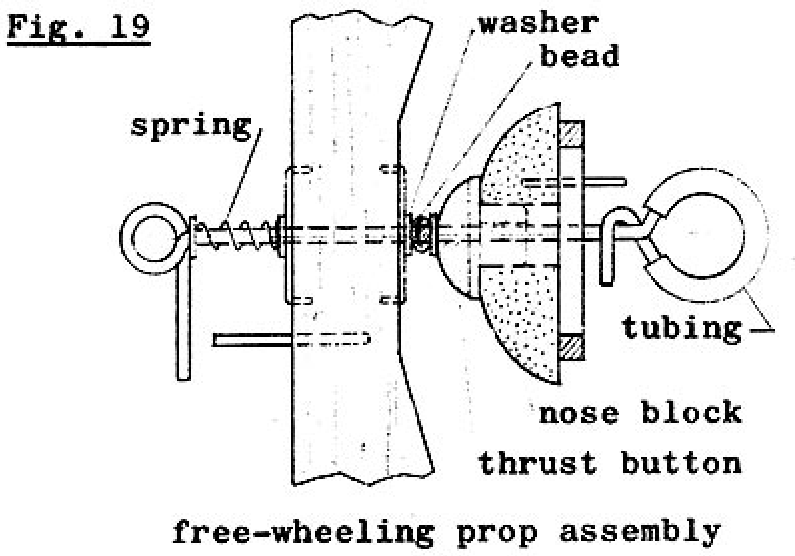


Figure 5.5: Free winding prop assembly.

When winding the motor, stretch it out to double length, and start turning, drawing it out to three or four times its relaxed length by the time you have a couple of hundred turns; then start coming in slowly, and finish up with the nose block back in place. After the motor is wound, let it go without delay; don't stand around talking it over - that's tough on the rubber.

For small jobs, make up and install the motor while the fuselage is still accessible; it's pretty tricky sometimes to feed it in through the front after everything is covered. Of course, on large endurance models you'll be taking the motor out to service or replace it from time to time, but since the model is larger, it's not so difficult. Small back-yard flyers often get through their entire flying life on the original four strands, so prepare them properly, and get them in as soon as you have something to anchor to.

To measure out a rubber motor, double the front-hook-to-rear-hook distance, and add one-third of the same distance; this will give you the length of two strands. Double back the same length for the next two strands, and so on until you reach the desired number. Tie the ends together securely, and bind them just above the knot with thread. Now, unfold and lubricate the rubber thoroughly.

Next, double the rubber up again to make half the final number of strands of a little more than twice the final length. Hook one end of this long loop over something (a doorknob will do) and twist the other end in the direction opposite to the normal winding twist. Give it about 50 to 100 turns, depending on how long the motor is; then carefully, to avoid kinking, bring the two ends together, and release the middle. The rubber will twist around itself, shortening up to the desired length. If it's still too long, undo that last maneuver, and twist it a little more. When it's just right, so that it will hang snugly between supports, bind the loose end with a bit of soft string to keep it from unwinding when released, and install.

Wings are generally easier to build than fuselages but in their construction precision is even more important. Straight material must be selected, and there must be no stresses

set up within the structure which may later result in warps. Most wings consist of a leading edge, trailing edge, spar, tips, and ribs. These components can be assembled to make wings that are flat, or with dihedral or polyhedral, tapered wings or straight wings, knock-off or integral wings, etc.
Flat wings are widely used on C/L models, which require no dihedral for stability. These wings are extremely strong, and easily built. Sometimes the tips and leading and trailing edges are laid out on the plan and the ribs added, but usually, since symmetrical or deeply undercurved ribs are used, precluding a flat layout, the ribs are placed in position on the one-piece spar, and the leading and trailing edges added (Fig. 5.6a).

Fig. 20

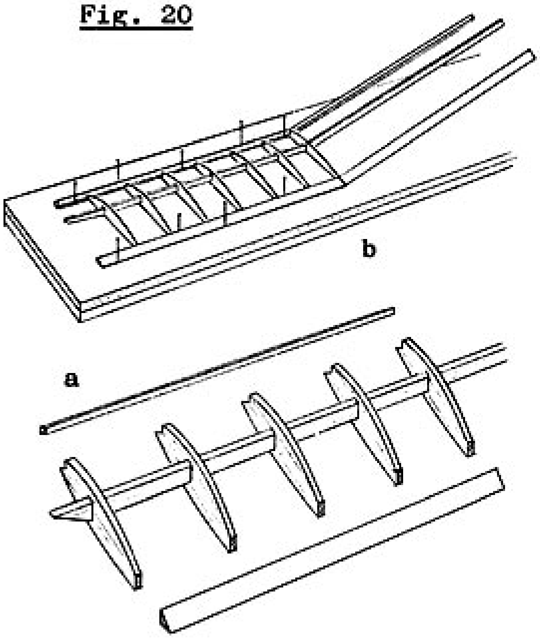


Fig. 21

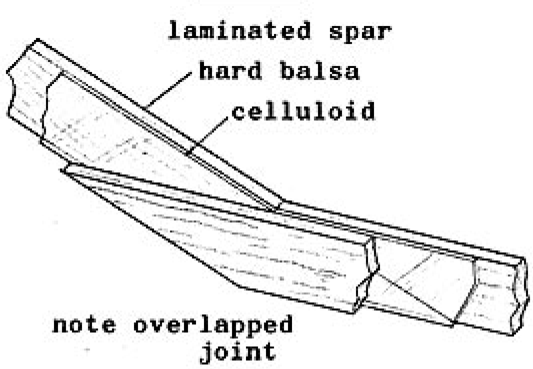


Figure 5.6:

A wing for a small rubber-powered model can sometimes be built flat and the leading and trailing edges cracked, bent, and cemented to the proper dihedral angle. Polyhedral or dihedral wings for larger rubber jobs and engine-powered models must be built with the angles as an integral part of the structure, for strength. One method is to build the wing in sections, each being laid out flat on the plan. The parts are then set up in the proper relation, and ribs and dihedral braces added at the joints to form a unit. More often, the spar and edges are first built over a pattern with the correct angles made by splicing strip balsa. The prefabricated members are then pinned to the plan, one panel at a time being in contact, and ribs added (Fig. 5.6b).
Most wings are so designed that the main load is carried by the spar or spars; accordingly, tough, straight material should be selected for this use. Any necessary joints must be double-cemented, and reinforced, preferably with plywood or celluloid (Fig. 5.6). Since the spar must resist vertical bending stresses, it is always higher than it is wide; the deeper the spar, the better. Spars can be made of a single piece of balsa or lightweight hardwood, or they can be spliced, laminated, or built up. A box spar, made from four strips assembled to form a rectangular cross-section, is strong and serves as a jig for assembling a wing. By laminating a layer of celluloid between two layers of tough balsa,

an exceedingly strong spar can be made. It is important here to cement the layers thoroughly without gaps. When splicing spars diagonally, cut carefully for an accurate fit.
Leading edges are usually formed from a single strip of medium balsa of proper size, notched into the front of the ribs, square or on edge. Sometimes the ribs are cut square, and the leading edge is cemented directly against them. A flat L.E. key strip can be used, fitted into a notch to help in aligning the ribs. This makes a good auxiliary member, but is not rigid enough to serve unsupported.
On larger models a wide strip of sheet balsa, moistened and formed around the ribs, makes a very strong leading edge. An alternate method is to cut the ribs to a V at the front and cement a flat strip against each angle. Fig. 5.7 shows several popular L.E. treatments.
When splicing a leading edge, match the dihedral angles to the spar to avoid built-in warps. It's easier to shape a leading edge after it is installed, and after leading-edge planking and/or cap strips have been added, since the rib stations serve as guides. Notches can be cut in the L.E. for the ribs, for extra rigidity.

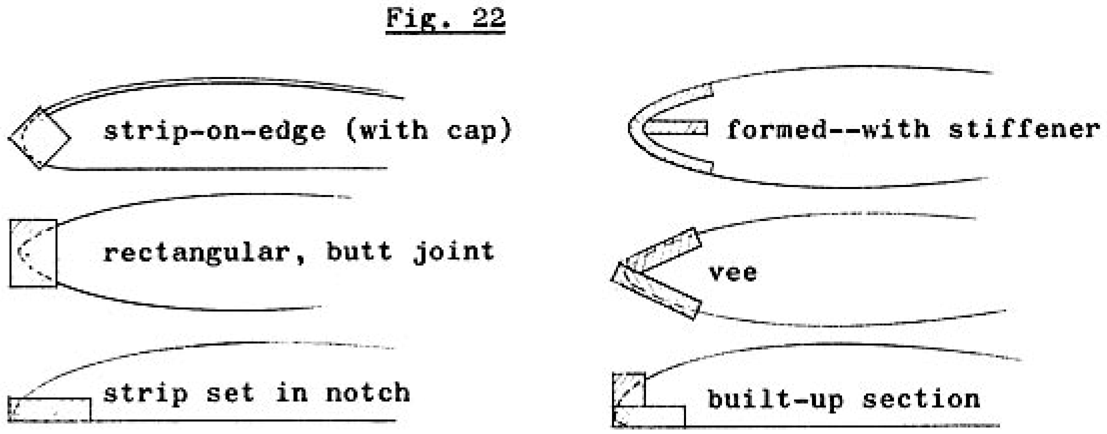


Figure 5.7: Leading edges.

Trailing edges are often of constant cross-section, and you can precut them to exact size using a power saw. A tapered trailing edge can be most accurately cut by first making a constant-section beveled strip of the proper length, then cutting the taper by removing a tapered strip along the thick edge. Another widely used T.E. is made by fitting a flat strip under the rear edge of the ribs, and notching another along the top surface, to form a hollow V section. Sometimes a thicker strip is used, notched into the bottom surface, with cap strips on top of the ribs to strengthen the joints. Since trailing edges are thin, they can often be scored and cracked to the proper dihedral angle, with a generous amount of cement rubbed into the break. Such angles can be strengthened by using gussets against the ribs at these points. The T.E. may also be notched to receive the ribs (Fig. 5.8).
While there are many different ways to make ribs, cutting them from sheet balsa is easiest and works fine. For a wing of constant chord, cut the ribs simultaneously by pinning together a stack of blanks, tracing a pattern on the outer blank, and cutting out with a saw or knife. The ribs are sanded as a unit, notches are cut as needed with a saw, and a matched set of ribs results.

Fig. 23

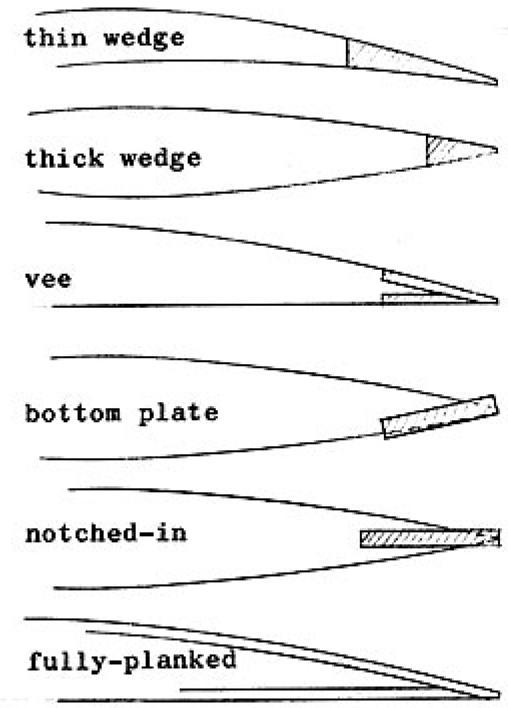


Fig. 24

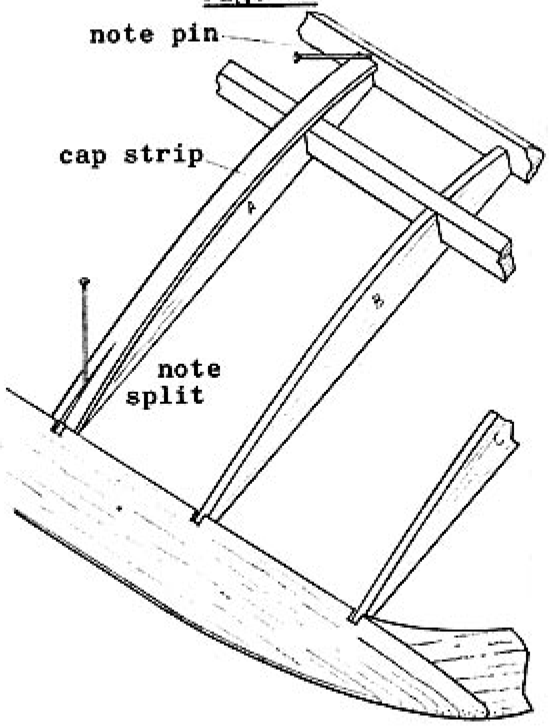


Figure 5.8: Wing ribs.

For very large models, ribs are sometimes built up as individual sub-assemblies in order to save weight. It is doubtful if any net improvement results; anyway, it's too much work. Cut your ribs from thin, hard balsa, and use cap strips, for maximum utility with the least effort. Smoother covering results when caps are used, especially if the strips butt against the rear face of the leading edge and taper out at the trailing edge. These strips are usually used on the top surface of the wing, but can be added to the bottom too if desired. They should be of the same thickness as the ribs, usually, but not over 1/8 inch thick even on giant ships with foot-long ribs. Make them three to four times as wide as thick, and be sure when cementing them that they are in contact with the rib full length. Hold the caps in place while drying by sliding pins at an angle into the leading and trailing edges across the strips; in other words, don't stick pins through the wood near the end, or it's likely to split (Fig. 5.9). Use a sanding block to smooth out the joints after the cement is hard.

There is a lot of variety available in wing tips. Curved formers cut from sheet balsa are used to form round or oval tips. A block of soft balsa serves for short tips up to about two rib depths wide. For intermediate tips, a piece of sheet balsa cut to shape will serve, with the spar cut at an angle to support it, and the covering continued over the top. With one of the methods shown in Fig. 5.9 you can build a tip of nearly any conceivable shape.

While one-piece wings are generally stronger and easier to build than two-piece designs, the latter are practical for extra-large models, and for some special applications, such as low or shoulder wing layouts, or scale jobs where a one-piece wing would detract from the appearance.

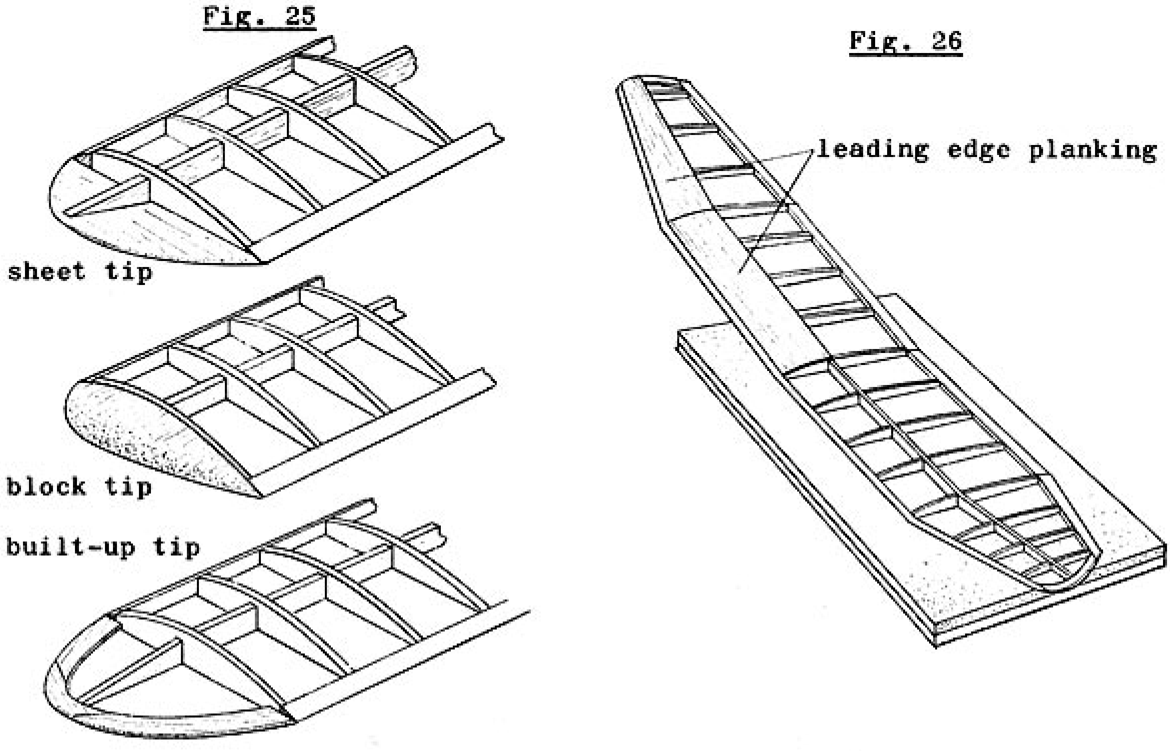


Figure 5.9: Wing constructions.

Two-piece wings are fitted with projecting members such as spars, wood or metal dowel pins, or lengths of tubing, which slip into sockets designed to receive them, either in the fuselage or the opposite wing root. These keying members must, of course, be just as strong as the rest of the wing. The two halves can be held together by hooked rubber or simply by a tight fit.

Both for strength and efficient airfoil, sheet balsa planking along the leading edge of a wing is desirable on any model having a span of more than 24 inches (Fig. 5.9). Material of the same thickness as the ribs is cut in sections to fit each panel. For this purpose use straight-grained, medium-hard balsa; if it's too hard it won't bend easily. It should extend back no more than a third of the distance to the trailing edge, and should be supported along the rear edge by a spar; otherwise, it will dip between ribs when the covering tightens up. It's a good idea to dope the planking on both sides after installing to prevent swelling and buckling from absorbed moisture.

After the wing is completely assembled, use a sharp knife or razor to trim off excess balsa from L.E., tips, etc.; then settle down for a half hour or so with a sanding block to shape the final contours. The L.E. cross-section must be sanded out to complete the curve of the ribs accurately; otherwise you have a built-in head wind to start with. Check the shape with a template at each rib as you work to be sure its the same, full length. Fair the tips into the L.E. contour and thin them out to fit the T.E. taper. Don't let any projecting humps get by you, where the ribs meet the edges, or where the spar fits into the ribs. A good sanding job is the key to an efficient (and neat-looking) wing.

Finish up with a coat of fifty-fifty cement-dope mixture over the entire wing structure

and daub it thoroughly into all joints. This welds the structure into a single unit and doubles its strength.
A great deal of time and effort has been expended by model designers on engineering elaborate tail assembly structures. This is unnecessary. Sheet balsa makes excellent rudder and elevator surfaces, and is light and strong enough for use on any kind of model, with the possible exception of very large models using an unusually thick section. The rudder and elevator need merely be cut from medium straight-grained balsa and sanded to a mildly streamlined cross-section. For tails made from 1/8" balsa or thinner (this covers up to about 18-inch elevator span) merely rounding the leading and trailing edges will do nicely. Of course, if you are building a scale model, you'll want to follow scale airfoil.
If a built-up tail is necessary (and frequently when it isn't, if you build from kits), the structural method is usually similar to that used in the wing, with an outline consisting of leading and trailing edges and tips, and ribs or spacers in the case of a flat surface.
On control-line models and R/C ships, control surfaces are hinged. A simple hinge can be made using strips of cloth in pairs; one tip under the stationary surface and the other over the moving one, the other member of the pair being reversed (Fig. 5.10a).
Another method is to slip cotter pins over a length of wire, the ends of which are bent at right angles and inserted in the trailing edge of the fixed surface, while the cotter pins go into the moving portion. A notch should be cut in both surfaces at the position of the cotter pin for free movement (Fig. 5.10b). If the movable surface fits into the stationary one so that both ends are covered, a length of stiff wire projecting from each end ca'n be engaged in tubing set in the fixed portion (Fig. 5.10c). In addition to these homemade devices, manufactured types are available at the hobby shops.

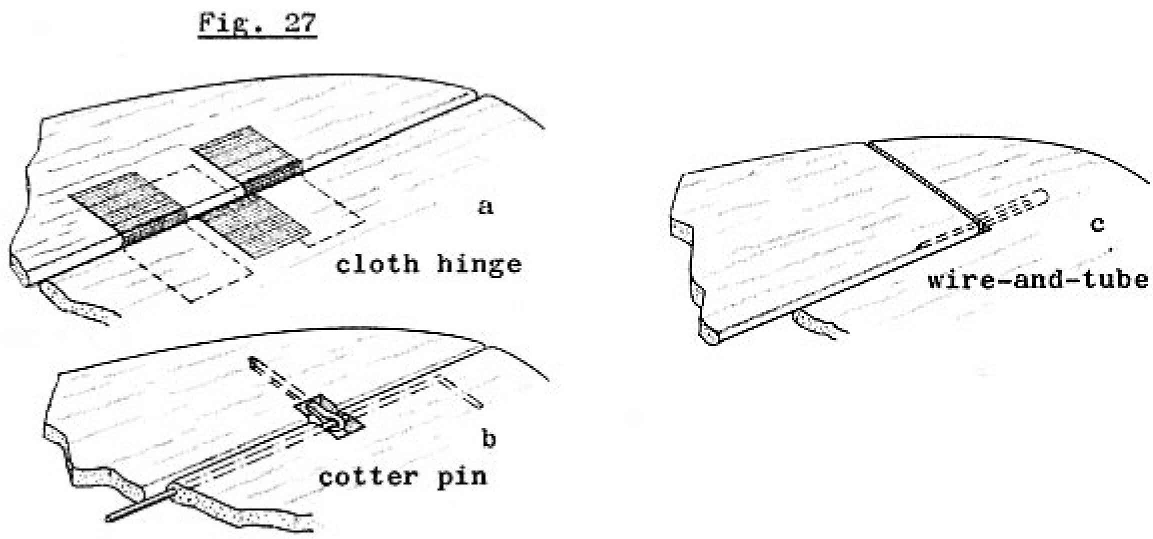


Figure 5.10: Hinging.

When cementing and doping hinged surfaces, be careful not to clog the hinges. If your control linkages are to be enclosed, don't forget to connect things up before attaching the surfaces permanently to the fuselage.
For free-flight models, a knock-off tail is standard equipment. The rudder is cemented to the elevator, and the assembly is attached to the fuselage with rubber bands, for

which dowels have been provided in the fuselage. The surfaces should be sanded and doped before being joined, simply because it's easier to do that way.

Grain should run lengthwise in an elevator, and vertically in the rudder. If the rudder is built up of several pieces, edge-cemented, the forward portion may have the grain running parallel to the leading edge. Sub-rudders may have grain running either way, depending on shape and thickness; vertically is usually best.

Movable tabs for adjusting trim may be cut from the outline of the rudder after it has been shaped, and held in position by soft wire set in rudder and tab; a tab can be cut from thin aluminum with small points projecting from its edge, which are pressed into the edge of the rudder. On large rudders the points can be spread slightly, so that as they penetrate the balsa, they emerge from opposite sides of the fin. The projecting tips can be bent back and cemented for a very secure mounting.

The landing gear is an aeronautical encumbrance on a model, but it serves the valuable function of coming between a relatively delicate structure and the unyielding earth, making take-offs possible, preserving propellers, and in general making everything a little more civilized. All sport and scale models have landing gears, even though they are usually hand-launched and land in grass (or treetops), and contest jobs often carry a wheel. This portion of the model must be rugged, since it takes landing and take-off shock repeatedly. This is where tough plywood and piano wire enter the picture. The main legs of the gear must be capable of taking the stress without bending permanently, and without tearing loose. They should be bent from wire of appropriate diameter and held firmly to a plywood bulkhead or mounting plate by thread or wire lacing, sandwiched between two pieces, or held down by a metal plate bolted in position. Joints should be wrapped with copper wire and soldered; lesser measures are inadequate. J bolts and similar fittings are all right for small models, but they're too flimsy for large ones, besides not being positive enough in their holding action. Don't rely on auxiliary L.G. struts to help much; they are usually of smaller-diameter wire, and merely bend in a hard landing. They are used chiefly for the sake of appearance on scale models.

Even a properly sized L.G. will flex amazingly when a model hits the ground hard. A nose dive can swing 1/16" struts, 2 inches long, in a 90[FFFD?] arc forward; a 3/32" nose-wheel leg can spring back far enough to punch a hole in the bottom of the fuselage, and rebound without taking a permanent bend. So don't look around for gremlins when holes appear in your model after an unsuccessful landing; just remember to beef up the gear in your next job.

You can take a lot of the jolt out of rough landings by installing a shock-absorbing L.G., or nosewheel. Bend the leg so that it passes horizontally through a length of brass tubing firmly attached to the mounting bulkhead. The upper extension of the leg is held by a rubber band or spring, so that it will swing back against tension as the model contacts the ground, absorbing the shock. Of course, rubber wheels and spring wire struts are in themselves shock-absorbing, but not adequately so for a real clobber-in. Fig. 5.11 shows a couple of simple arrangements.

Heavy R/C models are often equipped with knock-off gear, apparently on the theory that even if everything else is smashed, the wheels will bounce clear and survive. Of course, the same amount of effort and ingenuity could be used to build a sturdy shock-absorbing gear; still, with knock-off wings, tails, engines, etc., the wheels may as well go too. Probably some ghoulish types just like to see 'em scatter.

Another variation is the plug-in gear, which is removable for storage or repairs, or just

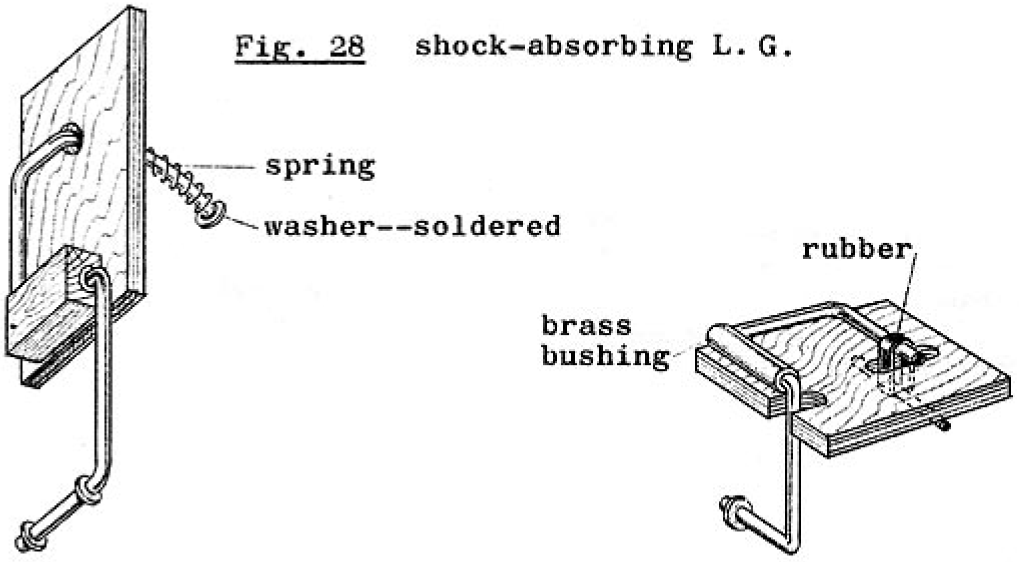


Figure 5.11: Shock-absorbing L.G.

to change the looks of the model. The mounting projection of the gear slips into a socket formed by a metal plate bolted or laced to a bulkhead, and is held by friction. By installing several sockets in the model, you can switch from two to three or four wheels in a moment.

The last word in landing gears for models is the retracting gear. Designing and building this type of installation constitutes a large subject in itself, and is dealt with in a separate chapter.

Whatever type of gear you use, the wheels (or floats) must be securely retained. A washer or bit of wire soldered to the end of the axle is effective and simple for this purpose. File a notch in the axle to help grip the solder. You can grind the end of the axle off flush after soldering, for a finished look. If you don't have soldering facilities, bind tough thread around the axle as a retainer and coat it with cement, or get a set of nylon or metal wheel collars. Use another retainer on the inside of the wheel to keep it from binding on the axle.

In building any type of model or any part of a model, keep in mind the fact that balsa is an extremely flexible material; it's not only bendable, it lends itself to alteration, correction, and replacement when necessary. Flawed construction can simply be cut out of a structure and replaced; if you whittle too deep, just glue that last shaving back on and try again; it will be as strong as ever. Tricky curves can be handled by cementing a balsa block, or even assorted scrap balsa in place, then sanding to shape. Joints can be cut free, if you're not pleased with them, and whittled down and reglued. A good sanding will do wonders for even a very rough job of assembling. To patch a hole or thin spot, just cut out a square around the flawed area, insert a chunk of balsa, and sand it smooth.

There is no reason for a modeler to be satisfied with an imperfect framework, as long as he has a sharp razor blade, balsa wood, and cement. And don't assume other designers have figured out all the possibilities in model structures. Keep experimenting - maybe you can do better!

Chapter 6

Covering and finishing

It's more fun building and flying a model if the appearance of the ship is as much a credit to the builder as the performance - doubly so if the plane is an original design. There's no point in building a scale model unless you're planning on a realistic finish, complete with details. Sport jobs, with the emphasis on flying fun rather than on contest performance, can be dressed up with colorful paint jobs and polished like shelf display models, and still fly perfectly. Actually, a good finish on a model not only adds to its beauty, but can even improve its performance.

Don't wait until you're through building to plan the finish; you should look ahead to the final steps at every stage of construction. Even the prettiest paint job can't conceal irregular joints, baggy covering, or hairy, unsanded wood surfaces. Decide at the beginning to invest the extra time that a fine finish will require; it takes less effort than you might think, and you'll have a better airplane for your trouble.

During construction it is essential that you check the airframe as new parts are added, to be sure joints are smooth and flush, that members are aligned properly, and that components fit together snugly. Some areas which will be difficult to reach at a late stage of construction should be given attention while they're still accessible, before adding parts which will prevent a proper job later. For example, a sheet balsa elevator can be shaped, sanded, doped, and finish-sanded more easily before being installed or having a rudder attached to it. Interiors which will be visible should receive priming, sanding, and doping before being sealed in, and provision should be made well in advance for the attachment of accessory details.

Particularly if your model is to be fabric or tissue-covered, consider how the covering is to be attached and provide a continuous smooth surface to receive it. If you have planking which ends with an abrupt drop-off, add fairing strips to fade the planking into the rest of the frame. Remove any corners or edges which project in such a way that they will make unsightly bumps under the covering, and check the lines of stringers and ribs to be sure they're smooth and straight. Balsa is an easily worked material; chop loose anything that's out of line, move it over, and glue it down again. Before attaching the first piece of covering, you should have inspected the whole ship, adding a bit of scrap here, trimming a little away there, until you have achieved what you really want - a truly aligned, smoothly built structure.

You are now ready for a session with the sandpaper. A quarter sheet of No. 2 or 3 garnet paper wrapped around a sanding block can be used first to cut down any areas which need to be reduced considerably, such as a cowling which has been built up of soft balsa blocks and carved to rough shape with a sharp knife. Be careful not to let the

garnet swipe across any previously smoothed area; it will cut deep lines.
Now use medium-grit paper to fair new sanding into old, and to cut down spots which need only a light treatment. You'll soon develop a feel for the paper, and will be able to select the right grade for the job at hand. The entire framework should be gone over lightly to remove any remaining scratches, loose fibers, and bits of excess cement. Hold the frame so that light strikes it at a shallow angle, and look it over for slight humps in wood surfaces such as balsa-covered leading edges of wings, or wood-filled fuselage front sections. Cut these down with fine sandpaper, but be careful not to sand through the wood, or to cut it so thin that it begins to buckle. If you do inadvertently damage a wood section, now is the time to bravely cut away the damaged portion, and replace it. Often it is possible merely to cut a rectangle around a bad spot and insert a piece of soft balsa sheet thick enough to be sanded to the correct shape.
When you are satisfied that you have a smooth frame, get out a bottle of thin clear fuelproofer and a sign-painter's flat camel-hair brush of appropriate size (1/2"-1"), and paint the entire framework, inside and out, as far as you can reach. This process not only protects the model from the future ravages of fuel soaking, but greatly increases the strength of both balsa and joints. Be careful not to use too much dope on the joints, or you'll loosen them; use just enough to give a good coating.
After allowing half an hour for drying, use your fine paper again to remove the fuzz which the dope will cause to rise up stiffly on the wood. Don't sand so energetically that you go through the dope, however. Now you are ready to start the actual covering.
Any wood planking should be done first. If you are covering flat or simply curved areas, like those shown in Fig. 6.1, sheet balsa can be used. Select medium-soft, straight-grained wood, and cut each piece to approximate shape, using a paper pattern if necessary. If the section to be covered is deeply curved, as over a turtle-back or cowl, soak the piece in warm water for a minute or two, then bend and hold it in place with rubber bands until dry; then remove and attach. It's an excellent idea to fuelproof the underside of each piece before attaching it; this is essential if the planking is at the front of the fuselage. Apply cement to every point of contact between covering and frame, for maximum strength and minimum buckling. Use slow-drying cements for planking.
When applying sheet planking, always trim the edge of the first side covered, and let the next side-plank overlap it, for easy fitting of joints.
Sometimes a combination of sheet and strip planking can be used, and for very curvaceous jobs, strip planking must be used throughout.
If the framework is to be planked with strips, be sure you have an adequate supply of the proper-size strips, all of similar texture. It is almost impossible to sand the finished fuselage to a smooth contour if the planking is alternately hard and soft. These strips should also be fuelproofed in advance. If the structure being covered curves sharply, you can get tighter joints between strips by beveling the edges of the strips. Be sure to use thick enough material to permit heavy sanding of the finished job.
For fuselages up to about 16 inches in length, 3/32" planking is adequate; for those between 16 and 30 inches 1/8" should be used; and for larger jobs, correspondingly thicker material.
When planking a fuselage, start by placing one full-length strip along the center of the top and another on the center line of the bottom, following with strips along the center of each side. Be sure to keep the fuselage in alignment at this stage as the first strip added may tend to pull it out of line. Next place a strip on each side of each strip already in place, alternating sides so as to keep the strain equalized. Use plenty of ce-

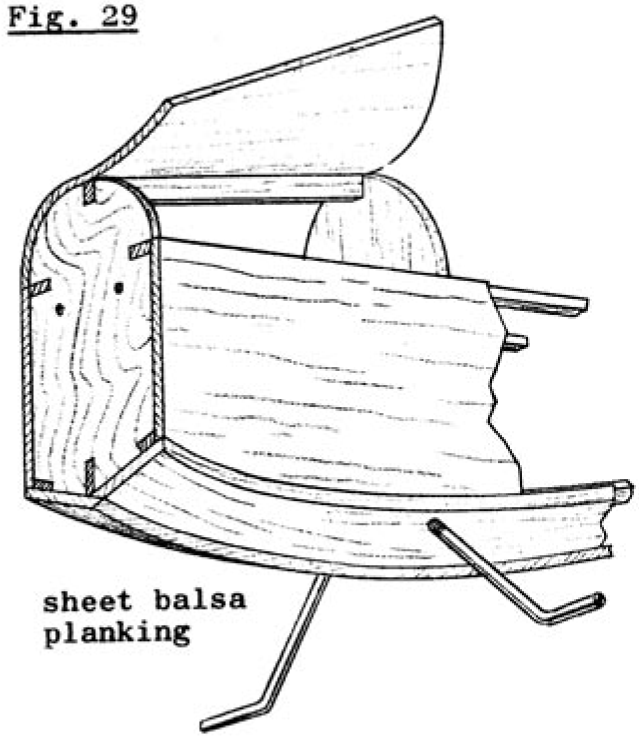


Figure 6.1: Sheet balsa planking.

ment, and pin each strip firmly in place, checking as the glue dries and squeezing the strips in closer if they move out of position. Clothespins make handy clamps for holding planking in place. Let the strips hang over at each end about 1/2 inch, and don't trim this excess off until the final sanding of the completed fuselage is done.

If there are sections which will later be removable, such as hatch covers, pop-off tail or wing fairings, etc., mark the exact point to be cut on each strip as you work around the fuselage. If this step is omitted, you may have to resort to surgery to find them after the covering is complete (Fig. 6.2a).

As you continue to add the strips, eventually you will find that two come together and overlap, usually at the rear first. Carefully trim the new strip to fit against the one already in place; the next strip should then go along the other edge of the open section, and fit against the strip just attached, so that the joints alternate. Fig. 6.2b illustrates this technique.

When the entire fuselage has been planked, let it dry thoroughly - overnight if possible. Then carefully remove the pins which are bristling from the planking, get out the No. 3 garnet paper, and settle down to some serious sanding. On the first rough sanding, try to cut down the ridges and projections to the level of the center of the strips; then check the contours in a low-angle light, and work down any bulges or high spots. If you have open cracks, smear cement into them and let the balsa dust from the sanding fill them. If you discover a depression in the contour which can not be corrected by sanding down the surrounding area, add scrap to the strips already in place at this point to build it up, then shape.

With the surface cut down to the correct curvature, smooth it off with medium-grade paper and check for any remaining holes which need filling. If there are gaps too big

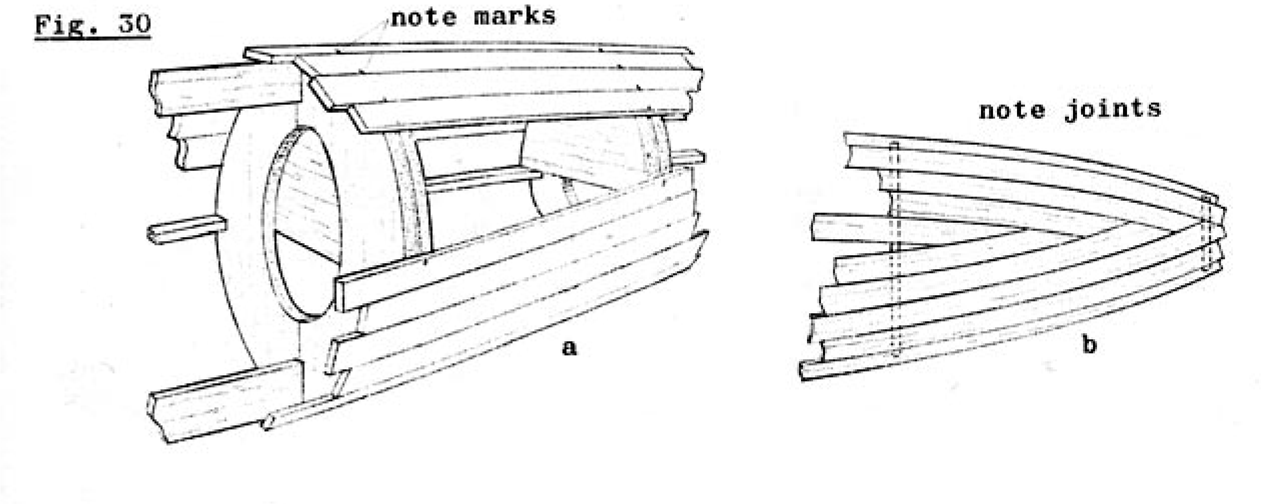


Figure 6.2:

for a cement-and-sawdust filling, cut slivers and pack them into the spaces. Then finish up with fine paper, trim the ends, cut loose hatches, etc. Attach any blocks which are required to complete the contour, such as cowl, rear end, and fairings. These blocks should be trimmed to shape, then sanded down to match the rest. The emergy boards are very handy for filing those hard-to-reach spots and for knocking off small bumps. Now fuelproof the entire fuselage and sand lightly.

Balsa wood in 1/32" sheet, firm and straight, makes excellent leading edge planking for free-flight wings up to 36-inch span, or for C/L up to 24-inch; 1/16" sheet will plank any wing, including all-balsa wings for large multi-engined scale jobs, up to 50-inch span.

Covering the wood surfaces not only increases the strength of the planking and reduces its tendency to split or chip, but it effectively masks the porous grain of the balsa wood and gives a far better finish. Covering of planking is done in much the same manner as described below for covering open frameworks, with the difference that the paper is fully supported and thus cannot sag. It should, however, be applied in sections, and cemented only at the edges so that it can be water-shrunk for a snug fit. All-balsa parts such as tail assemblies should be tissue-covered in the same way. The same method can be used to plank curved portions of wings, tail assemblies, nacelles, pontoons, etc.

Tissue covering is the point at which many otherwise well-built models lose their looks, together with much of their aerodynamic efficiency. This isn't the result of any inherent difficulty in covering, but rather of the fact that the modeler isn't going about the job properly.

There are several basic principles to keep in mind when covering: Don't attempt to cover a deep compound curve with one piece of paper. (A compound curve is one which curves in more than one direction, like a section of a sphere.) Remember that it is more important to get the paper on straight, without wrinkles or puckers, than to get it tight; water and dope will shrink it beautifully, if it is straight. And don't try to cover too large an area at one time. Don't use too much cement; it will spread on the paper and cause puckers. Cement the paper only at the outside edges of the area being covered. For example, when covering a wing, apply cement to only the leading and trailing edges, and the root and tip; but don't cement the paper to the ribs. Keep the cement away from the inner edge of the surface to which it's applied. Otherwise it can run down, harden, and pull the paper down with it; apply the cement along the extreme edge of the paper. And remember that you can dampen tissue or silk, and stretch it slightly to accommodate awkward areas such as elliptical wing tips. If you find that the cement dries before you have the paper in place, try mixing dope and cement fifty-fifty; or use mucilage in sparing amounts. It is very sticky, and dries slowly enough so that you can tug and pull the paper around all you want to before it sets up.

Start by selecting the first area to be covered, and cutting out a piece of paper big enough to cover it. To dampen the tissue, place it on a flat surface and spray it with water, or place a wet cloth over it and press it down. A simple blower of the type sold in art supply stores for spraying fixative on drawings is ideal for spraying water.

Apply the adhesive - whether cement, dope-and-cement mixture, or mucilage - being sure to leave no gaps, and carefully place the paper in position. Don't let cement get on the paper where it doesn't belong, as this will cause puckers. Working rapidly, pull the paper taut before the cement has set. If you find it stuck too tight to slide, pull it loose, and recement it in the right position. When the paper is firmly attached and spans the surface without sags or wrinkles, trim the edges carefully with a sharp razor blade. Double-edge blades work well for this job, although they are too flimsy for most cutting.

After trimming, check the edges and glue down any spots you may have missed; then do the next area in the same way. Always fit the paper over the area to be covered to check the fit before cementing. If the paper doesn't fit smoothly, reduce the area to be covered until you have a section that can be done properly with one piece of paper.

Silk and nylon covering are more resilient than tissue, and when wet can be stretched to cover rather deep curves; however, don't pull the covering so tight that it warps the structure. The paper covering should be continued over planked surfaces, with cuts or darts made where necessary to achieve a fit without overlapping (Fig. 6.3).

Fig. 31

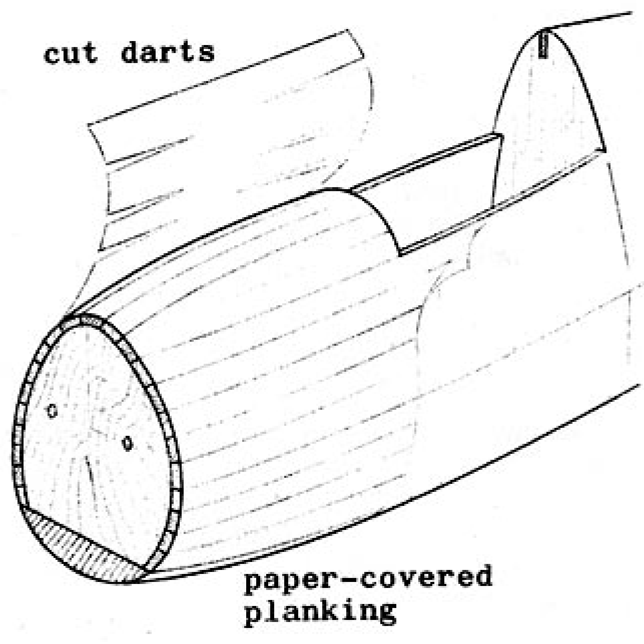


Figure 6.3: Paper-covered planking.

When the covering is complete, spray the fabric with water, and allow it to dry thoroughly. On wet days the tightening action is slowed down, so don't try to dope unless the room air is fairly dry. You can hurry up drying by placing the wet surface in direct sunlight or under a lamp. Don't put it so close to the lamp that the paper gets hot, though. This may cause it to split, or overshrink and loosen up when it cools. If, after drying completely, the paper still looks loose, don't despair. If there are wrinkles, or obviously baggy places, get out the razor, cut out each bad section, and attach a patch, using a brush to apply dope to hold it. Always cut the paper loose, don't try to peel it off; you may pick up the edge of the next piece and rip it, too.

If the paper is straight and tight, or only slightly loose after wetting, apply a coat of thinned-out fuelproofer or clear dope, either spraying or painting on with a wide flat brush with soft bristles, such as camel's hair or red sable. Although good brushes are expensive, the flat type are cheaper than round artist's brushes. Just don't let dope dry in the brush, and it will last a long time.

After the clear dope has dried thoroughly, check again for loose areas. If the covering is not yet taut, and the air is moist, wait for a dry day and check again. Many a covering job that looked limp on a wet Friday night was drum-tight on a sunny Saturday morning.

If you are satisfied that the weather isn't going to improve, there is one more measure you can employ. Take a tube of cement, thin it out to the consistency of thin dope, and give the offending areas a coat of this potent mixture. If the structure under treatment is a wing or tail surface, pin it down tightly to your board before applying the cement. If this fails to bring out a tight job, you weren't really trying in the first place; you'd better pull it all off and start over, covering smaller areas, and using fresh paper. Sometimes old tissue has shrunk because of moisture in the air, and pre-shrunk covering material is not desirable.

With the fabric covering applied, doped tight, and thoroughly dried, get out the fine garnet paper and work over the entire surface, removing the fuzz which the dope has raised. Be very careful in sanding the tissue not to wear through the paper or press too hard on unsupported surfaces. If you should stretch the paper, redope it, and it will tighten again. Use the emery boards to grind down the extra cement along the seams, and to level any overlaps on the planked areas. Usually one side of the emery board will be slightly concave and the other convex, from the die-cutting of the board; be sure to use the side which matches the contour of the surface on which you are working.

The above applies in general to the plastic coverings, such as Monokote, minus a lot of the hard work, since gluing is eliminated and shrinking can be controlled at will. But don't leave a Monokote job out all day in the hot sun!

If you haven't yet assembled components such as a C/L tail assembly, having wisely waited to finish the sealing and smoothing of the parts, now is the time to put them together. Don't absent-mindedly, attach the windshield or any part which will interfere with the painting; consider the remaining work, and plan the order of events. Wheels, engine, outside mounted bellcrank, etc., can be easily added after color doping, and you save taping them off.

For a truly smooth finish, especially for scale models, and on areas representing metal covering on prototypes, filling of the pores in the surface is a necessity, and need not add much weight.

Paint the filler on with a brush evenly, in thin layers; don't attempt to build up a large fillet with one application. The result is a hollow bubble which can mar the job and cause lots of extra work in whittling it away. Let each coat dry, then sand with fine sandpaper. Be careful not to cut through the filler and dope into the wood, or you will have an uneven spot to work out later. Try to remove all the filler from the high spots, leaving it only in the pores, grooves, and cracks. Dust the model off after the sanding, and apply another coat where needed. You can mix a thicker blend of filler, and use it as a putty or plastic wood to fill joints and make small fillets, but don't try to build up large volumes in this way. The material will add unnecessary weight, and will be susceptible to cracking and crumbling away. Instead, make clean cuts and fit balsa blocks to them, then sand to shape and fill.

When the finish is as smooth as you want it, go ahead with the first color coat of dope. After the dope is on, you may want to add more filler to some areas.

Spray-painting is preferable to brushing and is not difficult to arrange even if you don't own a spray outfit. Many colors of dope are available in spray cans and are easy to apply. It is less expensive, however, to have the job done at a sign or automotive paint shop. Such shops will almost always spray your model for you expertly, for a small charge. Be sure to ask first, though; a few operators will demand a large fee just for starting up the compressor. One dollar should buy you a three-coat job for the biggest model, if you supply the dope. If you cannot arrange for spraying, thin your dope to the consistency of milk, and start brushing with the same wide soft brush you used for the clear dope.

If the model is to be glow-engine powered, you must either use a fuelproof color dope, or add a final protective coat of clear fuelproofer to the finished job. There are a number of fuelproof dopes available at the local hobby shop or by mail order through the ads in the modeling magazines. Be very sure you have the right thinner on hand for the dope you use, as they do not mix. Also, some fuelproofers will dissolve the dope under them, or shrivel any decals you may have attached, or even bubble your cement fillets; so be sure to test the different dopes in contact with each other.

If you are finishing a large model, over thirty inches in span, it will be to your advantage to buy your dope in a large-sized container, such as a pint or quart. If your model shop does not carry the larger sizes, which are considerably cheaper per ounce than the small bottles, you can use ordinary pigmented lacquer, obtainable at paint stores, and automotive body shops and supply houses. This lacquer is not fuelproof, but a final coat of fuelproofer will protect it. If there is an aviation supply store in your neighborhood, you may be able to get butyrate dope in pints and quarts; this is a fuelproof dope, and you can get the authentic aircraft colors.

On the other hand, if your model is small or if you need only a small amount of a color for trim, the one-or four-ounce bottles handled by hobby shops are far more practical. There is little point in buying a pint of dope at a low price, if you intend to use only a few ounces and the rest dries in the can. Also, the range of colors available in the small bottles is very complete, and you can be sure of the finest-quality dope. Some modelers who do a lot of building have quart cans of the basic colors on hand, and a variety of bottled colors, too.

When spraying a model, apply light, even coats, avoiding overloading any one area. This not only causes runs and slow drying, but can impair the balance of your model. Be sure the dope is applied thin, and that it is blown down into the interior, inside the engine compartment, etc., so that no unfinished edges show. Let the first coat dry, then touch up the job with fine sandpaper; you will find loose fibers standing on end after painting. If you sand while the painter is working on another part of the plane, no time

will be wasted, especially if he has followed your instructions and sprayed a very light coat. The second coat should be equally light, and by now the model should be pretty solidly colored, although the finish may still be dull and porous.
If you have an enclosed cabin around which a windshield and windows will be installed, now is the time to add them. If no pattern is supplied on the plan, make one by placing a piece of stiff paper across the front of the windshield frame, as shown in Fig. 6.4, and wrapping it around both sides, covering all the window areas, which will be done with one piece of clear plastic or celluloid. It may be necessary to trim away some of the paper from the bottom center of the pattern at this point, in order to drop the pattern down to cover fully on the sides. With the blank fitted snugly, pin it in place and with a pencil outline the exact area of the opening to be covered; then remove and trim the pattern. Try a fitting now, and trim more if required. Leave enough of an edge to permit easy gluing, but not so much that it will overlap covered areas excessively. If you have inadvertently cut the pattern too small at any point, draw a line on the pattern along the narrow portion indicating the amount the pattern should be enlarged, then make a new pattern correcting the error. When you have a pattern which fits perfectly, place it on the windshield material and draw around it using a razor point. It will then break loose merely by bending along the line. Plastic or celluloid 1/64" stock works well for smaller models, and 1/32" or .030" will do for even very large ships.

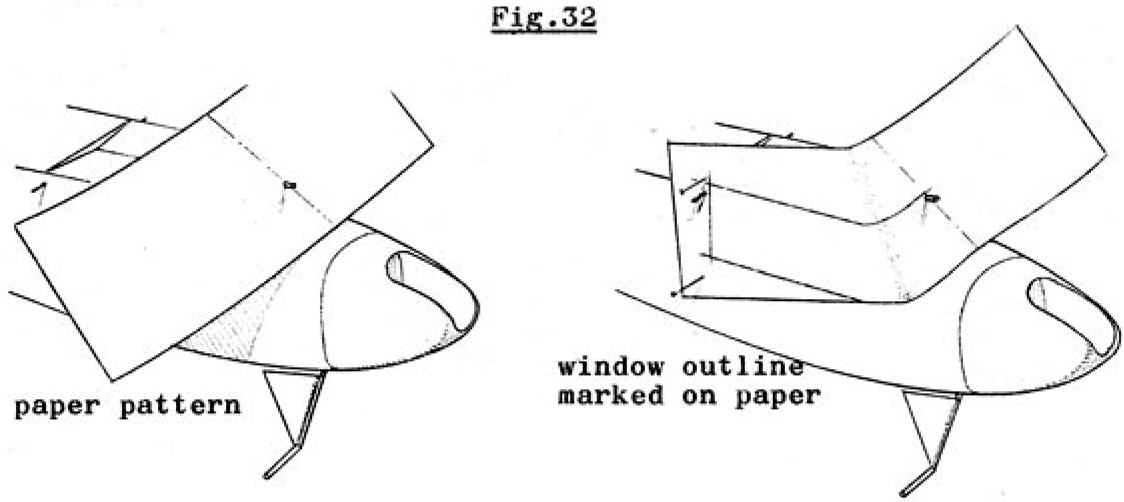


Figure 6.4: Windowing.

If a molded windshield is required, make a form to exact shape from smooth-grained wood, heat a piece of plexiglass or other thermoplastic until it becomes soft, and stretch it out over the form (see 3.3). It is helpful to make a frame to hold the hot plastic when handling it. The molded material should be held in place until set, then trimmed to fit perfectly. If the surface has been dulled in the process, use a fine buffing compound such as a car cleaner to buff it clear again.
Give a final coat of dope to the interior, if it requires it, and attach the windshield, using a cement which will adhere to the plastic without damaging it. (Make a test first. Some sheet plastics disintegrate into a mass of hairline cracks at the touch of dope or cement.) Start attaching the windshield at the center, then wrap one side around and

cement it down. When it is dry, do the other side. It is better not to punch pinholes in the edges; hold the plastic down by hand while it dries, but take care to avoid making gluey fingerprints on the windows.

Sand the whole ship again, if necessary, and apply a third coat of dope. If this coat does not eliminate the dull finish, although the structure is well covered and of an even color, don't spray on any more dope. Instead, get a half pint or so of the thinned-out dope from the spray gun, and using your wide brush, brush on a final coat. It will flow out without brush marks, and give a beautiful gloss.

Some scale and show model builders go on from this point to add any number of coats of dope, buffing each one with wet silicon-carbide sandpaper before adding the next. While it is true that a thick coating of paint can be built up in this manner, it is not necessary if you have a well-built, thoroughly sanded, filled surface to start with. If you are dissatisfied with the appearance of your job after three coats, you may wish to wet-sand it and apply another coat. This is a matter of taste and technique; a perfect finish can be obtained in three to four coats.

Rubbing the final coat out with Duco No. 7 cleaner will bring out a high gloss, and a hard paste wax can be added (after all trim is applied) to give a mirror finish; but none of this is worth while unless you have laid the groundwork properly in your sanding and filling; the higher the polish, the more obvious the imperfections.

If you brush-paint the model, apply the dope in thin coats, building up the color and sanding between coats. Don't brush over sticky areas, and don't try to cover in one coat; there is no dope made that will do it. If you have used a dope that is not resistant to your fuel (and you had better make a careful test, soaking a doped stick of balsa in the fuel for half an hour), finish by applying a good coating of clear fuelproofer, first testing to be sure it won't melt your dope. If you mix your own diesel fuel without high-potency additives, ordinary dope will be OK; but test it first.

With the base color applied, and the model checked over for any last spots requiring filling, sanding or touching up, you are ready for the trim color. If the trim is to be applied to flat or simply curved surfaces, perhaps you can use sheet decal color, cut to the correct outline and transferred. Usually, however, it is necessary to paint the colors on.

If you are brush-painting, use carbon paper or templates to transfer the trim outlines to the model. Use a soft pencil for marking on the balsa, and take care not to engrave the lines or poke through the paper. If you have a ruling pen, you can draw your straight lines with this, using a thin dope mixture. It is a good idea to warm up first on a piece of scrap wood or an old model.

For curved lines, and any lines you don't rule, use a small soft brush and paint in the outlines first, exercising the greatest care. The rest is easy, if you have a good outline in place first. If you accidentally run over the line, don't attempt to fudge it back in; quickly wipe the wet dope away with a fingertip, scraping it toward the center of the area to be painted so as not to spread the error. Then touch up if necessary with the base color and try again.

With the outline done, fill the rest in using your larger brush where practical for a smoother job. If two coats are necessary, be careful when working close to the edge of the colored areas; don't mess up that nice outline now!

For spraying, the areas to be trimmed must be outlined with masking tape, and the rest of the model carefully covered. Newspapers make good masking material; this should be taped down under the outer edge of the same strips that outline the areas to be painted, both for economy in tape and to avoid excessive sticking of tape to the model, which could cause complications in the form of torn covering and transferred adhesive. Don't begrudge the time it takes to mask carefully; the painting takes only a few moments after the masking is in place.

If your trim areas have curving outlines, make a one-piece mask for each curve and apply it as a unit. Using tracing paper, trace the outline from the plan, making one pattern for each side. Mark the location of underlying structure on the pattern to simplify alignment of the mask on the model. Since the lines can be seen equally well from either side of the paper, both patterns can be traced directly, and the tracing paper simply turned over to reverse the curve. Next, lay strips of tape on the paper pattern, covering the lines, and leaving at least a half inch or so of tape extending into the area which will not receive paint. Then cut along the line with a pair of scissors, and throw away the portion of the paper which represents the area to be painted. Carefully strip the tracing paper from the other portion, and apply the resultant tape outline to the surface to be painted, aligning it carefully. Straight lines connecting such curves can be added using straight strips of tape. All edges of the tape should be carefully pressed down to insure a tight fit to the surface. When the entire structure is cocooned with newspaper and only the precise areas to be painted are exposed, it is the work of a few minutes to shoot on a coat orˆtwo of the trim color. Since the surface is already well covered, the finish color will cover easily. Be careful not to let the dope build up thickly along the edge of the tape; it will make an unsightly edge when the tape is removed. When the dope is dry, remove the tape with the greatest care, as it is possible to tear the paper or to lift the color off if you go too fast. As you see the butterfly emerge from the chrysalis of old newspapers and tape, you'll feel amply rewarded for the effort you put into the job.

The snappy appearance of the model can be accented if you have some decals to add now. Engine manufacturers are usually glad to get a little free advertising, and will send you a set of decals representing their power plant on request. Model shops carry a variety of decorative decals, including military insignia, numerals, and mottoes. Paint and glass stores usually carry a line of black and gold letters and numerals in assorted sizes, to dress up your model.

With the decals on, and any remaining fittings and accessories such as wing walks or machine guns in place, you can add a coat of fuelproofer if required, solder the wheels in position, mount the engine, and head for your flying field, prepared to be modest about all that praise you're going to get.

Chapter 7

Getting aloft

The big moment arrives when you emerge from the shelter of your workshop to put theory into practice. To get off to a good start, make it a point to bring along the right equipment and a predetermined testing procedure. For any model more complex than a hand-launched glider or balsa ROG, the first necessity is a good flying box, containing a few well-chosen tools and supplies, so you can make necessary adjustments and minor field repairs without having to retire to the workbench, which is sometimes miles from the flying field.

A metal fishing-tackle box can be easily adapted for the modeler's use, or you can build a simple plywood box, like the one shown in figure 7.1, with room for everything needed. Here are the items you shouldn't be without to be prepared for any kind of flying:

Fuel (diesel or glow, to suit your engine), 1-1/2 volt battery (for glow engines), Battery leads with alligator clips on both ends, Fuel pump, (a hypodermic syringe with 1/16" O.D. needle ground square is good), Extra fuel tubing, three sizes, Spare glow plug with washer, Glow plug wrench, 6-inch adjustable crescent wrench, Long engine-mounting bolts and nuts, Small wood screws (for emergency mounting of engine), Spare engine (or rubber motor) to fit model.

Propellers and reamer if needed to make it fit shaft, Fuel tank for testing or emergency use, Razor blades and/or pocket knife, Slip-joint pliers, Small screwdriver, Sheet lead or strip solder for weights, Fast-drying fuelproof cement, Straight pins, Clear dope - 4 oz. bottle, Brush-flat 1/2", Thinner - 4 oz., Spare needle-valve assembly complete, Hacksaw blade, Rubber bands in several sizes - plenty of them. A lump of modeling clay (wrapped in waxed paper) for weight.

Sandpaper in two grades, Thin aluminum sheet for trim tabs, 1/8-inch plywood for emergency firewall repair, etc. Balsa, a few strips of each thickness, Sheet balsa 3" x 12" in several thicknesses. One sheet of light-weight tissue (in waxed paper envelope) for patching, Spare control lines, Spare handle, Spare wheels to fit model, Spool of fine copper wire, Small package of tissues or soft cloth, 1/16" and 1/8" drill bits - use as augers to make emergency mounting holes.

Some modelers carry more than this - but these items will cover most field emergencies. Adapt the list to fit your situation; if you use only glow engines, diesel fuel is unnecessary - except to lend to a pal in need. The diesel flyer won't need batteries, and a rubber-power fan can get along without fuel - but he needs a spare rubber motor. Get duplicate tools and equipment for your flying box, rather than use your regular workshop equipment, so you won't have the job of making up the kit each time you go out to the flying field.

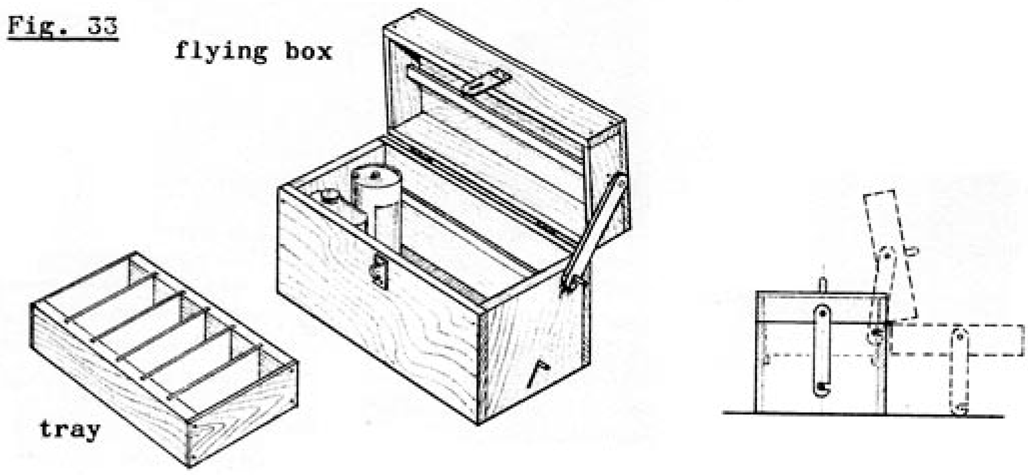


Figure 7.1: Flying box.

The next consideration is a place to fly. This would be first, but for the knowledge that a modeler armed with a ship that's ready to fly will inevitably find a place to fly it. If you live in a small city or town, or in a rural area, this may seem an unimportant consideration. The big-city dweller may find it quite a problem - but it can be solved. If you fly only C/L, you won't need a great deal of space, but it will be necessary to have the permission of the owner of the site and an OK on the noise from any near neighbors. To non-modellers, engines make quite a racket. The use of small engines and mufflers helps on this point.

Your C/L site should be at least half again as broad as the diameter of the flight circle; i.e., 60 feet square for 20-foot lines, 210 feet square for 70-foot lines. This will allow room for a few bystanders, and space to maneuver if the lines go slack in a gust. Be sure to warn your audience (you always have an audience) to stand well back, and keep the model above head-level when in flight - lines have been known to break, though rarely both at once.

For free-flight you'll need a generous field, at least several acres in extent, even for modest-sized rubber jobs. If your model stays aloft for just one minute and a light breeze is blowing at ten miles per hour, the ship will drift one-sixth of a mile, even though it flies in a perfect circle. It's ground travel that counts, not air miles. Pick a field without trees, fences, buildings, etc. and try to find one not bordered by steep roofs, TV antennae, or tall trees. If your ship flits past the cleared area, its going to be hard to find in that sort of jungle.

The perfect F/F flying site is an abandoned or little-used airport. Some fields with only one or two scheduled flights per day will allow modelers to use the runways between flights. Once you have gotten permission to use a field, don't abuse the privilege; observe whatever rules or limitations the owner imposes, and see to it that other modelers do the same. A good flying site is too valuable to lose by carelessness.

Once on the field (pick a calm day for testing) with your flying box, run through a pre-flight check. If the model is a free-flight, rubber or engine powered, look at the flying surfaces (wing, tail assembly) to make sure you have no unintentional warps. If you discover a warp, you'll have to correct it before you can fly successfully.' For an all-balsa surface, simple twisting may do the trick. Bend the warped member strongly against

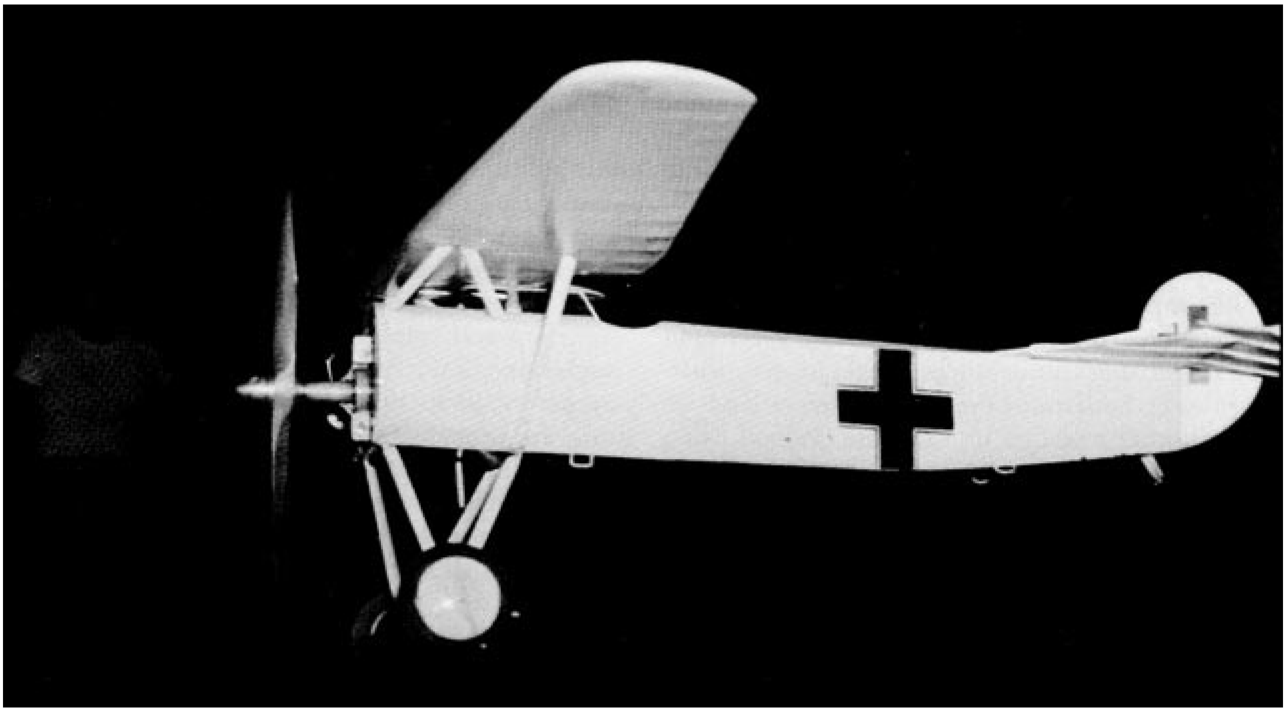


Figure 7.2: Night flying - a C/L scale model.

the direction of warp, and hold it for thirty seconds. If this doesn't work, wet it with water or clear dope and prop it in position until dry.
For a doped tissue-covered wing, brush on thinner and hold a reverse twist until dry. Recheck these surfaces after a flight or two, to be sure the warp hasn't crept back in.
With all surfaces flat, look the model over for alignment; the wing and elevator should be parallel, both from top and front views, with the rudder at right angles and on center. Be sure the engine has the proper thrust angle. You can check side-thrust by setting the propeller horizontally and measuring back from each tip to the rear of the fuselage. Most free-flight ships require down-thrust and offset to the right. For pylon models the latter rule is reversed, because of the prop wash against the pylon, which tends to turn the model to the right.
If no balance point was shown on your plans, assume one at the one-third point of the wing. If the model doesn't assume a level position when supported at this point (or near it), you'd better add some weight to the proper end to start with. The first test glide will show whether it's needed. If you have removable wings and tail, be sure they're adequately held down. It's better to use short rubber bands stretched well out, than longer ones with less tension.
For test glides, remove the propeller and substitute an equal weight; props tend to break easily on nose-overs, dives, etc., which are to be expected at first. Gliding over tall grass is a good way to minimize this kind of damage. Cover all engine openings with masking tape to keep dirt out. Aim the model into the wind, slightly down to avoid starting off in a stall position, and toss the model lightly forward toward a spot on the ground about twenty feet away. The idea is to give the ship flying speed and the proper flight angle; it may help you to trot into the wind with the model until you feel it beginning to lift, then let it slide forward. Throw it as you would a light spear - not a baseball.
If the model is properly trimmed fore and aft, it will continue at the angle at which you started it off, flattening out as it nears touch-down (Fig. 7.3). If the model bores

steadily downward and smacks the ground head first, it's nose-heavy - or else you threw it too weakly to give it flying speed. You can overdo it, too. By hurling a nose-heavy model at high speed you can make it whistle along in a flat glide, until drag slows it down. But we're assuming you've done your homework and are gliding the model properly. Put an incidence block under the leading edge of the wing, or the trailing edge of the elevator to correct nose heaviness (Fig. 7.4). This is where the balsa strips in your flying box came in handy. Start off with a thin strip and increase as needed.

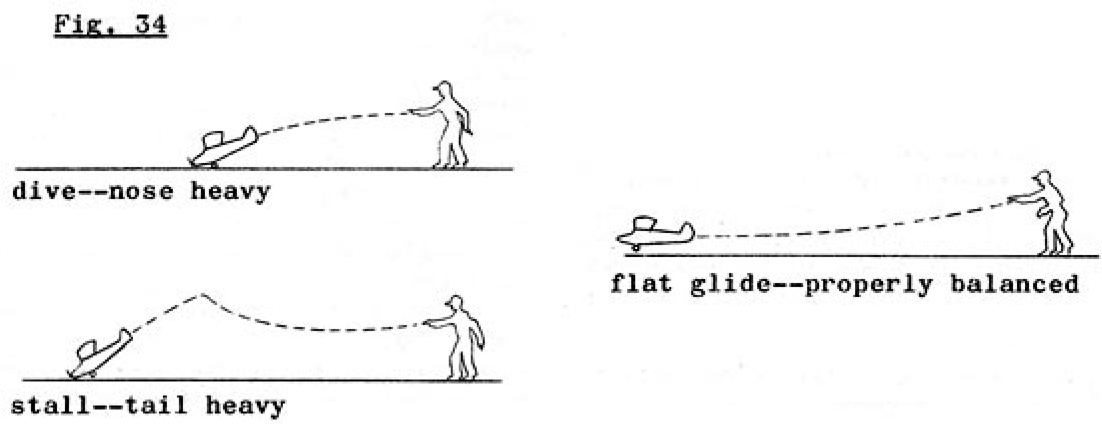


Figure 7.3: Trimming

The point at which many beginners become confused is with a stall in the test glide, because, although a stall results from tail heaviness, the model will still hit nose first. But the condition is easy to distinguish from nose heaviness. If the model dips in its glide, starting out flat or even climbing a bit - then dropping its nose and descending suddenly - that's a stall. The heavy tail causes the nose to move up, putting the model in a mushy attitude, with wings and elevator at an angle to the direction of flight. This extra drag slows the ship below flying speed. The flying surfaces become no better than dead weights, the weight of the nose asserts itself, and down toward the earth the plane goes - bang!

A stall is cured by placing an incidence block under the trailing edge of the wing or the leading edge of the elevator. Be very careful not to set up a negative angle between the wing and elevator, with the leading edge of the wing relatively lower than that of the elevator (Fig. 7.4); under power this will cause a spectacular power dive.

If you need more correction of trim than you can get with a reasonable amount of added incidence, start adding weight to the appropriate end of the model. Clay packs easily into any space available, and bits of lead can be embedded in it as needed. Once the balance is established, cement some balsa over the ballast to hold it in position.

After three or four glides and some juggling of incidence and weight, you will have arrived at a satisfactory initial trim. If any marked turning tendency has shown up, correct it by offsetting the rudder tab slightly away from the direction of turn. If this isn't enough, set the wing at a slight angle, as viewed from above, with the tip toward which the model has been turning slightly forward (Fig. 7.5). An alternate method is to block up one side of the elevator; this will cause the model to turn toward the high tip (see the Adjustment Check List at the end of the chapter).

Now comes the moment you've been waiting for - the first powered flight. Whether your ship is powered by rubber or an engine, all your power testing and preparation should have been done at home before coming out to fly. You'll have plenty to occupy you with adjusting the ship without also having to tinker with a cranky engine or make up a rubber motor. For your first tests with a rubber job, a hundred or so turns without stretching out the motor will do. If you use a glow engine, run it as rich (needle valve open) as possible with steady running. A diesel can be throttled back by slacking off the compression. Position the prop on the shaft so that it will rest horizontally as it begins to come up against compression. Put a little fuel in the tank, start up and launch the model just as for a test glide. This low-power flight will give you a much better opportunity to observe your model's flight habits. Here is where a turn is likely to show up. If it is not too pronounced, leave the rudder setting as is until you see how it looks under full power. Correct any power stalling or diving by adjusting the angle of thrust of the engine. In most cases, the trouble if any will be stalling, and a washer under the proper engine mounting bolts (or for rubber, a wedge under the thrust button) will correct the situation.

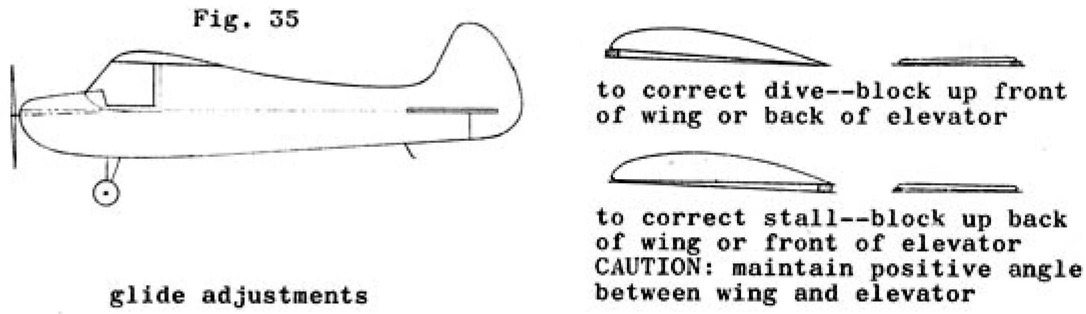


Figure 7.4: Glide adjustments.

With only a few turns, a rubber model will probably land with the prop still turning, so you won't be able to study the glide until you try more power. An engine-powered job will stay in the air as long as the motor turns, and give you a chance to watch a longer glide down. Make any further glide-trim adjustments now to achieve a smooth flat glide with a gentle turn. Be careful about adding left turn at this point, since with engine torque it may add up to a spiral dive under high power. A right turn is preferable, canceling out torque effects. Some turn is not only inevitable, it is highly desirable to keep the model in the vicinity of the modeler. Lost models and long chases are not generally the result of a straight fly-away, but of wind, which causes the circular flight path to move away in toto. That's why you shouldn't try to fly in a wind of more than about 10 mph. The wind also tends to buffet the model about and makes for hard landings. To combat wind drift, fly from the upwind end of the field, and launch the model crosswind, slightly into the wind; so that its natural turn will bring it into the wind. Of course, it will continue around and make a dash downwind before coming around into the wind again, but it will have gained its altitude and used up some motor run bucking the breeze, and won't be so likely to be a quarter of a mile downwind when power cuts.

Now you can hazard a flight under full power. Use only enough fuel for a five-to-ten-second motor run, and be certain there is no unexpended fuel from a previous motor run in the tank. An engine running a little off proper setting may quit early several flights in a row, then perversely burn it all on the next flight and end up in the next county. Even a low-powered sport model gets upstairs fast under full power, and it's amazing how quickly your model can dwindle away to a mere speck in the sky. Any time your model seems to be headed away from home don't hesitate to take off in pursuit in a hurry. Keep an eye on the model, and if it disappears from view behind an obstruction, stop and study the situation; fix in mind the position and direction of the ship as last seen. Then head for the spot where you calculate it should be, and start hunting. Most contest-type models use a de-thermalizer to bring the ship down abruptly but safely after a specified time. Commonest is the pop-up elevator, released by the burning of a timer fuse.

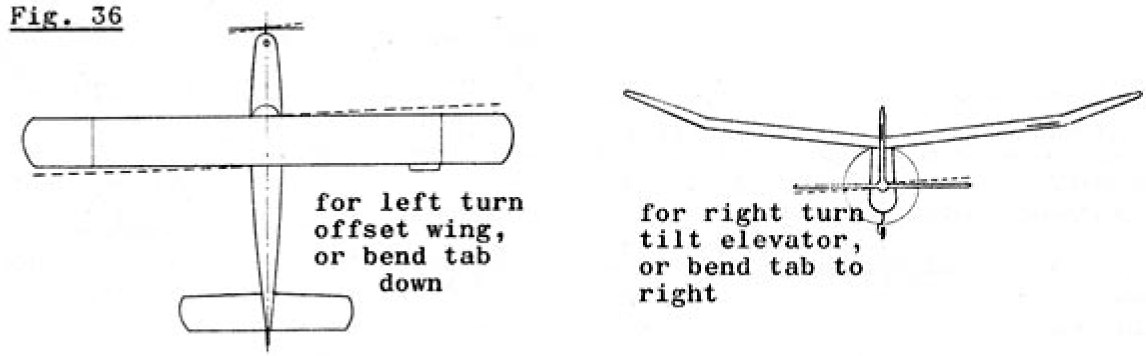


Figure 7.5: Turning.

The chief risk on the first full-power flight is a spiral dive, or loops ending in a nose-up power cut-off and a subsequent failure to pull out. The spiral dive is sometimes the result of excessive torque (assuming your glide is correct), and you can remedy this by using a lower-pitch prop and by offsetting the engine farther. More down-thrust will cure the loops. If the loops are straight-away, a little turn will convert a loop into a nice climbing spiral.

Use the tissue or soft rag in your flying box to wipe the model carefully after a motor run. Even fuelproof finishes can soften up some if fuel is allowed to remain on them indefinitely. By taking a moment to clean the ship, you'll save a lot of time later in scraping off sticky paint and embedded dirt. Recheck all settings and incidence blocks after each flight, and shake the tank dry, just in case. Be careful about preflighting the ship, and you'll save most of your crack-ups and flyaways.

Control-line test procedures are simpler, since you rely much less heavily on built-in flight patterns. Start by laying out and checking your lines. Use lines that are heavy enough, but don't load the ship down with oversized ones.

For small C/L jobs No. 30 linen thread is heavy enough. Single-strand steel wire, available at hobby shops, should be used for the bigger models. Stranded steel cable is needed for the biggest monsters, and for high-powered speed ships. Don't let steel lines get kinked, and try to keep spectators from walking on your lines; something they seem to love to do, claiming they can't see them when they're laid out in the grass. The audience also needs to be discouraged from stepping on models, kicking over fuel cans, and

testing fabric ("Ooh, I didn't know it was only paper!"). Next, check the balance of the model. Most C/L jobs balance at about the leading edge of the wing. This nose-heavy condition gives the pilot better control; you don't want your tethered job to start floating like a F/F while the lines hang slack.
Usually both an offset rudder and a weighted outer wing tip are used to keep the model out on the lines. Engine offset helps, too. It is customary to fly counterclockwise, but there is no reason not to install your controls so as to fly clockwise if you prefer - and you'll have torque helping to hold the model out. After a few flights, when you have the feel of the model, you may want to reduce your rudder and engine offset to increase efficiency.
If you're a novice at flying on lines, try to get an old hand to test-hop the ship for you. When he's satisfied all is well, you try it.
If possible, a C/L ship should be allowed to take off under its own power so as to enable the flyer to get the feel of the controls and lift the ship at will. For the initial flight, it's wise to set the control linkage for minimum control surface movement - particularly down - since the chief danger is overcontrol with an unfamiliar ship. After a few practice flights, set them as sensitive as you want them, but don't forget you've done so. Make a last-minute, but very important, check of your controls to be sure up is up, have your crew chief start the engine (with a modest fuel supply - you may get tired), and let her go. Hold the controls neutral until the ship is skimming along ready to rise. If it's sluggish about getting up on the main gear, try just a little down elevator to get the tail up - then neutral again as it picks up speed. When you're ready, and not before, give a touch of up, and back to neutral. (Be prepared for the model to take off before you give it any control, by the way; it may not wait for that touch of up.)
Once in the air and flying straight and level, cautiously try a delicate maneuver or two. Of course, if your ship is a bit tail heavy, or overly responsive, you may already have your hands full trying to keep it flying level; in this case, omit the maneuvers.
C/L models can't fly or be blown away, but a high wind can cause the ship to come in, on the upwind leg of the circle, so be prepared for this when you try flying in breezy weather. If you back-pedal in a hurry, you can keep the lines taut. This is where that extra room counts.
When the engine begins to change tone preliminary to stopping, bring the model down about waist high, and hold it in level flight. Let it glide in naturally, with a little up only if obviously needed. A big stall at this point can wash out the model. Give the ship full up as soon as it touches the ground firmly, to avoid a nose-over. As you become more practiced, you'll find you can whip the model around after the engine cuts and set it down at any point you wish.
The average sport model is capable of doing a wide loop; trainers usually are not, unless a bigger power-plant is installed. A true stunt model can do consecutive tight loops, and almost anything else you can think of. Work your way into these stunts carefully, and don't try maneuvers that are beyond the model on the lines. It's a lot more fun to watch your ship perform properly, doing what it was designed to do, than to see it laboring to do the impossible. Sport models don't climb like contest jobs; C/L trainers aren't noted for stunting. The real thrill of flying your ship is in obtaining correct, controlled flight - when you make that assembly of inanimate parts behave almost as though it had life and intelligence of its own.
Even if you're a solitary type, you'll find there's more pleasure in flying with other modelers. They're a congenial bunch for the best of reasons; a genuine common interest in

the sport. It's always interesting to see what the other guy has built, to see other models and engines in action, to learn new angles and tricks to help your own flying. Then, too, it's nice to have a little help with a cranky engine, or getting a C/L job aloft, or chasing a runaway. Don't be stingy with your own time and help, either. You can even carry extras in your flying box, including some items you don't use yourself, just in case somebody needs them. He'll pay you back when you're about to be grounded for want of a mounting bolt or a spare prop some day. Like flyers in the early days of aviation, modelers stick together.

If there's a club in your vicinity, join it. Clubs frequently have good flying sites, quantity purchase arrangements, and other advantages to offer, in addition to the company of other modelers. If the city fathers (or cranky citizens) object to flying in the park or on a vacant lot, a club can present a better case for a change of heart than an individual. Often the local hobby shop or department is the sponsor of a club. If yours isn't, suggest it. The more the merrier!

Businesses with large parking lots, like supermarkets, can often be persuaded of the public relations value of letting the club use the paved area for C/L flying on Sundays. Don't be bashful; scout around and get things lined up for more flying fun.

The Society of Model Aeronautical Engineers is the national organisation for aeromodelling in Britain. It has an average annual membership of 4,000 active aero-modellers and conducts a very active contest programme which runs from March to October each year. About 150 clubs are affiliated to the SMAE and this collective representation is responsible for the facility of using Royal Air Force airfields. For details of membership, contact the Secretary (a voluntary post, there is no permanent paid official) of the SMAE, c/o Royal Aero Club, 116 Pall Mall, London, SW1Y 5EB. A feature of SMAE activity is the regular National Championships held over each Spring Bank Holiday (Whitsun).

While some model builders think in terms of free-flight endurance competition as the only real measure of a model, the great majority of modelers fly for the pleasure of making something with their hands, tinkering with engines, watching their jobs buzz around, and associating with other modelers. While staying up ten minutes on a fifteen-second motor run is an interesting trick, it depends completely on the presence of thermals; the best model will glide down in a minute or so without a rising air current.

There are other feats a model can perform that are at least as difficult - realistic take-offs, flying a predetermined pattern, spot landings, free-flight speed - the possibilities are endless. Try out all the ideas you can think of, and if bad luck strikes and you clobber in - it'll happen now and then - head back to the old drawing board philosophically; that's part of the challenge and the sport of modeling.

ADJUSTMENT CHECK LIST

Glide:

Model dives -

- increase positive incidence in wing
- increase negative incidence in tail
- add weight to tail
- lighten nose Model stalls -
- decrease positive incidence in wing

- decrease negative incidence in tail
- add weight to nose
- lighten tail
- increase turn

Model wavers and falls off on one wing -

- check for warps in wing or elevator
- increase rudder area Model turns too sharply -
- offset rudder in opposite direction
- warp up trailing edge of wing on side to which turns
- offset wing (from top view) - tip opposite turn to rear
- tilt elevator - raise side opposite turn Model yaws or flips over -
- lower center of gravity
- increase rudder area
- increase dihedral

Power:
Model dives -

- raise thrust angle
- increase positive incidence in wing and add weight to nose

Model stalls -

- increase down-thrust
- increase engine offset for more turn

Model spiral dives -

- reduce engine offset
- use lower-pitch prop
- add rudder area below fuselage Model turns too sharply -
- reduce engine offset and increase down-thrust if necessary
- use lower-pitch prop

Chapter 8

Rebuilding a wreck

The old ship was a dandy, but one day a combination of high wind, a bad launch, and a premature power cutoff brought her in on the concrete runway like a ton of bricks. Pieces flew for fifty feet along the pavement, and when the dust cleared, the rear half of the fuselage was here, part of the front end there, the engine lay twenty feet away minus prop blades, the wing was folded in mid-panel, and the rudder was knocked clean off the elevator. It was a total washout.

At this point the philosophical modeler might sigh regretfully, gather up the big pieces just for the sake of tidying up, salvage the wheels and the engine, and start planning a new model.

The modeler with a few rebuilding tricks up his sleeve would have the same ship back in the air within a couple of hours. In the shattered fragments of a model plane, there is a big investment in your time. Most of this investment can be recovered by careful and systematic salvage.

The first thing to do is examine the remains before the helpful small boys in the area have descended on them and borne away trophies. Often by quick action you can prevent further damage. Perhaps a component is cracked but still hanging together; don't let it get pulled completely apart. Shattered balsa is easy to cement if the fibers are still in place, but it's hard to fit together two pieces that have been pulled completely apart cross-grain. If the ship is engine-powered, mop up spilled fuel and oil in a hurry; you can't cement oil-soaked balsa. And gather up every tiny fragment; you can fit them back together like a jigsaw puzzle, and they'll be stronger than ever.

With first aid administered, study the situation to decide what should be cut completely free and what should be pulled back into line and cemented. Using a sharp razor blade, cut apart the portions which clearly need to be rejoined by new material. Shattered structural members such as wing spars and leading edges and fuselage longerons can't merely be butt-joined; they will have to be spliced at an angle and reinforced, as shown in Fig. 8.1, so cut them clear. When the various major pieces have been separated, look over the projecting ends and start trimming back to solid structure. Cut away ripped paper, panel by panel. Don't strip all the covering off a wing just because part of it is damaged.

When removing covering, cut along the edge where the fabric was originally cemented[FFFD?]don't try to peel it off. New covering can be laid over the old which is still glued to the frame, but stripping will leave patches behind and make for a very bumpy job (Fig. 8.2).

With all major segments trimmed back and the trimmed-off pieces carefully laid aside for use as patterns, look over the minor fragments for usable parts. Often bits of plank-

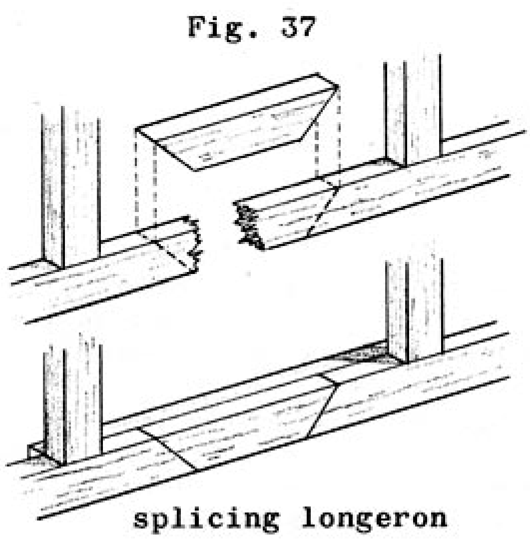


Figure 8.1: Splicing longeron.

ing, odd spacers, and chunks of cowling or bulkhead can be fitted perfectly back into their original positions. Figure out where each piece goes, and reassemble any small parts or sub-assemblies you can. If pieces are connected only by a fragment of covering tissue, keep the paper intact until the wood parts are back in place. If the parts can be recemented to each other, join them up and then pull the paper off.

Next, clean up any remaining foreign matter. Check inside for bits of debris which may be rattling around loose, and subject each part to a little twisting and flexing to locate any loosened joints or slightly cracked members. When you find a bad spot, don't hesitate to remove a panel of covering to get at it. Use extra-fast-drying cement for field repairs, and reinforce joints with pieces of hard balsa, plywood, or celluloid. Whenever possible, do your opening up of fabric on the bottom of a wing or fuselage to keep patches out of sight. Remember, your rebuilt job can look just as good as ever, if you take care with the restoration job. Bent L.G. struts should be straightened now, before you start reassembly. Try to hold the mounting bulkhead while bending the wire back into shape.

With all parts clean and sound, you're ready to rejoin the separated parts. Set them up in proper relation to each other, with any parts originally in contact cemented back together. Where a gap exists because of destruction of a length of longeron or trimming away of oil-soaked wood, cut a new piece to exact size and fit it in place. If the piece was originally a strip of balsa bent to a curve, substitute a curve cut from sheet balsa to avoid stresses and tricky assembly. Check the rejoined structure as the cement sets to be sure all is in line. While this portion is setting up, go to work on any other major reassembly needed.

With the parts precariously but correctly joined by the main structural members and the cement hardened, cement sturdy reinforcing pieces along the new joints; then start fitting displaced ribs, spacers, bulkheads, etc., back in. When all surviving or replaced framework is back in place, you may still have gaps where destruction was so complete that not even a pattern remains, or where souvenir hunters helped themselves. Here you can improvise, unless you were clever enough to pack a copy of the plans in your flying box. Of course, if you've transferred the scene of your repairs back to your workbench,

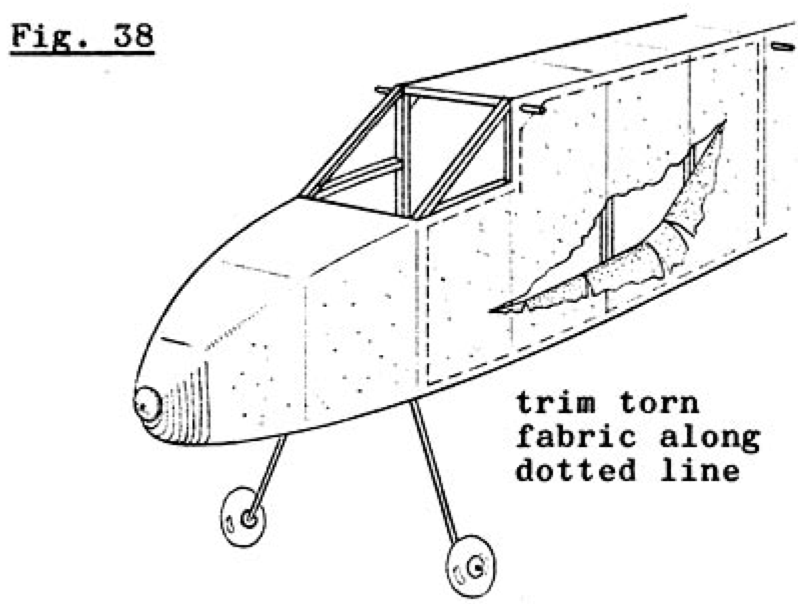


Figure 8.2: Torn fabric

you'll have the plan handy, because you never throw plans away - do you?
Use sheet and strip balsa to build the missing section back as it was, or as you remember it. A damaged or oil-soaked firewall should always be replaced, even if you have the pieces; it's got to be strong. Epoxy glue is recommended for use on heavy stress-bearing members such as L.G. mountings. Usually there will be very little that you'll have to do from memory. In a crack-up, a model comes apart, it doesn't dissolve.
If you're setting up a wing platform such as a cabin roof or pylon, take care to place it properly in line, and with the correct angle for wing incidence. If a windshield has been shattered, don't rip it all off; cut away the broken panel, just as for fabric, and replace it. If it isn't badly split, you can weld up the break by running a line of cement along the crack and holding the plastic in position until it sets. It will be as strong as new, and the scar will prove the ship is an old veteran.
Splits in paper can be repaired almost invisibly in the same way; run a line of cement along the break and spread it out with a fingertip. As it dries, it will draw the paper tightly together for a very neat job. Holes punched in the covering can be fixed by trimming out a rectangle around the puncture and fitting a slightly larger rectangle of tissue over it. Use clear dope around the edges of the hole as an adhesive; it will soften the dope on the covering and hold the new patch down nicely. Wet and clear-dope the patch when set.
Some portions of the model will require more cleaning than others. The nose particularly is likely to be coated with an accumulation of oil, softened dope, and dirt. Scrape the firewall or engine bearers down to clean wood, and cut away any soaked wood, even if it is still holding together. Now is the time to get rid of weak spots, while you can get at them. Sometimes a crack-up will reveal a weakness in some portion of a structure. Take this opportunity to reinforce such places, so that the ship will stand up to the next hard landing. Look for telltale splits in covering which indicate flexing of the framework under impact. You may find a few more parted joints this way, too. A good

hard smack can cause fuselage longerons to bow several inches out of line, only to pop back and look innocent, except for split paper. Catch all these weak spots and make them into strong ones.

With the frame reassembled, get out the sanding block and go to work to fade the patches into the old work. Use scrap balsa wherever you need to build out missing or crushed balsa. To restore a dented leading edge or cowl, cut away a rectangular or wedge-shaped chunk, fit in a new piece, then shape it, as shown in Fig. 8.3.

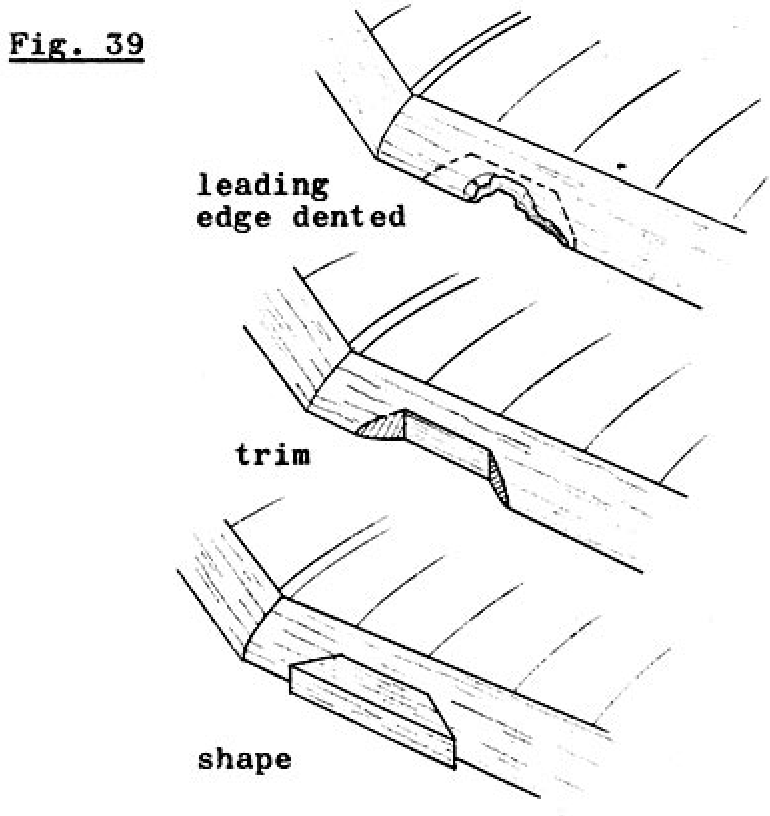


Figure 8.3: Fixing leading edge.

Use clear fuelproofer to protect the new wood around an engine. Then re-cover, lapping the new paper a uniform 1/8 or 1/4 inch over the old for neatness. Wet and dope the new paper and then touch up with color dope[FFFD?]and your ship is as good as new. Reinstall the engine, wheels, or whatever you may have removed during repairs, and check everything over for alignment. If it looks right (and it will, if you've worked carefully), start in with a new testing routine; don't assume that the model will fly just as it used to, it probably won't. It will be necessary to redetermine the proper trim, just as though you had never flown the ship before.

Some of these patching techniques can be very useful in making minor repairs, too, of course. Don't let ripped paper or dented flying surfaces go along unattended; they may cause a fatal crack-up and will definitely alter the trim of the model and its flight characteristics. It takes only a moment to slap a patch over a hole, stitch up a rip with cement, or fit a block into a nick, and it can save a major job.

Sometimes a little preventive maintenance is in order. Even though you wipe the model clean after each flight, fuel and grime accumulate around the engine compartment, landing gear mountings sometimes begin to work loose, rubber motors develop broken strands, and old covering gets brittle and weak. Take time to look the ship over and spruce things up before they're too far gone.

A model which has been flown often can get very dirty, with stains ground into the covering by oily fingers. A light application of soap and water with a soft cloth will remove a lot of this unsightly dirt. Cleanser is more drastic, and will take off anything that isn't actually embedded in the dope. For this kind of grime, a brisk rub with a cloth soaked in thinner will do the trick.

If you fly over sandy soil, your engine should be removed from the ship and washed in gasoline, kerosene, or thinner after each day's flights. Disassemble the motor carefully as far as necessary to allow the fluid to flow through the crankcase, carburetor, etc. Put the parts-in a pint jar and swish the whole works around. Wipe everything off after rinsing and put it back together, preferably the way it was before you started operating. Watch the gaskets, and get them all back in. A model engine is a very simple apparatus, and if you note what you do as you take it apart, you won't have any difficulty.

Most modelers like to have more than one model around, both for variety and in case of accident. The best way to achieve this is to care for the models you have, and don't let a little thing like splattering all over the pavement discourage you. Just grab glue and a basket and start rounding up the remains.

Chapter 9

Retract that gear!

The job parked on the runway is a scale WW II twin-engined bomber, with full war paint. The two glow engines, swinging three-bladed black props with yellow tips, are started up and tuned to a smooth symphonic howl. The pilot is on the handle, the fuel pump and power leads are detached, and the crew chief, on signal, lets her roll. The ship gathers speed, as the flyer holds her on the ground with a bit of down elevator, then eases her into the air with just a touch of up.

Engines thrumming, flaps down, she climbs quickly to ten feet, wheels still spinning; then the pilot plucks his third line. The flaps at once fade back into the wing, and the ship steps out faster, dropping a foot or two, then leveling out. The nose wheel swings slowly back, then up, the well cover closing over it, and the main gear folds deliberately inward to disappear as the covers seat in the wing. Landing lights flick off, and the flyer drops the model to two feet for a strafing run, then zooms up in a fast wing-over. The ship is smooth and responsive, the hot engines handling the heavy craft with ease.

Level again at ten feet, the flyer hits the extra line once more. Landing lights come on and the wells open for the gear as it swings down and locks. The pilot is ready as the flaps move out into the air stream, and he holds the ship down as it tries to balloon. The ship slows, dropping as the flyer brings her down for a touch-and-go landing. Under full power and flaps, the ship fights the ground, barely touches, then bounces back up to three feet. Once again the gear folds and the ship blasts around the circle at high speed.

Now the outboard engine, with a slightly smaller tank, fades and cuts. The model loses speed but continues to hold altitude smoothly. With about a minute's fuel remaining, the pilot hits the third line to drop flaps, ,and crank down the gear, ready for a power-on landing. The ship rides easily on one prop, easing toward the ground. Smooth as satin she oils onto the strip, kicking up a puff of dust, rolling fast for half a circle until the other engine cuts, then coasting to a stop, a little dust on her tires, oil streaks blown back along the nacelles, mission completed.

Sounds like fun, you say, but too complicated for you to tackle? Not at all! If you can build a control-line model, you can build the retractable landing-gear system you need to make your model complete. You don't need special tools or fancy equipment and you have a variety of types of systems to choose from.

Retractable gears are useful not only for scale and semi-scale models, but are a real aid to speed and maneuverability in a sport or speed job. They can be used on radio-control models with really beautiful results, and some types are adaptable to free flight.

A practical retracting landing gear must meet a few basic requirements. It has to be

rugged enough to withstand the shock of repeated landings and take-offs - some of them rough. A system depending on precise adjustment and delicate handling is useless in a model intended for regular flying.
The system must be light enough so that its weight does not offset its advantages. A model which can barely struggle into the air under its load of equipment makes a dull project, and is difficult to handle.
In addition, the installation must be capable of being built by the average modeler from common materials, using ordinary hand tools. We'll take a look at a variety of retractable landing gear systems which meet these criteria.

It takes more than a little blizzard to keep the R/C men at home Dick Stouffer photo

Figure 9.1: It takes more than a little blizzard to keep the R/C men at home. It takes more than a little blizzard to keep the R/C men at home.

Retracting gear range in complexity from simple one-wheelers, which are held in the down position by the weight of the model and retract on take-off, to scale tricycle systems capable of multiple up-and-down operation during a flight, often tying in with operable landing flaps and lights. While these types differ greatly in detail, there are a number of factors common to all. If you've never experimented with such mechanisms, you should start by constructing some of the simpler gears before attempting the more complex. Since each system is a custom installation, tailored to the requirements of a specific model, it is advisable to gain familiarity with the various principles, gadgets, and materials available, so you can adapt what you need to the desired use.
The simplest retracting gear, usually used on contest-type free-flight models, consists of a single leg with one wheel, used to permit take-off. The wheel retracts by a spring or rubber band as the ship leaves the ground, and remains up, reducing air resistance (drag) and raising the centers of gravity and frontal area. The retracted wheel may remain partly exposed to aid in landing. The basic requirement here is a smooth-working hinge and an easily adjustable spring tension. Too much tension will cause the gear to snap up prematurely, dropping the model on the ground, while too little will leave the

gear hanging like a broken leg. Several simple hinging arrangements are shown in Fig. 9.2.

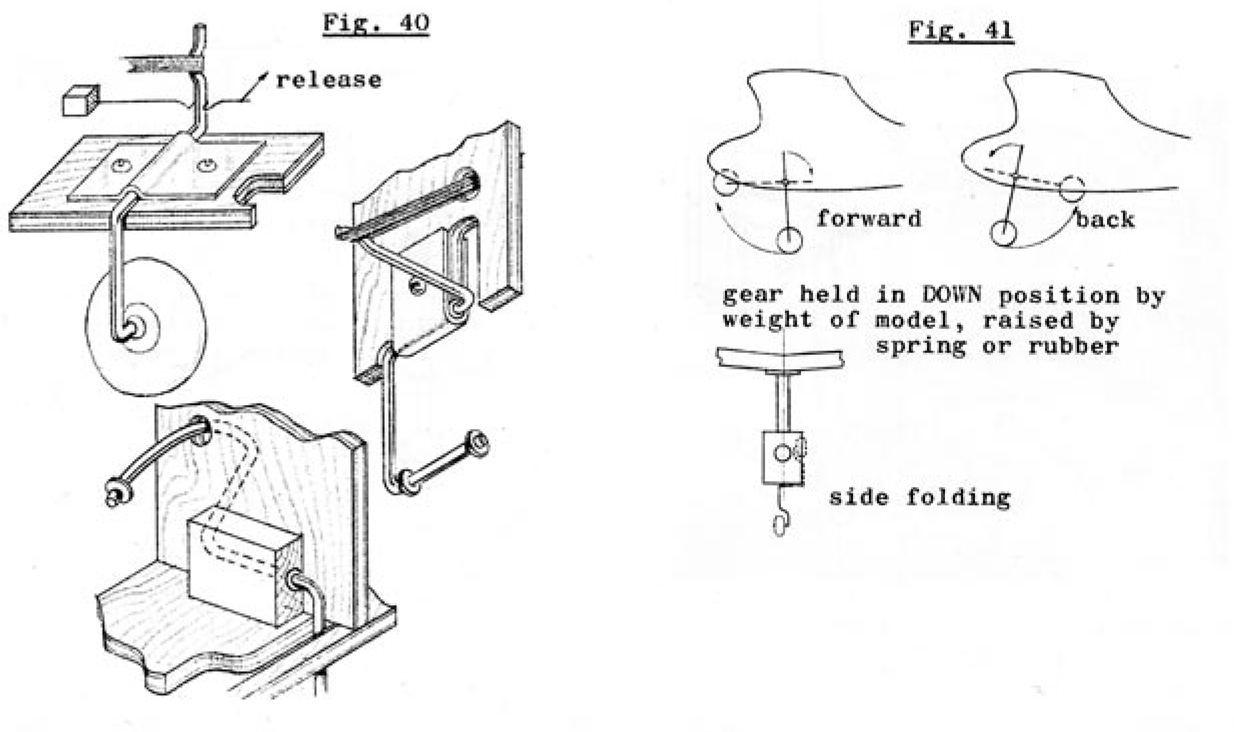


Figure 9.2:

This type gear may be arranged to retract forward, backward, or sideways (Fig. 9.2). The size of the piano wire used for the gear should be great enough to give adequate stiffness without undue weight. The 1/16" wire is sufficient for short-leg gears (under 3 inches) on light half-A models; 3/32" wire will do for longer gears, up to 5 inches, on models spanning up to about 48 inches. Beyond that, 1/8" wire is necessary, and on very heavy jobs the wire should be doubled.

Next comes the "one shot" gear, capable of being both raised and lowered for a one-cycle operation only. Such gears are also spring or rubber operated, and require only a "trip" action for each step of function. It is essential to have a positive lock feature, in both raised and extended positions, and a "fail-safe" arrangement in case of failure to lock up. This gear is ideal for light-weight scale or semi-scale control-line ships, and is very practical for any control-line type.

The gear can be installed so as to be actuated by the full "up" position of the up line, or, in the case of stunt models where extreme range of control is needed, by a third line. No. 30 linen thread is heavy enough for a third line for this and most other model applications.

The gear is raised after take-off by a quick plucking motion of the line, which releases the lock, and permits the spring or rubber to snap the gear up. The momentum of the rising gear drives it against pressure into the up-and-locked position, and the actuating rubber or spring disengages. The next flick of the line opens the lock, permitting the gear to drop of its own weight to the down-and-locked position. If the lock fails to engage on the up motion, the gear merely drops back to the down-and-locked position. The gear must then be "cocked" or loaded for the next flight.

Fig. 9.3 shows a couple of possible arrangements for front-, rear-, or side-folding systems. Sturdy hinges are a must for this or any other gear which must take landing shock, while, of course, smooth operation is essential. Any of the hinges shown in Fig. 9.2 are also suitable for this gear, along with brass-tube bushings for heavier models. Correct adjustment of the locking latch is a must; fortunately this is easily done by bending the wire slightly until proper action is obtained. By simply adjusting dimensions to requirements, this system can be adapted to many scale models.

Fig. 42

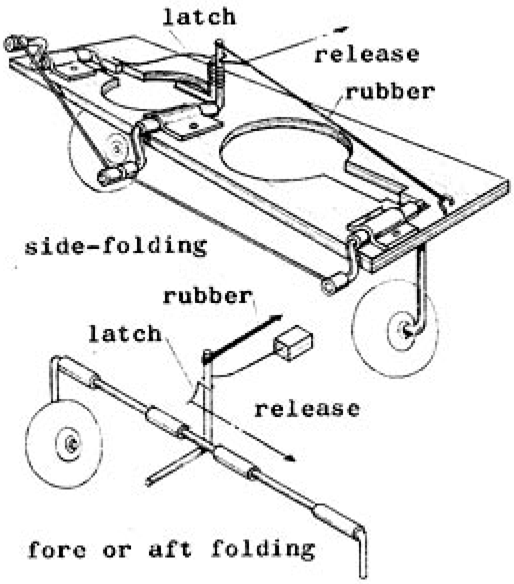


Fig. 43

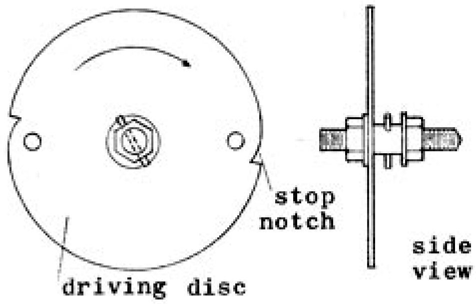


Figure 9.3: Fore and aft folding.

Full-operating, multiple-cycle gears are a big step beyond the one-shot gear, requiring a power source, and a power-driven action for both up and down. Again the positive lock for both up and down is a basic requirement of a practical system; without it, vibration will tend to cause the gear to crank down in flight, and landing shock will drive the extended gear up, damaging the model. Such systems can be built for a simple snap-up, snap-down action, powered directly from a source such as multistrand rubber, or a helical spring. If an electric motor is used, a gear box is necessary to convert high rpm to high torque needed to handle the load. A gear box is also used with the rubber or spring power if realistic slow cycling is wanted.

First, let's consider the linkage and hinging problems of this type of gear. Since almost all power sources produce a rotary action, it is necessary to convert this action into a thrust, either fore-and-aft or in-and-out as required. This is most easily done by using a driving disc, firmly mounted on the take-off shaft of the power source. Mere soldering of this disc is inadequate, since the forces acting in shear tending to cause the disc to slip on the shaft are extremely great. A tight press fit, onto a shaft having a key or flat exactly fitting the hole in the disc, is a good start. There should also be locking nuts tightened down hard against both sides of the disc, and if possible a pin inserted through a sleeve which is an integral part of the disc and the shaft. This is not so formidable as it sounds, since such a disc can easily be turned from brass or steel on a small lathe - or a large clock gear with the edge smoothed can be used (Fig. 9.3).

Assuming a two-wheel gear, folding sideways into the wing, the driving disc should be mounted in the fuselage on the center line of the wing, and in line with the center of the hinge of the landing gear legs. The legs, passing through the hinge, extend upward, then forward, forming the arm which must be linked to the disc. Fig. 44a shows the angle used to give the arm room for action, while Fig. 44b shows the linkage to the disc. In order to use the portion of the arc having the greatest lateral extension, for maximum effectiveness, the arm should be so adjusted that its up and down positions are symmetrical with relation to the vertical, as seen from the front.
With a reversible electric motor, both legs of the gear can be linked directly to the disc; turning one way raises the gear, the other lowers it. With a one-directional power source, however, only one leg can be driven directly by the disc, since two linkages will, of course, cross each other after one revolution, preventing further action. In this case, the second leg must be linked through a "dead man" to the first leg which is driven by the disc. If the two legs with their operating arms are carefully bent to identical dimensions, and the dead man employs equal arms, the two legs will automatically be perfectly synchronized.
If an accidental discrepancy in the length of the operating arms is created, you can compensate by using slightly different lengths of arm on the dead man, or distances from center of linkage holes in the disc in the case of the electric motor-driven system (Fig. 9.4).

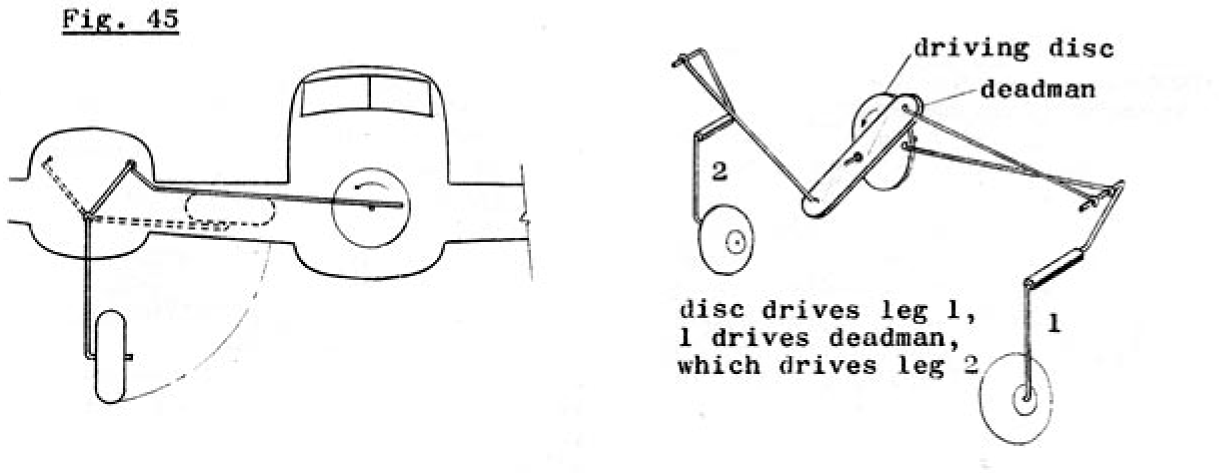


Figure 9.4: disc driven L.G.

The lock arrangement is simply made by filing notches in the edge of the disc into which a lightly spring-loaded lever drops against a high-speed gear as a brake, so that the braking load is not on the driving shaft. With a one-directional power source, the system is activated by pulling the line attached to this lever, which lifts it from the notch and permits the disc to rotate one-half revolution to the opposite setting, the lever riding the edge of the disc, to drop in again when it reaches the other notch. This cycle can be repeated to the extent of the stored power of the spring.
The same method can be adapted to an electric system, the lever being the switch which is closed by pulling the third line and automatically opens when it drops into the notch (Fig. 9.5).
The shaft on which the dead man is mounted can also be used to operate other mechanisms, such as a nose wheel in a tricycle ship, or landing flaps, in perfect co-ordination

with the main gear. There are a number of ways of translating this alternating rotary action to a fore-and-aft movement for nose wheel operation. Simplest perhaps is the use of a pin engaged in a bellcrank with an extended arm, as shown in Fig. 9.5. The pin, riding in a vertical slot in the upturned portion of the arm, causes the bellcrank to rotate in the horizontal plane, applying the push-pull action to the shaft linked to the nose wheel, the operation of which is covered below.

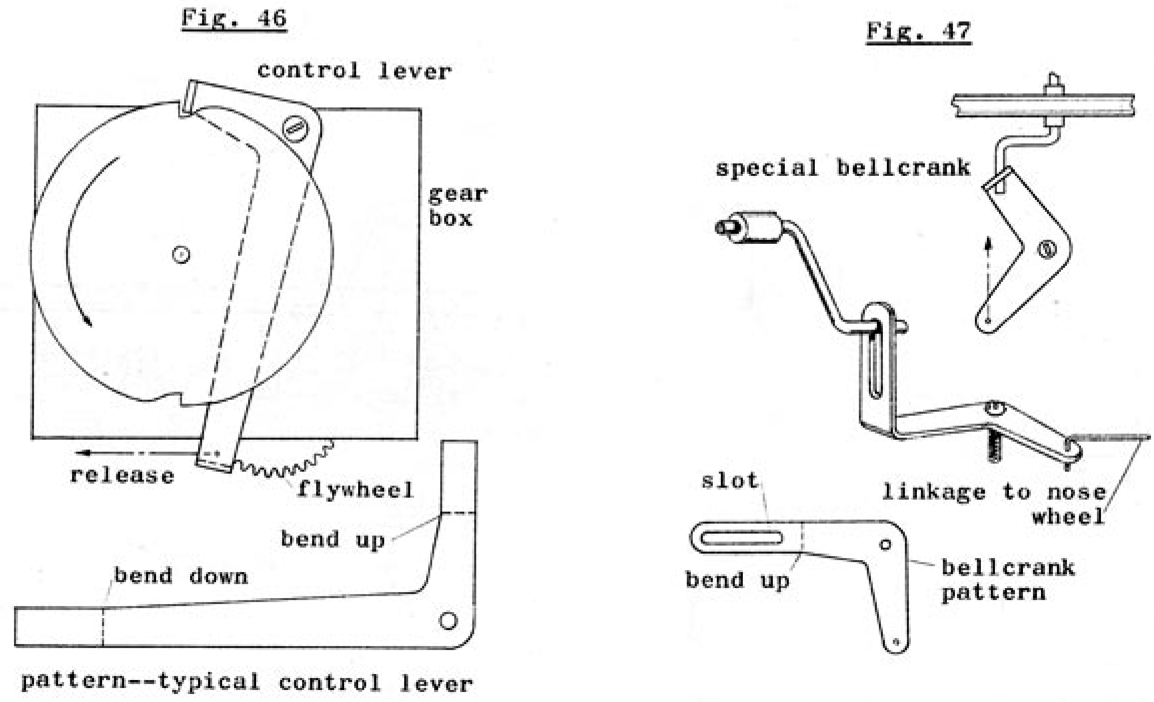


Figure 9.5:

Now that we've covered the operating gear, driven by a disc, let's give some thought to the power source that makes everything move. In actual practice, the power supply is usually decided on first, keeping in mind availability of apparatus, weight-carrying ability of the model, configuration of the airplane, etc. A model carrying batteries for lights might be overloaded by an electric system, unless insulated lines and an outside power source are used. Electric motors are available from hobby shops, while it is usually necessary to operate on an old alarm clock to procure a suitable spring motor. The clock is also an excellent source of gears for the gear box.

Whether an electric motor is used, or a spring motor which you wish to slow down for smooth realistic action, a gear box is a necessity. In the first instance, the purpose of the gear train is to slow the action from perhaps 5,000 rpm to about 10 rpm with a resultant increase in torque from one butterfly power at the motor to a force at the take-off of the gear box which is capable of shearing a heavy solder joint. To construct this gear box, it is necessary to use about four gears, each having about a 5:1 ratio, to achieve an over-all 500:1 ratio. The motor shaft, with a piece of plastic tubing slipped over it, drives a rubber-tired wheel or hard rubber disc, having a small gear on the same shaft (Fig. 9.6). This small gear engages a larger gear having about five times as many teeth as the small one, the teeth of course, being of the same pitch or spacing. Gears removed from a clock come in matched sets, so no difficulty should be encountered in selecting suitable gears. This gear again carries a small gear on the same shaft, driving the next large gear. By counting the teeth on each member of each pair of gears, and dividing the larger total by the smaller, you learn the ratio of the individual gears. Multiplying these ratios together gives the over-all figure.

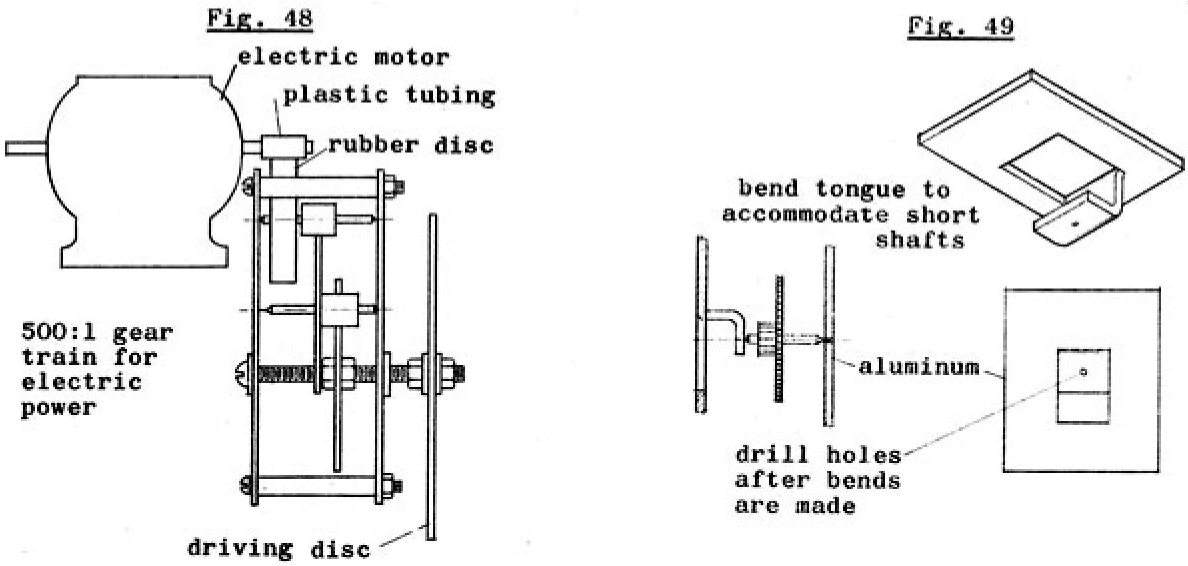


Figure 9.6:

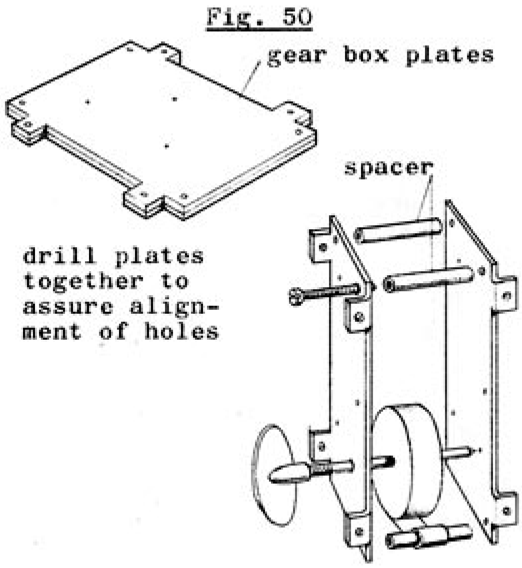
After determining the number of gears you need, to obtain about 10 rpm (from 5 to 15 will do), determine the optimum layout of the gears to give you the clearances you need inside the fuselage for elevator pushrod, structural members, etc. Then, using dividers, measure the center to middle-of-tooth distance of each gear and lay out the gear train on 1/32" to 1/16" aluminum. Arrange the train so that the motor will have room for mounting, and so that the take-off shaft will be on the center line of the wing. Also keep the switch lever in mind, and place the components so that nothing interferes with the actuating arrangement.

Don't forget to include "ears" on the plate for rigid mounting of the box.

The blanks for both plates of the gear box should be cut out and the two drilled while clamped rigidly together, to insure correct alignment of gears. Drill the smallest holes possible to accommodate the needle bearings which most gear shafts have. If you have no "pin" drills, a piece of piano wire sharpened to a "chisel" shape will cut aluminum nicely.

All of your gears, coming from a single clock, should have equal-length shafts. If they do not, it will be necessary either to remount the gear on a new shaft cut from steel wire and ground to a needle tip at each end, or to cut and bend down a tongue to reduce the span for the shorter shaft, as shown in Fig. 9.6. Four holes should be drilled near the corners of the plates, again being careful not to interfere with other components, and long bolts selected to hold the box together. Sections of brass tubing cut to exact length to permit the gears to turn freely, while not slipping out of place, serve as spacers over the bolts (Fig. 9.7).

It is usually necessary to replace the shaft on the final drive gear, since it must project from the box and receive the disc. A steel bolt, about 1/2 inch longer than the depth of the box, and about % inch in diameter, is ideal. The gear must be very firmly attached



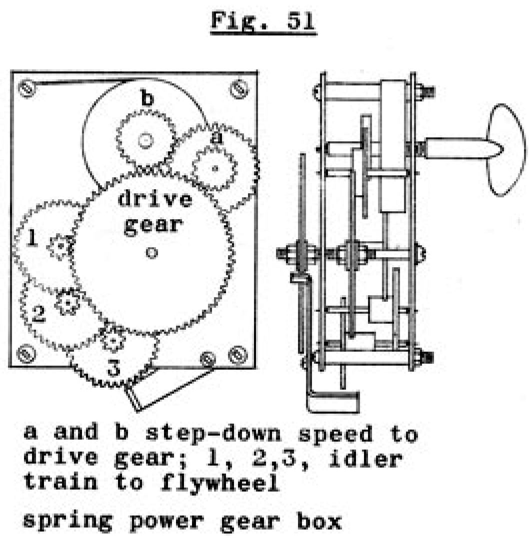


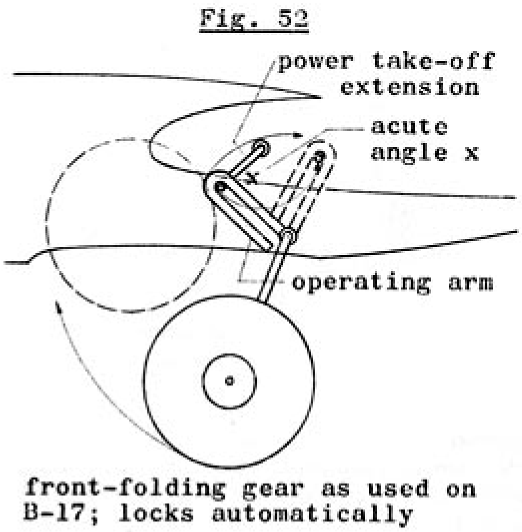
Figure 9.7: Splicing a prop.

to the shaft, as the disc is. Nuts tightened down against it help, but a pin through the gear collar and the shaft is very desirable. Too large a hole for the pin weakens the shaft, and it may be necessary to enlarge the shaft to about 3/16 inch if you cannot drill a hole small enough. The pin must be of piano wire to prevent shear. Test this assembly rigorously before you install it, by trying to force the gear to turn on the shaft, holding it with pliers, and turning the gear by hand. If you can move it at all, it's not good enough; try again.

For one-directional drives, such as springs or rubber, the purpose of the gear train also is to slow down the rotation of the driving disc, cutting down the number of revolutions of the disc on one winding of the motor. This is accomplished by stepping down the speed of the spring-driven shaft about 25:1 with two gears to the take-off shaft, and adding another three gears increasing the speed to a very high speed flywheel gear at the end of the line (Fig. 9.7). Since there is a physical limit to the speed at which this gear can rotate, the entire system runs at a leisurely pace. It is this last gear which is braked by the actuating lever, and the train must be so laid out as to make it accessible at the edge of the box, on the side toward the outer edge of the circle. With this type of gear box, the spring motor is usually mounted in the box as it is in a clock. A clock spring, about 1/4 inch wide and 8 inches long, complete with ratchet and winding key can be transferred in toto to your new box as well as, quite probably, the step-up gear train. Keep accessibility of the winding key in mind when selecting the location of the mainspring. If it is not possible to place it so that it is directly accessible from outside the finished fuselage, a flexible cable or a rigid extension shaft can be fitted easily. A length of 1/4-inch brass tubing with a slotted end can be used as an extension key to reach the box from the rear of the fuselage through a small hole.

If rubber power is used, as long a loop as is practical should be employed, made up of about 10 strands of 1/4" flat rubber, or equivalent. This can be wound easily from the rear, just as is an R/C escapement motor or rubber model.

For fore-and-aft folding gears a simpler arrangement can be used. The take-off shaft of the power source or gear box, placed at right angles to span of the wing, can simply be extended out through the wing and bent down to form the legs of the gear (Fig. 9.8). If the gear folds down to the rear, a block can be so placed as to serve as a bumper against which the legs seat to absorb landing shock. If the gear folds up to the rear, the shock is transmitted through the gear to the locking lever, which must accordingly be ruggedly built. It is also possible to adapt the locking principle explained below in connection with nose wheel design to this type of gear.



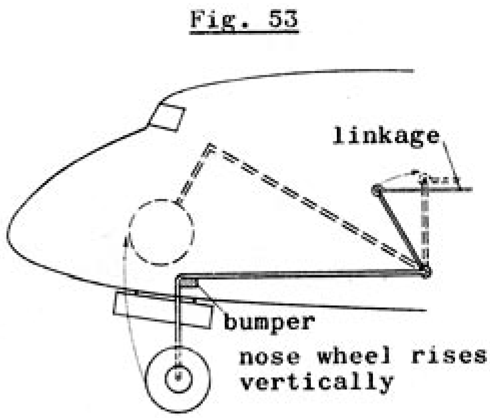


Figure 9.8: Front gear.

Nose wheels are usually driven by a take-off arrangement from the main gear system, both because this insures co-ordinated action, and because it is usually simpler. (One method of obtaining a fore-and-aft thrust for this actuation is shown in Fig. 9.8). Almost invariably, nose wheels fold to the rear. In some cases, however, they should rise almost vertically, and this effect can be most easily approximated by using a fairly long rearward extension of the landing gear leg to the pivot point (Fig. 9.8). The actuating motion in either case is a simple push to front or rear respectively. The problem here is locking the gear down in such a way that the hard landing shock is resisted directly before it can be transmitted back through the linkage into the rest of the system. Rough landings are frequently taken mainly by the nose wheel, and to be practical, it must be able to take this kind of treatment without damage.

Fig. 9.9 shows a very effective lock which can be built as ruggedly as a fixed gear. It will be noted that in the down position the bellcrank has moved past dead center, and a thrust against it from the nose gear doesn't tend to fold the gear, but merely presses the heavy bellcrank against a solid hard-rubber stop. The slightest pull from the linkage arm, however, unlocks the arrangement, and permits the spring-loaded gear to fold slowly, along with the main gear. While this type of individual lock is not needed with side-folding gears or with rear-lowering gears, it can be used to good advantage with front-lowering systems, as has been noted. It is necessary, of course, to adapt it accordingly for this use. The rear-pull unlocking action can be supplied by a short downturned arm at the end of the extended take-off shaft (Fig. 9.8). Thus the motor serves actually only to operate the lock, while the gear itself is spring-loaded for up, and is pushed down by the locking bellcrank against the raising spring.

Flaps can be added to any operating gear without much trouble. The flaps must, of

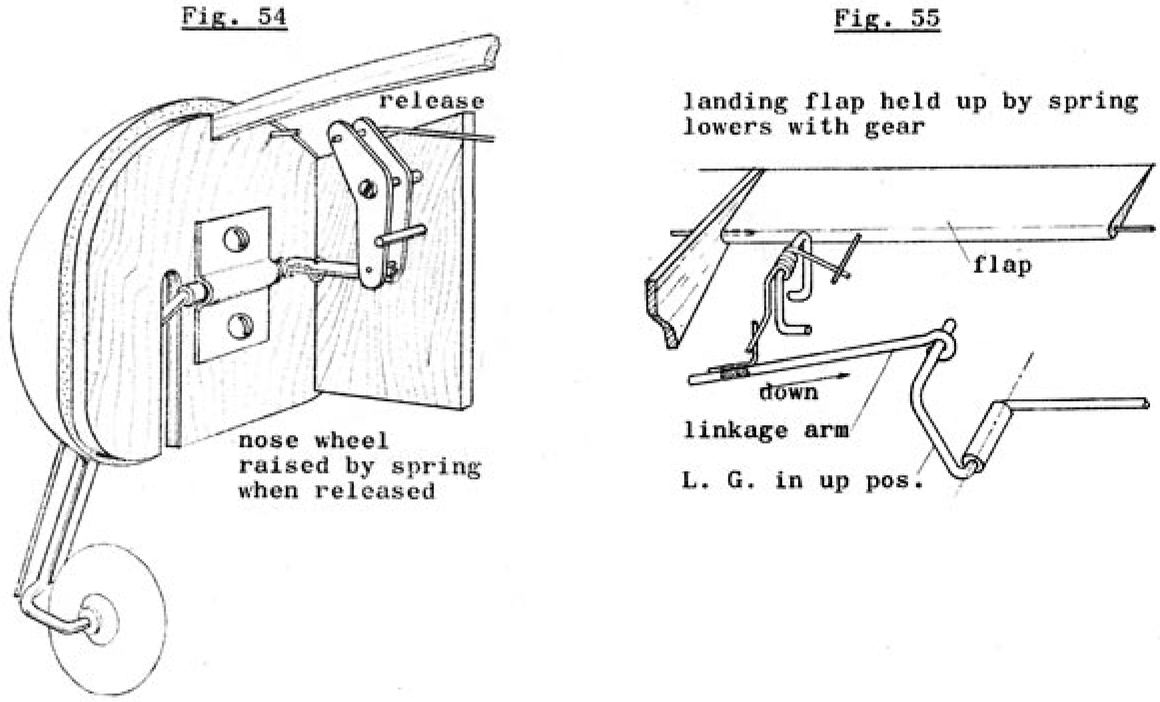
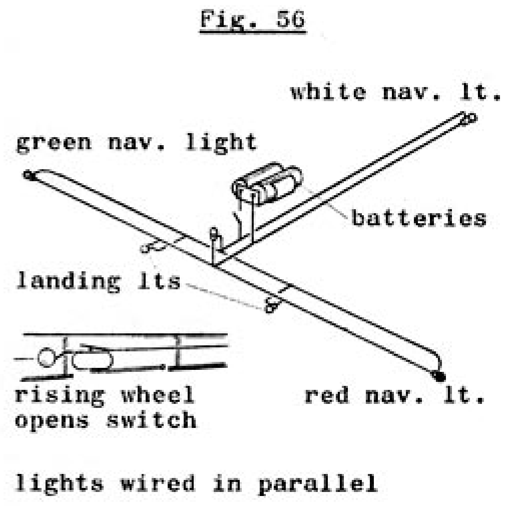


Figure 9.9:

course, be well mounted for smooth action, and should be linked together so that both can be actuated by a single mechanism. Fig. 9.9 shows a basic approach which can be adapted to almost any ship. The light spring holds the flap up as long as the gear is not fully extended. It is a good idea usually to adjust the travel of the operating arm so that the flaps pull in at once when the gear starts up and stay seated until the gear is almost fully extended. This makes the transition easier for the pilot to handle. The flaps should not be allowed to come down more than about 15-20[FFFD?], to avoid an excessive ballooning tendency and poor control.

Landing-light systems can be installed after the gear has been laid out. Regular two-pen-cell-type bulbs are excellent for this purpose, as they have built-in focusing lenses which produce a spotlight effect. Lightweight wiring such as telephone switchboard wire should be used, and simple cutoff switches can be snipped from shim brass and adjusted to open and close at any desired point in the cycle. If adjusted to cut in as soon as the down cycle begins and stay on until the gear is up and locked again, they can be a useful indicator of gear response. They also enable you to fly very successfully in poor light, or even in total darkness, if a few navigation lights are carried by the ship. Fig. 9.10 shows a typical layout.

For a truly smooth-looking job, and for the maximum in aerodynamic efficiency, it is a good idea to install well covers. Generally, the main portion of the cover is attached directly to the landing gear leg. It is important to install the landing gear so that it folds completely inside the wing or fuselage to a position at least 1/16 inch below the surface. A fitting, or fittings, can then be cut from shim brass or tin-can stock and be soldered to the leg, with points spaced along the edge ready to receive the cover. Covers are best cut from balsa or plywood and attached to the fittings, pressing the points



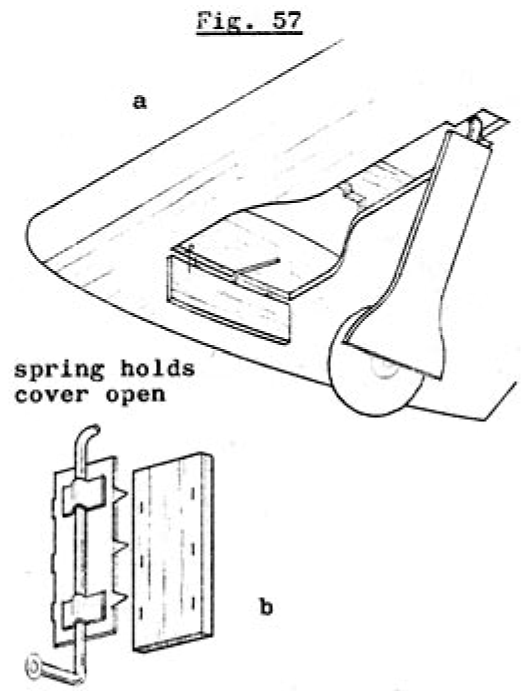


Figure 9.10:

into the wood (Fig. 9.10a). The cover outlines should be cut to a good fit so as to clear freely, and glued in place before shaping the surface to a perfect flush fit. Metal covers can be used, but these are more difficult to work, and do not match the surrounding finish very well.

The portion of the well accommodating the lower half of the wheel is thus left open, requiring a separate cover. This should be hinged solidly, to open away from the other half. A piece of wire bent at a right angle and glued to the inner side of the cover is all that is required to close it. As the wheel enters the well, it contacts the operating arm and pushes it ahead, thus closing the cover. When the wheel emerges, a spring opens the cover and holds it (Fig. 57b).

Hinges for well covers can be made neatly and strongly by the same methods used for C/L elevators.

It is usually an excellent idea to install the gear in the model as soon as there is sufficient structure in place to receive it. An open fuselage frame, with wing spars set in place, and a few ribs, including the ones on which the gear will be hinged, is the best setup for ease in working with the gear. The main gear leg assemblies should be built and placed first, followed by the gear box and power source. The linkages can then be added with ease. Note that it is necessary to establish the length of the operating-arm extensions of the gear legs so that they have clearance to operate inside the wing thickness or nacelle, as the case may be, and also so that the length of the arc in which they swing is equal to the travel of the point on the driving disc to which they are linked. Bend the linkage arms carefully to the correct lengths to give proper up and down positions. The nose wheel, if any, should be installed next and the lock adjusted to work smoothly before being linked to the power source. Flaps and lights are added last; add the structure of the airframe when necessary as you go along. Bottom wing skins should be added before making well covers, and before completing flap shaping, to insure flush fits. The entire structure should be doped inside before sealing off, to avoid oil-soaking from the lubricated system.

The systems and principles described above are as easily applicable to R/C as to C/L. You'll be able to develop variations, adaptations, and extensions thereto, if you tinker with these mechanisms; they can add a large measure of fun, authenticity, and performance to your models.

Chapter 10

Building Push-Up - a free-flight sport model

The time has come to try out some of the ideas we've been talking about, and a good way to start is by building the simple but efficient free-flight model Push-Up shown in Figs. 58, 59a, and 59b. Before starting to build, it will be necessary to enlarge the plan, or at least certain parts of it. All of the numbered pieces will have to be scaled up as well as the wing layout and the side frame for the fuselage. Get a sheet of plain paper 14% x 21 inches in size and tape it down on a smooth-surfaced table top or drawing board. A T square and a triangle will be a big help in drawing, but if they're not available, you can manage with just a ruler.

The actual size of the model is exactly 1-1/2 times as large as the plan in the book so this will be a good chance for you to practice some of the scaling-up covered in Chapter 12. Start by drawing up the fuselage side frame. It's all straight edges except for a few inches along the bottom edge, so this shouldn't give you much trouble. Just be sure to get all of your distances exactly right. You should also enlarge the pattern for parts No. 1, 2, 4, 5, 6 and 7. If you're in a drawing mood, go ahead and do the wing and tail layout now. If you're eager to get started building, that's all right, too. First, transfer your full-size pattern for part No. 3 to a sheet of 1/8" medium balsa; match the straight edge of the pattern to the edge of the wood to save a little cutting. With your pattern held in place, lift the edge of the paper and slide a piece of carbon paper under it; then draw over your pattern with a sharp-pointed pencil and be sure not to let the paper slip. With the first piece drawn up, you can get out your single-edge razor blade and your cutting board and cut the part out. Cut just a hair to the outside of the line, then use sandpaper wrapped around a sanding block to smooth up the outline. Now you can draw around your finished No. 3 to make the second one.

Next, select some good hard 1/8" square balsa strips and measure off the pieces for the top and bottom of your fuselage sides. Be sure to make two of each piece and lay the extras aside for the moment. Place the top and bottom strips on the plan and stick a few pins alongside each one to hold it in position. Using fuel-proof cement, apply a coating to the edge of part No. 3 where it joins the bottom strip and set it in place. You can stick pins through this one if you want to because it's wide enough so that it won't split. Don't let any cement squeeze out on your plan from the joint or you'll have the job of pulling the side frame off the paper when you're through. Now cut the 1/8" x 1/4" balsa pieces (there are four of them), apply cement where necessary, and put them in position. Now add the1/8" square pieces, all 6 of them, and your side frame is

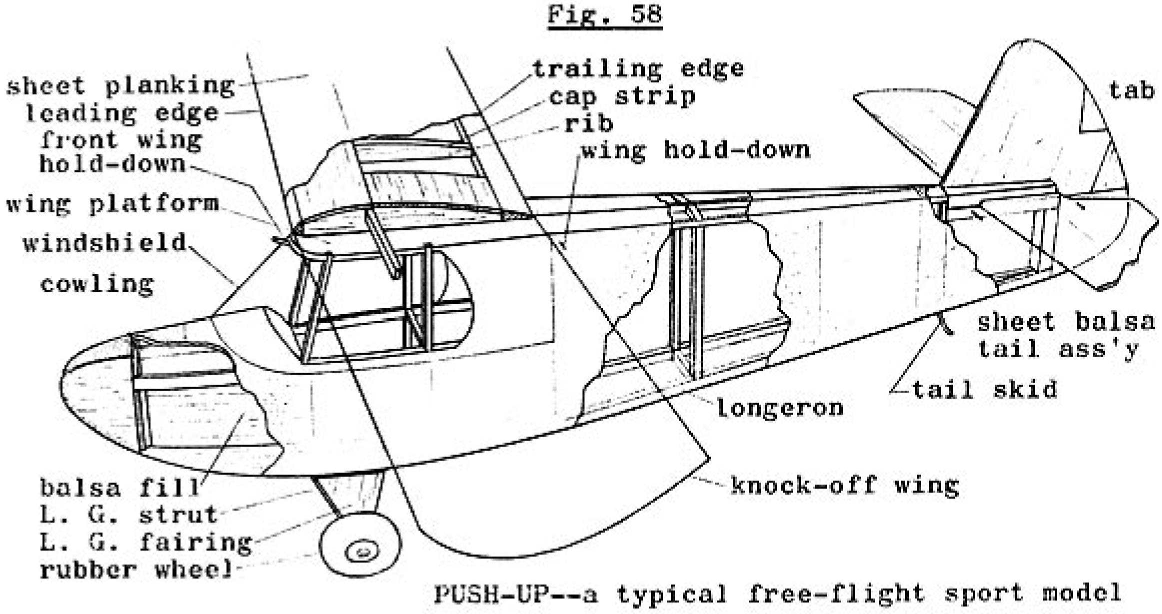


Figure 10.1: The PUSH-UP.

complete, except for the triangular gusset to support the wing mount. Cut this piece carefully and be sure the grain runs diagonally. Now use those extra pieces you've been cutting and laying aside for later use to build the second side frame directly over the first.

While your cement is setting up good and hard, transfer patterns 1 and 2 to a piece of 1/8" plywood and cut them out. Drill the holes in No. 1 for your engine mounting bolts and in No. 2 for lacing the landing gear in position. With the holes drilled, temporarily bolt the engine to the firewall (part No. 1). If you have a soldering iron, use the method shown in Fig. 5.3 to attach the mounting nuts. If not, cut two holes in a strip of plywood or hard balsa and cement it in place over the nuts. This will keep the nuts in position when you dismount the engine. Lay the firewall with engine attached aside and bend the landing gear from 1/16" piano wire, referring to the plan. You needn't draw up the pattern, just figure the enlarged measurements and bend the wire to the angles shown. Using a small needle and No. 30 linen thread, lace the L.G. to part No. 2, keeping your thread very snug as you work. Run the thread through each hole twice, and when you're done, squeeze cement through each hole from the back and smear plenty of it on the lacing and along the wire where it's against the wood.

Pick out some good hard 1/16" balsa and cut out parts No. 4, 5, 6 and 7, and sand them carefully to the correct outline.

By now your side frames are good and dry, so pull the pins carefully and remove the sides from the plan. No doubt they're stuck together; leave them that way until you've sanded the outline to trim up any rough spots. Now use your razor blade to split them apart. Having split them apart, the next step is to join them together again in the proper relation. This is easily done by cementing part No. 2 to one of the sides and then attaching the other side. You can put the assembly on the table, bottom down, with the landing gear hanging over the edge in order to square up the fuselage. Let it sit for a few minutes while you cut pieces of 1/8" square balsa to the length necessary for the

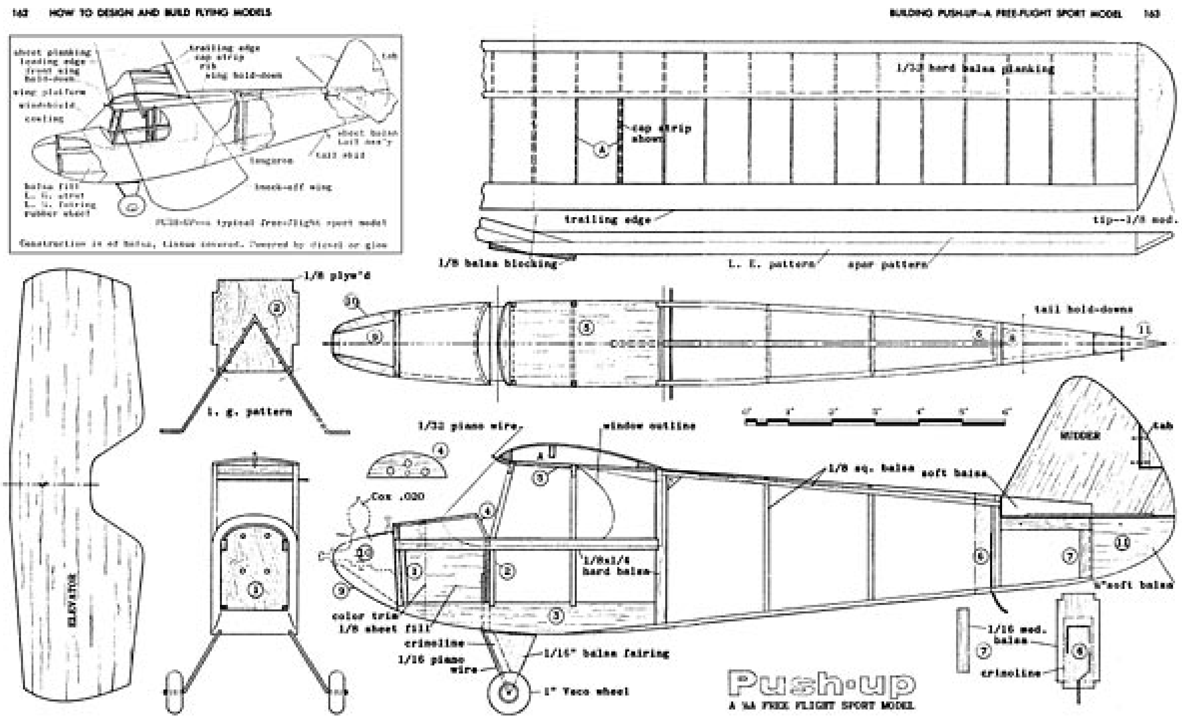


Figure 10.2: Push-Up plan. Outerzone planID:664.

cross pieces. You won't need to enlarge the whole top view - just measure the proper lengths for the spacers. Cement the three spacers (top, center, and bottom) in position in line with the rear of the wing. Cut two each of the spacers for the next two fuselage stations; as soon as the cement has hardened at part No. 2, you can install them. Use a rubber band around the rear end of the fuselage sides to pull them in while the cement sets. Bend the tail skid and glue it to part No. 6; hold it down with a piece of silk or crinoline glued over the wire. Now you can install No. 6 and No. 7.

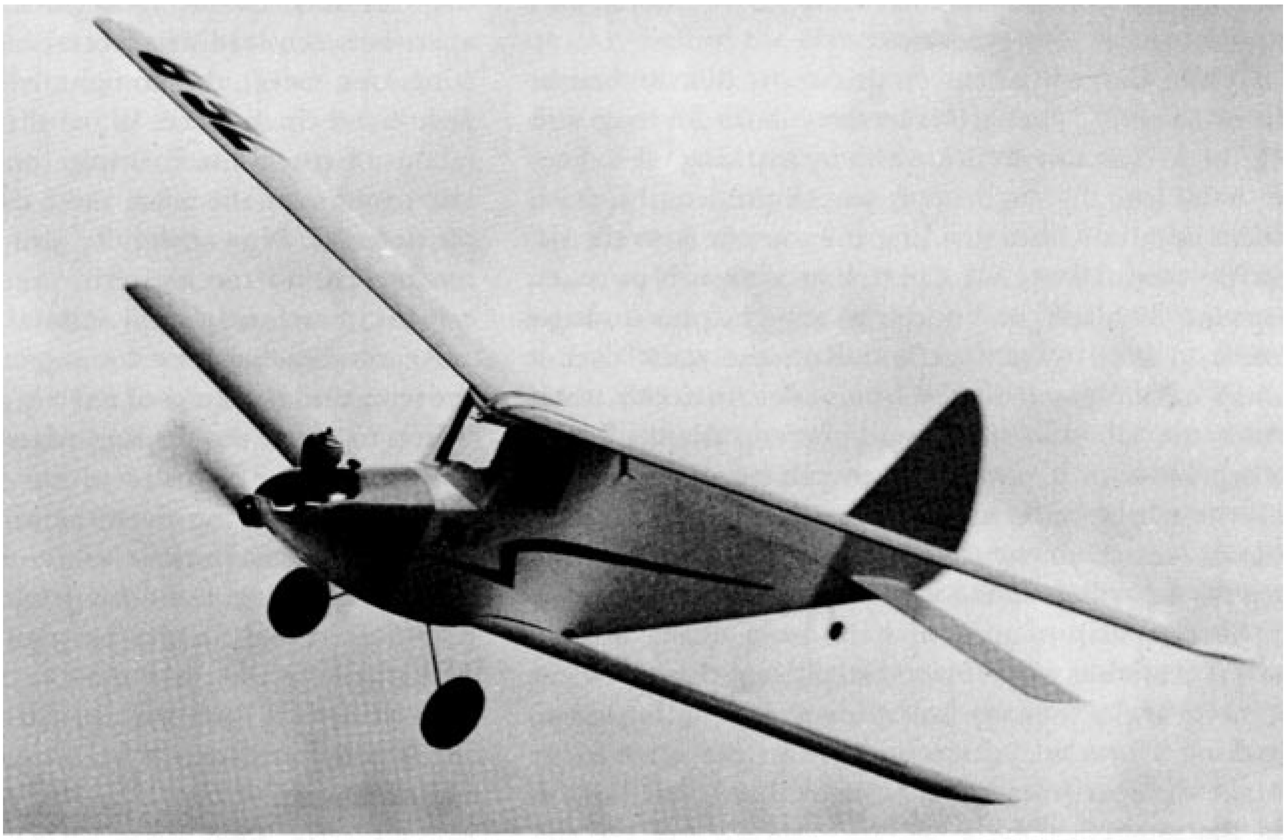
Now let's go up front and cement the firewall in position. Use a rubber band here also to hold the sides in. Measure the distance between the sides at station 3 and cut two more spacers and install them here. Bevel the bottom of part No. 4 and install it.

Measure the length of the cabin posts and cut them from hard 1/8" square balsa. Fit them into the notches in part No. 5; be careful to get them set at the right angles.

Add a piece of 1/16" x 3/16" hard balsa between the posts and against part No. 5 (the cabin roof) and another at the rear of part No, 5. Bend the front wing hold-down wire from 1/32" stock and force it between the pieces just added and the cabin roof. Now cut part No. 12, bend it as shown, and cement to part No. 5 and against the wire. The completed cabin assembly can now be attached to the main fuselage assembly.

Next, cut a piece of 1/8" square balsa to length to form the top stringer and notch it out to fit over the spacers at stations 5 and 6. Cement it in place and add triangles of 1/16" balsa to the top of the spacers against the stringer. Now use clear fuelproofer to

coat the inside of the fuselage back to station 2. Cut 1/8" balsa panels to fit into the sides from stations 1 to 2 and cement them in place. Use stiff paper to make an approximate pattern for the sheet balsa covering for the top of the fuselage from the firewall to part No. 4. Fuelproof the underside of this piece after you have cut it from medium 1/16" sheet balsa, and cement it in place when the fuelproofer is dry.
You can unbolt the engine now and cut out the cowl sides (part No. 10) and the cowl bottom (part No. 9) from soft 1/4" balsa. Bevel the edges to fit and cement them to the firewall. Now allow an hour or so for everything to set up hard; you can use the time to finish drawing up your full-sized patterns and layouts if you haven't already done so.
When the glue is thoroughly hard, use a sharp razor blade to whittle the rough cowling into shape and trim up the planking and any other rough spots. Then use garnet paper to go over the entire model. Cut part No. 8 to approximate shape from 1/2" soft balsa and spot-cement it in place temporarily. Cut out part No. 11 and glue it firmly to the rear end of the fuselage. Now use your sanding block and razor to shape these two pieces. When you've got them nicely faired in, cut No. 8 loose and lay it aside.
Now give the entire fuselage frame a coating of fuelproofer and a final sanding with fine sandpaper; then lay it aside to wait until you're ready to cover it.



A ½ A F/F model cruises past Keith Laumer photo

Figure 10.3: A 1/2A FF model cruises past.

We'll do the tail assembly next to get it out of the way in a hurry. Trace the rudder pattern onto 1/16" medium balsa; note the joint and the direction of the grain. Next, do the same for the elevator and sand the edges of both parts to a round shape as shown on the side view of the elevator. Notch out part No. 8 to fit over the elevator and cement it in place on the center line of the elevator. Glue the rudder in position on the elevator - be careful to get it centered and at right angles to the elevator.

While the tail assembly dries, cut 30 rib blanks from hard 1/32" balsa. Make the blanks 3" long and 1/2" high. You can do this easily by marking off a sheet of balsa into 3" lengths; cut five of the lengths, stack them up, draw lines dividing the top one into six 1/2" strips, then cut the whole stack as a unit. Now stack up your 30 blanks and push two straight pins through them to hold them together. Rub the stack over a sheet of sandpaper to level one edge perfectly, then trace the rib pattern A onto the top blank. Use a sharp knife or a power saw to cut the top curve of all the ribs at once, and sand smooth with a sanding block. Now trim the front and back end and cut the notch. A hacksaw blade works well for this.

Bevel a strip of pine or hard balsa, using a table saw if available, to preform the trailing edge. Now cut a strip of 1/4" square balsa for your leading edge, making a beveled joint as shown on the front view. Make the spar from 1/8 x 1/4" hard balsa and joint it in the same way. Now pin the leading and trailing edges in place for the right half of the wing. Separate the ribs and cement 15 of them in position 1 inch apart between leading and trailing edges. Cut out the wing tips, bevel the straight edge, and cement the right-hand tip in place. When the cement has set hard (about thirty minutes), unpin the structure and fit the left panel over the plan. Add the other 15 ribs and the left tip. Now carefully drop the spar into the notches cut to receive it in the ribs. Use plenty of cement in each notch and at the tips.

Again allowing time for the cement to dry, unpin the wing and cut strips of hard 1/32" balsa 1" wide with which to plank the leading edge. Check the joints to be sure the spar is flush with the top of the ribs; then attach the planking over the ribs from the leading edge to the spar. You can hold it in place while it dries by sticking pins into the leading edge above the planking and through the planking into the spar. The planking should extend over the tip and should be trimmed off flush with it. After planking the leading edge, cover the center section with 1/32" balsa, as indicated on the plan. Fill the underside of this section with 1/16" sheet balsa, fitting it between ribs so as to be flush at the bottom of the wing. Now use a sharp knife to shave the leading edge down to the proper cross section, as shown in the side view, and smooth the entire wing up with sandpaper. Give a coat of clear fuelproofer to the wing and tail assembly and follow with a final sanding with fine paper.

You're ready now to cover the model. Starting with the fuselage, cut a piece of lightweight Silkspan or Japanese tissue to the approximate outline of the fuselage side-frame. To attach the tissue, you can use cement or a 50:50 mixture of cement and dope, or even mucilage if you prefer. With the fuselage lying on its side with the landing gear over the edge of the table, apply the adhesive to the outline of the side-frame only; if you're using cement or a mixture, work rapidly so that it doesn't dry before you get the paper on; with mucilage, you have more time.

Keep the adhesive away from the inner edges of the pieces to which it's applied; otherwise, it will draw the paper down and ruin the evenness of the covering job. Quickly place your paper in position and, working from the center, pull the paper out so that it's smooth and flat without wrinkles, folds, or ripples. If a part of the job seems to be getting away from you and getting itself stuck down crooked, peel it up quickly before the cement has gotten a firm hold, re-cement it, and stretch it out straight. With the first side covered, do the second in the same way. Now cut a piece for the top, and crease it down the center to help in positioning it. Apply cement to the top stringer and the top edge of one side and attach the paper to this side first. When it's straight enough to satisfy you, check the other half to be sure it's going to lie flat; you may find it necessary to cut it loose along the center line and attach it separately. Now turn the model over and cover the bottom in the same way, then use small pieces to cover the cowling, the rear tip of the fuselage, and other planked surfaces.

The wing can be covered with three pieces of tissue, one for the bottom and two for the top. Start with the bottom; cut a piece of paper to approximate shape and cement it first at the center of the wing; then run cement along the leading and trailing edges and tip and stretch it out smooth, one panel at a time. Follow suit with the top covering. Now use an atomizer or a large soft brush to dampen all of the paper on wing and tail assembly. While the water's drying, cut lengths of 1/32" piano wire for the rear wing hold-down and the tail hold-downs. Don't install them yet; we'll do that when we're all through sanding. Cut out the hard balsa landing gear fairings and sand the back edges round. Cut the tab from the rudder and reattach it using soft copper wire.

Everything should be dry by now, so give the whole model a coat of clear fuelproof dope, then use fine sandpaper to sand off any remaining rough edges, fuzz, etc. You can attach the landing gear fairings now, holding them on with a strip of crinoline or silk wrapped around the leading edge. Cut the 1/8" balsa blocking to fit under the wing and cement it in place. You can go ahead now and install the wing and tail mounting dowels.

Next comes the color dope. Note that the nose and tail of the model are to be painted in a contrasting color to the rest of the ship. If the basic color is light, trim with one or more dark colors. If you want a dark model, use light colors for trim. In either case, apply the light color first. Assuming that the fuselage will be light, shoot the entire model, or brush-paint it if you haven't access to a spray outfit. Check the model over after the first coat and use the sandpaper where necessary, then apply another coat. Be sure to get it down inside the cabin and engine compartment, and along the leading and trailing edges of wing and tail. Now make a windshield pattern as described back in Fig. 6.4 and attach the windshield one side at a time. Apply the cement carefully here to avoid getting it on the windows; after all, the pilot has to be able to see out. Now tape off the windshield, following the window outline shown on the side view, and spray another coat on the fuselage. If you're brushing the dope on, mark the outline of the window lightly with a pointed grease pencil. Paint the outline first, then fill in the rest. Strip the tape off carefully after the dope is dry.

Tape off the center of the fuselage now, leaving only the front and rear exposed. Spray a bright color on the nose and a different bright color on the tail. Spray the tail assembly at the same time to match the rear end of the fuselage. Be extra careful when peeling this tape off since it is possible to tear the paper if you're in a hurry.

If fuelproof dope wasn't used, give the entire model a coat of clear fuelproofer now. Attach the wheels, and solder a retaining washer in place on the end of each axle. Mount the engine, offset the rudder tab 1/16 inch to the right, attach the wing and tail with a couple of 1-1/2" rubber bands each, and you're ready for test glides. Follow the procedures covered in Chapter 7 and you'll soon have Push-Up racking up one perfect flight after another.

Chapter 11

Building Flea-Whiz - a control-line sport model

Until you've tried out control-line flying, you're missing exactly half the fun of model building. If you haven't tried one yet, Flea-Whiz is a good job to start with (Figs. 60, 6la, and 61b). It's simple to build and will absorb a lot of pilot error, but at the same time makes use of the advantages of control-line to include good looks and plenty of extras. You can build the model the exact size of the plan for .020 to .049 power or scale it up for a bigger power plant. Increase dimensions by one-half for engines from .09 to .19 displacement, double the plan for still larger engines.

Fig. 60

FLEA WHIZ--a typical control-line sport model

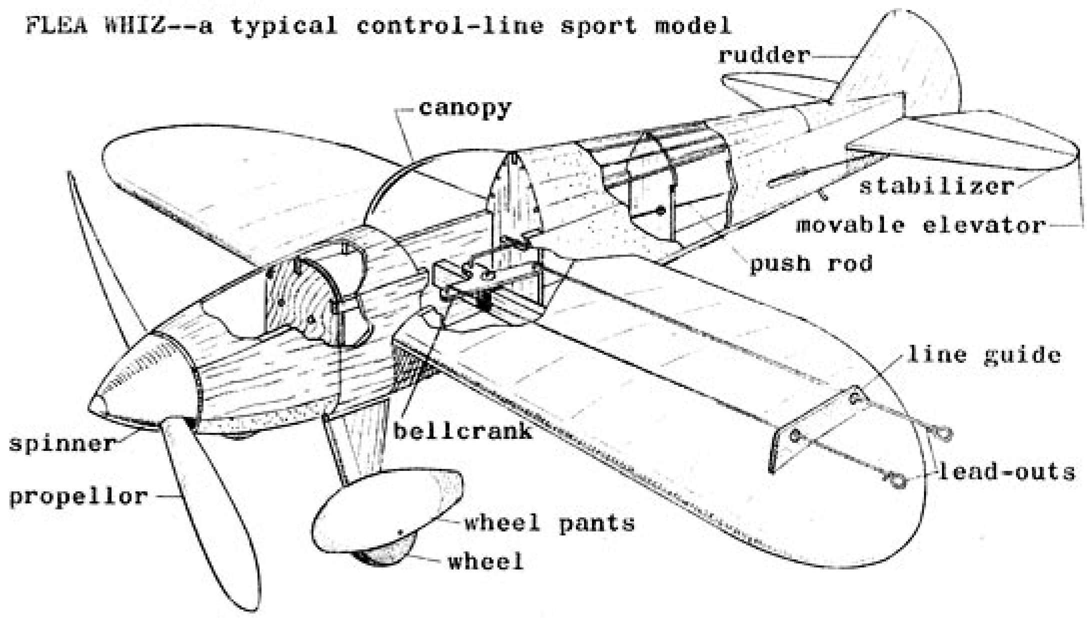


Figure 11.1: The FLEA-WHIZ

We'll assume you're building actual size from the full-size plan (Figs. 61a and 61b); so start by laying out the fuselage sides on medium 1/8" balsa. You know by now to utilize the straight edge of the sheet for the long edge of the pattern; use a straightedge to cut the other lines.

Make the slot in the rear for the elevator and cut out the openings for the wing leading edge, trailing edge, and spar. Next, cut out balsa bulkheads No. 2, 3, 4 and 5, and be sure the grain is horizontal in No. 2 and 3, vertical in the others. (No pattern is given for part No. 2 since it is a simple square 1-1/4 inches on a side). Join the two sides on part No. 3 and at the rear and align them carefully. While the cement is drying, cut the firewall, part No. 1, from 1/8" plywood. Bend the landing gear from 1/16" piano wire; be sure to bend it as shown on the plan to avoid the engine mounting holes if you are using the Cox .020. Lace the landing gear to the back of the firewall with No. 30 linen thread.

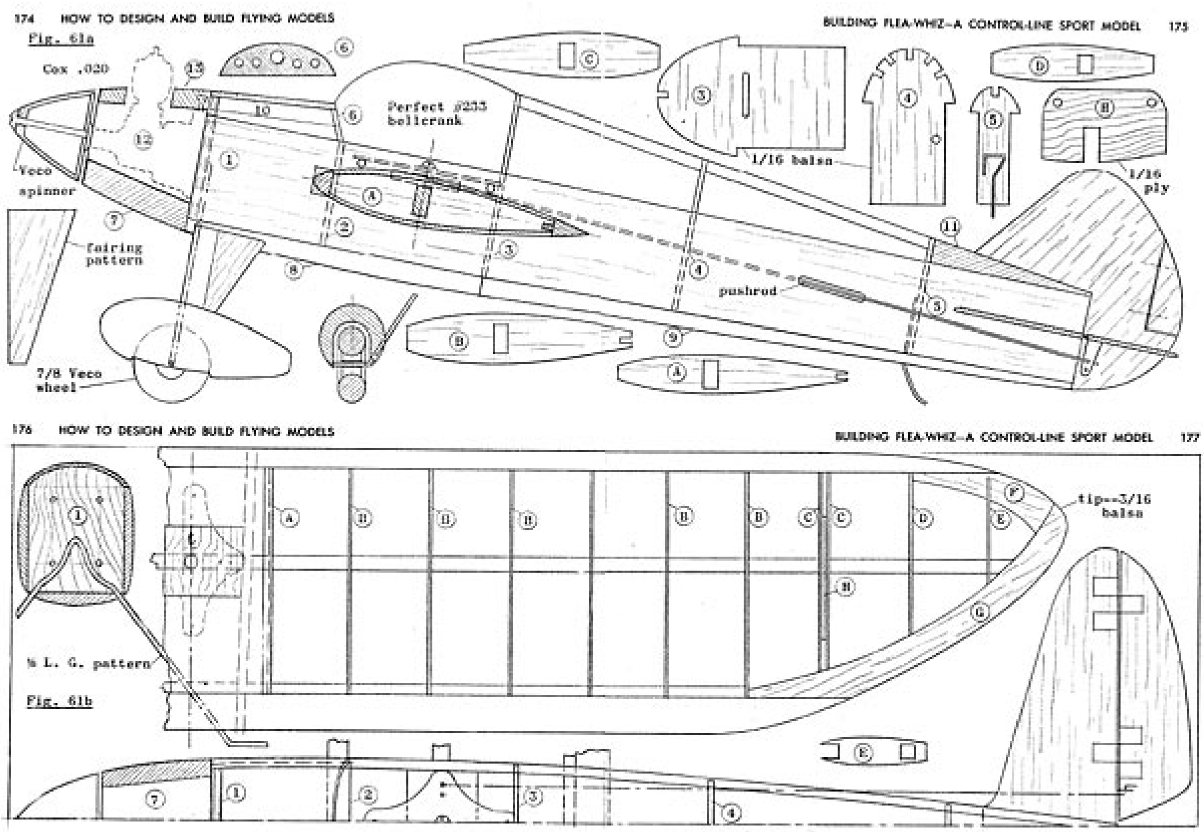


Figure 11.2: Flea-Whiz plan. Outerzone planID:834

Mount the engine and secure the mounting nuts to the back of the firewall by cementing a strip of hard balsa over them. If you prefer you can use a metal plate as shown in Fig. 5.3; in this case, attach the mounting bolts first, then bore holes and lace landing gear in place. Now you can install the firewall, using rubber bands to hold the fuselage sides together until dry. Then install parts 2, 4 and 5. Now check the bottom to make sure bulkheads and sides are flush, and cement part No. 8 (1/4" balsa) and part No. 9 (3/16" balsa) in place. Note that the top view of the fuselage provides the patterns for these two pieces, which are full width. Bore a small hole through No. 9 to accommodate the tail skid, and notch No. 8 around the main landing gear. Install parts No. 6 and No. 10 and fuelproof the interior of the fuselage.

Cut the cowling parts No. 7, 12 and 13 from soft balsa as indicated. Cement the two No. 12's in place first, then add 7 and 13. Now, using a sharp knife and coarse garnet paper, shape the lower half of the fuselage, then smooth it off with fine paper. The upper portion of the fuselage will be shaped after controls are installed.
Cut the leading edge from 1/4" x 3/8" medium balsa and the spar from 3/16" balsa and insert them through the openings cut in the sides of the fuselage. Note that the leading edge is not shaped until the wing is complete. The trailing edge, made of pine or hard balsa, is cut to approximate length and the 1/8" x 1/16" hard balsa key strip is cemented to it, and the trailing edge assembly is installed in the fuselage.
Cut three of rib A and twelve of rib B and install by sliding them over the spar. Fit them carefully between the leading and trailing edges one inch apart with rib A against the fuselage side. Note that A is smaller than B; this allows room for a 1/16" x 3/16" cap strip to be placed over rib A, top and bottom, to simplify covering. Now cut out tip parts F and G from 3/16" balsa and join them over the plan. When dry, cement the tip assemblies in place and add ribs C, D and E. Note that there are two of rib C in the left-hand panel to allow the line guide, part H, to be installed between them.
Next, cut out rudder and elevator from medium 1/16" balsa and streamline the outer edges. Cut the flippers loose from the stabilizer and attach an elevator horn to the right-hand flipper. Use strips of crinoline 3/16" x 3/4" to join the elevators to the stabilizer, and cement the elevator assembly in place. Align it carefully so that it rests horizontally and at right angles to the fuselage center line. Cut a plywood plate one inch wide to fit between the fuselage side over the wing spar and mount a small bellcrank, such as Perfect No. 233, in the center of it. Cement the plate in position in the fuselage. Bend a pushrod of 1/32" piano wire and install it, engaging one end in the short arm of the bellcrank and the other in the elevator horn. Measure the length of this rod precisely so that the elevator rests horizontally when the bellcrank is centered. Bend lead-out wires from 1/64" piano wire or fishing leader wire and install them, anchoring them firmly to the bellcrank and leading them out through holes bored in the fuselage side as shown on plan.
With the controls in, you can finish up the top of the fuselage. Cut a piece of 1/16" balsa to fit over the top between No. 1 and No. 2, fuelproof the underside and install. Hold it down with rubber bands while drying. Now put a stringer 1/16" x 1/8" in size in the notches in bulkheads No. 3, 4 and 5. Then add two more stringers on each side, fitting into the notches in No. 4, and butting against No. 5. Cut part No. 11 from soft balsa and install. Using coarse sandpaper, shape the top half of the fuselage and cowl as you did the bottom and finish up with fine sandpaper. Give the fuselage a coat of clear fuelproofer and sand again lightly. Fuelproof and sand the tail assembly and install the rudder.
Cut two landing gear fairings from 1/16" hard balsa and streamline the rear edge. The wheel pants are optional but they look very nifty. You can make them easily by hollowing out space for the wheel in blanks of 1/2" balsa, then cementing together and turning them to shape on a lathe. They can also be hand-whittled, of course. After the pants are shaped and sanded, fuelproof and sand them; then carefully paint the inside with the same color dope you'll be using on the fuselage. Carefully bore the hole for the axle in each pant and notch the inner side for the landing gear leg and fairing. Install the pants now and don't forget to include the wheel. Align the pants carefully and let them set hard before installing the fairing. Use a piece of crinoline to hold the fairing firmly to the landing gear strut.

The wings should be good and dry now, so get out a sharp knife and the sanding block and shape the leading edge and tip to the cross-section shown on the side view of the fuselage. Do this job slowly and carefully; it will make a lot of difference in your model's flying ability. Place part H in position temporarily and cement scrap balsa packing in front of it and behind it, between ribs C; then pull H out and install after the wing is covered.

Cut an opening in the cowling large enough to accommodate the head of your engine and a hole to give access to the needle valve. Sand these openings smooth and fuelproof all the raw edges. Look the model over for rough spots and eliminate any you find and you're ready to cover.

The wing is covered with four pieces. Cement first to rib A, then apply the stickum to the leading and trailing edegs and tip and pull the paper into place. You'll find that moistening the paper makes it more resilient and by using care you can tuck it down smoothly all around. Cover the bottom first, trim the edge, then do the top. Then cover the turtleback of the fuselage and continue the paper over the balsa portion for extra toughness and a smoother surface. Now go over the whole model with fine sandpaper, knocking off any rough spots. Be reckless and shoot an extra thirty minutes on this operation; it will insure a good finish.

Now apply your color dope using all that information you picked up in Chapter 6. Add color trim to suit your fancy and splash a few decals around to help visibility. Paint the instrument panel black and add some white dots, for realism. You can either mold a canopy (see Fig. 3.3) or settle for a windshield. You'll notice a lot of detail being left up to you because you're just about ready to start designing your own. Now install part H, bring the lead-out wires through it, and bend the loops in the ends. Install your engine and add a Veco 1-1/8" spinner.

Check the trim on your model before flying. It should balance just behind the leading edge. Try your first flights over soft ground if possible. The speed and responsiveness of your model will depend on the size engine used. The .020 shown will be snappy but easy to handle. You can hook on the lines now and beat it out to the flyine circle!

Chapter 12

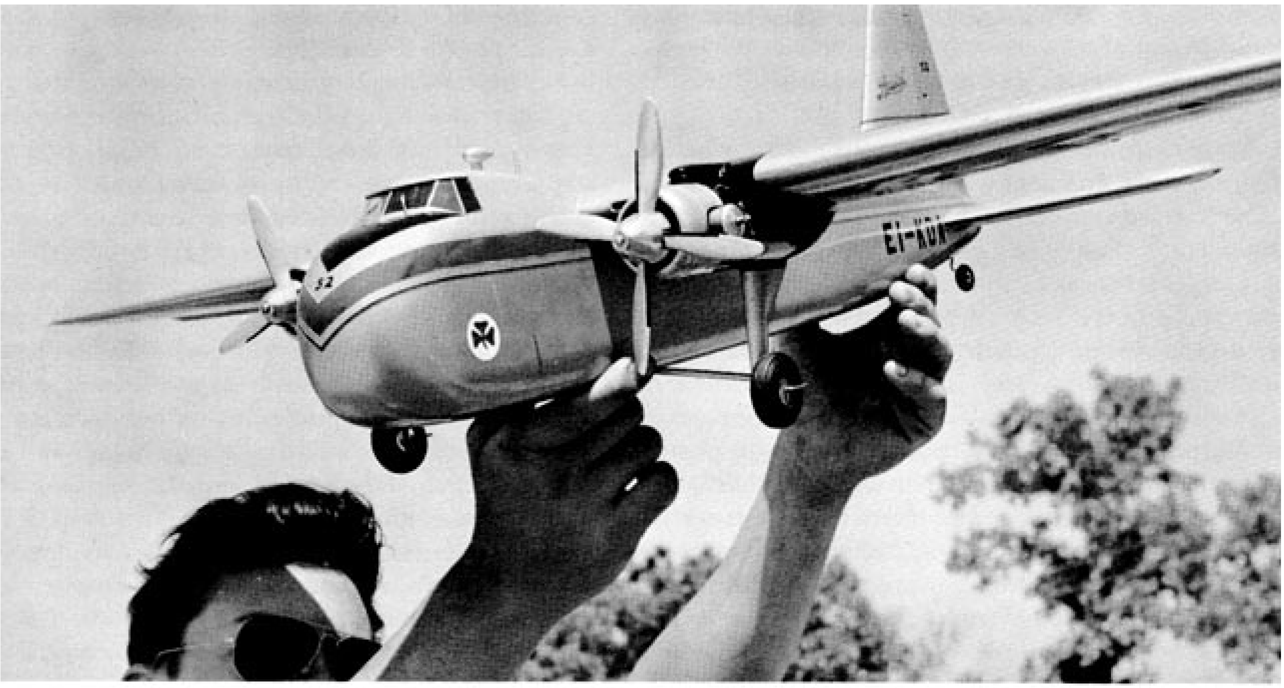
Designing your own

After you've built a few ships from this book, kits or magazine plans, you'll probably get the urge to design a model of your own; to see an original creation floating overhead or cutting circles on the control lines.
Maybe you want to build a scale model of a favorite ship and can't find a plan that suits you, or maybe you have a mental picture of something that will make those other crates look clumsy and out-of-date. But perhaps you haven't tried putting your ideas to work because you didn't have a degree in aeronautical engineering to help you master the intricacies of building an airplane without a printed plan to refer to. The fact is, by observing a few basic rules, you can turn out a model that will fly every time. Although some of the top professional designers use the slide-rule approach to setting up a new design, some of the best ships ever built were worked out empirically, by rule of thumb.
Don't get the idea that designing a model airplane is a haphazard process. It's not enough to assemble wings, fuselage and tail, add an engine, and fly. For each type of model, there are basic proportions and relationships which determine the flying characteristics and abilities of the ship. These are not precise and unalterable rules; you have quite a bit of leeway, varying one factor against another. The skill with which you do this determines your skill as a designer.
Before starting, first decide exactly what you want to accomplish with the model you are about to undertake. Your objective in this first design should be a limited one; to conceive and engineer a ship which will get off the ground, perform in the air, and land in one piece. Your design may be either a completely original conception, or a scale model of a full-sized plane. It is advisable, in any event, to start with a relatively simple straightforward design of conventional layout. After your first success, there will be plenty of time to develop competition jobs or experiment with helicopters, canards, Delands, pushers, and other mutated species.
If you're planning a scale model, you should have on hand the most accurate three-view drawings available. If you can get these photostatically enlarged, you'll save the labor of enlarging them by hand. If your project is an original, now is the time to sketch out some reasonably precise three-views at a small scale, to establish the basic shape of your model. If you want a highly maneuverable ship, keep the nose and tail moment arms short; for a smooth-riding stable job, lengthen them. In either case, the distance from center of wing to tail should be about 2-1/2 times the wing-to-nose distance. A deep fuselage helps give stability (except with a low-wing job), as does a wing of high aspect ratio, but at the cost of decreased speed and added drag. Low-wing F/F ships are less stable than high-wing designs as a rule; biplanes are frequently hard to adjust.

For free-flight, keep the engine thrust line fairly high, and establish a positive angle of incidence between wing and elevator. With C/L, try to keep engine, wing, and elevator nearly on a line for minimum drag, set the wing well back, and provide for a generous elevator area.

You can save yourself later trouble at this point, by avoiding unduly complex details - remember, you'll eventually have to build them. Try to decide on a simple engine and wing mounting setup, and uncomplicated landing gear, a minimum of complex cabin structure or needless curved sections. More elaborate ideas can all come later, with experience.

Sometimes the nature of the model you wish to build will dictate the type of construction; for example, if you want to do a scale model of a specific plane, its configuration will impose certain limitations. But let's say you're starting with nothing more than an idea as to the lines of the finished model and that the possibilities are wide open. In that case, let's consider some of the alternatives you'll have to choose from before you do any detailed planning.

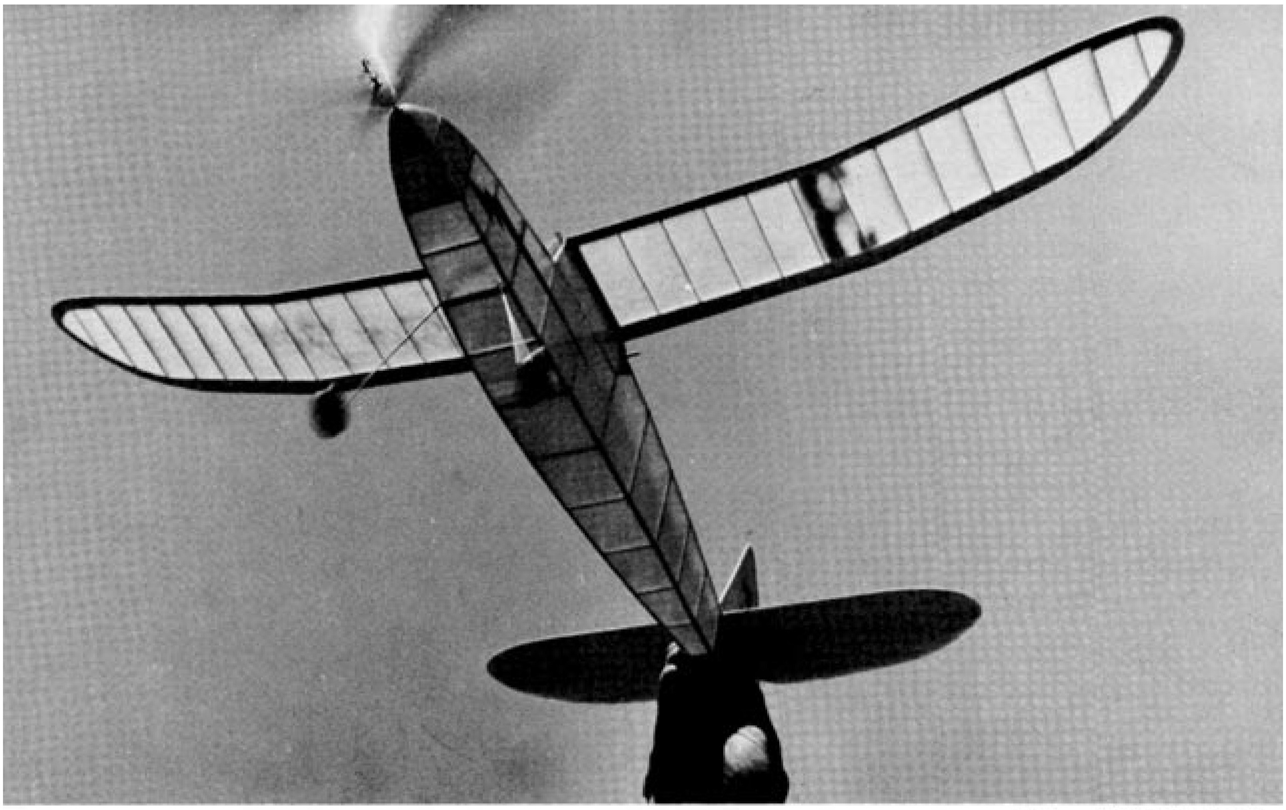


A twin-engine scale model Keith Laumer photo

Figure 12.1: A twin-engined scale model.

Scale models are, as a rule, more difficult to build, require more fine detail work, and depend more on their finished appearance for effect than other models. Frequently, though not always, their flying ability is cut down by the need to stick to prototype configuration and proportions. Still, for the builder who wants to see the real thing, there is nothing to equal a fine scale model going through its paces.

There are many airplanes which lend themselves to scale free-flight modeling, particularly light planes, military liaison jobs, WW I fighters, home-builts, etc. Good free-flight prototypes almost always have high wings and one engine, although a low-wing type with plenty of dihedral will often work out well. A multiengined airplane such as the Ford Trimotor or the Northrup Pioneer can be free-flown successfully with only the center engine functional, dummies with freewheeling props being used in the other nacelles. It is sometimes necessary to make minor changes such as enlarged tail area, increased dihedral, etc., to achieve a stable scale F/F model.



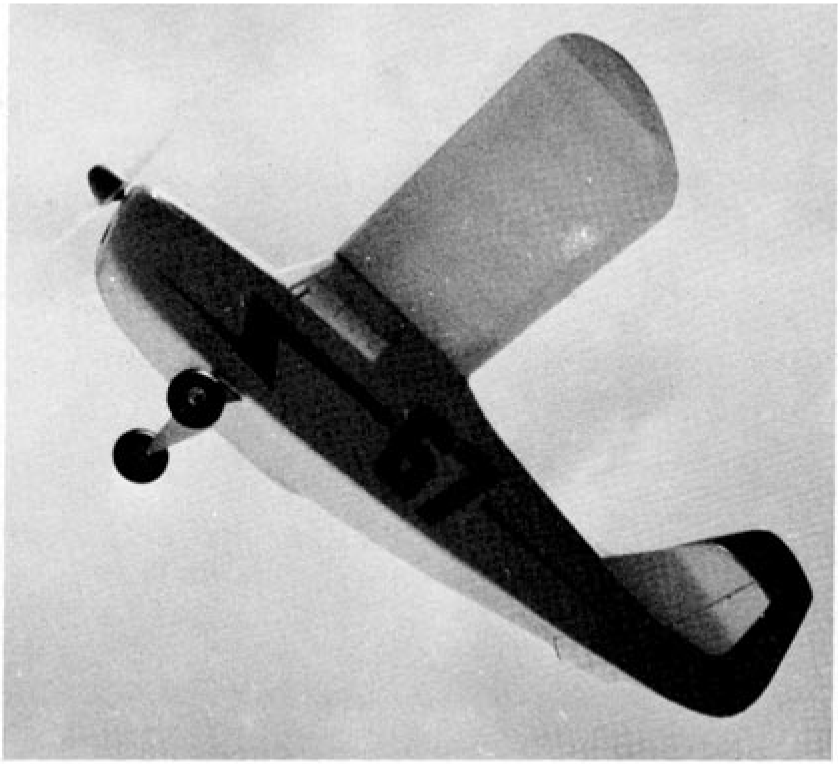
Hand-launching a rubber-powered endurance model Tom Wright photo

Figure 12.2: Hand-launching a rubber powered endurance model.

For control-line flying, there are few limitations on the full-scale designs which can be accurately modeled. It is a good idea in selecting a scale C/L project to stay away from ships adorned with fragile projecting antennae, Pilot tubes, exhaust pipes, rigging, etc. These don't last long under flight conditions, and there's not much point in building a scale model and leaving them off. Cumbersome cowlings, wheel pants, and canopies can become more trouble than they're worth if they mean inaccessible engines, or inadequate clearance for the propeller. It's no use having a pair of high-powered .15's sitting on the wing, and only space enough to mount 6-inch props. Also, think about installation of the bellcrank and lines. On a scale model it's desirable, when possible, to completely enclose the control system, or at least, to arrange a neat and inconspicuous installation.

The landing gear is an important item to check. Many a handsome model has had its looks spoiled by the alteration of the landing gear for practical reasons. A beautifully scaled fuselage is wasted if the landing gear legs have to be doubled in length, moved forward halfway to the nose, and fitted with oversized wheels. It should be noted, however, that such measures may be completely unnecessary, the result of excessive caution on the part of the builder. Good examples were the early gas models which used huge air wheels set out in front of the prop to protect the "delicate" engine; this wasn't really necessary. If the L.G. is a little ahead of the center of gravity of the plane, provides clearance for the prop in a take-off attitude, and is not unusually elaborate in design, it is O.K. for exact reproduction.

Make a final check before deciding to go ahead with a scale project, to make sure there are no insurmountable structural problems inherent in the design. Why get involved with an elaborate greenhouse, or tricky gull wings, unless you can visualize a method of building them? There are plenty of planes available which have beautiful lines, and are easily built; and for now, stay away from pushers and seaplanes. A compromise solution is a semi-scale model, essentially a sport model inspired by an actual airplane. These can be a lot of fun, are easy to build, and provide most of the scale effect of a true scale model. The use of profiles, painted-on details, and simplified lines makes it possible to get some very good effects easily.
When you've got a couple of good conventional craft to your credit, you can branch out into the unorthodox. For a few basic hints on how to lay out an unusual type, study kit and magazine plans of similar designs - they'll show you basic dimensions and relations for pontoojis, seaplane hulls, pusher engine mountings, etc.



Tom Wright photo

A pendulum-controlled F/F ship heads upstairs

Figure 12.3: A pendulum-controlled F/F ship heads upstairs.

After you've tested a model with wheels, you can convert it to floats - just build a set along the lines shown in Fig. 8 (Chapter 1) and fit them on the L.G. struts in place of wheels. They're aerodynamically balanced, so they won't affect trim much.
Whether you build F/F or C/L is mostly a matter of taste, with the added factors of flying facilities and model specifications thrown in. First, let's eliminate the obvious.
If you love free-flight and don't want anything to do with yo-yo's (or vice versa), the problem is simple. If you prefer F/F but don't have room to fly the loose ones, or like C/L but never learned to control 'em, or can't find a teammate to help you get them aloft, the matter is settled. But maybe you're lucky, and can take your choice. If that's the case, let's take a look at your dream ship. Do you picture a long, low-slung job with

plenty of power up front, stubby wings, and a trim little tail assembly? A job like that will fly with lines on it; not otherwise. But maybe you have visions of a spreading high-camber wing, a taut tissue-covered fuselage, something that takes off and lands like a feather. Don't put any tethers on that one!

Basically, C/L jobs are smaller, heavier, sturdier; they have big engines, lots of solid balsa construction, small tails without airfoil, rugged fixed landing gears, plenty of paint, spinners, wheel pants, scale details, and realism when desired. Free-flight jobs, on the other hand, are light in weight, bigger, more fragile, and more critical in weight and area distribution. For the sake of simplicity, we'll assume that your ship will employ a glow or diesel engine. Most of the principles discussed herein are equally applicable to rubber or jet design, but your choice of plans should take into consideration the power you will be using.

If you prefer rubber power, you can make up a motor of any desired size to fit your plane. It's not a bad idea to test the model with only a few strands, then add more for higher power. An average sport flyer of 24-inch span might carry from 4 to 10 strands of 1/8" flat rubber; a small ROG flies well on 2 to 4 strands; a big endurance model may use 24 or more strands of 1/8" rubber. The more rubber, the more power - and the more weight, not to mention more prop area required.

If you have a good dependable engine on hand, one that starts and runs consistently without excessive cranking and delicate adjustment, it is a good idea to plan your first original design around it; it is really simpler than using rubber power. There will be plenty to demand your attention when you go out for that maiden flight, without a cranky engine to contend with. Of course, if the whole project is based on a desire to see what you can do with a hot new engine, that's another matter; but be sure to test-run the motor until you know its characteristics thoroughly before you base any planning on it. If you're buying an engine especially for your new design, you'll find a wide selection available, of a quality which would have been unbelievable a few years ago. Some high-performance contest engines achieve their hot performance at the expense of easy starting and wide adjustment range; so it's best to pick a sport-type engine, such as the Cox Sportsman, with dimensions which lend themselves to the plane you plan to build.

Full information on many engines can be gotten from manufacturers' advertising, or from engine-analysis articles in the magazines. Some good hints can also be gotten from magazine plans, which usually indicate engines to be used; find a plan something like what you have in mind, and see what the designer used in his.

If your plane calls for an inverted engine for maximum good looks (warning: they're harder to operate upside down), don't pick a motor with fixed tank which can't be inverted. For a ship with a long nose, select an engine with a long shaft; and keep in mind the location of the needle valve or compression lever, and its accessibility when mounted in your plane. In other words, try to reduce your problems by giving some thought to picking the right engine.

You'll also have to decide on the size ship to build. It's always a kick to launch a monster model, and frequently easier to adjust a big ship, but they're more expensive to build, and harder to transport and store. Big models require big engines, which cost more and eat more fuel. You'll need bigger wheels, a bigger fuel tank, heavier-gauge wire for landing gear or controls, and lots more balsa, thicker plywood, more dope.

Big F/F ships need lots of room to fly in, and have a tendency to float away over the trees into never-never land (which must be getting full of lost models by now). But, on the other hand, large ships are impressive, and there is plenty of room in them to install tanks, controls, etc., without crowding. Big ships are less susceptible to breezes and rough ground, and they're fun to fly if you have plenty of space and you're willing to invest the extra money for the extra thrill of a large plane. However, if you want to start off modestly, or try out something unusual, it isn't a bad idea to start with a small ship. If the idea works out well, you can enlarge your plans and try a big one. Big or little, decide on a fuselage length and wing span now.

Before you can draw the first line on brown wrapping paper using a yard stick as a straightedge, you will have to decide on your approach to construction, the engineering of the model. It is up to you to select the best structural method for your particular plane and your own abilities. The simpler the structure, the better it is likely to be; simplicity means fewer members, fewer joints, lighter weight, and greater strength. Not that it can't be overdone; remember the structure has to be right for your ship.

So spend some time studying the outlines of the plane, whether sketches of an original or three-views of a prototype; and note the form of the wing or wings, the fuselage, the rudder, and the elevator, the configuration of the landing gear, and of wing struts if any. Since by comparison with the fuselage the other parts of the plane are usually simpler, let's consider the body first. In studying the outline drawings, the cross-sections are of more importance than the side and top views. If the fuselage is square or flat-sided, as are many WW I jobs, for example, a simple box is probably the best choice.

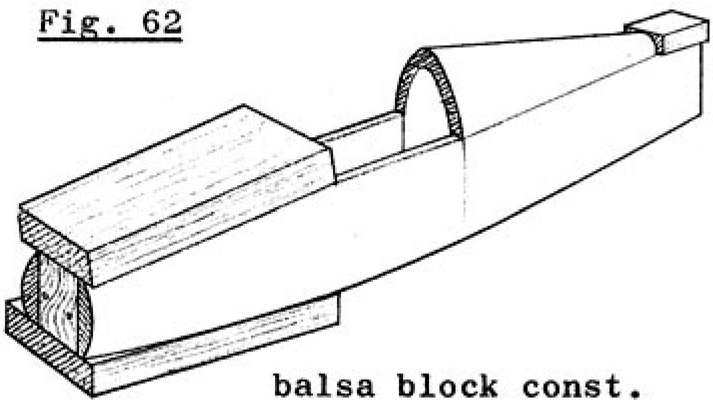


Figure 12.4: Balsa block construction.

If the cross-section is unusually complex, it may be easier to use crutch or half-shell construction; but remember, it is not necessary to resort to complex built-up structures as long as soft balsa is available (see Fig. 12.4). Unless you are already an expert builder (in which case you may step to the head of the class), you'd better stick to a simple method for your first few designs.

Next the tail assembly; for free-flight, elevators should be about 1/3 to 1/5 the area of the wing, with the rudder having about 1/2 the elevator area. Fig. 12.5 shows basic F/F sport proportions. For C/L design, the elevator should be about 1/5 the wing area, of which the hinged portion should constitute one-half. Rudder area is not critical on C/L models.

Scale-model designers, especially for F/F, have a habit of enlarging the tail assemblies; this is rarely necessary. One-third of wing areas is a standard elevator size for models,

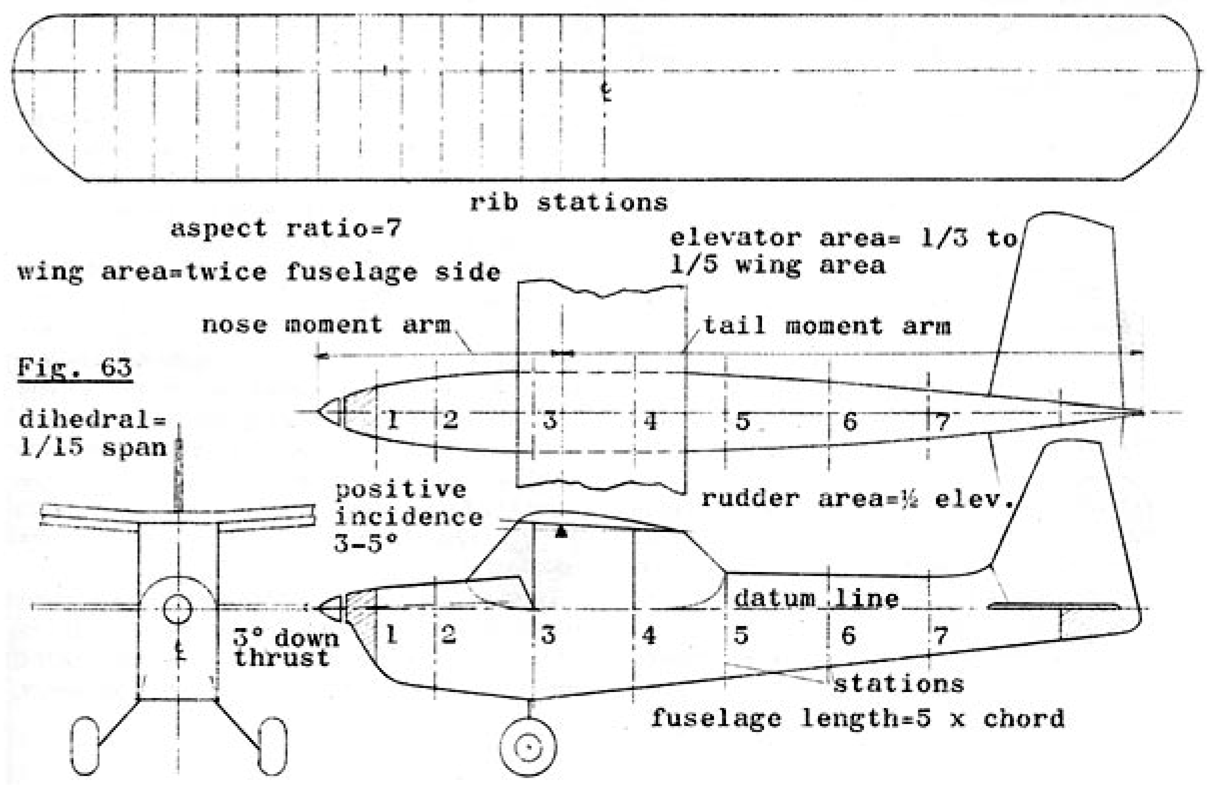


Figure 12.5:

but an elevator with 1/6 to 1/8 the area of the wing is perfectly O.K.
This is also a good time to give a thought to the method of attaching the tail members and hinging the control surfaces.
The area of a F/F wing should be about twice that of the side elevation of the fuselage, although you have wide latitude on this point. In terms of engine size, the average sport F/F wing for an engine of .049 cubic inches displacement has an area of about 100-200 square inches; for an .099, 200-350 square inches, and so on. Check magazine or kit plans for typical wing area-engine combinations. C/L wings are relatively much smaller - about 1/2 to 1/3 as large as a F/F wing for the same engine.
F/F wings should usually be of the knock-off variety, so consider how you'll attach them to the fuselage, and also how the cabin, wing struts, etc., will be affected.
Plan the mounting of the engine, landing gear, struts, etc., at this point, to obtain maximum strength with greatest simplicity; there is always a simplest way to solve any structural problem. While it isn't expected that all these points will be worked out before rough drawings are made, it saves work and complications later on if you can start drawing with some preliminary ideas.
Now you need a sheet of paper big enough to draw up the ship full-sized, a ruler and a long straightedge (a T square and a triangle if possible), a big eraser (who's perfect?), and a flat place such as a drawing board or a kitchen table to lay it out on. If you're doing a C/L job, have your fuel tank, bellcrank, etc., on hand to enable you to provide proper installation space for them.
To start the side view of the fuselage, draw a long straight line horizontally across the paper, parallel to the bottom, and high enough so that you can fit in the fuselage and

landing gear under it. This is the datum line of the fuselage, and all measurements and angles will be set up in relation to it.

You have already determined the length of your fuselage; lay it off on the datum line. Now find the datum line on your outline drawings, if you have scale views. If it's not indicated, or if you are using your own design sketches, assume a datum line through the prop hub, running back to the rear, parallel to the stabilizer.

If you are lucky enough to have enlarged three-views of your scale job, of course you are spared the next step, the construction of the full-sized outline, including wing and elevator cross-sections, around your datum line. If you are enlarging your small three-views, it is easiest to draw a grid over them, and then transfer the points to the large sheet, on which a correctly enlarged grid has been drawn (Fig. 12.6).

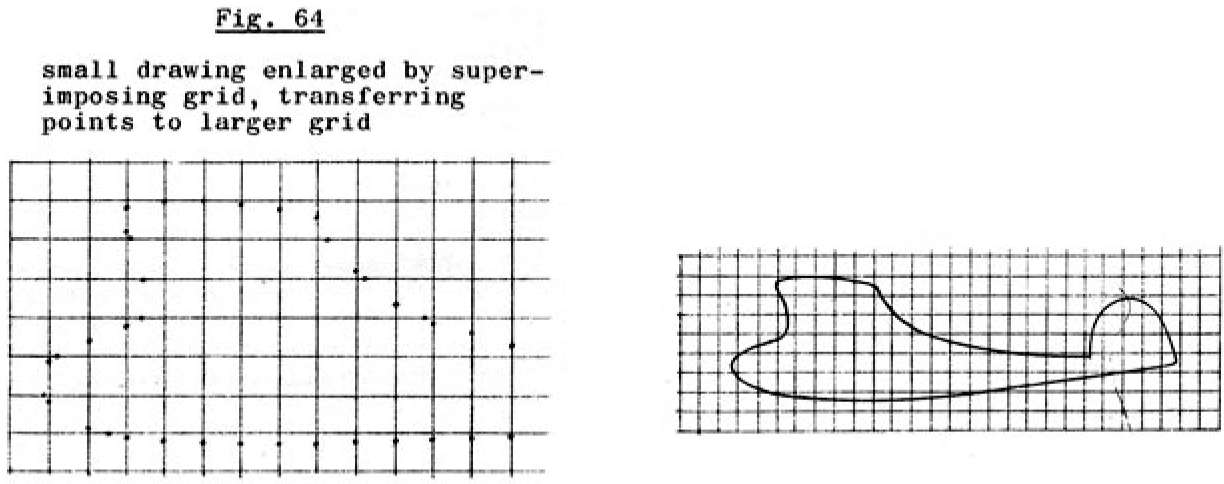


Figure 12.6:

The finished fuselage outline should show about twice as much area below the engine thrust line as above it, for stability. Sketch the engine, tank, wheels, etc., in position, and check clearances. Now look over the layout, and check a few general points. Is the wing positioned about 1/3 of the way back to the rear? If a F/F model, is the rudder about as big as the area of the side in front of the wing? If you're using a two-wheel landing gear, are the wheels a little ahead of the 1/3 point of the wing? (See Fig. 12.5.) If not, fudge the lines around until they are - this is where the eraser comes in.

When you have the side view outline done, draw the top view outline directly above it, with the front and back ends right in line. If you have cross-sections for a scale job, indicate their positions very carefully, and check to make sure their dimensions match the outlines. If they don't, stretch them around to fit.

Now you can start the engineering process by determining the location of your bulkheads, or former stations. Placing the engine on the plan, you can quickly locate the firewall. If the engine is radially mounted, the firewall must be placed so that the shaft protrudes the proper amount from the front of the fuselage. If the engine is beam-mounted, you have a little more leeway; but the closer the firewall is to the engine, and thus the shorter the unsupported projection of the beams, the better. This limited freedom of choice may allow you to place the firewall so as to attach landing gear or wing struts to it. You should keep in mind that holes may be cut in the firewall to accommodate rear-projecting tanks, air intakes, etc., thus shortening the beams. Don't forget to slant this section forward slightly to provide down-thrust, if the model is to be a free-flight job. Next, you'll have to provide a solid mounting for the landing gear. Assuming you're using a fixed gear on this first model, the simplest method is to bend a wire shape which has an upward extension which can be laced to a plywood bulkhead, with the legs projecting from the lower side of the plane (Fig. 12.7). This bulkhead will establish another station on your side view. If you're planning a low-or shoulder-wing model (not advisable on your first job), you may have to place the plywood piece horizontally or shorten it. The placement of the elevator should be decided now, too. If you plan a knock-off tail, which is a good idea on all free-flight models for ease of storage and crash protection, there will have to be a platform wide enough to provide a good base. If your top view is very narrow at the tail, you may have to add a balsa or plywood platform. Don't let any obstruction interfere with the pop-off of the tail. It is not a good idea to have a removable elevator in a slot; it's better to have the portion of the fuselage above the elevator, including the rudder, attached to the elevator and removable with it.

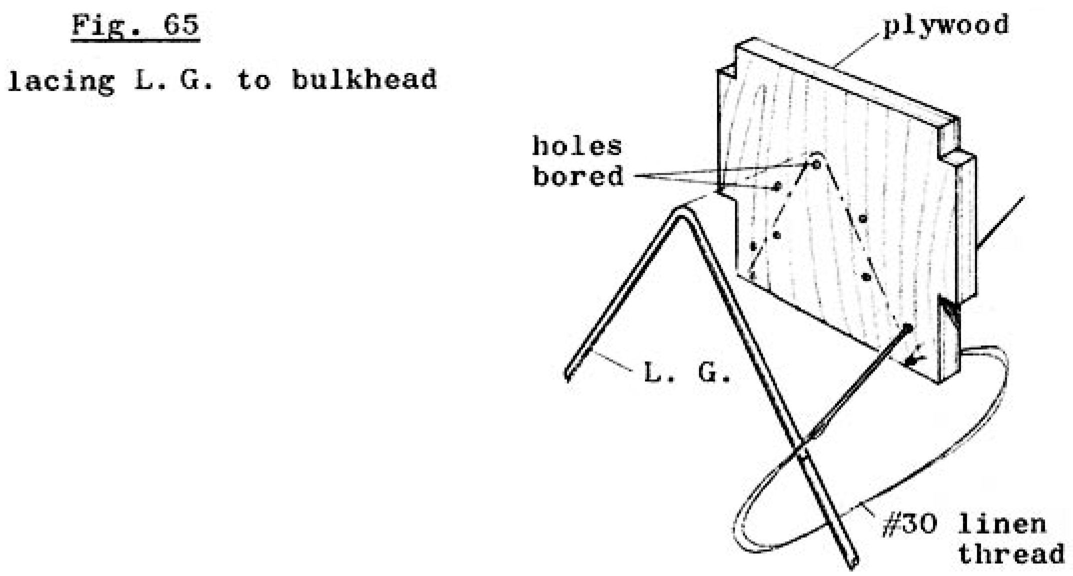


Figure 12.7:

If this is a control-line model, decide where the bell-crank will be placed, and how the pushrod is going to attach to the elevator, and where it is going to be located, whether inside or outside. Locate the holes in the bulkheads to accommodate it. If the ship is a profile job, or a simple sport flyer where appearance is secondary, it is often much simpler to mount the entire control system on the outside of the ship; but for good looks, the system can almost always be completely enclosed, if you have provided space for it. The wing mounting is next. The width of the wing (chord) should be somewhere in the general vicinity of 1/5 the length of the fuselage for free-flight, more for a stunt C/L job. The angle of incidence should be about 3-5[FFFD?] for the average F/F job, 0[FFFD?] for C/L. (The frequent use of the words "about" and "approximately" indicates the leeway you have as a designer.) A knock-off wing is a must for a free-flight job, except perhaps for the smallest all-balsa models. Dowels or rods for hooking the hold-down rubber bands should project about 1/2 inch, and should be very well anchored. Be sure they are evenly spaced at least as far in front of the wing and behind it as they are below it, to provide the proper fore-and-aft grip. If the wing is mounted atop a cabin with a curved front windshield, you can use a single center dowel for the front. A high-shoulder wing can be handled like a top-mounted wing, by having the portion of the fuselage above the wing removable with the wing. Cut the removable section at an angle of 45[FFFD?] to permit easy release in a crash (Fig. 12.8).

Fig. 66

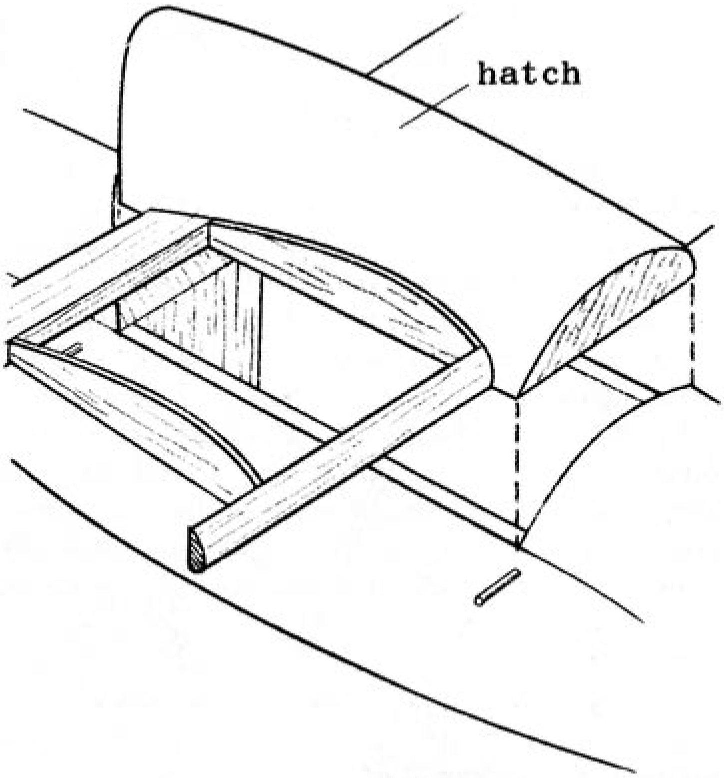


Figure 12.8:

Now, with these details worked out, set up the remaining stations, each of which will require a cross-section. You won't need more than eight stations altogether, including the firewall and rear post, unless you have something extra long or large in mind. The remaining stations should be spaced between the ones already established. Try to arrange things so that you have a vertical member (either a bulkhead or a side spacer at a station) to support the trailing edge of the wing and the wing mounting dowels, and another at the front of the elevator. A little juggling of the outline of an original should enable you to make everything come out about even. If you are building a scale model, the stations shown on your source three-views will probably be quite satisfactory, and should be used, especially if you have the cross-sections to match them.
Now decide how you will handle such items as the window outlines, strut mountings, and other features. Frequently, the window-sill line on a cabin model will give you a good starting line for a side frame or a crutch. Consider in advance how you're going to anchor load-bearing struts - don't try to fit them into a finished design.
If the design is an original, now is the time to work out the cross-sections. You know about what you want; just be sure you follow the widths and heights established by your side and top views, and lay out a firewall, a section near the center, and one to

the rear. Keep the placement relative to the datum line the same as on the side view. Looking at the cross-sections of the fuselage, pick out any flat side area which can be built directly on the plan; if there is no such area, look for a basic rectangle to which you can add formers to build out the outline. If the cross-section is curved all the way, it is still quite easy to build it up on a basic box. Start by drawing a rectangle on the plan of the firewall (of the section nearest the front). Try to determine the largest rectangle you can fit into the curved shape, touching at all four corners. Now measure down from the top of the curved cross-section to the top of the inscribed rectangle, and lay this distance off on the side view of that same section, which should be station No. 1. Next do the same with a section about halfway back; if there is a window sill to consider, use this as the location of the top of the rectangle, at the appropriate section. Repeat with a section near the rear. Through the three points thus established on the side view, construct a smooth curve. This can easily be done by placing pins in the points and bending a balsa strip along them. If you are doing a cabin model, the line should probably be interrupted at the rear of the cabin and continued higher up. Then lay off the bottom, spacing in the same way. Voila! You have the side frames laid out.

Now, on cross-section No. 1, measure the distance from the side curve in to the side of the rectangle and lay it off on both sides of the top view, repeating for the other two stations, again constructing a curve through the points.

Now, at each station on top and side views, measure the distances from the outline in to the curves you have just drawn, and lay these distances off on the remaining cross-sections to get the exact shape of your formers. If you have yet to draw these sections, construct them using these points and the heights and widths from your side and top views. If you need more than the four points of a rectangle to sketch in the required curves, draw a second set of rectangles, with corners falling between the corners of the first set and top, bottom, and side center points, and lay out a second series of points. By drawing the smooth curves on the side views, you will be assured of a smooth contour on the finished fuselage (Fig. 12.9). Of course, if you are doing a scale job and have all the sections, you can skip this step.

With the outlines of your side frames set up, you can select a size for the longerons and spacers, and draw them in. For a fuselage up to about 20 inches long, 3/32" square medium-hard balsa is generally large enough. 1/8" square will make a sturdy fuselage 30 inches long, and 3/16" will handle anything up to man-carrying size. Certain members, such as the window sills, the vertical at the rear of the wing, and the rear post, should be about double the size of the rest of the frame. It is a good idea to cut curved formers from sheet balsa of the same thickness as the frame members, to avoid having to bend any deep curves (Fig. 12.10).

Cabins can be laid out as a part of the side frame or they can be built up and added to the box after the sides are joined, as shown in Fig. 12.10. This is a good idea when the sides are curved at the position of the cabin. Keep wing mounting in mind, if you have a high-wing job, and plan a cabin roof to receive the wing. If you prefer, you can use another structural method to build up the body. If you use a crutch, place it so that it doesn't interfere with window sills on a cabin job, and so that beam motor-mounts, if used, can be attached to it. If your cross-sections have been laid out on a single line representing the datum line, you will easily be able to indicate the position of the crutch on both side and top views.

The crutch is built on the top view, with cross-pieces placed at each station. The crutch members should be about twice as large as box members for the same size ship. Cut

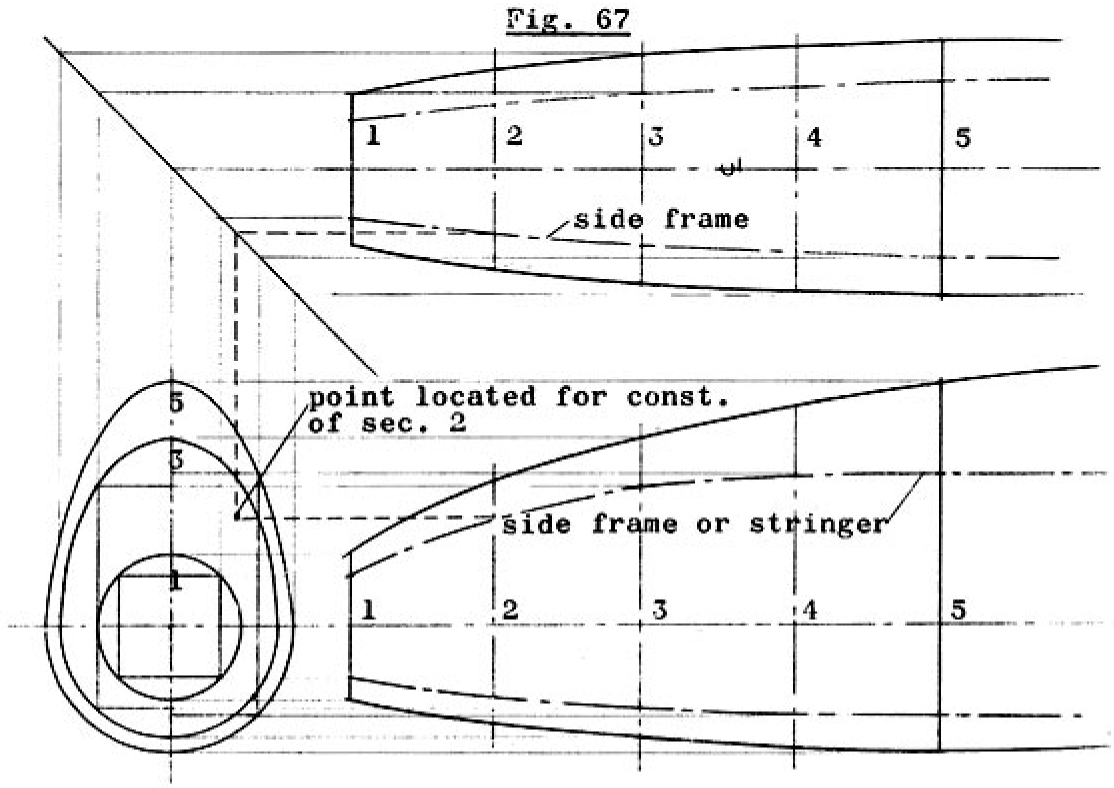


Figure 12.9:

the bulkheads apart at the line where the crutch divides them, and notch them to fit over the crutch. A bottom keel should be designed to give rigidity to the structure, and notches provided in the bulkheads to receive it. Curved formers should be used rather than deep bends, which will draw the frame out of line.

If the half-shell method is used, both top and bottom keels will be necessary. Draw them on the side view, and notch the bulkheads for them.

For these two methods, plywood bulkheads should be used where the greatest loads will be applied; e.g., firewall, landing gear mounting, etc. These should not be cut; the framework should be assembled without them on the plan; after the framework is complete, they can be installed with any required landing gears, wing struts, etc., already attached.

With the basic framework designed, it is time to give some thought to covering. If the framework is to be tissue- or fabric-covered, you don't need to do anything further at this point, but if you plan to use sheet balsa covering or strip balsa planking, the thickness of this should be indicated now on all views, including bulkheads, so that the formers can be cut undersized. The planking will build the section out to the required finished contours. In some places, as for example the nose section, it is advisable to either plank or fill the framework to give greater strength. Scale models representing other than fabric-covered prototypes should be balsa-covered if possible, for better appearance. If you are faced now with any awkward situations, such as compound curves, hard-to-manage fairings, tricky cowlings, etc., which present construction or covering difficulties, remember those soft balsa blocks.

Fig. 68

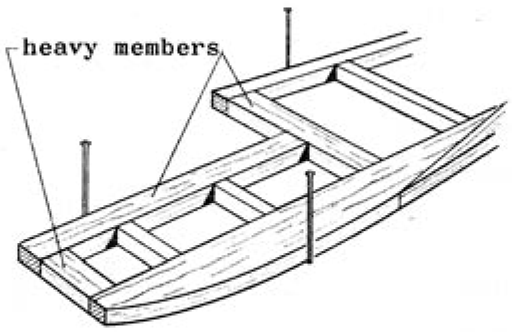


Fig. 69

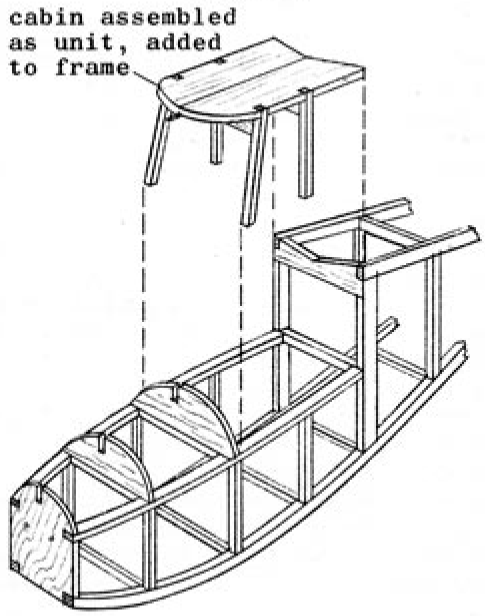


Figure 12.10:

Before going any farther with the fuselage design, you'd better give detailed consideration to wings and tail. Tail assemblies are easiest, so let's get the rudder and elevator out of the way first. Solid balsa, or sheet balsa tails can be used in almost every instance, even on contest-type models. The only exceptions are large free-flight or control-line scale jobs, where the weight might prove excessive. Small free-flight tails may also be cut from sheet balsa. For small models up to about 20 inches in span, 1/16" medium balsa is fine, 3/32" will do for jobs up to 36 inches; above that, use medium-hard 1/8" for C/L, and built-up construction for F/F.

Tail assemblies for scale C/L models having thick sections can be carved from soft balsa, for high-powered ships up to about four feet in span. Beyond that it is advisable to consider building up tail surfaces using thick soft balsa squares for leading edges, deep spars, solid tips, and sheet balsa covering.

Check the finished elevator and rudder outlines against the fuselage drawings to be sure everything is going to fit. Start the wing by drawing up an outline and a front view.

The wing, with few exceptions, should be built in one piece. If you are working on an F/F original, you can choose simple dihedral, polyhedral, or tip dihedral; just be sure to get the tips about 1/15 of the span above the center section. The outline can be rectangular with square or curved tips, tapered, or elliptical, in order of difficulty. Fig. 12.11 shows several dihedral schemes and outlines. You can vary these to suit your taste. For your first job, a constant-chord wing is recommended, as all the ribs will be identical and you will be saved the labor of working out a dozen different rib outlines. By varying the tips, a great deal of variety can be obtained with such a wing, and in both design and construction it is a timesaver.

Don't spend too much effort on the creation of your airfoil; on sport model planes, airfoil is not critical. For all practical purposes, in sport flying, an approximation of one of the widely used airfoils such as the Clark Y will work very well. Fig. 12.11 shows some basic types, and you can easily pick up a good airfoil from a kit or magazine plan.

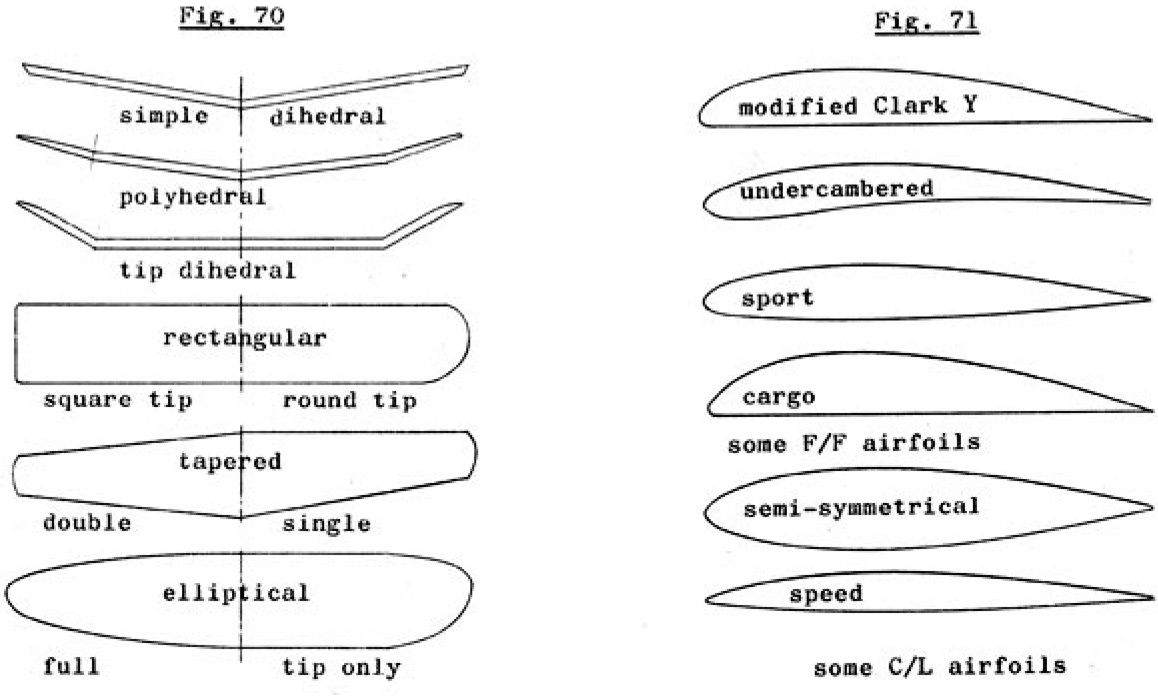


Figure 12.11:

Later, when you have graduated from the primary designers' class, you will have plenty of time to experiment with the fine points of airfoil design.

If you plan a tapered or elliptical wing in which all the ribs are different, start by drawing up a root and a tip rib and making a pattern for each from aluminum. Decide on your rib spacing and wing span, and count the number of ribs you'll need. Next, cut a set of blanks from 1/16" balsa, graduated in length and width to conform to the dimensions already established in your front and top views. Stack the whole set of rib blanks in the correct order, with the metal patterns on the outside, and drill a hole through the stack, preferably where the spar will be located; then run a bolt through the hole, and tighten it up. With a sanding block you can now quickly shape all the ribs as a unit; trim the front and rear ends and notch (Fig. 12.12).

Separate the ribs and use them as patterns for the ribs for the other half of the wing.

If the wing is balsa-covered, or if cap strips are used on the ribs, the slight bevel of the outlines will cause no trouble, although the ribs from the two sets should be alternated in each wing panel to equalize differences. If the wing is to be tissue-covered without caps, two new sets of ribs should be cut, using the first set merely as patterns. An alternate method is to construct each rib by a method similar to that employed to lay out the fuselage cross-sections (Fig. 12.13).

In drawing up a scale wing, particularly a deep-sectioned wing for a scale model of a heavy airplane, it is important that the front view show the correct datum line on which the spars are based; otherwise, you'll end with a wing having strange and mysterious warps which can't be corrected, usually the result of assuming that the angle of the bottom of the wing is constant from leading edge to trailing edge. This is definitely not true; the angle of dihedral or taper is constant from edge to edge only along the plane of the datum line. This line should be indicated on three views; if it isn't, it

Fig. 72

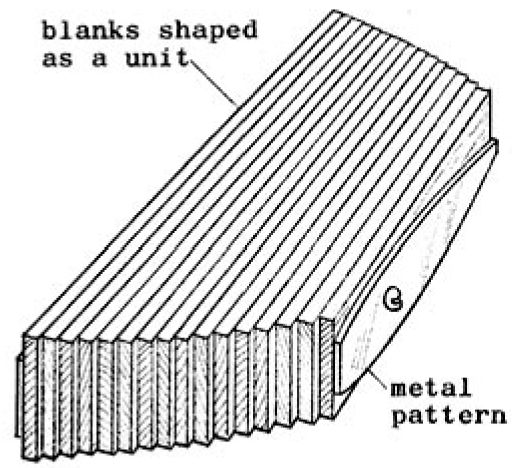


Figure 12.12: Wing rib production.

will be necessary to determine it before designing spars. For practical purposes, it can be assumed to run through the foremost point of the leading edge and the center of the trailing edge. This line should be carefully located on the front view, and the spars constructed on it, referring to the rib patterns for correct depth at each rib station. If the wing has a constant taper, the spar can be constructed from root and tip ribs only.

For non-scale wings, spars should be located at the deepest point on the rib outline, usually about 1/3 of the way back from the leading edge. The total cross-section area of the spar or spars, which should be made from hard balsa or yellow pine, or laminated balsa-celluloid-balsa for heavy ships, should be about 1/50 of the chord area. More simply, for a rib 5 inches long a spar 1/8" x 1/4" or 1/16" x 1/2" should be adequate. Unless you're using a one-piece or reinforced spar, reinforce dihedral joints with a piece of thin plywood or thick celluloid cut to follow the dihedral angle, and extending to the ribs on either side of the dihedral joint, as shown in Fig. 12.14. The trailing edge should be, in width, about 1/6 the length of the rib; the leading edge should extend back about 1/10 of the length of the rib, spliced in the same way as a spar, with reinforcement.

Free-flight wings are usually attached after everything is completed, but fixed wings are frequently installed midway through the building process. Sometimes a spar and leading and trailing edges are slipped through the finished fuselage, and the ribs and remaining structure added later (Fig. 12.14). Or it may be necessary to install an almost completed wing in a half-built fuselage, in order to get the greatest ease of assembly.

Before going further with the design process, the fuselage should now be built up to the point discussed. Note on the drawings any changes that become necessary or advisable during construction. With the basic frame complete, it is easy to visualize construction details, and plan the next steps, as well as to criticize what's already been done. Don't hesitate to chop, splice, alter, and improve your framework now and reflect the improvements in the plan.

Install the hardware, such as landing gear, motor mounts, tank, bellcrank, etc. Next, go ahead with the wing framework (or the portion of it which will be installed as a unit in

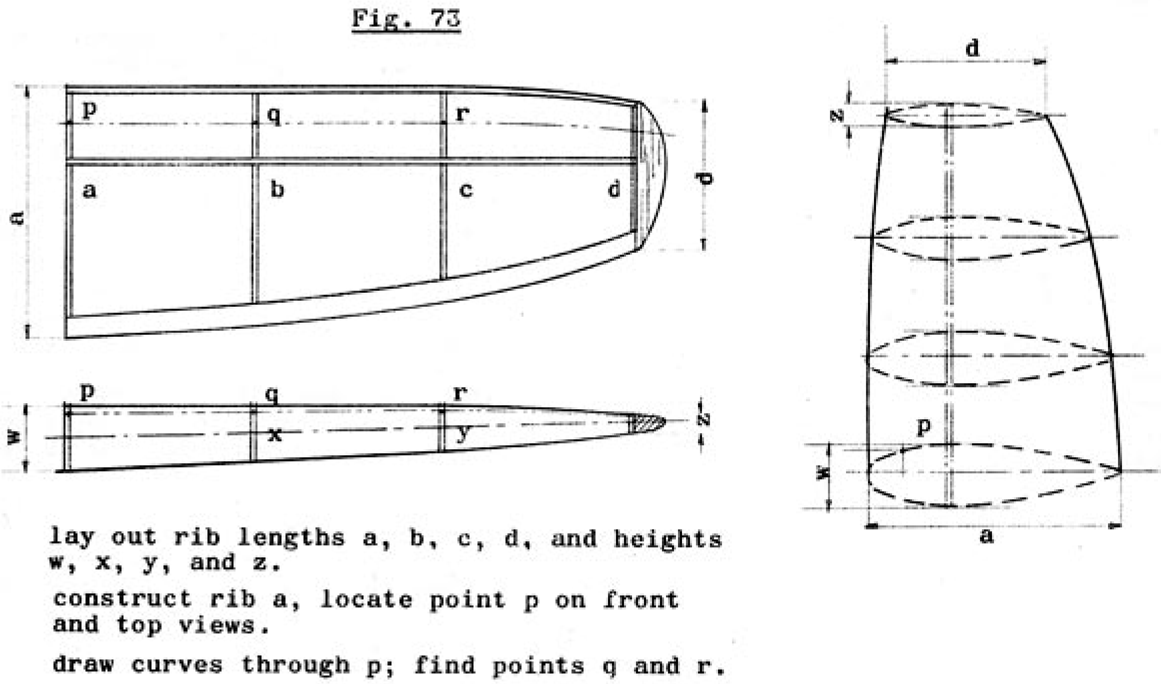
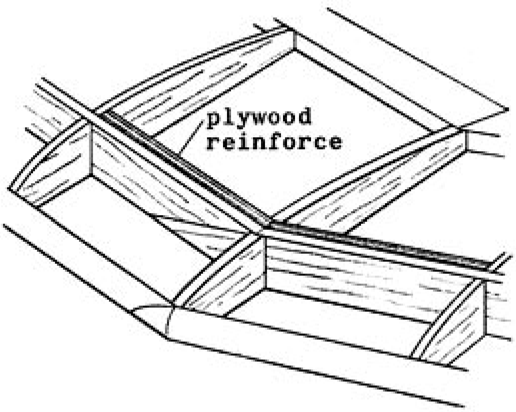


Figure 12.13: Alternate ribbing.

the fuselage) and the tail surfaces.
Check the installation of these to make sure everything is going to fit. Install any assemblies which can now be added without interfering with the development of the fuselage, but don't rush things. If you are satisfied the wing and tail will drop into place when ready, you can go ahead with the fuselage. Decide now where you'll need stringers, fairing strips to even up surfaces for smooth covering, reinforcing gussets and filling. Make any attachment points which may be required for cabane struts or other fittings. Don't wait until the framework is complete, and then try to put the works inside with tweezers - it won't do. Study the contours and decide what areas to cover with paper, which ones to plank, where to use blocks - if you still have any doubts on these points. Plan the method of building up the cowling, if any, and use direct measurements to fill in any doubtful points on your plan.
Now go ahead to complete the model, following your plan, amending it when necessary. Don't add any details to the ship at this point, or apply a fancy paint job. Complete only the part of the work that's necessary to enable you to make flight tests. Wheel pants, cowlings, rigging wires, etc., affect the flight very little, and will merely be liable to damage.
With other flyers, spectators, small boys and cows in the area alerted, you are now ready for the first flight of the X-l. Make your first tests even more cautiously than you would with a kit model, but following the same procedure of careful test glides, low-power flights, and constant adjustment. If you have adhered to the rules of thumb discussed above, you should have a flyable ship, but only after proper trimming. After you have gotten the ship trimmed, indicate the balance point, final angle of incidence, etc., on the plan. It may even be necessary to alter the ship by moving the wing, shortening the nose, shifting the position of the L.G. Don't be bashful about operating on the model to make these corrections; very few ships fly perfectly, right off the drawing



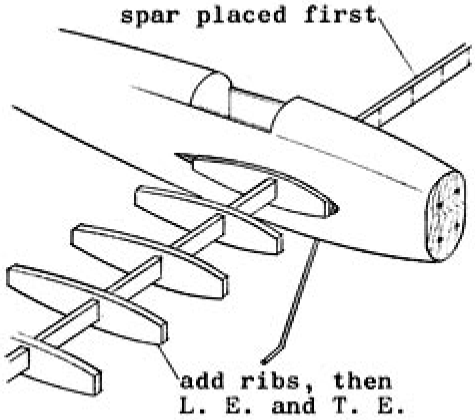


Figure 12.14:

board.

You may, of course, have the unhappy experience of discovering that your plane will not fly at all, even with every possible adjustment of incidence, thrust, trim, power, and balance. That means that you have another job ahead; finding the flaw in your design and correcting the trouble. After all, that's part of being a designer!

Let's picture a few symptoms of design error, and see if we can decide what to do about them. Suppose your F/F ship heads out fine under power, but begins to swing from side to side in a rocking motion, or flips over and spins in. Chances are, you need more rudder area. Sometimes this shows up only in the glide, or in a high wind, but that tell-tale rocking is a giveaway. Increase the rudder area by half for a start, and try again.

On the other hand, perhaps your job sails out in a nice climbing turn that keeps on turning - right into a spiral dive. That usually means too much rudder area, or not enough area down low, or inadequate dihedral. Or perhaps your center of lift is behind the center of gravity. In that case, reduce incidence and load the tail.

If the plane is very mushy in the glide, you probably have a built-in head wind, such as too much incidence to compensate for excessive nose heaviness, or possibly too thick a wing section, or in a biplane, wings placed at different angles of incidence.

If the plane upsets easily in a wind, while flying well in calm air, this could mean insufficient dihedral of rudder. If the ship glides, but bores in under power, perhaps you have a negative angle of incidence in the wing, in relation to the elevator, or too much down-thrust.

If none of these diagnoses seem to be applicable, ask an experienced modeler to take a look, or compare your ship with kit or magazine plans of a generally similar design, looking for the difference which might be causing the trouble. Unless you've wandered far from the general restrictions set forth above, the ship will eventually fly.

C/L trouble-shooting is considerably simpler, since the lines restrict the action of the ship, and inherent stability is not a necessity. If your ship complies with the usual balance criteria and has enough power to lift off the ground, it is sure to fly. If it doesn't, re-check balance, rudder, and engine offset.

Having seen your ship do its successful solo, you can go ahead and finish up the de-

A twin-engined C/L job with clockwork retracting gear Keith Laumer photo

Figure 12.15: A twin-engined C/L job with clockwork retracting gear.

tails and add the extras which give it the finished look you want. The experience you gained in flying the model may lead you to change some of your ideas along these lines. Items which look good on paper can sometimes be a nuisance on the flying field. But note it all on the plan; after all, the experimental ship was merely a device to assist you in drawing the plans. You may wish to make structural changes now, consolidate and smooth out some of the on-the-job corrections you made on the model. When you're satisfied that you have all the corrections, additions, deletions, and alterations done, re-draw the plan carefully on plain white paper. If you make your drawing on draftsman's tracing paper, using a No. 3 (or 3H) pencil, you can have it reproduced cheaply at your local blueprint shop, thus enabling you to pass out copies to your friends and see your job mass-produced. This is the acid test; the flying ability of a plane built by another modeler from your plans is the measure of your success.

Keith Laumer Plans

Full-size plans for Keith Laumer designs are available from Aeromodeller Plans Service, Box 35, Hemel Hempstead, Herts, England, HPI 1EE.

Whizzler - 24" all balsa glider (order code number G 791)

Flutterbus - 18" simple rubber-driven model (order code number D 797X)

Sure Flyer - 30" Rubber-driven duration (P. 185) (order code number D 800)

Sharp Scooter - 29" Free-flight power model (order code number PET 804)

Sharpoon - 36" Control-line acrobatic (order code number C/L 706)

Price of each plan approximately 45p.

the end