CONSTRUCTION *for* AEROMODELLERS

AN MAP FIVE SHILLING BOOK

and, with care, producing smooth, accurate shapes.

Precautions with Power Tools

In the case of all portable power tools where the electric motor is part of the unit we would particularly stress the necessity of connecting up the earth lead and not just disregarding this and making connection to an ordinary two-pin socket. Should a fault develop on the internal connections, and after all the leads do get a lot of rough treatment, the full mains voltage *can* be transmitted to the casing and give the user a nasty shock. Also, after sanding a lot of balsa the air will become thick with balsa dust, a good proportion of which will have been sucked into the drill. So do not work too long sanding in a confined atmosphere—or, if this is necessary, wrap a handkerchief over your mouth and nose as a mask. Otherwise you will find yourself getting literally clogged up with balsa dust. And remember to clean out the drill itself occasionally. An accumulation of dust can ignite and start a fire inside the casing.

The rest of the tool kit we will leave to your imagination. A rubber modeller will want a sharp knife for carving propellers. One or two screwdrivers will be essential to the power modeller, together with box spanners in appropriate sizes. Most modellers, too, will want a soldering iron, and so on. Then *all* modellers will also want one item we have not mentioned so far—a building board.

Building boards

A good building board is very important. One which is true and flat and large enough to take all the work likely to be undertaken. A large drawing board is undoubtedly the best type of building board, although these rank as rather expensive items. A good building board *is* worth the money spent on it, but it is readily possible to *make* a satisfactory board from ¼ in. balsa sheet, as in Fig. 8, for a cost of something like ten shillings. Choose hard or medium sheet and make the glue joints accurately. Ordinary wood glue can be used, being considerably cheaper than balsa cement. Such a board will have one very desirable feature of a good building board—that the material is not so hard that pins cannot be pushed in with the fingers.

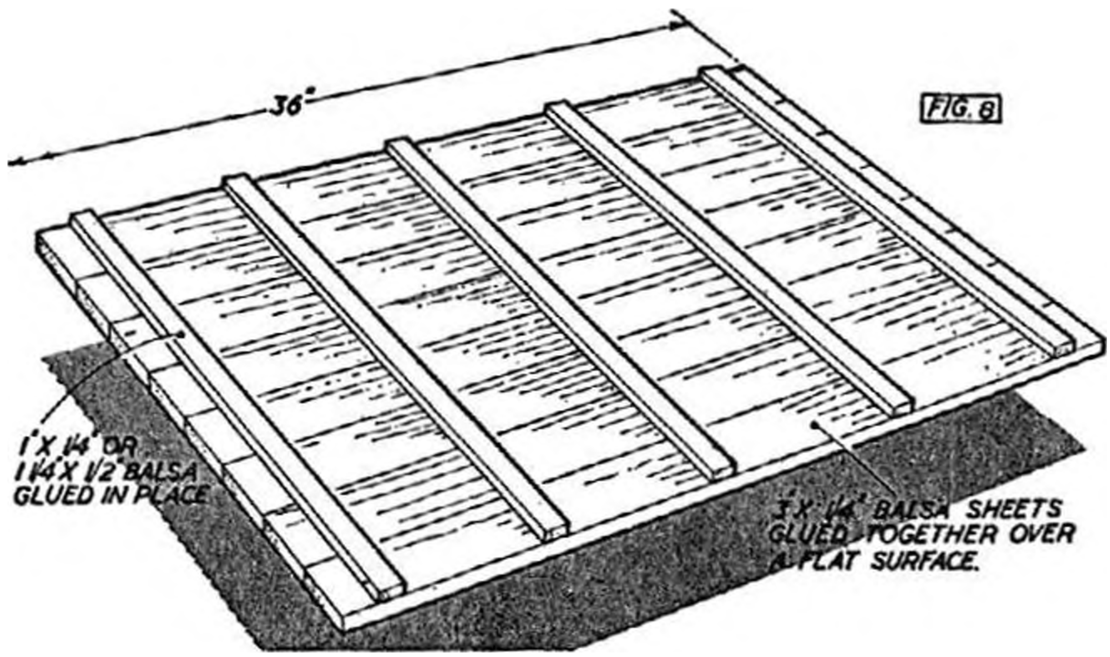


FIG. 8

Chapter Two Materials

BALSA wood is the universal airframe material and it is as well to know something of the properties of balsa wood before using it. Its most important characteristic is its extreme lightness for a quite remarkable strength. No other material compares with it in this respect. At the same time, balsa wood as a whole has one great defect—it is not homogeneous. That is, it is not *consistent* in quality or characteristics. In a single sheet one part is likely to be stronger and heavier than another, and even in a single *strip* length, both strength and weight can vary from end to end.

There are several ways of overcoming these defects. The best method is by careful initial selection of wood for a given job and then the proper *use* of that wood. So much depends on the type of model you are building. Where airframe weight is of extreme importance, wood selection is one of the most important items of the construction. On a control line model, where wood sizes are more generous and weight less critical, it is generally sufficient to use hard or medium hard balsa without worrying unduly about the quality.

Wood density

The weight, or rather the density, of the balsa wood alone is no accurate guide to strength. As a rough rule the heavier the balsa the stronger it is, but certain wood can be very heavy and at the same time brittle and lack strength. Experience is the only true guide to wood selection and, lacking this experience, the best plan is to get an experienced modeller to go along with you and help you with your purchases. Or you can rely on the retailer to help you with your selection. Many retail shops make a point of such service. The first step to becoming a good model builder is not to just buy "sheet and strip" but purchase *selected* sheet and strip. It can make a lot of difference both to the finished model and in making the actual building easier.

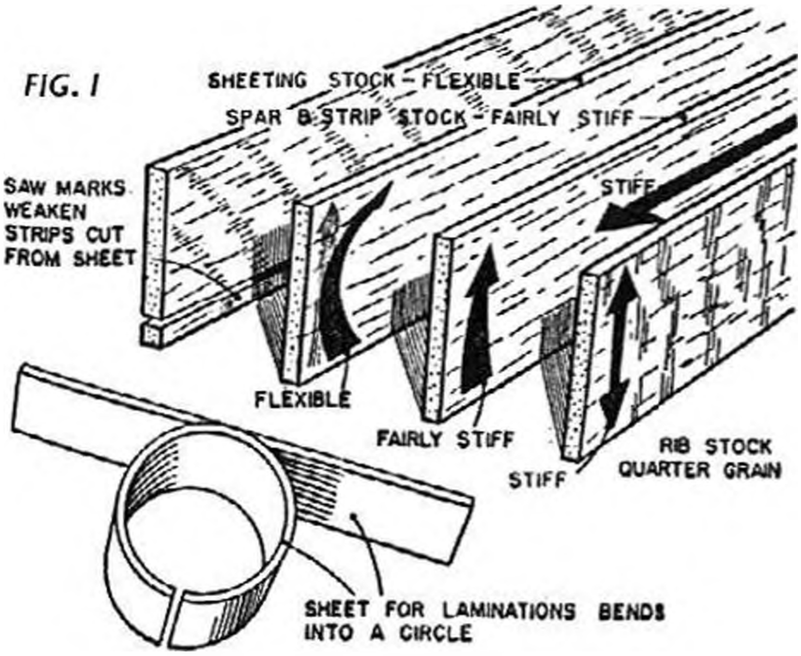
As far as sheet wood is concerned, here is a rough guide for selection. The usual type of cut is with the grain of the wood running from end to end and the best wood is generally that which has a uniform appearance as regards both colour and grain. When sheet has been well cut it is impossible to see saw marks, but if the saw was blunt, or a tooth was out of line at the time of cutting, this will be reproduced as a series of sweeping lines across the sheet. This is undesirable, but not sufficient cause on its own for rejecting such a sheet unless it was intended for stripping up into spars. More important is the manner in which the sheet responds to bending.

Sheet covering

For leading edge covering, and so on, sheet is required which will bend readily edge to edge. If it is stiff in this direction it may split when you try to apply it to the work. For leading edge covering work the sheet should be fairly stiff end to end. For laminated construction, where strips are cut off the sheet and then cemented together, layer on layer, around a curved former, sheet which bends readily end to end is required, with a certain stiffness edge to edge. Laminated work is mostly confined to the smaller models when the strips for lamination are generally cut from 1/32 sheet. Suitable sheet for lamination should readily be capable of being bent round into a perfect circle, when stripped down to $\frac{1}{8} \times \frac{1}{32}$ in. strips these can be bent "dry" through a one inch radius without splitting.

The ideal sheet wood for cutting ribs is of quite different appearance. It is known as quarter grain, representing a slightly different cut of the original

FIG. I



BALSA STRIP SELECTION
(Recommended Wood Density)

Use	Size (in.)	Rubber	Glider	Power
Longerons ...	3/32 sq.	12–14	—	—
	1/8 sq.	10–12	12–14	—
	5/32 sq.	10	12–14	—
	3/16 sq.	8–10	12	12–14
	1/4 sq.	—	10–12	12
Spacers ...	3/32 sq.	10–12	—	—
	1/8 × 1/16	10–12	—	—
	1/8 sq.	8–10	10–12	—
	5/32 sq.	8–10	10–12	—
	3/16 sq.	8	10	10–12
	1/4 sq.	—	10	10
Mainspars ...	...	12–14	14	12–16
Leading Edge	...	6–10	8–10	10–12
Trailing Edge	...	10–12	10–12	12–14

lumber. The surface is speckled in appearance and the sheet is very stiff and rigid in both directions. Quarter grain stock is easily recognisable by appearance but, on average, forms only a small proportion of the normal supplies which reach the retail shops. A common fault with quarter grain stock is that it is on the heavy side, so this is a point to be watched where airframe weight is critical. As a guide, a sheet of 1/32 balsa for Wakefield ribs should, ideally, weigh just under ¼ oz., and at the same time have the necessary rigidity and strength. Such wood can actually be stronger, and very much lighter, that 1/16 in. sheet, or even thicker, in the wrong *type* of sheet.

For estimating the *strength* of sheet and strip wood some modellers make an impression with their thumb nail and judge the strength from the resistance felt. Whilst, with practice, this can give excellent and quite reliable results, few retailers will take kindly to having their wood stocks treated in this way.

There is one tip about the packaging of sheet and strip

WEIGHT OF BALSA STRIP (Weight in ounces of number of strip lengths specified in lower line)
3 ft. Strip Lengths

Wood Density lb./cu. ft.	1/16 sq.	3/32 sq.	1/8 sq.	1/8 × 1/16 sq.	3/16 sq.	1/4 sq.	1/4 × 1/8	1/2 × 1/8	1/2 × 1/4	1 × 1/4
6	0·125	0·14	0·125	0·0625	0·281	0·5	0·25	0·25	0·25	0·5
8	0·17	0·1875	0·17	0·085	0·375	0·67	0·33	0·33	0·33	0·67
10	0·208	0·234	0·208	0·104	0·47	0·83	0·42	0·42	0·42	0·83
12	0·25	0·281	0·25	0·125	0·56	1·0	0·5	0·5	0·5	1·0
14	0·292	0·328	0·292	0·146	0·66	1·17	0·58	0·58	0·58	1·17
16	0·33	0·375	0·33	0·167	0·75	1·33	0·66	0·66	0·66	1·33
No of Strips	16	8	4	4	4	4	4	2	1	1

wood which is worth remembering. In the original packaging, as a general rule, adjacent sheets (or strips) have been cut from the same piece of lumber. If one piece appears very satisfactory, adjacent pieces on either side are usually very similar. Knowing this can speed selection quite a lot. Bear in mind, however, that the original sequence will probably be destroyed after the stock has been sorted over a number of times. Few retailers *mind* customers sorting over their sheet and strip stock, provided the customers know what they are doing and do not abuse that privilege.

If you must test strip wood on the spot—and for your own satisfaction you should do—then any length selected should pass the simple test illustrated in Fig. 2. This is, hold the strip at one end and wave the other end up and down gently. Cross grained or weak strip will snap. Faulty wood will crack. Sound wood will whip with a nice springy feeling. Even 1/16 in. square stock should be capable of passing this test.

We shall be dealing further with wood selection when we come on to describing the building of the actual components, as the requirements for spar stock are very different for leading edge stock, for example, in wing construction, whilst different wood is often used for longerons and spacers in a simple box fuselage. This emphasis on wood selection may seem unnecessarily complicated, but it is not. It makes the job easier to

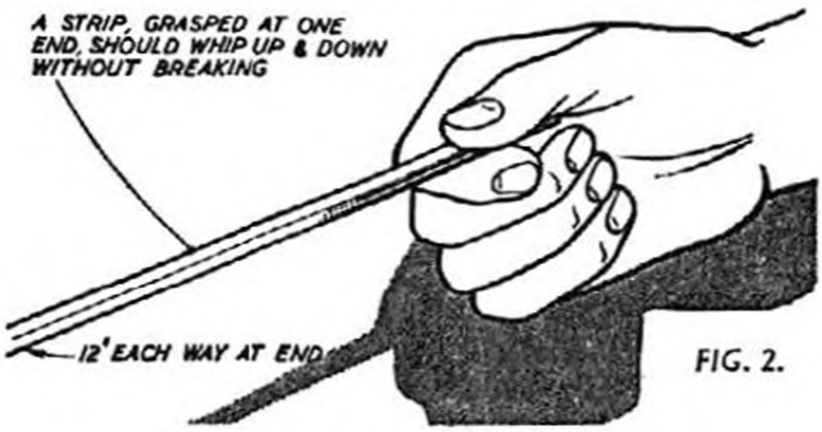


FIG. 2.

BALSA SHEET SELECTION

Use	Size (in.)	Rubber	Glider	Power
Ribs ... ... (Quarter Grain)	1/32	6–8	10–12	—
	1/16	8	10–12	10–12
	3/32	—	10	10–12
	1/8	—	8–10	10
	3/16	—	—	8–10
Ribs ... ... (Straight Grain)	1/32	10	12	—
	1/16	8–10	12	12–14
	3/32	8–10	10–12	12–14
	1/8	—	8–10	12
	3/16	—	—	10–12
Wing Sheeting	1/32	6–8	8–10	—
	1/16	6	8	10–12
Wing Tips, etc.	1/16	12	12–14	—
	3/32	10–12	12	12–14
	1/8	10	10–12	12
	3/16	—	—	10–12
Formers ...	1/16	12	14	—
	3/32	10–12	12–14	12–14
	1/8	10–12	12	12
	3/16	—	10–12	10–12

WEIGHT OF 3 ft. BALSA SHEET (ounces)

Wood Density lb./cu. ft.	1/32"	1/16"	3/32"	1/8"	3/16"	1/4"
6	0·1875	0·375	0·5625	0·75	1.125	1·5
8	0·25	0·5	0·75	1·0	1·5	2·0
10	0·3125	0·625	0·9375	1·25	1·875	2·5
12	0·375	0·75	1·125	1·5	2·25	3·0
14	0·4375	0·875	1·3125	1·75	2·625	3·5
16	0·5	1·0	1·5	2·0	3·0	4·0

build and produces a stronger overall result.

Kit Wood

Even kit models are not necessarily excused this preliminary construction stage. It will readily be appreciated that when a kit model is produced in its thousands close control over the quality of all the balsa wood in any individual kit is quite out of the question. Manufacturers generally combat this in two ways. Initially wood is selected according to requirements—certain lumber for sheet parts, certain stock for stripwood. Almost invariably, too, the design of the model itself allows for considerable variation in the strength of individual wood parts. The overall result is generally quite satisfactory, but that is not to say that any model built from an individual kit could not, perhaps, be improved by replacing certain kit parts with individually selected sheet or strip stock.

The serious model builder, in the long run, becomes very "weight conscious". Just as the full size aircraft designer is continually fighting a battle against increasing weight as greater strengths are required of his airframes, so the model builder sets out to reduce the weights of his structures without reducing their strength.

Hardwoods

Stronger, heavier woods, such as obeche, birch and spruce, are used to a much more limited extent in aeromodelling, mainly on account of the weight penalty involved. Birch and spruce are, however, very useful for strong spars in wings where weight is not critical, e.g., glider wings. Obeche is not so satisfactory as an alternative structural material since it tends to be brittle and lacks uniform strength. Woods of kinds other than balsa used in aeromodelling are generally referred to as 'hardwoods', although such a definition may not be technically correct. The one part of an airframe where hardwoods are used exclusively is for engine bearers—beech, maple and ash being favoured materials here.

A point to be borne in mind is that many ordinary balsa cements do not give satisfactory glued joints with hardwoods and so a slower drying nitrate or 'strong' cement is generally preferred. Double-cementing is advisable, as an additional precaution.

Plywood

The most satisfactory plywood for aeromodelling use is resin-bonded waterproof (aircraft quality) ply, which is available in a variety of thicknesses from 1/32 in. up. The really thin plywoods (up to 5/64 in.) are generally used only for nose formers on rubber models. The front former or fire-wall of power models is invariably made of ply —3/32 in. for small models, ⅛ in. for medium size models and 3/16 or even ¼ in. ply for large models. Similar remarks as above apply with regard to gluing plywoods.

Glass Plastics

No description of aeromodelling materials would be complete without mention of the glass plastics used for the production of moulded shapes. These are relatively new, being introduced on a commercial scale only in 1954. Briefly, glass plastic mouldings are produced by laying glass cloth or layers of glass tape onto a suitable form, coating with a thermo-setting resin solution and allowing to set. The result is an amazingly strong 'moulding', easily made and not unduly heavy.

The technique can be varied considerably, according to the requirements. Also resin-impregnated glass cloth or tape can be used as a binding to reinforce structures (e.g., the nose of a fuselage). Also the resins can be used with ordinary cloth or gauze bandage for the same purpose.

Although complete major components, such as wings and fuselages, have been made with glass plastic, generally these are too heavy for normal free flight models. Thus the main use of this material at present is for smaller moulded components, such as cowlings, fairings, etc., and for local reinforcement.

Chapter Three Simple Fuselages

THE simplest of all built-up fuselages is where the two sides are cut from sheet balsa and then joined together either with a number of formers or spacers to complete the assembly—Fig. 1. The side elevation of the fuselage is traced or drawn out on to a suitable sheet of wood, which is then carefully cut to shape. This first side can then be pinned over a second piece of sheet and used as a template for cutting an identical second side.

The main alternative methods of joining these two sides are also shown in the diagram. The simplest is probably using sheet formers. The depth and width of each former can be measured off the plan and the former positions carefully marked on the inside of each side. Starting with the widest formers, sides and formers are cemented together, using pins to hold in place and checking that the assembly is true and square. The other formers can then be cemented in one by one, also holding with pins, if necessary. The basic fuselage is now complete and requires merely the addition of the various detail fittings. For example, a thin ply nose former—or a balsa former, may be necessary, also local reinforcement of the sheet sides at the rear where the rubber peg is to be fitted on a rubber model, and so on. With a rubber model, of course, the formers will have been cut out previously to provide clearance for the motor.

An alternative method with formers is to key each in place. This means more work in cutting out the parts, for each former is cut with a tongue which engages with a corresponding slot cut in the fuselage side at each former station, as shown in the diagram. It does, however, make for easier and more accurate assembly once the parts have been properly cut.

The third alternative—using spacers cut to correct length from square strip to join the sides—is lighter, leaves more internal clearance for rubber motors and is generally stronger. It is a little more difficult to construct accurately, however, since each individual spacer has to be positioned carefully. Again, pins pushed through the sheet sides into the ends of the spacers will help.

The main point to watch in all these fuselages is that the assembly remains symmetrical in plan view and is not

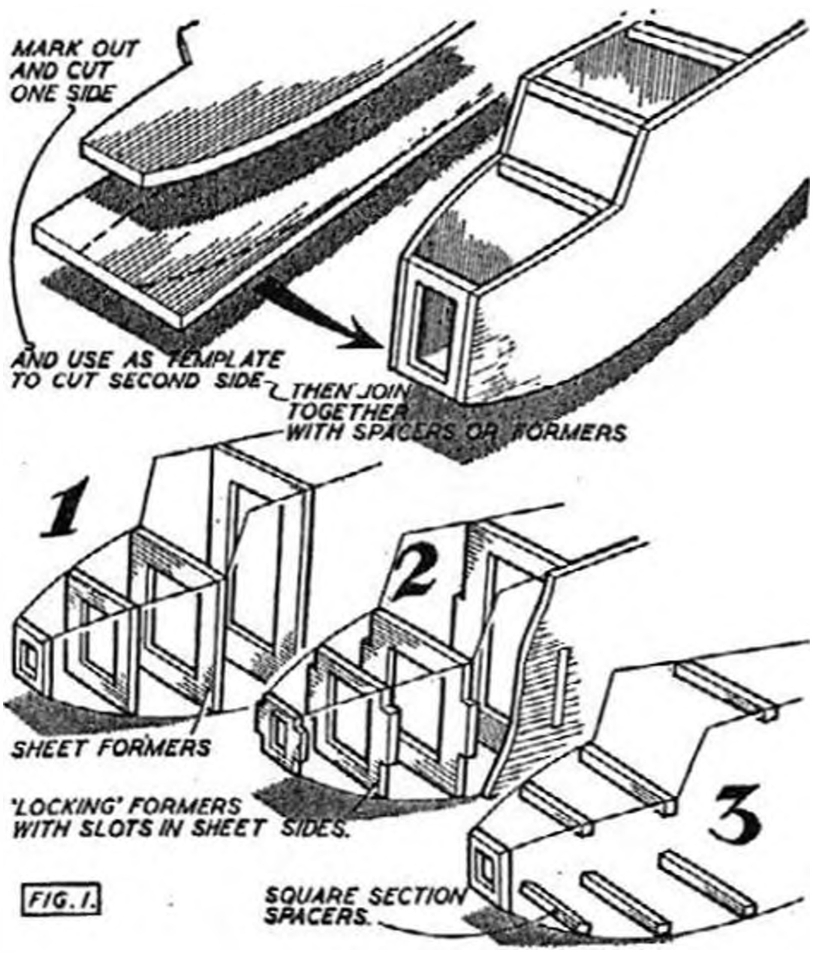


FIG. 1.

twisted out of line in any way. You should be able to check for symmetry by laying the completed fuselage out on top of the plan view of your drawing.

This type of fuselage is really best suited to small free flight models. It can, however, be used with success on larger models where fuselage weight is not so important.

Normally we would reckon that this type of fuselage construction is too heavy for rubber models more than about twenty to twenty-four inches wingspan. There is no reason why it should not be used on gliders up to " Nordic " size, or even larger, but if you build a big fuselage in this fashion you will find that it can be quite costly. To get a proper strength distribution, too, without excessive weight, the sheet wood used for the sides needs to be selected carefully. Stiff but light sheet is required, and so quarter-grain stock would probably be best. The significance of this type of sheet was described in Chapter Two.

Sheet thickness

To avoid buckling of the sides, too, 1/16 in. sheet thickness is about the minimum which can be used. Very tiny models of around twelve inch wingspan and under could use 1/32 sheet sides, but all larger models would require the thicker size.

As the fuselage size goes on increasing there will come a point where even 1/16 sheet is no longer strong enough on its own. To use thicker sheet would be adding a lot of unnecessary weight and the best solution is to brace the sides with an internal frame of stripwood. Almost any sheet-sided fuselage above fifteen inches in length requires some form of internal bracing like this.

Figure 2 indicates how this internal bracing can be added, cemented directly onto each side before assembly. This is quite a straightforward method which should present no difficulties. Make sure, however, that you cement the frames on to what will become the inside of each side. Final assembly can then be like the other sheet-sided fuselage. If formers are used these will have to be notched at the corners to fit the frames. Each former position should be backed with a vertical frame member which will assist accurate alignment of the formers and make for a stronger assembly.

Numerous other applications could be mentioned and some have a certain popularity amongst A.2 glider designers. However, construction is generally so obvious that further description is not necessary, and so we have merely sketched a few typical examples in Fig. 3. Where relatively large fuselages are sheet covered, except in gliders, it is more usual to find the fuselage built up by other methods and the sheet covering added as a final skin.

Built-up Box

By far the most popular type of fuselage for general use is the simply built-up box, comprised of four main fore and aft members (usually of square section) called the longerons, joined with both vertical and cross (horizontal) spacers. There are many variations on this simple theme. Numerous outlines can be accommodated with simple box frame, whilst the modern trend, particularly with rubber model fuselages of Wakefield size, is to locate the longerons diagonally, using rectangular section material. The more important of these variations will be described, but first let us deal with the simplest type of box.

The first main job is to select the wood carefully. It is important, for example, that the four

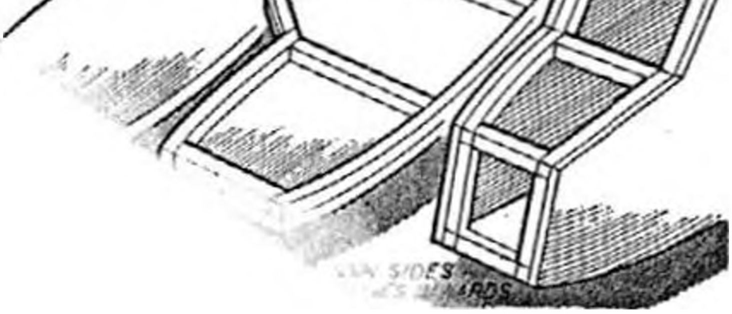


FIG. 2

longerons be matched, otherwise, if one is more springy than the others, it may well pull the whole fuselage out of shape when it comes to assembling the two sides. Spacer stock is not so important, but to save weight this can be lighter than the longeron material.

Select the longeron wood first. Pick out four pieces of wood which seem nice and hard and springy and look alike. Check that the grain in them is true and running from end to end—not across the strip—and the whole length is free from imperfections. A worm hole, for example, along the length of the strip will make it useless for longeron stock. Try the simple whipping test mentioned in Chapter Two and aim to get, as near as possible, four identical lengths of wood from what stock is available—whether from the contents of a kit or from a retailer's stock. A summary of suitable tests is given in Fig. 4—the final test being a check on weight. Matched strips should each weigh the same and in a contest rubber model the total weight of the four longerons is also important.

Weight check

Weighing will also show up another interesting point. Some lightweight models call for "hard 1/16 sq." longerons. Check weighing, you may find that four 3/32 square strips of roughly the same overall strength may weigh less than four hard 1/16 square strips. The larger section stock would then make the better fuselage.

Your fuselage will look much neater, too, if you make sure that the stock you have chosen is true in section and of the right dimension. A lot of "square" stock is often rectangular in actual fact, so that using spacer material the other way round to the longeron material could lead to the effect shown in Fig. 5 when the two sides are built on top of one another. This is exaggerated to emphasise

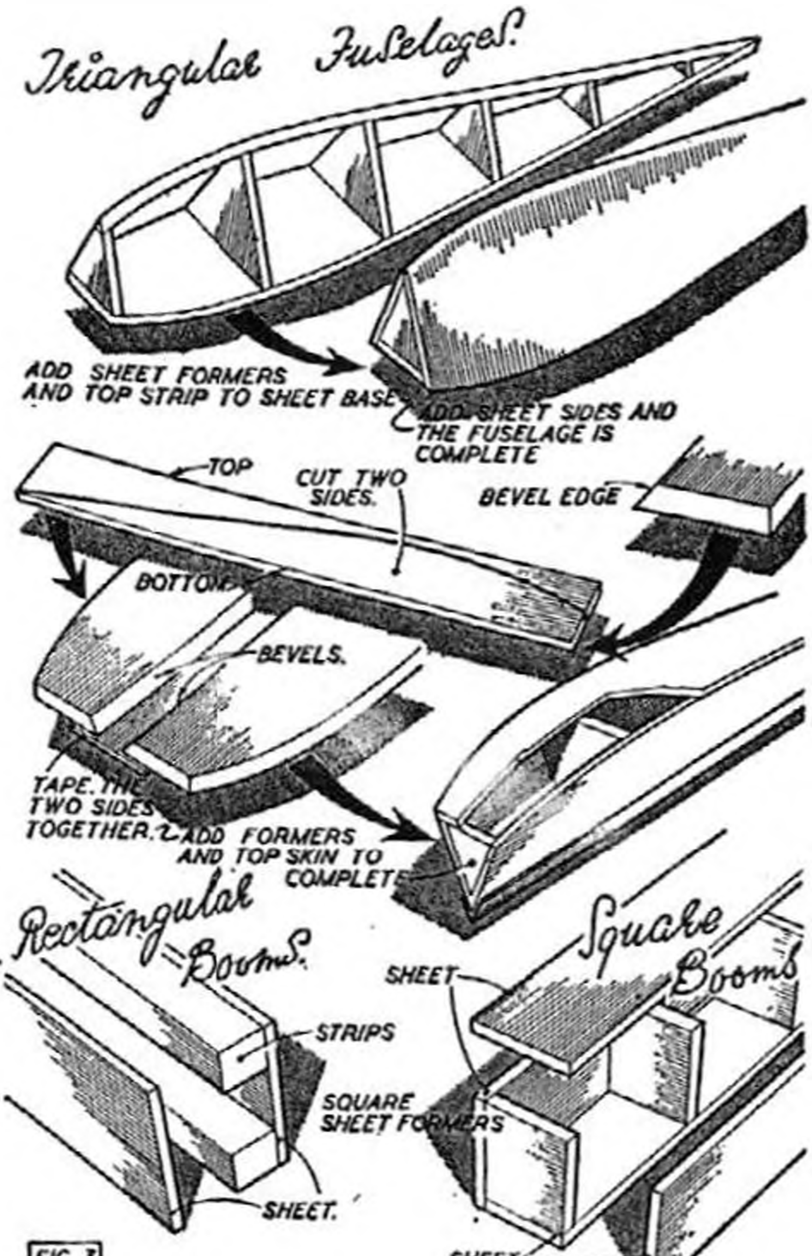
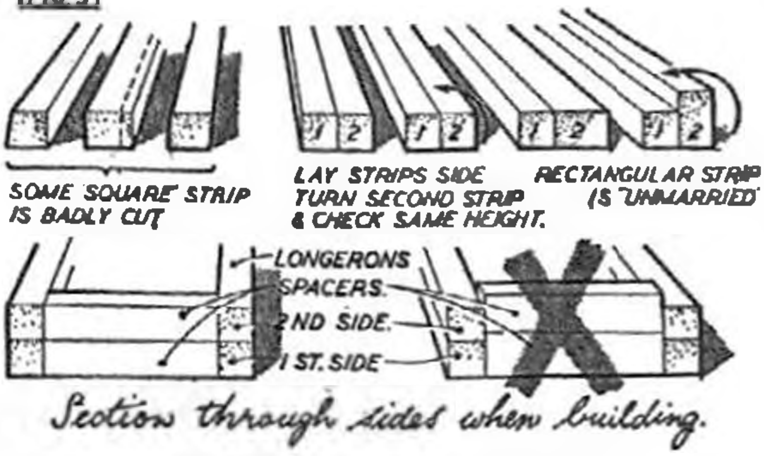


FIG. 3

1. A BUNDLE OF STRIPS SUPPORTED OVER EDGE OF TABLE. THE LIGHTEST WEAKEST STRIPS BEND FIRST. CHOOSE FOUR STRIPS OF THOSE REMAINING STRAIGHT.
2. A BUNDLE OF STRIPS DROPPED, THE HEAVIEST STRIPS REACH THE FLOOR FIRST.
3. WHIP FOUR OR MORE STRIPS TOGETHER. MATCHED STRIPS WHIP THE SAME AMOUNT.
4. FINALLY, CHECK THE WEIGHT OF STRIPS.

FIG. 4

FIG. 5



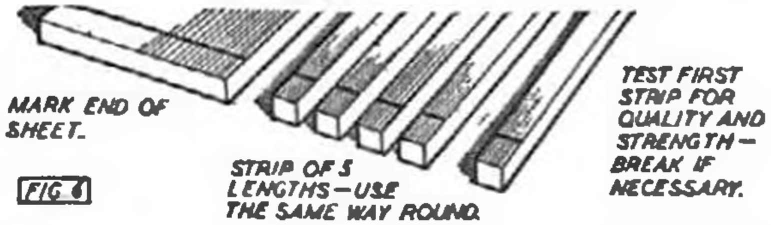


FIG 6

FIG. 7

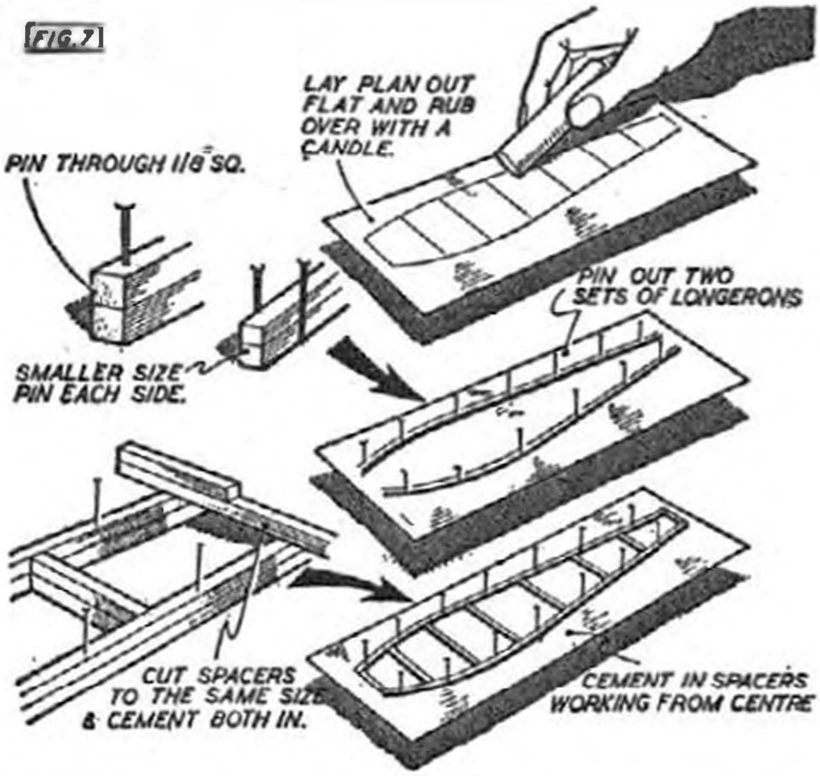
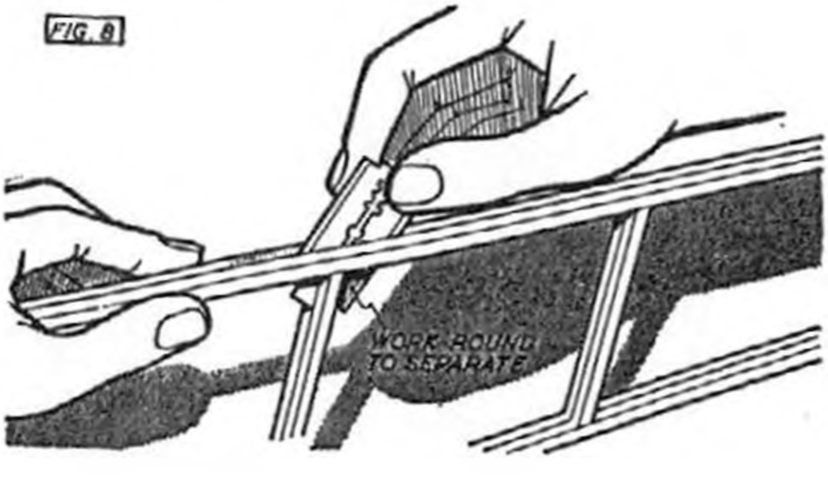


FIG. 8



the point, but even a small error in size like this can be annoying, and weaken the fuselage frame. Matched longerons, in fact, mean longerons equal in strength, weight and dimension. Spacer wood is not so critical, but this again should be of "matched" dimension.

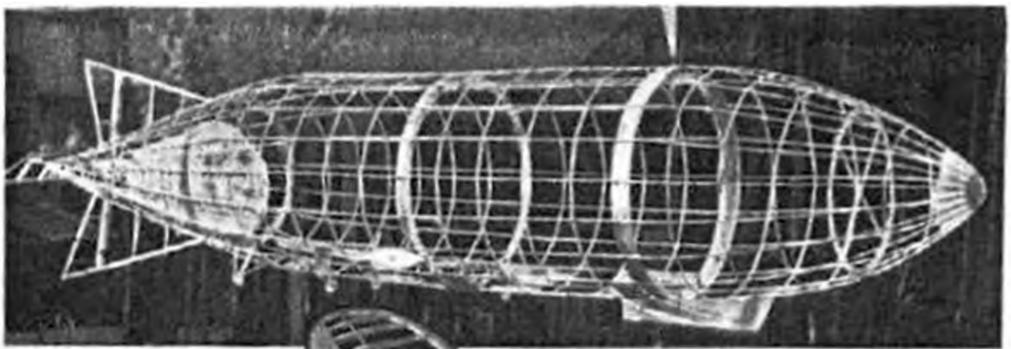
Some modellers take this question of matching longeron wood so seriously that they prefer to strip their longerons from sheet wood. This, in fact, is undoubtedly the best method, if you have a good wood stripper and can use it properly. Until you can strip wood *accurately*, however, it would be better to stick to selected machine cut strip from your local model shop.

Stripped Longerons

Preparing longerons from sheet, the sheet itself would first be selected for quality and uniformity and one end clearly marked — Fig. 6. The four longerons are then cut off as adjacent strips and used the same way round in building, i.e., all the marked ends at one end of the fuselage. This ensures close matching of four strips, but even then the strips can be subject to variations. Another point, too, is that it is virtually impossible to tell whether such strip is suitable for longerons until a test strip has been cut and tried for strength.

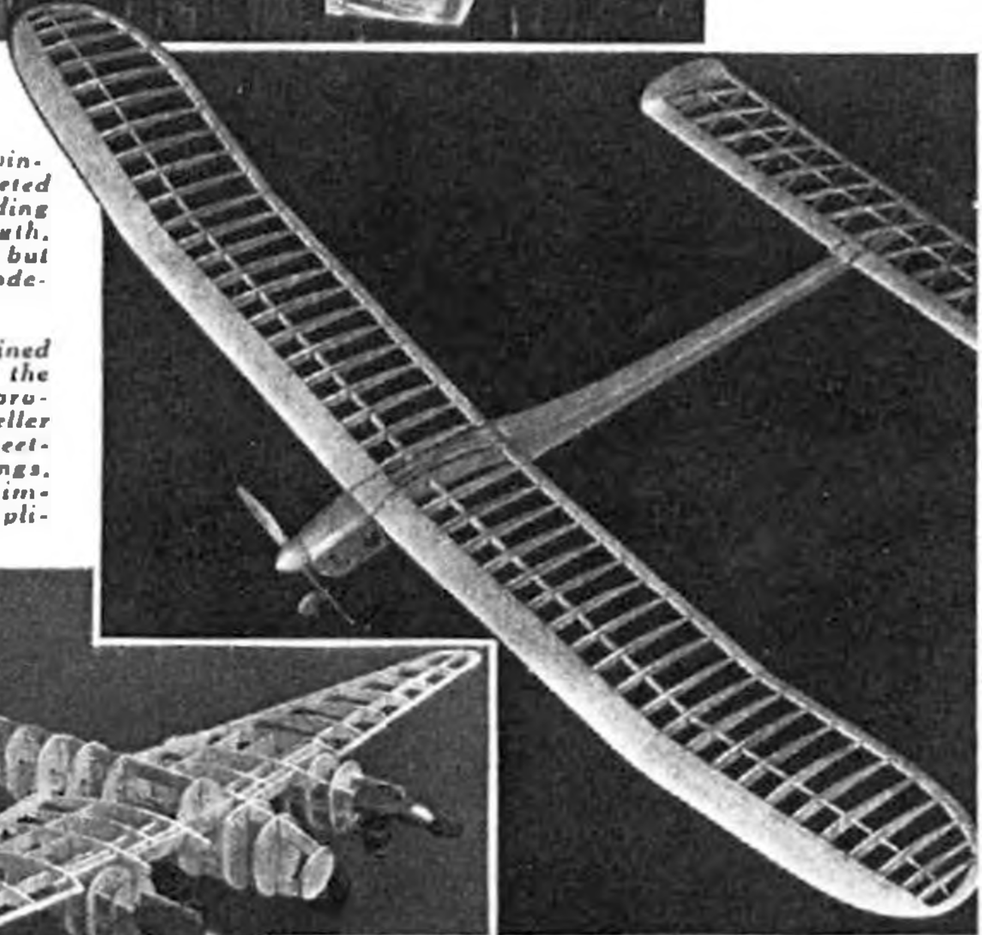
Accurate work is possible, however, with proper handling of the stripper. With the stripper set at the same dimension spacer stock can be cut exactly to correct width.

Once your longeron and

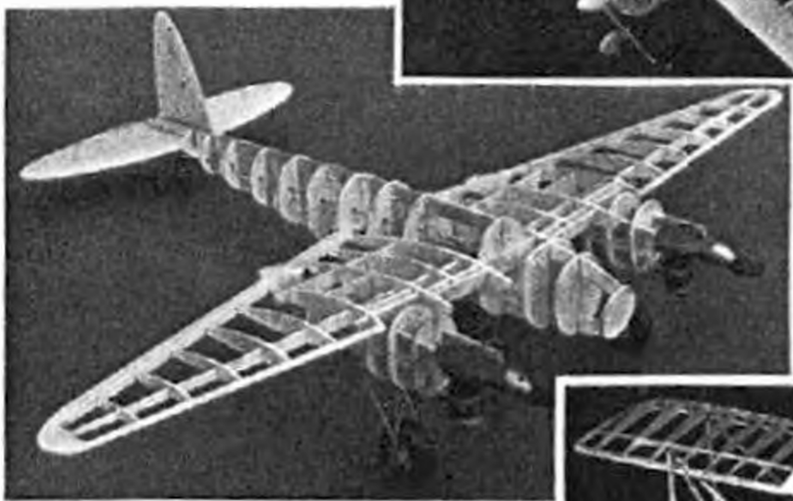


Hardly commonplace, this airship framework is a beautiful example of what can be done to combine lightness with strength. Length of model is about 10 feet.

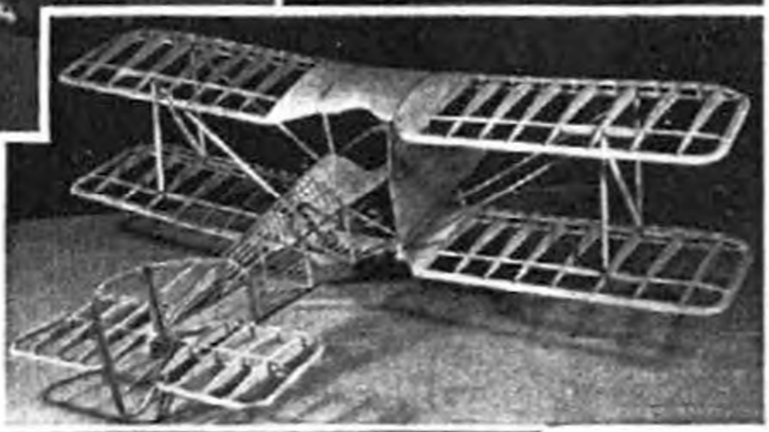
Right: This power model in the latest modern style is by Australian Wakefield winner Alan King. Sheeted fuselage and wing leading edges provide strength, while tail plane is light but very tough with its geodetic rib structure.

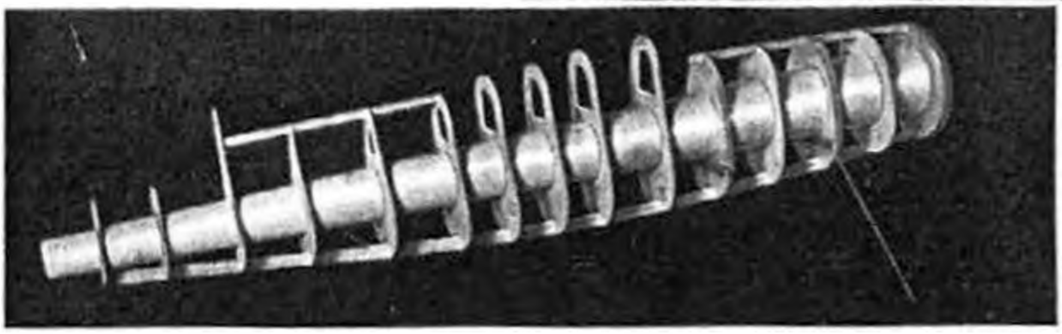


Below: A twin engined control-line version of the MK XVI Mosquito, produced by the Aeromodeller staff, shown before sheeting of fuselage and wings, emphasises the basic simplicity of a quite complicated airframe.

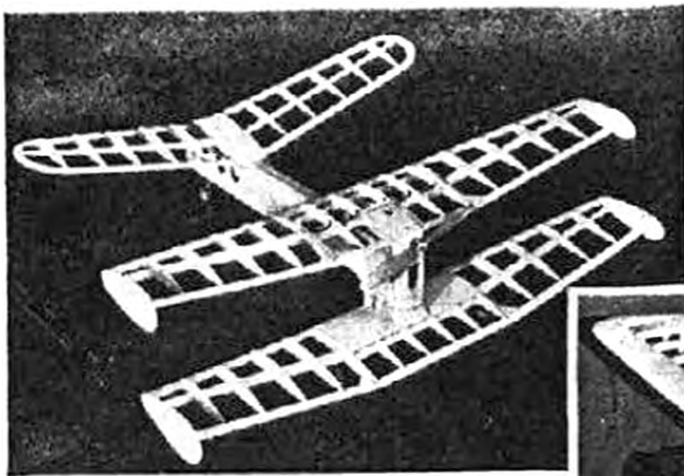


Right: Structural problems are always present with biplanes, but their appeal, especially to scale model builders is great. Here a combination of sheeting and stringers gives added strength only where essential, the builder skilfully reproducing scale structural detail in this Austin Whippet model.



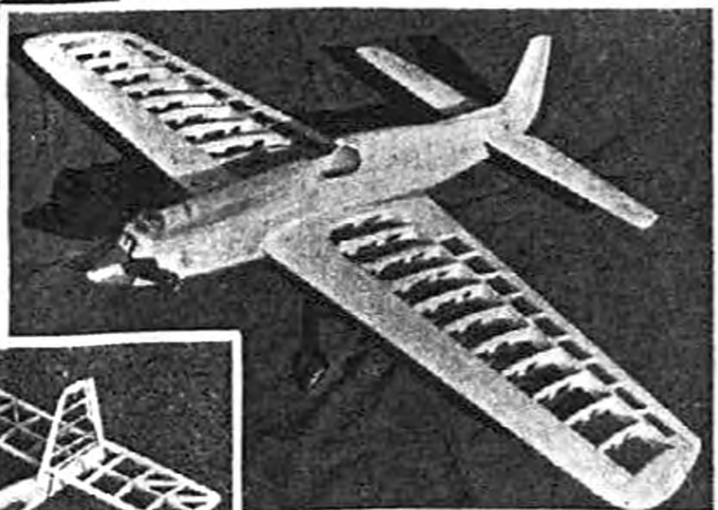


Tubed fuselage allows of most complicated shapes without loss of strength or accuracy of line up, and provides safe stowage for rubber.

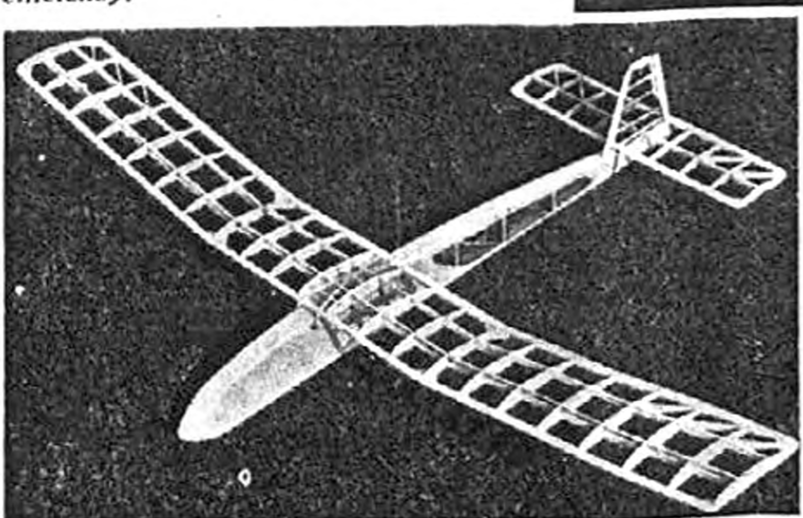


Left : Canard biplane with end plates to mainplane, an experimental free flight model of simple construction though, perhaps, elaborate design.

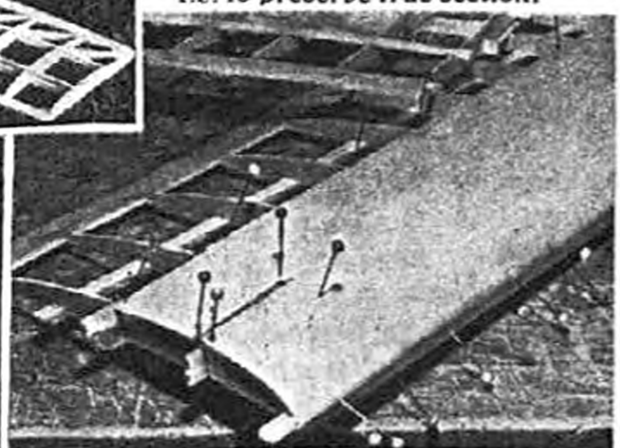
Below : U.S. kit the Kenhi Cougar, where stout construction in the right places, namely fuselage and leading edges, has not prevented builder from lightening wing ribs.

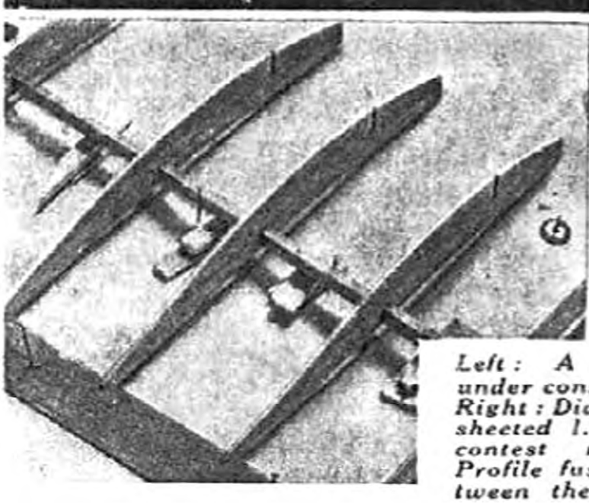


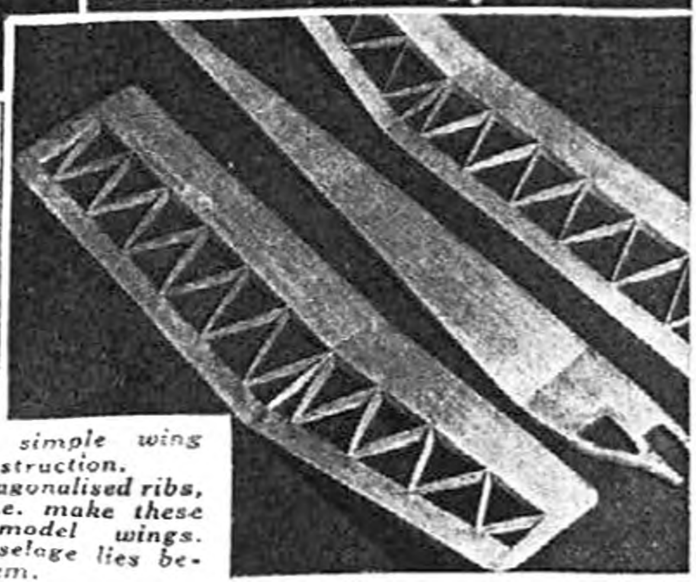
Below : Aeromodeller's Golden Wings A/1 Glider, a simple beginner's project designed for a first ever model. Simplicity has not been sacrificed to efficiency.



Below left : A curious all-wing flying saucer machine that has a definite appeal to those seeking a really "different" model. Below right : Close-up of sheeted wing. Sheet extends to main spar, and is wrapped right round l.e. to preserve true section.







Left : A simple wing under construction. Right : Diagonalised ribs, sheeted l.e. make these contest model wings. Profile fuselage lies between them.

spacer wood has been stripped or selected, one thing remains to do before starting building. Smooth each strip down *lightly* with very fine sandpaper on all four faces to remove any roughness or knife or saw marks. Use a sandpaper block, hold one end of the strip and rub the sandpaper along to the other end in one sweeping motion. Do not attempt to sand backwards and forwards or you will almost certainly break the strip.

Most box fuselages are made by building two side frames and then joining with spacers. The frames are built directly over the plan and should be identical. The best method of ensuring this is to build the two sides together, one on top of the other, laying down the longerons first and then cutting the individual vertical spacers to length and cementing in place. The logical steps are: lay out the plan flat on a suitable building board; protect the surface of the plan (either by covering with waxed paper or, more simply, rubbing over the plan with a candle); pin out the longerons directly over the plan, in pairs; then cut the spacers to length, again in pairs, and cement in place. These steps are illustrated in Fig. 7.

Basic Frames

Authorities differ as to how to pin down the longerons. The method usually recommended is to locate pins on either side of the longerons to hold them to the required curve. It should be possible to bend the longerons to the required curve without having to steam them.

It is important that each pair of longerons should assume an identical curve. They will naturally tend to do this if the wood is properly matched, but may also require quite a lot of pins to hold down properly. Contrary to commonly held opinion, it is quite alright to pin right through the longerons at intervals, provided these are at least ⅛ in. square in section and the pins used are thin ones. This will make it much easier to hold them in position. Smaller section longerons should *not* be pinned through.

With the longerons pinned out satisfactorily, the two sets of spacers are then cut and cemented in place. A good plan is to start with the middle spacers, and then work to each end in turn. Take the first spacer point, offer up a length of strip, mark the exact length required and cut off. Check for size and then cut another spacer of identical length for the second side. Cement these spacers in before going on to cut the second pair of spacers, and so on. This is more accurate, and gives stronger joints, than cutting a complete set of spacers and then cementing in place, followed by a repeat process for the other side.

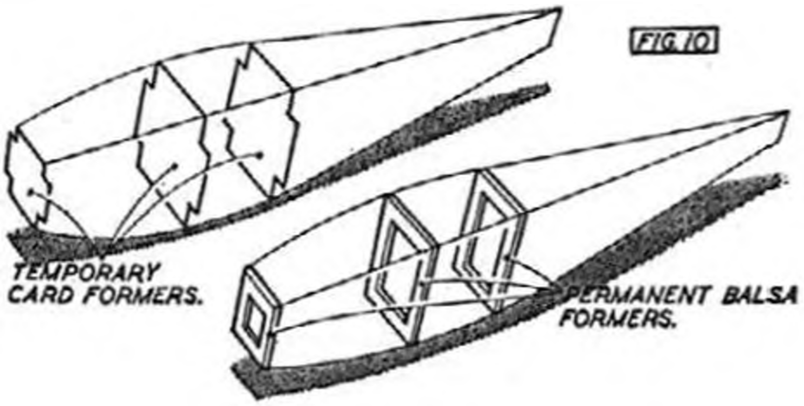
If there are any sharp curves in the longerons, wood stresses in these regions can be relieved by painting with hot water, *after* the frame is complete. Normally this should not be necessary. The two sides should then be left pinned down for several hours to allow all cement joints to set thoroughly.

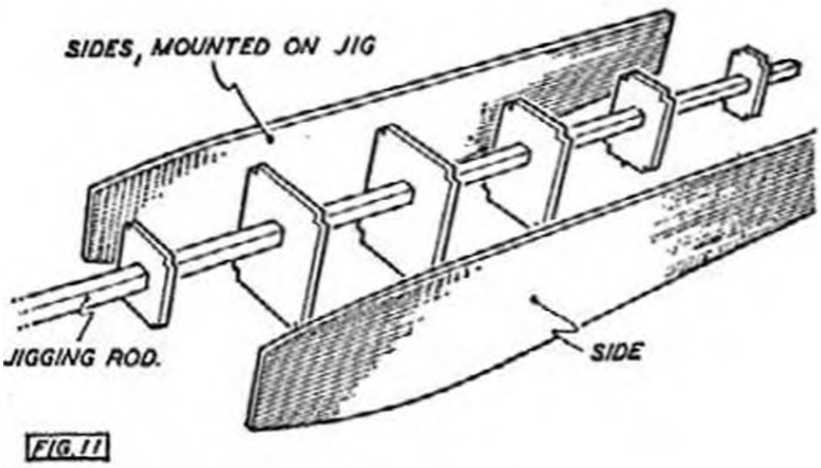
When removed from the plan the two sides will be stuck together, but can be separated readily by slipping a razor blade between them and running round the outline—Fig. 8—working carefully over each spacer joint.

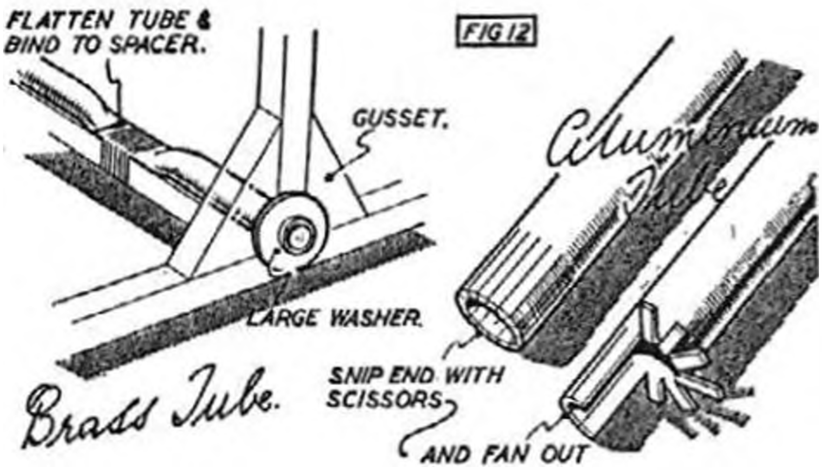
Joining Sides

There are several methods which can be adopted for joining the sides. The simplest is that whereby spacers corresponding to the mid section of the fuselage are cut exactly to length and the two sides joined with these, using pins to hold until the cement has set. The assembly is checked for squareness.

The next stage consists of pulling the two rear ends of the fuselage together, trimming as necessary, and cementing, followed by the nose spacers, holding with pins. When these have set, all the remaining spacers can be cut to size and cemented in their respective positions—either cutting these to length from the plan or against the actual assembly, working from the widest section forward and aft and cementing in each pair of spacers as cut and before measuring off the length of the next. Either way demands constant checking by eye and "sighting" against a possible twist or distortion of the frame setting in.







Other methods demand the use of formers—either false formers of card which hold the two sides whilst the spacers are located and are then removed ; or sheet formers which become an integral part of the structure—Fig. 10. An extension of the former method is shown in Fig. 11, favoured by some Wakefield builders, where the false formers are mounted on a stout jigging rod which does ensure a really accurate line-up.

We do not propose to describe the further constructional details to be added to complete the final fuselage. These consist, in the main. of such items as gussets to increase local strength, rear motor peg anchorage on rubber models, undercarriage fittings, and so on. Generally, these are quite obvious and straightforward. There are, however, a number of constructional tips which are worth passing on.

Double Cementing

The first concerns what is known as "double-cementing". This consists of pre-coating all joint faces with cement, allowing to dry and then re-cementing the parts to be joined and locating in place. A double-cemented joint is very much stronger than an ordinary straightforward cement joint and certainly does pay on most fuselages. However, quite a number of well-known, and successful, modellers never bother to employ it and so the choice is quite an open one. There is nothing to lose—only time—in making double-cement joints.

Then there is the fitting of brass tubes in fuselages, such as employed for undercarriage fittings. Unless these tubes are anchored at each end they will almost certainly push sideways. A cement joint coupled with thread binding is no safeguard. Brass tubes should have washers soldered to each end, bearing against sheet gussets in the fuselage—Fig. 12. Aluminium tube can be cut with a small pair of scissors and fanned out, as shown. Kinking the tube in the middle and binding tightly to the spacers will also help.

Chapter Four
Advanced Fuselages

VARIATIONS on the simple box fuselage are numerous. Rather than attempt to describe some of the more outstanding examples we have included a representative selection in Fig. 1. Such methods are popular with semi-scale and sports models. For competition work, elaboration is to be avoided as this usually adds weight—an undesirable feature.

Weight is most critical on old-rule Wakefield type models where, to get a four ounce motor weight quite a large airframe has to be built down to four ounces or less, including the propeller assembly, if the model is not to exceed about eight ounces total weight. As a general rule, therefore, such fuselages have been kept relatively simple both in outline and construction with streamlined or rounded sections in the absolute minority. To make any given length of fuselage down to a minimum weight means an almost automatic selection of a simple rectangular or square cross-section. Most other lightweight models—rubber powered or glider—it will be noticed, also follow this trend.

It has been argued in favour of the streamliner that a circular or elliptical section fuselage can be produced with *less volume* of wood than a corresponding box or slabsided fuselage. In practice, it is not possible to build a multi-stringered streamlined fuselage down to the same weight as that of a simple box of the same length and cross section.

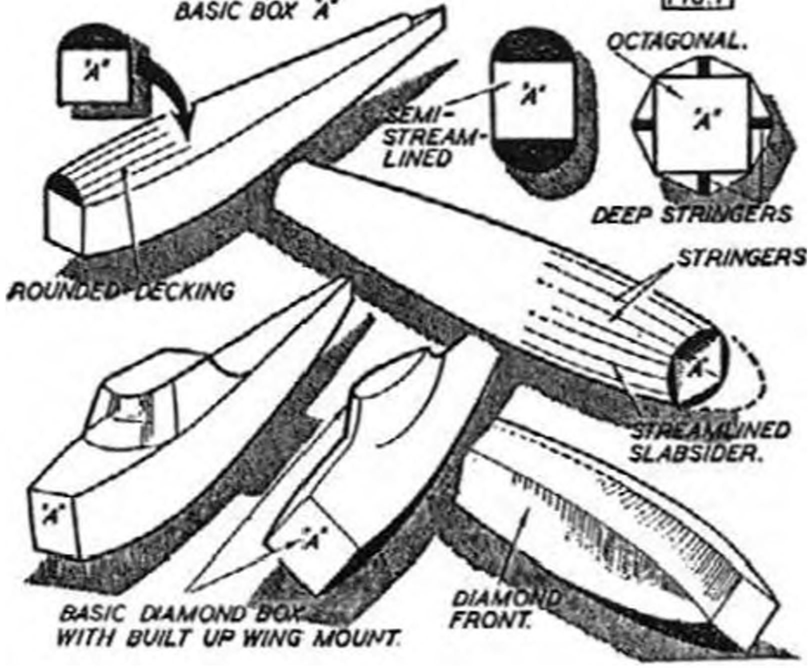
Quite a lot of development has taken place with the simple slabsided fuselage during the past two years which has resulted in *improved* strength for *less* overall weight, making it even more attractive for competition work. The price paid for this has been increased complication in building. The method, which is now becoming more widely adopted, is the use of diagonal longerons.

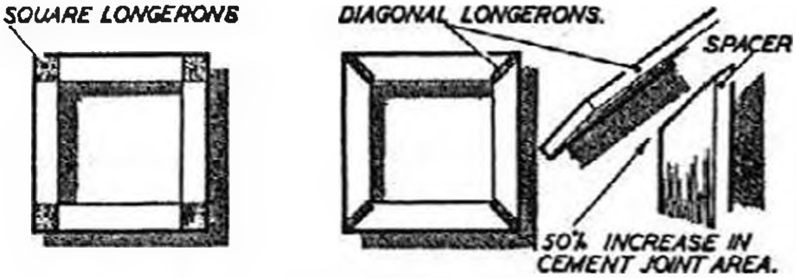
Fig. 2 compares the cross section of a normal slabsided fuselage with square section longerons with one using diagonal longerons. Typical wood sizes would be 1/8 square or 3/32 square in the first example, whilst the diagonal longerons would be 3/16 × 1/16 in. Bearing in mind the fact that the longerons are the hardest, and therefore the heaviest members of a slabsided fuselage, the saving in material volume, and therefore overall weight, is quite considerable with diagonal longeron construction. Using 3/16 × 1/16 diagonal longerons, for example, instead of 1/8 sq. longerons represents a saving equivalent to one complete length of 1/8 square. Using 1/8 × 1/16 diagonal longerons, as some builders have, represents a fifty per cent. saving (two complete 1/8 square longerons).

Nor is this the complete picture, for diagonal longeron construction is invariably used with 1/8 × 1/16 spacers. The same size spacers could, of course, be used with 1/8 square longerons, but the joints would not be so satisfactory for "diagonal" construction gives a glue joint surface roughly fifty per cent. greater.

The strength of a fuselage with

FIG. 1





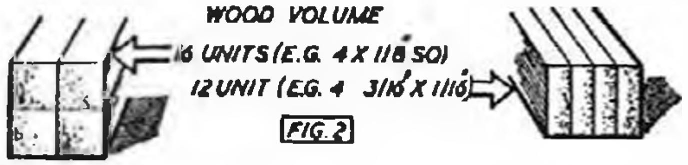


FIG. 2

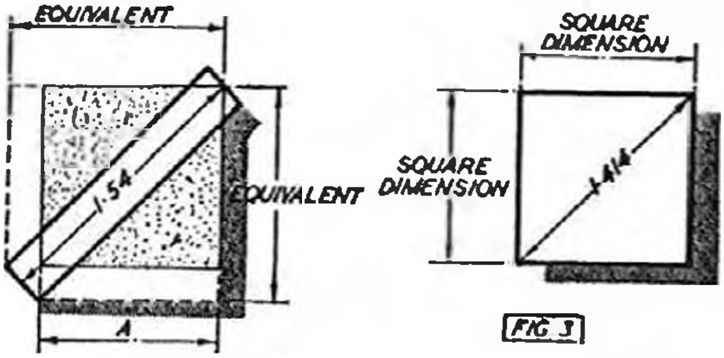


FIG. 3

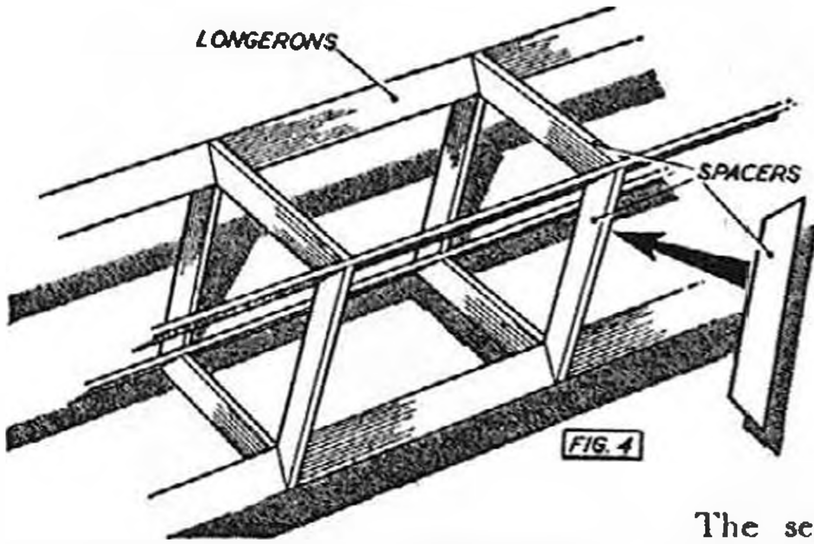


FIG. 4

diagonal longerons is generally superior to that of orthodox slabsided fuselage constructions with square section longerons, partly because there is more depth of longeron, either direct or projected, in any direction in which stress is applied—Fig. 3. This applies when comparing $\frac{3}{16} \times \frac{1}{16}$ and $\frac{1}{8}$ square longerons.

A part section of a fuselage with diagonal longerons is shown in Fig. 4 and, at first glance, would appear to present something of a problem to build. Obviously building two sides flat on a board and then joining in the usual way is impracticable and so the diagonal longeron fuselage immediately becomes a more complicated project.

We have investigated the methods used by those builders who have gone over to diagonal longeron construction and the four which seem to offer the best methods of approach are detailed in Fig. 5.

The first, and probably the most widely used method is that originated by **Evans.** This takes the form of an internal jig cut from soft $\frac{1}{16}$ sheet balsa. It is suitable only for square section fuselages, e.g., "diamond" types, and the two parts of the jig are cut to the exact shape of the *inside* line of the longerons in projected side elevation. The jig pieces are fastened together at right angles and the four longeron lengths tack-cemented to the jig. Spacers are then cut and cemented in place, each of the four spacers at any one station being of identical length and all spacers having the ends chamfered off at 45 degrees. When all the spacers have been added and the cement has set, the light balsa jig is broken up and removed.

The second method was used by **Warring** in duplicating his *Zombie* fuselage with diagonal longerons. Cross section is rectangular and so a form of construction similar to that normally employed for streamlined fuselages was used. False card formers were plotted for every other spacer station and mounted on a central jigging rod. Each card former was split along a diagonal and then rejoined with strips of cellulose tape, back and front. The corners of each former were also slotted to take and hold the longerons in their true diagonal position.

With all the formers on the jigging rod the four longerons were slipped in place in the corner slots, then the spacers cut to length and cemented in. When complete, the card formers were again split by peeling off the cellulose tape, the halves shaken out of the frame and the bare jigging rod removed. The front false former, incidentally, was permanently mounted on the jigging rod at the required angle of down- and side-thrust so that the nose former cemented onto the finished frame at the correct setting. This method, of all those we have heard of, is still the most satisfactory for building a *rectangular* section fuselage with diagonal longerons. All the other methods are suitable only for true *square* sections.

The third method shown was developed by **Gorham** and members of the Ipswich club. Here two false "sides" are laid out directly over a plan—actually a projection of the full side area—and joined with temporary 1/16 square spacers. These spacers run from the bottom longeron on one side to the top longeron on the other side, and vice-versa, at every station chosen. These stations are spaced at four or five inch intervals, depending on the length of the fuselage and the curve to be accommodated.

When these temporary spacers have set they are pinned together pair by pair, along the exact centre line where they cross. The two "side" frames can then be rotated apart. In this position the spacers proper can be cut and cemented in place, each set of spacers being of identical length, squaring up the fuselage at each point.

The fourth method is again by **Warring.** The jig is shaped to the outline of the outside of a full projected side elevation and the respective longerons are held in position by cellulose tape. Spacer stations are marked on the jig. To remove the finished fuselage, one quarter section only of the jig need be removed, the longerons untaped and the whole fuselage lifted out.

The jig itself is the major item of construction. Originally it is cut from four sheets of 1/16 in. balsa (i.e., the same as the longeron width). One half of the projected side elevation is plotted on one sheet and cut out. This part then forms a template for cutting the remaining three pieces. All four pieces are assembled, cruciform fashion, with suitable stiffening strips.

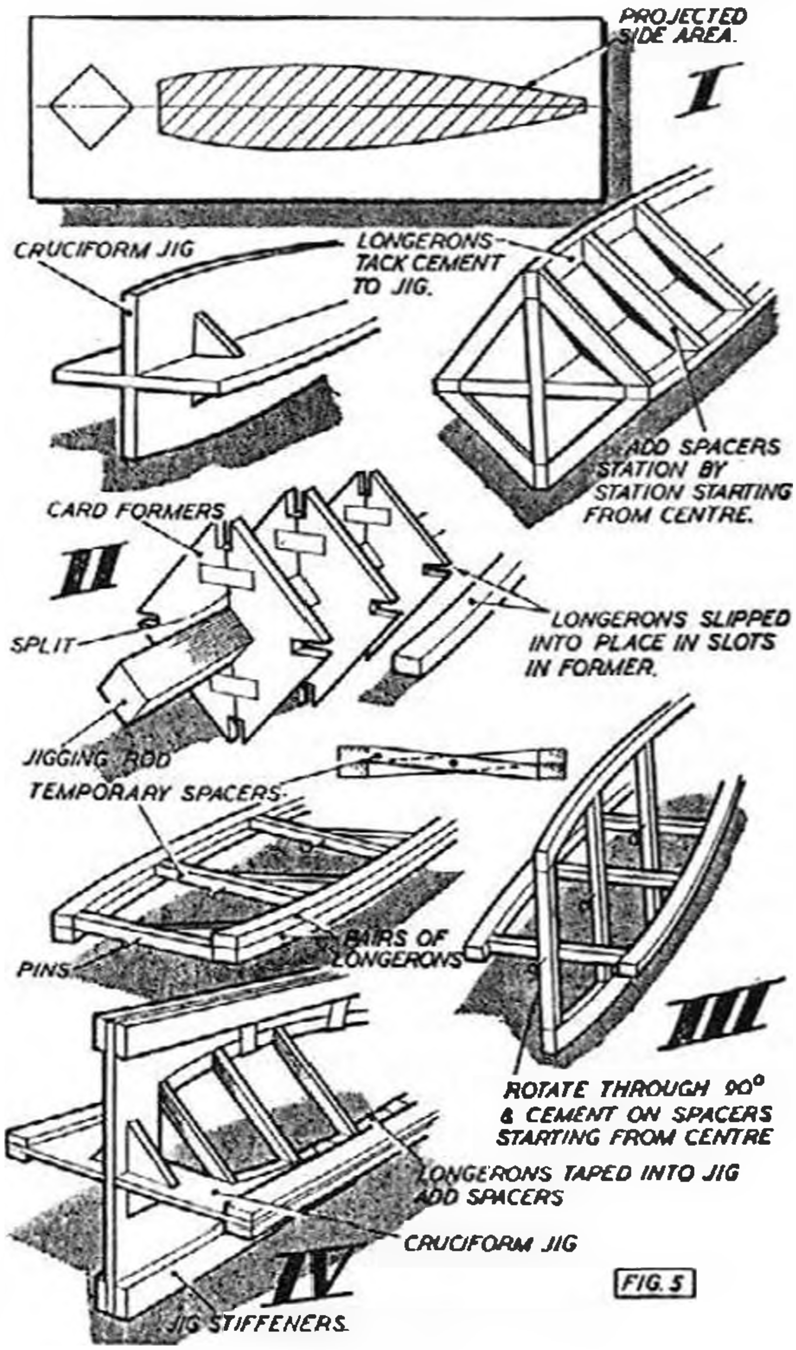


FIG. 5

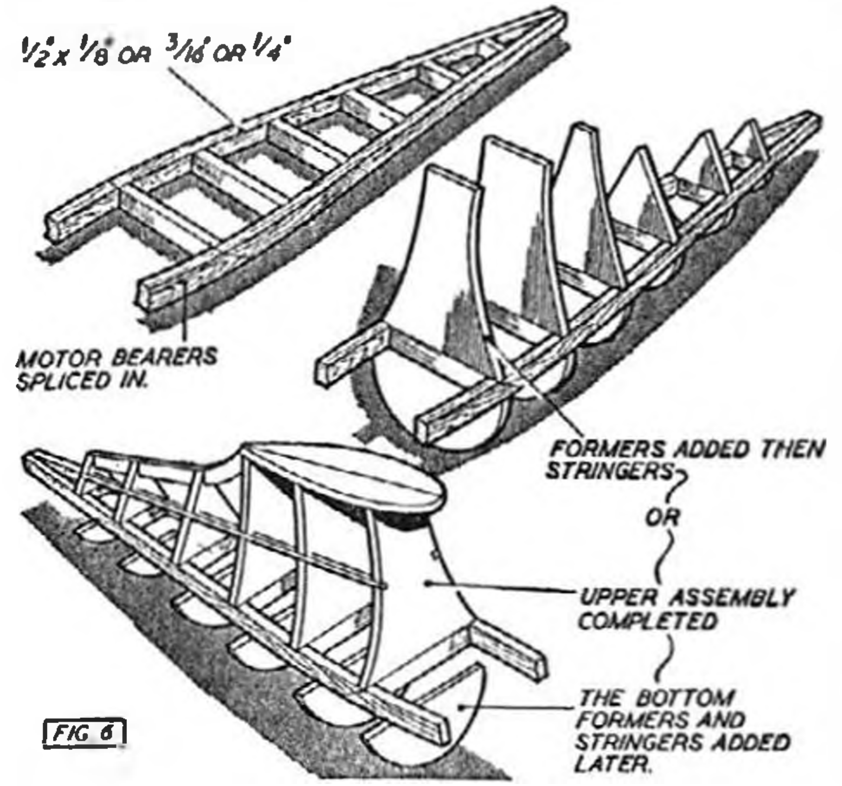


FIG. 6

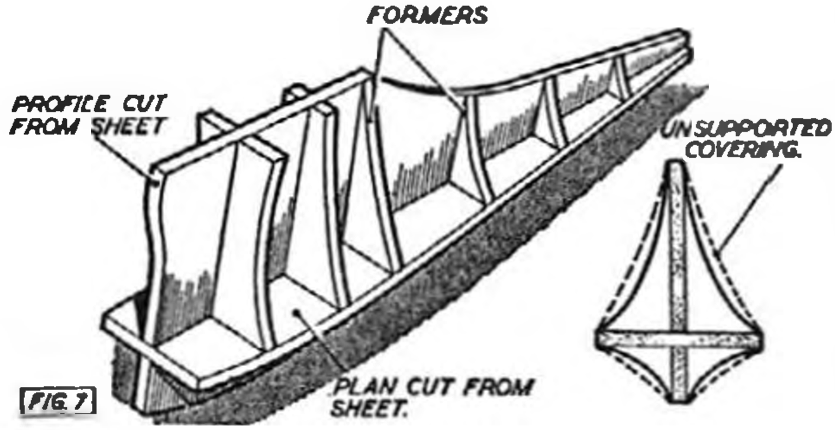


FIG. 7

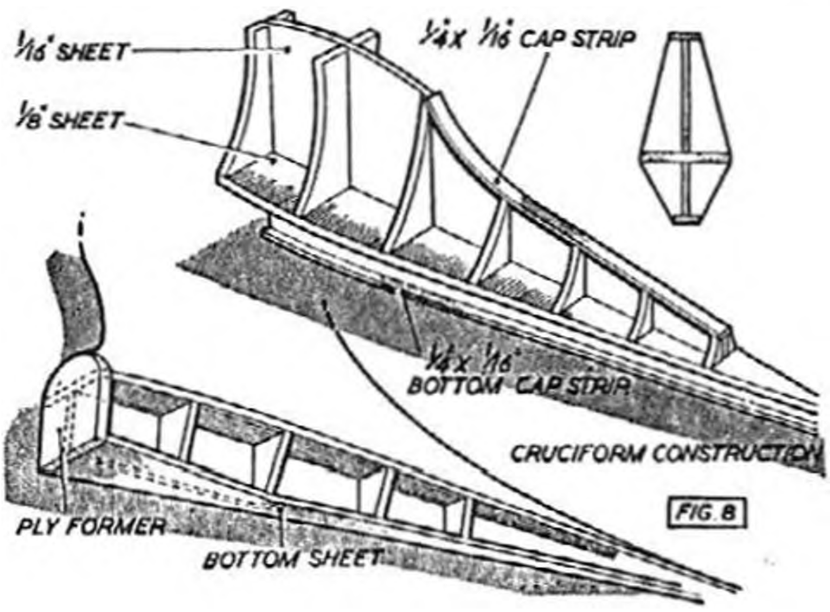


FIG. 8

Crutch Construction

For power models, at one time for streamlined gliders, crutch construction offers many advantages over orthodox " box " frames. It is, in fact, particularly adapted to streamlined and semi-streamlined fuselages where no end-to-end internal clearance is needed. It is strong, relatively simple, makes for accuracy and not unduly heavy.

As diagram 6 shows, the crutch is the main strength member of the fuselage. It must be made of fairly hard strip of generous section—deep and narrow, rather than square. A common error is to use strip which is both too hard and too heavy, which results in an overweight structure. With proper crutch sizes, wood stock about equivalent to that you would choose for the longerons of a box fuselage of similar length is erring slightly on the heavy side, if anything.

The crutch is simply built directly over a plan of the fuselage. On power models the hardwood motor bearers can be splice jointed to the crutch members and left to protrude from the front. When the crutch is set it is removed and full formers, cut from sheet, added. The addition of stringers then completes the basic fuselage. Alternatively, the formers can be cut in two parts—top and bottom. The crutch can be left pinned down, all the top formers cemented in place, stringers added and the whole framework of the upper half of the fuselage completed. This assembly will remain rigid when the crutch is finally unpinned, turned over and the bottom fuselage and stringers added.

Crutch construction has been largely superseded for contest type power model fuselages by sheet cruciform construction on the larger models, or a reversion to the pure pylon type of layout instead of the faired-in pylon.

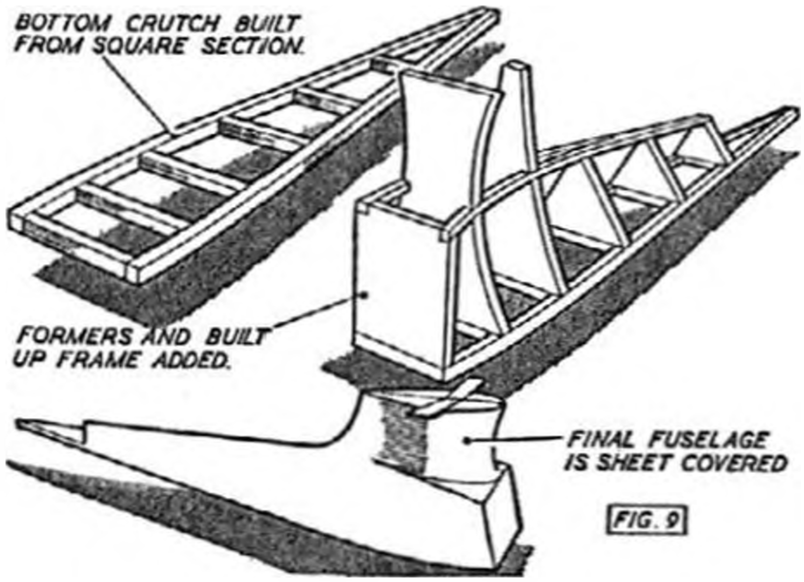


FIG. 9

'X' Type Assembly

Cruciform construction is interesting, if only because it is so simple. The first " popular " use of this building method was in Leon Shulman's *Banshee* where almost the entire fuselage covering was unsupported, except at the edges—Fig. 7. Making such a fuselage entails little more than cutting a side elevation profile, and plan view from suitable sheet and then cementing together, cruciform fashion. In practice, the side elevation sheet is split, so that the top can be erected with the plan shape pinned down on a flat surface to preserve accuracy. A limited number of formers and the nose and pylon section built up, completes the basic assembly.

Cruciform construction of this type has been adopted, and improved, by Gorham. His method gives greater rigidity to the sheet sections by capping the edges with strip—Fig. 8. This diagram of a typical Gorham power model fuselage design does, in fact, summarise tried and proven practice with this type of construction.

For the pure pylon model, of almost any size, a form of construction which is half way between " crutch " and a simple triangular box is widely employed. This method originated in the United States some years ago, was used on a limited scale on both sides of the Atlantic and now seems to have gained a new lease of life.

As Fig. 9 shows, the bottom of the fuselage is laid out flat on the plan. This becomes virtually a crutch member for the rest of the fuselage frame is now added to this elementary frame. Formers are cemented in place to give the required section—usually square or rectangular at the front, tapering off to triangular at the rear—and the pylon structure built in. On larger models, the sides, including the pylon are then covered with sheet before removing from the plan. The bottom is then sheet covered to complete the fuselage.

There are so many other types of power model fuselages which have appeared from time to time that it is impossible to mention them all. Those we have dealt with are representative of popular practice. Some others, perhaps equally good, are not so widely known. Many are simply variations around one or other basic scheme.

Simple box construction does not really suit power duration design other than the pylon types since, for example, a faired-in or semi-cabin pylon layout is bulky if a purely rectangular section is maintained throughout. Power duration fuselages are generally narrow and quite deep (from wing mount to the bottom of the fuselage) and ordinary " box " construction becomes less economic and less attractive the farther the cross section departs from a truly square section. The " best " type of slabsided fuselage, in fact, from the weight and strength point of view is the diamond type—even if used " flat " so that it becomes a normal square section.

Chapter Five Float Construction

SINCE floats come under the category of small 'fuselages'—and not always so small in the case of twin-float layouts—it has been thought advisable to include a short chapter on their construction. The design requirements of floats, e.g., size, shape, layout, etc., are fully discussed in *Design for Aeromodellers.*

In the case of rubber models, large diameter props, high torque, and general need for weight saving associated with rubber power bring in their own problems. The most obvious requirement is the necessity for long u/c legs, which must be stiff and light; bamboo is probably best in this respect. Thread or fuse wire bracing is almost essential to prevent the floats from spreading apart or whipping excessively without using too thick or heavy a leg. A wide track is needed to control the high initial torque on take-off, which further aggravates the tendency for the floats to spread apart. Normal position of the front floats is very slightly behind the prop, and float volume should be calculated exactly as for power floatplanes. The tail float should be about 30 per cent. of the total. Rubber model float forms in general use are shown in the diagrams opposite. Note that tissue covering is quite sufficient for all but fairly heavy models.

Points to watch when producing rubber floatplanes are: (*i*) Three equal size floats, or a tail float only slightly smaller; (*ii*) Inability of the floats to change position when set on water; (*iii*) Wide track up to 50 per cent. of span; (*iv*) Care in motor preparation, since a bunch causing a stalled descent into water will stop flying for an hour or two while things dry out.

The one thing which must be faced about models used for water flying is that there is no way to keep water out. Silk or tissue covered sheet construction can be made reasonably watertight, but wings, fuselage, etc., inevitably fill when immersed. No doubt complete waterproofing is possible, but only at the expense of tremendous weight. The best system is to dope the frame before covering, to slow up the absorption of water, and to dope tissue covering thoroughly, applying two coats of clear followed by one or two of banana oil or fuel-proofer. Silk or nylon will need seven or eight coats of clear dope to ensure that all pores are filled. A 1/16 diameter hole drilled or punched in the covering of each bay, near a corner,

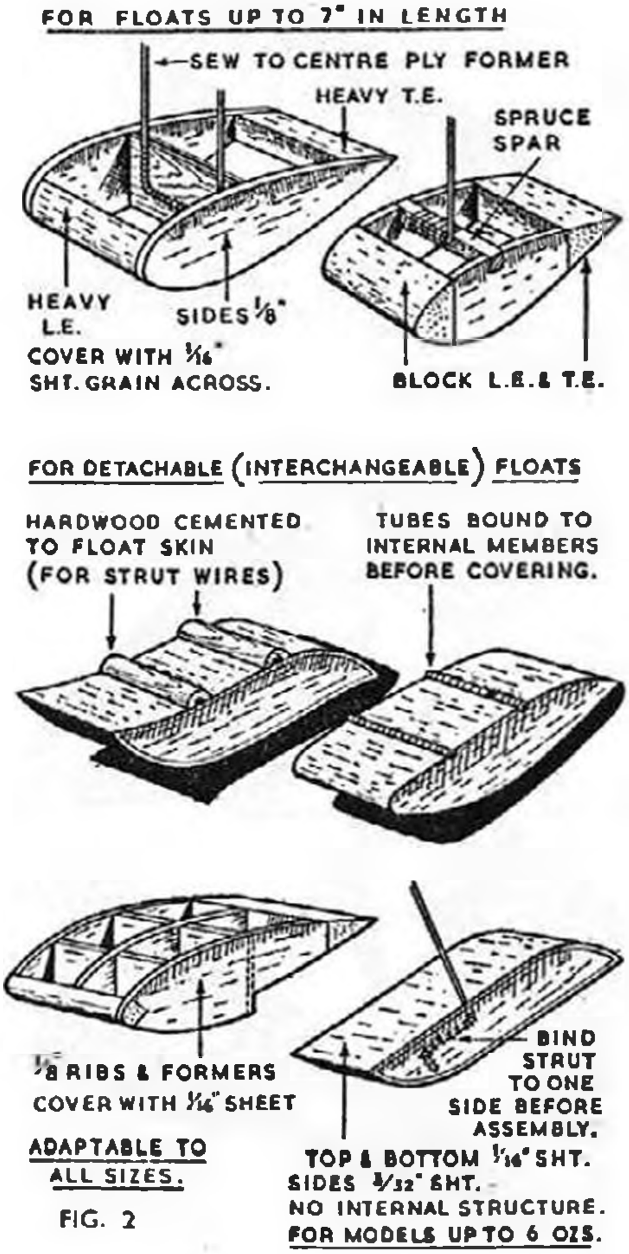


FIG. 2

will speed up drainage in the event of mishap. A tissue or silk reinforcing patch prevents the hole from starting a split. Sheet floats can be fitted with celluloid inspection panels or small drain-plugs ; leaks frequently develop and can be fatal if not detected.

A popular misconception is that contact with water is less likely to cause damage than normal prangs. This is far from true ! We know of hard ⅛ in. sheet floats, silk-covered, split from end to end by what appeared to be merely kissing the water. Wing panels suffer if the tip digs in, usually at the dihedral joint ; this is the most common form of damage experienced.

Twin pontoons are probably the most popular form of float undercarriage—in theory. Those of the vast army of semi-scale fans (who comprise 80 per cent. of power enthusiasts) who want to build a floatplane nearly all visualise a twin-float lay-out, naturally, since this arrangement more closely resembles full-size practice. Few models of this type are seen, however, probably due to lack of data and the fact that modellers seldom have the opportunity of seeing a twin-float job in action.

In general, for the average sports model, the float length should be 66 per cent. of the overall fuselage length. Cross-section is then determined by using the total volume required, usually at least 5 cu. in. per oz. of aircraft weight (i.e., 2½ cu. in. per float). Steps are advisable, and are best located at 50 per cent. of the float length. The float position should be such that the step occurs 5 per cent. of the model's length in front of the C.G. ; on normal machines this gives ample protection against nosing over. Float incidence should be such that the lower line of the float forward of the step makes an angle (the dead-rise angle) of 5 degrees to the aircraft rigging line ; the after-part of the pon-

Total weight ozs.	Minimum volume cu. ins.	Three floats, each minimum A	B	C
8	28	5	1½	2½
10	35	5½	1½	3
12	42	6	1½	3[illegible]
16	56	6½	1½	3[illegible]
20	70	7	1½	3[illegible]
24	84	7	1½	4

FIG. 1

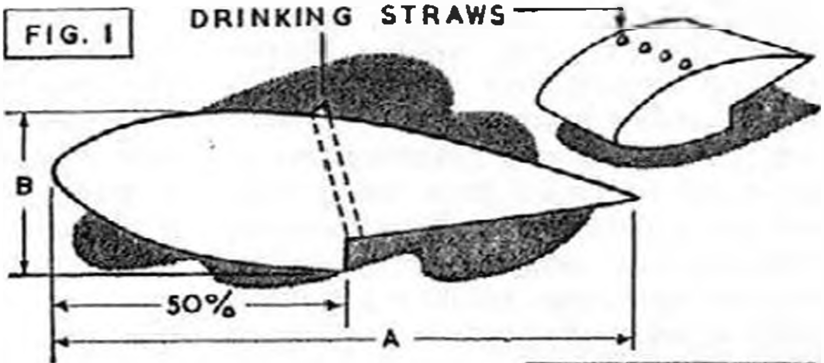


Table above gives float dimensions "A," "B" and "C" for various sizes of model.

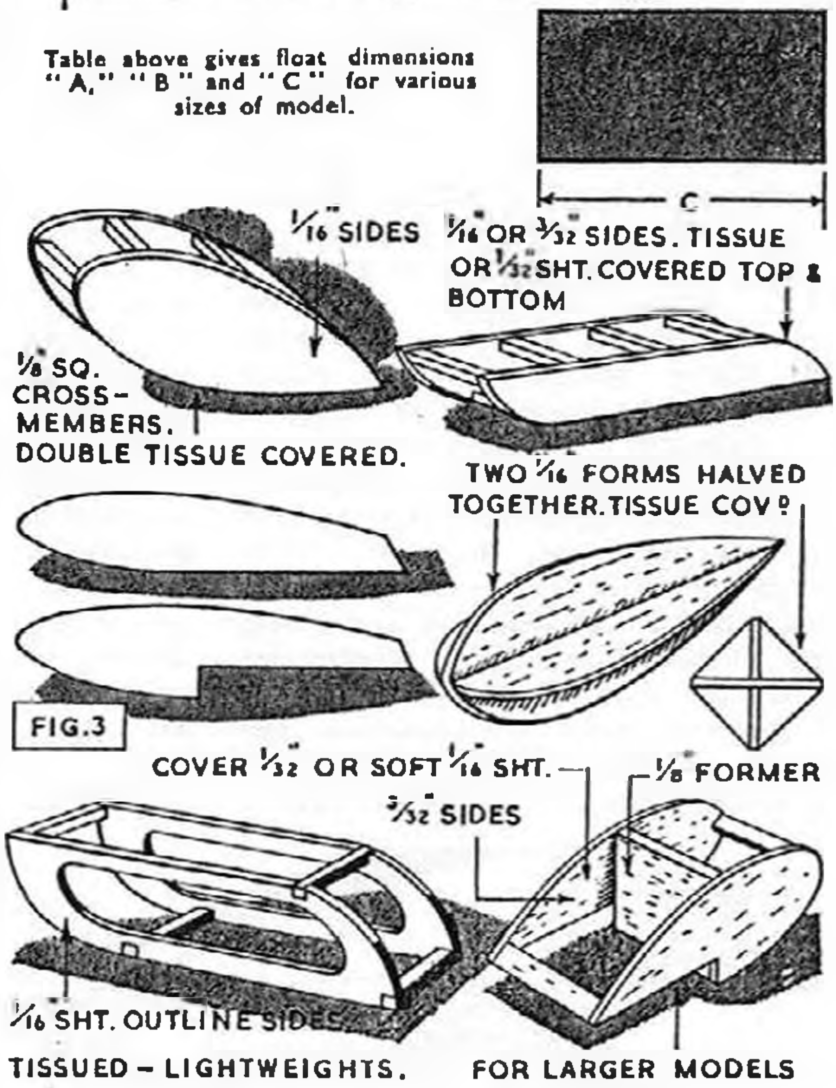
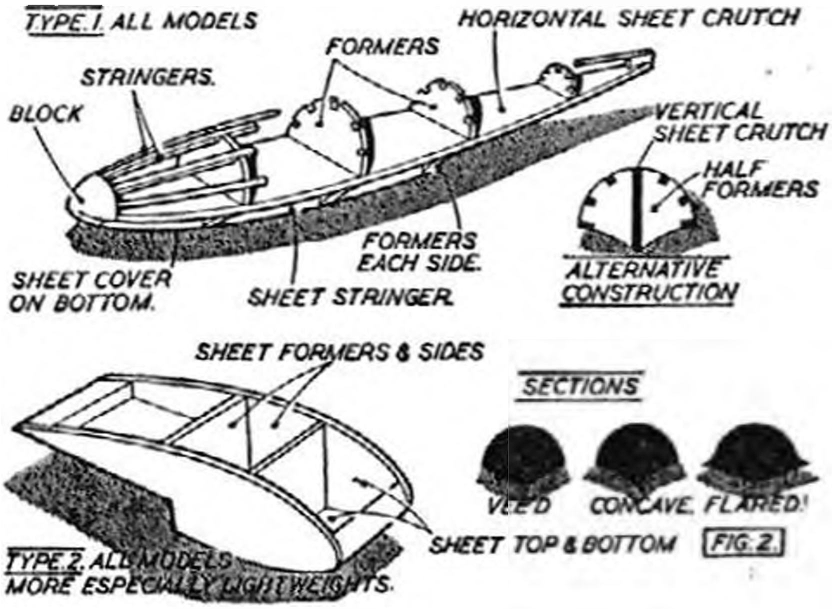


FIG. 3



Aircraft Weight	TYPE 1		
	Length	Width	Depth
8 ozs.	18"	2"	1¼"
12 ozs.	20"	2¼"	1½"
16 ozs.	22"	2½"	1⅝"
24 ozs.	27"	3"	1¾"

Aircraft Weight	TYPE 2		
	Length	Width	Depth
8 ozs.	18"	1¾"	1"
12 ozs.	20"	2"	1⅛"
16 ozs.	22"	2¼"	1¼"
24 ozs.	27"	2⅜"	1⅜"

Tables above give data for the design of pontoons for twin-float layouts.

toon is less important and its underside can be parallel with the rigging line or again at 5 degrees to it. Track should be about 20 per cent. of the wingspan or a little more, and care must be taken to ensure that both pontoons are parallel.

Float Section

Cross-sectional shapes in use vary widely, the simplest being a rectangular section which works very well but is somewhat lacking in modern scale appearance. Giving the sides a little tumblehome and veeing the bottom improves efficiency slightly and looks rather better. Elliptical tops with vee'd bottoms mean more work but look scalish and are probably the most efficient; the vee need only be in front of the step, with a deadrise angle of 15 degrees maximum, and the afterbody undersurface can be flat. Little advantage is apparent with vee'd rears, concave undersides, or flared floats. Width should be 1½ to 2 times depth, and the float noses should be kept rather broad. From the step back the height should remain fairly constant, allowing the sides to taper into a knife-edge. Fig. 2 shows some shapes and methods of construction in general use.

When mounting, some form of springing is desirable provided that the floats remain reasonably rigid and do not vary their incidence. Two wire struts per side permit them to spring slightly outwards and/or backwards, and this would appear to be the best form of mount. Chief considerations for pontoons then are: (*i*) 66 per cent. of fuselage length; (*ii*) enough cross-section to produce at least 5 cu. in. per oz. weight; (*iii*) 5 degrees deadrise angle; (*iv*) step 5 per cent. of body length forward of C.G.; (*v*) 20 per cent. of wingspan for track; (*vi*) reasonable rigidity; (*vii*) accurate line-up.

Chapter Six Wings

THE wings are probably the most important single component of a model aeroplane. They have to be strong enough to take quite a number of hard knocks, as well as normal flight loads, and must also be built true and remain substantially true throughout their life. Wings which have warped badly, or flex in flight, can wreck a model just as readily as a pair of wings which actually break in flight.

Wing construction is normally started by cutting a set of ribs. In kit models the outline of these ribs is usually printed out on sheet balsa—in some, the ribs are actually die-cut, which saves a lot of work.

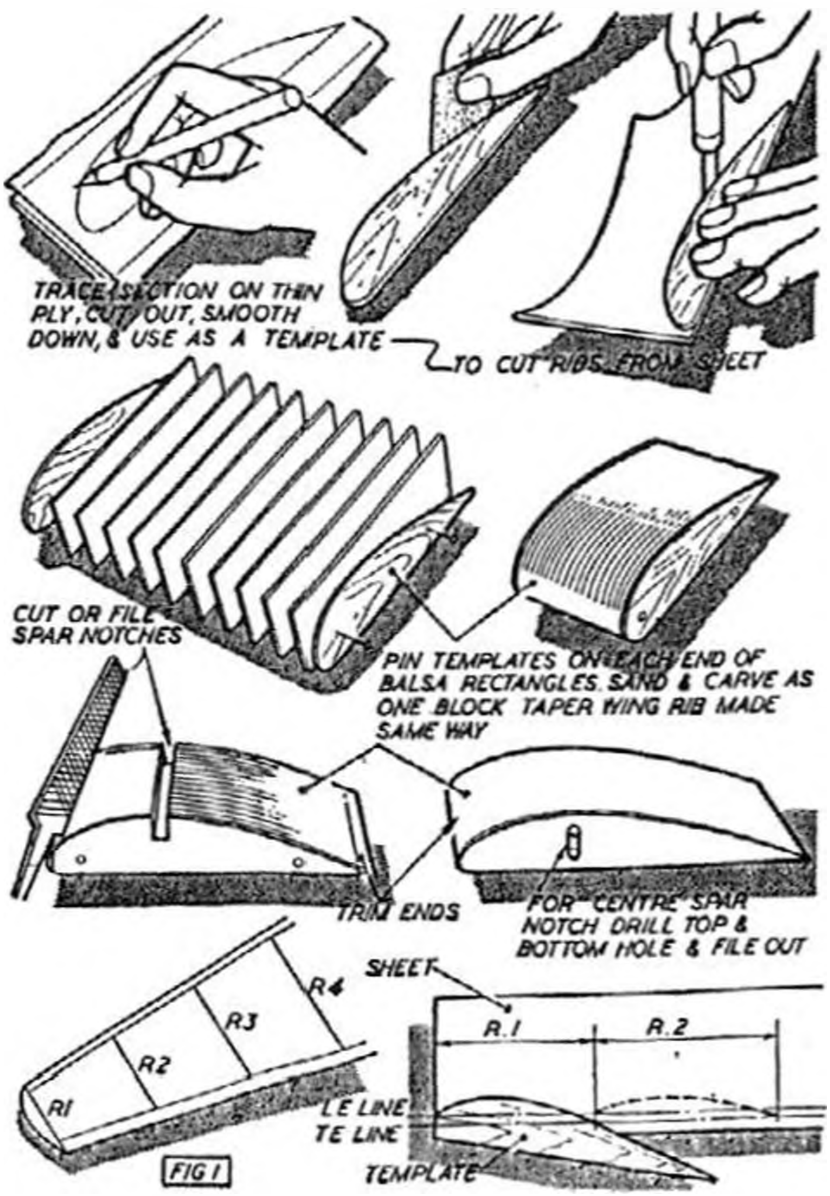
Cutting Ribs

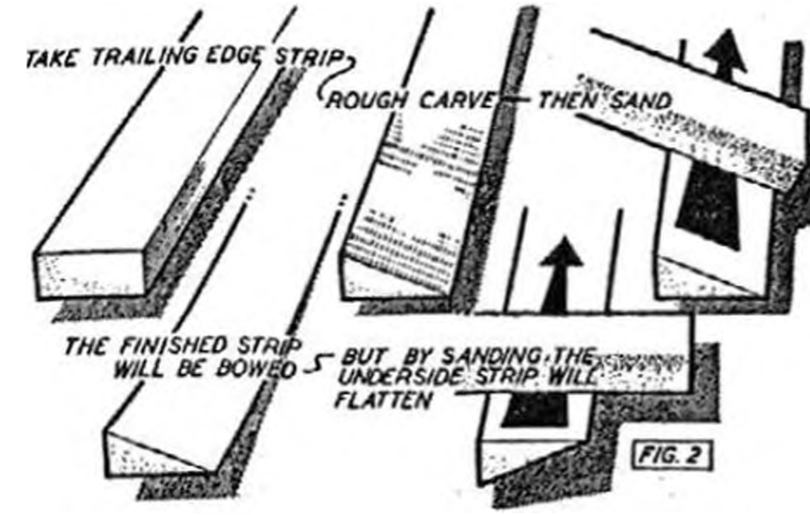
Cutting ribs is really quite simple. The main methods are shown in Fig. 1, using a prepared template of the rib section required. Never try to trace a wing section drawing directly onto sheet balsa and then cut out, but paste the drawing on to a piece of thin ply and cut this out to form a template. Cut the template accurately, smooth the edges with fine sandpaper and you will find it quite easy to cut a whole set of ribs with the template as a guide, each one identical in shape. Work along both edges of the sheet, as shown, for speedy production, and then use up the remaining sheet.

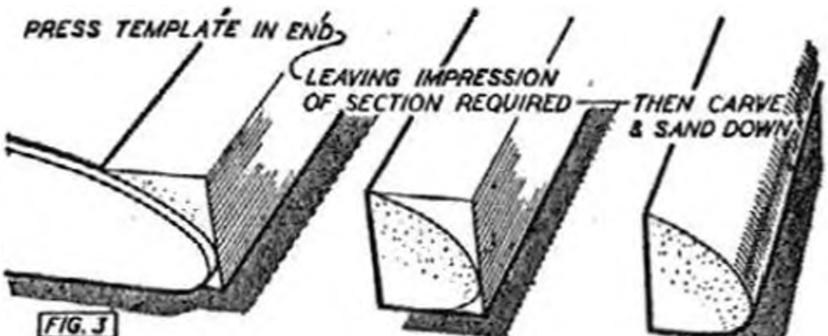
An alternative method is to make two identical templates. Then instead of cutting the ribs individually cut a number of rectangular pieces of sheet and sandwich between the two templates; the number of balsa rectangles should correspond to the number of ribs required. It is then a simple matter to carve and sand the " sandwich " down, like a block, to the section given by the template at each end. When separated you will have a complete set of identical ribs.

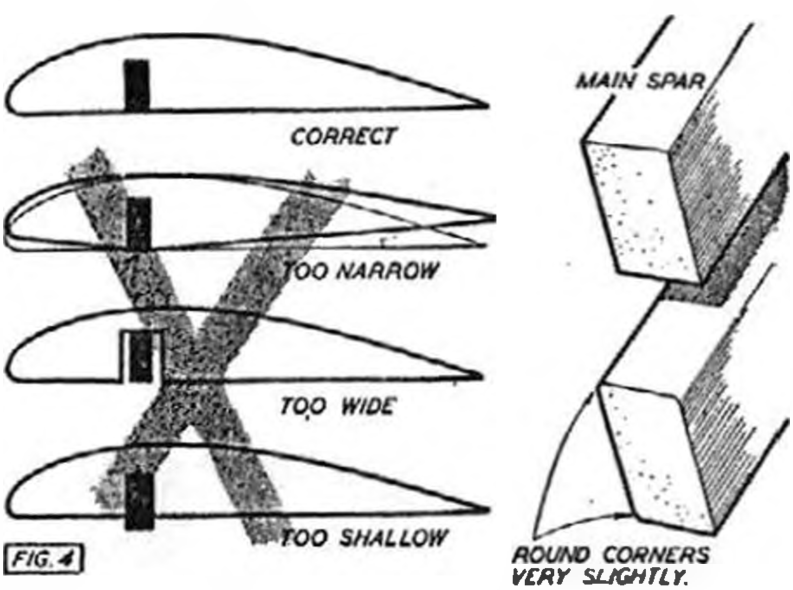
The two-template method can also be used for cutting a set of ribs for a tapered wing. One end template corresponds to the root rib, the other end template to the tip rib section. Sandwich balsa rectangles between them and carve and sand, as before.

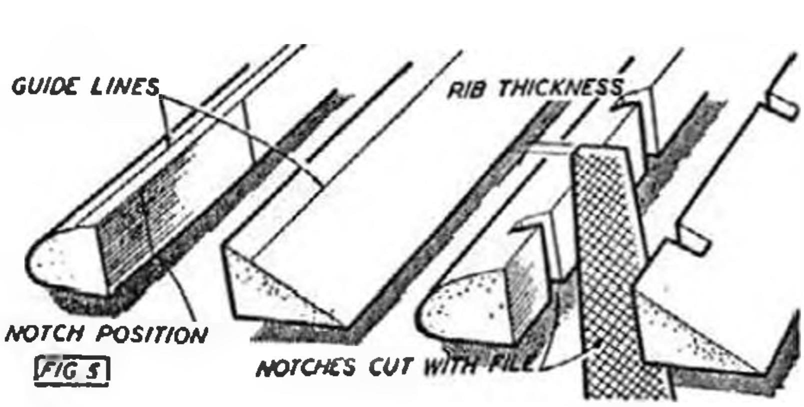
It is very useful to have your complete set of wing ribs " packaged " in this manner. Not only can they be sanded to identical shape, but spar notches can be cut far more accurately than if the notches were cut individually in each











rib. A file is very useful for notching a set of wing ribs, or the sides of the notch can be cut with a hacksaw or fretsaw and the complete notch chiselled out with a modelling knife. Where the spar passes through the centre of the ribs, then the notch can be cut by drilling through the "sandwich" at the top and bottom of the required notch and then removing the rest of the material with a round file (an abrafile for 1/16 in. wide notches) or a fretsaw for larger work.

Even if your ribs have been cut separately from printed sheet, it is still a good plan to pin them together in a complete set and smooth off with sandpaper, checking the spar notches for alignment or, better still, not cutting them until this stage. It is very difficult indeed, if not impossible, to cut a set of sheet ribs individually with complete accuracy.

Just one other method of cutting tapered wing ribs will be described. This is very useful for making the ribs for the tapered tip panel of a wing, where only a few ribs are called for and the two-template method does not seem justified and, in any case, is not really suited to sharp tapers where only a few ribs are involved.

As the diagram shows, taper wing ribs can be cut from the original template, measuring the length of rib required and marking the leading and trailing edge *depth* on the sheet. Line up the top of the template between these points and cut the rib.

Now to prepare the spars for the wing. Contrary to popular opinion, spars *do* need preparing before assembly. You do not just pin down the leading and trailing edge strips and proceed to cement the ribs in place—if you are after best results.

As a general rule, the trailing edge should *always* be shaped to section before pinning down on the plan. The leading edge is not so important. It is generally easier to shape this after assembly.

The trailing edge is invariably triangular in section, cut from rectangular strip, unless you have, or prefer to use, trailing edge stock already shaped. First reduce the strip roughly to triangular shape with a sharp knife and then finish off with sandpaper, as shown in Fig. 2. In sandpapering, hold the strip at one end and stroke the sandpaper block away from the hand. Never rub it backwards and forwards or you will almost certainly break the strip, especially on small sections.

Sanding Warps

The finished strip will now have a marked curl upwards. If you had shaped the trailing edge after assembling the wing structure, this curl would have been produced in the completed wing. Since you have shaped the trailing edge member before assembly you can take this curl out by sanding the *bottom* of the strip lightly until it is flat once more.

If you prefer to shape the leading edge also at this stage you can press the ply template of the complete rib section into the end of the wood, as shown in Fig. 3, to give you an idea of the section required and carve and sand down to this. If carved after assembly, however, the ribs themselves will be a guide as to the section required.

The mainspar will benefit from a little pre-assembly treatment, too. Just round off the edges very slightly with fine sandpaper, as shown in Fig. 4. This will tend to make the spar stronger, as well as being easier to fit in the rib notches. At this stage, too, you can check that the rib notches are the correct size for the spar. Each strip should slip in position easily, but firmly. If the notch is too big, then too much reliance is placed on the cement joint to hold it securely in place. If the notch is too small, then there is a danger of the rib splitting when forced in place, or, at best, the rib section being deformed, as shown. It is better to have the fit too loose rather than too tight. Another common fault is not to make the spar notches deep enough so that the spar, when finally assembled, stands proud of the ribs. This produces a poor covering job where the spar stands out and produces a ridge.

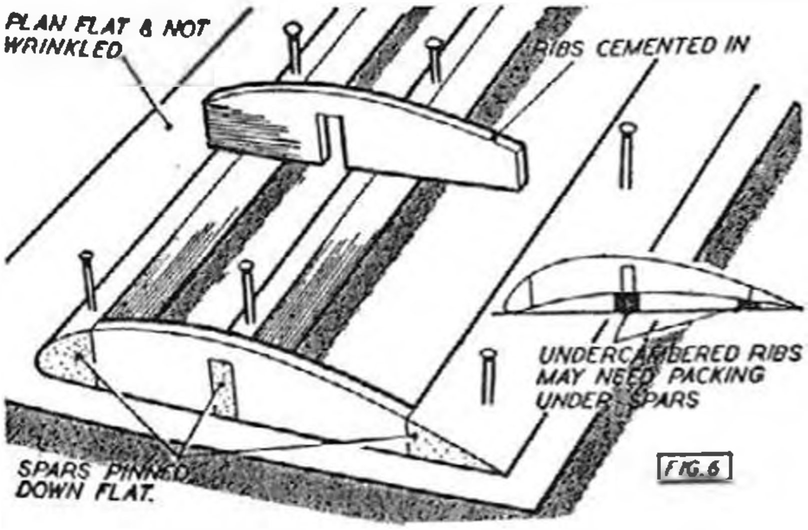
Notching with File

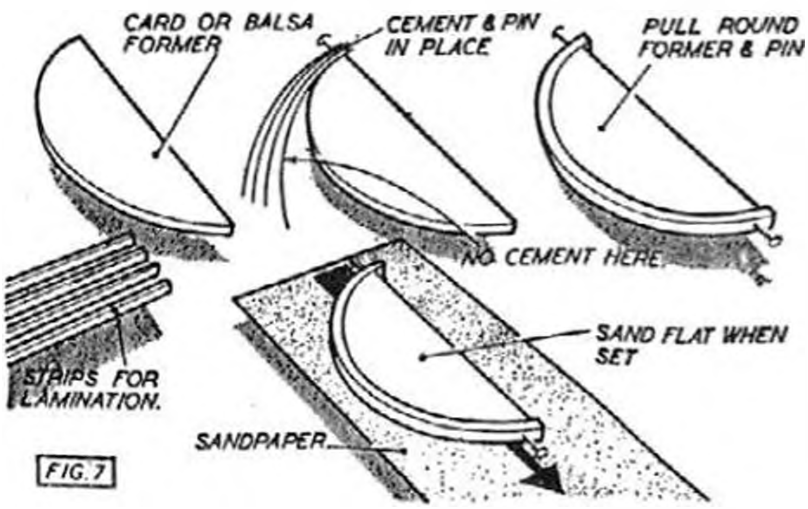
If the ribs are to be notched into the leading and trailing edge then the ideal tool to form these notches is a file of the same thickness as the thickness of the rib. Mark the positions of the notches carefully, also the depth of the notches, and file each individual notch, Fig. 5. Cutting notches with a saw, knife or razor blade is not recommended as these are generally imperfectly formed and usually weaken the spar. It is bad practice, incidentally, to notch the mainspar.

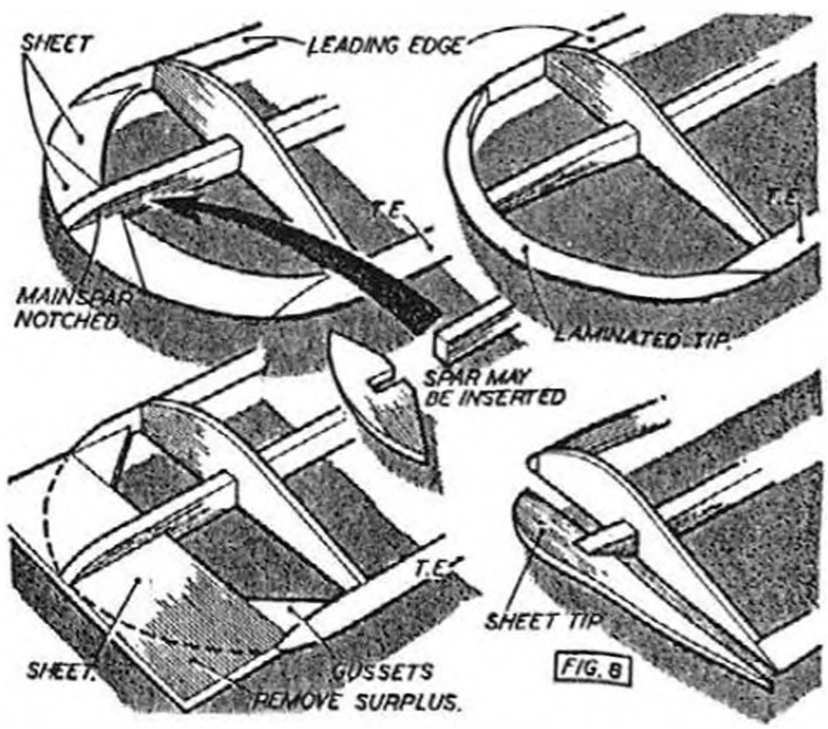
Assembly of the wing can now be tackled. The leading and trailing edge members are carefully pinned out over the outline of the plan—having previously protected the surface of the plan either by covering with waxed paper or rubbing over with the stump of a candle—together with the mainspar. Actually technique will vary with the type of wing being built. In some wings the leading edge is located above the plan itself—perhaps set diagonally in the ribs—or the mainspar has to be packed off the plan to conform to the undercamber of the ribs.

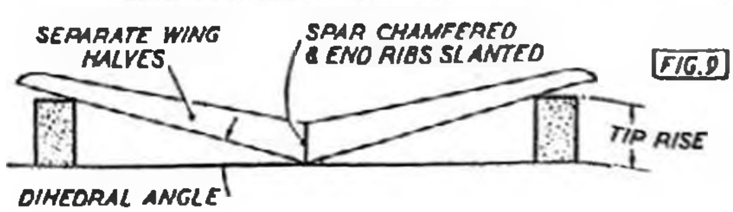
If the ribs are undercambered, then the front of the trailing edge may have to be blocked up to conform to the curve of the rib. This is done quite simply either by inserting small packing pieces under the front of the trailing edge, or a strip of required thickness under the whole length of the bottom edge of the trailing edge. The latter is best for the strip will form a support for locating the bottom of the individual ribs accurately in line with the trailing edge member.

Fig. 6 shows, briefly, how construction of a simple monospar wing would be









tackled. With the spars pinned down, each rib in turn is cemented in place as accurately as possible. Make sure that the spars *are* pinned down flat, particularly the trailing edge, and that the surface of the plan is also flat and not creased or wrinkled. When all ribs have been added then the tips can be cut and cemented in place.

There are very many ways of making the tip. For lightness, which is highly desirable on a rubber model, laminated construction is frequently used. The tip is then actually comprised of a number of layers or strips, cemented together, bent to the shape of the tip outline. The laminated tip can be carved and sanded down, as required, and is quite strong, as well as being very light.

Laminated construction is summarised in Fig. 7. First a template must be made of the *inside* outline of the tip shape required. This template should be at least ⅛ in. thick, and preferably more. It can be cut from card or sheet balsa with the edges sanded smooth and rubbed with a candle. The separate lamination strips are cut from 1/32 sheet balsa of stock which will bend readily without splitting. Avoid really soft sheet, however, or the resulting lamination will be weak when sanded down. It will warp under the tightening action of water spraying and doping the covering.

Lay the strips out side by side and coat each one with cement. Bundle together on top of one another, line up one end of the assembly and pin to the template. Then run round the curve of the template, forcing the laminations together, in line and tight against the template. Pin the other end and leave for the cement to set. One side, at least, of the completed tip lamination should be sanded flat before removing from the template.

For wings of up to 250 sq. in., which is about the maximum size for which laminated tip construction is recommended, the depth of the laminated strip wants to be $\frac{1}{16}$ in. Ideally one would wind a $\frac{1}{8}$ in. wide lamination around a single template and split this down the middle for two identical tips. However, winding wide laminations successfully demands a certain amount of experience and special care, otherwise " dry spots " occur in the cement joints, and less experienced modellers would be advised to wind each tip separately from $\frac{1}{16}$ in. wide strips, using two identical templates to save time. Laminated tips should be left to set for at least six hours before being removed from the template to which they are pinned.

Fitting Tips

The fitting of a laminated tip is shown in Fig. 8. The usual method is a scarf joint at both leading and trailing edges. Cut the tip ends first and use these as a guide for cutting off the same angles on the wing spars, with the tip located in its correct position.

Laminated construction is probably the best method of producing nice elliptical tip shapes on small wings. Similar shapes built up from separate pieces of sheet cemented together have a tendency to break away along the line of the cement joints. This can only be prevented by making these joints very accurate and double-cementing them.

One piece wings are usually made as separate halves which are then joined together at the correct dihedral angle. There are, however, many variations on this principle. Small wings are often built in one piece, cracked and re-cemented at the centre to dihedral. Polyhedral wings or wings with tip dihedral involve cracking and re-cementing the appropriate panels.

Joining two separate wing panels at a given dihedral is generally quite straightforward—Fig. 9. Ideally this should be done on a dihedral board, that is a hinged building board which is set to the required dihedral. This enables the two panels to be pinned down quite flat when they are joined and obviates any tendency to warp as the cement joints set. However, it is usually sufficient to work on a flat board and prop each wing up to the required angle.

Dihedral Joints

The spar ends and the root ribs will have to be cut or set at an angle so that they join correctly when the two panels are brought together and the whole joint is reinforced with dihedral keepers or local braces covering the spars at the joint. Hard balsa can be used for dihedral keepers on quite large wings—having the special advantage of being relatively easy to shape and also cementing well. Ply is often recommended, but requires more careful cementing. Sheet celluloid can also be used. Some typical applications are shown in the diagram.

A wing which is built in one piece and then cracked to various dihedral angles should have the mainspar prepared before assembly. In other words, the mainspar should be notched to conform to the dihedral it will ultimately assume, as in Fig. 10, before assembling the wing. When setting the wing to dihedral angles it is then only necessary to trim the leading and trailing edges at the joint.

A very good way of doing this is to pin one section of the wing down flat (preferably the inboard section). Find the corresponding tip or end rise of the adjacent wing panel and cut a piece of strip to this length. Now lever up the outer panel and shape the leading and trailing edges first by cutting right through cleanly at the joint line (if these spars are not already separate) and then working a small hand saw in the joint, continuing to raise the tip until the required dihedral rise has been achieved. Work on leading and trailing edge

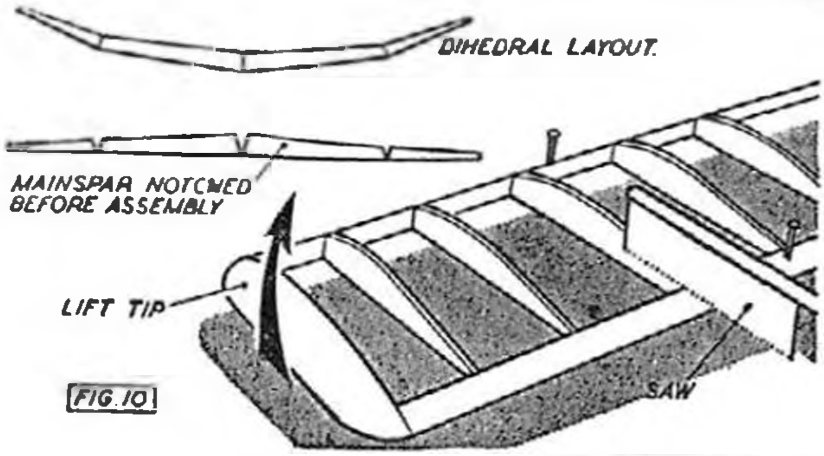


FIG. 10

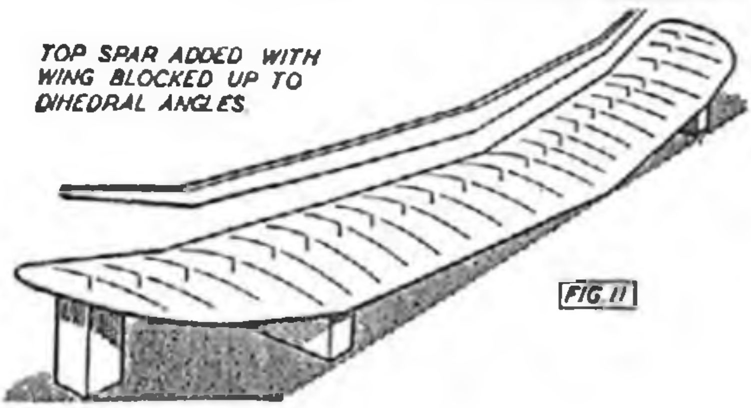


FIG. 11

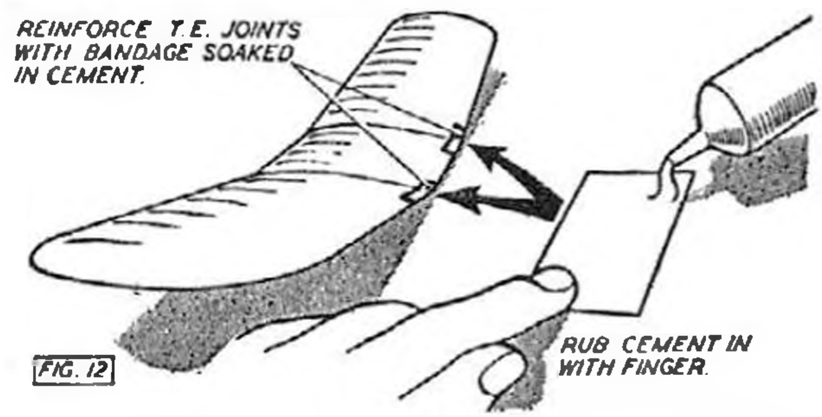


FIG. 12

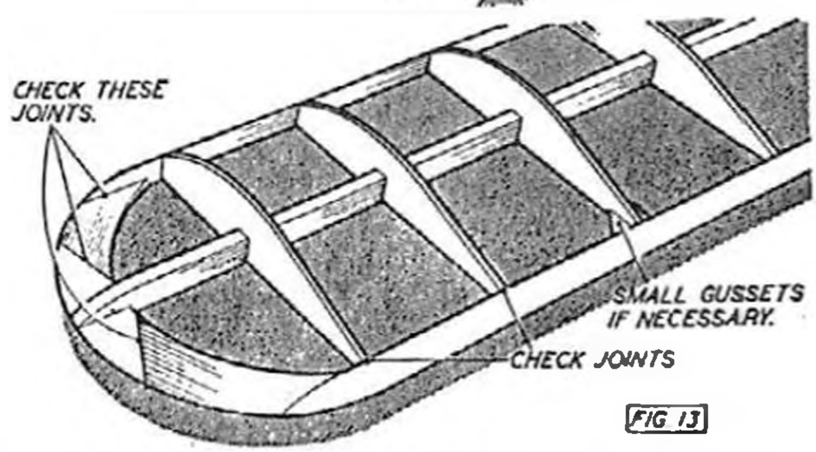


FIG. 13

joint alternately and you will find that the method of trimming with a saw is capable of giving a perfectly matched joint with the minimum amount of trouble. Cement the two panels together and add dihedral braces, etc.

Where the type of wing structures calls for one or more top spars, then generally it is best to build the wing flat with these top spars omitted, set up to the correct dihedral angles and then crack the top spars to fit and cement in place. Care must be taken not to distort the structure when top spars are added.

When the whole wing structure is complete it remains to sand it down smooth and ready for covering, checking that it is free from any warp or twist. Never rely on covering to correct a twist. Most likely it will aggravate it. The first essential towards building a true wing is a true uncovered structure.

Before actually adding the covering, however, it may be advisable to add local reinforcement. At the dihedral joints on the trailing edge, whether one or more in number, a binding of heavy tissue, silk, or gauze bandage on larger wings will greatly increase strength in these regions. It is these joints which are most likely to become uncemented if the wing gets a sharp knock. Reinforcement at the centre, too, prevents the rubber retaining bands from cutting into the wood—often a troublesome feature when you have gone to pains to produce a nice thin trailing edge on your wing.

Chapter Seven Tailplanes

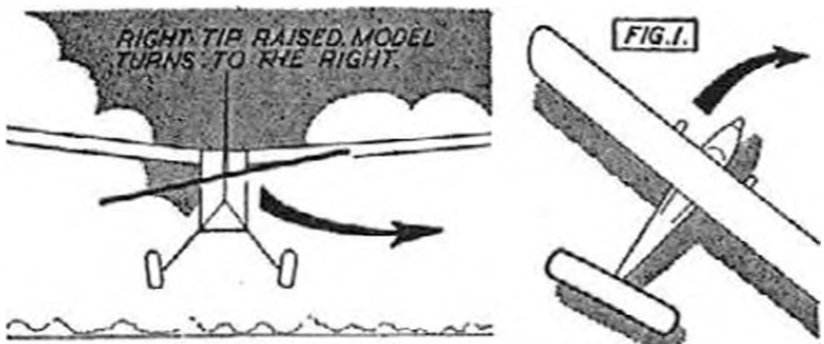
THE tailplane of a model is usually a relatively simple component—but most important in many respects. The Americans call it a stabiliser and it is, in fact, just that. It stabilises the model in flight and automatically compensates an involuntary dive or stall, when correctly rigged. Being at one end of the model, distant from the point of balance, it needs to be light—which is where simple construction comes in—but this introduces a conflicting requirement. It must also be true and remain true. If it warps when completed it may affect the stability of the machine—not so much in an "up-and-down" direction as sideways or in turning flight, for a tailplane can have quite a powerful turning action.

Many modellers use this effect in trimming for turn. Two such methods are shown in Fig. 1. If the tailplane is tilted as shown in the direction of the raised tip—tilt the right tip of the tailplane up for a turn to the right, and vice versa. This turning action is quite moderate and relatively "safe"—better in many cases than offsetting the rudder or trim tab.

A more powerful turning action is given by slewing the whole tailplane. In this case the model turns towards the side with the foremost tip. Slew the tail out of line with the fuselage so that the right tip is forward, the model turns to the right. A tailplane slewed through an angle of 10 degrees—5 degrees either side of its true position—can make a difference between a right and left hand glide circle on some models.

These effects, of course, do not directly concern construction. They are mainly a matter of rigging and trim. But as far as construction is concerned a *true* tailplane is the ideal to aim at.

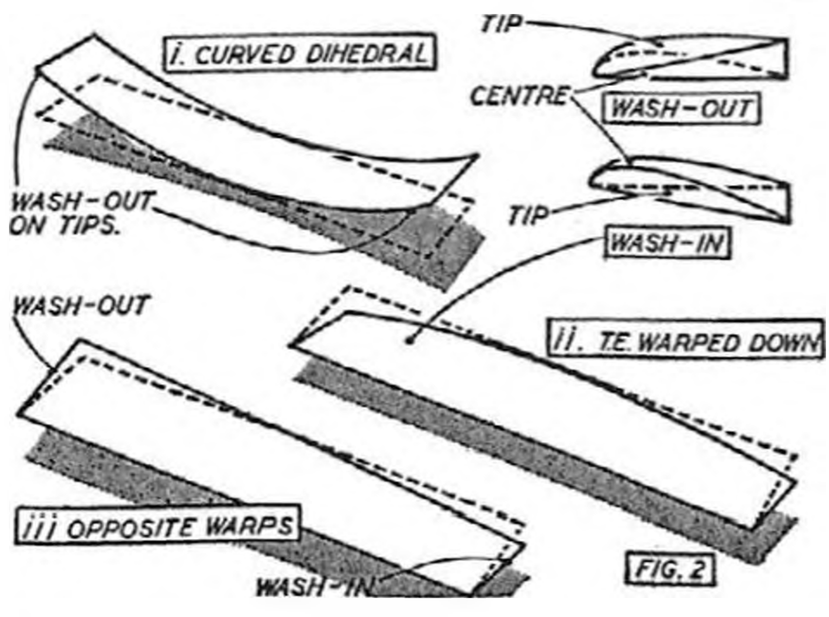
As far as warps are concerned, these are likely to be one of three main types (Fig. 2). The first, and most common, is where the whole tailplane bows upwards into a curved dihedral. Generally this also results in the trailing edge washing out towards each tip. If both the dihedral and washout induced are equal on both sides, such a warp is not harmful. It may even be beneficial. Quite a number of contest fliers do, in fact, deliberately wash out the tips of the tailplane for improved stability. The only danger is that a tailplane which warps readily in this fashion may change its setting during the course of a day's flying and thus upset the trim of the model.



'TAIL TRIMMING' FOR TURN USED TO ADJUST GLIDE CIRCLE

RIGHT TIP SLEWED FORWARD. MODEL TURNS TO THE RIGHT.

DIAGRAMS ARE EXAGGERATED.



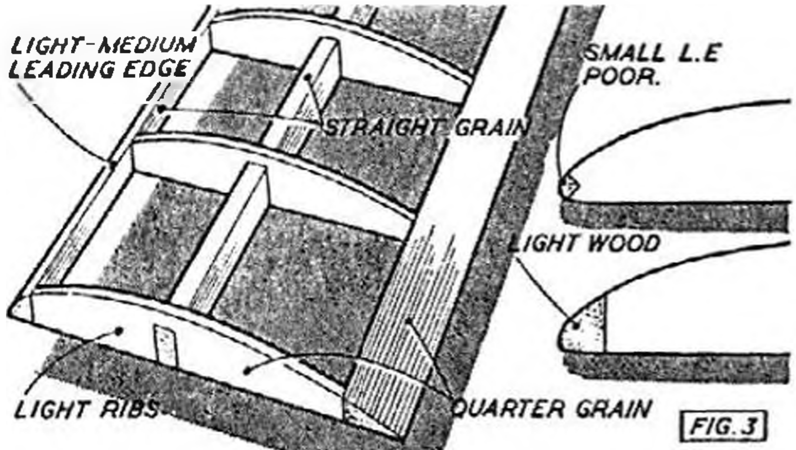


FIG. 3

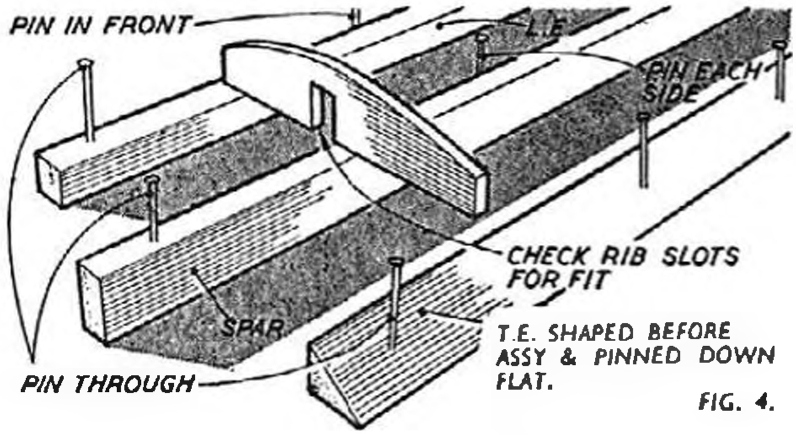


FIG. 4.

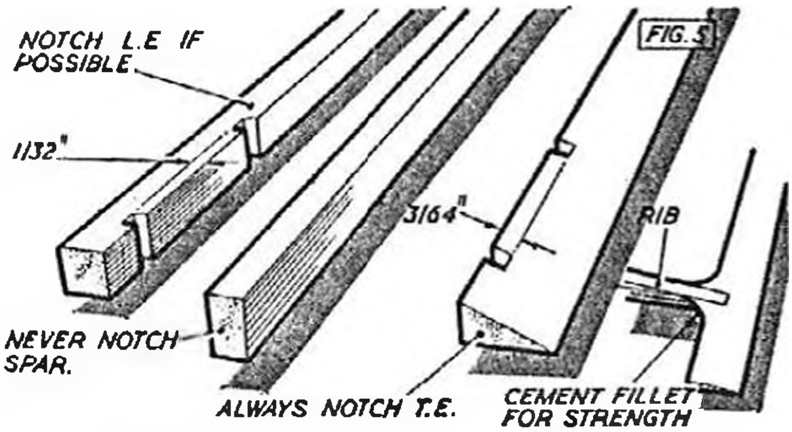


FIG. 5

The second type of warp is a bad one. Here the trailing edge warps downwards towards each tip and gives wash-in to the tailplane. Generally this is the result of faulty constructional *design*.

The third warp is also bad and may put the model into a spiral dive. Here one side of the tailplane warps up and the other down. One side has wash-out and the other wash-in. Generally this is due to faulty *construction* rather than design.

Fig. 3 shows the type of wood you might use. The leading edge and main spar are of straight grained stock, whilst the thinner trailing edge will be best cut from quarter grain. A common fault is to make the leading edge too small in section, so that hard wood has to be used for sufficient strength. A wider, deeper leading edge is usually better—stronger overall, giving a better entry, and quite as light if light medium or medium stock wood is selected.

Usually the tailplane incorporates an aerofoil section with a flat undersurface. The leading and trailing edges and the spars are pinned down, as in the case of wing construction previously described in detail, and the ribs then cemented in place. No harm will result from using thin pins through both the leading edge and the trailing edge, but the spar should only be pinned through outside the tip. Locate with pins either side within the outline of the structure (Fig. 4).

The most common fault at this stage is to have the underlying plan slightly wrinkled or creased so that the spar is not resting absolutely flat. In other words, you are actually laying out the tailplane with an inbuilt warp. Obviously this must be avoided, so take care to ensure that all the spar members are pinned down flat with the building surface and that the ribs are also properly bedded down when cemented in place.

Locating Ribs

It is a definite advantage to slot in the ribs to both leading and trailing edge if possible, but using only very shallow slots, otherwise the strength of these spar members will be reduced (Fig. 5). If the leading edge is of particularly narrow section, then do not slot it.

The trailing edge itself will not be very deep and if the end of the rib is cut to exact depth may, through a little inaccuracy in cutting, actually be less than the depth of the trailing edge at this point. This may spoil the appearance of the covering job later, but what is far more important it will reduce the strength of the rib-trailing edge joint. When working with thin trailing edges it is better to cut the ribs slightly oversize at the trailing edge, that is, slightly too high, and then sand down flush with the trailing edge later.

Trailing Edges

Shape the trailing edge before assembly and form the leading edge to section after assembly. However, a thin, finely finished trailing edge warps readily—i.e., it has little resistance to bending—and sometimes it is better not to finish this member to a true trailing edge section. This is a good tip when dealing with small tailplanes where the actual dimensions of the trailing edge are small (Fig. 6). The section is shaped by rounding off the top edge rather than tapering to a wedge shape, greatly increasing the effective depth of the trailing edge and its resistance to warping.

This is often done to all the outline members where a simple flat plate tailplane is called for—Fig. 7. This enables relatively small outline spars to be used to save weight and at the same time increase bending strength. In tailplanes of this type all the bending strength comes from the outline spars. A mainspar is very seldom used and, even if it were, would not be very effective. Such tailplanes are more prone to warp than built-up structures with a deeper aerofoil section. They are generally tissue covered on one side only and not doped. Their application is mainly limited to very small models, although similar construction is used on lightweight contest models.

The importance of ensuring that the building board is perfectly flat and that the plan is pinned taut and flat over it, has already been emphasised. But we repeat this point again, for the flat plate tail and its natural tendency to wander from the true line with warps at the extremities is not quite as easy to make as its structure would have us believe. Always keep the flat section tail pinned down whilst water shrinking and doping. If this precaution is not observed, the result will be somewhat like that indicated in Fig. 8. Even after the dope is

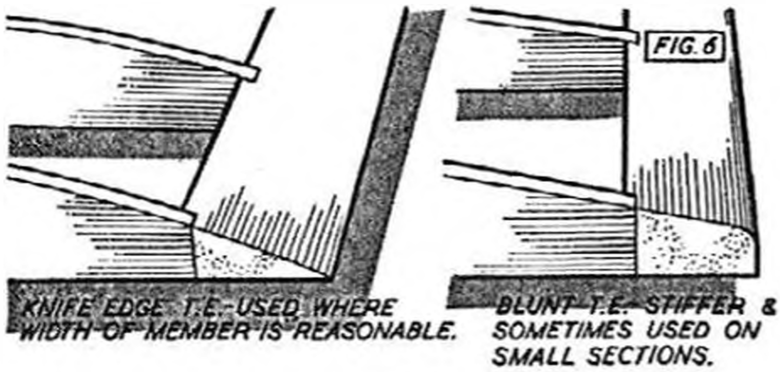
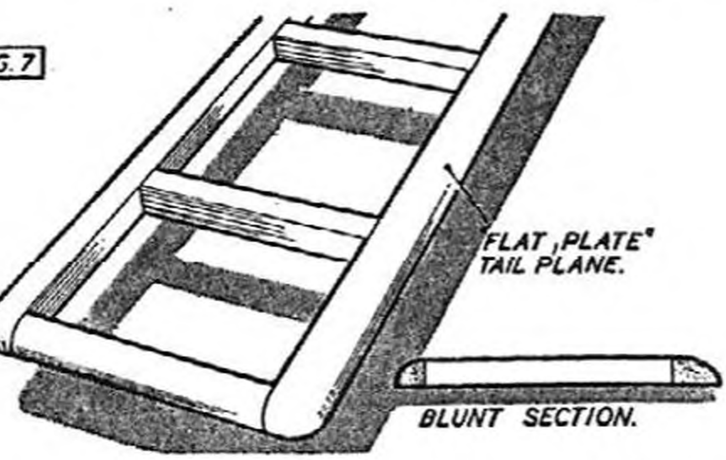


FIG. 7



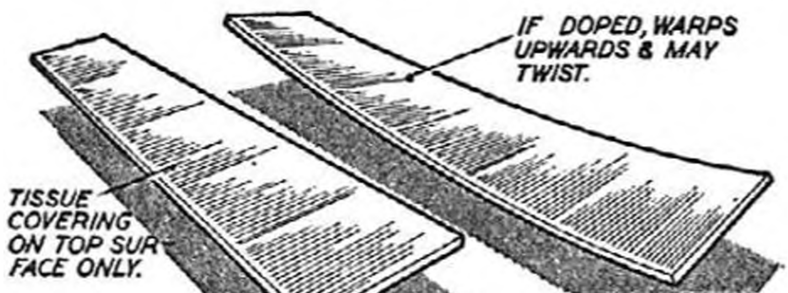


FIG. 8

thoroughly dry, changes in atmospheric temperature, particularly exposure to hot sun, will have the same effect. It is advisable, therefore, to keep the tail pinned flat between flying days.

One of the best ways of building a true symmetrical section tailplane is to do the job in two stages. The tailplane is virtually split along a line as indicated in Fig. 9, and the main part of it built flat, just like an ordinary tailplane. When completed it is turned over and the remaining part ribs added to produce the required symmetrical section. This method is generally easier, and more accurate, than building the same tailplane with full symmetrical ribs, propping up the leading and trailing edge members as required with scrap wood between them and the flat surface of the plan.

There are also quick and simple methods of tailplane construction which at one time found considerable favour for power models. No rib cutting is involved. Strips of wood of the required depth are cemented in place and sanded down to section after assembly is completed. The main spar is the same depth as the rib section, but thicker.

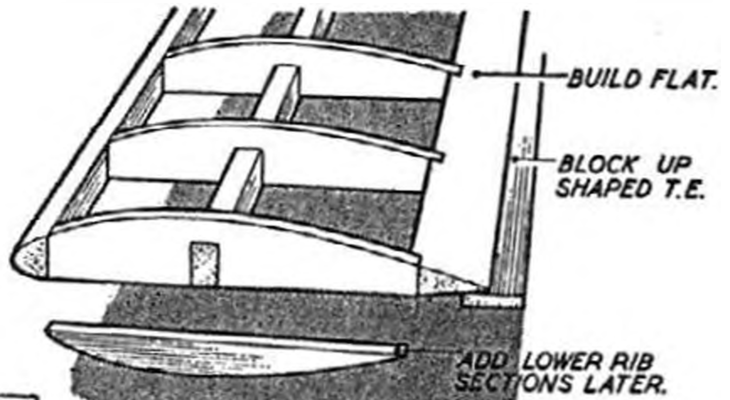


FIG. 9

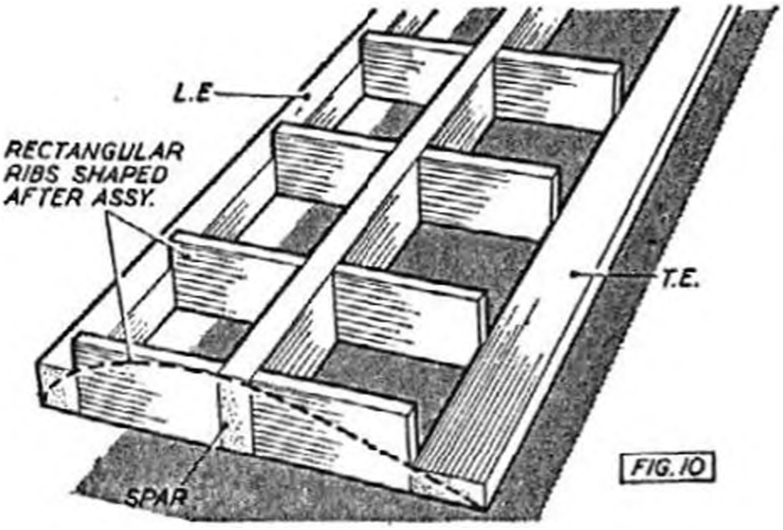


FIG. 10

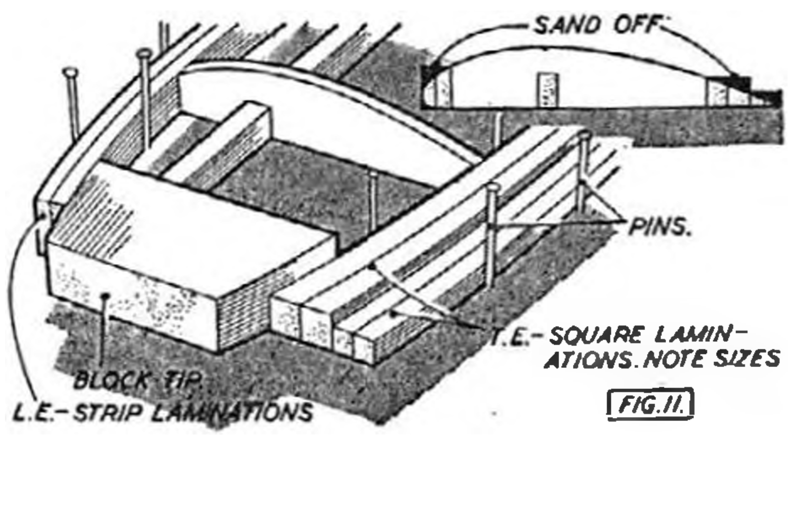


FIG. 11.

Shaping by Sanding

Mainspar leading and trailing edges are pinned down as shown in Fig. 10. All the rib "rectangles" are then cemented in place. When set, the whole lot is sanded down to aerofoil section.

Generally the results do not compare with orthodox construction using pre-cut ribs. It needs very great care to reduce all the ribs to the same section. It is very easy to sand "flats" in the tops of the ribs and unless the cement joints between ribs and spar are particularly good, these may fail when the tailplane is covered and let the section warp. After sanding, if this method is used all these joints should be checked over and possibly reinforced with a fillet of cement on each side.

With large power model tailplanes of this and similar construction elliptic outlines are often formed from laminated leading and trailing edges. Using narrow strips for the leading edge and square section for the trailing edge, moderate curves can be negotiated with ease—Fig. 11. A row of pins is erected around the inside outline, the strips cemented and then pinned down in place. Ribs and spars are added in the normal way, but the whole assembly should be left pinned down for several hours before removing to give the cement joints between the laminations adequate time to set. The laminated outlines are then carved and sanded down to conform to the rib sections to complete the tailplane ready for covering.

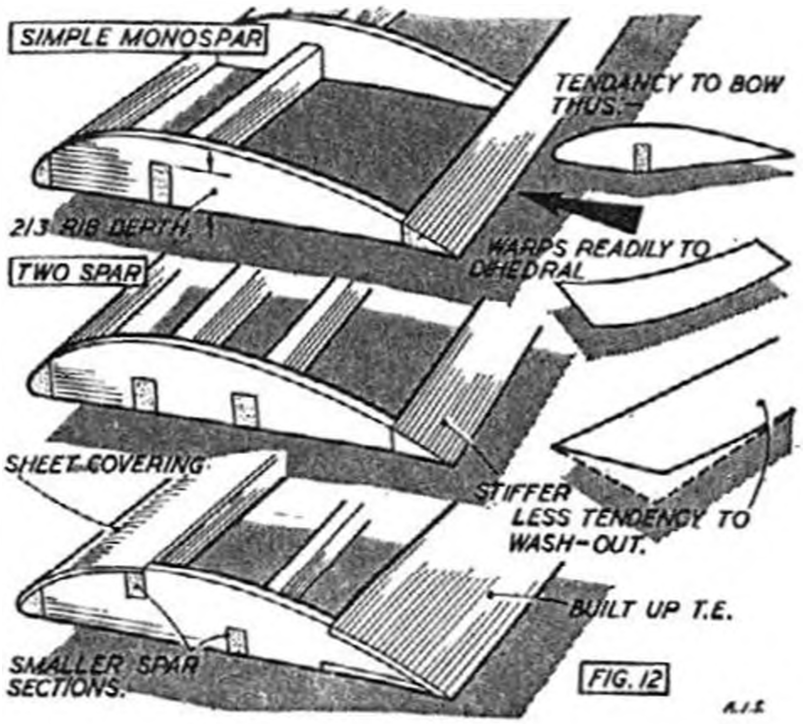


FIG. 12

Since the design of the tailplane itself is a major factor in subsequent warping, it is as well to have a little knowledge on this subject. Whatever form of construction is used, the frame should be perfectly true before covering. If not, then that is just bad building. Bad covering can induce warps—a subject which will be dealt with in detail in Chapter 15—but even the best of covering and doping jobs cannot be expected to correct in-built warps. All tailplanes will be subjected to a considerable amount of *stress* when covered and doped—the covering would not stay taut it if were not pulling on the points where it is attached—and it is how the structure reacts to these stresses that determines what warps, if any, will subsequently develop.

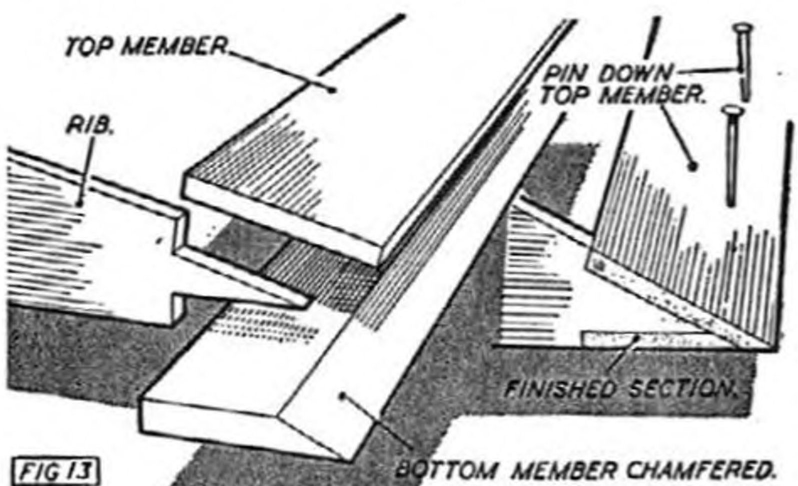


FIG 13

It is possible to make the structure stiff enough to resist warping under the action of normal covering tension if enough volume of wood is used in the construction, and really hard, rigid wood at that. Unfortunately such a tailplane would also be too heavy. The designer has either to compromise by using small section spars intelligently to get adequate strength at an acceptable weight, or resort to more advanced types of construction such as geodetic rib spacing, built-up hollow torsion box leading and trailing edges, and so on.

The most popular, and one of the simplest, types of tailplane structure uses a monospar of reasonable depth (Fig. 12). This is quite strong and reasonably light, as well as being easy to build. It usually gives a satisfactory structure, but one which is prone to bow upwards into a curved dihedral—the type of warp described in Fig. 2, which is not really harmful.

On larger tailplanes the same type of construction may be employed, only this time with two separate mainspars. This

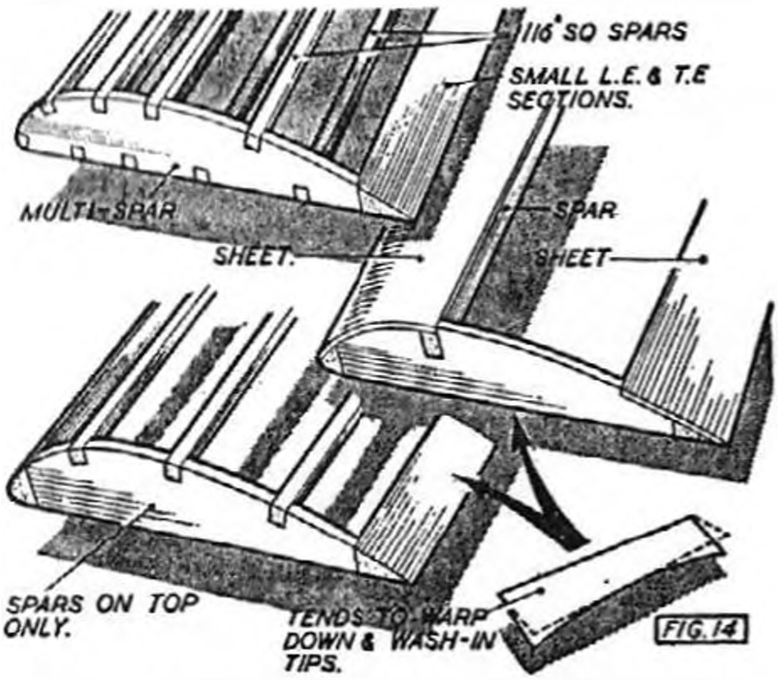


FIG. 14

is more warp-resistant, but proportionately heavier. Used, for example, in a power model tailplane, a more rigid structure at about the same weight—but more difficult to build—would retain the two spars, although of smaller section, have a built-up " V " trailing edge and sheet covering on the top surface of the aerofoil back to the mainspar. This is a very satisfactory design for most large tailplanes, particularly those of rectangular plan form. Careful workmanship is called for in assembly of the final trailing edge. The tailplane is first built flat on the plan with just the lower thin sheet member of the trailing edge pinned down. Previously this has been chamfered off as shown in Fig. 13. The ribs overlap this member.

When the main assembly has been completed, the upper trailing edge member is cemented in place and pinned down accurately. A final sanding down when set reduces the built-up trailing edge to the required section, as shown. Sheet 1/16 in. thick is invariably employed for built-up construction of this kind on power models. Similar construction has been duplicated in smaller sizes for Wakefields, but here the work is more tricky as it is all too easy to sand right through thin sheet in the final stages.

Rigidity

In general, rigidity of the structure is only obtained at the expense of increased weight, increased complexity of building, or both. Possibly the simplest of all " rigid " structures is the multispar, where a large number of small section spars are used, as in Fig. 14. These spars are roughly balanced along the top and bottom of the section and the resulting structure is extremely rigid. Its main failing is that, to keep the weight to comparable figures, each of the individual spars is of extremely small section—1/16 in. square, for example—and thus locally weak. It is easy, in other words, for a single spar to be broken and thus weaken the whole structure. Two such small breaks might even warp the whole assembly.

The types of tailplane structures to be avoided are those which are unbalanced, such as the two final examples. Here the bulk of the spar strength is concentrated in the upper part of the section in the hope that since tailplanes usually tend to warp upwards, adding rigidity to the upper surface will obviate warping. What does happen in such cases is that the structure warps downwards or produces a tailplane with negative dihedral. A tailplane with negative dihedral may not be bad in itself—some designers deliberately employ such a feature—but produced as it is by warping, almost certainly wash-in will be induced in the tips, which *is* bad. Far better, in fact, to have a tailplane which warps upwards.

To conclude with a further comment on dihedral, where this is deliberately employed as a design feature. There is still little evidence to show that this is necessary. In other words, what advantages might be gained by a dihedralled, or anhedralled, tailplane can generally be obtained, perhaps more effectively, by other means. To introduce a dihedral break into what has been built as a flat structure when it is not strictly necessary is bad practice. From purely structural considerations a flat tailplane is undoubtedly best.

Chapter Eight **Fins**

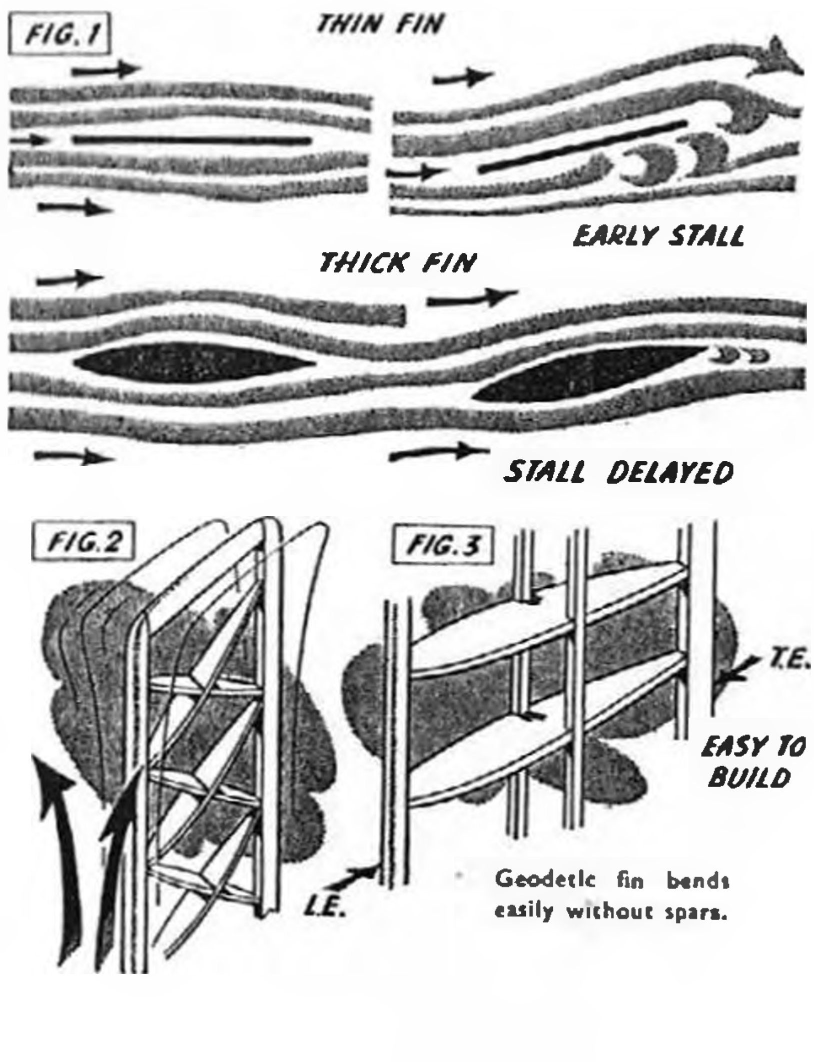
A MINOR component in many ways it must be remembered that the fin of a model exerts a very powerful stabilising force. One has only to watch how a model misbehaves should the fin accidentally become detached in flight to appreciate this fact. It will then be equally obvious that, improperly aligned, the fin can also be an *unstabilising* factor. Too much offset for a turn, for example, and the model winds up in a spiral dive.

As a general rule it is best to regard the fin as a vertical stabilising surface and not as an adjustment for turn. Very rarely is the whole fin offset to produce a turn. A small proportion of the total area, either in the form of a trim tab or a rudder is used, but the effect can be the same. Other forces are generally better, and more safely used, to promote a turn.

Equally true, as a generalisation, is that a warped fin should always be regarded as a potential danger. A model with a warped or badly aligned fin may fly all right normally, but instability may appear if, for any reason, the flight speed is increased. Such instability is often catastrophic — once started it gets worse, and goes on getting worse. A glider, for example, may behave perfectly in free flight from a hand launch, but be unstable under tow. A power model, or a rubber model, may misbehave in a similar manner under full power. A warped fin rates high on the list of possible " causes " in such cases.

We are not concerned here with the aerodynamics or shapes and sizes of fins, but mainly with their construction. But it is interesting to note that in some cases the two go hand in hand. A thin fin section, for example, is aerodynamically poor, Fig. 1. It stalls more readily than a thicker, symmetrical section. Structurally the " flat " fin is also undesirable for this is a type of structure which will warp more readily than a thicker section. Strangely enough most model builders are reluctant to use a fin of generous aerofoil section and nearly all err on the side of making this particular aerofoil rather on the thin side. A certain amount of weight may be saved by this means—but only a very small amount. Any possible saving in drag is questionable.

Using a fin section of moderate thickness—say ten per cent.—then it is fairly easy to design a stiff structure without adding excess weight. Of all the types of



Geodetic fin bends easily without spars.

FIG. 4

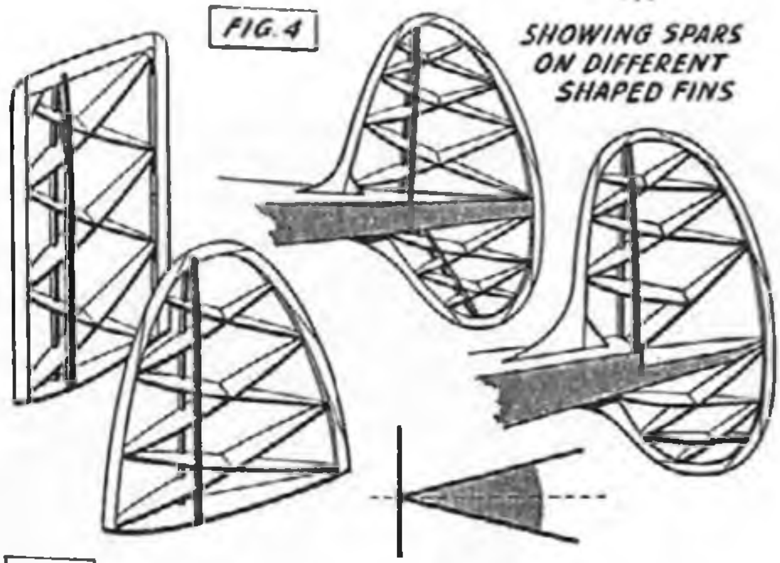


FIG. 5

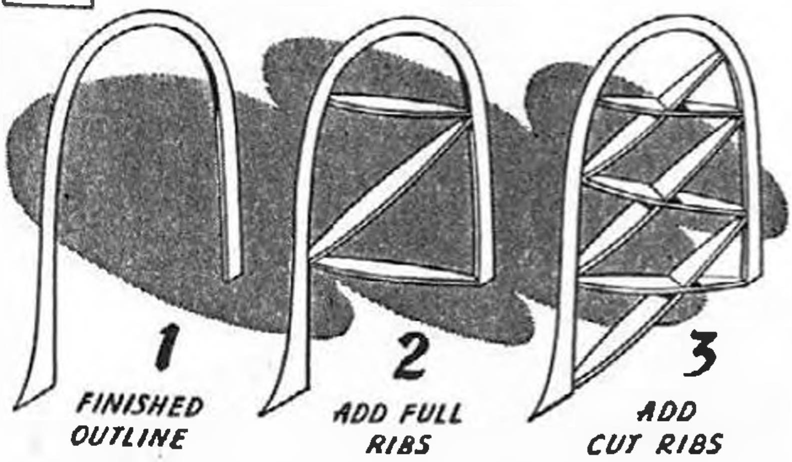


FIG. 6

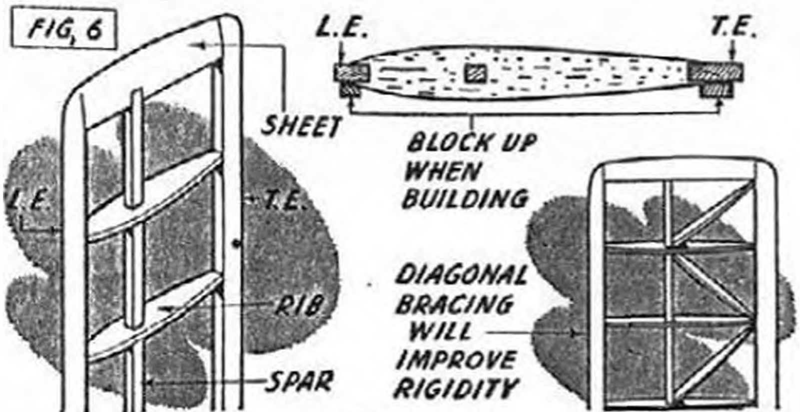
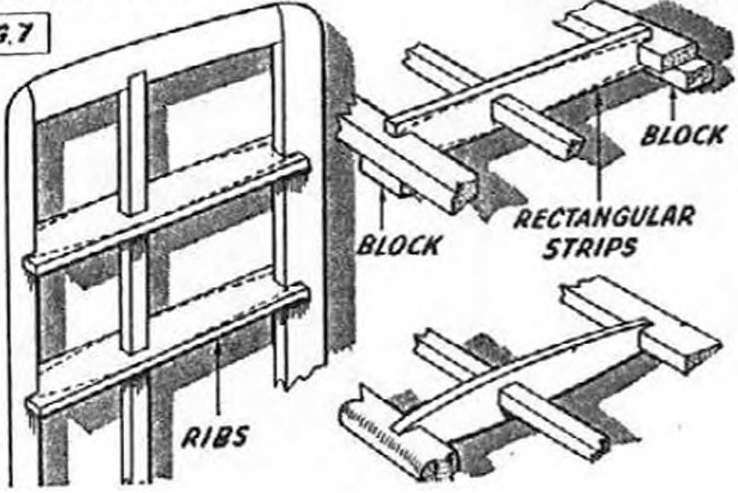


FIG. 7



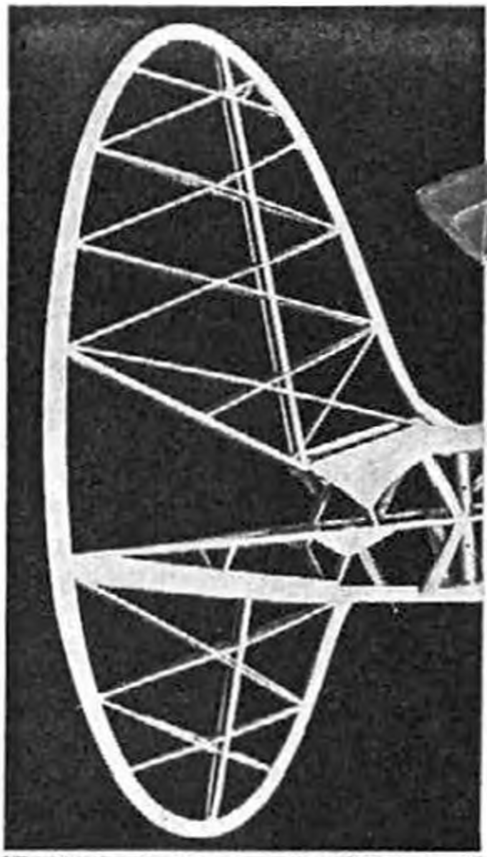
built-up structures the geodetic is undoubtedly the most rigid—again without a weight penalty—but only so far as twisting goes. A normal geodetic fin without spars as in Fig. 2, for example, would be quite likely to warp into a bend, even if it would not twist out of true. To obviate this a spar or spars to absorb any bending loads is necessary, as in Fig. 3.

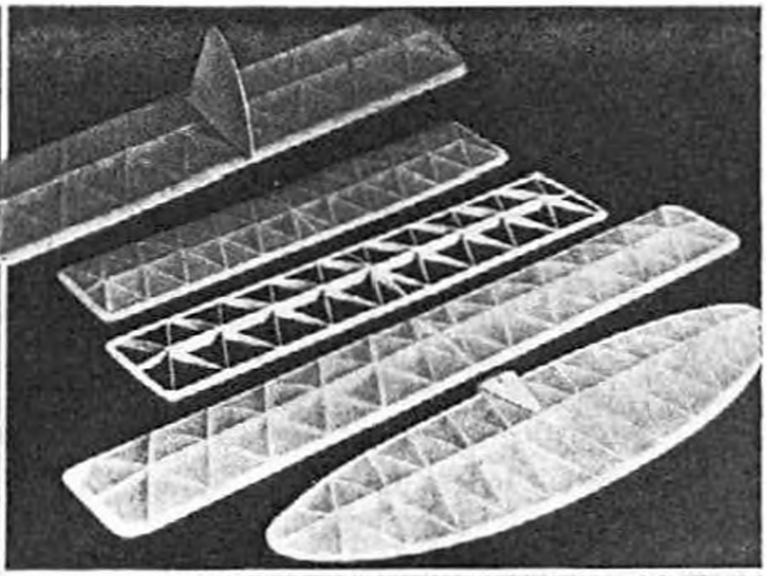
Geodetic ribs can be fitted into almost any fin outline. Naturally a simple rectangular outline is by far the easiest to deal with. Curved outlines may be quite difficult to design having a complete, but still relatively simple, geodetic rib spacing. Some examples are shown in Fig. 4.

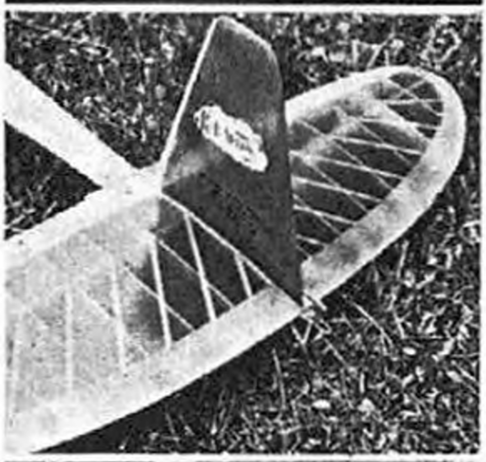
The one disadvantage of this method of construction is, of course, the more complicated work required. About the best way to build a geodetic fin is to work within a finished outline, as in Fig. 5. This outline must be rigid enough to maintain its true shape as the full ribs are cemented in. Half ribs are then butt-jointed in place and spars can be added later, when set. It is important to use a cement which does not contract unduly on setting.

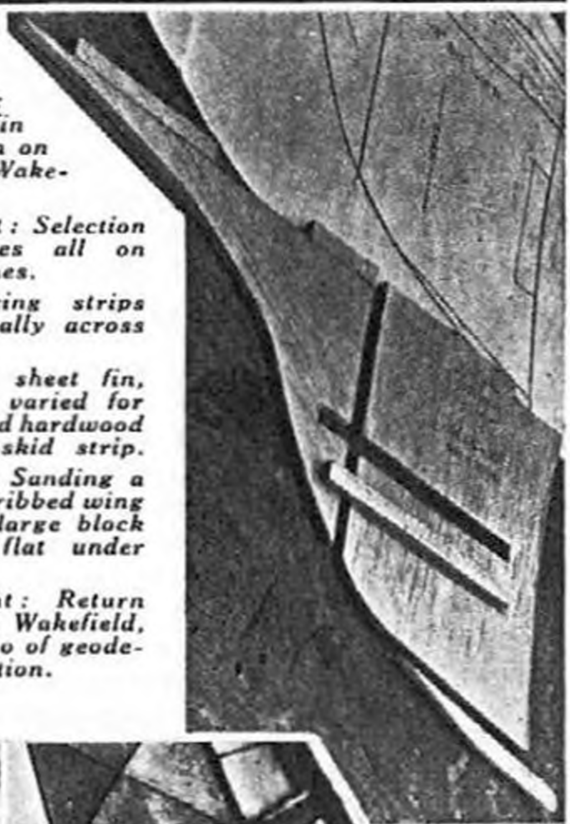
Simple Designs

Simple fin construction, using symmetrical ribs, as in Fig. 6, has a number of failings. The final assembly is seldom very warp-resistant, even if originally true. Many people, too, find difficulty in cutting symmetrical ribs accurately so that the final section, even after sanding, is not true.









Above left: Geodetic fin construction on a Warring Wakefield.

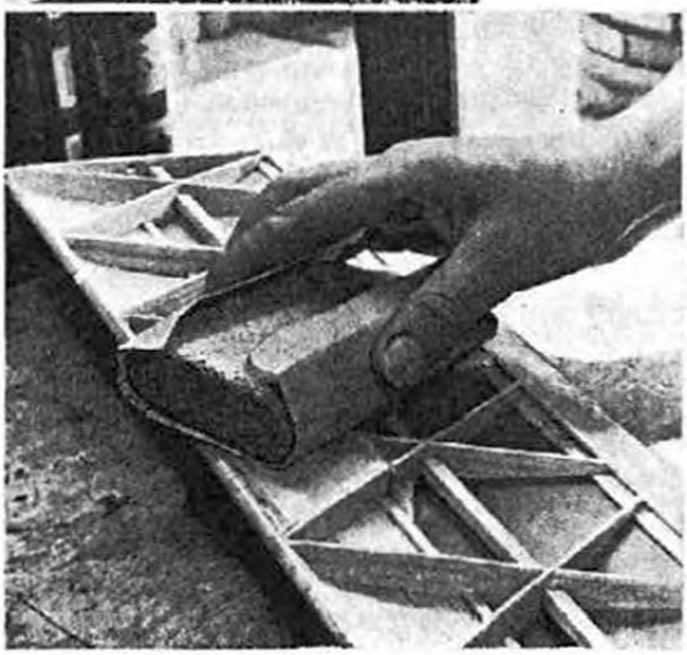
Above right: Selection of tailplanes all on geodetic lines.

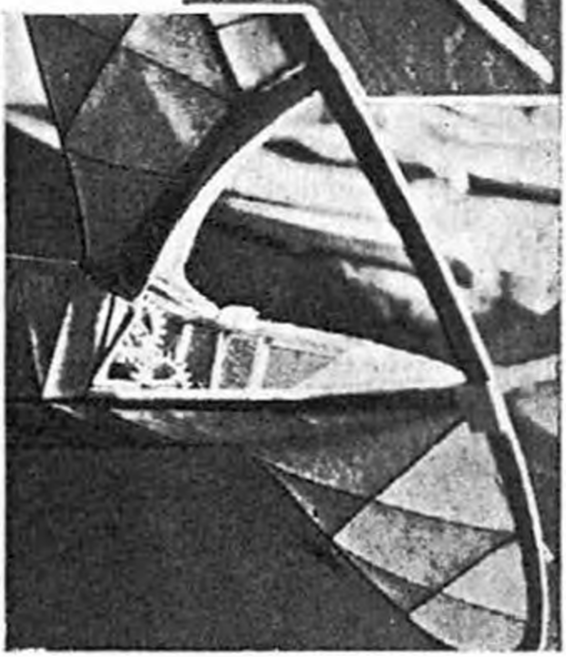
Left: Bracing strips laid diagonally across tail ribs.

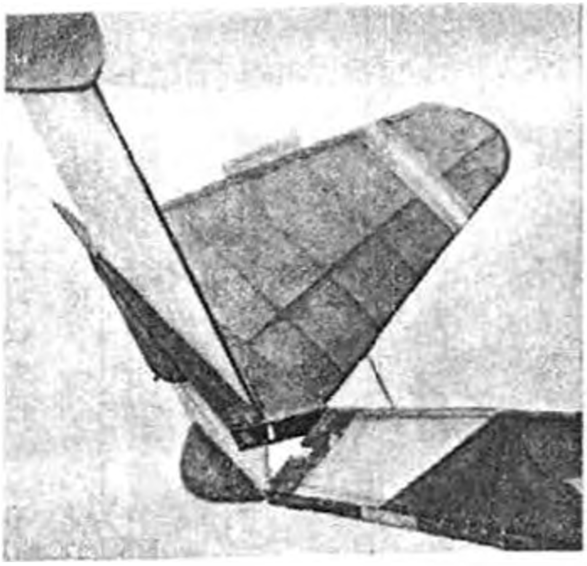
Right: All sheet fin, with grain varied for strength, and hardwood brace and skid strip.

Below left: Sanding a criss-cross ribbed wing requires a large block to ensure flat under surface.

Below right: Return gears on a Wakefield, which is also of geodetic construction.



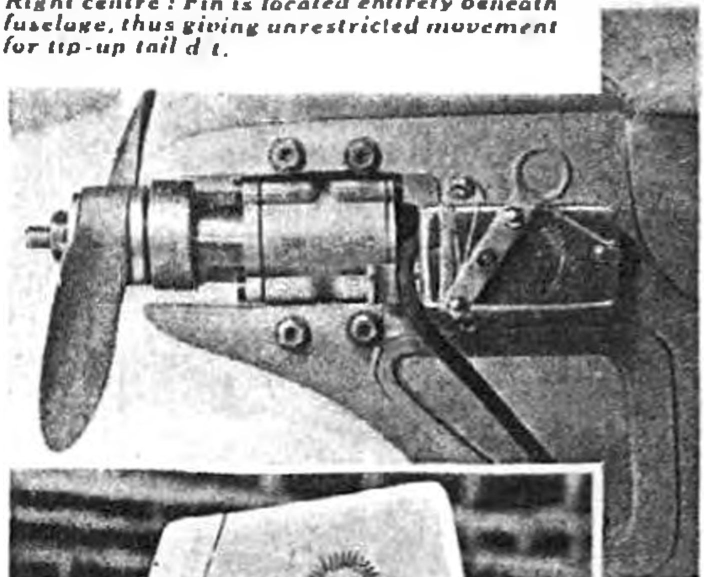


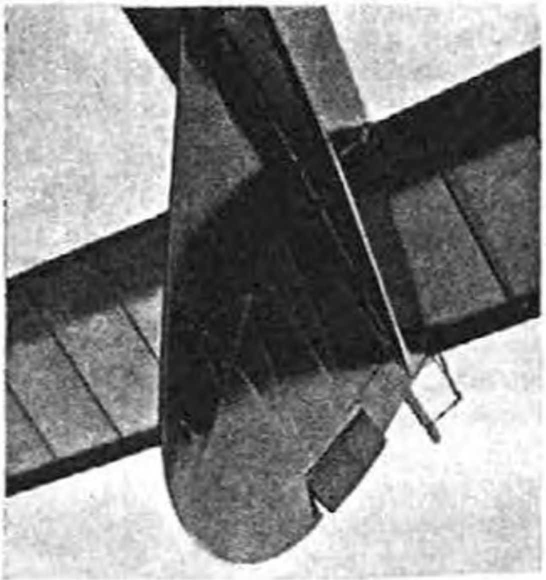


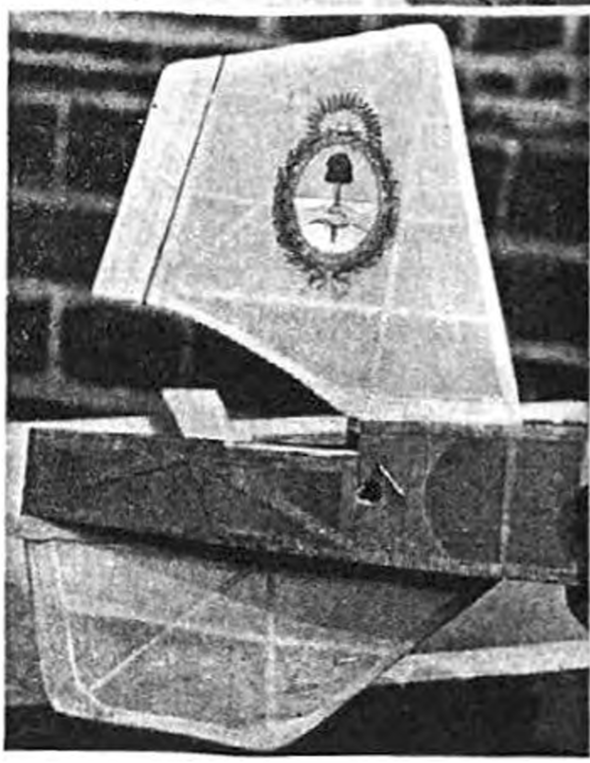
Above : Complete tail assembly tips up for d t ; providing at the same time direct access to rear motor peg of the Wakefield.

Right : A split-fin d t developed by an American serviceman.

Right centre : Fin is located entirely beneath fuselage, thus giving unrestricted movement for tip-up tail d t.



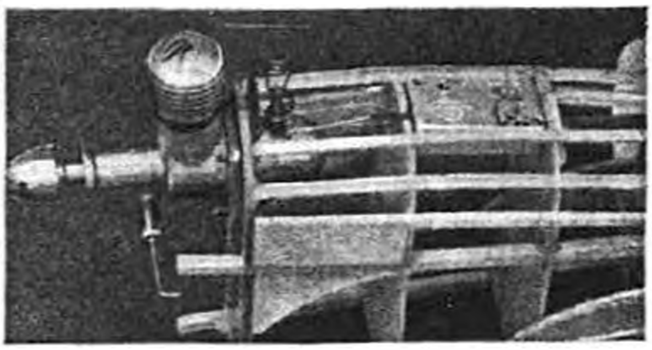




Above left : Practical location of engine timer cut-out, placed as near as possible to engine and in a direct line.

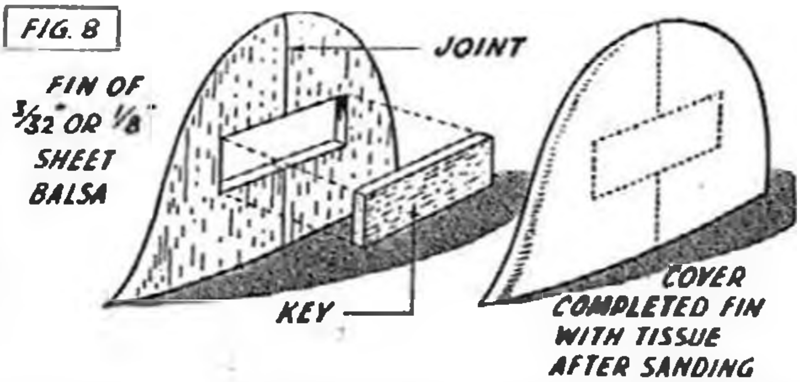
Below : Another timer location ; this one is attached directly to the plunger valve of a Micron tank.

Left : Fin cut-out on a Wakefield which serves to limit movement of tip-up tail d t.



Generally almost as good results can be obtained by using rectangular strips for the ribs as in Fig. 7, carving and sanding to shape after assembly. This offers an easier method of building and is usually satisfactory where fairly generous wood sizes can be employed (ribs at least 1/16 in. thick).

FIG. 8



Where simplicity, allied to stiffness, is the main aim there is no reason why the whole fin should not be cut from sheet. The poor aerodynamic qualities of a thin section fin can be ignored in this case—or possibly the fin area slightly increased, to be on the safe side. Sheet fins are not as heavy as many people appear to suspect, provided the right quality wood is chosen for the job. This wood needs to be stiff and light—light quarter grain, in fact, for preference. A minimum sheet thickness of 1/16 in. is recommended (1/32 in. sheet fins invariably have a tendency to warp).

Sheet Fins

Power models and gliders can quite readily use sheet balsa fins—where the thickness of the sheet is usually at least 3/32 in. All-sheet fin construction is also applicable to Wakefields now that structure weight is no longer a penalty.

The main failing of a sheet fin of adequate thickness is its liability to split. To overcome this, tissue covering must be applied, on both surfaces, and doped in the normal manner. Excessive doping must be avoided as this will warp sheet just like a tissue-covered built-up structure.

A further improvement on large sheet fins is an inset key piece of harder wood of the same thickness, as in Fig. 8. This is particularly effective for reinforcing a joint line which may be necessary between two individual pieces of sheet required to produce the necessary fin width. The key piece should be cut first and then used as a pattern to cut the fitting slots in the main sheet pieces. As a guide to sanding to final section a pencil gripped in the fingers can be run around the outline marking the centre line position.

In built-up fin construction the manner in which the outline is produced is important. If this is weak the fin will be prone to warp. With simple shapes—straight edges and a rounded top, individual sheet pieces are often used for the curved part of the outline. These are cut so that the largest possible cementing area is given between individual pieces and, as far as possible, the grain of the wood should run parallel to the outline. All the joints should be double-cemented as a matter of course, and checked again after sanding prior to covering. It is these cement joints which quite often tend to break loose.

Laminated Fins

Laminated construction is probably better suited to curved fin shapes since here the grain can be made to follow the outline. In this case the main fault is using too soft or too weak a wood for the individual laminations so that the resulting outline is weak when sanded down to the proper section. The snag is, of course, the harder the wood used for the laminations the more difficult it is to bend round the former to the shape of

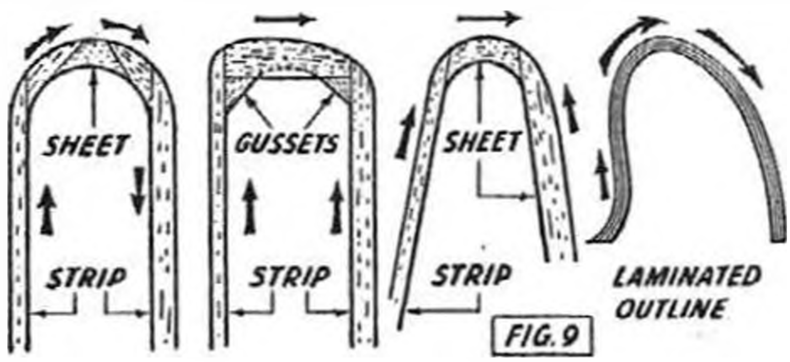


FIG. 9

FIG. 10

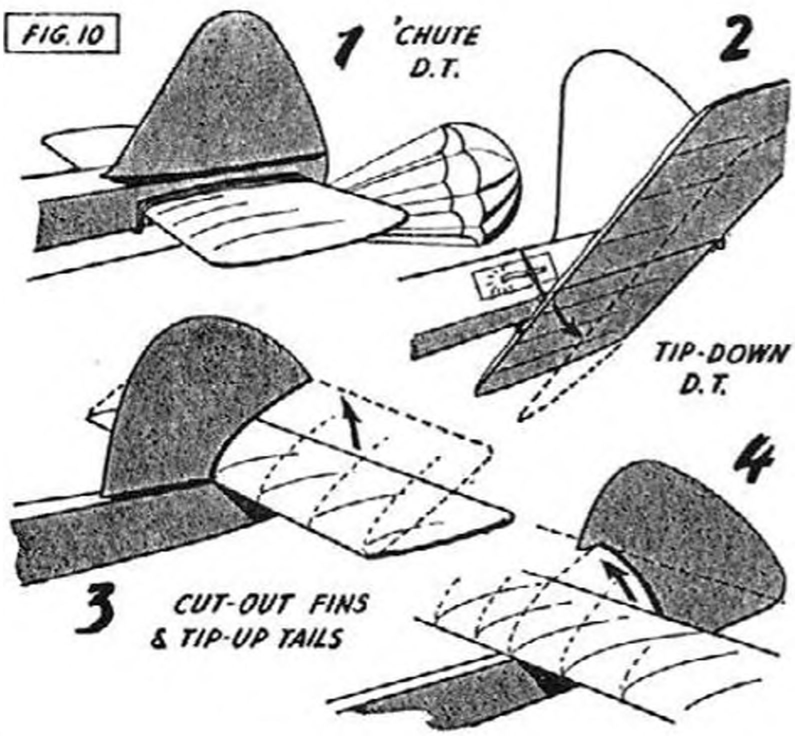


Fig. 10 shows three possible arrangements with a power model tail unit. The fin is integral in each case. In the former example the demountable tailplane is passed through a cut-out in the sides of the fuselage and strapped in place by rubber bands. Despite the fact that this would seem to be liable to damage to either the tailplane or the fuselage in a rough landing, where the model is tipped over on to a tailplane tip, in practice this has given very satisfactory results. In such cases, however, it is impracticable to provide a tip-tail release and so a 'chute dethermaliser is employed.

the required outline. Some details of fin outline construction are summarised in Fig. 9.

Usually the fin and tailplane are located together, and both detachable, although modern practice is to make the fin integral with the fuselage as far as possible. This started with power models—mainly to ensure that the fin was always maintained in the same attitude with respect to the fuselage and has since spread to gliders and rubber models. Unfortunately a fixed fin usually complicates the problem of fitting a tiptail dethermaliser which is by far the most popular type of dethermaliser on all types of models.

Underslung Tail

The second method mounts the tailplane underneath the fuselage where it can be tipped by releasing the leading edge, as indicated. This, again, has been used with success on contest models but does not appear an entirely satisfactory solution. The underside of the fuselage must be shaped to conform to the upper surface of the tailplane aerofoil for positive seating and in practice it has been found easy to disturb the tailplane rigging angle by slight mis-placement of the tail.

The other alternative methods shown employ a fin with a cut-out portion allowing the tailplane to be tipped up for dethermalised descent. The fin can also act as a stop to limit the tailplane movement.

Of course, an alternative solution, which has been widely used on gliders, is to stagger the tail group so that the fin is either forward or aft of the tailplane. This still enables the fin to be mounted as an integral part of the fuselage and provides a simple tailplane fitting with straightforward

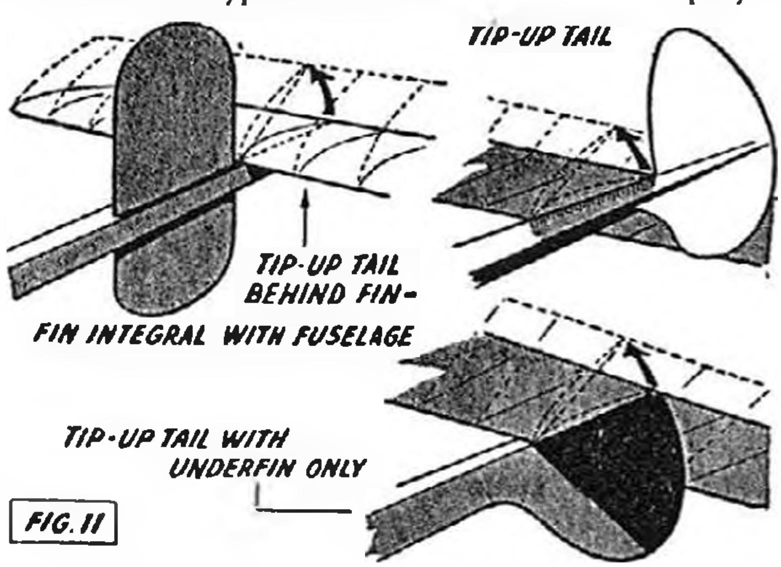


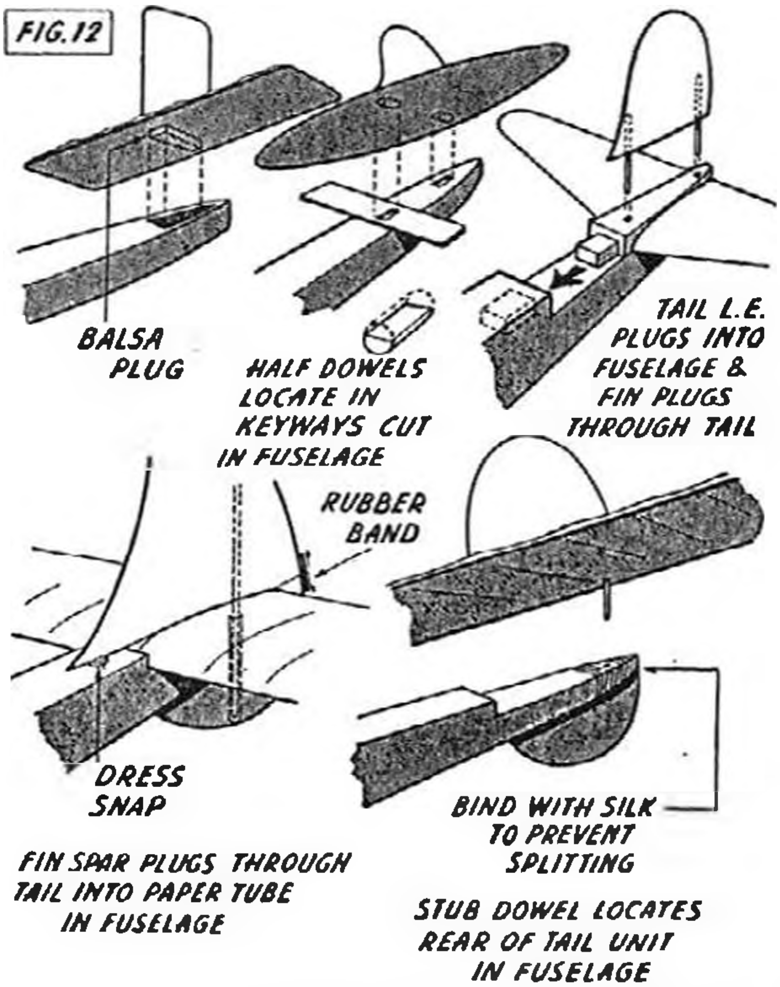
FIG. 11

dethermaliser action, Fig. 11.

With rubber models similar systems can be applied, although it is very rare to find the fin and tail staggered on such types. The cut-out fin is, however, coming into widespread use.

One of the simplest methods of assembly, which is particularly suited to all small models, is to cement the fin permanently to the tailplane and secure the assembly to the fuselage with a rubber band or bands. Where this is done, however, some means of locking the tailplane accurately in line, when assembled, is required. Suitable balsa or dowel keys are used which locate in the fuselage. Balsa keys cemented to the underside of the tail engaging the outside of the fuselage longerons are unreliable. They are too readily knocked off and the setting may be lost.

FIG. 12



Rigid Mounting

Often a quite rigid form of tail unit assembly is used on rubber models, so concerned are the designers in getting a positive line-up of these surfaces. The tailplane locks into the rear of the fuselage and the fin, in turn, locks through this and also into the fuselage. If no tip-tail dethermaliser action is required the fin locking spar (usually of bamboo) may engage a paper tube for the full depth of the underfin. In practice, despite such rigid mounting, such tail assemblies are seldom badly damaged. The most common failure in a rough landing is that the fin spar breaks at its point of entry with the fuselage—a field repair job, incidentally, which is not too easy to tackle and still re-align the fin in exactly the same position as before. Some typical demountable tail fixing of these and other types are summarised in Fig. 12.

If general rules can be advanced—and it is difficult to do this since individual designers have their own particular preferences—best practice would appear to be to mount the fin integral with the fuselage on all types of models, as far as possible. The tailplane should then be detachable, both for ease of transport and also to make it more "shock-proof" in bad landings. The life of a good model is determined not so much by its flight characteristics as the terrain over which it flies. Contest models, which may be perfectly trimmed and very stable in flight, are liable to land in built-up areas or strike obstructions downwind and suffer just as much strain as a badly trimmed model which dives in on its first test flight. But components must never be too flexible, for one of the golden rules of consistent flying is to have a model which always assembles *positively* the same each time. There should be no doubt at all as to whether the wings, tail and fin are correctly aligned.

Chapter Nine Dethermalisers

WITH a dethermaliser one can limit the distance which a model will drift by estimating the flight time to take the model out of the field and setting the dethermaliser for a slightly shorter period. Thus it is possible to trim a contest model safely on full turns, a full power run or the full towline length in conditions which would normally carry the model well outside the flying field but, by intelligent use of the dethermaliser, terminate the flight within the boundaries of the field.

Another use of the dethermaliser is in trimming out the climb on a power model. If a number of flights are made with the dethermaliser set for a definite time—say 30 seconds—making small adjustments to the thrust line or changing propellers—the best climb will be the one giving the best overall flight time (since it can be assumed that the model will descend at the same rate each time when dethermalised).

Limitations

Extremely powerful thermals are not as frequent as the more moderate kind. In nine cases out of ten a dethermaliser *will* be effective in a thermal. In the tenth case, even throwing the wings off on a light model, or the complete tail unit might not bring the model out of the thermal. In other words, such a high rate of descent would be necessary for the dethermaliser to bring the model down through the lifting air that, used under normal conditions, the model would be smashed on reaching the ground. We must accept the fact that in some cases the thermal may be powerful enough to even continue to lift the model.

The other limitation in the use of dethermalisers is not so much the fault of the dethermaliser as the requirements of the modern contest. Winning times are creeping nearer and nearer to the maximum aggregate. In other words, to stand a chance of winning, the contestant has to set the dethermaliser for a long flight each time in nearly all conditions.

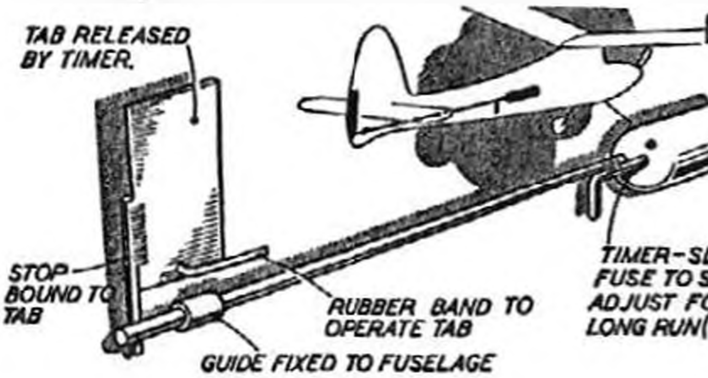


FIG. 1

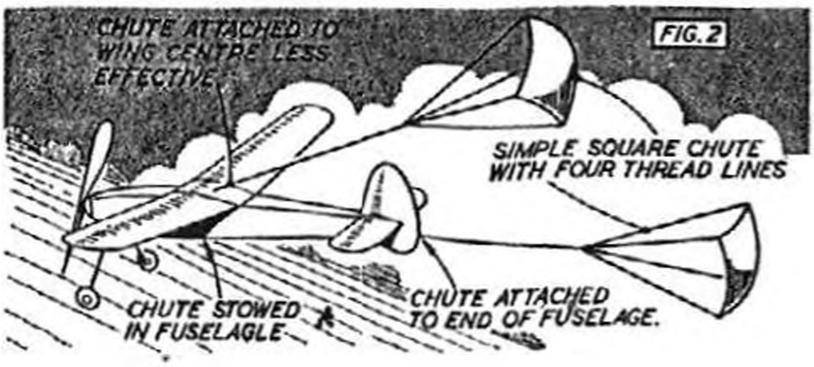


FIG. 2

History

One of the first persons to use a dethermaliser on a contest model was Dick Korda. In the early 1940's he appeared with a timer-operated trim tab on a rubber model. After a pre-set time the tab flicked over, putting the model into a spin to bring it down rapidly to earth. This method was quickly taken up by other modellers both in this country and America. Norman Lees was, as far as we can trace, the first British modeller to adopt the idea.

However, spinning the model down had one basic disadvantage. The model hit the ground pretty hard and so ran the risk of damage. A more gentle

" let down " was desirable, at the same time preserving a reasonably high rate of descent for true " dethermalising " action. Norman Lees, Bob Copland, and Ron Warring developed the parachute dethermaliser as an alternative which appeared to answer this problem completely, at the expense of the weight of the parachute—Fig. 2. All, incidentally, followed Korda's original idea of using an " airdraulic " timer, but whereas Korda used a commercial timer, British modellers built their own light weight units weighing about one-fifth ounce.

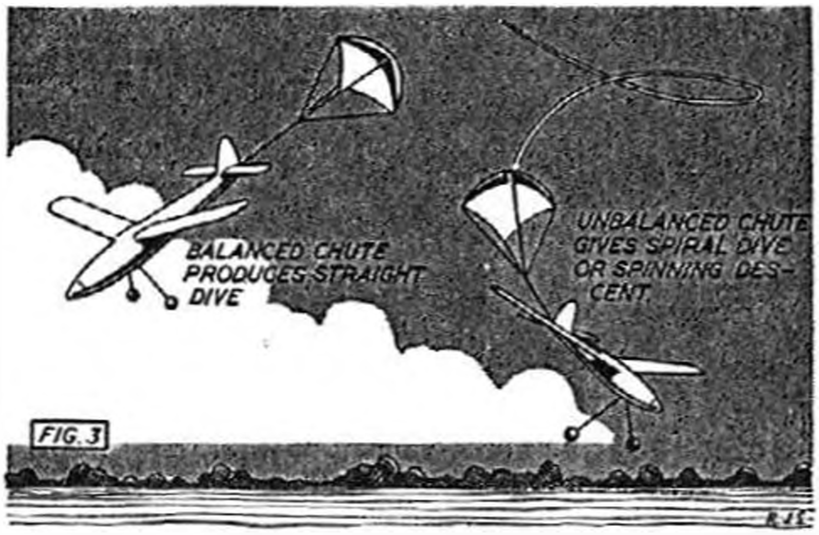


FIG. 3

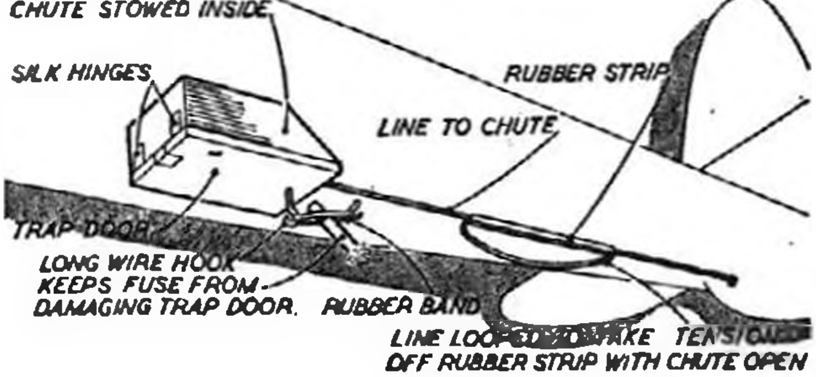
The Drag 'Chute

Drag parachutes had also been tried in America, but initially they made the mistake of attaching the 'chute to the centre of the wings, or near the centre of gravity of the model. With such an attachment the " let down " is quite safe, but the rate of descent is low. To be fully effective the 'chute has to be attached near to the end of the fuselage when it pulls the nose of the model down. The descent is then a steep, but not too fast dive. If the 'chute is not " balanced " or does not fill properly, the model will also spin as well as dive—Fig. 3.

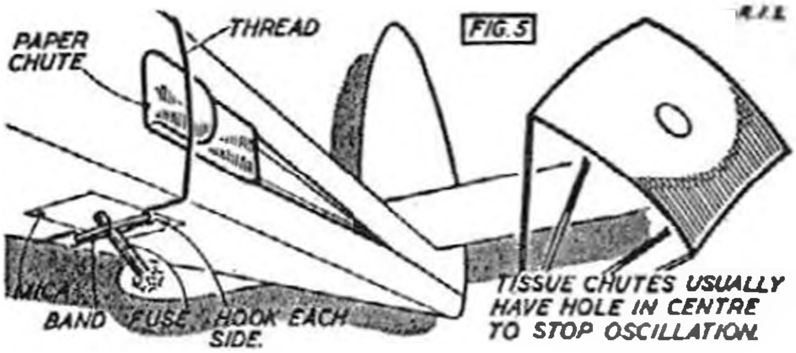
The necessary release mechanism for this is simplicity itself. The 'chute (generally made from silk) is stowed in a suitable hatch in the fuselage, the trap door of which is held shut by an elastic band. The 'chute lines emerge from the hatch and terminate at the tail of the fuselage. A length of fuse slipped through the locking band burns through the band, breaking it and releasing the trap door. The 'chute is then ejected, either by the pull of the 'chute line (given by incorporating a length of rubber strip in the line), or by a spring action from within the hatch. Typical details are summarised in Fig. 4.

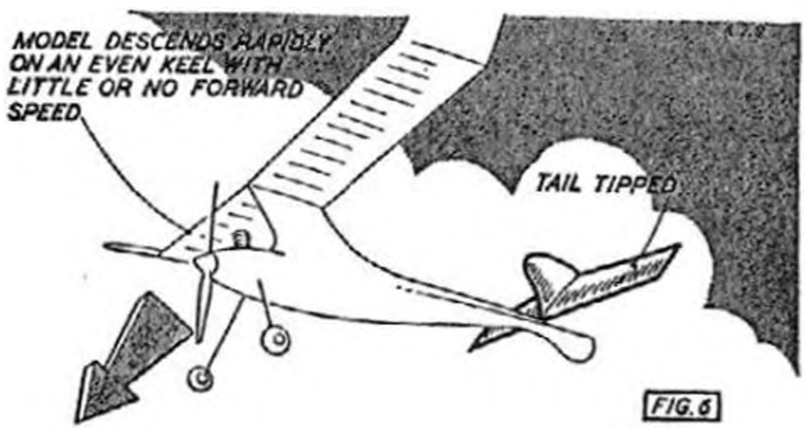
On many models this scheme is simplified still further. The 'chute is folded up and straps to the side of the fuselage, released by the fuse burning through the rubber bands completing the strap—Fig. 5. With this scheme, too, tissue paper is often used for the 'chute instead of silk. It is particularly adaptable to rubber models of all sizes, and small gliders, where the designer wishes to instal a dethermaliser with the minimum trouble.

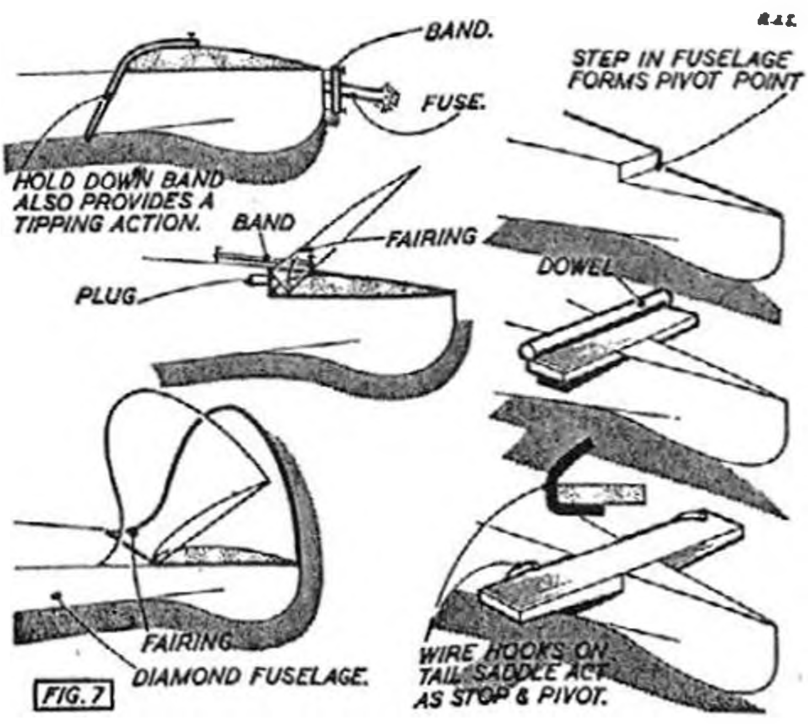
The 'chute type dethermaliser was by no means accepted as the ideal solution. A variety of other devices were tried out, ranging from drag flaps or spoilers opening out from wings or fuselages ; releasing the wing ; or tipping the wing up to a high incidence ; releasing a spool of thread tied to one wing tip ; and so on. Drag flaps and spoilers prove amazingly ineffective ; most of the other schemes failed by virtue of their relative complexity or difficulty in positive anchorage

FIG. 4


of the "control" components or the weight penalty involved. Carl Goldberg, however, was early in the field with a very simple device which, over the years, has proved about the best of all types of dethermaliser for every class of model. His idea was simply to release the trailing edge of the tailplane so that a high negative angle put the model into a super-stalled condition—Fig. 6.







The Tipping Tail

If a model is completely over-elevated in this way it becomes amazingly stable and sinks smoothly on an even keel. The rate of descent can be varied by altering the angle of tailplane tip so that you can adjust the speed at which the model strikes the ground. This method provides a better "let down" than the 'chute type dethermaliser since the model is substantially horizontal when it reaches the ground and the main impact is taken by the undercarriage or the under-fin, not the nose.

With due consideration to all the types of dethermalisers which have been developed and tried the tip-tail method is by far and away the best for almost every type of model. It is simple and positive. It also adds little or no extra weight. The necessary release mechanism can be incorporated very simply on most models, using the tail-plane hold-down band to affect the tipping action as well, once the rear hold-down band is burnt through by the fuse. Some practical applications are shown in Fig. 7.

The actual angle of tip is important. If you care to experiment, starting with a moderate angle, say 15 degrees, you will find that tipping the tail puts the model into a series of violent stalls. Increase the angle still more until when you reach about 25 to 30 degrees tip the model rears up into one initial stall and then sinks down in a nose-up attitude.

A 30 degree tip gives a safe, smooth descent, but hardly fast enough for effective dethermaliser action. A 35 degree tip angle is about right for most models, Fig. 8. Increasing the angle still further only results in bringing the model down faster than is necessary.

There are various ways of limiting the tailplane tip. The most obvious is to fit a stop line of cotton or thread, the length of which is adjusted to give the required angle—Fig. 9. If the tailplane is mounted on top of the fuselage a twin-line bridle will be effective in keeping the tailplane rigid in the tipped condition. If the tailplane slews or tilts to one side when tipped the model will have a spinning descent. If possible, then, it is better practice to so shape the tailplane components of the model that these themselves act as a suitable " up " stop. About the best method yet devised is the use of a fin with a cut-out as in Fig. 10.

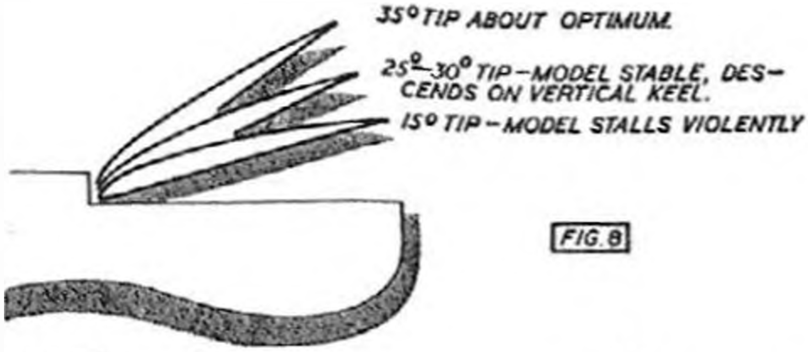


FIG. 8

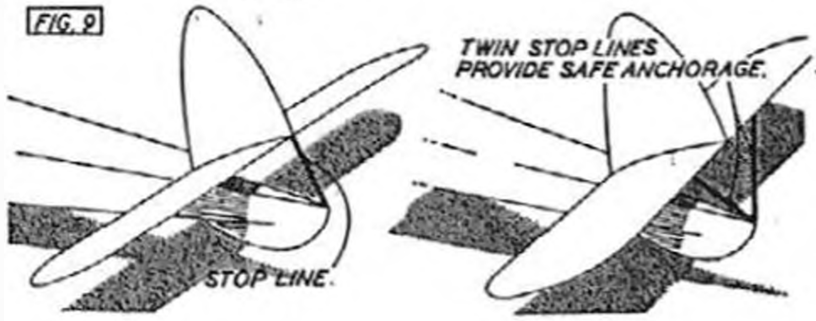


FIG. 9

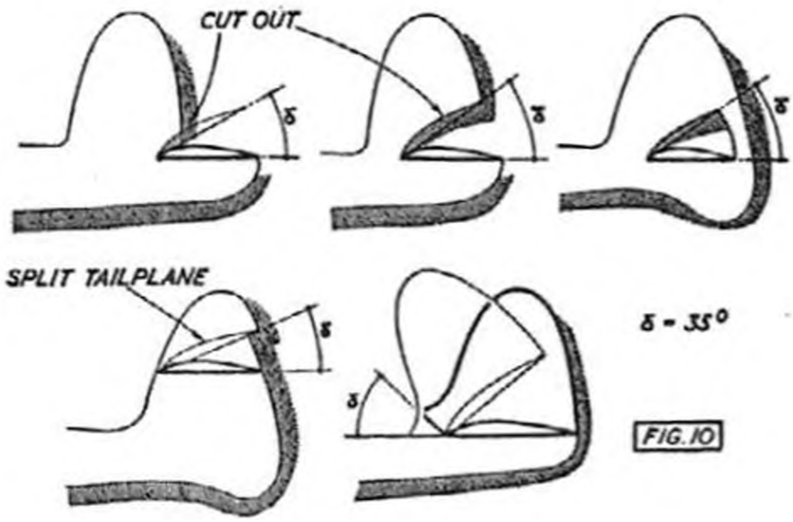


FIG. 10

Fuzes

All sorts of materials have been used for fuzes. Good quality white string soaked in a saturated solution of potassium nitrate and then allowed to dry remained a favourite fuze material for many years, but untreated string often proved equally successful. Treated fuze string is now out of fashion, ordinary cotton lampwick of between 3/16 and ¼ in. diameter being quite reliable and needing no special preparation. This burns at a rate of something like two minutes per inch, or ninety seconds " between marks " (i.e., between adjacent coloured marks on the outer covering of the wick).

The fire hazard from the rejected " end " can be reduced by employing a device to trap the fuse end after the dethermaliser has tripped, instead of letting this be thrown off. Such a device, although adding slightly to the complication of the system, is thoroughly recommended.

Chapter Ten **Auto-rudders**

ONE of the most essential factors in contest gliding today is the amount of height gained on the tow, and anything short of the permissible 164 feet represents a valuable loss. To get maximum height on the line, we must have towline stability, and with rudders set at up to 45 degrees for turn trim on the glide, some form of automatic neutralising rudder device has to be employed. Thus we have an auto-rudder of sorts on every contest glider.

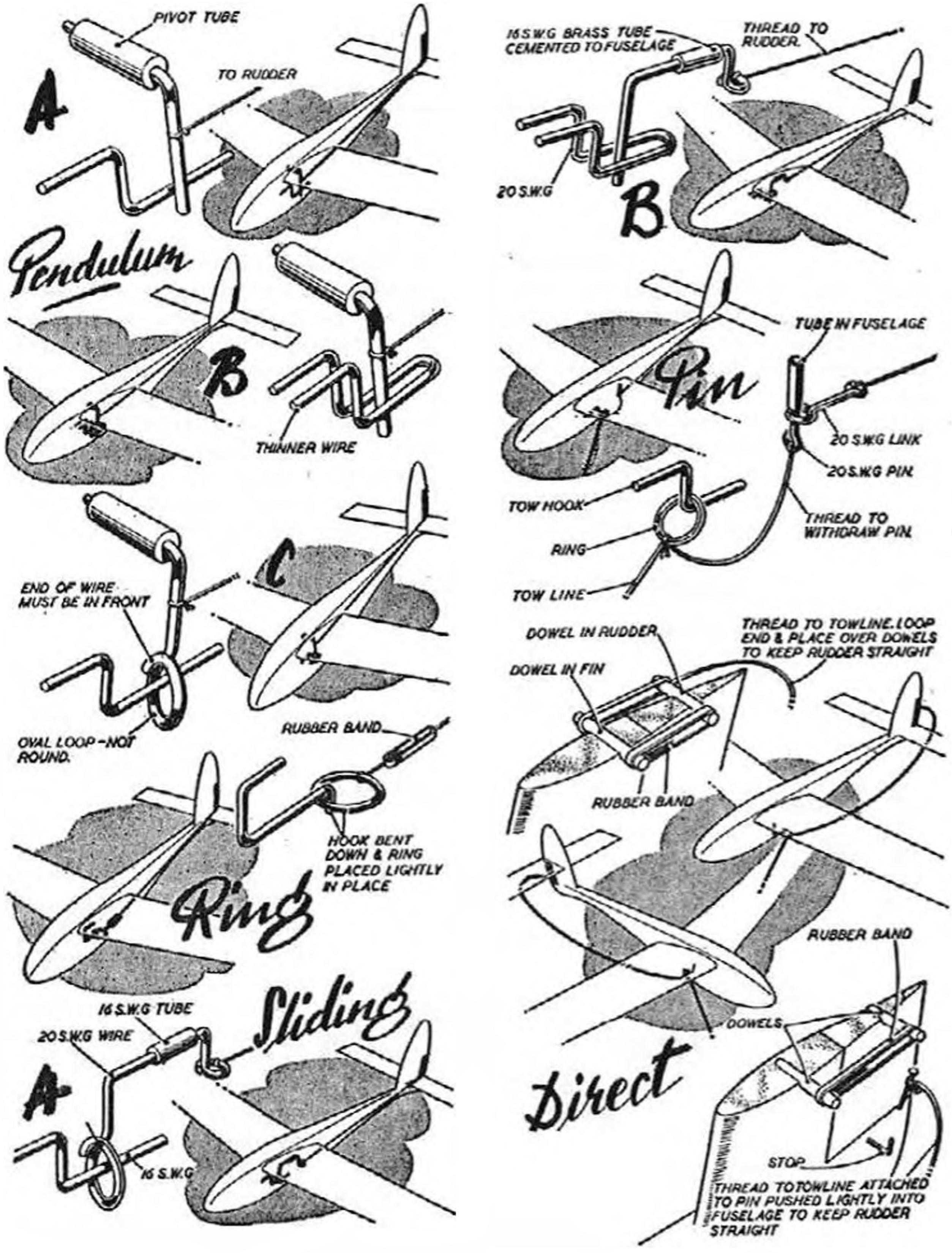
There are, however, auto-rudders of many varied types, and the beginner in aeromodelling can now take advantage of other's misfortunes by avoiding the pitfalls of earlier types. Making a survey of the subject we begin with the **Pendulum** variety, a built-in version which frequently appears on A.P.S. glider plans. The elementary form is shown as **A** and has a single towhook with a plain swinging arm beside it to operate the rudder. Though simple, this one has a serious snag in that the ring on the end of the towline can slip between the hook and pendulum to allow the rudder to go back to the turn position. By making the towhook double back upon itself as in **B**, we overcome this problem ; but there is still another disadvantage to remedy. This is when the model makes a dethermalised descent, the exposed end of the pendulum having to take the brunt of the pancake landing and becoming bent or even forced right into the fuselage. So yet another variation is made, this time with the earlier type single hook of 16 guage or larger wire, and having a swinging loop of oval shape. This works perfectly, but care is needed in bending the loop to make sure that the end of the wire comes on the front and not behind.

To avoid the " ejection " of the line, and to make construction more simple, the **Ring** type of rudder catch is a popular favourite. As well as the elastic band return system on the rudder, there is another band introduced to the auto-rudder line and this maintains a tension when the ring is engaged on the tow-hook. Too much tension may prevent release, too little means a possibility of early accidental release. The happy medium is soon found, and as the line can be entirely external, this ring method is good for modification on gliders without prior auto-rudder arrangement.

Combining the assets of pendulum and ring, the **Sliding** rudder trigger has a large following. For single hook as in **A**, a looped " slider " is essential and as with the pendulum, the end of the loop must come to the front. Double hooks are preferable however, and **B** shows how this aligns the slider in the towhook to prevent it from swivelling.

Also external, and frequently used to avoid " ejector " action as with pendulums and sliders, is the detached **Pin** method with a short extension line from the towing ring. A split pin makes a handy end for the rudder line, and this is so arranged to come in-line with a tube in the bottom of the fuselage so that just a little tension is required to pass a locking pin through and into the tube. When the towline is slackened and the ring detaches itself from the hook, the weight of the line is sufficient to withdraw the locking pin and the rudder trips over to turn trim. Two points need to be watched with this system, the first that the tube is not placed too far behind the C.G. to affect the launch, and secondly, that the free rudder line be held in some way after the launch and not allowed to thrash about in the airflow around the tailplane.

For modification to older gliders or kit models without provision for an auto-rudder, the **Direct** system is simple and effective, if not quite as good as the pin or sliding methods. Two short lengths of dowels in the fin and rudder are linked on the one side by a rubber band tensioner, and held on the other side by an extension of the towline. So that the line can release easily from the dowels, the actual loop should be a slip knot and



care should be taken to see that it will come undone without needing a tug on the line.

Size of the trim tab determines the amount of offset it will need for the desired turn, and small low aspect-ratio tabs are most common with movement of up to 45 degrees before affecting trim to any serious extent. Two square inches of tab area are ample for the A/2 size of glider, most modellers preferring to use slightly less than this.

Chapter Eleven Undercarriages

PROBABLY more arguments have centred around undercarriages on contest models than on any other single feature of design. Even where rules call for rise-off-ground flights, many contest models (rubber models in particular) do not need what could properly be termed an "undercarriage". Just a whisker of wire will suffice to fall within the definition that the model should be capable of supporting itself on the ground in a normal attitude!

Few high performance rubber models have any appreciable take-off run, particularly if there is any wind; they simply hop straight into the air as soon as they are released. In fact it has been demonstrated on occasion that a high-powered rubber will "take-off" without any undercarriage at all, simply by resting the tail on the ground and holding the fuselage so that the propeller is clear. Release the propeller first, then the fuselage, and off goes the model without any trouble. People who believe that an undercarriage *should be* an undercarriage do not take kindly to that, particularly as the functions of a "whisker" undercarriage are little more than a concession to the rules, and actual take-off is almost identical to that of the "no undercarriage" type.

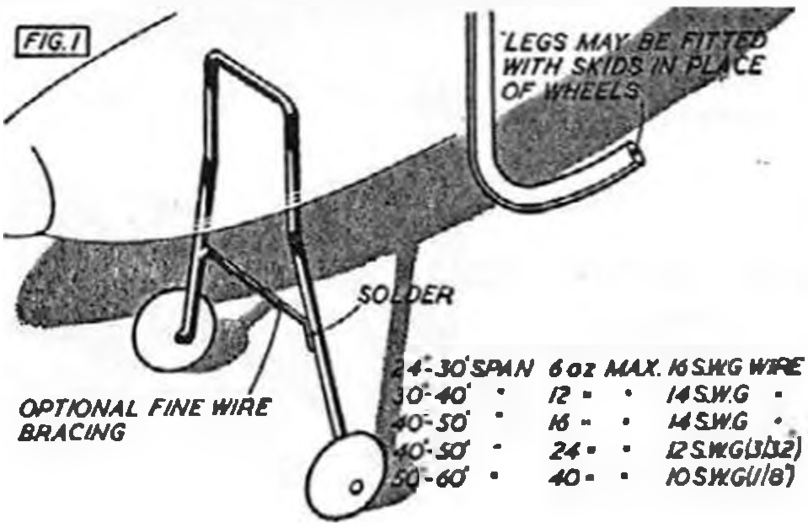
Why do modellers go to such trouble to virtually eliminate the undercarriage? Mainly because it is a parasite. It adds both weight and drag and only serves a useful function for the take-off. No contest model is really expected to land on its undercarriage, except possibly under ideal conditions. Most landings are often well out of the airfield, perhaps in built-up areas where a normal landing is not possible.

In the case of a sports model the question is a little different. Ideally, the designers want such a model to land on its undercarriage, and think of it as normal take-off gear, even if the majority of flights are hand launched. Logically, too, the larger (and heavier) the model the more vulnerable it is on landing and the more desirable that it should land properly. This is particularly important with Radio Control models where the normal duration type "crash landing" is highly undesirable and might well damage equipment.

Basic Design

The problem of undercarriage design and construction is thus twofold. First the "duration" type undercarriage, where the unit is regarded as a parasite, and secondly the sports model (including Radio Control models) where the undercarriage is considered very necessary. Since performance is not the main aim in the latter case, "weight" and "drag" factors become relatively unimportant.

FIG. 1



Since we started talking about duration models, we will deal with undercarriages for these types first. The problem of which type of undercarriage to use on a duration model is really one of personal preference, bearing in mind the type of model you normally fly. The power model offers the simplest example since this, as a type, is substantially the same in all model sizes and far less subject to controversy than rubber model undercarriages. For a power-duration model the simple wire cantilever undercarriage is still the best and is almost universally employed.

This takes the form of two wire legs, bent as one and securely anchored in the fuselage. The ends of the legs are angled to form stub axles on which the wheels are located, or (a modern trend) the ends of the legs are simply bent backwards to form skids. This type of skid undercarriage has been borrowed directly from the rubber model and is about the only noticeable change in power-duration undercarriage design since the late 1930's. Where wheels are used, these should be of the lightweight type—plastic rather than rubber tyred on the smaller models. Since power model wheels come in for some severe loading, particularly on the larger sizes, metal hubs are the rule.

Such a simple cantilever undercarriage is strong enough and flexible enough for most purposes. Drag is low and weight is also low, providing the right size of wire is used. A common fault is to use wire which is far thicker (and heavier) than it need be. Provided you select good quality spring steel wire, the sizes given in the table appended to Fig. 1 are quite adequate. If such an undercarriage does tend to splay out due to the weight of the model, then a simple spreader bar soldered across the legs will obviate that trouble.

Undercart Fixing

There are a variety of ways in which such an undercarriage can be fixed in the fuselage. The simplest is to attach it to a ply former, usually the front former or fire-wall. (Fig. 2 details a variety of ways in which this can be done.) Thread binding is by far the simplest method and quite adequate up to Class B free flight models. Tin, metal straps or " J " bolts are more commonly used on large models, and for control line stunt models too. The " sandwich " method and the use of grooved wooden blocks is quite satisfactory on most small models. There are other methods, but these are the main ones employed. Fig. 3 shows some important design features relative to the shaping of the legs.

A disadvantage of all such fixing is that the undercarriage is not detachable as a unit. Three detachable types are shown in Fig. 4, of which type B is probably the best and most reliable. In type A the vertical box is prone to break loose in a heavy landing and further, if the fit of the wire is on the slack side, the whole undercarriage may drop out. Type C is heavier, but positive and generally satisfactory. Soldering a second wire to

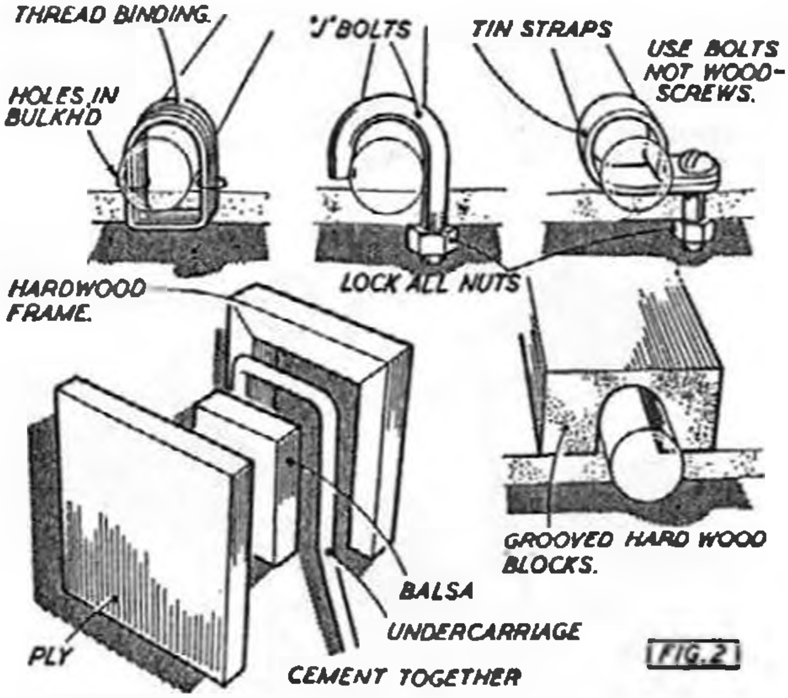


FIG. 2

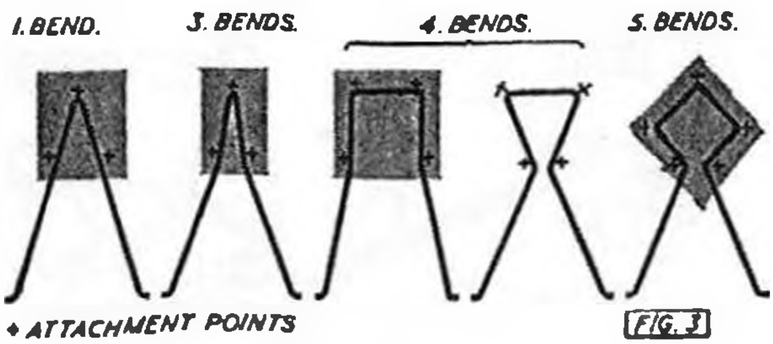
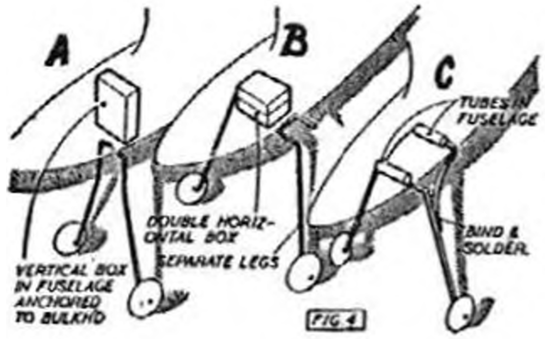
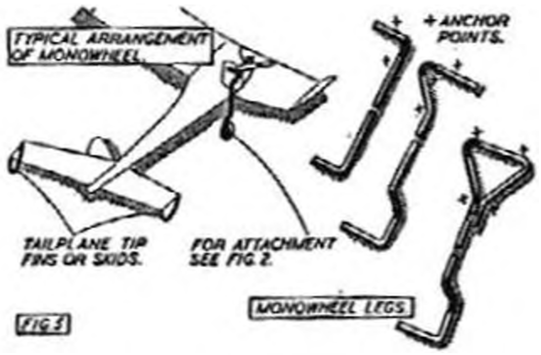
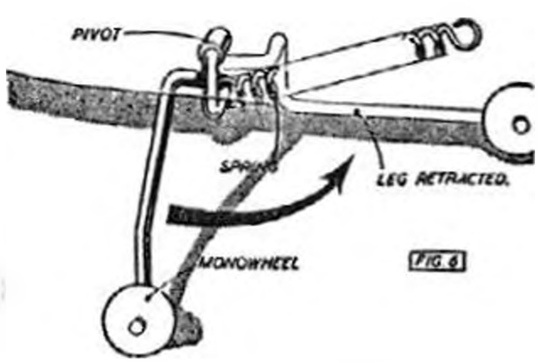


FIG. 3







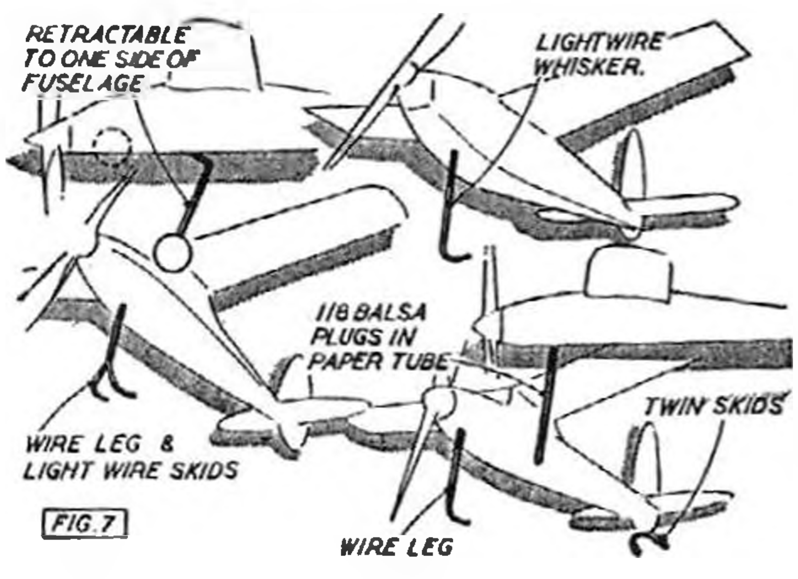
the top of the main leg increases the rigidity of the leg at this point. For contest work, detachable undercarriages have the advantage that they can be removed to save weight and drag in hand-launched contests.

If weight saving and drag reduction is considered important a single leg undercarriage can be used, as in Fig. 5, but the price paid for this saving is a certain loss of " ground stability " on take off. As soon as the tail of the model rises the machine is balanced on the single wheel and relies on wing lift to keep it from toppling over. Some models are quite satisfactory in this respect, others very " chancy ". Many designers prefer to play safe and use a two-leg unit.

The same basic defect applies to the retracting undercarriage, which is invariably monowheel on power duration designs. Actual drag saving is problematical and the propeller is more exposed to damage on landing, also the weight of such a unit must be heavier than its fixed monowheel counterpart. It is probably true to say that the *main* reason for using a rectractable undercarriage is that the designer wants to be different. Of the variety of systems which have been tried out that in Fig. 6 is the simplest, as well as effective.

Rubber Model Types

Now back to the rubber model. If you want to go the whole hog and eliminate the undercarriage as far as possible the " whisker " type is the solution, up to and including Wakefield sizes. Size of wire is chosen as the minimum diameter which will support the weight of the model without buckling. (One leading American modeller went to the extreme of using a balsa " whisker " which fulfilled take-off needs. What matter if it snapped off on landing? It was readily replaced ! Fig. 7.)



To conform to " three-point " requirements of an undercarriage more with a " whisker " for the main leg, the other two points are usually provided by attachments to the tailplane. These may be endplate, underslung fins, or possibly light wire skids. Further examples which have been used are shown in Fig. 7.

During recent years a more rigid form of "whisker" undercarriage—more truly a skid undercarriage—has come into use. Typical examples are shown in Fig. 8, the main unit usually being detachable for ease of transport. Again this has proved very satisfactory in practice and is virtually unbreakable. There is nothing to break except the fuselage fitting, and the legs themselves having a reasonable amount of flexibility should reduce the chance of this. Main disadvantage of the scheme is the extreme length of wire employed, which has to be 16 s.w.g. for the main leg(s) on models of Wakefield size.

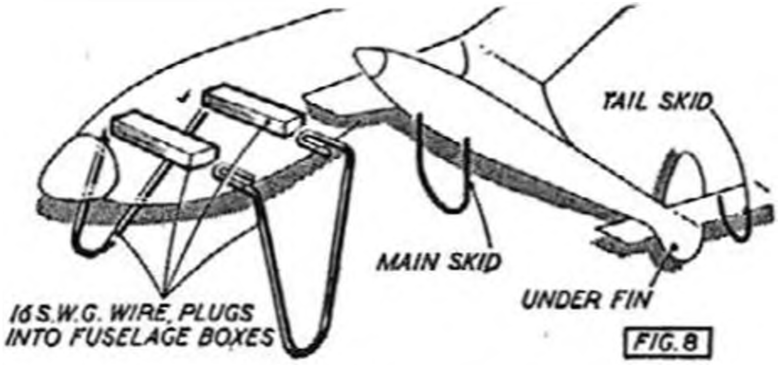


FIG. 8

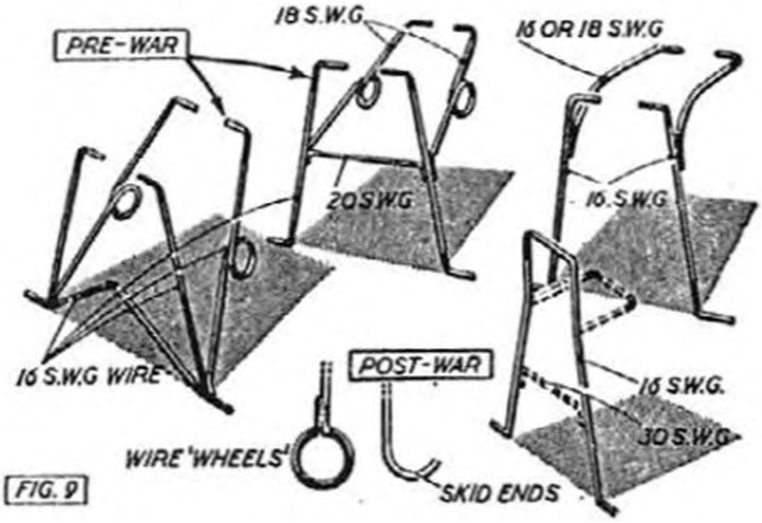
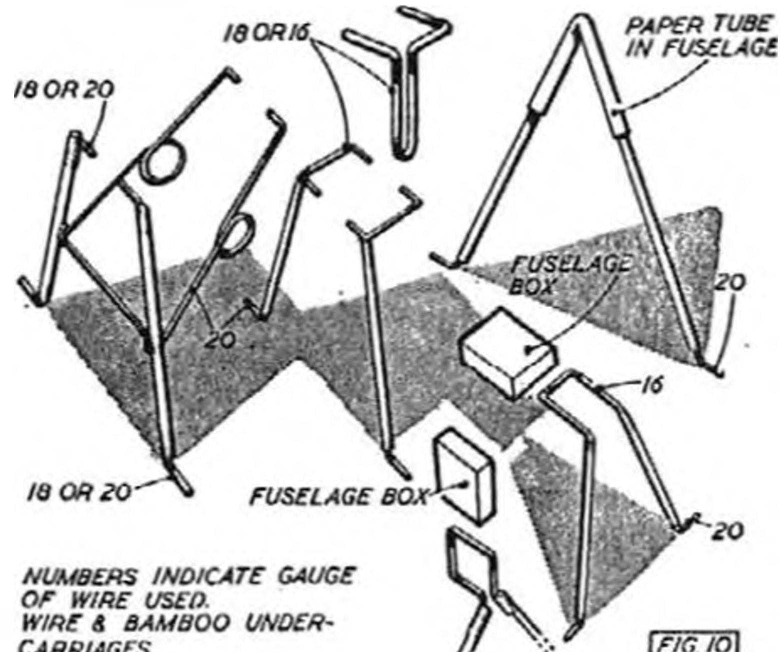


FIG. 9

Wire *v.* Bamboo

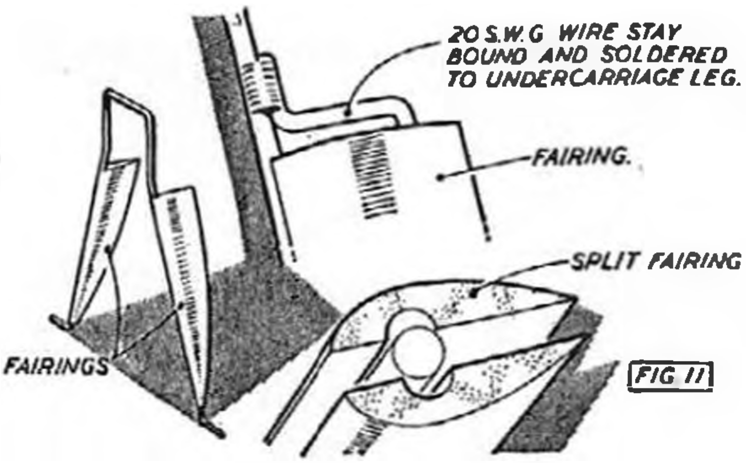
Wire has always been favoured for undercarriages on account of its flexibility and freedom from breakage. Development of the all-wire undercarriage is detailed in Fig. 9, where it will be seen, the amount of wire used has gradually been reduced, saving both weight and drag. (Wire sizes quoted are for Wakefield models.) The two main disadvantages of the simple wire cantilever unit are (*a*) difficulty in arriving at a good detachable fitting in the fuselage and (*b*) using 16 s.w.g. as the maximum wire thickness desirable on account of weight, a tendency for the legs to splay out. The latter can be obviated by using a light spreader soldered in place, 30 s.w.g. being adequate.

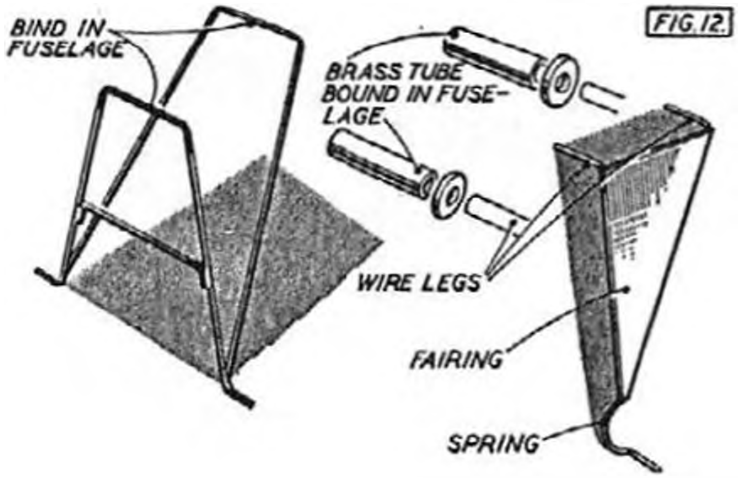


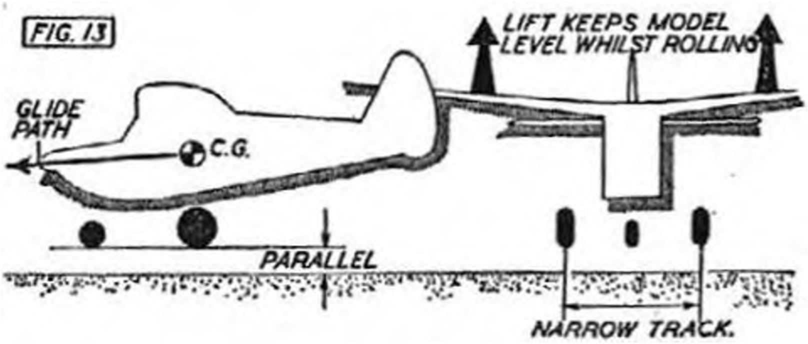
NUMBERS INDICATE GAUGE OF WIRE USED.
WIRE & BAMBOO UNDERCARRIAGES.

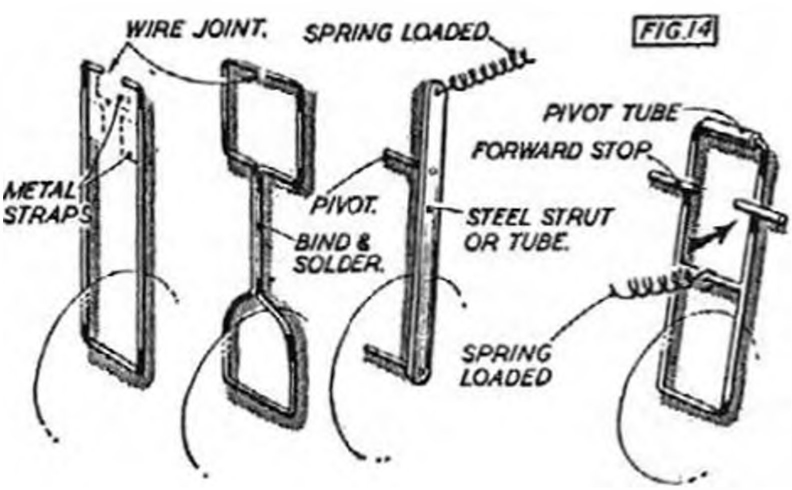
FIG. 10

Another reason that wire is widely favoured is that really tough, good-quality bamboo is hard to come by. The bamboo and wire undercarriage has been developed to a comparable stage—Fig. 10—but to compare in *weight*, the section of bamboo used must be quite small. Such legs tend to fracture readily either at the point of entry into the fuse-









lage (if plug-in type), or where bound to the top wire fitting. Weight for weight the all-wire unit compares very favourably and is robust.

A whole book could be written about undercarriages for sports models but in the main it can be said that these follow orthodox duration practice, with suitable elaborations. For one thing we come to a category where there is no argument as to whether to use wheels or " skids ". Wheels are the invariable rule, and usually of larger diameter than those used on duration models of similar size. The duration model relies on its wheels for take-off only ; if possible we want the sports model to land properly as well. Here the larger the diameter of the wheels the better, especially if you consider the nature of the ground on which most landings will be made.

Landing on Grass

Normal landings on grass airfields are possible provided the wheels are large enough and located well forward. Appearance enters into the question, and whilst wheels of an exaggerated size with the undercarriage swept forward in front of the propeller may be all very well for safe landings, such a unit looks both awkward and clumsy. Power modellers used to build undercarriages with a track equal to one half of the span or more, with literally yards of wire incorporated in the construction. Actually the wings—or rather the lift produced by the wings—plays a greater part in keeping a model upright on landing than does a wide track. A wide track may have the undesired effect of " digging in " and swinging the model violently to one side as soon as it lands.

For small sports models of the power type we can borrow directly from the duration sphere and use simple wire cantilever undercarriages. These will give quite satisfactory service and if necessary we can slightly increase the diameter of the wire used for the legs for greater rigidity, but since for the same size of model a smaller engine will be used (and thus a correspondingly smaller propeller) the length of undercarriage leg will be shorter. Wire of " duration " size should therefore be rigid enough.

Faired Legs

To improve the appearance of wire undercarriages simple fairings of the type shown in Fig. 11 will be all that is necessary. They can be cut from balsa, suitably shaped and then bound to the legs with silk or tissue, preferably the former. To prevent the fairing twisting out of line a small wire fitting is soldered to the top of the leg to which the fairing is secured. The fairing can be in one piece or split and grooved to fit around the wire which is sandwiched between the two balsa layers. Such wire undercarriages are suitable for sport models of up to 3 lb. in weight, provided the right diameter wire is selected. The only damage likely to occur is a split fairing in a particularly heavy landing.

For larger, heavier models the old fashioned type of all wire undercarriage is still widely employed. (Fig. 12). Addition of a secondary leg makes for a more rigid assembly but to prevent the unit splaying out some form of spreader bar must be employed. Such an undercarriage can be bound in the fuselage as a permanent fixture, or made detachable, plugging into metal tubes securely fastened in the fuselage. These tubes should have large metal washers soldered to each end and be firmly bound in place so that there is no risk of their being knocked sideways into the fuselage.

Where appearance is of primary concern there is no reason why a suitably shaped fairing block of balsa should not be bound between the two undercarriage legs. Alternatively the fairing itself can be some form of flexible covering.

The Tricycle Unit

Attractive for the sports model, and particularly the Radio Controlled model is the tricycle undercarriage. The " Rudder Bug " has done more to popularise the nosewheel undercarriage than any other. This model has almost the ideal proportions for tricycle gear—small track on the main wheels and these located close behind the centre of gravity, and a nosewheel of generous size, so located that the normal attitude is nose down.

The latter is an important feature in the design of a successful tricycle undercarriage. During glide approach the attitude of the model relative to the ground is nose down. Fig. 13. If the nosewheel hits the ground long before the main wheels it will tend to bounce the nose of the aircraft up into the air and produce a bad landing. Ideally all three wheels should touch at the same time. Full size aircraft with tricycle landing gear make a controlled approach and are pulled up or flattened out just above the runway so that the main wheels touch first. After running for some time the wings lose lift and the nose slowly drops until the nosewheel is also contacting the ground. We cannot duplicate this same procedure on a model unless we employ an excessive nose-down ground attitude which would look ridiculous, but we can make an effective compromise by having a small nose-down attitude.

In all tricycle arrangements the nosewheel takes the majority of the landing loads, initially, at least. Thus single wire legs for the nosewheel are seldom satisfactory, except on lightly loaded models. Double legs, or spring-loaded legs, are better—Fig. 14. Best of the lot for heavy Radio Controlled models is the torsion bar unit.

Chapter Twelve 'Quickie' Construction

ONE of the golden rules of aeromodelling could be " Work accurately, take your time ". Sometimes, however, comes the need to produce a model *quickly*. Using conventional construction, some modellers are fast enough builders to complete a model in a day. The story told of modellers who sit down on the Saturday before a contest and complete a glider or rubber model for Sunday's event is a true one, but such models inevitably show signs of hurried work, and more often that not, are not particularly successful.

What it means

The term " quickie " construction was first given to a certain class or type of prefabricated kit model, where, with all the parts pre-shaped and pre-cut, building the model was largely a matter of assembly and cementing all the components together. All built-up components, in other words, were replaced with sheet construction, or similar. The term " quickie " is now generally applied to any type of model, kit or " own-design " type, which employs a large proportion of sheet construction and the minimum of built-up components. In this sense the sheet-balsa chuck glider is truly a " quickie ". It is both *easy* and *quick* to build. But sheet construction can be adapted to other types of free flight models which normally call for built-up wings and tails, and even to the fuselage. From the very beginning a considerable number of control line models have employed what is, essentially, " quickie " construction.

Sheet Tails

The tailplane is an easy subject. The use of sheet balsa fins is already commonplace on conventional contest models, particularly power models and gliders. Sheet balsa tailplanes are also quite satisfactory on most sports type models, provided the span does not exceed about ten to twelve inches. Light, but fairly rigid 3/32 or ⅛ in. balsa sheet is used, cut to outline shape and then simply sanded down to a thin aerofoil section.

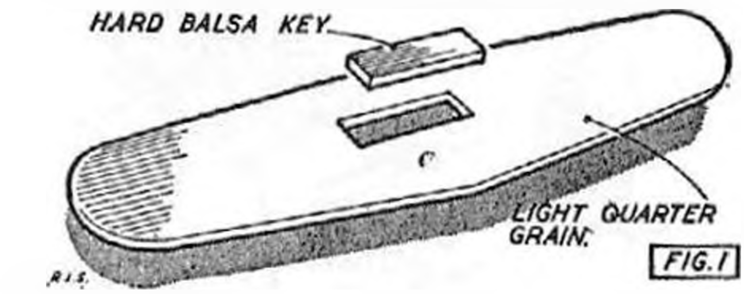


FIG. 1

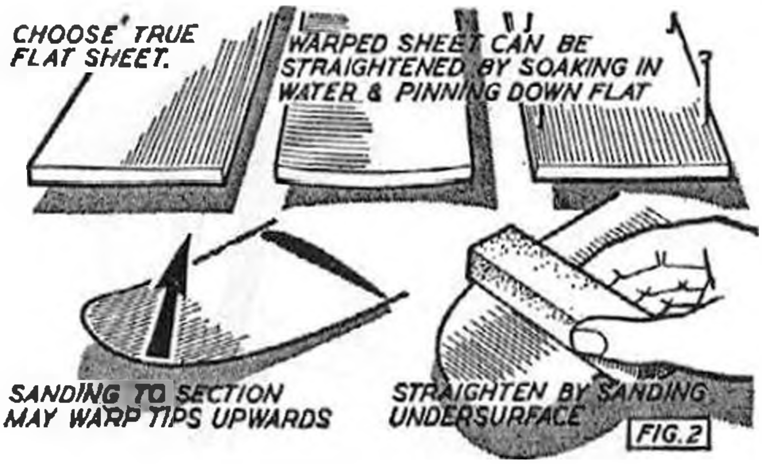
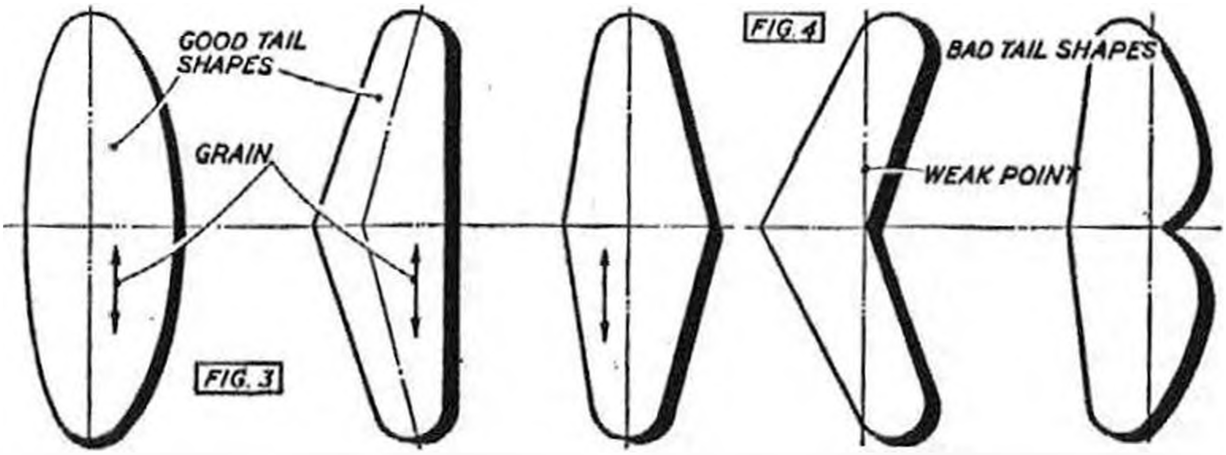


FIG. 2

One of the worst mistakes is to choose sheet wood which is too heavy for the job. A sheet tailplane wants to be as light as possible, so generally you can use the softest wood available. This may mean that the resulting tailplane may tend to be a little weak at the centre and so a key strip of hard balsa let in and cemented in place as in Fig. 1 is advised in such cases.

Another useful tip is to make sure that the sheet from which the tailplane is cut is true and free from warps. Warped sheet will produce a



warped tailplane with its consequent effects on the stability of the model. You may even find that when you have cut your tailplane from true sheet and then sanded it to aerofoil section (on the top surface only) it has now warped slightly into a dihedral angle. This is not necessarily harmful but if you want to take it out, sand the underside of the tailplane until it is perfectly flat once more—Fig. 2.

In the first place, a symmetrical tailplane plan shape will be more warp resistant than one which incorporates fancy curves, and if the tailplane tapers in planform towards the tip that will also be an advantage. Cut-outs in the planform both weaken the sheet by reducing the width of end-to-end grain available and increasing the tendency to curl or break along the lines indicated in Fig. 4. Good sheet tailplane shapes are shown in Fig. 3.

Proofing

To "weatherproof" the sheet tailplane a good waterproof coating is called for. This can be done by using grain-filler followed by several coats of clear dope, adding extra weight and also not being a *quick* method. The simplest solution is to cover with lightweight tissue applied by doping the surface of the sheet, allowing the dope to dry, laying the tissue in place and then "painting" in place with thinners, as in Fig. 5. Trim off with a razor blade and give a final coat of clear dope.

Tissue covering also strengthens the sheet against liability to split along the grain—one of the major failings of sheet components. Tissue covering, and the use of keys, as shown in Fig. 6,

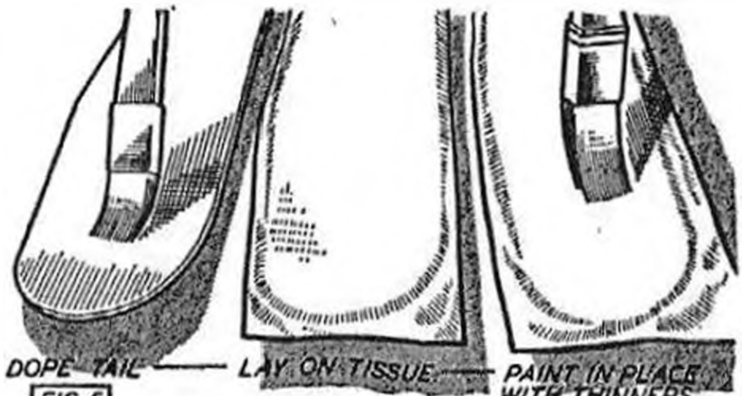


FIG. 5

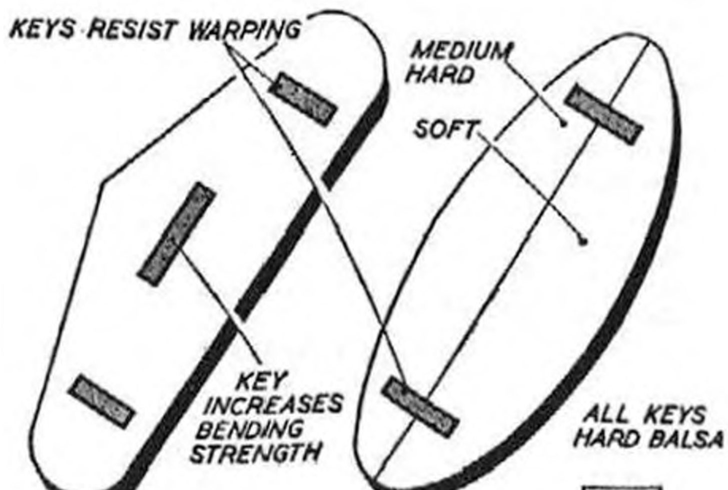


FIG. 6

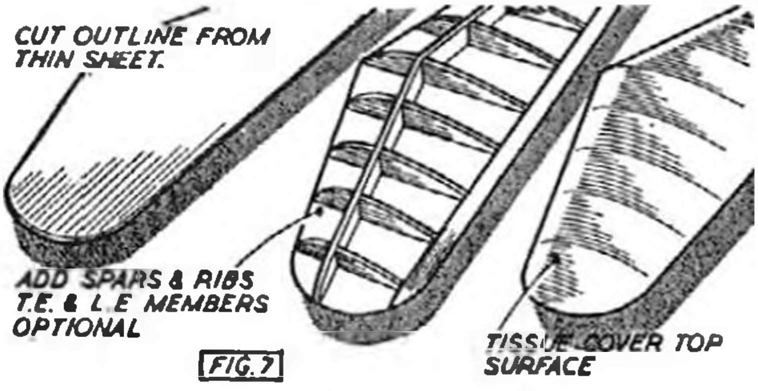


FIG. 7

are both desirable features on large sheet tailplanes. Keys running parallel to the span increase the bending strength of the component.

Where the tailplane is too large for solid sheet construction to be employed, the " quickie " method of Fig. 7 can be tried. Cut from solid sheet the required thickness to give the necessary bending strength would be prohibitive. By using thin sheet (1/32 in. thick in most cases) and then cementing spars and ribs directly on top, weight troubles are avoided. The top of the tailplane is tissue covered for quickness; sheet covered for maximum strength and rigidity, although rather more tedious. If you want to save weight, punch holes in the bottom sheet and cover with tissue.

Wing Construction

As regards wings, solid sheet construction has been used with success on sports models up to 36 ins. span. Such wings however, are generally on the heavy side. A typical wing panel of this size would be constructed from two 18 in. lengths of ¼ in. sheet, one medium hard and the other soft, cemented together as shown in Fig. 8. The outline should, for preference, be tapered or elliptic, not parallel chord. The two wing panels are joined with re-inforcing dihedral keepers of ply or hardwood let into slots and well cemented. A binding of silk or stout tissue cemented over the centre is also advisable for extra strength. The wings can also be tissue covered to get a good finish quickly.

A better method would probably be to use the sheet bottom and built-up ribs and spar type like the tailplane in Fig. 7. For smaller wings, however, thin sheet used for the top surface and then curved to shape over a number of ribs as shown in Fig. 9 has proved quite successful.

With this method the wing outline is cut from 1/32 or 1/16 in. sheet, depending on the size of the panel. Mark off the rib position and coat with cement and allow to dry. As the cement dries it will contract and tend to curl the sheet into an aerofoil curve. Now cement all the ribs in place and pin the complete panel down over a flat surface, as shown, making sure that the sheet is in intimate contact with each rib. When removed, the sheet will have a permanent camber conforming to the shape of the ribs. A stub spar can be added at the centre, if required, to increase bending strength, although this is not necessary on small wings. There is no need to cover the bottom surface of the wings with tissue.

Sheet Fuselages

Sheet fuselage construction is not always as satisfactory as built-up construction, especially on small rubber models intended to have good flight performance, and may not be all that much quicker in the long run.

You can, of course, make up a simple fuselage suitable for a glider or a power model using sheet or block and strip wood, utilising a pod and boom shape. Fig. 10 shows a typical example of such a fuselage which is quick and easy to make. However, particular care must be taken in selecting the material to use for the boom. This needs to be good quality, hard and straight grain strip, but at the same time must not be excessively heavy. Hence balsa is specified instead of hardwood.

The sort of strip wood suitable for a boom on such a fuselage should be chosen carefully from as wide a selection of strip as possible. Make sure that it is not " dead " wood which will snap if flexed but when bent into a slight curve

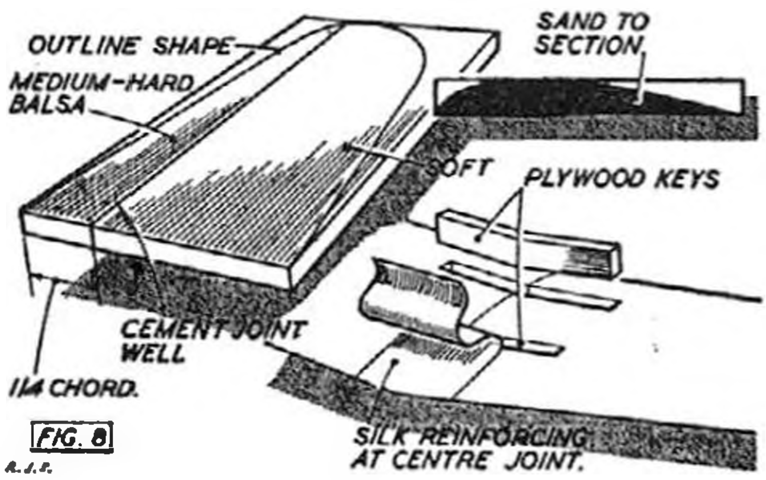


FIG. 8

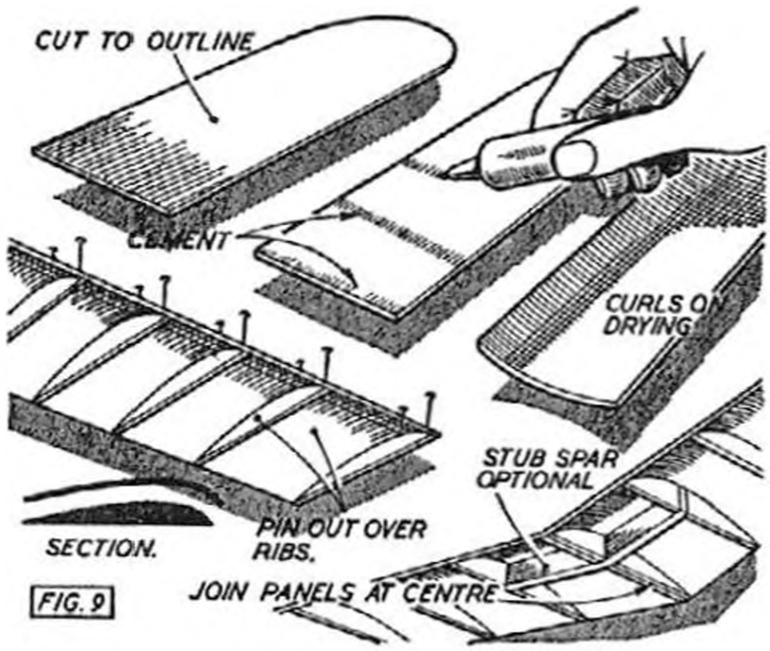


FIG. 9

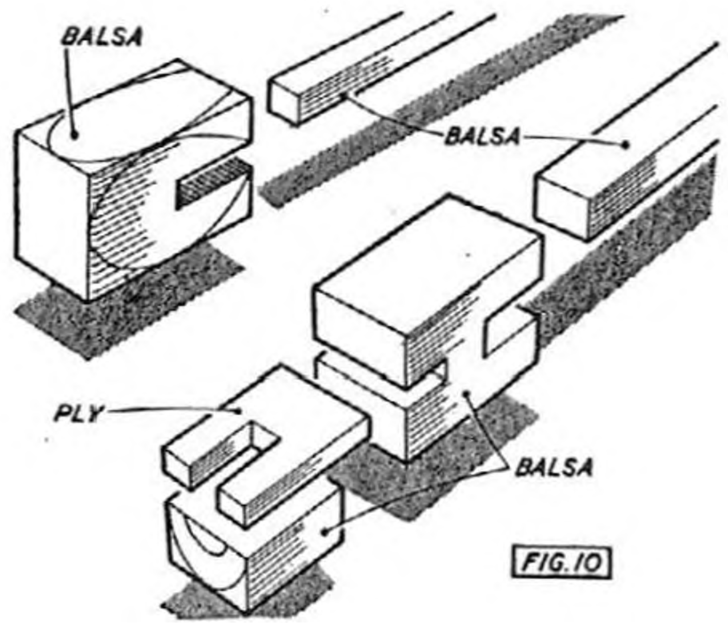


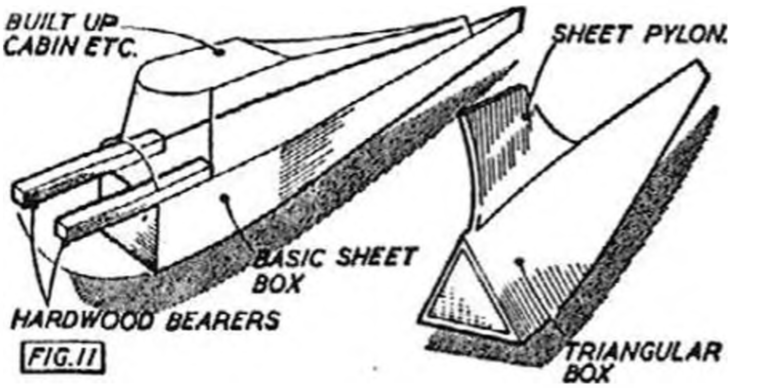
FIG. 10

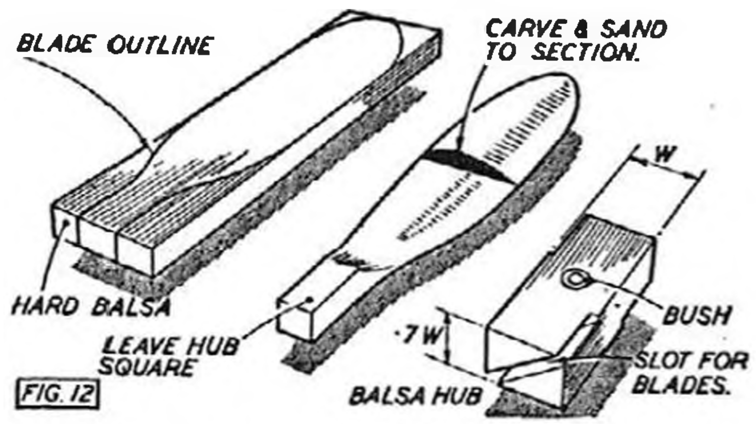
and released springs back sharply into its original straight length. The whole length, of course, must be absolutely true and free from twist or faults. Generally the strength of any solid member of this type can be increased somewhat if the edges are lightly rounded off. Do not remove too much wood in this operation. Just a light sanding which takes off the sharp edge.

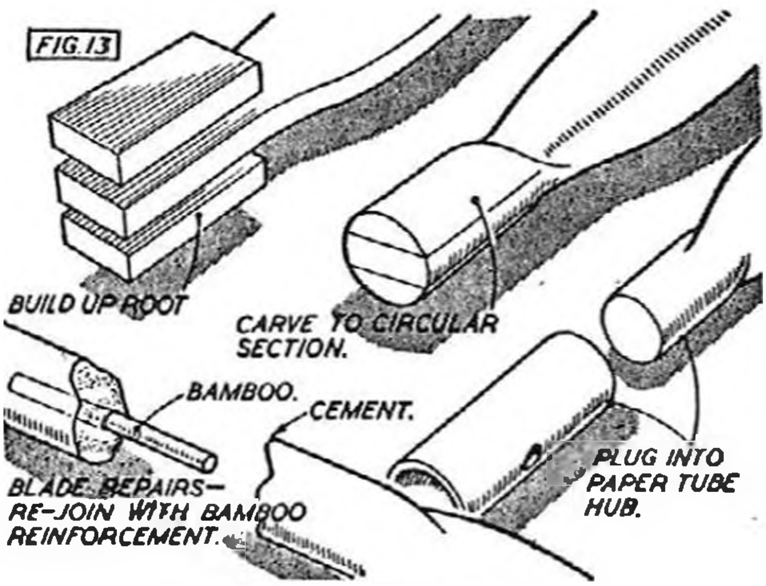
The Basic Box

The sheet, built-up box is, nevertheless, a good basis for the construction of power model fuselages of rather more complicated types. For fuselages up to about 24 ins. in length a 1/16 sheet box, and 3/32 sheet for greater lengths enables the main fuselage assembly, including the motor mount, to be completed in the minimum of time. The wing mount, cabin top or top and bottom fairings, as necessary, can then be added. Some typical examples of this practice are outlined in Fig. 11. The basic sheet box itself can be square or rectangular in section, parallel throughout its length, or tapered to conform to a certain finished outline.

From power models, let us go back to rubber models again and see if we can apply "quickie" construction to one component we have not mentioned so far, but one which does cause a lot of not-so-expert builders (and a good many quite experienced modellers) a considerable amount of trouble —the propeller. Despite many opinions which have







been expressed to the contrary it is doubtful if there is a very marked difference between the efficiency of a "reasonable" propeller and one which is carved meticulously to correct pitch throughout its diameter and with a properly shaped section with just the right amount of undercamber. The small difference in performance which may exist certainly justifies the extra effort as far as contest rubber models are concerned, but for sport flying a straightforward propeller will probably do as well. We can make this as simple as possible by cutting the blades from sheet wood and ignoring the normal variation in blade angle from root to tip produced with a propeller carved from a block.

The two blades of such a simple propeller are identical, both in outline shape and the manner in which they are sanded to a suitable aerofoil section, like a solid balsa wing. The main problem then is to provide a suitable hub to assemble the two blades.

The simplest type of hub is just a short length of *hard* balsa which should be between ½ and ¾ in. wide and thickness calculated to give the required pitch angle when the blades are slotted in diagonally, as shown in Fig. 12. Actually a pitch angle of about 35° will be about right for most propellers of this type, calling for the depth of the hub to be roughly 0·7 times the selected width—say ⅜ in. for a ½ in. wide hub and ½ in. for a ¾ in. wide hub.

A good cement joint is essential and the hub itself should be bushed to take the propeller shaft, if the propeller is to be of the free-wheeling type. The whole assembly can be smoothed down and the hub blended into the blades after finishing. The completed propeller should also be balanced by sanding away wood from the heaviest blade as necessary.

Actually it is only a short step from this type of propeller construction to the adjustable pitch type used on many modern contest Wakefields. Here the blades are usually carved from block, or thick sheet, to the required blade "twist" and then assembled in a cylindrical hub made either from gum-strip, or laminated plastic tubing. The same sort of propeller can be made, using sheet blades, if the root ends are built up by additional pieces of sheet cemented in place and then carved down to a circular section to fit the hub tube, as in Fig. 13. This will give a propeller where the pitch can be adjusted at will to get the best performance. Another advantage is that if a blade is broken in a crash simply withdraw the damaged stub and replace with a new blade. Repairs are simple, in any case. Just cement the two broken parts together again with a reinforcing length of thin bamboo, as in the sketch (Fig. 13).

Apart from "quickie" construction itself, there are a number of other ways in which time can be saved in building, even with ordinary construction, if you *plan* your model building and go about it the right way. Using the right tools, and in particular using a *sharp* blade in your modelling knife, is just one example. It is wonderful the difference a keen cutting edge will make at times!

Then there is the question of materials. Make sure that you have enough stock on hand *before* you start building. It is no good finding out half way through the evening that you are stuck for one length of certain strip size and everything is held up until you can get round to the local model shop to buy one. It may sound wasteful but if possible, you should try to build up a stock of useful wood sizes rather in excess of your anticipated needs. That allows for breakages and other accidents and allows a wider selection of materials for certain vital parts.

Probably the majority of models are built in "temporary" workrooms. The building board is laid out on the kitchen table for a few hours in the evening, or perhaps even on the bed. That means getting all the materials together before you can start the evening's work and then clearing them all away again at the end of the building session. Unless you plan your building evenings carefully you will find that you may be spending as much time looking for the necessary materials and equipment and packing them up again as you do in actual construction. Improvise a combined materials box and tool box to move around with the drawing board so that you can reduce wasted time to a minimum. No serious modeller ever has enough time to build *all* the models he would like to. Make sure that most of the time you do have available is spent in useful work and not non-productive "routine".

TYPICAL COMPONENT WEIGHTS

As a check on whether your adoption of "quickie" construction (or any other type of construction) is working out to the correct weights, the following tables of "break-down" weights are typical of good building practice. Component weights in excess of the proportions indicated are too heavy. Components of lower proportionate weight are likely to be too weak.

Power duration (open)

Fuselage, fin, undercart ..	30	Total
Tailplane	6.5	„
Wings	20	„
Engine, prop., timer ..	43.5	„

Power duration (F.A.I.)

Fuselage, fin, undercart ..	30%	Total
Tailplane	8	„
Wings	22	„
Engine, prop., timer ..	40	„

A2 glider

Fuselage, fin	35%	Total
Tailplane	3.5	„
Wings	30-35	„
Ballast	remainder	

Wakefields (new rule)

Fuselage, fin	20%	Total
Wings	15	„
Tailplane	5	„
Undercarriage	5	„
Prop. assembly	15	„
Rubber (80 grams) ..	30	„

Chapter Thirteen **Kit Models**

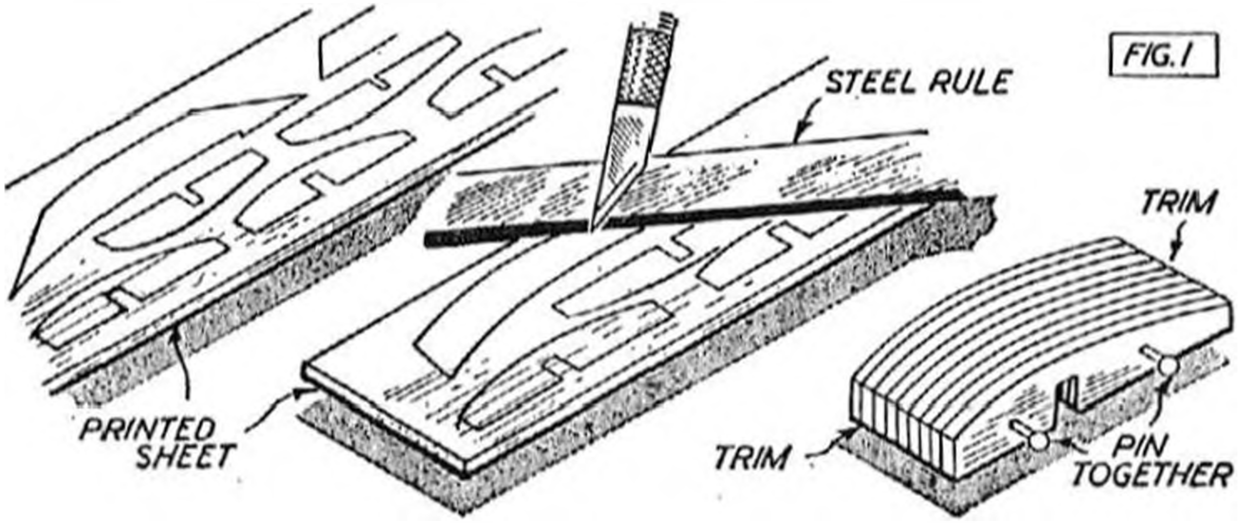
IT may seem strange to classify kit models separately from the various types of construction already discussed, especially as most kits conform to orthodox practice. There are, however, certain differences and quite often many ways in which kit construction can be speeded, or even improved.

Basically, the main difference between a kit model and a " freelance " or " one-off " design is that the former is designed for production in quantity. This is not true of all cases, of course. Many contest-winning models have been kitted without, or with only slight modifications. Also some kits are more elaborate than others as regards wood sizes, etc. But as a general rule individual *sizes* of wood are reduced to a minimum in a kit, the thinnest sheet stock used for ribs, etc., is $\frac{1}{16}$ in. and quite extensive use is often made of component parts cut from sheet, as opposed to laminating from strip or more expensive or more intricate methods. As a result the kit is cheaper to produce and can sell at a lower and therefore more popular price.

Kit Features

Quite often a kit can offer features which would otherwise be unobtainable, or beyond the skill of the average modeller to produce, such as moulded plastic components, fully shaped balsa shells for streamlined fuselages, etc. Also instead of being printed out, parts required from sheet are die cut in production with an accuracy normally higher than that which the average builder would obtain. Besides ensuring accuracy, such pre-shaped or pre-fabricated parts reduce building time and, carried to extremes, construction of a fully prefabricated kit becomes largely a matter of assembly. In some cases pre-cut sheet parts are also pre-decorated by printing, so that assembly results in a finished and coloured model. Such techniques are generally restricted to the smaller types of kit models.

Broadly speaking there are three basic types of kits—the traditional model kit where the material is supplied in the form of standard lengths of balsa strip and sheet, parts to be cut out being printed on the sheets ; the prefabricated kit which follows similar lines but all the sheet parts are die cut instead of printed; and the prefabricated kit which departs from orthodox constructional methods and introduces special features such as moulded fuselage shells, shaped wing panels, etc., so that building becomes really a matter of assembly. Obviously the degree of prefabrication can vary considerably with either of the two latter types, but the former remains still a *constructional* kit.



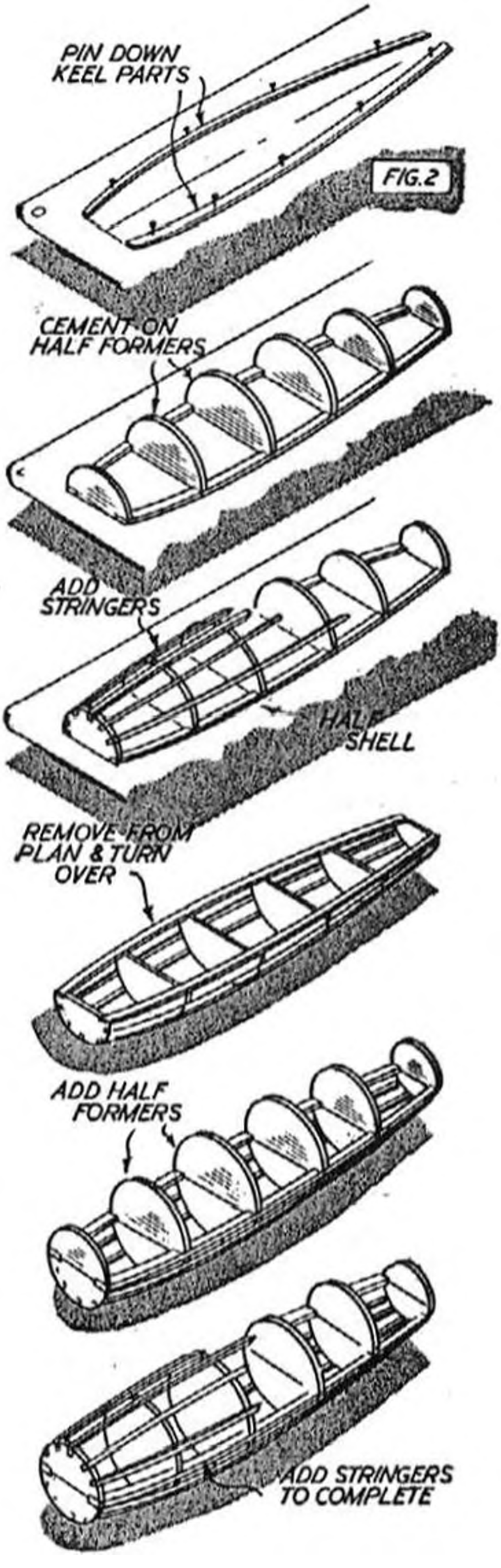
Die-cut Sheet

Kits with die-cut sheet parts have become standard in the United States. Printed sheets are still used to a large extent in this country, partly because the technique of die cutting raises production difficulties and partly because quite a number of modellers do, in fact, prefer to work from " basic " materials and cut everything out for themselves. Certainly more skill is needed to build a model from " basic " materials and it is often claimed in favour of printed sheet productions that they are nearer to true areomodelling because of this. Unfortunately for the beginner, however, the job of cutting out parts from printed sheet accurately, and without damage, is not always easy, especially in the case of lower priced kits where the tendency is to cram the printed parts together to economise on space, and material. Also balsa itself being an inconsistent sort of material, individual selection of sheets for printing is obviously quite impossible and the sheet stock used may be too brittle or too hard for easy working.

To cut sheet parts accurately it is absolutely essential to use a sharp knife—or a razor blade,if you find that you can handle this better. A blunt knife will always tend to tear as well as cut. If the sheet appears hard and brittle it will be a help to dampen it slightly before working.

It is a good plan to cut out all the printed sheet parts at the beginning—not just those required for immediate use. This eliminates the possibility of losing pieces of the sheet carrying parts not required until later. All parts, once cut out, should be kept in a small box and selected from this box as required. They should not be left lying about.

Quite a bit of practice is needed to cut accurately to the printed outlines given on the sheet. Normally it will pay the less experienced modeller to cut each piece very slightly oversize and finish to final shape after with sandpaper. Curved cuts will have to be made freehand, but all straight lines should be cut using a metal rule as a guide—Fig. 1. Parts which are duplicated, such as wing ribs,



should be pinned together after cutting out and finished to a smooth, uniform shape with sandpaper. Spar slots should also be trimmed whilst pinned together.

Building from Kits

Most kits follow orthodox constructional methods and so the building tips summarised in previous chapters apply. A majority of kits, too, also contain building instructions, generally in the form of a printed strip on the side of the plan. In such cases it is usually more convenient to cut off this printed strip for easy reference. Since these instructions are invariably prepared after the prototype model has been built and tested and the final plan drawn up, they represent the experience of the designer and often contain valuable hints. They are included *to* be read—not completely ignored, as they so often are.

Quite a number of the smaller kit models, especially those of the flying scale type, employ " half-shell " fuselage construction. This is a standard method of building streamlined or rounded fuselages using sheet formers and stringers which has been in vogue for some twenty years. Typical stages in construction are summarised in Fig. 2.

A start is made by laying down two master keel members flat over the plan, these being either strips or cut from sheet. A complete set of half formers are then cemented in place, taking care to get each one at right angles to the keel members and lined up with its station as marked on the plan. Normally these half formers will stand on their own once cemented, but they can be propped up with pins, etc., if necessary, until set.

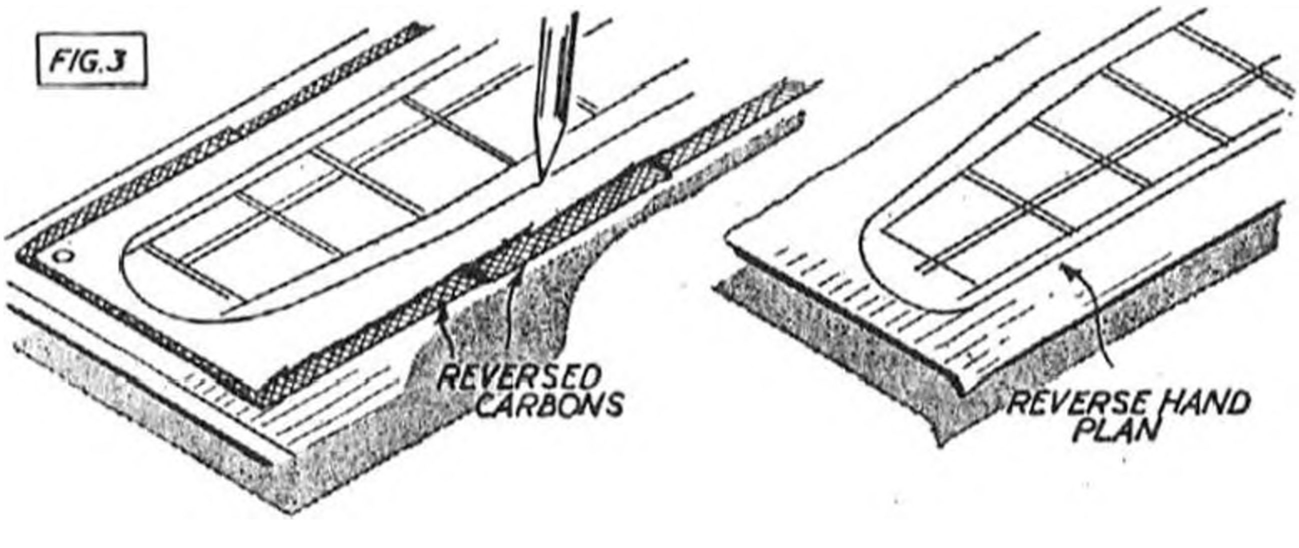
The next stage consists of cementing in all the stringers which go on that side. Normally the stringers will be fitted into slots cut in the individual formers. In some cases they are cemented to the edge of the formers, positions being printed on the formers. Whichever method is specified, some adjustment of position may be necessary to get accurate alignment, using your eye as a judge. Once satisfied with the alignment, leave the assembly to set thoroughly.

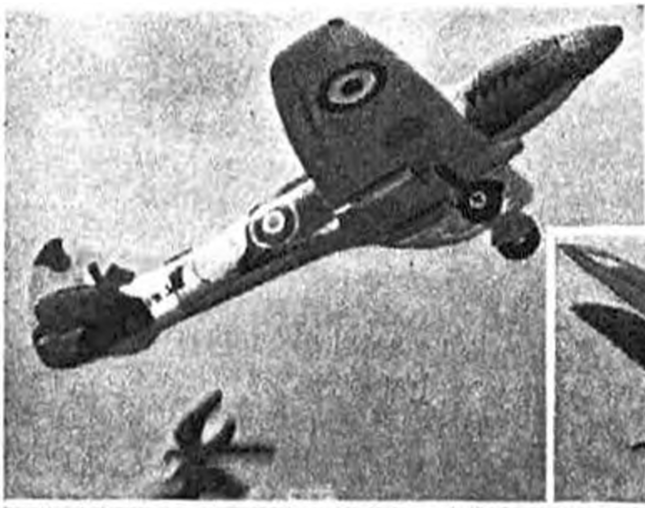
The half fuselage shell is then removed from the plan and turned over. Clean up, as necessary, to remove surplus cement from the inside of the keel members and cement on the second set of half formers. The second set of stringers is then added in the same manner as before and the basic fuselage is then complete. Other parts may have to be added before the fuselage is ready for covering, but these will be detailed on the plan.

Duplicating Wing Plans

Wings and tail parts are invariably built flat over the plan. On a number of drawings a plan of only one wing half is given (and also, very occasionally, only one half of the tailplane). In this case, unless the outline of the other wing is dotted or indicated on the original half plan, a tracing or drawing must be

FIG. 3

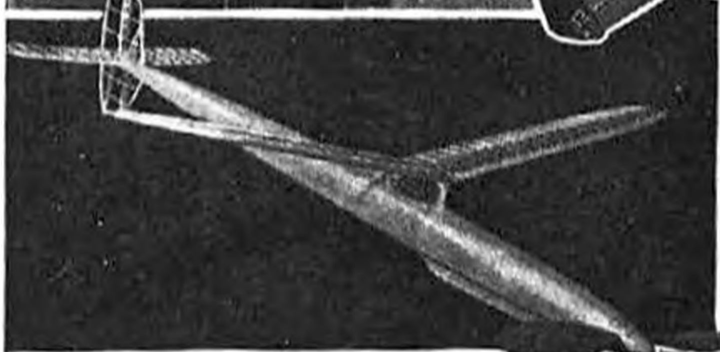




Left: One of the most difficult free flight scale models to trim this powered Spitfire is a popular winner in Aeromodeller Plans Service.

Below: Z. Wojda's highly detailed Championship Cup winner, a c.l. version of the Polish PZL 37. U.c. is fully sprung and working, flaps operate and cockpit is instrumented.

Left: Sqdn. Ldr. Ellis discusses unorthodox models with Peter Holland holding his "pseudo-jet" model Prop Secret *and Charlie McCutcheon with his auto-stable wing.*

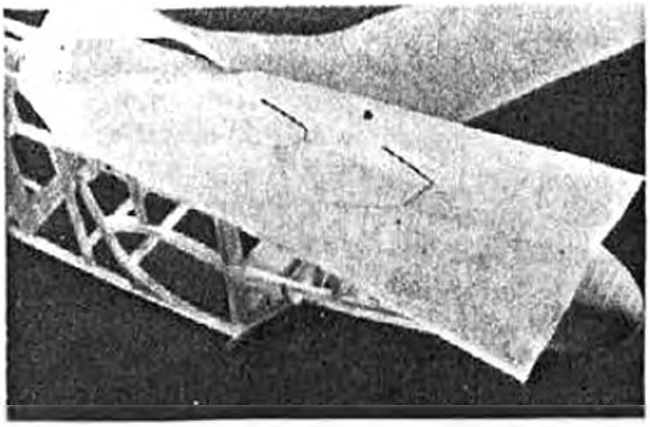


Above The ultimate in Wakefields produced by famous international modeller Ted Evans, designed to the new limited rubber formula.

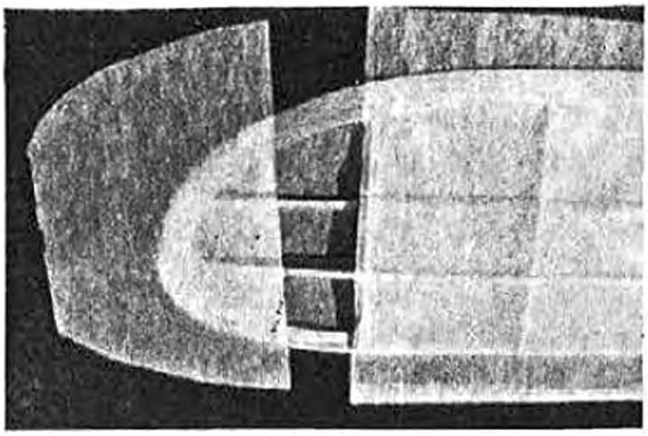
Above right: Captain Milani's Dornier 17. Cockpit glazing is a work of art, nevertheless model flies c.l. at 60 m.p.h. and could be looped.

Above: Pete Russell with his Gold Cup winner and a magnificent four-engined Liberator, also a polished c.l. performer.

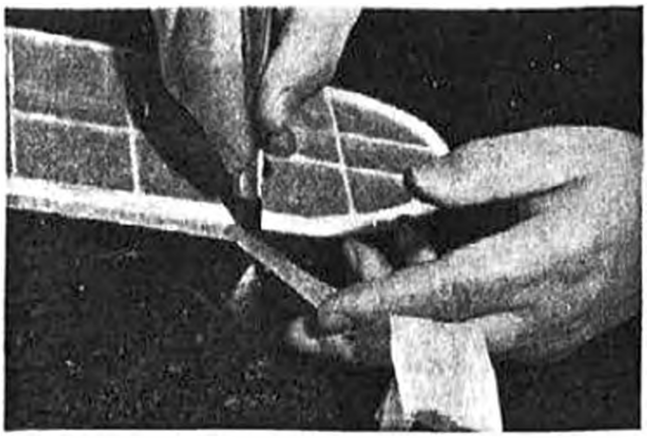
Left: Grumman Panther in U.S. Navy colours powered with a Dynajet, that is positively shattering in action.



Fuselage covering ; tow hooks pierce the tissue which is then pasted and smoothed down.



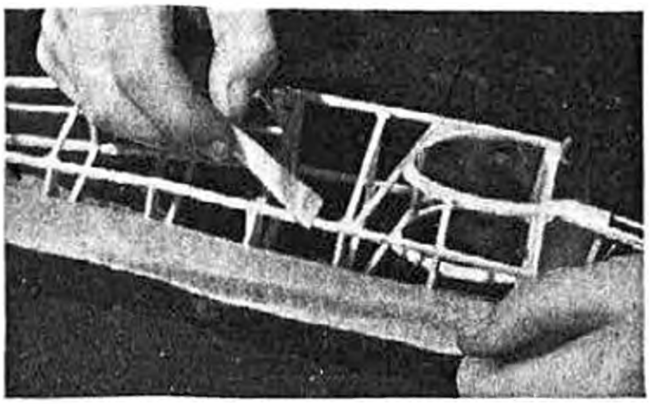
It is best to cover wing tip with a separate piece of tissue.



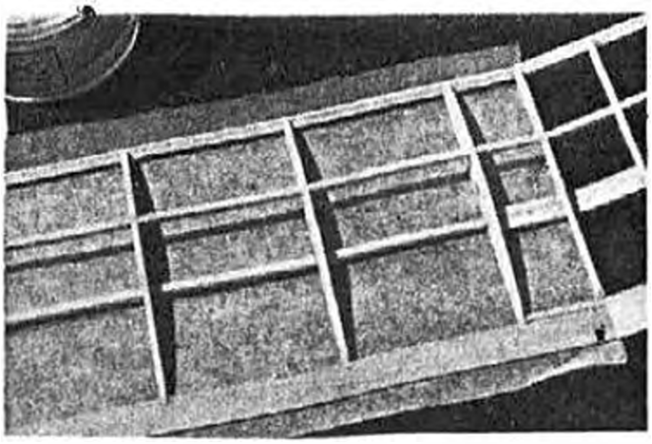
When dry, surplus tissue is trimmed away with modelling knife or razor blade.

Doped with a mop brush, the fine taut wing covering looks slack, but soon shrinks again.

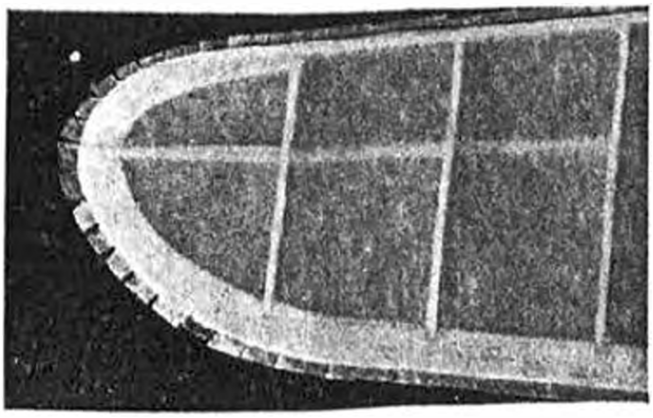
Pasteing longerons with the plastic spreader prior to laying on full length side of tissue.



Wing underside, which is so often flat, or nearly flat, is covered first.



Nicking the wing tip tissue enables a perfectly crease-free job to be obtained and aids in sticking down.



To avoid warps while drying, wings, tailplane and fin should always be secured to a flat surface.

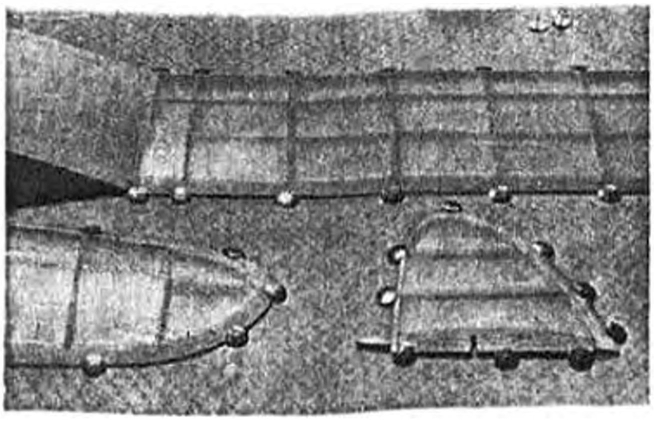
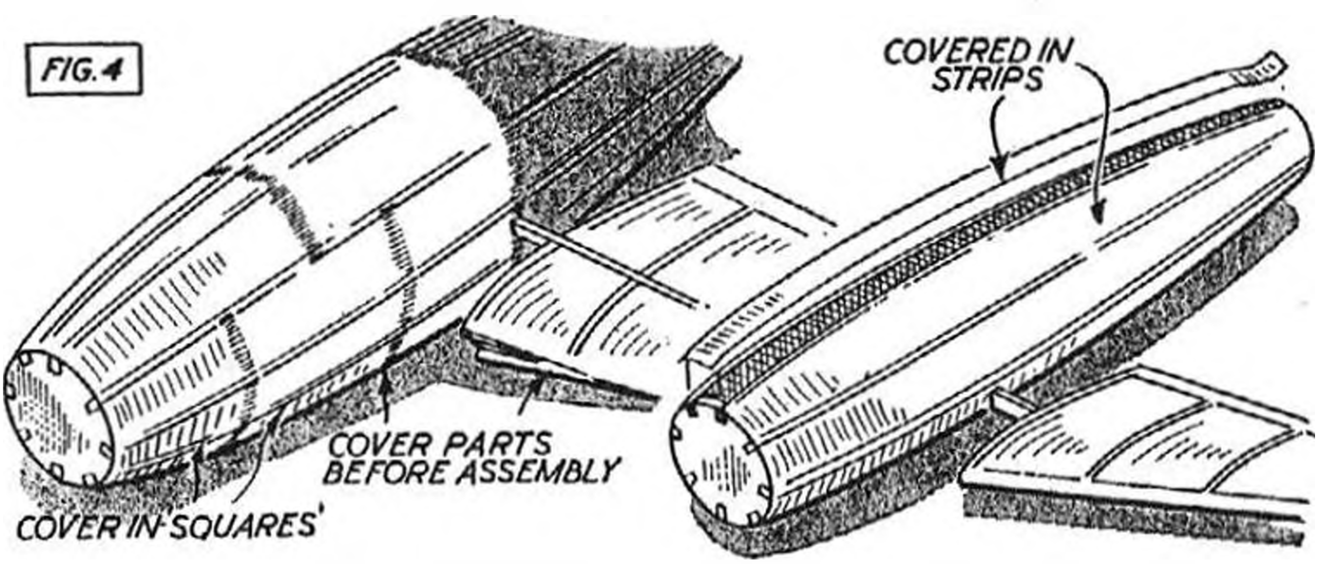


FIG. 4



prepared of the second half wing before it can be built.

One of the easiest ways of doing this is to use carbon paper to produce a "handed" drawing on the back of the plan—Fig. 3. Enough carbons are laid, black side up, under the wing plan to cover the whole area involved. Then trace over the wing outline, marking the rib positions, etc., with a sharp pencil. Use a ruler or a straight-edge for accuracy and speedy working. Tip curves can be done freehand. When completed, turn over the plan and you will have a "handed" drawing on the back over which the second wing half is built. But before pinning down to the building board, make sure that there are no blobs of cement, etc., on the original working side which will prevent the plan from being laid down perfectly flat.

The more elaborate prefabricated kits, especially those including moulded constructions, almost invariably include comprehensive building instructions with diagrams illustrating the main stages of assembly. Thus they should present little difficulty, providing these instructions are followed faithfully. Where builders are likely to come to grief is ignoring such instructions entirely, which is unfortunately a common attitude amongst many people once they have successfully completed one or two kit jobs.

Paradoxically enough, too, although the fully prefabricated kit includes all the cutting-out work ready done, many people regard these kits as "complicated", simply because of the large number of pieces they contain. Yet almost invariably they are simpler and quicker to build than a similar model produced along orthodox lines since each part is an assured fit and completion of a successful model is simply a matter of step-by-step assembly.

Covering

A feature of construction sometimes not always clear from printed instructions is the best method of applying the tissue covering, especially on rounded fuselages. In the case of a small flying scale model, for example, with the rounded fuselage shape formed by ten or more stringers, the fuselage will have to be covered in narrow strips, one section at a time, or in overlapping squares of tissue—Fig. 4.

In most cases where the model is an integral assembly (i.e., wings and tail permanently cemented to the fuselage) it will pay to cover the fuselage, wings and tailplane before cementing these components together. This avoids awkward working areas in trying to finish the wing covering flush against the fuselage on the root rib, and then finish that panel of the fuselage covering on the wing, etc. If the covered parts are likely to be handled a lot during assembly, then they should be watersprayed and given a single coat of dope first. Otherwise waterspraying and doping can be left until after assembly.

Chapter Fourteen Propellers

FOR the purpose of construction we can consider propellers as being of two entirely different types—propellers for rubber models and propellers for power models. They serve the same purpose—to convert the turning power or torque of the power plant (rubber motor or miniature engine) into useful thrust—but, as a generalisation, power model propellers are usually purchased ready made and simply attached to the front of the motor ; whilst rubber model propellers are carved from block, may be feathering, folding or freewheeling, and usually require quite an amount of additional work in mounting in place to complete the nose assembly.

Plastic Props.

Great Britain has led the world in the widespread adoption of plastic propellers for power models. Some of the first plastic propellers produced were American (Snafu) but, whilst of excellent aerodynamic shape, these were costly and, with their thin blades, dangerous to handle and also rather too prone to break. The first British plastic propellers were crude by comparison with thick blade sections, poor efficiency, but tougher. The modern British plastic propeller overcomes these early faults without sacrifice of strength and the certain amount of flexibility afforded by the use of plastic minimises the risk of breakage. Plastic propellers do break, but this is now a comparatively rare occurrence when the model is trimmed. With a high-performance wood propeller, however, it is quite common to break one or two on landing in completing just three contest flights. Thus the plastic propeller offers a considerable economy in the long run at the price of a slight loss in efficiency. This loss cannot be serious for many contest fliers use plastic propellers. But there are others who persist in the use of wooden propellers for contest work for peak performance and accept breakages as a normal happening. In other words they usually go prepared with three or four spare propellers whereas the flier using the plastic propeller generally carries just one spare.

For sport flying, then, everything seems in favour of the plastic propeller. This is particularly true with the smaller sizes of motors. In fact with diesels up to about 2·5 c.c. the plastic propeller is, perhaps, the better all-round propeller in any case, the slightly greater weight providing a flywheel action which seems beneficial to running. In the half-c.c. class, for example, the E.D. and Frog plastic propellers, to quote two typical commercial products, are probably as good aerodynamically as wooden propellers, particularly if the backs of the blades are filed flat. The one basic disadvantage is that the range of plastic propeller sizes is more limited on account of the high initial cost of dies. This is particularly true of pitches. There are few plastic propellers available with a low pitch and, for free flight duration, many fliers prefer to use a propeller with a low pitch : diameter ratio.

If you decide on a plastic propeller, then almost invariably the bought article will require a certain amount of finishing. Since these are moulded in split dies the edges of the propeller are usually quite sharp, often with a knife-edge " flash " of surplus material. All the edges need rounding off carefully with sandpaper, otherwise there is a considerable risk of badly cut fingers when operating the motor.

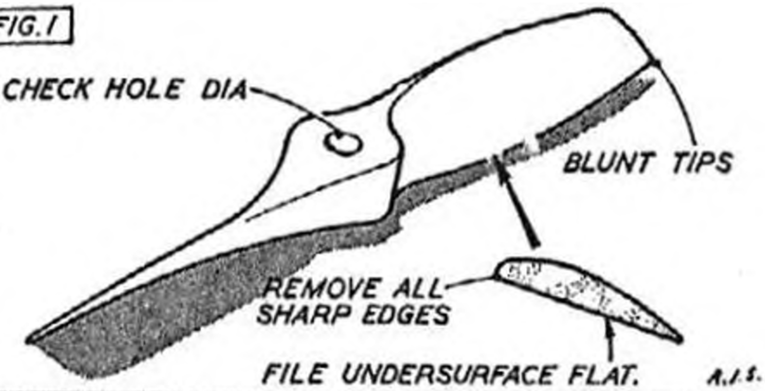
Drilling to size

In many cases, too, you may have to drill out the centre hole to a new size to fit the motor shaft. This is easy enough if the propeller is unbushed, but with the type where a metal bushing is cast in with the plastic material this bush often tends to turn if drilled into with an oversize drill. You then end up with your new hole drilled only part way through and the whole bush loose in the plastic. One way of overcoming this is to clamp the propeller in a vice as shown in Fig. 2. before drilling, where the vice is actually tightened down on the edge of the metal bushing.

With a wooden propeller, of course, drilling out an oversize hole is quite easy—if you have a drill of the correct size. Unfortunately some motors call for a clearance hole in excess of ¼ in. diameter (the usual maximum size of drill which an ordinary hand drill can accommodate). You can do the job properly by buying a special drill or reamer to fit your drill brace, or use a file tange to enlarge the hole as in Fig. 3.

If you are using a high pitch propeller, as on a control line speed model you may find that the propeller hub is too thick to go on the shaft and allow the prop. nut to be screwed on. In this case the simplest solution is usually to cut back the hub of the propeller, as in Fig. 4. The cut-out portion should be on the back of the propeller, as indicated. This will result in less loss of strength than a cut-out made in the front of the hub, with normal propeller shapes.

FIG. 1



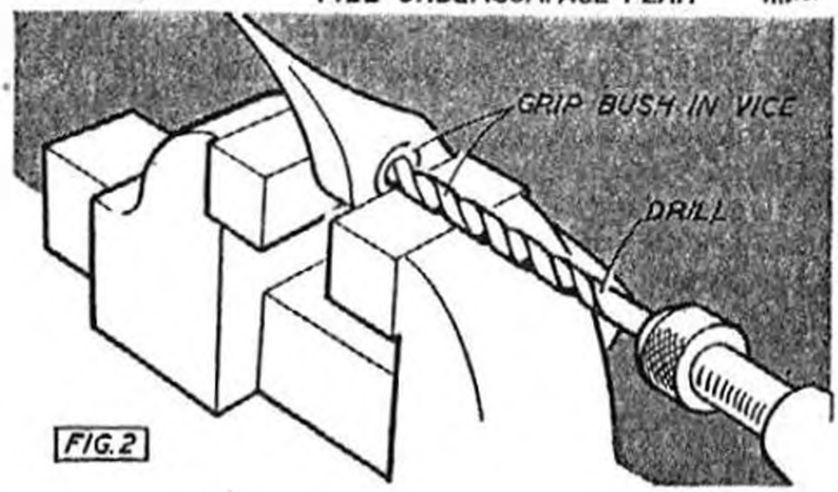


FIG. 2

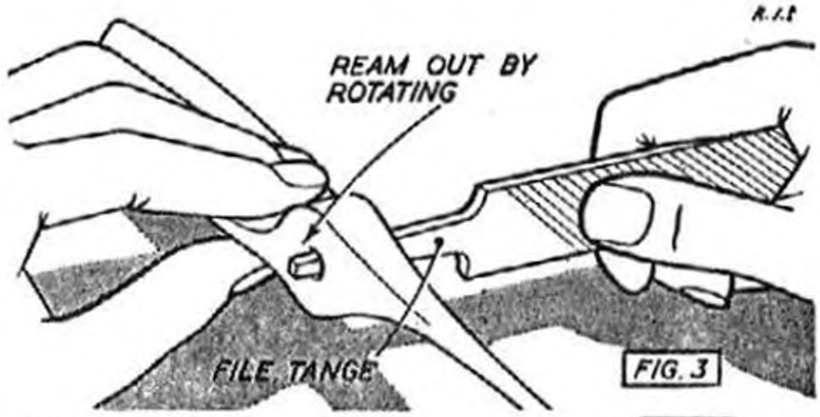
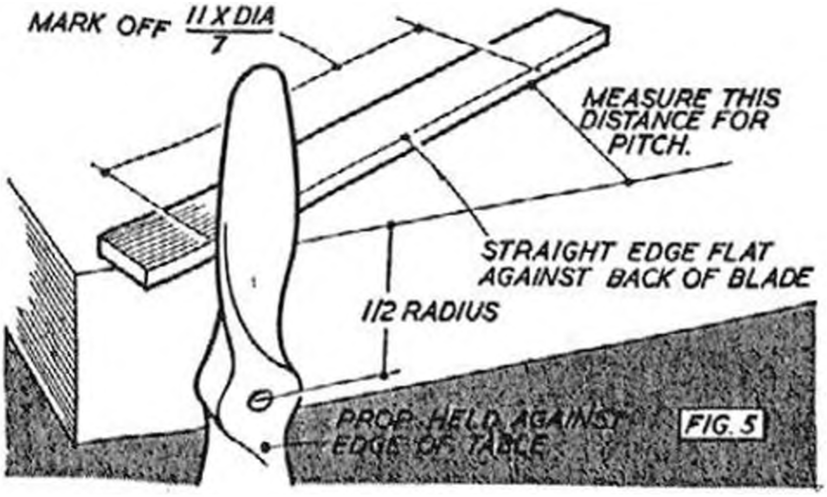


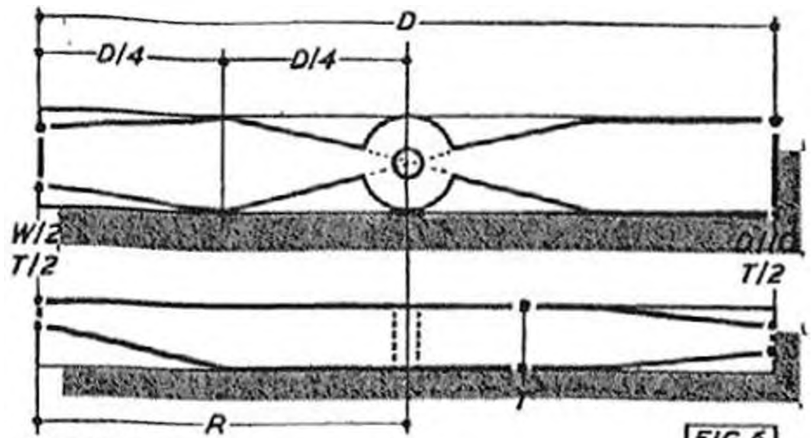
FIG. 3

FIG. 4

One feature that many modellers might like to check on any type of commercial propeller is the actual pitch. There is a tendency for different manufacturers to define pitch by different standards so that a 4 in. pitch propeller, say, of one make may have quite a different actual geometric pitch to another make of 4 in. pitch propeller. Thus it is difficult to get a true comparison relying on manufacturers' figures.

The best standard to adopt in checking is to measure the actual geometric pitch at one half the blade radius and this can be done quite simply. Mark the mid-position of one blade, e.g., 2½ in. from the hub on a 10 in. diameter propeller. Now hold the propeller flat against the edge of a table so that this mid-point comes just level with the table top. Lay a straight





ALTERNATIVE LAYOUTS SHOWN

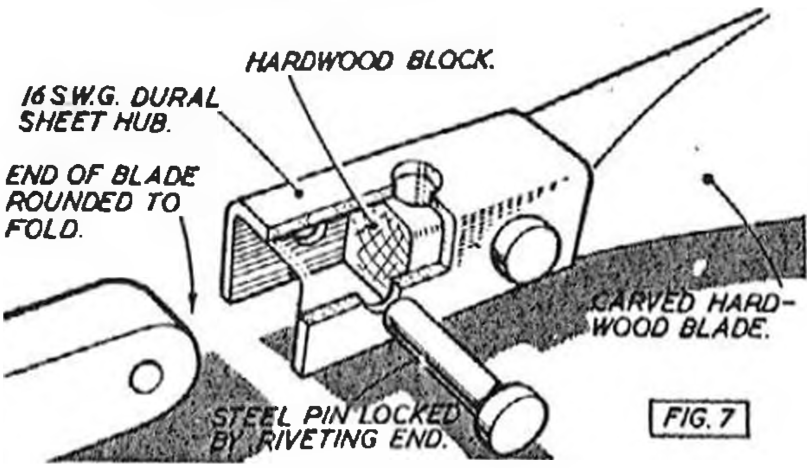


TABLE I.

Pitch (in.)	Propeller Thickness (*)
3	·19095 (3/16)
4	·2546 (¼)
5	·31625 (5/16)
6	·3519 (⅜)
7	·44555 (7/16)
8	·5092
9	·57285
10	·6365
11	·70015
12	·76380

*Proportions as in Fig. 6.
(Fractions in brackets are approximate.)

edge (e.g., a length of sheet balsa) flat against the back of the blade at this point. This will then give the blade angle at this point. Mark off a distance equal to 11 × diameter/7 along this straight edge and from this point measure the actual pitch of the propeller *perpendicular to the straight edge* to the table edge.

Another quick check on pitch is to assume that the width of the block from which they are cut is 10 per cent. of the diameter. The pitch is then simply related to the *thickness* of the propeller at the widest point of the blade, which in most cases is the same as the thickness of the propeller at the hub. A typical propeller blank of this type is shown in Fig. 6 and appropriate pitch figures are summarised in Table 1. This blank layout, incidentally, is a good one to use for free flight propellers, if you want to carve them yourself. Red fibre is an excellent material for "home-made" propellers, although tough to work. For sport flying and control line stunt work a slightly wider blade (often of curved outline) 12·5 per cent. diameter is sometimes preferred. For speed propellers a blade width of 7·5 per cent. of the diameter is recommended. The figures in Table 1 do not, of course, apply to these propellers.

Folding Props.

Folding propellers are now rarely used but were in favour some five or six years ago when plastic propellers were unobtainable. Rather than any drag saving, the main virtue of a folding propeller is that it is more crashproof than a fixed wooden propeller. They need very careful construction as there is considerable strain on the hinge pins. Typical details are summarised in Fig. 7.

Rubber Props.

The rubber model propeller is a somewhat different article. Invariably it is of larger diameter and pitch than its power model counterpart, designed to produce thrust at much lower rotational speeds and, equally invariably, it is carved from balsa to reduce weight to a minimum. From time to time modellers have used rubber propellers carved from light "hardwoods", but this is the exception rather than the rule.

Carving a satisfactory balsa propeller demands a certain knack which practice alone can bring. A limited range of commercial rubber model propellers are available—some fully finished and some partly finished which may be the ideal answer to the less experienced modeller. These, however, are relatively expensive for they have to be hand carved and consequently labour charges are high. Carving your own propellers is certainly cheaper. Almost every contest flier, too, will tell you that for his special purpose he can produce a far better product than a standard commercial type. Certain contest rules insist that the entrant does, in fact, make the whole of his machine, including propeller. All the evidence points to the fact that the man who wants to fly rubber models must learn to carve his own propellers.

Most rubber props are carved from solid block, irrespective of the size or type. In all cases the procedure is similar, starting with a rectangular block of the right overall dimensions, cutting out to blank shape and then carving edge to edge. Rather than a wordy description the complete process is summarised, step-by-step, in Fig. 8.

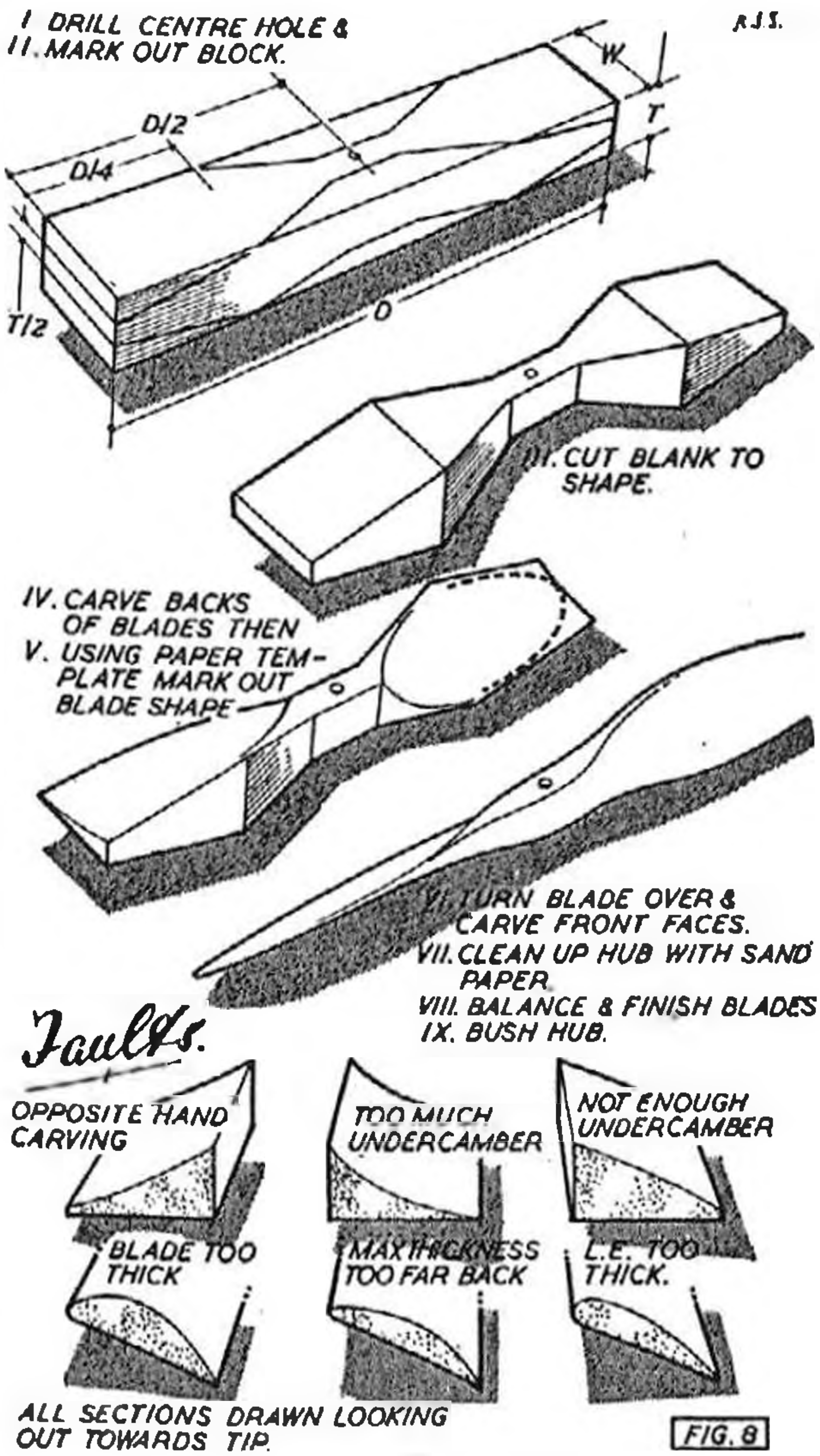


FIG. 8

The carving stages are relatively simple up to the third stage, simply calling for accurate carpentry. When the actual carving itself is started, however, most of the rest of the work is finished by eye.

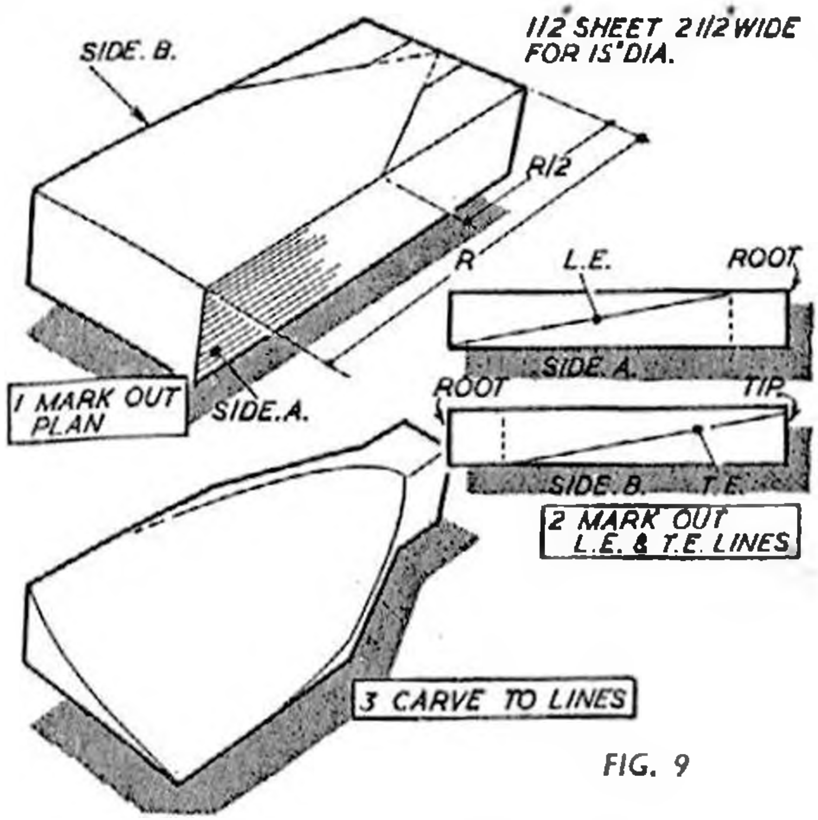
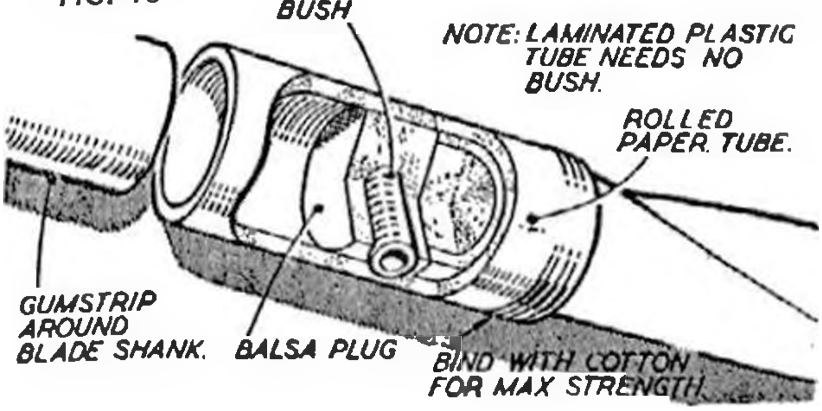


FIG. 9

FIG. 10



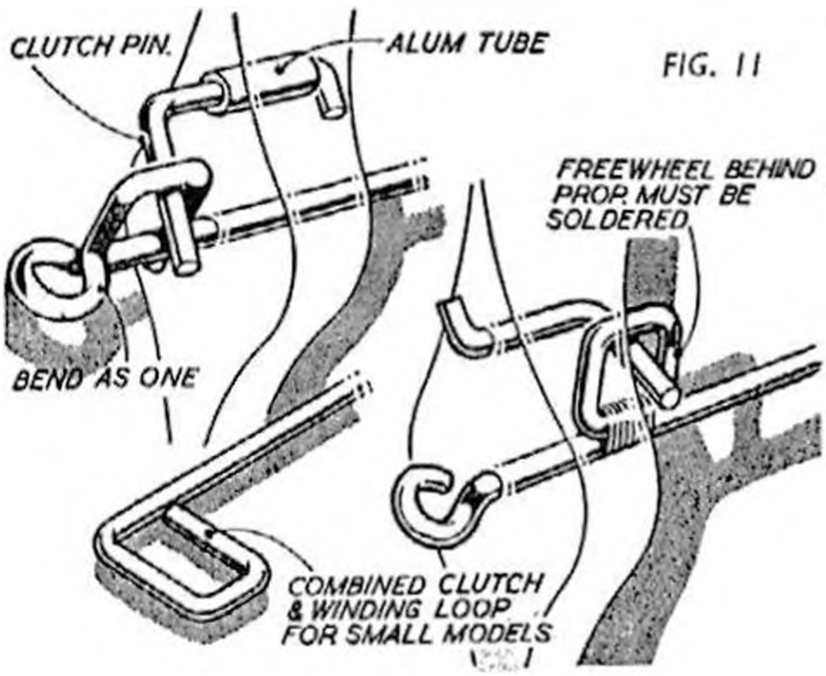


FIG. 11

The best guide to a beginner is an actual finished propeller carved by an experienced modeller. Borrow one, if possible, to act as a visual guide—or study closely the propellers carved by experts next time you get to a flying meeting.

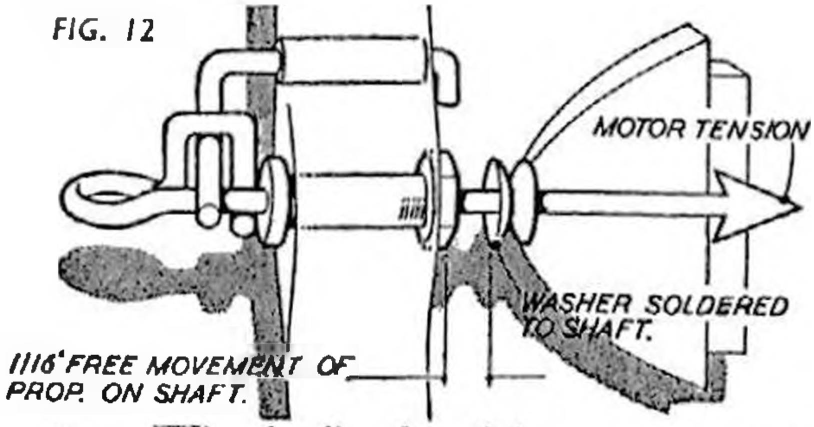
There has been a recent trend to carve the blades of even two-bladed freewheeling propellers separately and then mount them in a cylindrical hub, which may be a rolled paper tube or length of laminated plastic tube. Such individual blades can be carved from sheet balsa rather than block, with a consequent economy in both time and material. The same principle can, of course, be extended to single-blade folding propellers.

Blades from Sheet

In carving a propeller blade from sheet we are simply eliminating waste wood by using a propeller blank which is plotted along a diagonal of the normal squared block — Fig. 9. To get the required pitch angle change from root to tip we simply mark on the actual position of the leading and trailing edges on the edges of the sheet and carve to these lines. The only pre-shaping required of the sheet blank is cutting to plan shape.

For all practical purposes the leading and trailing edges lines on the edges of the sheet blank can be drawn straight, as indicated in Fig. 9. The step-by-step stages in finishing are then shown. Make sure that you properly identify the back and front of the blade before carving as it is easy, with this method, to start carving the wrong way round. Once you have got the hang of carving propeller blades from sheet, however, you will appreciate the great saving in both time and money. The trickiest part is then assembling the completed blades in a suitable hub. A simple system is shown in Fig. 10. In the case of a rolled paper tube the centre of the hub is filled with a disc of hard balsa to support the bush. With a laminated plastic hub neither the balsa filling or a metal bush is necessary. Once assembled in the hub the blades can be set to the required pitch angle, making sure that each is equal and should then be pinned in place.

FIG. 12



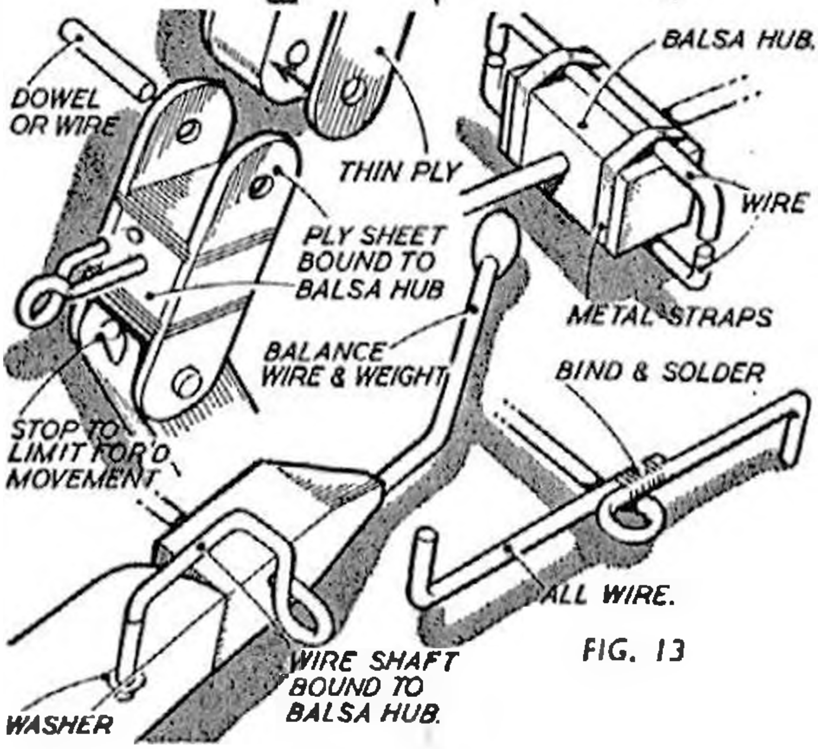


FIG. 13

Freewheeling Props.

Typical freewheeling propeller assemblies are then detailed in Fig. 11. There are many more, but these are a few which have given consistent, trouble-free results in the past. Wherever possible it is advisable to avoid soldering on stressed parts—the freewheel clutch, for example. Soldered joints have a habit of parting up at the most awkward moments. It is just as easy to bend the freewheel loop integral with the shaft. The winding loop should be a close fit on the hook in the winder to prevent climbing.

Strictly speaking a freewheeling propeller should have a fixed washer mounted behind it so that when the motor is unwound (but still in slight tension, to keep it taut in the fuselage) the propeller is free to freewheel without binding. But unless a really good soldering job is done on this fixed washer it is best omitted. If the joint fails under the tension of the fully wound motor the washer will slip along the shaft and even lock the propeller to the shaft. A couple of turns of fuse wire soldered in front of the washer makes for a stronger joint.

Some folding propeller assemblies are shown in Fig. 13. Here one of the main requirements is a stoutly anchored stop to tension the motor and lock the propeller in the correct position for folding. For the stop a long woodscrew is usually best, preferably screwing through two layers of thin ply incorporated in the noseblock. For maximum strength the stop should be as close to the back of the noseblock as possible. Bend the shaft stop integral with the shaft and bind with a rubber band or fuse wire for rigidity once the motor is in place.

Summarising, it may be said that the nose assembly is one of the most important parts of the model, as far as detail design is concerned. Everything should be positive, foolproof and as simple as possible.

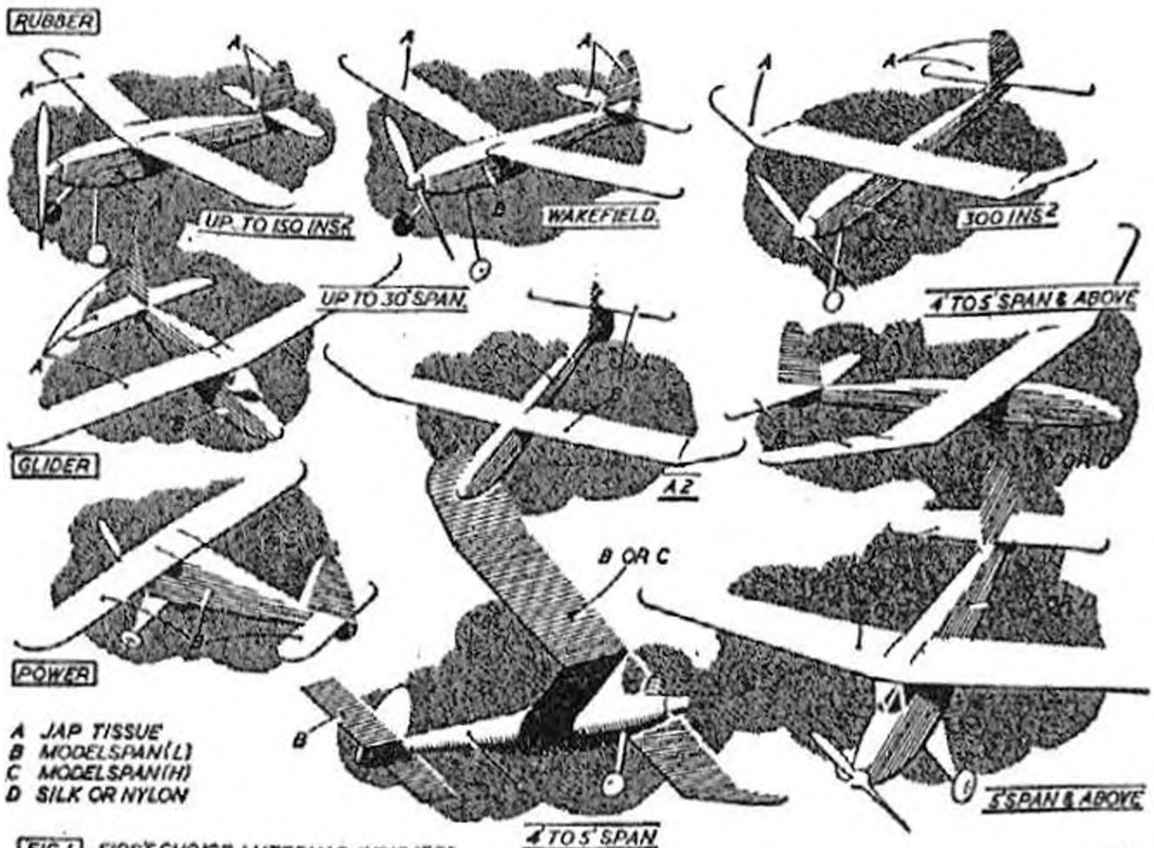


FIG. I. FIRST CHOICE MATERIALS INDICATED

Chapter Fifteen Covering

AS a general rule, small lightweight models up to about 24 in. span, rubber or glider, are best covered with Jap, if available. Wakefields used invariably to be covered in Jap tissue but many modellers prefer a slightly stronger tissue for the fuselages. This is excellent practice. Jap tissue covering on fuselages is too ready to develop small splits, especially on slabsided fuselages. An early cure was to double-cover with Jap tissue—forming a two-ply covering, in effect.

Tissue Types

At the present time, some of the experts still cover their Wakefields entirely in Jap tissue. Additional strips of tissue are then sometimes doped on the sides of the fuselage to resist splitting. Most Wakefield experts still use Jap tissue for covering wings and tail units, as far as this is obtainable, but many use a heavier grade tissue, like Modelspan and its American counterpart, Skysail, for fuselage covering. Just to emphasise that choice is as much a matter of personal preference as anything, other leading flyers use lightweight Modelspan covering throughout.

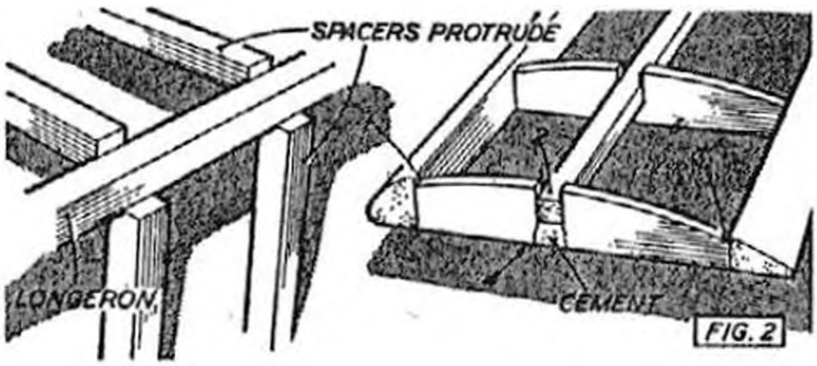
The same remarks can be taken to apply to small gliders. Once a glider gets above 200 sq. ins. wing area, however, and for all power models, weight is far less critical and it almost invariably pays to use a strong covering material throughout—say lightweight Modelspan if weight saving is still considered important ; heavyweight Modelspan on larger structures. Silk or nylon covering may well be considered for large glider and power model wings and fuselages.

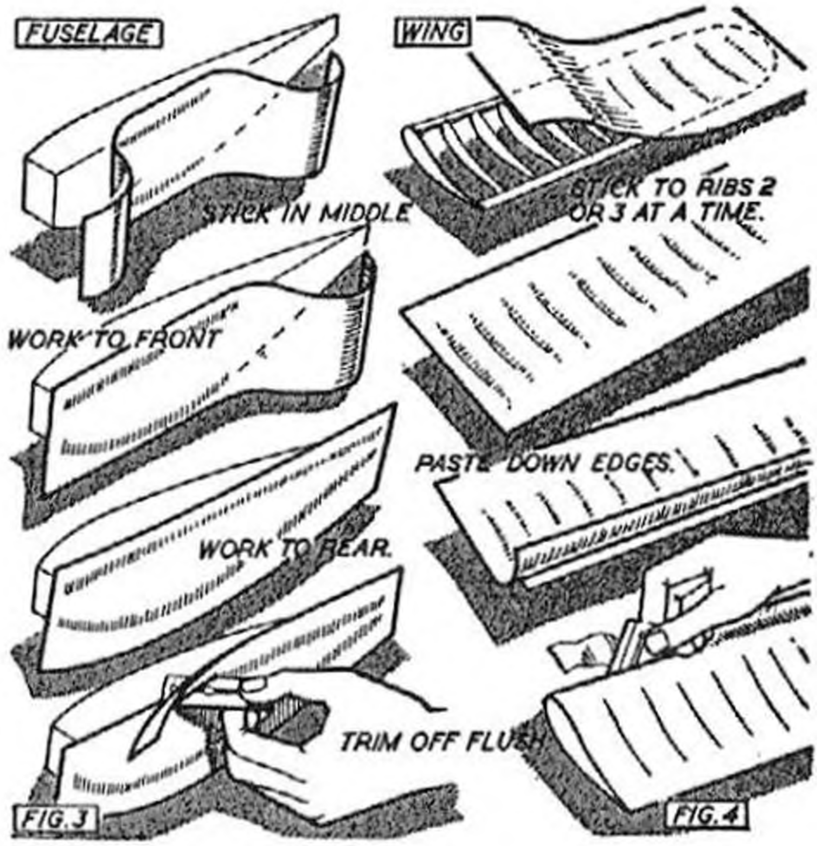
Lightweight silk covering compares very favourably with heavyweight tissues and is considerably stronger, but more expensive. Nylon, in "parachute" grade, is heavier still, but very strong indeed. All models with a wing span in excess of about 4 ft. would probably benefit from silk covering, if expense was no object. Both silk and nylon covering, however, is more difficult to apply and dope to a good finish. A guide to the selection of the best covering material is in Fig. 1.

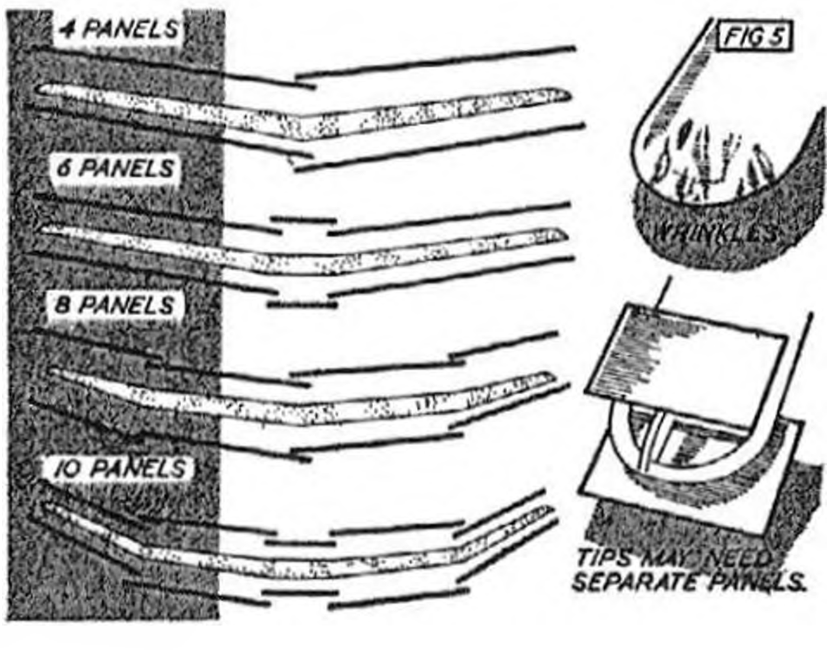
Before starting covering itself, the airframe must be gone over carefully to smooth down or remove any protuberances which might spoil the lay of the finished covering. Small points like these, as summarised in Fig. 2, can make or mar the covering job.

Almost all tissues are applied in the same way. A panel is cut somewhat oversize with respect to the frame to be covered, stuck down around the outline with a suitable adhesive, at the same time drawing fairly taut and wrinkle-free. It is more important to get the tissue stuck down free from inherent wrinkles than it is to draw it absolutely tight. The overlap of tissue is then trimmed off with a razor blade. A coat of clean water, sprayed or brushed on, then allowed to dry, first expands and then shrinks the fibres of the paper. When dry the whole area of covering should draw up taut between the cemented down outlines. Two or three coats of dope then preserve this tautness against damp conditions which would normally make the tissue slacken off again. Undoped tissue, too, is relatively soft and "dents" easily when fingered. Dope adds a certain plastic strength.

Fig. 3 summarises the method of covering slabsided fuselages, and Fig. 4 wing and tailplane covering. In







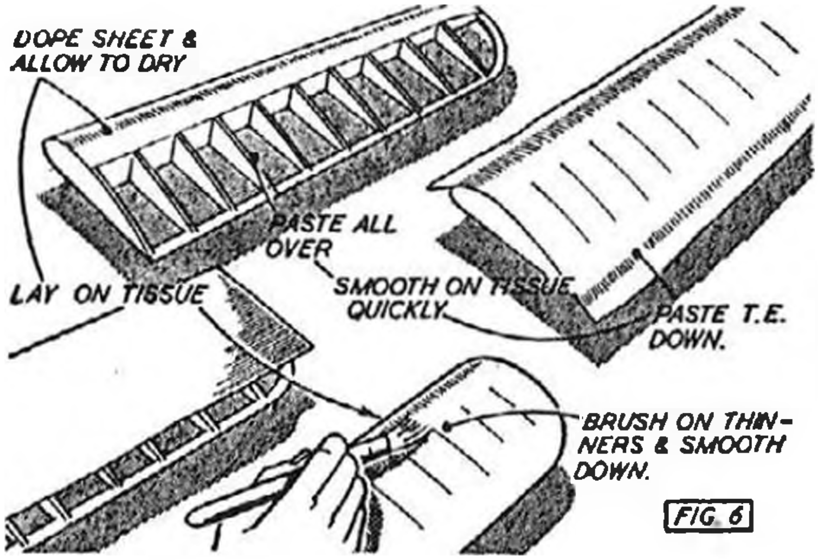


FIG. 6

the case of undercambered ribs, tissue must be stuck to each rib, using dope as an adhesive. With wings a separate piece of tissue must be used for each panel as it is impossible to cover satisfactorily past dihedral breaks—Fig. 5.

Many wings have sheet covered leading edges, which tends to aggravate covering difficulties. Any attempts to economise on tissue paste by simply tacking down the covering to leading and trailing edge will simply produce a series of wrinkles over the sheet portion. The sheeted areas must be thoroughly covered with a thin layer of paste and the tissue stuck down smoothly to this. Avoid excess paste which will "wet" the paper and cause it to tear when drawing taut. Also be sure to draw out all wrinkles over the sheeted portion. Any left in will be permanent.

For best results, work quickly when covering over sheet. As soon as the tissue is impregnated with paste it will begin to expand in size. If you delay laying out the whole panel and pulling in place it will be very difficult indeed to avoid wrinkles appearing in the final job.

Dope as Adhesive

Actually, provided you can acquire the knack of working with it, dope is probably the best medium for sticking down tissue covering to sheet. An alternative method is to dope the sheet, allow the dope to dry, then brush on thinners. Whilst still moist, smooth the sheet in place doping down with more thinners, as necessary. It should be attached permanently and smoothly when the thinners have dried again.

This method—dope, dry, and then brush with thinners or brush through the covering tissue with thinners when laid in place—can be used for covering the entire airframe. It needs practice and care to do properly, but once the art is mastered a really first class job is possible. Try it out on an old structure first before attempting to cover a new model by this method.

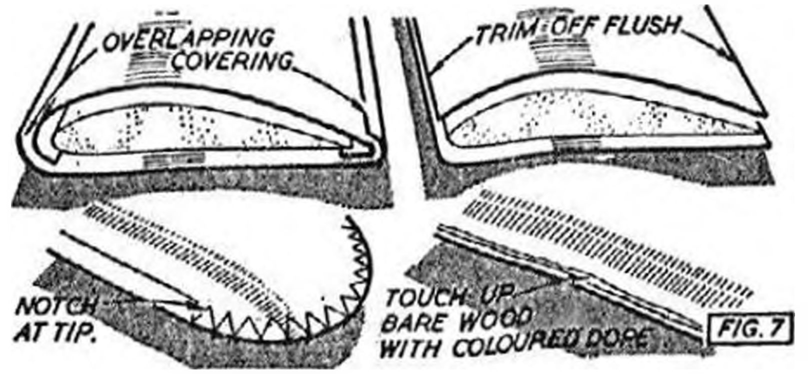
Finishing off covering when coloured tissue is used also presents its problems. The generally recommended technique is to make off one piece of covering around the leading edge, when covering a wing, for example, and overlap the second covering sheet, as in Fig. 7. This can be tedious, especially as the lapped over portion tends to pull away as the second layer is laid down. The area of double covering, even though it is backed by a spar member, will show up as a darker stripe in the final job.

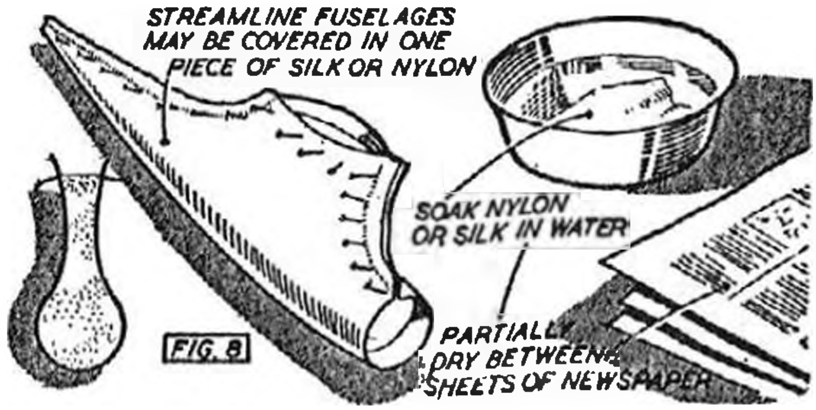
A fairly good job can be done by trimming each sheet of covering off flush at the edge, as in the second diagram. It will be impossible to get an even butt joint between the two tissue sheets all along the edge of the spar. In places it is bound to overlap, and in others leave a gap exposing the bare wood. This method is quicker and, when used, "bare" spots can always be touched up with coloured dope.

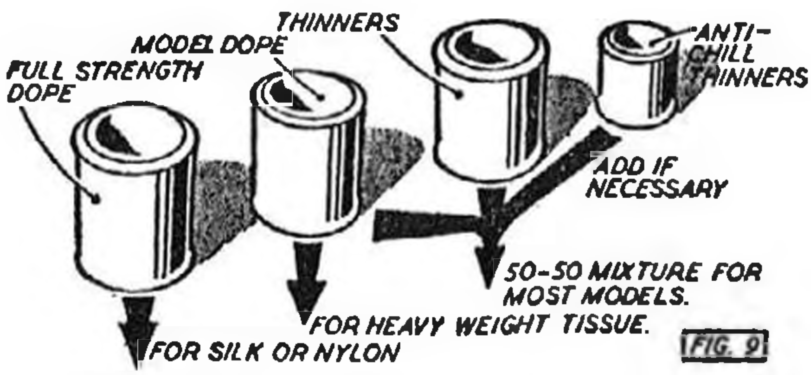
Silk and Nylon

Covering in silk or nylon demands a different technique. Such covering material should always be used in the damp state and drawn absolutely taut when stuck in place over the airframe. Use pins to locate, when necessary. Also try to cover as much as possible with one piece. Wings demand separate panels, as with tissue covering, but often whole streamlined section fuselages can be covered with a single piece of silk or nylon, Fig. 8.

If the silk or nylon dries out before covering is completed it should be re-dampened, *in situ*, by moistening with a sponge. Dry taut silk or nylon will usually slacken off when doped. Damp, taut silk or nylon will dry out with additional tautness to resist the slackening off apparent with the first coat of dope. No wrinkles at all should be tolerated with the original undoped covering. Water-spraying, of course, is omitted. Dope is applied direct after the covering has dried.







Until comparatively recently it was the universal recommendation to pin all wing and tail surfaces down to a flat board whilst drying out from water spraying and, later, doping. With the development of anti-warp structures this is no longer so necessary, except where very fragile structures are involved. Even with orthodox structures, too, it has now become common practice to let wings and tailplanes dry "naturally" without pinning down, on the assumption that it will warp anyway in the long run, so why not now? This method is acceptable, as long as the resulting warps are not excessive. If they are, they can be straightened out by steaming after the final doping.

NOTES ON DOPING

THE main object in doping a model is to make the covering waterproof and capable of being handled without damage—not to tighten the covering material. The covering itself can usually be drawn quite tight enough by other means, such as by water-spraying tissues or by using dampened covering material and drawing taut initially, as with silk, nylon and some forms of "waterproof" papers. If the dope then produces further marked tautening of the already tight covering, then the structure may well warp or deform under this additional tension.

Without being too technical we can say that dope types fall into the following categories:—

(*i*) *High shrinking dopes*—which are generally strongly resistant to slackening off again under damp conditions.

(*ii*) *Moderate shrinking dopes*—generally with good water-resistance if enough coats are applied.

(*iii*) *Low shrinking dopes*—usually slacken off in damp conditions.

(*iv*) *Non-shrinking dopes*—good water-resistance if applied over a prior coat of shrinking dope.

(*v*) *Strong shrinking dopes*—poor resistance to slackening off unless sufficient coats are applied. With all tissue covered surfaces, strong shrinking dopes are to be avoided.

Thus, one would not normally use a type (*i*) or (*v*) dope direct on tissue covered wings or tailplanes where a resulting warp would be inevitable due to the lightness and lack of rigidity of the structure itself. However, if we thin one of these dopes down we can reduce the tautening power and still retain much of its " waterproofing " characteristics—reduce the undesirable effects, in other words, but still retain the desirable characteristics of that dope. When thinned down, a type (*i*) dope usually becomes a type (*ii*) dope, in fact, this is just the type of dope preferred for tissue covered surfaces. The more rigid the structure and the thicker and more absorbent the tissue used, the less the dope need be thinned. In other words, starting with a type (*i*) dope and a supply of suitable thinners, experience will soon indicate which is the best proportion of dope and thinners for any particular covering job. The general rule is to use a dope which is too thin, rather than too thick in all cases. This offers the best control over tautening power. Additional resistance to slackening off in damp weather can then be given by an additional thin coat, if necessary.

Silk and Nylon

With silk or nylon covering, a type (*v*) dope is generally to be preferred, with the first two coats, at least, applied full strength. Even if silk or nylon covering is applied quite taut most likely the covering will slacken off and develop wrinkles unless a strong shrinking dope is used for the first coats. Once these wrinkles have formed it is very difficult to draw them out again, even with the application of strong shrinking dope.

For typical examples of doping practice, let us start with the small tissue-covered model, where the structure is usually on the weak side. Taut covering gives it additional strength and so it is important that the covering should *stay* taut. At the same time we do not want the structure to warp.

Now the degree of tautness in this covering is very much dependent on air conditions. If the air gets damp, then the covering will absorb water and slacken off again. In fact, if removed to any conditions which differ from those under which it dried out initially, tension in the covering will change. Removed to a hotter atmosphere the tissue will contract still more (only not to a very marked degree for most of the contraction takes place during the initial stages of drying out). If removed to a damper atmosphere it will slacken off.

Thus if tissue is allowed to dry out in a warm atmosphere it will only retain that tension under similar conditions. Ideally water-spraying and subsequent doping should be carried out at the same air temperature and humidity as the conditions under which the model will normally operate. However, these operating conditions change as well, so this is a practical impossibility.

Undoped Surfaces

About the only tissue covered surfaces which are normally left undoped are those which would inevitably warp if more than moderate tension was applied to the covering. A typical example is the tailplane of an ultra-lightweight model which has a flat plate section and therefore insufficient spar depth to resist much bending load. Such a component, too, is invariably covered on the upper surface only.

If the tissue covering is applied reasonably taut and then water-sprayed, unless the component is pinned down flat whilst drying it will warp upwards. Even if pinned down the resulting tension in the covering is likely to be considerable so that, when removed, an upward or curved warp is almost inevitable. Hence, more often than not, to limit the tautening action such covering is often steamed instead of water-sprayed. Dope applied to the tautened covering would have a curling effect ; applied to untautened tissue would not draw it as tight as steaming. The absence of dope will also afford a certain weight saving.

Such a finished component cannot be considered entirely satisfactory. The covering will add little strength, except under those favourable conditions where it is just taut, and, of course, the component must be handled carefully. Dope, in any case, must be used on the fuselage of that same model, and generally on the wings as well, unless these also are single surfaced.

Doping the fuselage does not generally present any undue difficulties. The covering is first shrunk by water-spraying and allowed to dry out. A shrinking dope is then used, thinned down with an equal amount of thinners. If the dope is too strong it will pull in the longerons or stringers between the spacers or formers, and give a " starved horse " effect. If this effect occurs after *water-spraying* then pretty obviously the structure itself is at fault (the longerons or stringers too weak or soft, or supporting stations too widely spaced). But if the longerons or stringers do not bow after water-spraying, then they will only do so after doping, if the dope used is too strong, so it will pay to err on the side of using too thin, rather than too thick a dope.

The First Coat

The first coat of dope is the most important one and should be brushed in or sprayed on quite generously. Spraying is invariably preferable to brushing, but few modellers have the necessary equipment. Hence they have to resort to a brush. Here it pays to use a soft, good quality brush about one inch wide—one which can do the job with the minimum of strokes and the minimum risk of tearing the fragile tissue.

As a general rule the first coat of dope applied to the fuselage should be a 50 : 50 mixture of tautening dope and thinners. Succeeding dopes can be thinned down rather more. Three coats are generally recommended as a minimum on almost all types of models.

From the point of view of weight saving, only clear dope should be used. Pigmented dope is invariably heavier and requires to be applied rather on the thick side, or heavily pigmented, to cover evenly in the colour required. However, this rule is often broken. A pigmented dope is used on the fuselage to get a colour effect. For satisfactory results this is really limited to one colour only—black. A small proportion of black dope or black pigment (a shoe dye has been used with success) mixed in with the normal clear dope for the job will produce an even finish all over in three or four coats if the initial proportions of the dope are correct. The resulting increase in weight is relatively small, but the method works even over white tissue.

Colour Finishes

Finishing the fuselage in any other colour, starting with white tissue again, is seldom as satisfactory. Reds, blues, etc., tend to come out streaky or semi-transparent, unless an excessive amount of pigment is used. Even black colouring is generally better (and somewhat lighter) if applied over black tissue, or white tissue which has been painted black with a water-soluble dye (e.g., indian ink) before doping. This enables the amount of pigment in the dope to be reduced and saves a certain amount of weight. The same method can be applied to using weak coloured dopes over tissue covering of the same colour. If you want coloured finishes on light, tissue-covered models, use coloured tissues in the first place and clear dope.

Where weight is of less importance, however, as on the fuselage of a power model, or the fuselage, wings and tail surfaces of a glider, clear dope lightly pigmented and then applied over coloured tissue of roughly the same shade is capable of giving the most pleasing results with the minimum amount of increase in weight. Once again, however, spray finishing is recommended for best results.

Chapter Sixteen **Solid Models**

THE solid scale model is an entirely different type of model—a wood-carving job rather than a frame assembly. You could, in fact, start with a solid block of wood and fashion a complete model with time and the necessary skill, but it would be a long, tedious and rather inaccurate process. Hence solids are invariably built up from component parts, carved and shaped separately. The method of assembly, in fact, is a basis for classifying the type of solid construction employed, although the shaping stages are essentially similar in each case.

Component Break-down

The majority of solids, especially those in this country, are assembled by butt-jointing the wings to the fuselage and attaching the tail parts in a similar manner—type A of Fig. 1. A popular American method is to employ stub spars which serve both to strengthen the wing-fuselage joint and assist in alignment of dihedral, etc.—type C. Another alternative—type B—is to make the wings in one piece and slot them into the fuselage, filling in the bottom of the slot, if necessary, with a shaped block.

Both A and C are particularly suited to balsa construction, type C tending to be a little stronger when a hardwood stub spar is used, making assembly easier but being a little more difficult to work. Method B is used on larger solids for exhibition purposes where hardwoods are employed for greater strength and durability. Butt joints of good strength are not so easy to obtain with hardwoods and so a more positive fitting is required. Also, of course, an assembly of type B which does not rely on the strength of glued joints to stay put will stand more rough handling. Hence it was widely used for the production of wartime recognition models. It is not normally used for amateur modelling.

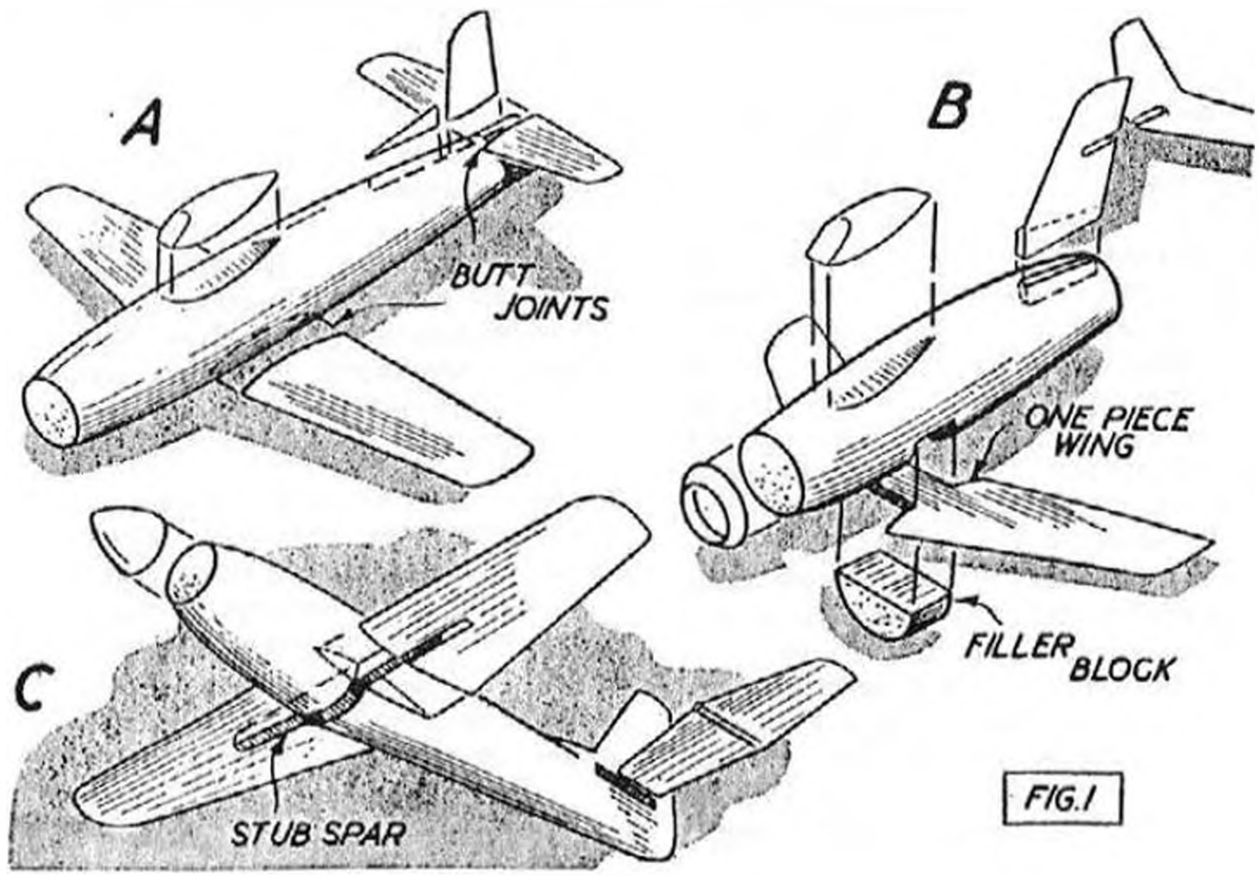


FIG. 1

Solid Plans

Starting point of any solid model is, of course, the plan. The better and more accurate the plan, the more accurate you can make the model. A complete three-view general arrangement drawing is a minimum requirement, together with typical cross sections of the fuselage, wings, etc. For detail finishing, views showing both the upper and lower surfaces are required.

There are so great a variety of good scale plans available that it is seldom necessary to have to draw them up. In particular those available through the *Aeromodeller Plans Service* are particularly recommended, being produced to both 1/72nd and 1/48th scale. The former is the most popular size for solid models, but the larger 1/48th scale has much to recommend it as so much more detail can be reproduced on the finished model. The main thing against the larger scale is that if you build up a selection of solid models and go on to include large bombers or airliners all to the same scale, the latter will be quite large models, e.g., 25 inches for a 100 ft. wing span to 1/48th scale, as compared with 16½ inches for 1/72nd scale. Largely, however, selection of scale is a matter of personal preference and collections of exhibition standard models often " mix " scales over a considerable range.

Solid model components start out as solid rectangular blocks of wood—balsa for easy working, a harder wood for a more durable model. Balsa is far and away the most popular material. The problem of transferring the plan outlines onto these component blocks is considerably simplified by the use of templates.

The Fuselage

Thus in the case of a fuselage a rectangular block is first shaped slightly oversize and marked with a centreline on top, bottom and end faces, and with a line corresponding to the fuselage datum line on each side. Exact plan and side-elevation outlines are traced from the plan onto card and cut out, these templates then being pinned or glued to

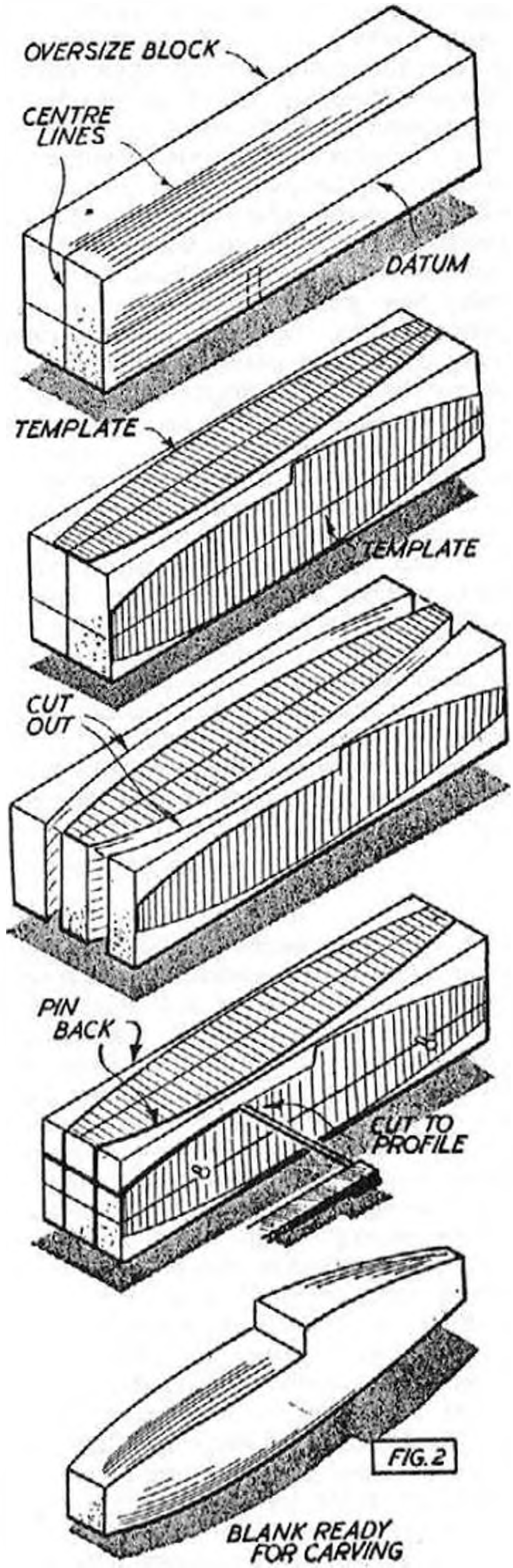
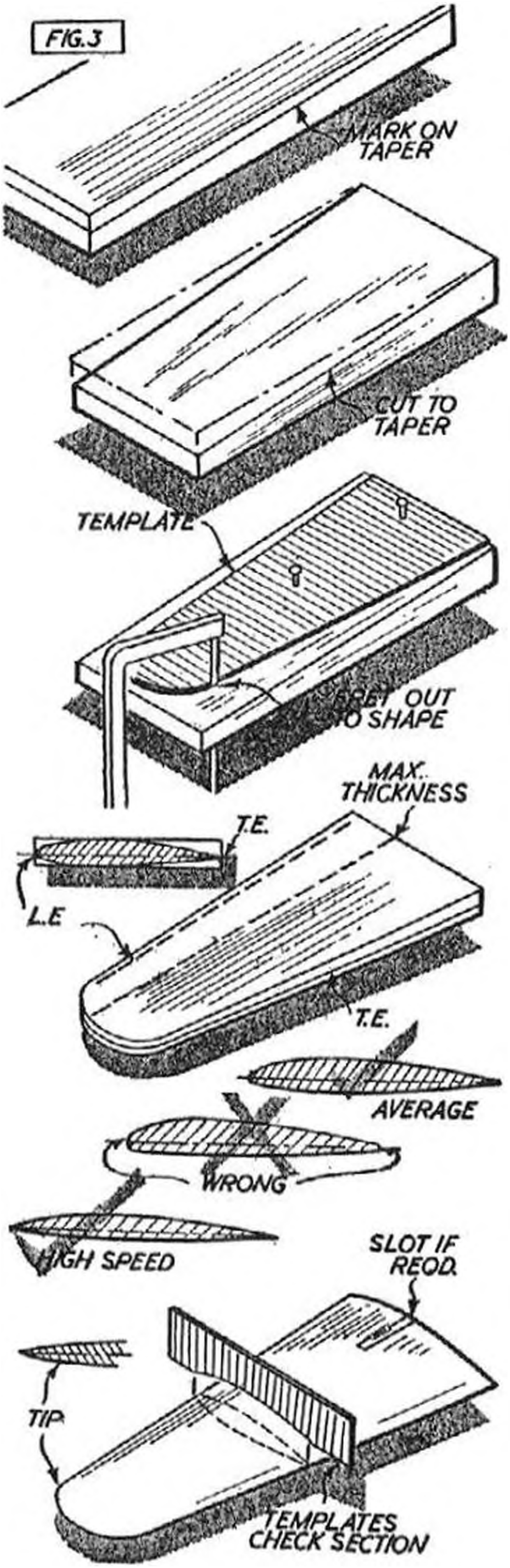


FIG. 2



the block. Fig. 2 details the various stages involved, step-by-step.

A fretsaw is the ideal tool for the next stage. Use it to cut the block accurately to the plan outline, as indicated by the template, taking care to make the cut square. As a check you can use a second template attached to the bottom surface. Do not throw away the pieces cut off, but carefully pin them back in place to restore the block to its original squared shape. In pinning the side pieces back, of course, you have also pinned back the side elevation template.

Using the fretsaw again, now cut the block to side elevation shape. The scrap pieces can then be unpinned and you are left with a squared up fuselage *blank*, ready for carving.

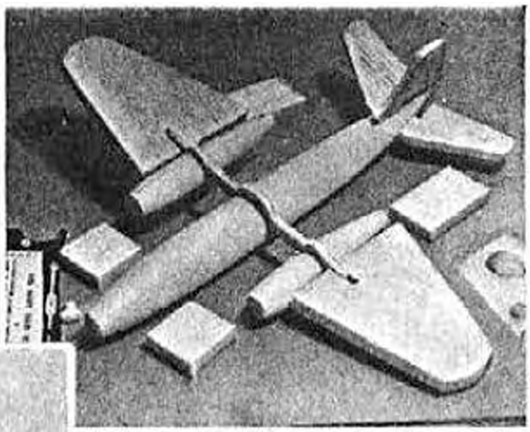
A point to watch: if you are using either type B or C assembly, then the slot to accommodate the wing spar, or the wing centre section, should be cut either when cutting to side elevation shape, or on the original block. This will be far more accurate than attempting to cut the slot in the shaped blank.

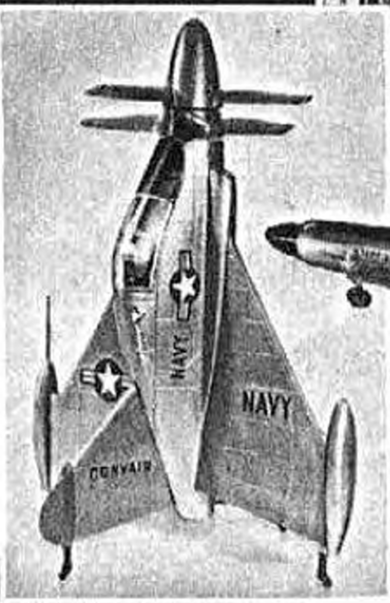
Carving the blank to shape is a very simple process. Use a very sharp knife and pare off the corners first, rounding away and gradually working away along the whole length of the fuselage down to the cross section required. Since balsa carves so easily there is no point in rushing this job, so make only small cuts at a time and work slowly and accurately. Avoid making deep cuts which may leave marks difficult to sand out.

Ideally you should carve down to about 1/32 to 1/16 in. oversize on all sections and then finish down to final size with sandpaper. Some people prefer to carve down to finer limits. The standard method of checking the sections is to use card templates of the fuselage cross sections, offering these up as work proceeds until each is an exact fit at its respective station. Some people prefer to work entirely by eye and ignore templates. The point in favour of templates is that they are a positive method of checking.

Shaping Wings

The wings also start off as rectangular

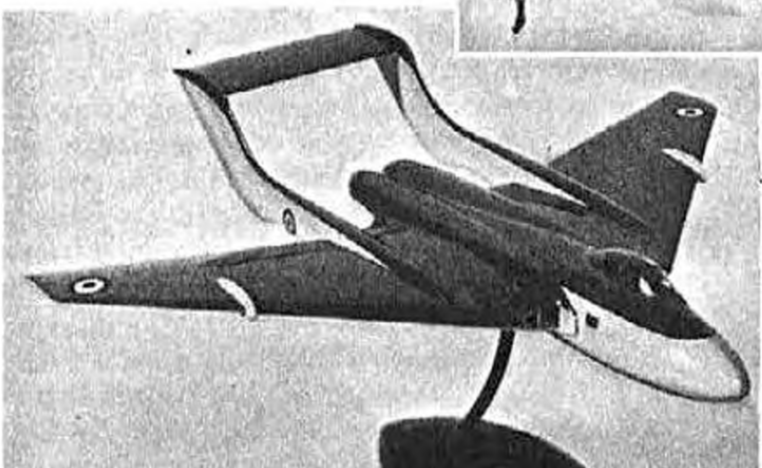




Above: A "working" solid model of the popular Mig 15. Apart from its value as a scale model, it can also be flown by catapult launch.

Above right: The Keil Kraft assembly method used in their solid kits. With the aid of interlocking braces it is impossible to line up inaccurately. Parts shown make up into a Canberra.

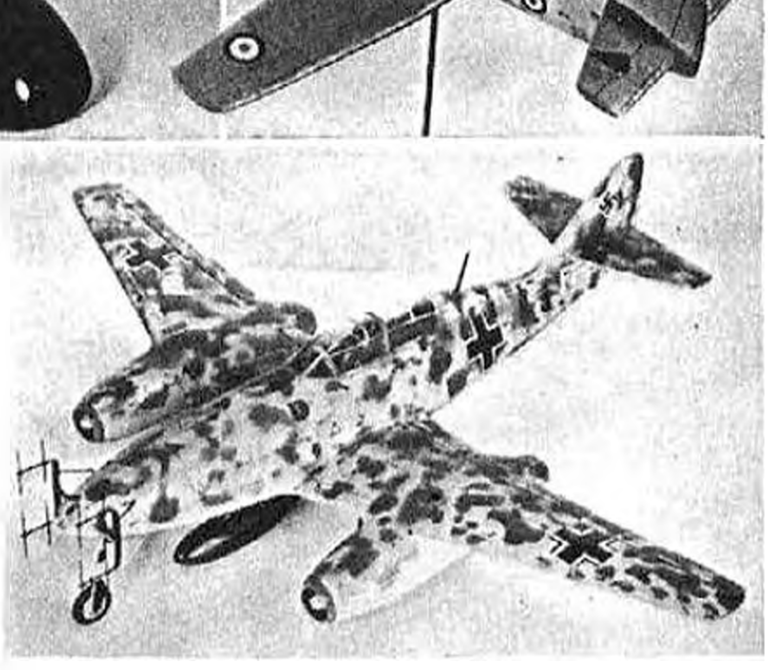
Above: These plastic kits from the U.S. market of the Convair Pogo and Lockheed Starfire make superb models, and recall the old Frog Penguin kits now, alas, no longer available.

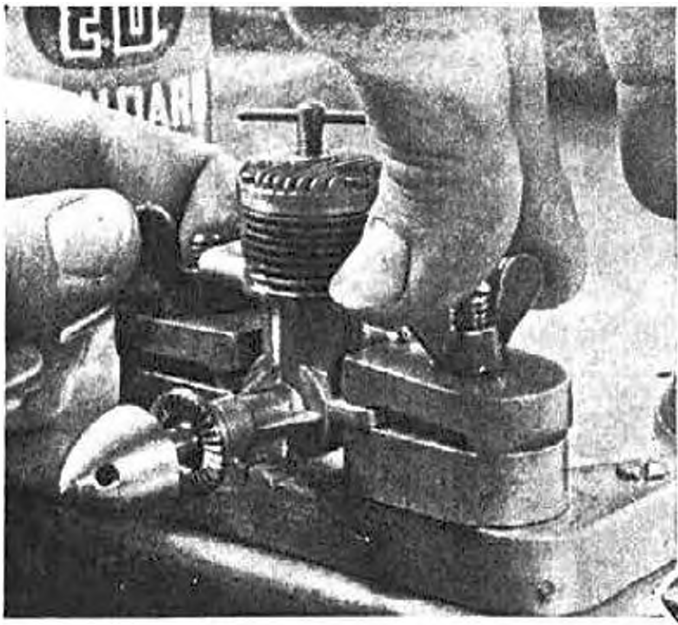


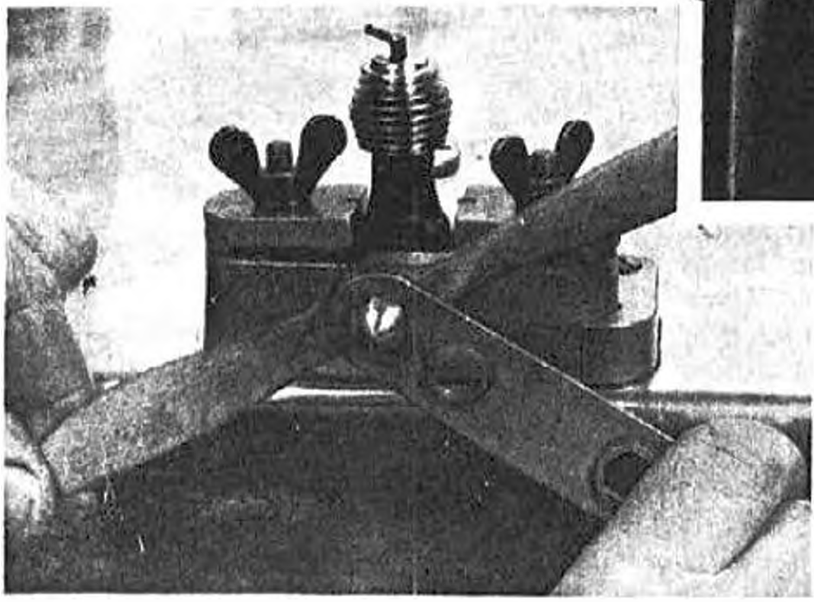
Above left: A professionally made model of the DeH. 110. Though excellent in finish the heavy mount detracts from its grace and should be copied with reserve.

Above right: Another kit model, made up from a Veron kit to represent the Fairey Gannet. Though cheap the commercial kit is a useful aid to quick and accurate presentation.

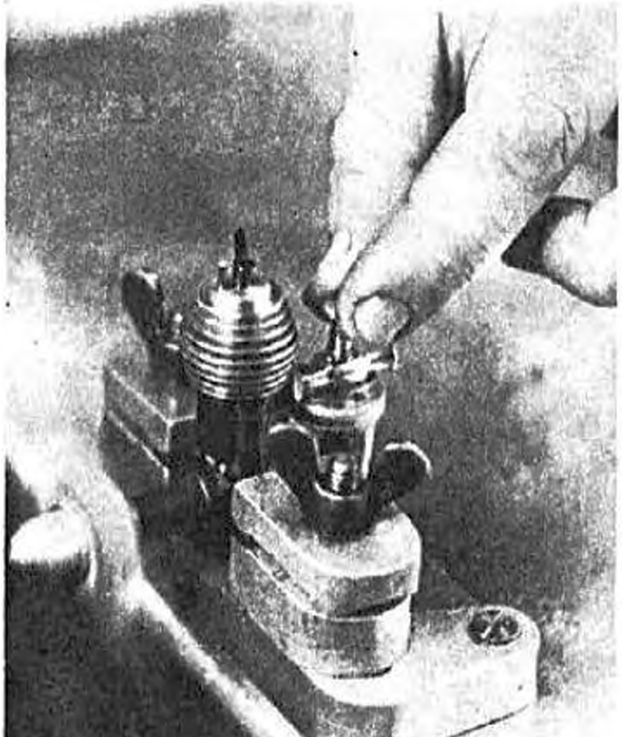
Right: This fine model of the M.E.262 rightly won the R.A.F. Championship for Sergt. McHard.

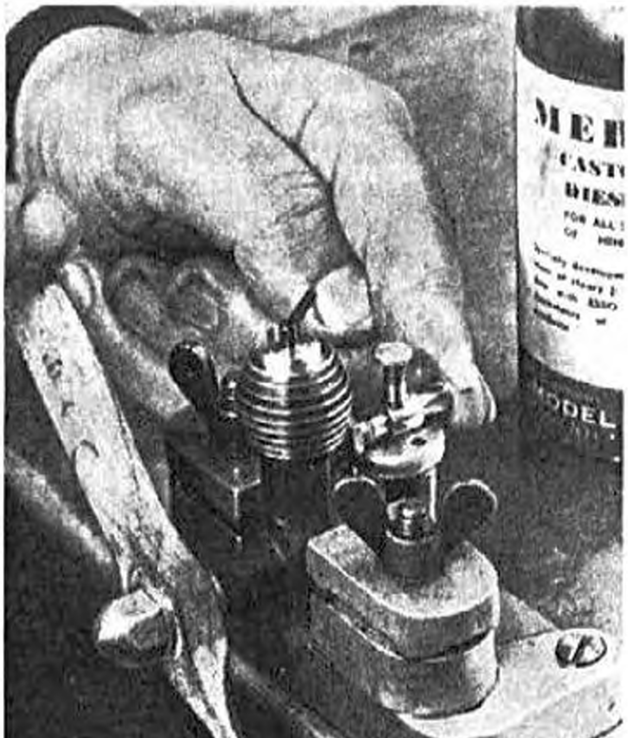






Workshop drill with a new engine is vital to its successful operation. Mount rigidly on the bench, preferably with a special test mount, fill with recommended fuel, and set propeller conveniently for swinging. Then adjust needle valve to opening advised, choke with finger, and the engine is ready for the starting flick.





blocks and the first job is to mark off the taper on the edge of the block and plane or carve down to this line—Fig. 3. Again a template is used for marking off the outline shape, prepared from the wing plan drawing. This is pinned or stuck to the tapered block and the wing shape carved or fretted out. A second wing panel is prepared in an identical manner.

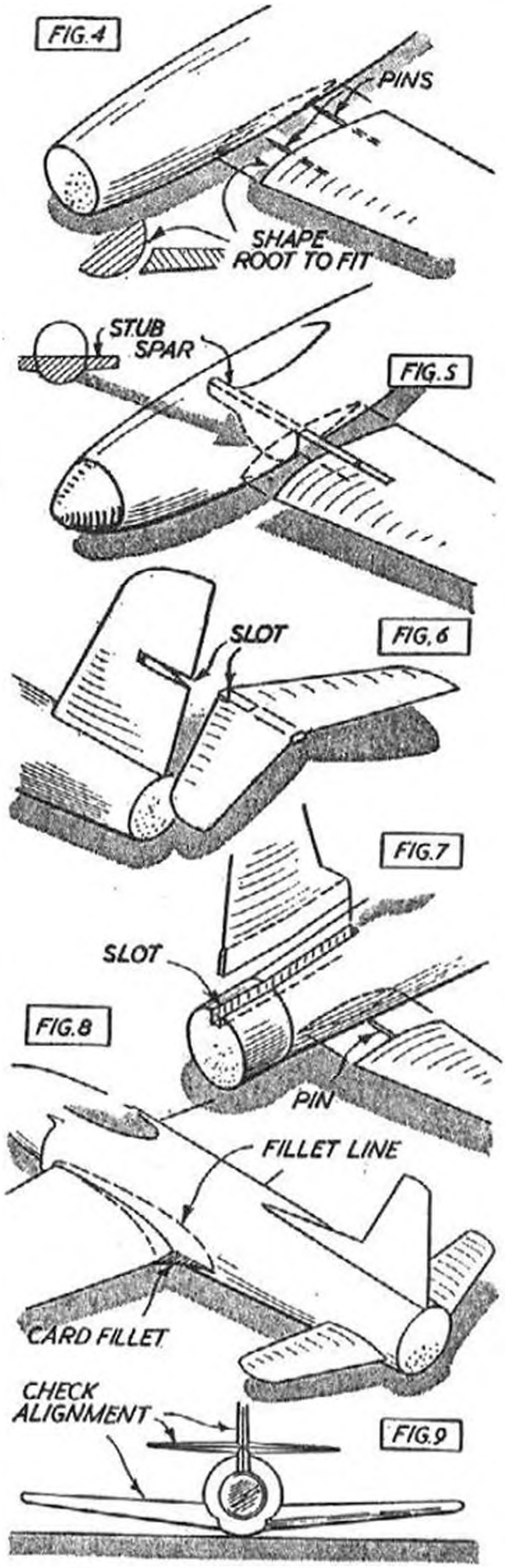
Carving the wings to shape is much simpler than in the case of the fuselage for they have only to be reduced to section one way, i.e., from root to tip. However, this is one point where many solid modellers come to grief—getting poor or hopelessly out of scale aerofoil sections on the wings.

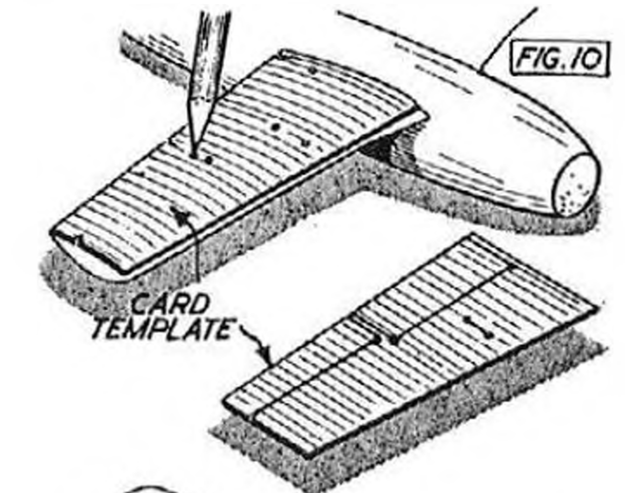
The actual section required should be indicated on the plan. It may vary from root to tip and such variations should be followed faithfully. Section shape differs considerably with different aircraft. Thus a relatively slow machine may have a thick, blunt-nosed section, whilst a high-speed fighter has a very thin section with a sharp, almost pointed leading edge. All sections will have one feature in common—a very thin trailing edge.

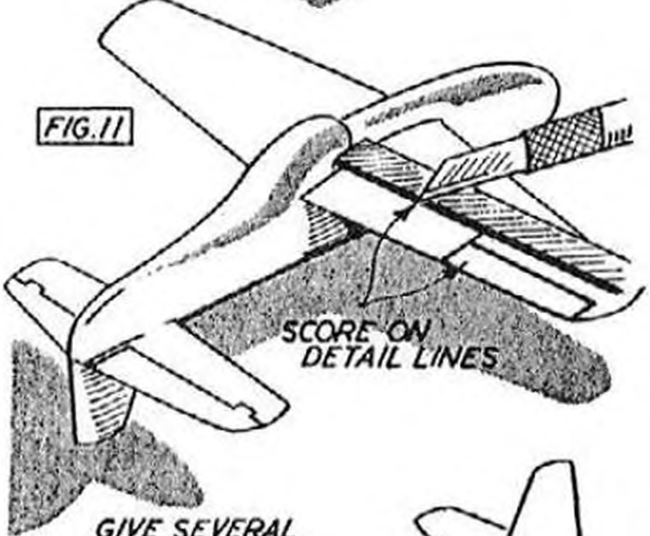
It is necessary to decide the point of maximum thickness of the section you have to duplicate and mark this on the top and bottom of the wing blank. The position of the leading and trailing edges should also be marked around the edge of the blank as a carving guide. Then carve the blank down to shape, first in a series of "flats", gradually rounding these off to form a smooth, uniform section. Points to avoid are: making the nose of the section too rounded or too blunt, leaving flats or hollows on the surface, getting the maximum thickness too far aft, and not finishing off the trailing edge to a knife-edge. The latter shows up one of the major defects of balsa as a material for solid models in that a true scale trailing edge is very weak and easily damaged in assembly, especially at the root. Hence the finished wing panels must be handled with care.

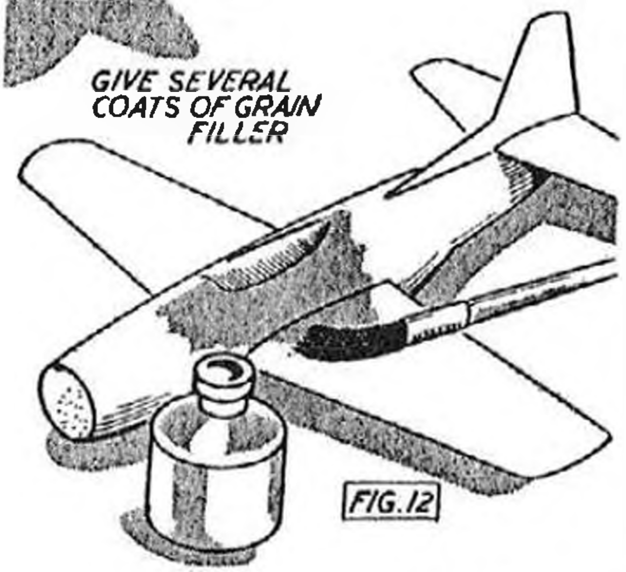
Joining to Fuselage

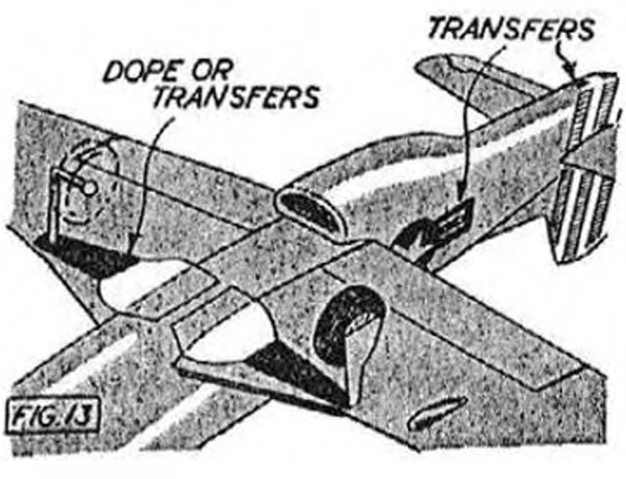
Wings to be joined with stub spars











will have to be slotted before carving. One-piece wings have their centre sections shaped before carving, this section then being left "square". Dihedral is given by cutting almost through along the centre line and cracking to the right angle, filling the crack line with glue or cement to hold.

On small models, at least, the tail surfaces are cut from sheet balsa. Again we would recommend the use of templates to ensure accurate outlines. The cut-out shapes should then be tapered like the wing panels, only using sandpaper instead of carving, and then finished to a symmetrical, streamlined section, again by sandpapering or very careful carving. The finished edges will be quite fragile, so avoid damaging them.

Various methods may suggest themselves for joining the tail assembly to the fuselage. If the tailplane is mounted on the fin, slotting the tail into the fin is generally better than butt-jointing two tailplane halves in position—Fig. 6. Similarly, it may be better to locate the fin base in a slot filed in the rear of the fuselage, rather than just cement it on top—Fig. 7. These features must be allowed for when shaping the tail parts.

It is normally best to assemble the wings to the fuselage first, checking that they are at their correct dihedral and incidence. Both wing panels should line up when sighted from the rear, and also when sighted against the front elevation view on the plan. Once you have got the wings and fuselage accurately aligned you can square up the tail components, when fitted—Fig. 9. The eye is a pretty good guide, but check both over the plan and by measurement for complete accuracy.

Butt joints can be reinforced with pins —Fig. 4. Cut off the head of a pin and push into the wing (or tailplane) before cementing to the fuselage. This will hold the wing (or tail) in place and allow you to adjust it accurately before the cement sets. Where the construction employs stub spars, of course, alignment is automatic against these spars— Fig. 5.

Finishing Stages

During this finishing stage you can

also incorporate any fillets which may be necessary. The shape of wing root fillets can be established by means of a small piece of card cut accurately to shape and cemented in place—Fig. 8. The actual fillet itself can be built up from a mixture of talc and thick dope. Avoid plastic wood or hard drying materials on balsa. These dry so much harder than the rest of the wood that they are almost impossible to sand down to blend into the rest of the model.

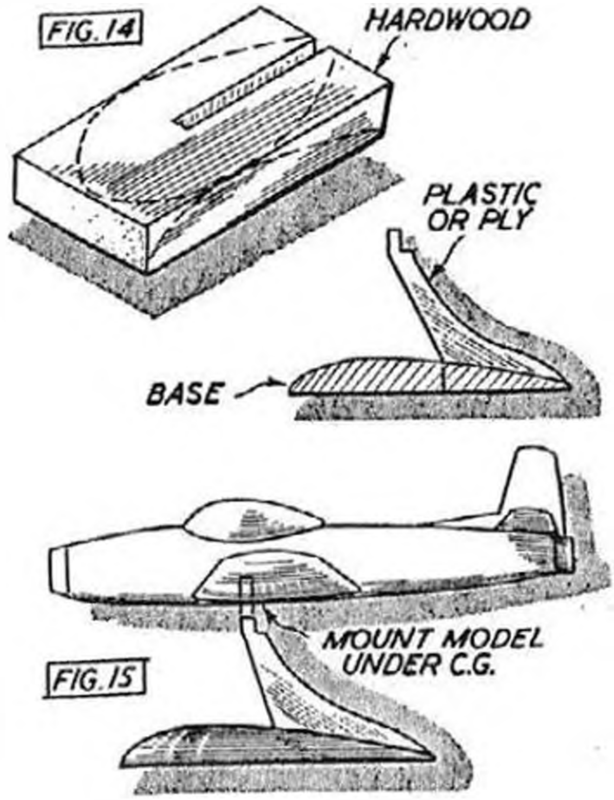
Detail markings can now be impressed on the surface of the finished model. The best way to lay out these markings is to use a template which is laid over the wings, etc., in turn, and " spotting " the positions of the ailerons, flaps, etc. —Fig. 10-11. Separate templates will be needed for the upper and lower surface of the wings although, of course, the same templates can be used for right and left wings by turning over.

Having marked these positions, the panels, lines, etc., should then be scored into the wood with a sharp, pointed instrument or a knife blade. You can cut right into the trailing edge at the ends of the ailerons, trim tabs, etc. Fuselage panel lines can be marked in a similar manner, although their actual position will be more difficult to lay off accurately on the rounded surface.

Once assembled the whole model should be given a coat of grain-filler and left to dry out thoroughly—Fig. 12. Sand down perfectly smooth with garnet paper, taking care not to cut into trailing edges, etc., and paint with grain-filler again. Repeat the process as many times as necessary until the whole model has a smooth, uniform, glass-like surface.

Detail Fittings

Before painting the model the remainder of the detail fittings should be prepared and fitted temporarily. The cockpit cover, for instance, should be trimmed to an exact fit and the area of the fuselage it covers carefully marked. Only external fittings to be painted in with the main colour scheme should be permanently fitted at this stage. The rest are offered up and their positions marked for ease of assembly after painting.



Provided you have done a good job of grain-filling and sanding down, three or four coats of coloured dope should produce an excellent finish, rubbing down smoothly between each coat.

Paint Finishes

Where the finish involves two or more colours, apply the lightest colour first. Use masking tape to separate the coloured areas, if these are sharply defined. Freehand painting is generally adequate for applying patches of camouflage colouring, but remember that on the actual aircraft these patches of colour tend to fade one into the other and are not sharply defined. Lettering, small colour strips, etc., are best applied in the form of transfers, as are national insignia, unless particularly skilled in hand lettering of this type—Fig. 13.

Except in the case of prototypes with fixed undercarriages it is normal practice to finish solids without an undercarriage. It is far better, then, to mount the model on a suitable stand in flight attitude. Plastic stands are available at quite a modest price and add that professional finishing touch, although very little ingenuity is needed to produce a suitable stand from scrap materials—Fig. 14-15.

Chapter Seventeen Rubber Motors

THE rubber-driven model is still the best introduction to "power" flying, relatively cheap, simple to construct and amazingly consistent, once properly trimmed and given the right care and attention.

Ultimate performance of the rubber motor will, almost entirely, depend on the way in which it is run-in. Like an internal combustion engine, a rubber motor cannot be expected to develop full power from its initial winding up. Unlike an engine, however, a "fresh" motor develops *more* power until run-in.

If the motor is simply made up to length and installed in the model it cannot initially be wound up to, say, about half *potential* maximum turns without fear of breaking. Its corresponding power output will be high, but its duration of run short. For the second winding, the turns that can be put on are some 20 per cent. higher, and so on, stage by stage, until the potential maximum is reached.

Breaking-in

In other words, turns and power output corresponding to successive initial windings, would take a pattern similar to those shown in Fig. 1. Continue with more windings and the maximum turns possible would now *no longer increase*. During this series of windings, too, the power output curve would be identical for each winding. After a certain number of windings, again, maximum turns would still stop at the same level, but the power output curves would gradually get lower and lower. The rubber motor has now become fatigued and its useful life is over.

A proper run-in period is essential with all new rubber made up into motors, first to develop its capabilities to take a maximum number of turns, and second to bring it to the state where it will give a constant power output.

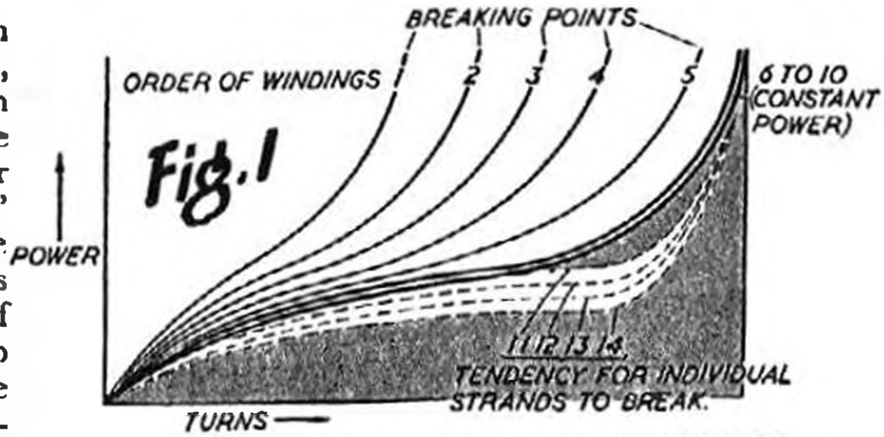
It is also interesting to note how the number of "useful life" windings varies with the number of turns applied to the motor. Properly run-in and then wound to maximum turns each time, motors may show signs of fatigue after only three windings—Fig. 2. Wound to 90 per cent. turns each time, "useful life" winding may be double that number, or more. Wound to only 80 per cent. maximum turns each time, "useful life" is doubled again. These are only rough figures, but indicate that "full turns" windings do drastically reduce the useful life of a rubber motor.

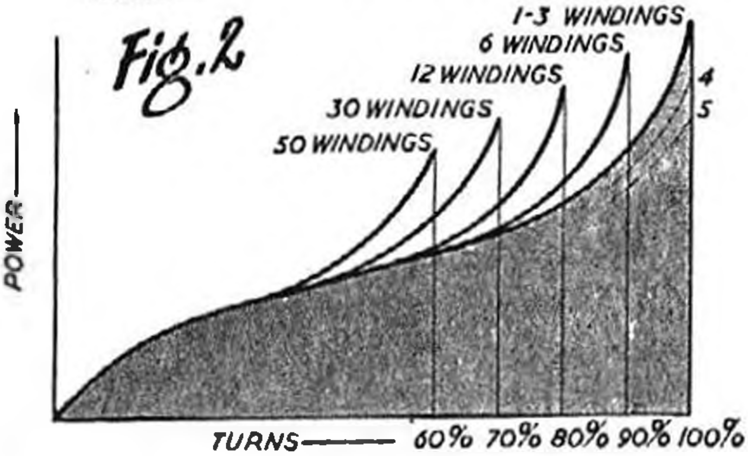
What the graph does not show is the mechanical failure of the motor on repeated high-turn windings. Individual strands are more prone to break, calling for constant repairs. Normally this does not affect the "useful life" figure, but it is annoying to find strands breaking during winding up, generally calling for a change of motor to be on the safe side. When one strand "pops", quite likely others are beginning to part and the whole motor may break suddenly if winding is proceeded with.

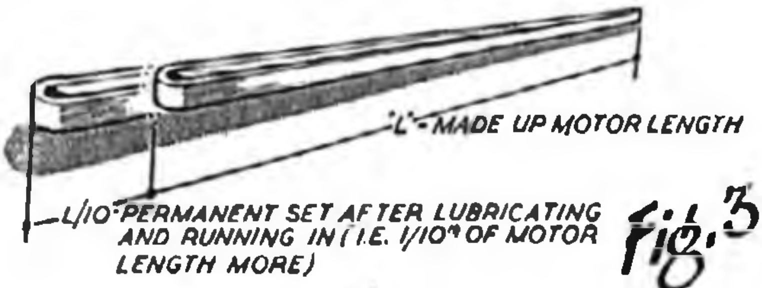
Dealing now with the practical side of making up and running a new motor, there are two main factors to be considered—the number of stages in which the motor should be run-in and the increase in length or permanent stretch the rubber will have after running in. Fresh rubber, properly run-in, has a permanent deformation equivalent to about 10 per cent. of its original fresh length—Fig. 3. In other words, if you made up a 30-in. motor from fresh rubber, ran it in stages and then re-measured its length, this final length would be about 30+3=33 ins. It should remain at that normal length for the rest of its useful life. The amount of permanent stretch is independent of the number of strands. The permanent stretch must be taken into account in making up the motor length.

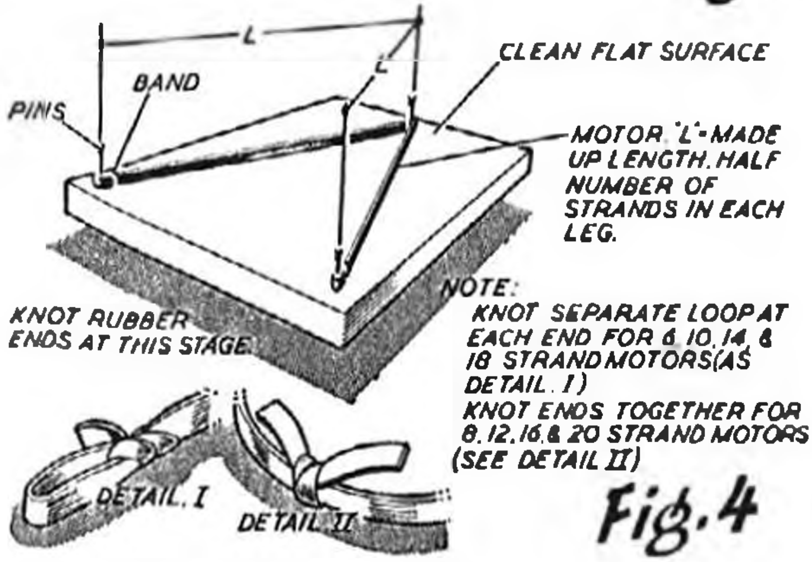
The best way to make up a new

motor is to lay it out in two "legs" over any *clean*, flat surface, as shown in Fig. 4, having calculated the normal length of motor required. Each "leg" comprises one half of the required number of strands in the finished motor. If the motor has to be made up to a definite *weight*, the resulting length can be calculated from Table 1, noting that lubricant increases rubber weight by about 1/12th. Rubber ends should be knotted permanently at this stage and the motor ends bound with a rubber band.









Lubricants

The motor should now be removed from the layout board and lubricated. Ordinary castor oil is a satisfactory, if messy, lubricant. Proprietary lubricants based on a soft-soap-glycerine mixture are normally regarded with more favour. The latter do provide slightly better lubricating action, as exemplified by the fact that knots can be tied to hold in rubber lubricated with castor oil, but the same knots will not hold on soap-lubricated rubber. With soap lubricant, any knots which may be necessary in the lubricated strip must be bound, preferably with wool

The motor is now ready for running in. An old propeller assembly should

TABLE 1
(weights in ounces)

	$\frac{1}{8}\times 1/30$	$\frac{3}{16}\times 1/30$	$\frac{3}{16}\times 1/24$	$\frac{1}{4}\times 1/30$	$\frac{1}{4}\times 1/24$
Per Inch	·0023	·0035	·0093	·0046	·0058
Per Yard	1/12	$\frac{1}{8}$	5/32	1/6	5/24
Feet per 1 lb. weight	576	384	306	288	230

be used for this, the rear end of the motor being looped over any suitable fitting. A door knob is widely favoured for the latter, although a large screw eye fitted to the workshop door frame is generally better—Fig. 5.

The optimum number of strands for running-in fresh rubber is a matter of controversy. If the stages are few in number (which gets the job over quicker !) there is more danger of the rubber breaking up. A particularly safe process seems to be to start with only *ten per cent.* estimated maximum turns and then work up, increasing the number of turns by a maximum of 80 each time (i.e., 20 turns on a 4 : 1 winder) up to some 80 per cent. of the estimated maximum. There is no real need to go beyond this point, unless the motor is intended for a short contest life on "near-maximum" turns, when a final winding to 90 per cent. maximum turns should be done, after an accurate determination of the *actual* breaking turns on a spare motor.

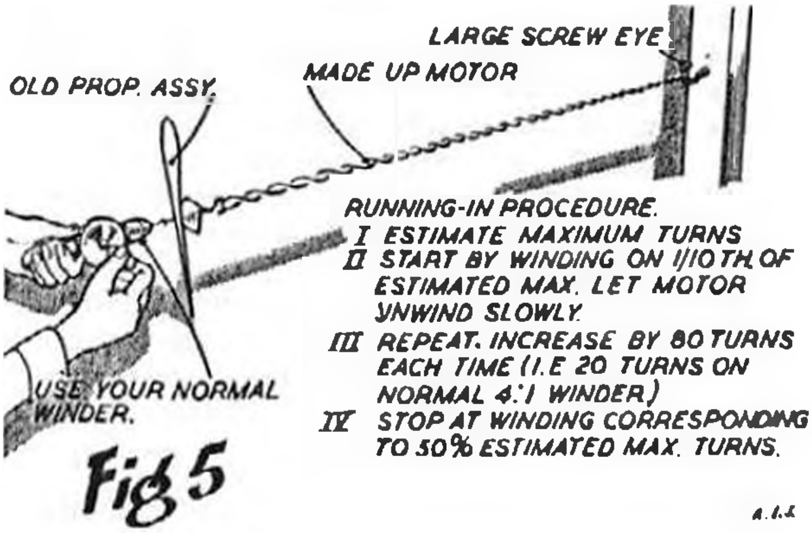


Fig 5

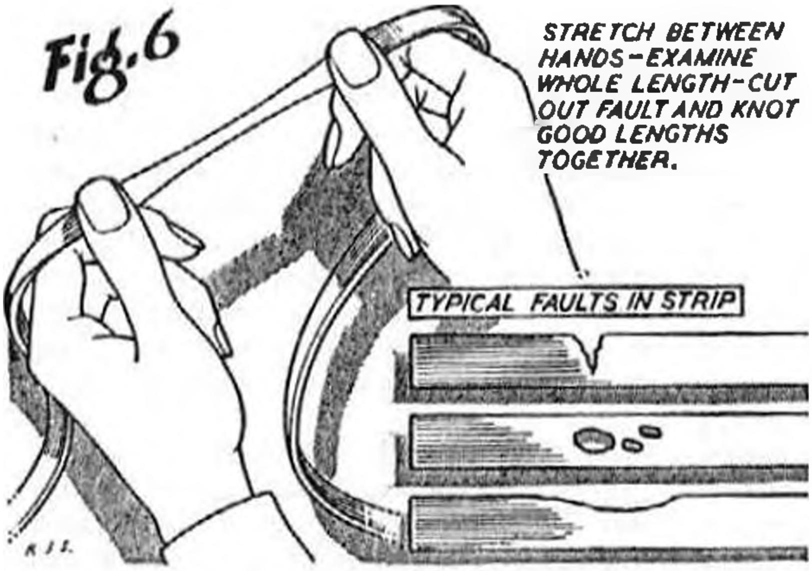


Fig. 6

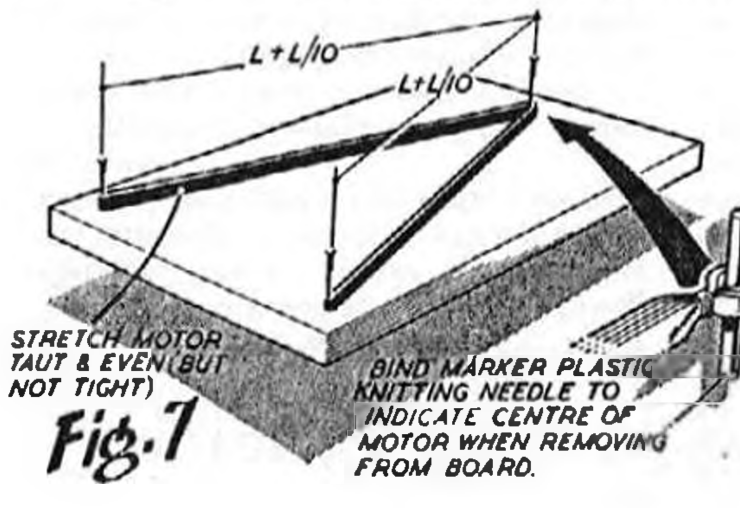


Fig. 7

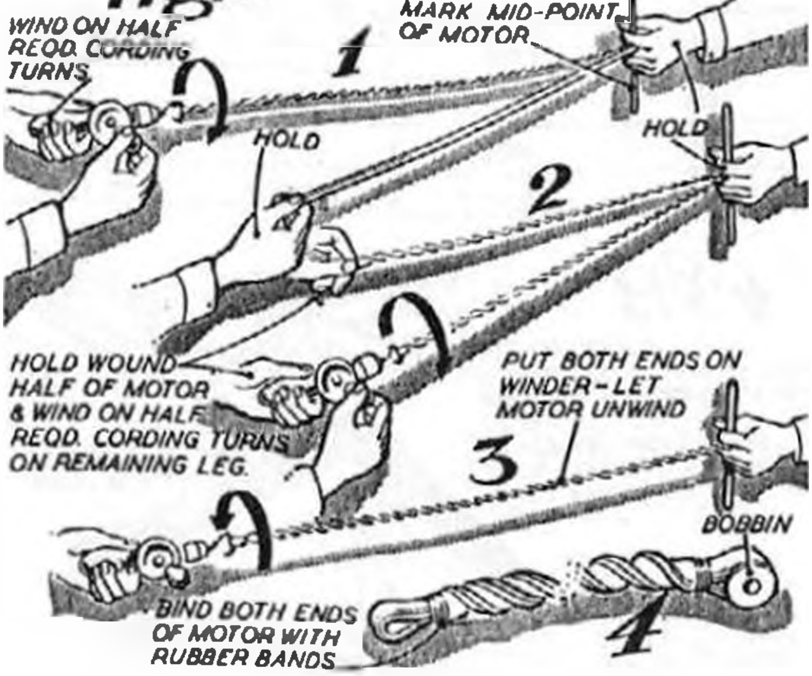
Broken Strands

It is quite possible that a strand or two may be broken during the running-in process. This does not necessarily mean that the rubber has inferior mechanical properties. The broken strands can be re-tied and the motor will be quite satisfactory, although it would be commonsense precaution to reject the motor if more than, say, one quarter of the total number of strands broke during running-in.

There is also the chance that the whole motor will break during the process. This happens with the best of rubber strip. Sometimes with three or four motors made up from the same skein one will break completely during pre-winding, another will break a strand or two and the others will show no signs of breakage. The danger point for complete breakage appears to be when running-in reaches the stage 50 to 60 per cent. full turns. Provided the motor takes up to 80 per cent. maximum turns during the running-in it can be relied upon to take at least these turns on the field and considerably more provided it is not completely over-wound.

After running-in, the motor should be inspected carefully along its entire length, pulling a single strand stretched between finger and thumb of one hand, well stretched, as in Fig. 6. This will indicate points of potential failure—nicks started in the edges or imperfections in the strip itself. The rubber must be cut at this point and re-knotted. If made up for use without such a check, strands are almost certain to break at these points on an early winding. Some rubbers are particularly prone to faults of this nature—others are remarkably free of such imperfections.

Fig. 8



The run-in, checked motor is then laid out over the marking board again —Fig. 7—re-adjusting the length of the " legs " to account for the permanent stretch achieved during running-in. With a " taut " motor the two ends are brought together and bound, the other end likewise bound with a small rubber band. Corded motors are dealt with as shown in Fig. 8.

Making up

Washing of the new rubber strip before lubricating has not been mentioned—simply because it is not necessary. It is sufficient to shake off any chalk adhering to the rubber. Nor is washing off the lubricant necessary after the motor has been used. Lubricant can stop on for a whole season, re-lubricating at intervals as required. Motors can also be left corded for weeks at a time without suffering any apparent ill effect, although the areas covered by the rubber band (end) binding should be re-lubricated before use. Normally, however, corded motors are unwound after a day's flying and re-corded again the evening before the next flying session.

Sensible care of the made-up, run-in motor consists of keeping it free from grit and dirt and storing it in a clean container (e.g., a plastic or glass jar) between flying sessions. Motors should not be left in a model from one week to another as this tends to dry out the lubricant. Good rubber, properly run-in, however, is surprisingly resistant to abuse and will seldom let you down if treated with *adequate* care. However, never take risks with unknown motors.

Comparing Motors

For simple " static " comparison of new motors, time the power run on a given number of turns and compare with the length of run on the same propeller and a proven motor with the same number of turns. If the new motor gives a longer run, then almost certainly it is weaker than the original motor. If a shorter power run, a more powerful motor. This test, of course, must be applied *after* the new motor has been run-in.

Another practical check is the " feel " of the motor during the winding stages associated with running-in. With enough experience this becomes a most valuable guide. During the running-in windings, though, a motor always feels more powerful than when wound on the field, partly because it *is* more powerful at this stage and successive windings, increasing the number of turns each time, is more tiring than a single winding. The "feel" check is most likely to detect a weak motor.

Flight Testing

The best check of all, of course, is a flight test on the model on each new motor. This need not be carried out on high turns. Most rubbers of the same brand, good or bad, follow a similar power output curve. Knowing the still air flight time on, say, half turns will soon indicate whether they are "up" or "down" on the original. Once again, of course, the new motors must be adequately run-in for this check to have a real significance.

The danger associated with running-in a new motor in the model, during actual flights, is that you *may* break the rubber at some stage. The destructive characteristics of a broken motor are too great to court lightly. For the same reason, high-turn flying in contests should be restricted to a *working maximum* which has been checked as on the safe side by a destruction test on a similar motor, preferably under similar conditions. Extreme cold tends to harden rubber and reduces the maximum turns possible. Extreme humid heat can also lead to premature breakage and, more likely, loss of power. Modellers in tropical areas are well aware of the short expectancy of life for their rubber motors; but similar humid conditions, though to much less a degree, can prevail in Europe, and must be guarded against with the use of reduced max. turns.

A lot of nonsense had been written about rubber motors, tending to over-emphasise the failures which may occur if elaborate care and attention is not given to the motor. At the same time there is more than a modicum of truth in the assertion that rubber is not always as consistent as it could be.

Rubber Variations

The basic facts are these. Normally, rubber of the same brand or specification can be expected to give a consistent performance. In other words, if you are using a certain brand of rubber, then new supplies of this same brand can reasonably be expected to have comparable performance characteristics. However, most rubber strip is produced in batches (strip is actually made up in sheet form and cut down to strip lengths after vulcanisation). If the specification or make-up of the original rubber mixture is not carefully controlled from batch to batch, some difference may be experienced from skeins of different age. These small variations in the composition may be within limits accepted by the manufacturers as normal to their production methods. Absolutely *fresh* rubber, too (i.e., straight from the manufacturer) is seldom as consistent as aged rubber. After manufacture, rubber characteristics generally tend to improve with storing—up to a period of six to twelve months.

Sometimes, variations in the heat-treatment process necessary to harden the rubber produces a batch which is not uniformly cured. As a result, the physical characteristics of the rubber may vary somewhat from end to end of a single skein. When this occurs, rubber taken from one end of a skein may be denser than rubber from the other end.

Turns per inch Motor Length					
No. of Strands	$\frac{1}{8} \times 1/30$	$\frac{3}{16} \times 1/30$	$\frac{3}{16} \times 1/24$	$\frac{1}{4} \times 1/30$	$\frac{1}{4} \times 1/24$
6	53	44	42	40	37
8	42	38	36	34	31
10	38	34	32	30	26
12	36	31	30	28	24
14	33	30	27	26	21
16	31	28	26	25	20

TABLE II

Chapter Eighteen Engine 'Know How'

CORRECT mounting of the engine in a power model is all-important. If the engine vibrates loose it can change the trim of the model and cause it to crash. Even if you do notice it when starting up, tightening up the hold-down bolts on the flying field is not always the easiest of jobs. In some cases even the engine bearers themselves are inadequate for the job so that even with the engine bolted down to them properly it still vibrates and as a consequence wastes a lot of its power.

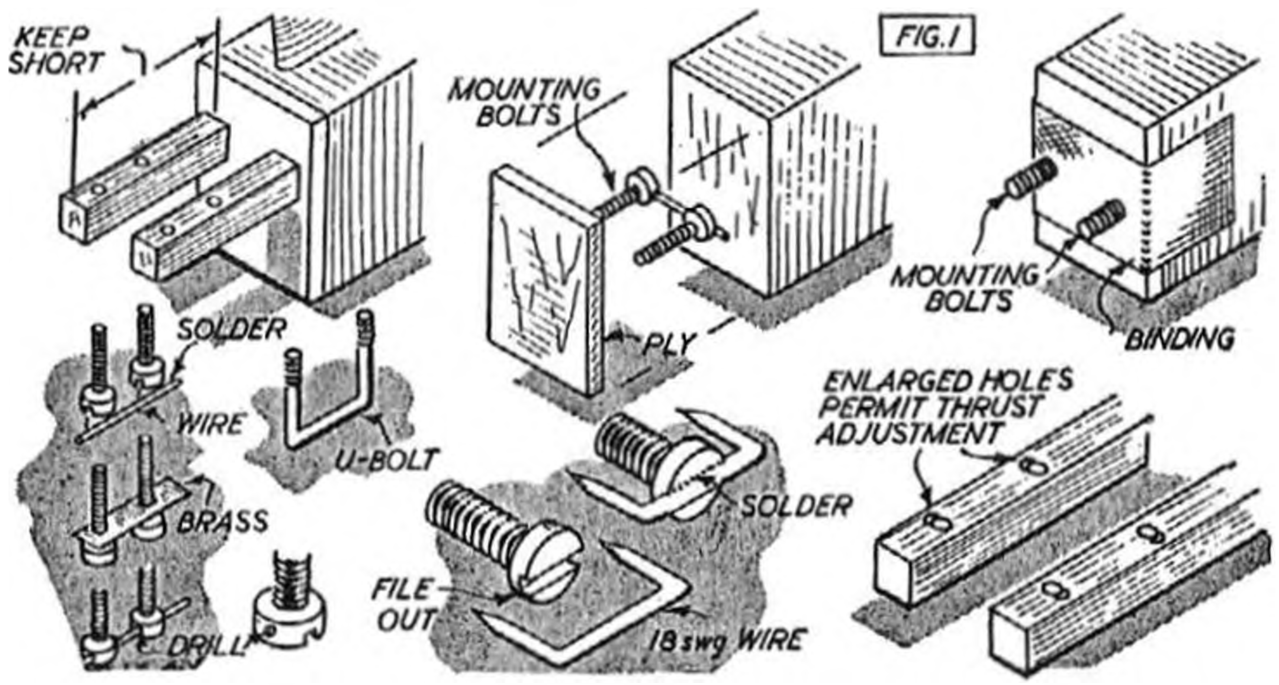
Correct mounting starts with the bearers. Hard, straight-grained wood is required for the bearers. A majority of British engines are beam mounted, the mounting bearers forming an integral part of the fuselage structure. Thus if these are too weak, and easily broken off at the fire-wall, replacing them may become a major repair job.

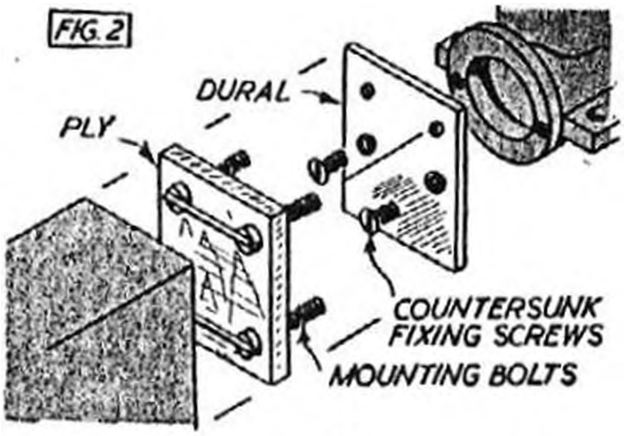
Beam Mounting

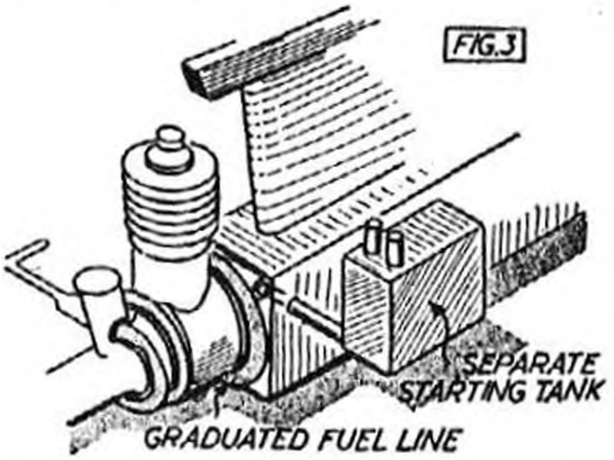
Beech, birch, ash and maple are typical "recommended" woods for engine bearers. Mahogany is sometimes used and is excellent if genuine mahogany. Quite a number of relatively soft woods are, however, marketed under the name mahogany and using a soft wood for bearer stock is asking for trouble.

The overhang of the bearers beyond the front bulkhead or fire-wall should be kept to a minimum. The actual length required will be dictated by the engine used. An engine with an integral tank fitted to the back of the crankcase requires a longer length of bearer to mount than one without a tank. Also with rear induction engines it is usually necessary to leave "finger space" between the end of the intake tube and the fire-wall for choking. For easy operation of an engine it is always advisable to have ready access to the primary "control" points—the compression adjustment (for diesels), needle valve, and the end of the intake for choking.

Fitting the motor is invariably done by bolting down with machine screws (6BA to 10BA size, according to the size of the engine). Simmonds lock nuts are available in 6BA size (but not smaller) and are particularly recommended in place of plain nuts, since they will not tend to vibrate loose. Those with nylon inserts are preferred on







account of their greater resistance to fuels.

For ease of installation and removal, particularly when the front of the fuselage is completely faired in, the "accessible" side of the engine fastenings should be the nuts. These can then be put on or taken off with the aid of a box spanner of appropriate size. Since the heads of the screws are "hidden" it is then necessary to lock them against rotation, some typical methods being shown in Fig. 1. Any one of these locking schemes is worth the extra trouble involved in making up—the method of soldering a short length of wire between the two screw slots being, probably, the simplest.

Radial Mounting

In the case of radially mounted engines, the fixing screws emerge from the ply fire-wall, with the heads of the screws behind the bulkhead. Since these are "built in" with the fuselage they must be locked against rotation and similar methods can again be used. Mounting or detaching the motor is then a simple matter of running the appropriate nuts on or off, whilst adjustment of thrust line position is equally easy. Split washers are ideal for thrust line packing since these can be slipped in place without unbolting the motor completely. A "conversion" from beam to radial mounting is shown in Fig. 2.

Normally no trouble is experienced in gluing in beam mount bearers. Many balsa cements, however, are not all that satisfactory for gluing ply and so, in radial mounting especially, the fire-wall is usually reinforced by a binding of gauze bandage or similar cloth strip soaked in cement and wrapped around the former back onto the fuselage sides. Alternatively, or additionally, one of the synthetic resin adhesives, like Aerolite 306, can be used for gluing the fire-wall in place initially.

Exhaust Oil

If the motor is completely cowled in when finally fitted, provision must be made for liquid exhaust waste and spilt fuel to escape from the bottom of the cowling. The whole of the inside of the cowling, and particularly the bearers, should be well doped to prevent oil absorption which would otherwise weaken the wood. The holes drilled for the mounting screws should be doped before finally mounting the motor.

Exhaust fuel can also affect other parts of the model. The bottom of the fuselage normally tends to collect a considerable amount of oily deposit, also the left side of the front of the fuselage and the underside of the right wing—these parts from exhaust oil blown back by the slipstream. Adequate doping in these areas is essential, or even fuel-proofing. Normally diesel fuels do not attack standard dope finishes and fuel-proofing is strictly essential only with glow plug motors or motors using a methanol-base fuel. Many modellers do, however, use fuel-proofer on diesel models to give additional protection.

The engine control accessories are just as important as the engine installation, particularly on contest models.

These are concerned with stopping the engine after a certain time and may consist of nothing more elaborate than a graduated tank or a graduated length of fuel line (which represents the total fuel capacity equivalent to the required engine run). Alternatively a fuel cut-off valve may be interposed between tank and engine, operating on a self-metering principle (and thus dispensing with a separate timer), or operated by an independent timer or incorporated as part of the timer.

Flight Timers

The most popular—and the least expensive—type of flight timers work on pneumatic principles and many are inclined to be erratic in operation, changing their original setting with different temperatures, etc. Also they are liable to be affected by oil contamination, if located on one of the areas of the model mentioned before. Clockwork timers are heavier, but more consistent. Unfortunately some types are prone to vibration effects and so can only be adjusted with the engine running and slightly different times may result for static running as compared with "in flight" conditions where the engine tends to speed up as the air load on the propeller is reduced.

The use of a graduated tank or a graduated length of fuel line is so obvious as a method of control that it needs little elaboration. Such methods are reasonably consistent and quite satisfactory for sports flying. For contest flying, the graduated length of tube gives closer accuracy, a separate "header" tank usually being employed for starting up and withdrawn just before launching—Fig. 3. The length of the fuel line is trimmed so that the volume of fuel contained in it is exactly the amount required for a given engine run, as determined by practical tests.

Cut-off valves have a purely mechanical action, shutting off the supply between tank and engine. For positive results, those employing a piston action must be accurately made. If only a small "bleed" remains with the valve shut, fuel can still pass and the engine

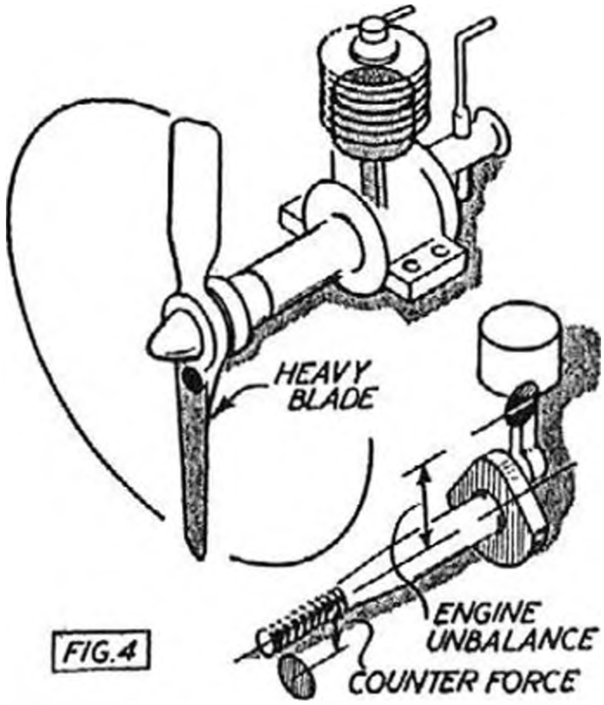


FIG. 4

will continue to run. Individual reworking is often necessary to be sure of absolutely positive results but the commercial standard is now generally high compared with what it was several years ago.

The best place to mount a cut-off valve is on the end of the spray bar of the engine itself, or alternatively as close to the engine as possible. A rigid mounting is required for it is operated by a pull from a timer, the timer perhaps being located some considerable distance aft on the fuselage and connected to the cut-off by a length of fine wire. One or two engines are produced with a built-in cut-off device, when it is only necessary to connect this up to a suitable timer, thus somewhat simplifying the problem.

The engine shut-off control merits particular care on any model. On a contest model where flights are on the basis of a limited engine run with disqualification for over-running, the value of a positive, reliable control is obvious. On a sports model the same accuracy of timing may not be necessary, but a positive shut-off is just as necessary for limiting power flight durations in windy weather, etc.

Fuels and Speeds

The modern diesel engine is itself a

relatively foolproof unit, once starting and adjusting technique has been mastered. It is not particularly critical on fuel, nor does it require extremely exact adjustments to run satisfactorily. Getting the best out of an engine by trying different fuels and adjusting for absolute maximum performance is a matter for the contest man. The sports flyer can afford to operate his engine at a lower efficiency, normally with greater economy.

To develop maximum power output, a majority of modern engines have to be operated at speeds of around 13,000 to 14,000 r.p.m.—in a few cases even higher. This normally means a relatively small size propeller, which is not always suitable for comfortable handling for sports flying.

Fortunately the diesel, in particular, usually generates good torque at lower r.p.m. and thus it can swing larger propellers quite satisfactorily at lower speeds, even though then generating less horse power. Most sports models are flown on this basis, using propeller sizes which limit the operating r.p.m. to 10,000 or so. This generally implies a higher pitch of propeller than would be used for duration purposes and again, since performance is not a major item, a non-reworked commercial plastic propeller for durability and convenience.

Almost any type of fuel which will then run the engine satisfactorily and give easy starting can be used. It is pointless to employ the more expensive racing fuels for purely sports flying, particularly as the sports flyer generally uses greater quantities of fuel in a day's flying than his contest counterpart. Thus any well known standard fuel should more than suit his purpose.

The contest flyer who is after performance is advised particularly to pay attention to the size and type of propeller he uses—see Chapter Fourteen—in order that he can operate his engine in the region of peak power, and thus get maximum performance out of it. Fuel selection then becomes more important, but is secondary to propeller selection. Different engines exhibit different behaviour on varying fuel mixtures. Some are particularly suited to certain fuels and show a marked improvement in r.p.m. with the same size of propeller, whilst others do not. Apart from control line speed, it is probably best to settle for a definite type or brand of fuel and stick to it for contest work. A changeover from one fuel to another can call for markedly different engine settings and differences in "warming up" times. The best type of contest fuel is normally one which gives a minimum of difference (or no change) between starting up r.p.m. and warmed up r.p.m., and also tends to promote "fineness" of compression setting control so that the mixture can be leaned out for maximum r.p.m. Subtle differences of this nature would largely pass unnoticed for sports flying.

Vibration and Balance

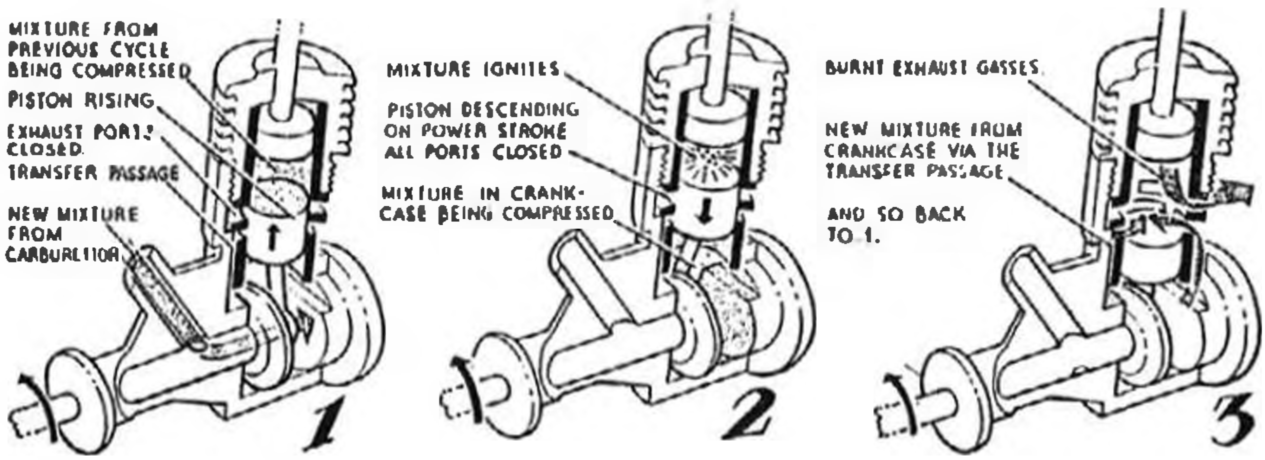
Since it is impossible to balance a two-stroke engine (even if statically balanced, the engine will be dynamically unbalanced when running), vibration can, at times, be a severe problem, even with good mounting. Some engines are more prone to vibration than others and quite a number of engines exhibit bad "vibration speeds". This means that if loaded down to run at that particular speed they will vibrate badly.

An unbalanced or out of true propeller can also cause vibration at any speed, although a perfectly balanced propeller is no cure for inherent engine vibration. Actually an *unbalanced* propeller is to be preferred, so locked to the shaft that the heavier blade is opposite to the piston. Then propeller unbalance tends to counteract engine unbalance to a large extent and the result is smoother running—Fig. 4. This solution is quite practical for the propeller position remains normal for starting.

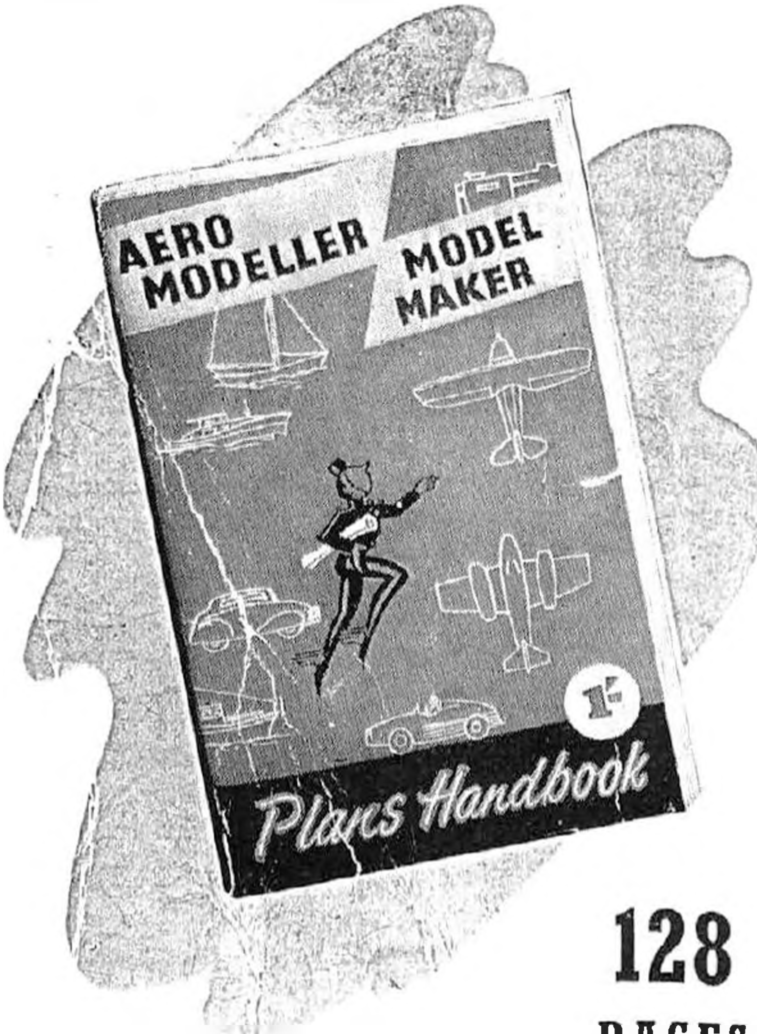
Apart from loss of power (which may not be important on a sports model), vibration is a particular evil on Radio Control designs, and excessive motor vibration may cause the receiver relay to skip and the control to be unreliable. Some form of flexible mounting is normally employed to minimise the amount of vibration transferred to the receiver in any case, but engine vibration n be a particularly severe problem with 1aller Radio designs. Equally im- ›rtant is to select the propeller size to ɔid "resonant" speeds at which, haps, the whole fuselage tends to rate "in step" with the motor. A l indication is to hold the rear end .: fuselage with the motor running ·el the amount of vibration trans- . through the fuselage. If con- le, something should be done to down. Even if not apparently rmful, excessive vibration is sub- ting all glued joints in the structure to nsiderable stresses.

amiliarisation

Success with power models depends on good design, good construction, and getting to know your engine. The place to learn starting and adjusting tech- nique is in the workshop when running- in the engine—not on the flying field. No new engine should be installed directly into a power model. It should be mounted on a bench stand and run in, as recommended by the manufacturers, which period of its operating life is the best time for getting to know its response to control adjustment, starting settings, etc. It is unwise to attempt running an engine in when installed in a model, if only on account of subjecting the model to unnecessary strain and exposure to fuel oil. Then check that all screws, etc., are tight on the motor (e.g., cylinder head hold-down screws, back cover to crankcase, etc., sometimes tend to loosen up after initial running) and install finally in the model. Make a thorough job of fitting the tank (if called for), fuel cut-out, etc. Use non-kinking fuel line of the type which does not age- harden and become brittle, and then have several proving runs with the com- plete installation before venturing out to the flying field for the first time.



OPERATION OF A TWO STROKE DIESEL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