same amount as the rest of the stringers.

The next method of building rounded fuselages is to make one half at a time. For this we cut the formers in halves and stand them on the drawing while we put the stringers or planking on. (See Fig. 29.) The second half to the glass. A pair of keels and a pair of backbones are required, and we must allow for the thickness of the two when cutting the formers. After doing one side like this, we turn the glass over and rest it on blocks of wood or a pile to books, to build the other side. Fig.

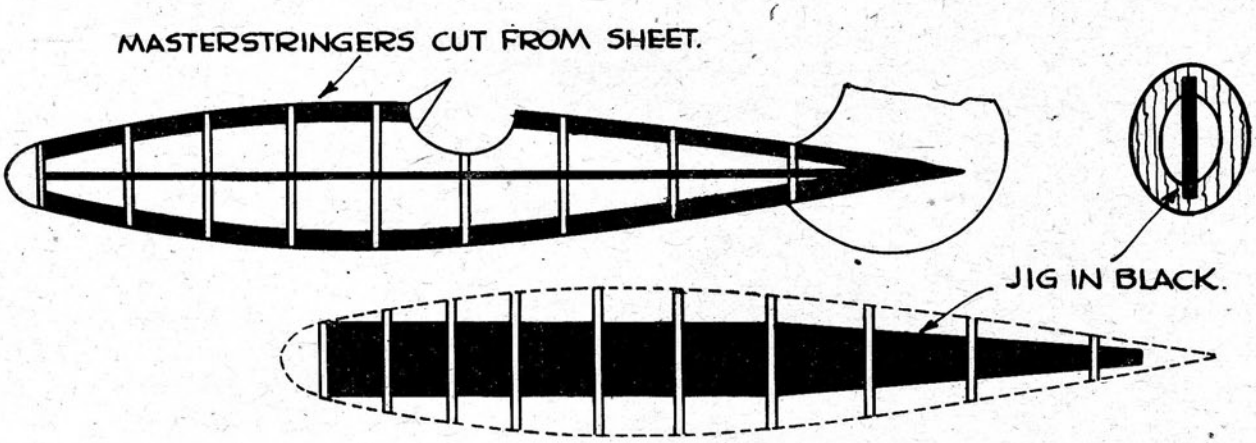


Fig. 28.

must, of course, be made opposite to the first, and this is most easily done by turning the drawing upside-down if it is on tracing paper, or we can put carbon paper underneath when the drawing is made, so that we get a drawing in reverse on the back.

Mr. H. J. Penny has devised a rather ingenious method of combining the master stringer idea with the fuselage built in halves. The sides are built on a piece of plate glass, such as an old windscreen, and there is then no difficulty in getting the two sides opposite. To make the first side, we lay the glass over the drawing and stick the " master stringers," which in this case are the keel and backbone,

30 shows the finished structure on the glass. If balsa covering is used, it can be put on at this stage. This structure can be released from the glass with the aid of a razor blade and then glued together.

There is still another way of building fuselages that is excellent for small models. The idea is to cut the fuselage sides out of 1/64 in. or $\frac{1}{32}$ in. sheet and glue them to the formers. Both sides must be exactly alike, and the front and rear formers should be glued on first, making sure that the sides are dead level with each other. We can stand these sides on blocks of wood while the glue sets, and the intermediate formers can be added. To put these in, spread glue along the sides of the formers, gently ease the fuselage sides apart with two fingers while the former is put in. Such a fuselage, partly completed, is shown in Fig. 31. Most of the present-day light aeroplanes have flat sides

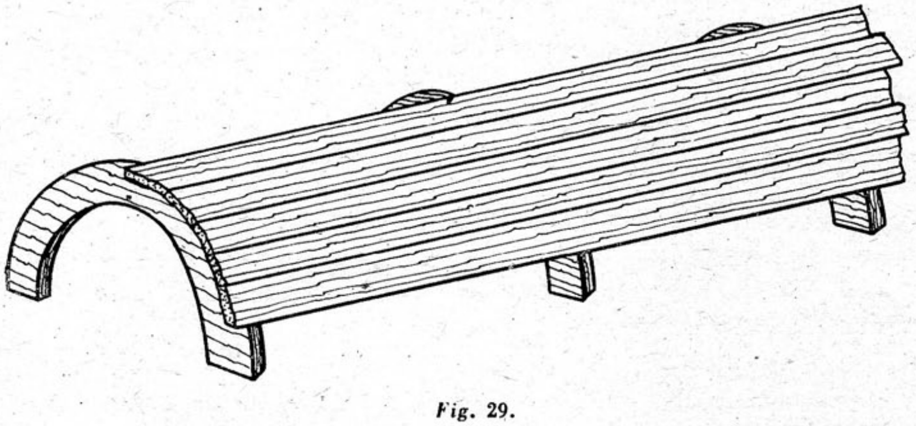


Fig. 29.

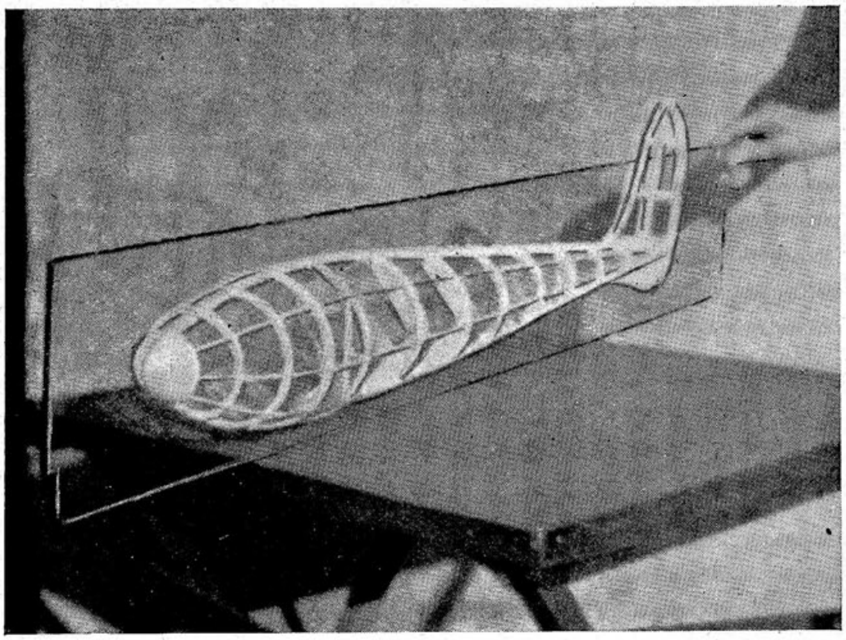


Fig. 30.

will be of the cabin type, and windows and windscreens for these are dealt with in the chapter on finishing, so we will make a few notes here on windscreens for open cockpits.

Some windscreens, like those on the " Swallow " and " Hart," are made from three flat sheets of glass or other transparent material. For our model we can use celluloid such as that used for motor-car sidescreens. It is about half a millimetre thick, and is much better than the thin stuff usually sold for model purposes, which, however, is quite all right for cabin windows. Our best plan is to cut patterns first, from thin card or sheet balsa, and adjust them to fit. We then cut the celluloid to the patterns. We cannot bend the celluloid to a sharp angle without it cracking, so we shall have to cut it to the three flat pieces and stick them together. Use only just enough glue for the job, and if possible have some blocks or wedges of wood to hold them in shape while the glue sets.

and bottom, with a straight tapered and rounded top that is very conveniently made in this way. Before trying to stick the top on the fuselage, cut out the balsa sheet and cover it with tissue paper. With the paper on the outside, gently bend the balsa round a circular rod such as a pencil or broomstick, according to the size of the curve. The grain of the balsa will have to run lengthways of the rod. Rub the balsa hard on the road as you bend it round. This method of bending will serve for any

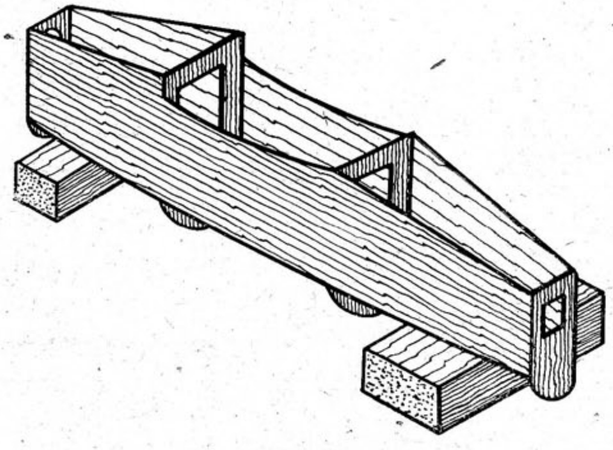


Fig. 31.

sheet balsa parts; but if the bend is very sharp it is best to soak the balsa in boiling water for a few minutes first.

Most of the machines we are likely to model

In some cases we have windscreens made from flat sheet bent round, as used for some " Moths." These are usually D- or moon-shaped, and here again half mm. material is

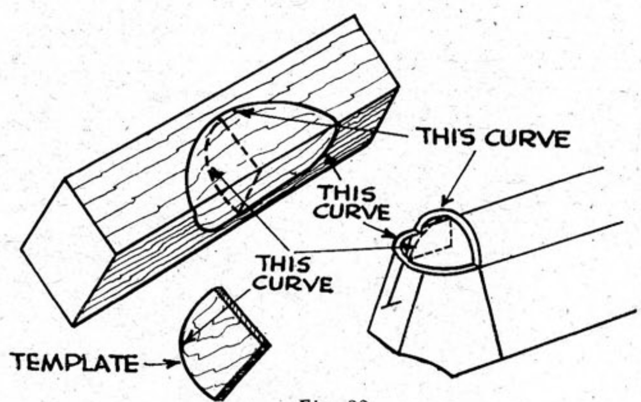
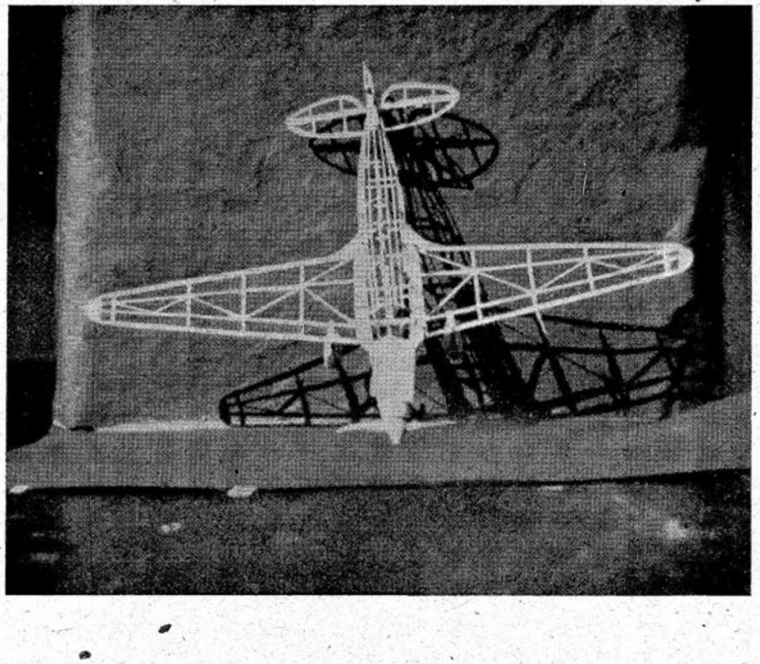


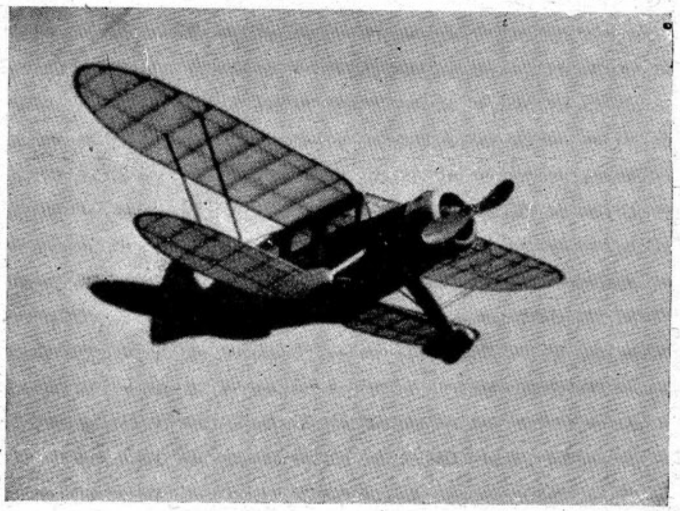
Fig. 32.

best. Our patterns can be cut from thin card or thick paper. They are sometimes a bit tricky to fix in place on the fuselage, but quick-drying glue will help us, since we can hold things in place while it sets. It is best to glue the middle first, and work towards the sides. Use the glue very sparingly.

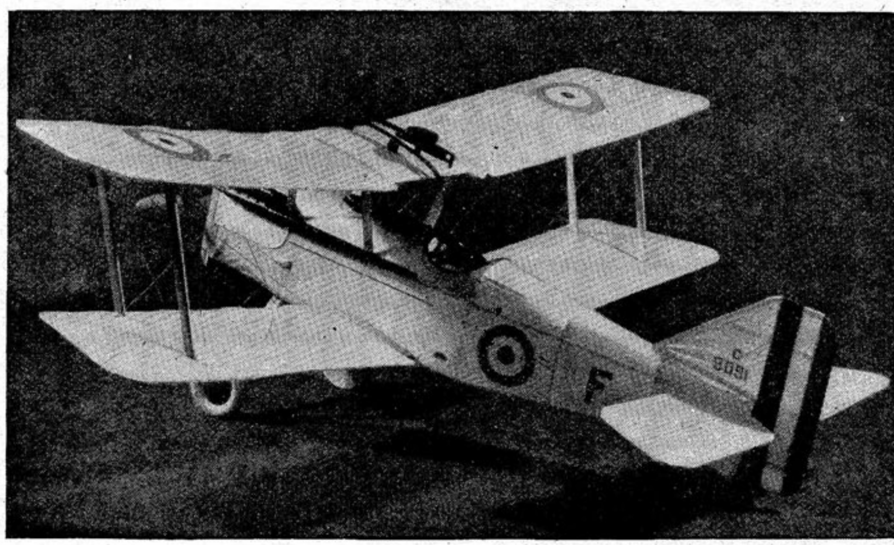
Windscreens cannot always be made from flat sheet celluloid, due to a double curvature, as, for instance, in the Miles machines, and the top front of the Lysander. Sometimes we are lucky enough to find curved articles of clear celluloid, such as wool containers and dishes, that have a suitable curve. Failing this, there is a method by which we can make the shape we want from a piece of flat celluloid such as is used for motor-car sidescreens. To do this we shall have to hollow out a block of wood to the shape we want. In most cases the curve will not extend round more than 90 degrees, that is, from a vertical to a horizontal line, looking on the side of the model. Suppose this is the case, as it most likely will be, this is how we should go about the job. On one side of a short square strip of wood, such as deal or pine, mark off the curve over the top of the screen, starting from one corner, and on the adjacent side mark off the curve round the front of the screen, so that the two curves join up at their ends (see Fig. 32). Now we make a template of the curve in the middle, that we see when looking at the side of the machine. The next job is to hollow out the wood to the curves, using the template to get the curve shown dotted. This hollowing out is best done with a gouge and finished with sandpaper. We want another piece of wood carved to fit inside this hollow, with clearance all round of the thickness of the celluloid. If we heat the celluloid in front of a fire it will soften sufficiently to take the curve when pressed between the two blocks. Boiling water is hot enough, but is inclined to make the celluloid cloudy, but it is likely to flare up if held too near an open fire. If we use a piece of celluloid that is only just big enough, that is, to leave about $\frac{1}{8}$ in. to be trimmed off all round, there will not be so much danger. Then again, so as not to burn our hands, it is best to hold the celluloid in a pair of pliers.

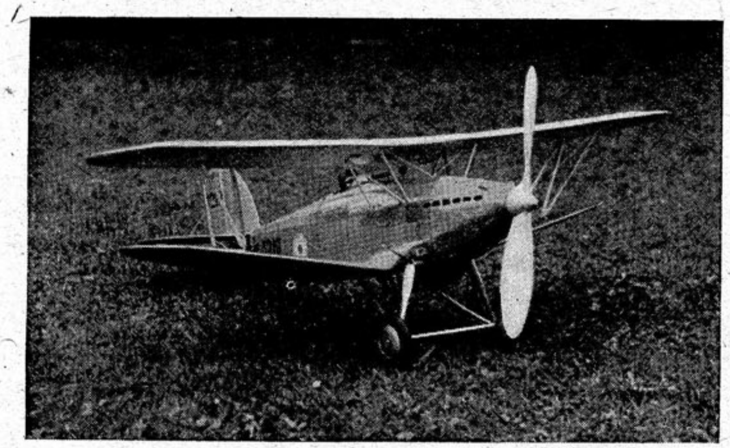


This model is the "T.K.2," a high-speed monoplane of De Havilland design. Full-size plans for building a 16½ in. span model are at the end of this book.



Biplanes are very popular with builders of scale model aircraft. The top photo shows an American 'plane, a "Waco" Custom Cabin five-seater. Span of the model is some 50 in. Below is a very old war-time favourite, the S.E.5a.





A fine flying model of the Hawker "Fury" built by Mr. Hastings is shown in this photo. Some details of the construction of this model are on page 61. (The propeller is not to scale, but is the one used for flying.)

CHAPTER XIV

WINGS

SECTIONS. SPARS. TIPS. CENTRE SECTIONS. FIXINGS.

FIG. **33** shows some of the commonest wing sections in use for full-size aeroplanes, and others are usually only slight variations of these. R.A.F. **15** is typical of light biplane sections, and while being very good aerodynamically it is not very convenient for models. The trouble is that to make it strong enough for a model would result in too much weight. Clark Y is typical of the heavier biplanes like the Hart and Fury, and light strut-braced monoplanes like the Wicko and the Comper Swift. R.A.F. **34** is the type used on cantilever monoplanes like the Wellesley, Mosscraft and the Moth Minor. It is also used on some strut-braced monoplanes like the Lysander and Taylorcraft. Gottingen **436** is another section similar to Clark Y, though one writer considers it better, and is that most likely used on machines of German origin, such as the British Aircraft "Swallow."

We need a number of wing ribs cut out to this section, enough to be spaced about **1** in. or $1\frac{1}{2}$ in. apart along the wing. If the wing is parallel it is best to cut one rib to size out of $\frac{1}{16}$ in. ply and use this as a template or pattern for cutting out the proper ribs. We can make these from $\frac{1}{16}$ in. or $\frac{1}{32}$ in. balsa. If the wing is tapered we shall have to cut out a number of different sized ribs, the length of each being obtained from the drawing. We shall require two of each size, one for each half of the wing. Getting these different sizes the right shape involves a little work. Anyone who has an enlarger for photographs can turn it to good account for this job. One way is to make a tracing of a small rib that we can put in the enlarger in place of the negative, or a better way is to photograph a large drawing of the section and use the negative. We can now enlarge the rib to any size we like. There is no need to be critical about the sharpness of the image, and we can in fact use the focusing adjustment to get the image the exact size we require. We can use any odd bromide paper and need not be particular about the exposure as long as we can see the outline when developed. When the prints have been finished and dried we cut them out and use them as patterns for cutting the ribs.

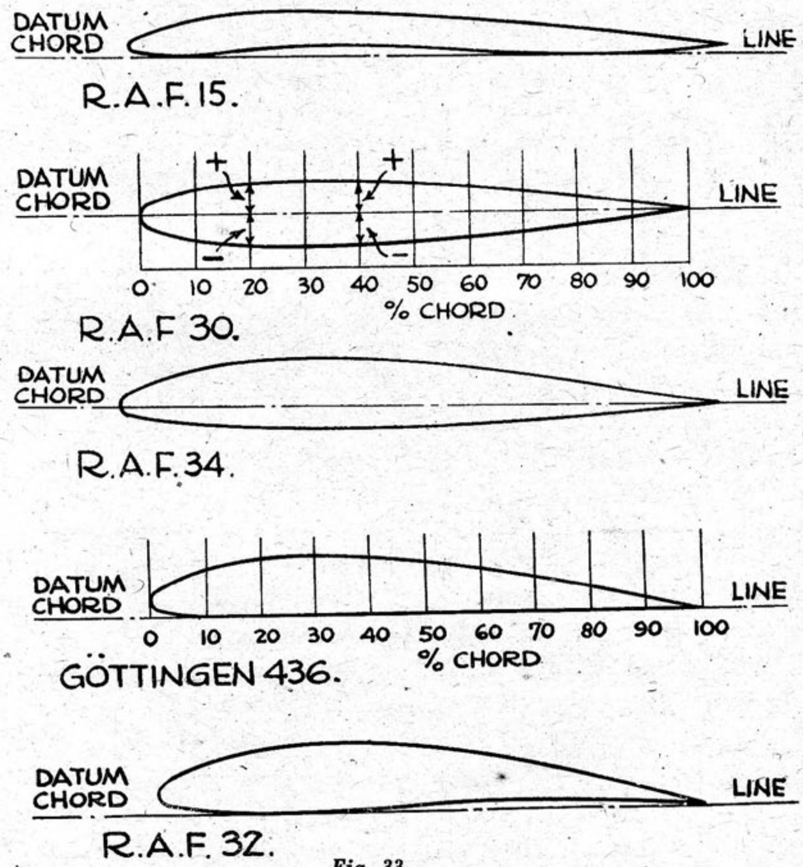


Fig. 33.

We can also obtain blue prints or drawings of wing ribs of various sizes from some dealers that prove very useful. We can usually find a set of ribs to suit by adjusting the spacing of them. Suppose the wing tapers from 4 in. to $2\frac{1}{2}$ in., and the span of the tapered part of one wing, that is, on one side of the fuselage, is 15 in. From the blue print we pick out a range of sections from $2\frac{1}{2}$ in. to 4 in. that vary $\frac{1}{8}$ in. at a time in length. The difference between $2\frac{1}{2}$ in. and 4 in. is $1\frac{1}{2}$ in., and the variation is $\frac{1}{8}$ in. per rib, or $\frac{1}{8}$ in. between one rib and the next. There are twelve $\frac{1}{8}$ in. in $1\frac{1}{2}$ in., so this means we shall have twelve spaces in 15 in., so each space will be $1\frac{1}{4}$ in. If the ribs on the blue print vary $\frac{1}{4}$ in. each instead of $\frac{1}{8}$ in., we must cut ribs to fit $2\frac{1}{2}$ in. apart, and cut by guess for those in between. It is fairly easy to guess the correct shapes if we cut out the rib roughly a bit on the large side and then hold it between the next rib smaller and next larger.

PROFILES OF AEROFOILS.

Distance from L.E. %	Gottingen 436.		Clark Y.	
	Upper.	Lower.	Upper.	Lower.
—	2	—	—	—
0	2·50	2·50	3·50	3·50
1·25	4·70	1·00	5·45	1·93
2·5	5·70	0·20	6·50	1·47
5	7·00	0·10	7·90	0·93
7·5	8·10	0·05	8·85	0·63
10	8·90	0	9·60	0·42
15	10·05	0	10·69	0·15
20	10·25	0	11·36	0·03
30	11·00	0	11·70	0
40	10·45	0	11·40	0
50	9·55	0	10·52	0
60	8·20	0	9·15	0
70	6·60	0	7·35	0
80	4·60	0	5·22	0
90	2·45	0	2·80	0
95	1·25	0	1·49	0
100	0	0	0·12	0

Sometimes we may want to use a section for which we have no drawing, and in any case some of us prefer to draw them out ourselves to just the size we want. After all, it is quite easy enough when you have the profile dimensions, as they are called. A table of these dimensions is included, because they are a great advantage when dealing with certain tapered wings. The sections given are the most suitable of those we are likely to come across. The method of drawing these wing or aerofoil sections is illustrated in Fig. 33. We start off with the chord line, and mark the chord the length we require. Then we divide it up into percentages and erect perpendicular lines to correspond with the column of values headed per cent chord. To get the height of

PROFILES OF AEROFOILS.

Distance from L.E. %	R.A.F. 30. Top and bottom.	R.A.F. 32.		R.A.F. 34.	
		Upper.	Lower.	Upper.	Lower.
0	0	0·0342	0·0342	0	0
1·25	0·018	0·0556	0·0196	0·0198	−0·016
2·5	0·025	0·0652	0·0150	0·0282	−0·0214
5	0·035	0·0784	0·0088	0·0411	−0·0281
10	0·048	0·0972	0·003	0·0583	−0·0353
15	0·054	0·11	0·0008	0·0697	−0·0391
20	0·059	0·119	0	0·0772	−0·0416
25	0·062	—	—	0·0814	−0·0426
30	0·0632	0·12	0·003	0·0832	−0·0432
35	0·063	—	—	0·0827	−0·0433
40	0·062	0·13	0·007	0·0808	−0·0432
45	0·06	—	—	0·0774	−0·0426
50	0·0566	0·1246	0·011	0·0721	−0·0411
55	0·0526	—	—	0·0659	−0·0393
60	0·0478	0·1106	0·0146	0·0587	−0·0369
65	0·0428	—	—	0·0513	−0·0343
70	0·037	0·091	0·016	0·0431	−0·0309
75	0·0312	—	—	0·0349	−0·0271
80	0·025	0·0616	0·0146	0·0270	−0·023
85	0·019	—	—	0·0195	−0·0185
90	0·013	0·036	0·0092	0·0126	−0·0134
95	0·007	0·0198	0·0052	0·0064	−0·0076
100	0	0·001	0	0	0

these lines we multiply the values in the other columns by the length of the chord. Sometimes these values will come above the chord lines for the bottom curve and sometimes below or on the line. The point marked 30 per cent chord is about the best place to arrange the main spar. Section R.A.F.30 is symmetrical and is used for tail-planes and rudders.

If we are making a tapered wing we do not need to work out the dimensions for all the ribs; we can do it by drawing as shown in Fig. 34. We draw out the largest and smallest ribs on the lines XX and YY and equally divide up the space between the two to suit the number of ribs we are using. We now divide each rib into the same number of parts, say at every 15 per cent, as at A, B, C, D, E, and A2, B2, C2, D2, E2, and join up with straight lines.

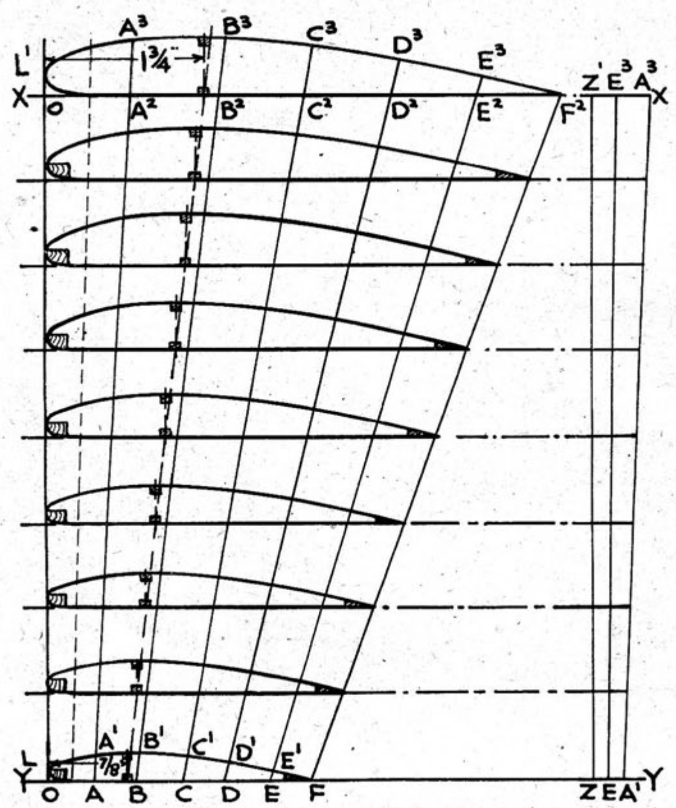


Fig. 34.

Next we draw a vertical line ZZ, and mark off the distance AA1 from Z to A1 and A2A3 from Z1 to A3. Now, by joining up the line A1A3 we find the height of each rib on the line

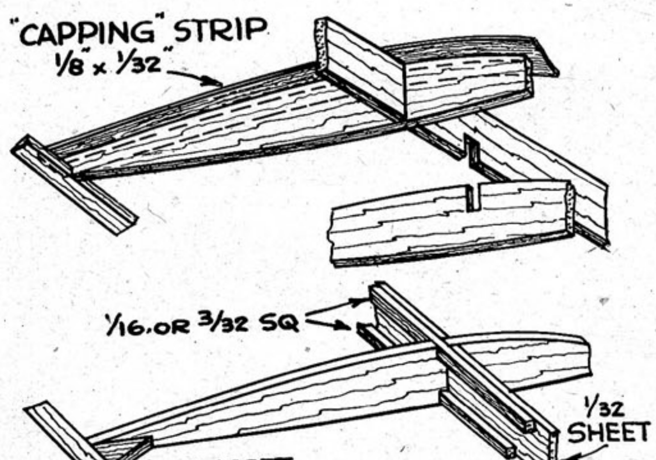


Fig. 36.

AA1A2A3 by measuring the distance between the lines ZZ1 and A1A3 alongside that rib. The same procedure is carried out for each of the points A, B, C, D, E, etc. The position of the main spar is shown for a wing tapering from 6 in. to 3 in.

Sometimes on a tapered wing the section is not constant, but varies in thickness/chord ratio like the B.A. "Swallow." It may be that the depth of the section at the tips is 10 per cent of the chord, and yet at the centre section it may be 20 per cent. In this case the same ordinates are used for plotting the wing section, but multiplied by 2, or if it is 15 per cent multiply by 1½. By using the drawing method it is easy enough to get the depth of all the intermediate ribs. Making the rib or section thicker than is correct is called "blowing it up." When each rib has been drawn it is cut out and used as a pattern. If the wing is not tapered very sharply we can cut out the ribs satisfactorily by making patterns of the largest and smallest ribs from ⅛ in. ply and then sandwich all the ribs, cut out roughly, between these two patterns. If we now cut across from one pattern to the other, as shown in Fig. 35, all the ribs will be the correct shape. We can cut slots for spars at the same time.

If we use 1/32 in. balsa for the ribs, when they are about 3 in. or more in length they will need stiffening. The amount of stiffening will de-

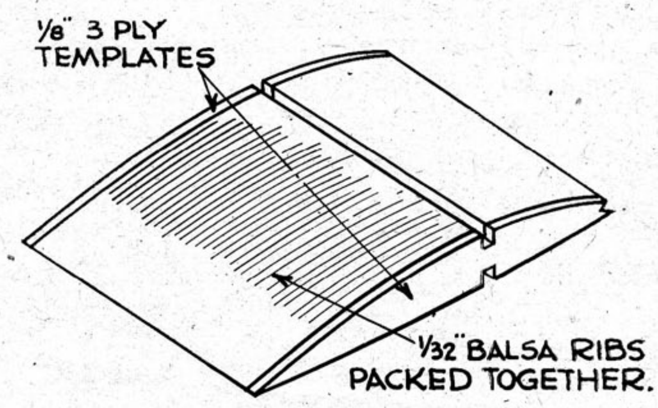


Fig. 35.

pend on the strength of the trailing edge spar. With a strong spar we need not stiffen the ribs so much, but it is best to keep the spar on the light side and have strong ribs. One way we can deal with the ribs is to make small gussets of 1/32 in. balsa about ¾ in. by ⅛ in. and glue them in the corners between the ribs and the trailing edge spar. A better way, however, is to stick a strip of $\frac{1}{8}$ in. by $\frac{1}{32}$ in. balsa along the top or bottom, or both, edges of the rib to lap over the T.E. spar. See Fig. **36**.

The trailing edge spar can be $\frac{1}{8}$ in. by $\frac{1}{16}$ in. balsa for a light one, or $\frac{1}{4}$ in. by $\frac{1}{8}$ in. for a heavier one. We can make a better spar, though, by forming a V section of two pieces of $\frac{1}{32}$ in. balsa $\frac{1}{4}$ in. wide, glued together. These spars will do for most models, providing the ribs are not more than $1\frac{1}{2}$ in. apart, but the built-up V could be made half the size for a small model. If we use $\frac{1}{8}$ in. thick balsa for the trailing edge it will need tapering to a V section, and for this we can make up a gadget to assist us, and it is shown in Fig. **37**. First we want two pieces of hard wood, such as oak, though deal would do. One piece should be **6** in. by $1\frac{1}{2}$ in. by $\frac{3}{8}$ in. and the other **6** in. by $\frac{3}{4}$ in. by $\frac{1}{8}$ in. In the smaller piece we make two slots about $\frac{3}{8}$ in. long, and wide enough to allow a small bolt to slide along. In the larger piece we make two holes for the bolts, and enlarge them underneath so that we can sink the nuts in. The sketch makes it clear. On the edges we nail or screw strips of brass or steel about $\frac{1}{32}$ in. thick, to prevent damage to the wood. We want a large washer under the head of the bolt, so that it will not jam in the slot. By putting the balsa on the step we can shape it down with a knife or razor blade and

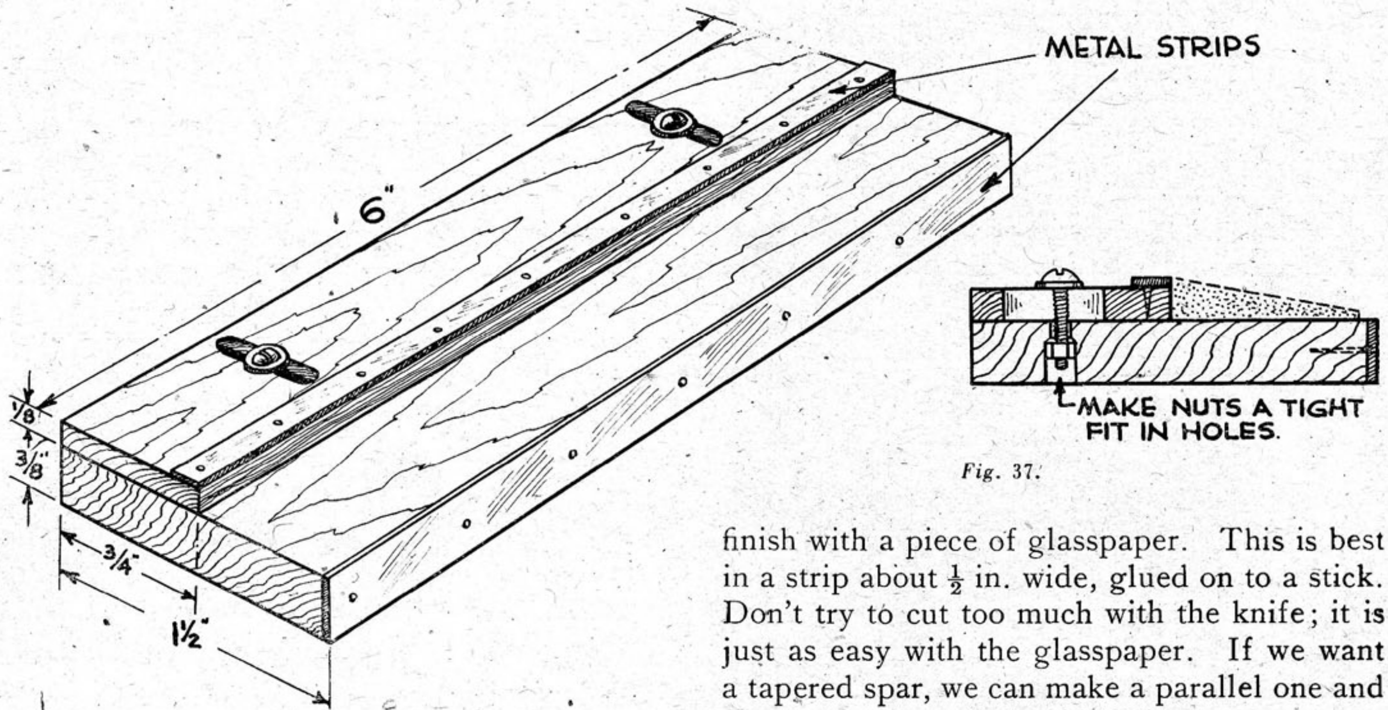


Fig. 37.

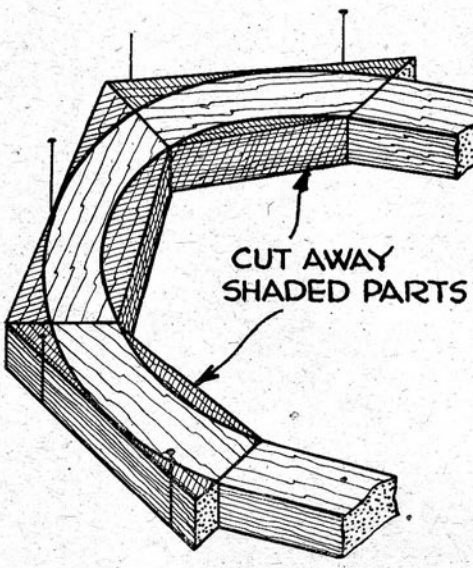
finish with a piece of glasspaper. This is best in a strip about $\frac{1}{2}$ in. wide, glued on to a stick. Don't try to cut too much with the knife; it is just as easy with the glasspaper. If we want a tapered spar, we can make a parallel one and cut the surplus off the thick side.

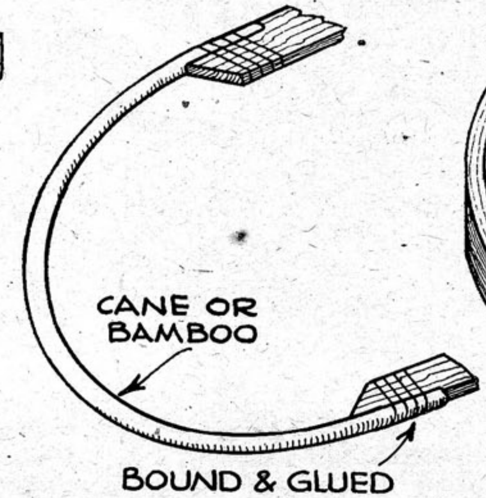
For the leading edge spar we can use $\frac{1}{8}$ in. by $\frac{1}{16}$ in. balsa or $\frac{1}{8}$ in. square, for almost any size model, providing we have ribs spaced less than $1\frac{1}{2}$ in. apart. Ribs farther apart than this need a stronger leading edge and do not look so good in the finished model.

The main spar is the one we can most usefully vary for different-sized models, and by always making this as deep as possible the variation we require follows as a matter of course. One of the simplest ways we can make such a spar is to use $\frac{1}{16}$ in. sheet balsa about $\frac{1}{16}$ in. less in width than the depth of the ribs. In this way we get a tapered spar with a tapered wing, which is all to the good. We can fit spars and ribs together by cutting slots half-way down from the top of the spar, and corresponding slots in the bottom of the ribs. We can make a better spar, though it is a little more trouble, by using $\frac{1}{16}$ in. or $\frac{3}{32}$ in.

square balsa top and bottom, with a web of $\frac{1}{32}$ in. sheet glued across. Either this web will have to be in pieces between the ribs, or the ribs must be cut in two and stuck on fore and aft. Cutting the ribs is really the best. A spar made like this, using $\frac{1}{16}$ in. square balsa, is strong enough for a model 4 ft. span weighing 8 oz. The spars are shown in Fig. 36.

must make sure everything is square and true while the glue dries. It is best, if we can manage it, to put spots of glue in the slots before the spars are put in, but unless we can work very quickly we shall be unable to do this with quick-drying glue. If the ribs have a flat bottom surface they will stand on the board nicely, and the T.E. spar can be pinned





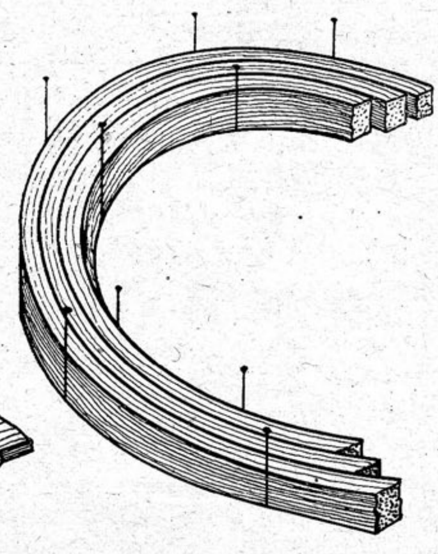


Fig. 37b.

Fig. 37a.

A new method of construction as far as spars and ribs are concerned is that used on the Airspeed Envoy, of which there is a photograph on page 12. The spar is cut from sheet to the full depth of the wing, and is slotted top and bottom for the ribs. The spar is lightened with oblong holes between the ribs, and the ribs also have oblong holes so that they can be threaded on to the spar and turned at right-angles to fit the slots. This will be clear from the photograph.

The wing is usually built in two parts, one for each side of the fuselage. In this way we can build each half on a flat board, and either join them together afterwards or attach them separately to each side of the fuselage. We can with advantage build the wing over a drawing (which must be protected with greaseproof paper), so that we get the ribs and spars in the right place. Spars and ribs can be held in place with pins stuck upright each side, and we

to the board, but if the ribs are a section like R.A.F. 34 we shall need some packing under this spar. For this we can use a strip or two of balsa to lift up the T.E. spar till it is level with the L.E. spar with the main spar resting on the board. Remember to make a wing for each side, but in the case of a parallel wing we may have no more difference than the end on which we fix the tips.

Well, now let us see how to make wing tips. One simple method that is very popular is to make them from sheet about $\frac{1}{16}$ in. thick. We cut the sheet into wide strips so that three or four can be joined together, as shown in Fig. 37a. The strips should be about $\frac{3}{8}$ in. or $\frac{1}{2}$ in. wide, and we can see how many to use by laying them on the drawing. The easiest way is to lay on the pieces that join up with the leading and trailing edges first, and pin them in place. Then we can join up in between with one or two more pieces, glued in place. Before cutting the outline to shape it is best to lift the parts gently from the board and put another spot of glue on each side of the joints. To get the shape we can lay a piece of tracing paper over the plan and trace the inside and outside lines, and cut out the paper to the pattern of the tip. We can glue this pattern to the balsa and cut it away each side. It is then ready to put on the wing. Another method of making tips is also shown in Fig. 37b. To make this we stick pins all round the outline of the drawing, and put three or four pieces of $\frac{1}{16}$ in. by $\frac{1}{32}$ in. balsa edge up on the plan, well glued together. The best way is to use one of the slower drying glues and stick the pieces together before putting them on the plan. The idea of using "slow" glue is that we can put the glue on, squeeze the pieces together, wipe off the surplus glue and bend them to shape before the glue begins to set. The pins on the inside of the bend hold the pieces together and to the shape of the bend. Put the middle ones in first. If the bend is very sharp we shall have to steam the balsa to be able to make it take the bend without cracking. We can also make wing tips from light reed cane or bamboo bent to shape and steamed if necessary, bound and glued to the leading and trailing edges.

With some machines we shall be able to have the wing in one piece all the way across, held on top or underneath the fuselage with rubber bands. When we build it this way it is best to leave the main spar a bit long at the centre of the wing, so that when the two halves are fixed together the two main spars nearly touch. To fix the two halves together we put them on a flat board with the centre ribs the correct distance apart, which will most likely be the width of the fuselage, and raise the tips on blocks of wood, or match boxes or something similar. The main spar should be shaved off at the bottom, so that the ribs lie flat on the board. Fig. 37c shows the wing set up. We must put pins in to hold things in place while we put in the joining pieces. For these we use pieces of the same section as the leading and trailing edges, cut to length so that they are a good fit; that is, not tight nor loose enough to shake. To join the two parts of the main spar we can use a piece of $\frac{1}{16}$ in. sheet cut to a good fit and glued on the sides. If we have a large, heavy model we can use two pieces of sheet, one on each side. If we want an extra strong job we can cover the centre section with 1/64 in. or $\frac{1}{32}$ in. sheet balsa. This will be useful if we are fitting the wing under the body. When fitting the wing this way, one of the best methods is to cut a piece out of the bottom of the fuselage to take it. Where we cut away the bottom longeron we must insert a plate of sheet balsa about $\frac{1}{16}$ in. or $\frac{1}{8}$ in. thick. This is cut to the curve of the top of the wing, and should continue under the front of the wing to the point where the curve of the wing meets the line of the fuselage. All inside this curve should be covered with $\frac{1}{32}$ in. sheet balsa. The wing can then be held in place with a rubber band. The side plates should, of course, be put in when the fuselage is built in place of the longerons at that point (Fig. 15a).

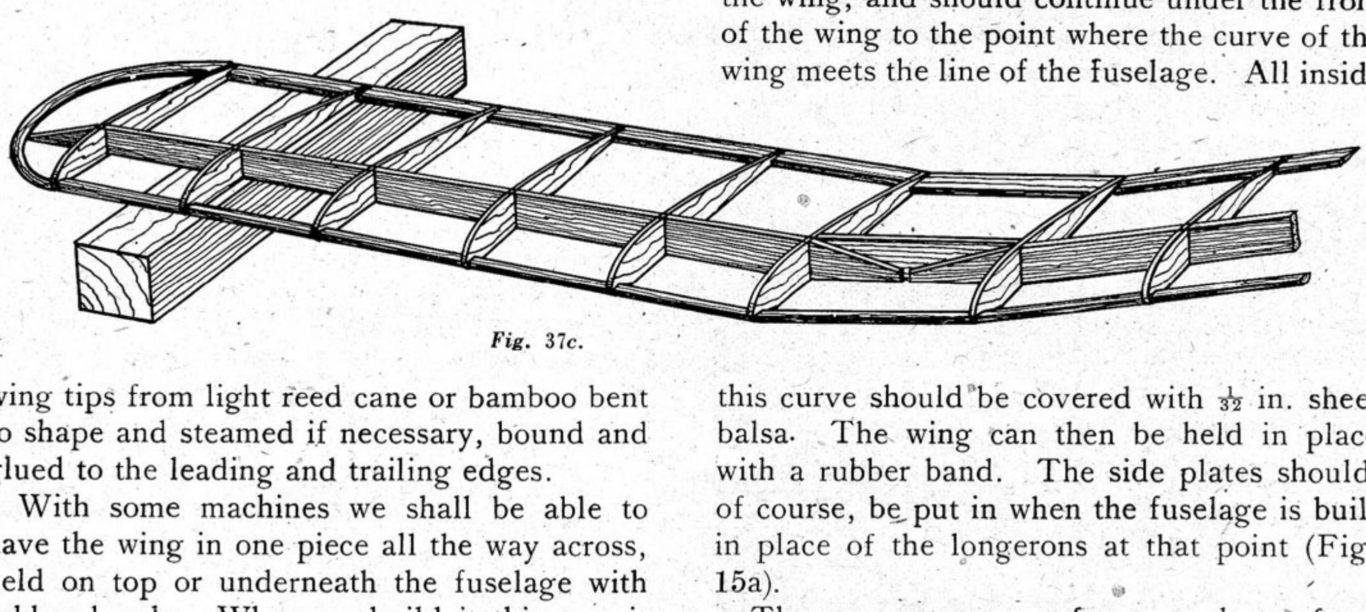
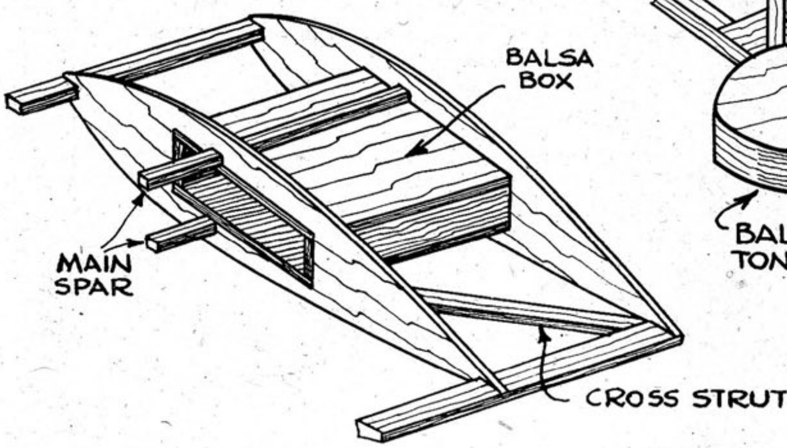


Fig. 37c.

There are many ways for us to choose from for fixing the wing to the fuselage, some of which will do for either high- or low-wing machines. One such method is shown in Fig. 38. We can make the tongue $\frac{1}{8}$ in. to $\frac{1}{4}$ in. thick and 1 in. to 2 in. wide, according to the size of the model, and the box can be made from $\frac{1}{16}$ in. sheet let into the first two ribs. We can, if we wish, cut away some of the balsa in the tongue to make it lighter, but if so we must leave a strip about $\frac{1}{4}$ in. to $\frac{3}{8}$ in. wide along the centre that has no hole breaking into it. To



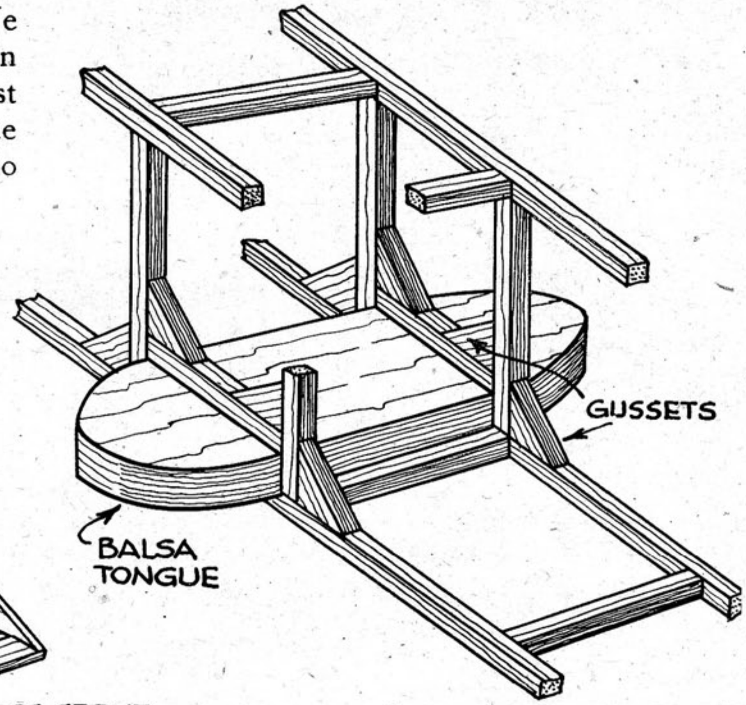


Fig. 38.

get the shape of the curved ends of the tongue, we draw the rear curve with the point of a pair of compasses on the leading edge of the rib that fits against the fuselage. The front curve is drawn with the compasses on the trailing edge of the same rib. When the box is put into the wing we must not forget the dihedral angle.

This tongue and box idea can also be used to make outboard wing panels detachable. These panels could be those outboard of the engine nacelles on a twin-engined machine, or outboard of wing struts.

Another idea is to use press studs or dress snaps as they are sometimes called. These can be sewn to the balsa, and when glued also are surprisingly strong. A better way, however, is to solder each part to the head of a small bolt and bolt it to the wing rib. This rib should be strengthened by putting a large thin ply washer under the nut.

Where we have the whole of the wing detachable on strut - braced machines we really want some means of keeping the wing in place on the fuselage, and let the struts take the weight of the model. Fig. 39 shows how we can have small bamboo plugs on the wing panel to fit into holes in the centre section rib. It also shows the hole through the centre section through which a rubber band is passed to fit on the hooks on the wing. In use we

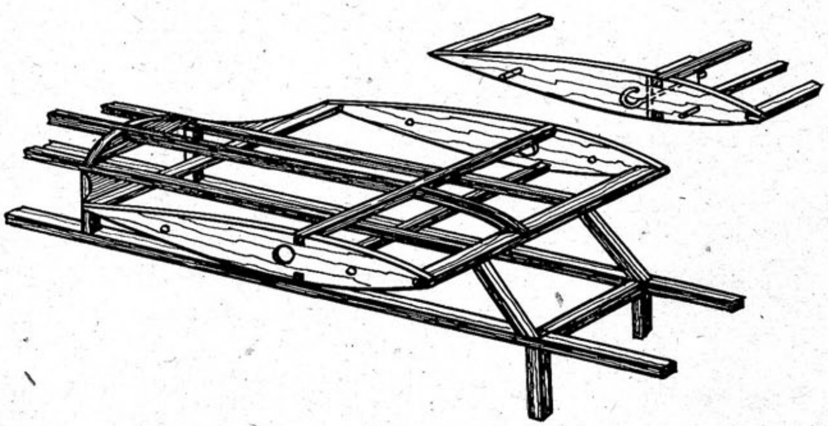


Fig. 39.

put the band on one hook and pull it through the centre section and fit it on the other. The band should be short, so that it is tight with the wing in position. About the only way of

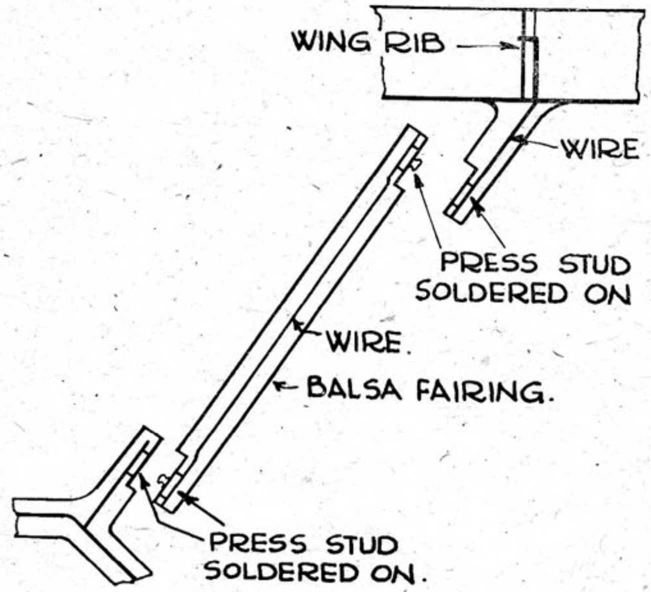


Fig. 40.

getting the band through is to use a long wire hook that will pass right the way through.

The wing struts are the biggest problem, but the following method has been used most satisfactorily on a model " Lysander." In fact no fault has been found with it. For this a piece of wire was soldered on to the undercarriage, and projected about ¾ in. in the direction of the strut attachment on the wing. At the top of this was soldered part of a small press stud. Another piece of wire was fixed to a wing rib, and projected towards the undercarriage, and had a press stud soldered at the bottom. The other halves of the press studs were then pushed on, with a spot of oil on the knob part. The next part of the job was rather tedious, but well worth the care taken. The fuselage was packed up level by putting books and slips of balsa under the tail, and slips of balsa under the wheels. The wing was supported on a pile of books at the tip, and attached to the fuselage at the centre. The dihedral and incidence were adjusted by means of little wedges of balsa. A length of wire was then

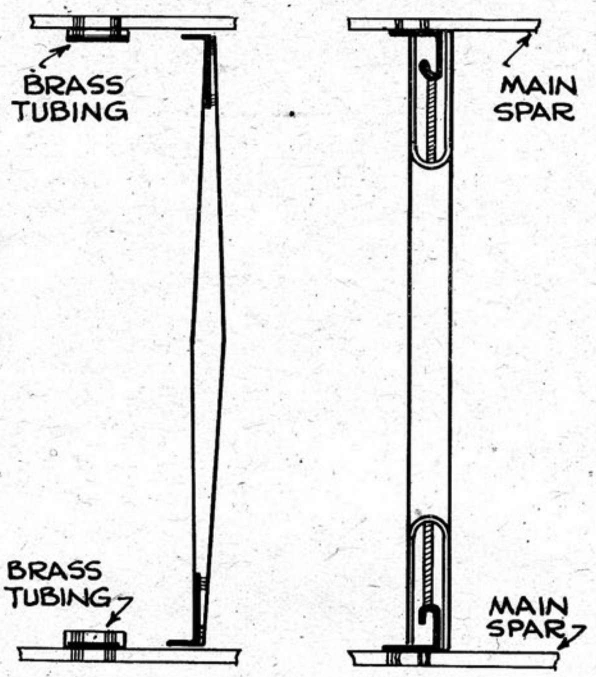


Fig. 41.

soldered to the outside parts of the press studs. The wires, which were about 22 s.w.g., were then faired (or streamlined) with balsa, leaving

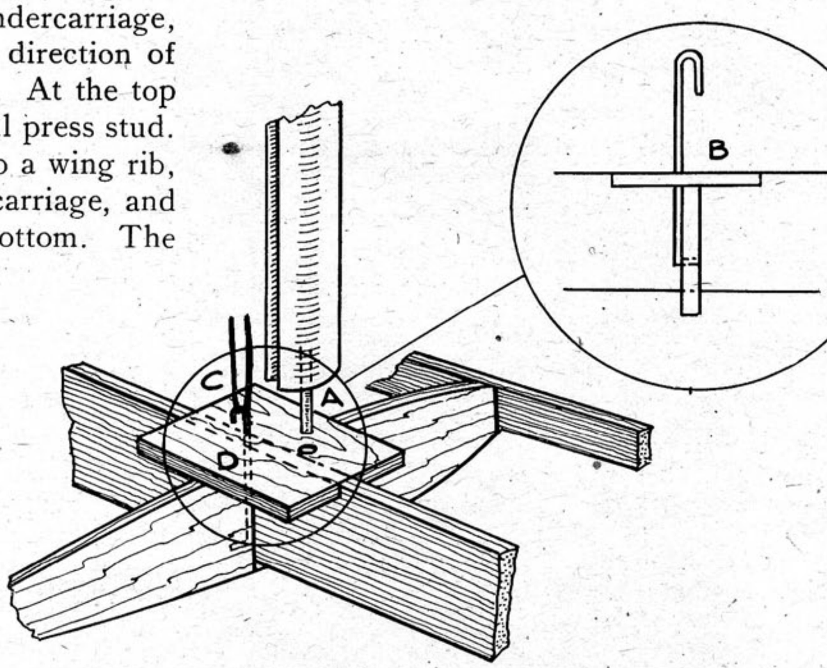


Fig. 42.

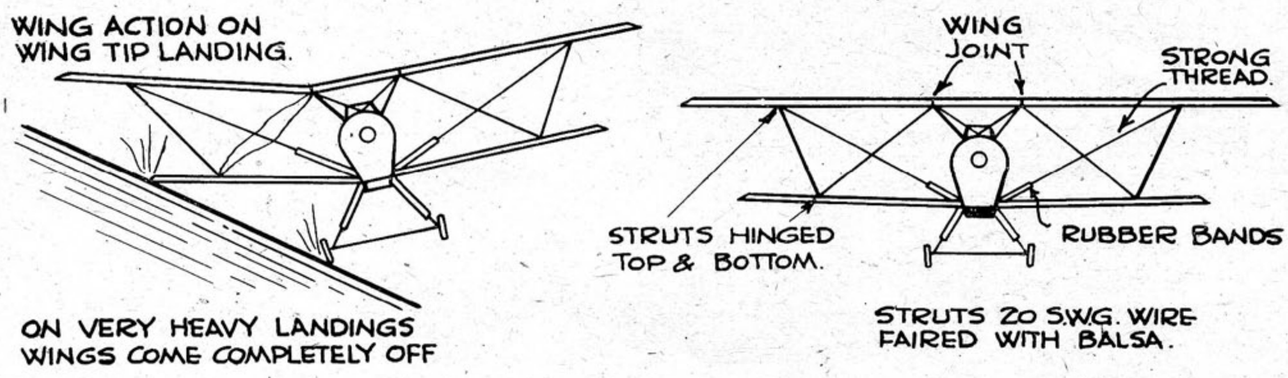


Fig. 43.

stepped ends, see Fig. 40. Struts for biplanes can be fixed up in the same way.

Another way of making struts for biplanes is shown in Fig. 41. For this we bind wire hooks of about 22 or 24 s.w.g. to the main spars and put on a rubber band enclosed in a paper tube. In the sketch the tubes have been cut away at the ends so that we can see the hooks. To make these paper tubes we need a former, that can be a piece of dowel, a pencil, a knitting needle, or if we want a streamlined strut we can make a former by sandpapering a piece of bamboo to shape. Round this former we put a piece of writing paper and then bind on strips of gummed paper tape as used for parcels. Writing paper or drawing paper can be used for the whole of the tube if we glue it well all over as it is wrapped round. Seccotine is very good for this job, as it can be spread all over with a wet finger. Damping the paper first also helps it to spread. If you use gummed tape, have a piece of sponge in a saucer of water for wetting it, or your tongue will get rather dry. As soon as the paper has been bound on to the former we must slip it off, because as it dries it shrinks, and if we allowed it to do that we should not be able to get it off without destroying the tube.

The other method shown makes use of a bamboo strut with a wire hook at each end that fits into a piece of tubing bound and glued to a rib or spar.

Fig. 42 shows another biplane strut fixing. The bamboo peg " A " could pass right through the balsa strut, the balsa being put on in halves. The slot for the rubber band could be covered with paper for most of its length, for neatness.

The wing fixing on Mr. Hastings's " Fury " is rather smart, and is shown in Figs. 43 and 44.

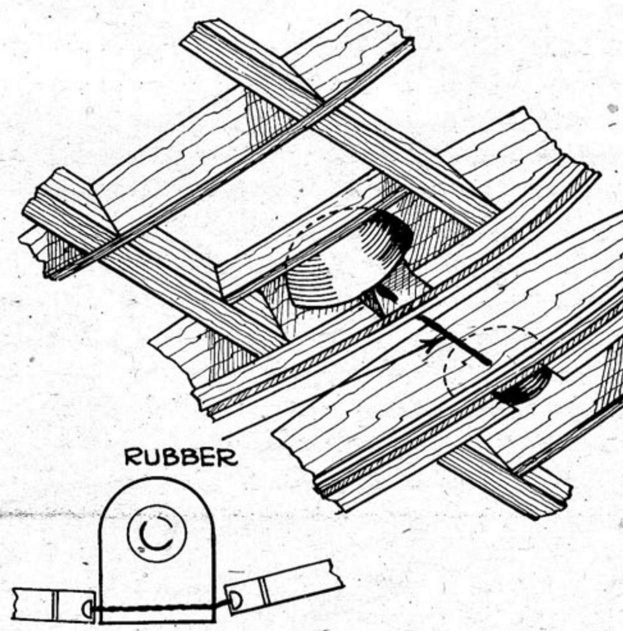
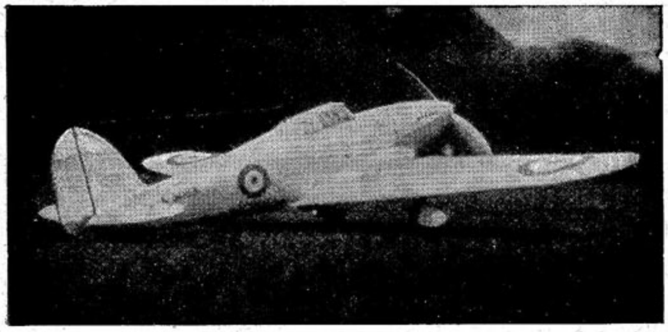
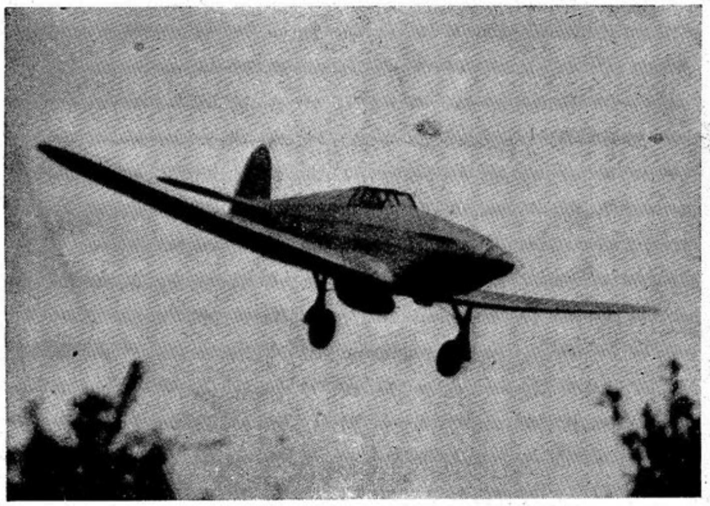


Fig. 44.

The rubber bands holding the thread " lifting wires " tight pass through the fuselage in square balsa tubes. Similar tubes are used in the centre section at the top. For the bottom wing fixing a strong rubber band is used with a hardwood sort of button on each end. This passes through the fuselage and pulls tight against the inside end ribs of the wing. These ribs are slotted to take the rubber.



The Hawker "Hurricane" is very popular with builders of flying scale models. Here are three examples, all worthy of admiration for the skill exhibited in incorporating so much detailed work in small models.



Chapter XV

TAIL UNITS

CONTROL SURFACES. VARIOUS ATTACHMENTS.

We can build rudders and tail-planes in the same way as wings. The main difference is that the tail unit can be made rather lighter. We can, for instance, use $\frac{1}{8}$ in. × $\frac{1}{16}$ in. balsa for the leading and trailing edges, $\frac{1}{16}$ in. × $\frac{1}{16}$ in. balsa for the main spar, and $\frac{1}{32}$ in. sheet for the ribs. This will be strong enough for quite large models, and the ribs should be made to the section known as R.A.F. 30. They can have holes cut in them to make them lighter, and should be spaced about $1\frac{1}{2}$ in. apart. If the tail-plane is a small one, say, not more than 8 in. span, there is really no need for a main spar, but when we do use one it should be continuous if possible from tip to tip, and attached to formers or spacers put in the fuselage for the job. Formers should also be arranged for attaching the leading and trailing edges. The method of glueing the spars to the formers is shown in Fig. 45.

We can, if we like, make the tail-plane and fin (or rudder) detachable for ease of transport, or in some cases for access to the rear motor fixing. We can use a bamboo dowel, plugging into a paper tube, a piece of wire in aluminium tube or into balsa, which should have plenty of cement in and around, or we can use a rectangular bamboo plug and balsa box. Very satisfactory results have been obtained from a rectangular plug fitted at the main spar, letting it project into the rudder and tail-plane

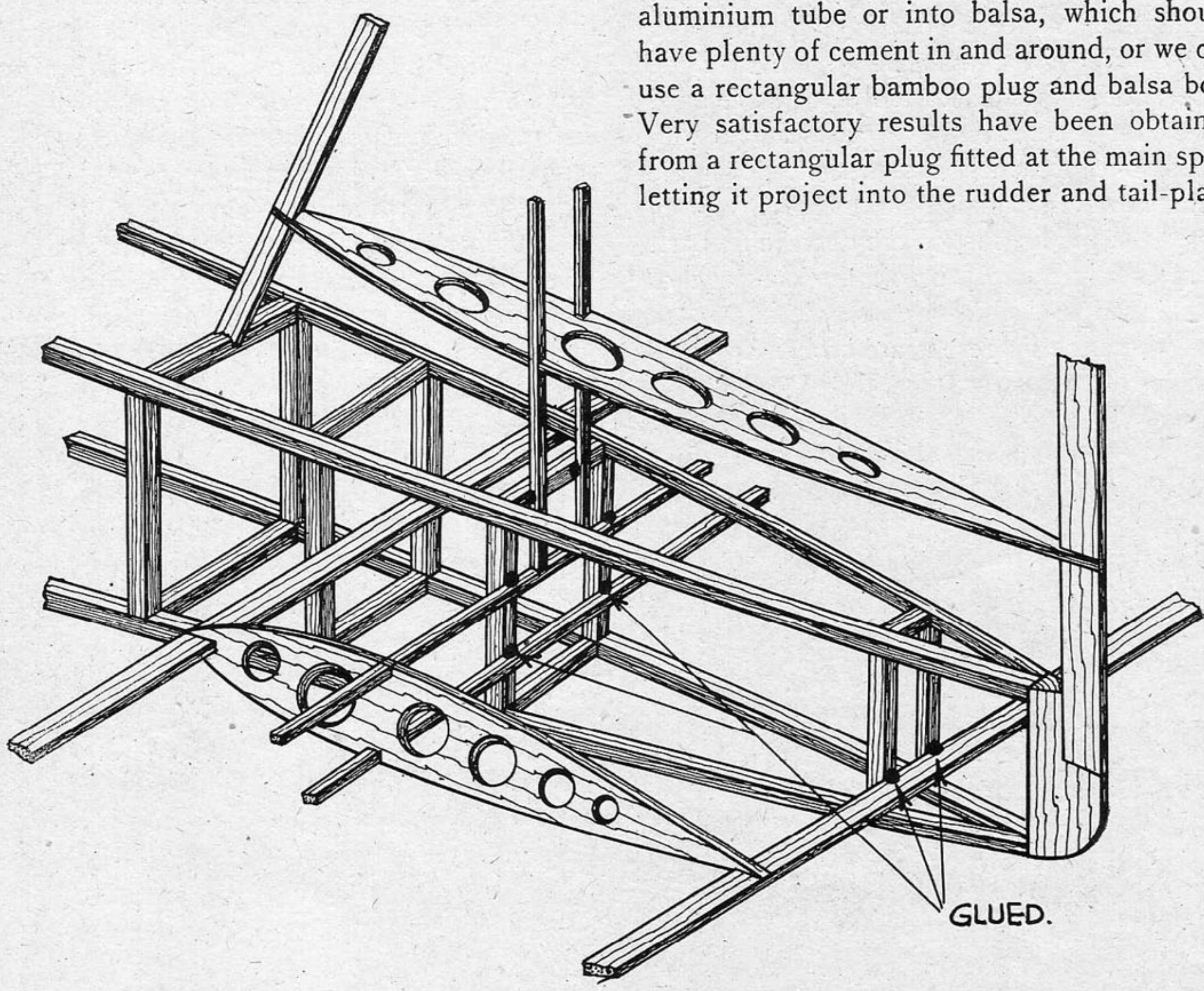


Fig. 45.

about $1\frac{1}{4}$ in., with a short plug poking through a hole in the first rib just ahead of the trailing edge (Fig. 46). The hole was strengthened with an extra thickness of balsa on the inside. This rear attachment serves to prevent the surfaces from altering their incidence. A certain amount of slackness developed, but was easily taken up by glueing a strip of tissue paper to the inside of the balsa box or hole. This was accomplished by putting a spot of glue on the paper, pushing it down the box and putting the tail-plane or rudder on to the plug and withdrawing it before the glue could set.

Another way of making the fin and tail-plane detachable is to have them fixed together and to the top of the fuselage, and have this top half of the fuselage detachable. If we look overleaf at the drawing of the Kestrel Trainer, we can just distinguish this feature. If we look carefully we can see two fuselage formers just in front of the fin; one is marked H and the other J. H is attached to the fuselage proper, and J is fixed to the detachable part. Just below the letter J we can see two longerons, one of which passes right down the fuselage to the sternpost, and the other is from former J to the fin post on the detachable part. There is a view just below the fuselage of locating strips, with an arrow pointing to the point where the longerons are broken away, to show the motor attachment. These locating strips can be balsa, about $\frac{1}{8}$ in. × $\frac{1}{16}$ in., and are glued to the inside of the detachable longerons to butt against the main longerons to prevent the top part from sliding about. This unit is held in place with rubber bands fastened to the fuselage and fitting on to hooks on the detachable part. We can see these hooks on the drawing; there is one on each side, fastened to former J, and marked rubber fixing; and another one on the fin post against the word "hinge."

Although it is best to have the tail surfaces fixed so that there is nothing to get out of trim, it is sometimes useful to have some sort of trimming device, which is usually a part of the surface made to hinge. The most popular method is to use small pieces of aluminium plate or soft iron wire let into the balsa to act as hinges. We can then move the hinge, but it will stay put. Another method is to make the elevator or rudder a tight fit between two ribs, and in the end put a short pin to act as a hinge. If it should not be tight enough, a paper washer will remedy matters. These hinges are shown in Fig. 46a.

In fixing the tail-plane and fin we must get them square and true with the fuselage. This is best done with some form of jig, which can be blocks of wood, books, tins or anything that

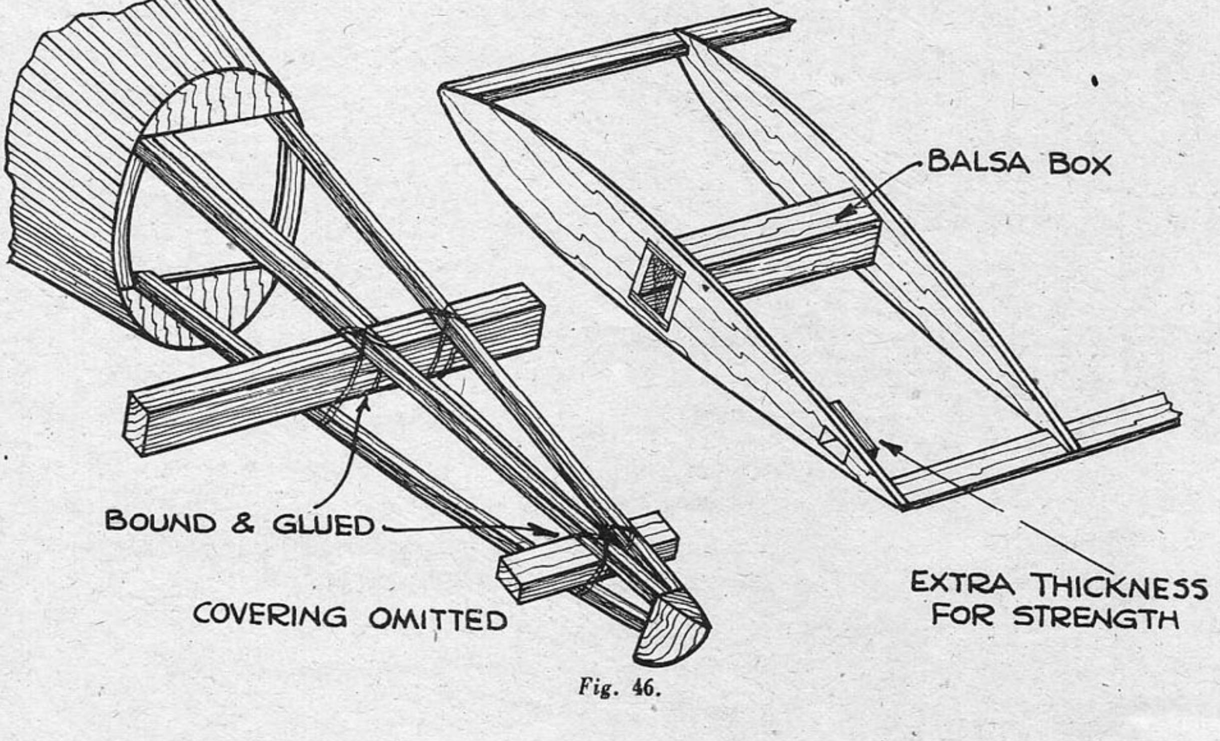


Fig. 46.

Here is Mr. Howard Boys with two tail-less models of his own design. They hold the British records in their class, one for hand-launched flight and the other R.O.G. Mr. Boys successfully treats his scale models very much like tail-less machines for stability, the idea being that a very small tail-plane is little better than none.

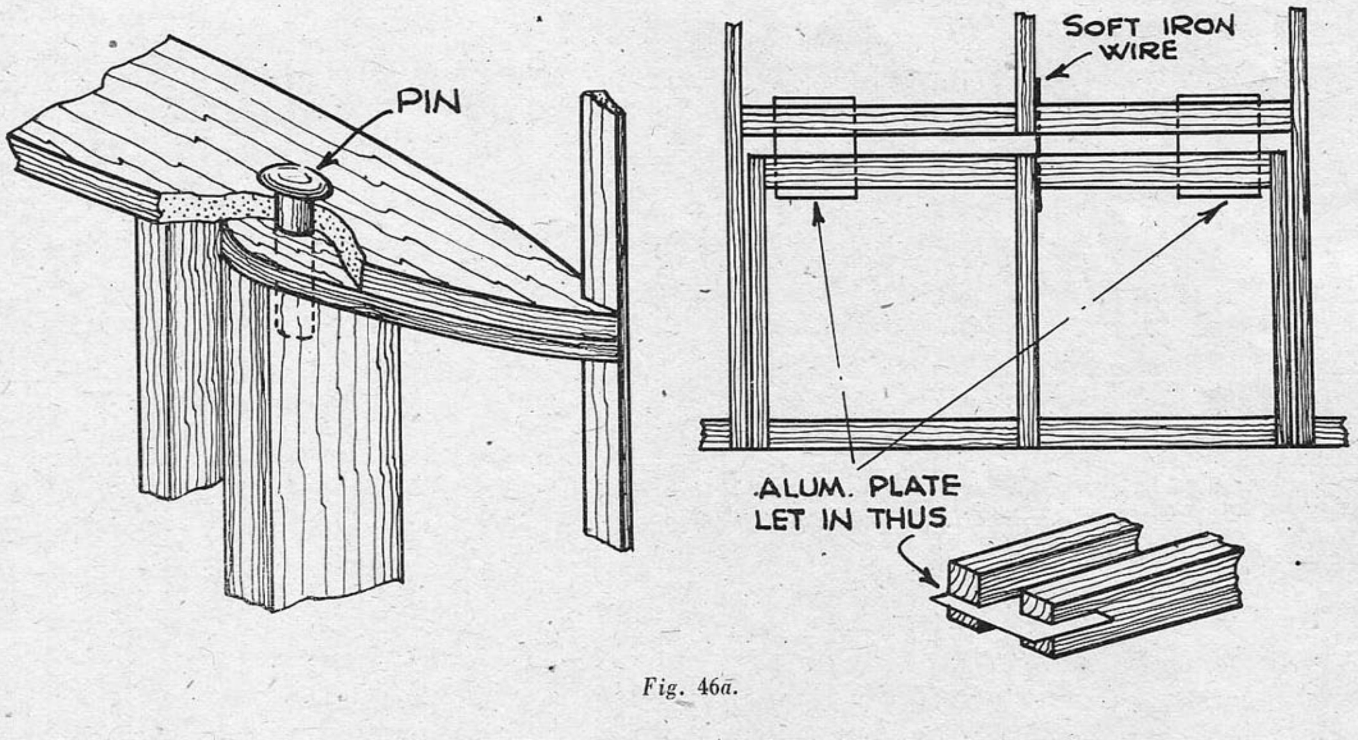
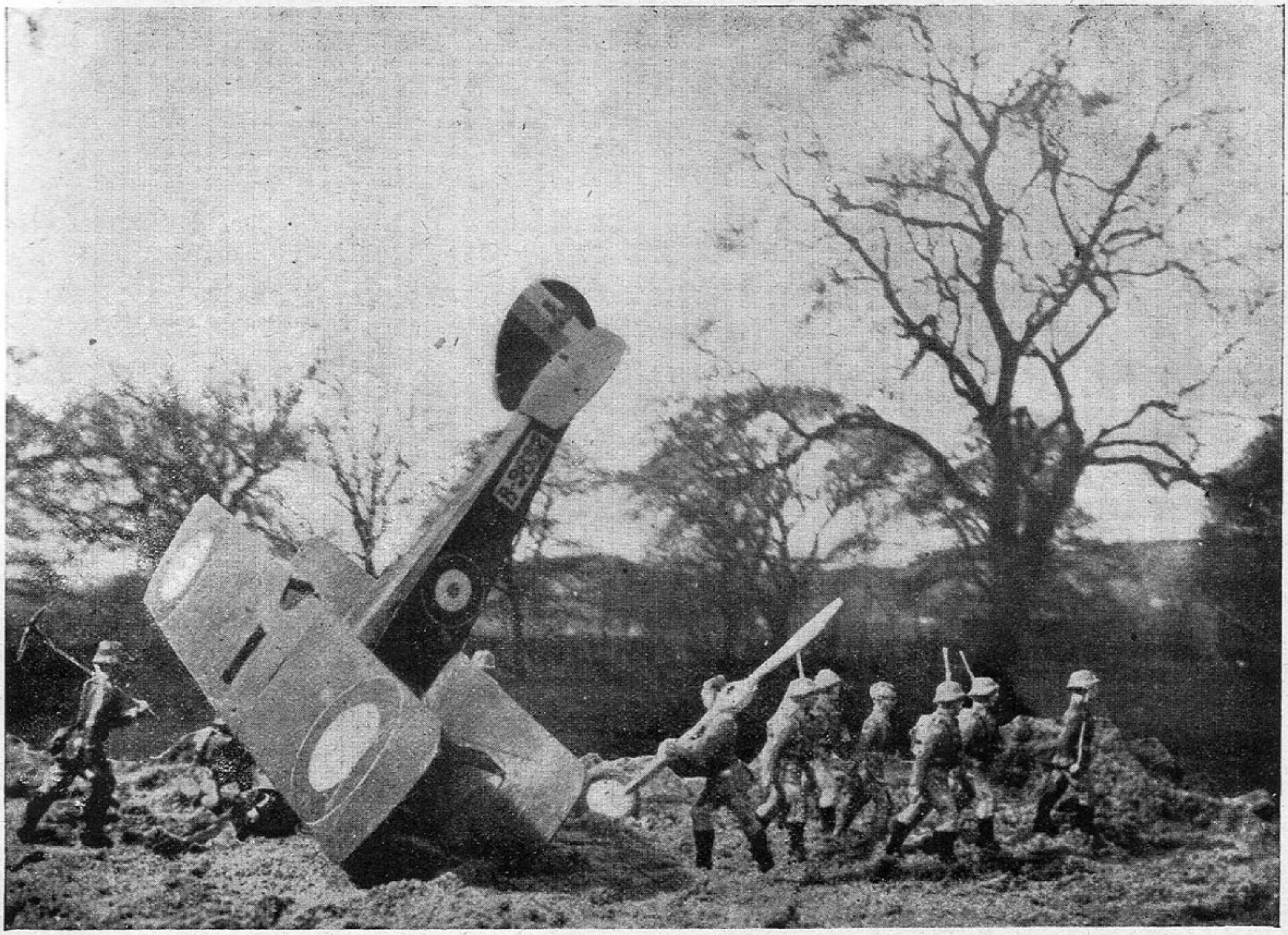


Fig. 46a.

will stand up on a flat table, and small wedges of balsa can be used to give a final adjustment. A piece of thread tied at the top, with weights on the ends, can be used to keep the fin upright. It is best to pack up the rear of the fuselage until the centre-line of the tail-plane is level. Take measurements carefully, and do not trust to what seems right to the eye. Measure from the table to get the tail-plane level, and to get the fuselage and fin upright a setsquare will be most useful. When all is set up true we can touch the parts to be glued with a spot of glue on the end of a piece of wire and spread it along the joints very carefully. A photograph showing a set-up as here described is on page 101.

THE REAL THING?



The photograph shows a Sopwith " Camel " which has crashed behind the German lines. The pilot is being marched off under escort, whilst the propeller and other parts are salvaged. An excellent example of " table-top " photography staged by Mr. J. H. P. Green, of Dundee, who took the photograph and also constructed the model.

Chapter XVI

CARVING AIRSCREWS

MAKING BLANKS. CUTTING FROM BLANKS. BALANCING.

Carving airscrews is by no means as difficult as a good many aero-modellers seem to think. It is necessary to have patience and take care, but apart from that there is little in it.

We have already seen how to mark out a blank, and this is then cut out carefully to the outlines. For this job we can use a bow-saw, or, on small propellers, it can be done with a knife. We can, of course, buy propeller blanks, but these are usually made to shape to suit duration type models, which require a large diameter, and consequently large pitch, and they are therefore unlikely to be suitable. That does not mean they will not fly the model, but that the model will not fly at its best. To get the best will probably mean trying two or three different pitches, and to get the most suitable one we shall almost certainly have to carve it ourselves.

It will be most convenient if we can have a large wood block clamped to the table or bench, on which to work, as shown in Fig. 48, which also shows useful tools for the job. Now in Fig. 49 we see on the left a blank with two lines marked A, which we draw about $\frac{1}{16}$ in. from the corners. We want to be careful which corners we choose, as they make a difference to direction in which the propeller revolves. Using the corners shown, we get a propeller that revolves anti-clockwise when viewed from the front, and this is the way that is easiest to wind up. Across the blank, from one line to the other, we make a series of saw cuts, as shown in the second view, and carve away the shaded part. If you have no chisel, do not worry, a pocket-knife is quite good. In fact the writer rather likes a pocket-knife for the job, in spite of the fact that he has been told that pocket-knife carpenters never go to heaven, and at one time he was employed for six months as a woodworker! Well, having cut away the corner, we smooth it down with a rasp or sandpaper. We turn the block over now and mark the lines B. On the top face (or widest) the line should be about one-quarter the width of the block. This gives the triangular blade section seen in the end view. We make more saw cuts and cut away the shaded part again, and smooth off. This time we do

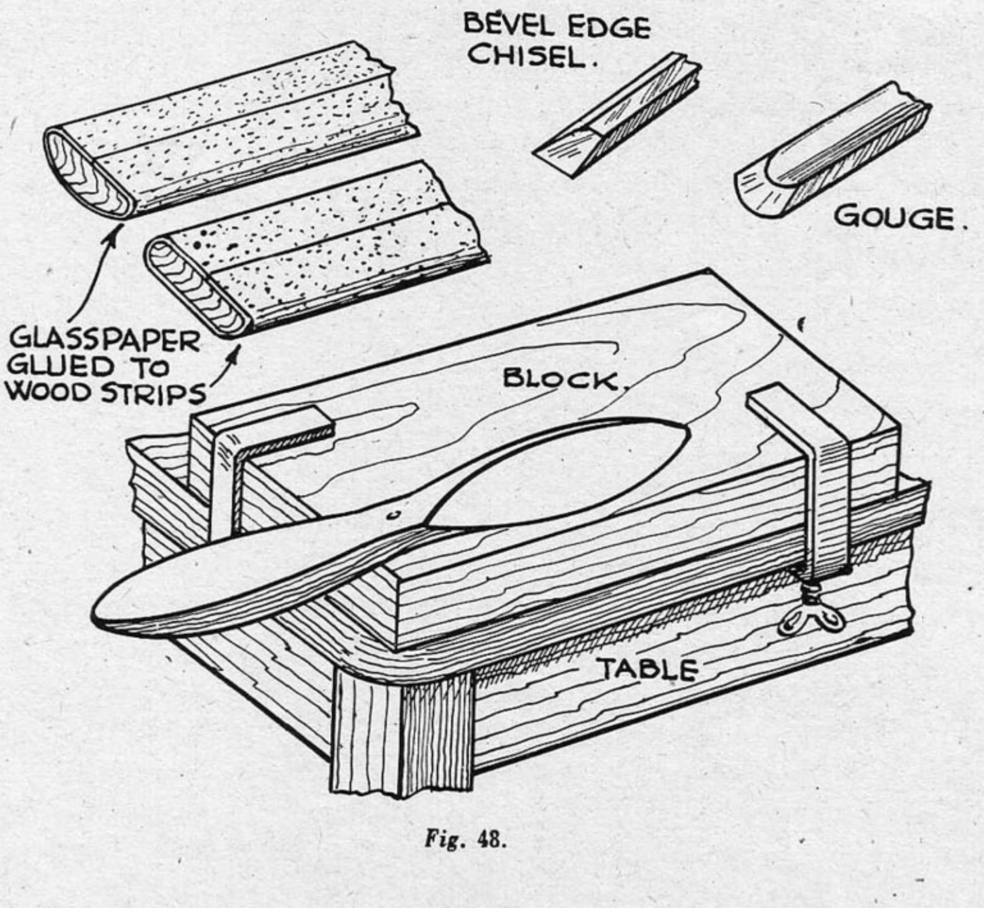


Fig. 48.

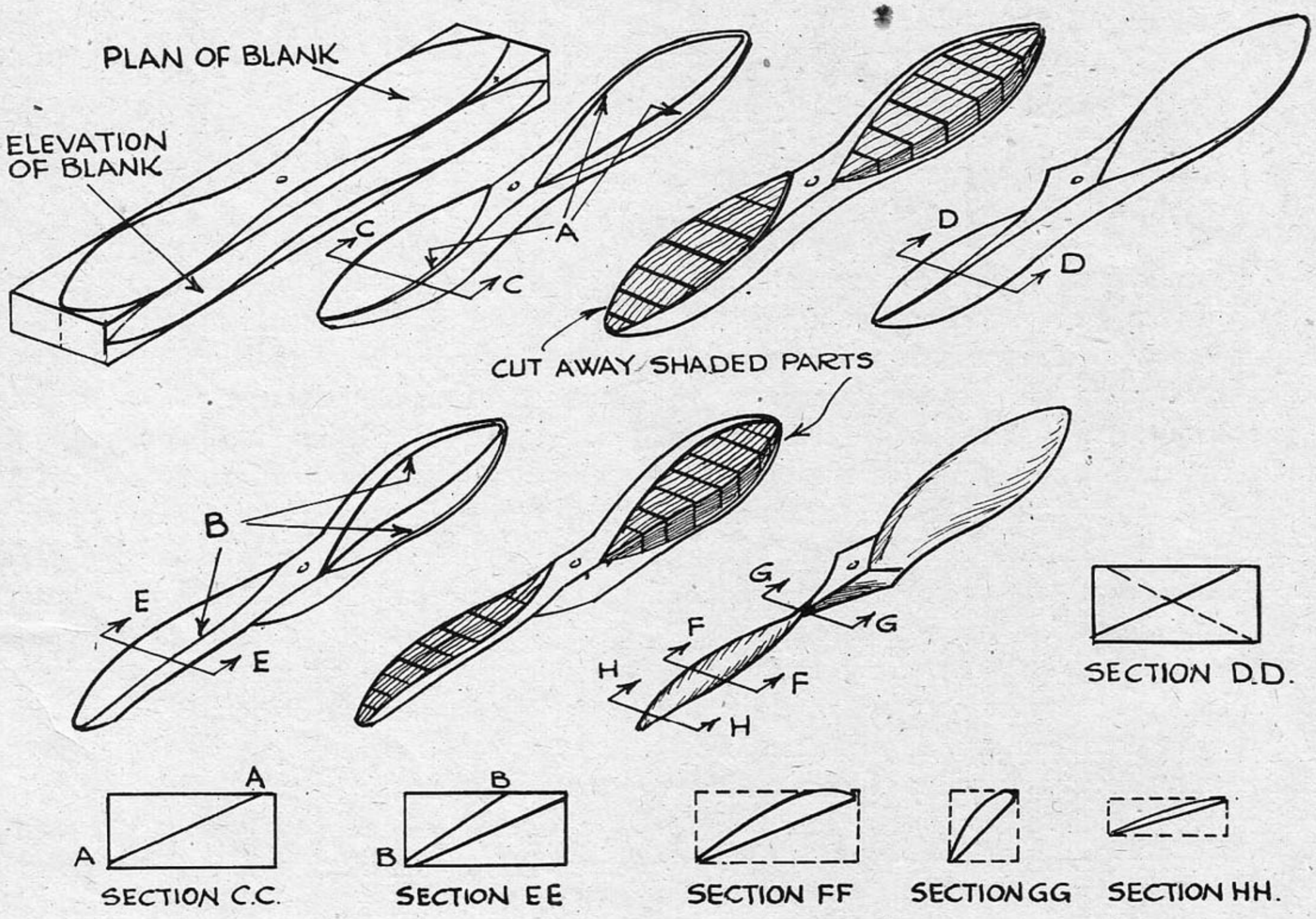


Fig. 49.

not make it flat across, but rounded, as seen in the end view, and also at AX in Fig. 50. We can, if we like, make the rear face hollow, as at BX, but it is doubtful if there is any advantage in this. Note the similarity to wing sections. In fact a wing section here is very good if we can manage it. The next job is to balance the airscrew, which should be done to the best of our ability.

A good way to get the balance right is to drive a strong needle into our block of wood, to use it as a spindle, with the propeller free to revolve on it. Now if we mark the blades A and B and revolve the airscrew slowly by hand, we can note which blade stops at the bottom. This blade, then, is the heavier, and must be lightened by sanding as near the tip as possible. Try for balance again and keep on till both blades are the same weight, and come to rest horizontally. The airscrew may not be properly balanced even now, so let's see what we can do about it. Rub off the old marks A and B and put on new marks AA and BB. See Fig. 50 again, and note that AA is for one whole side and BB for the other. If side AA always comes to the bottom we shall know it is the heavier, and we must sand all along that side from tip to tip. If side BB always comes to the bottom we shall have to sand that all along. We keep on like this until, when the airscrew is perfectly balanced, it will come to rest in any position. We can finish the airscrew by lightly sanding all over with very fine glasspaper and polishing or painting as desired.

On a lot of aircraft nowadays we find three-bladed airscrews are fitted, so we may wish to make one of these. The best way is to make each blade separately, and all as nearly alike as possible, and mount them in a boss or hub. Each blade should be marked out and carved as before, but the inside end should be made rounded. For the hub we can use two discs of wood about $\frac{1}{4}$ in. thick, grooved to take the blades. These grooves can be cut square at first, and then rounded with a piece of glass-paper wrapped round a nail or thin pencil. We want to be able to turn the blades to get the pitch right, but they must not be loose in the holes. To get them properly in place, with the angles correct, we shall find a chock handy. This can be cut from $\frac{1}{16}$ in. or $\frac{1}{8}$ in. sheet balsa and should give the angle at about two-thirds from boss to tip. We then lightly glue it to a board and mount the air-screw on a pin, as shown in Fig. 51. We can set the angle of

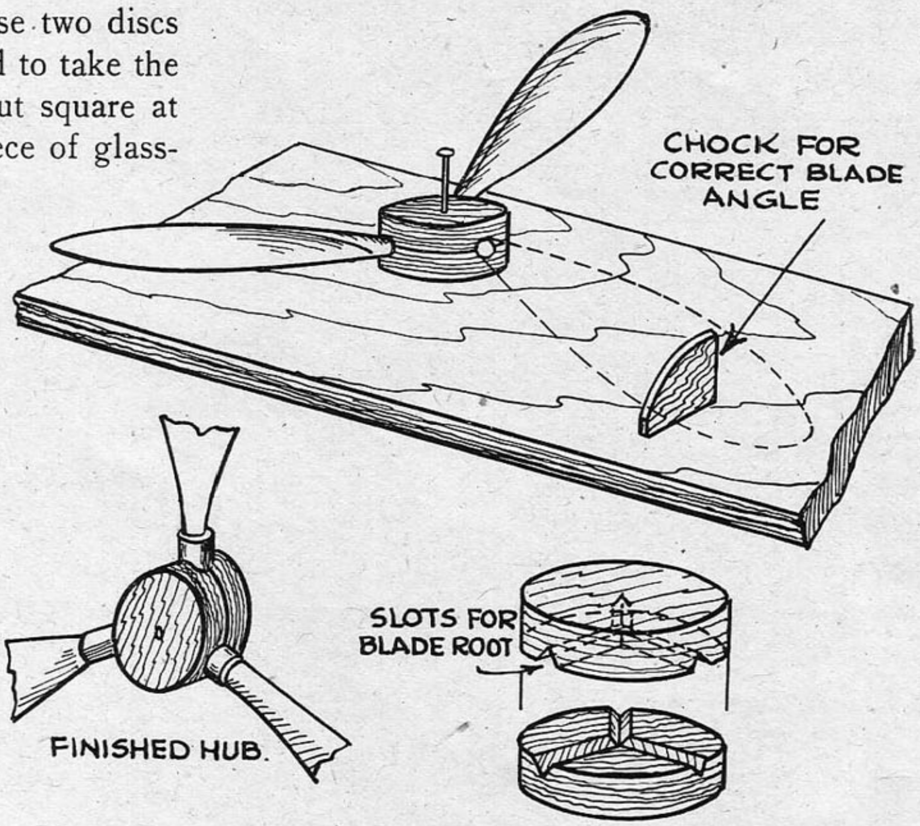


Fig. 51.

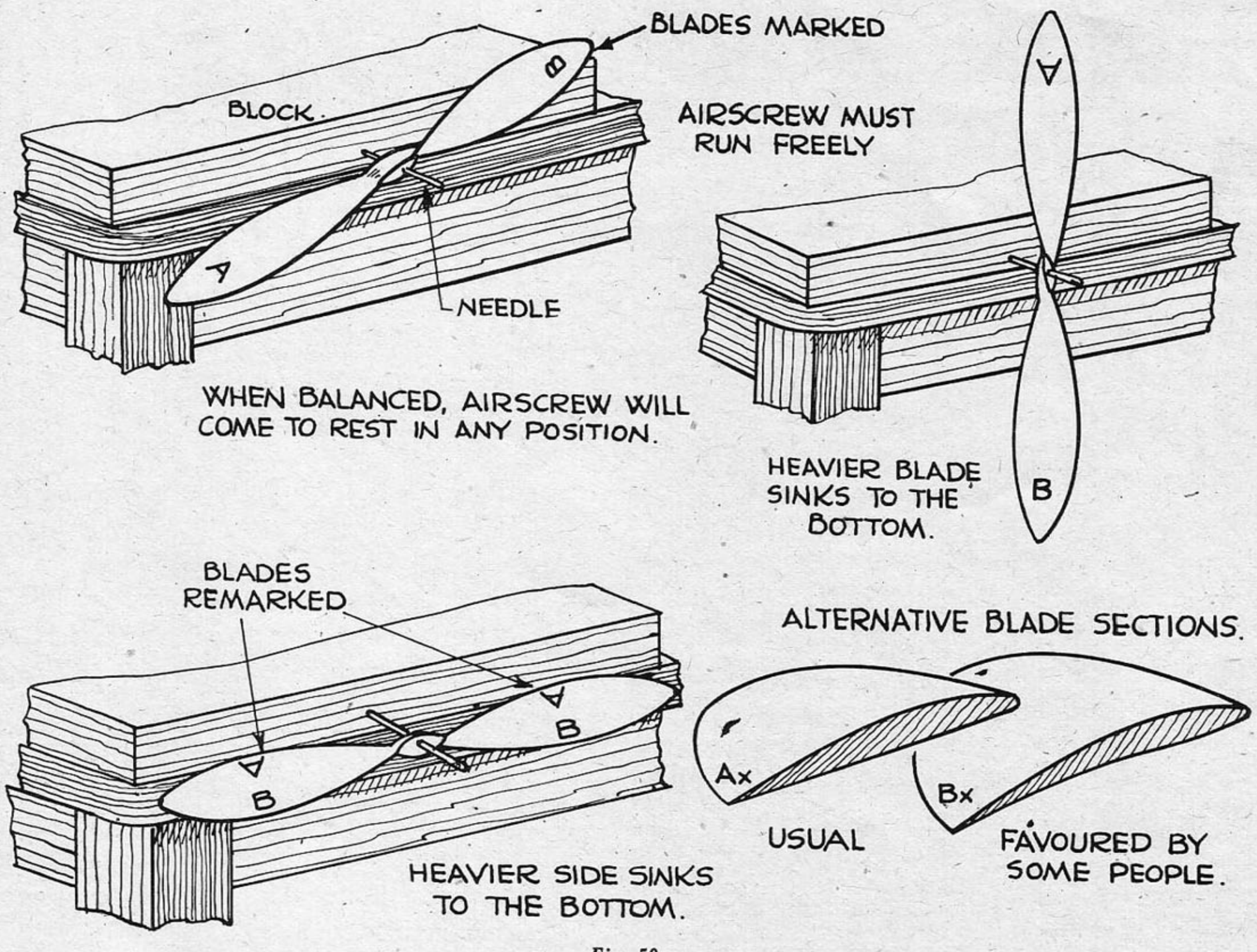
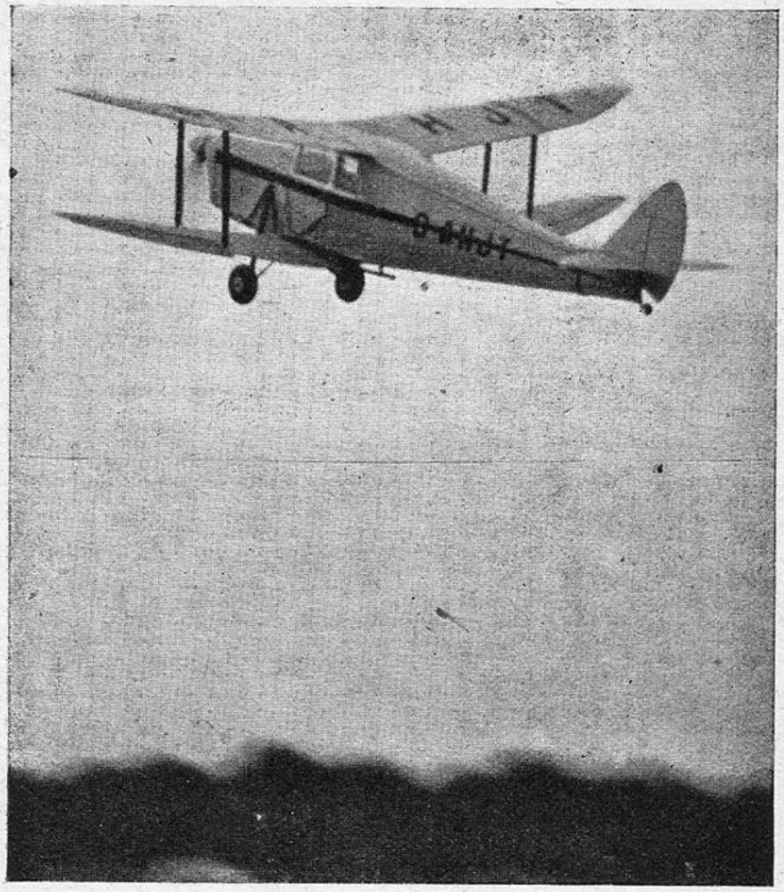


Fig. 50.



This photo shows another of Mr. Towner's models in flight—a De Havilland " Hornet Moth."

each blade by revolving the airscrew so that each blade in turn is brought on to the chock. For glueing this the slow drying type is, of course, the stuff to use.

Another method by which we can make a three-bladed airscrew would be to leave the hub end of each blade rectangular. For two of the blades we could use a two-blader cut across the middle. These blades could then be fixed between two discs of $\frac{1}{16}$ in. sheet balsa or ply, in which case the blade angle would be right straight off. The spaces between the blades should be filled with sectors of balsa and the boss carved to the desired shape. The blades should, of course, be spaced accurately. We can do this easily by drawing a circle the same diameter as the airscrew, and, using the radius, divide the circle into six equal parts. Three of these points will now be the position of the blade tips.

CHAPTER XVII

NOSE-PIECES

GEARBOXES. SIMPLE NOSES. FREE-WHEELS.

ONE of the most easily constructed types of gearbox is that shown in the drawing of Mr. Towner's Miles Kestrel Trainer M9. This drawing is rather small, but a similar type is shown in Fig. 52. We have a very fine photograph and sketches of a first-class gearbox designed and built by Mr. C. J. Burchell. It is the sort that would be very suitable for a model with " Gipsy " engine. Four gears are shown, but we can make this type with two or more.

The back plate is the most difficult, and most important, so let us do that first. Fig. 53 shows the shape, and it is cut from $\frac{3}{16}$ in. ply. Lay a rule on the ply and mark a line along the centre with a strong pin, needle or compass point. Near the top we drill a hole $\frac{1}{16}$ in. dia. for the spindle. We shall be using 16 s.w.g. wire for the shafts, as this is the size that suits the holes in the gear wheels. To get the position of the next hole, we put the first gear wheel in place, and push the second up to it so that the hole is over the centre line and the teeth are in mesh. Through the hole in the second gear we drill a $\frac{1}{16}$ in. hole through the ply.

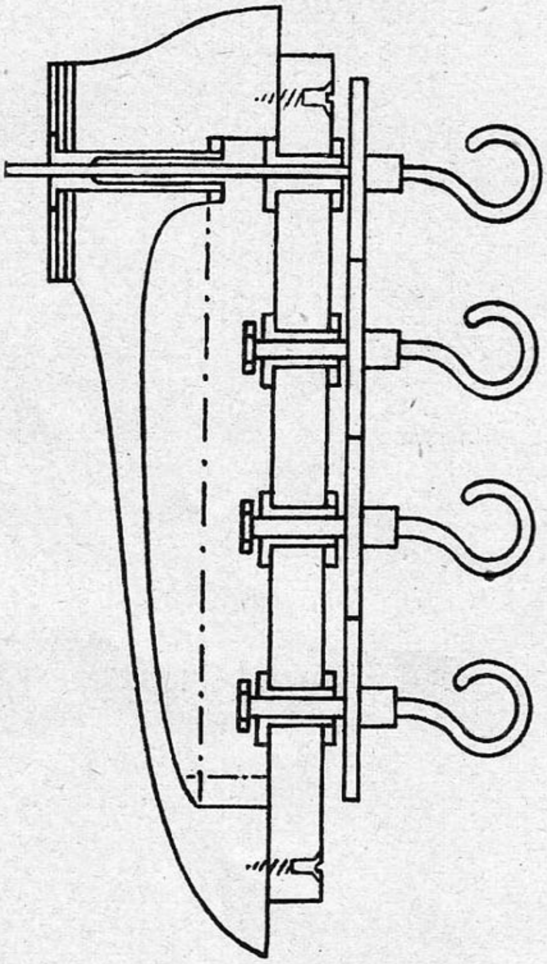


Fig. 52.

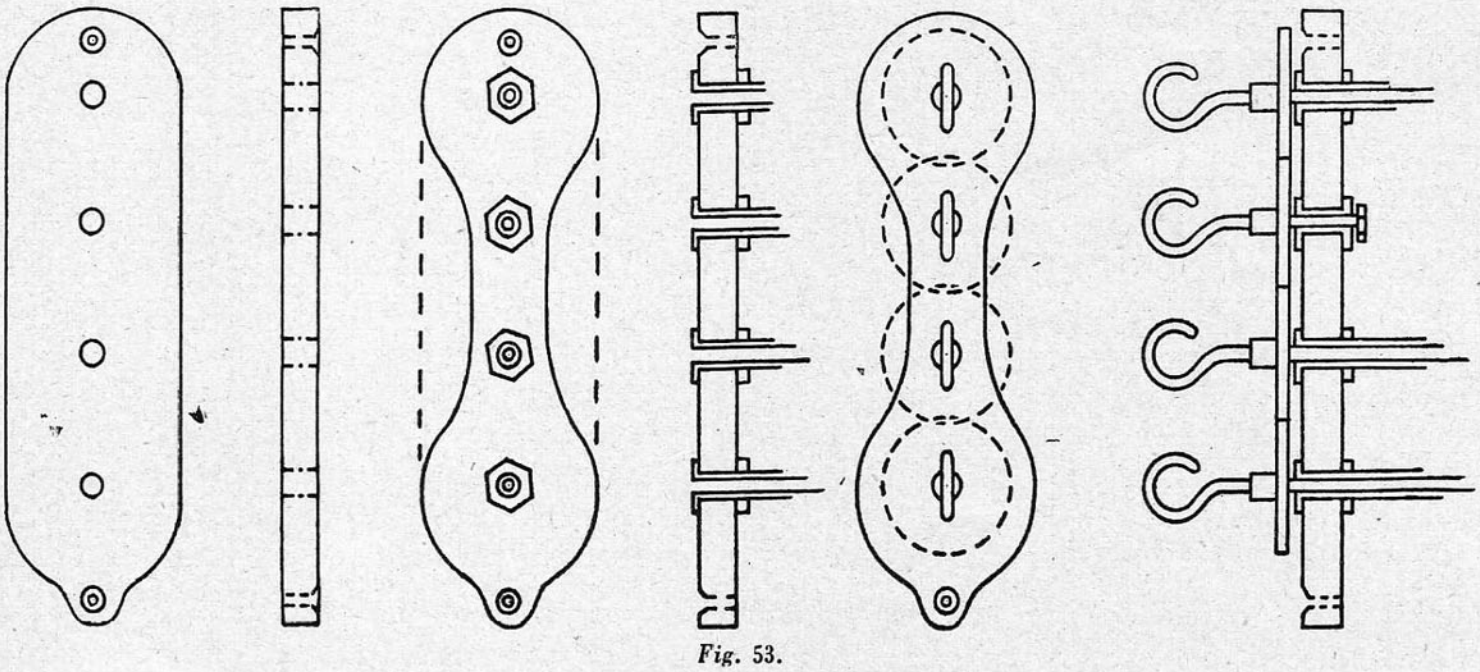


Fig. 53.

Holes for more gears are drilled in the same way. We also drill holes for the wood screws for fixing the back plate to the front or nose-block. The holes for the spindles are now drilled out large enough to take screwed bushes, which are pushed through and fixed with nuts. The bushes can now be cut short and glue put round the nuts to stop them unscrewing. Before going any further we had better see if the holes are in the right place. Put the gears on the spindles with the spindles through the bushes, and see if the gears will turn fairly easily. It is best for them to be a little bit tight, and if they are very tight, or if there is much play between the teeth, it is advisable to start again with a new piece of ply. If they are all right—as they will be if we have worked carefully—we can carry on. The gear wheels are soldered to the spindles, and the spindles put through the bushes. On the ends of the spindles we can solder cup washers or small brass nuts, except on the shaft that takes the propeller. This is left free for the time being to allow us to fix the top wood screw. The next thing to receive our attention is the nose-block, which can be made of some hard, or medium hard, wood like walnut, bass or spruce. Fig. 55 shows how we start with a rectangular block and cut away the outside and hollow out the back. We can best find the position for the hole for the propeller shaft by putting the back plate on first and drilling through the top bush with a $\frac{1}{16}$ in. drill. At the same time we can try the gears to see that the shafts are not catching on the inside of the nose-block. Now we take off the back plate and drill out the nose-block, and fit another bush. You will notice that a step has been left in the hollow part for the nut, fixing the bush, and the bush has been drilled slightly larger nearly all through to decrease friction on the shaft. Also we glue a disc of ply to the front to come flush with the face of the bush. A spot of glue on the nut will prevent it unscrewing. Now we can glue and screw the back plate to the nose-block and put in the top shaft. On this we thread a cup washer and solder on a driving disc, wire loop, or whatever we intend using to drive the propeller. On page 24 is a photograph of the finished gearbox.

To fit this gearbox to the nose of the fuselage, we can use a piece of $\frac{1}{16}$ in. or $\frac{1}{8}$ in. thick ply cut to the outline of the nose, with a hole in it to fit the back plate. This is glued on to the nose of the fuselage.

The simpler type of gearbox is made in much the same way as the one just described, but instead of a back plate of $\frac{3}{16}$ in. ply fixed to a nose-block we use two pieces of $\frac{1}{8}$ in. ply, glued and held together by the bushes. The front piece is the same size and shape as the front of the fuselage, and the back piece is a bit smaller, to fit in a piece of ply glued to the front of the fuselage. We drill the two pieces of ply as before, and put the bushes in with the nuts on the back, and leave them long.

These bushes can be held in place quite well by covering the nuts and faces of the ply with Durofix. The gears are put on the shafts or spindles as before.

Another method of building gearboxes is shown in Fig. 56. It is the type that never seems to wear out or go wrong, and the writer has had a number of years' service from one box so constructed. The two plates are of brass about 20 or 22 s.w.g., and we drill them with $\frac{1}{16}$ in. holes to suit the gears. We mark the positions in the same way as we did for the first type, and when drilled $\frac{1}{16}$ in. in the right place we open out the holes to $\frac{1}{8}$ in. Into the two plates we solder two short lengths of $\frac{1}{8}$ in. outside diameter brass tube of a fairly thick gauge. We can usually get this more easily from ironmongers or model engineer shops than from model aeroplane shops nowadays. The tubes then are soldered into the plates, and should project about $\frac{1}{32}$ in. at each end. The smaller plate is to keep the tubes the correct distance apart near the gears, and so need not be very big. About $\frac{1}{4}$ in. wide and about $\frac{1}{2}$ in. longer than the distance between the shafts is all right. We can either use ready-made shafts or make them from 16 s.w.g. steel wire, and solder the gears on. We drill the tubes with a $\frac{1}{16}$ in. drill and see that the shafts