CHAPTER IX

RUBBER MOTORS

It has been a matter of some difficulty to decide how this chapter shall be handled. Most literature on rubber motors becomes a list of technical formulae which can only be of interest to the mathematical mind. There exists, however, a large body of constructors that has neither the time nor the inclination for mathematical problems. The constructors in this group are by far the most numerous, and are those that require a rough and ready "rule of thumb" guidance; arriving at their conclusions by personal experiment.

The reason why these aeromodellists are so neglected is the very good and sufficient one that there exists no short method by which the amount of rubber required to fly a given model may be determined. This must be obvious when one reflects that the factors of weight, wing-loading, speed, propeller size and pitch, and, lastly, the drag all have a voice in the matter. The skilled builder and flyer knows by experience the approximate power required for any machine, basing his opinion on the requirements of previous aeroplanes.

As a considerable mass of mathematical data has been accumulated on the subject in the past few years, we have decided that any sketchy outline, such as could be included in this book, is worse than useless. We have, therefore, refrained from giving any mathematical statement of the case, especially as most of the formulae and results have been published from time to time, and should still be available to those interested. The alignment chart in Fig. 105 will give some idea of the safe number of turns which a given motor will accommodate. By placing a straight edge across any two known values, the third may be read on the remaining column.

Theoretically, the number of turns which a given length or weight of rubber will take is in inverse proportion to the number of strands in which it may be used. Actually the case is less favourable, as the following example will show.

A skein composed of two strands of rubber will accommodate only 70 per cent. of the turns that a single strand of the same length will take. The torque or turning force will, however, be increased to 2.8 times that of the single strand. If four similar strands are used, the possible number of turns will be half that of the single strand, but the torque will be increased to eight times that of the single strand. The more turns which can be put into a motor the longer a propeller will run. From the above it is clear that increasing the strands of which a rubber motor is composed reduces the traction duration of the propeller, but makes the turning force greater.

These properties of rubber motors have a decided effect on the design of model aeroplanes. The duration 'plane, for instance, is affected as follows :

We know that the greater the speed with which a wing is moved through the air the greater the lift obtained, which means that a greater weight of machine may be sustained in flight. Conversely, the lighter the model the less speed is required to sustain it. Less speed may be obtained by using a slowly revolving propeller, which will obviously require less power to supply the torque or turning effort than the same propeller running at a higher speed. We have seen that the fewer the number of strands of which a rubber motor is composed the less torque delivered, also the greater the number of turns which may be put into the motor. As the duration of motor run goes up with the number of turns employed, we arrive at the golden rule that duration 'planes must have a light wing-loading, which, because of constructional and landing problems, means that a light model aeroplane is necessary.

On heavily-loaded machines high flying speed is essential. This requires a high thrust from the propeller, demanding large power and torque at the expense of duration. This is well illustrated in the model speed aeroplane, which literally hurls itself through the air by a great application of power for a few seconds.

As these questions are closely linked with the problems of propellers, this chapter should be read in conjunction with Chapter X.

It must not be overlooked that if a given machine is required to fly twice as fast, the power necessary will be eight times greater ; the power required being proportionate

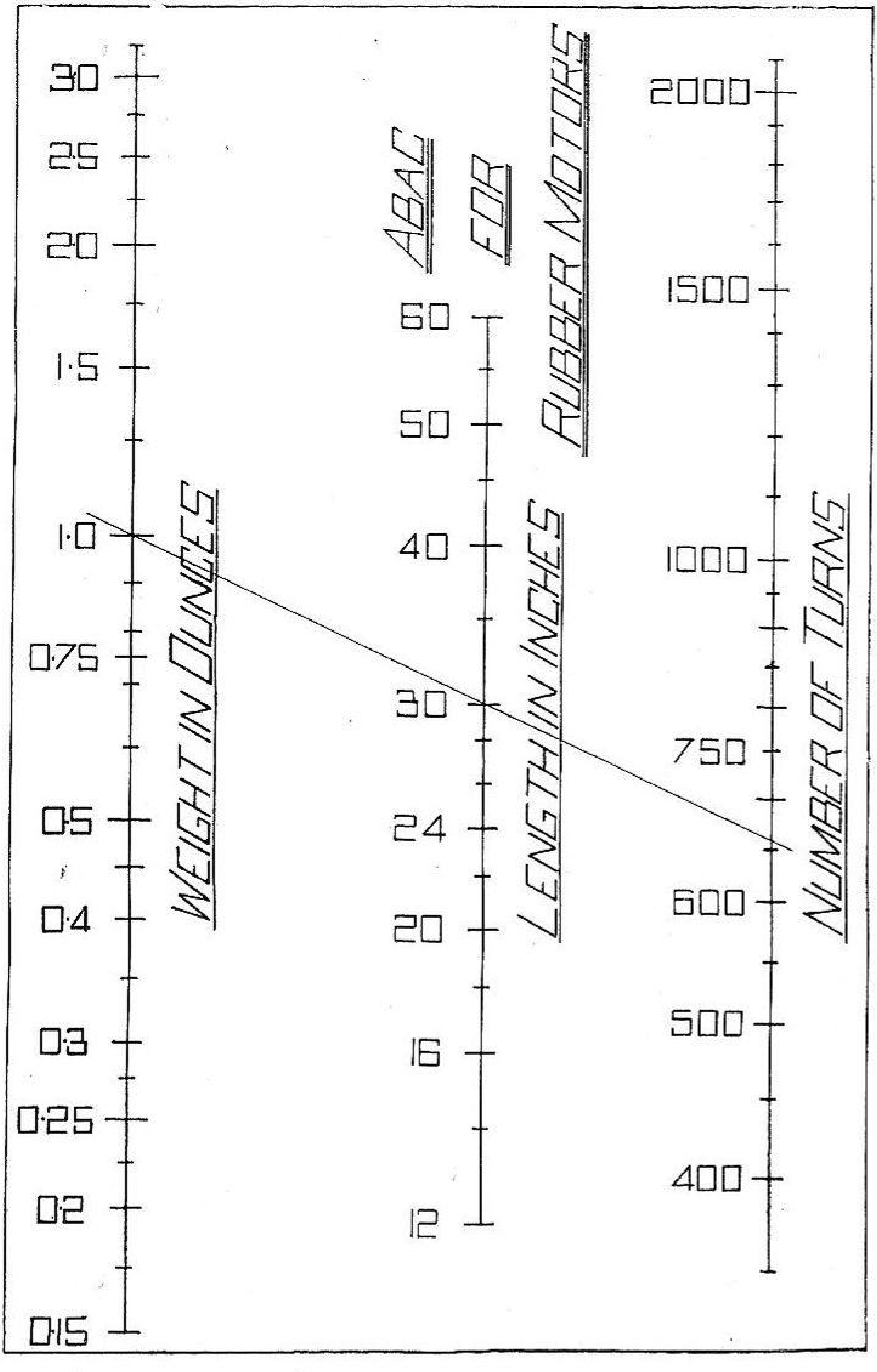
ABAC FOR RUBBER MOTORS
WEIGHT IN OUNCES
LENGTH IN INCHES
NUMBER OF TURNS
3·0
2·5
2·0
1·5
1·0
0·75
0·5
0·4
0·3
0·25
0·2
0·15
60
50
40
30
24
20
16
12
2000
1500
1000
750
600
500
400

Fig. 105

to the cube of the speed.

If a motor of a given number of strands is doubled in length, the number of turns which may be put into it will be doubled also, as the possible number of turns is in direct proportion to the motor's length. We shall do well, in view of this, to make the fuselage as long as possible, that it may contain a motor of maximum length. It is usual to employ a motor which is one-quarter as long again as the distance between the rubber hooks, and the motor should be stretched to two or three times its normal length when being wound. This will raise the number of turns above the number

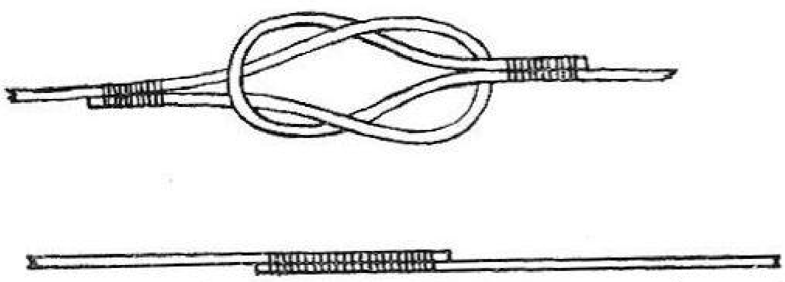

Fig. 106

possible if the motor is wound unstretched. The torque will also be considerably increased.

To obtain a long motor run and yet retain a sufficient torque, two or more thin skeins of rubber may be geared together. The results obtained from geared rubber skeins are not so favourable as one might at first imagine. It is true that if a skein of a given number of strands is divided into halves which are geared together, the possible number of turns will be increased. Unfortunately, this does not mean that a longer duration of flight will necessarily be obtained. This is partly due to the power loss in the gears themselves, but chiefly to the extra weight which the gearbox and extra fittings add to the machine.

This increase in weight will mean an increase in speed, possibly making a stronger undercarriage necessary, again adding to the weight. We may then arrive at a point where an actual increase in the amount of rubber is required ; the original number of strands being insufficient to provide the power necessary to turn the propeller at the higher rate of revolution which the faster flight demands. Although we have only considered the effect upon the flight duration due to the actual propeller run, the *total* time of flight may be still further reduced owing to the faster gliding speed of the machine.

Rubber for the propulsion of model aeroplanes is obtainable in several widths ranging from 1/32nd to $\frac{1}{4}$ inch. The thickness varies according to the width. The rubber generally employed in this country is known as "brown rubber." The Americans, by the way, call this "black rubber," their own brown rubber being much lighter in colour. One should remember this when calculating from American formulae, which usually states whether black or brown rubber is concerned.

The best method of joining rubber is by means of a reef-knot, as shown in Fig. 106. When the knot has been pulled tight, the ends are bound with floss-silk, the rubber being well stretched whilst being bound. The ends of light rubber motors may simply be bound together with floss silk, as in the lower illustration in Fig. 106. Rubber should always be stretched whilst binding, and the join made before the rubber is lubricated, otherwise it will slip when the rubber is wound.

Good rubber will stretch to eight times its length without harm, and will return to its normal size when released. Nevertheless, it may be stretched beyond the safe point, when it will remain, to a certain extent, in a stretched condition. This causes rubber to become fatigued after repeated windings, when not so much power may be stored in it. One pound of new rubber will store 3,500 ft. lb. of energy, and it should be noted that if only 80 per cent. of the maximum turns are applied, only 2,000 ft. lb. of energy is stored. As the last few turns impart so much energy, it is desirable to give a rubber motor as many turns as possible for competition flying and record attempts. This maximum must be gradually attained.

Gears

Gears, for many reasons, have fallen into disuse in recent years. One of the reasons, although not the most important, is their reputed unreliability. How often has one chuckled at the whirring of an unwinding skein, and remarked to one's neighbour, "Aha! another gear gone west!"

This has been due, in the main, to the inability of the average constructor to build an efficient gear, and, in particular, to the inability to solder the brass gears to the shafts.

As gearing is essential on large, heavily-loaded models, especially of the racing type, a brief description of a method of making an exceptionally strong gear is given.

A piece of 18 S.W.G. mild steel, about ½ inch wide and 4 inches long, is folded in halves, as in Fig. 107, and the positions of the holes for the shafts and screws marked upon it.

These holes may now be drilled. By cutting the metal along the fold, or by filing, two plates will be obtained, in

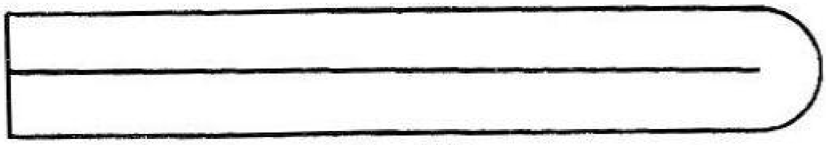

Fig. 107

which the holes are exactly positioned, if the handbrace has been held squarely to the job during drilling.

The correct distance between the holes may be ascertained by meshing the gear wheels, and measuring the distance between the *sides* of the spindle holes, taking, of course, two left-hand sides or two right-hand sides, as the case may be. This is more accurate than trying to guess the centres of the spindle holes (Fig. 108).

Before actually drilling the plates, a piece of tinplate should be drilled at the proposed distances, and the gears—mounted on the shafts—tested for mesh. A fresh template may be made if the holes are not the correct distance apart, and this is preferable to scrapping the whole job.

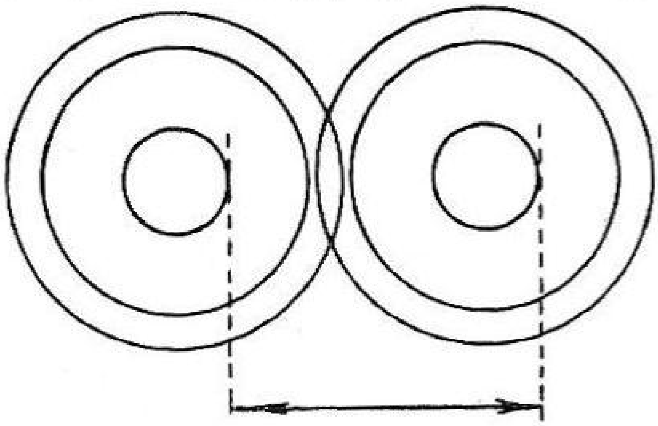

Fig. 108

While gears should run freely, they should not be too much out of mesh. On the other hand, it is a grave error to mesh gears too tightly, as the teeth will then "bottom," and great friction will result.

Now take the block of wood which is to be used as a nose-piece, and after screwing the front plate into position, carefully drill two holes through the block, using the plate as a jig. Pass the steel spindles through the holes in order to locate the back plate, and screw the latter into position. The plates are now removed, and the holes in the wooden block opened out to clear the spindles. These details take a little longer time to attend to than would be occupied by doing the job in a slip-shod fashion, but is the only way to secure reliability.

Now for the most important part of the job.

Steel knitting needles make the best and most easily procured shafts. They are cheap, accurate, straight and tough, and also have the advantage of being readily hardened for tool making. Take one of the needles of the required size, and carefully file it half-way through, as shown in Fig. 109. Now heat to a bright red, and plunge into water. This will make the steel reamer "dead hard." In this condition it cannot be used as a tool, for it is exceedingly brittle. Clean the point with a piece of fine emery cloth, so that any changes in colour may be seen, and hold the tool in a very small flame. As the steel heats up, colours will form on the bright portion ; first a light straw colour, chang-

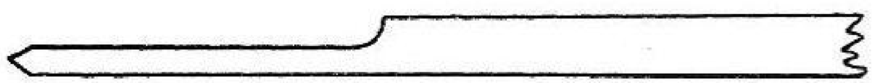

Fig. 109

ing to dark straw, then brown and finally blue. The reamer should be withdrawn from the flame immediately it becomes dark straw colour, and at once plunged into cold water. If you are not sharp enough, and the steel becomes too hot, re-harden it by heating to redness and quenching out as before, and again try the tempering operation.

In passing, it may be remarked that it is difficult to understand why amateurs are so afraid to try this very useful art of making and hardening small tools. The whole process is amazingly simple if the above directions are followed, and the amateur need never be at a loss for all kinds of small or special tools, which may be made from knitting needles, silver steel rod or old files.

To continue. Take the gear wheels, and slowly and carefully open out the spindle holes with the reamer you have made. Be sure that it follows the hole which is already truly drilled in the gear wheel. They will then fit perfectly, and run truly.

Now heat up the ends of the shafts to redness, and bend them to form the rubber hooks. Do not harden. Clean the shafts, and thread the gear wheels upon them. Apply a little *Baker's Fluid* or *killed spirits* to the spindles at the joint, hold the gear and shaft in a gentle flame, and, as the flux boils off, apply a stick of solder to *one side* of the gear. The solder *must* flow through to the other side. If it does not, the gear will sooner or later come adrift—probably sooner. Assuming that you have not made the solder run through, do not continue to heat the job until it becomes covered with oxide, and impossible to solder. Take the work out of the flame, and apply more flux on the side on which the solder has not yet appeared. *Do not* apply solder to this side, but carefully re-heat, until the solder does run through. When it does, you may be reasonably sure that it is so firmly fixed that it is possible to break the shaft by turning it (holding the gear in the vice), rather than turn the shaft in the hole. This can actually be demonstrated.

It will, of course, be necessary to place the backplate upon the shafts, between the gears and the rubber hooks, before the gear wheels are sweated on.

The gears and shafts are now assembled to the nose block, two cup washers are threaded into place, and the two gears

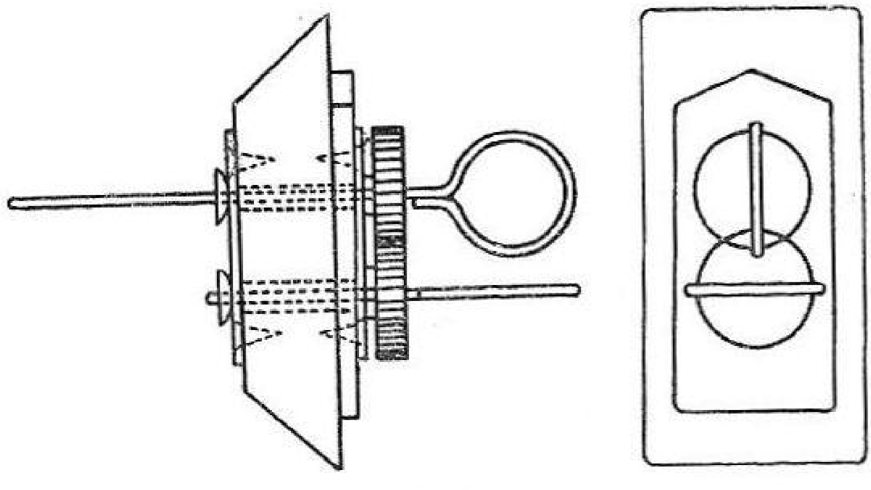

Fig. 110

ascertained to be in perfect mesh. With a soldering bit, apply a bead of solder to the washers to hold the shafts in place. No difficulty will be encountered with the solder running through the washers on to the plate, if care is taken to see that the plate is *not* clean. Fig. 110 illustrates this gearbox

The most frequent cause of failure of gear trains is slipping of the gear wheels on the shafts. This will never happen if the wheels are sweated on in the manner described. The mere melting of blobs of solder on to each side of the gear wheels will definitely not do. If the shafts are fitted by means of a special reamer made from a piece of the shaft itself, the joint will be as strong as if it were silver-soldered, and very much better for the purpose, as the hardness of the shafts and gear wheels will not be so much interfered with.

Multi-skeined rubber motors could form a chapter in themselves. They are used mostly in racing machines, where an enormous power output is required for a short period. In these machines, it becomes necessary to carry as much rubber as the fuselage can hold, and, at the same time, to

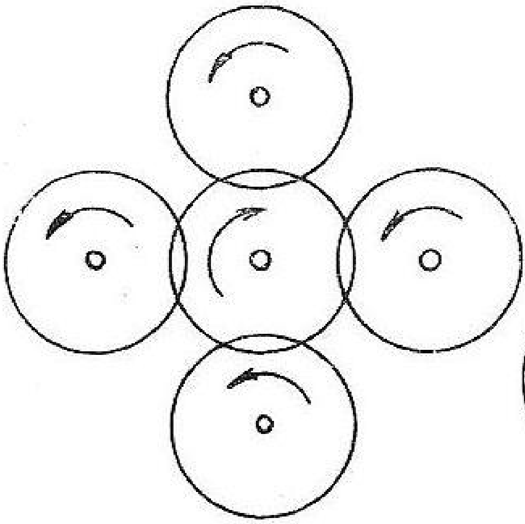

Fig. 111

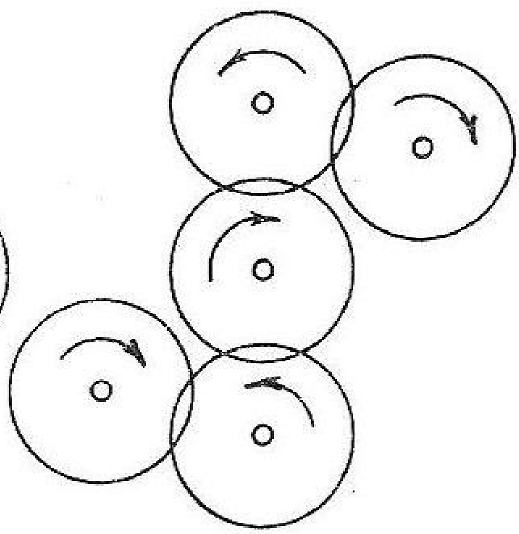

Fig. 112

put as many turns as possible into it. An arrangement wherein each skein runs in the opposite direction to its neighbour, is to be favoured. This not only decreases the torque effect upon the fuselage, but, more important still, does away with the tendency which each skein has to roll around its neighbour when all are running in the same direction. In Fig. 111, an arrangement of five pinions is shown, in which four of them run in the same direction. In Fig. 112, the same number of gear wheels is shown arranged so that each revolves in opposition to the next.

A simple twin skein gear may be made from standard components, which may be bought from the model stores. Complete gear assemblies may also be obtained quite cheaply. These are suitable for the light and medium-weight machines.

but will not stand up to the special requirements of the speed machine, which requires exceptionally heavy gears, stoutly made on the lines already indicated.

An efficient gear-box may be made by assembling the gears and shafts directly on to the nose block, in the manner shown in Fig. 113. No dimensions are given, as these will naturally vary with the size of the gear-box required. The bearings consist of screwed brass bushes, which are located in holes in the nose block and nutted at the back. The brass gear wheels are sweated on to the shafts, which may be of piano wire or steel rod, and care must be taken to ensure that the gear teeth mesh correctly. The shafts are retained by means of cup washers soldered on to the shafts. These washers also take the thrust.

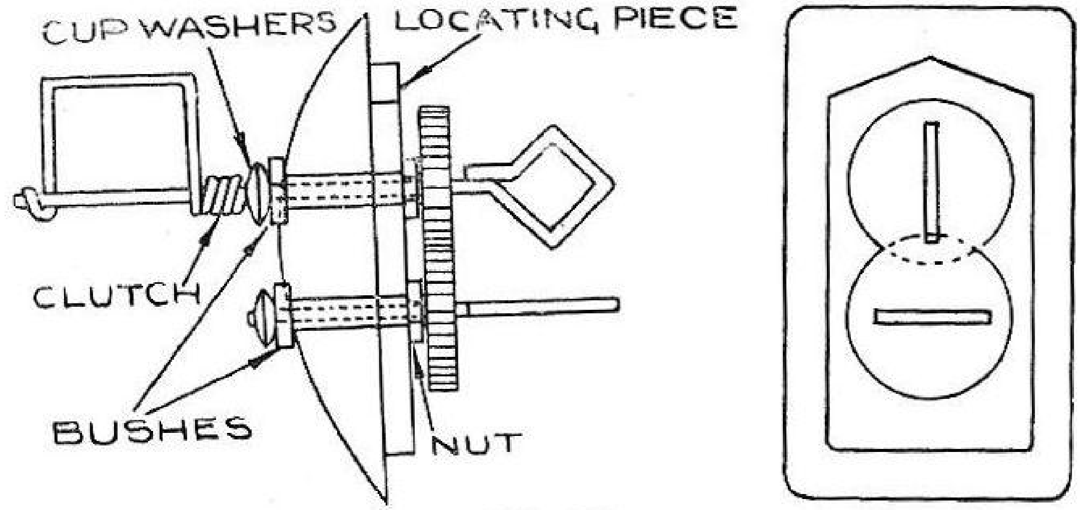

Fig. 113

An effective propeller clutch is also shown; this is also sweated to the shaft. The rubber hooks illustrated are of particularly good design, as the rubber motor does not tend to slip off the hook so easily as is the case with circular hooks. Hooks, both front and rear, should be covered with cycle valve tubing, to prevent cutting of the rubber motor.

Tensioning Rubber Motors

In order to obtain as long a propeller run as is possible, it is, as already pointed out, desirable that the rubber motor used should be considerably longer than the distance between the points of anchorage within the fuselage. In the old days, this meant that the exhausted skein lay in a jumbled mass in the fuselage, when its power was expended, with disastrous results to the stability of the aeroplane, due to the uncertain position of the centre of gravity.

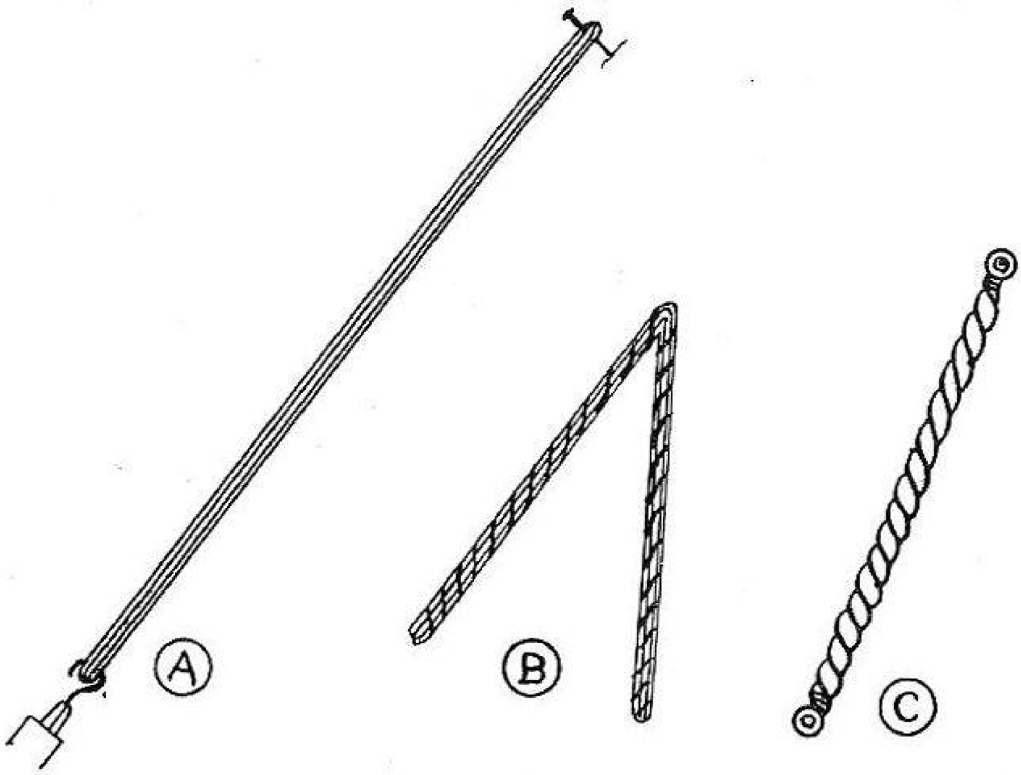

Fig. 114

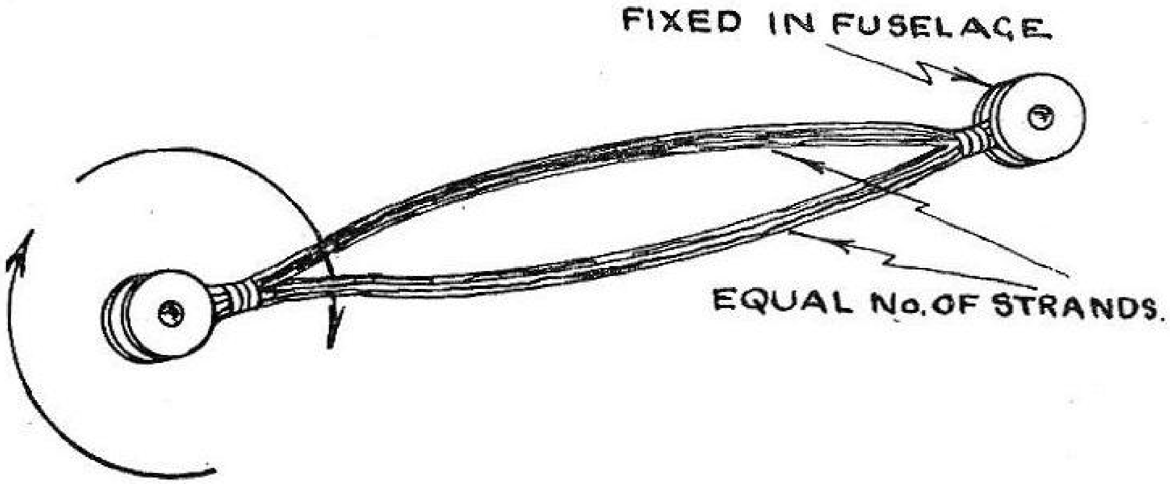

Fig. 115

Several systems have been invented whereby the rubber skein will always return to a predetermined state of tension, no matter how often it is wound and unwound. Credit for the invention of the first rubber tensioning system goes to Mr. H. E. White, of the Northern Heights Model Flying Club, and his original method is still one of the best. It is shown in Fig. 114.

In this system, it is first necessary to make up the rubber skein into one of *twice the length* and *half the number of strands*, of the desired skein. This means that should a motor of

8 strands, 30 inches long, be required, it will be necessary to make this up as a motor of 4 strands, 60 inches in length. Such a skein is shown in Fig. 114, marked (A). One end of this skein is looped over a nail driven into the workbench. The other end is hooked over a wire hook which is held in the jaws of a geared handbrace, as shown.

In this way, a certain number of turns is given to the skein, when it is then doubled upon itself, in the manner shown at (B), and the halves allowed to entwine, one with the other. We are then presented with a twisted rubber skein, such as is depicted at (C) in the illustration. Bobbins are then inserted into the ends, and small rubber bands passed over them to hold the skein neatly. It will be found that the rubber will always return to this predetermined state of tension, the tightness of which depends upon the number of initial turns given in the first winding.

The second system, shown in Fig. 115, is quite efficient, and is, in fact, to be preferred for skeins having up to 8 strands of rubber. It is somewhat simpler than the White system, and the effect is to tighten up the strand with a less number of turns.

As may be seen, the rubber is made up into a skein in the ordinary way, and one end of this skein is fixed, as usual, into the rear end of the fuselage. We then take the free end, and divide the skein into two equal portions, as indicated. It is now necessary only to pass the free bobbin through the loop formed by the parted strands, as indicated by the arrows on the illustration. This winding is done some considerable number of times, until the desired amount of prewind is obtained.

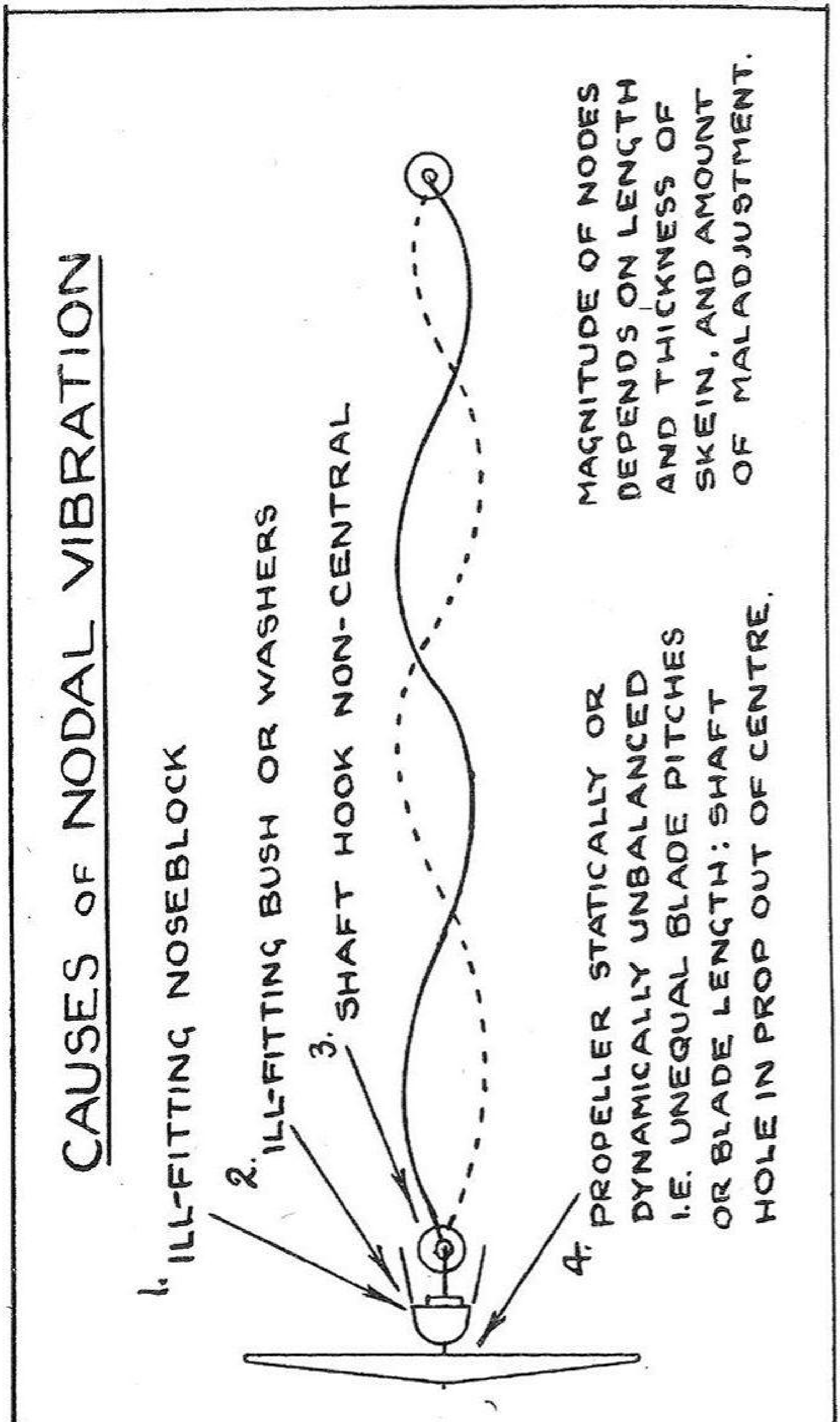
CAUSES OF NODAL VIBRATION
1. ILL-FITTING NOSEBLOCK
2. ILL-FITTING BUSH OR WASHERS
3. SHAFT HOOK NON-CENTRAL
4. PROPELLER STATICALLY OR DYNAMICALLY UNBALANCED I.E. UNEQUAL BLADE PITCHES OR BLADE LENGTH; SHAFT HOLE IN PROP OUT OF CENTRE.
MAGNITUDE OF NODES DEPENDS ON LENGTH AND THICKNESS OF SKEIN, AND AMOUNT OF MALADJUSTMENT.

Fig. 116

CHAPTER X

PROPELLERS

The function of the propeller or airscrew on a model aeroplane is to convert the torque given by the power of the rubber motor or engine into the thrust which is required to move the machine forward. Strictly speaking, the term "propeller" is only applicable in the pusher aeroplane; "tractor airscrew" being the correct word to use when speaking of tractor aeroplanes. However, this distinction has become, to-day, a hair-splitting difference which will be ignored here, and the two words will be used to denote the same thing.

The manner in which the propeller or airscrew performs this function is still subject to some difference of opinion. Some theorists hold that a propeller "screws" its way through the air in exactly the same manner as a woodscrew into wood. Others maintain, however, that the blade of a revolving airscrew behaves in a similar manner to a moving wing or aerofoil; a propeller being, in fact, two or more aerofoils revolving around a central axis, the thrust of the propeller corresponding to the lift of the wing.

The larger body of opinion attaches to the latter theory, although it is possible that a certain element of truth lies in both. It is probable that both a "screw" and "aerofoil" action takes place, the prominence of one or the other changing with the speed of rotation of the airscrew. At low speeds the aerofoil action is possibly the chief factor, while at high speeds the screw principle may obtain, owing to the air behaving relatively more like a solid.

As the propeller on rubber-driven model aeroplanes usually revolves slowly in comparison to full-sized airscrews, the aerofoil theory seems to fit the case, and we will, on that account, consider the propeller as two or more suitably shaped and cambered wings revolving around a central axis, and obtaining the thrust or " lift " in the same manner as detailed in Chapter I. Unfortunately, the theory is somewhat complicated by the fact that, unlike the flying wing which moves in a straight line, the " wings " of a propeller describe a helix. Furthermore, every section of the blade travels on a different helix ; the tip, for instance, moving on a much larger helix than sections nearer to the boss. The velocity also is greater at the tips.

We are aware that the faster a wing is moved through the air the greater the lift, and it will be obvious that, under these conditions, more lift or thrust will be obtained from the fast moving tips of the propeller than from the slower moving inner sections. In order to derive a similar thrust from all sections of the propeller blades some modification of the propeller itself is evidently required, and this brings us to a consideration of what is called the *pitch-angle* of the blades. This is really only the angle of attack at which the blades are set, and is exactly the same thing as the angle of attack of a main wing.

Within limits, the greater the angle of attack the greater the lift obtained, so that, although we cannot control the relative speeds of the various sections of a propeller blade, we can, by graduating the pitch-angle, determine the amount of " lift " or thrust which each part of the blade will impart. This is actually what is done ; the pitch-angle of the blades being gradually lessened from the boss to the tip of the airscrew.

A propeller is always referred to as being of a certain diameter and pitch. The diameter is the distance from tip to tip of the blades, while the pitch is the theoretical distance that a propeller will advance in one revolution. Thus, when we say that an airscrew has a pitch of 18 inches, we mean that the blades are set at such an angle of attack that the airscrew will, theoretically, advance 18 inches in one revolution. Actually the term " pitch " has little value except as a term of comparison, as, not only does the distance actually advanced vary with the speed of the propeller's rotation, but the airscrew can only advance per revolution as much as the drag or resistance of the aeroplane *will allow*.

What we obviously require from a propeller is that it will convert the available power into the greatest possible amount of forward movement, and whether this given power is converted into a *fast* forward movement for a *short* time or into a *slower* forward movement for a *greater* time depends upon the size and pitch of the propeller used. Basing our requirements, for the moment, on the duration type of model, it is plain that we require the longest propeller run that we can obtain. This implies the use of a large, slow turning propeller in order that the power from the motor may be expended as slowly as possible. On the other hand, we must be sure that the airscrew is capable of giving enough forward speed to the aeroplane to maintain it in flight.

The following table gives the approximate cruising speeds of models of various wing loadings :—

Wing Loading (ounces per sq. ft.)	M.P.H.	Feet per minute.
1	6	523
1½	7.4	650
2	8.5	740
2½	9.5	815
3	10.4	916
3½	11.2	990
4	12	1,056
4½	12.7	1,122
5	13.4	1,152
5½	14.1	1,212
6	14.7	1,296
6½	15.3	1,344
7	15.9	1,398
7½	16.4	1,446
8	17	1,494
9	18	1,584
10	19	1,672
11	19.9	1,751
12	20.8	1,830
13	21.6	1,901
14	22.4	1,971
15	23.2	2,041
16	24	2,112

Speed varies as square root of loading.

Without actual tests it is impossible to say exactly how fast a given propeller will fly a model aeroplane. Some approximation may be arrived at by multiplying the *effective* *pitch* in inches by the revolutions of the propeller per minute, and dividing the result by twelve. This will give a rough idea of the forward speed of the aeroplane in feet per minute.

The speed of the propeller may be ascertained by winding the motor to a given number of turns, and timing the duration of the propeller run. This time will be about 10 per cent. less during actual flight, as the "air brake" action of the blades will be less owing to the forward motion through the air. It is impossible to compute exactly the *effective pitch* of the airscrew, but this may be taken as 75 per cent. of the theoretical pitch.

The formula for determining the approximate forward speed that a propeller of certain pitch will give to the model is as follows :—

$$S = \cdot 054\, P \times \text{Rpm.} \qquad \text{where}$$

S = Speed in feet per minute.
P = Pitch of airscrew in inches.
Rpm = Revolutions of airscrew per minute.

This extremely simple formula, which takes into account all losses, should ensure that the pitch of a propeller is suitable for a given model, but there still remains the question of the correct diameter of the airscrew. Although the power may be ample and the propeller pitch correct, an airscrew will still fail to produce sufficient thrust if it is of too small a diameter. As the speed of revolution is limited, and it is, furthermore, desirable to keep the speed as low as possible, the diameter of the propeller must not be too small, certainly not much less than half the pitch. The pitch of an airscrew is often referred to in terms of the diameter ; a propeller having a pitch of 18 inches and a diameter of 12 inches, for instance, being said to have a pitch of $1\frac{1}{2}$ times the diameter. A pitch varying between 1 and $1\frac{1}{2}$ times the diameter is usually the most suitable, and $1\frac{1}{4}$ times may be taken as a good guide.

Starting from this, the most suitable propeller diameter and pitch can only be finally settled by experiment ; bearing in mind that the smaller these are made the faster the propeller will run, the power remaining constant. Some model builders of experience work to the rule that the propeller diameter should be approximately equal to one-third of the wing span of the model. This is for duration machines. The heavier models will, of course, require a fast revolving propeller delivering plenty of thrust. This entails large power and an airscrew of moderate diameter or pitch.

The *static thrust* of a propeller is the thrust obtained by revolving the propeller, at the same time securing it so that it cannot advance at its natural forward speed. This is usually done by connecting it to a weight or spring device which will allow the amount of thrust to be read off on a suitable scale.

Although forming a basis of comparison between one propeller and another, the results of static thrust tests are misleading from a flying point of view. High static thrust is of use in obtaining a quick take-off in rise-off-ground attempts, but is no criterion of the flying capabilities of the airscrew. To test static thrust, a special and somewhat complicated apparatus is required, and the model flyer will be much better repaid by working on the lines we have suggested.

Static thrust tests indicate that, under these conditions, a moderate blade width is most efficient ; a width of about one-tenth the diameter being found to be the best. This seems to be another instance where this type of test is misleading, as some very different results have been obtained in actual practice. American model flyers, who certainly know how to obtain duration, use propellers with a blade width as large as one-fifth of the propeller diameter, and even larger than this. These American airscrews are often of large pitch (sometimes of twice the diameter), and the motors are by no means excessively large or powerful. These conditions must result in a slow moving airscrew. Of course, the American duration models have always a light wing-loading but the remarkable results obtained from these machines would indicate that the use of wide blades for slow-moving propellers makes for efficiency. These wide-bladed, high pitch American propellers are, by the way, very ugly to English eyes.

A great variety of blade shapes is available, and the choice depends upon the purpose for which a propeller is intended. A high-revolution propeller should have a narrow blade, the widest portion of which should be situated about one sixth of the propeller *diameter* from the tips. The blades of the slower turning airscrew may have the widest part nearer to the tips than this, in some cases almost at the tips themselves. Fig. 117 shows a few of the most popular blade shapes ; a typical American duration sample being illustrated.

Propellers for ultra-light-weight or indoor flyers may be made by simply cutting a piece of 1/32nd inch balsa sheet to the desired shape and twisting the blades to the pitch-angle in a jet of steam. These propellers are, however, inefficient, and, for the more ambitious machines, airscrews of definite pitch and blade section are essential. These may be purchased in various combinations of pitch and diameter, and are inexpensive.

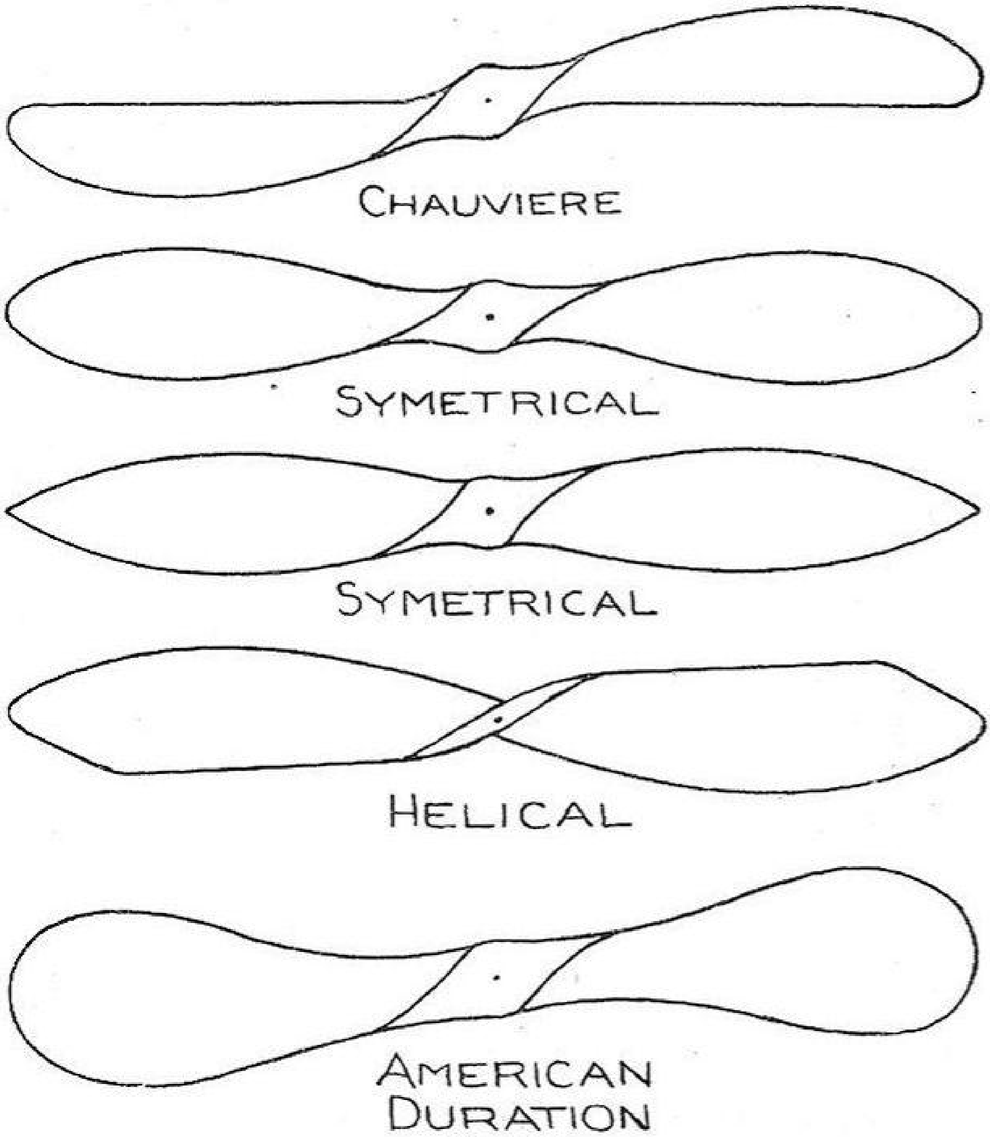

Fig. 117

A method of obtaining the size and shape of the wooden block from which an airscrew of definite proportions and characteristics may be carved is shown in Figs. 118, 119, 120. For the sake of example, the propeller chosen is of 12 inch diameter and 18 inch pitch, although propellers of any size and pitch may be designed.

On a sheet of graph paper draw a line (AB), equal in length to the *radius* of the propeller, in this case six inches. The length of the vertical line (BC) is obtained by dividing the pitch by 2π (6.28). This figure remains constant for any diameter and pitch of propeller. In our example this gives $\frac{18}{6.28} = 2.86$ inches. Now complete the triangle by drawing the line (AC). The angle (BAC) will be the pitch angle at the extreme tip of the blade, and is $25\frac{1}{2}$ degrees. The line (AB) should now be marked off in inches (D, E. F), and a point indicated $\frac{1}{2}$ inch from A, and marked (G) in the diagram. Lines are now drawn from all these points (G, D. E. F) to

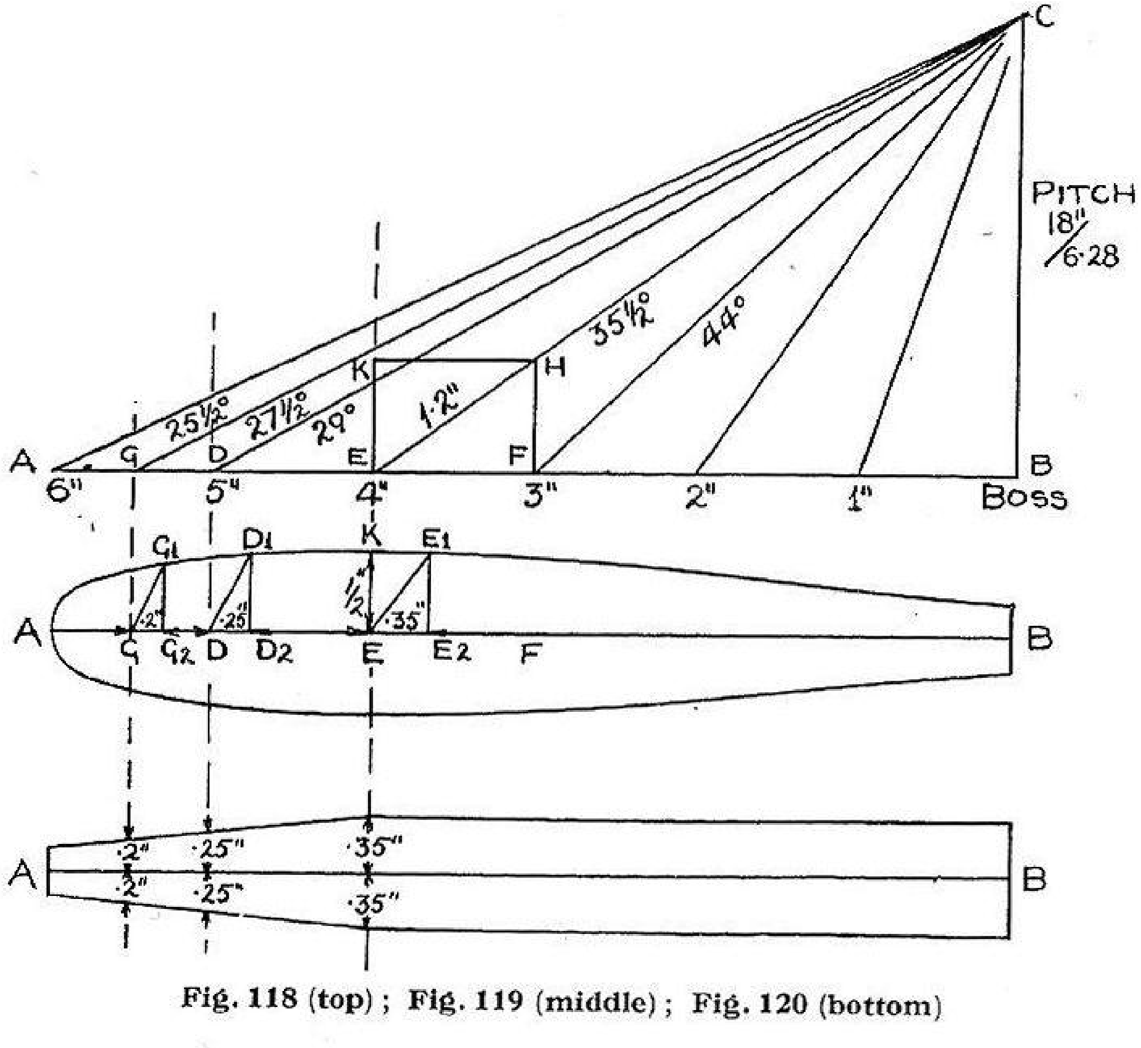

Fig. 118 (top); Fig. 119 (middle); Fig. 120 (bottom)

the point C, and the angles which these make with the line (AB) are measured with a protractor. These angles are marked against their respective lines, and are the pitch-angles of the blades at these points. The pitch-angles near to the boss will be found to be not constant owing to the design and shape of the wooden block, and it is impracticable to make these pitch-angles constant. These angles will be too small, but this is of little consequence in model work.

We must now decide upon our maximum blade width and the position of this along the blade. In this instance, we will make the blade width one-tenth of the propeller diameter ; that is 1.2 inches, and this shall be situated two inches from the tip.

As the line EC lies two inches from the tip, we must mark the propeller diameter (1.2 inches) along this, and mark the point (H). Now, EH is the diagonal of the propeller block at two inches from the tip. Draw the rectangle (E, F, H, K) which is the section of the block at this point. This is one inch wide and .7 inch deep. We have now completed Fig. 118, which not only gives us the pitch-angles of the blade at various points, but indicates the size of the necessary block.

Fig. 119 is the plan of one propeller blade. First draw a line of the same length as (AB) in Fig. 118. This is six inches long, and forms the centre line of the blade. Along this line mark the points (G, D. E. F), in positions corresponding to those in Fig. 118. At (E) erect a perpendicular ½ inch long (EK), i.e., one-half the width of the block. Now draw the shape of one-half of the blade, which may be of any desired pattern, but the curved edge of this must pass through the point (K), which must be the widest part. The blade shape may now be completed beneath the line (AB), forming a symmetrical blade shape.

To mark the blade sections in Fig. 119 proceed thus :—

From line (AB) draw the verticals (G) (D) (K E). Draw the line ($E\,E_1$) at 35½ degrees to (K E). Then ($E\,E_2$) equals half the thickness of the block at (E) ; that is, ·35 inches.

Proceed in the same manner at points (G) and (D) ; the angles in these cases corresponding to those of (D) and (G) in Fig. 118. The measurements between (G) and (G_2), and (D) and (D_2) represent half the thickness of the block at these points.

A half section of the block is shown in Fig. 120, and it will be seen that the end is chamfered off for a distance of two inches in a manner corresponding to these figures. Thus, at ½ inch from the tip the thickness of the block is .4 inch : at one inch from the tip the thickness is .5 inch, while at three inches and four inches the thickness is .7 inch.

The above method is for setting-out propellers with symmetrical blades. For the very efficient Chauviere type of airscrew the procedure is slightly different. These propellers are set out, in the first stage, exactly as in Fig. 118. Fig. 121 shows the subsequent stages and it will be noticed that the base line (AB) forms one edge of the propeller, while the resultant measurements along line (AB) represent the total

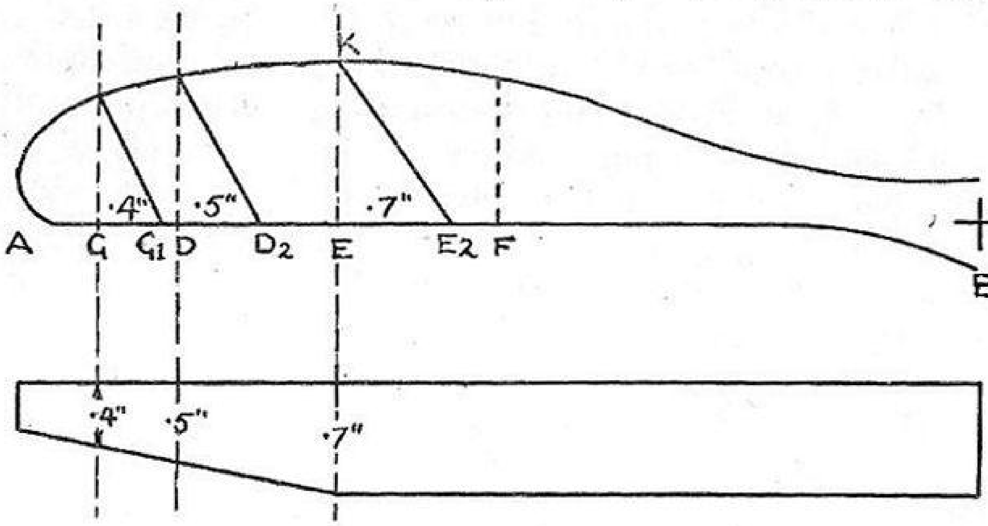

Fig. 121

thickness of the block at the various points. It will also be seen that the block for a Chauviere airscrew is only chamfered off on one face.

In preparing the block for any airscrew, a piece of wood should be obtained with measurements slightly larger than those of the proposed propeller. After planing to the *exact* thickness, the ends should be chamfered off at the correct angles. The propeller shape may now be set out on

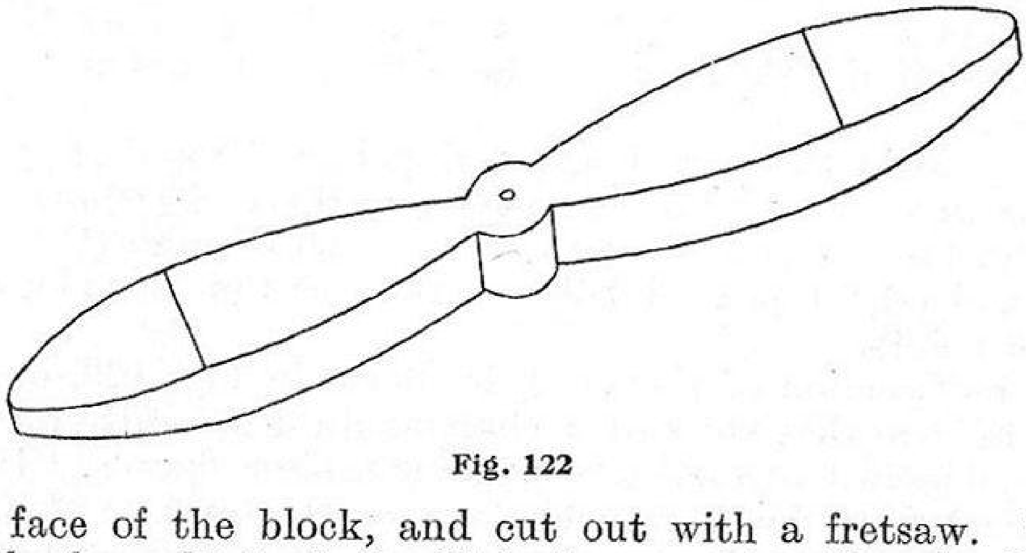

Fig. 122

one face of the block, and cut out with a fretsaw. The blank thus obtained should look something like the illustration in Fig. 122, for a symmetrical propeller. These blanks, ready for carving, may be obtained, shaped and chamfered, from the model supply stores.

Having bought or made our propeller blank, the next step is to carve it. This job is much easier than it appears, as the correct shape and pitch develop automatically during the carving.

The first step is to determine the direction in which the propeller shall revolve. This, looking from the front of the aeroplane, is usually in an anti-clockwise direction, and only in special cases need this be departed from. Having decided that this shall be the direction of rotation, we first mark one side of the block "front" and the other "rear," and drill a hole through the exact centre of the block, making sure that it is square with the faces. This is the spindle hole.

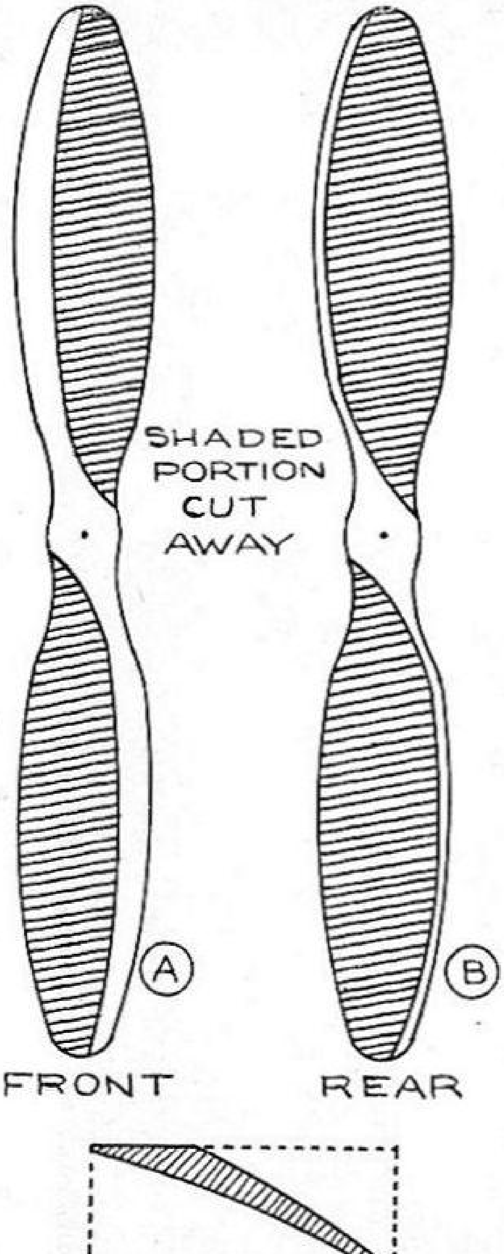

Fig. 123

We must now place the block vertically before us, or lay it upon a table, with the front face uppermost, and one blade pointing directly away from us. We will call this the "top" blade. Along this "top" blade draw a line one-third of the blade width away from the left-hand edge, and, after revolving the blank through 180 degrees, mark the other blade in like manner. This is shown in the drawing marked "A" in Fig. 123. Now turn the blank completely over so that the "rear" side is uppermost, and draw lines down the side of each blade as in "B" in Fig. 123. These lines are 1/16 inch from the edge. By marking in this manner and carving to the lines, the all-important aerofoil section is given to the blade, as is made clear in the small drawing in Fig. 123. The line on the rear side of the blank will prevent cutting to an undesirable knife edge.

The block may now be secured to the bench with a clamp, and the rear side of the propeller roughed out. A spoke-shave is probably the best tool for this purpose, as the amount of the cut can be regulated. Some constructors employ a gouge for removing the main body of surplus wood,

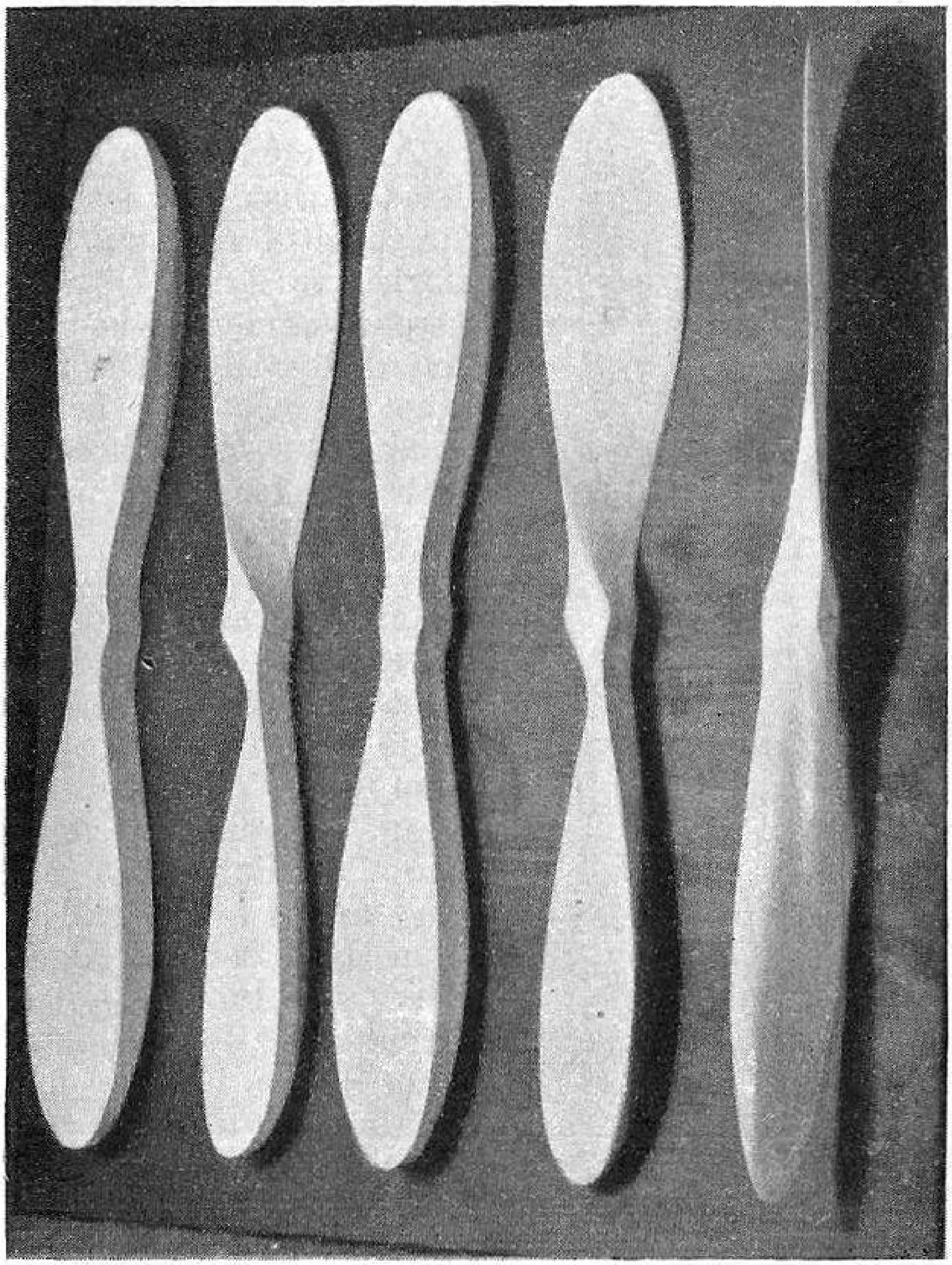

Fig. 124.—Reading left to right: (1) Rear of blank marked out. (2) Rear of blank carved. (3) Front of blank marked out. (4) Front of blank carved. (5) Finished propeller

but, in the hands of a novice, this tool is likely to be too drastic in its action. With a spokeshave there is much less likelihood of accidentally tearing or otherwise mutilating the wood.

The rear of the blades of an airscrew, or "working face," i.e. that side which is towards the rear during flight, is usually flat or slightly concave in shape. For slowly revolving propellers this concave or hollow shape should be given, and the tips of the blades may be made very slightly spoon-shaped. It is advantageous to carve and finish the rear sides first; obtaining the concave shape with glass-paper. Ensure that the hollow of each blade is alike, checking this by placing a ruler across the edges of the blade and holding up to the light. When each undersurface is similar, the front of the propeller may be roughed-out, using the spoke-

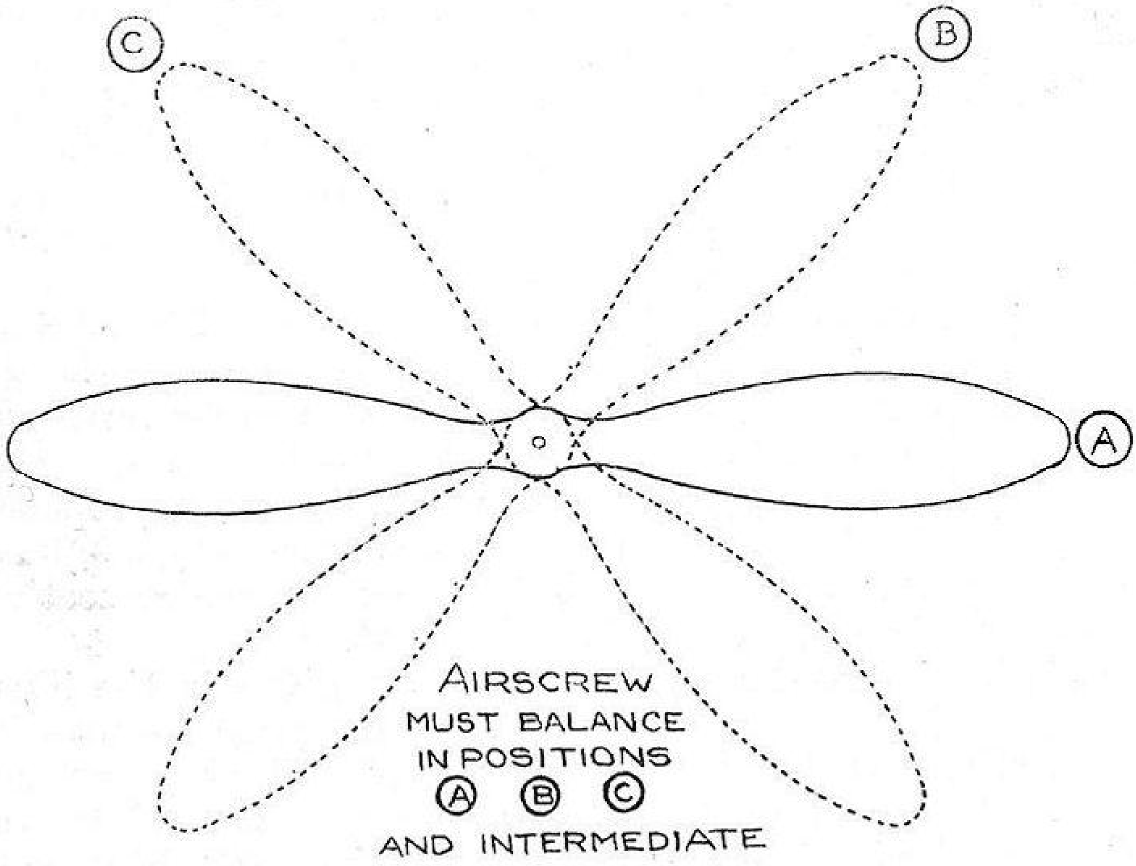

Fig. 125

shave as before and finishing with glass-paper. If the propeller is carved to the lines on the front face the blades will take a thicker section at a distance of one-third the width from the leading edge. This will give the true aerofoil section to the blades.

In addition to a spokeshave, wood-rasp and pocket-knife, a few glass-paper files will be found useful. These are quite simple to make. Strips of glass-paper of various grades are glued to small strips of wood, the glass-paper being stuck to either side, say, coarse on one side and fine on the other. A round file is useful for shaping the propeller boss, and a round glass-paper file may be made by sticking glass-paper to a short length of $\frac{3}{8}$ inch diameter wooden dowel.

When the propeller has been carved and sand-papered to shape, it is necessary, before finishing, to check for balance (see Fig. 125). This is done by swinging the airscrew on a piece of wire passed through the spindle hole. If one blade is heavier than the other it must be glass-papered down until the propeller balances correctly. The actual finishing is done with flour glass-paper ; all rough edges are smoothed off, and the curves blended into the final shape. Any high spots, which may be felt by running the tips of the fingers lightly over the work, must be removed with fine glass-paper, and the propeller finally tested for balance.

For balsa airscrews the spokeshave will not be of much use for roughing out, as the soft wood will clog the blade, and a sharp pocket-knife and the glass-paper files should be sufficient tools. Use fine glass-paper on balsa ; grades 00 to 1 are the most suitable.

While hardwood propellers may be finished with cellulose lacquer, varnish or french polish, balsa airscrews are better left in the plain wood, as the application of paint or varnishes brings up the grain and adds weight.

A very finished appearance may be given to a propeller by fitting a spinner to the boss. This spinner may be glued to the boss after the propeller is made, the centre section being suitably shaped to accommodate it.

Details of a good propeller clutch are given in the illustration of the gearbox in Fig. 113, and the propeller may be removed and replaced almost instantly with this arrangement. Alternatively, the airscrew may be secured to the shaft by simply bending the end of the shaft back and embedding this in the propeller boss, as shown in Fig. 126. Extra duration of glide is sometimes obtained by incorporating a free-wheeling device, whereby the propeller is allowed to turn freely upon its shaft when the power from the rubber motor is expended. This lessens the drag, as the propeller does not tend to wind the rubber motor when the propeller is turned by the airflow. Fig. 127 illustrates a simple free-wheeling device which is constructed of piano wire. The drawing is self-explanatory, but it may be noted that the loop on the propeller shaft is also for use with a geared winder, which will be explained later.

Plain bearings are almost universally used for model

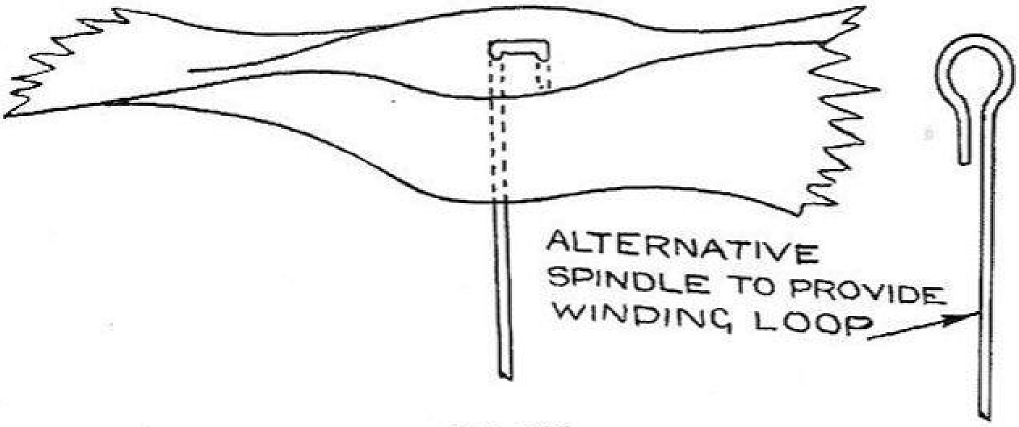

Fig. 126

aeroplane propeller mounting, but, of late, tiny ball-bearing thrust races have been coming into favour. These may be obtained through the usual channels. and users claim that better results accrue. Plain brass bushes, which are obtainable as standard accessories, are the more usual fitment. These bushes are either a push-in fit in a hole in the nose-block or are threaded to enable a nut to secure them.

Most aeromodellists, at some time or another, experiment with three or four-bladed airscrews in the desire to obtain higher efficiency. The results are usually disappointing, and the experimenter returns ultimately to the more orthodox type. Although more thrust may be obtained by using three

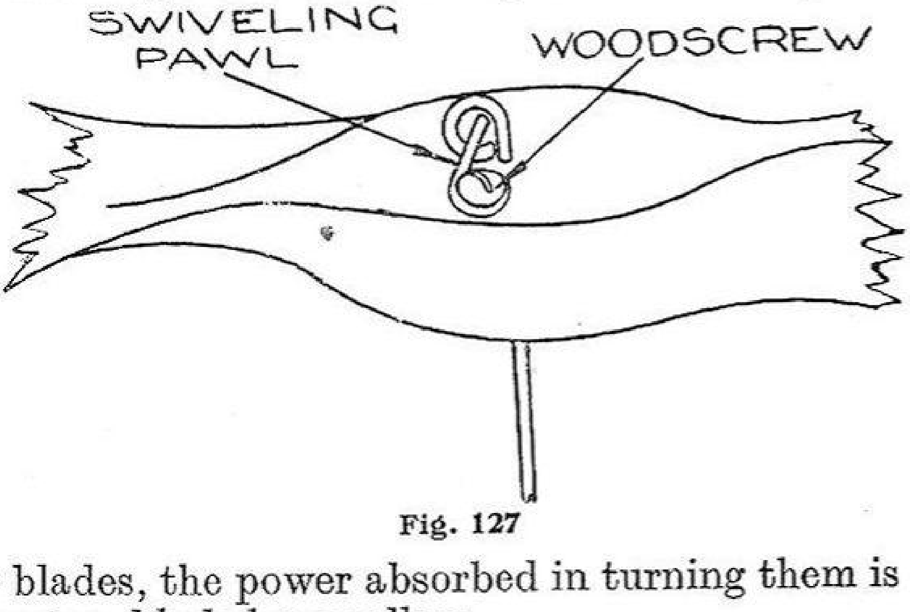

Fig. 127

or four blades, the power absorbed in turning them is greater than for two-bladed propellers.

Considering the additional weight and the difficulty in making them, three or four-bladed propellers do not seem to be worth while. They may be used with advantage, however, when it is essential to keep the airscrew diameter low, as is the case for structural reasons, with certain types of pusher aeroplanes.

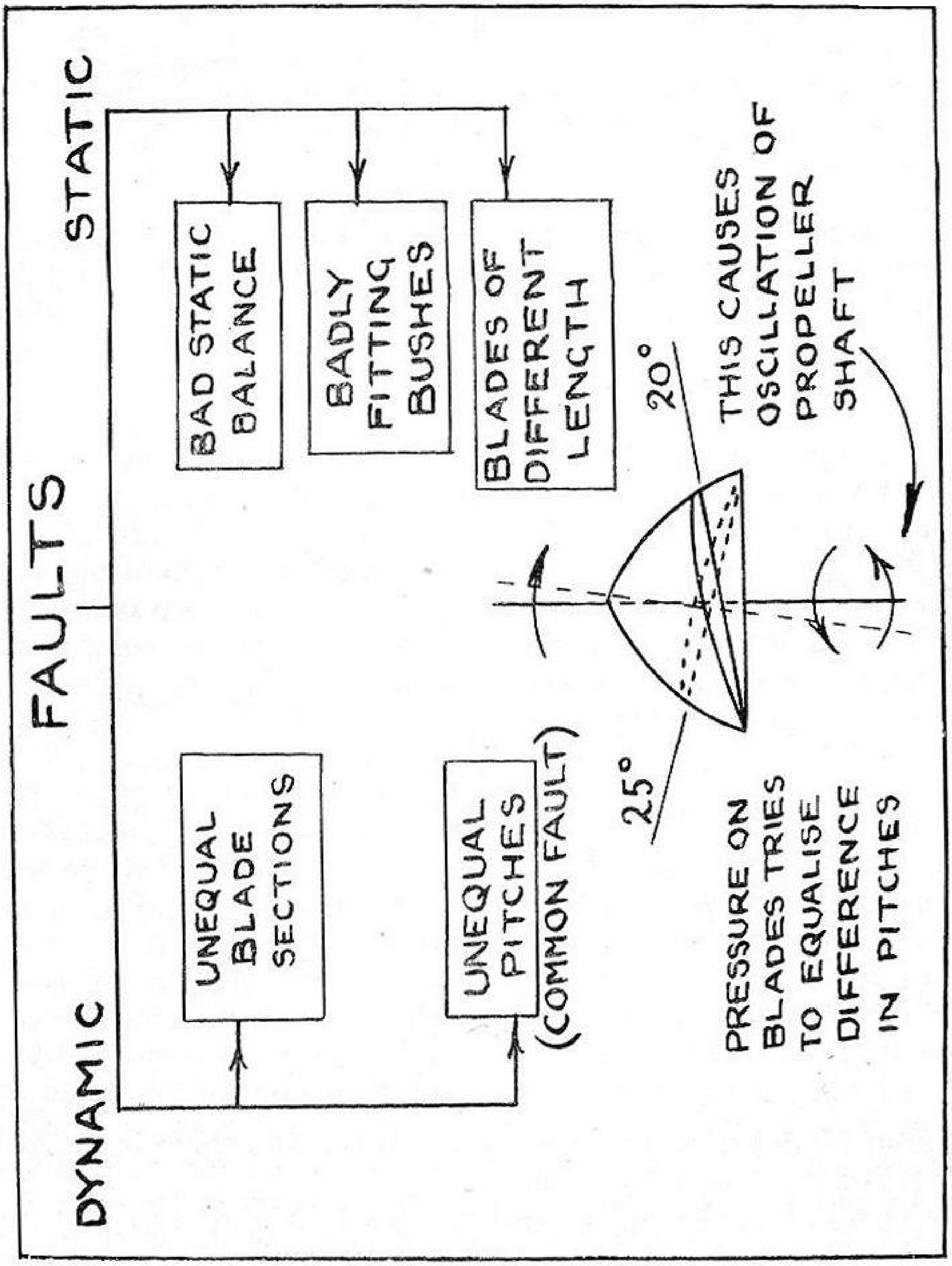
FAULTS
STATIC
DYNAMIC
BAD STATIC BALANCE
BADLY FITTING BUSHES
BLADES OF DIFFERENT LENGTH
UNEQUAL BLADE SECTIONS
UNEQUAL PITCHES
(COMMON FAULT)
20°
25°
THIS CAUSES OSCILLATION OF PROPELLER SHAFT
PRESSURE ON BLADES TRIES TO EQUALISE DIFFERENCE IN PITCHES

Fig. 128

CHAPTER XI

FLYING SCALE MODELS

The growing popularity of flying scale aircraft has made them to-day an important branch of model aeronautics. This reason, combined with the fact that their design and construction follow a definite technique, has made it advisable to devote a special chapter to the problems which this class of model aeroplane involves.

It is not proposed to deal with non-flying scale models, as these are not allied, in the usual sense of the term, to model aeronautics, but form a branch of model making along with all non-working models in other spheres. Their problems, therefore, lie in the direction of clever craftsmanship and a painstaking ability to copy, and not in the difficulties which the flying model enthusiast is called upon to face.

Whereas the ordinary duration type of model aeroplane is concerned mainly with flying qualities—with appearance only as a secondary consideration—the non-flying scale model is associated only with appearance. The flying scale model occupies a place between, and in this chapter the term " scale model " will refer only to this type.

Appearance is, obviously, the main object; the flying qualities being relatively unimportant, as it is plain that flight duration cannot be expected to compare with that of models especially designed for that purpose. Although the duration of flight is usually short, it is of a very pleasing nature, and there are few sights to compare with that of a well-trimmed scale model in operation. Furthermore, they make a pleasant change from the stereotyped duration model, where individuality has to be sacrificed upon the altar of efficiency.

Happily there are signs of a great increase in scale model flying in this country after a long neglect, due mainly to the handicaps involved. This movement has spread from the United States, where, it may be safely said, it forms the main branch of the pastime. This interest has been chiefly fostered by the great number of commercial scale model kits available to the public, and although the flying qualities of these machines are usually low, they seem to have had no adverse effect upon the design of the duration class, whose performance is generally excellent. Here again the kindly American weather may have played its part, although it is necessary that the helpful influence of American weather be not exaggerated, as some American machines have performed very convincingly in this country.

Scale models may be divided into three classes as under :—

(*a*) Modified duration type or semi-scale models ; incorporating certain full-sized features such as wheel spats, cockpit, cabin windows, etc.

(*b*) Approximate scale models embodying the general features of the full-sized prototype, but modified considerably to give best flying characteristics.

(*c*) True scale models following exactly the features of the prototype, and retaining the ability to fly.

The class under the sub-heading (*a*) comprises a large number of models, all resembling, in their general characteristics, some full-sized machine. Only the minimum of detail is incorporated ; the general lines and lay-out being just sufficient to identify the model with some full-size aeroplane. As a good duration of flight is aimed at, it is necessary that this class of machine be as simple as possible, and therefore these models should not be based upon some complicated or otherwise unsuitable prototype. The examples chosen should be machines noted for good stability, and preferably of large wing area so that the wing-loading may be as light as possible.

The heading (*b*) covers what is probably the most popular class of scale models, as sufficient detail is incorporated to render the making extremely interesting, and the finished model very pleasing to behold, yet sufficient flying performance is retained to make the machine interesting in the field. There is no doubt that this type of aircraft offers more scope for ingenuity than almost any other, and the builder is called upon for the constant exercise of his wits and judgment in reconciling the questions of detail and weight.

True scale models (*c*), whilst forming a most intriguing type, approach more nearly the non-flying models, both in their realistic appearance and curtailed flying qualities. It is safe to say that the closer a model follows its prototype the less may be expected from it in the air. Whilst the ability to fly is retained in greater or lesser degree, only short durations may be looked for from this class of model, therefore its appeal must lie in its appearance and true representation of the prototype. Most of the commercial scale model kits fall under this head, the machines evolved usually having a duration of only a few seconds.

One of the greatest drawbacks to exact scale models is that the unusual amount of detail involved renders the machine delicate and liable to damage ; the necessity for

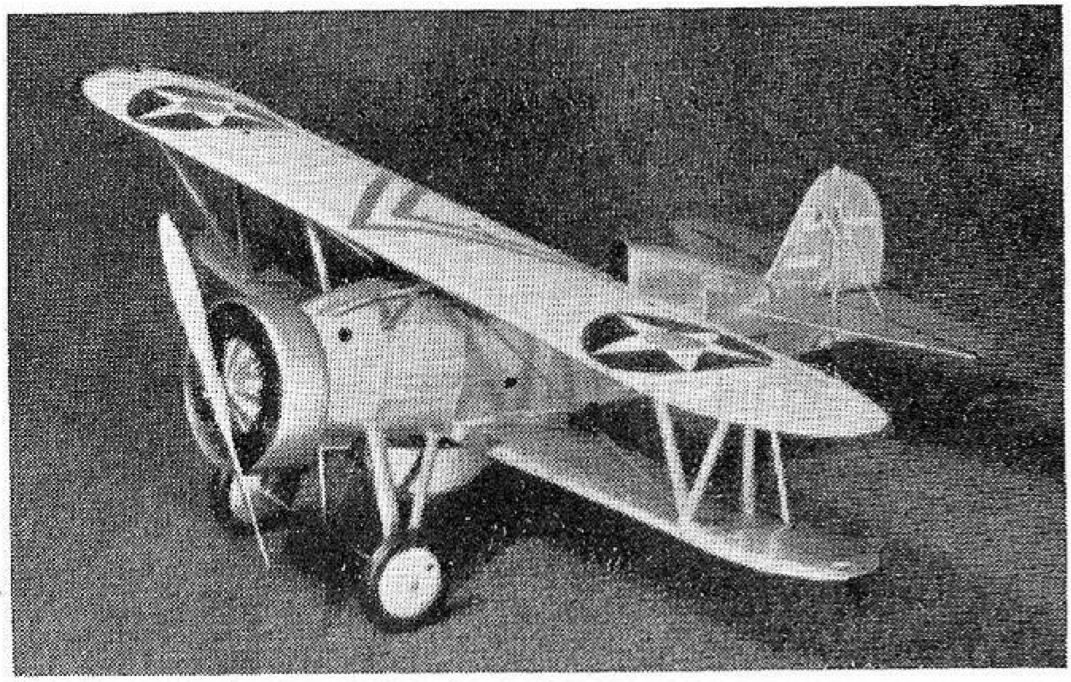

Fig. 129.—"Boeing Fighter." Built from an American scale-model kit of parts

keeping the machine light resulting in a number of fragile features.

The difficulties which scale model aeroplanes present centre mainly around the fact that they cannot easily be designed in accordance with the requirements of model flight, and the absence of a pilot, or any controlling influence except automatic stability, makes some modification of full-sized designs almost indispensable. For instance, the design of full-size aircraft does not take into account such happenings as nose dives into the ground, an eventuality to which model aircraft are particularly liable. In the full-size machine, of course, it is the pilot's job to see that a nose dive does not occur, but in the case of the model some feature must be added or modified with a view to making such an event impossible. In addition, no account is taken in "real" aeroplanes of accidental damage due to handling or transport, and no attention at all is paid to that great problem of the aeromodellist—portability.

All the foregoing are of the utmost importance to the scale model, and are complicated by the fragile construction necessary if the weight is to be kept down to reasonable proportions.

The presence of a heavy engine, usually situated in the nose of a full-sized machine, offers difficulties in the way of

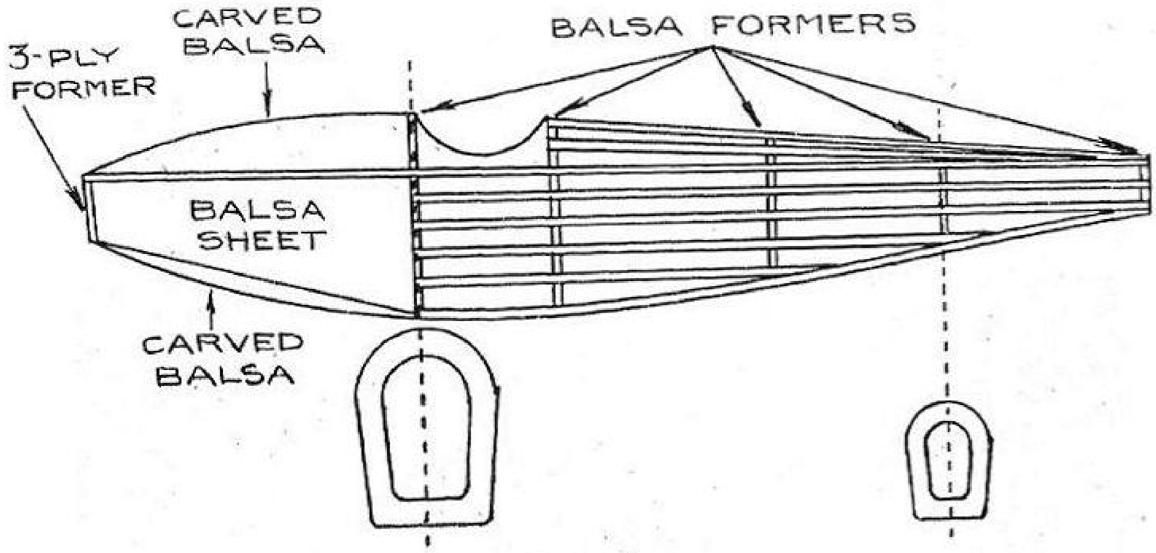

Fig. 130

obtaining a correct centre of gravity in the model, the rubber motor of which has its centre of gravity halfway along its length. This makes some addition of weight to the nose, and a lightening of the rear portion, essential in the scale model.

Dihedral in the wings has to be incorporated in the design to a greater degree than in full-sized machines, again owing to the absence of the controlling influence of the pilot. Many full-sized machines have only a minute dihedral in the wings, and are obviously unsuitable as prototypes without considerable alteration in this direction. Tail planes and rudders must also be made larger, that they may have a greater stabilising effect without outside control.

If it is desired that the model shall make rise-off-ground flights, the undercarriage must be situated nearer to the nose of the machine than in full-sized practice, as any unevenness in the ground will tend to topple the machine over on its nose. Ideal take-off conditions, i.e. a perfectly smooth surface, are seldom met with except in indoor flying. The undercarriage legs must usually be lengthened to provide clearance for a large propeller, as scale size propellers can rarely be used unless the model is extremely light and of good streamlined shape, or is geared up from a rubber motor of heavy type. This latter feature involves the use of a very strong but light fuselage to withstand the compression strains of the elastic. Alternatively, the model builder may be contented with extremely short flights. The increased length of the undercarriage legs renders the model still more liable to turn over in rise-off-ground attempts or on landing on a rough surface. This tendency to overturn makes the use of a strong rudder upright essential, as this is much exposed to damage.

Downthrust or some other form of control is advisable to govern the speed range and high initial thrust of the rubber

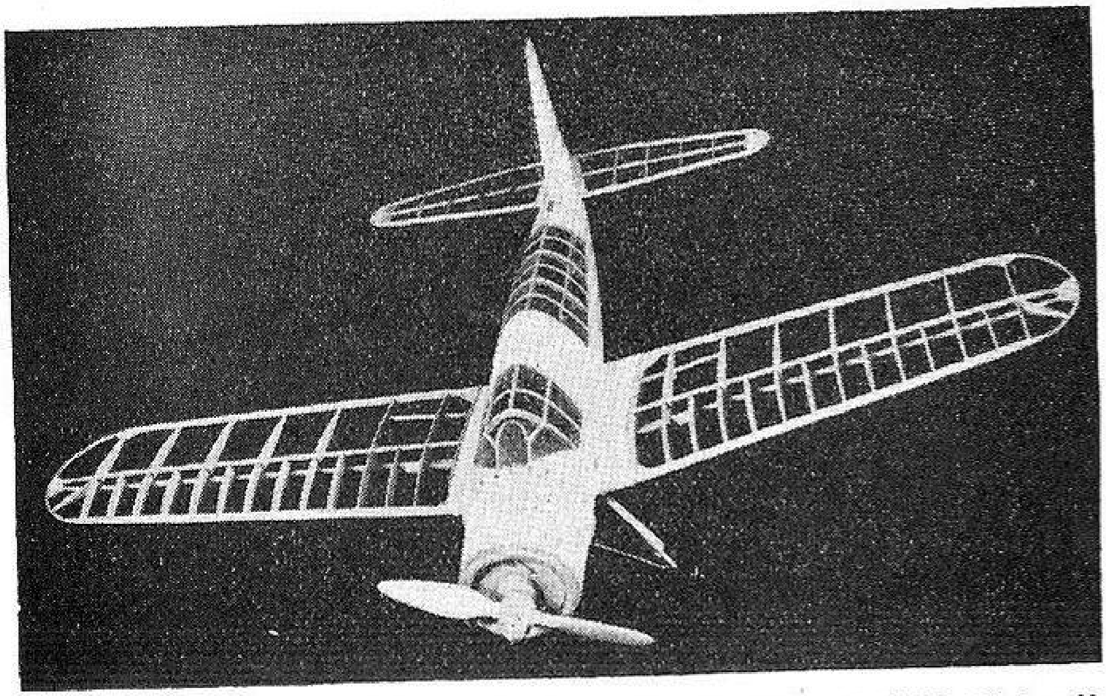

Fig. 131.—Scale model (1 in. to 1 ft.) of Vought-Sikorsky "Kingfisher." A fine example of construction

motor ; another point of difference between the scale model and the full-sized aircraft.

The types suitable for selection for scale model aeroplanes may be either high- or low-wing monoplanes, or biplanes, but should be, for preference, of the single engine type. Machines with "in-line" motors, that is engines with the cylinders in line, are most suitable if unnecessary addition of weight is to be avoided and a good gliding angle obtained. Air-cooled radial or rotary engines involve a lot of detail work on the portion of the model most liable to damage, and it is extremely annoying, to say the least, to have hours of work spoiled by one unlucky flight. However, models with this type of motor have been successfully flown, and an engine of this character certainly repays the maker for the work expended on it from an appearance point of view. Fortunately, owing to the increasing use of streamlined cowlings, it has, in many cases, become simpler to copy radial or rotary engines, as only simple details need be incorporated to give a most realistic appearance.

An absolute duplication of full-size structure cannot be attempted, and methods of construction must be employed which give the maximum strength for as little weight as possible. For models up to 36 inches span this condition is met by the use of balsa wood ; models with a greater span usually embodying a mixed construction of hard woods and balsa, if excessive liability to damage is to be guarded against and flying in all reasonable weather is required.

Fuselages are best built on a rectangular, four longeron, strut-former basis, and any subsequent shape such as oval, or "half-round-top" built on afterwards. This building up on a simple initial framework simplifies the task of getting the fuselage accurate.

Circular fuselages may be built on circular formers cut from balsa sheet, with several light stringers. It is often advantageous to make the rear portion of the fuselage in this manner, and to carve the front portion from solid balsa, which is hollowed out where possible. This method of construction has several advantages :—

(*a*) Appearance (carved portion may easily be made to represent cowlings, etc.).

(*b*) Strength.

(*c*) The weight of the carved-out balsa front is slightly greater than that of the longeron and former rear portion, and adds weight in the correct position for scale centre of gravity.

(*d*) If movable wings are used these may be affixed to the solid balsa portion of the fuselage, and damage is not

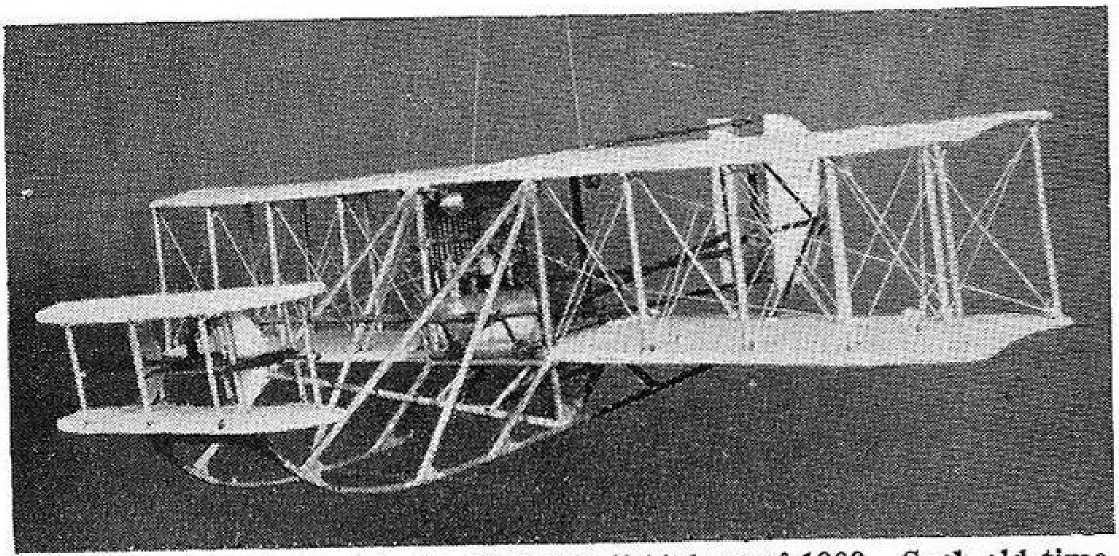

Fig. 132.—A scale model of a "Wright" biplane of 1909. Such old-time aeroplanes make interesting scale models

done to the tissue covering in the event of a crash.

(*e*) Aluminium sheet can be fixed conveniently to the nose portion on a fairly solid base.

If an extremely solid construction is required, balsa sheet of 1/64th inch or 1/32nd inch thickness may be used for sides and top, with a carved balsa nose as before. This combination is immensely strong and will withstand an amazing amount of knocking about without damage.

For large models, birch or spruce may be employed in the conventional manner. This type of construction applies particularly to petrol-engined aircraft. but large rubber-driven models employing geared motors may be made successfully on this principle. It is well to remember that if an even number of rubber skeins is used the fuselage need only be designed to withstand compression strains, but if three or any other uneven number of skeins is employed, some precautions against rubber torque must be taken.

Owing to the restricted length of scale model fuselages, it is not generally possible to get maximum duration with only one skein of rubber, and two or more gears are essential. These give an added advantage by placing useful weight in the nose of the model. To this end also, it may be necessary to terminate the rubber skeins before the extreme end of the fuselage is reached, thus helping to bring the centre of gravity position forward. However, the skein length may be one and three-quarter times the distance between the front and rear hooks when both are in position.

Whilst on the subject of rubber motors it may be pointed out that care should be taken not to be too liberal in the use of rubber lubricant. A mysterious loss of performance may often be traced to this cause, as the excess lubricant is flung off on to the covering and longerons. If these latter are of balsa they will absorb an amazing amount of rubber lubricant, which not only adds considerably to the weight of the machine, but causes warping and ultimate rotting and collapse.

The actual power required to fly a scale model can only be determined by actual test flights, as the speed and the drag are impossible to gauge accurately. The number of turns given to the propeller will, of course, depend on the length and amount of rubber used.

The advent of the small petrol engine into model aeronautics opens up great possibilities for the scale model, as it offers a constant output power unit with good power-weight ratio. Also, the correct position of the centre of gravity is automatically obtained, and an exact scale distribution of weight may be attempted.

In petrol-engined models extreme simplicity should be aimed at, machines with good, clean lines being best suited to the problems involved. Small engines may be run—usually without much alteration—in an inverted position, and this facilitates the copying of certain full-sized aeroplanes. The small engines of from one to five c.c. should be highly suitable, but the use of larger engines would involve a large model which would be unwieldy for transport except by motor car. The opinion has been expressed in authoritative quarters that the one true and useful field for the model aero-engine lies in *scale model aircraft*.

Single engine tractor aeroplanes are easily copied if a miniature petrol engine is used, but it is not impossible that two such motors be employed to drive propellers revolving in opposite directions, thus neutralising torque.

Wings for scale models up to 36 inches span should be constructed of balsa, preferably with thin section front spars of birch or spruce to avoid breakage due to collisions. These heavier front spars also help to bring the centre of gravity of the machine more forward. Tissue paper, doped in the usual manner, makes the best covering for machines of moderate size. Biplane wings should be made separately, doped, and dried on a flat surface to avoid warp, the struts being cemented in afterwards. It is very advantageous to assemble biplane wings, both top and bottom, into one rigid unit, which may be moved along the fuselage as the " trim " may require. By this method the wings are less liable to damage than they would be were they fixed rigidly to the fuselage as is the case with the bulk of American machines.

Strengthening pieces should be added where the interplane struts are fixed to the wings, and where the wing spars meet the fuselage. If ailerons are employed they should

Fig. 133.—The Vought-Sikorsky "Kingfisher" completed

be built into the wing, covered at the same time, and the covering cut afterwards.

The foregoing remarks are intended to indicate a method of approach to this most fascinating branch of model aeronautics, in the successful pursuit of which individuality and enterprise must ever play the most prominent parts.

CHAPTER XII

MODEL GLIDERS

For some years prior to the war, full-sized gliders enjoyed great popularity, and model aeronauts were quick to follow this lead. To-day, model gliding is one of the most popular branches of model aeronautics, and has a fascination which is all its own. This resurrection of the glider, both large and small, is well deserved, for gliders have contributed more to the science of aeronautics than has any other contrivance. Among the great names which stand out from the host of aerial pioneers, those of the glider experimenters, Otto Lilienthal, the German, Octave Chanute, the American, and Percy S. Pilcher, the Englishman, assume high places, and many of their findings have a place in aeronautics to-day. The great Wright brothers themselves devoted many years to glider experiments, and it was undoubtedly the experience thus gained in controlling gliders in the air which, later, enabled them to pilot the first power-driven aeroplane successfully.

Be this as it may, there is little doubt that the model glider presents one of the most interesting aspects of model flying, and a well designed and built glider is capable of giving flights equal both in duration and interest to those of the powered aeroplane.

The " Twenty Minute Glider " described in Chapter XVII contains in its design most of the good features which this type of model should incorporate. Nevertheless, it may be of help to give some general principles of design and management, so that readers may be somewhat prepared to design machines for themselves.

In spite of the changes wrought by the war, model glider competitions are still usually governed by the rulings of the F.A.I. (French Aeronautical Institute), which is still recognised as the governing body in world aviation. These simple rules lay down that model gliders for competition purposes may have a wing span of not less than three feet, and not more than eleven feet, with a wing loading of not less than 4.92 ounces per square foot of wing area. In addition, the area of the tail plane must not exceed the somewhat curious figure of 33 per cent. (not 33 1/3 per cent.) of the main lifting surfaces. The fuselage formula which must be used in the design states that the greatest cross-sectional area of the fuselage must not be less than the overall length of the machine, squared, and divided by 200. That is :—

$$\frac{\text{Length}^2}{200}$$ All measurements in inches.

Within these limits almost any type of glider might be

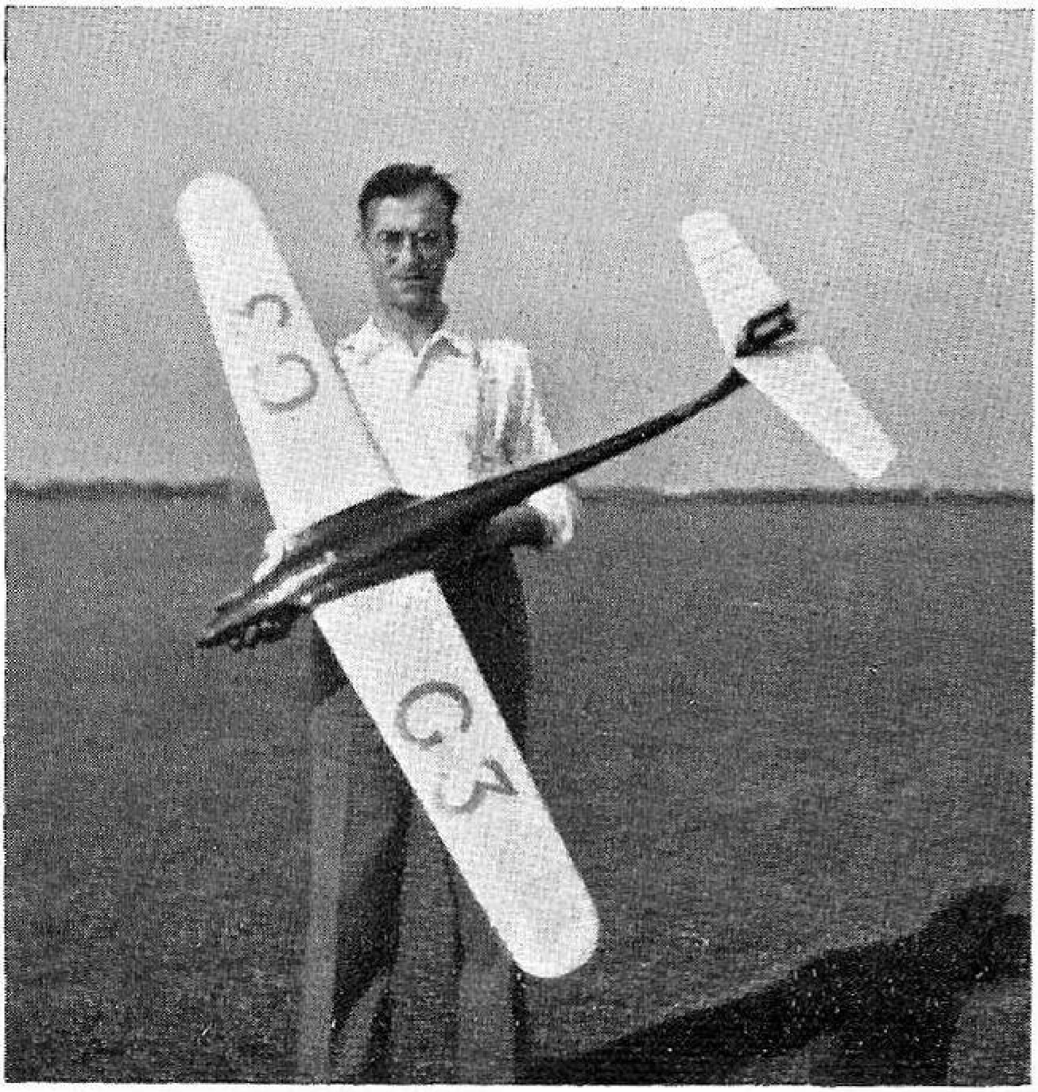

Fig. 134.—Glider built by Mr. A. S. Cox, N.H.M.F.C., which helped Great Britain into second place in the King Peter International Glider Contest. Held by a friend.

included, which accounts for the wide variation which might, before the war, be seen at any model glider meet, both at home and on the Continent. In particular, the International Competition, held biannually, for the King Peter of Yugoslavia Cup, showed as many ideas as there were competitors. The Continental machines mostly ran to the large sizes, with the ten-and eleven-footers predominant. This was an effect of the Continental practice of flying the machines under hillside conditions; that is, in the hilly and even mountainous country which so many of the nations possessed. Such terrain produces strong updraughts and thermal air currents which are ideal for the large sail planes; on the other hand, the light thermals which are the rule over the English undulating country, suit better the smaller gliders. It may be taken as a maxim that large gliders do better in strong winds and hilly country, while flat country and light winds favour the smaller machines.

A great deal of variation is permissible in the wing loadings, and, what is really remarkable, both the light and heavy loadings perform equally well. English builders seem to favour the light loadings around five ounces, but there are signs that the large machines with much heavier loadings are gaining favour. Another type of glider much favoured in this country is the *large* glider with a light wing loading. All this latitude in design and specification, however, does not mean that any old "hook-up" will make a good glider. Quite the contrary is the case, and the designing of gliders is a highly specialised branch of the pastime.

Speaking generally, the neat, shoulder-wing type of model seems to be the ideal. Low-wing machines do not seem suitable; in fact, the tendency is to place the wing very high, as in the parasol and gull-wing types. Although very stable machines may be attained with the parasol arrangement, there is a danger that that arch enemy of gliders, parasitic drag, may be encouraged by the somewhat complicated wing-fixing arrangement which parasol mounting involves. On the other hand, shoulder-wings may be very neatly and efficiently blended into the body by means of balsa fairings.

This attention to streamlining is of the utmost importance in model gliders. Not only must the body be a good streamlined shape, but special attention is required to ensure the neat fixing of the wing and tail unit to the fuselage. In addition, all the surfaces should be as smooth as possible; they should, in fact, be polished. With the larger gliders it is customary to finish the machine in cellulose lacquer, and to rub this to a fine finish with metal polish.

It is not intended to enter here the mathematical side of the question, but only to present some main features of design. Foremost among these is the need for a wing of high aspect ratio. Aspect ratios of between 12 to 15 to 1 should be used, and even higher; in fact, a figure of 20 to 1 is advantageous. At the same time, these extremely high aspect ratios, because they necessitate the use of narrow chords, should only be used with the larger machines. The reason for this is that wings of less than 3 inches in chord are aerodynamically inefficient, and the aspect ratios of around

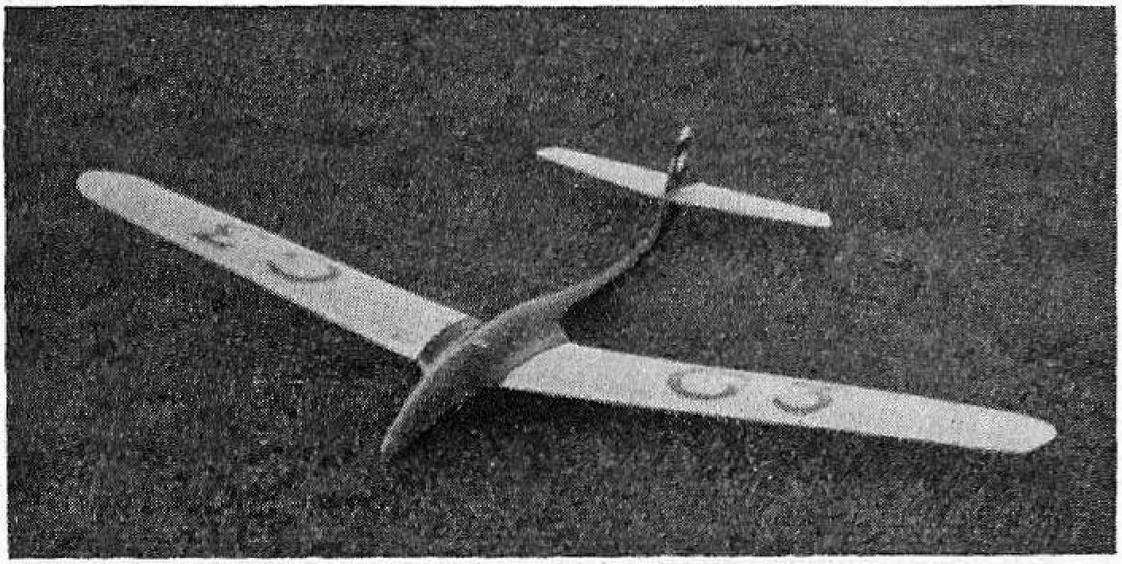

Fig. 135.—" G 3 " on the ground. This picture shows the typical lines of the modern, high-performance glider

20 to 1, on the smaller gliders must, of necessity, restrict the chord of the wing to below this figure.

Wings tapering in both plan form and thickness should be used, with round or elliptical tips, and it is, perhaps, preferable to taper the wing on the trailing edge only. Wings of such large span are by no means easy to construct so that they will remain rigid and true, and a very sturdy structure is required. Fortunately, the high loadings which are permissible somewhat simplify the matter. With gliders all the weight may be used structurally, as there is no propeller or motor to commandeer the precious ounces.

Gliders, in common with other model aircraft, are very apt to land in awkward and dangerous places, and to collide with trees, fences and houses when on the wing. For this reason, some form of wing fixing is wanted, such as the plug and socket method, whereby the wings may be knocked off the machine in the event of an accident. Glider wing-fixing arrangements are, however, further complicated by the need for a firm fixing which will not pull out under the strain of tow-line launching. A good many model gliders have suffered from this calamity, and it is by no means uncommon for the wings to be pulled completely from the fuselage by an extra heavy jerk on the towline. As the glider is often some fifty feet or more in the air, the results need not be detailed.

High-lift wing sections, such as those presented by the Gottengen range, should be used; while the beautiful Eiffel 400 is to be recommended. These deep sections, moreover, enable a main spar, or spars, of considerable depth to be incorporated, with beneficial results to the strength and rigidity of the wing.

Glider wings for the machines of the shoulder-wing or high-wing type need no excessive dihedral angle, one of about 5 degrees being sufficient. This is for the ordinary type of wing, wherein the dihedral is incorporated from root to tip. There is in favour, however, a type of wing wherein the dihedral angle is incorporated only in the tips, the main part of the wing being flat. Although the appearance is somewhat against them, this class of wing is extremely efficient, and many good sailplanes have been constructed on these lines.

A good fuselage length may be taken to be about 55 per cent. of the wing span. Besides being of good streamlined shape, the tail end of the fuselage should taper to rather thin proportions. The cross-sectional area, at the point of greatest area, will, of course, conform to the fuselage formula as already given. Construction may follow any of the usual methods, but a multi-stringer construction, using shaped formers, is extremely suitable for the machines of medium size. Bodies for the larger and heavier machines may be made on the monocoque system, or even carved from solid balsa. In this case it is usual to carve and hollow each half of the fuselage separately, and to glue them together afterwards.

The lifting type of tail plane is seldom used on model gliders, and one of symmetrical section is usually incorporated. A section such as the R.A.F. 30 is very suitable, although this section may be modified so that it is thinner than the standard. The high-lift wing sections, such as the Gottengen, owing to the readiness with which the centre of pressure moves with a change of the angle of attack, make it necessary that a somewhat large tail area be used, so that the machine responds instantly to the stabilising influence of the tail surfaces. An area of from 25 per cent. to 33 per cent. of that of the main wing should be used; machines with a long moment arm requiring the lesser amount. Unlike rubber or other powered machines, a dihedral angle may be usefully incorporated in the tail plane, and this angle may be of about the same amount as that given to the wings.

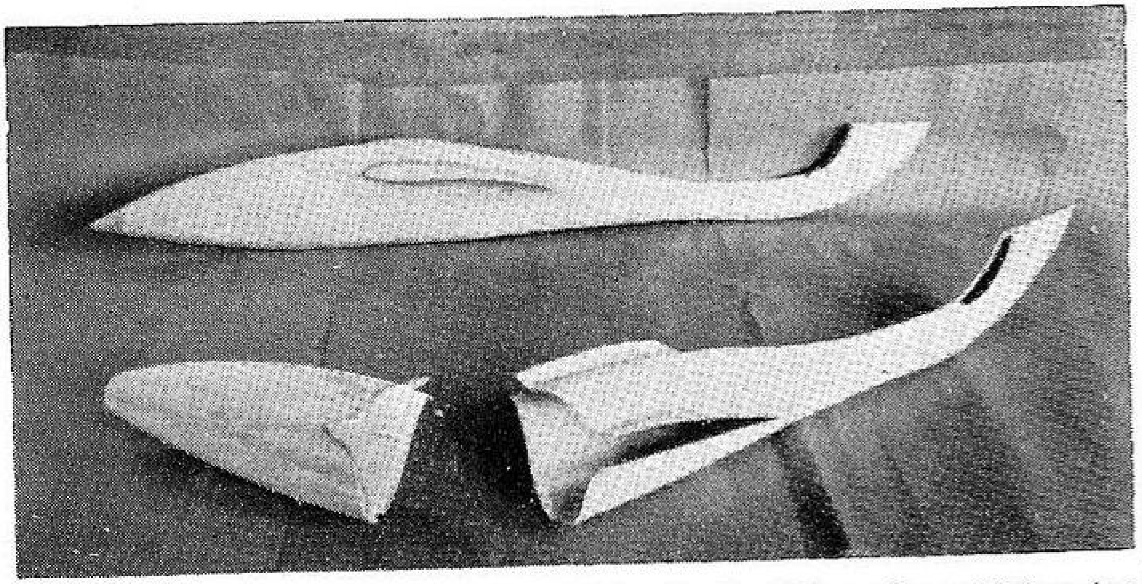

Fig. 136.—The monocoque fuselage of Mr. Cox's glider, after withdrawing from the building jig

The air which leaves the trailing edge of the wings of any aeroplane or glider in flight has a pronounced downward flow and eventually resolves itself into two vortices, which revolve in opposite directions along the sides of the fuselage. The efficiency of the tail and fin is much lessened by this turbulent mass of air, and, in an endeavour to lessen these effects, it is desirable that the tail plane be placed as high as possible. Some designers advocate that the tail plane be placed on the top of the fin, using this as a tail mounting. While, no doubt, this arrangement is aerodynamically good, there exists considerable structural problems, in so far as it is difficult to build a fin of sufficiently thin section which is strong enough to support the tail in a rigid manner. Furthermore, a good margin of strength must also be available to cope with accidents. A seemingly easy way out of the difficulty is to brace the tail plane with struts, from the underside of the tail to the bottom of the fuselage, but struts contribute a considerable amount of unwanted drag, and most good builders avoid them. A good compromise is afforded by fixing the tail about a third of the height of the fin above the fuselage. The arrangement usually comprises a sturdy mounting, which becomes part of the fin, and upon which the tailplane is placed. The remaining two-thirds of the fin is then attached by some socket and dowel device.

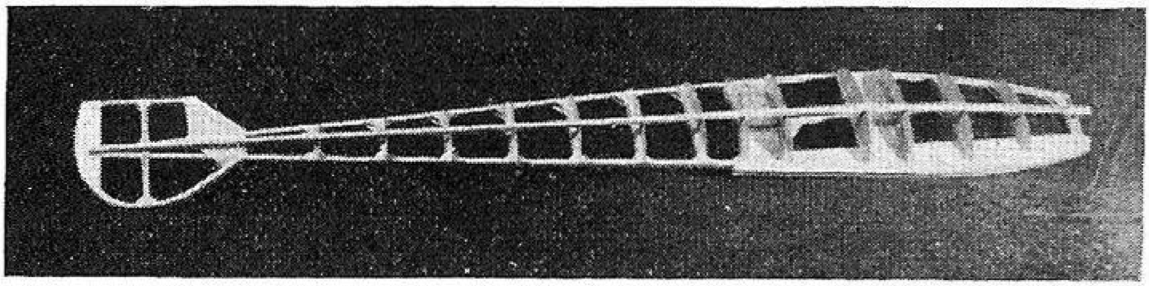

Fig. 137.—Novel method of fuselage construction suitable for large gliders. A flat "outline" of the fuselage is first built of ¼ in. × ¼ in. birch strip, and half-formers are cemented on, as shown. Similar half-formers are then glued to the other side, and the construction completed with stringers

Fin areas may be about half that of the tailplane, and should not exceed this amount, but may err, if at all, on the lesser side.

Launching

Apart from the simple hand launch, usually attempted from the side of a hill, there are several good methods of getting your glider into the air. All of these employ a towline of stout thread or thin twine. For machines up to about one pound in weight, "macramé thread," which may be obtained from art needlework shops, is very suitable. It is light and extremely strong. Models above this weight require thin twine. The weight of twine becomes a serious matter when one may have anything from 100 to 650 feet in play, and for this reason there is nothing lighter and stronger than fishing line of the medium-weight type. It is, however, rather expensive in the quantities which we require. Competition rulings allow a length of between 100 to 655 feet.

To the end of the line a small metal or bone ring is attached, and this is slipped over the launching hook with which all gliders are fitted. It is also usual to attach a small streamer of silk to the line at a distance of a few feet from the ring. This serves to indicate the direction of the wind, and to locate the end of the line upon the ground when the machine is free.

The simplest use of the line is made by the "running launch." In this method, the glider is held by an assistant at the extremity of the line. The operator then runs into the wind, pulling the glider after him. In this manner the glider is made to rise, in exactly the same way as in launching a kite.

Winch Launch

The standard competition method of launching a glider is by means of a towline and winch. A suitable winch may be made from a cheap, geared, hand-operated grindstone, such as may be purchased from most ironmongers or tool stores. The necessary conversion is very simple, as it consists only in replacing the grinding wheel by a plywood drum of about 9 inches in diameter, and clamping a wooden handle into the thumbscrew attachment normally used to clamp the grinder to the bench. This handle may, if desired, be replaced by a length of broomstick, which forms a leg upon which the winder is supported. The arrangement is shown in Fig. 138.

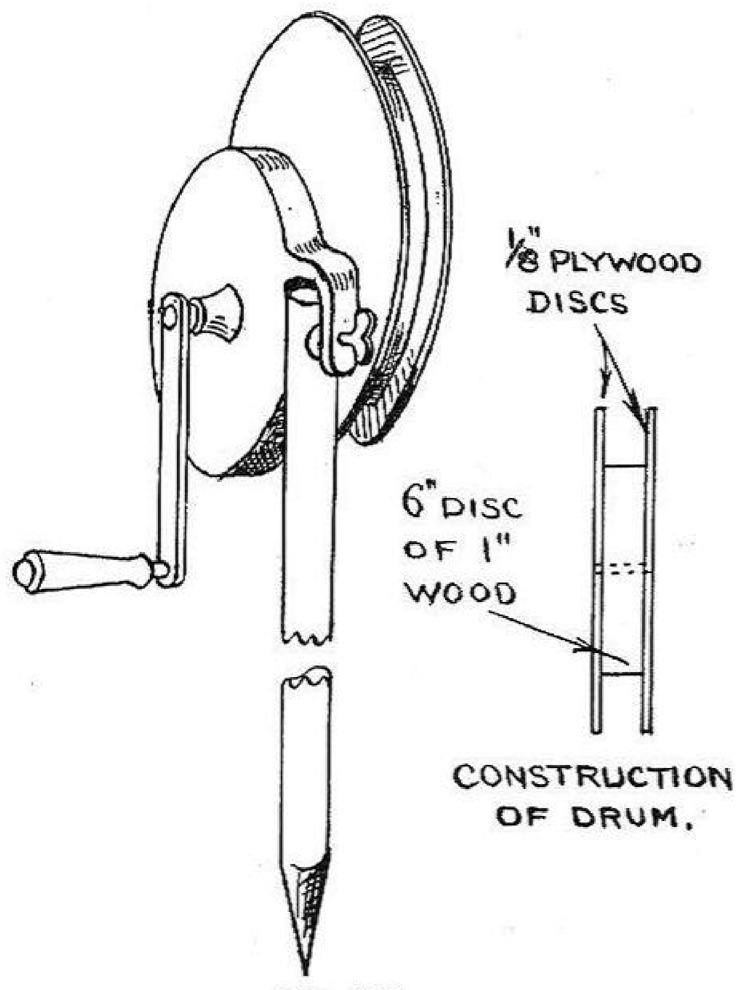

Fig. 138

Proceeding in the same way as before, the assistant carries the glider to the extreme end of the towline (in this case 655 feet is the maximum allowable length), walking away from the operator in the direction of the wind. The operator then tightens the line, and at a given signal the assistant releases the machine. A quick wind-in will cause the glider to soar into the wind, and, when a reasonable height has been gained, the rate of wind-in may be lessened, and the machine "played" to attain altitude. The object is to obtain height with as little loss of line as is possible, until the glider is overhead. At this point, the ring should slip from the towing hook, and the machine commence its glide. The rules of competition do not allow the operator to move out of a circle of 6 feet in diameter while launching is taking place; thus, all the operations must be carried out by means of the winch alone, aided by a very limited movement of the operator.

Catapult Launch

This is one of the best of methods for single-handed operation, and good altitudes may be attained. The British Glider Record, held by "The Twenty Minute Glider" described in this book, was achieved with this type of launching. Once again a towline is used. This is made up of 75 feet of twine and 25 feet (unstretched) of $\frac{1}{8}$ inch or 3/16 inch strip elastic. The end of the elastic is attached to a peg driven into the ground. After attaching the glider to the line, the operator walks, with the wind, away from the peg, until the elastic is stretched some 50 feet or so. On releasing the machine, the pull of the elastic will cause the glider to soar. In this case also the ring automatically slips from the hook when the glider is vertically above the point where the elastic is anchored.

Pulley Launching

The launching of gliders by means of a towline and a system of pulleys is well known, and has several advantages to recommend it. Various arrangements are used, and in all of these it is possible to propel the craft at speeds greater than that at which the operator moves upon the ground.

The simplest method is shown in Fig. 139, where it will be seen that the end of the line is attached to a peg driven into the ground. The line is then passed through a pulley held by the operator, and from thence to the machine. Upon walking backwards the operator will pull the machine towards him at twice the speed at which he himself is proceeding.

Figure 140 depicts a variation of this method, and it will be noted that the end of the line is again secured to a stake. From this, the line proceeds to a pulley attached to a handle which the operator holds, and from thence back to another pulley which is fixed to the upper part of the stake, and, finally, to the glider. It will be appreciated that when the operator moves from the stake the glider will be pulled forward. It will thus soar into the air, especially as it will have been arranged so that the direction of launch is into the wind. In this case, the speed of the machine is three times that of the operator, and it is possible for this system to be used for solo launching.

Mr. C. A. Rippon, in conjunction with Mr. S. Collins, has experimented a great deal with pulley launching, and they have, between them, done much to perfect the system shown in Fig. 141. Three pulleys are used. and the speed of the machine is four times that of the operator. This gives a great deal of control over the launch, and the method is, in fact, one of the best yet devised.

Figure 141 shows that from the stake the line is carried to the lower pulley of a pair, affixed to a suitable handle.

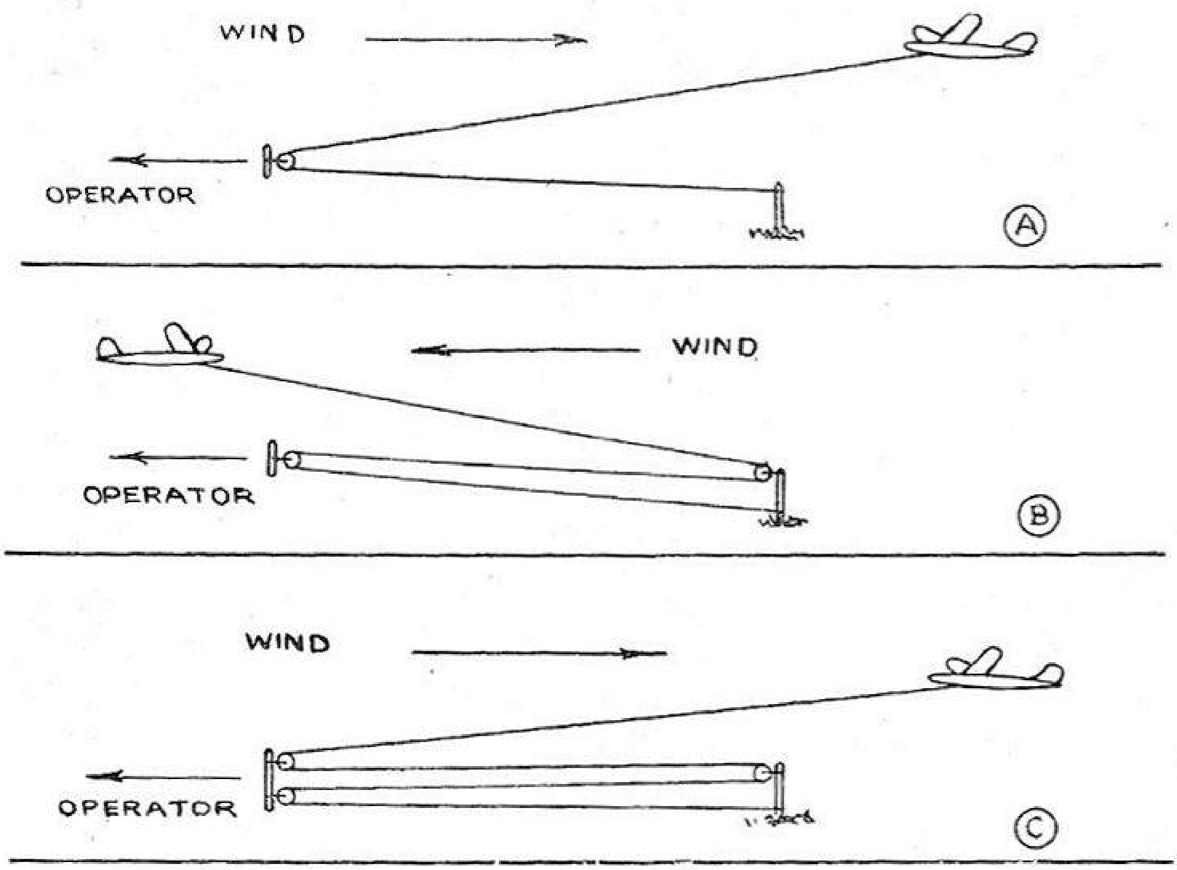

Fig. 139 (top) ; Fig. 140 (middle) ; Fig. 141 (bottom)

Passing over this pulley, the line returns to the stake, where it again engages a pulley, and then proceeds to the upper pulley on the handle. From thence it is carried, in the usual manner, to the glider.

It will be realised that the operator may move but slowly, which is an advantage when rough field land has to be negotiated. In addition, the operator may have the machine

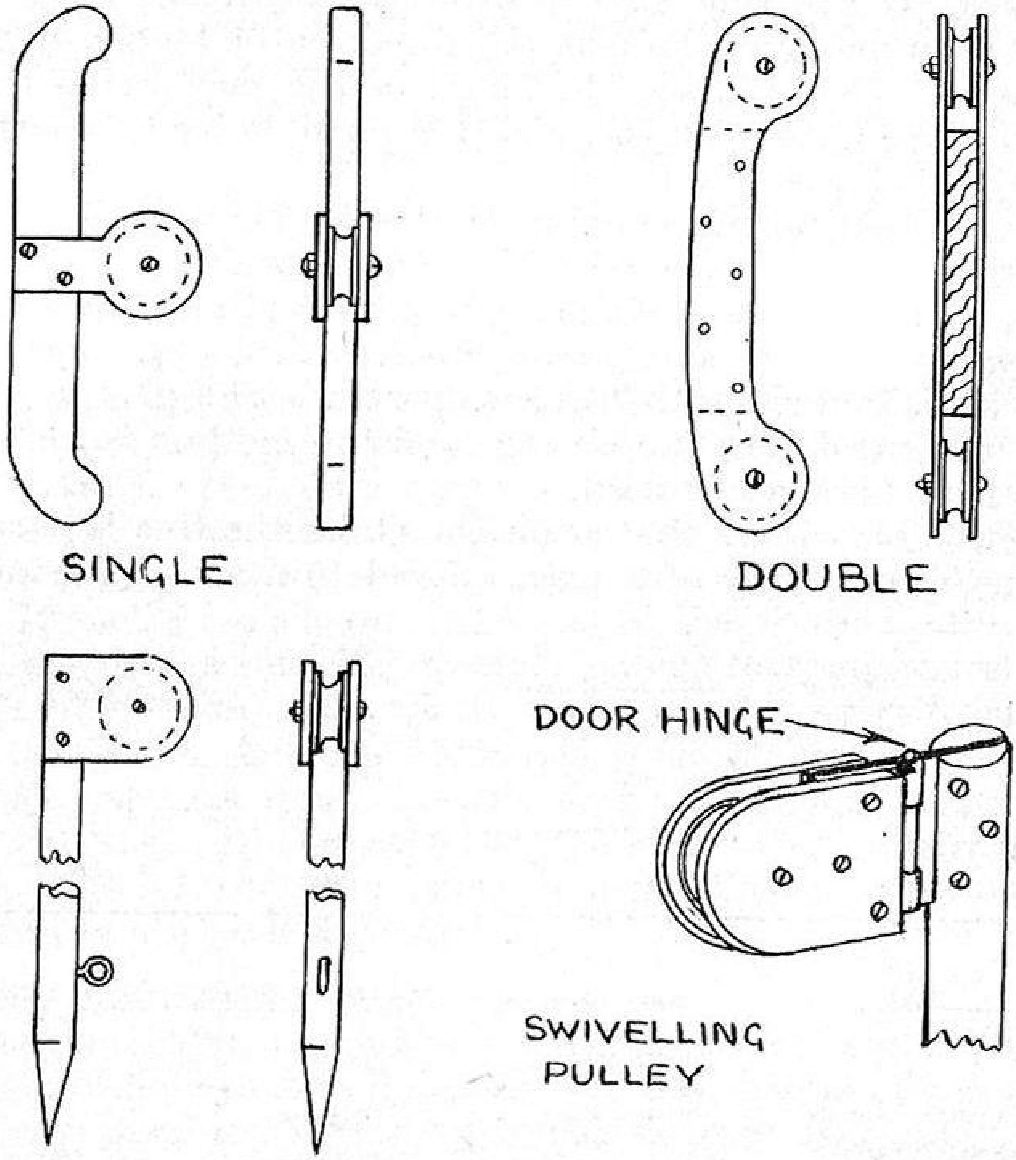

Fig. 142

fully in view during the launch, and it is here that the advantage of the slow movement is apparent, in so far as one's eyes must not be continually withdrawn from the machine to avoid any pitfalls of the path.

Launching Apparatus

With the exception, perhaps, of the pulleys, the whole of the apparatus required for pulley launching is essentially a home-made job. Suitable pulleys, turned from aluminium, may be obtained from some model supply shops. In default of this, they may be turned from hardwood, or may even be cut, in the form of plywood discs, with a suitable washer-cutter. Very suitable pulleys indeed may be often obtained, second-hand, from jobbing builders. They come from old venetian blinds, and are the small pulleys over which the blind cord runs.

The details of the arrangement are not important, and may be left to the maker's fancy. At the same time, those interested will find a suggestion or two in Fig. 142. It is an

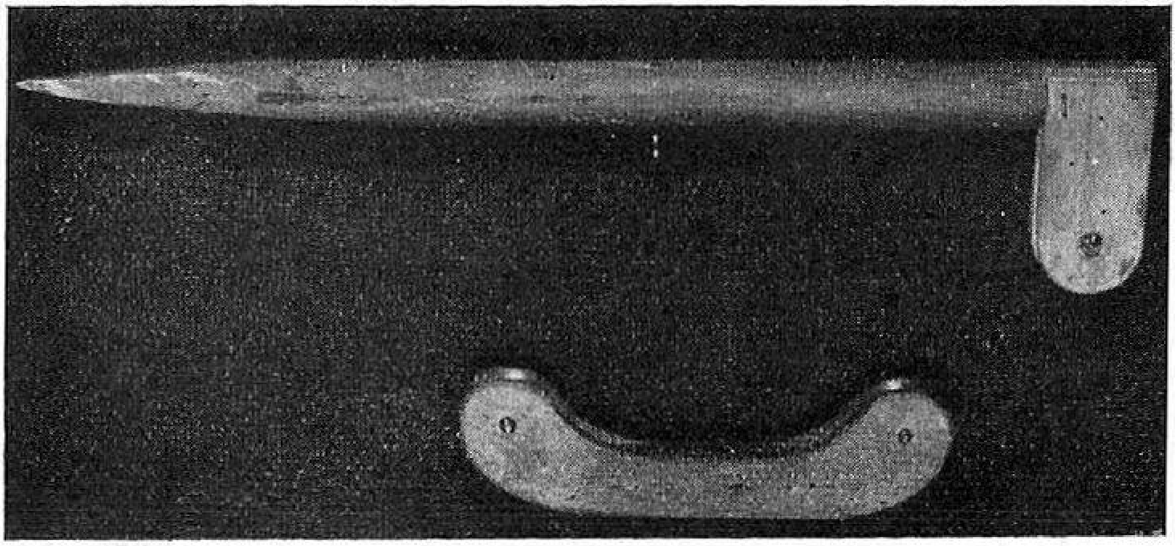

Fig. 143.—The original launching apparatus used by Mr. Rippon and Mr. Collins

advantage to have wooden pulleys bushed with brass tubing, as it is essential that they run as easily as possible upon their bearings.

Some advantage is obtained by having the pulley to swivel upon the stake, as this does much to prevent the line from running off. It also enables the operator to change his direction of pull while the machine is being launched. In this way the machine may be "weaved" about to accommodate it to any slight changes in the direction of the breeze.

CHAPTER XIII

HINTS and TIPS

Some of the following hints are well known, but others are the outcome of many years of personal experience. They are given in the hope that they will assist the beginner and possibly refresh the memory of the experienced builder.

Being extremely soft, balsa is not readily cut with a saw, as the saw teeth become clogged, and there is a tendency for the saw to " run off." Large blocks are, however, difficult to cut by any other means, and must usually be sawn roughly to size, and finally shaped with a sharp knife and glass-paper. Balsa sheet is easily cut with a safety razor blade ; the blade being drawn several times lightly along the cut. When double-edged safety razor blades are used, a small guard may be made from a piece of bent tin, and secured with small nuts and bolts. This will prevent cut fingers.

It is often a problem to make small circular holes in balsa sheet. These are sometimes required for lightening purposes, and may be cut quite easily with a piece of brass tubing. The tube should be bevelled on the *inner* edge, with a file or countersink bit, to a cutting edge. (Fig. 144.) For very small holes a cheap tin pencil case may be used in a similar manner.

Thin sheet balsa, usually of 1/64th inch thickness, is often used for fairings, cowlings, etc. This thin sheet may be curled to the desired curve by coating one side with cellulose cement, and allowing this to set. As the cement dries it will contract and curve the wood in so doing.

Balsa is considerably strengthened and toughened by soaking in dope or cellulose cement.

Balsa tubes for struts and undercarriage legs may be made by soaking thin sheet balsa in water and allowing to dry whilst bent around a round wooden dowel. They should be bound with tape, which is removed when dry, when the edges of the tube may be secured with cement.

A piece of glass forms an ideal scraper for balsa or other woods. It is particularly useful for scraping bamboo.

When sheet balsa has been used for fuselage covering it is often difficult to obtain a smooth finish owing to the rough grain which does not sand-paper very smoothly. Tissue paper doped on to the balsa will give a smooth surface upon which colours or insignia may be painted.

Wheel discs may be cut from balsa sheet or plywood with the simple tool illustrated in Fig. 145. This consists of a small piece of hardwood into which two panel pins have been driven at the required distance. The tool is used like a

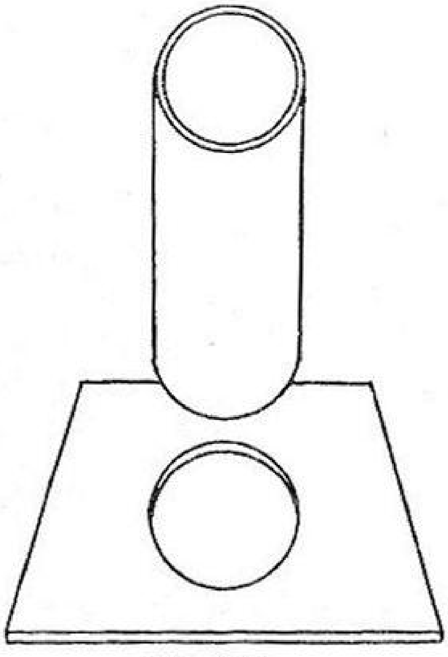

Fig. 144

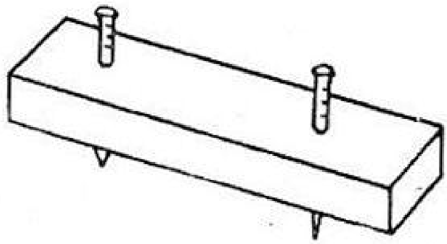

Fig. 145

compass ; one pin forming a pivot, the other being sharpened to a cutting edge.

Bentwood propellers of sheet balsa or other woods can be made by coating the wood on both surfaces with varnish which is allowed to set. The wood is then warmed, twisted and immediately plunged into cold water. The blades will be found to retain their pitch-angles if bent by this method.

Bamboo or reed cane must be bent under dry heat. This need not be excessive but the wood must be thoroughly warmed through. When ready, the wood, whilst being held at the desired curve, should be plunged into cold water. The bamboo or cane will then keep its shape.

Reed cane is sold in coils, and is rather difficult to straighten out. If the cane is soaked in water and allowed to dry while suspended with a weight hanging from one end, no difficulty will be encountered.

A useful steaming jig for bending dihedral angles in wing spars is shown in Fig. 146. This consists of a length of board upon which a centre line has been drawn. Two nails are driven into the board along this line (one nail (B) being offset to allow for the thickness of the wood to be steamed),

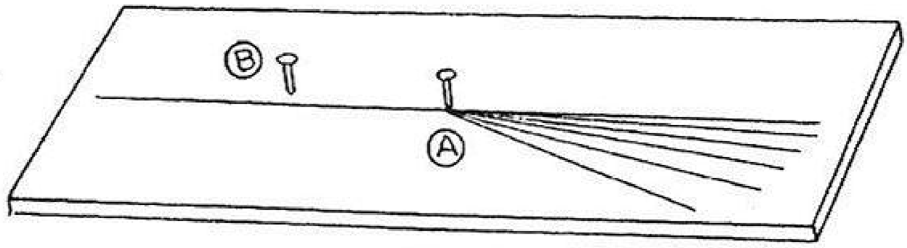

Fig. 146

and lines are drawn upon the board at various angles radiating from the nail (A). When being steamed the wood is bent against this nail to the desired angle. Use the jig for checking the dihedral when the wood has cooled down.

To make a strong glued joint it is essential that the joint should be a good fit before gluing. This is the secret of success, and no amount of glue will make a bad joint strong. If Scotch glue is used it must be *hot* and of thin consistency. It is a good plan to warm the wood before applying the glue.

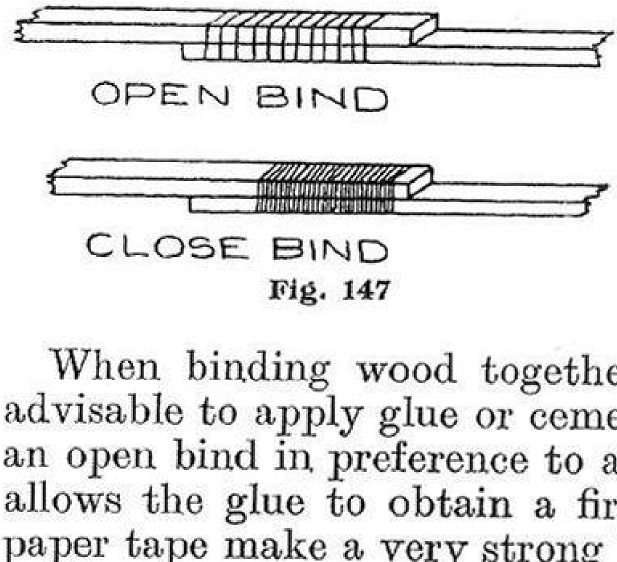

Fig. 147

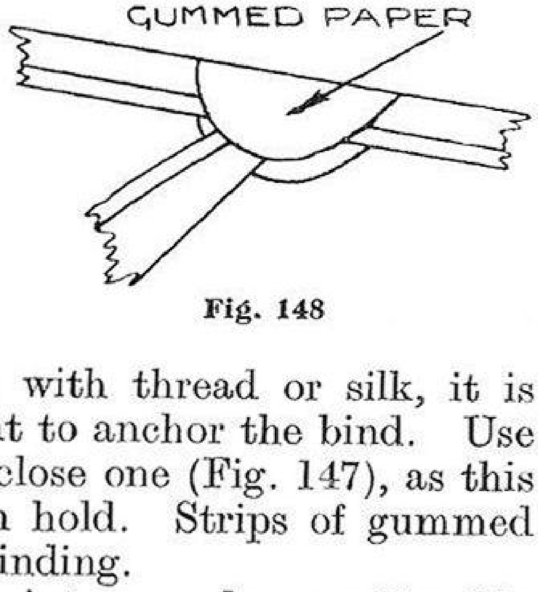

Fig. 148

When binding wood together with thread or silk, it is advisable to apply glue or cement to anchor the bind. Use an open bind in preference to a close one (Fig. 147), as this allows the glue to obtain a firm hold. Strips of gummed paper tape make a very strong binding.

The strength of small glued joints may be considerably increased by the use of gummed paper discs which are stuck over the joins. These are particularly useful for strengthening the junctions of wing ribs and the leading and trailing edges, as shown in Fig. 148. These discs are cut from gummed paper strip such as is used for securing parcels, and may be made by using a halfpenny as a template and cutting around the edge with a razor blade. If a large quantity is required, several dozen thicknesses of gummed paper may be clamped between pieces of plywood and fretted out together ; a circle being inscribed on one piece of plywood as a guide. The strength which these paper discs impart is enormous in proportion to the added weight.

Every model builder should make up a few clamps as illustrated in Fig. 149. These are simply pieces of piano wire bent into the shape of a " C." Bicycle trouser clips

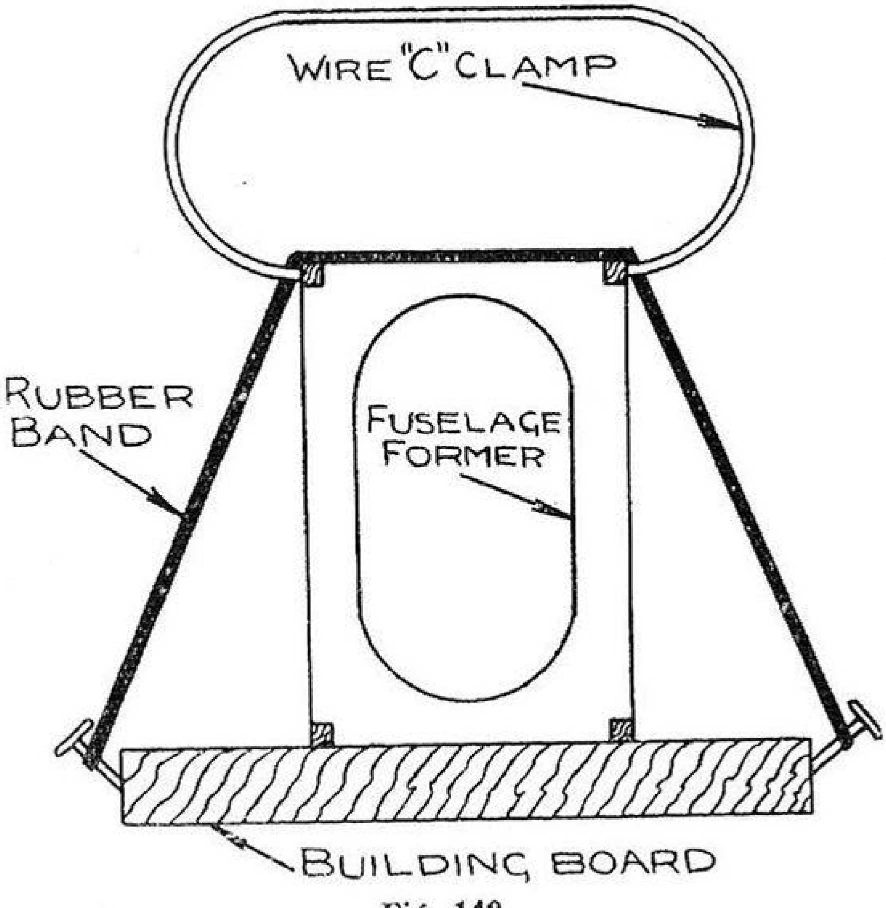

Fig. 149

are ideal for this purpose, and their application is shown in the drawing. This also illustrates a method of holding the fuselage " square " while being built. Rubber bands are placed, under tension, at various points along the fuselage, and the ends looped over nails in the building board. Ensure that the fuselage sides are square with the board by checking with a set-square. If the structure tends to lean over to one side, this may be corrected by varying the tension on the band on either side of the fuselage.

Wooden washing pegs, as used for hanging clothes on a line to dry, form ideal clamps for holding small pieces of wood together whilst gluing. These pegs are of the type illustrated in Fig. 150, a small spring being incorporated. They are inexpensive.

A most useful substance for the model builder is plastic wood. Not only may this be used for fairings, wing and tail fillets and streamlining in general, but a variety of small fittings may be constructed from it. This is especially applicable to scale models, as such things as tail wheels, propeller spinners and the many similar small parts which scale models require, may be made.

While talking of scale models, it may be pointed out that devotees of this type of machine should be always on the look out for pictures or photographs from which insignia or other aeroplane details may be cut. For instance, the

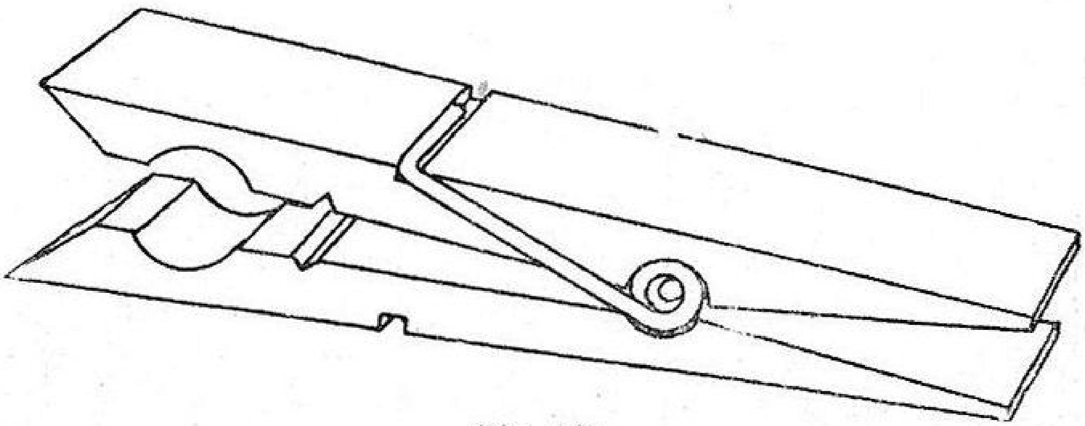

Fig. 150

periodicals devoted to aircraft sometimes publish photographs of cockpits showing the instrument boards. These instrument boards are often puzzling things for the model builder to imitate, and the pictures should be cut out and saved for use on future occasions, These portions may often be stuck on to a model with good effect.

Imitation engine cylinders can be carved from balsa, and the finning imitated by a spaced winding of thread or string, the whole being afterwards painted black. This is good for small models where little detail is required. Larger cylinders may be built up of alternate discs of balsa and thin plywood, the latter being cut larger, that they may protrude and give the effect of fins.

It is often possible to use ordinary drinking straws as struts on light machines. These straws are strong and light.

There are two essentials to good soldering : cleanliness and a hot soldering bit. Therefore, clean all parts to be soldered with emery cloth, and see that the copper bit is hot and well tinned. Do not, however, have the bit red hot. If spirits of salts is used as a flux, make sure that it is wiped from the joint after soldering; otherwise it is likely to corrode the metal. Use a resin flux if possible.

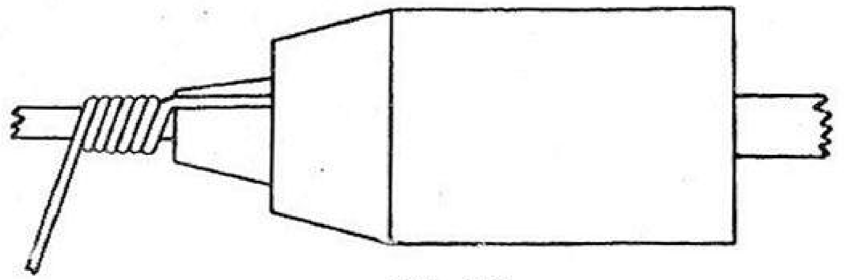

Fig. 151

When soldering metal fittings which are touching wooden parts, use an extremely hot soldering bit so that the solder runs immediately it is applied to the join. Withdraw the soldering bit directly the solder has "taken." You will then not burn the wood.

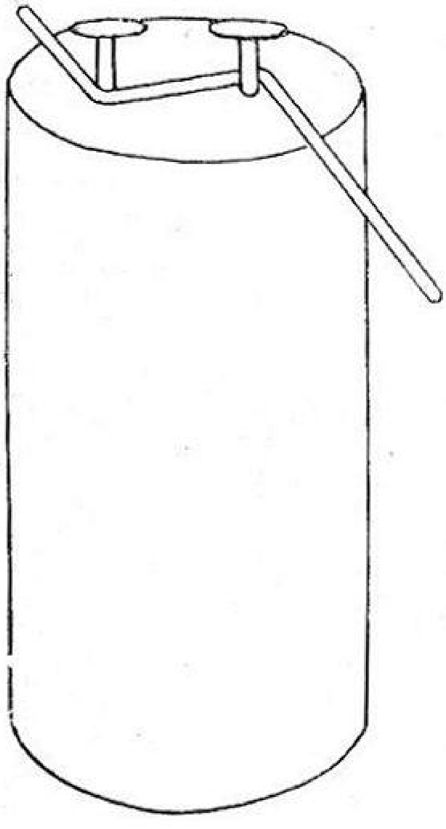

Fig. 152

A great number of small fittings may be made from celluloid. Tubing is easily made by wrapping celluloid around a warm steel knitting needle or any other warm metal rod. The seam may be joined with celluloid cement.

Never use metal if another lighter substance will suffice.

When covering structures with oil-proofed silk, the silk is rendered more pliable and easily worked if it is warmed before and during the process.

Piano - wire springs may be wound with the help of a geared hand brace. Fit a drill, of a size smaller than the required inside diameter of the spring, into the chuck, and clamp the brace horizontally in a vice. Use a long piece of piano-wire, and bend one half an inch of the wire at right angles. Insert this into one of the slots between the chuck jaws, and wind the wire on to the drill (Fig. 151). Wind on quickly, as a better spring will result. It is quite easy.

A wire bender, as illustrated in Fig. 152, is a handy accessory. It is made with a piece of broom handle and two nails.

It is advisable to fit some device whereby the nose-block is retained in the fuselage when the rubber motor is unwound.

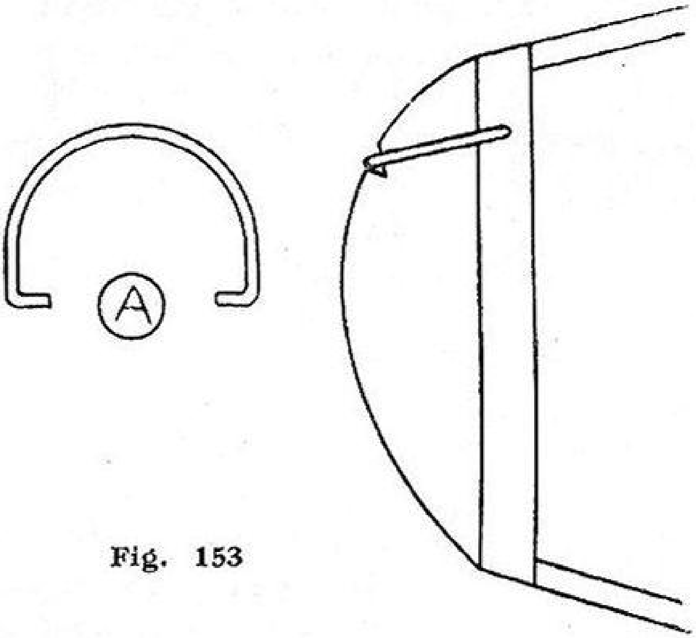

Fig. 153

If the block is allowed to fall out when the machine is in the air it will upset the balance and spoil the glide. A simple wire clip is illustrated in Fig. 153. A piece of wire is bent as shown in " A " and pivoted by the two spikes into the nose former. The weight of the wire clip itself will retain it in the slot cut in the nose-block.

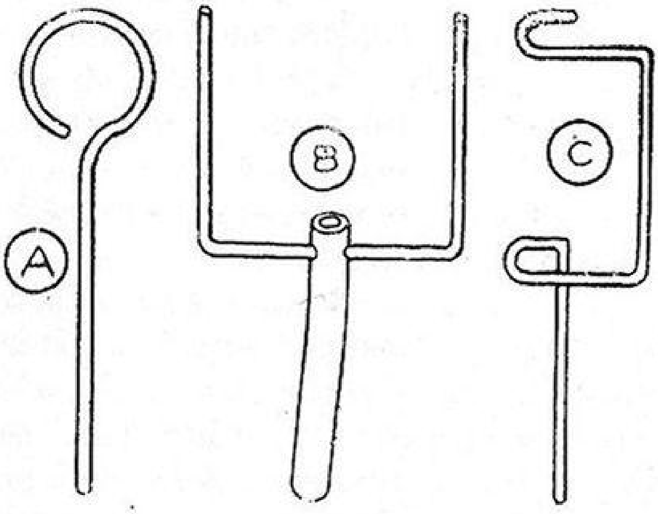

Fig. 154

When measuring rubber into skeins do not stretch it, or the loops will be of uneven length. A satisfactory method is to loop the rubber loosely over two nails driven into a board at the required distance from each other.

Never use oil to lubricate rubber motors. It will render them useless.

Before covering wire hooks with valve tubing or Sistoflex, paint the hooks with cellulose lacquer. They will rust beneath the covering if left unpainted.

A geared winder for winding propellers is an essential. Three adapters are shown in Fig. 154, for use in a geared hand brace. The plain wire hook is for use when the propeller-shaft has been bent into a loop. The attachment (B) is for use when the propeller-shaft has a plain end; while (C) is for a similar purpose, but will allow the rubber to be stretched when being wound.

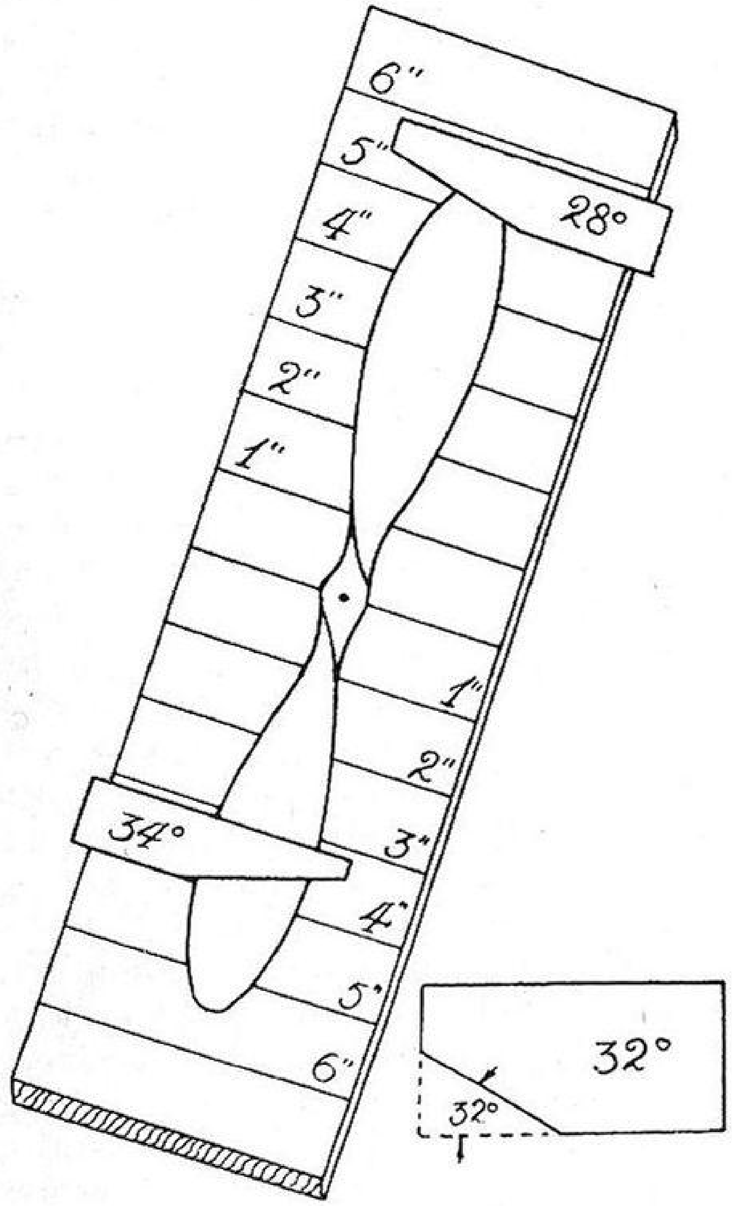

Fig. 155

An arrangement for testing propeller pitches is shown in Fig. 155. It consists of a *flat* board upon which lines have been inscribed at intervals of one inch. A nail, from which the head has been cut, is driven into the exact centre of the board, and must be "square" with it in all directions. The propeller to be tested is mounted upon the board by pushing the nail into the spindle hole. It must be a tight fit so that the propeller cannot rock.

Now cut a number of cards, as shown in Fig. 155. These may be ordinary plain post cards, and a number of them should be cut at various angles. The propeller pitch is tested by placing a card of the correct angle upon the board at the appropriate distance from the propeller boss, and seeing that the blade angle conforms to the angle at which the card is cut. A pitch tester should always be used when carving propellers.

Before any model is built it is necessary to prepare drawings, not only for guidance in measurement, but that the actual structure may be built upon the drawing. It is often helpful to use graph paper for this purpose as a great deal of measurement may be obviated. Squared paper is also helpful in ascertaining the area of a wing or tail surface, especially one of irregular shape, as the whole squares may be counted off, and the part squares added together fairly accurately. Squared paper is obtainable in either metric or inch measurements.

If a model is flown consistently near to trees it is almost certain, at some time or another, to land on the topmost branches of one of these, and it is not always possible to reach the machine by climbing. A ball of strong twine will often solve the problem. Attach a weight, such as a stone, to the string, and coil the string on to the ground so that it will not become entangled. Now take hold of the string about three feet away from the stone, and whirl this around. When sufficient velocity has been obtained, let the string go so that the stone will carry the string across the offending branch, and will fall upon the ground at the other side of the tree. With the help of an assistant, both ends of the twine are pulled simultaneously, and the branch made to sway. With a little patience the model will be loosened and will fall. Several attempts will doubtless be necessary before the twine is thrown in an effective manner.

When a body of model flyers, such as a club, uses a certain flying ground, a jointed rod for removing models from trees is often obtained as a communal possession. Any fishing rod maker will make one of these for a few shillings, and a rod of 30 feet in length is possible if stout bamboo poles are used for the lower joints.

A model subjected to the treatment outlined above would doubtless have the covering torn in places. Paper covering may be repaired by sticking a paper patch over the tear with dope. This will stick quite well and will form a very inconspicuous repair. Tears in silk should be trimmed off neatly with scissors, and the edges of the patch frayed for a distance of about a quarter of an inch. The patch is then doped over the damaged portion, the frayed edges being brushed out smoothly.

Steel knitting needles make excellent shafts for propellers or gearboxes.

It is often desirable to use birch or spruce strip of round section for such things as trailing edges and tail edges.

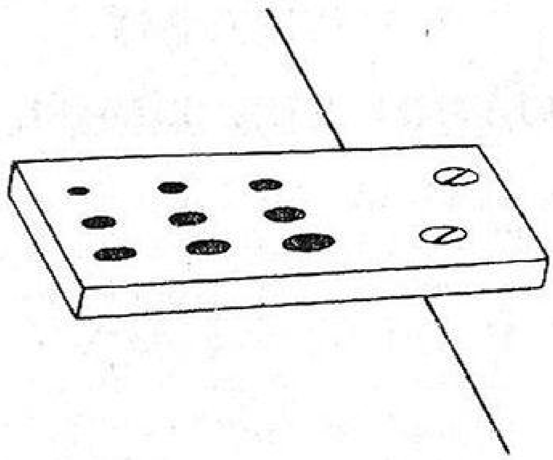

Fig. 156

This is not obtainable commercially in the smaller sizes, although square section strip may be purchased in sizes from 1/32 inch upwards.

A useful die plate, as shown in Fig. 156, may be made from a piece of $\frac{1}{8}$ inch brass or steel, and consists of a plate with a number of holes of decreasing sizes drilled into it. They may range from 1/32 inch to $\frac{1}{4}$ inch.

The square strip is inserted into the hole which is of slightly less diameter than that of the strip, and pulled through. This is repeated, using successively smaller holes, until the required diameter is attained.

CHAPTER XIV

FLYING THE MODEL

Model aeroplanes should be flown in a large open field, free from trees. This latter qualification is often difficult to attain, and if trees are in the vicinity always launch the machine so that the wind will carry it away from them. Trees are the model flyers' greatest bugbear; the next on the list being well-meaning but ham-handed spectators who are always anxious to assist. If you fly your machine in any public park, you will soon be the centre of attraction, and the crowd of adults and small boys—to say nothing of enthusiastic dogs—will often make flying impossible. The model flyer, however, is usually able to find a suitable field where these handicaps do not exist.

Having arrived at the scene of action, the machine must be assembled and checked for alignment. The wing and tail must lie in the same plane, which means that they must sit squarely to each other upon the fuselage when sighted from the front of the aeroplane (see Fig. 157, illustration (A)). Also, the centre lines of the wing and tail must be at an angle of 90 degrees to the centre line of the fuselage (illustration (B)). Be sure that neither the wing nor tail plane is warped.

The model having been assembled, it is first necessary to ascertain the trim of the machine. If you are testing a new model, you will, of course, have chosen a day when there is little or no wind. The gliding trim may be found by placing the centre of pressure of the wing just a little behind the centre of gravity, and gently launching the machine into the air with the propeller stationary. Fig. 158 shows how the model is held when launching. Launch the model into the wind, and tilt the nose down slightly.

If the gliding angle is too steep, move the wing forward along the fuselage, and try again; repeating this procedure until the glide is perfect. Move the wing about $\frac{1}{8}$ inch at a time. If, on the contrary, the glide is too flat, and the model shows a tendency to stall, the opposite procedure is

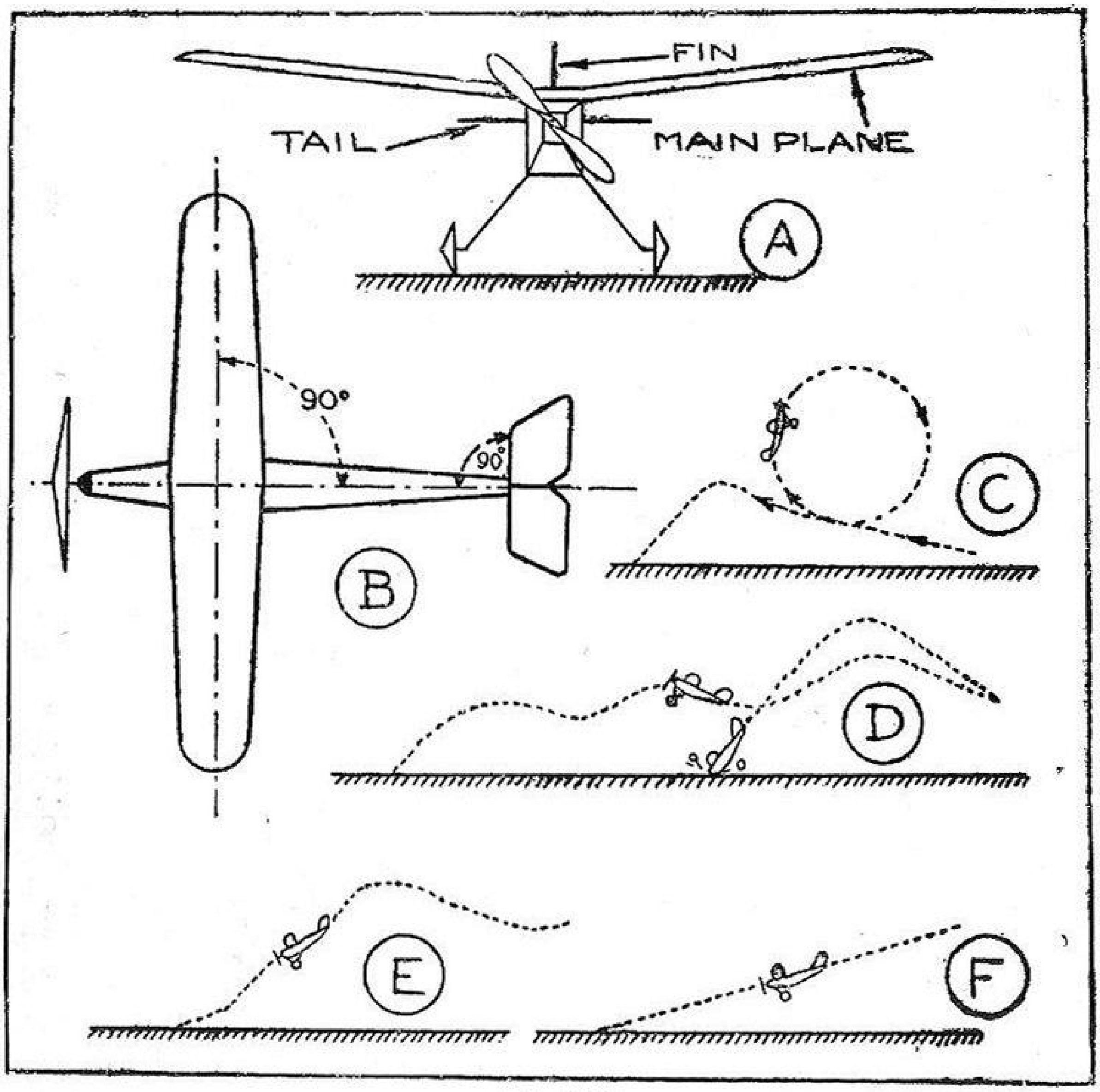

Fig. 157

necessary; the wing being moved back. Do all these adjustments gradually, and avoid making drastic alterations at one time.

The gliding trim being correct, the propeller may be wound to two or three hundred turns, but, before launching, move the main plane back about 1/16 inch. This is a precaution against stalling. If the model has been built truly, and is correctly trimmed, it should now fly quite well, although no great climb may be expected with so few turns on the motor. Under these satisfactory conditions the motor may be wound more fully, and good climbing flights should result.

It is seldom, however, that perfect results are obtained so quickly, and a fair amount of preliminary adjustment of trim is usually required. As a help to this the illustrations in Fig. 157 may be studied.

The drawing (C) shows the probable behaviour of a machine that has too much power. The machine is in the act of looping the loop, but the "sticky" end consequent upon the model making the final loop too near the ground is not shown. This is not a common fault, and the remedy is obvious.

The drawing (D) illustrates the behaviour of a model that is over-elevated, i.e. the centre of pressure is too far ahead of the centre of gravity. This results in stalling. If the centre of pressure is very much forward, the model will stall steeply and then crash to the ground; a disastrous occurrence under full power. Should the maladjustment be slight, the machine will follow an undulating path as depicted; not always with "fatal" results. Move the wing back along the fuselage to correct. Stalling may also be caused through the tail being set at too great an angle of incidence.

In (F) we see the result of under-elevation. The machine will fly steeply to the ground, and the remedy is to move the wing forward. The same symptoms may denote that the machine is greatly underpowered, and more rubber should, therefore, be used. Sometimes, however, a machine that is slightly under-powered will fly fairly well for a short distance under the first burst of power, but will suddenly lose flying speed. This causes the model to execute a sort of lazy stall, ending in a slow nose-dive. This is shown in drawing (E).

If none of the above troubles is obvious, the difficulty may be due to the tail being set at too small a negative incidence.

The chief cause of bad flight is a warped wing or tail plane. Under these conditions the behaviour of the machine is extremely erratic, and nothing can be done until the warps are corrected. A warped wing will usually make the aeroplane tilt sideways and cause it to take a banking dive into the ground. Warped tail planes cause very erratic behaviour; the model turning and twisting in all directions.

Sometimes the torque of the propeller causes a model to turn persistently in one direction. This may be corrected by adjustment of the rudder fin. Should the torque effect be excessive, however, it should be rectified by packing the noseblock of the machine to one side with a slip of balsa. The packing is inserted so that the propeller shaft points to the opposite direction to that into which the aeroplane tends to turn. A packing slip of about 1/16 inch thick should be enough for a trial flight, the correct thickness being found by experimental flights. When the correct amount of "side-thrust" has been found, the packing may be cemented in to form a permanent feature of the trim. This matter of side-thrust is really a compromise between

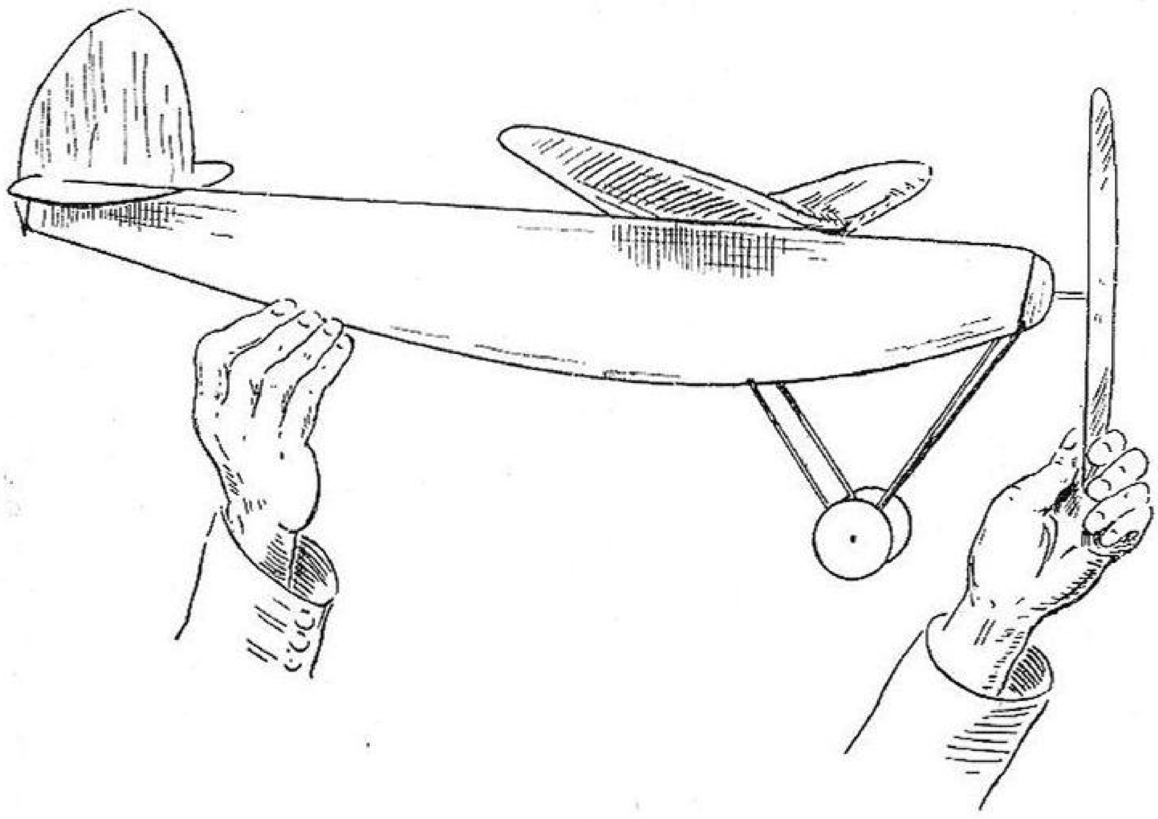

Fig. 158

"right" rudder and "right" side-thrust. If too much side-thrust is given to the noseblock and too little to the rudder the machine will fly in wide right-hand circles, but will tend to glide straight down wind. If, on the other hand, too much rudder and too little side-thrust is incorporated the machine will fly in circles, but will spin violently to the right when the power is expended. The ideal is, of course, a correct combination of the two, which may only be found by careful experiment with individual machines in the field, and is the secret of long duration flights. Failing perfection, it is better to give too much side-thrust to the noseblock and too little rudder, as the machine will then not be in danger of a violent spin to the ground.

If a model sideslips it is a sign of insufficient dihedral angle in the main wing. Should the model wallow, too much dihedral is indicated.

When a machine is hand launched, it should be launched into the wind with the nose of the machine pointed slightly downwards. On no account must the machine be pointed upwards, unless it is exceptionally powerful and stable, or a stall will, in all probability, result. Never launch a model down wind, as not only must the aeroplane attain considerable speed before it is air-borne, but there is a danger of a gust getting under the tail before the machine is properly under way, with a resultant nose dive. If launched across the wind the propeller torque should turn the 'plane into the wind. The machine will then climb to its maximum height.

Always launch a model carefully, especially if it has a light wing loading. Heavily loaded machines may be launched faster ; in fact, the speed of the launch should be, as near as possible, the flying speed of the aeroplane. If the airscrew is allowed to revolve for a few moments before launching a smoother take-off is sometimes obtained.

Rise-off-ground flights should only be attempted from smooth ground. Launch the model either into the wind or at an angle of 45 degrees to it. This allows the torque to draw the machine into the wind.

Competition Flying

To-day, successful competition flying is a fine art, which not only calls for a model of exceptional capabilities, but requires a great degree of skill and preparation. The days when a practically untried model could win a competition are over, and it is now necessary to know the characteristics of the competing machine under all conditions. For this reason it is as well not to enter for too many competitions of various kinds, but to specialise in one type. This will allow plenty of time to develop your competition machines and to learn to fly them.

To become used to a model it must be flown consistently. This calls for a robust machine, with special attention paid to parts which must be frequently handled. Fly the machine in all reasonable weather, as one can never say what this will be like on the actual day of competition. If competing in rise-off-ground events see that the undercarriage is strong and rigid and that the wheels track properly. Undercarriages which wobble in flight have a very disastrous effect upon stability.

Select, then, your competitions, and concentrate upon these, making quite sure that you understand the rules which govern them. Many competitions are run under special rules, as distinct from the usual S.M.A.E. regulations, and there are few things so disappointing as to arrive at an event with a good machine which does not comply with the regulations.

If, during the preliminary or eliminating flights, your machine gets out of trim, do not make unofficial test flights while other competitors are flying. Ask the judges for permission to test your 'plane. This is not only a competition rule but is one of the courtesies of flying.

As a man is known by his friends, so is a wise competitor known by his helpers. Choose these carefully, selecting those who not only know how to handle a delicate machine, but who will be more interested in helping you than in watching the other machines performing. Above all, select those who will not talk while you are counting the last fateful turns on the rubber motor.

It is important to know the exact number of turns that your motor will take. Do not put on the maximum number until the last flight, as a broken skein will often wreck a light machine. Have two or three identical rubber motors at hand, in case you break strands during the early flights. These spare motors must be well lubricated and *run-in*. Do not trust to new rubber, and watch the rubber hooks carefully during winding to ensure that the motor is not slipping off these.

On windy days see that the wing and tail are firmly fixed to the fuselage. Increase the number of rubber securing bands if necessary, as it is disastrous for the wing or tail to lift from the fuselage during flight. On windy days, also, it is better to obtain trim by slightly weighting the nose rather than by moving the main plane backwards upon the fuselage. The wind will supply the necessary extra lift.

Should the day be hot and sunny, do not, between events, leave your model in the full glare of the sun. Always place it in the shade, and look at it from time to time to see that the shadow has not moved so as to expose the model. Many competitions have been lost through neglect of this precaution; the model becoming too warped to perform correctly.

When flying on hilly ground or near large buildings (such as aeroplane hangars) endeavour to fly the machine so that advantage may be taken of any upcurrents of the air. These will be found on the same side of the hill or building as tha from which the wind is blowing.

CHAPTER XV

THE "A.C.2"

A Lightweight, Shoulder-wing Monoplane

This machine is a direct development of the original "Air Cadet," which was specially designed by Mr. C. A. Rippon for the Air Cadet Corps, and it has speedily gained a reputation for its good, all-round qualities. The design has brought the machine more into the duration class, and forms a good example of modern practice.

While it is not an over-simplified design, its building should present no difficulties to the ordinary run of aero-modellers, and even the absolute beginner should not find the job too difficult. The matter has been simplified by the fact that full-sized blueprints of the aeroplane are available. The drawing, Fig. 159, is a much reduced reproduction of the actual print, and from it builders may see that the construction has been well detailed. All points which might not be clear to those unaccustomed to the reading of drawings have been shown in isometric form, and, together with these notes on the building of the machine, should clear the path of any obstacles. All intending builders must, therefore, obtain a copy of the print; in fact, it is difficult to see how the job can be satisfactorily tackled without it.

On obtaining the print it should be carefully studied in all its parts, so that the constructor is familiar with every detail before commencing to build. Having thus become acquainted, the print should be covered with a sheet of tracing paper, and the two pinned to a flat board. If such a large board is not available, it becomes necessary to trace the various components, such as wings, fuselage, etc., upon smaller pieces of tracing paper, which may be more conveniently pinned to the available board. In this manner the

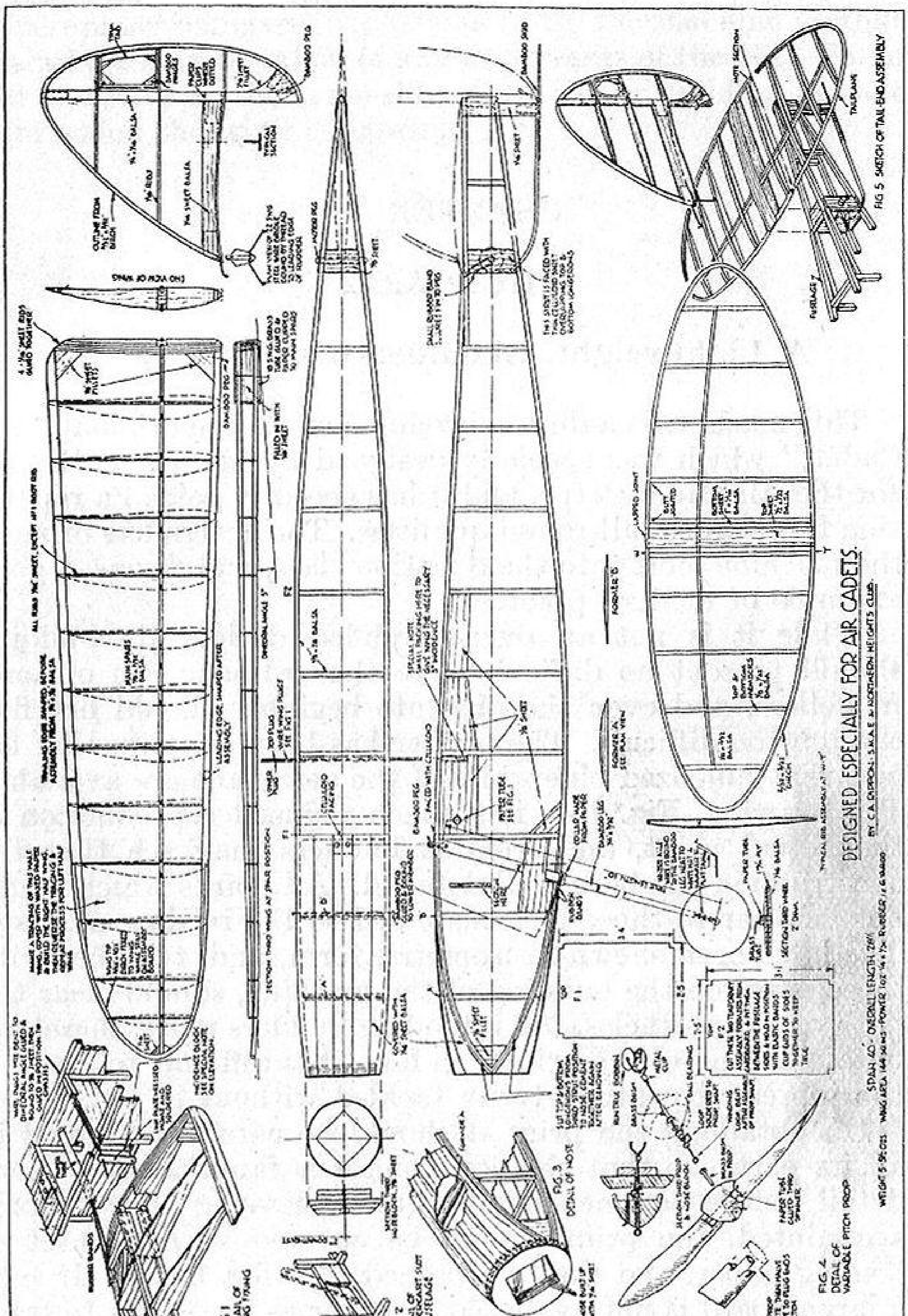

Fig. 159

machine may be built upon a piece of floorboard, 36 inches long by 5 inches wide—but it must be smooth and free from warps.

Fuselage

By studying the side view drawing of the fuselage, in conjunction with the photograph in Fig. 162, it will be seen that each side of the fuselage consists of two pieces of balsa, joined together with balsa uprights. At the front end, the two longerons are drawn together to form a point. Between

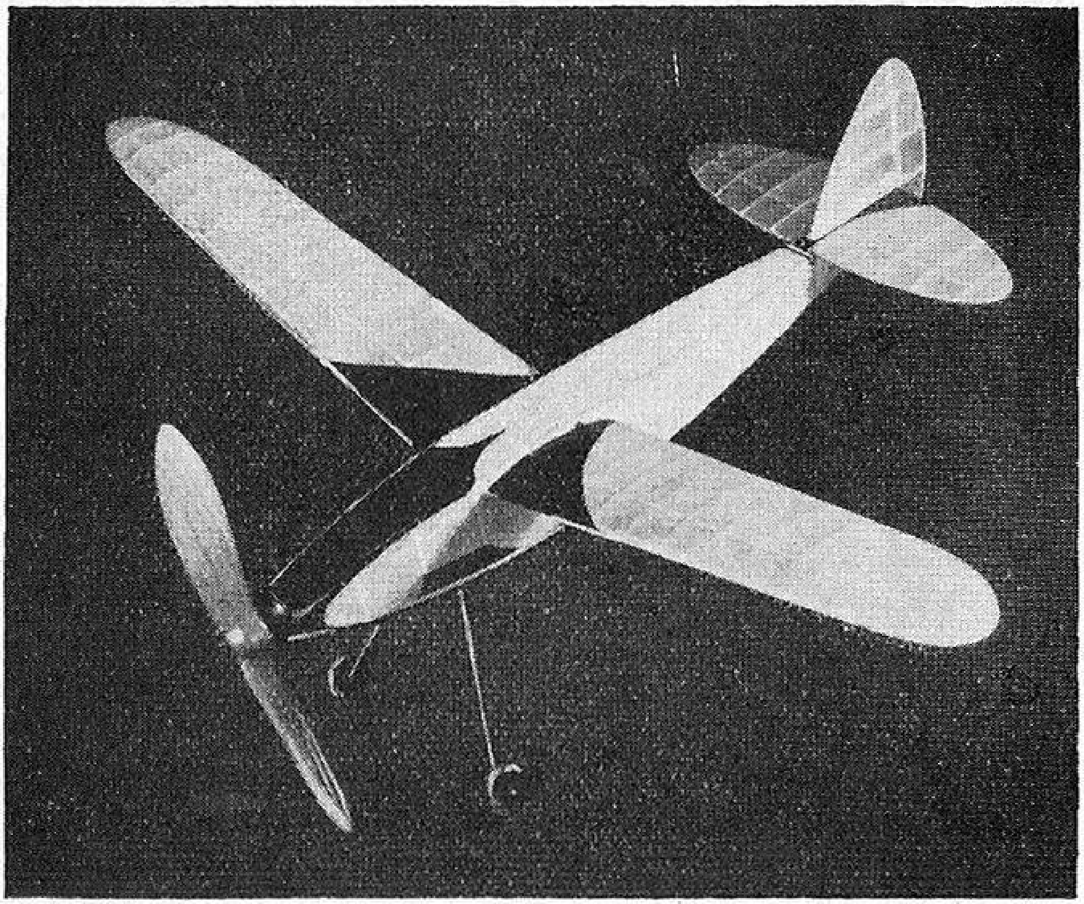

Fig. 160. "A.C. 2" ready for the air

these points a round nose former is cemented, and the nose of the fuselage completed by sheeting in with 1/6th inch sheet balsa, which is cut into strips, and cemented, upon small supporting formers, from the nose to the end of the third bay of the fuselage.

The arrangement presents no difficulties, except, perhaps, in obtaining the acute bends necessary on the side longerons, so that they may be drawn together to a point. Balsa of 1/8 inch square section will not, in the usual course, bend to this extremity, and the following procedure must be adopted. Marking the points on the longerons where the bend commences, the longerons are split from here to the nose, in the manner shown in Fig. 161. By doing this it is possible to bend the balsa to very acute curves, as it is really equivalent to bending two strips of 1/8 inch × 1/16 inch balsa. Before bending, the slit is filled with cellulose cement, and when once bent, and the cement set, a very permanent curve is formed. An alternative method is to use two strips of 1/8 inch × 1/16 inch balsa for the curved portion, and to splice these into the main longerons which are retained at the rear. The splice is shown in the lower sketch of Fig. 161.

Having built one side of the fuselage upon the drawing, the second side is built flat upon the first. Small pieces of tissue paper should be placed between the two sides at the points where cement will be applied, to prevent them from sticking together. It is a great aid in obtaining identical sides if the small balsa joining pieces are cut in pairs ; that is, those for both sides are cut together.

The two identical sides being thus obtained, they should be pinned, in a vertical position, upon the plan drawing. As the bottom longerons are in the form of a long curve it will not be possible to pin these to the board, so that it is the top longerons which must be pinned down, and the fuselage built, as it were, "upside-down." The two false formers, cut from cardboard, are now inserted, and held with elastic bands, or by means of the wire "C" clips shown in the chapter on "Hints and Tips."

As before, it is again recommended that the cross-struts be cut in pairs. The bottom set of struts should be cemented in first, and there is no difficulty here as these lie upon the board. In cementing in the top struts, however, the wire "C" clips just mentioned should be employed to hold the fuselage sides together.

Next, sheet in the nose, and cement in the balsa reinforcements at the wing location, and at the points where the undercarriage legs emerge. The peg for anchoring the rear end of the rubber motor passes through holes in small pieces of 1/8 inch balsa, which are cemented into all four sides, at the points shown. The two side pieces are then covered with thin sheet celluloid, the edges of which are lapped over the top and bottom edges of the fuselage. The celluloid sheet is cemented on.

Wing-fixing

An extremely neat and efficient method of attaching the wings to the fuselage is used. It consists of two wire plugs, or prongs, which protrude from the sides of the fuselage, and locate into short pieces of brass tubing affixed to the wings. The assembly is then clamped together with a rubber band, which passes, from one wing to another, through a tube rolled from gummed-paper strip.

The wire plugs are of 18 S.W.G. piano wire, with the correct dihedral angle bent into the ends. These wires are cemented and bound with paper strip to a piece of 1/8 inch balsa, which is cemented across the fuselage at the position shown. The paper bindings should be about 3/16 inch wide, and may be cut from a length of gummed-paper, parcel tape. Next, roll the paper tube from similar paper tape, and cement it through the holes in the balsa side plates, as shown in the plan. The isometric drawing in the top left-hand corner should make the foregoing matter clear.

Special note should be given to the small metal link-plate which is pushed over the protruding wire prongs, and

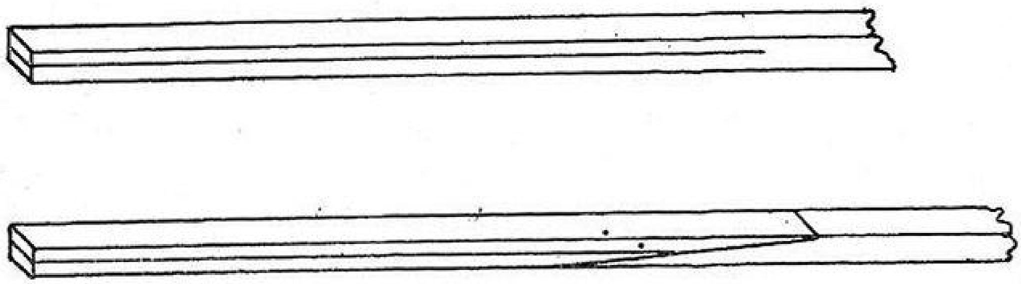

Fig. 161

soldered into this position. Cut the link-plate from a small piece of thin brass, and drill the holes accurately. As this plate butts up close to the inner rib of the wing, when it is in position, it is necessary that the plate should be packed out at the bottom to conform to the wing dihedral of 3 degrees.

Undercarriage

This is of novel pattern, designed and well tested by Mr. C. A. Rippon. Briefly, the legs are swivelled at the tops to the top planking of the fuselage; they then protrude downwards, through slots in the lower fuselage sides. At this point, rubber bands are incorporated which return the legs to the front of the slot when they have been pushed backwards by the landing of the machine. As the undercarriage is so well shown in the drawing, little comment should be necessary.

The legs are of bamboo, tapered and shaped to be a slide-fit in the slots. The small holes at the top of the legs, through which they are anchored by rubber bands to the fuselage top, are best bored with a piece of 16 S.W.G. piano wire which has been made red hot. If an attempt is made to drill the holes it will be found difficult to prevent the bamboo from splitting.

Wings

These are constructed with fairly sturdy leading and trailing edges, and a main spar composed of two lengths of 1/8 inch × 3/32 inch balsa. Tracings should be made of all the ribs, as shown in the drawing at their respective positions. The tracings may then be transferred to the sheet balsa from which the ribs are to be cut, or they may be pasted to the balsa sheet and cut around the outlines.

It will be noted that the trailing edge is shaped before assembly of the wing, but the leading edge is sanded after assembly to conform to the nose profile of the ribs.

As in the case of the fuselage, a full-sized drawing should be made upon tracing paper, pinned to a building board, and the wing construction done upon this. When one of the wings has been built and removed, the paper may be turned completely over, the drawing traced through, and the second wing built upon this. In this manner, right- and left-handed wings are obtained.

Pin the leading and trailing edges to the board to conform to the drawing; also the lower member of the main spar. Now insert the wing ribs, which are butt-glued to the wing edges. It will be necessary to pack the leading edge up from the board with a piece of 1/16 inch balsa strip, to allow for the underpart of the ribs which are lower than the leading edge.

While the cement is setting, the wing tips of 3/32 inch × 3/32 inch birch, may be cut to length and steamed to shape. To ensure identical wing tips it is well to bind two lengths of birch together, with cotton, and to steam them in one operation. After steaming they should be held in the bent position until the wood has cooled down.

From the front view of the wing, as shown in the plan, it will be seen that the space between the main spars is filled in with 1/8 inch sheet balsa, for the distance between the two root ribs. At the same time it will be noted that the root rib itself is composed of four 1/16 inch balsa ribs cemented together. The brass tubes which receive the wing-fixing prongs, are cemented to the top and bottom of the main spar, and are further reinforced by sticking strips of gummed-paper tape over them. These details are amplified

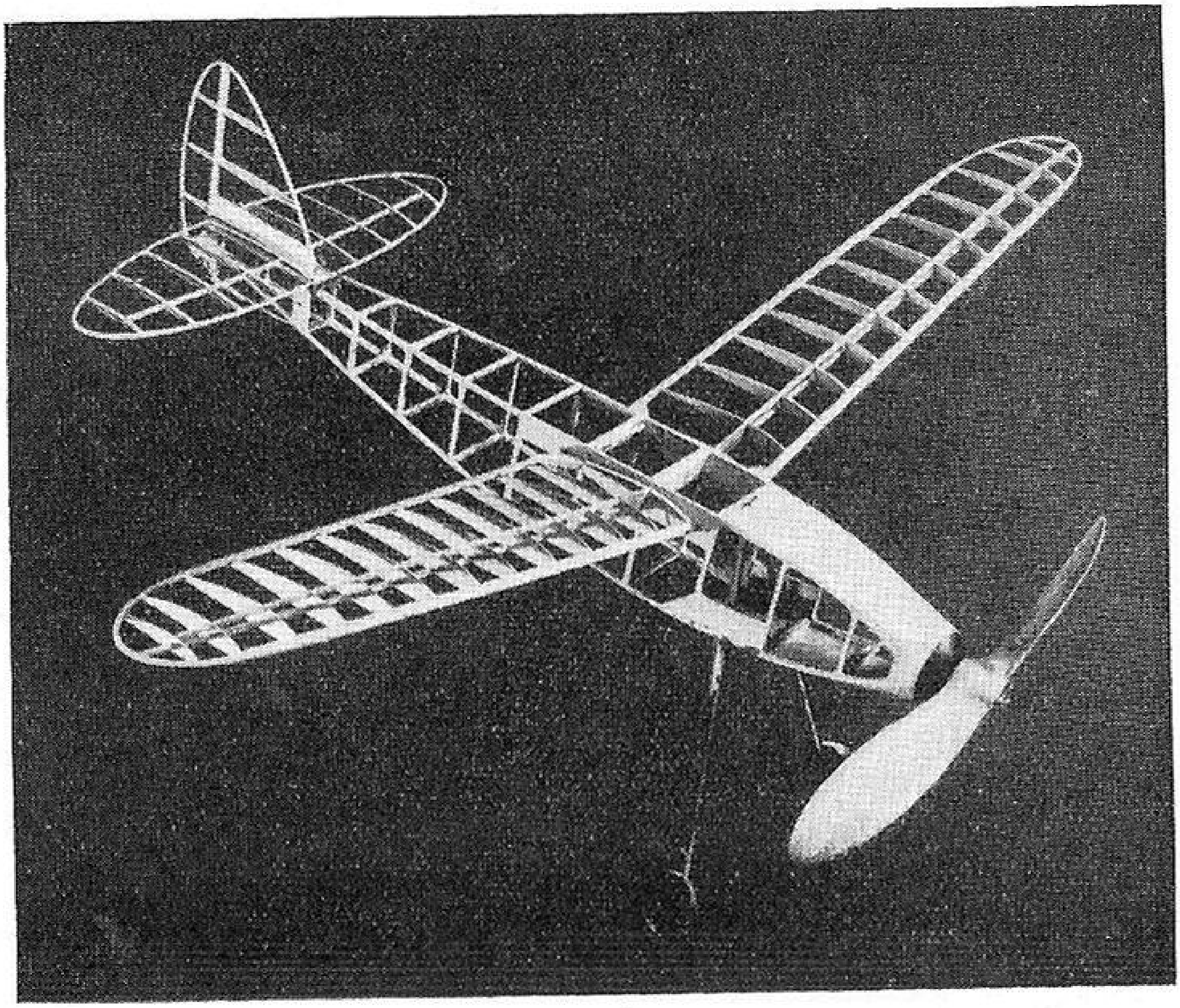

Fig. 162.—The completed framework of the machine

in the excellent isometric sketch in the top left-hand corner of Fig. 159.

Tail Unit

A non-lifting tail plane is used, of quite simple construction. Having prepared our tracing we must proceed to bend the edges of the tail and fin in the steam from a boiling kettle. It will be apparent from the plan that the tail edging is in two halves, which are joined together in the centre, by means of a lapped joint. Taking two pieces of 3/32 inch by 3/32 inch birch, of suitable length, bind these together with cotton and steam them to shape, as was done with the tips of the wings. Now pin the edges to the drawing. It will be noted that the ribs are composed of two strips of 1/8 inch by 1/32 inch balsa, through which runs the main spar. The lower portions of the ribs may now be cemented between the edges, and the piece of sheet balsa cemented into the centre. Now glue on the main spar. All that is now required is to cement in the top portions of the ribs, and the top balsa sheeting over the centre, and to round off the birch edges with glasspaper.

Tailfin

Owing to the method of construction used, the tailfin cannot be built flat upon a board. It will be necessary, therefore, to steam first the edge to shape. Now, carefully measure the length of the main upright, cutting the ends to the radii which will conform to the edging. Do the same also with the piece of 1/16 inch sheet balsa which is cemented at right-angles to the upright, and runs along the lower rib. On the plan it will be observed that the upright is located into the rectangular holes cut into the three ribs. Cut the ribs to length and thread them on to the upright spar, but do not cement them for the moment. The next step is to cement the balsa upright to the fin edging, in the position indicated, and next, to cement the piece of 1/16 inch sheet balsa from the upright spar to the extremity of the front edge. This will hold the structure firm, when it will be possible to slide the fin ribs into their positions, and cement up.

A small trimming tab is provided, and this is made up from 1/16 inch balsa, to be an easy fit in the appropriate panel of the fin. It is then hinged between the two ribs upon small bamboo pegs. Do not overlook the balsa fillets, nor the clippings of gummed paper which are indicated on the drawing. The isometric sketch of the tail assembly, in the lower, right-hand corner, fully explains how the tail is secured to the fuselage by rubber bands hooked to the wire fitting in the front, and the peg at the rear.

Propeller and Noseblock

An unusual feature of this machine is the propeller of adjustable pitch. A propeller of 14 inch diameter is used, and this should be curved to shape in the usual way, with a pitch of approximately 16 inches. The propeller is carved as a whole, and then cut into halves, so that the butts of the blades may be shaped into small dowels. The spinner, which, it will be observed, is hollowed at the back to accommodate the freewheel device, may now be made. Next, drill a hole through the spinner from side to side, and bush it with a tube made from gummed-paper tape, so that the dowels of the blade-butts are a tight, push-in fit. This system holds the blades firmly enough for flight. It will be understood, of course, that an airscrew of fixed pitch, such as is commonly used, may be substituted for the one of adjustable pitch, if desired. In this case the pitch should be about 18 inches.

Whichever propeller is used, the following steps are now necessary. Drill the propeller boss for the spindle, and bush it with a piece of 16 S.W.G. brass tubing, or with one of the special bushes sold for the purpose. A length of 16 G. piano wire, formed at one end into a yoke for the "Run True Bobbin," comprises the propeller shaft. It may be seen in exploded view at the bottom left-hand corner of the print, where it will be seen that it passes through a brass bush in the noseblock, and that a small, ball-thrust race is then threaded on. A loop of 22 G. steel wire is then soldered to the shaft between two cup washers, which are also soldered. The propeller is then threaded on to the shaft, and is retained by a loop formed in the end. A freewheel, clutch action is provided by a piece of 18 G. wire, which swivels in a brass tube let into the noseblock, and engages with the loop on the propeller shaft.

Covering and Doping

The whole machine is covered with medium-weight tissue paper, sprayed with water and left to dry. This water spraying will, in itself, considerably tighten the paper covering, even before it is doped. The model should be well rubbed down, before covering with the tissue, with fine glasspaper, as any rough places are liable to catch in the tissue and cause wrinkling.

All the covering should be given a coat of banana oil dope, and when this is thoroughly dry, apply a second coat to the wings and fuselage only. The tail unit, being a comparatively light structure, might be warped by the considerable pull which two coats of dope will exert.

Rubber Motor

One ounce of ¼ inch by 30 rubber strip ; that is, 6 yards, is made up into a skein of eight strands. It should be pre-wound by the White tensioning system, and well lubricated before use.

General

The machine is such that it may be flown in any competition formed under the Flight Cup formula. The record duration of flight for machines of this class is over 16 minutes, so that the "A.C.2" should form a useful challenger in this type of competition.

The method of fixing the wings to the sides of the fuselage, as is done in the present machine, has the advantage that full benefit may be had from the total wing area of the machine, no part of the wing being obscured by the top of the fuselage.

CHAPTER XVI

THE "PEDIGREE PUP"

A Low-wing Lightweight Monoplane

The "Pup" range of model aeroplanes, designed by Mr. C. A. Rippon, and starting with the now famous "Cruiser Pup," are too well known to need introduction. This latest addition, designed specially for this book, has all the good features which were found in the previous models, in combination with the latest practices in model building. In appearance, too, the machine is, probably, the best of the range. The duration of flight equals or surpasses that of the previous machines, whose recorded durations have run into many minutes.

Fuselage

Owing to the manner in which the wing is fitted up into a recess in the bottom of the fuselage, a rather special procedure must be followed in the construction of the fuselage for this machine, and the following notes will be necessary.

It may seem strange to commence the building of the fuselage by first making a portion of the wing, but, as will transpire, this is the best method. The first step, therefore, is to build the small centre-section of the wing, as shown in the print, and also in the photograph, Fig. 165. While this is drying, build the base of the fuselage, flat upon the building board, to the special detailed drawing of this component which is given on the blueprint. The cross-members of this base are of 1/8 inch × 1/16 inch balsa, laid *flat* on the board.

Now we must cut out the 1/32 inch sheet balsa webs to the exact shape shown on the drawing. It is important that these pieces are correct, and that the two of them are

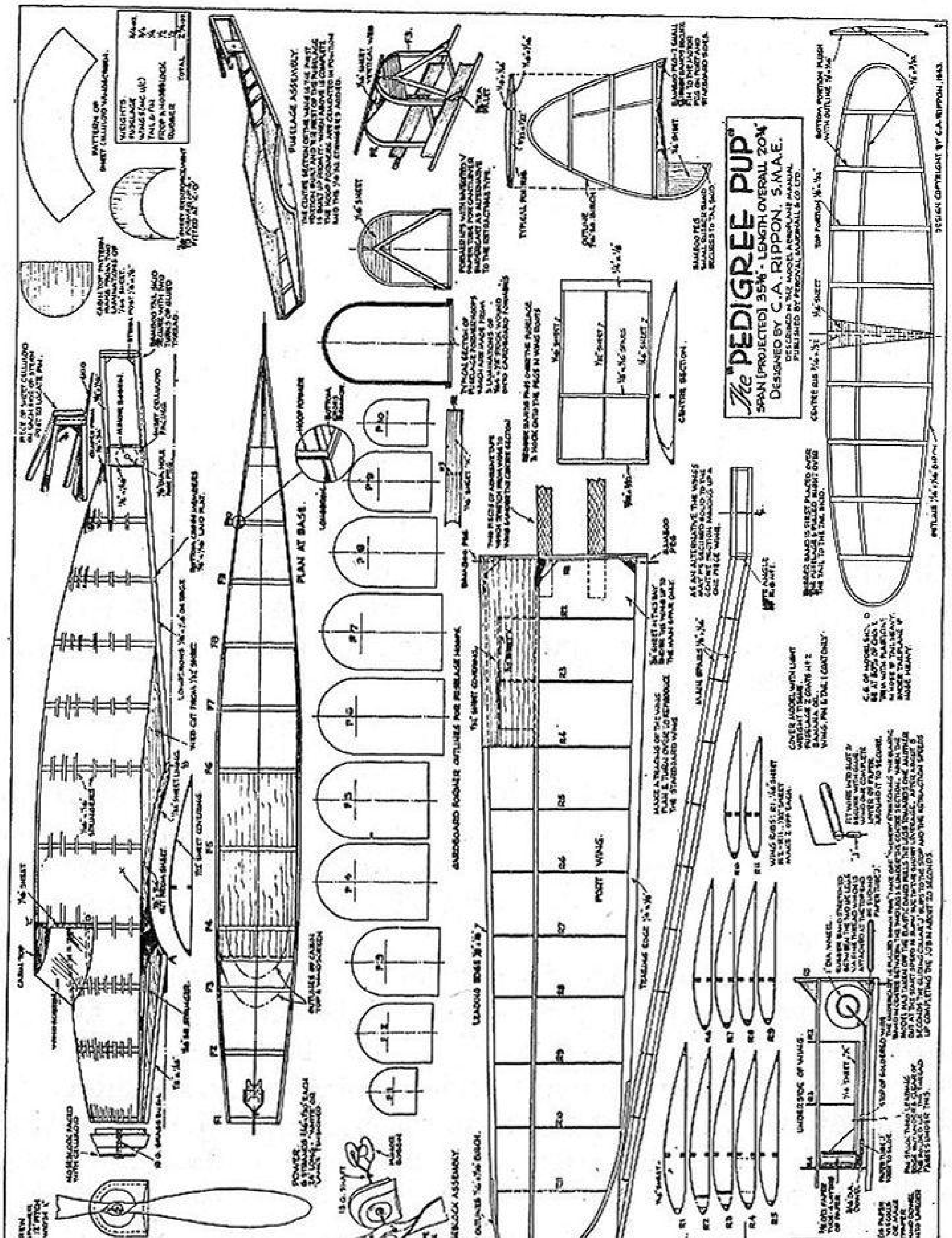
The "PEDIGREE PUP"
SPAN (PROJECTED) 35⅝" · LENGTH OVERALL 20¾"
DESIGNED BY C. A. RIPPON, S.M.A.E.

Fig. 163

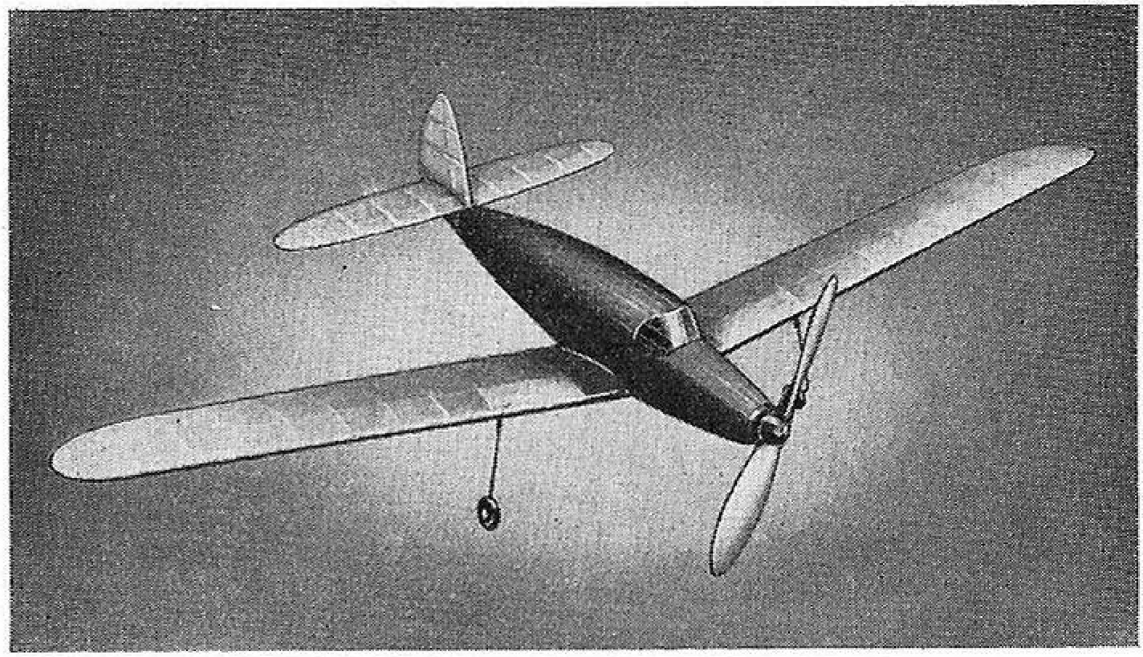

Fig. 164.—The completed "Pedigree Pup"

identical, especially the base angles (A) and (B). Next cut out the curved stiffeners (X) and cement them to the webs, remembering that these are right- and left-handed.

The centre section being now ready and covered with 1/64 inch sheet balsa with the grain running crosswise, make a similar balsa covering upon the top of the centre-section, but separated from it by a sheet of tissue paper. Now, place the webs on the top of this separate balsa covering and cement them to it. We may now take the base, which we have already made (see print), cut out the centre portion, and cement the remaining portions to register with the angles of the 1/32 inch webs. Incidentally, the webs

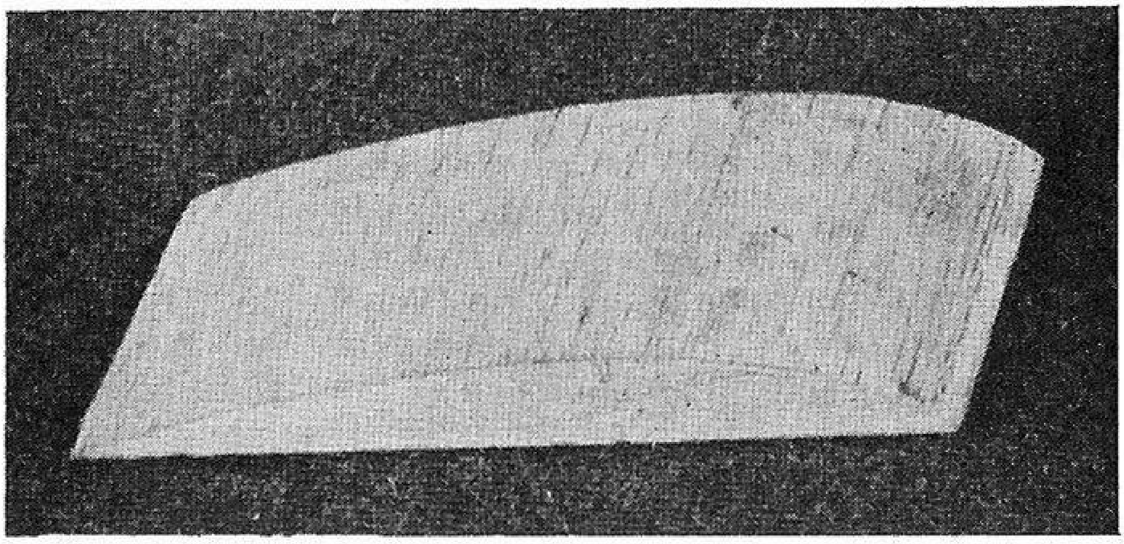

Fig. 165.—The centre wing-section upon which the fuselage is built

must be notched to register with the built-up base.

The structure so far attained forms a basis upon which the fuselage may now be completed, so it should be packed up at each end with parallel pieces of wood, and firmly pinned down to the baseboard.

While the cement is again drying, make the formers or hoops. The jigs are cut from cardboard to the shapes shown on the drawing. The hoops themselves are wound from three layers of 1/64 inch sheet balsa, which is cut into long strips 3/32 inch in width. In winding, each layer is cemented to the next as the hoop is wound. In the case of hoop No. 4, after removal from the jig, a shaped balsa half-former is cemented into the rounded top portion. This as shown shaded in the drawing.

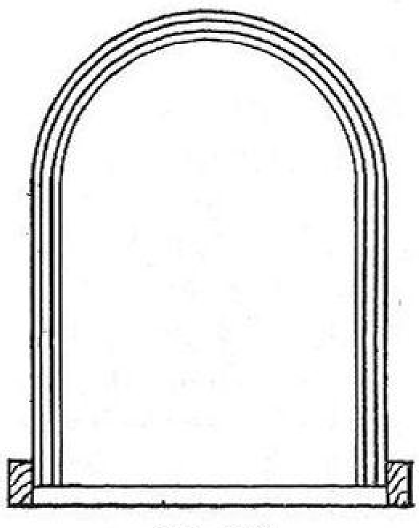

Fig. 166

At this stage, while waiting for the cement to dry off on the formers, the rear portion of the fuselage, upon which rests the tail-plane and fin, may be built up. The side plates for the reception of the rear rubber hook, and the top stiffeners, are of $\frac{1}{8}$ inch sheet balsa, and the correct sizes may be had from the drawing. This portion being completed, the hoops may next be cemented into their respective places upon the base. Before doing this, however, each hoop must be carefully sanded to thickness. The manner in which the hoops are cemented in is shown in the drawing (Fig. 166), where it will be noted that the ends rest upon the cross-members of 1/8 inch × 1/16 inch balsa, and register against the balsa side longerons of the base.

The stringers may now be applied. Cement on the top stringer (i.e. stringer No. 1) which runs from former No. 4 to former No. 11 at the rear of the fuselage. Now apply the next two stringers upon either side (i.e. stringers No. 2, 2, right and left) which run from former No. 4 and terminate between formers Nos. 8 and 9. The ends of these stringers are chamfered off to a wedge shape, so that they will not make unsightly lumps in the covering, and may be seen quite clearly on the top of the finished fuselage portrayed in Fig. 167.

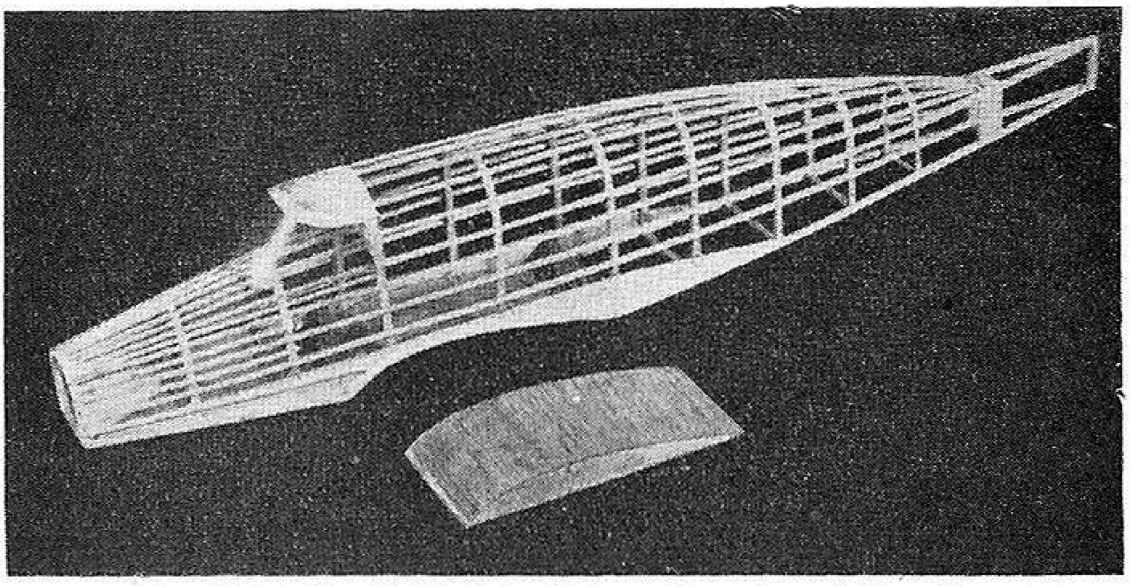

Fig. 167.—The finished fuselage and centre wing-section

Stringers No. 3 (right and left), while starting at former No. 4, terminate between formers Nos. 9 and 10, where they are likewise chamfered off. Stringers Nos. 4 and 5 run the complete length of the fuselage to former No. 11; as do stringers Nos. 6, 7 and 8 along the sides of the fuselage.

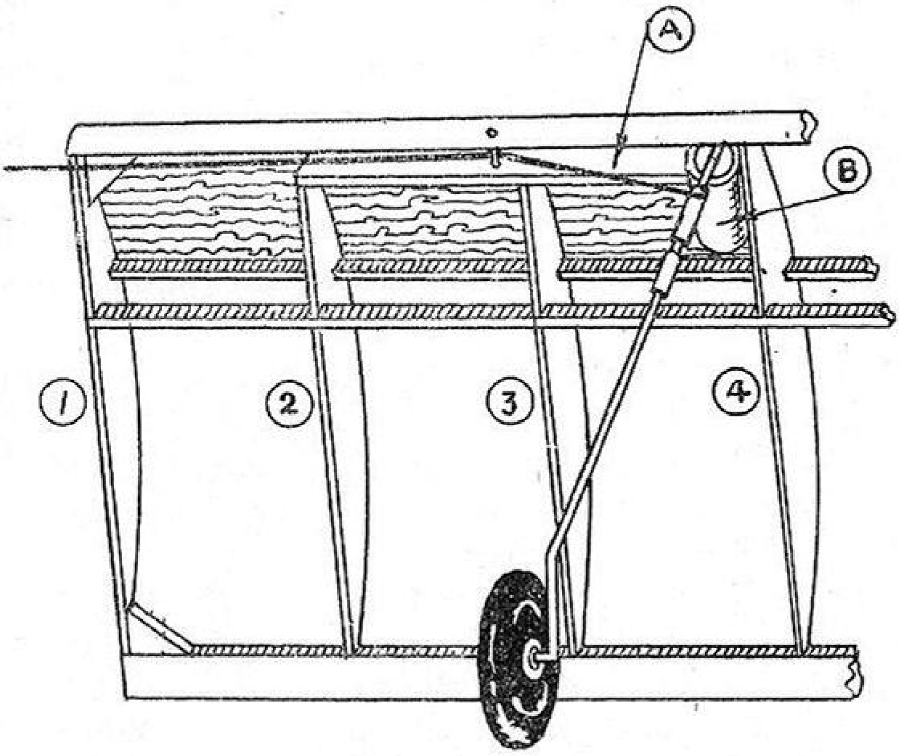

Fig. 168

Next, the nose is filled in with the stringers, as depicted on the drawing.

The balsa cabin cover may now be fitted, the shape of which may be obtained from the print. The pattern for the celluloid windscreen is also given, with a small allowance for trimming after cementing in. At this stage, the structure should appear as shown in the photograph in Fig. 167.

Wings

The primary step in wing construction is to cut the ribs to the shapes shown, from sheet balsa. Two sets of 11 ribs are required. This done, pin the leading and trailing edges down to a plan drawing of the wing. The leading edge may be packed up from the board with small pieces of 1/32 inch balsa, to allow for the undercurvature of the ribs. Shape the trailing edge to a wedge section before pinning down, but the leading edge may be sanded to shape after assembly. The lower member of the main spar may also be

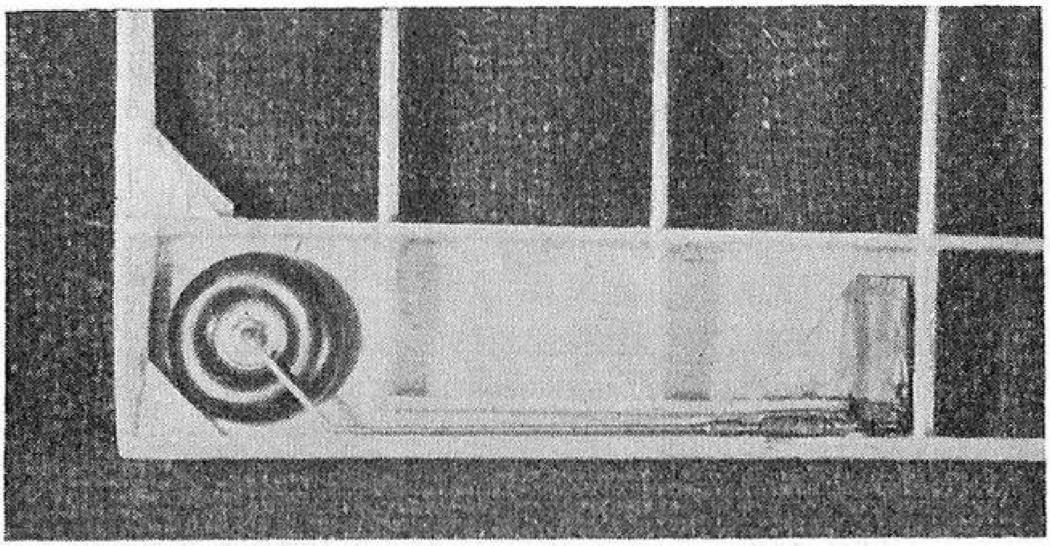

Fig. 169.—The wheel and leg retracted into its housing beneath the wing

pinned to the board, after which the ribs should be cemented into place, and the top member of the main spar added.

The self-retracting undercarriage requires a rather special arrangement of housing to be built up behind the leading edge of the wings near the root. While this arrangement is well shown on the blueprint the isometric drawing in Fig. 168 will, perhaps, serve to make the matter more clear. Here, it will be seen that the ribs marked 2 and 3 are cut short so that they terminate about ¼ inch from the leading edge. Across the noses of these two ribs is cemented a strip of balsa, marked (A); this, however, falls about 5/16 inch short of rib No. 4. To complete the undercarriage housing it is now only required to sheet over the leading edge between rib No. 4 and the root rib, from the main spar to the leading

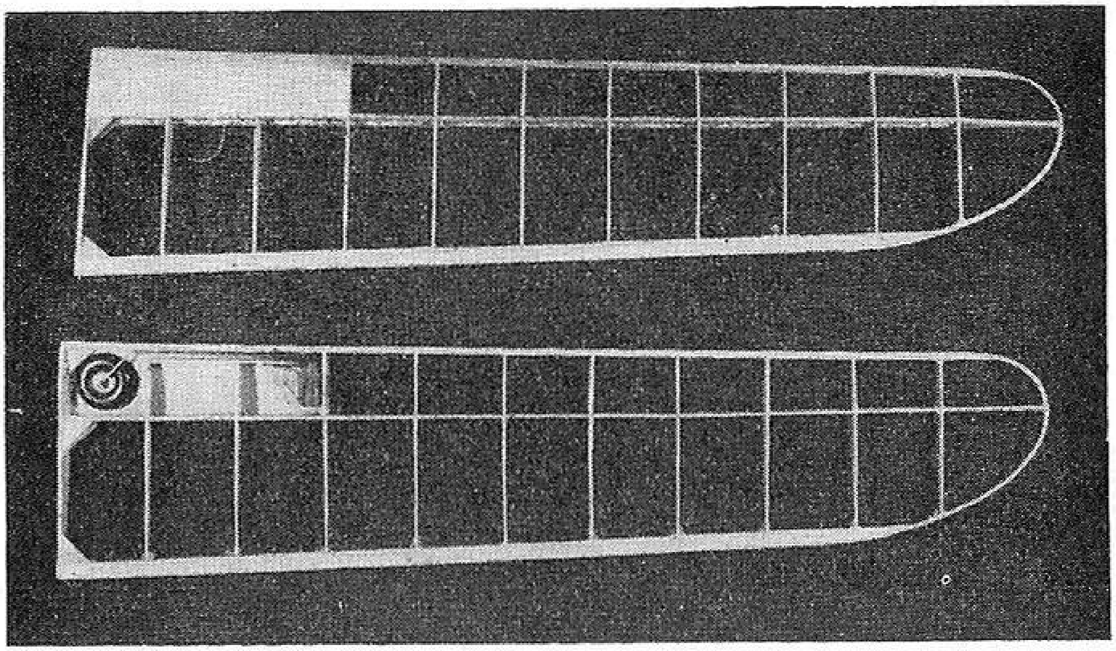

Fig. 170.—The wing frameworks, showing one wheel retracted

edge. In this manner a channel is formed along the inside of the leading edge, into which the undercarriage leg may lie ; at the same time, a compartment is formed between ribs Nos. 1 and 2 which will house the wheel. The photograph, Fig. 169, shows the arrangement quite well.

On removal from the building board, the wing tips, which have been steamed to shape in accordance with instructions given elsewhere in this book, should be cemented into the recesses prepared for them in the edges of the wing. The addition of the small corner blocks, shown on the print,

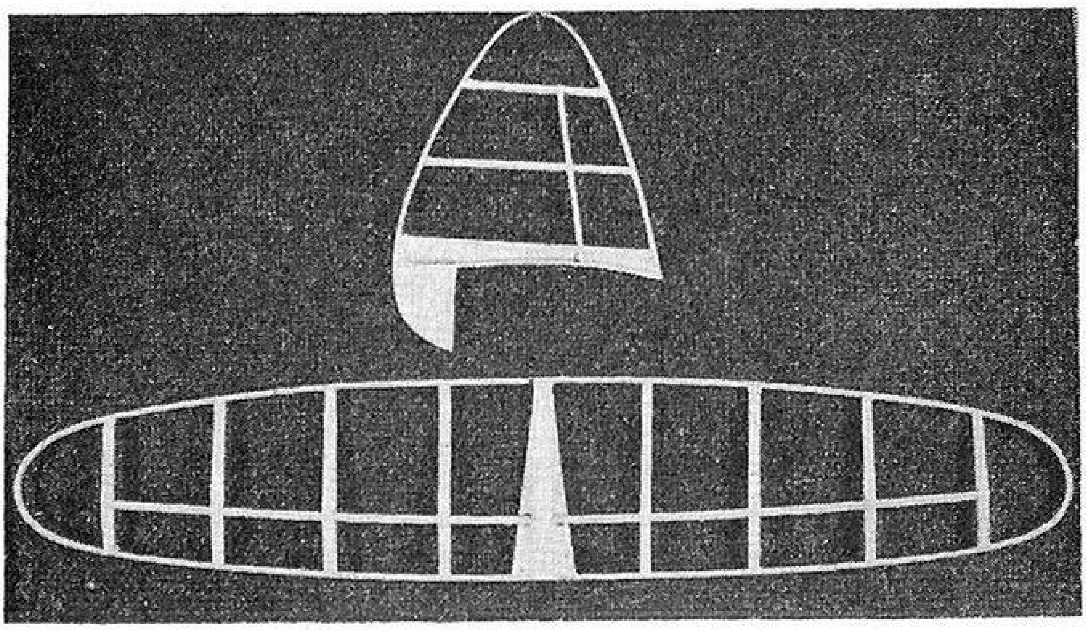

Fig. 171.—Tail and fin ready for covering

completes the wing structure. Two identical wings are required, but they must be, of course, right- and left-handed.

Tail Unit

Though of pleasing shape, there is nothing elaborate about the construction of the tail unit of this machine. As is usual, the tail should be built flat upon a plan drawing pinned down to a building board.

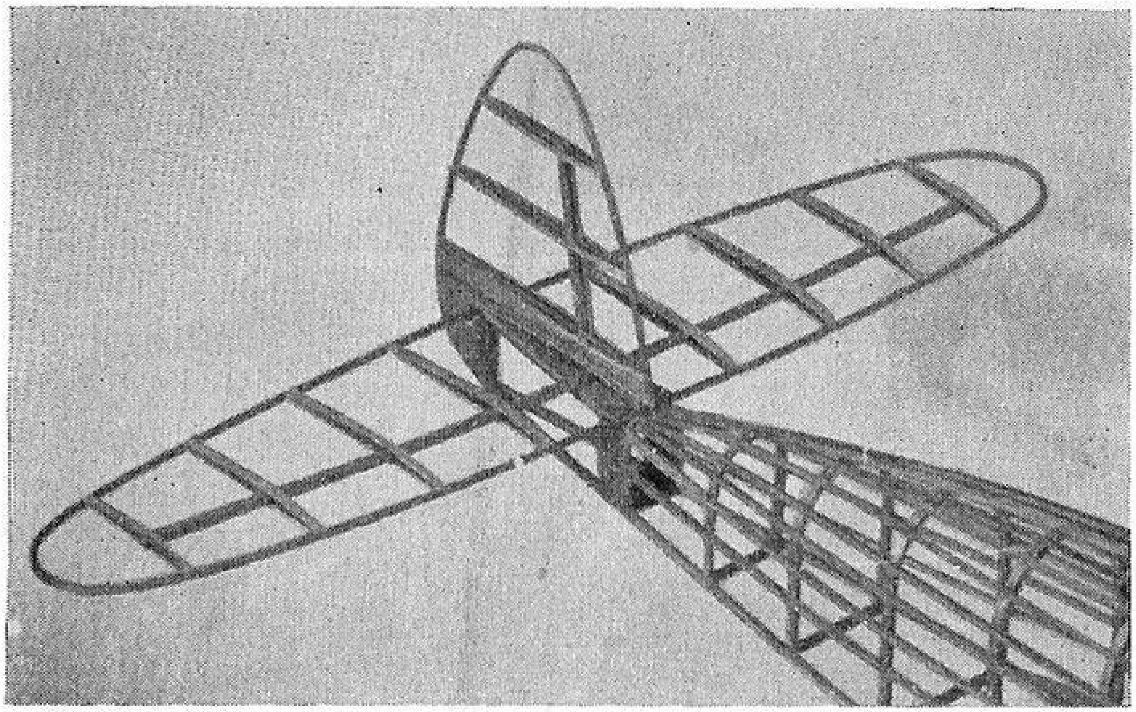

Fig. 172.—The tail unit fixed to the fuselage

Having steamed the edges to the correct shape, they must be pinned down to conform to the tail outline of the drawing. The ribs are formed by two strips of balsa, as may be gathered from the print. When the edging is secured, the lower portions of the ribs should be cemented into their respective positions, when the main spar may be cemented upon them. The sheet balsa centre panel will, of course, have been cemented into place. Now cement in the top strips of the ribs. Upon lifting the structure from the board, it must be carefully sanded with fine glasspaper, and the edges of the tail rounded over. This completes the tail plane.

The fin cannot be built upon the board, as the arrangement will not allow it to lie flat. As before, steam the edging to the shape given; and pin it down to conform to the drawing upon the board, for this first step. This consists in cementing in the strip of sheet balsa which runs from the rear edge to the extremity of the front edge. When the cement is dry, lift the structure from the board.

We may now cement on the bottom rib, which is cut from sheet balsa, so that it conforms to the shaped underpart of the balsa cross-piece. Then add the sheet balsa panel to the underslung portion of the fin.

The structure is now rigid enough for further operations, the first of which is to cement into place the twin fin-uprights. This completed, the remaining ribs are cemented on. They consist of two strips of balsa each, cemented between the edges of the fin, and passing over the upright spar.

On completion of this operation, the tailplane and fin should present the appearance shown in the photograph in Fig. 171.

Undercarriage

This is a most ingenious retracting type, which has been evolved by Mr. S. Collins, of the Northern Heights Model Flying Club. Briefly, it consists of a pair of hinged, wire legs, which carry the wheels. The hinge is constructed from a piece of round, wooden dowel, which turns in a short length of paper tubing. The wire leg is attached to the dowel. The ingenious part of the matter lies in the manner in which the movement of the dowel is retarded within the tube. The legs are connected together by lengths of strong thread and a rubber band, which tends to close them up into the wings. To prevent too fast a movement, however, the turning motion of the dowel is retarded by a strip of sticky tape (such as a piece of fly-paper) which is rolled around the dowel, and interposed between it and the tubing.

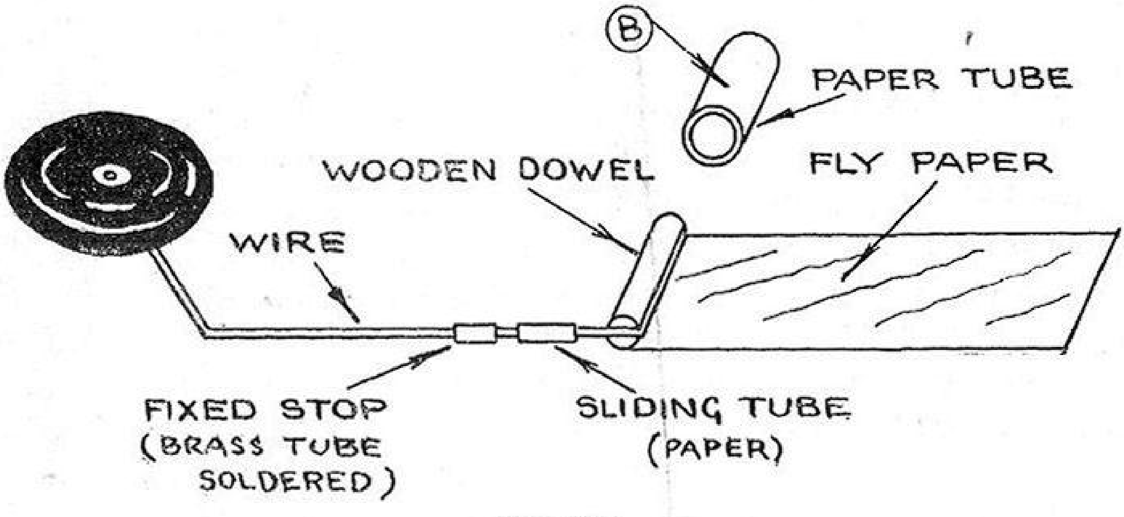

Fig. 173

The illustration in Fig. 168 shows the undercarriage leg assembled, while Fig. 173 shows the arrangement in exploded view. First roll the paper tube (marked (B) in the drawings) and put aside to dry thoroughly, allowing at least 12 hours. Meanwhile prepare the dowel. This consists of a short length of wooden dowel stick which must be about 1/16th inch smaller in diameter than the inside of the paper tube. Along one side and across one face a slot is cut, into which the bent-up end of the wire leg is cemented. Around this dowel is now wound a strip of fly-paper, thus building up the dowel to be a slide fit into the paper tubing. In default of fly-paper, a strip of ordinary paper coated with any sticky substance which will not dry off too quickly may be used. The substance known as "rat varnish," which may be procured from many oilshops, is very suitable. Even such an unlikely substance as cod-liver-oil-and-malt, very slightly diluted with glycerine, has been successfully employed.

Before attaching the wheel, two small tubes are slipped over the wire leg. The outer one is soldered to the leg so that it cannot move, thus forming a stop. The inner tube is, however, allowed to slide along the leg.

We may now glance at the drawing, Fig. 168, of the assembly. It will be seen that a piece of thread is attached to the sliding tube, and from thence passes beneath a pin set into the leading edge and the wooden partition (A). The thread is then connected to a rubber band which links up, in a similar manner, with the thread from the other undercarriage leg.

It will be understood from the foregoing that, when the legs are opened and released, they will be gradually shut together by the pull of the rubber bands. The movement is considerably retarded by the friction of the sticky paper, while, at the same time, the movement is regulated to be slow at first but quickening as the legs become more retracted. This is by virtue of the fact that the pull exerted by the thread is regulated by the varying leverage which the position of the sliding tube upon the leg exerts. At first, the leverage is applied at a very disadvantageous angle, the efficiency of which increases as the tube slides upwards along the leg. In this manner, the movement of the undercarriage leg is very slow for the first few seconds of the take-off, being retarded sufficiently long to enable the machine to take-off from the ground. When in the air, however, the retraction of the legs speeds up, until, after about twenty seconds, the legs are fully concealed. The speed of the retraction may be regulated by the strength of the rubber band used to pull the legs together.

Covering

The whole machine is covered with light-weight tissue paper, which should be water-sprayed and given one coat of No. 2 banana oil. It is recommended that the wings be

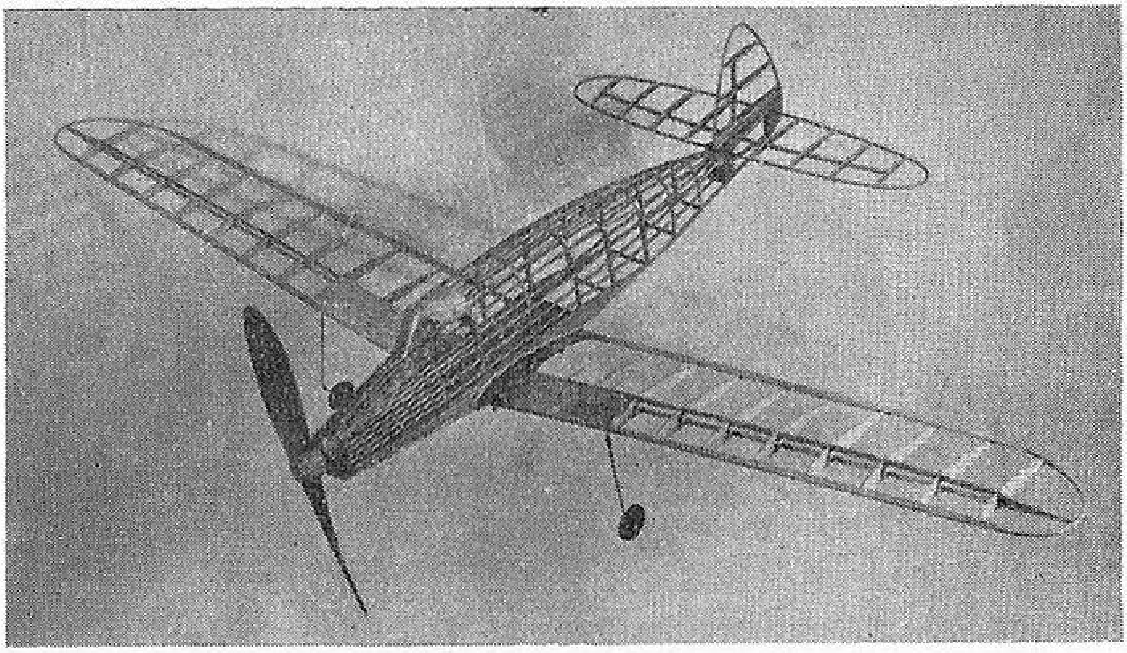

Fig. 174.—The completed framework of the machine

covered in white tissue, but that the fuselage be covered in black or some dark colour. In this way, the machine is easily visible under all conditions when in the air.

Airscrew and Motor

A propeller of 9 inches diameter and 12 inches pitch is suitable for this model. A motor consisting of four strands of 3/16 inch × 30 rubber, looped into a skein of 30 inches in length, is used. It is recommended that this skein be tensioned by the Lance system of prewind, as detailed in the chapter on rubber motors.

CHAPTER XVII

THE "TWENTY-MINUTE GLIDER"

(Holder of British Model Glider Record and Winner of "The Model Engineer No. 1 Cup")

Very little introduction should be necessary for this machine, as it is one of the best known gliders which have yet been built. This is hardly to be wondered at when one considers that the machine holds the British Model Glider Record, with a flight of 20 minutes 7 seconds. In addition, it is the winner of the "Model Engineer Cup No. 1" for this class of machine, and has performed well and consistently on all occasions.

..Designed by Mr. E. Chasteneuf, of the Blackheath Model Flying Club, the glider is representative of some of the latest practice in this branch of aeronautics; yet it is by no means over-complicated, and its building may be successfully undertaken by even the inexperienced. If built to the specification, and flown by the methods outlined in Chapter XII, the builder will be well rewarded for his pains.

Fuselage

Full-sized blueprints of the machine are now obtainable, and must be procured. The fuselage is of the multi-stringer type, built upon balsa formers, and is well shown in the accompanying photographs. In order that the fuselage may be built truly in line, the formers are strung upon a length of $\frac{1}{4}$ inch round wooden dowelstick and for this purpose $\frac{1}{4}$-inch holes are cut into the centres of the formers. Formers up to, and including, No. 9 have the whole centres cut out. From this point to the rear of the machine the formers are left solid. When the centres of the first formers have been cut out and detached, they must be replaced, and lightly

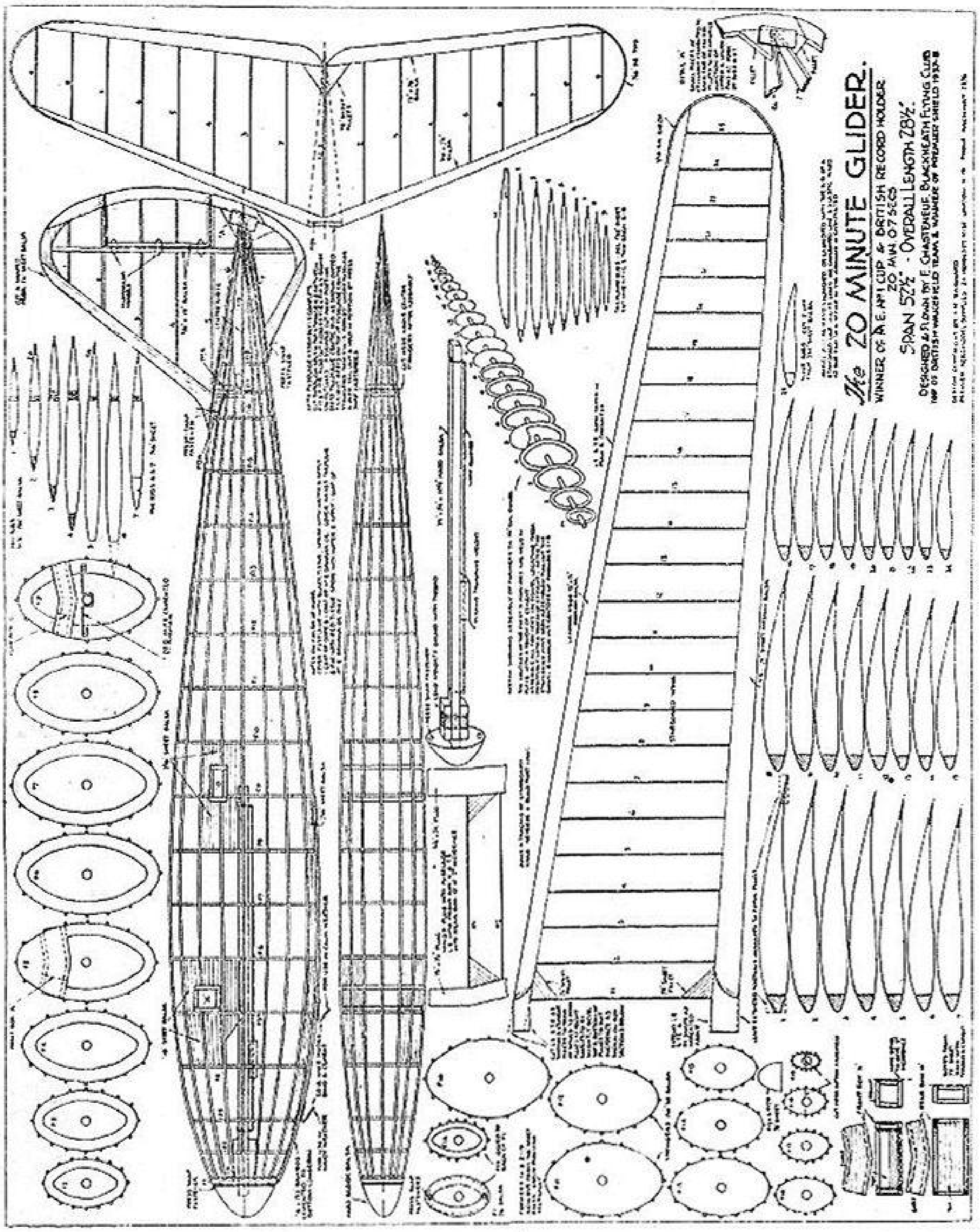
The 20 MINUTE GLIDER.
WINNER OF M.E. No1 CUP & BRITISH RECORD HOLDER
20 MIN 07 SECS
SPAN 57½" · OVERALL LENGTH 28½"
DESIGNED & FLOWN BY E. CHASTENEUF BLACKHEATH FLYING CLUB

Fig. 175

secured with a touch of cement here and there. On completing the building of the fuselage, these centres must be pushed out to enable the fuselage to be withdrawn from the building rod; hence the need for *light* cementing. The positions of the stringers must be correctly marked upon the edges of the formers, as the line-up of the fuselage depends upon the accuracy of these markings.

To facilitate the building of the fuselage, it is desirable that a building jig be constructed, somewhat on the lines of the one shown in Fig. 177. This is made from $1\frac{1}{2}$ inch $\times$ 1 inch deal, and consists of a pair of uprights nailed to a long base strip. The tops of the uprights have "V" nicks

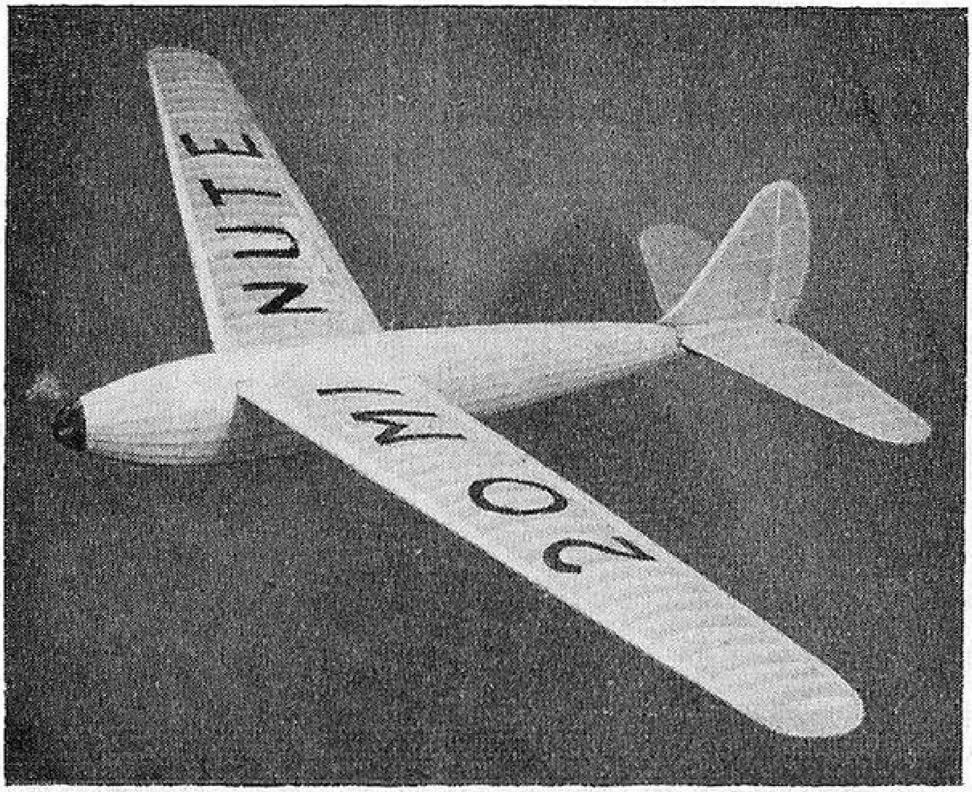

Fig. 176.—The "Twenty-Minute Glider": holder of the British Glider Record (model)

cut into them, in which the dowelstick is free to rotate. If desired, the base of the jig may be cut into halves, so that it may be adjusted to length by nailing a piece of similar wood to the bottom. Two cross struts act as feet, and the uprights are braced by large corner blocks.

This picture also shows the first steps in construction. First, mark the positions of the formers upon the building dowel, and thread them on to it; check that they are "square" in all directions with a setsquare. The formers may be lightly cemented to the dowel, or secured with pins if they, by mishap, are too loose a fit. It is essential to get the stringer marks on the formers in line when on the

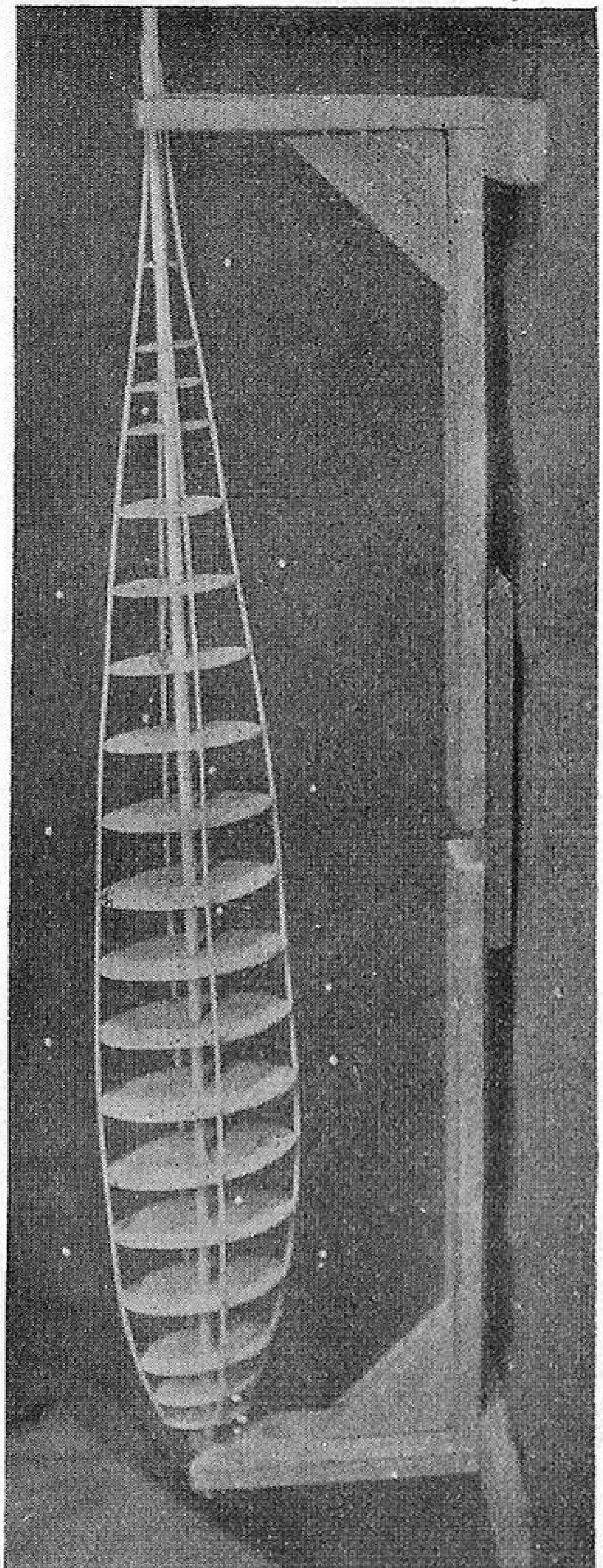

Fig. 177.—First steps in fuselage construction

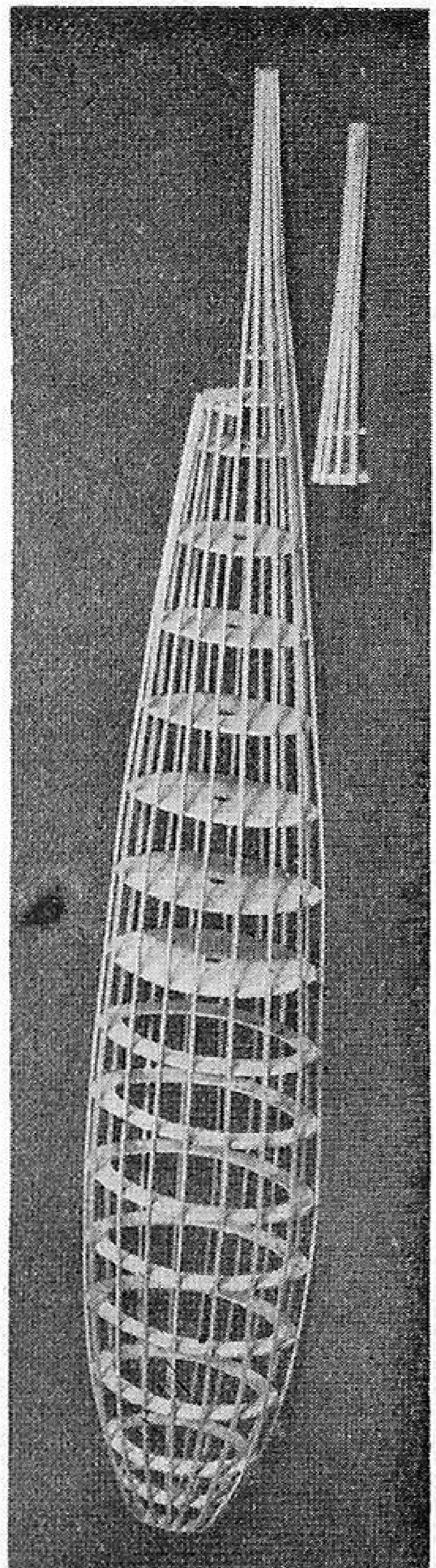

Fig. 178.—Partly-finished fuselage, showing detached tail portion

dowelstick ; otherwise the stringers will not lie in a straight line from front to rear, when assembled. It will be seen

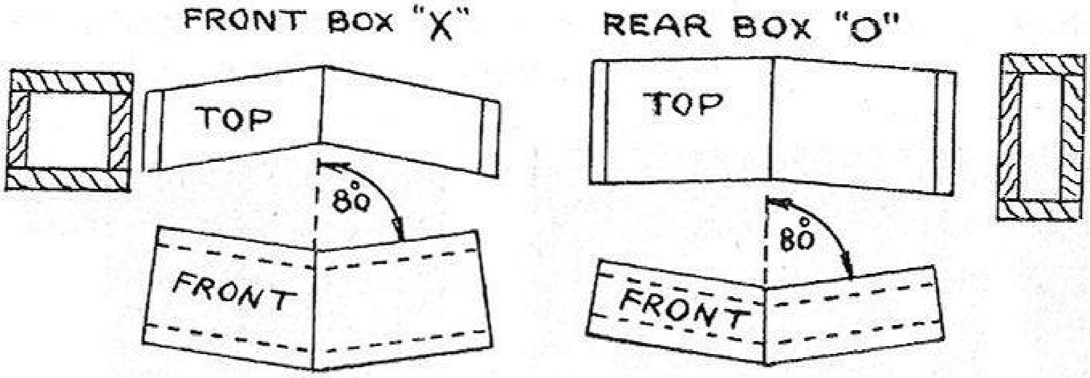

Fig. 179

that the four main stringers have been cemented on, and when the cement is set the structure will be firm enough to stand further manipulation.

The application of the remaining stringers brings us to the point where the structure may be removed from the rod. When free, the stringers must be cut to length, and drawn together at the rear and cemented. The fin of the glider is fixed to a small piece of the fuselage, which is detached from the extreme end, and this portion may now be removed. Figure 178 shows the fuselage at this stage, while a glance at the blueprint will make the matter clear. The construction is such that, upon cutting through the appropriate stringers, the cement may be loosened with a razor blade, and the top of the fuselage end removed. Fig. 178 also shows very well the manner in which the front formers are cut out, while the rear ones are left solid.

Wing fixing is by means of dowels, formed by an extension of the leading and trailing edges of the wings, which plug into boxes cemented within the fuselage. The construction

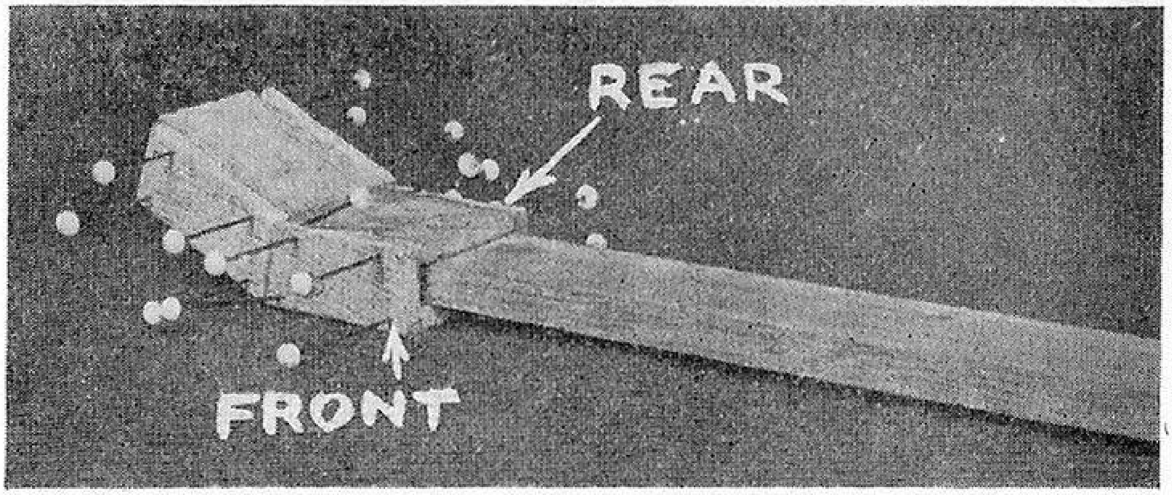

Fig. 180.—Method of making wing-fixing boxes

and placing of these boxes calls for some care, as the dihedral angle of the wings depends upon them. As the wings of the

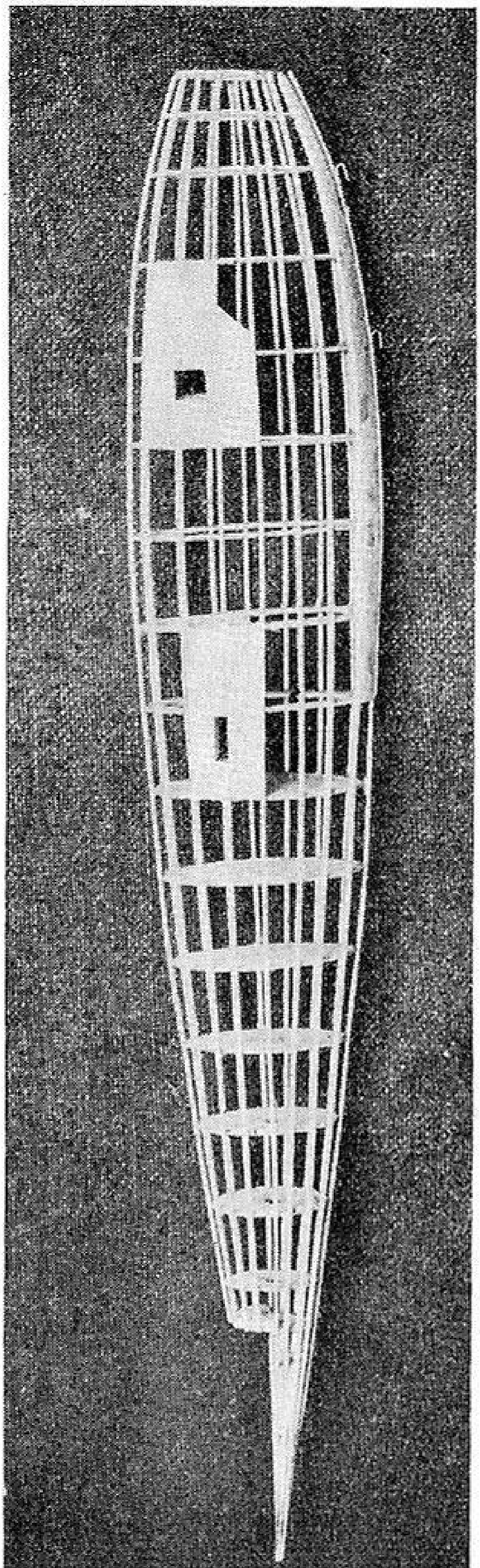

Fig. 181.—The finished fuselage structure

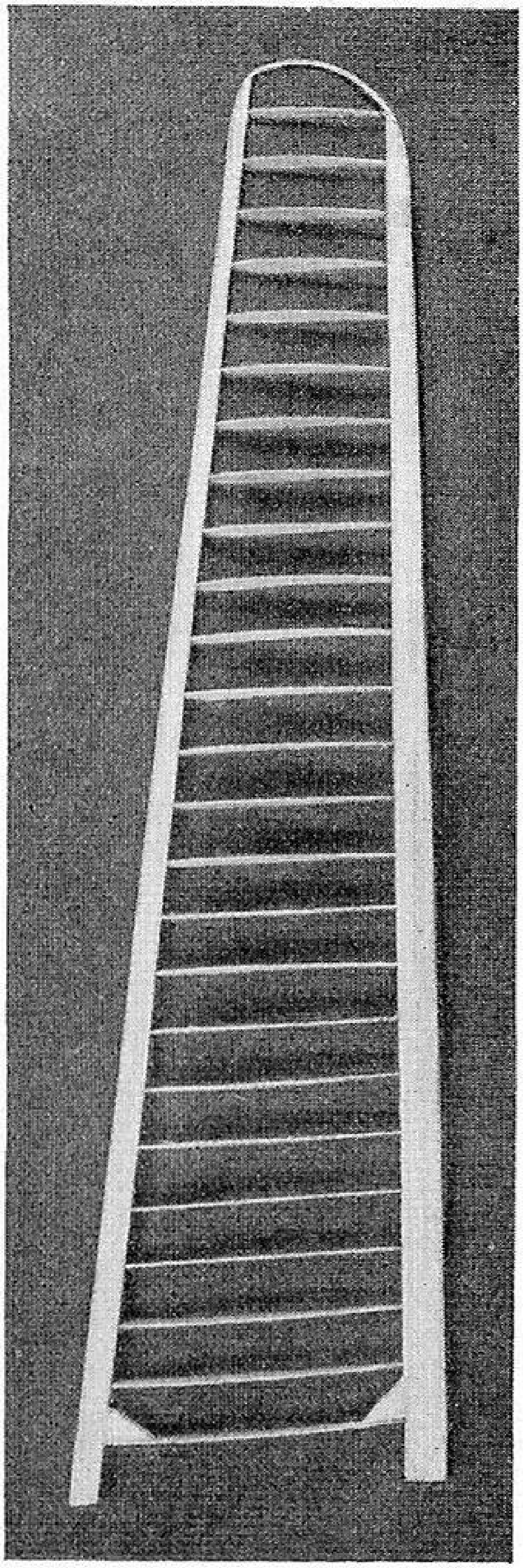

Fig. 182—The finished wing framework

machine are also swept back, some provision for this must be made. The drawing, Fig. 179, amplifies the drawings of the wing boxes as shown on the print, and should make the construction plain.

The best method of making these boxes is to cut the front and rear pieces to the angles shown in Fig. 179. These are marked " Front " and " Rear " in the picture in Fig. 180. It will be seen that the front consists of two pieces of balsa, and that the rear piece is likewise divided. This is to accommodate the sweep-back of the wing. Now, cut the top and bottom portions of the box, again in two pieces each (to allow for dihedral angle). Next, cement the sides to the bottom, and cement the two halves together, but leaving the tops of the boxes open.

Dealing with the front box first ; take a piece of the wood which will be used for the leading edge of wing, and place one end within the open box. Taking now the top piece of the box, cement this into place, pressing it down tightly upon the leading edge spar, and securing it with pins. Now, withdraw the leading edge, and allow the cement to set, proceeding, meanwhile, with the other side of the box in a similar manner. The process is depicted in Fig. 180, which shows the leading edge ready to be withdrawn. In this manner the boxes will be a nice fit on the spars when the wings are finally located. As the boxes carry the whole load of the wings they are strengthened with a binding of thread and cemented all over.

The next step is of high importance, being the cementing of the wing boxes within the fuselage. When the fuselage formers are being prepared you will, of course, have marked out the position of the wing-boxes on formers Nos. 5 and 9, in accord with the blueprint instructions. It will be necessary to cut away parts of certain fuselage stringers, and also part of former No. 9, to allow the entry of the boxes. Care will be required to ensure that the boxes are cemented into exactly the position shown on the print, and that they are at right-angles to the vertical axis of the fuselage, and also in line with each other when viewed from the top of the fuselage.

The best way to ascertain that the boxes are correctly placed is to plug short pieces of the leading edge of the wing into the front boxes, and similar pieces of the trailing edge into the rear boxes. With these in situation it is an easy matter to view the manner in which they protrude from the fuselage sides ; thus indicating the positions that the wing edges will assume, when the complete wings are later plugged into the boxes. While the cement is still tacky, the protruding spars may be lined up by eye, thus adjusting the boxes within the fuselage. When all is satisfactory, the boxes may be secured to the formers with pins and left to set. With the addition of the balsa panelling which surrounds the wing boxes, and that which reinforces the belly of the fuselage and the binding-on of the towing hooks, the fuselage structure is complete.

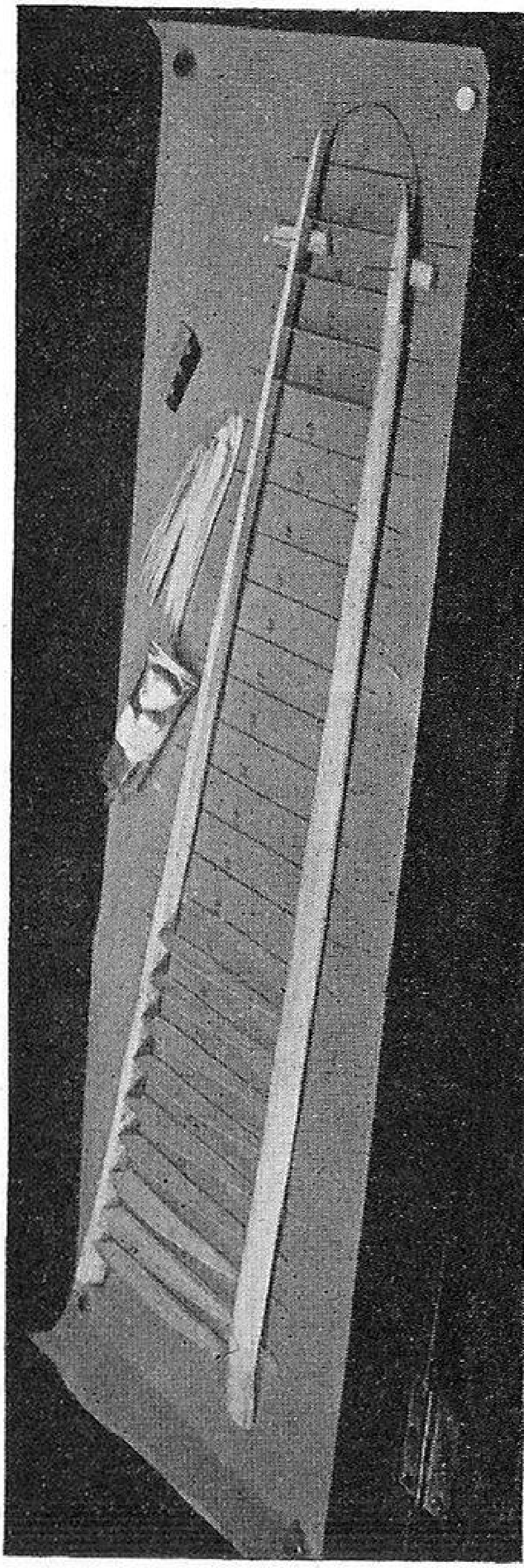

Fig. 183.—Building the wings. Note that each rib is being cut to the required length as the work proceeds

Wings

Success in the making of the wings for the glider lies principally in the shaping of the leading and trailing edges. They are of stout balsa, and tapered in both plan and thickness towards the tips; thus the whole character of the wings may be spoiled by clumsy or uneven tapering of the edges. Fig. 182 shows one of the finished wing frameworks, wherein the tapers are well pictured.

The first step will be, therefore, to shape the leading and trailing edges of the wings in accordance with the measurements shown on the print. We may get a guide as to the correct taper of the thickness of the spars from the sizes of the noses of the ribs. In shaping balsa such as we are now dealing with, few tools are so successful as a sharp pocket knife and some pieces of glasspaper in various grades. Always cut the wood with the grain, as the greatest danger lies in attempting to cut the balsa against the grain, thus causing the knife blade to "run-in" below the required depth.

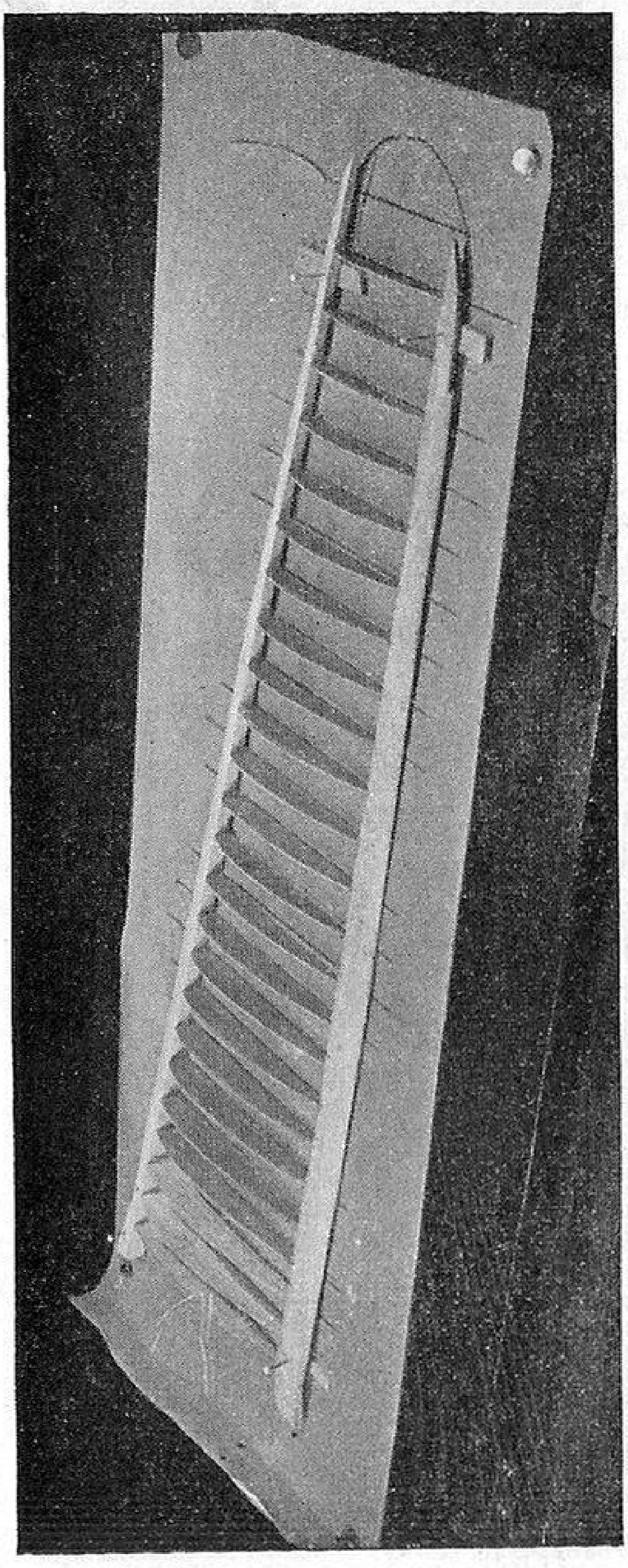

Fig. 184.—Wing framework ready for removal from the board so that the wing tips may be cemented in

Cutting the ribs is a tedious business, especially as there are fifty of them to do. The shape of each rib is given on the print, and there seems no alternative but to trace the outline of each rib upon tracing paper, transfer it to the balsa, and cut and sand to the exact shape given. The wing section used is the "Eiffel 400," a most efficient section, but one which depends upon a close following of its subtle curves, especially on the undersurface, for its satisfactory performance. Great care should therefore be taken to cut the ribs to the exact shape given on the print. The tips of the ribs are shown, on the drawing, marked with a white portion which indicates the section of the trailing and leading edges, but in cutting the ribs this should be ignored, and the ribs cut to their full lengths.

Figure 183 shows the first steps in building. As the bottoms of the "Eiffel 400" ribs protrude below the leading and trailing edges, it is not possible to pin these directly down upon the building board. It will be necessary, therefore, to jack up the wing edges upon small pieces of 1/8 inch balsa, as may be seen in the photograph. It will be as well to check that the distance between the leading and trailing edges of the wing correspond to the distance between the wing sockets in the fuselage. If you have followed the drawing fairly

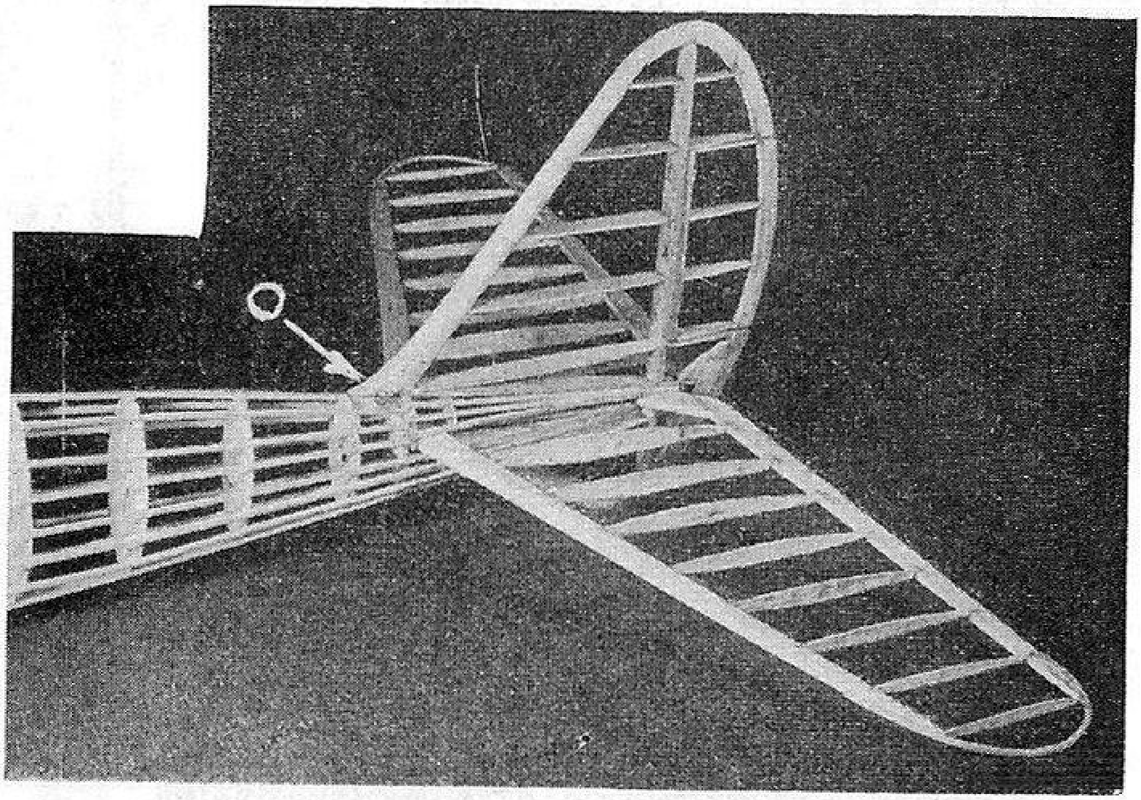

Fig. 185.—The complete tail unit mounted on the fuselage

closely, the difference should be very small, so that the distances between the edges may be adjusted to correspond, without upsetting the wing design to any great amount.

In the picture some of the ribs have already been cemented into place, and it will be seen that the ribs are being cut to the correct lengths as the work proceeds. In Fig. 184, the wing ribs have all been cemented in, and the wing is ready for removal in readiness for cementing the wing tips into the recesses prepared for them. As advocated elsewhere in this book, it is as well to steam the two wing tips together, by binding with cotton, and manipulating in the steam from a

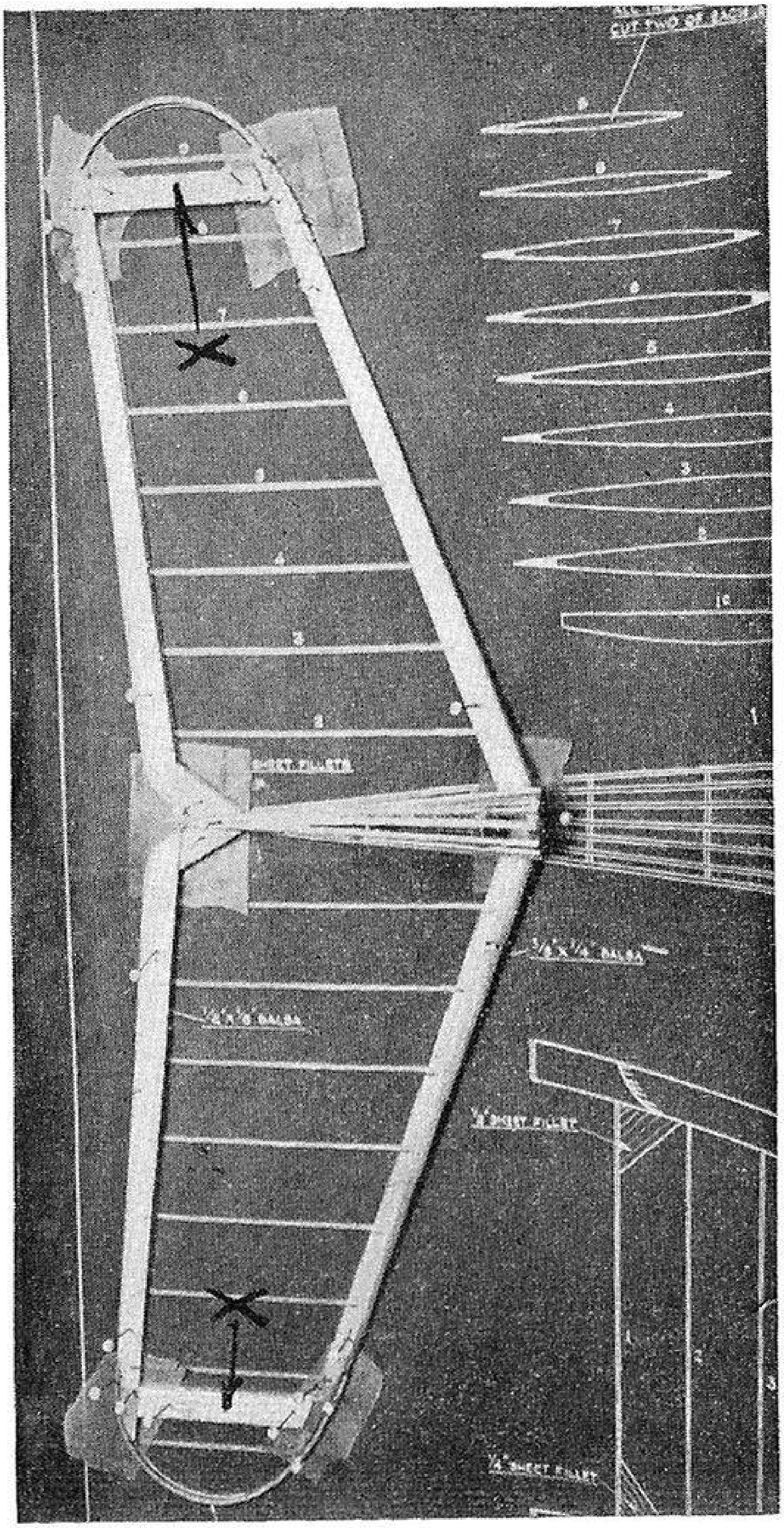

Fig. 186.—First steps in tail construction

boiling kettle. In this way we may ensure conformity between the two wing tips.

This completes the main wing structure, and, after cementing in the small corner blocks, the wing may be tried for fit within the sockets of the fuselage. It is improbable that the fit will be satisfactory at the first attempt, so the ends of the wing spars may be carefully sanded until the wings fit easily but firmly into the sockets. Should the fit not be perfect, the wing will be distorted when in position. This is a serious fault, and there is no way to remove it except by fitting the wings perfectly to the fuselage.

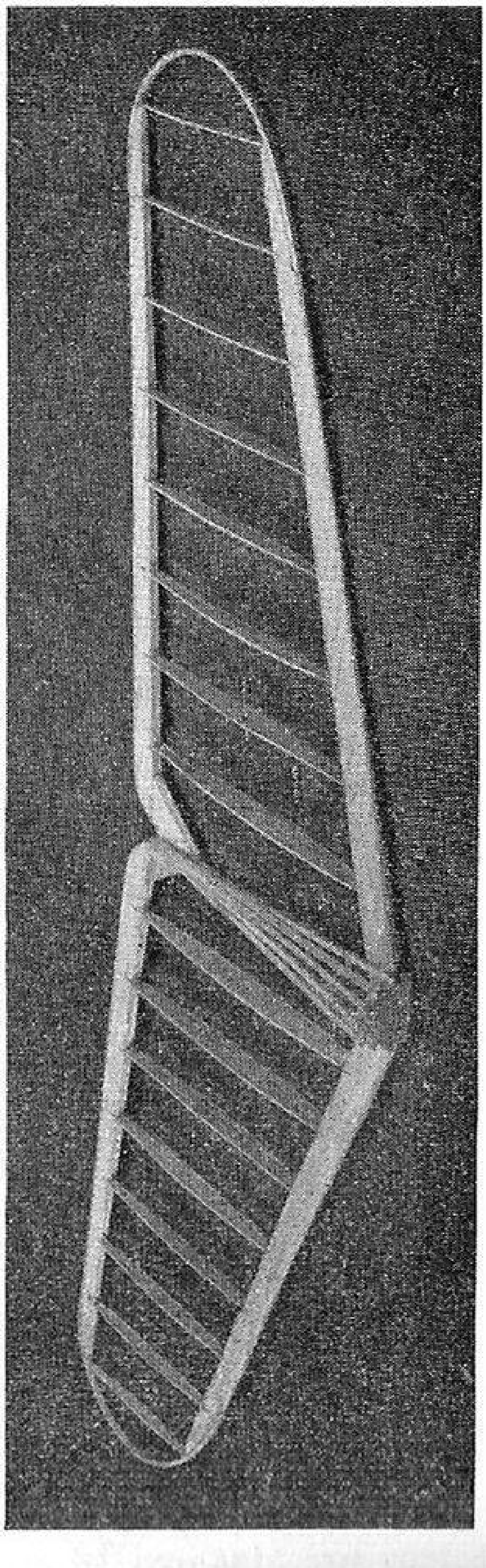

Fig. 187.—Completed tail-plane framework

Tail Unit

A similar method of construction for the tail plane to that detailed for the wings is used; that is, no main spars are incorporated, the strength being obtained by the use of sturdy leading and trailing edges. An idea of the finished assembly may be had from Fig. 185, which shows the tail assembly attached to the machine.

As before, the first step is to shape the leading edges from balsa. These edges are again tapered, and are rounded off on the front edge, as many of the pictures will show. Next, the remaining framework of the fin should be cut to the shape shown in the print, and then, together with the leading edge, pinned on to a tracing of the plane, upon a building board. The photograph, Fig. 186, shows the framework thus shaped and pinned down. Across the centre is now cemented the detached portion of the fuselage, while at the ends may be seen two pieces of 1/16 inch balsa marked (X), (X). These two pieces of balsa are not actually part of the construction, but serve only as supporting pieces. They are not, therefore, shown in the blueprint. Their purpose is to hold the framework rigid while the ribs are being cemented in, as the framework must be removed from the board for this operation. Cut the ribs to their full

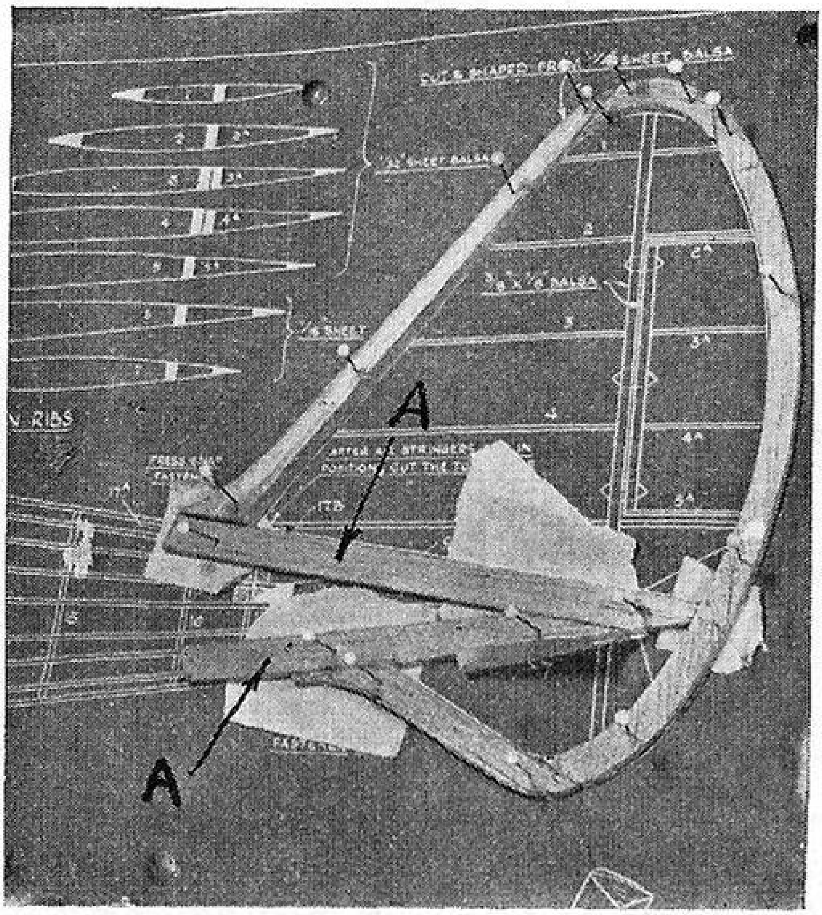

Fig. 188.—First steps in fin construction

length, and trim them to fit the job as you go. It is a good plan to make small nicks in the leading and trailing edges, so that the ribs just register into them while being cemented.

The tips are steamed to shape from 1/16th inch square section birch, and, as before advocated, two lengths of the wood should be bound together with cotton and steamed in one operation. When the tips are cemented in, the supporting pieces (X) are removed, when the structure should appear as shown in Fig. 187.

The fin has a framework of balsa, cut to shape and pieced

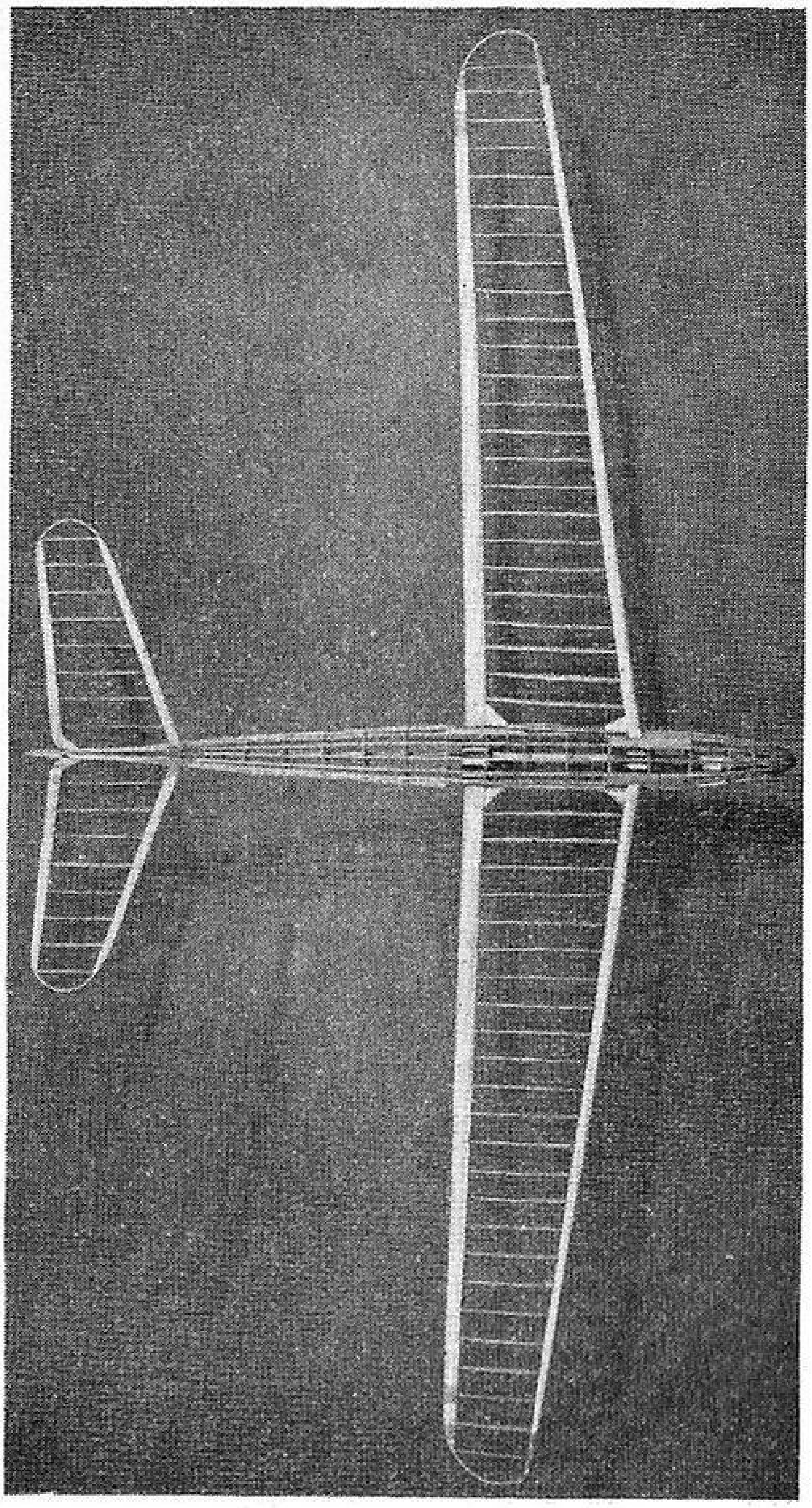

Fig. 189.—The framework of the glider ready for the covering

together, with a leading edge shaped from $\frac{1}{4}$ inch sheet balsa. The picture, Fig. 188, shows the framework thus shaped, and pinned down to the drawing. In this picture two pieces of balsa, marked (A), (A), may be seen. These, again, are not part of the actual structure, but are cemented in as supporting pieces during the fin construction. They are, of course, removed when the ribs have been cemented into place. They are removed by loosening the cement with a razor blade. Ribs Nos. 1 to 5 should now be cut from 1/32 inch sheet balsa; ribs Nos. 6 and 7 are of 1/16 inch sheet. Their shapes are obtained from the blueprint, and they may be seen in the top left-hand corner of the photograph. The parts shown in white indicate the portions which will be removed to make room for the edges and spars of the fin, but it is advisable to cut the ribs as a whole, and to divide them later.

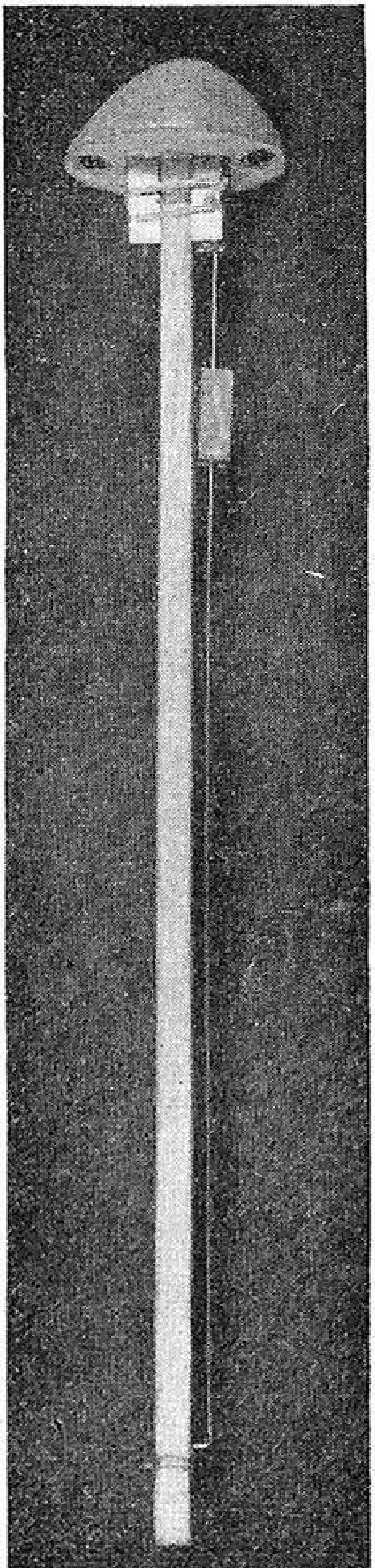

Fig. 190.—Noseblock with leaden trimming weights in position

The framework, as shown in Fig. 188, should be removed from the print, and rib No. 6 cemented in. Now cement in rib No. 7 and the main spar. The other ribs may now be cemented in, dividing each rib and cutting it to length to the actual job. Half ribs, marked 2a and 5a, will now be cut, together with a short spar forming the inner edge of the trimmer. This trimmer spar should be lightly cemented to the main spar in a couple of places, and the trimmer ribs cemented into place. It will be noted from the picture that the rear edge of the fin has been left in one piece; that is, the portion for the trimmer has not been cut out.

After cementing in the corner blocks at the apex of the "V" opening, and also the plywood stiffening pieces, the pieces of wood marked (A), (A) should be carefully detached

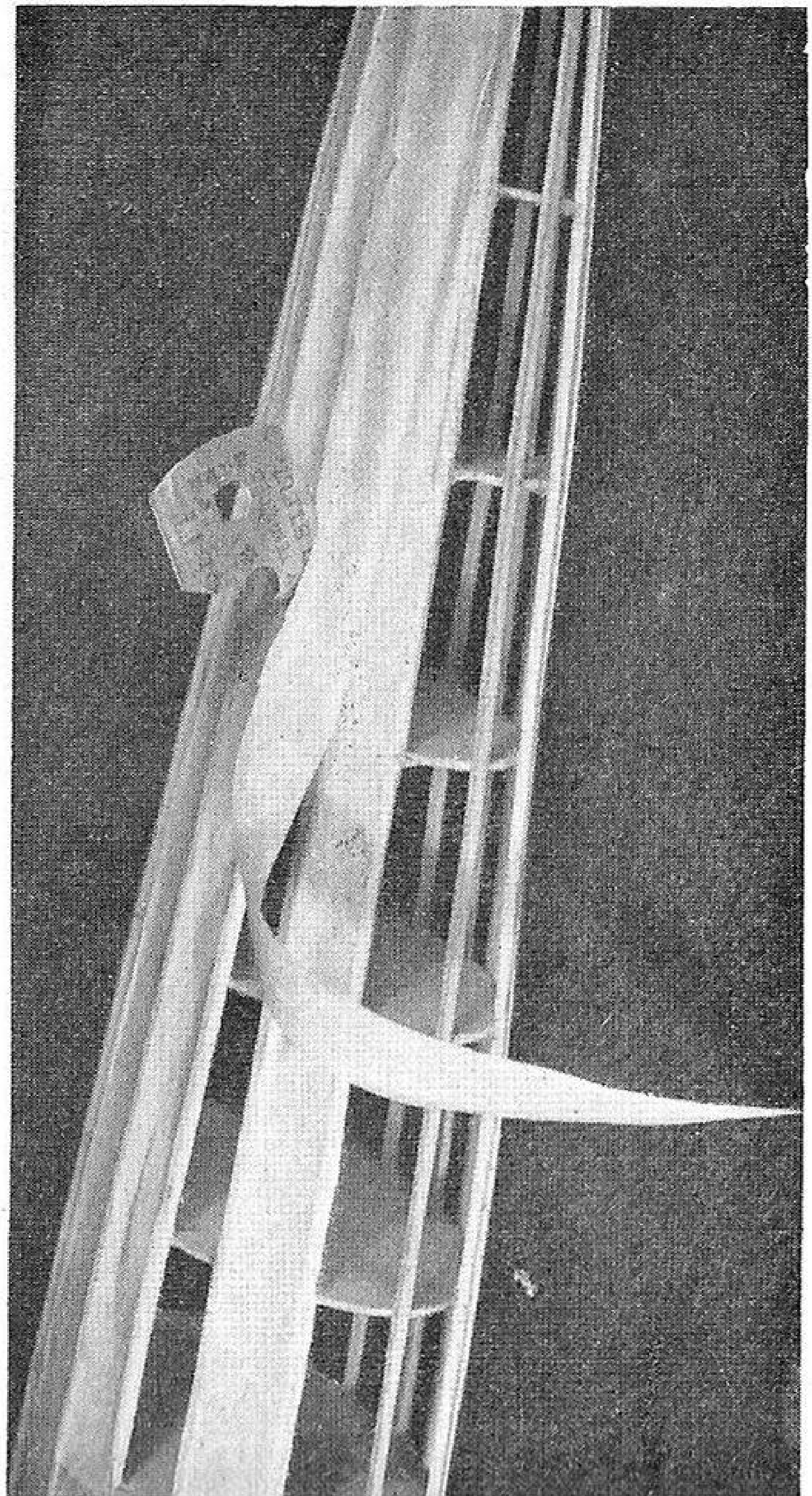

Fig. 191.—Showing the method of covering stringer fuselages

and removed. Now cut through the rear edge of the fin, thus freeing the trimmer. The trimmer is now hinged within the fin upon small strips of aluminium, which are cemented into slots which are pierced with a broken razor blade. This process completes the fin structure.

The fin and tail unit are attached to the fuselage by means of press-stud fasteners, which are cemented to the fin and fuselage. One of these studs may be seen at (O) in Fig. 185. It will be necessary to recess them into the wood, so that a snug fit will result when the parts are clipped together.

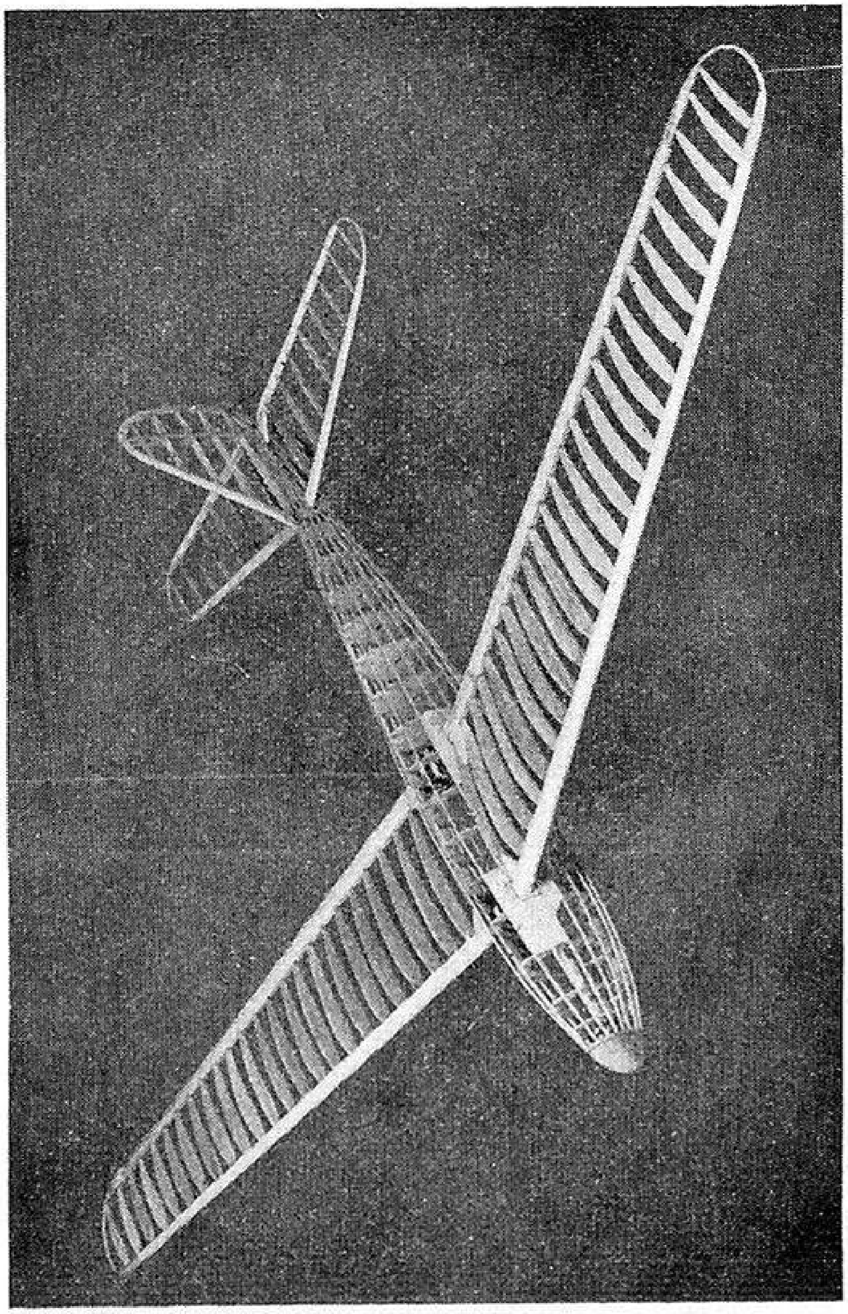

Fig. 192.—Complete framework of the "Twenty-minute Glider"

Noseblock, etc.

A system, which consists of a sliding weight which adjusts along a balsa dowel fixed into the noseblock, is used to obtain trim of the glider. The blueprints give full details of the contrivance, while the photograph, Fig. 190, shows the completed assembly. The noseblock itself is of hard, block balsa, which should be roughly cut to shape and finally sanded to a contour which will carry on the lines of the fuselage at the front end. Into this noseblock a length of $\frac{1}{4}$ inch $\times$ $\frac{1}{4}$ inch hard balsa is cemented, and a length of 16 S. W. G. piano wire, bent up at the ends, is affixed along the underside. Two leaden weights are bound to the spar close up to the noseblock, while a third weight, drilled through the centre, is threaded along the wire in such a manner that it is free to slide backwards and forwards.

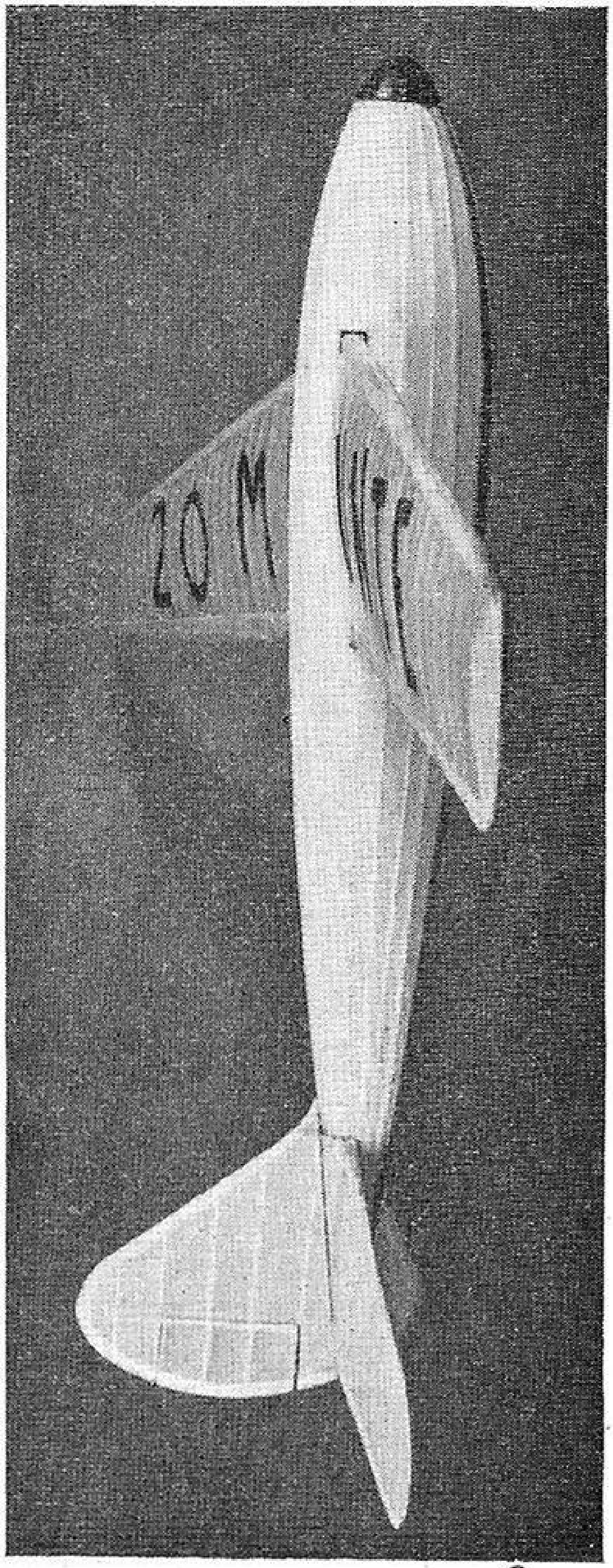

Fig. 193.—Side view of the "Twenty-minute Glider"

The noseblock is secured to the fuselage by two small snap-fasteners which are cemented to the inside face of the noseblock and to the nose of the fuselage. When snapped into position, the rear end of the spar locates into the wire framework which is cemented across former No. 9.

On completing this trimming device, the whole framework of the glider is ready for covering. It is shown in this stage in Fig. 189.

Finishing

The original glider, which holds the British Model Glider Record, was finished with the fuselage in black and the wings and tail in red tissue, but any forms of contrasting colours may be employed. It is advisable to have one of these colours on the dark side, as this enables one to keep the machine in view should it glide away on the thermal air currents.

Experience seems to show that the best way to cover stringer fuselages of this type is to cover each bay, between the longerons, separately. It is possible to cover one space between two longerons with one piece of paper, from nose to tail, and Fig. 191 shows the method employed. Coat the selected longerons with paste, cut the required strip of paper, and, holding it at each end, place it lightly upon the pasted surfaces. Do not attempt to pull the tissue into place, but let it fall naturally upon the job. If you attempt to manipulate the tissue too much it will wrinkle, and will have to be lifted and relaid. Now, run a finger over the tissue along the pasted longerons, thus sticking it down. Evenness of tension is of more importance than tightness at this stage, but as a few wrinkles may appear here and there, they may be worked out with the fingers towards the edges.

The strip thus applied may be left for the paste to dry ; meanwhile another strip of tissue may be applied to longerons at some other part of the fuselage. When the paste is set, a return may be made to the first strip, when the overhanging surplus of tissue may be trimmed off with a razor blade. This process is in operation in Fig. 191. The wings and the tail section are just plain covering jobs which require little comment. It must be remembered, however, that the "Eiffel 400" section has a pronounced undercamber, and it will be necessary to paste the bottoms of the ribs, and to press the undersurface covering to them. It will, therefore, be advisable to cover the bottoms of the wings first.

The tail has no complicated coverings, except, perhaps, the small, detached part of the fuselage. Some difficulty may be encountered by the inexperienced in obtaining a neat fair-in between the plane and the centre structure, but if the job is tackled with a little thought and experiment, and small pieces of paper are used, piecing-in as one goes, the matter will be rendered easier.

Before applying the dope to the machine, all surfaces should be water-sprayed with clean water. The tissue should then be allowed to dry thoroughly, and this will have a great tightening effect on the paper. While the wings are drying they should be clamped down to a flat board, and anchored here and there with small weights. This will ensure that the pull of the covering will not warp them. Apply one coat of cellulose dope to the fuselage only, and put aside to dry for several hours. The wings and tail do not have this coat of cellulose dope, but are given one coat of banana oil No. 2. Finally, one coat of the banana oil is applied to the covering of the fuselage.

CHAPTER XVIII

THE "G.B.3"

World's and British Official Duration Record Holder

The name of "Bob" Copland of the Northern Heights Model Flying Club needs no introduction to those familiar with the world of model aeronautics. Mr. Copland has gained an *international* reputation as the designer, builder and flyer of record-breaking duration 'planes. He has represented England in the winning Wakefield Cup team in the U.S.A., and has steadily upheld the reputation of British model flyers in several European countries.

Among a long series of super-duration models, designed by Mr. Copland, the "G.B.3," illustrated and described in this Chapter, probably represents the peak of achievement in this class of model aeroplanes, and the thanks of the whole model aeronautical community are due to him for the ready and sportsmanlike manner in which he has allowed his design to be published.

"G.B.3" presents, both in design and structure, a perfect example of modern practice, and is capable of a performance which, a few short years ago, would have seemed incredible. The successes of this machine have culminated in the winning of the Weston Cup, with a flight of 27 mins. 56 secs., thus establishing a new British Rise-off-Ground Record. Since then, it has risen to further "heights," by establishing a new official *Rise-off-Ground Record for the World*, with a flight of 33 mins. 9 seconds.

So much for the performance of "G.B.3."

A glance at the illustrations in Figs. 194 and 194A* will show

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* Full-sized blueprints of this machine are available.

that no undue difficulties or complications are to be met with in the design. Both the tail unit and the main plane are faired into the fuselage, and a spinner is incorporated at the propeller boss. These features, together with the oval section fuselage, help to present that clean, streamlined appearance which characterises the machine.

The Fuselage

This is of eliptical cross-section, with formers and stringers as the basic construction. The formers are of the wound-former type, which have been previously mentioned. It may be helpful to give readers a brief outline of the exact manner in which these formers are wound.

In the first place, it is necessary to prepare a number of cardboard jigs, corresponding to the measurements given on the print. These jigs are ¼ inch smaller all round than the diameter of the finished formers. It will be seen that the jigs have a round hole in the centres, and that they are split across their greatest axis. The round, central hole is for the purpose of stringing the jigs upon a length of ¼ inch dowel rod, and if desired, these holes may be square, and a square building rod used.

Now we must cut a number of strips of 1/32nd inch balsa, 3/32 inch in width. Turning our attention to the photograph (Fig. 196), the exact method of procedure may be seen. In the centre of the picture may be seen one of the cardboard jigs, with the central hole, and split into two halves. On the left it will be observed that the jig has been closed up and pinned to the board. We now apply one wrap of the balsa strip, holding this tightly against the jig with pins placed here and there. Now, proceed with the next wrap, applying cement as the wrap is made, withdrawing the pins and reinserting them outside the second wrap. In this way, four complete wraps are made, and the picture shows the last wrap about to be completed.

When the wound former is made, it should be loosened from its jig, and should present the appearance of the one shown in the right-hand side of the picture. Next, the former is again replaced on the jig, and sanded, in position, to a width of 3/32 inch. The building rod is now marked off along its length with the correct positions of all the formers, and these, still mounted upon their jigs, are threaded on.

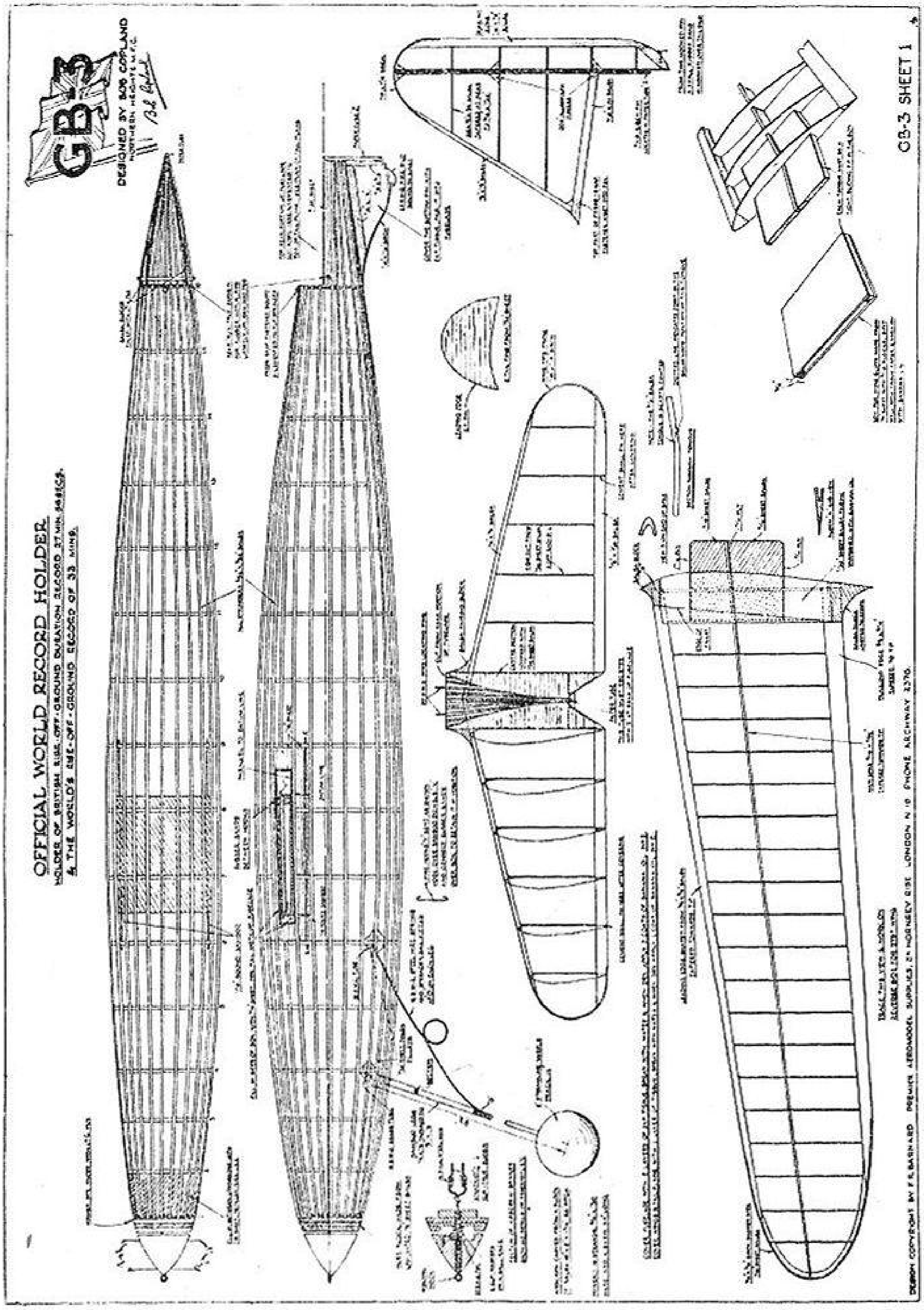
GB-3
DESIGNED BY BOB COPLAND
OFFICIAL WORLD RECORD HOLDER
GB-3 SHEET 1

Fig. 194

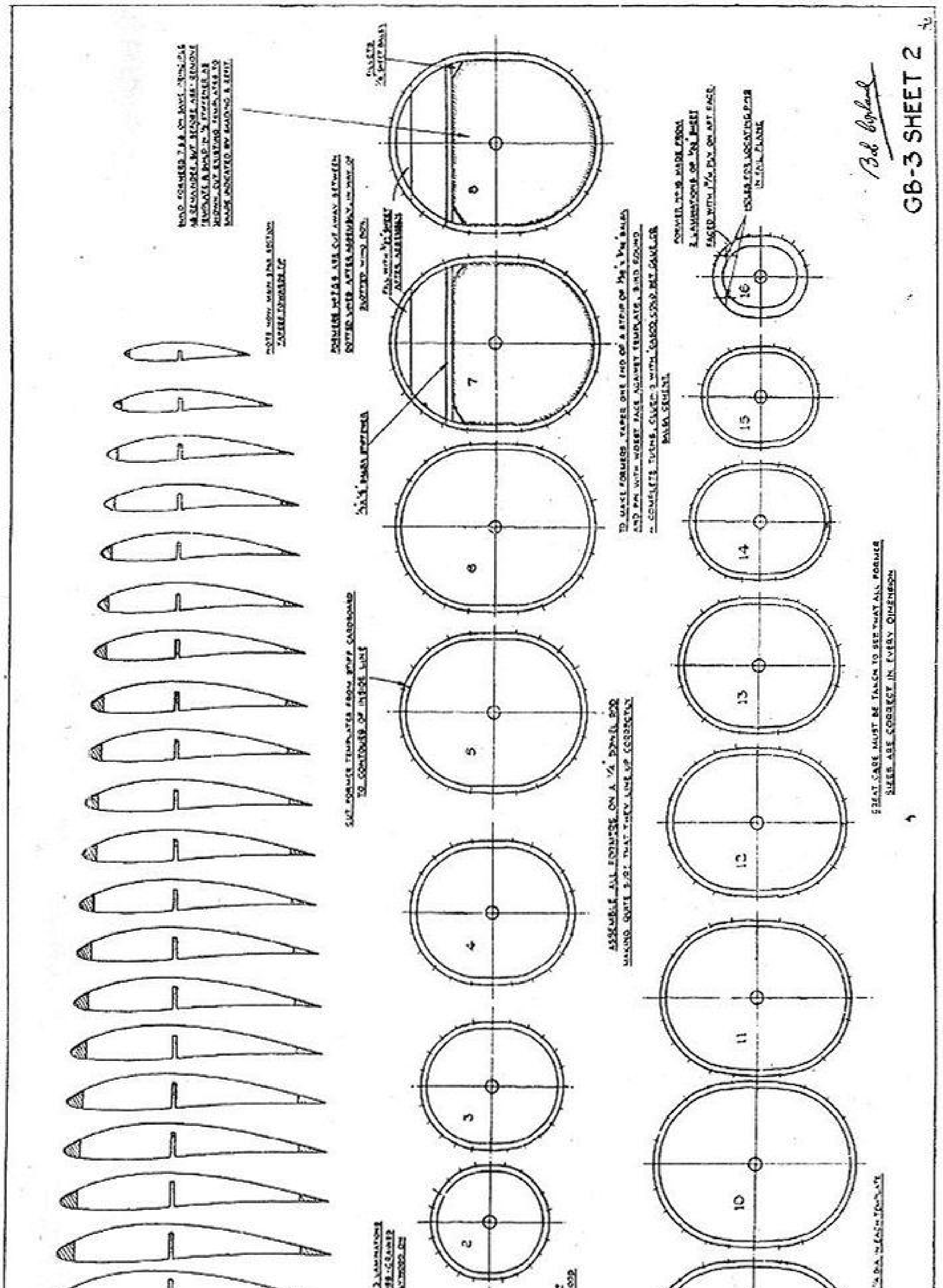

Fig. 194a

At this stage we may construct a building stand, somewhat after the pattern of the one shown in Fig. 177, in Chapter XVII. Although showing a somewhat different method of construction, this picture really indicates the next steps in the making of the present fuselage. It will be seen that the formers have been mounted upon the rod, and the stringers applied. If the four main stringers are cemented on as shown, this will hold the structure firmly while the remaining stringers are glued into position.

This leaves the fuselage ready to have the remaining stringers added, and this should now be done.

Former No. 1, that is the nose former, is circular in shape,

Fig. 195.—" G.B. 3 " in Yugoslavia. The victorious British team after winning the King Peter Cup

and has a rectangular hole cut in the centre into which the locating piece of the nose block should fit. The outside edge of this former has 24 slots cut into it. These slots are spaced equidistant around the circumference, and their purpose is to receive the front ends of the stringers.

At the rear end of the fuselage, the stringers are drawn together and cemented, and a small paper tube is also cemented at the position shown in the drawing. It will be noted that this paper tube protrudes below the general level of the bottom of the fuselage, and that it is reinforced with small balsa strips. It is to the lower end of this tube that the extremity of the birch tail skid is cemented. Note also that a small wire skid is bound to the birch strip. This wire forms the tail skid proper, as, in the finished machine, the birch strip forms the framework of an underslung fin, which is covered with Jap tissue.

The top half of the end of the fuselage, from former No. 16, is now completely cut off, and is cemented to the centre of the top of the tail plane, thus carrying on the lines of the fuselage when the tail is in position.

Provision for anchoring the rubber motor at the rear end of the fuselage is made by cementing a small piece of balsa to either side of the fuselage. A bamboo peg passes through holes in these pieces of balsa and through the centre of a "Run True" bobbin, to which the rubber is affixed.

Wing-Fixing

The wing-fixing is, perhaps, the most difficult part of the machine.

The formers are cut away, as shown on the drawing, to allow the wing mount to be moved. The stringers on which the mount slides are then reinforced with sheet balsa. Two bamboo rods, 1/16 inch in diameter, are located in holes drilled in formers Nos. 8 and 9. In the drawing these are marked "X."

A box-like structure forms the mount itself, which is built of *hard balsa*. It will be seen in the lower right-hand corner of Fig. 194. The whole of this box must be bound with tissue paper and cement, and varnished with banana oil. If desired, glasspaper may be cemented to the bottom of the box, to make a friction fit. It should be noted that the wing mounting box should not protrude beyond the width of the fuselage.

On again glancing at the drawing, it will be seen that fixing tongues are built into the root of each half wing. These tongues must be a tight sliding fit into the locating box, and it will be understood that, when in position, the effect is to form one complete wing.

Rubber bands form the method of securing the locating box within the fuselage. These bands are stretched over the top of the box, and are attached to the ends of wire hooks; the other ends of these hooks are looped over the bamboo rods.

Wings

These are built up in a straightforward manner, and have the ribs spaced at a distance of every inch. The leading- and trailing-edges are slightly stouter than are normally used, but the incorporation of these results in a wing which is particularly robust and free from any tendency to warp. A rectangular centre spar passes through each rib, and is built into the wing fixing tongue. Ribs are butt-glued to the leading- and trailing-edges, which are shaped to conform to the wing section. Ribs Nos. 1 and 2 are of 1/16 inch sheet balsa ; all other ribs are of 1/32 inch sheet balsa.

Particular attention should be paid to the cutting of the slot in rib No. 1. This slot locates the wing-fixing tongue, and upon it depends the whole line-up of the machine. It is

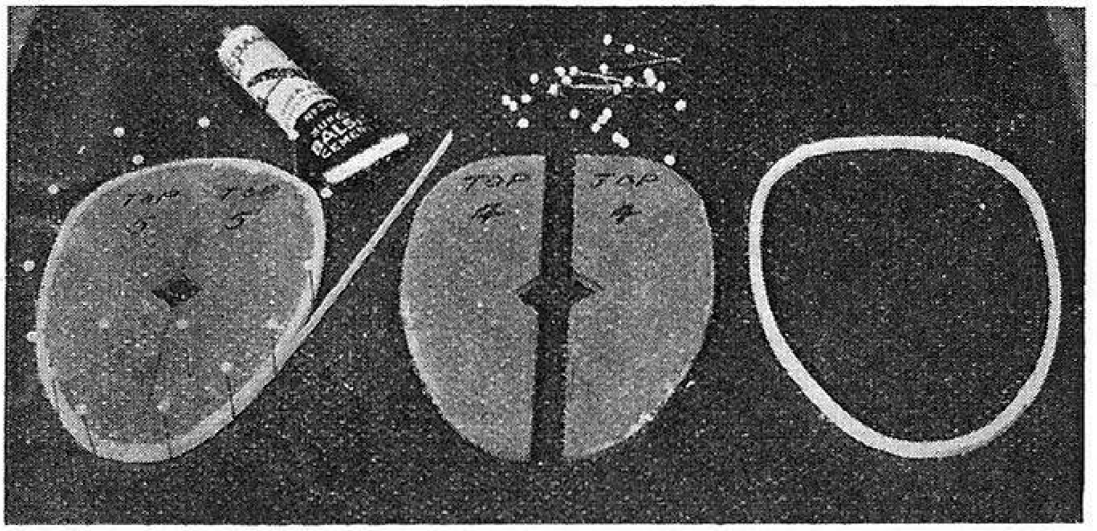

Fig. 196.—Showing method of winding formers such as are used in the construction of "G.B. 3"

essential that this slot be cut to give a *three degree* positive incidence to the wing.

The wing-fixing tongues are built-in structures of 3 mm. plywood and 3/16 inch sheet balsa, and the construction should be readily understood from the drawing in Fig. 194.

Wing tips are of 1/16 inch × 1/16 inch birch strip, steamed to shape, and backed with 1/16 inch sheet balsa. The birch is inset into the leading- and trailing-edges, and is well smoothed with glasspaper when finished.

As it is essential that the wing-fixing tongues be strong, they are covered with three layers of tissue paper ; cellulose cement being applied between each layer. They must also be a tight fit in the wing mount, as this is all that keeps the wings in position.

If the wing fillets and fairings are built up carefully, they can be made to look quite good, but it is a job requiring care. A small block of balsa is cemented to the front of the leading-edge, at the wing root. A similar piece of balsa is also cemented to the trailing-edge in a like position. These blocks are then shaped to fit the fuselage, and also to the shape of the fillets themselves. These are shown in the plan drawing of the wing, at " A " and " B " in Fig. 194. When these have been shaped, 1/32 inch sheet balsa is cemented between them, so that the whole fillet fits the fuselage.

Undercarriage

This is a very simple arrangement. Legs are of $\frac{1}{4}$ inch × 1/8 inch bamboo at the tops, tapering to 1/8 inch × 1/8 inch at the extremities. They are fixed to the fuselage by means of 18 S.W.G. piano wire ; one piece of wire only is used. This is passed through a piece of 18 S.W.G. brass tubing which is bound and cemented to former No. 4. These points of fixing are reinforced with small pieces of 3/32 inch balsa. The protruding ends of the wire are bent to give a 14 inch track to the wheels, and are then bound and cemented to the bamboo legs.

A length of 18 S.W.G. piano wire with small loops formed in it, constitutes the simple springing device. One piece of wire is again used to form the springs of both legs. It is passed through a length of 18 S.W.G. brass tubing (affixed to former No. 6, and held in the manner described above). It is then bent to give the desired track to the wheels ; the loops are formed, and the ends bound and cemented to the bamboo legs. Streamlined balsa wheels, of two inches diameter, are used.

Tail Plane

Simplicity is again a feature of the tail plane. It is built with a lifting section, with ribs cut from 1/32 inch balsa, 1/8 inch × 1/8 inch balsa leading-edge, and a trailing-edge of 3/8 inch × 1/16 inch balsa. Wing tips are of 1/16 inch × 1/16 inch birch strip.

The centre portion is faired on to the top of the fuselage by means of the piece of fuselage end, already described as being cemented to the centre of the tail fin.

At the front end the tail is held by two small wire prongs which locate into holes in former No. 16. At the rear end of the tail a small piece of paper tubing is cemented, and reinforced by a small piece of balsa sheet. This small paper tube should locate with the paper tube affixed to the underslung fin on the fuselage. A small birch dowel on the rudder fin locates in both these pieces of tube ; thus, the rear end of the tail, and that of the fin itself, is secured.

A press snap-fastener, one half of which is bound and cemented to the fuselage top, and the other half to the front of the fin, secures this at the front end.

An unusual refinement, not often found on this class of model aeroplane is the adjustable rudder or trimmer at the back of the tail fin. The fin is constructed by similar

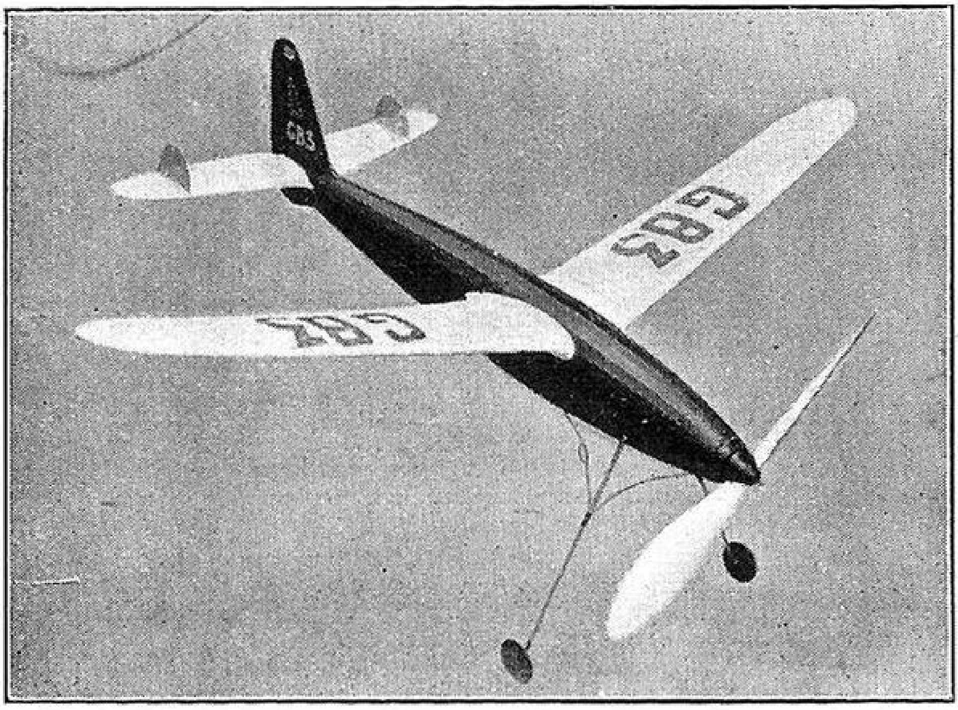

Fig. 197

methods and of similar materials to those employed for the tail plane. The trimmer is hinged to the fin proper by means of small strips of 0.006 G. aluminium.

When the tail plane has been covered, two small stabilising fins, cut from 1/32 inch sheet balsa, are cemented in an upright position on each of the last tail ribs but one. An inspection of the drawing will make this matter clear.

Propeller and Nose Block

The propeller is carved from a block of balsa wood of 18 inches × 2 inches × 1¾ inches dimensions, to a pitch of 26 inches. The spinner is carved as an integral part of the propeller boss, and is recessed to allow room for the free-wheel device. When carved and balanced, the blades are covered with tissue paper and french polished.

The nose block is built up of four layers of 1/8 inch sheet balsa, cemented together with the grains running in different directions. This nose block is also recessed to bring the spinner close to the nose.

It will be noticed that "Run True" bobbins are used to hold the rubber, both at the front and rear ends of the skein.

Power

A skein of 44 inches long, composed of 18 strands of 3/16 inch × 1/30 inch rubber supplies the power.

Covering and Finishing

The fuselage is covered with two layers of Jap tissue paper. When covered these should be sprayed with water, and when dry, two coats of Banana Oil No. 2 should be given. Wings and tail unit have only one layer of Jap tissue. These should also be water sprayed, but only one coat of Banana Oil No. 2 should be applied.

ABAC

For Multiplication or Division of Numbers.

For Finding the Log, Square or Cube of Numbers.

For Finding the Square or Cube Roots of Numbers.

Instructions

To Multiply Any Two Numbers :

Place straight-edge across the multiplier on scale A and the multiplicant on scale E. Read product on scale C.

To Divide Any Two Numbers :

Place straight-edge across the number to be divided on scale C, and the divisor on scale A. Read quotient on scale E.

To find the Log, Square or Cube of Any Number :

Place straight-edge across the number of which these functions are required, on scales A and E. Read off the corresponding values on scales B, C or D.

To Find the Square or Cube Roots of Any Number :

Place straight-edge across the number on scale C or D, at right angles to the scale. Read off the required root on scale A or E.

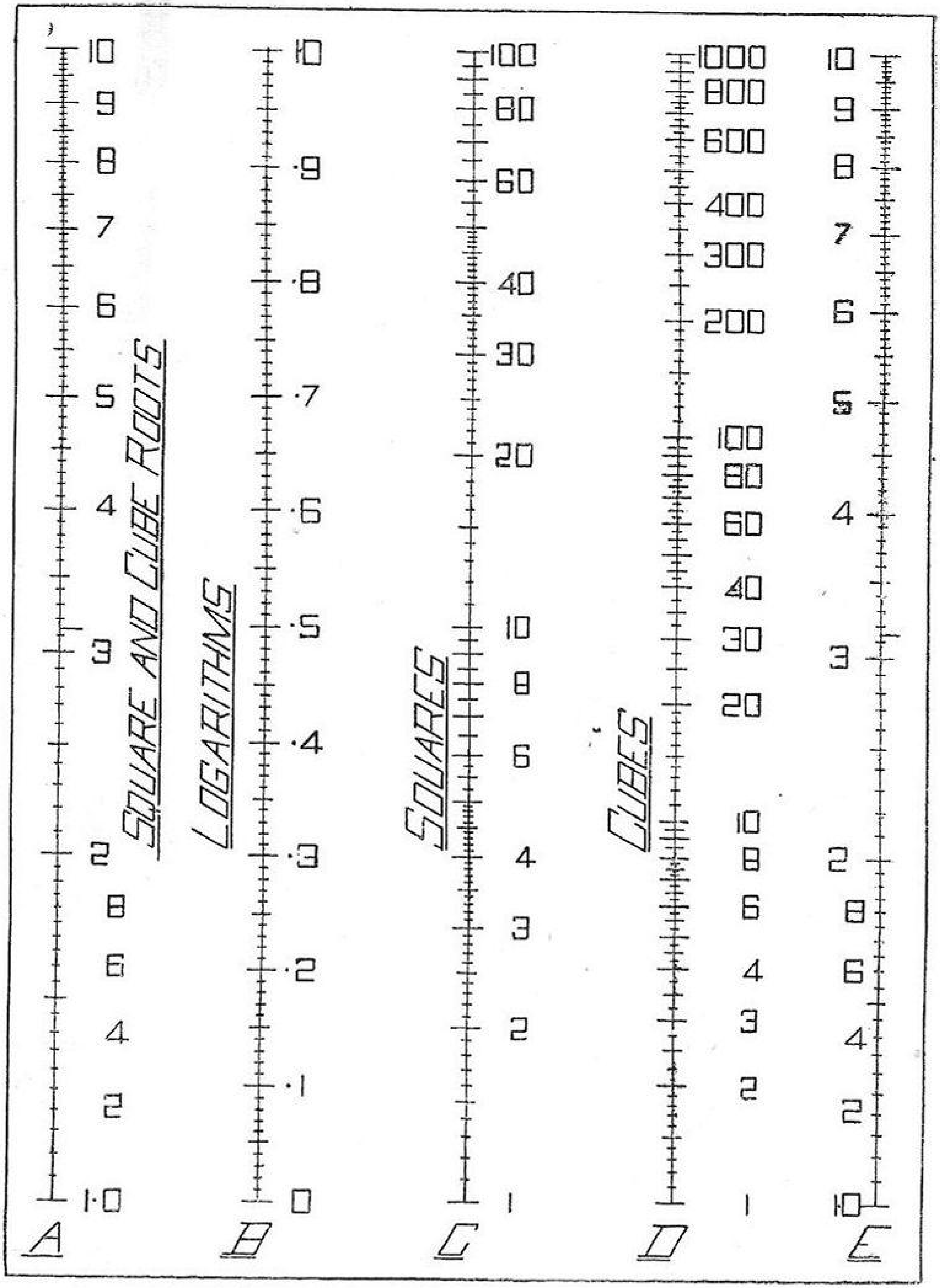

Fig. 198

ABAC

For Finding Proportionate Height and Width of Square, Rectangular, Triangular or Elliptical, and Diameter of Circular, Fuselages, to conform to S.M.A.E. Formula

$$\frac{(A = L^2)}{100}$$

To Find Height and Width of Square-section Fuselage:

Stretch thread at right angles to centre scale at point indicating length of machine. Read off height and width on two outer scales.

To Find Height and Width of Rectangular Section Fuselage:

Stretch thread across point indicating length of fuselage on centre scale. Swivel thread on this point until it intersects desired width of machine on outer left-hand scale. Read off height on outer right-hand scale.

To Find Height and Base of Triangular Section Fuselage:

Stretch thread across centre scale at point indicating length of machine. Swivel thread on this point until it intersects desired base of triangle on outer left-hand scale. Read off height of triangle by doubling the figure indicated on the outer right-hand scale.

To Find Diameter of Circular Section Fuselage:

Stretch thread at right angles to centre scale at point indicating length of machine. Read off diameter on either of the two inner scales.

To Find Height and Width of Elliptical Section Fuselage:

Stretch thread across point indicating length of machine on centre scale. Swivel thread on this point until it intersects desired width on inner left-hand scale. Read off height on inner right-hand scale.

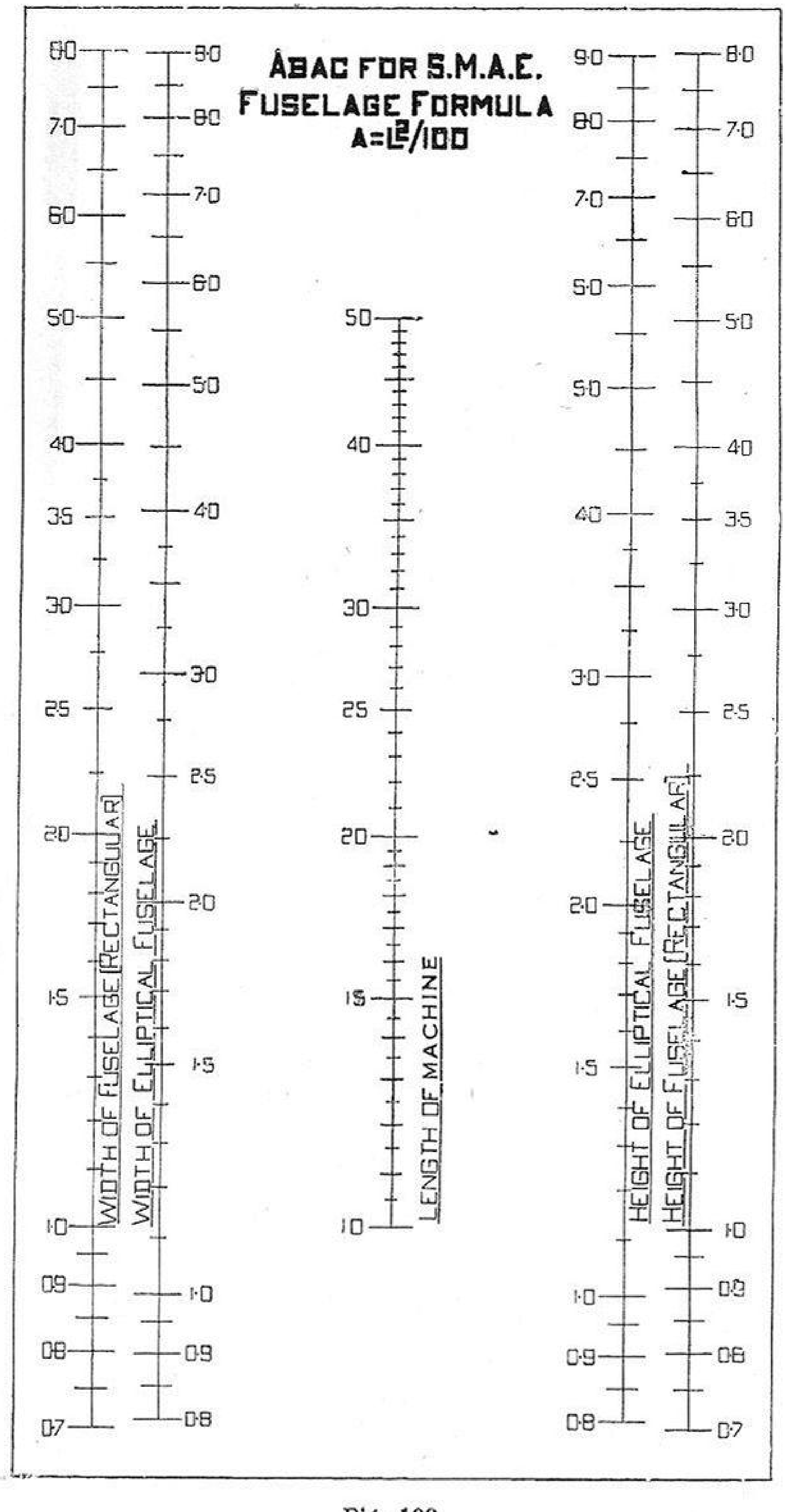
ABAC FOR S.M.A.E.
FUSELAGE FORMULA
A=L²/100
WIDTH OF FUSELAGE (RECTANGULAR)
WIDTH OF ELLIPTICAL FUSELAGE
LENGTH OF MACHINE
HEIGHT OF ELLIPTICAL FUSELAGE
HEIGHT OF FUSELAGE (RECTANGULAR)

Fig. 199

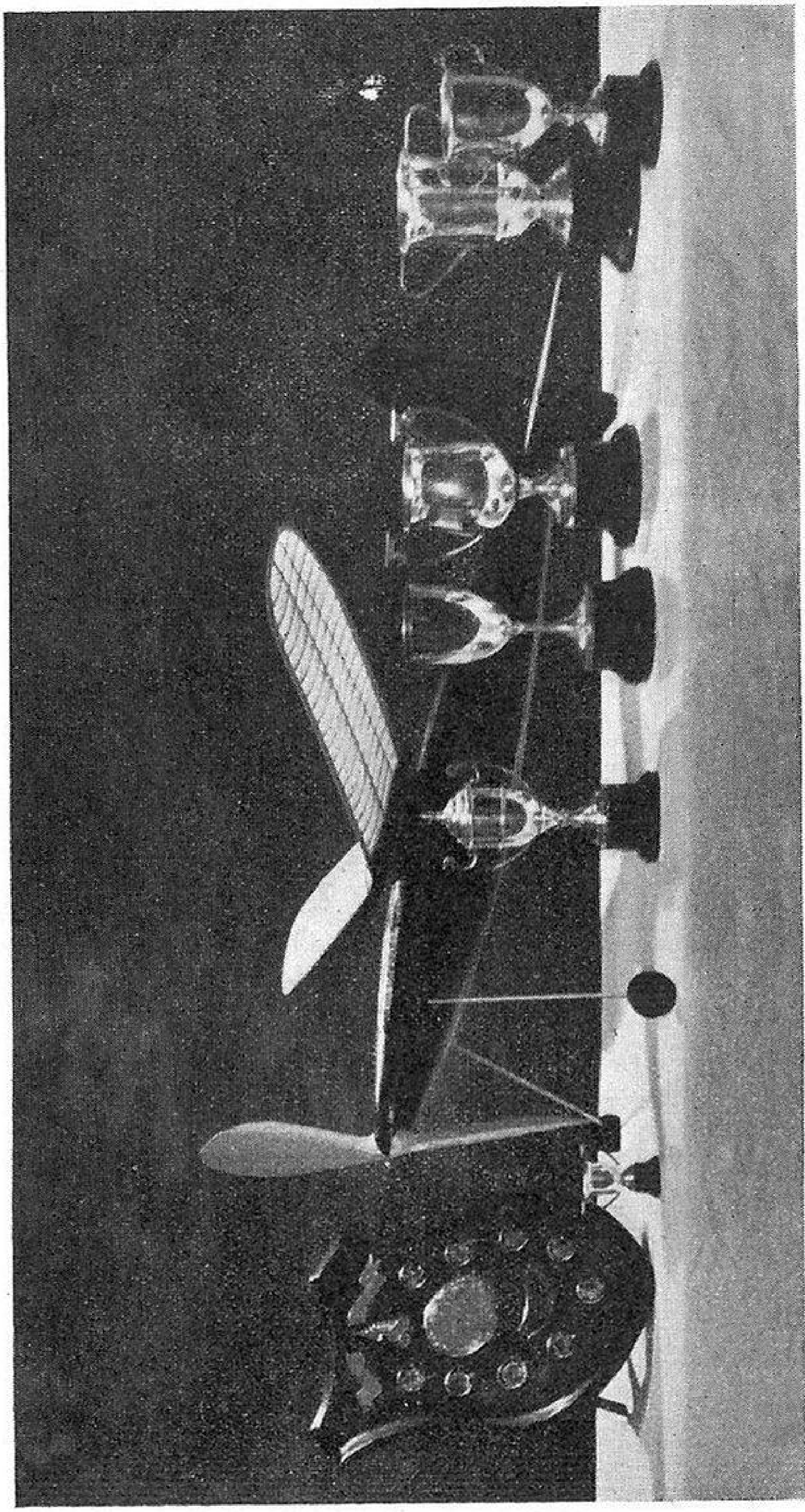

Photo by courtesy] [*A. G. Bell*

"BY EFFORT WE ACHIEVE"

A modern type duration model aeroplane, and some of the trophies which it has won