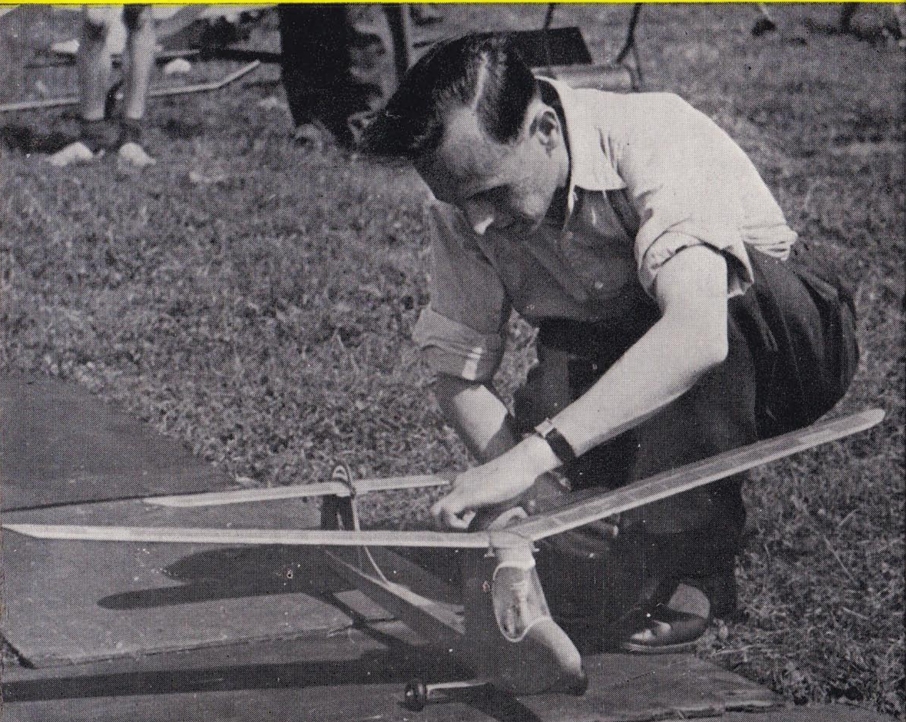
AEROMODELLING

Vic Smeed



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Best wishes —
Vic Smeed

Aeromodelling

This new book on the subject of model aeroplane construction is a practical introduction offering four or five models of various basic types which can be built simply from the drawings and instructions in the book. All existing types of models are described, but detailed construction is concentrated on these basic, simple designs, so that the beginner knows what the hobby has to offer and can also start off on a sound footing. Author Vic Smeed is one of the best-known designers and writers on model subjects; he is editor of the monthly "Model Maker" and is also associated with the magazines "Aeromodeller", "Radio Control Models", and "Model Cars".

General Editor: CHRISTINA FOYLE

The cover photograph shows the Author with a model which won the Bowden International Trophy.

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Aeromodelling

by

VIC SMEED

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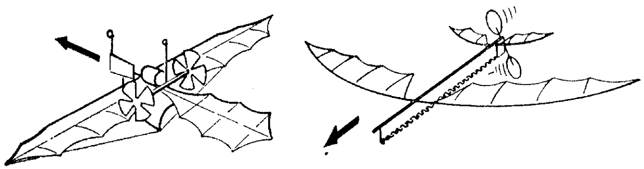
One

Aeromodelling Then and Now

AEROMODELLING, believe it or not, goes back further than man-carrying flight – the first successful flight by a powered model took place in 1848, and by a piloted aeroplane in 1903. The 1848 model, built by Englishman John Stringfellow, used a steam engine, and in 1871 a Frenchman, Alphonse Penaud, successfully flew a rubber-powered model of surprisingly advanced design (Fig. 1). The publicity attached to the manned flight by the Wright brothers in 1903 was, however, the starting point of model aeroplane building as a hobby, and the early years of this century saw the first groups of enthusiasts flying models powered by rubber strip, steam engines, compressed air engines (which carried a cylinder pumped up by hand pump), electric motors, and even one or two early petrol engines.

By the early 1920's a number of clubs existed, and these were grouped into the Society of Model Aeronautical Engineers, a body responsible for controlling the hobby, its powers being delegated to it by the Royal Aero Club. The S.M.A.E., as it has always been known, is still the national organisation, and still exercises control and guidance in Great Britain in all matters relating to model aircraft. Similar bodies exist in most other countries, and the world authority is the Models Commission of the full-size Federation Aeronautique Internationale, or F.A.I. for short. The F.A.I. agrees specifications and rules for international competition in all categories of model aircraft.

The first international contest took place in the late 1920's; at this time models were almost entirely rubber driven and there were very few experimenters with other forms of model



STRINGFELLOW *Fig. 1* PENAUD

flight. Lord Wakefield put up a trophy for annual competition, and this prize, the Wakefield Cup, is still competed for and, to most modellers, still holds the greatest prestige of any international award.

At about this time, when models were built of spruce, birch, bamboo, wire, and oiled silk, small amounts of balsa began to find their way to this country, and this 'new' wood brought about something of a revolution in constructional techniques. (At about this time, incidentally, the author was building his first models!). By the early 30's balsa was supreme as a building material, and one result was an all-round increase in performance. With the public becoming more and more air-minded, the growing market for commercial accessories and even kits (you could buy a small but elaborate rubber-powered kit for 9d.!), easier building, and better performances by average models, aeromodelling became more and more popular.

Competitions were usually run on the simplest of rules, and duration of flight was all that counted. In 1934, however, a young American began winning competitions with a model powered by a miniature (9 cc.) petrol engine, and it wasn't long before it became necessary to establish a separate classification for petrol-engined models. The first engines, all spark ignition two-strokes, were on sale in 1935/6, and power models became ever more popular (Fig. 2). Chuck gliders and, in Europe, catapult or tow-launched gliders also provided variety in the late 1930's, and in some contests as many as ten nations competed.

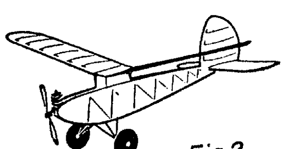


Fig.2

The 1939/45 war stopped development except in America – power models and gliders over 7 ft. span were banned in Britain, and rubber, balsa, etc. were almost impossible to obtain. Engine development and production continued in the U.S.A., and early in the war control-line flying was developed; it was not introduced to this country until 1946. Spark ignition engines held sway immediately after the war, but the 'diesel' or compression ignition engine was introduced in Britain and Europe, and the glow-plug engine in America, and spark engines were soon running a bad third. Radio control, dating back to the 1920's, 'arrived' in about 1950.

Post-war development was rapid and varied, so that there are now a dozen or more classes of models, many of which are the subject of international competition with as many as twenty-six nations sending teams of competitors. Basically, there are three broad classifications – sport, open competition, and formula competition models. The first is obvious – sport models are built for the fun of flying a model. Open competition models are designed for ultimate performance in contests allowing unrestricted size or engine capacity, etc. Formula models are built to comply with strict rules; usually these are F.A.I. international rules, but occasionally there are national or 'unofficial' international contests (such as the Coupe d'Hiver) which impose special restrictions. Briefly, the specific competition classes are as follows:

1. *Control-line* – speed (0-2.5 cc., 2.5-5 cc., 5 cc.-10 cc., jet) stunt, and team racing. There is also a 'combat' (streamer-cutting) type of competition.
2. *Free flight* – Wakefield (rubber) A2 (glider) and F.A.I. Power. There is also a recognised A1 class, and the Coupe d'Hiver rubber class.
3. *Radio* – single-channel (rudder only control) and multi-channel.
4. *Scale* – free-flight, control-line, and radio control scale events are very popular.
5. *Indoor Models.*

Control Line

As explained elsewhere, control-line models remain tethered to the operator and under his control. Speed models, travelling in some cases at 170 m.p.h., are tiny aeroplanes powered by relatively large motors; a 2½ cc. engine normally flying a 5 ft. free flight model, is fitted into an aeroplane only 12 or 13 ins. in span. The models are super streamlined and highly polished; usually they take off from a 'dolly', a cradle on wheels which remains on the ground when the model lifts into flight (Fig. 3). The line lengths on which the models are flown are standard.

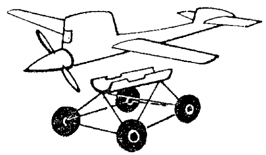


Fig. 3

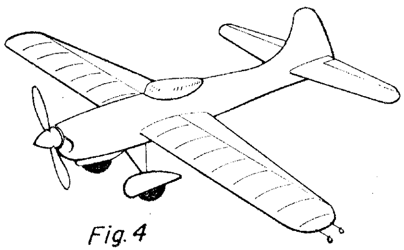


Fig. 4

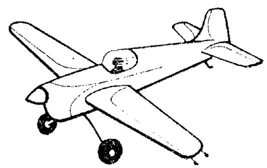


Fig. 5

Stunt models are much larger and are built to perform every aerobatic possible using elevator control only. In fact all top-class stunt models now have wing flaps coupled to the elevators but working in reverse, i.e. down flap with up elevator and vice versa, which enables them to turn much tighter and to do 'square' manoeuvres such as a square loop etc. (Fig. 4). Top models use 5 to 10 cc. engines, are about 5 to 6 ft. span, and fly at 80–90 m.p.h., but a good range of manoeuvres can be carried out with small engines and models travelling at, say, 50 m.p.h.

Team racing involves three models flying in the same circle, the 'pilots' standing close together and faster models passing by the pilot moving his control handle over the head of a slower model's pilot. The models must bear some resemblance to full-size aircraft (Fig. 5), with undercarriage, cockpit, and cowled engine, and have an accurately measured fuel tank. During a race the models run out of fuel, land, and are refuelled and

restarted by a team of two mechanics. Pit stops of less than 10 seconds, including reaching the model, filling the tank, and restarting the engine, are quite common. Obviously there is a choice of a slower model, using less fuel and stopping only once in a race, or a fast 'plane which may need to stop two or three times. It can be very exciting, especially as faster models travel at 120 m.p.h. or so. The international class requires a 2½ cc. (maximum) engine and minimum dimensions on wing area and fuselage cross-section.

Very popular, though heavy on models, is combat flying, where two models each tow a paper streamer and the flier attempts to cut (points awarded for each cut within a time limit) the opponent's streamer, without having his own cut, or tangling the control lines, or colliding with the other model. The aeroplanes are designed to be highly manoeuvrable, fast (80–90 m.p.h.), but also cheap and quick to build and repair. Engines of 2½ or 3½ cc. are usually used.

Sport models are usually fairly simple and strong, and are usually capable of only limited stunting and moderate speed. They can give a lot of fun and, of course, are widely used to practise the art of control-line flying.

The most outstanding c/l models are undoubtedly scale designs. Since the lines take care of most stability problems, and the model remains under the control of the operator, almost any prototype can be built. Many would never fly as free flight designs, for reasons of inherent stability, or are so complicated and require so much work, or need to travel so fast to fly at all, that they would never be built were it not for the safety factor provided by the lines. At any big meeting it is well worth making a point of examining the scale models.

Before leaving this type of flying, the jet must be mentioned. Model pulse jet engines are steel tubes a couple of feet long, shaped into a combustion chamber at one end, and fitted with a fuel-conducting nose-piece and valve mount. The noise they produce is awe-inspiring – it will carry three or four miles – and the steel tube is red-hot when working. These engines can only be used on control-line models (Fig. 6), and produce speeds

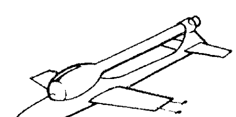


Fig. 6

in the region of 200 m.p.h. Not surprisingly, there are very few such models flown, but watching one fly is an experience that will be remembered for a long time!

Free Flight Models

In direct contrast to the jet, both in noise and popularity, is the glider or sailplane. A glider is towed up on a line (standard is 50 m. or 164 ft.), released at the top of the climb, and then floats back to earth. A good International A2 glider (about 6 ft. span, Fig. 7) will make a still-air flight of $2\frac{1}{2}$ mins. or so from such a launch. Still air is rarely encountered, however, and the present-day designs are so efficient that the slightest rising current in the air will extend the flight considerably or take the model up with it and out of sight. Competitions thus fix a maximum time per flight (usually 3 or 4 mins.) and the flight of the model is spoiled at the end of that time by a device known as a 'dethermaliser'. The usual system is to spring the

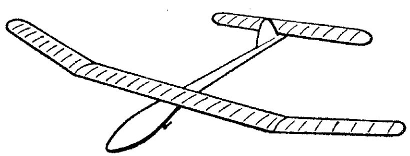


Fig.7

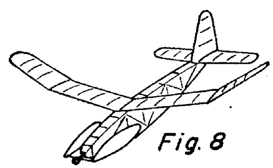


Fig. 8

tailplane with rubber bands and hold it down with one band which is melted by a slow-burning fuse after the appropriate time. The tailplane pops up and the wing is thus caused to lose lift and the model descends rapidly, on an even keel, fast enough to bring it out of the rising air but not so fast as to damage it when it lands. All modern free-flight models use this or a similar system to limit fly-aways.

Most flying with sailplanes is carried out with either the A2 or the A1 class, the latter being a smaller-size model which is nevertheless very efficient. Scale model gliders are not very good performers unless modified to such an extent that they lose much of their scale appearance. A 'compromise' A1 design will be found in Chapter 3.

Rubber-powered models are the cheapest form of power

flying, but they are also the most difficult to make fly really well. For sport flying they are excellent, and a modeller who learns to fly rubber models well is unlikely to have much difficulty with other types of model. Basically, the model is a glider adapted to use the rubber motor to take it to a height from which a long glide can be obtained; for this reason, competition models use every device to help the glide, such as folding propellers and pretensioned motors which do not alter the balance of the model etc. (Fig. 8). More on this subject in Chapter 4.

Because of the additional skill needed to fly rubber models really successfully, and the ease and cheapness of obtaining small motors, rubber power has fallen in favour over the last few years; it still has a special appeal, however, and the Wakefield international rubber model is often considered, as mentioned above, the acme of the aeromodeller's skill.

'Power model' is a term used to cover any free-flight model fitted with a miniature internal combustion engine, of which there are three types. The petrol engine, or spark ignition engine, is at present hardly ever seen, though it has some advantages which may yet bring it back into favour. The typical engine is two-stroke, and is equipped with a set of contacts, a coil, a condenser, and a small battery, which between them produce a spark in a tiny sparking plug. Just like many small motorcycles, in fact. There have been four-stroke engines for models, and we have also seen, and in some cases used, two cylinders, opposed or in line, four cylinders in line or in opposed pairs, and even three and five cylinder radial petrol engines.

Most models nowadays, however, use diesel or glowplug engines. 'Diesels' are more correctly termed compression-ignition engines, since they work on the usual two-stroke principle but rely solely on the heating of the gases by compression for ignition, whereas the true diesel (as lorries etc.) injects the fuel as compression is reached. Glowplug engines use a small plug like a sparking plug but fitted with a tiny coil of special wire. The wire glows when a battery is connected, and ignites the fuel; once running, the heat generated each time the engine fires is enough to keep the plug glowing without the use of the battery, which is therefore disconnected.

Although diesels have been made down to .1 cc., the smallest commercial ones nowadays are about .5 cc. and the largest single-cylinder 5 cc. There are one or two twins made, the commonest being 8 cc. total, and there is one 15 cc. twin, normally used for boats. The usual maximum size is 3½ cc. Glowplug engines are made from .16 cc. up to 10 cc.

The average 'sport free-flight' model uses an engine of .8 cc. (.049 cu. ins.) to 2½ cc. (.15 cu. ins.). British and European engines are usually in c.c. (cubic centimetres) but Americans are usually expressed in cubic inches, .06 cu. ins. equalling 1 cc. The smallest glowplug motors are American; the glowplug is almost standard in that country, very few diesels being used, whereas in Europe diesels outnumber glowplugs.

A majority of free-flight power models fall into the sport category, i.e. models flown for fun, the owners enjoying the pleasure of simply flying a model. Usually sport models tend to look semi-scale (Fig. 9), with a fairly bulky fuselage including a cabin, and an undercarriage; their power is enough to keep them climbing well, but generally they are less efficient (and a great deal easier to fly!) than competition models.

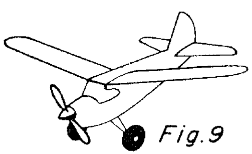


Fig. 9

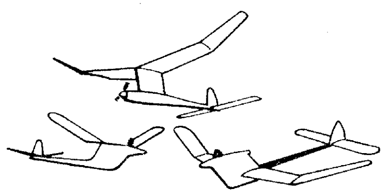


Fig. 10

Once again, a competition model is in effect a glider which uses an engine to take it to a height from which a long glide is obtained. International rules allow only a 10 second engine run, but a top model may reach 500 ft. altitude or so in this brief time, going up like a rocket. To control the amount of power needed to climb at this speed calls for great skill and a first class model design, but to a layman the design may look decidedly odd and not much like any full-size aeroplane. The sketches (Fig. 10) show one or two typical configurations. Many modern models use the timer which cuts the engine to adjust settings such as tailplane angle, rudder, etc. for maximum efficiency on

the glide, where the model is flying much slower and under somewhat different conditions from those of its breathtaking climb. Beginners must, of course, work up to the building and trimming of such a model by easy stages, rather as one works up to piloting a supersonic fighter through experience on other, simpler aircraft.

Radio

The fastest-growing branch of aeromodelling today is in radio-control, and in view of the interest and the relative complexity of the subject to a beginner, this book includes a complete chapter explaining the basic types of model and equipment. In this introduction, therefore, nothing more need be said than if you have not yet made a flight under radio control, we envy you the thrill which you have yet to experience!

Scale Models

One big difference between a full-size and model aircraft is that the former is flown by a pilot and must respond fairly easily to his control, but at the same time must tend to fly itself enough to make piloting less fatiguing. The ability to fly itself is due to inherent stability, but too much of this means great effort by the pilot to manoeuvre. A model, on the other hand, needs a greater degree of inherent stability, since it has no pilot at the controls. Thus an accurate scale model of a full-size aeroplane is unlikely to be stable enough to make a successful flier. There are also factors like the efficiency of the tailplane dropping more than that of the wing, so that an adequate tailplane full-size is too small in model size, etc. A very few aircraft will scale down and make successful free-flight models, but normally some stretching of scale is necessary.

Moving to radio-control, we have a position much nearer to full-size flying, where the model is in fact being flown by a 'pilot', so that lack of inherent stability is less important and the scale factors (such as tail efficiency as mentioned) are the only limits. The number of full-size machines capable of scaling down is thus greatly increased.

Literally any scale model can be made to fly on control-lines; this is in fact one of the big attractions of this method of flying.

Prototypes which could be impossible to fly any other way are relatively safe on lines, so that builders have a very wide choice and are prepared to put in an immense amount of work into scale subjects. To date, C/L flying is the only way in which *average* modellers can fly such subjects as four-engined bombers and midget air racers. A visit to the scale circle at a big meeting is always worthwhile.

Indoor Models

Imagine a three-foot model, powered by a rubber motor, weighing altogether less than one hundredth of an ounce! No flight of fancy, this, for a typical indoor model (Fig. 11) will be just that. Moreover, in a large hall – the best are the airship hangars at Cardington, 130 ft. high! – flights of over half an hour are frequent, and the world record stands at over forty-five minutes. Such models are built from balsa perhaps 1/32 in. square at its thickest, down to 1/100 in. thick or even less, and

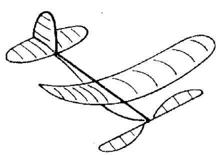


Fig. 11

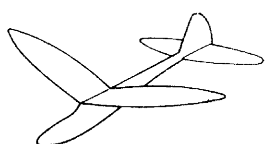


Fig. 12

are covered with microfilm. You have seen oil floating on water; microfilm is made by floating a solution on water, and, when it dries, picking up the incredibly thin film on a wire hoop and covering the model with it. The film is coloured like an oil patch, the actual colour indicating the thickness. Needless to say, one sneeze and there is no covering left. Once again, such models are for experts, and require a lot of experience to build and fly. However, the simple model is Chapter 4 can be made for indoor flying as a start.

In America, indoor chuck gliders (Fig. 12) are popular, but the subtle skills needed with these tiny gliders are not often appreciated until a flight of twenty or thirty seconds has been seen. It's a very long time for what looks like a child's toy to stay up.

The sport of R.T.P. (round the pole) flying has largely died out. A model is tethered by one wingtip to a very freely swivelling pylon head so that it flies in circles for as long as possible on one winding of its rubber motor; timing is from take-off to the first touch of the landing gear, and flights of over 5 mins. have been made. An average model would be lucky to do $1\frac{1}{2}$ mins., a good one 3 mins.

This, then, is a brief history of model flying and a glimpse of the astonishing variety of types of model now built and flown. Few people can expect to be expert in more than two or three categories, if as many, but with so wide a choice an intending aeromodeller can pick the type of model which will give him the most pleasure, and, after all, pleasure is the chief reason for our building models at all.

Two

What to Use

ONE OF THE big attractions of aeromodelling is the fact that very few tools are needed. Basically, a flat board, a packet of steel dressmaker's pins, glasspaper, and a single-edge safety razor blade or a modelling knife are the chief requirements. Next in priority is a small pair of pliers, preferably snipe-nosed, then a small saw (a junior hacksaw or a fretsaw, or a baby tenon), a hand-drill and two or three twist drills, a steel straight-edge (the back of a hacksaw blade will do), and a soldering iron. There are ways of getting round the absence of the last-named. In addition, a pencil and ordinary ruler, scissors, needle, brush, and a piece of kitchen greaseproof or tracing paper are required. Other tools may suggest themselves – for example, a small vice is occasionally useful – but the foregoing will cover everything required for the models in this book.

Chief among materials is, of course, balsa, a word meaning 'raft'. We get our balsa from rafts, in fact – the trees (ochroma lagopus) grow wild, principally in Ecuador, and are felled to make rafts to bring cargoes of bananas down the rivers of that country. At the rivermouths the balsa logs are sold to mills set up to deal with them. Attempts to cultivate the tree have been unsuccessful, and if it were not for the bananas it might be uneconomic to cut and transport the balsa, or at the very least it would be much more expensive.

Balsa grows fast – 36 ft. in five years – so that it is very subject to climatic variation. A dry season means a hard growth, a wet season soft growth. A tree on a well-drained

slope will be much harder than one growing in a swamp; weight may therefore vary from an astounding 2 lbs. per cu. ft. to 20 or more lbs. per cu. ft. The average for modelling is between 8 and 12 lbs. per cu. ft. Because of its growth rate and open cellular structure, a lot of water passes through the wood, and depending on the mineral content of the soil it grows in, it may vary in colour from silvery white to a rusty brown or red.

The logs are kiln-dried and cut, and depending how the cut comes, the characteristics of a sheet of wood will vary (Fig. 13). A tangent-cut sheet (A) will have a wide grain pattern and will bend or roll very easily; a radial-cut sheet (B) will have close-spaced parallel grain lines and will be stiff, splitting along the grain if an attempt is made to bend or roll it too far. Between these two cuts comes quarter-grain (C), distinguished by a freckly, gold or silvery speckled grain, and this is the best cut to use for average jobs. It is reasonably stiff, yet resists splitting, and for the same weight is stronger than either of the other cuts.

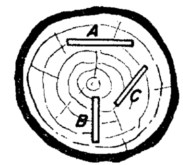


Fig. 13

Balsa is sold in something like 60 cut sizes, from strip 1/16 in. square to block 2 in. x 3 in. or sheet up to $\frac{1}{2}$ in. x 6 in., all 36 in. long. The most useful size of sheet is usually 3 in. wide, but narrower sheets can always be butt-joined by cementing along the edges if necessary.

The next most important timber is ply, usually in very thin sizes such as .8 mm. (1/32 in.) 1.5 mm. (1/16 in.) with 3 mm. ($\frac{1}{8}$ in.) as the thickest normally used. The first two of these are usually to aircraft specification, i.e. resin-bonded birch, and very strong. It pays to buy $\frac{1}{8}$ in. to the same standard if possible, but it is not absolutely essential.

The only other timbers used commonly are beech, in the form of engine bearers in appropriate sizes, and birch in dowel form. Occasionally bamboo or cane may be used for a specific item, and spruce is sometimes used for highly stressed parts such as wing spars on a fast radio model. Experts' models may incorporate other timbers – for example, a speed model fuselage carved from white pine – and foreign models may employ unusual woods which, however, can usually have a more common material substituted.

Wire for model aircraft is almost always spring steel piano wire, sold by the 3 ft. length by a standard wire gauge (s.w.g.) number. This wire is very hard and tough, and is best cut by filing a nick and breaking. Average wire cutters tend to have a very short life if used on piano wire.

Another important 'ingredient' is cement. Balsa cement is usually acetate or nitrate based, and has the ability to soak into the wood. It never completely dries, but remains very slightly flexible. An ordinary glue is brittle when dry, and would snap under the conditions of model flying. Cement is fairly quick-drying, but not so quick as most modellers think. It is better to leave a cemented joint for five or six hours if possible. Other adhesives used nowadays are white PVA (polyvinyl alcohol) which, however, needs pressure while drying, contact adhesives (for sheeting frameworks), and epoxy resin, used for very highly stressed parts or metal joins.

Covering is most often in the form of special tissue paper, but silk or nylon is also used. Different adhesives are used for this, and cellulose dopes etc. are applied after covering. Since this is one of the trickier parts of modelling, Chapter 7 is devoted to it.

For cabins, etc. acetate sheet is usually employed; this also comes in for reinforcing stress points. An acetate cement is desirable for sticking it in place, since nitrate does not etch into it, Acetate can be heat-moulded to various shapes, or bubble canopies etc. can be purchased at a model shop.

Nowadays few people carve their own propellers or make their own wheels; these can be bought inexpensively from model shops (by mail order if you live miles from such a shop). Similarly, bolts, washers, bell-cranks, and other 'hardware' can be purchased for a few coppers.

Other items – thread, soft iron wire, scraps of aluminium foil, and suchlike – are usually to be found around the house.

Some of our materials can be a little smelly, and some of the work a trifle messy, and it therefore pays to consider the rest of the family when working. Sanding balsa produces a lot of fine dust which floats everywhere, so sand out of doors if possible.

Doping is offensive to some people in a confined space, so do this in the garage or out of doors (if the weather is right). Modelling is your pleasure, and your pleasure is likely to diminish if you upset the lady of the house by lack of a little consideration!

Three

Gliders

THE CHEAPEST type of model to build and operate is a glider or sailplane; in many ways it is also the easiest. There is no motor or rubber or propeller to buy, nor any wheels etc., and running costs are nil. All you need is 50 metres (164 ft.) of light line – very thin twine, terylene, or even nylon monofilament which is, however, a bit tricky to handle – wound on a spool. For a chuck or catapult glider you need less than this. Yet you can enjoy long flights, enter competitions, and experience the thrill of the occasional outstanding flight just as much as any other aeromodeller.

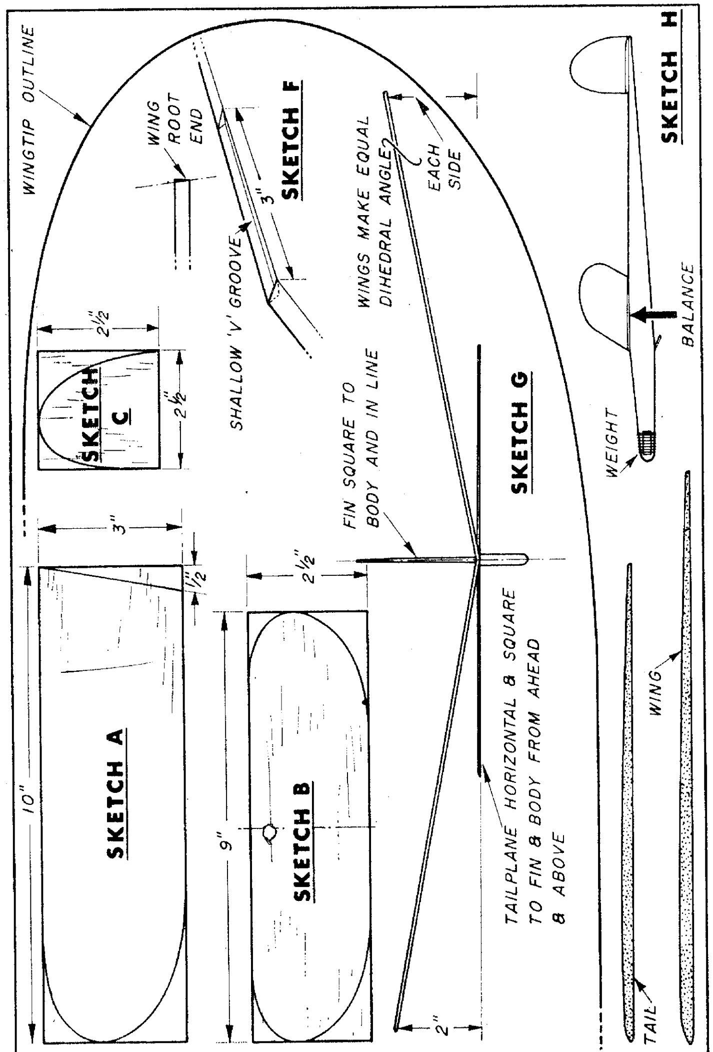
Let us start with a chuck glider. As the name implies, this is a small glider thrown from the hand, and there is far more in it than meets the eye. We have on several occasions watched such a model disappear upwards into the sky, and one flight on record lasted for over 39 mins. before the model vanished. A target of 30 secs. is reasonable, though, for a beginner, but on a good day – calm, hot, and humid – the model shown here is quite likely to stay aloft for a minute or more, and a minute is an extremely long time when you're watching a model.

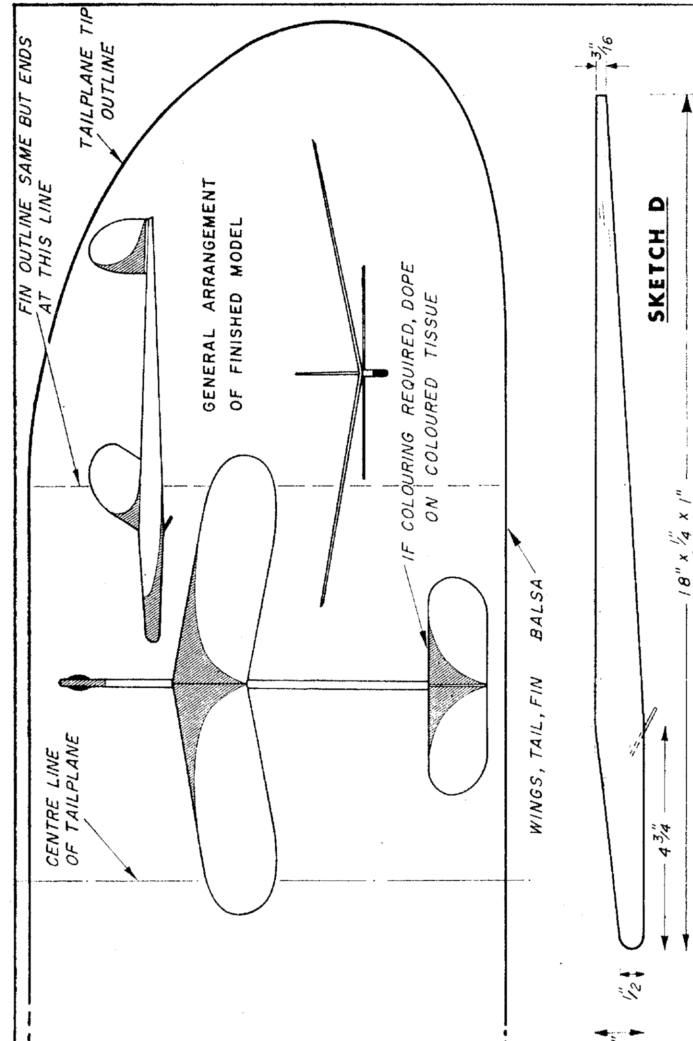
You will need a sheet of medium hard balsa $\frac{1}{8}$ x 3 x 36 in., and a strip of hard balsa $\frac{1}{4}$ x 1 x 36 in. Actually only 18 ins. is needed but half strips are not usually sold. Cut two 10 in. lengths off the $\frac{1}{8}$ in. sheet, and trace the full-size wing-tip shape shown, on the extreme ends. At the other ends mark $\frac{1}{2}$ in. along and cut the ends at an angle, as sketch A. Cut a rectangle $2\frac{1}{2}$ in. x 9 in. and trace on the tailplane tips (B). Cut another piece $2\frac{1}{2}$ in. square and use the tailplane tip to mark on the rudder

shape (C). Mark and cut the fuselage out as in D. Now take a sheet of medium glasspaper on a block of wood about 6 x 4 ins. and sand the pieces to the sections shown in E – make sure you sand a left and right wing. Keep the balsa panels flat on a clean piece of wood, and use patience. A few minutes extra sanding at this stage will mean much better flights.

When everything is sanded, mark the fuselage top $4\frac{3}{4}$ ins. from the nose and cut a shallow V groove for 3 ins., as in F. Sand the wing root ends to a slight angle as shown. Cement all the joints, fit together, and *take apart again*. Leave the cement to dry. Prop the fuselage upright between two blocks or books, and cement the wings in place; pins can be used to hold them temporarily. Make sure that the dihedral angle (the V of the wings) is equal at 2 ins. each side. The tailplane and rudder can also be cemented on; ensure that these are absolutely square, as in drawing G. When dry, squeeze more cement round the joints and allow to dry. Check the model all over, sand lightly with fine glasspaper, and, for maximum performance, apply three or four coats of sanding sealer or french polish. Do not use colour dope, though you can decorate it with coloured tissue doped on if you wish. Sand and polish to a high shine.

The nose must now be ballasted with lead, solder, or clay or Plasticene. If metal is used, bind it on with thread. Add enough to balance the model in the centre of the wing where it joins the body (H). Find some long grass and launch the model gently into it, trying to hold the model at which you think will be its gliding angle and launching the model smoothly along its probably glide path, into wind, at what is something near its flying speed. This is perhaps asking a lot, but a few launches will soon give you the idea. If the model appears to glide very steeply or even dive into the ground (and you are sure that it wasn't the way you launched it!) take off a little of the weight and try again. It is more likely, however, that the model will swoop upwards, hesitate, and drop its nose. This is called a stall, and in a bad case the model will either fall on its back or put its nose down so far that it will not try to recover in the height available from a hand-launch. In a mild case the model will make an undulating, swoopy sort of flight. The cure is to add more weight to the nose until a smooth, steady, floating glide is obtained.


WINGTIP OUTLINE
WING ROOT END
SKETCH F
3"
SHALLOW 'V' GROOVE
WINGS MAKE EQUAL DIHEDRAL ANGLE
EACH SIDE
SKETCH H
2½"
2½"
SKETCH C
FIN SQUARE TO BODY AND IN LINE
SKETCH G
WEIGHT
BALANCE
3"
½"
10"
SKETCH A
2½"
9"
SKETCH B
TAILPLANE HORIZONTAL & SQUARE TO FIN & BODY FROM AHEAD & ABOVE
WING
TAIL
2"


FIN OUTLINE SAME BUT ENDS AT THIS LINE
TAILPLANE TIP OUTLINE
GENERAL ARRANGEMENT OF FINISHED MODEL
IF COLOURING REQUIRED, DOPE ON COLOURED TISSUE
CENTRE LINE OF TAILPLANE
WINGS, TAIL, FIN BALSA
3/16"
SKETCH D
18" x ¼" x 1"
4¾"
½"
1"

Make sure the weight is securely fixed before trying a fast launch. To launch for maximum height, grip the model firmly beneath the trailing edge of the wing, hold it banked at an angle of 45 degrees to your body, and hurl it upwards at an angle of 45 degrees, still banked at 45 degrees. The flight will be longer and give more time to observe how the flying trim might be improved. If the model loops, launch with more bank, or warp one wingtip slightly by twisting it in the fingers and breathing on it. A more permanent way to put in a warp is to steam it or pin the warp in on the building board and apply another coat of finish.

Another way of flying this model is to force a piece of wire into the fuselage beneath the wing leading edge, as shown in the drawing. Take four or five yards of $\frac{1}{8}$ in. flat rubber and tie one end to a wood peg (Fig. 14). Tie the other to fifteen yards of

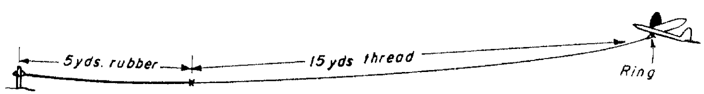


Fig. 14

thread, and tie a small curtain ring or wire loop to the free end of the thread. Push the peg into the ground, hook the model into the ring, check the wind direction, and walk downwind, stretching the rubber. Release the model directly into wind (free flight models must always be launched into wind). The model will climb away quite quickly and reach a height of 50 ft. or so before detaching itself from the line.

'Waif'

The A1 class glider is a popular junior class, capable of excellent flights. *Waif* is a simple model to the class specifications, and is a development of a design built by a number of people with great success; one flight of over 19 mins. and one of 13$\frac{1}{2}$ mins. are among many good flights recorded. Despite its simplicity, therefore, performance will be excellent provided you build carefully and trim the finished model properly.

Lay out on a sheet of 1/16 in. med. balsa the fuselage profile shown, working from the reference line marked. Cut the outline,

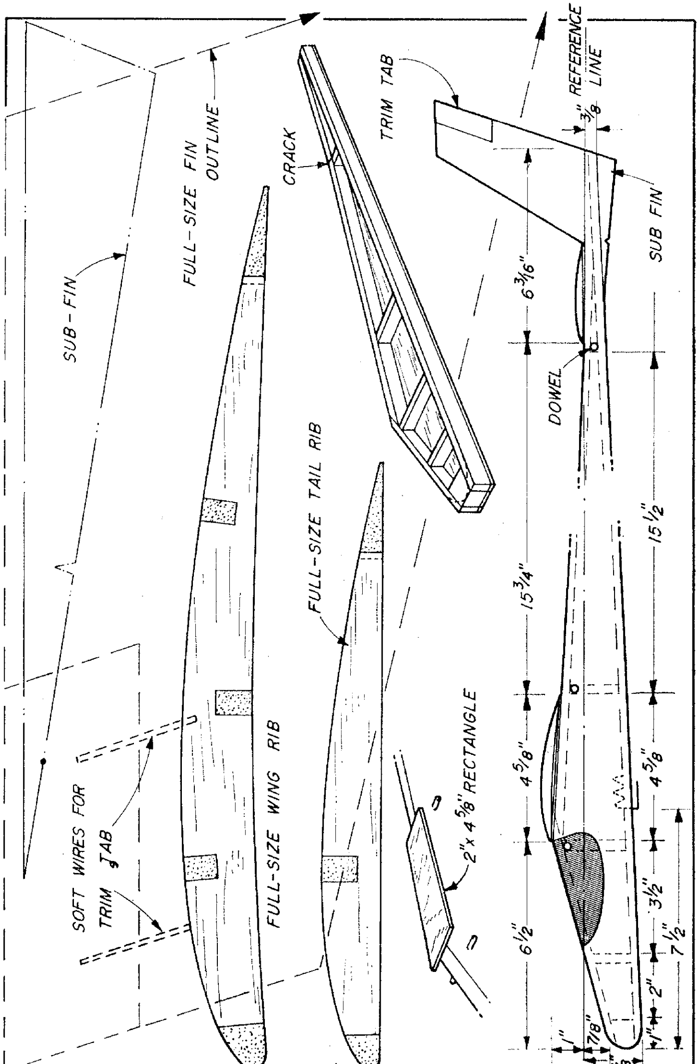
and use this to cut a second identical sheet. Mark off on one the positions of the uprights, making sure that you follow the dimensions shown and that you know which edge of the upright you have marked.

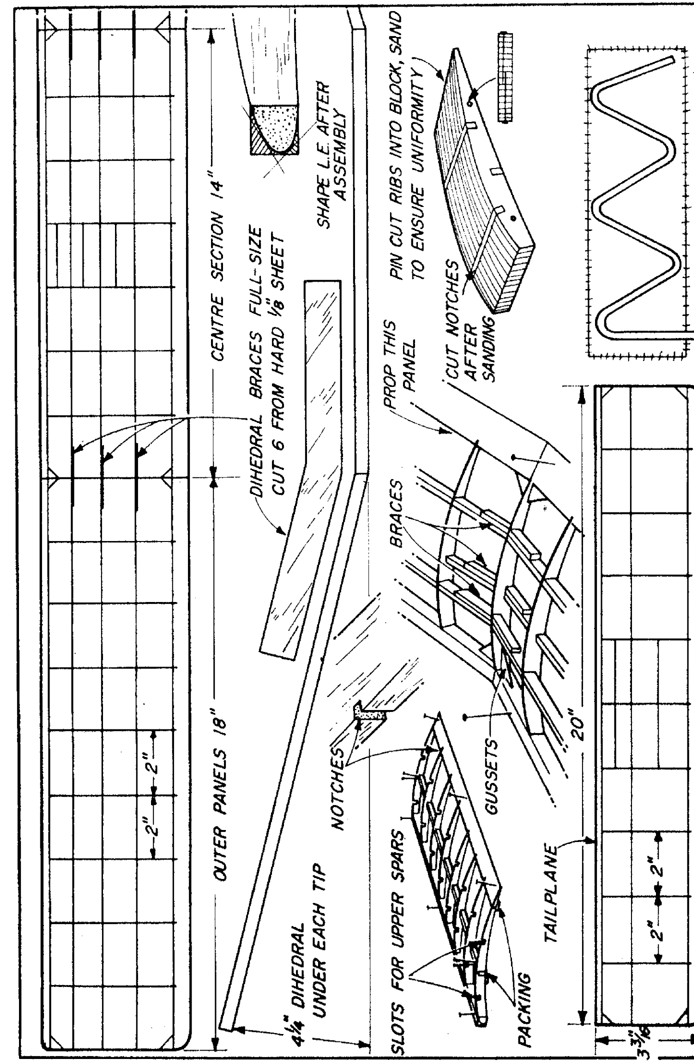
Now lay the marked-out profile flat and cement a length of $\frac{1}{4}$ x $\frac{1}{2}$ in. med. (edge-on) along the bottom edge, flush with the outside line. The top edge is fitted similarly, but it will be necessary to do this in two pieces, one at the nose and the other jointed to it beneath the wing leading edge position. Make the joint carefully. This second piece will have to be scored and cracked gently beneath the tailplane leading edge, and it will also have to be tapered to fit against the bottom piece over the last three inches or so.

Position the uprights and cut a block of $\frac{1}{2}$ in. sheet for the nose; alternatively, fit four pieces of $\frac{1}{4}$ x $\frac{1}{2}$ in. side by side to make a nose block. Allow to dry, then trim the nose to a curve and drill $\frac{1}{8}$ in. holes for the two wing and one tailplane dowels. Cement on the second side and allow to dry, then trim the nose of this piece to shape and run the drill through the dowel holes. Sand all over; apart from the wing and tailplane seatings the corners can be rounded off all round.

Cement in the dowels and the two platforms; the wing one is a rectangle 2 in x 4$\frac{5}{8}$ in. with the grain running *across*. It will have to be cut in two pieces, and cemented together, from hard 1/16 in. balsa. The tailplane platform is the same except that it is 1$\frac{1}{2}$ in. x 3$\frac{3}{16}$ in. Lay a ruler across them to check that they are parallel from ahead, and allow to dry thoroughly. Cut and cement the rudder and sub-fin from med. $\frac{3}{32}$ or $\frac{1}{8}$ in. sheet and cement firmly in place, making sure they are true from all angles.

Bend the towing hook from a piece of 18 s.w.g. piano wire and cement it to the fuselage side, then cover the cemented area with a scrap of silk, nylon, or bandage, rubbing cement through the pores of the material to make a strong joint. If the hook is on the port (left) side, the fact that it is fractionally off-centre will mean that the model will want to turn slightly to the right on towing; this is offset by a touch of left on the rudder trim tab, and the model will circle left on release from the line. Many sailplanes use auto-rudders, tensioned by a rubber and pulled straight by the tow-line, but this slight offsetting of the hook obviates the need for this complication.


SUB-FIN
FULL-SIZE FIN OUTLINE
CRACK
TRIM TAB
REFERENCE LINE
3/8"
SUB FIN
6 3/16"
DOWEL
15 3/4"
15 1/2"
4 5/8"
4 5/8"
6 1/2"
3 1/2"
2"
1"
7 1/2"
1"
7/8"
1 1/8"
1 1/8"
SOFT WIRES FOR TRIM TAB
FULL-SIZE WING RIB
FULL-SIZE TAIL RIB
2" x 4 5/8" RECTANGLE


CENTRE SECTION 14"
DIHEDRAL BRACES FULL-SIZE CUT 6 FROM HARD 1/8" SHEET
SHAPE L.E. AFTER ASSEMBLY
PIN CUT RIBS INTO BLOCK, SAND TO ENSURE UNIFORMITY
CUT NOTCHES AFTER SANDING
TOW HOOK FULL-SIZE
PROP THIS PANEL
BRACES
OUTER PANELS 18"
2"
2"
2"
NOTCHES
GUSSETS
20"
TAILPLANE
2"
2"
4 1/4" DIHEDRAL UNDER EACH TIP
SLOTS FOR UPPER SPARS
PACKING
3 3/8"

The fuselage etc. may now be tissue covered, doping the tissue on, and finished completely. You may like to paint a dummy cabin on as shown, either in blue or black, depending on the colour scheme you choose for the rest of the model. Cut out the rudder trim tab and make holes with a pin to receive short pieces of aluminium or soft iron wire; force these in with a little cement but see that the tab is not cemented to the rudder. The wires allow the tab to be bent to adjust trim.

Both wing and tail need a simple drawing laid out on a smooth piece of paper – merely a few guide lines. For the tail, which is the simpler, draw a rectangle 20 ins. x $3\frac{3}{16}$ ins. and divide it with lines drawn every 2 ins. These lines show the rib positions, and assembly procedure is as follows.

First cut 11 ribs by tracing the shape given on to $\frac{1}{16}$ in. balsa and cutting out one rib. Sand this to the right shape, then use it as a template to cut the others. Note that the front of the rib finishes square, to butt against the leading edge piece, and that the rear of each rib must be about $\frac{1}{16}$ in. longer than you might expect since this thin end will be notched into the trailing edge spar. Do not cut the mainspar (centre) notch. Now shuffle the ribs and tap them lightly on a smooth surface until they are neatly stacked, then slide two pins through to pin them all together. Use fine glasspaper on a block to sand them lightly to identical shape and length, ensuring that in doing so you maintain the required shape and especially the height of the front and rear ends. Carefully mark the spar notch and file or cut it out accurately; this ensures that the spar will fit easily in place with no waves. Try a piece of spar for fit before unpinning the ribs.

Now pin the drawing to a smooth, truly flat piece of timber (usually the building board) and mark off the 2 in. spaces on the fat edge of a piece of $\frac{1}{8}$ x $\frac{1}{2}$ in. shaped trailing edge. Use a $\frac{1}{16}$ in. thick file to file a small notch at each mark, or use a razor or modelling knife to nick out a slot at each mark, $\frac{1}{16}$ in. wide and $\frac{1}{16}$ in. deep, as in the sketch. Pin the notched t.e. over the drawing, with the notches corresponding and the outside edge in line. Fit a rib temporarily at each end and pin the $\frac{3}{16}$ in. square leading edge in place. Remove the temporary ribs and cement all ribs to t.e. and l.e., followed by the spar cemented into its notches. Make sure that the ribs line up with the pencil

lines and that they are touching all along their bottom edges, i.e. no rib is out of line when you sight along them.

Allow to dry thoroughly, then unpin and trim any excess spar length etc. off. Add gussets – little triangles cut from $\frac{1}{16}$ in. sheet – before slightly rounding off the tips. In the centre, mark and cut notches for a piece of scrap $\frac{1}{8}$ in. sq. to fit across the three centre ribs on the underside, just ahead of the spar, and another piece on the top surface, just about half way between spar and t.e. These help protect the tissue covering when the tailplane is mounted.

Check each cement joint carefully, and go over the whole framework re-cementing all joints with a light touch. When dry, sand the whole frame all over, smoothing any cement blobs or unevenness down to leave an uninterrupted surface ready for covering.

The wing is basically similar but has the complications of dihedral angle, more spars, and, in this instance at least, a slight undercamber or concavity of the under-surface. However, it is built one panel at a time, each one tackled in much the same way as the tailplane, so that no difficulty should be experienced.

First draw out the wing in much the same way as the tail, except that the centre-section is one rectangle $4\frac{5}{8}$ x 14 ins. and the outer panels are each 18 ins. long. If convenient, draw the whole wing out, as a rectangle $4\frac{5}{8}$ x 50 ins. Rib spacing is 2 ins. as before. Cut twenty-six ribs. Build the centre-section first; notch the trailing edge and position the leading edge as before, and also position the lower spar. Because of the undercamber, this spar will not be flat on the building board, so it must be packed up to the right height with scraps of wood slipped underneath. The t.e. front edge also needs a small amount of packing to match the ribs when it is pinned down. Cement the ribs in place on l.e., t.e., and lower spar, then add the top spars. Across the two centre ribs add three 2 in. pieces of $\frac{1}{8}$ in. sq. as drawn, on the top surface only, to support the tissue when the rubber bands are stretched over to hold the wing in place.

When dry, remove from plan and cut notches in the end ribs against the spars so that the dihedral braces can be cemented in. Now pin the centre-section down over the plan, propping up one end $3\frac{3}{8}$ in., and build one outer panel on to it, cementing the spars to the dihedral braces projecting from the centre-section.

When this is thoroughly dry, prop the centre-section the other way, supporting the first outer panel with a box or pile of books, and build on the other outer panel. If the centre-section is propped to the right height and the dihedral braces are lined up carefully with the spars, when the wing is laid flat on the board, the tips will be the required 4¼ ins. height for correct dihedral.

Re-cement all joints, especially at the dihedral breaks, add all gussets, and allow to dry before carving and sanding the leading edge to shape. Sand all over and you are ready to cover as discussed in a later chapter.

With the whole model covered and doped, drill a hole in the fuselage top into the first bay, i.e. behind the block in the nose, and make a plug for this hole. Assemble the model; hold the tailplane in place and hook a rubber band over one dowel, stretch it over the tail, down under the fuselage (across the notch in the sub-fin), up over the tailplane the other side and on to the dowel. Repeat with another band. The bands should be tight enough to hold the tail firmly in place but not so tight as to prevent it being knocked out of place by a collision. The wing bands run from one front dowel to the opposite rear one, i.e. they make an X over the wing. Again, tight enough to be firm but not so tight that the wing cannot move if the model hits a fence or tree etc.

Now balance the model with the fingers under the main (lower) spar by adding lead shot or similar small weights in the nose box, until the model balances slightly nose-down. Plug the hole in the nose. Choose a day with no wind if possible, and pick a piece of ground with tall grass or weeds. Hold the model slightly above head height, slightly nose-down, and push it smoothly towards a point on the ground forty feet or so in front of you. Make the launch a smooth action and keep the nose pointing slightly down; the speed of launch should be as near flying speed as possible, and this will be running speed in still air, so that you could run and release the model when you feel it want to fly if you prefer.

Watch the flight critically. Is it tending to swoop up and dip suddenly? Add more weight. Does it seem to dive gently to the ground? Shake a little weight out. When satisfied that a reasonable glide is achieved, squirt a little cement in the nose box and replace the plug.

Your towline should be very strong carpet thread or thin fishing line. Tie a small curtain ring or wire loop to the end, and about 15 ins. from this tie a tissue or silk flag about 4 ins. square (Fig. 15). Have an assistant hold the model slightly above

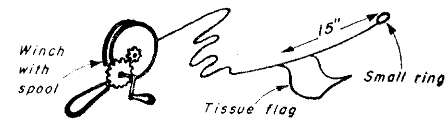


Fig. 15

head height, nose very slightly up, hook the tow-ring in place and walk away into wind thirty or so feet. Call or signal, then walk or trot upwind; your assistant should walk or trot with you until the model lifts out of his hand. Let the model climb gently on the line, and when it reaches 'the top' allow it to settle and fly itself away from the towline; the flag on the line will allow this to happen, but a gentle throwing action will help. Watch the tow (a short line is easier to control, especially if you take it gently) and the subsequent flight and make trim adjustments as necessary.

For longer flights use more line, but also use a D.T. by inserting a pin in the tailplane t.e. and hooking one band under this. Melt the other with a fuse in the sub-fin notch and the tail t.e. will spring up. Limit the angle to which it can spring to 30–35 degrees by tying a thread round the t.e. pin and round another pushed into the fuselage side.

Four

Rubber Models

RUBBER MODELS, as we have already stated, are perhaps the most difficult to fly well. The reason is bound up with the characteristics of the rubber motor, which, although it is a very efficient means of storing energy, tends to release a large part of the stored energy in a burst of power before settling to a more gradual release of the remainder. This first burst of power produces the difficulties of trim etc. which make rubber models harder to fly. Nevertheless, many people are fascinated by 'rubber jobs', whose almost silent climb upward is owed to what is still the cheapest form of power available.

Most of the rubber models built are small kits, often of scale or semi-scale type. They will certainly fly – they can fly well in expert hands – but they are not ideal for a beginner. Far better to spend a few coppers more on a bigger, simpler, and possibly, to the layman, uglier model. No raw beginner should tackle any built-up model of less than 24 ins. span, in our opinion, and 30 ins. is an even better proposition. Scale models are not good subjects for rubber power, since to use rubber efficiently calls for a relatively big propeller, which means a longer undercarriage; because the greatest weight, the rubber, is spread along the fuselage, stability problems are aggravated. Add the points on scaling down made earlier, and it will be obvious that if a model looks quite like its full-size prototype it is not likely to fly well, and if it stands a chance of flying it will not look much like the prototype! A better beginner's project is the 'stick' model, and a small one capable of good flights is detailed at the end of this chapter.

The secret of high performance rubber flying is in the propeller, and the people who can carve a really good propeller are now very few. Most competition models nowadays use folding propellers, with some free-wheeling feathering props seen now and then. The reason is that a large prop is needed to absorb the torque (twisting power) of the rubber motor, especially in the initial burst, but when the rubber has run out the big propeller is just a nuisance, causing tremendous drag, especially since it is usually at least a third of the wingspan of the model. Any rubber model, whatever its size, should have a least a free-wheeling propeller, and the simplest form of free-wheel is shown in the sketch (Fig. 16). The little wire pawl through the propeller should be bushed in a stub of aluminium tube to prevent it wearing a sloppy hole in the wood – it takes quite a lot of power for a thin piece of wire.

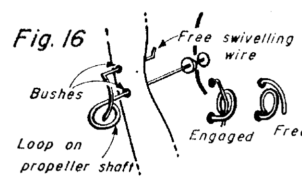


Fig. 16

The loop in which it engages also has another use. A rubber motor will deliver power faster if it is wound fast; rubber fatigues very rapidly, and though it will recover if rested, slow winding or holding the motor wound for a short time will tire the rubber, with a surprising loss of power. Winding is therefore done quickly with a hand-drill, a hook in the drill-chuck being engaged with the loop in the propeller shaft. Most turns can be packed safely into a rubber motor if it is stretched while winding, so winding procedure is: hook drill into loop with an assistant holding the model, commence winding, at the same time walking backwards until the rubber is stretched to about four times its normal length. Walk slowly back towards the model, timing it so that the noseblock is ready to slip into place as full turns are reached. Engage free-wheel pawl, remove winding hook while holding propeller, and launch model as soon as practical.

To increase the length of power run without unduly increasing actual power, it is usual to have the rubber skein about half as long again as the distance between the hooks. This might mean that the rubber would 'bunch' as it unwinds and spoil the trim of the model, so it is pre-tensioned to hang between the hooks without slack. The simplest method of doing this is, when making the motor up, to divide it into halves, put on a few turns, and bring the halves together. For example, we want an eight-strand motor to fit a model with 18 ins. between hooks. The motor length will actually be 27 ins. untensioned, so we need 8 x 27 ins., or 6 yds. of rubber. This is tied into one loop with a reef knot, and the free ends bound with cotton as in the sketch (Fig. 17). One loop equals two strands, so we double it on itself once, which makes four strands. Doubling again gives eight strands, 27 ins. long. Going back to the one loop, after knotting we lubricate the motor with rubber lubricant, then double it to make four equal strands. Hook one end over a clean nail (no dust etc. must be allowed near it) and put on 50 or so turns. Find the exact centre and double into eight strands; as the pre-wound rubber touches it will wind itself into one rope. Check length – 18 ins. is the aim – and rewind if necessary. Bind the ends of the skein with rubber bands (Fig. 18).

Fig. 17

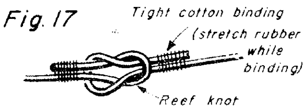
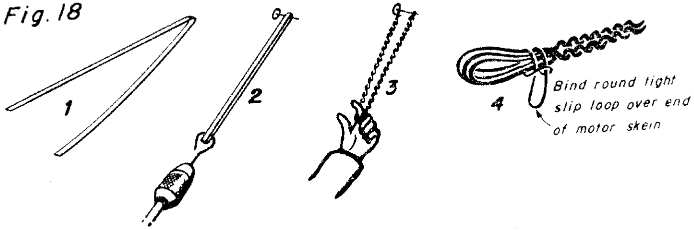


Fig. 18



For convenience and smoother operation – also to prevent bunching – motors are often made up on bobbins. (These and lubricant are sold by good model shops.) The bobbin is inserted into the skein and the rubber binding slid up tight (see sketch, Fig. 19). Dowel, aluminium tube, or a piece cut from an

aluminium knitting needle form the best rear 'hooks', and it is easy to drop the motor down the fuselage and slip a dowel through the bobbin. The dowel etc. should be a tight slide fit in holes drilled either in thin ply or sheet balsa reinforced with acetate sheet, as in the sketch, Fig. 20.

Fig. 19

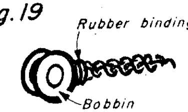


Fig. 20

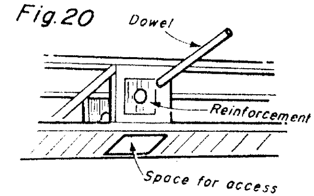
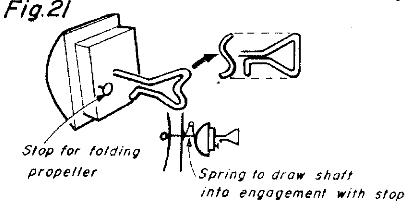


Fig. 21



At the noseblock end it is essential that the propeller shaft is straight. The inner end must be shaped to accept a bobbin or formed into an S-hook and covered with neoprene tubing to prevent the wire from cutting into the rubber. The S-hook saves the weight of a bobbin but prevents the motor from 'climbing' round the hook and causing a bunch (Fig. 21).

In the case of a folding propeller it is necessary to stop the prop in one particular position, and this is done by introducing a small spring between the prop. and the bush through the nose-block so that as the rubber unwinds the spring pushes the prop. forward together with the shaft. A projection on the shaft behind the block, either the end of the hook or a specially soldered sprig, touches against a stop fitted to the noseblock. Thus, as the rubber motor runs out, the spring moving the shaft forward brings the sprig into contact with the stop (Fig. 21).

Trimming a rubber model for flight calls for a knowledge of torque reaction When the motor turns the propeller, the propeller fans air. The air, however, tends to brake the propeller and this force is transmitted back to the model and tends to bank it. It is easy to understand if you think of winding the motor, then holding the propeller and letting the model go. The model would rotate, of course. The braking effect of the air is not so drastic as your holding the propeller still, but it is a degree of the same effect.

This torque reaction banks the model, and when it banks it turns. With the standard right-hand propeller (imagine launching the model; as it flies away from you the prop. is turning clockwise) the model will bank and turn to the left, sharply with the initial burst of power, less as the power settles down. The initial burst is also likely to make the model climb very sharply, or even to pull it up into a loop.

Trimming procedure is, then, as follows. Assemble the model, complete with pre-tensioned motor, and check that all surfaces are square and free of warps. Test for glide. Most functional rubber models have a wing which can be slid forward or back a small amount; in this case, to cure a dive the wing can be moved forward a little, or to cure a stall, back a little. Alternatively, the angle of incidence (the angle at which the wing or tailplane sits relative to the centre line of the fuselage) may be adjustable by a small amount; packing up the leading edge of the wing or the trailing edge of the tailplane will reduce diving tendencies, packing up the wing trailing edge or the tailplane leading edge will help cure a stall. It is better to use leading edge packing than trailing edge packing, i.e. dive, pack wing l.e., stall, pack tailplane l.e. Even $\frac{1}{16}$ in. packing makes a big difference. If the model is scale-type with fixed wing and tail, it will be necessary to weight nose or tail with Plasticine etc.

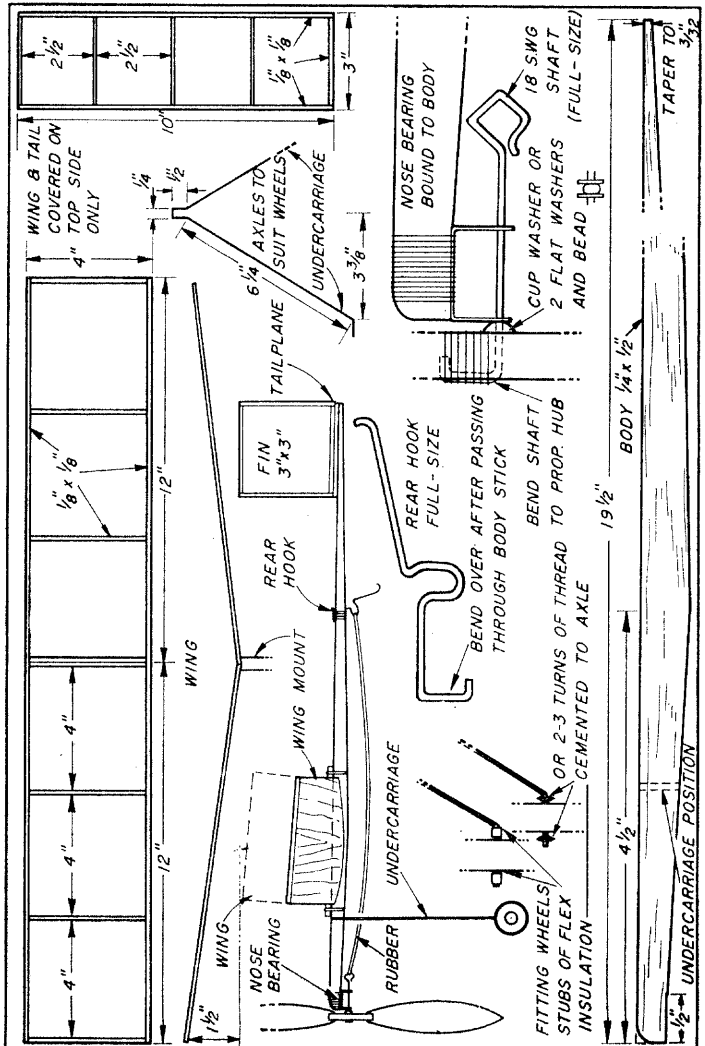
Having achieved a reasonable glide, put on a few turns – not more than a quarter full turns, as for one thing the motor needs to be 'broken in' gradually and for another trimming must proceed gradually or you could wreck the model. Launch and watch what happens. Probably the model will turn off to the left, so apply a little right rudder and try again. Watch to see that the glide is satisfactory. Add a few more turns and try again; if the model glides well but tends to stall under power, add a very thin piece of packing behind the top of the noseblock. Add more turns; there will come a point where the right rudder gives a right-hand glide circle as tight as can be accepted, and if the model still turns too tight to the left under power, add 'right sidethrust' by putting a thin packing strip behind the left-hand bottom corner of the noseblock. All that should then be needed is an increase in 'downthrust' – the packing behind the top of the noseblock – to handle full power with safety. When this stage is reached, cement all packing permanently in place and, if the wing is adjustable fore and aft, carefully mark its position. You will have learned a great deal, and have a model which is thoroughly trimmed and ready to fly at any time.

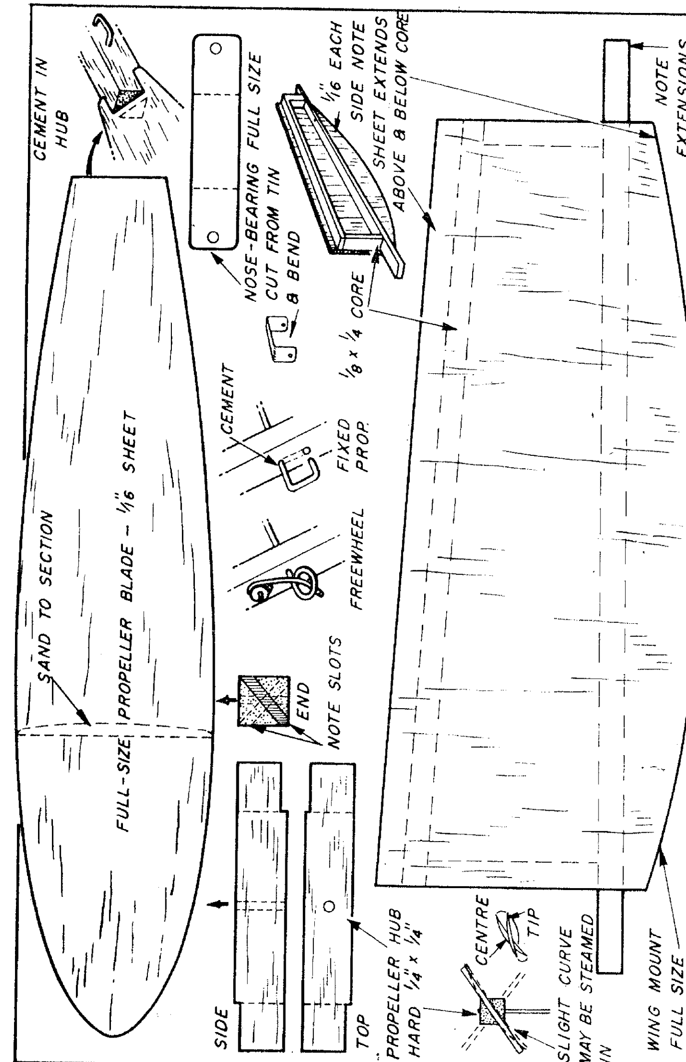
'Tiny Tot'

Not quite so sophisticated as a competition model, and not requiring quite so much trimming technique as described above, this little model will nevertheless provide a lot of fun and satisfaction. If you have a little experience and would like to fly it indoors (in a large hall) or only under flat-calm conditions outdoors, it is possible to halve the dimensions of the woods specified – i.e. $\frac{1}{16}$ x $\frac{1}{16}$ instead of $\frac{1}{8}$ x $\frac{1}{8}$ – to produce a very much lighter but, of course, more fragile model. In the form shown it is tough and capable of a long and happy life.

You will need four 36 in. lengths of $\frac{1}{8}$ in. sq. medium balsa, one $\frac{1}{4}$ x $\frac{1}{2}$ in. medium, one $\frac{1}{4}$ x $\frac{1}{8}$ in. and a scrap of $\frac{1}{16}$ in. sheet, plus a length of 18 s.w.g. piano wire, a small piece of tin, and other odd items. First draw a rectangle 4 x 24 ins. and divide it off into 4 in. squares, a second rectangle 3 x 10 in. divided into four $2\frac{1}{2}$ in. spaces, and a 3 in. square. On the first rectangle pin a 24 in. length of $\frac{1}{8}$ in. sq. on each edge, then cement $3\frac{3}{4}$ in. lengths over each division line. At the centre two lengths are needed, but only one should be cemented at this time. When dry, crack the leading and trailing edges in the centre, cement in the last $\frac{1}{8}$ in. piece, and prop the wing with one piece flat on the board and the other 3 ins. up at the tip, or with each tip raised $1\frac{1}{2}$ ins., which amounts to the same thing.

The tailplane and fin are built in the same way but do not require to be cracked. When dry, lightly sand all these pieces, rounding the outside edges slightly. Cover with hard tissue on one surface only – the top for wing and tail and the right-hand (starboard) side of the fin.


WING & TAIL COVERED ON TOP SIDE ONLY
2½"
2½"
1/8" x 1/8"
3"
10"
4"
12"
WING
12"
4"
1½"
WING MOUNT
REAR HOOK
TAILPLANE
FIN 3"x3"
AXLES TO SUIT WHEELS
UNDERCARRIAGE
6¼"
3⅜"
NOSE BEARING BOUND TO BODY
18 S.W.G SHAFT (FULL-SIZE)
CUP WASHER OR 2 FLAT WASHERS AND BEAD
BEND SHAFT TO PROP. HUB
REAR HOOK FULL-SIZE
BEND OVER AFTER PASSING THROUGH BODY STICK
OR 2-3 TURNS OF THREAD CEMENTED TO AXLE
FITTING WHEELS STUBS OF FLEX INSULATION
UNDERCARRIAGE
RUBBER
NOSE BEARING
WING
TAPER TO 3/32
BODY ¼" x ½"
19½"
4½"
½"
UNDERCARRIAGE POSITION


CEMENT IN HUB
NOSE-BEARING FULL SIZE CUT FROM TIN & BEND
1/16 EACH SIDE NOTE SHEET EXTENDS ABOVE & BELOW CORE
NOTE EXTENSIONS
1/8 x 1/4 CORE
CEMENT
FIXED PROP.
FREEWHEEL
SAND TO SECTION
FULL-SIZE PROPELLER BLADE - 1/16 SHEET
END
NOTE SLOTS
SIDE
TOP
PROPELLER HUB HARD ¼" x ¼"
CENTRE
TIP
SLIGHT CURVE MAY BE STEAMED IN
WING MOUNT FULL SIZE

A piece of medium $\frac{1}{4}$ x $\frac{1}{2}$ in. light but firm balsa 19$\frac{1}{2}$ ins. long is used for the 'stick' body. Mark off from the full-size drawing given and cut to shape. Lightly sand and round edges except at tailplane seating, nose-bearing, and approximate wing position. Cut and bend the nose bearing and cement and bind in place. Bend the under-carriage to the dimensions shown and cement and bind in place. Fit a pair of lightweight 1 in. plastic wheels, holding them on by a turn or two of thread cemented to the axle (roughen axle with a file to give a grip) or a stub of wire insulation tubing forced on. Bend the rear hook and fit it 6$\frac{1}{2}$ ins. from the extreme tail.

Make the wing mount core from $\frac{1}{8}$ x $\frac{1}{4}$ in. and when dry cover each side with $\frac{1}{16}$ in. sheet, grain vertical, noting that the sheet projects above and below the core. Cement the mount to the wing, cementing the centre 'ribs' in the groove formed by the projecting sheet, which braces the wing sufficiently. The lower sheet projections fit over the body stick, and rubber bands wrapped round the body and the mount core extensions hold the wing in place but permit adjustments fore and aft and in incidence angle.

The propeller is simple to make, following the sketches. Steaming the blades to a curve improves efficiency, and if desired this can be carried further by steaming a twist in each blade, reducing the angle towards the tip as in the small sketch. Bend the propeller shaft hook, slip through nose bearing and slip on cup washer or flat washers and bead, fit on propeller, and finish either by bending back into propeller hub or in a simple free-wheel as drawn.

Before assembly, lightly steam the tissue on the flying surfaces, dry while weighted flat, then apply a thin coat of banana oil or clear cellulose lacquer (*not* clear dope, which would shrink the tissue too much). Cement fin to tailplane centre and tailplane to body stick. Slip wing in place. Check that all surfaces sit true (as in the chuck glider in the previous chapter) and check that the propeller shaft is parallel to the body and turns truly. Make up a loop of $\frac{1}{8}$ in. flat rubber 24 ins. long (i.e. 48 ins. of rubber) and double this to make a four-strand motor (two loops) only a fraction longer than the distance between the hooks. Bind each end with a rubber band and lubricate. Cover hooks with rubber tubing to prevent them

cutting the motor. Glide and trim model as previously described. To wind with a hand-drill slip rubber off rear hook and engage with hook on winder, replace quickly on rear hook after winding.

Five

Power Models

POWER MODELS of the sport type are much easier to fly than rubber models, since the power developed by the engine is constant throughout its run and the propeller is much smaller in comparison, so that torque reaction is less and also constant. There is also no real limit to the power – you can have as long a motor run, within reason, as you wish. Weight is not so critical; if the model comes out an ounce or two heavy its climb will be correspondingly slower, but by running the motor a little longer the same height is attainable. The biggest trouble with sport power models is usually wind; ignoring, for the moment, thermal currents etc., a glider or a rubber model has a limited flight time, possibly between $1\frac{1}{2}$ and 3 minutes or so, but a power model can have an engine run of more than this time, so that far longer flights are possible. Obviously, in a breeze, a model with limited time in the air can only be carried so far downwind and in three minutes is still likely to be in sight, but a sport model with a full tank can be in the next county. One of the author's designs once made a 180 mile flight, and it was only by chance that its point of landing was learned, especially since it had crossed eighty miles of sea!

With the length of motor run borne in mind, there should be little difficulty in trimming the average sport model for flight, employing the basic principles already outlined for rubber models. The glide is first checked, using the same techniques to cure tendencies to dive or stall. By running the engine very rich, it is possible to keep the power low for initial powered flights; torque effects are the same, i.e. a tendency for the model to turn

left under power, cured with right rudder so that a typical flight pattern is a climb in left-hand circles followed by a glide in right-hand circles. Sharp turns in either direction are undesirable, and side thrust can be used in just the same way as a rubber model, except that it means drilling the holes in the engine bearers a little oversize and twisting the engine a little before tightening the bolts. In the case of a radial mounted motor it is simply a question of using washers under the bolts on one side. The amount of adjustment can be checked by setting the propeller horizontal and pinning a thread on the tail of the fuselage or on the rudder, centrally, and measuring with the thread to the propeller tips (Fig. 22).

FIG. 22

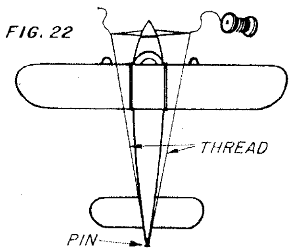
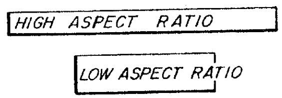


FIG. 23



Downthrust, to prevent stalling under power, can be introduced by tilting the motor forwards with packing washers. The rule is that once the glide is satisfactory, all other adjustments should be with the thrust line; only one adjustment should be made at any one time, so that its effect is clear.

Constructionally, power models are much the same as those already discussed, though usually stronger, and, of course, the nose is built to accommodate the motor. The increased strength inevitably means increased weight, which means a stronger undercarriage etc., which in turn means more weight. A successful design employs a structure which is a good compromise between strength and weight.

Aerodynamically, there are differences. A glider needs only to be towed up straight and it then simply glides. There are no upsetting forces such as torque and it is unnecessary to design for power on/power off conditions. When it is being towed up any amount of force can be applied (provided the structure is strong) so that design can concentrate on maximum efficiency at one speed only. Weight is fairly evenly distributed, the only concentration being the ballast in the nose. The greater the span in relation to the chord (width) of the wing (called the aspect ratio, Fig. 23) the more efficient the wing, at least at gliding speed, so that gliders tend to have long, thin wings and are generally more efficient than other types of model.

Rubber models, as we have seen, must be designed to cope with a fierce initial burst of power which then tapers gradually away, so that transition from powered flight to glide is gentle. To cope with the first power a larger dihedral angle (the 'V' of the wings) is needed, and this in turn calls for larger fin (rudder) area for stability. Because the model flies faster under power, with a large propeller thrashing round, and because cutting weight is important with only limited power available, the wings are usually of lower aspect ratio than a glider, since to make long thin wings stiff enough would mean extra weight. Thus a rubber model's wings are a compromise between aerodynamic efficiency and structural strength/weight ratio.

With a power model, especially a sport model, strength and durability are more important than absolute efficiency, and the stubbier a wing the easier it is to make it strong with reasonable weight. Transition from power flight to glide is sudden, so that we must design for two different flight conditions with a sharp division between. In fact, careful trimming with the use of sidethrust etc. to balance the rate of turn under power with the rate on the glide can reduce the transition point to a minor one. However, the model must be stable enough to be able to recover from any unusual position in which it may find itself; unfortunately, if it is too stable, it can easily 'recover' by winding itself into a spiral dive, where the more stable it is the more it locks itself into the dive. These are problems faced by the designer and are merely mentioned in passing, as they are beyond the scope of this book.

Competition power models are, of course, far more concerned with efficiency and higher aspect-ratio wings etc. are therefore employed. They may also have retracting undercarriages, folding or feathering propellers, and similar refinements, but the basic trimming is exactly the same, as are the problems. The difference is that because of higher speed and the

necessity of absolutely top-line trim, all adjustments are made to much finer limits and additional complications are acceptable if they increase overall efficiency. Rather like the difference between tuning a family saloon and a Grand Prix car. To take the simile a little further, many family saloons repay care in tuning by turning in a much higher performance than the average, and the same can be said of sport model aeroplanes.

'Gamin'

This 39½ in. sport model, for under 1 c.c. engines, is straightforward to build and fly. Much of the model is similar in principle to the *Waif* sailplane already described; the body is a little more complex, the wing if anything simpler, and the tail surfaces much the same.

First lay out the fuselage sides as drawn; each can be cut from one 4 in. wide sheet if available, but otherwise cut each in two pieces as shown and cement and butt join along the meeting edges. Trace or measure the bulkheads; the material thickness is specified for each and it is of course balsa unless ply is stated. Measure your engine carefully and space the bearers to suit – any .5 to .8 cc. diesel or glow motor can be used, and a later note describes fitting a radial mounted motor.

Mark the bulkhead positions on the inside of each fuselage side and bend the undercarriage to shape. Use a heavy pair of pliers or a bench vice and ease the wire into the bends with firm steady pressure; do not try to make sharp bends, but radius them as in the drawing on the full-size bulkhead B2. Cut the wire by filing a nick all round and breaking with pliers. Drill or pierce the holes shown in B2 and nick the edges where shown. Lay the undercarriage in position and bind it in place by using very strong thread in a stout needle. Use at least two strands of thread between each pair of holes, and coat the completed binding with cement.

Now lay one fuselage side on the edge of the board as sketched and cement in bulkheads B2, 3, and 4, skewing pins through to hold them firm and square while the cement dries. The undercarriage will hang over the edge of the board which should of course be at the edge of the work-bench. When dry carefully cement the other side to these three bulkheads making sure it is in alignment. Allow to dry, then draw the tail ends together and cement in B7. Add B5 and B6; allow these to dry before cementing the extreme tail ends together, using a clothes peg to hold the latter while drying.

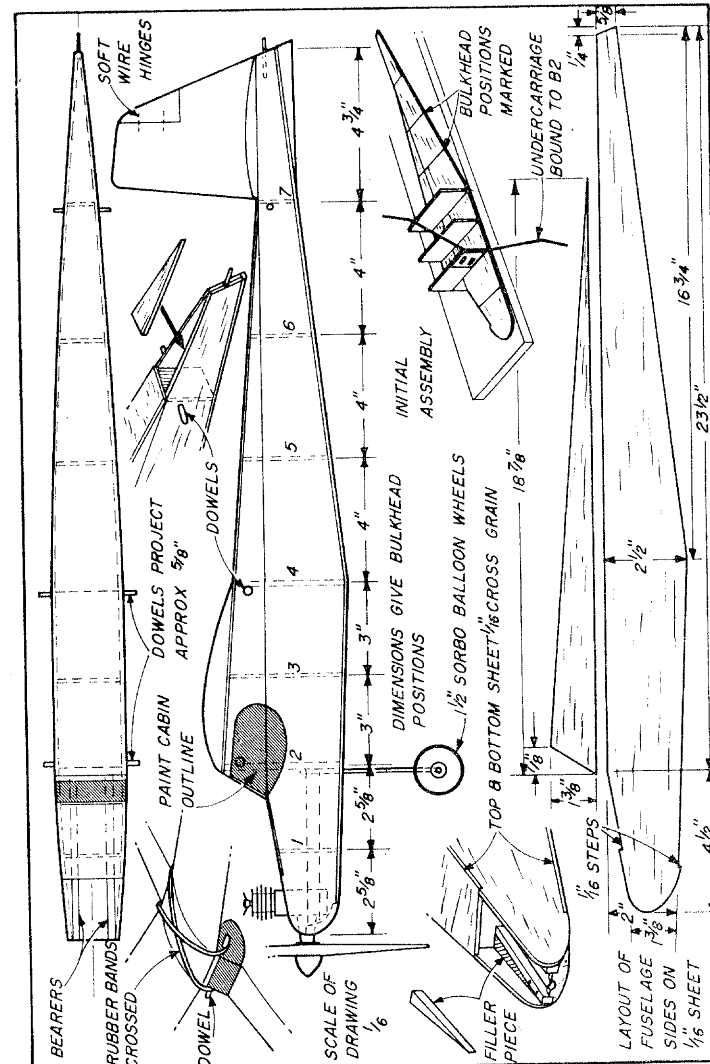
Cut two $5\frac{3}{8}$ in. lengths of $\frac{1}{4}$ x $\frac{3}{8}$ in. engine bearer (usually beech), mark the position of B1 and slide it on and cement. Cement the bearer ends into B2 and the fuselage sides to B1, holding with a rubber band till dry. Cement the nose ends of the sides to the bearers at the front, and fill with a triangular filler piece each side as sketched. The filler pieces should be $\frac{1}{4}$ in. thick, but two pieces of $\frac{1}{8}$ in. will do.

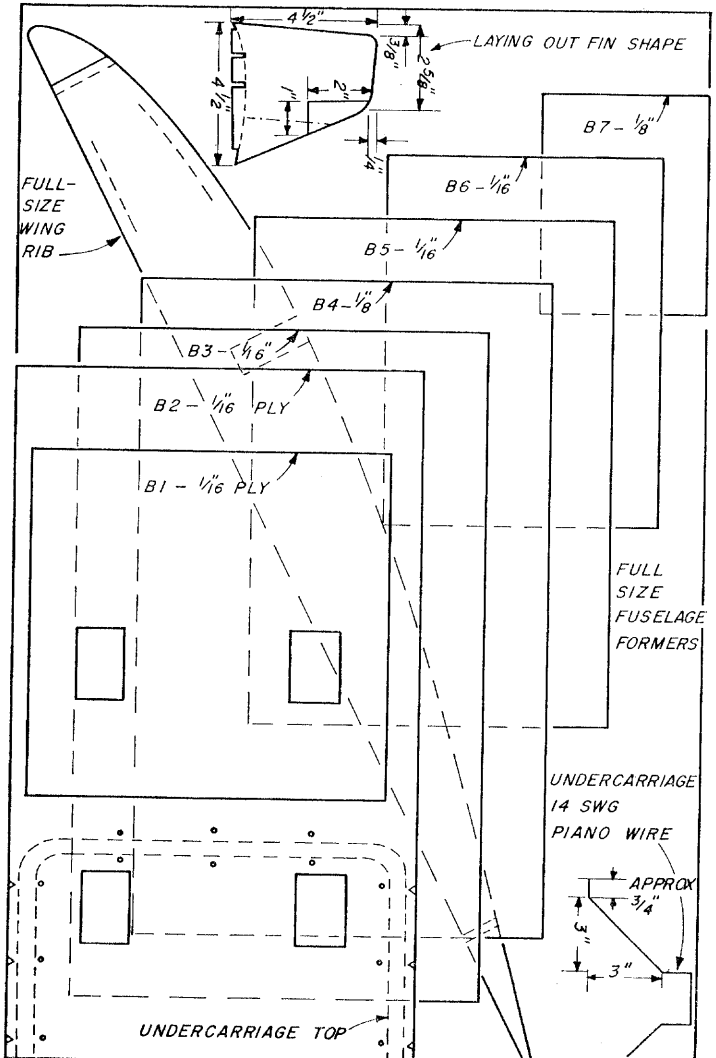
Drill and cement in all dowels; $\frac{3}{16}$ in. dia. for the wing and $\frac{1}{8}$ in. for the tailplane for preference – and run a good cement fillet round B1 and B2 and the engine bearers etc. The fuselage top and bottom can now be sheeted with short pieces cut off a 3 in. wide sheet of $\frac{1}{16}$ in. balsa, the grain running across the fuselage; this makes a much more rigid 'box'. Remember to cement the joins between the pieces of sheet.

Mark the position of the engine lug holes by placing the engine on the bearers and spotting through with a pencil. Drill for the engine bolts. The best method of fitting the bolts is to solder a piece of wire across their heads when they are in place, and to staple the wire to the bearer by driving in a pin and bending it over; the bolts then cannot turn or drop out. Correct size washers under the bolt heads will prevent them from being crushed into the bearer when the engine is mounted.

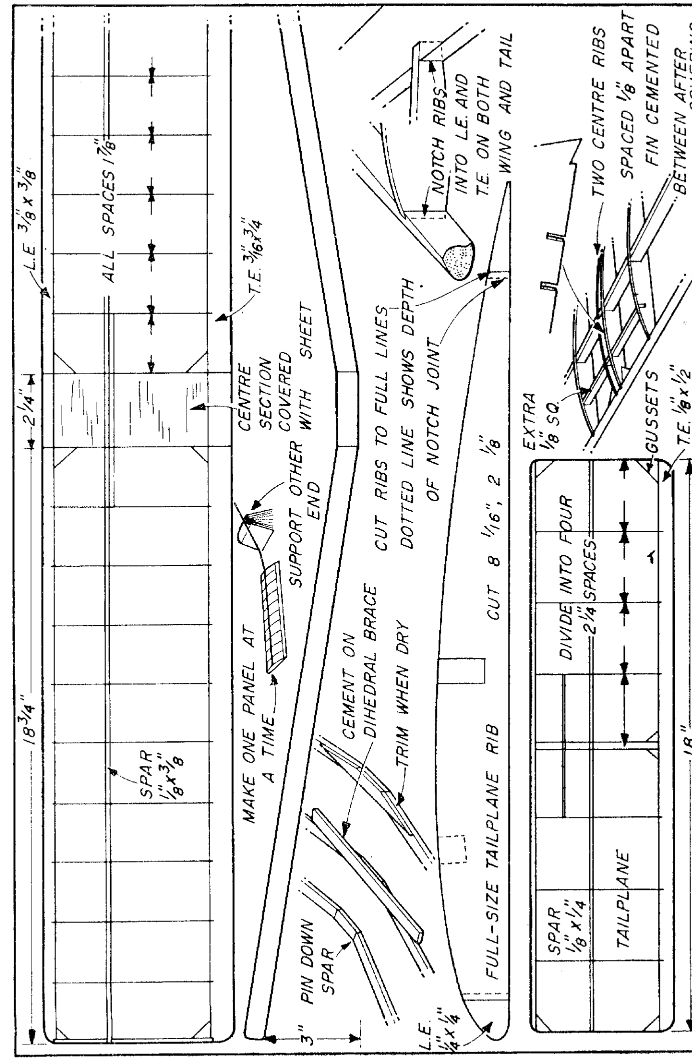
Fill the underside of the nose with a piece of soft block balsa or pieces of thick sheet cut and fitted; sand to shape when dry. Sand all the fuselage carefully ready for tissue covering, and after covering (see later chapter) thoroughly fuel-proof inside the nose and bolt the engine in place. If the engine is not fitted with a tank, provision must be made, and a small commercial tank may be fitted either against B1 or on the fuselage side, outside. It need only be small – a maximum of say 30 secs. running. Solder washers on the inner ends of the axles, slip the wheels in place and solder further washers on the outside and the fuselage is finished.

The tailplane is much the same as before except that it has two ribs in the centre instead of one and uses $\frac{1}{8}$ in tip ribs. After covering, the tissue is cut away between the two centre ribs on top (i.e. an $\frac{1}{8}$ in. strip) and the rudder cemented between the





LAYING OUT FIN SHAPE
4½"
4½"
2⅝"
3/8"
2"
1"
¼"
FULL-SIZE WING RIB
B7 - ⅛"
B6 - 1/16"
B5 - 1/16"
B4 - ⅛"
B3 - 1/16"
B2 - 1/16" PLY
B1 - 1/16" PLY
FULL SIZE FUSELAGE FORMERS
UNDERCARRIAGE 14 SWG PIANO WIRE
APPROX 3/4"
3"
3"
UNDERCARRIAGE TOP



L.E. 3/8" x 3/8"
ALL SPACES 1⅞"
T.E. 3/16" x 3/4"
2¼"
18¾"
SPAR 1/8" x 3/8"
CENTRE SECTION COVERED WITH SHEET
SUPPORT OTHER END
MAKE ONE PANEL AT A TIME
CEMENT ON DIHEDRAL BRACE
TRIM WHEN DRY
PIN DOWN SPAR
3"
L.E. 1/4" x 1/4"
CUT RIBS TO FULL LINES DOTTED LINE SHOWS DEPTH OF NOTCH JOINT
NOTCH RIBS INTO L.E. AND T.E. ON BOTH WING AND TAIL
CUT 8 1/16", 2 1/8"
FULL-SIZE TAILPLANE RIB
TWO CENTRE RIBS SPACED 1/8" APART FIN CEMENTED BETWEEN AFTER COVERING
EXTRA 1/8" SQ.
GUSSETS
T.E. 1/8" x 1/2"
DIVIDE INTO FOUR 2¼" SPACES
SPAR 1/8" x 1/4"
TAILPLANE
18"

ribs. The rudder is simply cut from soft $\frac{1}{8}$ in. sheet to the dimensions given (note slots for slipping over tailplane spars) and sanded smooth with a rounded leading edge and tapered off trailing edge. Cut the trim tab and secure it back in place with two pieces of soft wire, and tissue cover.

Wing construction is also much as previously described except that the centre section is only the width of the fuselage and it is easier to build a true wing in this case by building the spar first. In addition to a simple drawing of the wing, therefore, the spar shape should be drawn – just a single line will do. The centre-section is flat, $2\frac{1}{4}$ in., and each tip is raised 3 ins., $18\frac{3}{4}$ ins. out. Cut and pin the spar ($\frac{1}{8}$ in. x $\frac{3}{4}$ in.) to this line, then cement over it a piece of hard $\frac{1}{8}$ x $\frac{3}{8}$ as drawn. When dry, cut off to match the spar. When the first panel is being assembled, prop the free end of the spar, then prop the first panel while building the second. Join up the centre-section leading and trailing edge last. The tip ribs should be at least $\frac{1}{8}$ in. thick, and the two centre ribs should be reduced by $\frac{1}{16}$ in. on both top and bottom as the centre section must be sheeted with $\frac{1}{16}$ in. balsa, grain across, on the top and bottom. Note also gussets at tips and centre, and the fact that the ribs are notched a fraction into the leading edge as well as the trailing edge. Sand as before and cover.

Assemble the model and check that wing and tail etc. sit square to the fuselage. Balance it on the finger-tips $2\frac{1}{2}$ ins. behind the wing leading edge, i.e. just behind the mainspar. Check glide into long grass etc. For power tests, run the engine rich to slow it down or put the propeller on back to front, which reduces its efficiency. Bend the rudder trim tab to give a little right turn. Use an 8 in. diameter by 4 in. pitch propeller, or as recommended by the engine manufacturer.

Trimming procedure is discussed elsewhere.

If you wish to fit a radial-mounted motor, this can be arranged during construction by sawing off the bearers to the appropriate length (measure the length of your engine from the airscrew drive washer to the mounting plate) and fitting an additional $\frac{1}{8}$ in. ply bulkhead glued and screwed to the ends of the bearers. A dethermaliser can also be fitted as in Fig. 34.

Although details are rather beyond the scope of this book, this model makes an excellent little single-channel radio-control project for equipment weighing a total of up to $6\frac{1}{2}$ ozs.

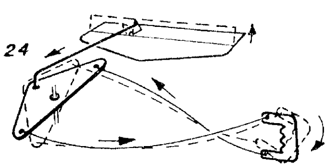
A rubber-driven escapement can be mounted on B4, the rubber hook being fitted at the base of B7. Receiver and batteries should tuck in between B2 and 3, the batteries being stowed at the bottom and the receiver above, separated by sponge rubber. Apart from an access hatch beneath the wing and another small one under the tail ahead of B7, the only other modification is clearance for the rudder push-rod and the provision of a slightly larger and freely hinged rudder tab area.

Six

Control Line Models

THE IDEA of flying a model via two wires followed the development of model engines; early models were crude, as is only to be expected, but the basic method of control remains the same today despite various attempts to introduce improved systems. A handle held by the operator bears two wires, one above and one below the hand, which are guided into the model and connected to a bell-crank. A push-rod is connected to the crank at right-angles and this operates the model's elevators via a horn on the elevators. Thus movement of the hand is transmitted to the elevators (Fig. 24), giving control over the model in 'pitch', or in the vertical plane. The lines stabilise the model in 'roll', and determine its path in 'yaw' – it simply flies in a circle round the operator, who turns with it. A powerful model can, of course, fly anywhere in the hemisphere of which the 'pilot' is the centre.

FIG. 24



An improvement which is more or less standard for stunt models is to couple flaps on the wing trailing edge to the bell-crank by means of a second push-rod; when the elevators go up,

the flaps go down and vice versa. This greatly increases manoeuvrability and a top class model can in fact turn so abruptly as to make square corners. A simple loop, a fairly easy manoeuvre, becomes quite a skilled stunt when performed as a square loop. Normal stunts include loop, wingover (half a circle level and half a circle in the vertical plane, i.e. passing right over the pilot's head), horizontal figure 8, vertical 8, overhead 8, half loop and inverted cloverleaf, and many others, plus all these manoeuvres done from the inverted position and square. The average sport model may just about be able to loop, wingover, and horizontal 8.

The one alternative system which is occasionally used, mostly for speed flying, uses a single control line which is twisted by a special handle, the twists being converted into control movements by a mechanism in the model. The advantage of the system is a reduction in drag from the use of one line only, but it is a fairly specialised method of control.

The lines themselves may vary from 10 or 12 feet in length to 70 ft.; we have seen models flying on 6 ft. of lines and also on 110 ft. lines, but it is rare to exceed the 70 ft. and dizzy-making to use very short lines. Average sport models using say $1\frac{1}{2}$ c.c. engines usually use 25–35 ft. The lines themselves may be flax fishing line or Terylene, piano wire or stainless steel wire of very fine gauge, or three or five strand wire 'cable'. Oddly to some laymen, they will still allow control of a model when twisted; if you do three or four loops, the lines will be twisted the same number of times, but the elevators will still work as the lines slide over each other. Obviously a smooth steel wire will slide easier than twine, so that steel lines will permit more twists than flax or Terylene. Steel lines, however, are harder to handle and once kinked are likely to break; they must be kept wound on a reel and treated with care to prevent them springing into a tangle. Stranded wire lines are easier to use since they are less springy, but they will still kink if handled carelessly. They 'slide' more than flax or similar, and are thinner, but slide less and offer more air drag than single-strand wire. For sport flying the ease of handling flax lines usually outweighs their disadvantages.

Special control-line handles with built-in reels for the lines are available, as are simpler cast or stamped handles, but a ply handle sawn to the shape sketched (see 'Shooter' model) is usually quite adequate for a beginner. One end should be painted a bright colour so that the handle is picked up with the 'up' line on top, otherwise in the excitement of getting going it is easy to pick it up upside down, reversing the controls with possibly dire results. Some handles have a spike at the bottom to stick into the ground to make them easy to pick up correctly.

Usually the bell-crank is fitted with two short wires terminating in hooks, called lead-outs, and at the inner wingtip a piece of ply with two holes, or a shaped wire, provides a lead-out guide. Most models have the lead-outs running inside the wing, with the guides built into the tip so that two hooks or loops emerge from the tip for connection of the lines. Trainers usually have everything mounted externally for simplicity. Larger models require some care to ensure that the lines cannot become disengaged, and the lead-out hooks may be fitted with short tubes to lock them closed. Wire lines are made off into loops through stubs of tube as sketched (Fig. 25), the joint being soldered; this method prevents kinking and possible snapping of the loop. There are various forms of attachment, some incorporating a wire bent rather like a safety pin, or incorporating swivels to allow each line to unwind any turns which may have wound into it, but for simple models these are unnecessary complications.


FIG. 25

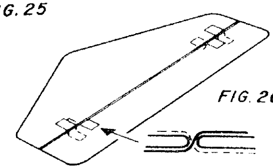


FIG. 26

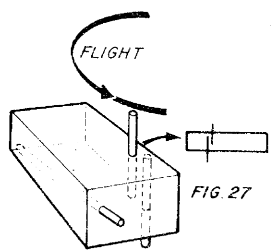


FIG. 27

The most important thing with a control-line model is that the control linkage should be completely free – the weight of the elevator should be enough to move the system when the model is held upside-down etc. Any stiffness or binding will make the model very much harder to fly. The usual form of elevator hinge is made from four pieces of tape or nylon ribbon, the pieces

being cemented 'under and over' as in the sketch, Fig. 26. Keeping the centre bend free of cement will help to avoid stiffness of the hinges.

To help keep the model flying at the maximum radius, since if it comes in towards the operator the lines naturally slacken and control may be lost, the lead-outs may be so placed as to rake the lines back slightly from the bell-crank, pointing the nose slightly out of the circle. The engine may be offset to pull outwards, and permanent rudder bias may be built in. Too much of any of these measures will make the model crab and reduce its speed drastically, but a little of each is helpful.

Flying in a circle, the model is obviously subject to centrifugal force, which helps to keep the lines taut except when the model is flown up high enough for its own weight to offset centrifugal force, when it may tend to slide in towards the operator. The offsets mentioned should be just enough to prevent this from happening. The centrifugal force, however, also affects the fuel in the tank, which is thrown towards the outside. A special tank is therefore needed to ensure a constant flow of fuel to the engine (Fig. 27). Once again, suitable tanks can be purchased, but some modellers make their own from tin-plate and brass tube. Small tins can be used, soldering all the seams and fitting three tubes as drawn. The feed pipe runs from the bottom rear corner; the other two tubes are a filler and a vent. Arranging them as shown means that the tank is always vented, allowing the fuel to feed properly, but fuel is unlikely to spill out in any normal flight position. If the model is a trainer or team racer etc., not likely to be flown inverted, filler and vent can both be fitted in the top and need only be short tubes.

Let us now consider flying a c/l model. Where possible, take-off from the ground should be carried out, since these models fly fairly fast and if a hand-launch by a helper is not first-class it may be difficult to get the model under control before it touches the ground. Take-off or launching should always start *downwind* – the opposite to free flight – as the wind (there should be as little as possible!) will then tend to blow the model away from the operator, helping to keep the lines tight, during the critical first half-lap.

Set the model in a suitable spot, with fuel and tools etc. three or four feet outside the proposed flight path. Check that the flight circle is clear of obstacles. Never fly near electricity pylons – a large number of modellers have been killed or badly injured through flying near overhead cables. Current will jump a gap of several feet, and on a humid day a huge shock can be transmitted along even flax lines, so play safe and sensible and find a flying site clear of this danger.

Connect up and lay out lines. Make sure that lines are of equal length and all connections are secure. Pick up handle and check that 'up' is 'up' and that controls move freely. Check lines for weak spots etc. Fill tank and start engine, leave model with assistant and pick up handle, checking that circle is still clear. Before signalling assistant to release, test that handle is right way up. On release, allow model to pick up speed and ease gently off ground with only a touch of up. If hand-launching, try to ensure that the elevator is neutral on launching, which enables the model to pick up speed and come under full control quickly. Launching with up elevator often results in the model staggering along semi-stalled and dropping to the ground before anything can be done. If the lines are slack, step quickly backwards; for this reason, always allow a margin of clear space outside the intended circle.

Quite gentle control movements are all that is needed, and if you are a beginner the best method is to hold the arm out straight with a stiff wrist and move the whole arm up and down without bending the wrist. Try to fly level at about head height. As experience is gained, movement of the wrist without moving the arm will come naturally. Let the model fly itself as far as possible, keeping the arm in line with it, and concentrate only on watching the model to avoid giddiness. Later you will be able to 'whip' (lead the model by pulling the handle ahead of it) and take more notice of the background generally.

'Shooter' – for 1 to $1\frac{1}{2}$ cc. engines

This is what is called a 'profile' model in that the fuselage is a single sheet of wood. For a trainer it is a very simple and strong method of construction. You will need one 36 in. sheet of $\frac{1}{4}$ x 4 in. medium balsa, a piece of $\frac{1}{8}$ in. sheet, a piece of $\frac{1}{16}$ in. ply, a length of 14 and one of 18 s.w.g. wire for the basic construction.

First cut off 19 ins. of the $\frac{1}{4}$ in. sheet, mark the centre line ($9\frac{1}{2}$ in.) of this piece and mark a point $\frac{3}{4}$ in. in from one edge at each tip. Join these points with the centre line and cut off the two shallow triangles resulting. Cement these pieces to the straight edge on the other side, wide ends touching at the centre line. Finish drawing the wing shape, 3 in. wide at each tip and $4\frac{1}{2}$ in. at the centre, and cut off the surplus. The wing must now be thoroughly sanded to the section shown. Use a sheet of glasspaper folded round a 6 in x 4 in. block; trace and cut the top curve out of a postcard and hold it to the top of the wing from time to time. The section is not critical, but should be reasonably close to that drawn.

Draw the fuselage on the remaining 17 in. piece of $\frac{1}{4}$ in. sheet; it will not be quite long enough, but the nose end has a $\frac{1}{16}$ in. ply plate each side, so that it will be quite strong enough if we make it up to length a little later. Cut out the fuselage, and mark and cut the two ply plates. The size of the cut-out in the centre will depend on your engine, so measure the width of the crankcase and how deep you will need to cut out the slot, then mark and cut out. A fretsaw is useful for this, but if not available saw the two horizontal cuts and use a knife for the third side. Cement one plate to the fuselage, fill in the nose with $\frac{1}{4}$ in. sheet, cement on the other plate and leave under a weight to dry thoroughly. The extra $\frac{1}{4}$ in. sheet can be trimmed off when dry.

Check that the wing fits nicely to its seating on the underside of the fuselage and that the $\frac{1}{8}$ in. slot for the tailplane is a good fit. Sand the fuselage, rounding the top and bottom corners (except at the wing seat) and mark the undercarriage positions. Drill holes for binding the wire in place, and also for the engine mounting bolts.

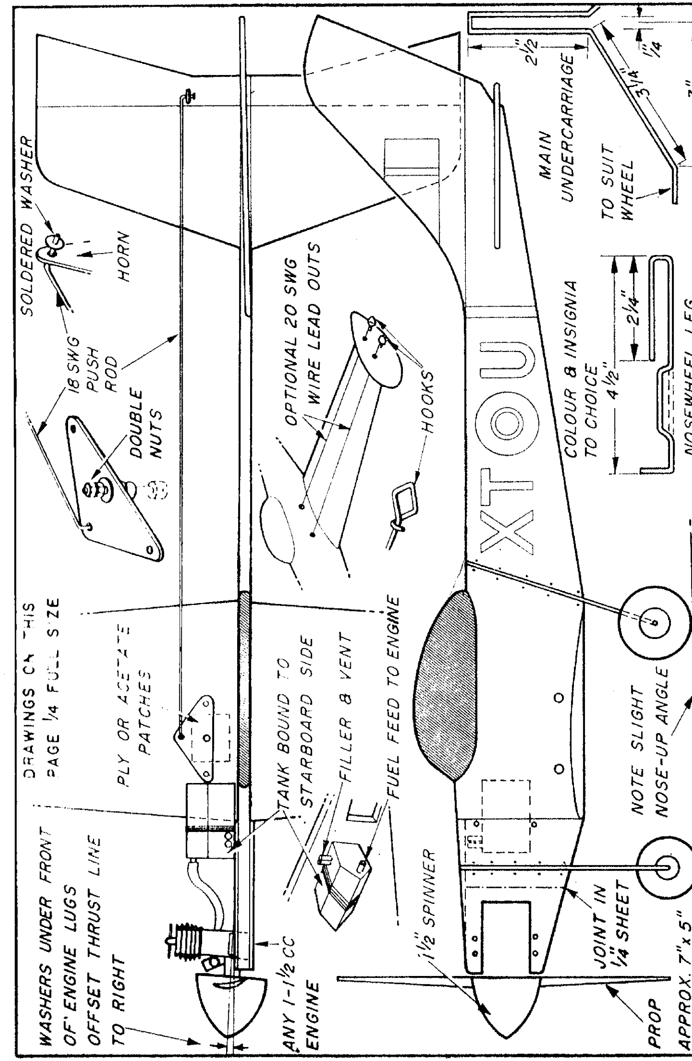
Cut out the fin, tailplane, and elevator, and hinge the elevator to the tailplane with narrow tape, as previously described, after sanding carefully. Cement the tailplane firmly into its slot, lay the wing on a flat surface, and cement the fuselage to it. One coat of cement allowed to dry before bringing the pieces together, then a second coat on making the join, gives a very much stronger joint. Make sure that wing and tail are parallel and square to the fuselage. The fin can also be cemented on at this stage; position it so that the trailing edge lines up with the *right* hand side of the fuselage and the leading edge with the *left* hand side, so that it is slightly angled to turn the model to the right.

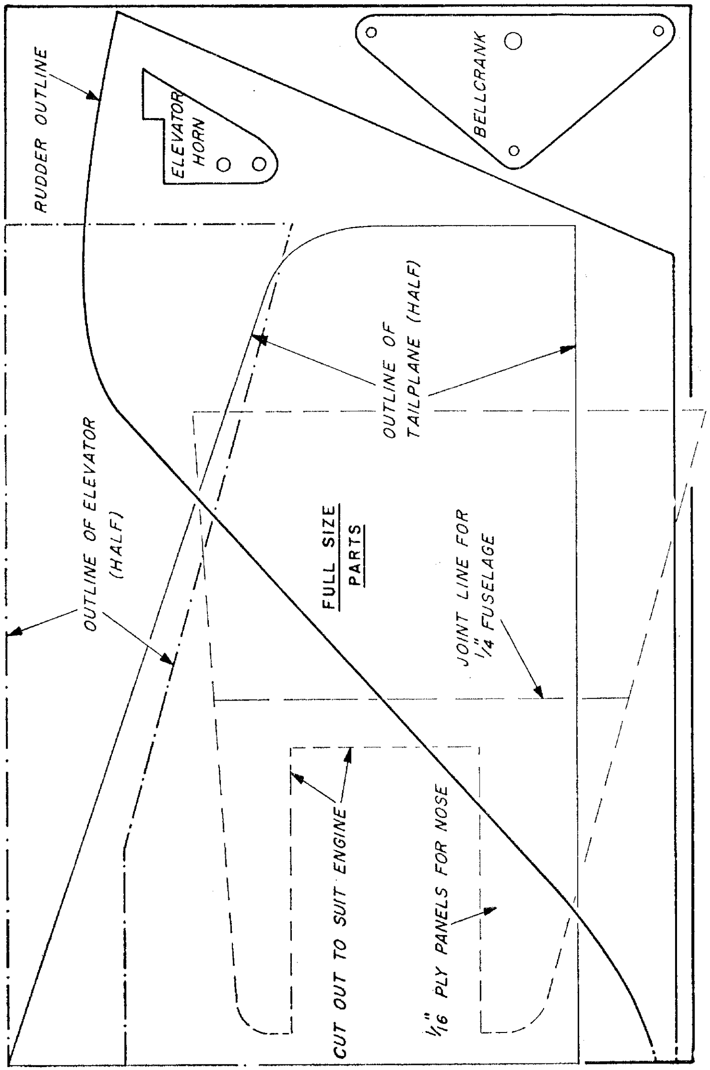
While this assembly is drying, bend the undercarriage to shape. The main wheels require a 14 in. length of 14 s.w.g. wire. First bend it into a long narrow U, $\frac{1}{4}$ in. wide (inside) at the top, then $2\frac{1}{2}$ ins. down from the top bend each side out to the angle shown. Bend the remainder to form an axle each side. The nose-wheel is a single leg; bend a U with $\frac{1}{4}$ in. inside clearance and one arm $2\frac{1}{4}$ in. long and the other $5\frac{1}{2}$ ins. It would look best to bend in the long arm as sketched, but it can be left straight if preferred, in which case bend for the axle $4\frac{1}{2}$ ins. from the U.

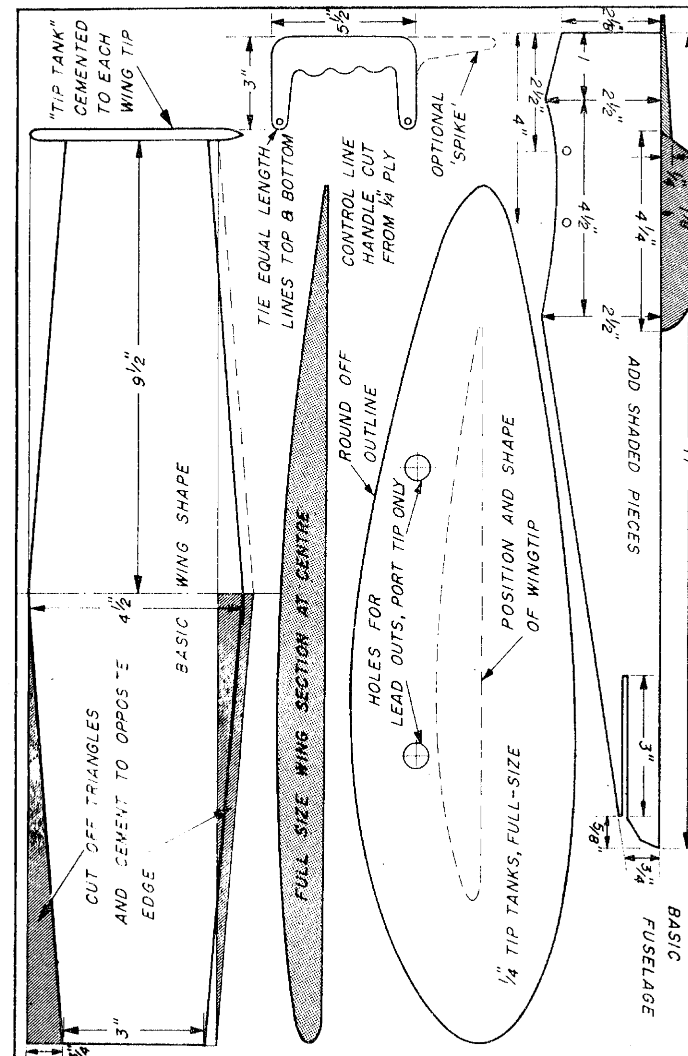
The bellcrank can also be made up, or a similar one bought, together with the elevator horn. Also cut out the $\frac{1}{4}$ in. 'tip tanks', noting that only one of these requires two holes drilled in it where shown.

When the main assembly is dry, slip the undercarriage pieces in place (file two notches in the top edge of the fuselage) and sew and cement firmly. Cement the 'tip tanks' firmly in place, the one with the holes on the port (left) tip, and the model is ready to tissue cover, dope, and colour to your choice. Drill a hole through the starboard (right) wing $1\frac{3}{4}$ in. back from the leading edge and $\frac{5}{8}$ in. from the fuselage, and cement a piece of ply or acetate about 1 in. square above and below the wing, drilling so that the wing hole lines up with the centres. Pass a 6 B.A. bolt upwards through this hole and screw on a nut, tight. Slip on a washer, then the bellcrank, another washer, and two nuts, tightening the nuts together so that the crank moves freely but not sloppily. Cut a little nick in the elevator and cement the horn in place $1\frac{1}{4}$ in. from the centre line. Connect the crank and horn with a length of 18 s.w.g. wire so that both are at neutral; the best way is to make a right-angle bend in the wire, pass it through the hole, and solder a washer in place to retain it. It is possible to bend the wire again after passing through the hole, so that no soldering is necessary, but this is not so free a connection and can lead to binding.

The easiest way to hook up the control lines (flax is quite adequate) is to thread them through the holes in the port tip tank, through the two holes in the fuselage, and tie them securely to the bellcrank. However, if preferred, wire lead-outs can be fitted to the crank (in the same way as the push-rod) and




RUDDER OUTLINE
ELEVATOR HORN
BELLCRANK
OUTLINE OF TAILPLANE (HALF)
OUTLINE OF ELEVATOR (HALF)
FULL SIZE PARTS
JOINT LINE FOR 1/4" FUSELAGE
CUT OUT TO SUIT ENGINE
1/16" PLY PANELS FOR NOSE


"TIP TANK" CEMENTED TO EACH WING TIP
3"
5½"
TIE EQUAL LENGTH LINES TOP & BOTTOM
CONTROL LINE HANDLE CUT FROM 1/4" PLY
OPTIONAL 'SPIKE'
9½"
BASIC WING SHAPE
4½"
FULL SIZE WING SECTION AT CENTRE
ROUND OFF OUTLINE
HOLES FOR LEAD OUTS, PORT TIP ONLY
POSITION AND SHAPE OF WINGTIP
1/4" TIP TANKS, FULL-SIZE
CUT OFF TRIANGLES AND CEMENT TO OPPOS E EDGE
3"
3/4"
2⅝"
1
2½"
4"
4½"
4¼"
ADD SHADED PIECES
17"
5/8"
BASIC FUSELAGE

extended through the fuselage and port tip and made off in hooks. In either case check that the controls move freely.

A small commercial tank is recommended – your model shop will advise – and this is positioned on the starboard side of the fuselage and sewn in place through the holes drilled to suit. Fit the wheels, using soldered washers, and bolt the engine in place with the cylinder on the starboard side. Slip a washer under the lugs at the front to point the engine slightly to the right. Fit the propeller, with a $1\frac{1}{2}$ in. spinner which helps to dress the model up, connect the tank, and your work is finished. The model should balance at about the front lead-out, but provided it is between the wing leading edge and the bellcrank pivot you should have no difficulties in flying.

Seven

Covering and Doping

THE USUAL material for covering is a proprietary tissue called "Modelspan', available either as light or heavyweight. There are also other tissues – hard or Swedish tissue, which rustles when handled, Japanese tissue, which is not easily obtained, rag tissue, which is like paper handkerchiefs, and condenser tissue, which is smooth, shiny, semi-transparent and buff in colour. Normally only Modelspan or hard tissue can be bought in the average model shop, and the former is used for almost all models. It is available in white, black, red, blue, and yellow, and is fairly soft to handle and covered with minute 'pores'. Hard tissue is smooth and absorbs far less dope; it is available in a wide range of colours and is harder to apply and not so strong as lightweight Modelspan, but it is useful for small or very light models.

Other materials used for covering larger models are silk and nylon, both available in colours and looking something like chiffon.

There is quite a selection of adhesives suitable for covering, and there are a number of different techniques. The following methods are those most common and likely to make this somewhat tricky part of construction easiest for the novice.

Since Modelspan is most widely used, we will deal with this in detail. It can be attached with tissue paste, tissue cement, dope, balsa cement, white pastes such as Grip-fix, mucilages, flour paste, and so on, but everyone eventually finds the adhesive that suits him best and tends to work with that. Beginners, we have found, seem to get on best with Grip-fix for simple surfaces and dope for concave or undercambered items.

Covering should be carried out in the largest pieces possible with only one-way curvature. For example, a simple square fuselage can be easily covered in four pieces. A standard wing with a flat centre-section needs six. Let us take the wing of the power model in Chapter 5. The undersides are covered first, so we need one piece for each wing panel and a small piece for the centre-section. The pieces of tissue should be cut about 1 in. bigger all round and laid ready to pick up. It is only necessary to paste round the extreme edges of a flat or convex panel, so we spread a thin film of Grip-fix along the leading and trailing edges, not all over the wood, but just, say, $\frac{1}{8}$ in. along the edge, and across the root rib and the tip. The tissue panel is now laid approximately in place and pressed down gently in the centre of the root rib. It is drawn smooth and lightly pressed to the centre of the tip. Now spread it evenly across the wing in the centre of the tip. Work from this point towards the root rib (Fig. 28), smoothing the tissue out with the thumbs and drawing it fairly taut before pressing on to the adhesive. If it is necessary it can be gently lifted at any point, but the adhesive makes it a little soggy so care must be taken not to tear it. Turn the wing and work from the centre towards the tip. When satisfied, trim the edges with a sharp razor blade to about $\frac{1}{4}$ in. and paste this overlap round onto the other side. At the tip it may be necessary to cut the tissue with a razor blade into a number of narrow strips, pasting each one down with a tiny overlap. With a curved shape to the tip, it is advisable to paste the tissue to the end rib and cover the tip outward from this rib with a separate piece of tissue.

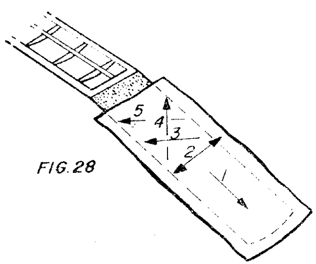


FIG. 28

The underside of the other wing half is covered in the same way, followed by the centre-section; it is best to cut this strip to the required width and trim only the leading and trailing edges.

Because of the curvature, the upper surface of the wing is a little more difficult, but the basic method is the same. The places where wrinkles usually try to appear are in the corners of the tissue panel, but they can be eased out with care. Trim the top tissue off at the edge of the structure, i.e. do not leave an overlap to turn round and paste down.

An undercambered wing (with a concave undersurface) requires rather different treatment, the tissue needing to be stuck into the concavity. It is quite in order to use Grip-fix, pasting each rib and spar as well as the edges, but it is necessary to work fairly quickly to prevent the paste drying and losing its tackiness. The tissue should be held taut (not stretched) and held in the fingers to form a long U along its length. It is laid along the mainspar, or the centres of the ribs if there is no lower spar, and the ends lightly pressed down as before. The finger is then run along the spar and a rib in the centre, and the remaining areas pressed down stage by stage, working from the centre towards each end and making sure that the tissue sticks firmly to all members.

An alternative method is to clear-dope all the wood surfaces in contact with the tissue, then lay the tissue in place and dope along the line of the surfaces beneath. The dope soaks through the tissue and binds it to the previous coat of dope, even if the previous coat has completely dried. With this method it is advisable to pin the frame down (see later) to prevent warping.

Tailplanes and rudders follow the same method as used for the wing, but the fuselage may need some thought. A simple square body can be covered in four panels (bottom, sides, then top) but more pieces may be needed if the shape is more complex. Study the framework and decide which areas can be covered with one piece of tissue each, remembering that for best results only a one-way curvature can be handled. A rounded or curved body must be covered in a series of long tapered strips.

It is important that all bare wood is covered, since bare balsa soaks up dope or paint and becomes considerably heavier and more brittle, both obviously undesirable points. Small sheeted areas can often be covered in with the tissue panel adjacent to it, but large areas require different treatment.

The sheet (or block) must first be sanded to a silky finish. Apply a coat of clear dope or sanding sealer; this will bring up a fuzz on the wood which must be sanded off. Cut tissue panels to cover the area (only one-way curves can be negotiated again), lay the panels in place, and clear dope over them. Work from the centre out to brush out any tendency to wrinkle. When dry, sand lightly with fine worn glasspaper and apply further coats of dope or sanding sealer.

Tissue over open frames must be doped to fill in its pores and make it airproof; dope also has a shrinking action but unless the covering is reasonably smoothly applied it pays to shrink the tissue initially with steam or water. Steaming, by holding the frame in the jet of steam from a boiling kettle until it goes slack, is not quite so drastic as water-shrinking. The latter is best carried out by using a scent-spray or squeeze bottle to spray a fine film of water on the tissue – not so much that it runs or drips, but enough for the tissue to be visibly damp. As the water (or steam-damping) begins to dry off, the tissue will tauten up, and at this stage it is desirable to 'pin' a wing or tail down with weights (or actual pins) to a flat surface which, to be safe, is best covered with waxed or at least greaseproof paper (Fig. 29). This ensures that the structure will not be warped by uneven shrinking of the covering.

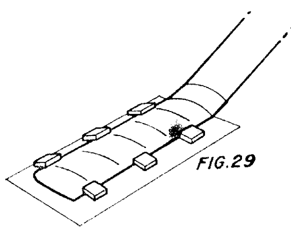


FIG. 29

When thoroughly dry, the tissue is brushed over or sprayed with clear cellulose dope and again pinned down to prevent warps. Two coats of dope are usually the minimum required; look closely at the tissue and you will see tiny poreholes, which must all be filled. Light structures can be disastrously warped by clear dope, and they may therefore be treated with one very thin coat of dope (thinned with cellulose thinners) and/or a coat of thin banana oil, which is a cellulose clear lacquer which does not shrink.

Brushes used in dope should be soft and of good quality, and should be cleaned out thoroughly with cellulose thinners after use, before they have had time to dry hard. Cellulose dries very rapidly and, incidentally, should never be used near an open flame. Doping is affected by weather and should always be carried out in warm and dry conditions; a cold, damp atmosphere will cause 'blushing', where milky white patches appear in the dope (clear or coloured) as it dries. These will disappear if another coat is applied in drier and warmer conditions.

Coloured dopes or paints should be used sparingly, since they add weight at an alarming rate. Small models should rely only on coloured tissue, and larger models are best if only the fuselage and perhaps a fancy flash on the wing etc. are coloured. Lighter colours, incidentally, are heavier than most dark ones, due to the pigment. At one time, coloured cellulose dope was the lightest means of adding colour, but plastic enamels (Humbrol, Joy, etc.) can often be lighter than dope. All power models require a certain amount of proofing against fuel, which can soak in and weaken the structure as well as ruin the paintwork and appearance. Fuel-proofer is available commercially and is usually a type of clear varnish which is rather heavy. Most models can get away with fuel-proofer only in and around the nose-end and such other areas as may come into contact with fuel, especially if a fuel-proof clear dope (butyrate or ethylrate) has been used elsewhere. This is especially so with diesel-engined models, since the fuel, though messy, will not seriously affect other than the nose of the model. Glow-plug fuel is more serious, since it attacks paintwork etc., and it may therefore be advisable to use fuel-proof dopes throughout or to apply a thin coat of fuel proofer over the whole model, or at least over the whole fuselage.

Silk and Nylon

Covering technique with silk or nylon is much the same as with tissue, but nylon does not shrink, unless it is a very fine weave, when the fibres do not shrink but the spaces between them will contract slightly; silk does shrink, but not as much as tissue. The usual method of application is to 'wet cover', in other words, to damp the material thoroughly before application, which causes its area to expand slightly. Using it damp means that water-soluble adhesives are not entirely satisfactory, but it can be attached with cellulose cements or other non-soluble adhesives; the neatest job can undoubtedly be made with thick clear dope used as outlined above. Cellulose cements or dopes will blush from the damp in the silk or nylon, but this will disappear when further coats of dope are applied.

The procedure for covering is exactly the same, except that in skilled hands slight two-way curvatures can be covered in one piece, and it is usually necessary to pin the material in place until the adhesive has set. It is also necessary to use more coats of dope to fill the pores in the fabric. Covering is a little trickier, but the resultant strength is considerably greater than with tissue; weight, too, is higher, so that use of nylon or silk is usually confined to larger models or to medium-size radio-controlled or stunt control-line models, where the increase in strength is well worth an extra ounce or two.

Warps

Care must be taken at all stages of construction and covering to avoid warps which produce unwanted flight effects – after all, early aeroplanes used warping of the surfaces to control their flight! In advanced models, warps are sometimes deliberately built in, but the beginner should aim at true, warp-free surfaces.

FIG. 30

If, despite all precautions, a warp does appear, it can often be removed by warming the offending surface in front of an electric fire, twisting it to an equal distortion in the opposite direction, and holding till it is cool. This type of treatment may not be permanent, the warp creeping back, and it may then be steamed thoroughly and pinned out with a slight opposite warp and left for a couple of days. If it still creeps back, the best course is to re-dope the surface with thinned dope and pin it down with just a trace of opposite warp and leave it for at least forty-eight hours.

A structure once warped may still tend to rewarp, especially if the model is left in the sun etc., and it may be possible to learn to live with the warp. Examine it and think what it will do – will

it, for example, tend to lift or depress one wing? In this case, adjustment of rudder and/or engine sidethrust can turn the warp into a permanent trimming feature. Equal warps in both wing-tips can often be accepted, and the same applies to the tail. Generally, however, care in building to avoid warps will save a lot of trouble on the flying field.

Eight

Engines

THE BASIC types of engine – petrol, diesel, glow – have already been outlined in Chapter 1. Petrol engines are nowadays obsolete for aircraft, and can be discounted for the average enthusiast, as can any motor other than the two-stroke diesel or glow engine which is more or less standard all over the world.

Let us look at a two-stroke to see how it works (Fig. 31). Starting at somewhere in the cycle, the sequence of events is: the piston begins to move up from B.D.C. (bottom dead centre) and as it does so the volume in the crankcase begins to increase and that in the cylinder to decrease. The increase in volume in the crankcase lowers the pressure, and this pressure drop is used to suck in a mixture of fuel vapour and air through an induction port. As the piston gets near the top of its stroke, the charge in the cylinder begins to burn, either because of the temperature rise caused by compression (diesel) or because of this plus the glowing element of the plug (glow). The combustion increases the temperature and thus expands the gases, the design of the engine, or, in the case of the 'diesel', the adjustment of the compression ratio by means of the contra-piston, ensuring that the time at which the greatest expansion of gas occurs is just as the piston commences its downstroke. As the piston moves down the mixture in the crankcase is compressed and the piston uncovers, first, an exhaust port through which the spent gases begin to escape, and, second, a transfer port linked to the crankcase, through which the fresh mixture flows. The flow of fresh mixture pushes the exhaust gases out, the piston passes through B.D.C., and the cycle recommences.

FIG. 31

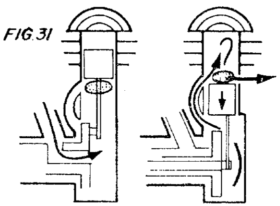
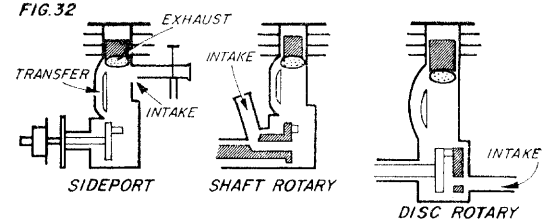


FIG. 32



The port timing is the main key to performance, since the larger the charge which can be introduced into the cylinder the greater the power will be when it burns; therefore ports should be large, open early, and close late to get the maximum amount of gas through in the fraction of a second they are open – at 20,000 r.p.m. the piston moves up 333 times and down 333 times *each second*. Too large ports, or too much 'port overlap', will, however, lead to leakage, most noticeable at low speeds and especially on starting.

In the early days of model engines, most were 'sideport' or 'three port' types where the piston uncovered the induction port to the crankcase as well as the exhaust and transfer ports. Such engines were – and still are – easy starters in general, but limited in performance because the induction port can be open for only a short time and the amount of mixture thus drawn in is correspondingly small. To get more mixture in the crankcase other types of port have been developed – crankshaft or rotary shaft porting, in which the crankshaft is hollow and a port in it registers with the intake once per rev. as sketched, rotary disc induction, where a disc, mounted on the back of the crankcase and driven by the crankpin, has a port registering with an intake once per rev., rotary drum, which is similar, and reed induction, where a thin sprung metal plate opens an intake when crankcase pressure drops and closes it when pressure rises. A sideport or reed engine will run in either direction equally well, but rotary inlets are eccentric for timing reasons and run only one way, or only poorly in the opposite direction unless the timing can be varied by changing the crankshaft or driving the disc or drum from an alternative point, i.e. moving the port round in relation to the crankshaft.

Most modern motors have transfer passages and ports arranged all round the cylinder; similarly exhaust ports usually encircle the cylinder, even in motors where a single exhaust outlet is provided, the gases being collected into a manifold.

On a glow engine the only control is adjustment of the fuel/air mixture by means of a needle valve; a throttle, if fitted, does the same thing in effect. With most glow motors the throttle is a two-part device, one adjusting the mixture on the intake and the other, interlinked to the first, restricting the exhaust area.

Controls on a diesel are two – the fuel/air needle valve as used on a glow-motor, and a compression adjustment which is a screw in the cylinder head controlling the position of a contra-piston which forms, in effect, a movable cylinder head. Having two controls makes running a diesel a little more difficult to to learn, perhaps, but against this is the fact that a glow engine needs an external battery or accumulator to start it. Throttles on diesels are usually simpler, and adjust the amount and richness of mixture entering the engine. Most beginners' engines do not have throttles, the use of which is only necessary for radio control models or, in rare instances, for special effects with control-line models.

Starting a motor should not be difficult, but there is something of a knack involved, particularly in flicking the propeller. The necessity of a good, practised flick is less with a glow motor than with a diesel, but quicker starting can result with glow by flicking correctly, not only because more heat is generated when the piston travels faster (as when pumping up a bicycle tyre – the pump gets hotter when worked faster) but because more fuel is drawn in and transferred when the prop is flicked rather than turned. The flick is hard to describe; for a right-handed person fit the propeller on the crankshaft so that when standing in front of the engine it is just coming up to compression at about 2 o'clock, i.e. the propeller will still be not

quite vertical with the piston at T.D.C. Use the first two fingers of the right hand and position them near the hub on the underside of the upward-rising blade; turn the propeller over compression with the fingers sliding out along the blade and slipping off it as T.D.C. is reached. Most of the movement is in the wrist, and the fingers should not be moved in relation to the hand. The whole action is a snap or flick – and like shaking down the mercury in a clinical thermometer, only practice can give you the knack.

Many beginners' engines now incorporate a spring starting device, which when engaged and the propeller wound backwards a turn or so, turns the propeller over three or four revs. on release. Such fittings simplify starting, but it is still necessary to know whether the right amount of fuel is getting into the cylinder.

With a glow motor, no firing will take place if the cylinder is dry and it is often safer to err on the side of a little too much fuel, by priming the cylinder through the exhaust ports. When the battery is connected, a tiny frying noise may then be heard, and the motor will fire when flicked. If it runs for a quick burst and stops it is probably not getting sufficient fuel through, but check by flicking over again with the battery still connected. If it fires immediately it will be likely to mean that too much fuel is being sucked, but it is more probable that it will not fire, so open the needle a quarter turn, re-prime, and try again.

When the motor is running in longer bursts, it may gradually slow to a stop (too much fuel) or suddenly speed up and stop abruptly (too little fuel). Always try a check flick with the battery on before making an adjustment, since if it then fires it may have been too wet, and if it doesn't it probably wasn't getting enough fuel. Stick to the makers' recommended fuel until you are really familiar with the engine, since a different fuel may be too hot or too cold for the plug fitted in your motor.

Diesels exhibit similar characteristics – slowing when too wet and speeding up to an abrupt stop when too dry – but the compression adjustment may produce similar results when the needle setting is approximately right. Usually, with diesel or glow, fuel is sucked into the engine before starting by choking, i.e. blocking the air intake with the finger and turning the propeller a couple of times. A diesel may also be primed through the exhaust port, and this is the best method of getting to know an engine. Choke the motor and prime through the port, then turn the propeller slowly to make sure that any excess of fuel will not cause a hydraulic lock, i.e. prevent the piston from reaching the top of its stroke. If clear, flick, advancing the compression screw a few degrees at a time until the engine fires. If the engine is locked, back off the compression until it will turn over, and flick, advancing compression until it fires. If there is fuel (and the right fuel!) in the cylinder, it must fire, and having found the compression setting at which firing takes place, it is then a question of finding the right fuel setting. Running in short bursts may indicate insufficient fuel or insufficient compression, labouring to a stop too much of one or the other. When a motor stops, always flick it over before making an adjustment, to try to 'feel' what is the reason for the stoppage. Knowledge by feel of whether the engine is wet or dry, or under or over compressed, comes very quickly.

It is safest to stick to fresh, reliable makes of fuel, but some modellers make up their own. Suitable mixtures for average engines are:

Glowplug – 70% methanol (dry methyl alcohol), 30% castor oil or Castrol R. Up to 25% nitro-methane can be added for increased performance.

Diesel – 40% paraffin (kerosene), 30% ether (anaesthetic or technical), 30% castor oil or Castrol R. Up to 5% amyl nitrate or nitrite can smooth running and increase performance.

Nine

Tips

No one can pretend that beginners will never run into snags in constructing models; may of the problems which can crop up seem laughably simple when the answers are found, and as experience is gained the number of queries arising naturally diminishes. Unfortunately, what may seem obvious to one novice puzzles another, who in turn may have no difficulty with something that baffles the first. Thus it is hard to give general guidance covering every possible question in one small book, and the following points are therefore just a few useful hints.

1. Never be satisfied with anything less than the best you can do. better to have to buy another sheet of balsa and rebuild one part than wreck the whole model because you were in a hurry and used a sub-standard piece.

2. Never rush – better a successful first flight a week later than you hoped than a wreck on schedule!

3. When cutting balsa, several light cuts are better than forcing the blade, which crushes and tears the wood.

4. Waxed paper, even greaseproof paper, laid over the plan will protect it from cement blobs which may stick the structure to the drawing. Alternatively, rub joint areas on the plan with a candle or dry soap.

5. Read the remarks on warps in structures in Chapter 7.

6. Balsa (and other woods) can be curved more easily by damping in water – boiling water for a sharp curve. Pin the

curve in place and allow the water to dry out completely before cementing.

7. Very sharp curves can be eased in by rolling a pencil or dowel over the piece of wood, with pressure. Alternatively, score with a sharp blade at close intervals, or nip with the thumbnail to crimp in a bend. Run a skin of cement over afterwards.

8. Always use very sharp blades – blunt ones produce an inferior job with much more difficulty. Use common-sense precautions, e.g. never cut towards yourself etc.

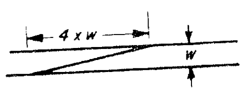
9. Glasspaper is almost the most important tool – certainly it is virtually impossible to make a good model without it.

10. Use a steel ruler or back of a hacksaw blade to cut straight lines, and make sure the blade is held upright.

11. Double cement – i.e. cement, join, draw apart and allow to dry, then recement and make the joint – all stress joints, especially wing spars and where end grain is involved.

12. If it is necessary to make up one long piece of wood from two short pieces, use a scarf joint, i.e. cut the ends to be joined

FIG. 33



at an angle by laying one on the other and slicing through both, then turn one over and double cement to the other. The minimum distance should be four times the width, e.g. a joint in $\frac{1}{4}$ in. strip should be 1 in. long (Fig. 33).

13. To trace from a plan, lay a piece of transparent paper (greaseproof will do) over the plan and draw round the shape to be traced with a soft pencil. Turn the paper over on to the wood, and draw over the line from the back, which will transfer it to the wood.

14. Make a template from thin ply for parts which are cut in quantity, e.g. wing ribs, and lay the template on the wood and cut round it. Pin the cut out parts together carefully, and sand lightly to ensure that they are identical.

15. Use a pin in the cement tube, and replace the pin each time the tube is used. This makes for economy, keeps the cement fresh, and the nozzle stays free of blobs and is therefore easier to use.

16. When pinning parts down with pins, use hardened steel dressmakers' pins and do not push pins through small parts – a pin each side will hold small sections firmly down.

17. Use a building board which is flat and true, of adequate size, and of timber which will take pins without having to hammer them in. Deal or similar softish wood is best. If pins become trapped by cement, give them a gentle twist with pliers and they will come out easily. Use a separate board for cutting out parts.

18. Clothes pegs make excellent small clamps.

19. Use good quality dope brushes – they are easy to wash out in a small amount of cellulose thinners and will last for years with care.

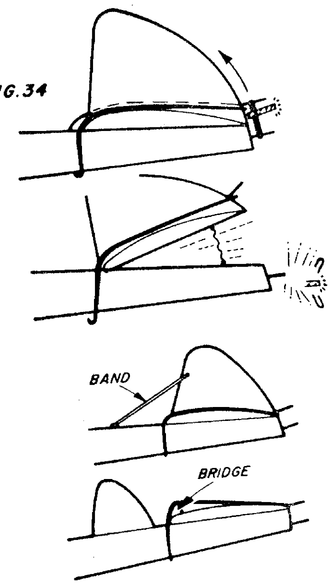
20. Coloured cellophane tape can be used for decoration; stick a length on a piece of glass and it can be sliced into very narrow strips for pin striping. After sticking on the model, seal it in place with fuel-proofer on a small brush.

21. Spray guns or aerosols can be useful in finishing, but always try them out on something unimportant first.

22. Very small scraps of wood cemented beneath the wing and tailplane will provide keys to ensure that the surfaces are always sitting properly in the same position. These are usually fitted when the model has been fully trimmed; similarly, any packing pieces used in trimming should be cemented permanently in place.

23. Use a dethermaliser when flying. This may not be necessary 99 times out of 100, but may prevent your losing the model on the 100th occasion. The customary method is to hold

FIG. 34



the tailplane or tail unit in place with rubber bands which exert a pull tending to tip it up as in the sketch, Fig 34. It is held down by one rubber band set clear of the fuselage and held in this band is a fuse, usually soft white lamp wick (from iron-mongers) which smoulders when lit. The usual white wick has red flecks, is about $\frac{3}{16}$ in. diameter, and burns about 1 in. in three minutes. When the fuse burns down to the rubber band, it melts it and allows the tailplane to pop up. The angle of tip may be limited by a thread, and is adjusted so that the model is fully stalled and sinks fast on an even keel. Too little angle will produce loops or violent oscillation, too much will cause the model to pitch all over the sky. About 30 to 35 degrees is usual.

24. As an additional precaution, always write your name and address clearly on the model, where it will be seen easily. Use indian ink for preference, as most other writing materials fade quickly.

25. Third party insurance is a sensible precaution, and protection up to £50,000 is afforded to all members of the S.M.A.E. The simplest way to enjoy this advantage is to join an affiliated club, and the S.M.A.E. Ltd., 10a Electric Avenue, Brixton, London, S.W.9., will send you the address of your nearest club on receipt of a stamped addressed envelope. Joining a club has other benefits – you learn fast, you have the opportunity of comparing your models with others, you enjoy flying facilities, competitions, trips to other clubs, talks, etc. etc.

Ten

Radio Control

THE SUBJECT of radio control is so large that it is only possible to give an outline of it, in the hope that it will be informative and sufficient to whet an appetite for what is undoubtedly the biggest thing in model flying today.

Probably the first thing one hears is 'single-channel' or 'multi-channel'. Now, a radio receiver is in effect a switch operated by remote (radio) control, and the simplest form is just a single switch, i.e. there is one channel of communication, hence 'single-channel'. Such a set is simply a button on a box which, when pressed, emits a radio signal which throws a switch in the model. The radio signal is a constant, basic wave form and is called a carrier wave because on this basic wave can be superimposed tones of differing frequencies. Most modern single-channel equipment is, in fact, 'tone', since it has been found better and more reliable to send the carrier wave modulated by a single tone or note.

With multi-channel equipment, more than one tone or note can be superimposed on the carrier wave, so that if, say, four tones are used, we can have four switches in the model. The usual maximum in the model world is ten tones (ten channel) although occasionally twelve are used; we don't really need any more. Usually these tones can only be selected one at a time, but with some of the more expensive equipment up to three may be sent simultaneously, and such gear is known simply as 'simultaneous'.

Ten channels are usually used in five pairs; you need one to give left rudder and one for right, so that is one pair. The others give elevator up and down, aileron left and right, engine faster and slower, and the last usually gives fine trim up or down on the elevator, which is the most important control for flight trim, though these two channels might be used for flaps and/or brakes. The transmitter for ten channel gear has a main on/off switch and five toggle switches which can be pressed either way and spring back to centre when released.

There is one other important definition – super-regen or superhet. A super-regenerative receiver will respond to any signal in the relatively narrow wave-band (26.96–27.28 megacycles) allotted for radio control purposes. If two ten-channel super-regens are operating at the same time, they will interfere with each other, even though the frequency modulation of their tones may be different. The only way round this is to provide a carrier wave on an exact frequency – it is theoretically possible to provide 130 exact spots in the wave-band, though twelve or fifteen is a more practical number. This is done by the inclusion of specially ground and matched crystals in the transmitter and receiver, but a crystal cannot be fitted in a super-regen circuit and so the receiver has to be of the superheterodyne type. A superhet is a little more complex and therefore more expensive, but for reliability, absence of tuning bothers, general efficiency, and the ability to operate more than one model at a time, the difference is well worth it.

The receiver, on receipt of a signal, closes a switch or switches, as we have said. In the case of multi-channel, the receiver decodes the signal, either through a bank of reeds or tuned filters, to close the right switch. The switches may be in the form of relays – metal contacts drawn together by the magnetism created in a coil – or transistor switches. Relays can pass a fairly strong current (they are switching on independent electrical circuits) but transistor switchers are limited in the current they can pass and this current needs amplification. Either type operates servo mechanisms; in the case of relays, the receiver is more expensive but the servos are straightforward, with transistor switches the receiver costs less but the servos are more expensive because they include amplification circuits.

Most present-day equipment is all-transistor, though some sets still employ a miniature valve. Valve sets usually need

higher voltage batteries, plus an additional battery to heat the valve filaments.

Having operated our switch, we have completed a circuit through a mechanism which will move the model's controls. This mechanism may be an escapement, an actuator, or a servo, which has been briefly mentioned already. The simplest is an escapement, usually driven by a loop of rubber but occasionally clockwork powered. Use of escapements is usually confined to single-channel outfits, and the receiver simply switches on a circuit which energises a coil which in turn attracts a pawl. Moving the pawl releases the escapement rotor; the pawl is usually L-shaped so that when the top is withdrawn from the rotor's compass, the bottom swings forward into it, and the rotor is therefore stopped. Cessation of signal releases the pawl, the bottom of which swings out, releasing the rotor, but the top has swung in, so the rotor (which has two arms) is again stopped before it has travelled far. The normal escapement allows the rotor to turn 90 degrees at a time, and a crank connected to the rotor shaft operates the rudder. A sequence would thus be – rudder neutral, signal, rotor moves to quarter-circle, rudder right. Stop signal, rotor moves to half-circle, rudder left. Signal, rotor moves to three-quarter circle, rudder left. Stop signal, rotor completes circle, rudder neutral. Thus there are two neutrals, and if you have used right rudder and wish to use it again, it is necessary to press, release, and press again, to skip through left rudder. This is called sequential control.

By altering the rotor shape, variations on this scheme are possible, and the usual variation is to provide a rotor which gives press, right, release, neutral, press, press, left, release, neutral, and to introduce a 'quick blip' position (press, press, blip, neutral) which, if the second press is followed very quickly by a third, will cause the rotor to stop in a position near neutral rudder which closes a pair of contacts, energising a second escapement for, usually, motor control. Under normal circumstances the rotor passes so quickly over this third position that nothing happens, and only when the blip is introduced will the second escapement operate.

It is also possible to drive other escapements by cams etc. off the main rotor, and this is known as a cascade system. It begins to tax the memory, however, and complex systems usually have a 'think box' attached to the transmitter which mechanically sorts out the right sequence of signals, depending which button you press, for what you want to do.

The other main use of single-channel equipment is for pulse proportional or mark-space control, in which the signal is sent by a mechanical or electronic pulse-box as a series of pulses. The ratio between signal-on and signal-off time can be varied (i.e. a long signal and short silence or vice versa) as can the speed of the pulses, and by this means full control of the model can be achieved, using ingenious mechanisms at the receiver end. The control achieved is remarkable, but it is not a system which can be recommended to beginners unless they are electronically minded or can buy the complete equipment and study carefully how it works.

Intermediate between an escapement and a servo is the actuator; this can perhaps best be defined as an electrically driven escapement or perhaps an electric mechanism which is irreversible. A servo makes a mechanical movement, then reverses that movement to return to neutral, but an actuator will not 'drive backwards'. Some years ago there were one or two solenoid-operated devices which returned to neutral by means of a spring, and these were termed actuators; so are the electrical mechanisms used with pulse proportional equipment which do drive both ways but employ a spring bias to find neutral. In general, however, a non-self-reversing electric mechanism is as good a definition as any. Actuators are usually operated by single-channel equipment, or by one channel of multi-channel sets, whereas servos always need two channels.

Of servos, there are three types – progressive, progressive self-neutralising, and proportional. A progressive servo will move when a signal is sent, and stop when the signal ceases, or when it reaches its limit of travel. Thus you can apply, say, half right rudder and leave it there, and from that position you can later give more right rudder, or by selecting left rudder, move it in the opposite direction, to reduce the amount of right rudder, move to neutral, or give what degree of left rudder you wish. The rudder stays where it is when the signal ceases, even though the transmitter key returns to neutral. If the action was cyclic, i.e. on reaching the limit of right rudder the

mechanism automatically started to move the rudder in the opposite direction (as it would with a simple rotating crank) it would be a progressive actuator and not a progressive servo!

A progressive self-neutralising servo is one in which the control moves in the desired direction until it reaches its limit of travel, but on cessation of signal it returns automatically to neutral. Thus to do a gentle turn it is necessary to tap the key repeatedly and the rudder will wag – if you hold on signal the rudder will move out and the turn tighten, if you release the key completely the rudder will automatically straighten.

The ultimate is proportional control. A proportional servo will follow exactly the movement of the transmitter control, and the transmitter control stays put, i.e. you know where the controls are by glancing at the knobs on the transmitter. If you want five degrees of rudder you apply that much. If, after altering other controls, you've forgotten how much you have on, you can look at the rudder knob to see. The main advantage is that the controls can be moved from anywhere to anywhere as slowly or as quickly as desired, making flying smooth and accurate.

At the time of writing, such equipment is expensive, and some experts who are used to progressive self-neutralising systems find difficulty in unlearning their established techniques in order to use the advantages of this relatively new development. However, proportional control will undoubtably become standard – and, of course, less expensive – before many years have passed. Even in the relatively short time over which radio has developed, there has been a history of marked changes and resistance to them by established practitioners, but progress continues nevertheless. When one thinks of the first commercially available radio control equipment, a scant fifteen years ago, and what is now available, what will be produced in five or ten years' time is anybody's guess. We already know of one single-channel model which, complete with engine, radio, etc., weighed a bare three ounces, and the three-foot fully aerobatic multi-channel model weighing a couple of pounds all up is within sight. We have seen simple formation aerobatics with three models; the only thing we can envisage which has not yet occurred is air racing round pylons by half a dozen small models simultaneously. Whatever comes, however, the backbone of the movement and the person who matters most will be the man who doesn't really want to do a lot of high-pressure competition work, but who is quite happy to take a model out by himself for a little sport flying. The man, in other words, who flies for fun.

That, after all, is what aeromodelling is about.

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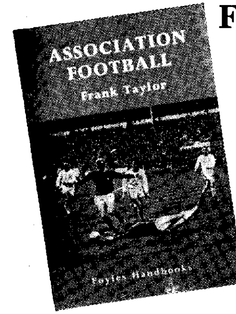

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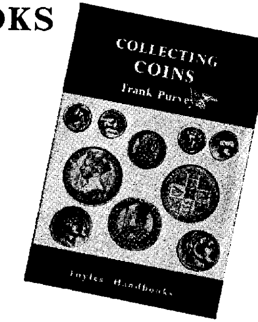

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