

THE ENCYCLOPEDIA OF MODEL AIRCRAFT

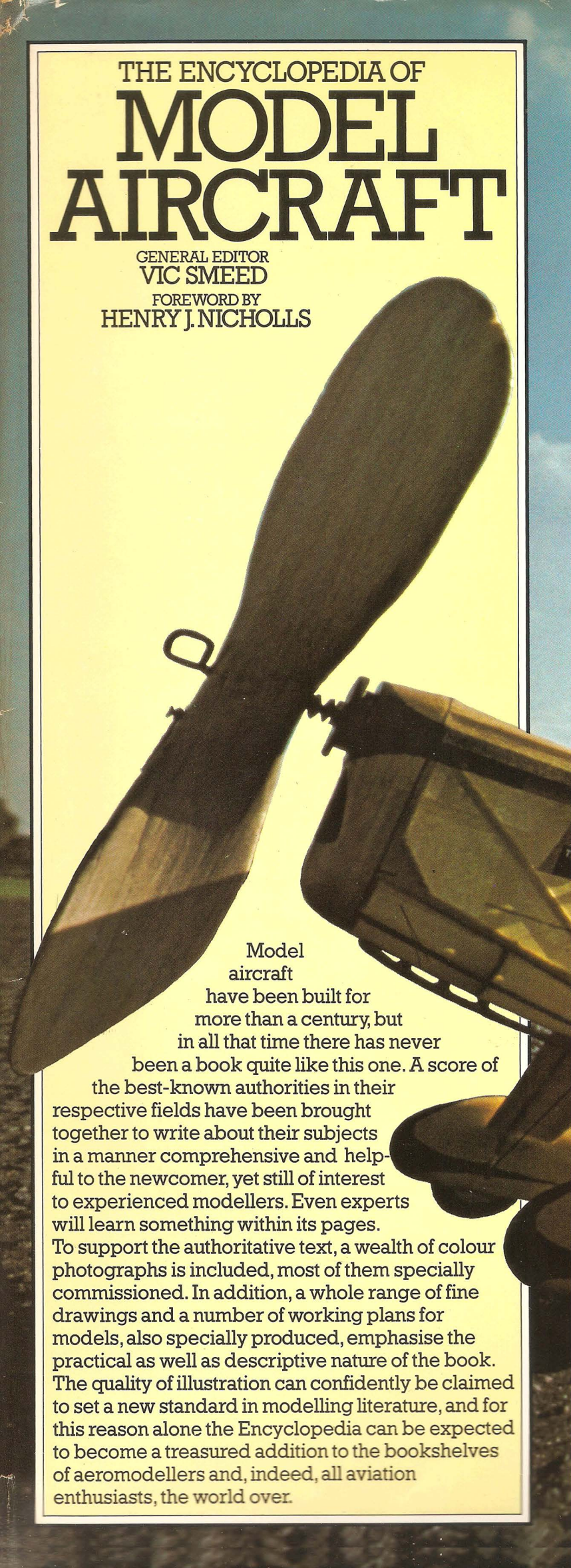


GENERAL EDITOR
VIC SMEED
FOREWORD BY
HENRY J. NICHOLLS

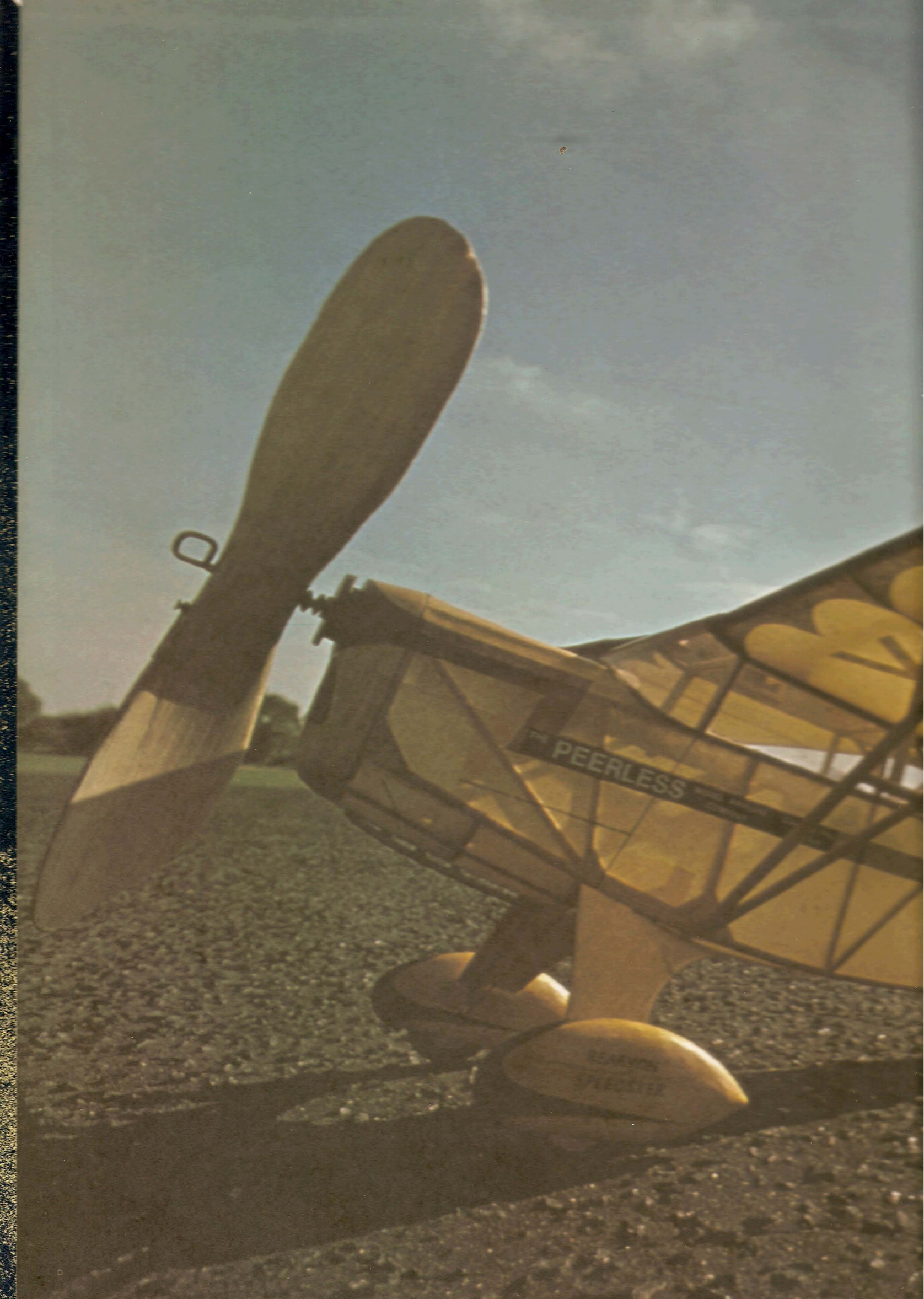
THE ENCYCLOPEDIA OF MODEL AIRCRAFT

GENERAL EDITOR
VIC SMEED

FOREWORD BY
HENRY J. NICHOLLS



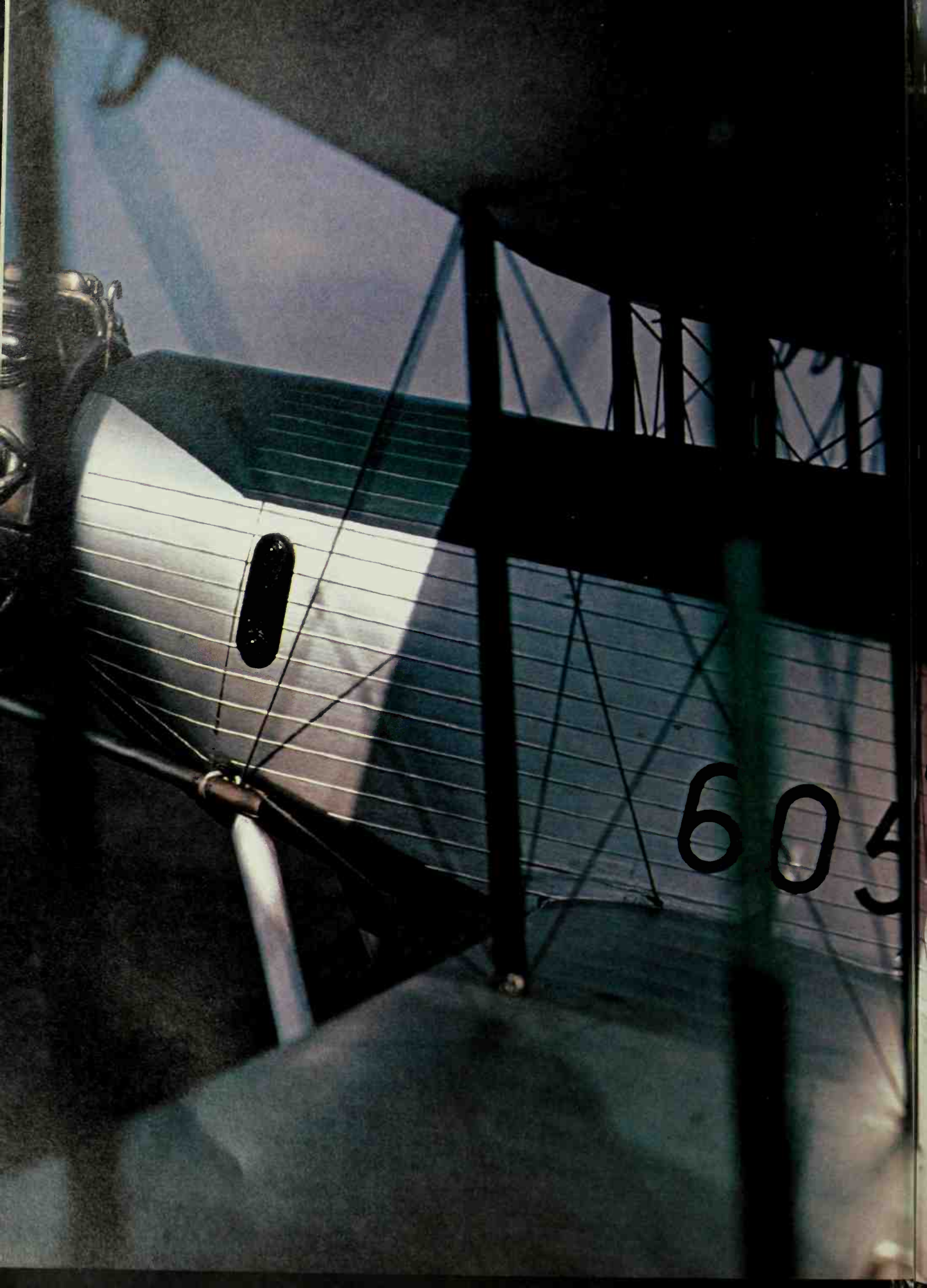
Model aircraft have been built for more than a century, but in all that time there has never been a book quite like this one. A score of the best-known authorities in their respective fields have been brought together to write about their subjects in a manner comprehensive and helpful to the newcomer, yet still of interest to experienced modellers. Even experts will learn something within its pages. To support the authoritative text, a wealth of colour photographs is included, most of them specially commissioned. In addition, a whole range of fine drawings and a number of working plans for models, also specially produced, emphasise the practical as well as descriptive nature of the book. The quality of illustration can confidently be claimed to set a new standard in modelling literature, and for this reason alone the Encyclopedia can be expected to become a treasured addition to the bookshelves of aeromodellers and, indeed, all aviation enthusiasts, the world over.





ENCYCLOPEDIA OF
MODEL
AIRCRAFT





603

ENCYCLOPEDIA OF MODEL AIRCRAFT

General Editor Vic Smeed
Foreword by Walt Schroder



octopus

First published 1979 by
Octopus Books Limited
59 Grosvenor Street
London W1

© 1979 Octopus Books Limited

ISBN 0 7064 0988 4

Manufactured in United States of America



Contents



Foreword

1. History of Model Aircraft Vic Smeed	8	8. Radio Control Equipment Bill Burkinshaw	120
2. Plastic Kits		9. Radio-controlled Models	
World War I; Ray Rimell	16	Gliders; Vic Smeed	132
Between the Wars; Fred Henderson	24	Power and Sport; Peter Russell	140
1939 to the Present; Bryan Philpott	28	Helicopters; John Barnard	148
3. Building in Plastic		<i>Plans—Quasar Free Flight Power Model</i>	154
Plastic Card; Harry Woodman	34	10. Electric Flight George Bushell	158
Vacuum-formed Models; Ray Rimell	42	11. Flying Scale Models	
4. Models in Other Materials		Free Flight; Alan Callaghan	170
Wood and Metal; Fred Henderson	46	Control Line and	
Industrial Models; Ron Moulton	52	Radio-controlled; Dennis Thumpston	178
5. First Steps in Flight Dave Linstrum	56	12. Materials and Building Techniques	186
<i>Plans—Asteroid Chuck Glider</i>	66	Ian Peacock	
Building a Simple Kit; Martin Dilly	68	13. Engines Ron Warring	196
6. Free Flight		14. How to Fly Vic Smeed	212
Competition Power Models; Martin Cowley	74	Glossary Vic Smeed	
Rubber and Glider Classes; John O'Donnell	82	Index	
Indoor Flyers; Mike Fantham	88		
<i>Plans—Meteorite Tow-line Glider</i>	92		
7. Control Line			
Basic Trainers; Glen Alison	96		
Team Racing; Dave Clarkson	108		
Speed and Combat; Peter Richardson	112		
<i>Plans—Pulsar Control Line Power Model</i>	118		

Foreword

I would not believe it possible, after more than forty active years in the model aircraft hobby and having read most every book written on the subject, that I could find another that could hold my interest for any reasonable period of time. I did however, with the *Encyclopedia of Model Aircraft*.

It covers every major facet of the model aircraft field of endeavors in good, even great depth and is compiled in such an interesting manner as to hold your attention right to the very end. Even on such subjects that may have never drawn your interest before!

In my more than thirty years of editing model aircraft material of many categories, it is difficult to work up



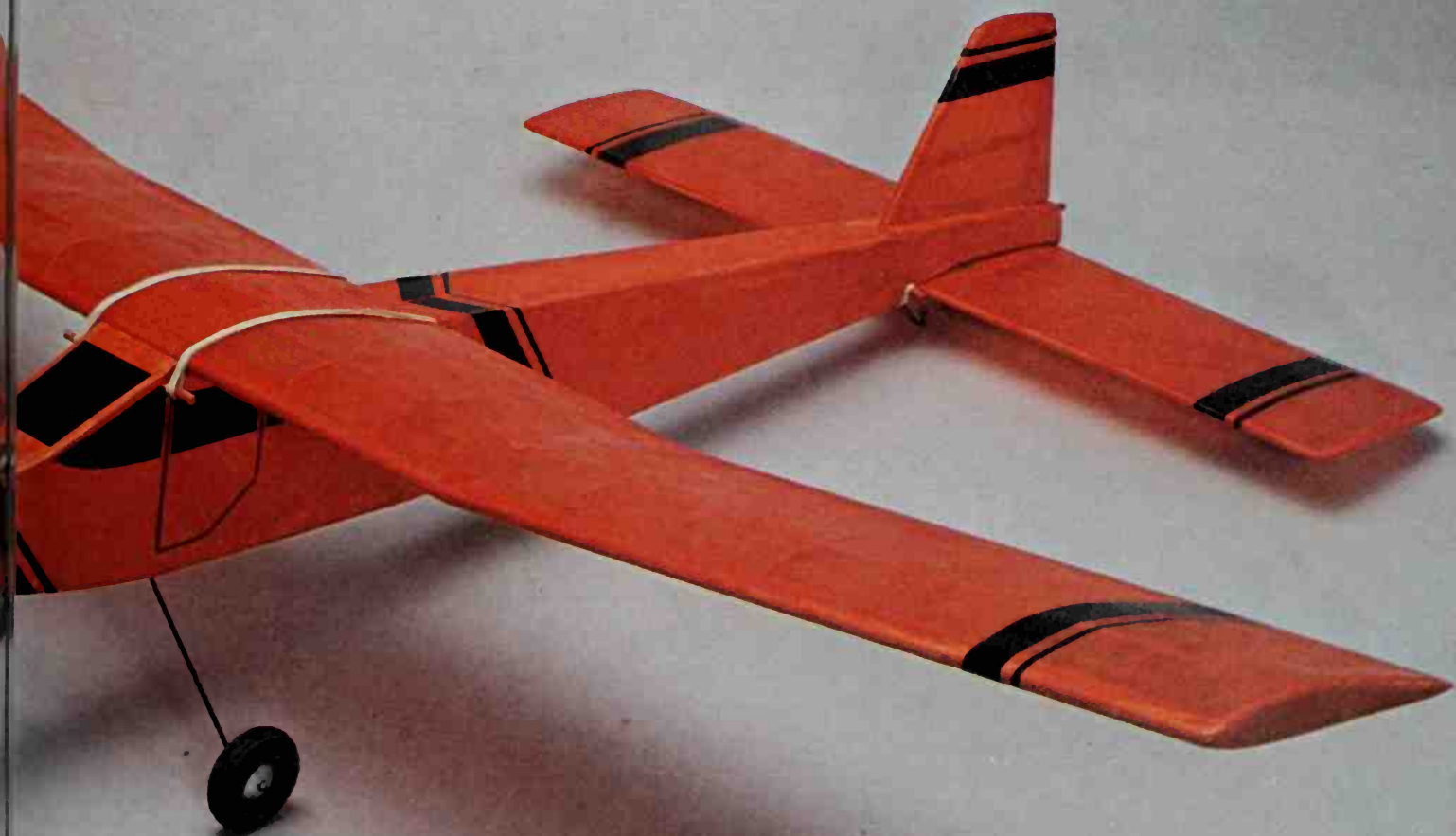
enthusiasm, but I found something in each of the chapters that held my attention to its finish, and holding an editor's attention is a real challenge for any publication.

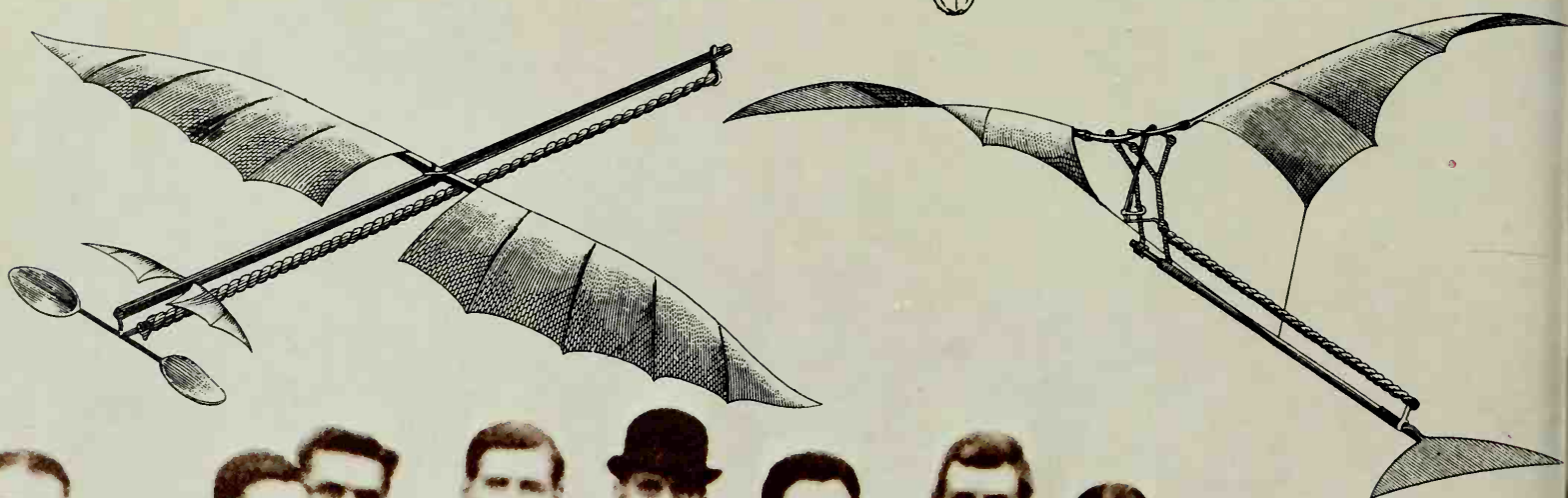
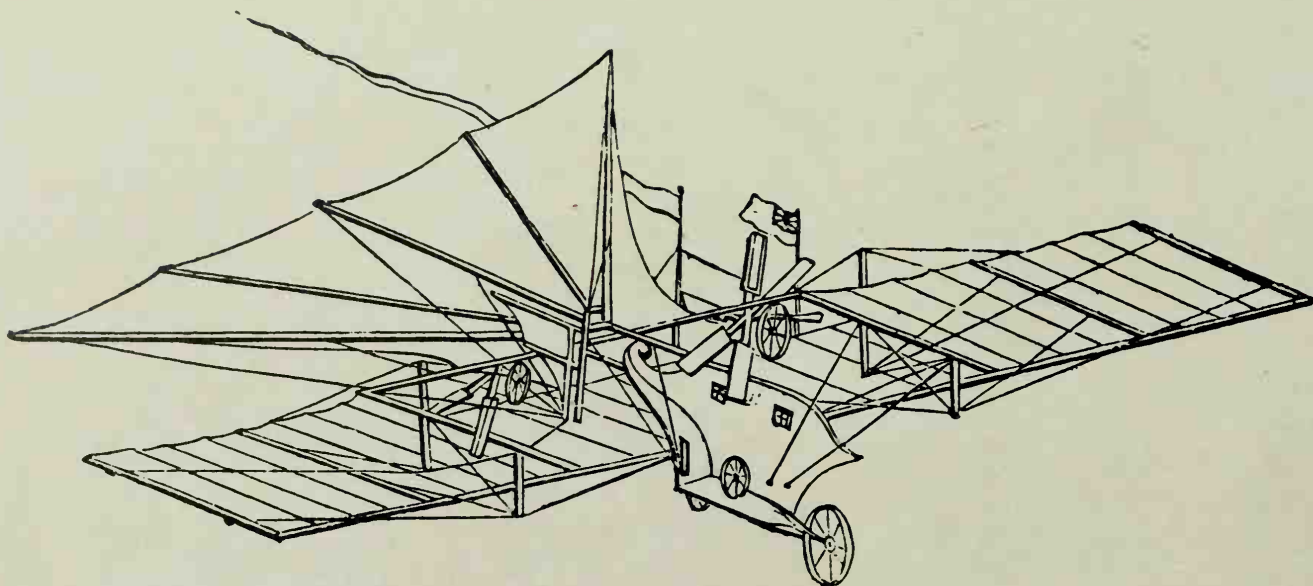
Vic Smeed is to be complimented on the selection and organization of the varied contributions of those selected to add their expertise to this volume.

It should do much to continue the upward movement of this very complex hobby sport which requires the expertise and knowledge incorporated in this encyclopedia. It will find a very important place in this always growing and ever more sophisticated aircraft modeling hobby!

Walter L. Schroder

Walter L. Schroder
Publisher Model Builder Magazine





History of Model Aircraft

Reproductions of contemporary engravings on opposite page show, *top*, William Henson's 'Aerial Steam Carriage', a full-size project based on the successful Henson/Stringfellow model of 1848, *left*, Alphonse Penaud's 'planophore' rubber-powered model of 1871 and, *right*, a practical ornithopter, also by Penaud, which flew in 1872. The photograph *below* shows a meeting of the Bristol Model Aircraft Club in 1913. Models are mostly twin pusher propeller A-frames, but one tractor type is visible at extreme left.

Man has always been fascinated by flight, as is evidenced by the mythology of early civilizations and the work of artists through the centuries. The remarkable Leonardo da Vinci, who is believed to have made a successful model helicopter, was the first to leave a record of possible designs for flying machines, one or two of which could well have proved sufficiently successful to have encouraged further development. Other figures of history were less practical, for example Roger Bacon, who wrote a specification in 1250; he was convinced that air had an upper surface, on which a sufficiently light vessel would float. In 1670, Francesco de Lana wrote of experiments he had made with balloons, but he did not proceed because he felt that attempts to

navigate the air might be regarded as impious and he also foresaw, with astonishing clarity, the effects of air raids.

Successful flight was achieved in 1783 by the Montgolfier brothers, using a hot air balloon, and balloons flew extensively for the next hundred years or so. Navigable balloons proved something of a problem, however, until the practical development of semi-rigid balloons and power units of moderate weight for the amount of power developed. Before this, balloon flights relied on wind direction, and it is of interest to mention that the first aerial crossing of the English Channel was achieved by Blanchard and Jefferies as early as January, 1785.

Heavier-than-air machines were inhibited to a large extent by the



conviction that flapping wings (ornithopters) were necessary, and the inability of a man's muscles to provide adequate power. The first successful heavier-than-air flight was by a 3m (10ft) wingspan steam-powered model weighing a little under 4kg (9lb) built by Englishman John Stringfellow in 1848. This model was the fruit of cooperation between Stringfellow and William Henson, and the latter's patent of 1842 covers virtually all the elements of a present-day aeroplane.

The next successful pioneer was Alphonse Penaud, a Frenchman who produced a number of model designs employing rubber motors. His 'planophore' covered a distance of 60m in 13sec in 1871, and he built a successful ornithopter in 1872, the principles of which are identical with those used by such models today.

Successful man-carrying flight is normally ascribed to the work of Otto Lilienthal, who was the first person to study gliding flight scientifically, and whose machines would not look too out of place at a modern hang-gliding gathering. Lilienthal's actual flights began in 1893 and he died following a gliding accident in 1896. Percy Pilcher had travelled from England to Germany and made flights on Lilienthal's machines; his first design flew in 1895 and he was readying a machine for power installation in 1899 when he too sustained fatal injuries in a gliding accident.

One other 19th century pioneer should be mentioned, Sir George

Cayley, known as the Father of British Aeronautics, and who is considered by many authorities as the true inventor of the aeroplane. He built the first of a series of model gliders in 1804, and recent experiments, which included the building and flying of a man-carrying glider from sketches and details in his notebooks, lend substance to the claims that he had built and flown (with his chauffeur as pilot) a successful man-carrying glider some sixty years before Lilienthal. Cayley conducted aerodynamic research years ahead of its time and is credited with early discoveries on airscrews, cambered wings, stability, and even streamlining.

The first outdoor free flight by a power model (Stringfellow's having flown in a disused lace factory) was made in 1896 by Professor S. P. Langley in the USA; Langley then scaled the machine up and in 1903 two unsuccessful attempts were made to fly it with C. M. Manly at the controls. Although the failures were clearly due to the launching gear, Langley's backers refused further financial help and the project stopped. In 1914 Glenn Curtis borrowed the machine from the Smithsonian Institute, replaced the fabric, mounted it on floats, and flew it without difficulty.

Orville and Wilbur Wright became interested in, particularly, Lilienthal's work and built a glider in 1900. Their experiences with it led to construction of a wind tunnel, and a second glider was made in 1902, incorporating lessons

learned with the aid of models in the tunnel. It was this machine, fitted with a four-cylinder petrol engine chain-driving two own-designed propellers, with which the first man-carrying power flights were made at Kitty Hawk, North Carolina, in December 1903.

Interest in aviation spread rapidly, and many models were made and flown in the early 1900s. Among the modellers in Britain were de Havilland, Sopwith, Fairey, Handley Page, A. V. Roe, and Camm, all to become household names in full-size aircraft manufacture. Most of the models were rubber-powered and of the A-frame twin-pusher configuration, though there were some 'spar monoplanes', or what would nowadays be called stick models. One or two clever model engineers produced successful small petrol engines in the 1908-1914 period, notably, for aircraft models, the Stanger and Bonn-Mayer engines, but apart from one or two individuals, gliders seemed to hold little interest. There was sufficient activity for a semi-national body, the Kite and Model Aircraft Association, to run competitions, and the first Wakefield Cup was presented in 1911 by Sir Charles Wakefield. There was even a short-lived magazine, the *Amateur Aviator*, which first appeared in 1912, though the model sections of *Aero* and *Flight* magazines and the *Model Engineer* were the widest-read sources of information.

The materials used in model construction then were usually birch



strip and veneer, spruce, sometimes piano wire or bamboo, and oiled silk covering. Wings were usually single-surfaced, with ribs steamed in a jig, and propellers were 'bent-wood', i.e. steamed to shape from fairly thick veneer. If the propeller was at the front, it was a tractor, if behind, a pusher. Flights were most frequently hand-launched, but ROG (rise off ground) records were separately categorized, covering duration or distance for any model, 'hydro off water', and 'single tractor screw spar model'.

In France in 1911 the Godfroy brothers flew a model with a V-twin petrol engine for five laps, tethered to a pole, and in 1914 D. Stanger set a free-flight petrol-engined model record (51sec!) in front of Royal Aero Club observers at Hendon; this record stood till 1932. The model was a 2135mm (7ft) span tail-first biplane weighing 5kg (10½lb) with a V-twin engine weighing about 1250g (2lb 12oz).

One other form of power became available before the 1914-18 war, and this was the compressed-air engine. A small, usually three-cylinder radial engine was fed with air from a large but very light brass foil tank, which was usually wire-wound for strength and often com-

Meeting of the Air League in the London area in 1909. Models are Twining type with double stick fuselages.

Compressed-air models on Wimbledon Common in 1924. Air tank size is noticeable. Rarely seen today.

pressed the fuselage itself. Air was pumped into the tank with a motor-cycle tyre pump. A record flight of 67.6sec was set with one of these engines as late as 1929.

The Great War, while interrupting model development, created much greater air-mindedness, and the London Model Aeroplane Society, revived from pre-war, changed its name in 1922 to the Society of Model Aeronautical Engineers and succeeded the K. and M.A.A. as the national governing body. One of the early Presidents was Air Vice Marshal Sir Sefton Brancker, the Minister for Civil Aviation, and it was he who approached Sir Charles (later Lord) Wakefield in 1927 on the matter of an international trophy. The earlier cup, last competed for in 1914, had been lost, and an international trophy was sought following the visit of a small British team to Philadelphia in 1926. Sir Charles presented a splendid cup, which became the most prestigious international award for some thirty years, and is still competed for today.

At this time, materials for modelling had remained almost unchanged, though ply and cellulose-doped Japanese silk had joined the list; geared rubber motors, usually using small clock gears, were being used by experts, and the first kits for flying models were becoming established. Gears had first been introduced in 1914, the year in which covered fuselages began to be noticed, but the progression to

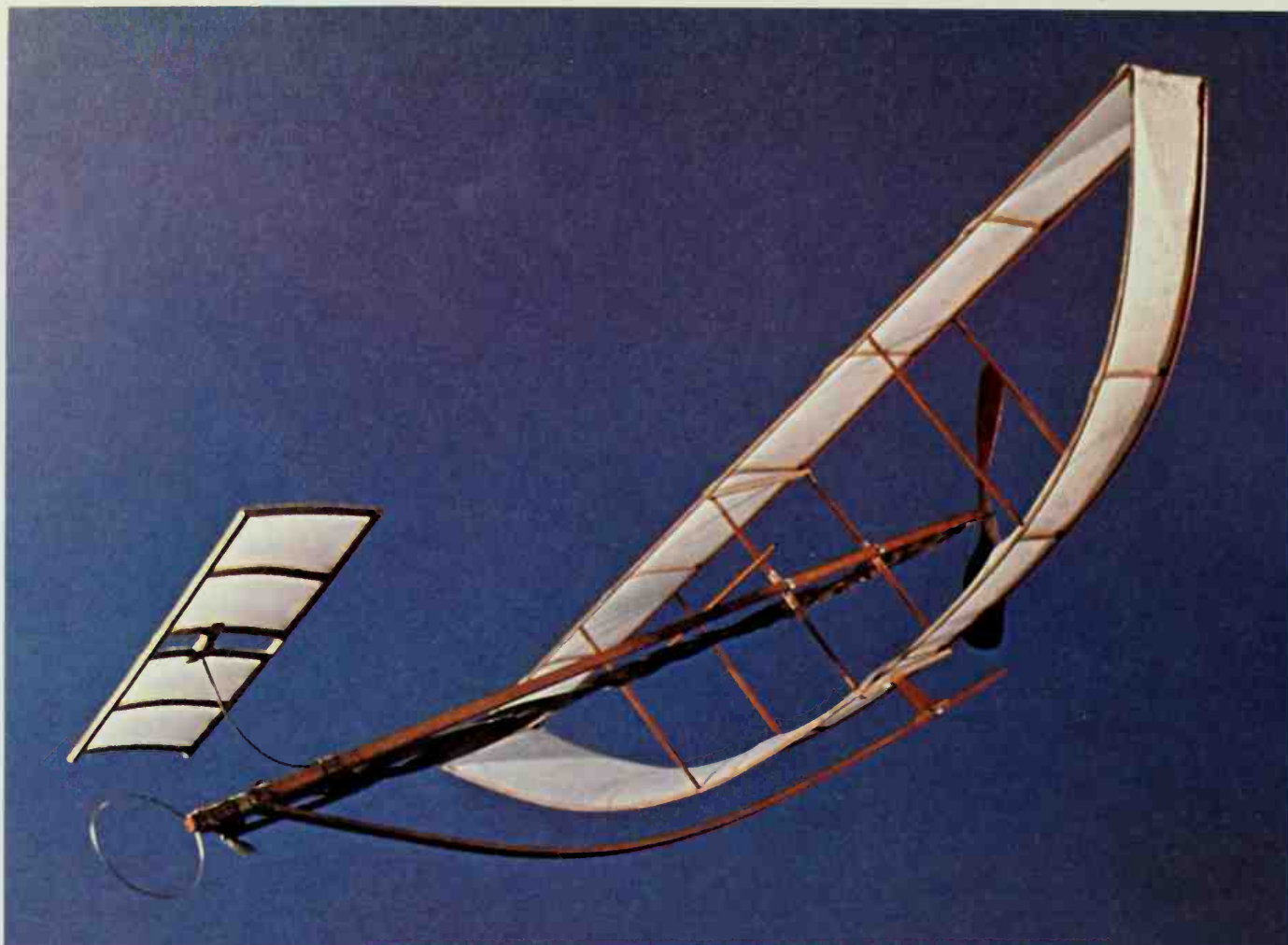
geared, fuselage models was very slow. In terms of durations, flights had crept from about 40sec in 1914 to 60sec in the late 1920s; the first competition for the Wakefield Cup in 1928 was won with a flight of 52.6sec (T. H. Newell) and the 1929 event with 70.4sec (R. N. Bullock).

A revolution was about to occur, however. Records of early activities in other countries are difficult to trace, but aeromodelling was gaining ground in most European countries and all English-speaking countries, especially the USA. In the late 1920s, balsa structure and tissue covering appeared in America, and someone discovered stretch-winding of rubber motors. These techniques were used by Joe Earhart to win the 1930 Wakefield Cup event for America with a best flight of 2min 35sec, using a straight-forward model of balsa/tissue construction which weighed only 70g (2½oz) against the 230-280g (8-10 oz) of the other competitors. Conditions were blustery and so relatively flimsy a machine had been given little chance, so the shock can be imagined!

Conversion to balsa, tissue, and ungeared single-skein motors turning large propellers was rapid and almost total, but America again won the Cup in 1931 (4min 24.8sec). The competition was declared null in 1932, won by Britain in 1933, 1934, and 1936, America in 1935, 1938, and 1939, and France in 1937.

Petrol engines began to reappear in 1932/3, mostly large by today's standards (15-30cc) until the intro-





duction in 1934 of the famous Brown Junior 9cc motor, in America, followed soon after by the 6cc Baby Cyclone, also American, and the then tiny 2.3cc Elf, which originated in Canada. They caused a rapid tightening of rules, since on both sides of the Atlantic there was initially nothing to prevent such engines entering the established rubber powered events!

Glinters, or sailplanes as they began to be called, also returned in the early 1930s, a leading influence being the German, Horst Winkler. Rubber-powered free-flight speed models enjoyed a vogue, and there were experiments with autogiros, indoor models, steam power, flying boats, and many other slightly off-beat types of model, as well as the first steps into accurate scale flying models.

Increasing numbers of kits became available; in Britain a 500mm (20in) model kit could be bought for 9d (4p) and a 1270mm (50in) rubber model kit for 5/- (25p). Equivalent kits in the USA were 15 cents and \$1. Engines were more expensive, from about £10 in Britain and \$20 or so in the USA. Specialist model shops began to appear, often relying on mail order, and manufacturers proliferated. A majority of

these were one or two-man businesses, established by enthusiasts, and many of today's major model firms stem from such small beginnings. Regular monthly magazines devoted solely or primarily to model aircraft began publication in several countries, and model flying clubs by the score came into existence. Sunday flying became a regular summertime pastime.

Successful radio controlled flights were made in 1936/7, though they were not the first ever, since in the 1920s a radio controlled airship was used as a music-hall turn. This

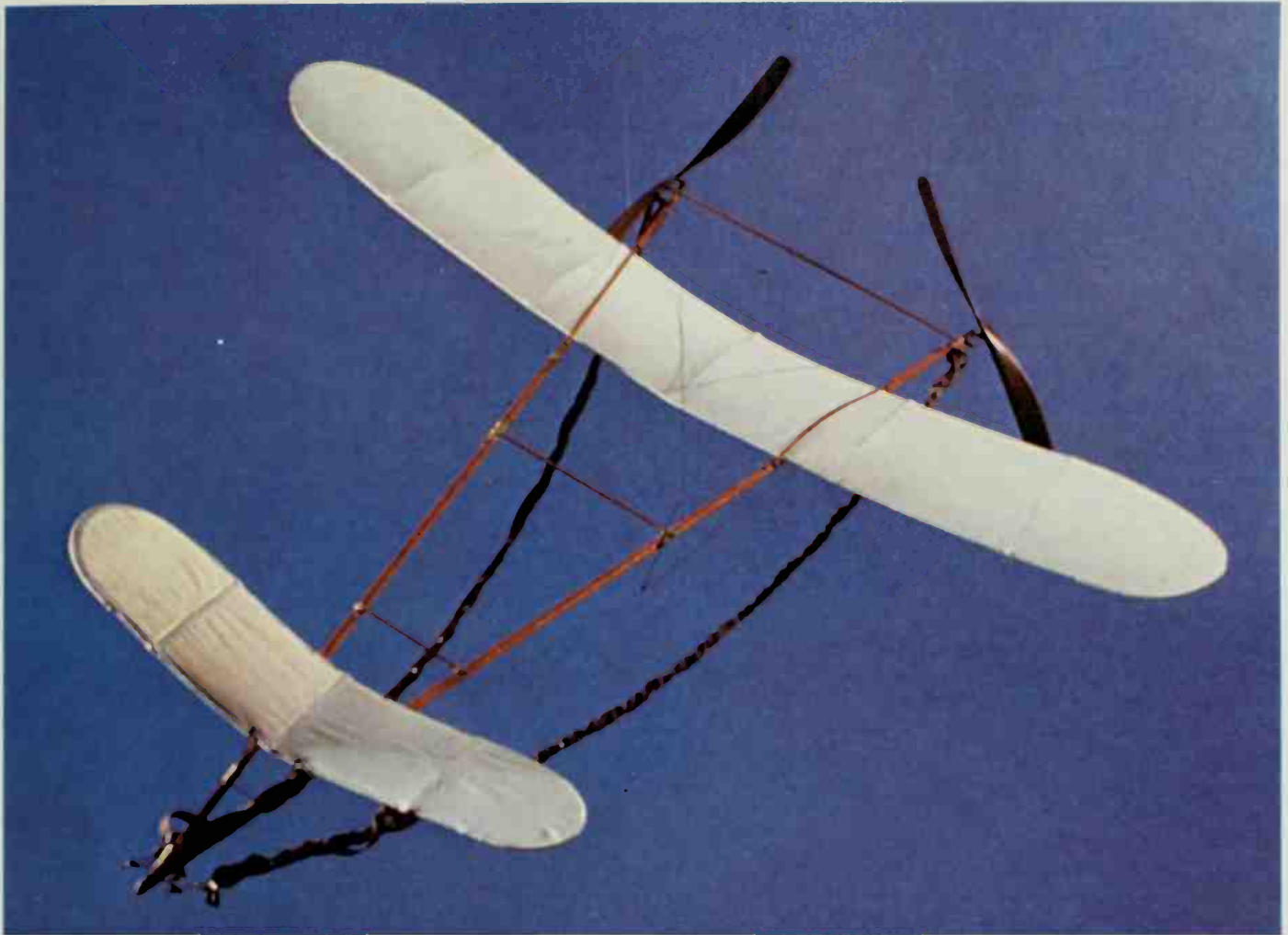
Above: Well-known in its day was the Bragg-Smith single pusher of 1912. This model is a faithful replica.

Below: An early commercial model, sold ready to fly, was the 'Skysail' spar tractor of 1927-8.

Opposite top: the original A-frame built by D. A. Paveley in 1926 which won national trophies in 1926, 1927 and 1928 and was the first model sent to America for proxy flying.

Opposite bottom: Stanger V4 petrol engine built in 1906 and flown successfully in 1908.





model used a spark transmitter and coherer receiver and dropped sweets and occasional bank notes on the audience! The 1936 aircraft used valve (tube) equipment which was heavy and at times temperamental, but these pioneer attempts led ultimately to the marketing, fifteen years later, of reliable commercial radio control equipment and today's miniature sets.

International competitions were getting into their stride, with as many as eight nations attending and others sending models to be flown by proxy, when World War 2

broke out. All large models, and any with petrol engines, were banned in England, and competitive activity virtually ceased here and in Europe. The war, however, made many more people conscious of the air, particularly the younger age groups, and with the need for aircraft recognition and the help afforded by scale models for this purpose, the number of modellers actually increased during the years between 1939 and 1945, despite shortages of ideal materials.

America was more fortunately placed and two major developments occurred there during the war years, the introduction of control-line flying, which opened up a vast new area of model operation, and the invention of the glowplug, which removed the need for heavy and sometimes unreliable ignition equipment for model engines. At the same time, the so-called 'diesel', or compression-ignition engine, was developed in Switzerland, achieving the same purpose.

The immediate post-war years saw an enormous surge of interest in model flying. Though rubber power maintained its following, it was soon equalled and surpassed by towline gliders, free-flight power models, and control-liners. The die-

sel engine, which never really caught on in America, reigned supreme in Europe for several years, with innumerable examples flowing from small manufacturers in, particularly, Italy, France and Britain. Another form of power plant made a brief appearance – the pulse jet, which produced a blast of noise audible for some 5km on a still evening, and control-line speeds of some 250kmh (160+mph). In contrast, RTP (round the pole) rubber models, flown tethered indoors, enjoyed a brief vogue. These were developed late in the war, and flights of three or four minutes were possible. International meetings restarted, with 20–25 nations participating.

Commercial radio control equipment started to appear in 1950, and immediately another whole new dimension was added to the hobby. Initially, only one model could operate at a time, due to mutual interference, and the sets were heavy and sometimes temperamental. Transistors were virtually unknown to most people at the time, but within three or four years they were being incorporated in model gear, and technology advanced at an ever-accelerating pace.

The last, and very recent, innovation is electric power. A model



powered by an electric motor made a short hop seventy years ago, and electric RTP models were demonstrated in 1946. There were electric free-flight kits on sale in 1948, but practical and consistent electric flying for the average modeller, tethered, free-flight, or radio-controlled, has only been developed over the last ten years.

Nowadays the intending modeller can be bewildered by the number of avenues to explore in the world of aeromodelling, and it may therefore be helpful at this juncture to categorize the various aspects. There is one immediate division, flying or non-flying. The latter is now dominated by the injection-moulded plastic kit, but there are devotees of traditional wood and metal construction, vacuum-formed plastic kit modellers, and a growing number who build from plastic card and strip. Almost all non-flying models are scale representations of full-size aircraft, but occasionally a builder will experiment with a 'dream machine', or build a replica of only part of an aircraft – perhaps a section of a wing showing the structure with the installation of cannon and necessary ancillaries. Most models fall into one or other of the recognized standard scales, but occasionally large and detailed non-flying aircraft are seen.

Flying models are basically separated into three main groups:

- (i) Free-flight – rubber, glider, power, scale or functional.
- (ii) Control-line – stunt, speed, team-racing, combat, scale.
- (iii) Radio control – power or glider, scale or functional.

Unfortunately it is not quite as simple as this, as each broad group sub-divides. Thus a glider, either free-flight or radio, may be intended for slope-soaring or thermal flying; it can be for either if it is a scale model. There are sport models in each category as well as competition models, and the latter are divided into various classes for different contests. These classes are set out in the following chapters, and it is perhaps therefore sufficient at this point to define the term 'sport model'.

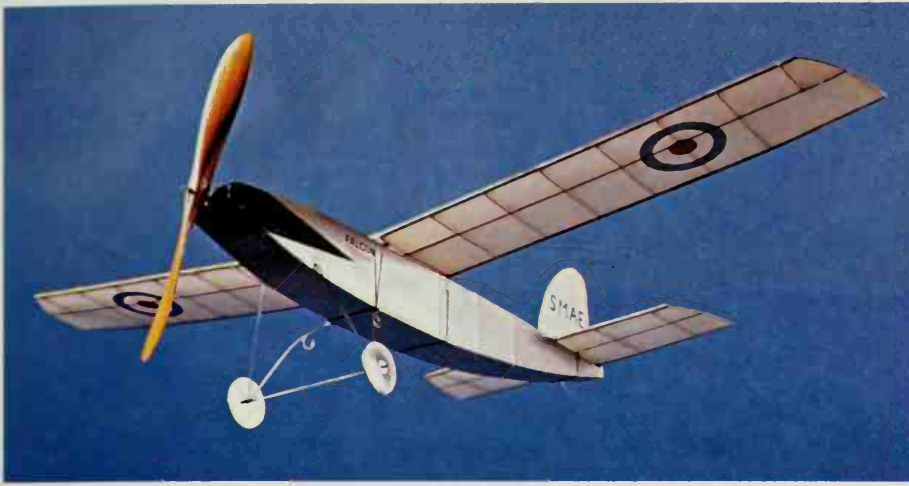
Serious competitive flying appeals to a relatively limited proportion of aeromodellers – 5% is a figure which has been suggested – and thus compares with, say, yacht racing, which is indulged in by only a small number of those who enjoy pottering with boats. Competitions normally produce the advances in design and the new materials and

techniques which create progress and which filter down to improve all models, but regular participation in competitions demands dedication and expenditures in time and money (not least in travelling to the events) beyond the average modeller, whose pleasure comes from a weekly trip to the nearest flying field and who, if persuaded, may have a go at the local club's spot landing event as the limit of his competitive ambition. This enthusiast flies for fun, and in many cases prefers a simply-maintained, rugged and long-lived model of moderate performance to

a highly-tuned, sensitive, and possibly more expensive contest model. A sport model may therefore be a model designed specifically for fun flying, or possibly training, or it may be, effectively, a detuned version of a competition model.

What sort of person constitutes the average modeller? Surveys over a number of years indicate that the average age is 23, and this is an indication of the number of older people who retain an interest, since about a quarter of all aeromodellers are still at school or college, even omitting plastic kit builders. Flying





Above: Accurate replica of T. H. Newell's *Falcon*, winner of the first Wakefield Cup competition in 1928, built by Lt Cdr Alwyn Greenhalgh, official historian to the SMAE.

Below: A modern non-rigid airship model, radio-controlled but usually flown in a large hangar.



models can be exciting and offer a challenge to young people; furthermore, the number of tools required is very small, and reasonably quick results can be obtained. Increasing numbers of schools are encouraging modelling as part of practical work or as an extra-curricular activity.

There is a gap in the 20-30 age group, the decline in active modelers being attributed to marriage and home-making, but considerable numbers return to building and flying in their 30s and many pursue their interest into their 60s and 70s. Modellers come from all walks of life, but a noticeably high proportion are professional men, doctors, dentists, architects, solicitors and so on, who find relaxation from the stress of everyday life in model construction and operation. As would be expected, a lot of engineers, particularly from the aeronautical and electronics industries, are enthusiasts, but the butcher and the baker derive as much enjoyment, and can be just as competent, as their scientifically qualified club-mates.

Aeromodelling offers a challenge and the opportunity to develop manual dexterity, planning and foresight, powers of observation and mental calculation, and patience. It teaches simple aerodynamics, how to read a plan, the use, advantages and limitations of various materials, even simple stress laws and meteorology. As a pastime it is healthy, exciting and satisfying (if at times frustrating!) and it has therapeutic qualities; it encourages craftsmanship and the appreciation of skill. It can be regarded as a hobby or as a serious sport, and it can be enjoyed on an outlay of a few pennies a week or on a millionaire level. Not an unimpressive catalogue for an amateur pursuit!

Professionally, models are extensively used in scientific investigation, from solid wind-tunnel models to accurate radio-controlled scale machines used to establish, for example, the safest technique for ditching a particular full-size design. Models played a large part in solving the Comet disasters and in correcting a particular spinning characteristic of the Javelin fighter; they are used militarily as R/C targets and visual range R/C missiles, and quite extensive use is now being made of them for meteorological and monitoring purposes. Non-flying models play a major part in livery design for airlines, as publicity and sales aids, and of course, for record purposes, as in museums.



Plastic Kits

World War I

Between the Wars

1939 to the Present

Typifying the colourful biplane fighter, this Bristol Bulldog is made from a $\frac{1}{48}$ scale plastic kit originally produced by Impact but more recently available from Life-Like. Kits in $\frac{1}{72}$ scale for this aeroplane are also made. *Model by F. Henderson.*

Despite the fact that most plastic kits are easy to assemble, there are still several basic rules that may prove useful, and it is hoped that the following suggestions will help improve modellers' skills. Before attempting to build any plastic model aeroplane kit, one should first wash all parts in soapy water, which serves to remove the mould release oil from the components. The cleaning is important because it reduces static, found on most plastics, and aids adhesion of paint and cement. Once dried the components should

be cut from the 'trees' that hold them together in the box. Never be tempted to break pieces off, as they are easily damaged and will demand unnecessary filling or repair later.

Assembly

Fuselage halves are usually the first major item to be assembled and all interior detail is best added and painted beforehand. Most aircraft kits now include interior parts, although there will be room for improvements. How much detail should be included depends on the



skill of the modeller and the degree of reference material available.

When cementing fuselage halves together, always apply glue to the mating edge of one or both sides and bind the parts together with tape until the adhesive dries. Usually this takes about 24hr before the joint is really firm. The joint line must then be completely removed by scraping with a knife blade, or alternatively filed, but always finishing up with wet and dry paper liberally lubricated with soapy water.

During the building of the model it will become obvious that some parts fit badly, leaving gaps that will require filling and smoothing if a neat job is the aim. There are a number of proprietary brands of modelling filler on the market and most work reasonably well if carefully applied. Many modellers have found, however, that interior Ready-Mixed Polyfilla (a plaster filler for home decorators) is a more suitable alternative. It is easily applied and sanded and does not melt or attack plastic as some other fillers do if applied too liberally.

Always follow the manufacturers' instruction sheets carefully; only when experience grows can one proceed to assemble the model in-

dependently. Test fit each component before actually glueing and never rush a stage, but work carefully and thoroughly. It is worth bearing in mind that polystyrene adhesive fails to work on painted areas. When pre-painted parts are ready to install, scrape off any paint that might have strayed onto the glueing area.

It is a common 'fault' of aircraft models that items are moulded too heavily, undercarriage doors and wing trailing edges usually being the first to suffer. The latter can be filed and sanded down, but undercarriage doors are best replaced by cutting replacements from thin plastic sheet. The original kit part can be used as a template before it is discarded.

Biplane subjects can be a cause of headaches during assembly, but care and common sense can render construction of these types no more difficult than a sleek jet fighter. The most important point to consider is whether wings and fuselages should be finished, painted, and decals (transfers) added before assembly. There is nothing more difficult than trying to wield a paint brush around the inside of engine cowls or applying decals to a fragile structure supported merely by fine struts. On

most model aircraft, important details (including aerals, wheels, undercarriage doors) need not be attached until the aircraft is almost finished. Again it is advisable for small parts to be prepainted before assembly.

Undercarriages are all important. If the model is to be represented on the ground, oleo legs should be reduced in height and tyre bases flattened. The latter is easily accomplished by heating gently then pressing onto a flat hard surface. The walls of the 'tyre' should bulge quite realistically as a result.

Painting and finishing

Before attempting to paint the model, major components should be more or less completely assembled (except as above) but with all detail parts left unfitted and clear parts masked, if spraying. Paints – always enamels – should be rigorously stirred and thinned too. Aim for a consistency akin to milk and ensure the paint is devoid of lumps and dust. Always work the brush (choose a fine sable) in one direction at a time and avoid the desire to cover in one coat. At least 12 hours should elapse before a second coat is applied, in case the first moves. Brushes should be washed



carefully and diligently in white spirit before storing in a light-proof box. Hairs should be protected at all costs and lengths of tube can be slipped over the shanks to achieve this.

One of the biggest problems is painting the framelines of cockpit canopies and gun turrets, and a method of achieving a realistic appearance is the use of painted stripes. Thin lines of adhesive tape or decal sheet can be made by careful slicing with a sharp knife, using a steel rule as a guide. These should be prepainted in the surrounding base colour and left to dry, after which they are simply cut to length and applied with tweezers.

If handpainting the frames is considered, at least ensure that a firm and comfortable grip of both canopy and brush is possible. To achieve this the canopy should be mounted onto a small length of wood serving as a handhold. Double-sided tape can be used for 'adhesion' and serves another purpose in that the glueing areas are kept free of paint. With the canopy easier to handle, painting should be made correspondingly so, and the result will show.

Decals are perhaps the simplest of operations and usually are the last. They should always be carefully trimmed to remove backing film and then applied to their correct positions on to the model. Forceps or tweezers are essential to transfer the smaller items, and they can be eased into final location by a soft sable brush, after which a soft lint-free cloth is used to absorb excess moisture around the decals. It is imperative that decals should never be *soaked* in water, because if this is done, the adhesive qualities will be seriously reduced and they can subsequently fall off the model. Smooth gloss finishes provide the best base for decals and many modellers varnish their creations before adding markings, regardless of the intended finish. When the decals have dried they are further fixed by more clear varnish, matt, satin or gloss dependent on the subject. Such a procedure usually results in removing all traces of untrimmed carrier film.

In order to produce really fine models and include correct details and colouring, the modeller will have to become more than just a

modeller, but an amateur historian as well. It should be important to collate photographs, magazine features and books to create a useful reference library; luckily there is a vast amount on the market.

Local libraries are rarely considered but really are a great source of reference and most volumes can be made available through them. One should always manage to collect as many references as can be afforded and subsequently file them under a sensible indexing system. But in the final analysis, photographs remain the only viable source of reference and these should be studied whenever possible. Only then will the modeller really appreciate the aircraft in question and this will reflect in the model as he strives to capture its character in miniature.

World War 1 Models

To many modellers the character and appeal of a vintage aircraft is difficult to resist, particularly of those colourful warplanes produced during the 1914-18 war period. There was a time when the range of World War 1 plastic aircraft kits offered a healthy selection of prototypes. Recently, however, the number has regrettably dwindled as

moderate sales result in moulds being 'rested' for a few years. Any hope of new WW1 subjects is really now in the hands of the vacform manufacturers.

For anyone wishing to construct some of these early types, very few subjects provide so much enjoyment in their creation – not that they are the easiest to build, but by demanding more skill from the modellers they represent a greater challenge. This is especially true when considering that many kits of WW1 aircraft are inaccurate and below current standards.

The following suggestions will be more or less applicable to any WW1 aircraft kit because there are several important and common factors to consider while building. The thickly moulded trailing edges of wings, for example, should always be refined by sanding until they are wafer thin, and the same procedure applies to wing tips, which also need reducing. Obviously this will destroy some of the wing rib detail which might as well be eradicated anyway, for few manufacturers have really captured the character of a fabric doped flying surface properly or convincingly.

Basically, new rib positions can be applied by heat stretching plas-



Left: $\frac{1}{48}$ scale Fokker DRI in authentic markings of von Richthofen.

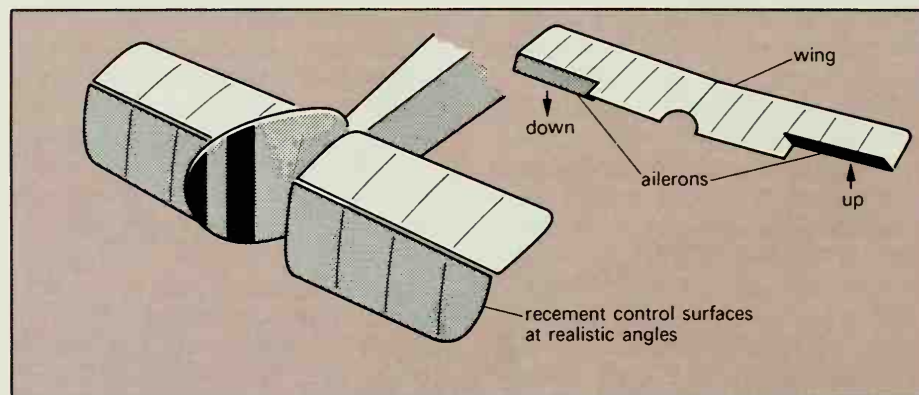
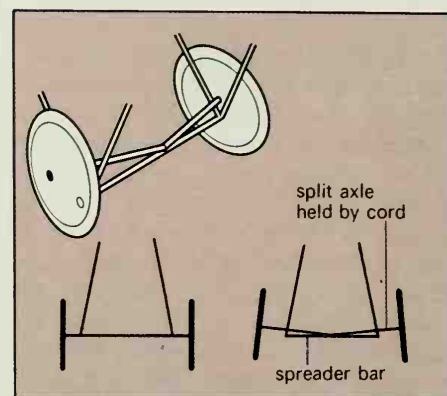
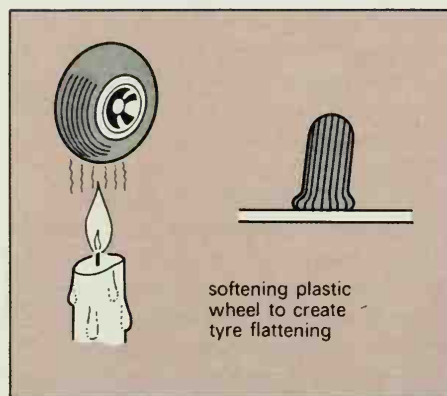
Right: Albatros DVA, $\frac{1}{72}$ scale, also in Richthofen markings, with sprue struts and rolled wire rigging. Both models by R. Rimell.

Plastic Kits

tic sheet strips to make fine 'ribbons' which can be cut up and applied to the upper surfaces of wings and tailplanes with careful amounts of liquid polystyrene cement. This also gives the modeller the chance to reposition the rib tapes correctly, for often they are moulded at the wrong angle or unequally spaced. Under the wings, the corresponding positions are marked by scribing closely spaced parallel lines for each rib with a metal point and then sanding down afterwards. Additionally, it is essential to separate ailerons, elevators and rudders and re-cement them at different – albeit realistic – angles.

Tail surfaces are rarely moulded thin enough in section and in most cases complete replacements should be considered; these can be easily cut from thin plastic sheet suitably shaped with rib tapes added and scored as described above.

Cockpit detailing is limited only by personal skill and the amount of reference material available. The character of these early types is always enhanced by interior fittings, and at the very minimum these should include a floor, seat, harness, control panel, control column and rudder bar. It is left to the real enthusiast to add more, such as internal structure, throttle quadrant, and pressure pump, all of which can be built up from stretched plastic sprue, and plastic sheet. Seats should also be replaced by scratch building, since few supplied in kits



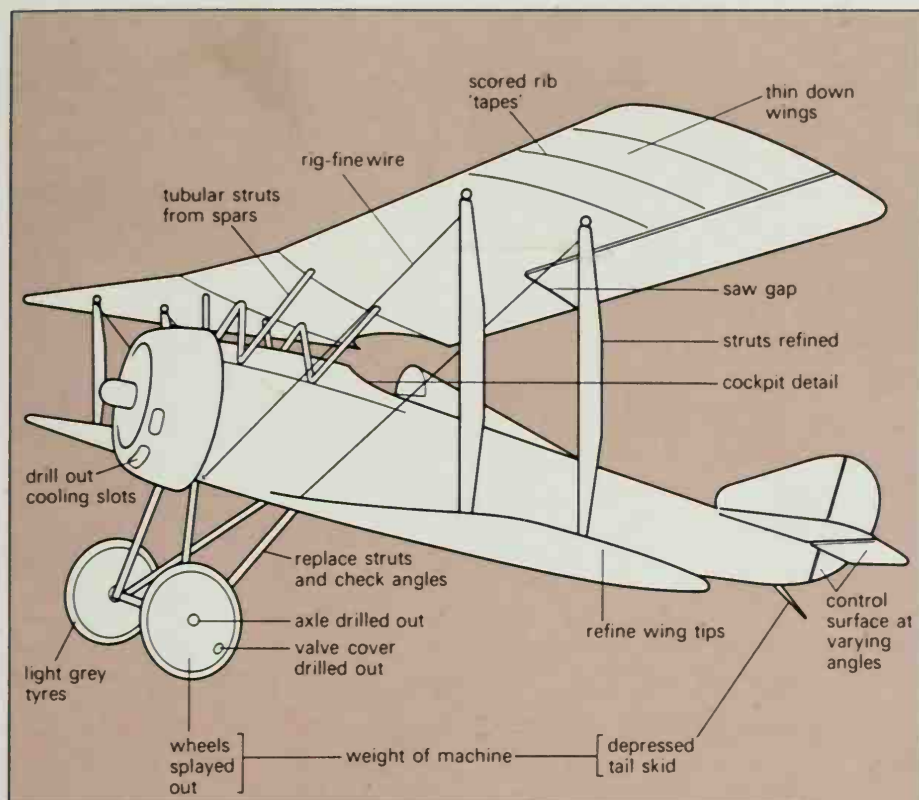
ever look realistic, usually misshapen, always oversized.

Interiors should of course be painted before and during the addition of cockpit detail, and care should be exercised to keep all colours muted. A neutral shade such as light buff or dull grey is suggested and these should always be matt. Attach each small additional component with small dabs of PVA wood glue, which dries invisibly and will not melt fine plastic, and

Above: Some of the simple modifications which can turn a lifeless plastic model into a convincing representation of an aeroplane as it actually appeared.

Below: This BE2c used a combination of DH4 wings and other components from a $\frac{1}{72}$ Airfix kit with a fuselage built up from plastic sheet, incorporating a fully furnished cockpit. The model represents the machine flown by Lt Leefe Robinson, VC. *Built by R. Rimell.*





the use of tweezers and a stand magnifying glass should be seriously considered when undertaking such fine work. The most important point to remember when modelling vintage subjects, whatever their physical dimensions, is to keep each component as *near to scale* as possible. If small details cannot be reproduced small enough they are best disregarded altogether, although there are several important components that should be attempt-

ed, such as control horns on elevators, rudders and ailerons. These can be cut from thin plastic sheet or stretched plastic sprue, depending on the shape and section of the original. Also tubular gun sights and tail struts should be replaced with rod of finer section, but little details such as these are best left aside and attached only after the model has been painted. Windcreens are rarely provided in kits and are grossly oversized when they are. Obtain thin sheets of clear plastic or stiff cellophane which can be easily cut, folded to shape and attached with PVA adhesive. Where bombs are included these simply plug into wings and fuselages, usually with complete disregard for a bomb rack. The latter can be built up with care and the bombs themselves improved by the addition of finer fins and reshaping.

The importance of thinning wings has already been mentioned, and now struts too, must come in for the same treatment. Invariably these are moulded oversize, which is a problem few tool-makers are able to prevent.

Tubular struts can be fabricated from stretched plastic sprue, which are the 'trees' that retain all the parts in a kit. The procedure is simple, for the sprue is merely held over a mild heat source such as a candle and when the plastic becomes floppy, both ends are pulled quickly apart to produce a fine strand. If the sprue is carved beforehand to streamlined shape, thin

streamlined section struts will be formed, and the same process can be used for forming louvres and air scoops of varying sections. Several aircraft types feature large-chord struts that are usually more or less accurate in most kits as far as the outline goes, nevertheless they still need reducing in thickness with leading and trailing edges carefully thinned down by sanding. At first sight sprue struts may appear weak and liable to collapse, but once the model has been rigged it is surprising just how rigid the structure can become. Just like its full-size counterpart, of course.

Exhaust pipes, gun barrels and split axles should always have their ends drilled out or replaced with fine tube which can be fashioned in the same way as sprue, though a different material is used. On many ball-point pens the ink-carrying tube, when emptied, can be heat pulled and produces quite fine tubes to create exhausts, intakes, and gun muzzles.

Always check carefully with photographs and drawings when assembling a particular aircraft, for angles of undercarriages, wings and struts are surprisingly difficult to represent, and time taken measuring lengths, angles – even setting up a jig – is well spent. Most WW1 undercarriage axles were split in the centre and flanked by spreader bars; when aircraft were at rest this resulted in the wheels splaying outwards, a feature readily apparent in many Sopwith types, for example.

One major failing with WW1 aircraft kit subjects is some manufacturers' insistence on treating main components to an 'authentic fabric finish'. This usually takes the form of a coarse stippled effect overall and is of course, pure nonsense. Fabric weave is practically invisible on the actual aircraft, filled as it is with several layers of dope, and so there is *no* excuse for representing it on any model and it should always be removed completely by gentle sanding.

Painting these early types often presents problems due to the amount of conflicting references available. In practical terms, a little careful pre-planning is essential. For instance, it is advisable to paint completely all the sub-assemblies and major parts and add decals before final assembly takes place.

Apart from the sprayed camouflage on certain German aircraft of the period, there will be little use for an airbrush when painting WW1 models. Since most will be



quite small, masking off appropriate areas could be rather tricky anyway. Brush painting is usual.

The overall 'khaki' finish coded PC10 and applicable to most British aircraft is perhaps the easiest of all to apply. But it should be noted that there was a common practice for the upper colour to wrap around the lower clear doped surfaces, giving an outlined appearance when viewed from underneath. Draughting tape can be utilized to achieve a hard line during painting this feature.

Repair patches and 'recovered' control surfaces can add extra touches and are simply applied by using a slightly paler mix of the main surrounding colour. Patches may take the form of small circles or squares but one should resist the temptation to add a great number.

In the majority of cases, two- or multi-colour disruptive patterns such as used by Germany and France were applied by hand brushing at the factory. Therefore demarcation lines separating the colours should be hard and not soft. Lozenge patterns on German and Austrian aircraft are the most difficult to achieve, especially in $\frac{1}{72}$ scale, for there were several variations in colours and patterns, and their application should be carefully researched. At least one decal manufacturer supplies a four-colour German pattern in strip form, but one must resort to handpainting the other styles. One method is to cut stencils and spray the colours through, or alternatively hand paint by number – a laborious process, to say the least!

The aluminium finishes used by French and German manufacturers can cause problems when trying to reproduce them accurately. Mixing matt pale blue with 'silver' enamel makes for easier application and certainly looks more authentic if several thin coats are carefully applied. Aim for a semi-gloss finish for WW1 models – never a *high* gloss sheen as this would be totally out of place and disastrous on small scale aircraft. Admittedly, most WW1 dopes were glossy when fresh, but toned down considerably in service use.

Engines and machine guns were very often exposed on early aircraft and so special attention must be paid when modelling and painting these items. The correct colouring of engines involves quite a lot of thought – do not be satisfied with a mere coat of matt black. Cylinders and crankcases should be painted a

dull silver grey with push rods in aluminium, and manifold pipes a dull copper. Tone down each metallic colour and when dry wash the engine with thinned deep brown enamel, to provide an 'oily' appearance. Paint machine guns in a dark grey colour with just a touch of dull silver.

A close study of photographs shows that rarely, if ever, were aircraft tyres coloured black; use dark grey instead, and very pale grey in many cases would be more accurate.

Propellers and struts, often clear varnished, pose other problems in trying to reproduce them by painting. Many more experienced modelers even carve these components from wood, alleviating the chore of careful brushwork. Where differing woods were used for laminations, a really steady hand is needed when lining in the appropriate colours. The propeller hubs are invariably a dull metal colour and don't forget that these appear on both sides – or should. Brass leading edges, sheaths and fabric covered propeller tips are easily painted on if the subject demands it.

The model's appearance, even if painted properly in the correct markings, fully detailed and cor-

rected during construction, still needs the final touch – rigging. A daunting task to many but one that is essential if the character of these early types is to be captured.

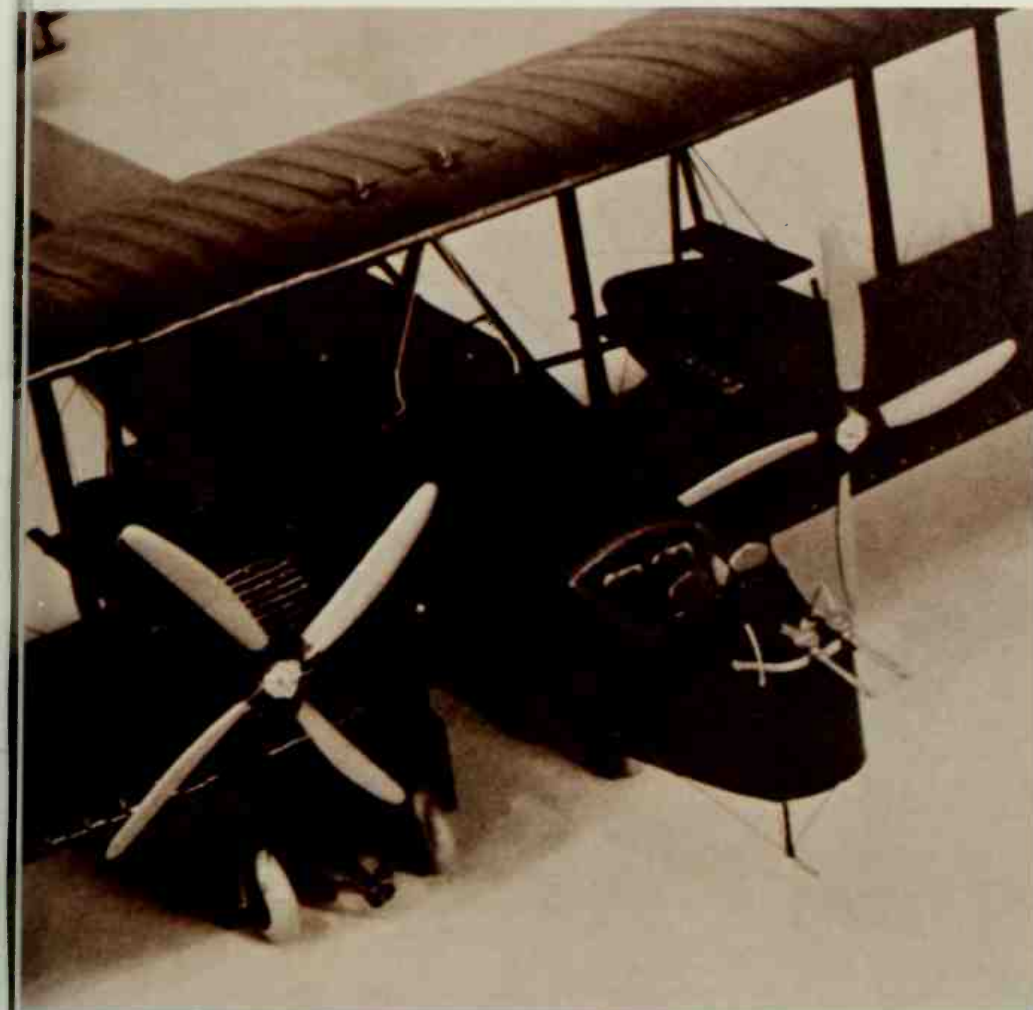
For $\frac{1}{72}$ scale models, fine copper wire (44swg) is the ideal material and can be bought in rolls from suppliers of radio and electrical equipment. It needs to be straightened out by rolling on a flat hard surface under a steel rule or by cold drawing. The latter technique involves clamping one end of a length into the jaws of a vice and gripping the other with a pair of pliers. Gentle pulling should cause the wire to stretch and remain taut.

The distance between pick-up points on the model is transferred to the wire using a pair of dividers for direct measurement. A small dab of PVA wood glue is applied to each point on the model and the wire dropped into place with tweezers. Start with the centre section struts and work outwards, care-

Below: Rumpler CIV using $\frac{1}{72}$ Airfix Hanover CLIII wings and plastic card fuselage. Airfix Roland CII behind.

Right: $\frac{1}{72}$ Handley Page O/400 with full internal detail, from Airfix kit. All built by R. Rimell.





fully applying one wire at a time. PVA adhesive is really superb for the purpose for it is quite resilient, and holds even on painted surfaces.

For larger subjects and scales, cables can be made from stretched sprue instead, but the process of application is just the same. Never, ever, use fine thread of any kind.

'Weathering' the model should be done carefully and restraint exercised with reference sources constantly being consulted. From the adjacent areas beyond the ends of exterior exhaust pipes, light stains over wings and fuselages should be applied using dark grey paint. An airbrush is really essential for this but not for the residue streaked on lower fuselages of rotary engine powered aircraft. Careful mixing of browns and ochres to represent mud also adds realism. Dry brushing the mix by careful stippling of wheels, tail skid and lower portion of the rudders looks exceptionally characteristic if not applied too liberally. But do not cake the model in mud, subtlety is the key for a convincing result.

Most WWI aircraft kits lend themselves to conversion and even semi-scratch-building, for many components provided are common to many other types. Indeed it is perfectly possible to make almost the entire Albatros fighter family based entirely on the two versions kitted. Yet others yield wings and fuselages that are simply adapted to suit the most varied of subjects. The Revell Nieuport 17 for example (now hard to find) can be changed into many types in its family, the 11, 16, 24, 27 and triplane plus of course the German copies, Siemens Schuckert and Euler D fighters. With such potential it is surprising that WWI types are now infrequently available, but in the fickle world of plastic kits, the trend may well be reversed in the future.

Displaying WWI models can be an even more enjoyable pastime if you lack neither space nor imagination. Even simple dioramas can enhance the completed model considerably and section of stubble field, a few wheel chocks, oil cans etc., scattered about plus a few figures is often more than sufficient. Taking it further, ambitious projects could involve whole squadrons, complete with staff cars, trucks, tents, hangars, and adjacent farm buildings.

The scope is unlimited, for once the techniques of building WWI types have been mastered, the modeller is usually hooked for life...

Between the Wars

Defining the era

A clear definition of the machines of the between-wars era does not come easily because its extremities are decidedly indistinct. For four or five years after the armistice of November, 1918, for both military and the emerging civil purposes, First-War machines continued in service, while new types of aircraft appearing from 1935 onwards were mostly those which were to find fame, or failure, serving the warring nations in the conflict of 1939-45.

The appellation 'biplane-era' is often given to the period; but that is clearly a misnomer for, although biplanes predominated, monoplanes were very much in evidence and by 1932-3, notably in the USA, where the Martin B-10 bomber and Boeing 247D and Douglas DC-2 transports were pointing the way to the future, the biplane's ultimate eclipse was becoming evident.

The model approach

It is a sad but true fact that the model kit manufacturers have not regarded the between-wars years as a lucrative source of subjects for their kits. There have been a number of forays of varying enthusiasm, notable among them the production, some years ago, by Inpact, of four outstandingly good kits, in $\frac{1}{48}$ scale, depicting the Bulldog, Fury, Flycatcher and Gladiator; the kits were superb but were obviously not a commercial success and the firm soon went out of the plastic kit business, the moulds passing to Life-Like from whom the kits are

still available. Airfix, Frog, Matchbox, Revell, Monogram, Heller and others have all tested the water and, apparently, achieved some degree of success with their limited ventures but not sufficient, it seems, to tempt them into wider coverage. On the other hand, the Williams Brothers, one of the smaller American companies, have made a speciality of the period and cater for the real enthusiast modeller. One of the most ambitious projects so far has come from Hasegawa who produced, a few years back, four American fighters of the early 1930s, the Boeing P-12E, F4B-4 and P-26A and the Curtiss BF2C-1 and all in $\frac{1}{32}$ scale.

The following among modellers for the twenties' and thirties' aircraft is enthusiastic but limited and thus the mass of the kits produced is angled towards the periods in greatest demand, World War 2 and the modern jets. Fortunately the vacuum-formed kit makers can remedy this, for they are involved in much smaller expenditure on their moulds and thus can undertake limited production runs. Concerns such as Contrail, Rareplanes and By-Planes produce many types of aircraft never likely to appear commercially from any other source. These kits are a vital part of the coverage of the more neglected periods of aviation. Despite the obvious neglect, it is still possible, by using all $\frac{1}{72}$ scale kits, injection moulded and vacuum-formed, so far issued, plus some simple conversions, to build more than a hundred between-wars types.

The dire need for economy in the stringent days of the early 1930s meant that the designers tended to make the maximum use of a proven design, adapting it to various tasks, and this means that the aircraft concerned are particularly suitable for conversion subjects. The De Havilland Moths are dealt with later in this chapter but others come readily to mind, such as the Hawker Hart, two-seat day-bomber, which spawned the Audax, Demon, Hardy, Hart Trainer, Hector, Hind and Osprey, all convertible, with varying degrees of difficulty, from the Airfix Demon kit. Other good examples are the Boeing P-12/F4B series and the variants of the Curtiss biplane fighters of which several can be modelled using parts from existing kits. The ultimate in satisfying an urge to possess a model which is never likely to be produced as a kit is to build it completely from scratch and the aeroplanes of the twenties and thirties lend themselves well to this advanced branch of modelling.

Adding that characteristic touch

In the days when around 192km/h (120mph) was considered a respectable speed, the need for streamlining was not of prime importance and external appendages such as bomb racks, camera guns, radiators, oil coolers and even spare wheels and propellers were attached to the

The Handley Page Heyford of 1933, last of the RAF's heavy biplane bombers. From plastic card, $\frac{1}{48}$ scale.



exterior of aeroplanes, adding to the built-in drag of the rigging, control horns and wires, fixed undercarriages and, frequently, uncowed engines. It is important, in order to give a model the true period character, to incorporate such features and, for a biplane, rigging is mandatory for any modeller truly aiming at realism; nor does it have to be too difficult, provided that it is tackled in the right way and the most suitable materials used. For very small models, probably the easiest method is to use finely stretched plastic sprue which can be cemented into place without the need for drilling holes, but it is less durable than fine nylon thread which requires holes for fixing but will better withstand handling. For larger models, fine brass wire, cut accurately to length and then stuck into place using cyanoacrylate or quick-setting epoxy glues, looks very well and is not affected by changes of temperature or humidity which can cause thread to sag. The vital thing is to choose a thickness of rigging material compatible with the scale of the model, for overscale rigging can look worse than no rigging at all.

Colourful finishes

Compared with the drabness of the war years immediately preceding and succeeding it, the inter-war period was, by and large, a colourful one and provides excellent opportunities for the modeller with an aptitude for painting. Undoubtedly the most common basic finish was aluminium, either as polished panels or painted on fabric or wood. The polished metal areas can be well represented by a rub-on

silver finish such as 'Rub-'n-Buff', but it is difficult to get a really satisfactory dull aluminium appearance for, if a brush is used, the paint tends to appear streaky and, if sprayed, too shiny. For a smooth finish, spraying is virtually essential and the brightness can be reduced by adding a little compatible matt light grey paint to the silver. There are, in fact, household types of aluminium paint available from department stores which can give excellent results and cost only a fraction of the price of specially prepared model paints; a word of caution, however, test first on a piece of scrap plastic to ensure compatibility.

In the Royal Air Force, the night-bombers were painted a dull green, known as 'Nivo', but most other types wore brighter hues and the gay unit markings of the fighters are a model painter's delight, or nightmare, depending upon his ability at hand painting! There are few commercially available transfers (decals) available for planes of our period, although Modeldecals have produced one useful sheet (Number 31) with attractive $\frac{1}{72}$ scale markings for the Bristol Bulldog, Hawker Fury, Gloster Gladiator and Armstrong Whitworth Siskin, all of which are available as kits. Numbers and letters for serials can usually be obtained from Letraset and other rub-down transfers.

Diorama settings

A pre-World War 2 airfield can give inspiration for many diorama settings, with simple ground equipment and aircraft of generally moderate size. Control towers, crew-rooms and even small hangars

are a practicable proposition in $\frac{1}{72}$ scale and some OO/HO model railway buildings can be utilized. Typical of the period are such items as the Hucks Aero-Engine Starter which was mounted on a modified Model T Ford chassis and the 'wind stocking', always present on the old grass aerodromes to indicate the wind direction. Road vehicles of various sorts can be adapted from military or railway accessory kits.

References

Books specifically referring to the inter-war years are not too plentiful, but there is much information in the histories of individual aircraft companies, air forces and airlines. The aeronautical periodicals publish a great deal of useful material and many plan-packs are available of types suitable for modelling. If you should be so fortunate as to live within easy travelling distance of any of the great museums with aeronautical collections, you can find many preserved aircraft on display; the Royal Air Force Museum at Hendon, London, is a fine example, while at the Shuttleworth Collection at Old Warden, Bedfordshire, the many historical aircraft are kept in flying condition. Other countries also have their collections and visits to them can be of inestimable value to the modeller.

Below left is a Boeing P-26A 'Peashooter' and, right, a Boeing F4B-4, (a Monogram kit), famous US Army and Navy fighter aircraft of the early 1930s. These models are both to $\frac{1}{72}$ scale, but $\frac{1}{32}$ kits are produced by Hasegawa. Models built by F. Henderson.





Record-breaking aircraft; $\frac{1}{2}$ models of a Northrop Gamma (Williams Brothers' kit) and the Fairey Long-range Monoplane (Airframe kit).

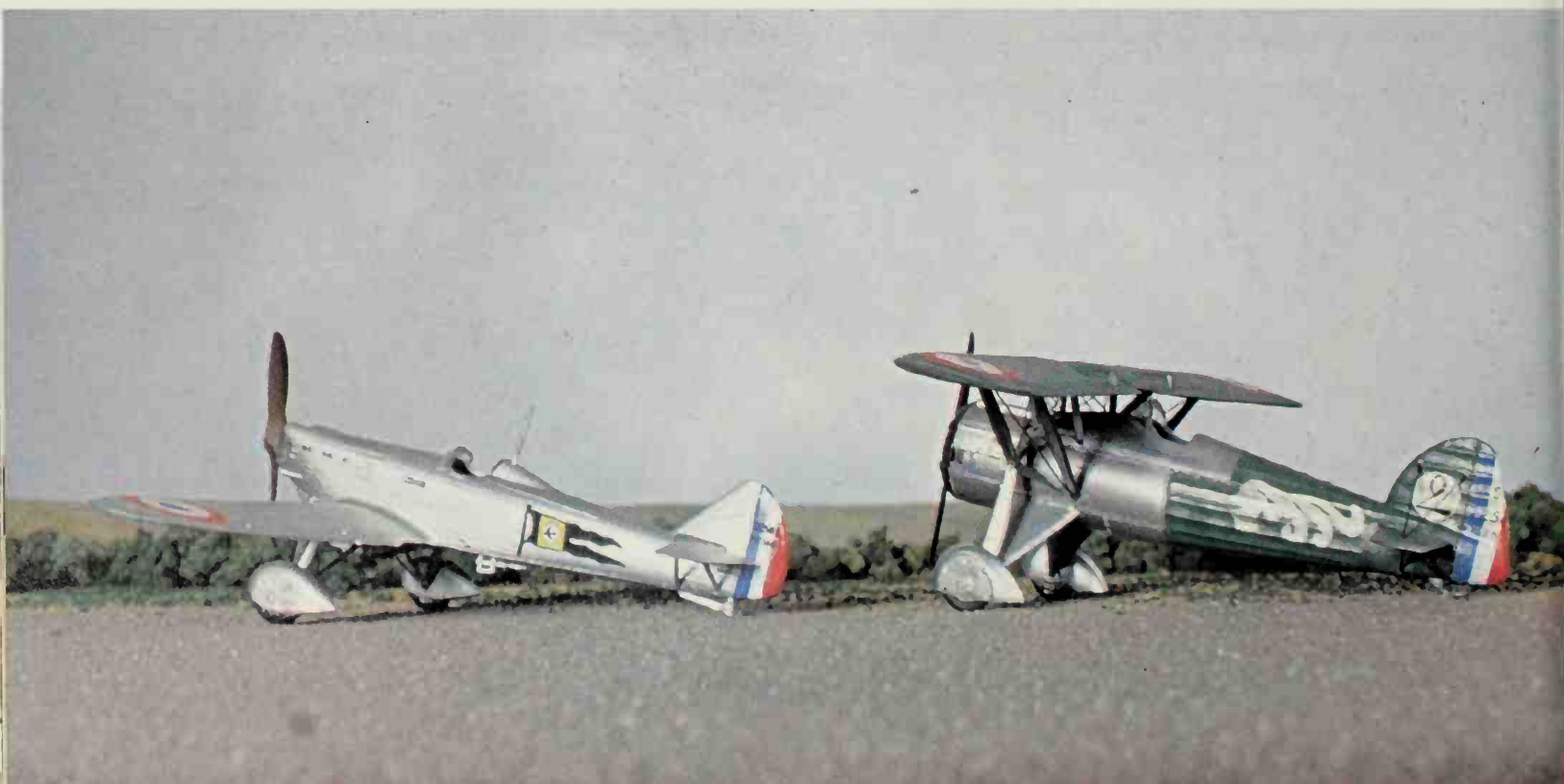
The Moths: spirit of the era

When, in February, 1925, Captain Geoffrey de Havilland first demonstrated the prototype of his DH60 Moth biplane, towing it behind a car with its wings folded to a width of only 2.95m (9ft 8in) so as almost to fit into a family garage, he started what was to become a virtual revolution in the design of the

light plane, suitable for instruction and for flyers of moderate means; few indeed are the aircraft which more truly convey the spirit of the inter-war period. The family of small biplanes which evolved from the basic, 60hp Cirrus I engined Moth appeared over more than a decade and many examples will still be flying well into the 1980s.

Far and away the most prolific, principally because of the mass-production undertaken to supply the need for primary trainers in

World War 2, was the DH82a Tiger Moth, many being transferred to the Civil Register in the post-war years. The variants of the original DH60 Moth mostly took their names from the type of engine fitted, Cirrus, Gipsy and Genet Moth among them so, because the airframe varied only in detail, it is possible, from only two $\frac{1}{2}$ scale French Armée de l'Air fighters, the dainty 1935 Dewoitine D501 and the parasol-wing Morane Saulnier MS225 of 1932, both from $\frac{1}{2}$ scale Heller kits.



kits, the Gipsy Moth by Frog, now marketed by Novo, and the Tiger Moth by Airfix, to build a series of models, employing only quite elementary conversion techniques. The four different Moths shown can all be built from the two basic kits and the following notes cover the main conversion features.

DH60G Gipsy Moth G-AAAH

The famous *Jason* which was used by Amy Johnson for her record flight from England to Australia in 1930 is now on permanent exhibition at the Science Museum in London; the engine is a 120hp Gipsy II. The Frog/Novo kit is made for this machine and no conversion is required although some improvements can be effected by thinning down the various struts, which all tend to be oversize in section.

DH60 Genet Moth J8820

The Royal Air Force used, among other Moths, a version fitted with the 75hp Armstrong Siddeley Genet I five-cylinder radial engine which gave a very different appearance, although the basic airframe remained unaltered. This example was one of a batch of six used by the Central Flying School around 1927, some taking part, as an aerobatic team, in the Hendon Air Display of that year. The conversion follows similar lines to that for the Cirrus Moth, but the overall length was slightly greater and the cylinders of the radial engine can be made as described in Chapter 4. The exhaust pipes are separate curved stubs for each cylinder and can be made from wire.

DH60GIII Moth Major G-ADAT

Inverting the in-line, four-cylinder Gipsy engine, uprating it to 130hp and completely enclosing it with a neat cowling resulted in a totally different outline, but it still fitted neatly into the Moth's slim fuselage. This conversion calls for rather more work than the others and involves cross-kitting parts from both the Gipsy Moth and Tiger Moth. From the Airfix Tiger Moth kit take the nose section of the fuselage and the complete landing gear, for this version had a split-axle undercarriage and, more often than not, low-pressure wheels. After cutting the nose from the Gipsy Moth fuselage, as with the other conversions, mate the Tiger Moth nose section to it, re-shape to get a smooth contour



and fill any gaps. Also from the Gipsy Moth kit take the wings, tail surfaces, interplane and centre-section struts and propeller. Finally, a long exhaust pipe, made from brass or nickel silver wire, is fitted between the landing gear legs.

DH82a Tiger Moth G-ARAZ

Many Tiger Moths were made surplus by the Royal Air Force and found their way on on the Civil Register: this example is

one. The model can be built directly from the Airfix kit.

All of these types had a petrol pipe leading from the centre-section gravity tank to the top of the fuselage; it can be made from wire, shaped to suit each individual aircraft. Where new wooden nose sections are required for these conversions, reference can be made to Chapter 4 for tips on shaping balsa wood components and bonding them to plastic.

1939 to the Present

The tremendous growth in the hobby of model making owes a great deal to the modern injection moulded plastic kit. Since its introduction some 25 years ago, the basic kit has been refined to a degree which makes comparison between the offerings of the early 1950s with those of today a worthwhile and informative exercise.

The modern trend is to include more and more detail, both internal

and external, as well as optional parts to enable the constructor to produce a variant of his own choice from the basic kit subject.

This trend does not have the effect, as many suppose, of reducing skill levels; on the contrary, it tends to create a necessity for extra dexterity in handling the many components and fitting them correctly. But when the model has been completed there is a common factor

which, in many ways, is a great leveller, and this is in the finish achieved by the individual modeller concerned. Many of the early plastic kits which are still available in their original form have provided the basic material from which really experienced modellers have produced models capable of holding their own against the very latest releases. Apart from the obvious modification work necessary to



achieve such acceptable comparisons, the common denominator is, more often than not, the final paint finish. A new model assembled skilfully, but poorly painted, will not stand comparison with an old model which has been worked on carefully in both the construction and painting stages.

With all modelling there is no substitute for patience and practice, and these two important factors must be cultivated to the full, especially when it comes to achieving authentic and acceptable finishes. But before going on to look at some of the techniques which will enable such finishes to be obtained, let us first consider some of the basic differences and factors controlling the reasons for applying either a new-look factory fresh finish, or a worn and weathered one.

The variety of kits now available is such that even the most fastidious modeller is able to be very selective in his choice of subject matter, a choice often governed by circumstances not directly associated with model making. The most restrictive element is often the space available to the modeller, not so far as the actual modelling is concerned, but where to display the fruits of his labours when they are complete. Because of this, scales small enough to enable a reasonably representative selection, but large enough to enable every skill to be practised to its full, are the most popular.

Almost since the start of aircraft modelling as a serious hobby, the two scales which fit the defined parameters have been universally adopted, these are $\frac{1}{72}$ and $\frac{1}{48}$ scales. Within these two there are enough kits available to satisfy practically every requirement for what can be termed a 'theme' collection.

There are many modellers who derive enormous pleasure from constructing perhaps one large scale kit on an occasional basis, and, in contrast, there are those who rush through every phase of construction and painting, producing maybe four or five models every month. Between these two extremes are those who form the backbone of the hobby and are its most serious devotees. These modellers will eventually decide on a particular period in history, a certain type of aircraft,

or the aircraft used by a chosen squadron, and concentrate their efforts towards constructing models with such a common bond. In such a collection, it is important that all models are the same scale and finished to a common standard; deviation from the former might become necessary and is very much a personal matter, but every effort should be made to adhere to the latter by finding a standard one is capable of achieving on a regular basis, and then sticking to it.

During World War 2 aircraft were mechanically maintained to a very high standard, but in many cases their paintwork weathered very badly due to the outside environment in which many of them were kept, as well as the continual attention from ground crews servicing and rearming them. Although standard camouflage colours and patterns were laid down by officialdom, it was not always possible for the rules to be strictly observed. On many occasions paint of the specific colour was not readily available, or other more pressing operational commitments took priority over painting. Even new aircraft tend to show evidence of wear, especially around panel fastenings, so it is very rare to see any aircraft in the sort of pristine finish obtained if no effort is made towards authenticity. The basic difference can be summed up by asking the question, 'Are we making a model or a replica?' A model is, for example, a perfect scale reproduction of a particular aircraft in authentic markings and correct camouflage as it *should* have appeared; a replica is a perfect model of a particular aircraft as it *did* appear. Once again personal choice is very much the deciding factor and the reader should not be influenced by something he does not agree with.

In addition to wear caused by exposure to the elements, paint also faded or was a different tone when produced by a variety of makers over a period of time. Whether or not such tonal differences should be allowed for in modelling is well outside the scope of this particular chapter. Many people, and the writer is inclined to agree with them, feel that this really is trying to carry scale modelling too far, especially as colour viewed by several people is rarely exactly the same to any two of them. But if you wish to tone down camouflage colours by all means do so by judicious use of paler shades than those

originally specified.

Immediately after the War, air forces were run down and for a long period of time operated old aircraft with fewer people. In many cases the aircraft concerned did not show signs of wear as quickly as they had done when they were engaged in warlike activities, the reasons being that there was more time to tend to them and paints used gradually became more durable. As peacetime air forces took delivery of new equipment and the jet-age was born, aircraft became more colourful and their natural aluminium or high gloss camouflaged paintwork tended not to show as much wear and tear. The hey-day of immaculate aircraft and gaudy squadron markings started to draw to a close in the mid-1960s; since then there has been a definite move towards more sombre tactical schemes and camouflage patterns, which are only broken by yellow stencilling and perhaps the colours of national markings, although of late even the latter have been toned down. So, before deciding just how any model is to be completed, it is a good idea to collect as many photographs as possible and form a mental picture of just how you want the model to look when it is finished.

Weathering and wear must be kept within acceptable proportions and relative to the scale of the model being worked on. It would, for example, be quite wrong to reproduce a scrape 12.5mm ($\frac{1}{2}$ in) on the fuselage of a $\frac{1}{72}$ scale Spitfire where it would represent a mark of nearly 1 metre (3ft), but acceptable for such a blemish to be included on a $\frac{1}{48}$ scale model. The best guide is to remember that the model should only show suggestions of detail that would be seen if the real aircraft were to be viewed from a distance where it appears the same size as the model.

There is no substitute for looking at the real thing whenever possible, and this can be achieved by visiting museums and air displays and making sure that a careful note is taken of every small detail that will come in useful when modelling. Those who like making models of airliners have the advantage of being able to visit the public viewing areas of major airports and seeing their subjects at fairly close range. Airliners are extremely expensive and represent a big investment on the part of the company owning them; they are therefore looked after most carefully, and generally speaking do not show as many signs of wear

The nose of a $\frac{1}{48}$ scale Vought A7D model, considerably greater than life size. Slight variation in colour on the noseleg is the only obvious lack in a very convincing model.



as their military cousins. However, if a really close look is taken at an airliner, it will quickly be seen that panels are chipped, oil has seeped through on to some surfaces, and what seems to be pristine white paint is slightly streaked in places. With care such blemishes can be reproduced, but in the small scales often used for airliner kits, extra care, and knowing precisely when enough is enough, are essential.

There are many ways any model can be weathered and all of them should be tried on a scrap model or perhaps even one built for such a purpose. To represent paint chips it is entirely wrong to take a brush with silver paint on it and spot one or two blemishes in appropriate places. All aircraft have a primer applied to their natural finish over which is applied the final paint scheme, and when the paint is

Top: Four-engined bombers of World War 2 are more frequently found in $\frac{1}{72}$ scale, due to sheer physical size. Slightly out-of-focus background enhances realism on this B-17 Flying Fortress.

Above: Particular aircraft can often be modelled, when detailed references sources are not difficult to find. The Handley Page Halifax *Friday the Thirteenth* is mounted on a simulated concrete hard standing.

Above right: Republic F-84s were supplied to many NATO countries; this one is in French colours. Early kits tended to over-emphasize panel lines, as is evident in this picture.

Right: One of the first supersonic fighters in service was the North American F-100, which can make a colourful subject. A history of fighter development is entirely possible, using available plastic kits.

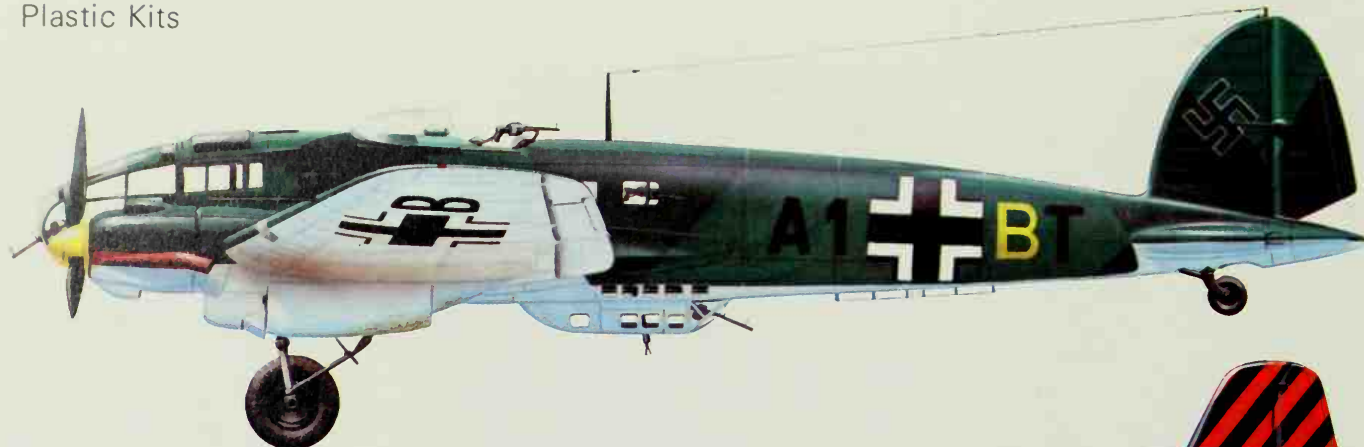




chipped, the primer or the natural metal shows through. So on a model the same procedure will produce convincing results. Spray or paint small areas of silver before any other finishing is carried out, then take some masking fluid or tape and apply this in the areas which will eventually be exposed. Now paint the model in its final scheme then remove the masking, the result will be areas of exposed silver which look like wear rather than daubed-on silver paint.

Any national markings must be applied before any weathering is carried out, since these are just as prone to wear as the rest of the airframe. Scuffs on the wing surfaces or around inspection panels and crew entry hatches are produced by using an ear bud to apply gently a minute portion of 'rub 'n buff' to the engraved panel lines. This must





Luftwaffe Heinkel He-111



Gloster Meteor Royal Air Force



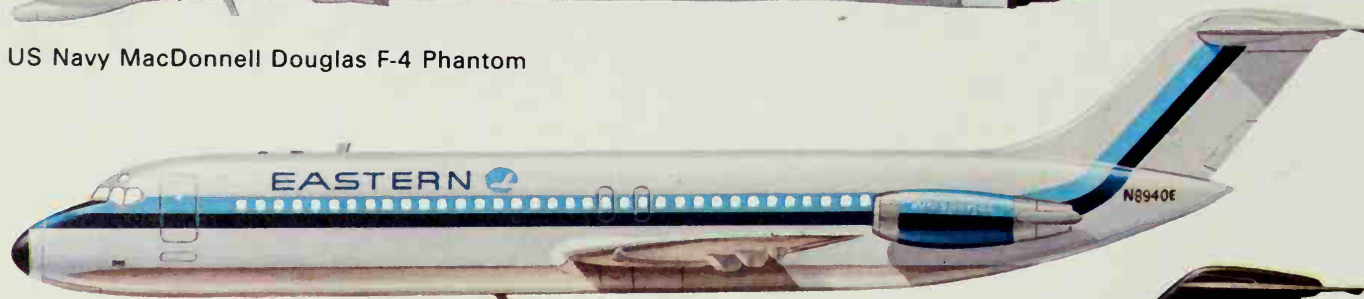
Royal Canadian Forces CF-104 Starfighter Armed



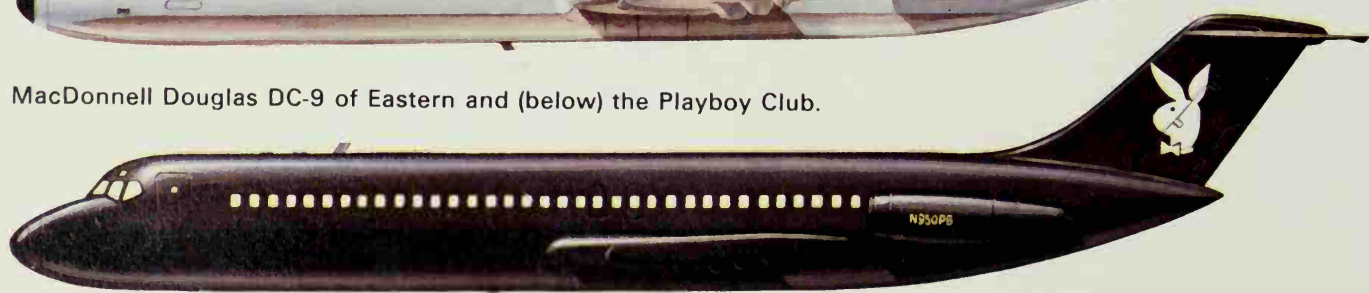
US Navy MacDonnell Douglas F-4 Phantom



US Navy MacDonnell Douglas F-4 Phantom



MacDonnell Douglas DC-9 of Eastern and (below) the Playboy Club.



be done very carefully, but if it is overdone, it is not too difficult to repaint or spray the exaggerated area after cleaning off the paste.

Engraved panel and control surface hinge lines should be accentuated by running a very diluted mix of dark grey or black paint and thinners along them. This is easily done by dipping a size 00 or 000 brush into the mix and gently touching it at the base of the line; capillary action will do the rest. Similarly graphite dust, obtained by rubbing the lead of a soft pencil on glasspaper, can be used to highlight matt black painted gun barrels or bombs or other areas on the model. The dust is simply rubbed into the component or area and the degree of sheen arrived at is governed by the amount of time spent working it in. Moving parts such as undercarriage oleo legs should never be painted in silver; the paint should be toned down with a touch of grey or better still steel, and then dry highlighted or toned down even more by the dry brushing technique. This is a very useful skill to master, especially when it comes to weathering.

Basically all that is done is that a brush is dipped in silver, black or grey paint which is then brushed off on a piece of card or scrap plastic. The brush is then worked over the area concerned and small particles of the original colour are worked into it. This is one of those tasks which sounds hard, but is in fact quickly mastered once it is tried; the effect is well worth it.

Attention must be paid to every part of the model, since it is pointless to make the airframe look worn but ignore, say, the wheels, which may have tyres in a new and immaculate finish. It is best to use a

American aircraft often offer a variety of attractive colour schemes, the F-4 Phantom being a case in point. Land-based aircraft are tending to become more sober, since bright colours render concealment difficult.

very dark grey paint for tyres and highlight the treads with a mix of black or brown, depending on the aircraft and where it is likely to have operated from.

Indian ink is a very useful addition to the modeller's paint box. Diluted with water and allowed to run from filler caps, panels, wheel wells, and vents, it will produce very authentic looking stains.

The watchword in weathering is moderation: don't overdo it, for nothing looks worse than a model which looks ready for the scrap heap. Always stop one step ahead of where you planned to, and, if you have an air brush, make the final step an overall light spray with a very diluted wash of grey or black. This tends to tone in all the areas weathered with those not touched, and avoids a patchwork quilt effect. Always remember there is no substitute for practice, and weathering skills will come if you try hard enough and use imagination.

Displaying completed models in a glass case or on a shelf is the method favoured by most modellers. It is fun occasionally to make a change and try other modelling skills by creating a diorama. This is a method of using the model to tell a story, which can be complex or simple, fact or fiction.

A Phantom standing on a concrete hardstanding with all its weapons carrying 'remove-before-flight-tags', the nose wheel tethered, and the pilot's ladder in place, creates a simple scene which attracts attention. Similarly, a Lancaster bomber at the end of a wheels-up landing can be shown with its crew having scrambled clear looking at the furrows carved by their aircraft and the path it followed strewn with pieces of wreckage. A poignant scene, but a familiar WW2 one captured in miniature for all time.

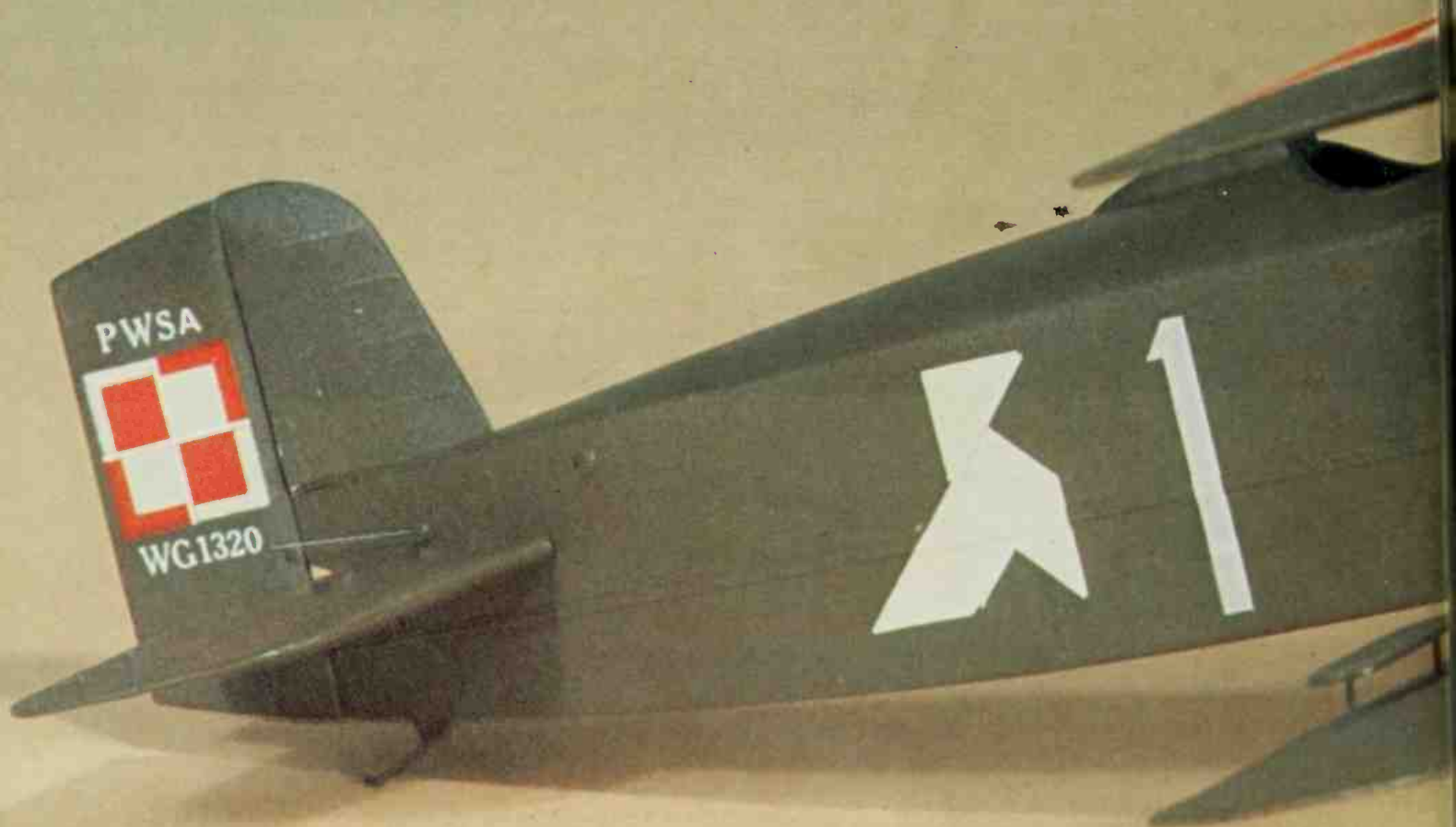
There is nothing difficult about creating a diorama providing some basic rules are observed. Always

try to make the base big enough; at least twice as long as the subject matter is a reasonable guide. Use Polyfilla, papier mâché, or plaster-of-Paris to form the landscape, and remember that all objects have weight and must be shown to be resting in the terrain rather than on it. It seems obvious that all components must be to the same scale, but quite often one will see a $\frac{1}{32}$ scale aircraft with $\frac{1}{48}$ scale people or vehicles. The scene must also be a realistic one. Do not, for example, make a superb job of creating a desert oasis then insert into it a piece of equipment only associated with the Arctic!

The base should be made of wood which is thick enough to look right, too thin and it might warp, too thick and the model looks unbalanced; it should also have as much attention paid to its finish as the rest of the model. Far too often good dioramas are spoiled by the base having exposed edges which appear to have been chewed off a tree trunk by the modeller's teeth. A smooth regular border painted or edged with veneer adds that essential touch of class. Almost any material used by model railway enthusiasts can be employed in creating an aircraft diorama, and finishes can be achieved with water paints, oils, enamels or a combination of all three. Plants, shrubs and trees can be bought or scratch-built, but when laying these out remember that unlike man, Mother Nature does not build in regular rows and patterns, but follows a random order.

Ideas for dioramas can come from books, films, television, newspapers, magazines and a fertile imagination: it is another aspect of modelling which is worth trying, for perhaps not only will that loved Spitfire look better in a genuine reproduction of a 1940 blast-proof pen, but in constructing the pen another useful skill will be mastered and turned to many other uses.





Building in Plastic

Plastic Card

Vacuum-formed Models

Plastic Card Modelling

The title of this section may seem less familiar than the overused 'scratch building' but, in fact, it is the only correct description of this area of modelling for it describes exactly what it is and indicates quite clearly that it is derived from card or paper modelling. Plastic card modelling, therefore, is an extension of the old art of card

modelling utilizing the versatile medium of polystyrene plastic sheet, which resembles fine quality card. It owes almost everything to card modelling and nothing to plastic kit construction and it is important to appreciate this from the start.

In plastic card modelling, a three-dimensional form is created from flat sheets of plastic card by the modeller using his skills and know-

Below: An unusual subject, an Avia BH33 built in plastic card to $\frac{1}{48}$ scale by H. Woodman. *Left:* A Boulton Paul Overstrand to the same scale which was awarded a Championship Cup at a recent Model Engineer Exhibition.



Top: A simple square-type fuselage typical of early aircraft offers few difficulties especially when the front decking curves only one way.

Centre: A slightly more elaborate turtle-backed fuselage, though still straightforward and built on a basic box.

Bottom: Stages in shaping a plug for a moulded fuselage with, beneath, the female half of the mould.

ledge of the material. If the terms 'wood' or 'metal' are substituted for 'plastic card' the definition can apply to all areas of modelling activity.

Materials

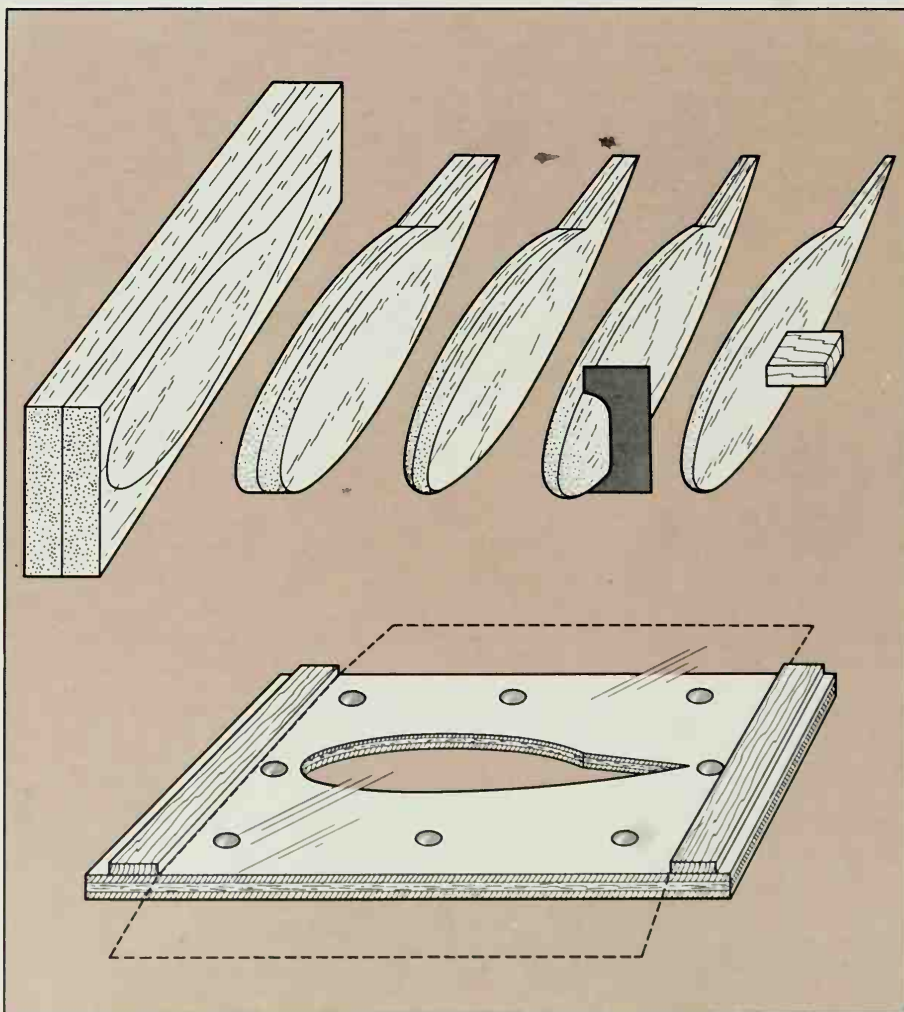
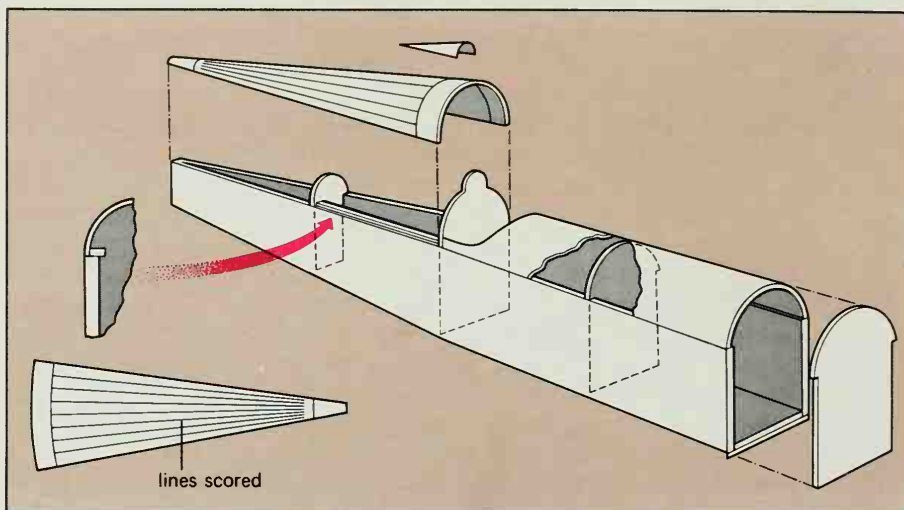
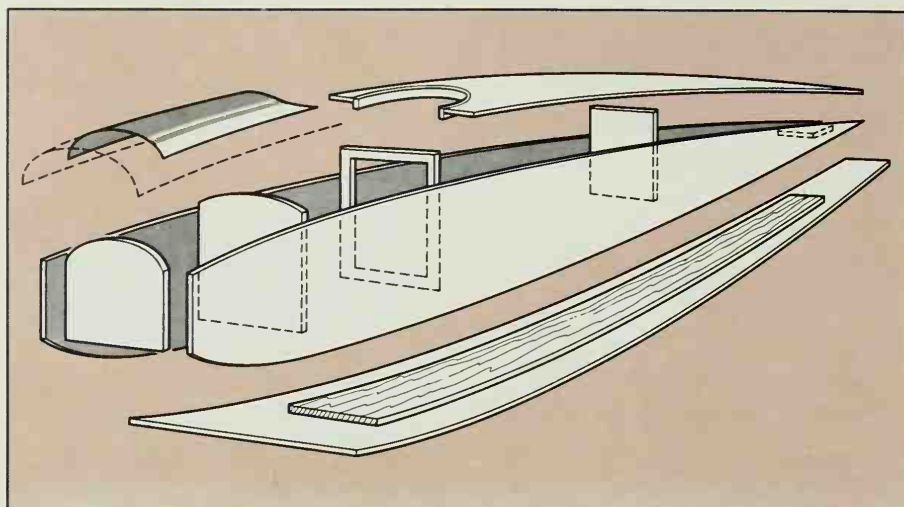
Plastic card is polystyrene formed into convenient flat sheets in varying thicknesses; the thinnest available is five thousandths (5 thou) of an inch (an eighth of a millimetre) which is about the same as the pages of this book. It is also available in 10, 20, 40 and 60 thou (0.25, 0.5, 1.0 and 1.5mm) and greater thicknesses. It is white, which is the best for modelling; colour has no advantage. (Transparent card is a different material, its only advantage is that it can be fixed with plastic cement, and acetate sheet is often of more use.)

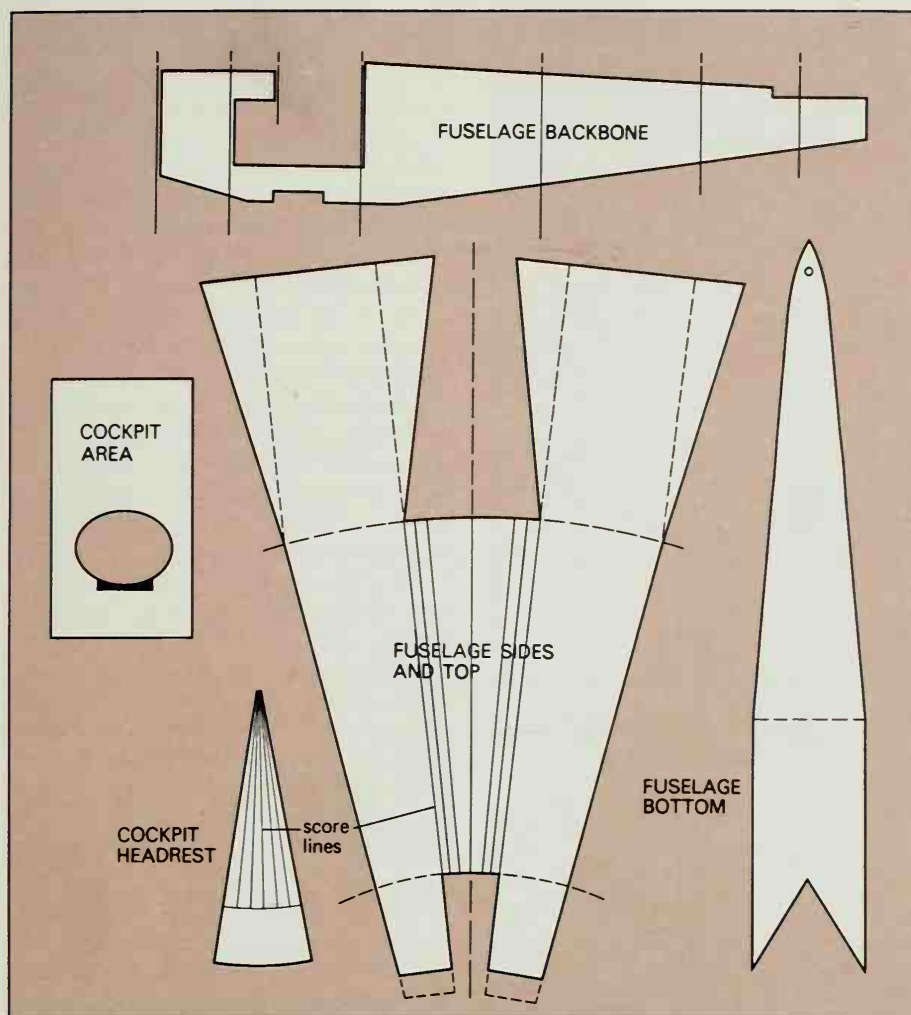
In appearance the material is rather like extremely good quality Bristol board used by commercial artists for mounting. It has all the board's qualities and more besides, including the most valuable one of softening slowly when a gentle heat is applied, so that it can be moulded by simple techniques.

It can be cut easily with a sharp blade and indeed it is not necessary with the thicker card to cut all the way through, for a firm initial cut will allow the card to be broken cleanly. Cutting with scissors should be avoided as the action of the scissor blades tends to warp the card. It can also be scored, laminated and sanded.

Plastic card is available from many model shops and is usually supplied in sheets about 25 × 30cm (10 × 12in). The disadvantage of this is that should a larger unit be required the modeller has to find another source, probably a specialist plastics supplier.

The best adhesive is plastic cement, which 'sticks' by dissolving the plastic card slightly and forming a weld when it is dry. This method of adhesion should be remembered, for if it is not understood disasters can occur. Cement





is available in two forms, thin, in bottles, and thick, in tubes. If a quantity of thick cement is deposited on a palette it can be thinned as required by the addition of thin cement. A good guide is to use just enough cement to do the job; avoid excessive amounts, for the work can be ruined. For very thin card matt varnish can also be used.

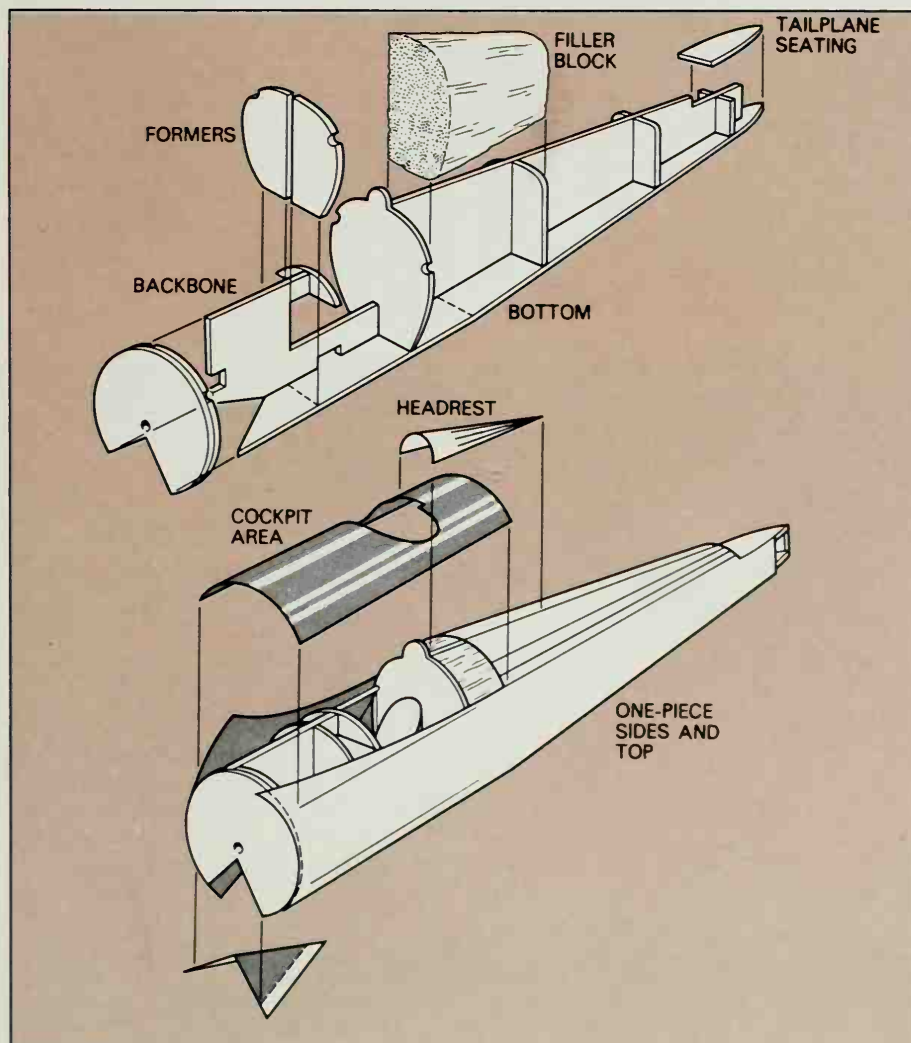
Tools

There are few essential tools, but one is obviously a cutting knife. The best is one with easily replaceable blades and a long narrow wedge shape which can be used equally well for long straight cuts, involved angles or curves. The most useful is the type which consists of a handle and a pack of snap-off blades. With a knife a straight-edge is needed, and a steel rule is ideal. For curves, some inexpensive French curves can be used and, with care, it is easy to learn the technique of using the curve as a guide without damaging it. Cutting circles and discs is even easier, for all that is required is a set of dividers of the type found in children's geometry sets. The circle is scribed on to the card and it can be pushed out with no difficulty.

Probably the most expensive items are a set of fine files and a set of miniature drills with a pin vice to hold them. As the drills and files are used on a soft material they never wear out and with care will last a lifetime.

Occasionally a fine saw is needed, mainly for cutting up a balsa block when making a male mould. (It is best not to use the saw on plastic as the friction melts the plastic and clogs the saw teeth.) A balsa plane which uses a razor blade is useful for trimming down balsa when making wing cores etc. and forming male moulds. The ideal sanding material is 'wet and dry' paper as used in the motor trade. When used wet with soap it gives a very fine finish on plastic card. It is available in varying grades of coarseness, the most useful being the two finest grades.

Top: The various parts of a fuselage laid out on flat plastic card.



Below: The assembly of the cut out parts; note the use of filler block. Accurate alignment is essential to ensure that the tailplane sits squarely on its seating so that it is parallel with the mean line of the wing(s).

Other useful items include such things as cocktail sticks, bulldog clips, household pins, elastic bands and Scotch tape, masking tape (which is easier to remove), and double-sided tape.

Finally, some drawing instruments are essential, not only for drawing (for it may be necessary to create one's own plans) but for marking out the plastic card for cutting. The necessity for accuracy when doing this cannot be over-emphasized.

Fillers are used to conceal a crack, a space or a junction, and so in plastic card modelling they are used very little. Plastic kit modellers use fillers a great deal to create different shapes and structures, but in plastic card modelling this is all done by moulding or shaping lami-

Below: Stages in forming wings. Balsa cores prevent sag and add to overall stiffness, and are secured with double-sided adhesive tape. Undercambered wings need a temporary packing piece beneath to produce the correct section. *Below right:* Modern wings are thicker and bi-convex. Cut-outs are made for landing and navigation lights, and ailerons should always be cut away, detailed, and replaced, as shown.

nated card and filler is unnecessary. 'Plastic fillers' available commercially can damage the plastic, so if making a shape which requires the use of a filler (such as the building of a wing fillet) a cheap and harmless water-softening wood filler, such as Brummer Stopping, is ideal. It dries hard and attaches itself to plastic card provided that the base is firm; it can be sanded and shaped to quite a fine edge without crumbling and is used by carpenters and cabinetmakers.

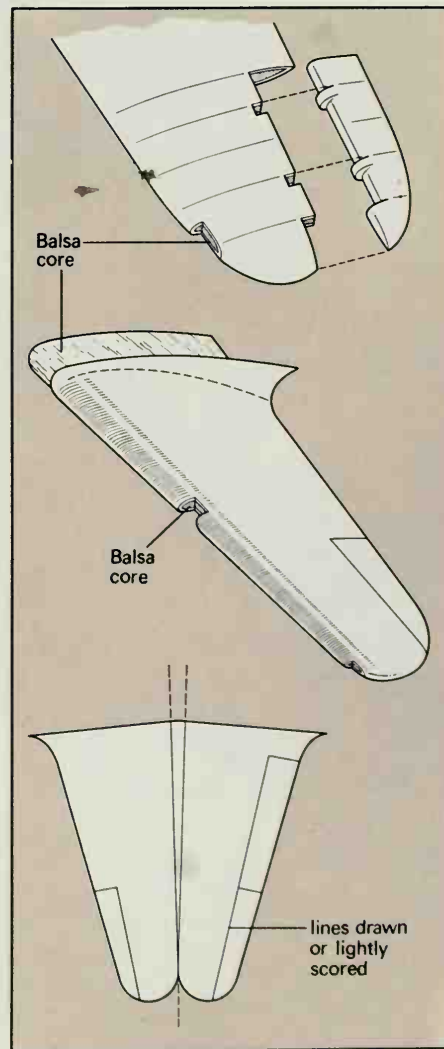
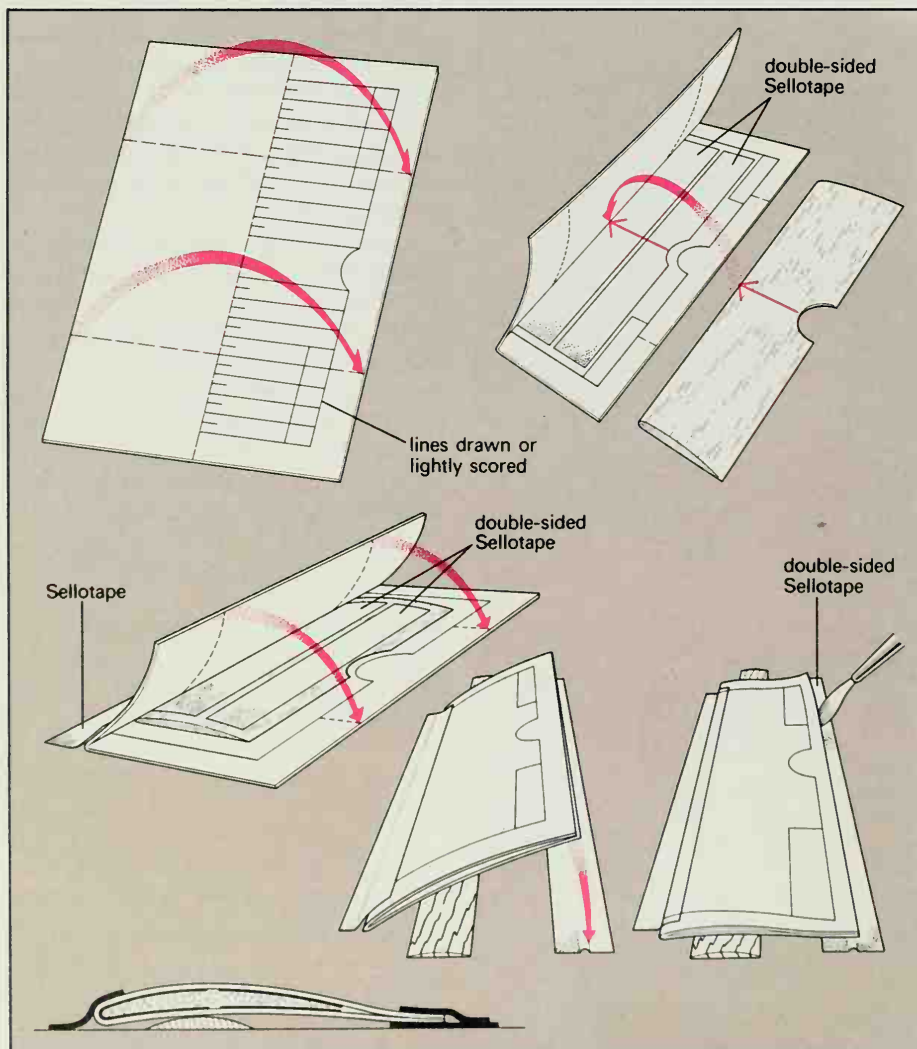
Techniques

The first fundamental is to realize that a three-dimensional model is to be created from pieces of flat plastic card and the second is to gain a thorough knowledge of the properties of that material. Waste some material in experiments in cutting, scribing, scoring and moulding to get the feel of it. Try applying cement to see how far it is possible to go before damage occurs. Practise scoring using a not too sharp point for fine lines and, say, an empty ball-point pen for thicker ones. Like cardboard, the material can be folded, but only up to 10 thou (0.25mm) thickness, over this it will crack.

A cornflake box starts out as a series of flat rectangles, and a machine cuts, scores and folds the flat design into the final shape; this is termed a 'flat cut out', and is useful when building the fuselages of aircraft of WW1 vintage and earlier. Another method is to cut out the top, bottom and sides and attach them to a central keel or core of thicker card, which gives greater strength and helps with alignment and shape. This is called a 'simple box'. A further refinement is to attach to the box a series of additional structures such as a curved turtle back or side panels and this becomes a 'built-up box'.

If the shape contains a great deal of double curvature, such as the fish-shaped fuselage of an Albatros DV, it becomes necessary to mould it in two half shells. Some fuselages can be built up with a mixture of all the above; the modeller must decide for himself how to go about it.

To make a moulded shape two moulds are necessary, male and female. The male is made slightly undersize to allow for the thickness of the plastic card, and the female mould is an aperture through which the male is inserted, with heated plastic card in between. It is a very



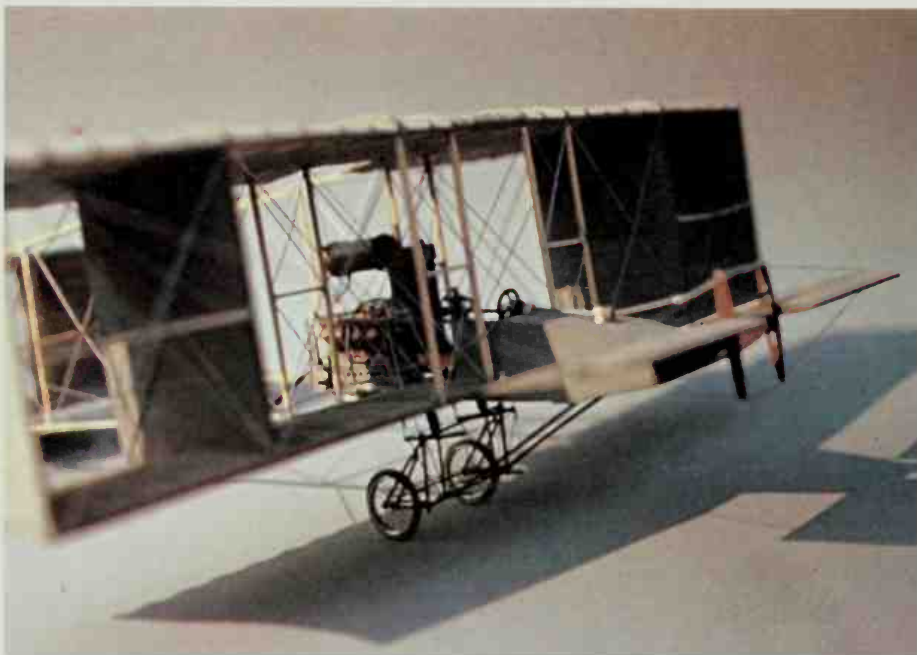
simple procedure and in some small items, the female mould is not needed at all. To heat the plastic use a small spirit lamp, or for a large area use an electric fire. The plastic card will soften visibly after only a small degree of heat is supplied. When it starts to go very shiny and discolours it is too soft and only practice will indicate when the right moment occurs.

To make fuselage moulds, two pieces of balsa are lightly stuck together into a block, using minimal balsa cement. The shape is then carved and sanded using the joint line as the central guide; the two halves are then gently prised apart and the two male moulds are ready. The female mould is merely an appropriately shaped hole cut in a piece of balsa sheet. Do not use too thin a sheet as it may split and spoil the mould. For very small items, such as gun or cylinder blisters, the male mould is best made from hard wood (a tooth pick is often ideal) and merely pressed into a piece of plastic card immediately after heating. In this way, using acetate sheet, tiny transparent shapes for navigation light covers can be made without difficulty. Such small items are stuck

Top: A $\frac{1}{48}$ Travel Air 2000 painted to represent a Fokker DVII for the 1938 film 'Men With Wings'.

Right: A 1909 Voisin biplane flown by Moore-Brabazon, holder of the first British pilot's licence.

Below: Supermarine Walrus amphibian on a ship's catapult. This model won the Championship Cup in the 1978 Model Engineer Exhibition.





Above: An Armstrong Whitworth Siskin, now included as part of the RAF Fighter Command memorial.

Right: A Curtis BFC-2, a US 'pursuit ship' of the early 1930s.

in place with matt varnish.

The interiors of fuselages can be strengthened in various ways, depending on shape and size; for example, the male mould can be used as a fuselage filler, appropriately cut away at the cockpit area. Apart from bulkheads made from heavier card, expanded polystyrene, being virtually weightless and easy to come by, is ideal for internal support as long as varnish is used to stick it in place.

A final refinement is to 'skin' the fuselage partially or totally with 5 thou (0.125mm) card or metal foil, adding external detail (rivet heads, stitching, panel lines etc.).

Matt varnish is used to attach the skin, both surfaces being painted and allowed to become tacky. The very thin plastic card can be attached with cement but only with very great care and after some experience.

Wings and tails

The whole basis of wing and tail surface construction consists of folding a piece of the thinner plastic card; the fold becomes the leading edge and the two edges joined



together become the trailing edge. The trailing edges of aircraft of all periods must be sharp, and in the smallest scales, razor sharp. For the narrow leading edges of early aircraft it is necessary to form a tight fold and without using some heat this is not possible without cracking the plastic. To obtain the fold using card up to 20 thou (0.5mm) thickness a balsa sandwich must be used.

The beginner is again encouraged to experiment with some card, say a piece of 10 thou material. First, fold the card carefully; it will be noted that the fold does not stay tight but slowly opens up. To keep it tight the folded card should be inserted between two pieces of

balsa plank to form a sandwich with the folded edge not protruding beyond the edges of the balsa. If this sandwich is held firmly and in front of an electric fire, the plastic will soften at the only part which is exposed, the fold. At the same time squeeze the two pieces of balsa together between the fingers and then take the work away from the heat. Allow about 10 seconds to cool and it will be seen that the plastic has formed a very tight and permanent fold. Another advantage of the sandwich is that when modelling wings of fabric-covered aircraft, the wing ribs are represented by scoring and during the heating and folding process the scoring is covered and so protected

from the heat, for the scored lines will flatten out if subjected to heat.

To give internal support a 'core' of sheet balsa is used, which not only prevents warping but also acts as a base to support struts. The core is roughly shaped to the correct aerofoil section and planform, somewhat smaller than the correct size of the wing, inserted between the folded plastic card wing, and held in place with double sided Scotch tape, which is more effective than adhesives. Any camber required is achieved by supporting the wing as necessary during the formation stage. The same basic principles apply when modelling the wings of modern aircraft. The balsa core is shaped from a plank of appropriate thickness using the razor blade plane and glasspaper. It is a good idea to paint the finished balsa core with plastic cement to seal it and provide a firm surface for the Scotch tape.

Ailerons and where necessary, flaps, *must* be cut away from the wing, the leading edges rounded and then replaced and held with pieces of fuse wire. The same principle applies to rudders and elevators, although in some cases it is best to make the items separately, depending on the design of the original. Vertical fins and tail-planes are made in the same way as wings, but to achieve the very thin appearance of such appendages appropriate to early aircraft, the balsa core can be dispensed with.

Waste sprue from plastic kits can be used for many details, as described elsewhere; delicate parts should be stuck in place with matt varnish. Plastic sheet can also be used to make sprue, for by carefully cutting a narrow strip of 40 thou (1.00mm) card and heating it, a very fine flat (or shaped) strip of plastic can be obtained. Many ink containers in ball-point pens are made from a soft and flexible translucent plastic tube which if carefully heated will soften and can be drawn like plastic sprue. The result is a fine hollow tube which is most useful for exhausts and guns. The best adhesive is again matt varnish.

Spare parts from kits

Engines, propellers, exhausts, wheels and engines and in some items can be made from plastic card and other plastic materials. Scrap plastic kits also provide quite a good selection of items, such as wheels and engines and in some cases, propellers, which may require remodelling or refining. A

tread on the wheel of a DH9a, for example, is not acceptable. Early aircraft wheels can be made using plastic curtain rings or plastic 'O' rings, used by engineers.

Radial engines fitted to early aircraft were often fully exposed and so require much detail. Kit engines can be used, but such clumsy practices as moulding the push-rods as a solid wedge integral with the cylinders means that much reworking is necessary; such measures as disguising this with paint are unacceptable; one of the most enjoyable things about scale modelling is the addition of such small items.

Another material which has many uses is the range of tough plastic components produced in Britain by Plastruct. Primarily for architectural modellers, the range includes a good range of plastic tubing which can be used for cylinders ('bound' with fine sprue to emulate cylinder fins) and the smallest tubing is supplied with a wire core which can be removed with stripping pliers, leaving a fine tubing which can be further modelled and shaped for exhaust pipes and guns.

Choice of subject and scale

The techniques outlined can apply to aircraft models of all periods: indeed, the rather stark lines of modern jet aircraft provide easier subjects than their more curvaceous forebears. A model of an antique aircraft always seems to attract more attention than that of a jet, partly because it possesses more character and has the same romantic appeal as vintage cars, period ships and steam locomotives. Perhaps it is the closer association of man with its levers, wires, copper tubing, brass radiators, wire wheels, plywood and fabric than the modern computer-built, computer-flown mass of internationally standardized equipment. The reader must make his own choice of subject.

The subject of scale is one of degree. The smallest general scale is the universally popular $\frac{1}{72}$; building in larger scales entails a considerable increase in the amount of detail, which in turn requires more research and reference. A scale of $\frac{1}{48}$ allows a model of sufficient size to include a great deal of detail without being too big. It is a matter of personal choice, but the reader is advised not to embark upon a large scale model without all the available reference material collected together and handy.

Research

There is not enough space to do more than touch on the very important subject of research, except to give a few hints. The traditional modeller starts with an idea, an urge to build a model of something that takes his fancy, and is not intimidated by the fact that the model is not available in kit form. He will collect material, photos, pictures from magazines, data on the dimensions and construction of the original. This involves a great deal of work and time sifting through the vast amount of material published on aviation subjects. A basic guideline is that all pictures (i.e. photos or photographic reproductions) are useful and the true researcher collects these and pastes them in some form of book to be studied closely. Historical societies' journals contain vast amounts of material at a fraction of the cost of some books and is of far greater accuracy. Research also means visiting reference libraries and museums (with camera or sketch-book) or state archives.

A good set of drawings is essential, and the modeller may have to create his own if accurate ones are not available. Check a published drawing with all the detail available on the subject, from basic dimensions to overall shape.

In a few cases original aircraft can be seen in museums, and sketches and photographs are useful adjuncts to studying the machine at close hand, though to get the true feel the sight of the real thing must be supplemented by pictures of it in service.

Total coverage in research is rarely possible, so that guile and knowledge must bridge the gaps. This is accepted procedure in restoration work everywhere.

A true model is a reconstruction of a fragment of history in miniature, to as high a degree of accuracy as possible. This means the whole model, not just the colour scheme and markings. The reader should regard the art in that light.

In these days of mass production and labour-saving devices it is the original creation brought into existence through hard work, determination and skill that is valuable; there is no short cut.

References

Scale Model Aircraft in Plastic Card by Harry Woodman published by Argus Books Ltd., Argus House, 14 St James Road, Watford, Herts at £2.95.

Vacuum-formed Kits

Despite the enormous number of injection moulded aircraft kits available to modellers the world over, there are still many fascinating subjects that will never be kitted. The reason is pure economics. While Spitfires and Messerschmitts sell rapidly to youngsters who make up the bulk of the market, rarer types will just not have mass appeal. With the staggering costs of even small moulds, one can hardly blame manufacturers for shunning less saleable products.

But several years ago when the plastic aircraft hobby really began to be taken seriously, it was realized there was also a market for more individualistic models – albeit a small one. The answer was the vac-form kit, components moulded directly to sheets of plastic card, economically produced and generally of short duration runs. The child grew up swiftly and now there are many brand names being produced in the UK, Canada, USA, Germany and even Czechoslovakia.

It would be irresponsible to recommend vac-form kits to the complete novice, but after plenty of practice, and experience of making more complex kits, a good vac-form is a natural and obvious progression. We use the term 'good' advisedly for it has to be said that many vac-forms require a lot of improving, but in most cases the effort expended is completely repaid by the results that can be achieved by a careful modeller.

What is a vac-form?

In their most basic forms vac-form kits contain one or more (depending on the subject) plastic sheets that carry the major – sometimes all – components required to build the model. If relevant a sheet of transparent plastic, not usually polystyrene, is included for cockpit canopies, windows, etc. Recent and welcome innovations by a few of the better-established manufacturers are the inclusion of injection moulded or diecast detail components such as wheels and propellers. Even more welcome are decal sheets – a rare item in such kits.

In several cases production runs are limited to around 1000 and as might be expected, overall quality can vary within the available models and out of a dozen or so manufacturers, only a few really approach the finesse of an injection moulded equivalent.

Nevertheless, the advantage and real purpose of vac-forms is the provision of aircraft subjects of appeal to enthusiasts which are unlimited in size, as they are in scope. Another advantage of vac-forms is the very thin sections of fuselage and engine cowlings. Detailing of cockpit areas is made simpler and can be more realistic by having a thin wall to work on. Cockpit widths are more to scale and there are no lugs, location tabs, steps etc. to remove and fill. Careful application of internal structure can be more easily carried out as a result and if a cockpit door

is to be cut open, it too looks better for being of finer section. Really large models can and have been produced including $\frac{1}{72}$ scale airliners, and huge modern bombers. The larger models demand even more skills and should not be tackled unless the modeller is confident of the result. Much of the hard work is alleviated on many kits by the supply of the aforementioned smaller parts in a different material. Nevertheless, most manufacturers continue to mould wheels, undercarriage legs etc., integrally with the formed sheets. Such small components are rarely usable and are unconvincing if they are, so the modeller will have to resort either to manufacturing his own or robbing the spares box.

Techniques

Due to the fact that vac-form sheets are generally of thin plastic, choice and use of adhesives should be considered carefully. Liquid polystyrene cement such as Slater's Mek Pak, Humbrol Poly 70, and the American Weld On No. 3 are to be preferred to tube cement. The latter can all too easily melt vac-form components but, then, so too can the liquids if used carelessly.

Before assembly can commence each major item needs to be removed from the plastic sheets and A 1914–15 Etrich-Taube modelled at $\frac{1}{72}$ scale from an Airframe vacuum-formed kit. Wheels and propeller left-overs from another plastic kit.



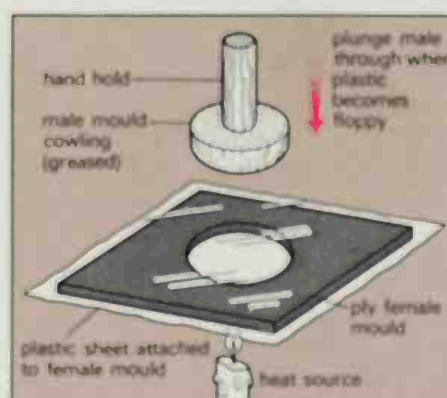
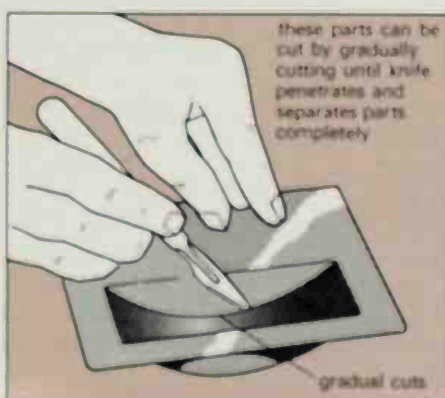
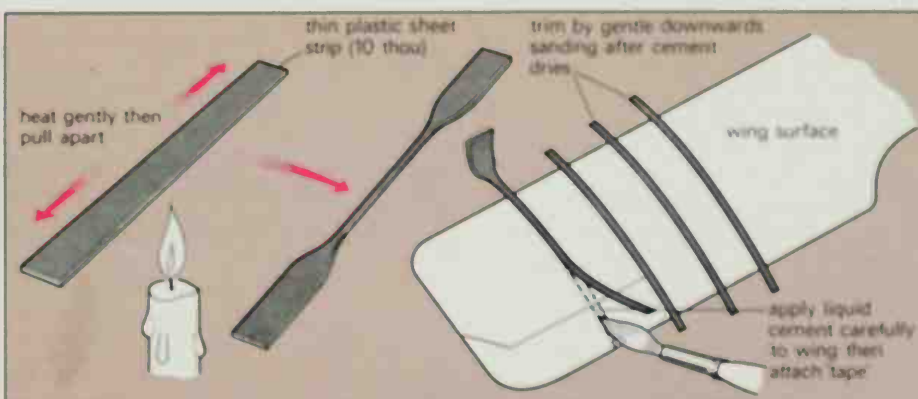
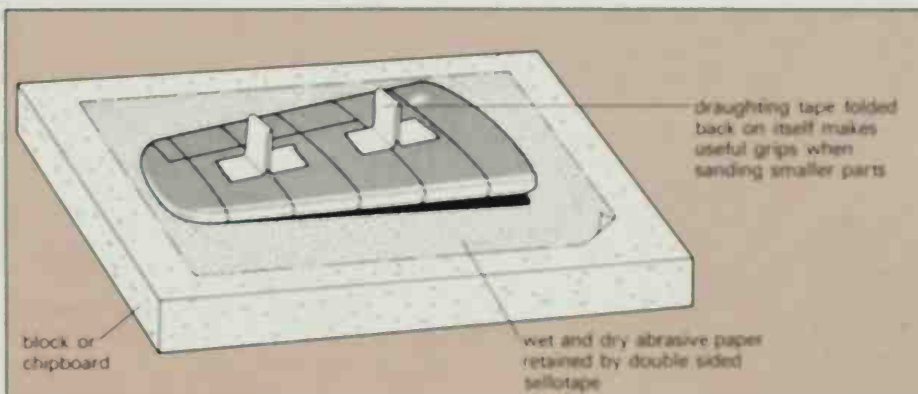
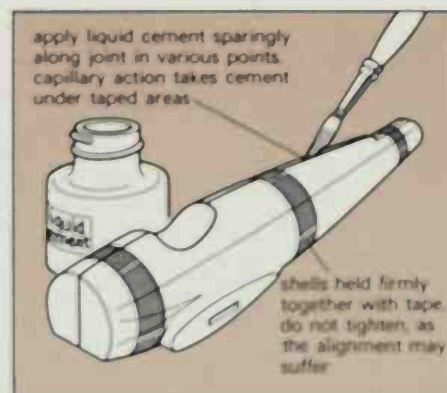
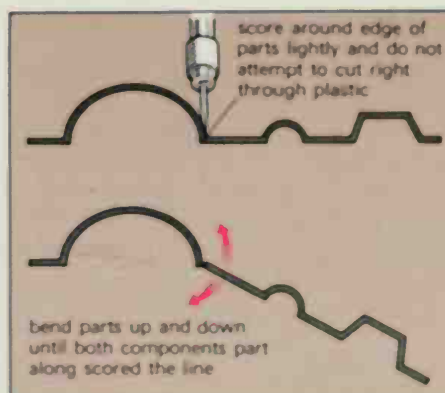
this can be a tricky procedure. To undertake the task without risk of damaging the components, no attempt should be made to cut the part out in one operation. Instead carefully score around the edges of the component using a sharp craft knife. Repeat this several times and go lightly. All too often a heavy handed approach at this stage can make the knife slip and damage the moulded sections – often almost beyond repair. The next operation is to flex the sheet and the component gently until the part more or less separates by itself, and this process should be repeated until all components are released. It might be a good idea to retain the scraps of backing sheet for use as strengthening tabs later in the construction.

Before joining together the two halves of the fuselage, the edges that require glueing must be sanded perfectly flat. To do this efficiently one requires a really flat cutting/sanding board. This need be no more sophisticated than a sheet of glass or a block of chipboard of reasonable dimensions. On to one side of this should be mounted a sheet of wet and dry paper, fixed with strips of double sided tape.

The paper should be liberally dampened and the component carefully rubbed to and fro until the surfaces to be glued are flat. It is essential that a check is constantly made on the progress of the sanding. A common error is to remove too much plastic, which results in a skinny ill-fitting fuselage, for only the true thickness of the carrier sheet ought to be eradicated. One useful tip is to run a fine pencil along the edge of the lip formed by removal from the sheet. This easily indicates the depth to which the plastic should finish.

As regards to wings and tails, it is of extreme importance that all trailing and leading edges are kept as thin as possible. Nothing is more harmful to realism than a wing trailing edges which if scaled up would resemble a large plank. Wings can be difficult to grip when sanding, especially if they are very small, and to overcome this, hand-holds should be manufactured from tape folded back to back.

Even on the more delicate World War 1 types or later biplanes, most vac-form kits supply wings and tails in two halves. This provides problems in endeavouring to obtain fine sections and it is probably better to discard the lower section, refine the upper half, and score in rib positions underneath with a



metal scriber. These operations are really essential for many early aircraft tail units, where even a single thickness of plastic may look clumsy. On larger aircraft wings, a balsa core may also be considered to avoid sag, although several kits supply material for strengthening spars. Don't forget to separate ailerons, elevators and rudders where feasible and re-cement at desired angles – so much more realistic for display.

The newcomer to vacuum-formed kits or even plain plastic card must accustom himself to new techniques. Even cutting parts out is quite different from cutting wood or metal; the card tends to be stiff and slippery, making light cuts and good control of the knife essential. Some of the more useful pointers are illustrated in these sketches.

Construction

Having removed and cleaned up the various components, now is the time to really study the kit instruction sheets and go to work. It is logical to commence with the fuselage and before joining the two halves all internal detail is added along with bulkheads, stiffeners and location tabs. Prepainting must also take place in the interior before gently taping the fuselage parts together.

Ensure that the parts mate accurately before any attempt is made to glue them. Then apply liquid cement to the joint lines in various positions around the fuselage. If carefully applied with a soft sable brush, capillary action will take the solvent along the joint and under the tape. Repeat the operation several times and leave to dry. If the model is an extremely large one, further careful applications may be required, but ensure the first has hardened.

When firmly dry, remove the tape and clean up the joint with wet and dry paper. Carry this through until all sign of the joint has vanished and although moulded detail will be lost this can be restored with careful re-scribing. On longer fuselages location tabs are really vital to keep the sides located. On many of the larger models, especially those of lesser quality, several areas will require filling and smoothing. Commercial and proprietary brands of model putty should never be used on vac-forms as they too can easily melt the plastic. Even more so for vac-forms, ready mixed interior Polyfilla is, again, just the right medium. Easy to apply, it dries out quickly, sands easily and only requires one undercoat, perhaps two, before final painting. Subsequent assembly of the vac-form more or less follows the traditional methods of kit construction. Most manufacturers provide full size drawings along with detailed instructions and building tips for newcomers to the hobby.

Improvements

There are a great many vac-form kits whose fidelity of detail falls way behind that of their contemporaries. In these cases the accent seems to be on quantity not quality, and several models fall foul of this policy. The lack of ribs on biplane wings and panels on fuselages – all have to be reinstated by the enthusiast. Happily it is not at all difficult.

Already mentioned has been the scoring of rib tapes on smaller 'fab-



ric' covered wings but for the bigger subjects the upper surfaces at least need more drastic treatment. The tapes can be represented by stretching thin plastic strips over a heat source in the same manner for producing fine sprue. With care ultra-thin plastic 'tapes' can be produced and then carefully daubed into place with a cement charged brush. Small panels can be represented either by scribing outlines with a metal scribe or the addition of 0.125mm (0.005in) plastic sheet rectangles glued into the correct positions. Stretched sprue can double for small door hinges, louvres and even cockpit padding.

It would be quite wrong to assume that the addition of extra detail on vac-forms is greater than injection moulded kits. Vac-forms may lack detail and require extra work but so do many of their more numerous brethren. The trouble with plastic kits is that the moulding process usually results in over-emphasis. Rarely are items like control horns, mass balances and aerial masts to scale, and they have to be replaced, just as the vac-form needs them to be added.

Very often, the vac-form has dis-

Top: A Fairey Swordfish at $\frac{1}{72}$ scale.

Above: Handley Page O/400 and Sopwith Camel fighter, both at $\frac{1}{72}$ scale.

Right: $\frac{1}{72}$ Morane L. Saulnier as flown by S/Lt Warneford, VC from an Airframe vacuum-formed kit. Models by R. Rimell.

tinct advantages over the more traditional and numerous injection kits. For small WW1 biplanes, the thin sectioned wings are easily modelled and with care can even look translucent, for on clear doped fabric aircraft the structure was often visible through the covering. Vac-form plastic is so thin that this can be simulated by painting or lining the rib positions in mid-brown paint and leaving to dry. Then using an airbrush or spray unit, dust a thin coat of pale buff over the wings. When the part is held up to a light source the effect is astonishing, but for it to work properly, only very light coats of paint should be applied.

Conversions

Vac-forms can be converted just as easily as any other type of kit and perhaps a little more so. In fact

there are even several manufacturers offering vac-form conversion kits designed to mate with existing plastics, thus enabling modellers to create yet more variations. These can take the form of new canopies, nacelles, cowlings – even complete fuselage shells – but care should be exercised when fitting them. The problem is that unless the vac-form components are very well moulded, the mating of injection parts is very difficult. They just look so obvious. The only solution is that if the vac-form parts carry scant detail, remove moulded-line panels from all components and re-apply by scribing

or split in two lateral halves on vac-formed sheets, making them unconvincing and difficult to model. A suitably shaped wooden dowel smoothed and greased is the ideal male mould. The female is merely a sheet of thin plywood with a circular hole cut into it which should have its edges rounded off and be slightly larger in diameter to allow the male mould to push plastic through it without jamming. A sheet of 0.5mm (0.02in) plastic sheet is pinned to the plywood and heated over an electric ring, plastic uppermost. When the latter begins to ripple, plunge the male mould

there are a great many commercial ranges available to the enthusiast and these are recommended. Nevertheless, most are designed only for specific injection moulded kits – not vac-forms. A decal spares box therefore is to be seriously considered and as most kits nowadays provide optional decals, these should be saved whenever possible.

One should have access to reference sources, too, as there are several vac-form manufacturers that leave modellers in the dark as far as colour schemes and markings are concerned. True, the most sophisticated manufacturers supply drawings, schemes and most important, a list of reference works, but modellers should never shirk in their quest for detail.

Unusual subjects

Vac-forms really score by filling as they do gaps in manufacturers' ranges. Some really interesting types have appeared, especially those of early civil and inter-war subjects. Also there are now more vac-form WW1 types from one manufacturer than there are available injection moulded versions, a difference from a few years ago, when the opposite was the case. For biplane enthusiasts, it is the vac-forms that serve them well.

As has been mentioned, early aircraft lend themselves to the process, where the delicate lightness of the original can be carefully matched. Nevertheless, it is surprising that several more modern types which one would consider to have real selling potential are only available as vac-forms, types such as the late Seafire, DH Rapide biplane, Douglas DC4, Avro Manchester, Pfalz DIII, Avro Vulcan, Victor K2, Focke Wulf Ta 154 and many others. Still, vac-forms create their own trends on occasion, for more than one has been closely followed onto the market by an injection moulded duplicate.

In summary, vac-forms demand a lot of care in construction, and considerable experience, but they fulfil an important role in plastic modelling. As more and more sophisticated kits match and sometimes even surpass injection-moulded models they should take on even greater significance. In providing a whole range of rare and unusual subjects, hitherto considered only by scratch builders, new avenues are opened to a wider market. For modellers wishing to improve their skills they can be unreservedly recommended.



ing. At least that way the model will look consistent and not just an obvious jumble of parts.

Liquid cement only should be used to cement vac-form parts to injection moulded parts, and again use a soft filler such as Polyfilla. Conversion kits demand a lot of careful thought and one should always follow the manufacturer's instructions very carefully. In a few cases some vac-forms even include a choice of parts themselves, allowing further variants to be built. This is good, as most enthusiasts will wish to buy at least two kits.

Moulding

Of course modellers can mould their own cowlings, fuselages, fairings, to extend the range of subjects even further. But this is into the realms of scratch-building, which is the natural progression from vac-form modelling.

Suffice it to say that moulding thin plastic sheet is not at all difficult and may be used in conjunction with vac-forms quite easily. Cowlings are natural subjects, especially those circular ones that enclose radial or rotary engines on vintage aircraft. Often these are ill formed

through. Leave to cool then remove and a perfectly shaped scale thickness cowling should have resulted – but it is advisable to make several in case of accidents. The advantages are obvious, with just one mould the number of cowlings that can be manufactured is unlimited.

The front of the cowling can be removed by gentle scribing with a pair of dividers in order to remove a circle of plastic. It is best to do this with the male mould in place.

With practice moulding will prove simple and effective and can be used to mould cockpit canopies, even quite complex shapes.

Presentation

Vac-form kits if carefully made and painted should appear indistinguishable from injection moulded kits if placed alongside in a collection. Being so much lighter in weight they are surprisingly more resilient. If both types of models are accidentally dropped the vac-form (if it is a small one) will always sustain less damage.

Most vac-forms lack decals and one must be prepared to search out appropriate transfers. Luckily



Models in Other Materials

Wood and Metal

Industrial Models

The heritage of wood models

Before the age of plastics a wide selection of kits of non-flying scale models was available in wood, usually either balsa or obechi but sometimes hardwood, and in what are still the two most popular scales, $\frac{1}{72}$ and $\frac{1}{48}$. In many cases, the work involved was almost tantamount to scratch-building, for the wooden parts were usually only formed to approximate outlines, leaving the bulk of the shaping to

be done by the modeller. The main advantage of the kits was that they provided items such as engines, airscrews and wheels, sometimes die-cast in metal, also scale drawings which were by no means as easy to obtain as they are nowadays. Pre-eminent in their respective fields were such makes as Skybirds in the UK and Hawk in the USA, the former containing hardwood fuselages and wings, as well as metal, fibre and celluloid

One of the finest fighting scouts of World War 1, the Sopwith Camel has appeared in various scales in plastic kit form. This $\frac{1}{24}$ example is, however, built of card, with wood struts, wheels and propeller. *Model by F. Henderson.*



components, the latter featuring mainly balsa wood and die-cast metal parts.

There are still some modellers who regret the passing of the wood kits and the special skills which went with them, so perhaps it is apposite to revive some of those skills and apply them to currently available materials.

Planning the model

The first consideration is the choice of a suitable subject and clearly there is little point in picking one which is already available as a plastic kit, so the opportunity will normally be taken to make a model of a favourite aircraft which is not likely to be produced as a kit. Having decided upon the type to be built, the next step is to find the necessary drawings and as much information to supplement them as possible, principally photos in books and magazines.

Working with wood

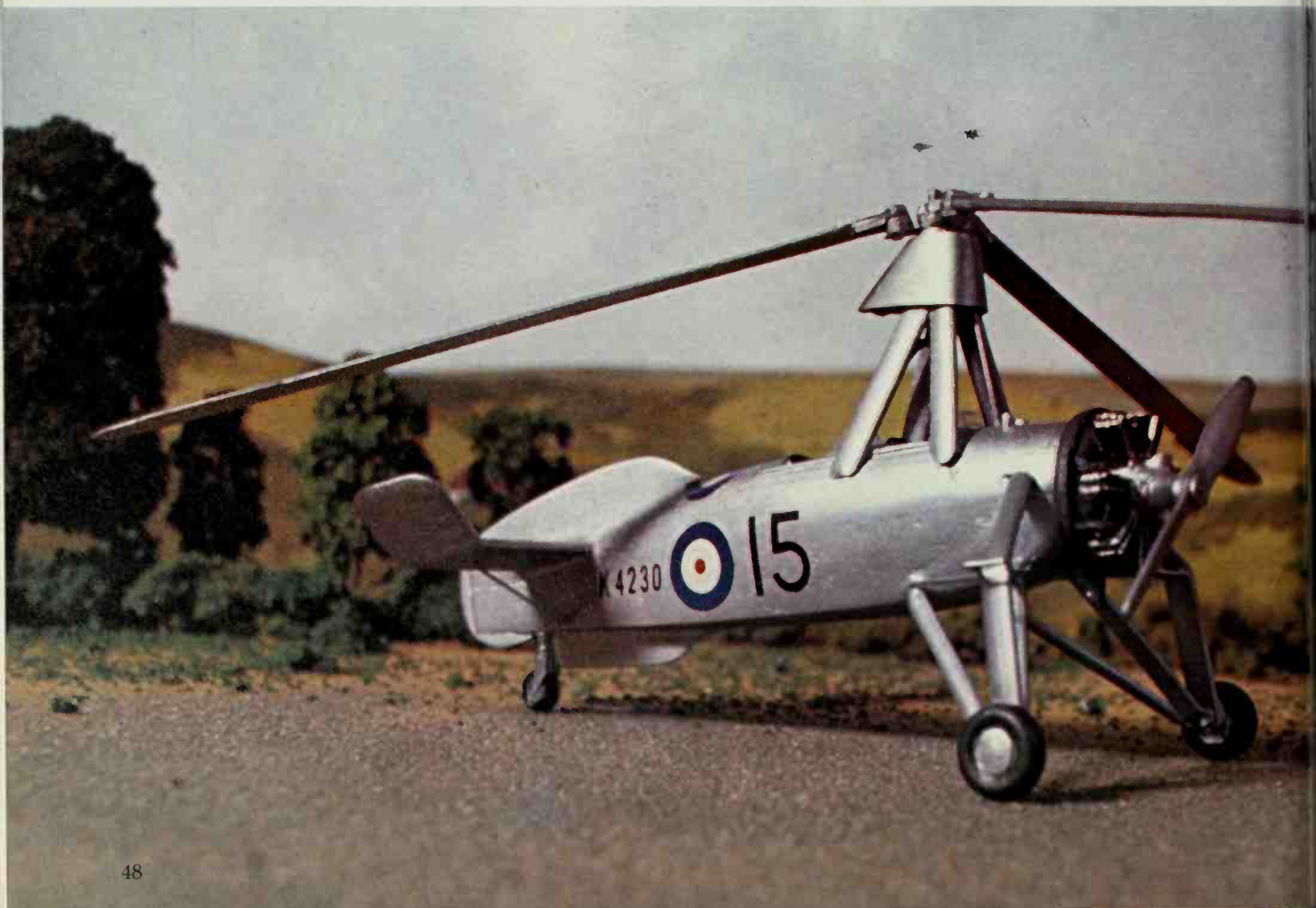
It is possible to carve virtually any shape from wood but the basic method is simple enough; first take a medium-hard balsa block with its three dimensions slightly larger than those of the part to be model-

led, then draw the outline on the two sides, always allowing about 0.75mm ($\frac{1}{32}$ in) oversize all round to allow for sanding. Carve the block first to profile and then mark out and carve it in plan. Next make templates from plastic sheet to give the correct section (half templates will usually suffice) at stations covering each major change of section, and carve the wood carefully to fit the templates, remembering always that it is much easier to take a little more off than to put it back! A rub over with fine glass-paper reduces the component to its final size and shape and several coats of filler (sanding sealer or, alternatively, clear dope mixed with talcum powder) will be required to obtain a smooth, firm, blemish-free surface; after each coat has dried the wood should be rubbed down with flour-paper. This procedure is followed similarly for the wings, tail surfaces and, where applicable, engine nacelles.

The smaller parts

Modelling a radial engine may seem to be a daunting prospect and yet, if tackled methodically and with patience, it is not too difficult. The crankcase and reduction-gear

housing are best built up from laminations of plastic sheet and then carved to shape, after which the centres of each cylinder are marked, a hole drilled and a small wire dowel inserted as a locator. The cylinders can be either plastic rod or wooden dowel, of suitable diameter, bound with thread to simulate the cooling fins, coated with thinned cement and, when dry, cut to length; a hole is then drilled in each cylinder to fit over the locating pin. Push-rods are cut from wire and rocker box housings and other small items made from plastic or wood. Cowlings can be made by wrapping thin plastic sheet around wooden dowel rod of suitable diameter, building up the required thickness in half-circles, laid alternately with the joints 180° apart; the dowel should be waxed to aid separation. Wooden-type propellers can be carved from wood blocks in the same manner as the larger components. Struts are best made from plastic sheet, reinforced with wire, and wheels, if not available in a suitable size from the spares box, can be made by laminating discs and rings cut from plastic sheet and then carved and sanded down, or turned if possible.





Above: This De Havilland DH89a Rapide was built recently from an original Skybirds $\frac{1}{72}$ wood kit, produced over 40 years earlier. The Rapide was a highly successful 'feeder liner' and later saw war service as a navigational trainer, the 'Dominite'.

Below: The Cierva C30A, also known as the Avro Rota, built in $\frac{1}{48}$ scale from an LDM cast white metal kit and finished as one of the original batch of 12 supplied to the RAF in 1934. The rotor of an autogiro is not engine-driven but rotates due to aerodynamic forces.

Making the most of materials

The wisest approach to any kind of scratch-building of aircraft models is to study the available materials and then use them in whatever combination will give the best results. There is no need to try for production line methods, nor to be commercial, for the aim is a one-off model, built entirely for the modeller's own satisfaction and the time taken to achieve the desired result should be of only minor concern. The combination of wood, metal and plastic parts does not constitute a problem in assembly, because modern adhesives can cope with virtually anything, but a tip here about the sticking of polystyrene plastic to wood is appropriate. If the wood is first coated, in the area to be joined, with at least one thin layer of plastic cement which is then allowed to dry, polystyrene parts can easily be bonded to it with the same type of cement; wood glues will not bond to plastic.

Going into details

Representing rib and stringer effects on the wooden parts can be done by cementing narrow strips of paper, or thin plastic sheet, in place; thread can be used for this

purpose but is more difficult to place accurately and to fix securely. Small appendages, such as radio antennae and pitot tubes, are best made from wire, soldered where necessary – soldering can be very useful at times – for they need to be durable to withstand handling and possible knocks; plastic or wood can be used for these parts but are easily broken, whereas wire just bends and can be straightened.

The forming of cockpits and cabins is achieved by cutting away the appropriate area of the fuselage and, after fitting out the interior, inserting new side panels with windows formed and shaping and filling, where necessary, to blend into the fuselage lines; the amount of interior detail to be incorporated is at the discretion of the modeller. Once the wood has been completely sealed, surfaced detail can be marked, with a knife or scribe, against a metal edge or, for curved surfaces, a piece of plastic sheet. The painting of wooden or metallic surfaces has one useful advantage over plastics in that cellulose lacquer-based finishes can be used. Transfers (decals) are available, in great profusion, from a number of commercial sources.

Tools of the trade

Only a simple tool kit is necessary, much of which will be in the hands of the plastic modeller already. Essential items are a modelling knife with a selection of blades of various shapes, small fine-nosed

and square-nosed pliers, wire cutters, small drills with a pin-vice to hold them, a razor saw, a few small files including ones of flat, round, square and triangular sections and fine grades of glasspaper, including flour-paper. Additionally a metal set-square and straight-edge will prove of great value when setting out the wood blocks.

Metal – a new approach

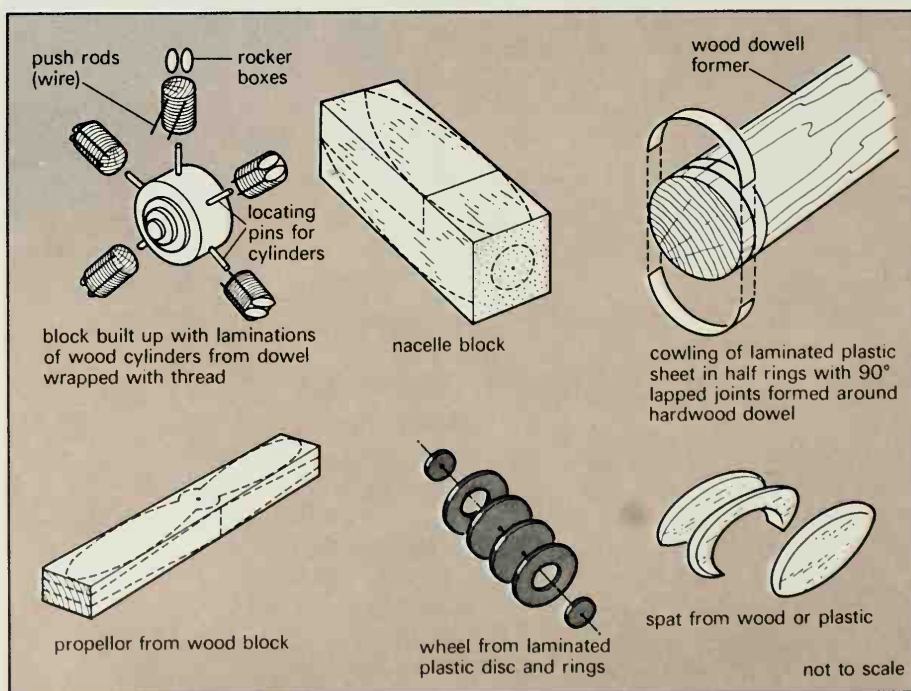
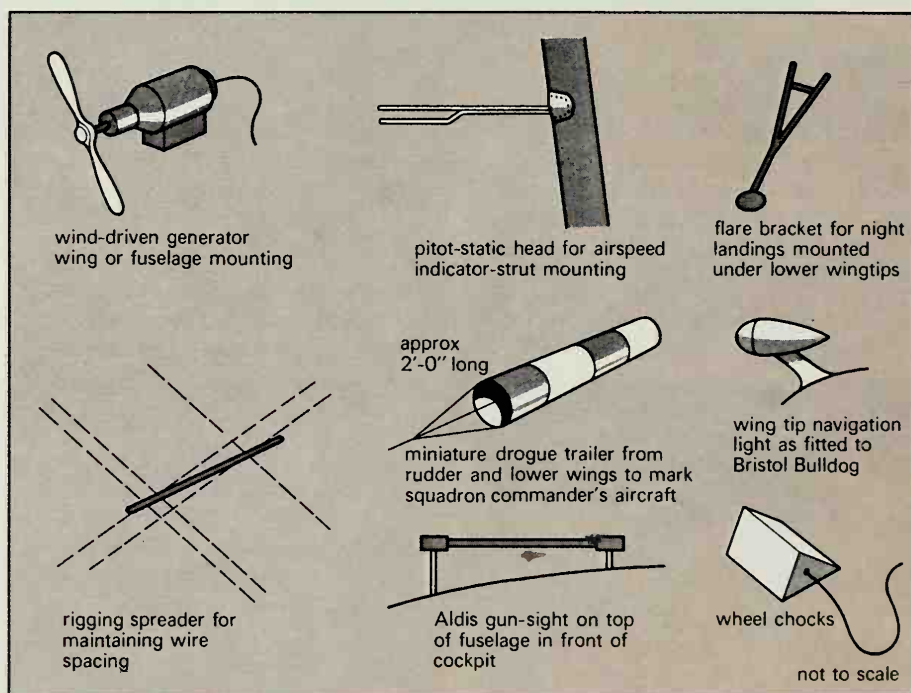
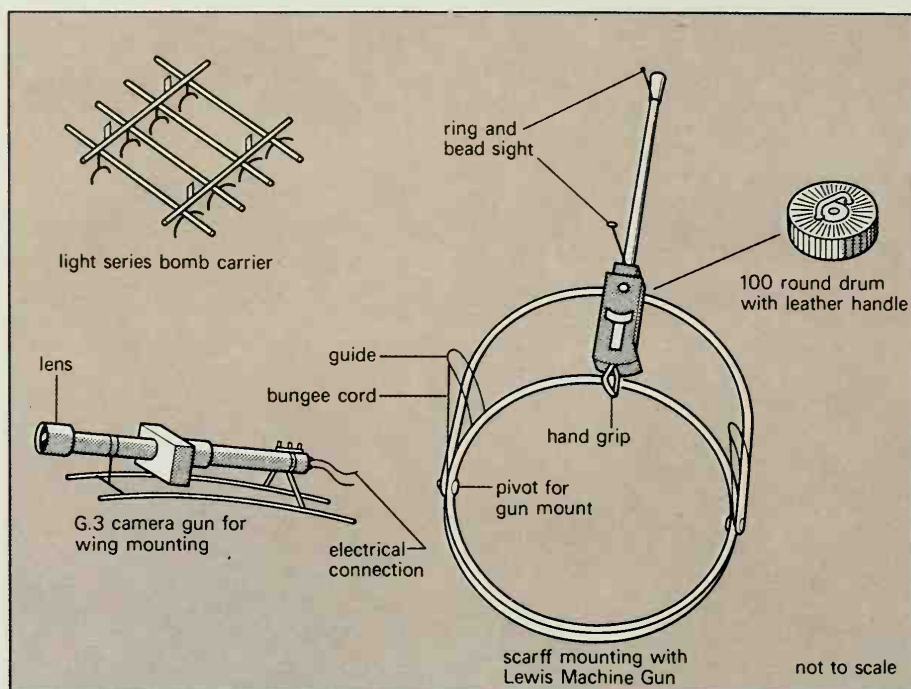
Kits in $\frac{1}{48}$ scale composed almost entirely of white metal components have recently begun to appear. The feel and weight of the completed models is distinctly odd to the modeller accustomed to working in plastic or balsa, but the appearance is undoubtedly good and the detail comparable with most plastic kits. The casting method has the advantage of being viable for relatively short production runs, totally uneconomic for plastic kits for which the mould cost would be vastly greater, so types of aircraft can be produced which have a limited appeal and might never appear in any other form. Two notable examples are the Pitts S2a Special and the Cierva C30a Autogiro.

Apart from the unaccustomed weight, there are other features of the die-cast model which are strange, although it is not really difficult to adapt plastic kit building techniques to suit. Most of the requisite tools will be to hand, files, pliers, wire cutters and 'wet and dry' carborundum paper being the main ones. Some cleaning up of the castings is necessary and possibly bending carefully in places to obtain an accurate fit of the parts, but assembly is not difficult, using quick-setting epoxy glue (low melting point soldering can be employed but only by the practised user). For spot-fixing the smaller parts the most effective adhesive is cyanoacrylate glue which has the useful property of setting positively in about ten seconds. Where any filling is necessary, auto-body fillers are suitable, but not those normally used for plastic kits.

Painting calls for a different approach. After thoroughly cleaning the metal, a primer needs to be applied, preferably by air-brush or aerosol spray, to prepare the surface for finishing. After that painting can proceed in the normal manner.

Modelling in card

Undoubtedly the cheapest, although certainly not the easiest, material with which to work is



The amount of visible detail on, particularly, military aircraft provides endless scope for a modeller's ingenuity. Some of those details, and standard methods of work with wood models, are illustrated here.

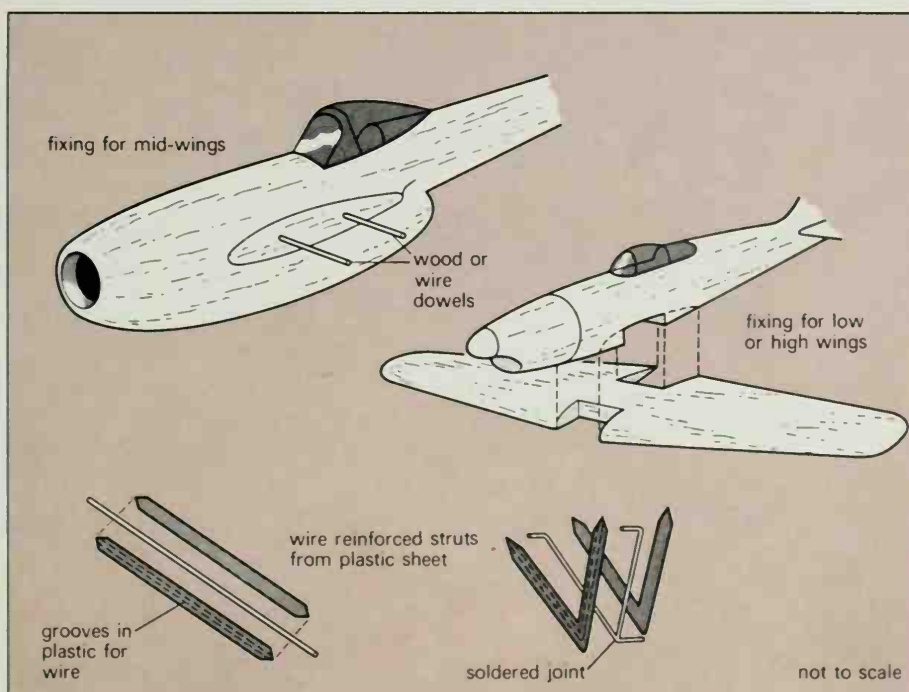
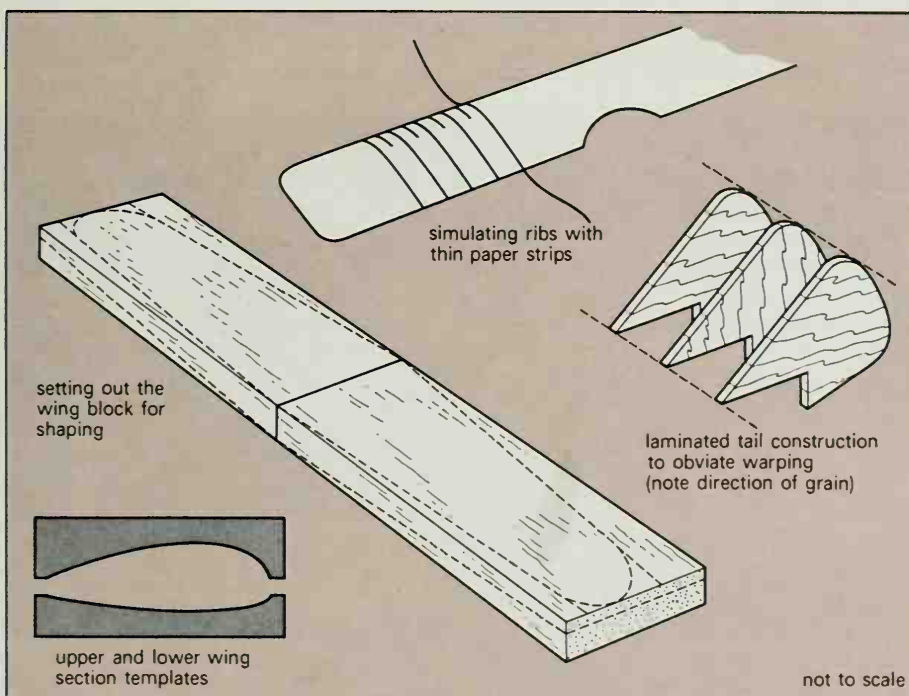
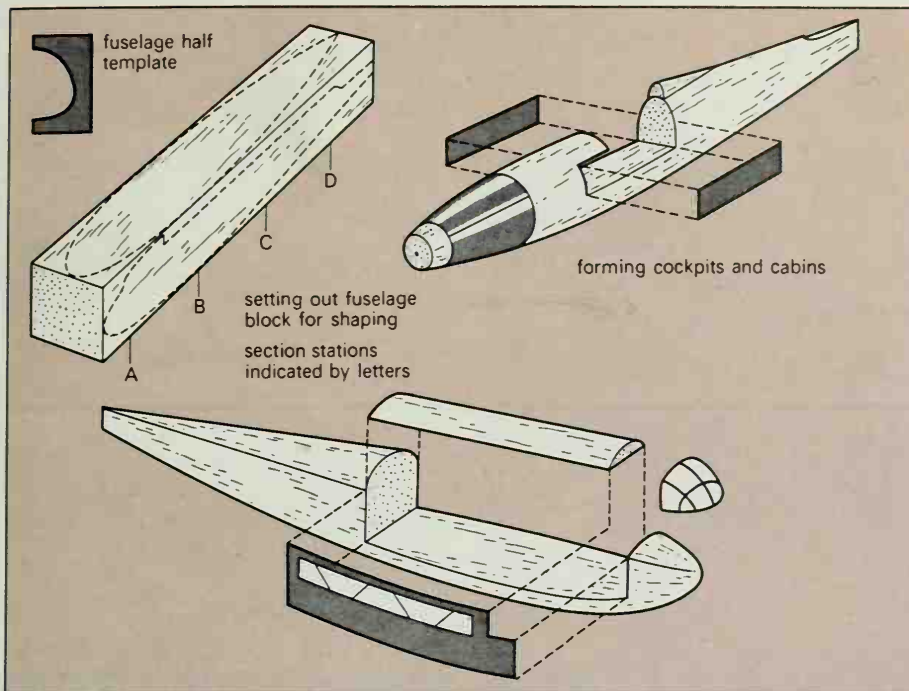
card, or board as it is sometimes termed. Nowadays the readily available, and easily worked, plastic sheet has largely superseded ordinary card and paper modelling as far as aircraft are concerned, but they are still popular for model railway buildings.

The history of the card model, as far as the UK is concerned, goes back at least to the late 1920s when a firm called Appleby produced pre-coloured cut-out sheets which purported to be for flying scale models. Although quite acceptable, for their time, as models, their performance was disappointing. A high point in the state of the art was reached in the mid-1930s when a large range of $\frac{1}{24}$ and $\frac{1}{48}$ scale models was made by Aeromodels, a Liverpool firm. These were printed in black lines on white card, so required painting by the modeller after assembly. The models were truly remarkable for their accuracy and completeness, the $\frac{1}{24}$ scale kits, featuring fully-fitted cabins, opening doors and even folding wings! Cork was used as reinforcement internally and there were some hardwood parts, and the resultant model was far more durable than were the built-up balsa wood models of the period.

For practical purposes, $\frac{1}{50}$ is the smallest advisable scale and the present-day cut-out card sheets, produced by such firms as Wilhelmshavener Modellbaubogen, of West Germany, are mostly to that scale; such models are not comparable with the late-lamented Aeromodels series but can, with care and patience, be made into realistic miniatures, and they are pre-coloured.

Building from scratch in card involves techniques similar to those employed for plastic sheet, described in another chapter, but white PVA glue takes the place of polystyrene cement. However, card is more difficult to work with than plastic sheet and the latter material does most jobs better so, unless cost is the main consideration, scratch-building is best done in plastic card.

For card and paper modelling the tool kit required amounts to little more than a modelling knife, straight-edge, pencil and a pair of household scissors, plus suitable glue.



Industrial Models

The value of research and test models is inestimable. They are used for every stage of aerodynamic development, to prove the feasibility and performance potential of new projects, but they must not in any way be confused with the sport flyer's scale model, no matter how closely related is the appearance to the full size. In fact, the model enthusiast generally produces a much more easily recognized replica. Drop test, wind tunnel and structural test models are normally very simple in detail; they do not need embellishment, for the primary requirement is accuracy.

Tunnel models have been used to prove aerodynamic factors ever since the first experiments by the Wright Brothers. Machined from close-grained timber, or in recent

years steel and plastic resins, wind tunnel models are made to extremely close tolerances. When designed to break down so that changes in configuration can be checked, the tunnel model gives results relatively quickly.

The free-flying test model has become a valuable supplementary tool in research and development. Typical is work on the Anglo-French Concorde supersonic jet airliner. Prior to construction of the actual prototypes, the one time world speed record-holding Fairey FD2 was converted with an 'ogival' wing (curved leading edge delta) of the same shape as Concorde. Before the FD2 could air test the wing, a free-flight model of this airframe had to be drop tested.

The sophistication of the task

created changes in model construction techniques, for the fuselage shell had to carry equipment weighing up to 25% of the total weight, and the wings, by virtue of their supersonic intent and desired ground impact resistance, had to achieve a strength/weight ratio well in excess of previous experience.

The answer came with moulded epoxy resin and glass cloth assemblies. First, a wooden mould pattern of extreme accuracy was carved to tolerances of 0.025mm (0.001in) including French polish finish. Next,

Below: A high standard is needed for commercial production of epoxy-cast models for airline publicity use. This type of modelling is close to mass production, with assembly line techniques and methods.



'Titanite' exothermic setting (heat generating) cement moulds were made, braced into steel frames. Into the moulds, layers of glass cloth and resin (Araldite) coupled with a calcium carbonate filler formed a shell for the eventual model, which had cavity areas cold urethane foam-filled for rigidity. Components were then assembled in a precision jig, where metal fittings were added, and final work on the exterior executed to bring the wings to limits of 0.125mm (0.005in) and the fuselage to 0.25mm (0.01in). One set of moulds in yellow pine could thus be used to produce repeated test models fairly quickly.

These drop test experiments employed a helicopter release. A very close approximation of the Concorde flight envelope, especially at extremely slow speeds, was accumulated long before the prototypes were first flown.

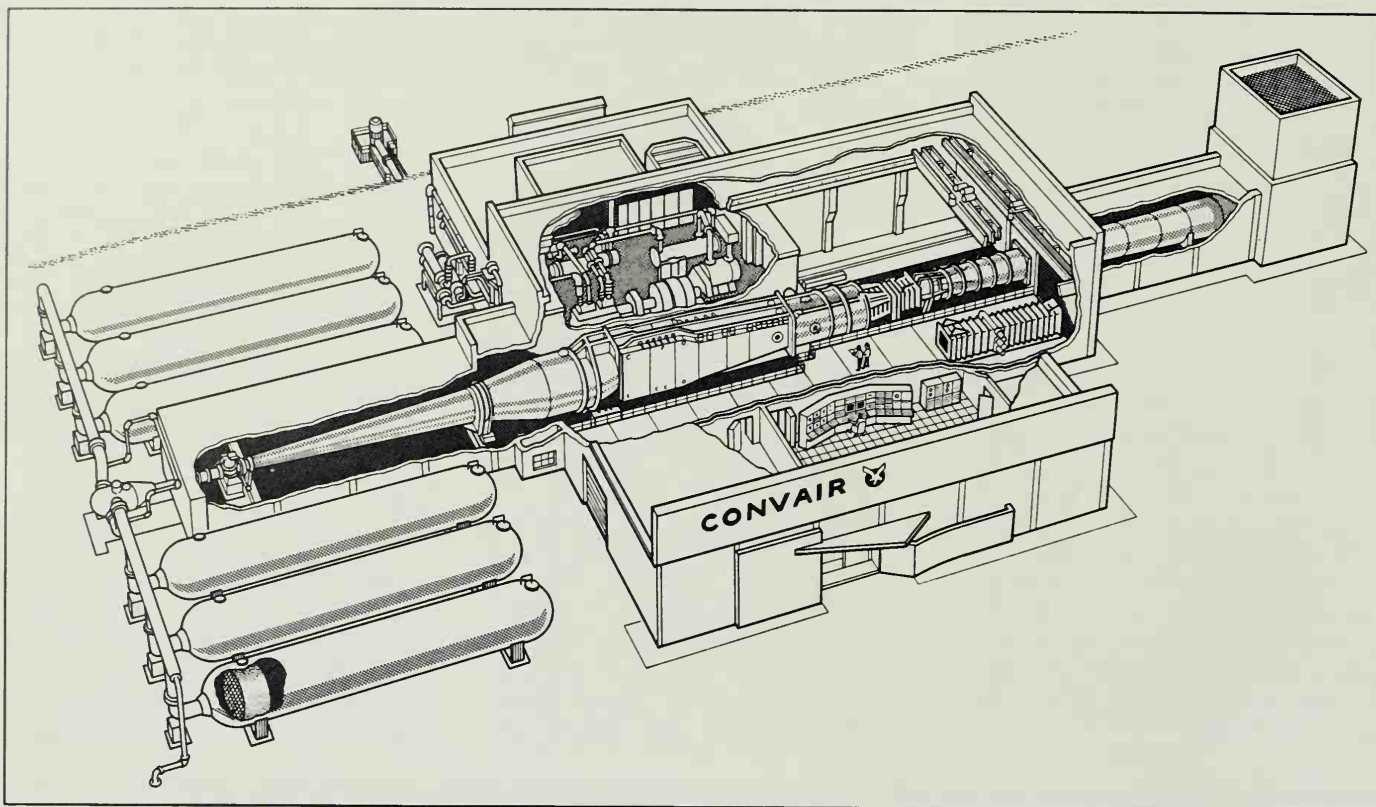
High speed research employs models of a different calibre. Made to much smaller scales and propelled by solid fuel rockets the velocity is in the order of 1600km/h (1000mph). At such speeds, visual observation is impossible, so the small model is equipped to telemeter measurements of pressures and accelerations from up to 20 stations. During the cruise (power-off) stage, a series of kine-theodolite survey cameras record azimuth and elevation, and velocity is determined by Doppler ratio. Such tests are used to discover pitching motions, divergences at speed, and stability. Scientists are concerned only with the aerodynamic shape, so the weight problem does not arise. Machined in steel and sometimes carrying further small rockets to fire at intervals to provide an oscillatory motion, these supersonic free-flight test bodies are

beyond the concept of general modelling.

Standard aeromodelling techniques have long been employed at NASA in drop tests. Models as heavy as 104kg (230lb) have been dropped from a helicopter at 1200m (4000ft), prior to deployment of a Rogallo type para-wing, for space recovery research. Precision was such that landings were positioned within a 6m (20ft) circle.

Robert Reed, then Head of Advance Planning, Re-entry Vehicles, at NASA Edwards Field, reported most favourably on the use of aeromodelling methods to an Astronautics Conference in Los Angeles. He revealed the use of a 7kg (15lb) 'carrier' model, of 3.2m (10ft 6in) span and 2.5m (8ft 3in) length, which was designed to air-launch up to 9kg (20lb) payloads which could be any of six re-entry bodies ranging from a 150gm (6oz) light-





weight fixed control slender lifting body to a 1m (40in) long 4.5kg (10lb) fibreglass scale M2-F2 with a pop-out para-wing. Such studies offer low-cost, minimum risk examination of basic problems in research and are by no means limited to government establishments.

The Sandia Corporation of Albuquerque, New Mexico, saved itself much time and money thanks to sport modelling experience. Dan Parsons, a Scandia supervisor engaged with the company's tracking telescopes, conceived the idea of using radio-controlled (R/C) models for telescope tracking practice to accustom the operators to the skilful task of observing high flying jets. Drop tests of dummy bomb shapes, involving a study of target colours, were another aspect of

their experiments with the 1.8m (6ft) 3kg (7lb) models, which use 0.60 engines. A development was carriage of telemetry equipment to relay model-borne instrument readings as the small plane was guided 450m (1500ft) above an explosion. Blast pressure readings would be difficult to obtain by any other method.

Consolidated Vultee and Dornier have tested flying boats in radio-controlled model form. The object of these tests was primarily to ascertain hydrodynamic characteristics so that changes to the planing hull could quickly resolve problems. A colossal $\frac{1}{10}$ scale Convair XP5Y-1 of 4.46m (14ft 8in) span with four 2hp horizontally opposed twin-cylinder engines was flown at San Diego and a similar though

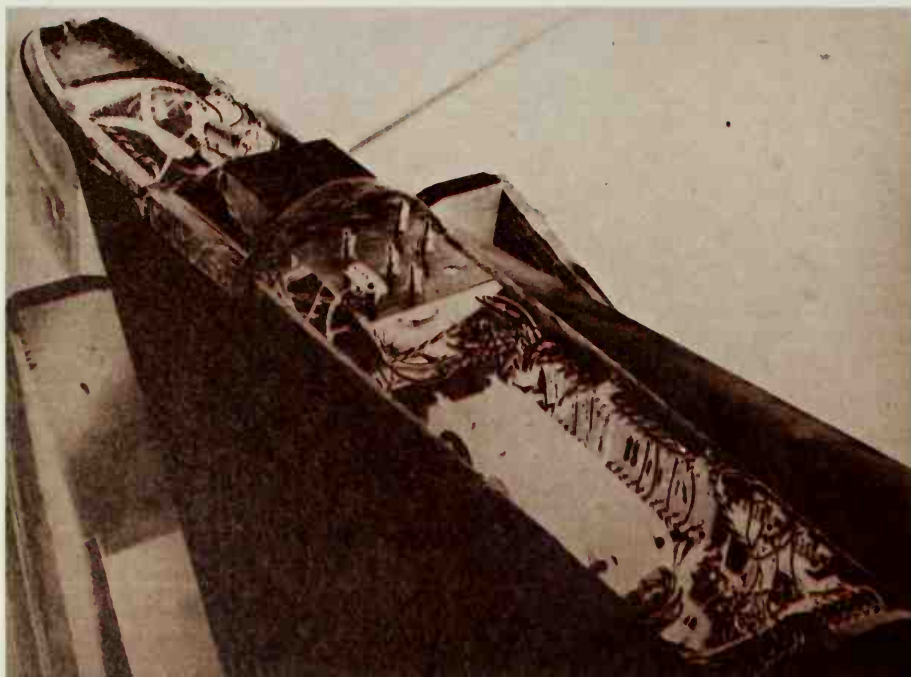
smaller Dornier Do24 at Bremen.

Convair became famous for their model department; another aspect of their research involved mechanically actuated models in a wind tunnel for filmed observation of crew escape systems. The rocket propelled shuttlecock action ejection seat which tilted the pilot back in his seat before leaving the cockpit in emergency was first tested with scale models before full-size experiments at Edwards.

Lockheed's model department is also famous for its achievements. The solution to the early problems of the Electra's disastrous wing failures was discovered through models with scale elasticity designed into their structure.

Films

In the 'special effects' departments of the film companies, the model comes into its own for crash scenes. Gone are the days when model 'planes slid jerkily along stressed wires in a studio. Crash shots with all the blast in the wrong direction and obvious studio break-ups are past. So successful is the use of R/C scale aeroplanes before the cameras that the film makers maintain a deception that it is the real stuff they are flying. All that can be said



Left and above right: Dynamic drop-test model of the type released from a helicopter or captive balloon to give invaluable information on performance characteristics relatively cheaply. Radio control can be used to produce special situations on the way down.

is that when the screen shows two Ju 87s in spectacular mid-air collision, filmed in 1968 when there has not been a single example flying anywhere in the world for 20 years, what else could one possibly imagine has provided the spectacle? As art directors develop the techniques whole new fields open up for action scenes of extreme realism.

Airline models

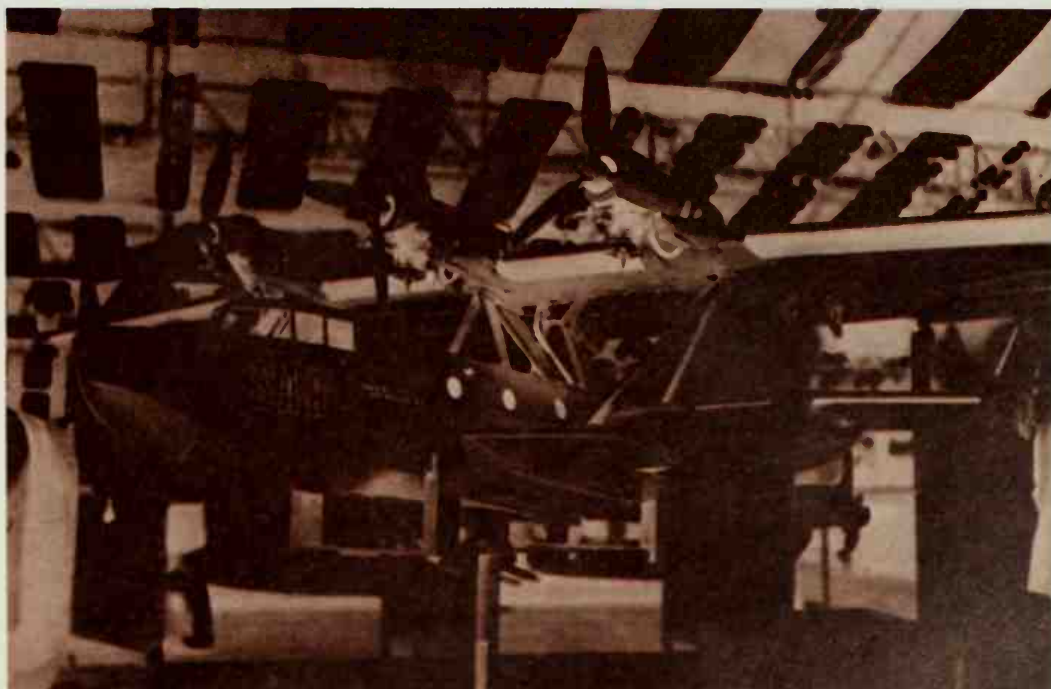
In the airline world the need for visual impressions of new aeroplanes and their colour schemes has created an industry of professional model makers engaged in production of sleek mini-liners for travel agencies of every nation. Pride of the trade are the $\frac{1}{4}$ scale 'sectionals' where a transparent plastic fuselage is left only partly painted to show the cabin interior. When re-equipment of an airline involves an entirely new type, such as the A300 Airbus and Boeing 767, the model suppliers have a boom on their hands.

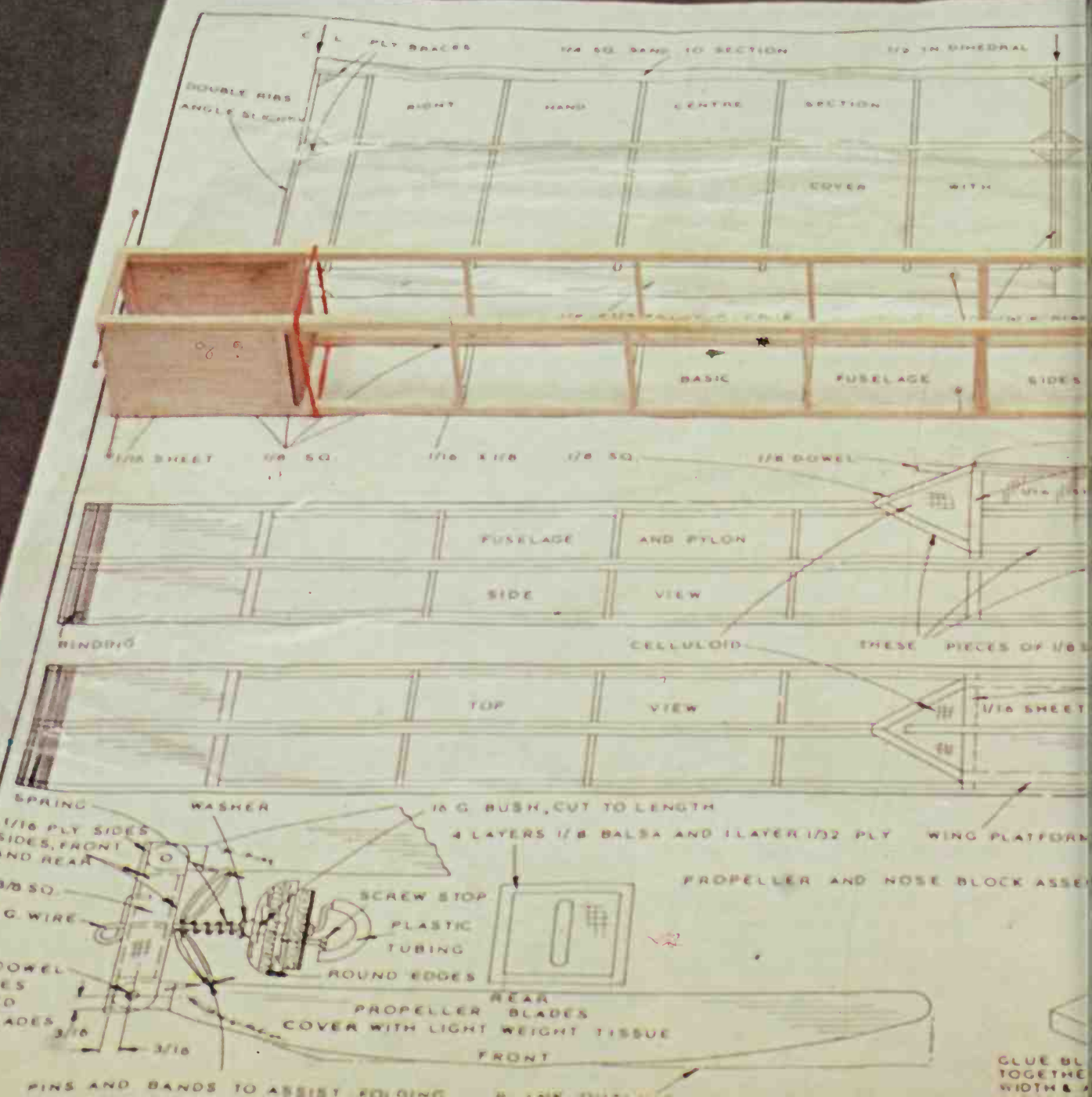
Plastics feature largely in this business. Wings are of epoxy-fibre-glass, with styrene mouldings with transparencies for the fuselage and, often, solid wooden tail surfaces. The smaller models are all styrene, vacuum formed or injection moulded in a one-piece assembly and decorated with special livery decals. It is not entirely unknown for an airline to adopt the livery created by a modeller for a prototype design.

When a full-scale aviation show is planned, such as the Paris or Farnborough Air Shows, these modellers come into the most interesting side of the job, for they alone have the responsibility of conveying to the public and their customer's opposition companies how good are the future projects. Models appear up to three years before an actual aircraft makes a first flight, and their surface finish, shape, cleanliness and presentation are critically important at Le Bourget or Farnborough.

There is a place for modelling in every manufacturing establishment, and although formal training courses are virtually non-existent, opportunity abounds for the hobbyist who is genuinely skilled in his craftsmanship, adaptable in his interests and adventurous in his techniques.

Right: This radio-controlled flying scale Dornier Do24 was part of a research study on the feasibility of new production of this 40-year-old flying boat for commercial purposes such as water-bombing of fires and the like.





First Steps in Flight

First Flying Models Building a Simple Kit

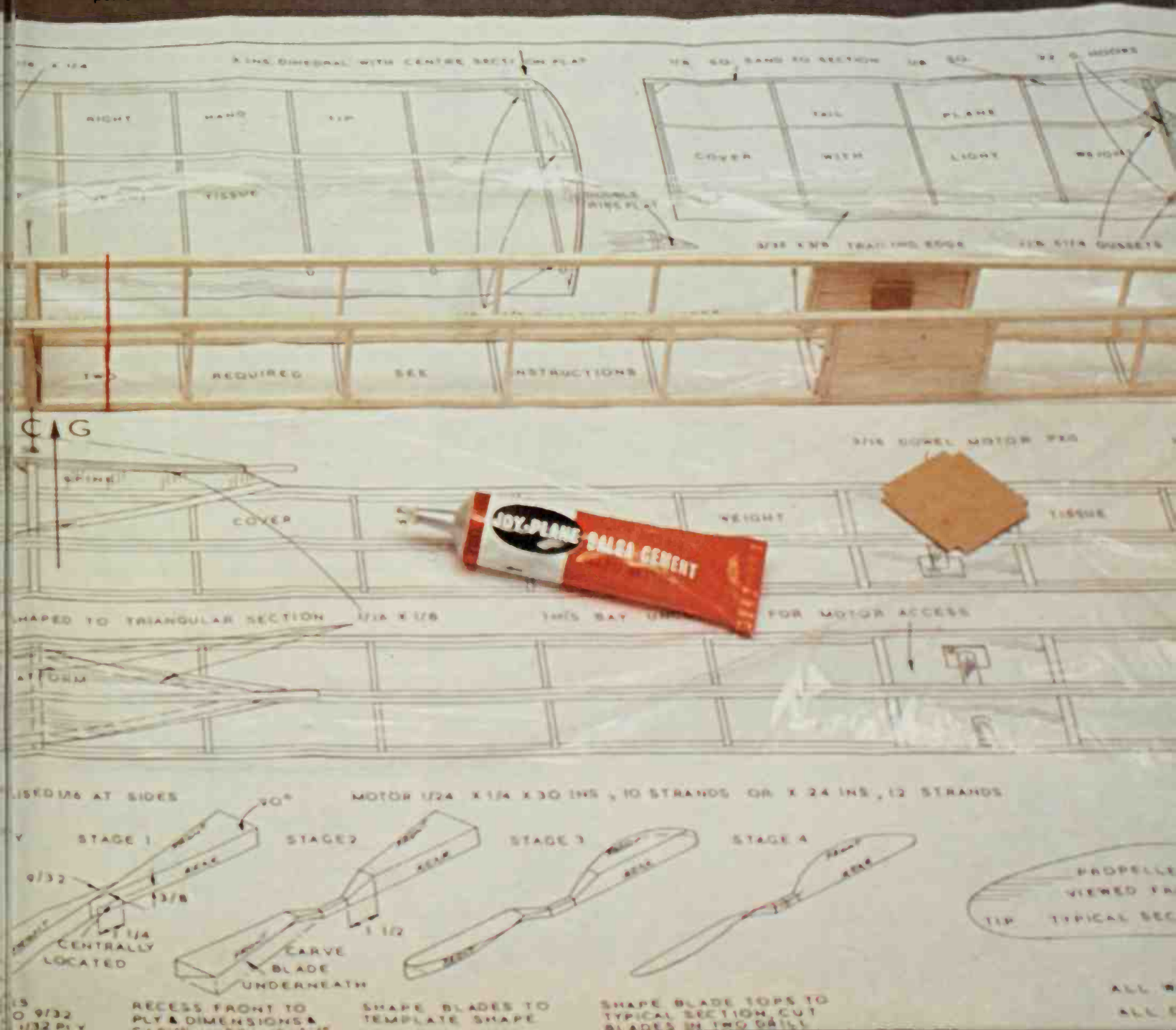
Far left: Young beginners with three examples of kitted novice models, a C/L stunt trainer, R/C trainer power model, and a towline glider trainer.

Left: A1 class gliders in the hands of young fliers have many advantages — they are inexpensive, straightforward to build, and have a satisfying performance.

Why build a flying model?

When Stringfellow and Penaud created the first powered flying model aircraft over 100 years ago, the answer to that question was the same as it is now — to achieve flight, to master the forces of nature and defy the laws of gravity is a natural desire of mankind. We have always wanted to fly, from the days of Icarus to the Wright brothers. If you can't actually go flying in a full-size aircraft, then there is no thrill quite like that of seeing your own model creation take flight! Since the times of Penaud, there

have been many design refinements that enable even the neophyte to achieve initial success. In the USA, over half a million small rubber-powered 'Delta Darts' have been built and flown by beginners. Some of them are incredibly crude (built by youngsters who have never used a hobby knife or balsa glue) but the satisfying part is that they all fly. This act of flight is the thrill and stimulus to the imagination that bonds all the aeromodelers of many nations. You can feel that thrill for yourself!



Choosing the right model

There is such a great choice of aircraft types and model designs that it is difficult for the beginner to pick one that will give him initial success rather than crashes and frustration – or worse still, an incomplete and thus unflyable model. The natural tendency is to look for models that are very realistic, that have true scale appearance. The more complex or stylish these are the better – everyone would like to have a flying model of the Lindbergh *Spirit of St. Louis*, or the Wright Flyer, or the famous gull-wing F4U Corsair. However, even expert modellers have great difficulty in getting those particular examples to fly at all, let alone well.

If you must have a scale type model, choose one of the pioneer types or a home-built aircraft design. Generally these have the characteristics that make for easy construction and good flying. They have squarish outlines, box fuse-

lages, long noses and tails, and large tail surfaces, relatively speaking. There are no complex curves to impede construction, and their proportions give them a built-in stability that is essential to 'pilotless' model flight.

Simplicity cannot be over-emphasized in choosing your first model, if you ever expect it to fly. If it has so many parts that you may tire of building before that exciting first flight, then avoid it. Seek instead a creation of few parts, perhaps all sheet balsa with no covering material. Covering is an essential skill for the high performance lightweight modeller to master, but it can be sidestepped. The great success of the AMA *Delta Dart* and the sister ship BBC *Hawk* is that the airframe is glued right to the covering. This covering is the actual plan for the model, so construction is rapid and almost fool-proof. The triangular flying surfaces, while not very realistic in

terms of full-scale appearance, are easy to make and warp-proof. Twisted warps in a first model can often spell disaster in flying.

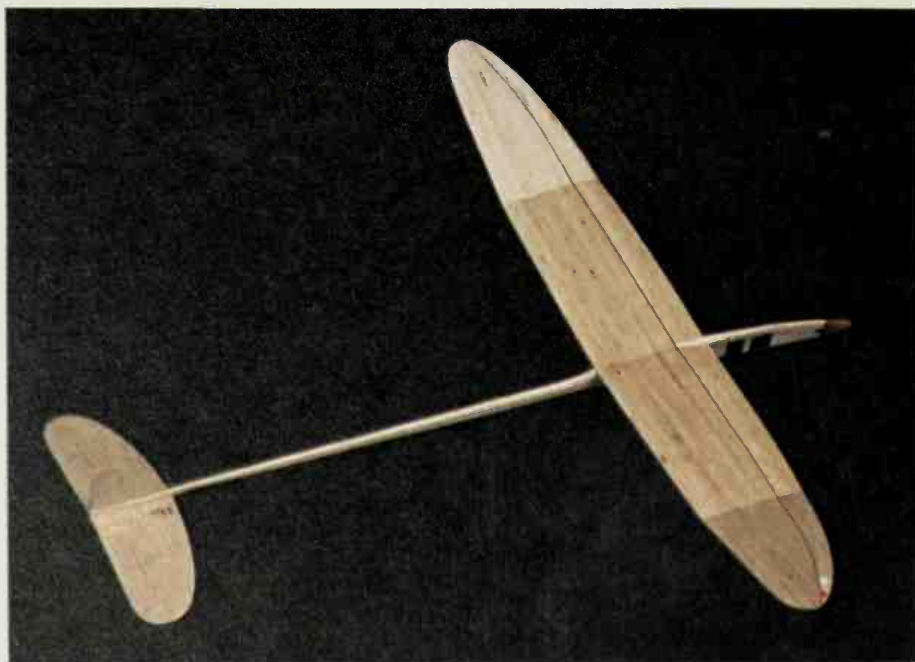
Strength is another factor in choosing your flying model design. Look for structures that have thick balsa parts or sheet wood, rather than flimsy small strips. Reinforcement at critical points that take flight stress is important, such as the wing centre, propeller mounting and landing gear. All-balsa structures are generally very strong and have the added attraction of being able to be repaired easily in the event of a crash. Profile or stick bodies, while not realistic, are very good and quite sturdy.

Strength and simplicity are important, but probably the most critical factors in success are proportions and built-in stability. Models with long bodies and relatively large tails usually are the outstanding flyers. The dihedral (or 'bent' wing) angle of wing panels is important in providing built-in spiral stability, since most models fly in circles. Low wing models are more difficult to fly than shoulder wing or high wing designs, and biplanes are especially difficult. While a biplane has glamour, it also has potential for misalignment of wings, and the tail is usually small for the wing surface.

Power is another factor to consider. Gliders, either handlaunch or tow, are the simplest flying models. More thrills can be had by adding a propeller powered by rubber strands, a CO₂ motor, electric motor or internal combustion engine. Each of these have advantages, but the rubber model is the most universally popular.

Indoor model flying

Newcomers to flying models should keep in mind that many good indoor flying sites abound in their communities, and indoor flying can provide all-weather fun day and night. Indoor models are generally much lighter in weight and seldom powered by anything other than



Above far left: the P30 class rubber model is a good introduction to rubber-powered competition flying.

Above left: This 7-year-old's 'Metric Penny' flew for 5m 12secs on his first visit to a 15m (50ft) high gymnasium.

Left: An indoor hand-launched glider, 610mm (24in) span and 27g (0.9oz) weight. British record-holder at 78secs.

rubber or CO₂, since oily, noisy internal combustion engines are unwelcome in school gyms and auditoriums. The heavy batteries required by electric powered models also make them very unlikely for indoor use. Towline gliders, which must be kited up to launch altitude, are also unsuited to flying indoors.

Nevertheless, a lot of enjoyment can be had from indoor flying. One of the most popular of internationally flown scale model classes, Peanut Scale, is flown indoors. These models are restricted to 330mm (13 in) wingspan and must be rubber powered. They take off from the floor in a realistic way and can often put in flights exceeding one minute. Normal endurance indoor models can be flown for up to ten minutes in small halls by beginners. The professionals can achieve half-hour flights with ease in larger sites. Such models are covered elsewhere in this book, but for the novice, we recommend that the first indoor model be a Pennyplane. This class was developed in the USA when it was found that the lightweight 'Easy B' (or EZB) was actually too difficult! Pennyplanes can be built with heavier grades of balsa to withstand flying and handling knocks. Many full size plans and a few kits are available for Pennyplanes. Try the MAP Plans Service *Penny Wise* or Vintage Aero kit *Metric Penny*.

The best beginner models

Earlier on advice was given on how to choose a model that will fly well. The simple chuck glider, profile towline glider and basic engine-power models in this book are all good flyers and worth building if you do not choose to try a kit your first time out. However, there is a lot to be said for using a kit. They have all the materials, sometimes cut to shape, and the plans are usually full of building and flying advice. Often they are developed from a long line of prototypes before being mass produced. Feedback from builders helps to ensure that they fly well, especially if they are used in large school beginner classes. Good flying kits are a key part of these classes.

The two types of models that will give you the most satisfaction and good flying for your investment of time and materials are the small hand-launch glider (or chuck glider) and the Simple Rubber Power Stick Model (SRPSM). They are available in many varieties. The

Humbrol *Ladybird* HLG and Wasp SRPSM are excellent choices. USA counterparts are M & P *Miniflash* and Jasco *Flash X-18* SRPSM. These 'top choices' are available in most hobby shops and have had extensive consumer testing. While the AMA *Delta Dart* and British BBC *Hawk* are excellent first flying models, they are not always on the dealer shelves. They are more often seen in class work or promotion of model aviation by aeroclubs.

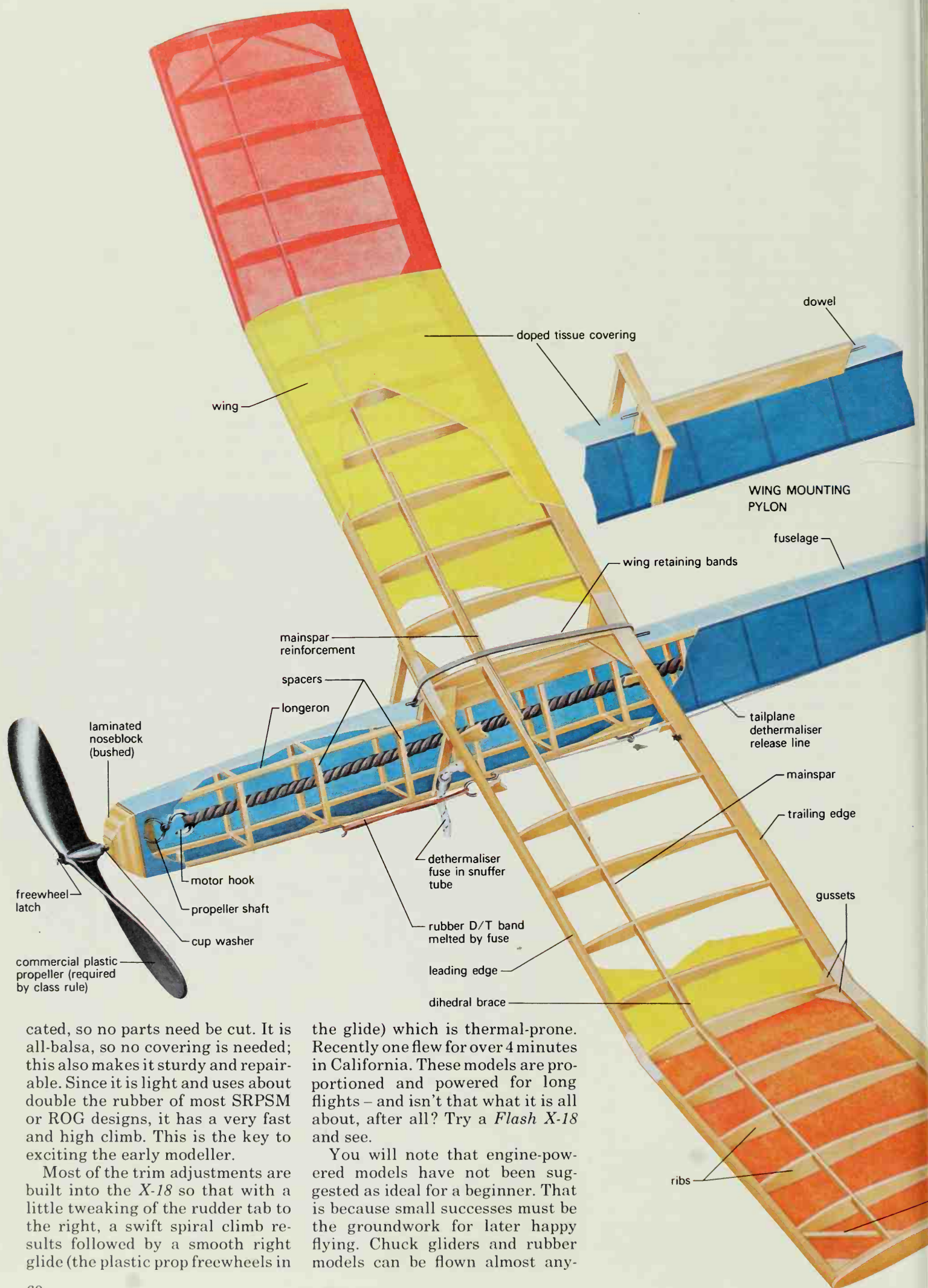
The *Ladybird* and *Miniflash* gliders, while produced in different nations (UK and USA) are similar in approach. They are small, require less than an hour to assemble, and trim out easily. The former has vee dihedral and the latter tip dihedral, but this does not affect performance. Note that such chuck gliders can be flown indoors as well as out, and teach all the basic principles of flight (except power thrust) with minimum effort.

The Humbrol *Wasp* is actually a small ROG (Rise Off Ground) type but can be flown without wheels if you wish a true SRPSM. A 'stick model' is one where the rubber motor is hung from a bearing/shaft and a rear hook mounted on a motor stick, completely exposed. The use of a stick allows the wing to be moved fore and aft for trimming and motor can be wound easily from rear. Alternatively, you can wind up by simply turning the prop.

The Jasco *Flash X-18* is very simply the best SRPSM ever kitted. Years of development went into the design and kit instructions, and it is a very high performance model. The *X-18* is completely prefabricated.

National German adhesive manufacturers run a nation-wide beginners' glider competition. The 1978 winner at Buhl was Stephanie Scholz, one of the relatively few lady competitors.





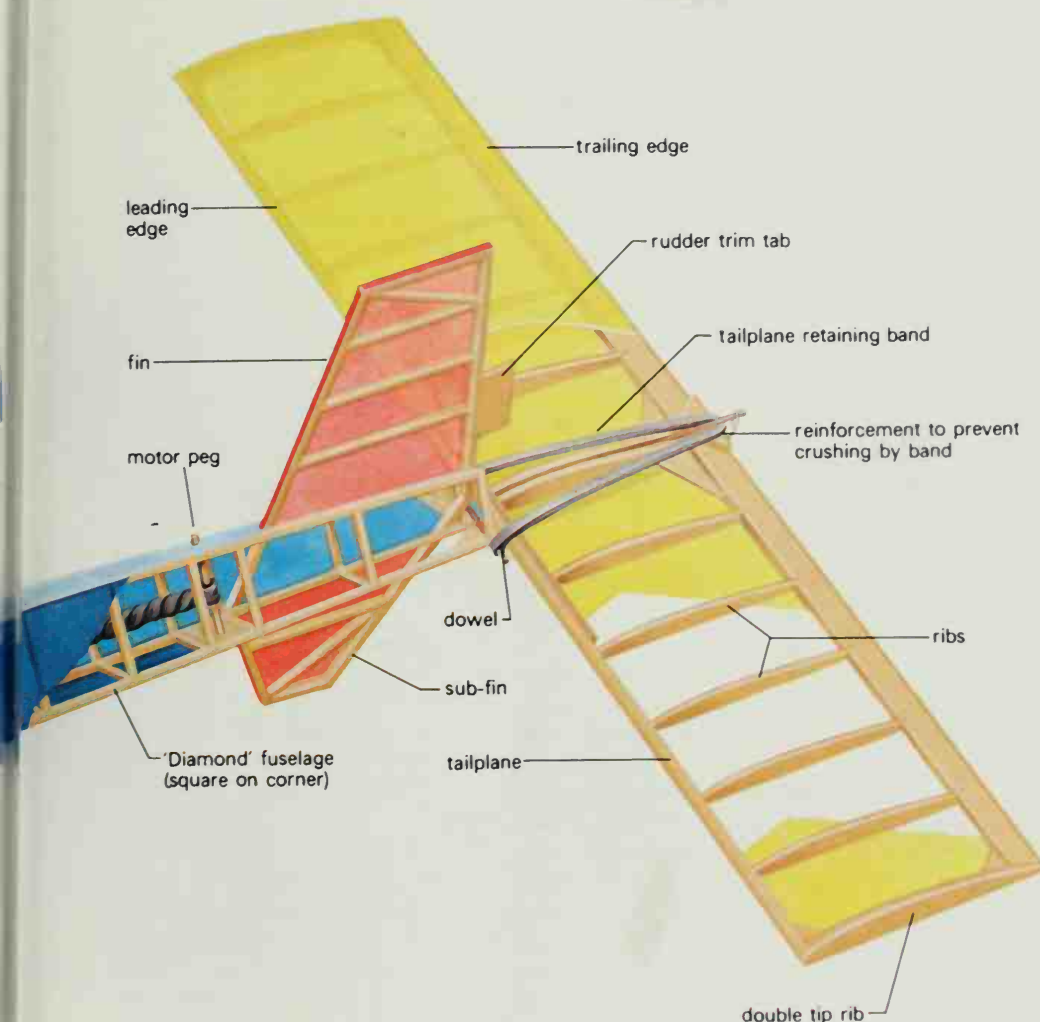
cated, so no parts need be cut. It is all-balsa, so no covering is needed; this also makes it sturdy and repairable. Since it is light and uses about double the rubber of most SRPSM or ROG designs, it has a very fast and high climb. This is the key to exciting the early modeller.

Most of the trim adjustments are built into the X-18 so that with a little tweaking of the rudder tab to the right, a swift spiral climb results followed by a smooth right glide (the plastic prop freewheels in

the glide) which is thermal-prone. Recently one flew for over 4 minutes in California. These models are proportioned and powered for long flights – and isn't that what it is all about, after all? Try a *Flash X-18* and see.

You will note that engine-powered models have not been suggested as ideal for a beginner. That is because small successes must be the groundwork for later happy flying. Chuck gliders and rubber models can be flown almost any-

P30 CLASS RUBBER MODEL (for small-field flying)



where, with no engine starting problems or equipment. A crash with an engine-powered craft will almost certainly result in damage, while lightweight HLGs and SRPSMs can bounce back for more after most prangs. Also there are limits on cost – almost any young enthusiast can afford the simple models, but power can become costly. Even the CO₂ motor can be expensive in initial cost and operation. But because it is adaptable to most small rubber power models (even fitted to SRPSM!) it is a good compromise; also it can be flown

anywhere, including your local school gym on rainy days.

Sooner or later, many flyers will want to advance to engine power and the noisy thrill of an internal combustion engine. Since control-line models are universally powered by engines, they are dealt with in a separate section near the end of this chapter. Free-flight models with 0.049 engine power are the best for beginners. Often a reed-valve engine from a demolished and discarded plastic control-liner can be adapted to free-flight sport use. If simple sport free-flight is desired, then a largish (900mm (36in) or so) cabin model can give many hours of flying fun. No timer is needed to control motor run; simply limit the amount of fuel used in the integral tank on the 0.049 engine. There are a number of kits that can be seen in the hobby shop; one good one is the KeilKraft *Wizard*. If you enjoy building from scratch, the *Tomboy*

(PET 398) and *Mandy* (PET 861) are good choices from the MAP Aeromodeller Plans Service (see 'Resources' at end of chapter).

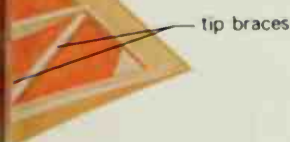
If simple flight thrills you and motive power is optional, then the towline glider is second only to the chuck glider for most pleasure for the investment. Such models can be flown to a good altitude by kiting on tow, and launched into warm thermals for long flights. A slight variation on the towline glider is the 0.049 engine powered RC thermal soaring glider. For the same reasons that power models are not suggested for the complete beginner (crashes and cost), thermal RC flying seems best left for later. However, the new Cox *Sport-Avia* ready-to-fly model (requires only component assembly and simple radio installation) is a very good way to start in the sophisticated and expensive (\$200 or £100 to get flying) world of radio control. It is a first-rate, quality kit.

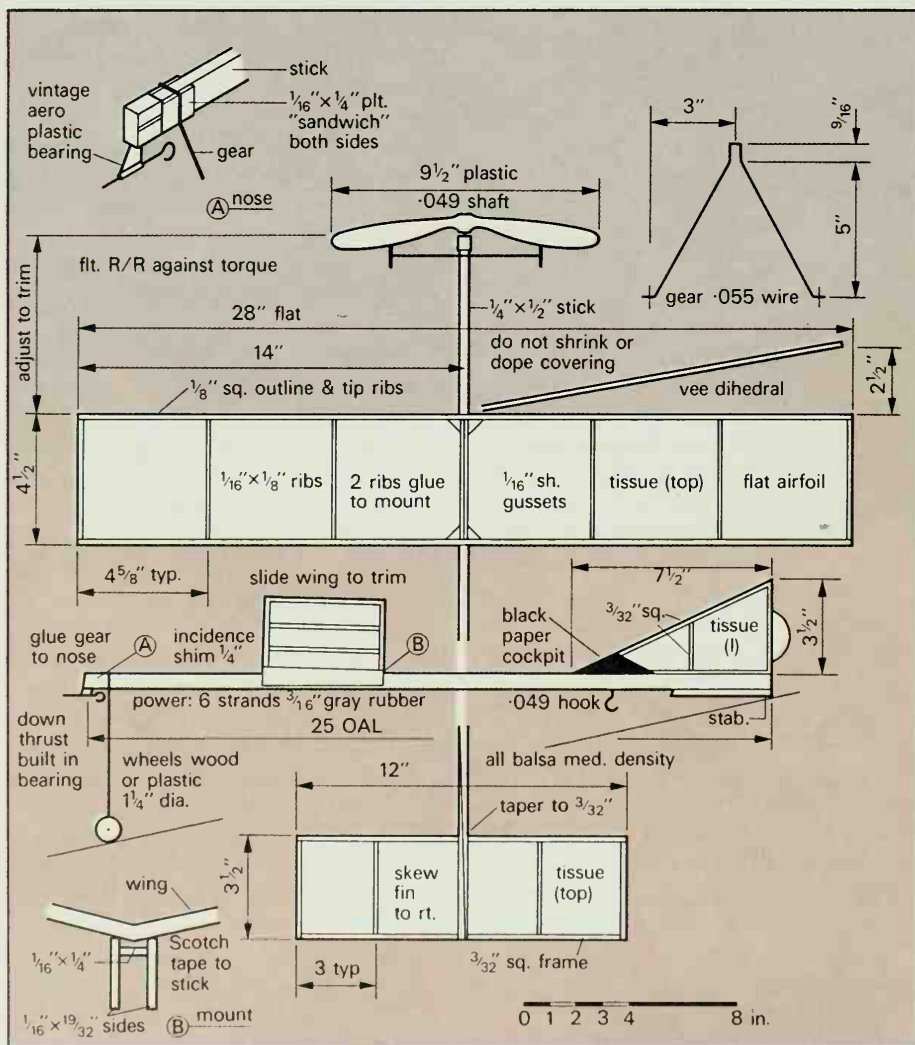
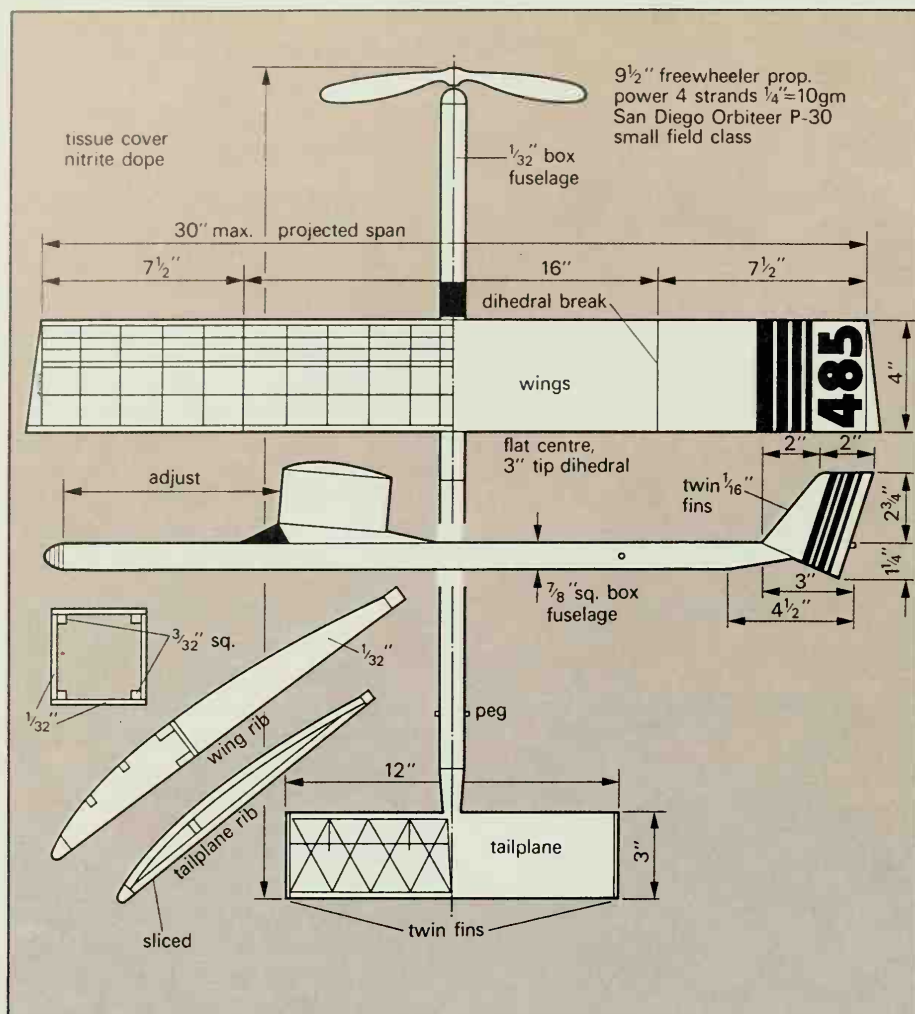
Control-line aircraft

Control-line models (or U-Control as they are sometimes called) are a special type of powered model aircraft that may be most familiar to beginners because of the mass marketing of small engine-powered, plastic devices. While these tiny scale and semi-scale designs have a great deal of consumer appeal, they are not the best way to get started in control-line flying. The potential for trouble in operation and flying is great and the opportunity to get advice from a salesperson is non-existent. The vast majority of these ready-to-fly plastic models end up in the rubbish or the back of the cupboard, a monument to disappointment.

Back in the days before injection-moulded plastics made such things possible, the novice had to create his own model from balsa sheet and strip, then cover it and paint it himself. This is still a very good approach, as it gives some understanding of the mechanics of the U-Control system and the airframe components. Building your own model also tends to make you more careful on the flying field and more likely to repair accidental damage so that you can go flying again. There are a great many good kits on the market and an equal number of plans available along with instructive articles on U-Control trainers.

The U-Control system itself is actually a patented invention of a man with a brilliant creative gen-





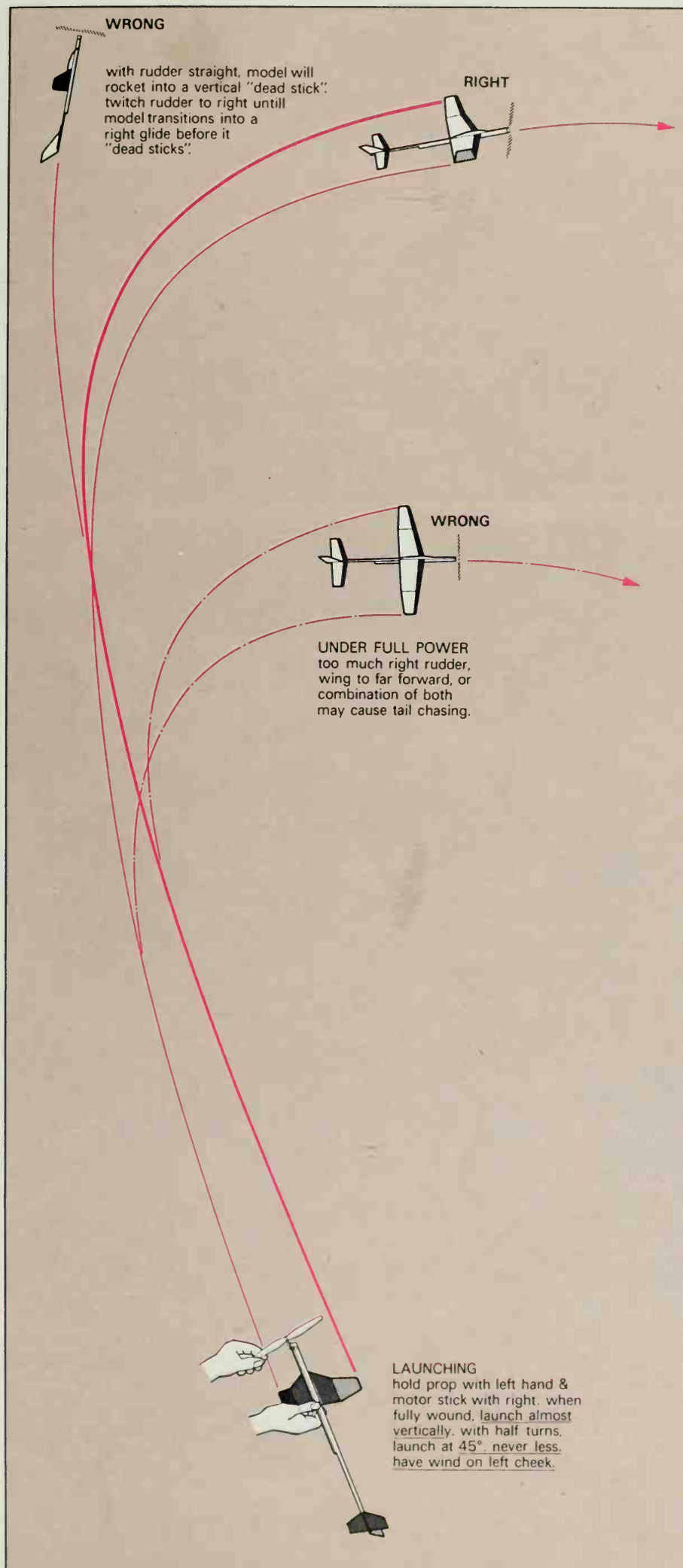
ius, Jim Walker of the USA. In the early 1940s, Walker developed a control device for models which allowed them to be flown in a circle on two lines (wires) attached to a wingtip. These lines were affixed to a U-shape control handle at the pilot end and to wire leadouts inside the wing. These leadouts in turn controlled a small bellcrank in the wing root which moved a wire pushrod back to the hinged elevator surfaces, where a control horn transmitted 'push-pull' to 'up-down' motion. Simple wrist action by the pilot on the handle resulted in a tug on the up or down line and a resultant up or down elevator action. This enabled the pilot to loop, fly inverted, change altitude at will, and make precision landings, all within the bounds of the circle. This U-Control system has remained unchanged in principle to this day in worldwide use.

With this common control system, there are many varieties of models flown, often with subtle variations. The early models tended to be mostly aerobatic, since it was such an innovation to be able to loop the loop or fly inverted. The natural desire for power and speed led to higher speed performance craft, racing against the stopwatch. Then the brilliant idea of multiple pilots in the same circle struck, and team racing was born. Models of this class tended to look alike due to specifications laid down for the competition class. Meanwhile, aerobatic enthusiasts, bored with the loop, came up with the idea of aerial combat, as described in Chapter 7.

The modellers who preferred more scale realism still had many chances to show their skill, with true-scale replicas which merely took off and flew in circles, or with military types which took off and landed on small aircraft carrier decks with arresting gear. These scale replicas were also judged on appearance and scale fidelity as well as flight performance.

There developed, along with the above competition classes of flying, a great interest in sport control line. The models could be flown in the local schoolyard or park with no risk of flyaway, and the pace was easy. While competition classes

Two excellent beginner-type rubber models, a P-30 design and a 'stick R.O.G.' (rise-off-ground). Since both are all straight lines, scaling up to the dimensions given is simple if you fancy building one of them.



could be emulated, there was no pressure to win and the skills of flying (and repairing after the inevitable prangs) could be mastered. Even plastic models contribute – the power plants are excellent and can often be recycled in another built-up model with success. These engines are all relatively easy to start and economical to run. They can also be muffled easily, an important point to remember if you fly in inhabited areas. The buzzing noise of a control-line model is often enough for a citizen to complain to the local authorities, and a flying site can be lost.

Another word of caution – never fly a control-line model near electrical transmission lines, which can be lethal. High tension current can kill you.

Choosing a Beginner Control Liner

The 0.049cu.in engine powered model design included in this book is an excellent way to get started, as it is a reasonable size and can be adapted to many powerplants, including the ones available from scrapped plastic models. However, you may wish to purchase a kit or try a design with a different flavour. You may also want to design your own, or at least modify an existing design to fit your concept and styling ideas.

The best thing to look for in a trainer aircraft is simplicity and strength. It should be easy to build and hard to destroy, with a lot of solid wood! A profile fuselage of solid wood is better than a box of sheet, and solid wings and tail surfaces are desirable. The problem with plastic models is that when they break, they cannot easily be repaired. However, a solid wood model can be pieced together with the magic of 5-minute epoxy glue or the rapid curing cyanoacrylate adhesives and made to fly again. Often these repairs can be made on the flying field, avoiding a trip home to the workshop. Covered, built-up wings need more time to repair.

There is no reason why a trainer has to be crude looking; in fact, it can be fairly realistic and scale-like, painted nicely and with a pilot in a simulated cockpit. Squarish lines

Part of the instruction material of the Jasco Flash X-18 shows the flight pattern at which to aim. Too little or too much rudder will reduce flight times; most models prefer a gentle turn to the right under power.

First Steps in Flight

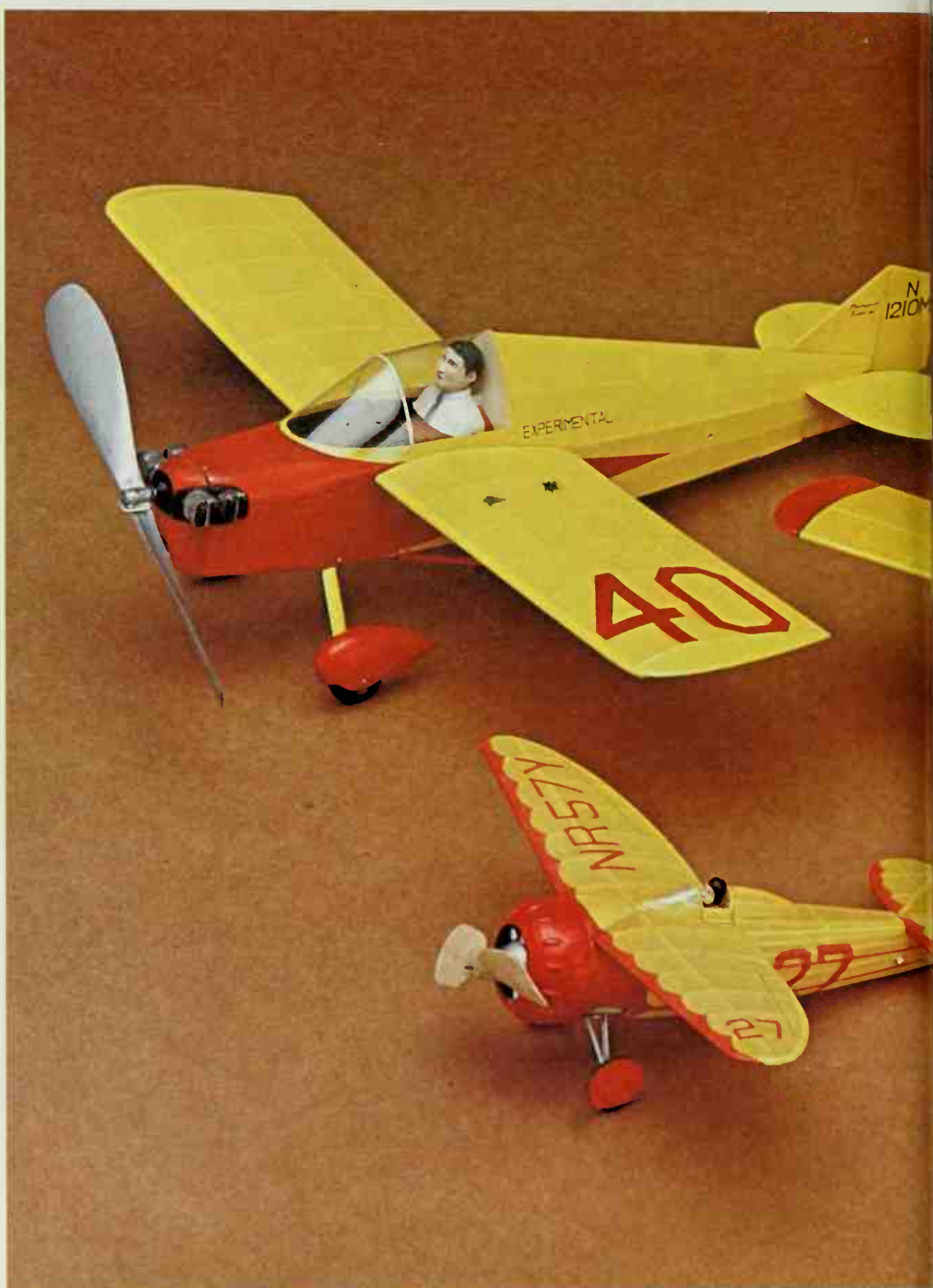
and a fairly long body are good design characteristics. A short coupled model is more sensitive to control and thus more likely to crash due to over-controlling. The new flyer has a natural tendency to overdo on control – actually very little wrist action is needed. An adjustable control horn on the elevator can also help. Try a very short throw on the pushrod for the first few flights, so the model almost flies by itself. A stunter or combat ship can be such a trainer.

Most model shops carry a selection of trainers or can order them from a manufacturer. The following is a brief list of some possible kits: KeilKraft *Champ*, *Phantom*, *Phantom Mite*, *Firefly*; Veron *Colt*; Cambria *Scout*; Quest *Imp*; Goldberg *Shoestring*, *Flitestreak*, *Stuntman*; Topflite *P-40*; Midwest *King Cobra*; Sterling *Ringmaster*, *Mustang*, *Spitfire*, *P-40*; Dumas *Tom-Tom* and *Little Tom-Tom*. There are many more from manufacturers in the UK, USA and Germany. MAP Plans Range *Deerfly*, *Shoestring* and *Little Brother* are good. There is no reason why selection has to be limited to the small 0.049 powered craft. A good 0.19 engine in a larger trainer, or a profile stunter with the control horn throw limited, can be an excellent first choice. The larger model can be flown in the wind and is often more docile on the controls. Such a model should always be flown with a muffler if near housing.

Another approach to a trainer aircraft is to try a model designed more for speed than aerobatics. The Rat Racer and Mouse Racer fall in this class, the former usually powered by 0.40 engines and the latter by 0.049. Reed valve 0.049 (again from surplus plastic crashes) engines can power very competitive Mouse Racers. One of the best Mousers we know of is the *Cat's Paw* which is available only as full size plans for construction – no kit – from Model Airplane News, One N. Broadway, White Plains, N.Y.

Once the beginner has developed skills in controlling his craft and running the engine, he can advance to more exciting flying such as stunt, combat or racing. That is why we suggest that a dual-purpose model can be useful, especially the racing type. There are many combat kits available in the shops, sometimes in pairs so you have one to fly while the other is under repair. The attrition rate is high!

Accessories and making a first flight are described later.





Resources for further flying fun

If aeromodelling interests you and you want to progress to more complex models and perhaps to competition flying, you will need to do two things to expand your horizons and increase your skills. One is to join a club and the other is to read the other books and magazines available on model aircraft. Your local hobby shop can give advice on how to join a club, or you may wish to write your national aero club for information. In the UK this is the Society of Model Aeronautical Engineers (Kimberley House, Vaughan Way, Leicester) and in the USA the Academy of Model Aeronautics (815 Fifteenth St. NW, Washington D.C.) which has a good club programme that helps beginners. Sweden is another country where the

aeroclubs help the fledgling – contact SMFF, Box 10022, 60010 Norrköping. Addresses of aeroclubs in other countries are available from the Federation Aeronautique Internationale offices at 6 Rue Galliee, Paris, France.

Current model magazines often have beginner articles or features. The UK magazine *Aeromodeller* (MAP Publications) has a regular section to help fledgling flyers. In the USA, *Model Airplane News*, *Model Aviation* and *Flying Models* will sometimes have articles of interest to newcomers. Sadly, the magazines that are published in other countries seem to cater to the experts.

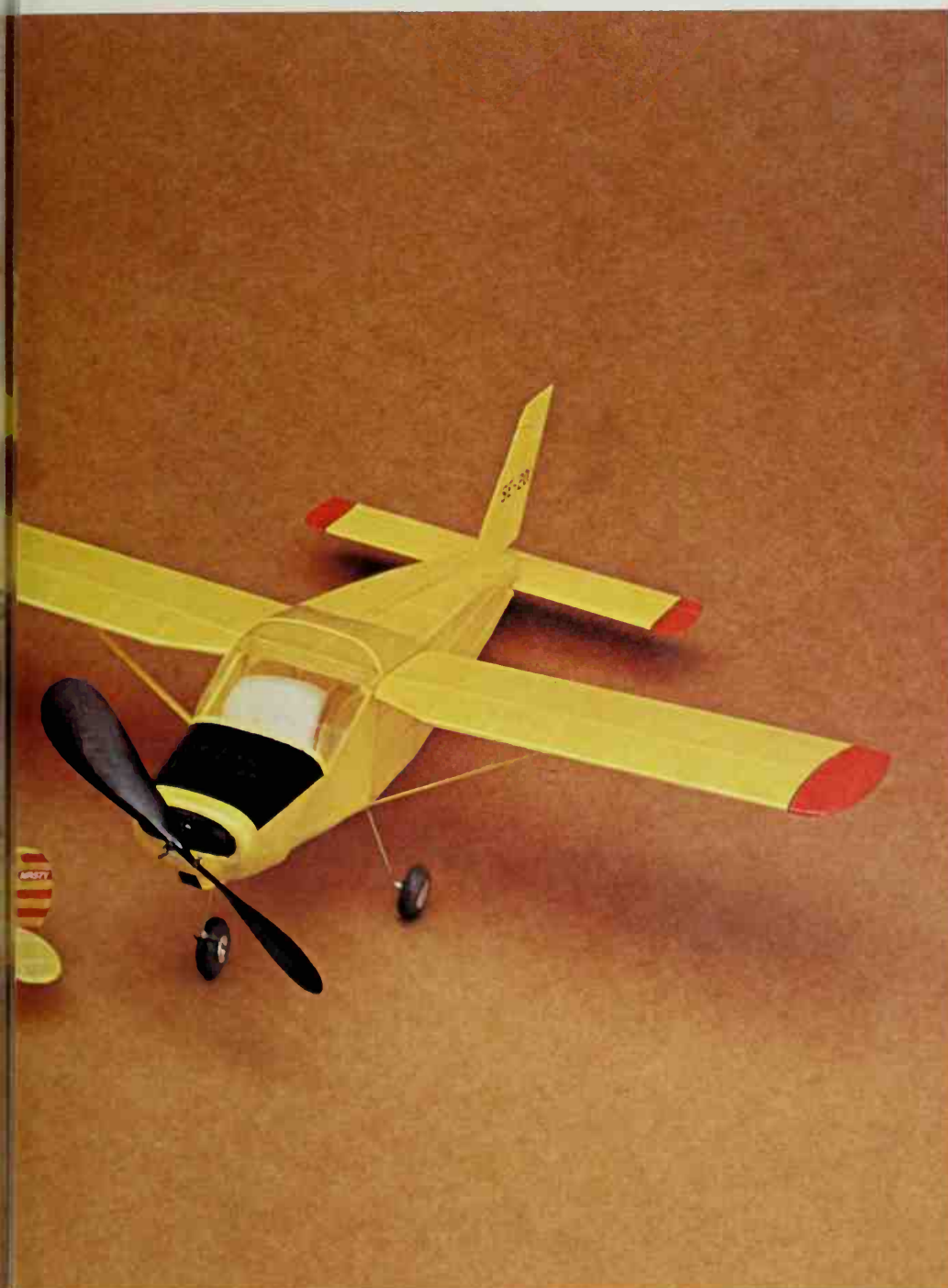
General interest books that can stimulate interest and impart know-how can be seen at bookstores or library. Among the best are: *This is Model Flying* by Martin Dilly (Hamish Hamilton, London); *Basic Aeromodelling* by R. H. Warring (Argus Books, Hemel Hempstead); *Model Aircraft Aerodynamics* by Martin Simons (Argus Books); *Flying Hand Launch Gliders* by John Kaufman (William Morrow, New York); and *Indoor Model Flying* by Ron Williams (Simon & Schuster, New York).

While we are advising on the best kits, we must mention the Humbrol line of 'Five Stages of Modelling'. This graded, progressive approach starts with a simple HLG, goes to a SRPSM/ROG, then a cabin rubber model, then to a pair of towline gliders (the *Dragonfly* is the best). Similar graded sets are not available from others, but good kits are. For HLG we suggest trying the St. Leonard's *Atom 12* or *Atom 18*, the Cambria *Bandit* and *Lucifer*, the Sig *Flip* and *Pigeon*. For SRPSM, build the Sig *Thermal Dart*, *Uncle Sam* or *Cub*. The Peck Polymers *Peck ROG* and *Stringless Wonder* are great flyers, while the Vintage Aero *Mini-Square Thing* and *Square Thing* are outstanding. Look for these on the hobby shop shelf, or ask for them. Happy landings!

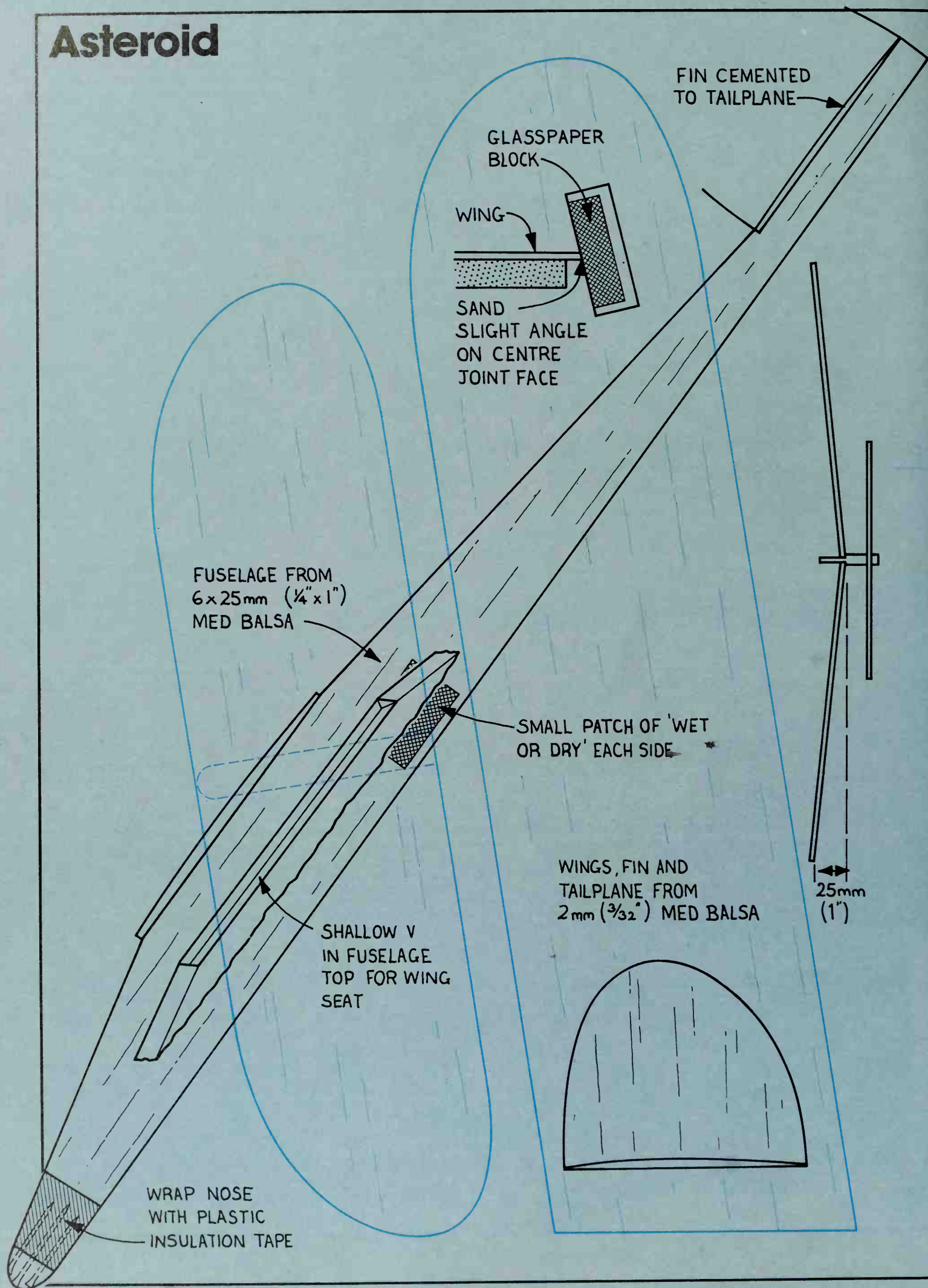
Above far left: An all-balsa beginners' control-line model available in kit form. All-sheet models are tough.

Above left: 'Peanut' class models are popular for indoor flying. This is a Pietenpol Air Camper from a kit.

Left: Three rubber-powered scale models; that on the right would be by far the best choice for a beginner. A big, high-wing boxy model is easier to build and to fly.



Asteroid



A simple chuck glider is an excellent introduction to aeromodeling and can provide experience in working with balsa as well as basic trimming technique. It's fun to fly, too.

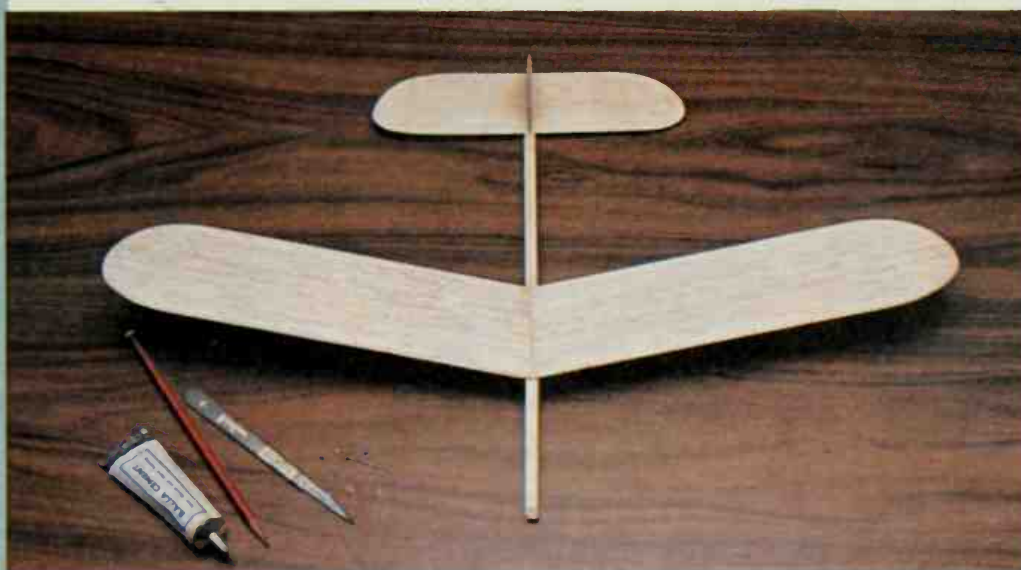
Start by tracing the parts with a soft sharp pencil on to kitchen greaseproof paper. Turn the paper over, position on the wood, and draw over the lines from the back, which will transfer them lightly. Cut out carefully, using light cuts and a straight-edge for the straight lines.

Hold the wing panels on the edge of the building board and sand the wing with garnet or glasspaper on a wood block, to as close to the section drawn as you can manage. Repeat with the tailplane. Cement the joint faces of the wing halves, bring together, then separate and leave to dry. Recement and join, propping up to the dihedral angle shown.

Sand the fuselage, rounding the edges, then cement the tailplane in place. Add the fin; double cement all joints. Pare out a shallow V for the wing seat and double cement the wing in place. Make sure that the wing, tail, and rudder all sit true and square.

Use a small drill in the fingers to drill into the nose and push in strips of solder or headless nails till the model balances when held at the wingtips. Apply two coats of clear dope, sanding sealer, or banana oil and rub down with very fine paper. Polish model with wax polish.

Check glide into tall grass and add pins to nose to achieve smooth glide. Launch hard upward at 60° with model banked 45° to right. Adjust flight by breathing on the fin and holding a warp for a few seconds, and by modifying nose weight as necessary.



Building a Simple Kit

Building and flying a simple beginners' free-flight kit gives a valuable grounding in the skills involved in using balsa and making accurate joints, as well as a feeling for the way an aircraft reacts to the air on which it depends for flight. This experience will be useful when you progress to high-performance control-line, radio-controlled or free-flight aircraft, and to the challenge and enjoyment of competition flying.

Tools and Equipment

With any flying aircraft, efficiency rather than appearance is the essential, and flat flying surfaces are the heart of the matter for model aircraft. To produce them a flat building board is needed, large enough for the biggest flat component of the aircraft and soft enough to push pins into. A piece of blockboard about 20mm ($\frac{3}{4}$ in) thick and 300mm (12in) \times 1000mm (40in) will do the job, but first check that it is flat, by laying a metal straightedge along the surface in several directions, ensuring that it touches along its whole length. For cutting on, a small flat piece of plywood or chipboard will save damaging the plan, which will be laid over the building board during construction.

While razor blades are the traditional tool of the model builder, the advent of stainless steel blades has made them almost useless for the purpose, since the edge bends and blunts very quickly when used on wood instead of hair. Carbon steel blades, if available, are well worth stocking up with, and can be identified by their greater thickness and a tendency to snap, rather than deform, when bent through a small radius. They can be carefully broken with pliers to give a pointed

blade for delicate work.

While so-called 'modellers' knives' are advertised, by far the best cutting tool is a surgical scalpel; these take replaceable blades, which can either be discarded when blunt or else re-sharpened on a fine oilstone. Straight and curved blades are useful for different jobs; if a genuine scalpel handle is not available, several companies make Craft Tools that take similar blades and are a good substitute.

Cutting balsa is far easier to practise than to describe, but do not try just to push the blade straight down through the wood in one go. Use a stroking motion, holding the balsa firmly down on the board, and as near as is safe to the blade, which should be kept vertical to the wood. Be prepared to make several passes with the blade, especially when cutting sheet wood, and be aware of the wood grain, which will tend to divert the blade from the path you intend to take. Practise on some scrap wood first to get the feel of the material and the tool.

Balsa can vary from the very soft and light, about 65kg/m³ (4lb/ft³) to hard and comparatively heavy, 300 kg/m³ (19lb/ft³), and its grain type is also important, greatly affecting its stiffness and thus its suitability for various parts of an aircraft structure. Learn to recognize the characteristic speckled appearance of quarter grain or C-cut balsa, used for ribs and parts which must remain flat, compared with straight grained or A-cut wood, used for spars and components which need maximum strength in a lengthways direction. While a kit manufacturer will probably not select wood with as much care as a competition model flyer, try to assess the wood in your

kit and use the stiffest strip wood for fuselage longerons and wing spars, rather than cutting it into short lengths for other components. Serious model flyers weigh each piece of balsa before buying it, for weight control is a vital part of any high-performance aircraft.

One of a modeller's most useful tools is home-made – a sanding block. Abrasive paper is vital for shaping and smoothing balsa, but is almost useless held as a loose sheet in the hand. Firstly, ask for garnet paper, or for wet-and-dry paper, rather than glasspaper, which cracks and sheds particles of glass all over the work as it rapidly wears smooth. Garnet paper is reddish-brown in colour and wet-and-dry (or silicon carbide waterproof paper) is grey; buy grades 320 and 120 in garnet, or 600 and 120 in silicon carbide. Next, cut some plywood or hardwood to about 150mm \times 50mm \times 10mm (6in \times 2in \times $\frac{1}{2}$ in) and cut a piece of abrasive paper to cover the face and two long edges of this: stick the paper onto the block, using either rubber solution or double-sided Scotch tape, and ensure it is flat by rolling with a suitable cylindrical object. Curved sanding blocks can also be made, and are useful for reaching into concave parts.

A steel rule is useful for cutting along as well as measuring with, but any flat straight length of metal can be used as a cutting guide, although beware of nicking the edge if you use a soft aluminium alloy. A 300mm (12in) length will be

Below left: Quarter-grain balsa (bottom) compared with A-cut.

Below: Fuselage sides are lightly sanded; always sand away from where the component is being held.



adequate at first, but a metre or yard long straight-edge is helpful for cutting strip balsa and aligning long parts during assembly.

For sawing plywood or large sections of balsa a fretsaw is useful but not essential; a small 'junior' hacksaw taking a 150mm (6in) blade can serve in many cases, although parts will have to be rough-cut to shape with the saw before trimming and sanding to final outline. A razor saw, which is a thin, stiff-backed tenon saw, sold for model making, can be used for fairly light jobs where a straight cut across a large section is needed.

For shaping of balsa block a razor plane is handy and prevents the digging-in that occurs when a knife is used on soft wood; it can be adjusted to take a very fine cut, and uses a normal razor blade.

Pliers are used for bending light wire, up to about 16swg or 1.6mm (0.064in), and a pair of cutters incorporated will be satisfactory for most modelling jobs. Long-nosed pliers with flat faces tapering from about 3mm to 10mm ($\frac{1}{8}$ in to $\frac{3}{8}$ in) will be more versatile than larger ones, although parallel-action pliers of the Bernard type, with back cutters, can make light work of most cutting and bending jobs.

Some kind of drill, either hand or electric, will soon be necessary; a drill press is a useful accessory for the latter, to ensure that holes are drilled perpendicularly in the work. Initially it is possible to improvise when it comes to drilling holes in balsa or thin ply, since the materials are quite soft; a thin flexible file (i.e. soft-centred) can be a useful aid

for enlarging holes and slots.

For joining wire parts a soldering iron is essential; the type used for electronics assembly has too low a heat output to handle the larger masses of metal we will be dealing with. Look for something around 50 watts minimum; with this some solder will be needed, un-cored and of 40/60 tin/lead alloy. For joining steel wire a good acid flux like Baker's Fluid is needed, although acid-cored solders are also available, which some prefer; the resin-cored electrical solders have too high a tin content to give a strong joint. Cleanliness of the materials is important in soldering. Steel wire is always slightly greasy to prevent rusting in stock; fingertips are greasy too, so clean the metal thoroughly and wash it in a solvent like carbon tetrachloride to remove all contamination, for dirt, corrosion and grease prevent the molten solder from bonding on to the surface of the metal and forming a strong joint. The parts to be joined should first be tinned by applying flux, heating with the iron and then touching the solder, preferably with a drop of flux on the end of it, to the heated metal. The result should be a thin film of solder all over the surfaces to be joined; keep the iron in contact with the work for a few seconds to ensure that the solder has flowed where you want it to. When cool, assemble the parts, bind them with tinned copper fuse wire if possible, and then re-flux before re-heating and applying further solder to flow smoothly into the joint and form a fillet onto the surfaces of the metals. If the solder seems to be forming blobs on the metal, re-clean the work, re-flux, and let it get hotter before applying the solder again, and keep the iron in contact with the metal after the solder flows into the joint.

Pins are an indispensable item; while dress-making pins can be used, try to find steel ones rather than plated brass, which bend under pressure, have blunter points and cannot be kept on a magnet for convenience. Avoid the glass headed type of modelling pin, which can cause a nasty injury if the head breaks as they are being pushed into the building board. Large-headed pins can be made by rolling the head of a normal pin in epoxy glue to which balsa dust or talc has been added as a drip-retarding filler.

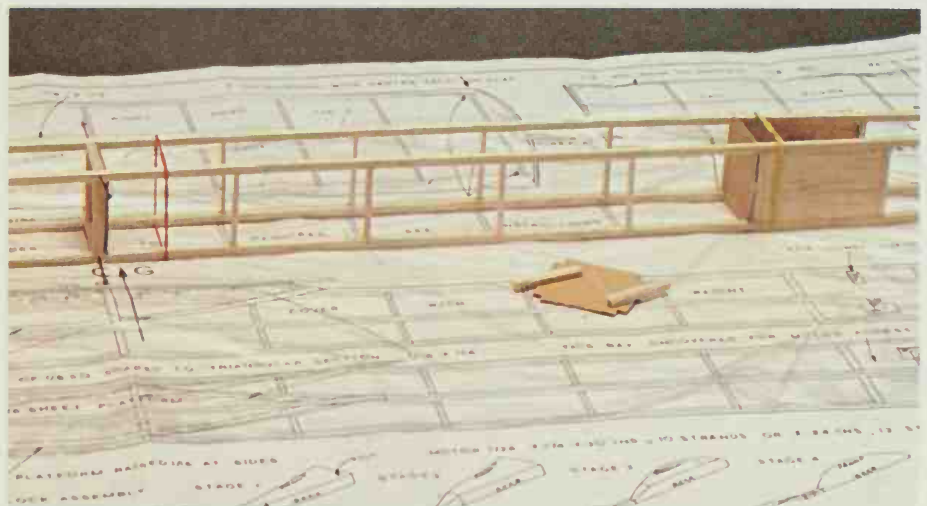
Construction

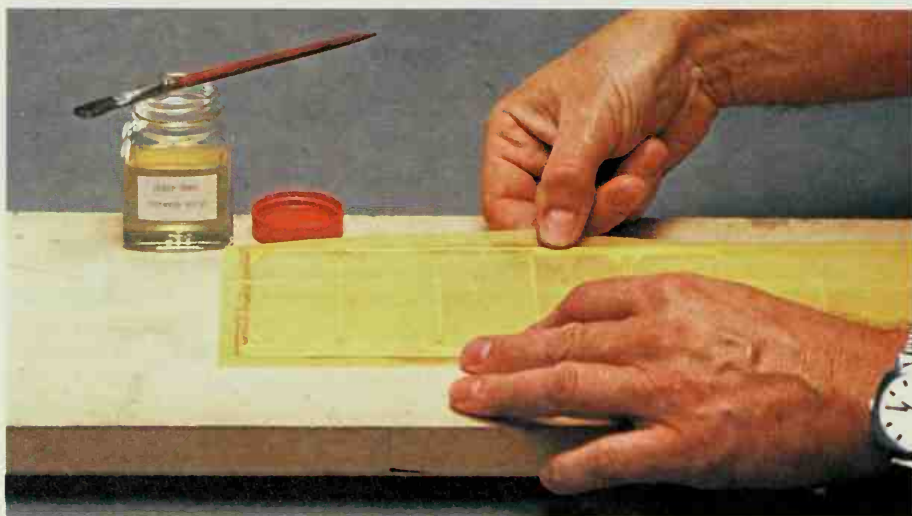
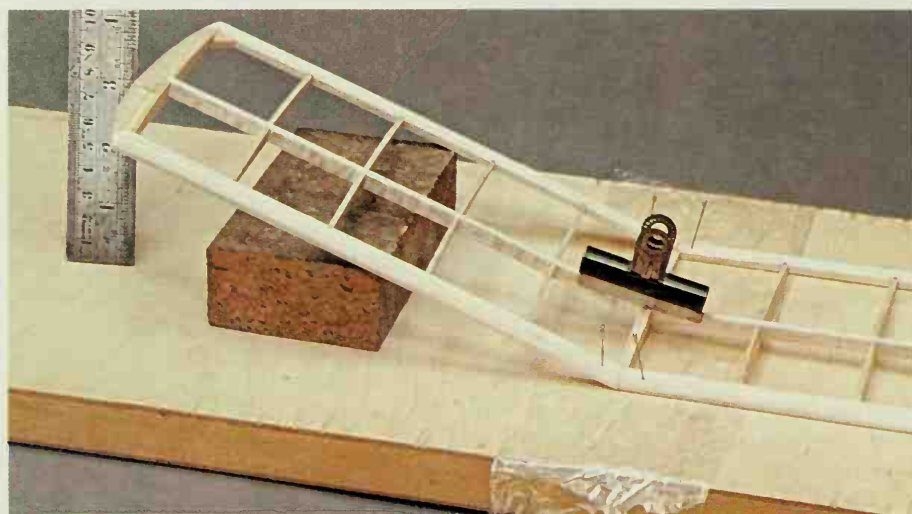
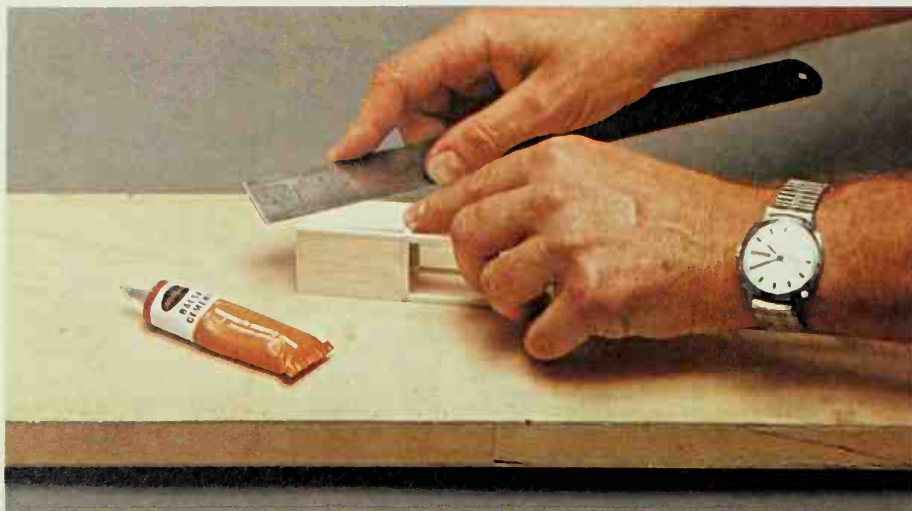
The first thing to do on opening a kit is to read the instructions thoroughly and relate them to the plan; some instructions are written more clearly than others, but at least the person who wrote them has probably built the aircraft, so try to visualize each step as you go through them. The various views shown on a plan are used as a base over which to build the flat parts of the aircraft; wings and fuselage are usually built as sub-assemblies and later brought together, in the case of the wings, joined at the correct dihedral angle, while the two flat sides are joined with spacers to form a hollow fuselage. On some plans only one half of the wing is drawn, to save space; on these, either lay carbon paper face side against the back of the plan while the outline is traced on the printed side, or else rub the plan with a little cooking oil, which makes it transparent enough to see through. When building, double check everything before actually cutting any wood.

In building the St. Leonards *Performer* rubber-driven free-flight aircraft, the wing is started first. Like most beginners' models, this has a flat-bottomed airfoil section, which

Below right: Card or scrap balsa false formers with notched corners hold a fuselage square.

Below: Simple cutting jig when a number of equal-length spacers are needed.





makes assembly simpler than an undercambered one. Most modern kits include die-cut ribs which theoretically just push free of the balsa sheet from which they are stamped; however, dies get blunted and some judicious work with the scalpel may be needed.

Lay the plan out smoothly on the building board, ironing it first if very wrinkled; cover it with a sheet of greaseproof paper or clear cooking film, which will both protect the plan and prevent surplus glue from sticking parts to it.

Wing

After the ribs are separated from their sheet, it makes for a better final result to stack them together in a block, with a piece of scrap wood running through the spar slot to align them, while the upper and lower surfaces are lightly sanded with the block to remove any irregularities and ensure all are identical. Identify the leading and trailing edge wood and lightly sand the latter on both sides to remove any saw marks, which weaken the wood, as well as spoiling the finished appearance of the aircraft. Although not suggested in all instructions, it makes final shaping easier if some of the surplus wood is removed from the square section leading edge before assembly, so it is on the way to being rounded along one corner. Use the razor plane for this, being careful to work always away from where the wood is being steadied on the building board, to prevent the strip from buckling; follow this principle also when sanding wood. Mark the positions of the rib notches, if any, in the trailing edge and cut them, preferably with a small rectangular section file the same thickness as the ribs. If a razor blade is used make sure not to cut deeper into the wood than the notch depth; a bulldog clip can be used as a temporary stop to prevent doing so.

Pin the strips in position over the plan, pushing them against a straightedge to ensure they are really straight; use three ribs as a

Top: Wiping an inlaid sheet balsa panel into place with a metal rule.
Second: Use books or blocks to hold wingtips at correct height for dihedral; note centre panel pinned flat.
Third: Easing tissue in place and pressing on wet clear dope or paste.
Bottom left: Remove tissue surplus by sanding with fine paper when dry.
Bottom right: Use balsa strip for turn adjustment, or fit tab – both shown.

guide to check leading edge, trailing edge and spar spacing. Although the ribs are die-cut they may be of slightly different length, so check each piece by putting it in place dry – that is without glueing it; if it needs forcing into place shave it down until it fits snugly. Discard any loose-fitting parts; bad fits can lead to warps and poor strength, so get used to building accurately, because it pays off in performance and reliability, whatever the type of aircraft.

Fuselage

Select the hardest and straightest strips for the longerons; in the *Performer* these must be spliced to give the correct length. To do this lay strips side by side in pairs and carve and sand an absolutely flat chamfer on adjacent ends; try to make this at least four times wood thickness for maximum joint strength. Turn the strips so the chamfered ends line up and glue together, using a straightedge to keep the wood straight while the glue dries, and weights, tape and pins as necessary. Lay the strips over their marked positions, pinning them to the board in vertical pairs; make sure they are vertically aligned, or the two fuselage sides will not be identical. Use pins every 100mm (4in) or so, each side of the wood, or lined up with the positions where horizontal spacers will later be fitted, because the pin holes will help the glue to key the joints when the sides are later assembled.

With some models, if the longerons are sharply curved, it may help to pre-shape them before starting; to do this, hold them in the steam from a boiling kettle, and, being careful not to hold the fingers there too, bend the wood to the approximate curve needed. Remove the wood from the steam and hold it in shape for a few seconds while it cools; check against the plan and re-shape if necessary.

To cut the spacers to length, first trim square one end of a piece of the right sized balsa strip, and align this end accurately over the plan so it just butts against the longeron; use the blade to mark where it should be cut to length, being careful to sight down vertically over it, and to hold the blade upright. Do not try to cut right through the wood, but transfer it, probably with the blade still embedded in it, to the cutting board to finish the cut on a firm surface. If identical spacers must be cut, make a simple jig.

Glue the first pair of spacers in

position. Do not worry if glue oozes slightly from the joint, but remove it with a pointed piece of wood, for excess glue adds weight. Fit the remaining spacers and let the glue dry. If using a PVA glue leave it overnight to dry before removing the pair of sides from the board. Balsa cement, while less satisfactory structurally, and hard to remove from fingers and clothes, dries much faster; this can make some assembly jobs harder, as the cement may be partly dry before the parts are accurately aligned. Whichever glue is used, the fuselage sides will probably be stuck to each other when the pins are removed; they can be carefully cut apart with a razor blade.

To fit the inlaid pieces of balsa sheet reinforcement to the nose and motor peg areas, sand one edge of the sheet dead straight and offer it up to one of the spacers against which it will be finally cemented; mark a parallel line along the edge of the other spacer and cut the sheet to this width. Observe the correct grain direction shown on the plan. Lay this strip of wood over the bay to be filled and cut the third edge to line up with the inside face of a longeron; finally ease the piece into place and cut the final edge. Glue it into place, using the flat edge of a ruler to 'wipe' the inlay flush with the surrounding fuselage structure.

Carefully sand the fuselage sides to remove fuzz and blobs of glue. Make rectangular false formers from cardboard or scrap balsa to fit the inside of the fuselage at its widest points; cut square notches out of each corner to locate the formers exactly on the longerons. Use rubber bands to hold the fuselage sides onto the formers, and cement the horizontal spacers into place, starting with the ones adjacent to the formers, which are removed when the glue is dry. The rear of the fuselage can be held together with bands and pins while the rest of the spacers are installed, being sure to keep the fuselage both square and symmetrical, and using the top view on the plan as a guide.

A plywood former at the nose is useful, in order to reduce wear and to prevent the joint between the removable noseblock and the fuselage from becoming sloppy. Face these two surfaces with 0.8mm ($\frac{1}{32}$ in) plywood; cut a former with a square hole in it to fit exactly the rear spigot on the noseblock, and glue it to the front of the fuselage. A similar one is fitted to the rear face of the noseblock.

Propeller

The lower surfaces of the propeller blades should be carved first; in the case of most basic aircraft the blade airfoil is flat-bottomed, and the X-shape of the blank, seen from the front before carving, ensures that the pitch reduces progressively towards the tips. Use a knife, long-bladed if possible, only for the rough carving; use progressively finer garnet paper for final shaping. Mark and trim each blade to outline after the lower surface is finished, and then carve the top surface to airfoil section; be sure not to over-thin the blades near the roots.

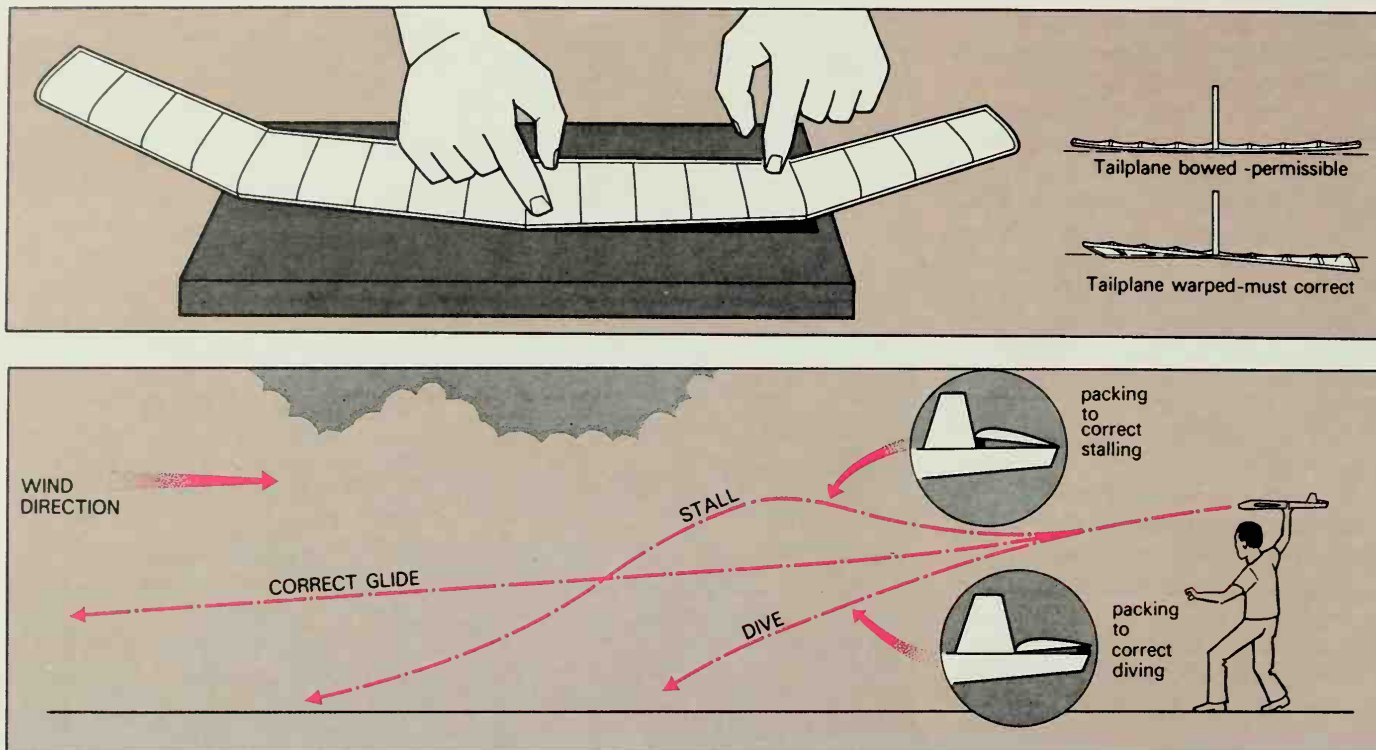
If the noseblock of your aircraft is laminated from several pieces of sheet balsa, arrange them with alternate grain directions at right angles, like plywood. Cut the parts oversize, drill a hole in the centre of each to take the propeller shaft bearing or bush, and use slow-drying epoxy to glue the laminations and bearing together. If the epoxy is slightly warmed it will become less viscous and will soak into the wood grain and strengthen the noseblock. Make sure the bearing is thoroughly cleaned and slightly roughened before starting.

When the assembly is complete, position it in the front of the fuselage and rotate the propeller blades so they fold flat along the sides; add the woodscrew stop so that it will prevent rotation of the blades as the motor tension declines, with the shaft in the correct rotational position to achieve a perfect fold. Several coats of clear dope and tissue covering will add to the strength of the blades. Mark the noseblock and fuselage to ensure that the former is always replaced the same way up.

Tissue covering

This is far easier than most beginners think. First, give the entire structure a couple of coats of thinned clear dope everywhere the tissue will touch, sanding very lightly between coats with fine garnet paper. Next, cut the tissue about 10mm ($\frac{1}{2}$ in) oversize all round, using a separate piece for each fuselage side, each surface of the tailplane and fin, and for the top and bottom of each panel of the wing (i.e. eight pieces for the polyhedral wing of the *Performer*). Use a fresh blade for cutting tissue, as even a slightly blunt edge will cause tears.

Brush clear dope round the leading edge, trailing edge and dihedral joint ribs of the undersurface of one



wing panel and quickly lay the tissue on it; press the covering firmly onto a doped rib at one end of the panel, and gently ease it down onto the rest of the wet dope, all the time pulling the tissue gently spanwise and outwards, away from the first rib, herring-bone fashion. Do not try to get the covering drum-tight, but just reasonably wrinkle-free. If the dope dries before the job is finished, run some more dope on top of the tissue in the areas still to be stuck; tissue is porous and the dope will quickly penetrate and bond to the wood beneath. Do not be afraid to get dope on the fingers while smoothing the covering down; if a compound curve is to be covered, wet the tissue first, which lets it drape smoothly, as well as tightening it as the water evaporates. If the wing has undercamber, i.e. a concave undersurface, the tissue must be stuck to each rib, using tissue paste or wallpaper adhesive. Run a finger along each rib to press the tissue onto the paste; the dampness will show through the paper when the paste has penetrated. Overlap the tissue up onto the leading edge.

Once the adhesive is dry remove the excess tissue by rubbing gently round each component with fine garnet paper, which will cut the paper neatly. Finish the covering and spray lightly with water, using a scent spray; this will tighten the tissue. Further tightening will take place when you apply clear dope, thinned 50/50; keep the brush full, using it to flow the dope on, rather than trying to brush it in. Be careful with the first coat, as the tissue

is quite delicate until the dope stiffens it and fills the pores; with the lightweight Modelspan provided in most beginners' kits 3-4 coats of thinned dope will make the covering impervious to air. Avoid coloured dope which is far heavier than clear, due to the pigment, and does not tighten; it is best totally avoided for free-flight aircraft.

It is important to keep the flying surfaces free of unwanted warps. Pin each flat panel to the building board while the dope dries thoroughly, if possible overnight; allow the lower surface to become touch dry before pinning down, to prevent sticking. A small amount of washout (trailing edge twisted upwards towards the wingtips) is helpful, as this delays tip stalling, but avoid asymmetrical warps; to remove them hold the wing in steam from a kettle or in front of an electric fire (not gas, due to the fire risk), while twisting the warped panel in the opposite direction. Hold the twist and remove from the heat, allowing the wing to cool. Lay the panel on a flat surface and check that no corner is raised. Re-steam if needed. Re-check from time to time during the life of the aircraft, as sun and moisture induce warps.

To save space the building board with drying components still pinned to it can be stored vertically, making sure that the work will not be accidentally brushed against or damaged. Still on the subject of domestic harmony, plan your work so that sanding jobs can be done out of doors, or at least in an area where fine balsa dust can be kept

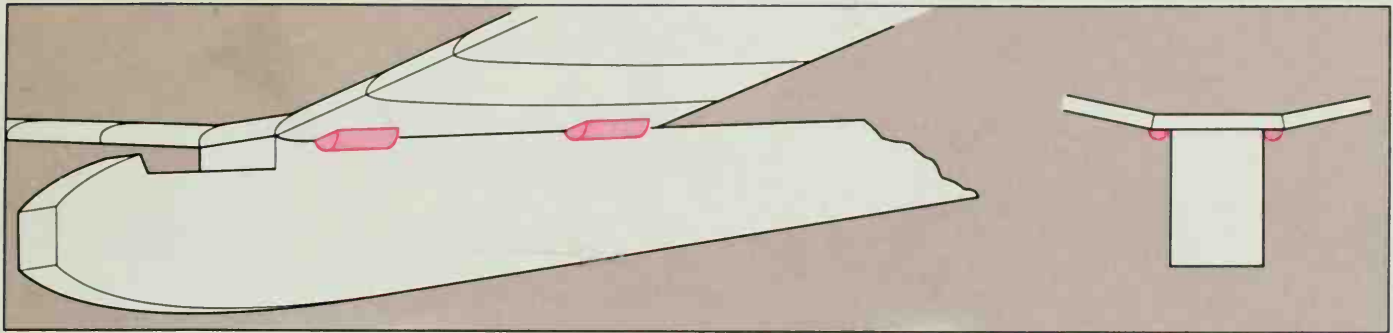
under control; doping, too, produces fumes which some people dislike, so ensure ventilation is good.

Alignment and completion

Before taking the aircraft out of doors make sure a clear name and address label is attached to it, with a request to the finder to contact you, and an offer to refund expenses. Correct alignment of wing and tailplane is vital if the model is to fly well; use a steel rule or even a length of string to measure between the same rib position at each wing and tail tip, and the end of the fuselage, to ensure that the distances are equal and the wing and tail are therefore square to the fuselage when seen from above. It is equally important to see that the flying surfaces *stay* correctly aligned during flying; D-section locating keys stuck on the leading and trailing edges, and butting up to the fuselage sides will prevent skewing, but will allow the wing to ride up against the tension of the hold-down rubber bands if it receives a sharp blow in a heavy landing.

The *Performer* uses a dethermalizer to prevent fly-aways in rising air currents; be sure that a snuffer tube of aluminium foil is used to retain and extinguish the slow-burning fuse that allows the tailplane to pop up to bring the aircraft safely down.

Install the rubber motor, using cycle valve rubber or plastic tubing on the wire hook of the propeller shaft to avoid cutting the rubber. See Chapter 6 for details of rubber



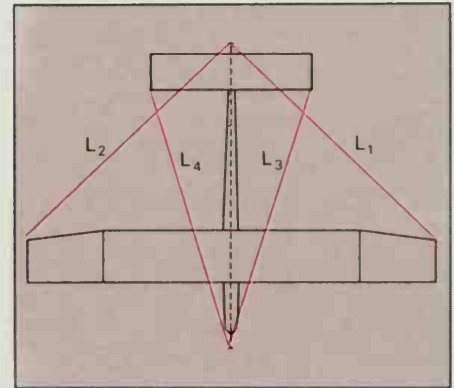
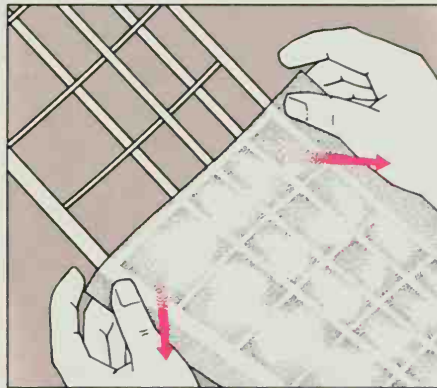
Opposite, top: Checking for warps on a flat surface. Some warps are acceptable, but it is safer to avoid them as far as possible.

Opposite, bottom: Trimming for a smooth glide is vital—do it over long grass to reduce the risk of damage, and wait for an almost calm day.

Above: Fitting little keys will ensure that surfaces are always correctly aligned but will knock off when necessary.

Right: Secure one end of each tissue panel, then ease diagonally along the panel to produce a smooth wrinkle-free surface.

Far right: Alignment checks are simple and take only a minute or two, but may save a crash. $L_1 = L_2$ and $L_3 = L_4$.



treatment and lubrication. Add a few turns to tension the motor and prevent bunching, and then check the centre of gravity (CG) by balancing the aircraft on a fingertip held under each wing root. Add modelling clay to the nose or tail until the CG is in the positions shown.

Flying

Attach the wing and tailplane with light rubber bands; for most small or medium sized rubber models bands about 1.5mm ($\frac{1}{16}$ in) wide and 75mm (3in) long stretched to about three times their normal length will be adequate for holding the flying surfaces firmly in place.

Choose a calm day for first flights; windspeed should be 2m/sec (5mph) or less because a light aircraft like this is easily upset by gusts. Often the calmest time of day is about an hour before sunset. Adjust the glide first; try to find some long grass to cushion heavy landings, and start by launching gently into wind and slightly nose down, aiming at a point about 20m (60ft) away. Try not to throw the aircraft, but bear in mind that it glides at a little more than walking speed. If it stalls, add 0.8mm ($\frac{1}{32}$ in) ply packing to raise the leading edge of the tailplane, cementing it in place to prevent loss. The aircraft may be stalling because of excess airspeed, so try a slower hand launch to see if the stall persists, before making the adjustment.

Repeat until the glide is stall-free.

If the result of these hand launches is a dive, add the packing to raise the trailing edge of the tailplane, until the aircraft just stalls; then remove the final piece, which should give the flattest glide. The aircraft should turn to the right, both on the glide and during the power run; the glide turn should be just detectable from a hand launch, the diameter being about 30m (100ft) for an aircraft like the *Performer*. The reason for the circling flight path is to keep the aircraft in sight for longer and to ensure that it stays in rising thermal air currents instead of flying straight across and out of them. Adjust the glide circle either by bending the trim tab (usually of aluminium foil) in the desired direction, or by adding a strip of 2.5 mm ($\frac{1}{8}$ in) square balsa to the trailing edge of the fin on the side to which the model should turn. Try a short length at first and increase it until the turn is correct. This acts as a drag strip and is more reliable than a flexible trim tab, which can be accidentally bent.

Wind about 150 turns on the motor; see Chapter 6 for details of the technique. Set the dethermalizer fuse to about one minute. Hold the hub of the propeller with one hand and the fuselage under the wing with the other, releasing the propeller fractionally before gently launching the model forward into the air and slightly to the right of the wind. It should climb and turn to the right until the propeller folds. If it stalls under power or

does not show a definite turn to the right, add downthrust or sidethrust by cementing strips of thin ply to the top or one side of the rear face of the nose-block to angle the thrustline in the required direction.

Gradually increase the number of turns on the rubber, preferably after having found the number at which the motor goes tight and breaks, with a spare motor outside the fuselage, or from tables. The aircraft will climb steeper and fly faster at the beginning of the power run and as the motor is wound more, because the power delivered by the rubber decreases as the turns run out.

Repairs

Most damage to model aircraft can be repaired fairly simply. Try to save all fragments; cut away the tissue from the damaged area and re-assemble on the building board, lightly cementing the broken wood together and pinning while the glue sets to re-form the original structure. Then cut replacement strips of wood with long chamfered ends; lay these over the damaged wood, which is cut away and replaced with the new. Alternatively, tapered doublers can be glued alongside breaks, or gussets added as reinforcements. The tapers are important in order to spread the stresses back into the sound wood; try to stagger the joints so they are not in a straight line across the component. Tissue damage can be repaired by doping round-edged patches over the perforations, or torn areas cut out and recovered.





Free Flight

Competition Power Models

Rubber and Glider Classes

Indoor Flyers

In breezy conditions gliders such as this A2 are safer if 'parked' upside-down with the dethermaliser in the operative position. Glass fibre fishing rod sections or archery arrows are often used for 'pod and boom' fuselages on high performance gliders. The magnificent flying site is a service aerodrome little used by full-size machines at week-ends.

Exciting and exhilarating, power models combine the thrill of aerial drag racing, during the powered vertical phase, with the graceful gliding of silent thermal soaring.

The attraction of tinkering with miniature engines, the fascination of simple clockwork activated gadgets and the over-riding constraint of power to weight ratio and model efficiency, in an effort to defy gravity, are all key ingredients of its inherent appeal. The real chal-

lenge to the model flyer is how to control the very fast initial climb and achieve the transition into glide.

Early lessons

One modeller's first venture into power model flying involved fitting a small motor to an old glider, with the nose shortened to compensate for the additional weight. Even the very first flight was a great success, indeed almost too successful for the



model was nearly lost. Using the integral fuel tank fitted to the engine resulted in an excessively long motor run. The flight pattern, too, was erratic. As the motor warmed up in mid-flight the model flew faster, performing an impressive series of loops, but by then the model was so high it no longer mattered.

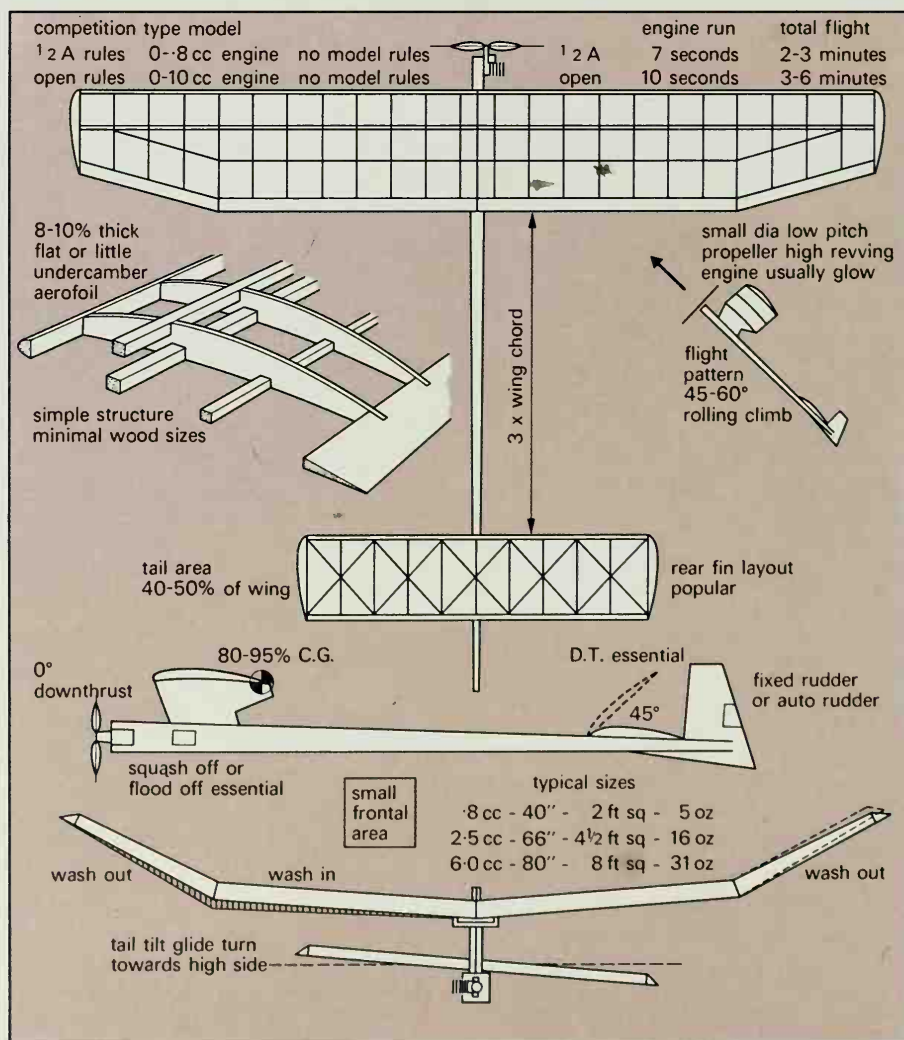
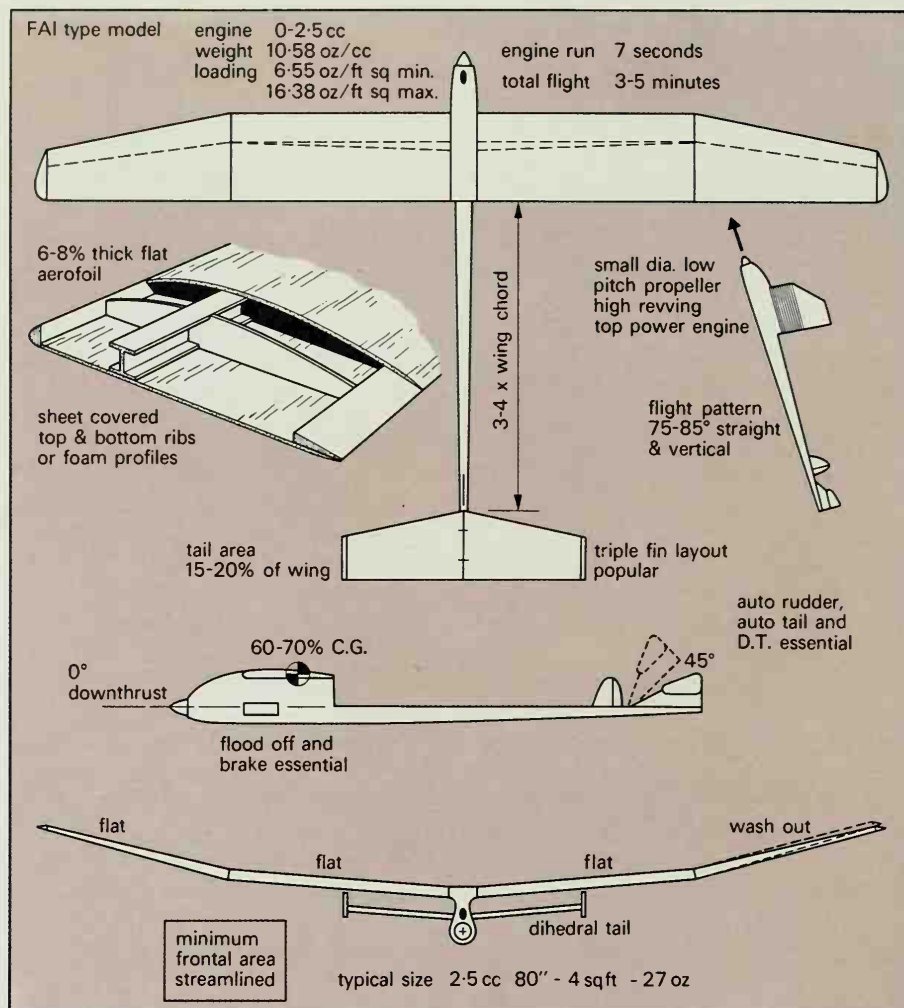
First principles

The inherent appeal of power model flying plus some of the problems to be encountered are illustrated by this anecdote. Firstly, the need to limit the duration of the motor run, second to control the increased flying speed. Gliders, or indeed power models after the motor has cut, are adjusted to fly in a gentle state of equilibrium, lift balancing gravity giving a slow floating glide. Upset that equilibrium with increased speed and all manner of aerobatics result as various elements take increasingly dominant roles in the flight performance. It is the balance of these two phases, the high speed launch and the slow glide, that offers the key and the enjoyment of power flying.

Design considerations

How then are these problems overcome? In simple terms there are two solutions: by the geometry of model design itself or by the use of controls operated by simple clock-work timers. Slower power-assisted gliders or cabin-style sports models tend to give less difficulty because their power speed is little more than their gliding speed; a little engine downthrust is usually all that is required. But it is only natural that all modellers are tempted to push forward the limits of performance. It is these high performance types of model which will be considered, although naturally the aeronautical principles discussed hold true, in degrees, for all power models.

The ideally trimmed model will have a maximum rate of climb for a short period to gain altitude, followed by a long floating glide to achieve the maximum duration. Many factors affect the flight of a power model during power and glide phases. The ratio of wing area to tail area: the larger the wing the more it lifts at increased speed, producing loops, the larger the tail the more it lifts, balancing the wing's lift to retain equilibrium. The wing incidence: the more wing incidence or up elevator effect required to compensate for a for-



ward centre of gravity (CG) balance point, of a nose-heavy model, again the more the unwanted looping tendency there is; reduce the incidence and move the CG back to correct the glide, and this tendency is controlled. Wing sections also play their part, excessively under-cambered glider sections being most unsuitable at speed compared with the flatter sections preferred for power.

Rudder offset for glide turn can produce unwanted wing-overs at speed, diving the model sideways towards a potential crash. Tilting the tail relative to the wings produces the desired turn for the glide without the other unwanted effects during the power phase. Even the rotation of the propeller, normally clockwise (as seen from behind), results in a counter-clockwise twisting reaction known as torque which can roll the model upside down to the left. This rolling torque effect can be lessened by using a lower pitch higher revving propeller, or counteracted by turning the model slightly to its right, using rudder offset or small amounts of engine sidethrust. The danger of overdoing this turn, and ending up in an unwanted spiral dive to the right, is overcome by the use of increased wing incidence on the inboard right-hand wing known as 'wash in'. Wash in and torque on their own would result in a steady barrel roll to the left, so they need counteracting by the opposite turning effects achieved by rudder or sidethrust.

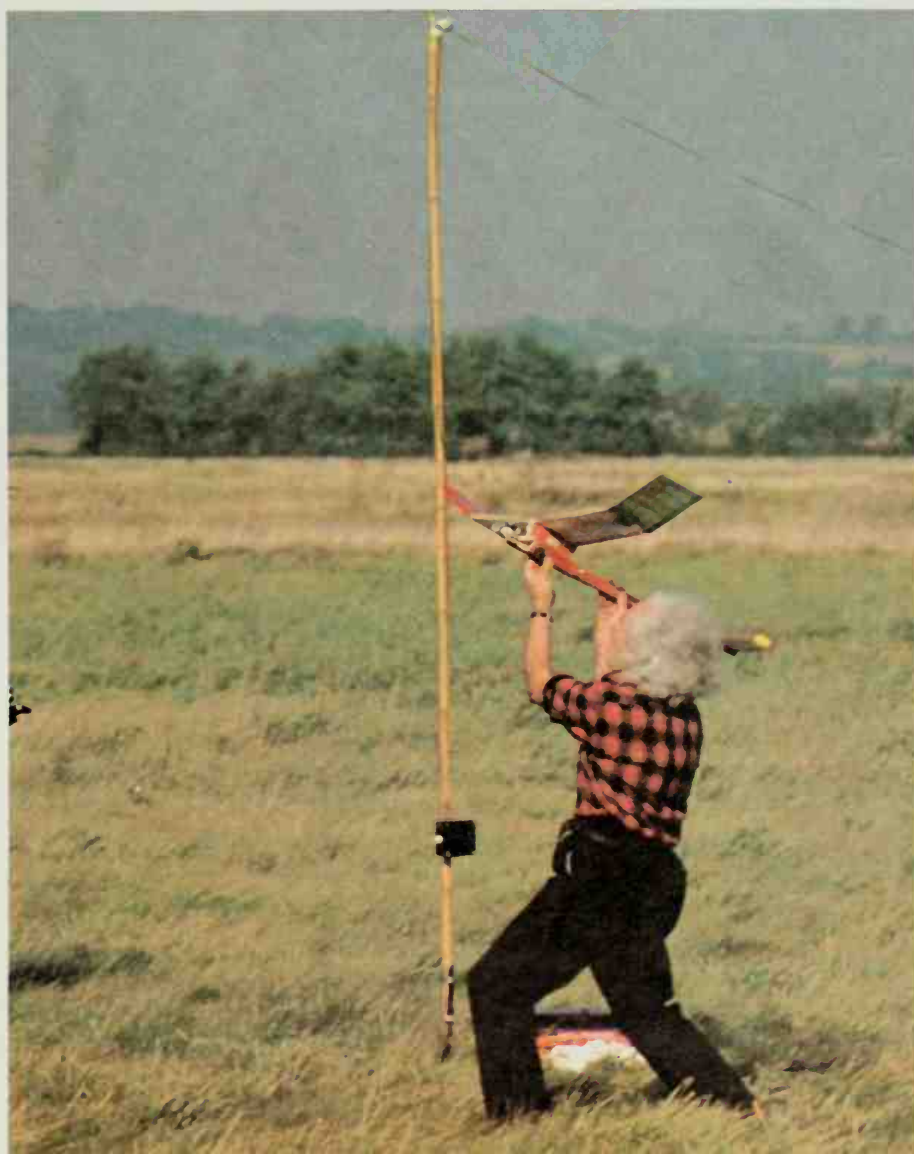
The secret of power flying is being aware that these forces exist and knowing the effect each has on the flight pattern. The simple balancing of equal and opposite forces is determined by a few trial flights.

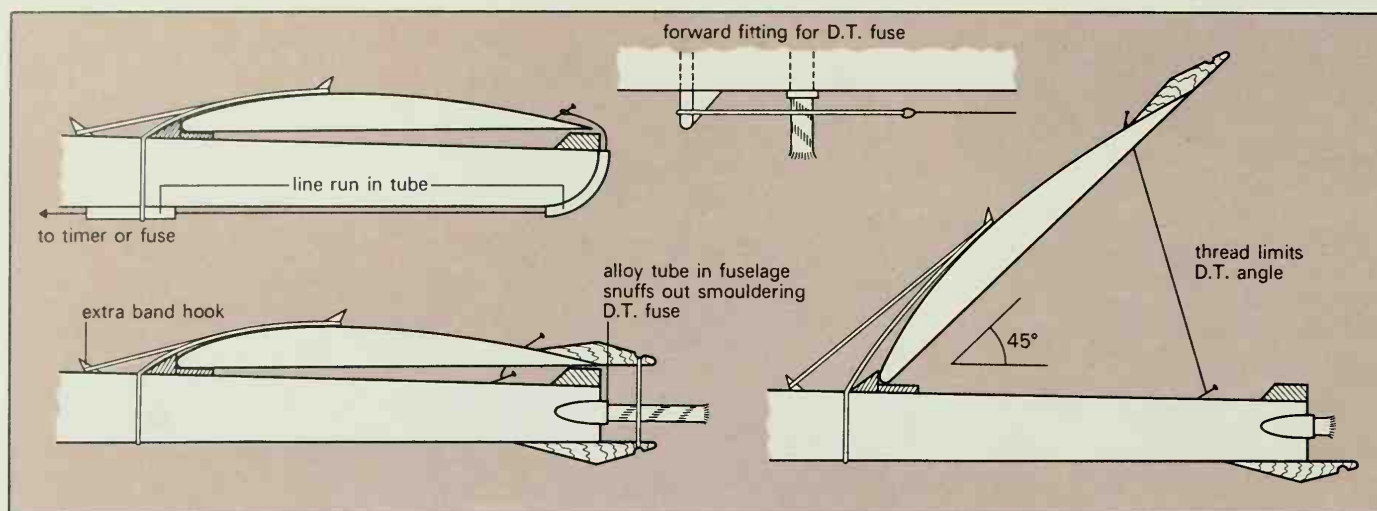
Clockwork gadgets

The use of an engine makes potential flight time almost limitless. The real challenge, however, is to obtain maximum flight time from minimum length of engine run, the permitted engine run being normally 7 to 10sec. Commercially available clockwork timers provide the answer for accurate control of engine run. A soft fuel supply pipe to the engine, such as cycle valve

Above: Checking and adjusting the engine. This model has sheet balsa-covered flying surfaces for truth and efficiency.

Right: Launching a $\frac{1}{2}$ A model. The pole in the background carries a bubble machine, releasing streams of soap bubbles which help to detect thermals.



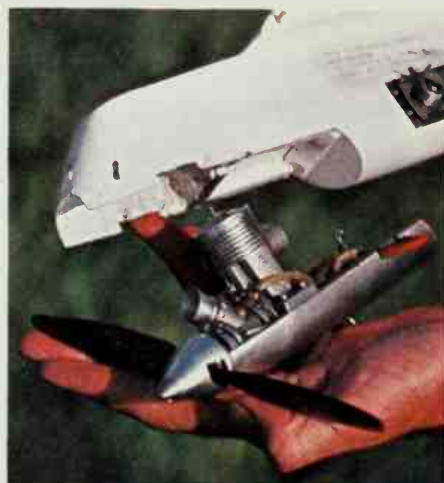
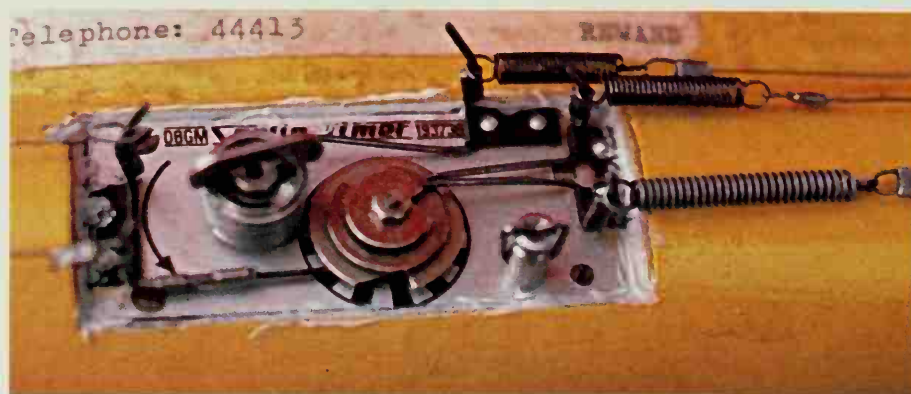


tubing, is squashed shut by a moving arm, called a 'squash off', which immediately starves the engine. Another option is to 'flood off' the engine, by releasing more fuel from the tank under pressure from the engine crankcase or a balloon type tank. An extra pipe runs from the tank feed, directly to the engine air intake, trapped closed by a wire arm during the run. When released by the timer the engine is extinguished with a squirt of fuel.

The aim is now a smooth transition between a fast nose-up climbing attitude into a slower level glide. The use of tail tilt has an increasing turning effect as the model slows and can produce good transitions on a simple model. The rudder ceases to balance opposite sidethrust as the motor stops, but the best answer is to use the clockwork engine timer as an automatic pilot, controlling other functions. A simple auto rudder, held straight for the climb, can be released to provide turn for the glide as the timer cuts the motor.

In competition classes, where rules dictate the total wing area be limited, modellers naturally want to use that precious area primarily on the wings, thereby achieving a better glide. The resultant proportionately smaller tail can cause instability, and the method of overcoming this is to use an auto tail, again operated by the timer after the motor cuts and producing a change of tailplane incidence from that ideal for a straight climb to the best for a stable glide.

The use of wing flaps or folding wings is the ultimate development. Either system radically alters the geometry of the model, into power and glide configurations, to attempt optimum efficiency for both phases. Flappers use a large spanwise hinged flap, which is raised to

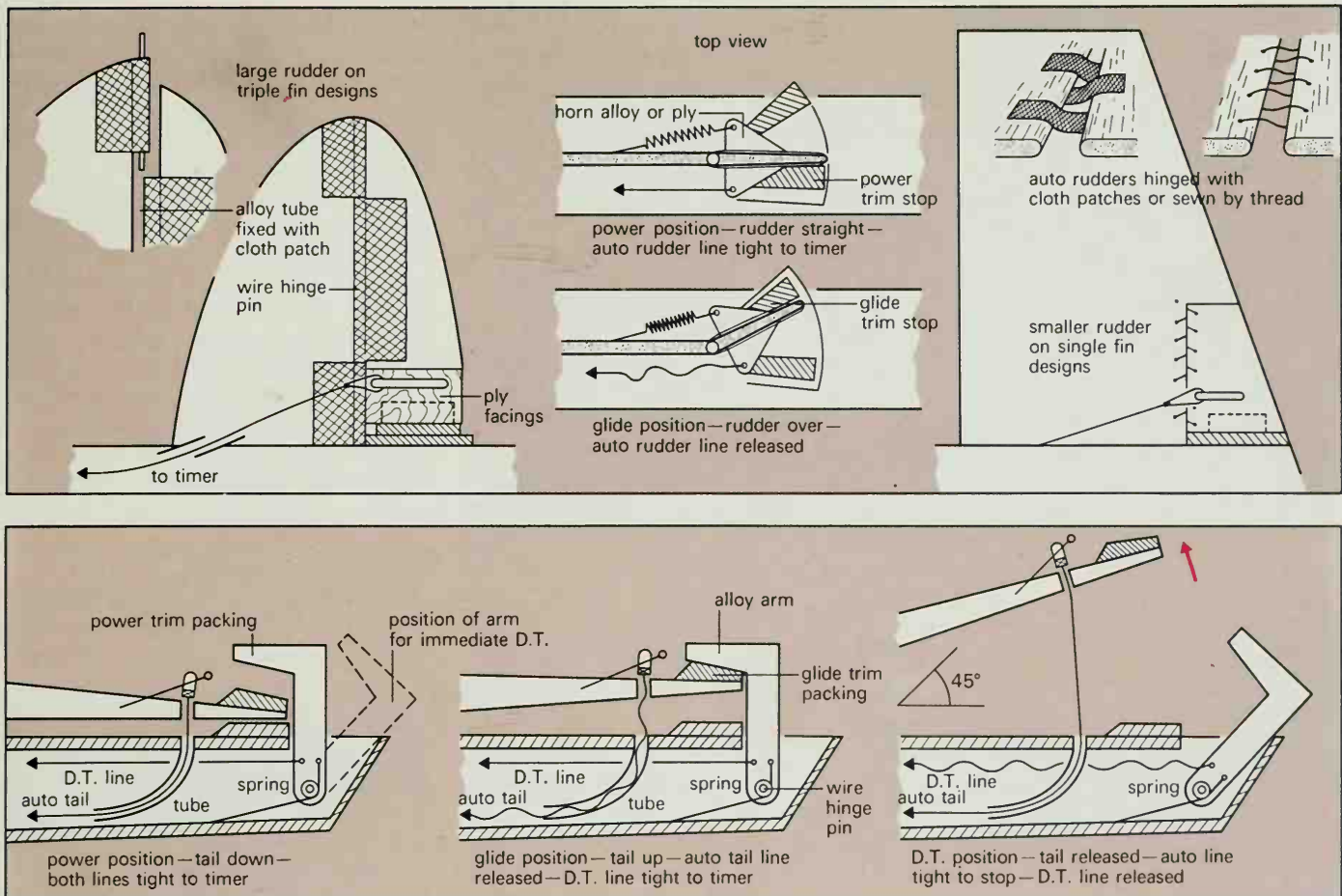


Top: Dethermaliser details, essential to all high performance free-flight models. *Above:* Operation of engine cut-out, variable incidence tail, rudder trim and D/T can all be carried out by one clockwork timer.

Left: Pan-mounted engines are common in top international models. *Below:* The claw which controls tail angle is withdrawn, a rubber band tips the tail, and a restraining line stops it at the correct angle.

Opposite: Rudder and tail angle control methods.





produce a flat bottomed aerofoil section for the fast climb, and lowered to give an under-cambered section for the slower glide. Folders hinge the outer half of the wing, tucking up under the inner half to produce a power model of half the span with a symmetrical section for the climb, re-opening out to full wing area for the glide. Such experimentation illustrates the variations open to the power modeller, although these are extreme examples so far only used by a handful of modellers throughout the world.

The final gadget, and the most universal, is the pop-up tail DT. The air in which models are flown, although invisible, is never still. We are aware of wind direction, but it also rises and falls in thermals and downdraughts, all the more prevalent on hot sunny days. In order to prevent models being carried away upwards by thermals, or to limit flights in a small field, a DT device is used. The tail, traditionally fixed in place by rubber bands, is released to pop up and be restrained at a higher angle, usually about 45°. In this position the model becomes super-stalled and settles gently back to earth safely, wings still level. Once again the operation can be actuated by a clockwork timer, but to save weight, most modellers use a small length of DT

fuse. This looks like thick string, and smoulders slowly, like a cigarette, until activating the DT by burning through an elastic band to release the tail.

Structures

In general, the lighter the model the better the flight, depending, of course, upon the design of the model and its total wing area. The common criterion is wing loading: the lower the model weight per unit area, the better its chances of long flights.

The power model suffers in that for the largest portion of its flight, the glide, it is carrying an unwanted dead weight, namely the engine, tank and timer. The solution is obviously to build the model as light as possible, but if it were just that simple, then perhaps it would be less fun. For every piece of structure discarded the weight goes down, but the strength also decreases. No problem during the glide, but during the power phase strength and rigidity are needed to overcome the increased forces. What is required is that each part does its job to the utmost and is not just along for the ride. Balsa itself is very variable material, so choose the grade carefully, only the lightest, stiffest wood for spars and structural members, and soft light wood for ribs and sheet covering.

Hard and heavy balsa has other uses, but not for power models. Strips of spruce, cut from thin sheets, can be used sparingly to reinforce wing spars, especially for those all-important few inches at the centre, where a break might eventually occur. Lightweight structures may often be strong enough to withstand flight loads, but may not be rigid enough to stand flight speeds. Such structures will flex and flutter as the model accelerates. Tissue and dope adds greatly to rigidity, especially when correctly water shrunk first, or double covered. Extra diagonal ribs and bracing are used to produce a rigid geodetic structure. Covering with thin lightweight sheet balsa acts as a surface-active structure on larger faster models. Further developments include covering over tissue or sheet with ultra light glass cloth (22gm/m² or 0.6oz/yd²), using two part epoxy or polyurethane finishes, which, using the monocoque principle, improves the structure. Models that may look solid actually consist of thin balsa sheet over structural frames of ribs and spars or cores of lightweight expanded polystyrene. Fuselages, too, consist of hollow balsa boxes or tubes rolled to shape round simple formers such as billiard cues. Whatever the materials, the objects are lightness, strength and rigidity.

Model flying

Model planes, even if built exactly to a well-known design or from a manufacturer's kit, will not fly automatically. In fact the chances are that they will not fly very well, if at all, without some simple adjustments made during the initial test flights, known as trimming the model.

Having chosen a design and constructed the model, how then does the model flyer go about trimming it for flight? The first stage is to resist the temptation to rush out and fly almost before the dope has dried. Then check out the model completely at home to ensure wing warps, balance and mechanical systems are in order. More models crash through lack of pre-flight checks and malfunctions of this kind than for any other reason.

Pre-flight checks

Follow the check procedure outlined in Chapter 5. For high performance power models tailplanes and left inner wing panels should be dead flat. Right inner wing panels should have some wash in (1-2mm per 100mm chord or $\frac{1}{16}$ - $\frac{1}{8}$ in per 4in chord and both wing tips some wash out (2-4mm per 100mm chord or $\frac{3}{32}$ - $\frac{3}{16}$ in per 4in chord). If the wings differ from these desired warps by very much, they will need correcting.

Strap the wings and tail on the model using thin rubber bands, well stretched so that components cannot be lifted away from their mounts once in position. The forces acting during flight can be quite strong. Check and key components as previously described.

Run the timer and check that the

mechanisms, if using any, always work and never jam. Ensure that, if using auto rudder or auto tail, they always move positively and are not liable to be moved by the force of air pressure. Now run the motor up several times, holding the model's nose vertically upwards, to check that the motor will be able to suck fuel up from the tank during the climb. Finally, check that the timer and all gadgets work with the engine running, to see that vibration or propeller thrust do not result in any malfunction. Time the engine run for various timer settings until fully familiar with the correct settings.

Test flying

Calm weather really is essential for first flights; evenings are usually ideal, although once trimmed,

Extra height can legally be gained by a javelin-like launch enabling the model to reach climbing speed swiftly. Care is needed to avoid fuel surge interrupting the engine run.

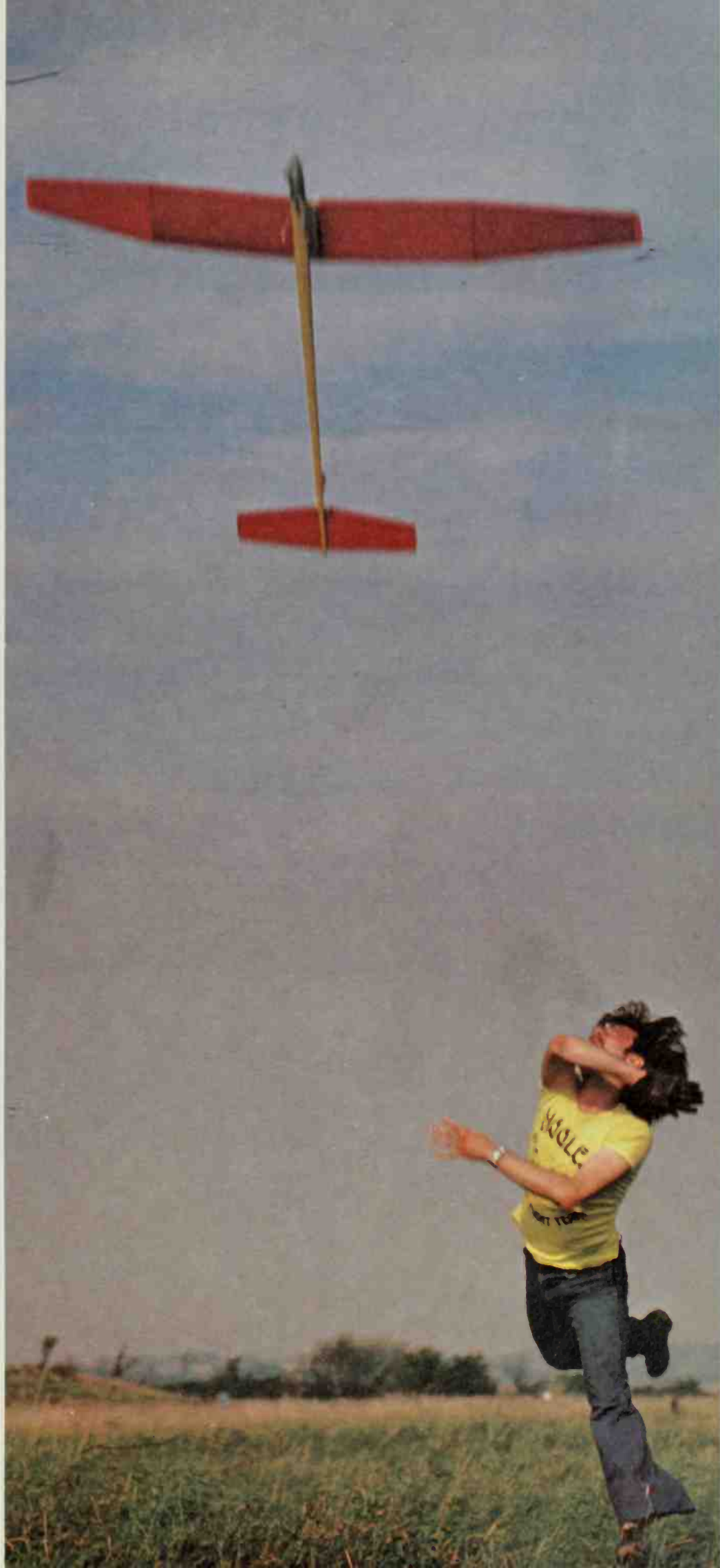


models can be flown in literally any wind speed. A few hand launches at gliding speed are traditional to test for a smooth glide, adjusting with tail packing, rudder or tail tilt.

Now comes the critical moment, that first power flight. There really is no substitute for simply letting go and seeing what happens. No one can tell exactly how a new model will fly, that's why it is so exciting. The most important factor however, is to *watch what happens*. Observations from the first flight, followed by corrective adjustments, will help make the second more successful, and so on. Plan the desired flight pattern by deciding the length of engine run, 1 to 5sec is all that is required to start with. The safest possible way is to link the pop-up DT tail, even if only temporarily, so it operates the instant the timer cuts the motor. Models with auto tails will already have this facility, but others with no gadgets will need a temporary release wire fitting. With this method a very short run of 1 to 2sec, will lift the model 15 to 30m (50-100ft) into the air, to DT immediately and safely return to earth. This is just long enough to watch critically the direction of flight and allow any minor corrections before they develop into unwanted and dangerous loops, dives or spirals. Models without this inbuilt safety valve would simply stall and dive back to earth on such a short engine run, so they need slightly longer runs of 3 to 5sec, to allow them enough altitude to make a safe transition into glide. Go ahead, face into the wind, try it and watch what happens. Do make sure the engine run is genuinely short, a lot can happen to a power model in a few brief seconds.

Once that all-important first flight is over, and adjustments made, a second flight with the same length of engine run will show if unwanted tendencies have been corrected successfully. Patience is the key factor to start with. Once the model is performing as expected, gradual increase of engine run with further flight adjustments can be made, finally concentrating on adjustments to glide trim.

Ultimately, the flyer will have a perfectly trimmed model that he can confidently start up, launch and experience the thrill as it rockets skywards faster and faster until as a small speck overhead, suddenly quiet, it flips over into the glide for another long flight. That's the challenge of power models.



Rubber and Glider classes

Historically, the first model aircraft were of the glider and rubber-powered varieties. Since then aeromodelling has progressed from being the province of the experimenter to that of the hobbyist and, more recently, almost to that of the sportsman. Inevitably the types of model fashionably popular have changed as well. The silent forms of free-flight model have been overtaken in the public eye by other classes, but nevertheless have a great deal to offer in their own right, and are well worth a long hard look.

Rubber-powered models

In their simplest form these are well known, most laymen being familiar with children's ready-to-fly all-balsa stick models, sold plastic-wrapped in many toy shops. These simple models can teach the basis of 'trimming' (the experimental adjusting of the model to make it fly properly), and indeed can fly remarkably well in expert hands. The principle of using twisted loops of rubber to turn a propeller is used on all rubber-powered models.

Commercial constructional kits are usually the beginner's first encounter with 'proper' aeromodelling. Those who attempt a duration design, as distinct from a scale model, can still run into real difficulties with building and/or flying.

Most of these kits feature built-up 'stick-and-tissue' construction which can be fiddling and time-consuming for the beginner. The design is usually a compromise between 'looks' (meaning a cabin and wheels) and function. Moreover, many designs are old, and intended for superseded contest rules. Even if satisfactorily completed, attempts at flying the model can be handicapped by inadequate knowledge of trimming, although the best designs can fly very well.

Nowadays, there is little 'sport' (or fly-for-fun) rubber model activity in the clubs. Consequently there is a tremendous gap between the models just described and the other extreme of modern contest designs intended for out and out duration flying. Such models use the energy stored in a tightly-wound rubber motor to climb as high as practical, while still preserving a reasonable length of motor run. When the turns have unwound, the model descends as slowly as possible in an unpowered

glide. Nowadays contest models are invariably hand-launched (so wheels and the like are superfluous) and are fitted with folding propellers. When the turns wound onto the rubber motor are expended the propeller stops and its hinged blades fold back alongside the fuselage. This decreases the drag (or air resistance) and improves the model's glide noticeably, hence prolonging the flight.

A tip-up-tail dethermalizer (DT), operated by either a burning fuse or a clockwork timer, is invariably fitted to curtail flights when required, either for ease of test flying or to prevent the model flying away. Contest rubber models fall into two main divisions:

1. *Open or unrestricted* ('unlimited' in America) designs.

This is the purest form of outdoor free-flight as there are no artificial limitations to the model design or its mode of flying. The usual approach of lightweight airframes and plenty of rubber gives too much performance for the facilities commonly available. Flights of four to seven minutes (without thermal assistance) will take the models beyond the bounds of most flying sites in any weather windier than a light breeze.

Competitions usually require three flights to a three minute maximum (max), almost a formality in good weather, and are settled by 'flying off' in an additional all-out effort. The Americans favour a progressively higher max for their fly-offs.

Open rubber is a test of structural design as much as aerodynamic considerations. Sophistication has to be worth its weight penalty, and it can be better and easier 'to simplify and add more lightness'. Various practical aspects such as strength, ease of building, visibility, etc. tend to restrain the models from becoming too extreme.

2. *Specification designs to the internationally agreed 'Wakefield' and 'Coupe d' Hiver' rules.*

Both sets of regulations (detailed in appendix) severely limit the amount of rubber, while simultaneously demanding high airframe weights. The World Championship Wakefield class also has tight limits on the wing-plus-tail areas. Contests usually have more flights (seven or five) than open events, but can still need fly-offs to resolve 'all-max' ties.

Although given heavy emphasis in the aeromodelling press, Wakefield and Coupe d'Hiver are not really suitable classes for the beginner; even a relatively competent modeller can find it far from easy to obtain high performance under such restrictive rules. Development has produced refined aerodynamics, much involved metalwork (often at true model engineering level), and assorted gadgets to alter the model's trim in flight. There still remains the necessity to wind the rubber motor right to its limit.

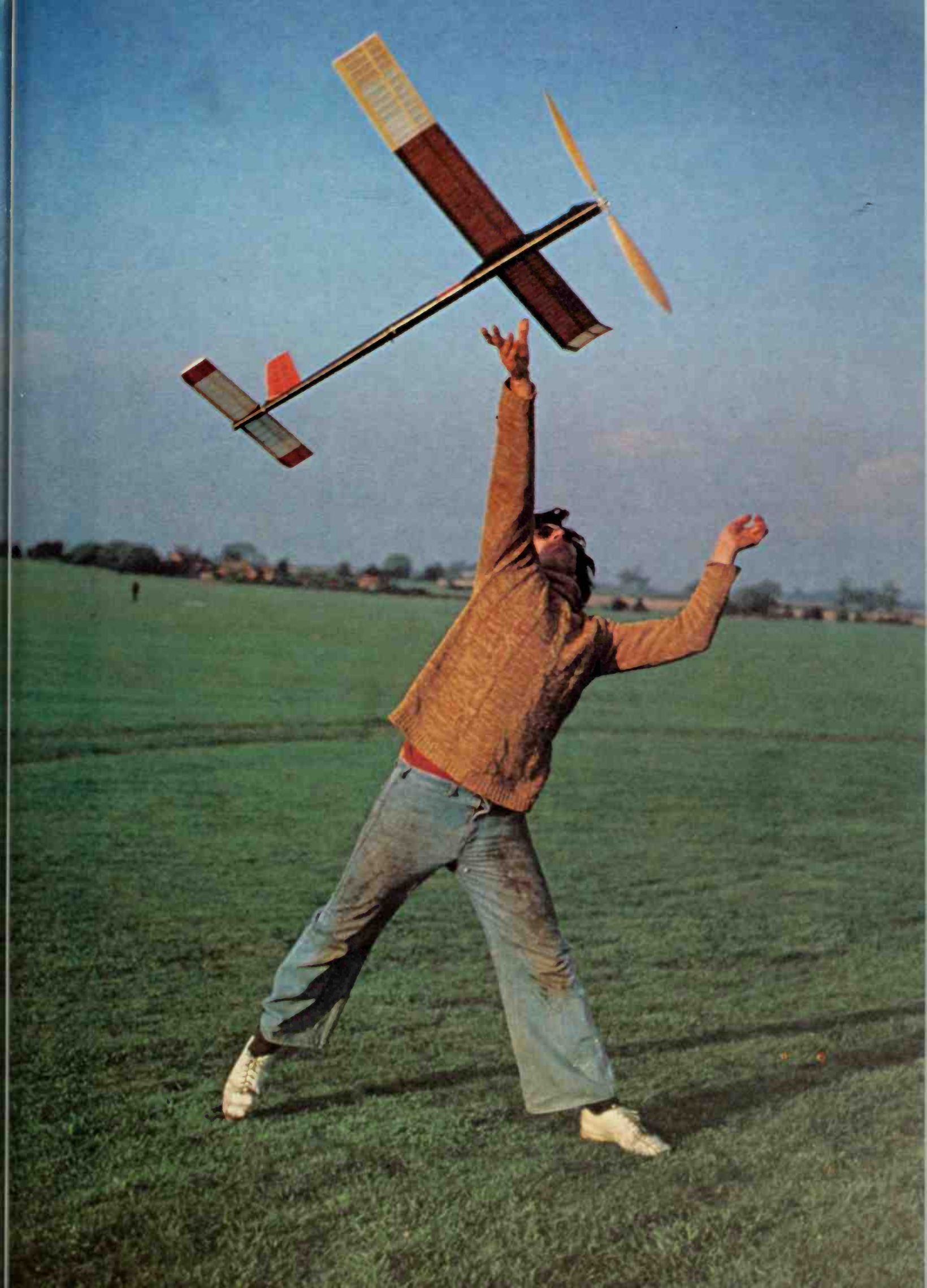
Experts can get over three minutes from a Wakefield in 'still' or 'dead' air, and around two minutes from its smaller brother. Contests, however, are rarely flown in such conditions, and to be successful the flier must avoid sinking air, and hence endeavour to launch his model into thermal lift. This situation has led to concentration on the detection and utilization of rising air-currents, as even the world's best Wakefield will not 'max' in a downdraught.

The universal motive power is strip rubber, commonly 6×1mm ($\frac{1}{4} \times \frac{1}{24}$ in) in section, obtainable from specialist suppliers and many model shops. A suitable length of rubber is arranged in a number of loops to give the power required. Proprietary designs normally specify the number of strands appropriate to the particular model. The novice should note that a loop is *two* strands.

As it is hardly practical to 'finger-wind' such motors by turning the propeller by hand, some mechanical aid is required. Various adaptations of hand-drills are the usual approach. The tension of the rubber is such that merely fitting a hook directly into the drill-chuck is extremely risky.

Rubber should be washed to remove grit, and allowed to dry before being lubricated with either medicinal castor oil or a glycerine and soft-soap mixture. Motors will not take their predicted ultimate turns without some form of 'breaking-in'. This involves preliminary winding or stretching, and is often combined with test flying.

Stretching the rubber while winding is standard procedure intended to increase allowable turns. Ivan Taylor launches a Wakefield model. This class of rubber model originated over 50 years ago but has now become very sophisticated.



Free Flight

and assist the motor to unwind evenly. The latter aspect is particularly important on open models where the rubber motor is usually longer than the fuselage. The excess length is accommodated either by mechanically retaining some turns on the almost unwound motor, or by a 'pre-tensioning' process that effectively plaits the rubber round itself.

Regrettably, rubber quality is variable, and can affect model performance quite dramatically. While most modellers have to be content with what they get, 'Vintage Pirelli' can be quite an advantage. Even the best rubber breaks if overwound, and the worst can fall apart unpredictably. Clearly this can be a disaster for a fragile model. The use of a metal or hard plastic 'winding tube' to protect the fuselage is a more than sensible precaution.

Starting off on the right tack really demands a small, simple and strong model with a 'zippy' climb followed by a *poor* glide. This combination will provide real flying in a smallish space, and teach the beginner how to handle, adjust and fly his model.

If specific advice is required as a follow-up to kit building, then certain P-30 designs can be suggested as an up-to-the minute approach. They fit American ideas for a 'small-field event' using small models 76cm (30in) with a commercial plastic propeller and a limited amount of rubber.

Plans for P-30 models are available from several sources, one very popular one being 'Teacher's Pet', featured in *Aeromodeller* magazine. Even rough and heavy versions have proved capable of around 1½ min flights, ideal for local playing fields. Building from a plan and set of instructions may not be quite as convenient as the pre-packaged approach, but it can be much more educational.

Assuming there is the urge for 'bigger and better', the next in a logical sequence would be a 'Delinquent' (from the same source) partly because it involves carving a balsa propeller.

By now the modeller (no longer a beginner) will be able to cope with assembling built-up frameworks on a flat board, joining sides to form a box fuselage, covering with tissue, and a host of other techniques. He should appreciate trimming and the effects of CG (centre of gravity) position, thrustline offset, rudder, wing warp, tail tilt and the like. Hopefully he will have learnt to fly



a model – and to keep it by use of the DT! A contest model could now be a realistic project.

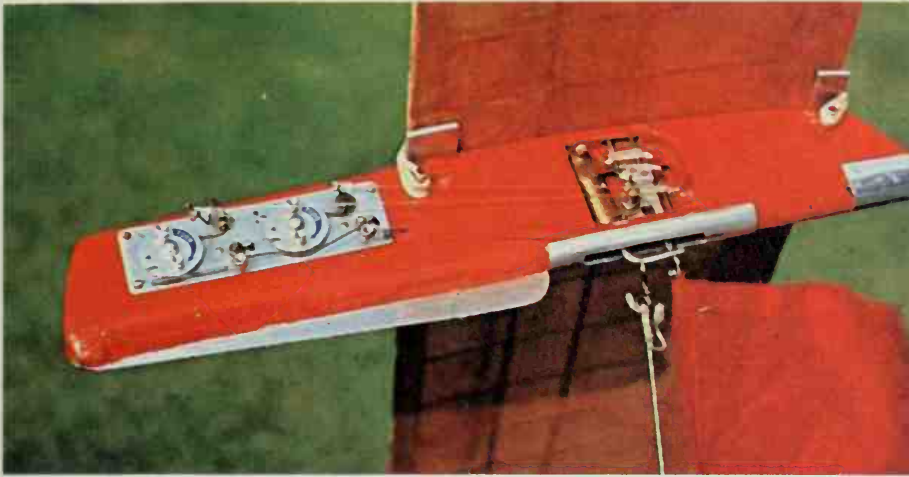
Gliders

The unpowered free-flight model is often more involved than appears at first sight.

Paradoxically the deceptively simple all-balsa 'chuck' glider (outdoor hand-launch glider to be formal) presents the most difficult problem of all. The idea is to throw the glider as high as possible, after which it should glide down slowly and reluctantly. The usual trim to give a slow stable glide is unsuited for the high speed imparted by a hard throw. A series of tight loops might thrill a youngster with a rudimentary 'toy' glider, but is hardly the aim of the more knowledgeable modeller.

To resolve the conflict between climb and glide requirements, a 'zero-zero' trim of identical wing and tail incidences is accepted practice. Launch techniques are then similar to those described elsewhere. This approach is far from safe, but it is the only way to obtain durations of, say, 40 seconds or more without thermal assistance.

Another form of hand-launch gliding is slope-soaring. The model is launched off a hill, hopefully to ride the upcurrents produced by deflection of the wind by the hillside. For success the model has to remain flying into wind – a most uncertain procedure. A flight that turns out of wind usually goes *over* the hill, which can make for exhausting retrieval. Magnet steering is practical enough and far



more predictable, but it must be conceded that the real answer is to use radio control for this form of flight.

The easiest method of obtaining long flights is to use a line to tow the glider to altitude, and then release the line from the model so it is free to glide down, or ride thermal upcurrents. The similarity to kite-flying is obvious, even solo launching is possible, although less reliable than making use of an assistant.

Release of the glider is achieved by a simple ring and hook system. The line ends in a ring which fits onto a rearward facing hook on the model. With tension on the line, the ring remains in position, but when the line goes slack, the ring

moves backwards and falls free, usually assisted by the drag of some form of pennant.

One peculiarity of the towline glider is its need for circling flight, to stay within reasonable bounds as well as to remain within thermal lift. Merely offsetting the rudder would give turn on tow as well as on glide, making height difficult to attain. Hence standard practice is to use an 'auto-rudder', a spring-loaded tab being held straight until freed by some device actuated by release of the towline.

Since lengthening the towline will increase the height attained by the glider, and hence its duration, contest rules restrict the length of line to 50m (164ft). This is insufficient for even the best models to fly long enough for a 'maximum' score without thermal assistance.

Remembering that air is rarely 'still' in the up and down sense, it is not surprising that glider contests have become a game of avoiding sink and catching lift. Although most of the models descend slowly

enough to 'thermal' very easily, launching them *directly* into lift is the only consistent way to success. The pull of a thermal can be felt by the flier while towing his model. Protracted kiting is an obvious approach for finding (or rather waiting for) lift, made practical by use of a clockwork timer to operate the DT. Release of the towline starts the timer as well as activating the auto-rudder.

Towing in calm weather requires the flier to run, and he can run out of space (or breath) before finding lift. The recently developed solution is to 'circle tow'. The line is *locked* onto the model to prevent premature release. The glider is towed up to height, then allowed to glide in one or more circles part way down (with the line still attached) before being towed up again. This process can be repeated, continuously testing the air until it 'feels' (literally, via line tension) good enough for a deliberate release. There are various approaches to the mechanics necessary to do all this, some very complex, and *none* recommended to anyone not fully competent at ordinary straight towing.

While many glider contests are 'open', or unrestricted, nevertheless the vast majority of the entrants fly models designed to the International A/2 rules (see appendix). This popularity is due to the A/2 being a good practical all-round contest model, of about 2m (6-7ft) wing span, and strong enough to wear well. While large or light designs can be advantageous under some conditions, the margin is insufficient to justify such models to most fliers. They would rather concentrate on A/2s, and fly them in both open and specialist events. Such contests require from three to seven flights, with a three-minute maximum and the usual fly-off procedure.

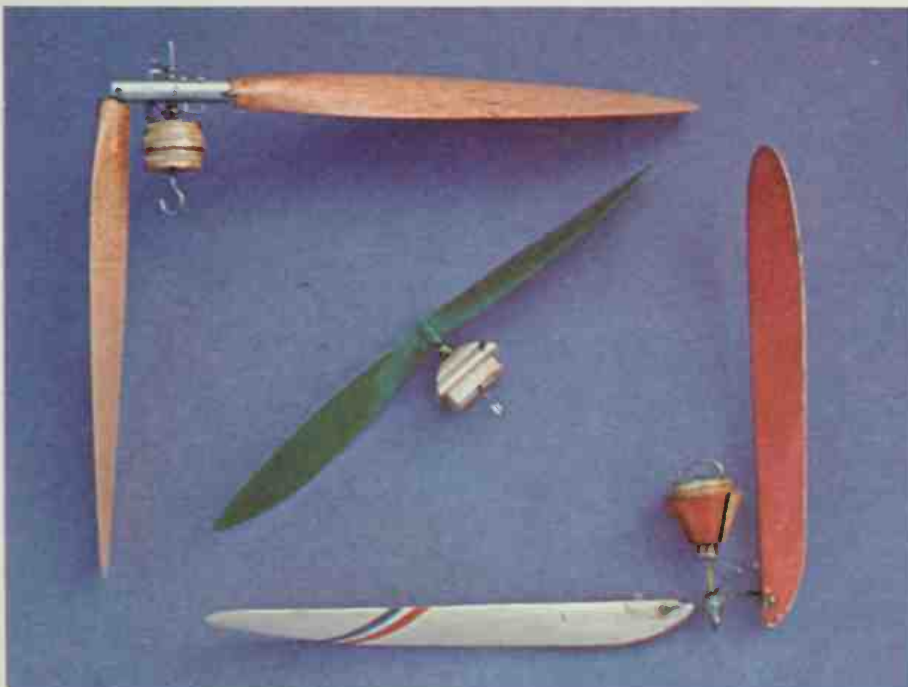
There is another popular specification, for A/1 gliders. These are small, heavy, and usually flown to two-minute maxs (see appendix).

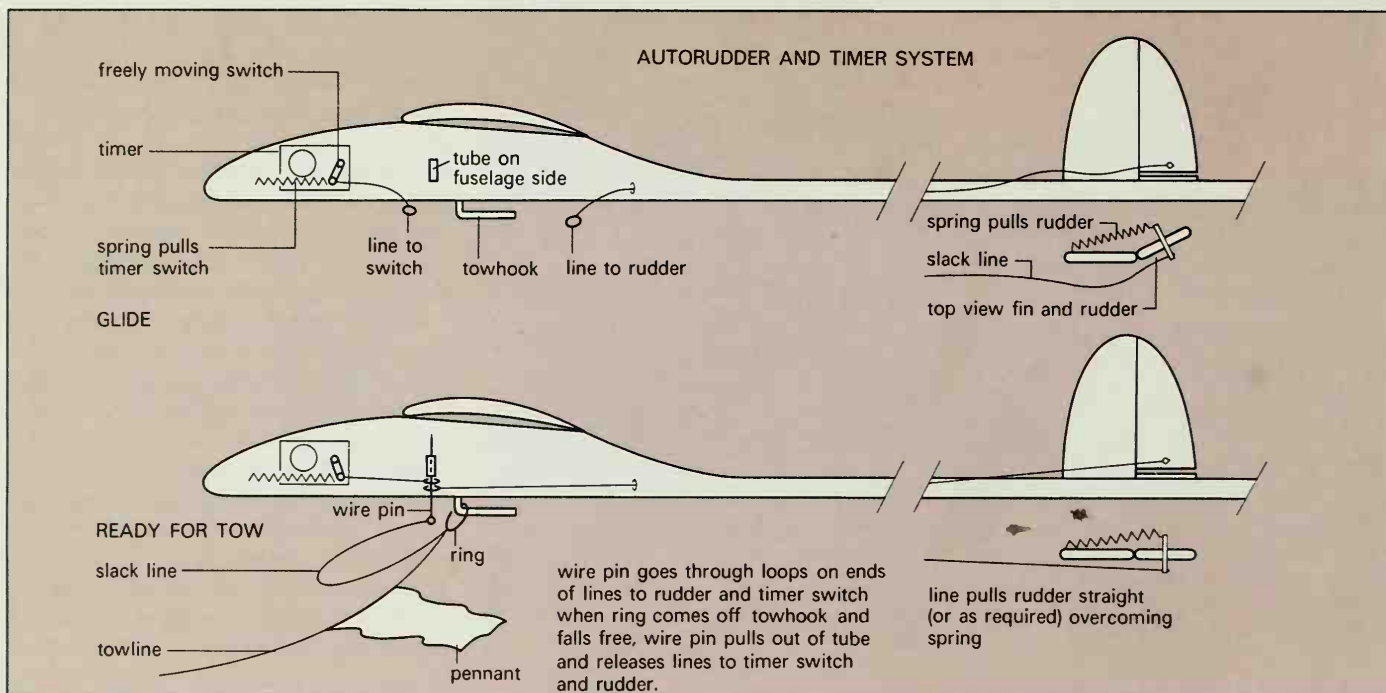
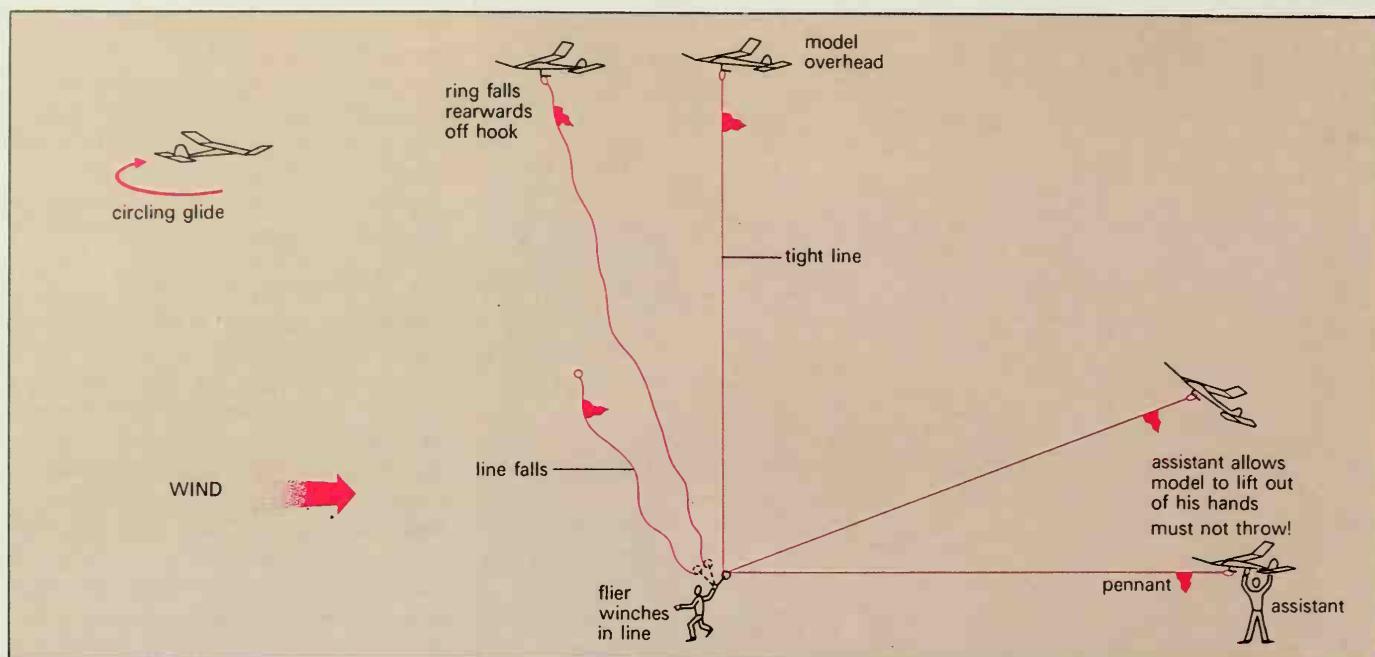
Modern British glider design has settled down to a remarkably stereotyped and rule-of-thumb layout. High aspect ratio (over 12:1) wings of constant chord (width), small light tailplanes (well under 20% of the wing), a pod-and-boom fuselage, and a mid-chord CG are virtually universal. Practical considerations require strong wings to withstand towing loads in wind, while the use of glass-fibre tubes has rendered fuselages virtually

Left: Complex 'egg-box' construction of an A2 glider by Soave of Italy.

Above: A circle tow system and, for safety, a double D/T timer on an A2.

Below: Folding propellers from Wakefield models with (centre) a P30 plastic prop assembly.





unbreakable in normal use.

The newcomer would do well to avoid the very small models offered as towline-glider kits, as they are difficult to handle on tow. Models around A/1 size, say over 1m (about 40-50in) span, are far more practical. Suitable designs are available as plans and there are some kits. If in doubt, opt for simple straightforward designs rather than advanced contest winners. Construction is usually similar to, but more substantial than, that of rubber models.

Regular use of a DT is essential to avoid losing the glider in a thermal. Burning fuse is adequate as a timing device while learning to fly, but a clockwork timer is far more convenient (even though liable to disastrous stoppages if allowed to become dirty).

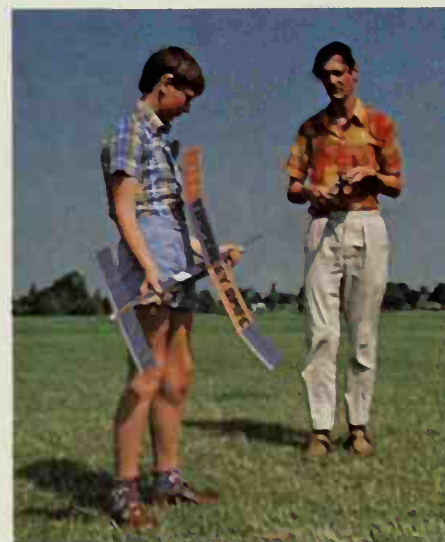
Trimming is easier than for rubber models as there are less variables. Unwanted warps should be removed, and sufficient nose-weight added to bring the CG to the designer's recommended position. Field adjustments are then limited to packing the tail to trim the glide, and altering the rudder settings to suit both tow and glide requirements.

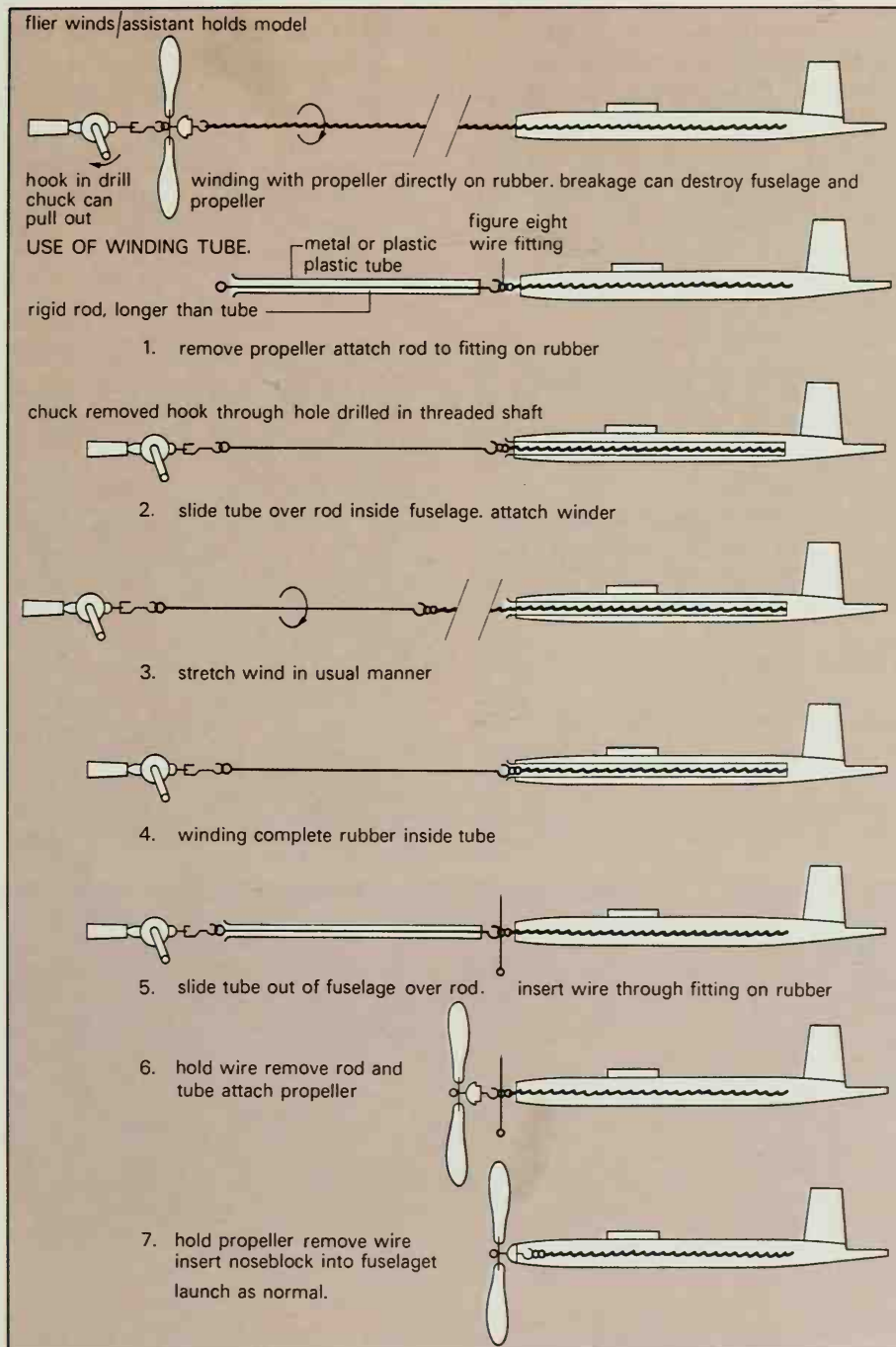
The towline itself is important. Nylon monofilament fishing line is ideal and readily available, if a little difficult to knot. It needs to be kept on a spool, with some sort of geared winch being required to wind in the line after use.

One final word of advice. Put your name, address and phone number on any free-flight model. Otherwise, if it flies away, it is gone forever!

Below: Youthful P30 builder Allan Warman holds model and tube while father winds.

Right: Enormous 'open' rubber-powered model by John Carter.





Characteristics of rubber driven models, world championship formula, 'Wakefield' (Class F1B):

Total surface area, 17 to 19sq.dm (263.5-294.5sq.in).

Minimum weight of model less motor(s), 190g (6.70oz).

Maximum loading, 50g per sq.dm (16.38oz per sq.ft) of surface area.

Maximum weight of motor or motors lubricated, 40g (1.41oz).

Coupe D'Hiver rubber class (Class F1G):

Model specifications:

Minimum total weight of air-frame (less rubber), 70g (2.46oz).

Maximum loading: 50g per sq.dm (16.38oz per sq.ft) of surface area.

Maximum weight of rubber motor (lubricated): 10g (0.352oz).

Minimum area of maximum fuselage cross section measured in the vertical plane with the model in a normal horizontal flight position: 0.20sq.dm (3.1sq.in).

Characteristics of gliders, world championship formula, A/2 (Class F1A):

Total surface area, 32 to 34sq.dm (496-527sq.in).

Minimum total weight, 410g (14.46oz).

Maximum loading, 50g per sq.dm (16.38oz per sq.ft) of surface area.

The maximum length of the launching cable shall be 164ft (50m) when momentarily subjected to a tensile load of 4.4lb (2kg), and no cable in excess of this length shall be allowed on the cable holder. In order that the commencement of a glider flight can be correctly judged, a small pennant of minimum area 39sq.in (2.5sq.dm) must be fixed close to the free end of the cable.

A/1 glider class:

Model specifications:

Maximum total horizontal surface area: 18sq.dm (279sq.in).

Minimum total weight: 220g (7.76oz).

Maximum loading: 50g per sq.dm (16.38oz per sq.ft) of surface area.

The maximum length of the launching cable shall be 50m (164ft) when momentarily subjected to a tensile load of 1kg (2.2lb) and no cable in excess of this length shall be allowed on the cable holder. In order that the commencement of a flight can be correctly judged, a small pennant of minimum area 2.5sq.dm (39sq.in) must be fixed close to the free end of the cable. The cable may be of any material.



Indoor Flyers

Rubber powered indoor models

The aim of indoor microfilm models is purely to achieve the maximum possible flight duration. The duration record, set in an airship hangar in the United States, is almost 51min, a very long flight for a rubber-powered model. The International contest class has restrictions of 650mm span (25.6in) and one gram *minimum* airframe weight, but flights of 35min are quite common. Even apparently simple models can make long flights. The 'Easy-B' class is for models of simple construction with tissue covering. Fuselage and propeller blades must be of solid balsa and no curved outlines are allowed. In expert hands these models can fly for up to 20min and even the beginner can get flights of 5min from his first model.

There are various other classes of model flown, including so-called 'cabin models' (which must conform to minimum cross-section requirements and have a cockpit and undercarriage), helicopters, tailless models and even ornithopters.

With all these models, a prerequisite for long flights is a low wing loading. This usually means that the aircraft must be made as light as possible for its size, consistent with maintaining sufficient strength and stiffness for it to be handled and flown; it must be as efficient as possible aerodynamically and structurally, and great care must be taken to match the rubber 'motor' to the airframe.

The power source

The power to fly the model comes from the energy stored in the twisted rubber strip 'motor'. High flight times require many turns on the rubber run off very slowly. This means thin rubber and a big propeller, which will give a slow rotation speed, yet still provide enough thrust to keep the model airborne. Best performance is achieved when the model is under power for the whole flight, landing as the last turns of the rubber are used. The high initial power of the tightly wound rubber makes the model climb at first then, as the torque or twisting effect reduces, the model levels off – ideally just under the roof – and begins a slow cruising descent, using all the stored energy by the time it lands. If the rubber is too thick or too short the propeller will turn too fast and the model will

run out of energy before it lands. If the rubber is too thin or too long, the model will land with energy still stored in the motor, and that energy will have been wasted. The adjustment and matching of the rubber to the airframe and propeller is essential for best performance.

Rubber, being a natural material, is very variable in quality and expert flyers will test as many types and batches as they can to find that with the best energy storage characteristics for its weight. The rubber motor used on a model can weigh more than the airframe: an International class model would be up to 60% rubber in a 2.5g total (0.088oz).

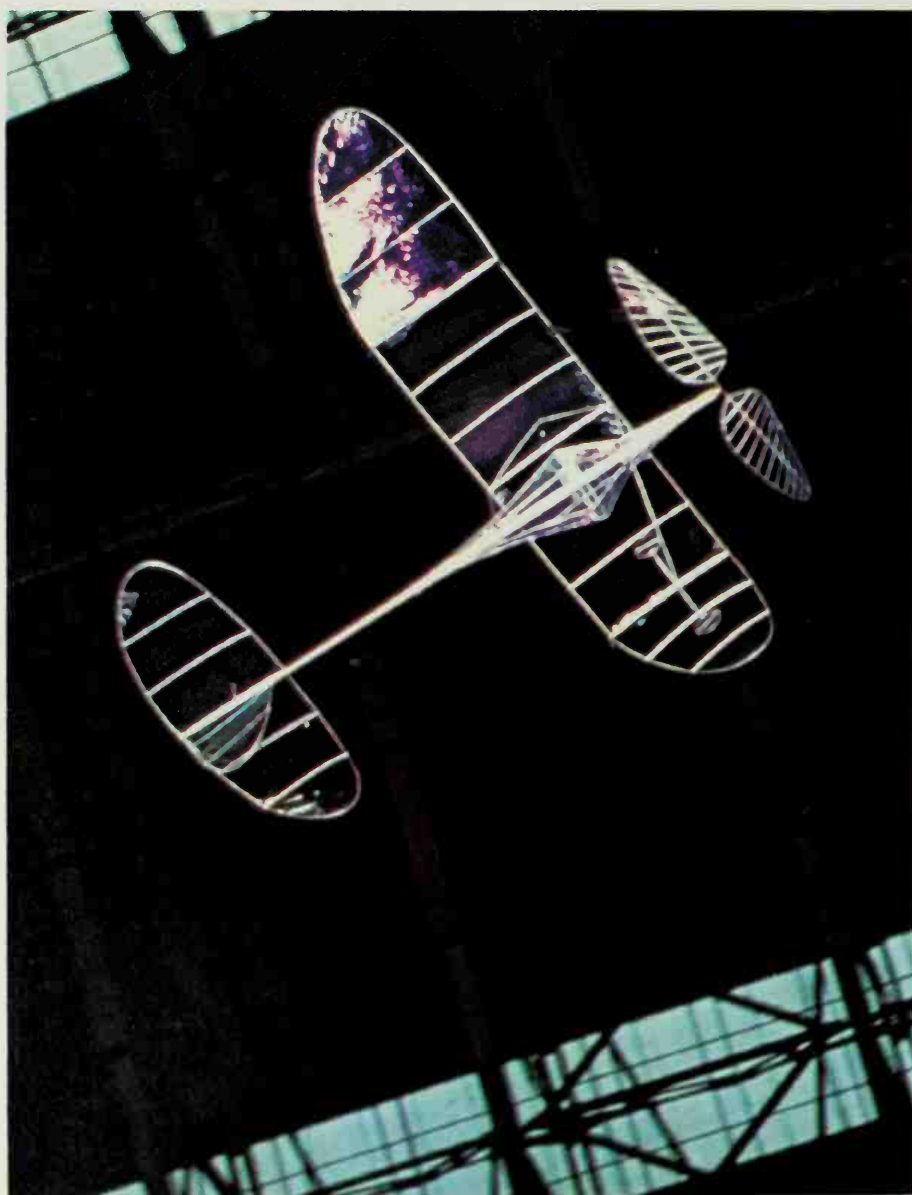
The airframe structure

Indoor model structures are built mainly of balsa, which varies in density between about 60 and 250 kg/m³, (4–16lb/ft³), so wood selection has a major effect on final structure weight. For a given weight,

low density strip has a larger cross-section than high density and consequently has greater stiffness. Wood properties can even vary in different parts of the same sheet, so some selection is always necessary. The beauty of indoor flying is that we use so little wood, we can afford to be selective, and only the lightest balsa is chosen.

Structures used in indoor flying are often braced with wire to achieve maximum stiffness at low weight. The bracing causes drag, and to minimize this while retaining sufficient strength, a high tensile material is used. This is most often nichrome wire (Nickel-Chrome Steel) and is used in diameters from 0.015 to 0.03mm (0.0005–0.0015in).

Other metal parts in a typical model are the propeller shaft and rubber anchorages, which are made of 0.35–0.4mm diameter steel wire (0.014–0.016in). The propeller shaft bearing may be fabricated from



steel wire or aluminium alloy sheet. The metal parts of a microfilm model can account for about 10% of the airframe weight.

Construction methods

The flying surfaces are built up from balsa outline spars and ribs and covered in tissue paper or microfilm. This construction is also used for the propeller on most models, although simple designs and some of the heavier types have sheet balsa propeller blades.

Wood sizes used in these built up surfaces vary from 0.5 to 2mm (0.02–0.08in), usually in rectangular sections with the greatest depth in the direction of the maximum load.

Fuselages are of solid balsa on simple models, but built up tubular units give a better strength to weight ratio for lighter models. The fuselage of a typical International Class contest model is in two sections. The forward part, which must withstand the torque and tension of the rubber motor, is a 6mm diameter tube (0.25in) which is rolled from 0.36mm (0.014in) sheet balsa. It has external wire bracing to help resist the bending effect of the rubber which hangs beneath it. The rear part of the fuselage, supporting tailplane and fin, is a tapered tube, going from 6mm to 1.6mm diameter (0.25–0.06 in). The wall thickness is 0.2mm (0.008in). Some classes of indoor model have built up fuselages similar to outdoor types but of lighter construction.

Any curved balsa outline spars or tubes required for a model are formed by soaking the wood with water and then binding it to a former while it dries. This process can be speeded by the application of gentle heat – even by baking in a very low oven. Curved strips for ribs are made by profiling the edge of a sheet of wood by cutting round a template, sliding the template down the required rib depth and repeating the cut.

Very thin strip balsa is easily damaged so it must be handled with care. Conventional tweezers will crush the wood but a light-weight pair of home-made balsa tweezers can be used.

The narrow balsa strip required for indoor models can be cut from thin sheet using a sharp pointed blade and a straight edge or a small custom-made wood stripper. The thinnest sheet balsa normally stocked by model shops is 0.8mm (0.03 or $\frac{1}{32}$ in) but thinner sizes can be obtained by sanding this down.

Most flyers prefer to purchase wood from specialist suppliers who can saw wood down to 0.2mm (0.008in) and less. A thick bladed, high rotation speed saw is used but the difficulty of the operation and high wastage make the wood expensive by comparison with normal sheets. Costs are still low overall, however, because the last thing we want in a light model is a great deal of wood.

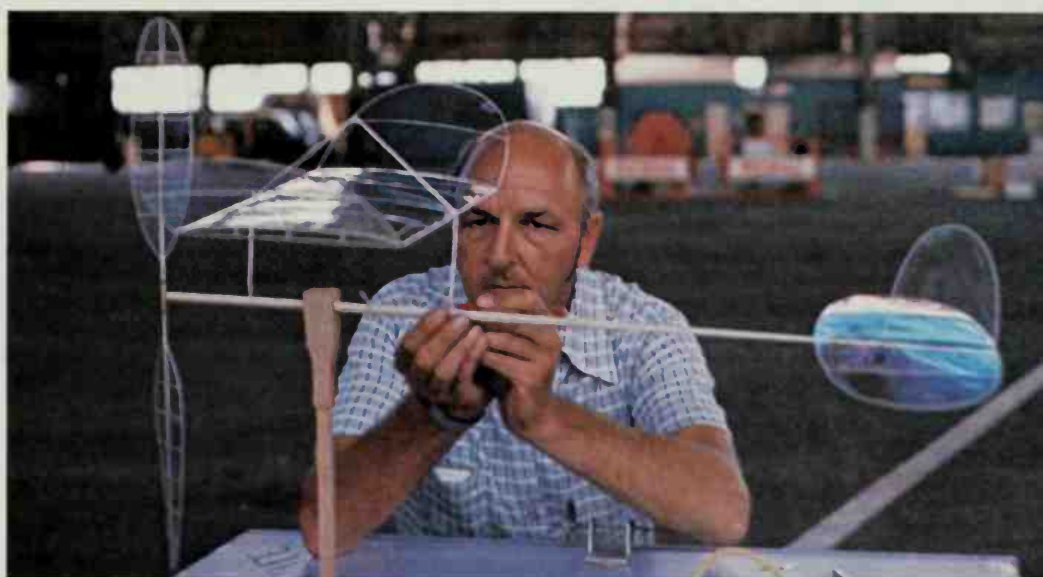
Adhesives

The adhesive used for airframe construction is thinned balsa cement or a similar special glue, made for

Left: Climbing gently but steadily is a fuselage model – the 'bump' on the fuselage gives the required cross-section.

Right: Film colour is a guide to thickness.

Below: Transparency of the film is obvious; 100 parts nitrate dope, 30 amyl acetate, 30 methyl isobutyl ketone, 25 acetone, plus a touch of cellulose acetate butyrate is one formula!



indoor models. The glue is applied with a hypodermic syringe which has had its needle ground off square and blunt – not just for safety, you get smaller glue drops that way. Paper coverings are stuck to balsa with thinned tissue paste or white glue applied with a small brush. These adhesives will not melt the cement used to build the airframe. Microfilm is stuck to the framework with saliva or beer, both of which are said to contain enzymes which bond the film to the wood. Thin plastic covering materials used on some indoor models are stuck to the balsa with thinned rubber solution or contact cement.

Covering materials

Indoor models are usually covered in tissue paper or microfilm. The tissue is normally condenser tissue, a very lightweight non-porous paper. It ranges in weight from 3.5 to 7g/m² (0.008–0.016oz/100in²). Normal lightweight tissue for outdoor models is heavier at 10 to 15g/m² (0.023–0.034oz/100in²).

Microfilm is the lightest covering material used, weighing as little as 1g/m² (0.002oz/100in²). The most striking feature of the film is its beautiful iridescent colours which, apart from looking nice, enable the film thickness to be judged. The colours are due to interference effects, which means that the film thickness must be of the same order as the wavelength of visible light, about 0.0005mm (0.00002in). Silver/Gold is the lightest, and thicknesses range through Blue/Yellow, which most flyers prefer, to Red/Green, which is considered 'heavy', but is still much lighter than paper.

Some models, notably those powered by CO₂ motors, are covered in thin plastic film called mylar. This ranges from 0.0025 to 0.006mm in thickness (0.0001–0.00024in) and weighs 2 to 5g/m² (0.0046–0.011oz/100in²).

Covering techniques

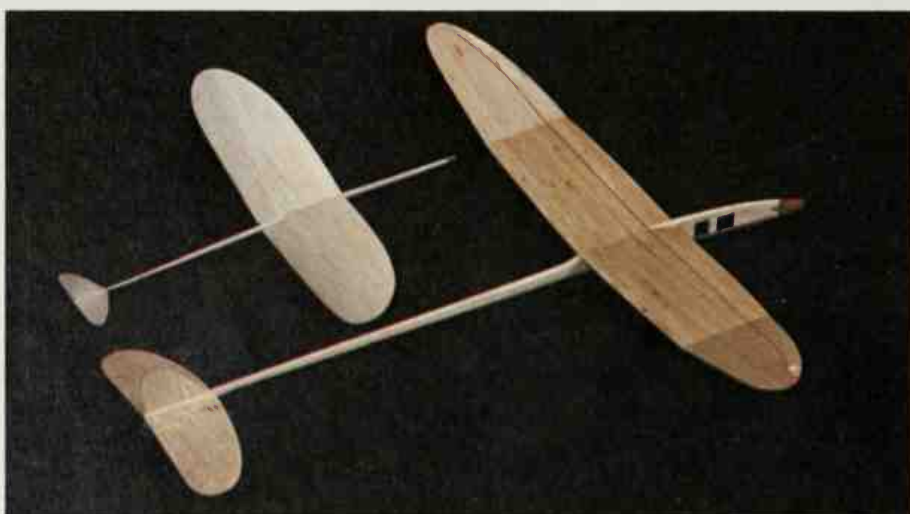
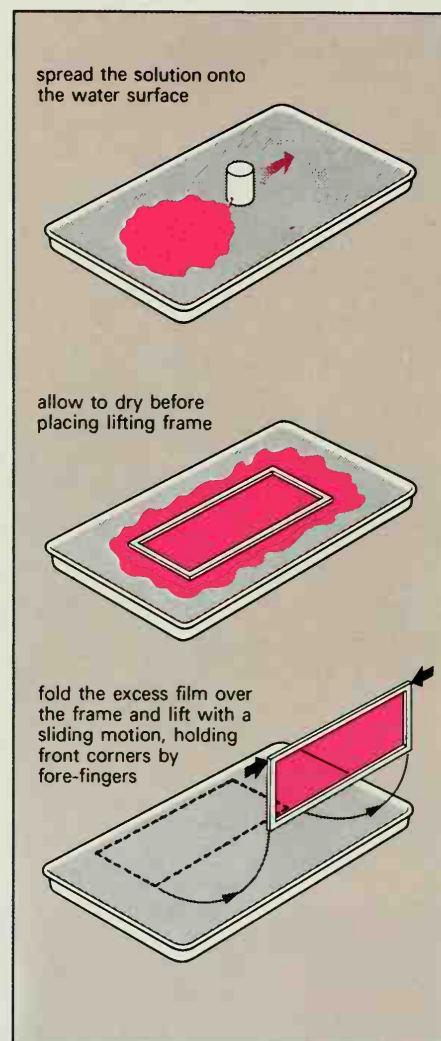
Small structures are best covered by placing the framework onto the covering material, having first applied the adhesive. Tissue and mylar can be trimmed with a very sharp blade but microfilm is cut by melting it with a hot wire or a brush moistened with solvent. Large structures, which can distort if the method mentioned above is used, are covered by laying the covering over the framework, which is lying on a flat surface. Microfilm is kept on its lifting frame until the covered surface is finally cut free.

Making microfilm

The film is prepared by pouring a cellulose solution onto the surface of clean water at room temperature. A shallow tank about five times the area of the required sheet is needed and may be made by draping a sheet of polythene over a wooden frame on a flat surface. Film thickness is controlled by thinning the solution or changing the amount poured onto the water. Film is poured by letting the solution run out of a 2.5 mm (0.1in) hole in a small container as it is drawn along close to the water surface. After 5 to 10min when the film has stopped shrinking and dried, it may be lifted from the water surface. This is done with a balsa frame with a border about 12 mm wide and 6mm thick (0.5 by 0.25in). The lifting frame is moistened with water and laid gently on top of the film. The excess film, outside the frame, is gathered by pushing the frame close to each edge of the tank in turn and folding the resulting narrow border of film over

Below: Tissue-covered Manhattan class model capable of 6 minute flights. Span is 500mm, weight 6g.

Bottom: Two indoor hand-launched gliders. The smaller is 315mm (12.4in) span and weighs 2g.



the edge of the frame. Lifting starts with the frame at the far side of the tank. Holding the frame lightly, with the forefingers at the front corners, it is drawn towards the body lifting it at the same time in one smooth action, finishing with the frame clear of the water and pivoted to a vertical position. When the excess water has drained off the film is hung in a safe well-ventilated place to cure before use.

When lifting microfilm some flyers use rubber solution to stick the film to the lifting frames. In this case, the 'excess' film outside the frame can be simply torn away. This method is more convenient but also more expensive.

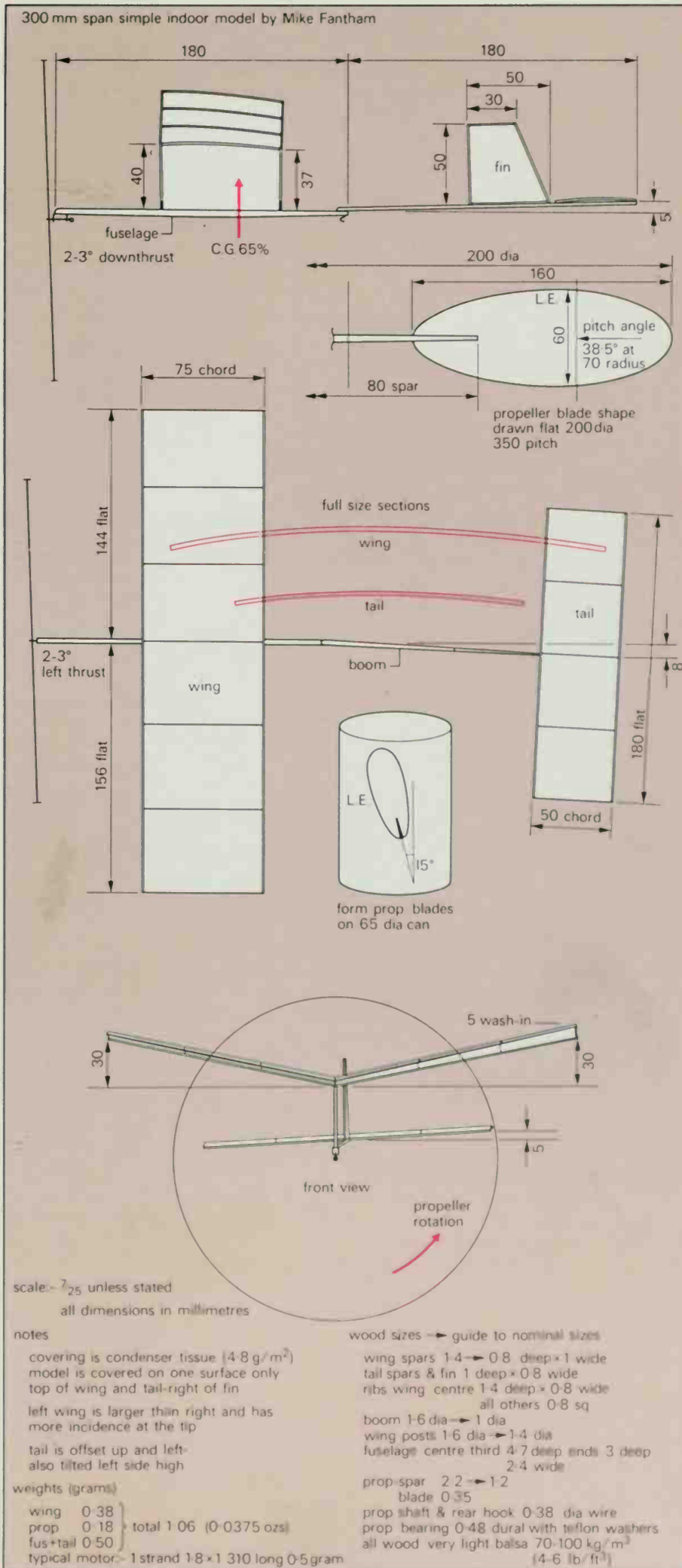
Hand launched gliders

The World Record for a hand launched glider flight indoors is 90 sec. This was made in an airship hangar in the United States, using a 560mm span (22in) solid balsa glider which weighed 22g (0.78oz). This type of duration is achieved by having a model which can be thrown very hard and uses the launch energy to climb to a good height, perhaps 35m (115ft), before beginning a slow glide back to the floor. As with other types of model, stiffness and strength are very important because the stress imposed at launch is very high. The model's size and weight must be matched to the available ceiling height and the thrower's strength. A heavier model will climb higher and a lighter model will glide better. In a low ceiling site the lightest model which can just be thrown to the roof is used, weighing perhaps 4 to 5g (0.14-0.18oz) for a 10m high site (33 ft) for example, with a span of about 450mm (18in).

Flying sites

The best known indoor flying sites are the giant airship hangars which are 50m (164ft) or more high, but are only to be found at a few locations in the United States and one in England. Other large halls are available in most large cities, but perhaps the most curious site known is the salt mine at Slanic in the Transylvanian Alps, Rumania. This site is over 50m high (164ft) and more than 100m (328ft) underground!

A great deal of fun can be had flying indoor models in any size of site. Most schools and sports centres have a reasonable sized hall or gymnasium which could be used for indoor flying, allowing flights of several minutes duration.



Meteorite

This 36in towline glider introduces built-up structures and tissue covering in a straightforward model which will appeal to a novice.

Requirements are:

2 $\frac{1}{8} \times 3 \times 36$ in medium balsa (fuselage sides, ribs etc.)

2 $\frac{1}{8} \times \frac{3}{8} \times 36$ medium balsa (fuselage frame).

1 $\frac{1}{4} \times \frac{1}{4} \times 36$ medium hard balsa (wing l.e.).

1 $\frac{3}{16} \times \frac{3}{16} \times 36$ medium hard balsa (tailplane l.e.).

2 $\frac{1}{8} \times \frac{1}{4} \times 36$ hard balsa (wing and tail spars).

1 $\frac{1}{8} \times \frac{1}{8} \times 36$ hard balsa (wing rear spar).

1 $\frac{1}{8} \times \frac{1}{2} \times 36$ medium balsa (wing t.e.).

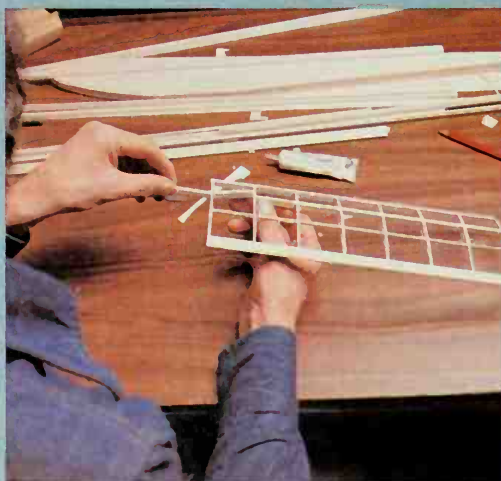
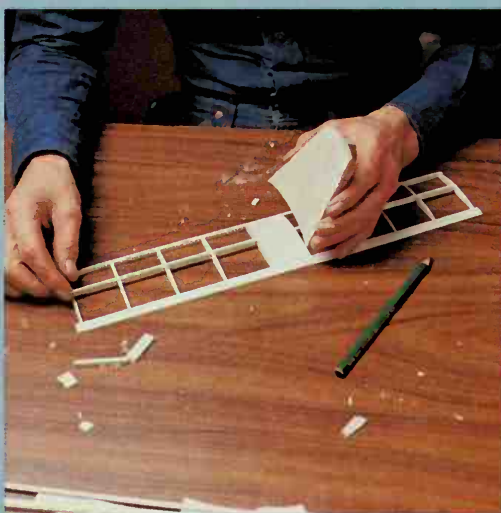
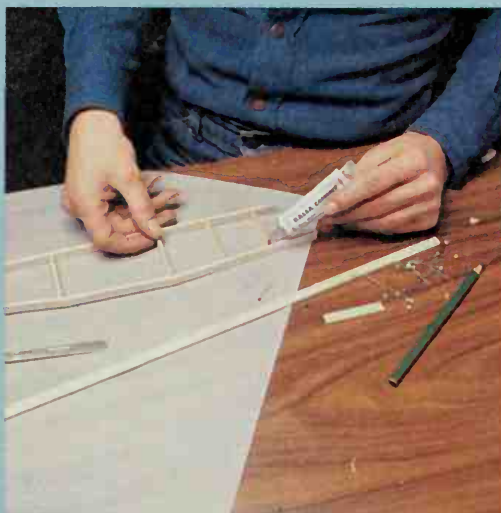
1 $\frac{1}{8} \times \frac{3}{8} \times 36$ medium balsa (tail t.e.).

A scrap of soft $\frac{1}{8}$ in sheet balsa, $\frac{3}{32}$ in ply, $\frac{1}{8}$ in dowel, 18swg wire, two sheets of tissue, cement, dope. (Possibly additional scrap $\frac{1}{16}$ in sheet.)

Trace the fuselage side view on to kitchen grease-proof paper and pin to building board. Pin $\frac{1}{8} \times \frac{3}{8}$ in strips top and bottom, cement in bottom reinforcement strip, then cut and cement spacers. Laminate nose from $\frac{1}{8}$ in sheet. When dry, remove pins and sand top face. Apply cement and position $\frac{1}{16}$ in sheet, weighting till dry. Remove from plan, trim round sheet, fit towhook, sand second face, and sheet cover. Trim and sand when dry. Add wing and tail platforms (accurately) and dowels.

Trace wing and tail – note that all wing panels use the same basic tracing. Trace wing rib on to thin ply and cut out accurately; use the ply as a template to cut out 22 ribs from the rest of the $\frac{1}{16}$ in sheet. Repeat to cut 10 tail ribs. Pin ribs together over a piece of spar material and sand to ensure that they are all smooth and identical. Build wing centre panel, notching trailing edge and pinning down together with leading edge, then inserting ribs. Add mainspar. When dry lift and add rear spar.

Pin down one tip panel l.e. and t.e., then join centre panel to them, propping end to dihedral height. Build tip panel and add mainspar dihedral brace before lifting. Repeat for other tip. Alternatively build tip panels

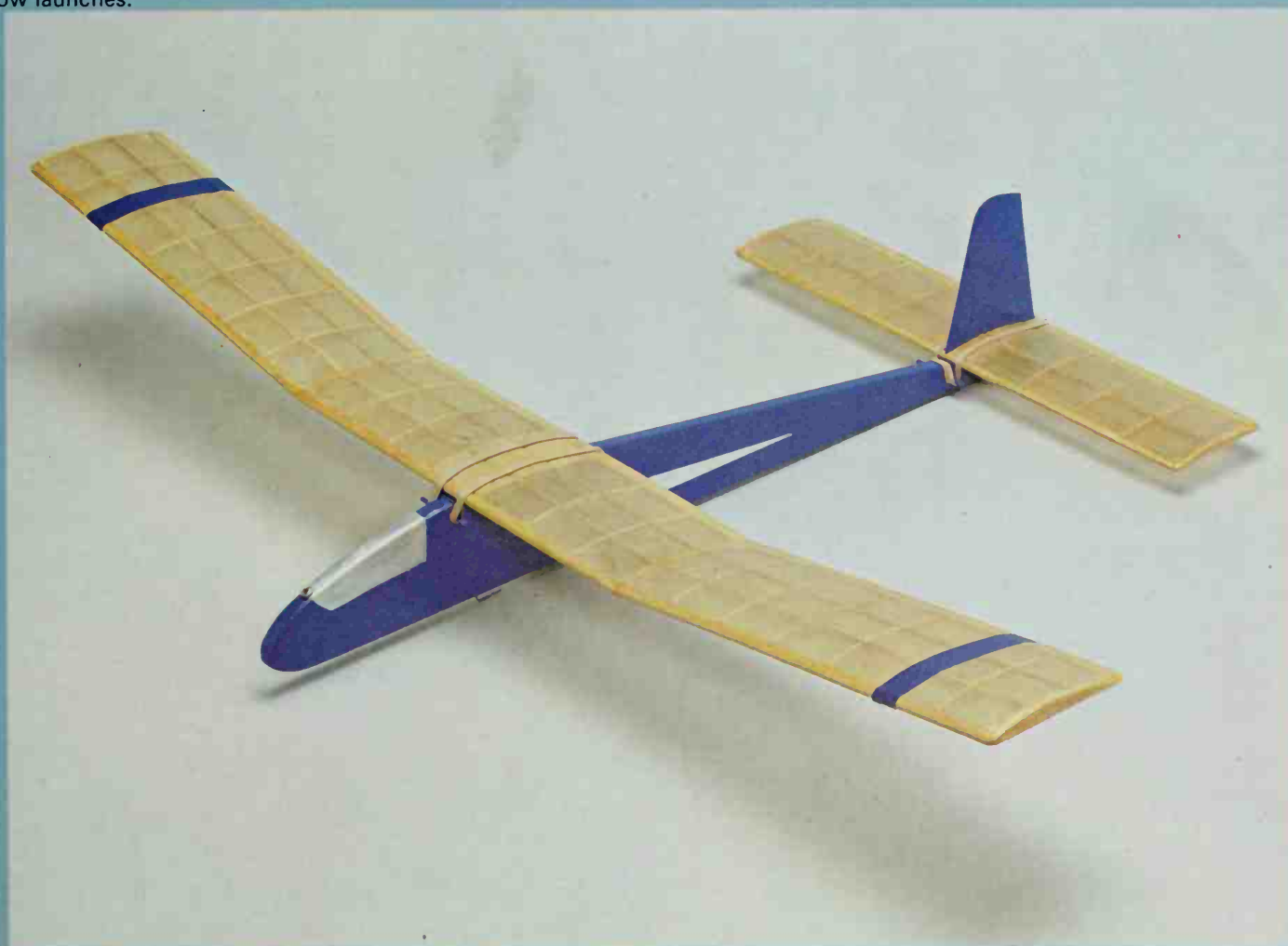
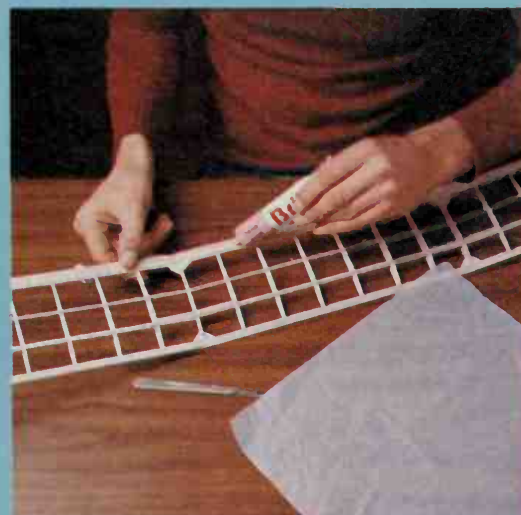
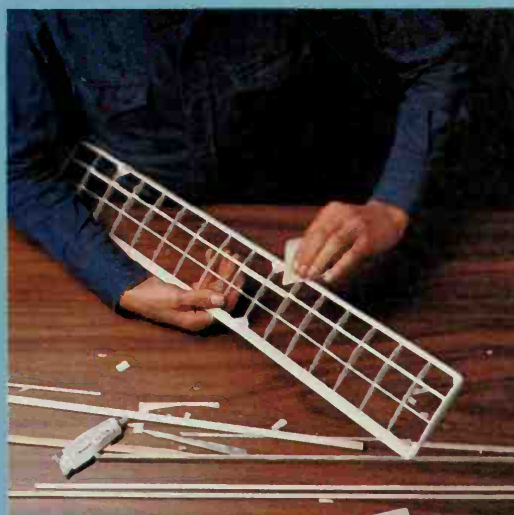
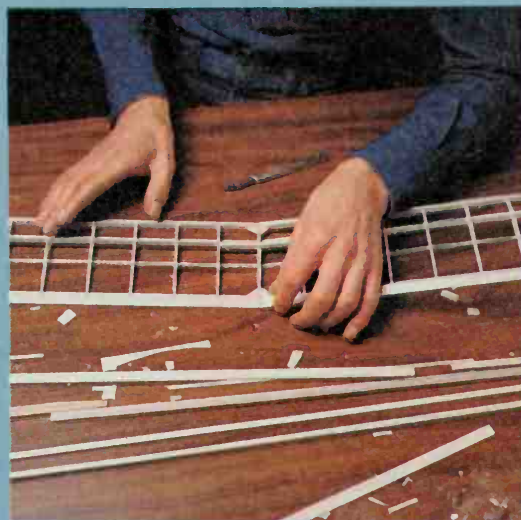
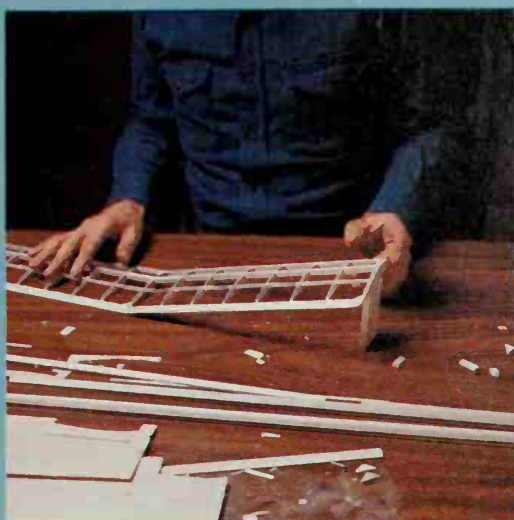


separately, trim spars, and join completed panels to centre, blocking each tip to dihedral height. Add centre sheeting, gussets at dihedral break and soft scrap to tip ribs. Sand all over, shaping leading edge and ensuring a smooth surface for covering.

The tailplane is a simpler version, without dihedral or a rear spar; the fin is cut from sheet and its bottom edge shaped to fit to the centre sheeting, though it needn't be cemented until after covering.

Dope tissue straight on to fuselage, one panel each side with sufficient overlap to cover the top and bottom edges. Cover wing with six panels of tissue, the three bottom panels first, and the tail-plane and fin with two each. (Read the notes about warps elsewhere!) Two coats of dope overall should be adequate; plus a *thin* coat of colour on fuselage.

Attach wing and tail with rubber bands and add lead in the ballast box till the model balances at the point shown. Follow the trimming procedure of hand launches, adding or removing weight to get a reasonable glide before moving on to gentle tow launches.



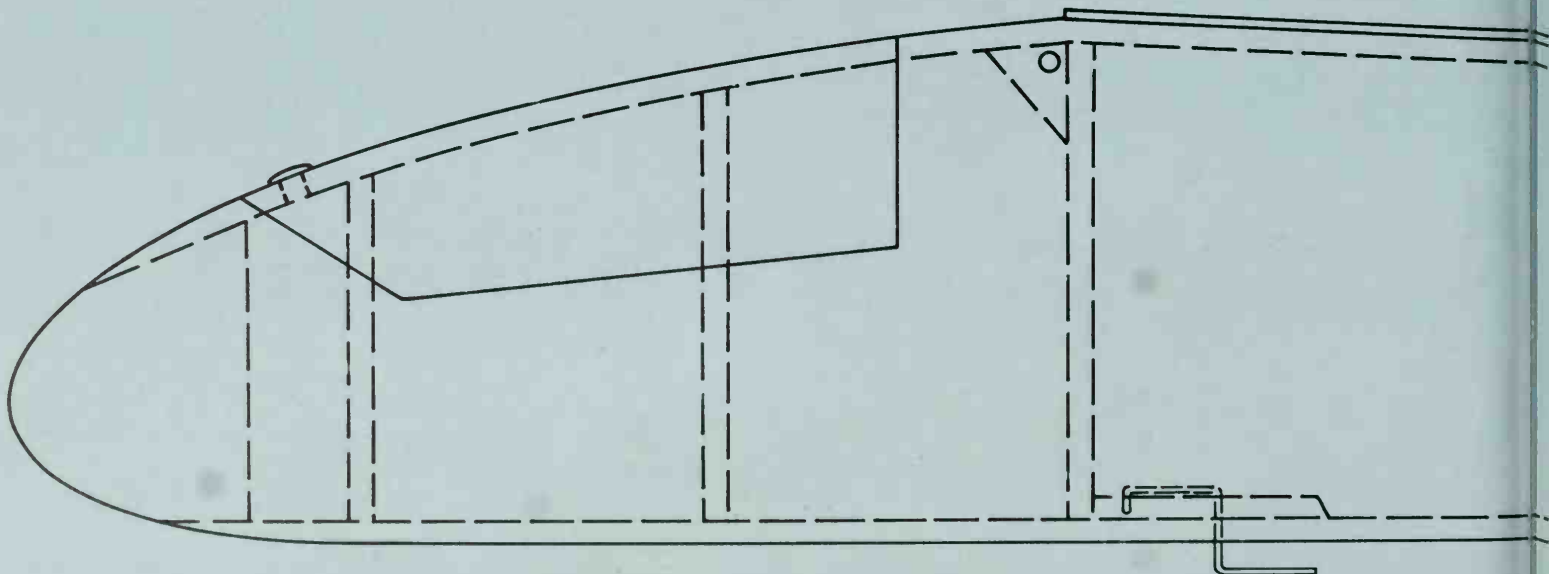
Meteorite

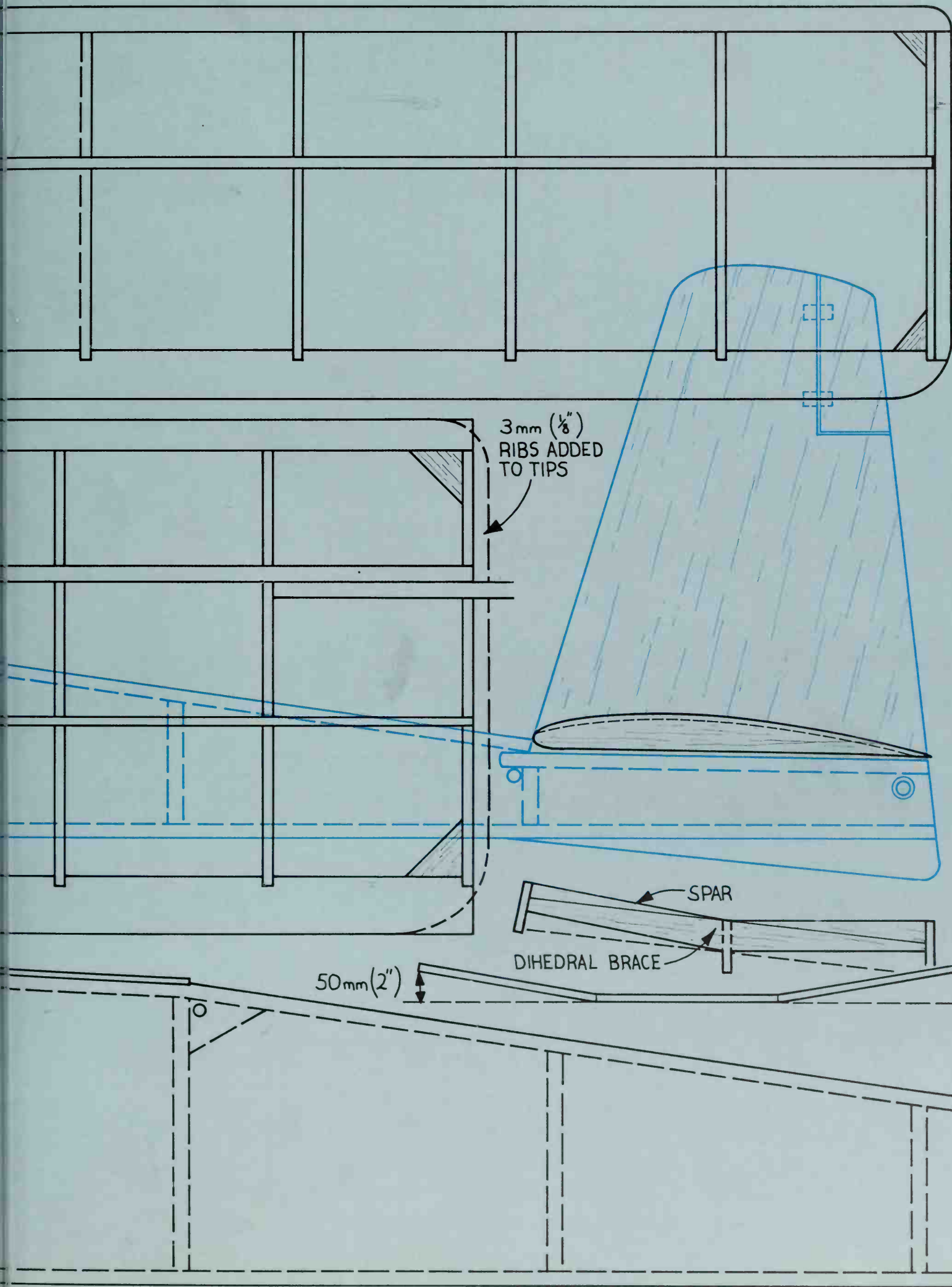


TAILPLANE RIB



WING RIB





This Russian FAI stunt model, flown by Alexander Listopad at the 1978 European Championships at Verviers, Belgium, typifies the attractively finished .40 powered modern stunt model. This aeroplane was also an entry at the 1977 World Championships in Kiev.



Control Line

Basic Trainers
Team Racing
Speed and Combat



What is Control-line flying?

Control-line flying, as discussed in Chapter 5, was developed by the American Jim Walker during World War 2 as a system of controlling a model aeroplane tethered to fly in a circular path. Early attempts were with free-flight models but these were unsuitable due to problems in maintaining line tension, principally caused by the wind as the model circulated. It was soon realized that dihedral was unnecessary to maintain stability in the rolling plane as the aircraft was automatically stabilized by the lines, and as the pilot had direct control over the elevators then the size of the tailplane could be reduced to more scale-like proportions. This immediately opened up wide possibilities to the scale aircraft enthusiast, who could now build and fly models which were previously impossible as free flight projects or even radio control at that stage. Even multi-engine installations were possible.

Another advantage of control-line flying is the relatively small area required, just a circle which is large enough for the length of the lines as a radius plus a safety margin. This is one reason why control-line flying is popular for displays in public parks for carnivals etc.; it can be done almost anywhere there is a reasonable surface.

Principles of Control-line flight

The principles of control-line flight are outlined in Chapter 5, but it must be stressed that control over the model is only maintained while the lines are taut and several features must be incorporated in control-line models in order to help maintain the line tension, as it is termed. As it is conventional for the models to fly in an anti-clockwise direction, it is desirable to introduce a bias in the opposite direction trying to make the model fly away from the pilot in order to keep those lines tight.

1. The point of connection of the lines to the model, at the lead out guide, must be behind the centre of gravity of the model. The greater this distance then the more line tension.
2. There must be some weight added to the outboard wingtip: this counterbalances the weight of the lines and is very important, especially when the model is flying high, to make the model tend to roll outwards.
3. Engine and rudder offset,



where the engine thrust line and rudder are offset to the right, may be needed.

4. Centrifugal force, which is the product of the weight of the model and how fast it is flying, means that a light model flying slowly will have little tension and vice versa.

What are the requirements of a training model to learn control line flying?

Firstly and foremost it must be stable in that it does not require constant control movements in order to stay flying. Secondly, the controls must also be insensitive so that overcontrolling by the pilot does not result in violent reactions by the model. Thirdly, the model must be ruggedly constructed to withstand the inevitable crashes which occur as the pilot learns the skills required. Finally the model must maintain good line tension in reasonable wind conditions.

Top left: Japan's Hara fills the tank on his O.S.40 powered World Championship entry.

Below left: British semi-scale D.H. Chipmunk starting up.

Below right: Take-off by an Italian model starts the scoring manoeuvres. Another F.A.I. Class F2B machine.

The most popular type of model for learning to fly control line is the all-sheet profile trainer, so named because it is entirely made of solid sheet balsa with no built-up construction such as wing ribs etc. This makes it quick to build and also very tough. The fuselage is also solid sheet on its edge, but its side view or profile is representative of an aircraft.

Such a model would be about 500mm (20in) wingspan and be powered by an engine of 0.8–1.5cc (0.049–0.9cu.in) capacity, either diesel or glowplug. There are kits of this type of model available from most major manufacturers, or a plan for a suitable model is included in this book. Larger models are generally more stable and easier to fly than smaller ones.

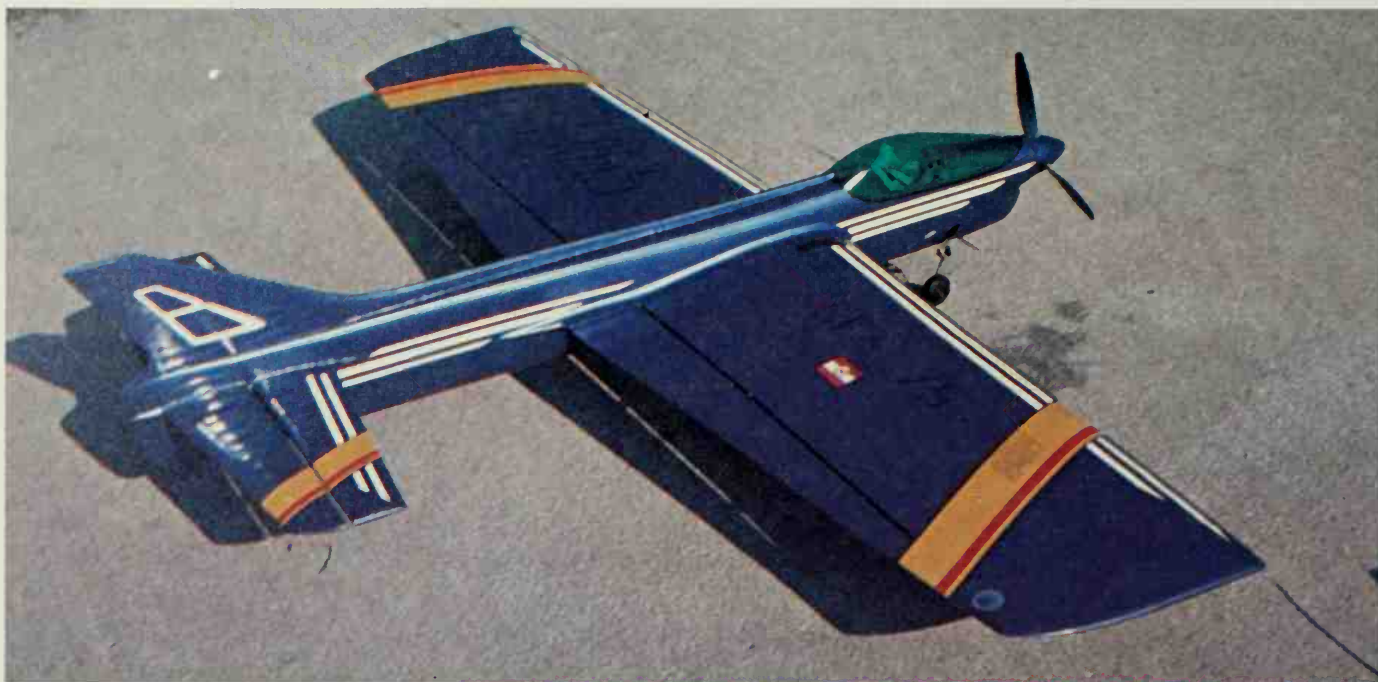
Having built a training model, what equipment do you need to go flying? First of all the pilot needs a control handle to hold. These are available made of metal or plastic in many varieties, but the important features are that it should be comfortable to hold and light, and it should feature an adjustment to compensate for unequal line lengths, as the handle should be in a comfortable upright position with the elevators at neutral. Some

handles even make the vertical distance between the two lines adjustable. This is very good for beginners, because control is less sensitive when the lines are closely spaced, and vice versa. As the flier becomes more proficient then he can open up the spacing to give greater control response.

Line connectors are the next item in the chain to connect the handle to the control lines, and these must be strong enough to withstand the maximum line tension likely to occur. Also they must not have any sharp protrusions likely to snag. Proprietary connectors are available from model shops, of course, but there are similar items in any angling store which may be cheaper. Split rings are excellent in use, although a bit fiddly to connect. Do not in any circumstances tie the control lines to the handle unless they are the Terylene cord type, because knots will strain the lines and reduce their strength.

Control lines are the most important single item in the control system. For the simple lightweight trainer model it is possible to use waxed linen thread or light fishing twine. They are certainly cheap and easy to look after but suffer from the disadvantage that they are





slightly stretchy, which imparts a 'spongy' feel to the controls when flying. They are suitable for use with models powered by engines up to 1cc capacity and can be up to 10m (33ft) long.

The most-used type of line is a three-strand, high tensile steel, braided wire known as 'Light Laystrate'. It is approximately 0.3mm (0.013in) diameter and is bought on small cardboard reels in lengths of 21m (70ft) or 30m (100ft). It is supplied in a tinned state to give protection from rust, which greatly aids soldering loops at the ends, but it is easily kinked, so the lines must be looked after very carefully, and always stored on a reel when not in use. They are suitable for any





Opposite, top: Aaltio of Finland used car paint on his HP40 model.

Opposite, centre: Three-blade prop, three-wheel undercarriage and three fins distinguish this Dutch model.

Opposite, bottom: Slightly unusual are the detachable wing and tailplane on Tindal's highly developed Chipmunk. *Above:* Sbragia of Italy about to start his Facit model with Super Tigre 46; note silencer.

model up to 1500g (50oz) in weight. For heavier models or very fast models which therefore have a higher line tension a heavyweight grade at 0.45mm (0.018in) diameter is also available.

Fast becoming popular with competition fliers is a seven stranded American stainless steel line known as 'Pylon Brand' which has the big advantage of being almost impossible to kink and is very flexible and soft to the touch. A set of these lines is much more durable than the high

tensile lines, though rather more expensive. They are available with the ends made up with brass eyelets, which saves a tedious chore, and in a wide range of diameters for different weights of model from 0.2 mm (0.008in) diameter up to 0.5mm (0.021in) diameter.

For specialist applications such as speed and team racing where the absolute minimum line drag is required to maximize speed, then

single strand wire is used, as its smooth surface reduces wind resistance. However, it requires very careful use as it is very prone to kinking and damage. Large diameter storage reels are required.

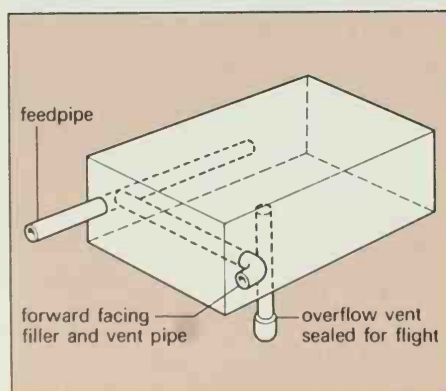
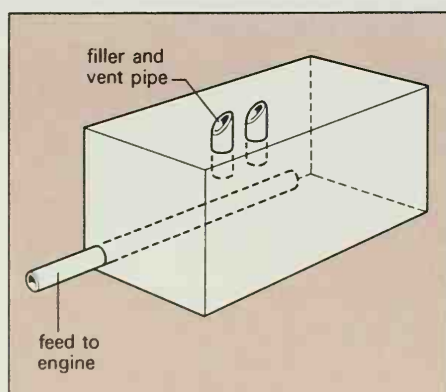
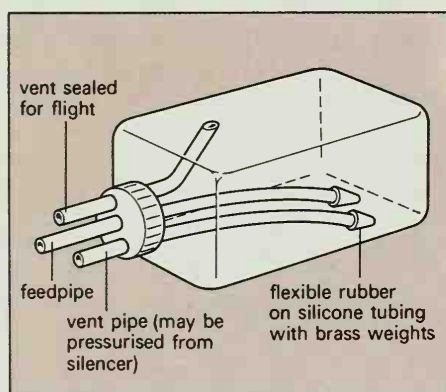
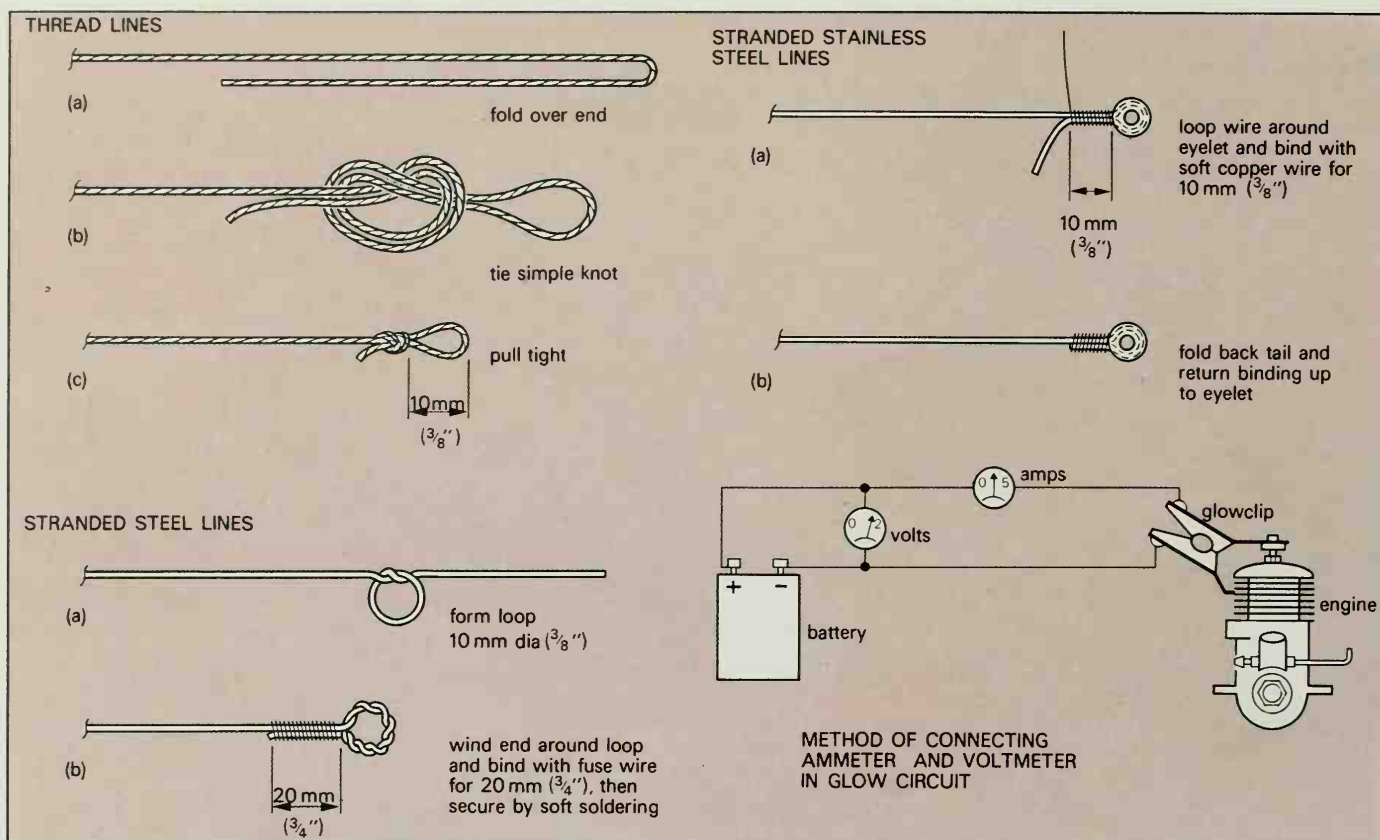
All lines require loops or eyelets at each end for any connection to handle and model, but for safety's sake this must be done correctly. Follow the methods shown in the sketches. Recommended lines are:

Type of model

Elementary trainer
500mm wingspan, up to 1cc engine
Sport combat models 1m wingspan, engine 1.5–2.5cc
Competition aerobatic models 1500mm wingspan engines 4–7cc

Line length and diameter

8–10m Terylene thread, or very light steel line, 0.2–0.3mm (0.008–0.012in) diameter, 12m (40ft) length.
15m (50ft) 3-strand light Laystrate.
17–21m (56–69ft) light Laystrate 0.3mm (0.013in) or 7-strand stainless steel 0.4mm (0.015in).



Fuel tanks

Fuel tanks can cause much trouble to modellers and are viewed with suspicion by those who feel there is a secret art to fuel systems in model aircraft. This is not true at all: all one has to do is to remember and take account of the forces which act on the fuel, that is gravity – which always acts vertically downwards, centrifugal force – which acts horizontally away from the pilot, and inertia, which only acts when the model changes speed or direction.

Traditionally fuel tanks are made of thin tin plate, fitted with copper or brass pipework soldered in place. Nowadays, although metal tanks are still in the majority, there is a growing tendency to use transparent plastic bottle tanks, fitted with flexible internal plumbing. They have the advantages that you can see exactly what is going on in the tank, and they are not prone to leakages due to split seams or bad soldering as the metal ones are.

A fuel tank for an aerobatic model must be capable of delivering fuel to the engine when the model is in any attitude, upright or inverted, climbing or diving.

Do not forget when deciding on the size of tank for your model that glowplug engines have about twice the fuel consumption of a diesel of the same size. On large glow powered models fitted with internal tanks, for instance, it can be quite a problem to find the space required for,

Opposite: The British team at the 1978 World Championship rallying round to start John Newnham's Merco 35 powered Nobler. Note model is started inverted, and timekeeper in background is checking elapsed time.

say, a half pint fuel tank (300cc).

Glow fuel is very much cheaper bulk-bought and is usually sold in plastic containers of 5 litres (1gal), although small tins are available which are much more convenient to use, as they are usually fitted with a spout to fill the tank direct. Most fliers make or buy a 'squeeze bottle' for filling their tanks, merely a small plastic bottle fitted with a spout. This enables a convenient quantity of fuel to be carried about and can be squeezed to pressurize the fuel into the tank.

Batteries and glowplugs

If your model is fitted with a glowplug engine then you need a battery of the correct voltage and a suitable connecting clip in order to start it. American and most small engines are usually fitted with a $1\frac{1}{2}$ volt glowplug and therefore it is important to use a dry cell battery in order not to 'blow' the filament. Use as large a battery as is convenient





Ammeter reading

1. No reading.
2. Full scale deflection.
3. Higher than normal reading.
4. Low reading.
5. Normal reading.

Interpretation

Circuit incomplete, blown plug or loose connections somewhere.

Short circuit – clip shorting on engine, bad insulation on leads.

Engine 'flooded' with fuel, cold plug element draws more current.

Battery going flat, meter may read correctly initially but needle moves slowly down.

Learn by experience for each type of plug, usually 2–3 amps.

in order to have a good working life. It can be very frustrating to have to stop flying due to a flat battery preventing the engine from starting. Wet lead/acid cells, or accumulators as they are sometimes called, are 2 volts per cell and have the advantage of being rechargeable. They have a longer working life than dry cells and the voltage falls off slowly as they become discharged with use, so giving adequate warning that a recharge is necessary. More expensive to buy initially, they are cheaper and far more satisfactory in the long run.

Opposite, top: Highly developed semi-scale Mustang by Al Rabe, USA, uses wet-moulded balsa fuselage and Super Tigre 60 engine. Runner-up in 1978 World Championships.

Opposite, bottom: Current World Champion as this book is prepared is Bobby Hunt, USA, a pioneer of hollow foam wings on stunt models. Unusual engine choice is Schnerle-OS40 FRS in his Genesis design.

The competition-minded enthusiast will have the battery mounted in his flying box complete with an ammeter and voltmeter in the circuit to give him information about the battery and glowplug conditions.

The voltmeter is used mainly as a confirmation check on the state of the battery.

How to fly Control-Line

The model is complete, you have all the equipment and the moment has come to go out and fly for the first time. You need three things:

1. A person to help you hold and launch the model who is an experienced control line flier if possible. He will recognize and help to correct the mistakes.
2. A suitable flying site, which must be reasonably level and smooth if take-offs from the ground are expected, and preferably grass, as it is more forgiving than tarmac in the event of a crash. Check that model flying is allowed at the place that you intend to fly, as in some public parks etc. it is forbidden. Finally and most important of all, keep well away from any overhead electric power cables, since if the model contacts or even approaches high voltage lines then you may be electrocuted. It has happened.
3. A reasonably calm day is important for these first flights. A blustery wind can make the model lose line tension and crash.

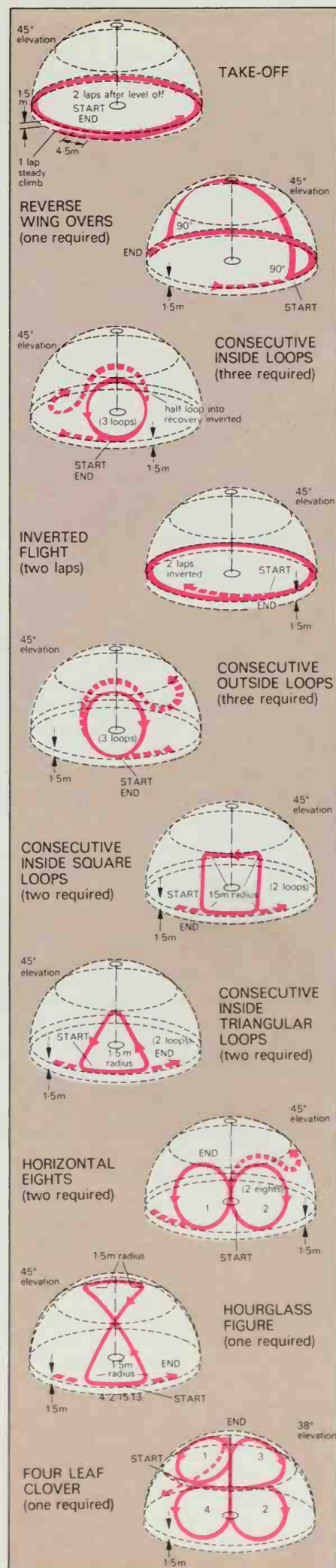
Before attempting to fly, start and run the engine in the model for a tankful of fuel to check that everything is OK with the engine mounting and fuel system. Connect the lines and handle, making sure that up or a backward movement of the handle gives up elevator control. For safety's sake do a pull test on

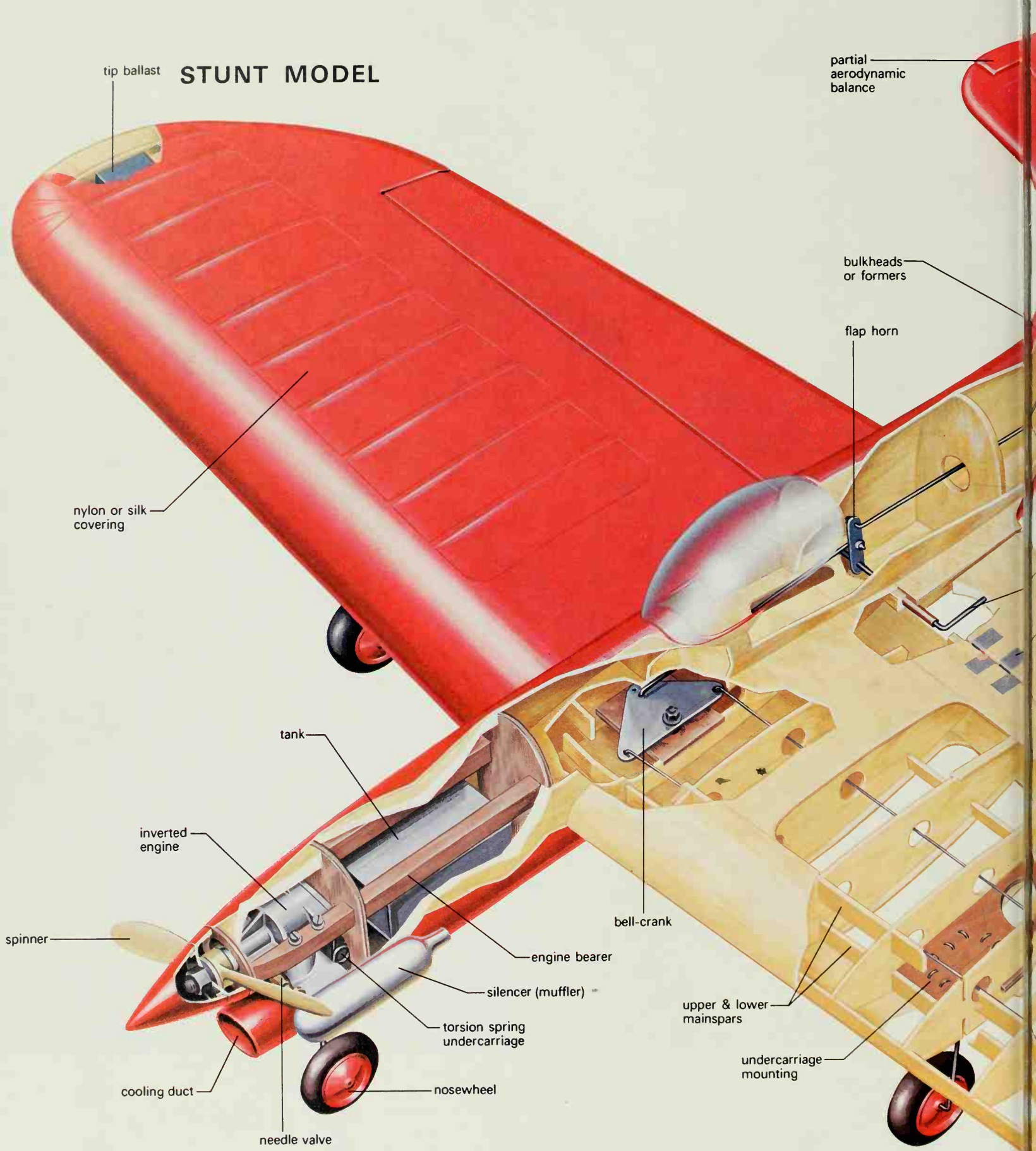
the lines; with the helper holding the model securely pull on the handle approximately 5kg (12lb). This tests the strength of the whole system, handle, connectors, lines, leadout wires and bellcrank.

Now you are ready to fly. Position the model in the downwind side of the circle the model will fly in and check that there are no obstructions in the flight path; get on-lookers to stand well back. Start the engine and walk to the handle, hold it the correct way up and signal your helper to release or launch the model. Hold your control arm fairly stiff in a straight line and raise or lower the whole arm when controlling the aircraft. This has a desensitizing effect, and enables the model to fly at the altitude that your arm is pointing at. To fly high raise the arm, to fly low lower it. Try to maintain a flying height of about 3m (10ft) initially. Be gentle in control movements and concentrate on looking at the model and not at the scenery passing behind it, which will alleviate any tendency to dizziness. When the engine stops lower the arm very slowly as the model descends on its glide down to the ground. Just before the landing is made apply some up elevator control to round out the glide and slow the model for a gentle touchdown.

Aerobatic Control-Line flying

Once a pilot is competent at straight and level flying with a trainer it is time to become a little more adventurous and try an aerobatic or 'stunt' model. Such models are generally larger than trainers and much more lightly constructed in order to reduce the wing loading for stunts. The engine is larger to give the power necessary and the control systems are much more sensitive to ensure manoeuvrability. The wings are also very thick, which helps to produce more lift, although the wing section is symmetrical so that the model will perform equally well when flying inverted. On advanced stunt models the wings are fitted with flaps on the trailing edge rather like ailerons on a fullsize aircraft. These are connected to the control system to move in opposition to the elevators. When the elevators go up then the flaps move down in order to change the symmetrical section into a cambered section with a greater lift. This enables the model to perform sharper turns without mushing or stalling. Special fuel tanks are required to ensure a constant supply to the engine whilst the





tip ballast

STUNT MODEL

partial
aerodynamic
balance

bulkheads
or formers

flap horn

nylon or silk
covering

tank

inverted
engine

bell-crank

engine bearer

silencer (muffler)

torsion spring
undercarriage

upper & lower
mainspars

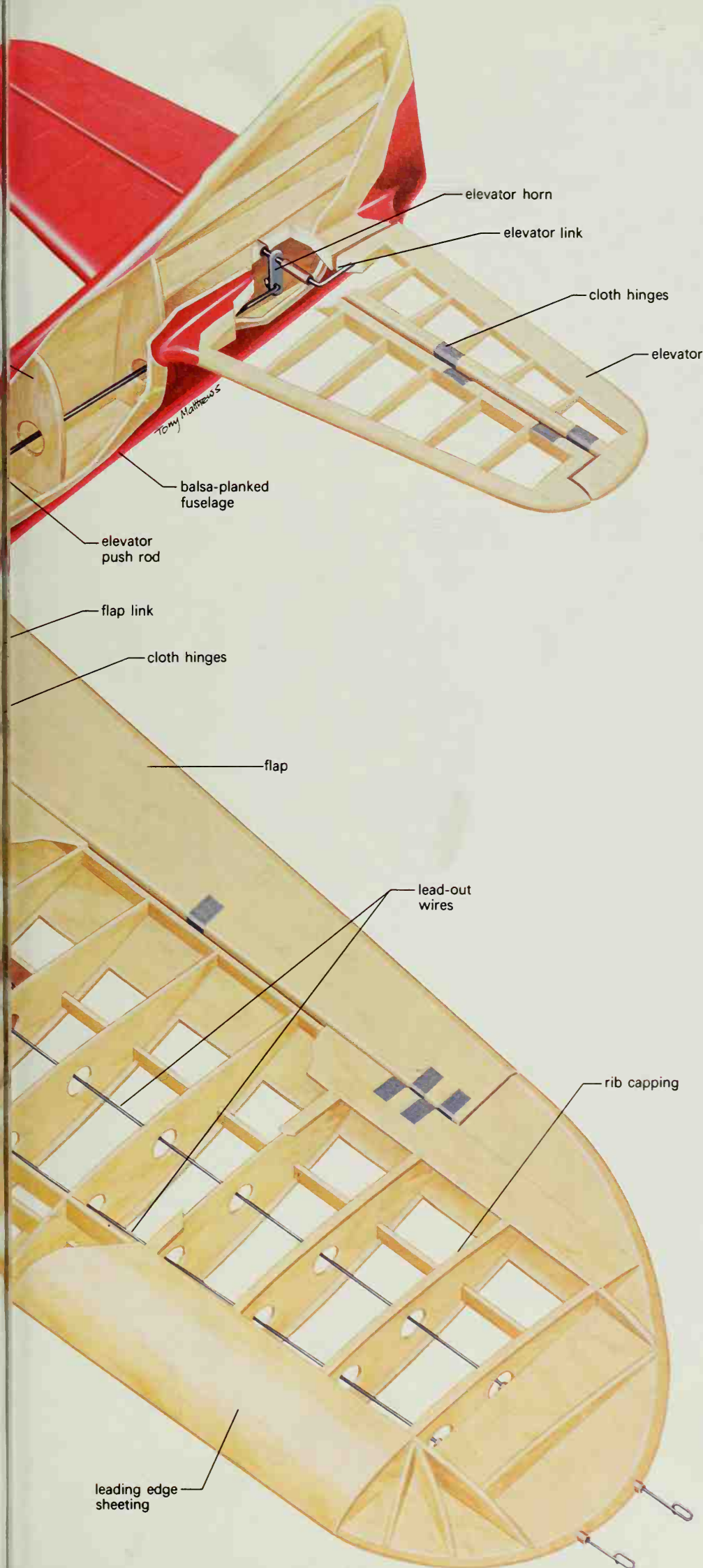
undercarriage
mounting

spinner

cooling duct

needle valve

nosewheel



model is climbing, diving, or flying inverted.

Once a pilot can master simple manoeuvres such as loops, eights and inverted flight, he (or she) is ready to enter competitions as a novice. In aerobatic competitions the pilot performs a set schedule of manoeuvres in front of a judge who marks each one out of a score of ten. This score is then multiplied by a 'K' factor which varies as to the difficulty of the stunt. Competitions usually have two or three rounds.

In international aerobatic competitions the models must conform to the regulations of the FAI – the Federation Aeronautique Internationale – class F2B, which say: The model shall have a maximum weight of 5kg (12lb) maximum surface area (wing and tail) of 150cm² and a maximum engine size of 10cm³ (0.61cu.in). The line length shall be between 15 and 21.5m (49–70ft) and shall be pull tested to ten times the model weight.

The stunt schedule itself consists of fifteen manoeuvres, starting naturally enough with the take-off, followed by one of the most difficult stunts, the reverse wing-over. This is followed by the relatively simple inside loops, inverted flight, outside loops, and then the square inside and outside loops. The triangles are next, followed by a succession of figure of eight type stunts, the horizontal, square horizontal and vertical. A variation of the vertical eight is next, termed the hourglass, which has straight sides. The schedule finishes with overhead eights, the four-leaf clover and landing. There is a time limit of seven minutes for the whole period from the moment the pilot signals he is ready until the model stops rolling when it lands. An overrun will disallow the landing points. The pilot must raise a hand to signal the start of each manoeuvre and fly at least two level laps between each stunt to allow the judges to consider and write down their score.

Competition stunt flying appeals to individualists, as it is not a team event such as combat or team racing, and also, as the specifications have few restrictions, there is wide scope for variation in model design and approach to the whole event. The models can vary, the classical style of stunter and semi-scale jobs at one extreme to super sleek jet-style types at the other.

Whether or not you wish to enter competitions, the challenge of stunt flying is a most rewarding and satisfying form of control-line flying.

Team Racing

The essence of any race is for two or more people to compete together to see, in direct comparison, who can cover a set distance in the least time, or possibly who can travel the greatest distance in a set time. This simple principle applies in most sports, and it should be no surprise to discover that control-line aeromodelling (held by its devotees to be the most versatile part of a versatile sport) has its racing aspects. To many, racing is the most exciting form of control-line aircraft competition.

For a race to be an exciting contest, the participants should be well matched in potential and the whole race should be well controlled, which means that rules are essential. With a considerable number of variables, many different sets of rules exist with, rather obviously, engine size limitation being the principal differentiating factor. So around the world control-line racing is seen in many forms and below are indicated just a few of these:

Class	Engine Size
Mouse Race	0.8cc (0.049cu.in)
$\frac{1}{2}$ A Team Race	1.5cc (0.09cu.in)
FAI Team Race	2.5cc (0.15cu.in)
Goodyear	2.5 or 3.5cc (0.15 or 0.21cu.in)
B Team Race	5.0cc (0.29cu.in)
Rat Race	6.5cc (0.40cu.in)

Airspeeds vary from as low as 110km/hr (70mph) in Mouse Race to as high as 240km/hr (150mph) in Rat Race.

Goodyear and FAI Team Race classes are probably the most popular in numerical terms around the world; these two classes show the greatest divergence in approach with respect to the governing rules, and yet both produce extremely close and exciting racing.

Goodyear

Goodyear models are profile models of full-size racing aircraft and must have the engine un-cowled. The rules (as applied in the UK) may be summarized as follows:

Motors – 3.5cc maximum.

Models – Profiles to $\frac{1}{8}$ scale ($\pm 5\%$ error in any dimension allowed, except the tail, which may be increased in area to 25% of the wing area) of PRPA 'Formula 1' midget racing aircraft. Models must have profile fuselage and scale-like finish.

Lines – 15.92m from centre-line of model to centre-line of control-handle.

Races – Heats: 100 laps including two pit-stops.

Finals: 200 laps including five pit-stops.

There are additionally a number of rules covering matters such as race conduct, principally aimed at achieving safety and fairness; the aspiring competitor is recommended to study the rule book thoroughly.

This makes an apparently simple class, for the models are about as basic as can be, and many plans including all of the necessary mechanical and constructional detail are available. (The best sources are probably from England, the *Aeromodeller* magazine, and from America, *Model Aviation* magazine.) The catch, if it may be so described, is contained in the rule requirement for compulsory pit-stops. The rules state only that there must be the required number of pit-stops, and no requirement is stated concerning when these pit-stops need to be made, or whether re-fuelling must occur. Particularly, there is no limitation stated as to what fuel can be used or how much of it can be carried. It will be fairly obvious that, since fuel consumption is unimportant, success in Goodyear is all about engine-power – the more, the better. So for Goodyear, the most powerful engines available, used in their maximum power set-up, are essential, and this means racing glow motors using high nitromethane content fuels. In the UK with a 3.5cc motor size limitation, it is currently the American K & B 3.5 and the Italian OPS 21 motors that dominate, and a typical fuel formula is:

Nitromethane	40%
Methyl Alcohol (Methanol)	40%
Castor Oil	20%

In America, where the engine size limitation is 2.5cc, the dominant motor is the Italian Rossi 15 FI and fuel with a nitromethane content in excess of 50% is common. Airspeeds of over 190km/hr (120mph) can be achieved and the pilot's job can be difficult with lap times of under 2sec and line pulls approaching 14kg (30lb).

What was intended to be a simple class for rather basic models has thus turned out to be just as challenging as any other. Goodyear

today still features cheap, easily built models, but the cost in fuel and 'blown' glowplugs is considerable.

FAI team race

Perhaps the form of control-line racing that requires the most inventiveness and presents the greatest challenge is FAI Team Race – the challenge because it is the only World Championship class of control-line racing, and the inventiveness because it is the most rule-bound. The basis of the rules is summarized as follows:

Motors – 2.5cc maximum.

Models – wing and tail area, 12dm² minimum in total.

Fuselage at pilot location, 50mm wide \times 100mm high minimum with a minimum cross-sectional area of 39sq.cm.

Pilot's head must have forward vision and must have minimum dimensions of 14mm wide \times 14mm deep \times 20mm high.

Motors must be fully enclosed with only controls allowed to protrude.

Fuel capacity – 7cc maximum.

Lines – 15.92m from centre-line of model to centre-line of control-handle.

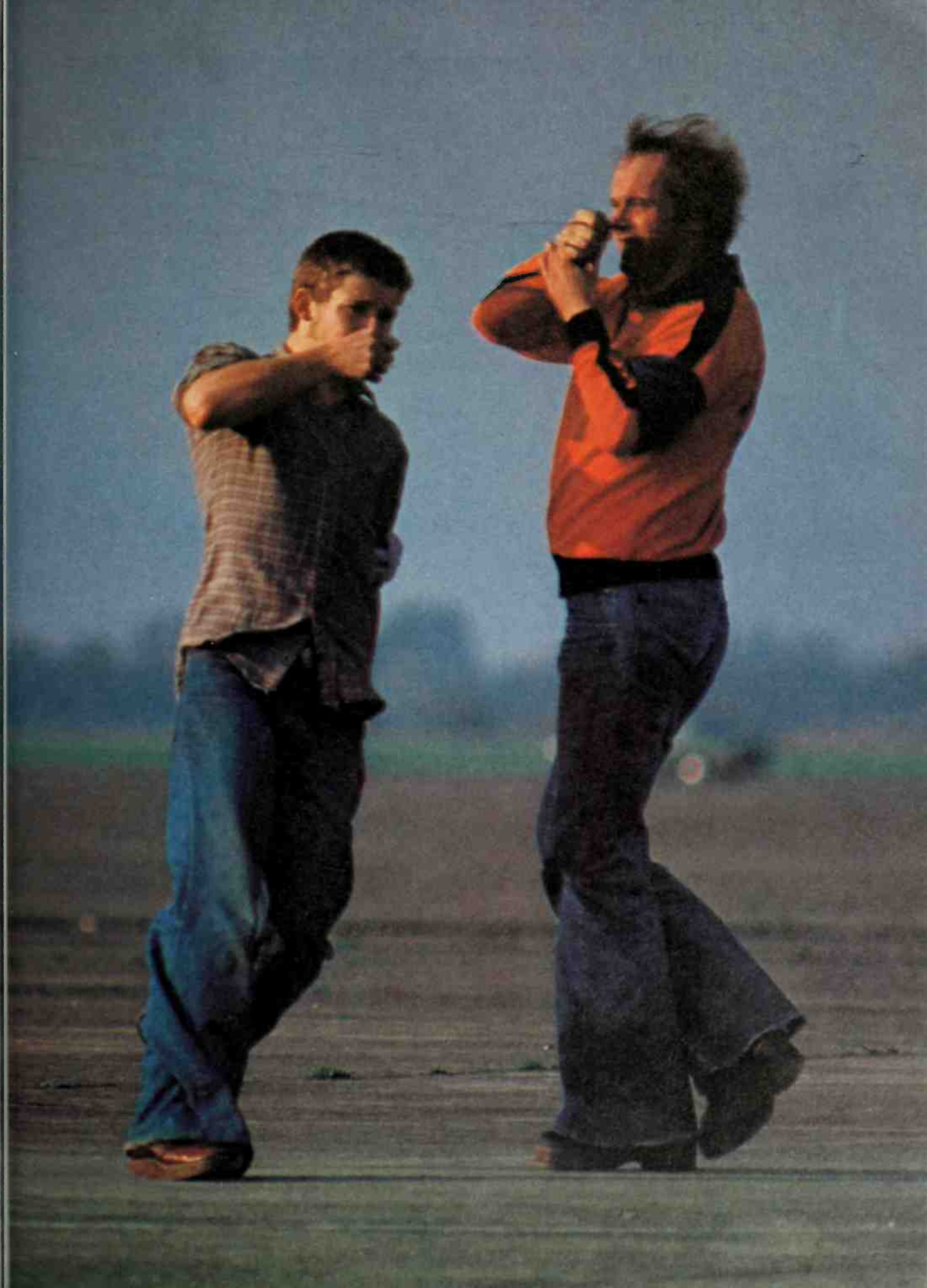
Races – Heat, 100 laps.

Final, 200 laps.

A considerable number of rules exist as to the conduct of the contestants and the conduct of the races; this is one event where full knowledge of the rules is an absolute essential. There are at least 18 different 'offences' that may lead to a team being (a) warned with respect to their conduct (three warnings means disqualification from a race) (b) disqualified instantly from a race, or (c) disqualified from the whole contest.

The key feature of FAI Team Race is that the permitted fuel load is insufficient to complete the race without at least one re-fuelling pit-stop. There thus has to be a balance achieved between brute horsepower and fuel consumption; it is one of the very few events where engine efficiency really matters. Many people all over the world have become addicted to the search for this balance.

Two pilots flying together must clear each other. Handles held high and close mean minimum distance covered by model, important in a 5 minute race.





Racing

All races are in essence the same: two or three teams flying in one circle race together from a cold start over the set distance or time, performing pit-stops as necessary, with the winner judged by the stop-watch or lap-counter. Typical set distances are as follows:

Top left: Catching a team racer at high speed takes skill and judgement.

Top right: Refuelling and restarting is helped by fuel line taped to finger and battery contacts on thumb and finger.

Lower left: A typical Goodyear class racer.

Lower right: the 'works' of a top-class team racer – compare with drawing opposite.

about 2sec, so it could be said that in a 4min heat the pilot is at work for 234sec and the mechanic for just 6sec, hardly an equitable division of work! Yet both jobs are highly exacting, and the result is the teamwork that sets control-line racing apart from most other forms of aeromodelling. In his 234sec, the pilot can make many minor mistakes without serious prejudice to the result, but the mechanic's 6sec have to be perfect – one mistake and it could be 16 or even 60sec!

Event	Line length	No. of laps	Distance
½A Team Race	14.00m	100 (heats) 200 (finals)	8.8km 17.6km
FAI Team Race	15.92m	100 (heats) 200 (finals)	10km 20km
Goodyear			
B-Team Race	17.69m	90 (heats) 180 (finals)	10km 20km

The anatomy of a team racer

For its size, it could be argued that a modern FAI Team Race model is one of the most complex forms of competition model in aeromodelling. However, as with all contest-aimed models, three basic principles apply:

KICK (Keep It Clean, Klaus). Aerodynamic cleanliness is important and this means gentle changes in cross-sections and smooth surfaces with the minimum of holes and/or protrusions, especially when it is remembered that the air displaced by the propeller is rotating rapidly and that this rotating air-stream flows over the fuselage.

At best, in all of these events, heat times are around 4min and final times in the vicinity of 8min. For FAI Team Race a heat time of 4min means an average speed of 150km/hr, (over 93mph), including the start, and all the pit-stops. Taking this example just a little further, it is possible to analyse such a performance as below:

Initial start at 4sec lost	4
Two pit-stops at 8sec lost each	
100 laps at 2.2sec per lap	220
Total time in seconds	240

Even though over 90% of this time is spent in the air (and therefore sheer airspeed is all-important), the time spent on the ground during a race can be crucial to the result. The time allowed above for a pit-stop of just 8sec includes deceleration, landing, reception by the mechanic, re-fuelling, re-starting, launch by the mechanic and finally acceleration back to full racing airspeed. From model reception (the 'catch') to model launch during such a pit-stop, the time elapsed is

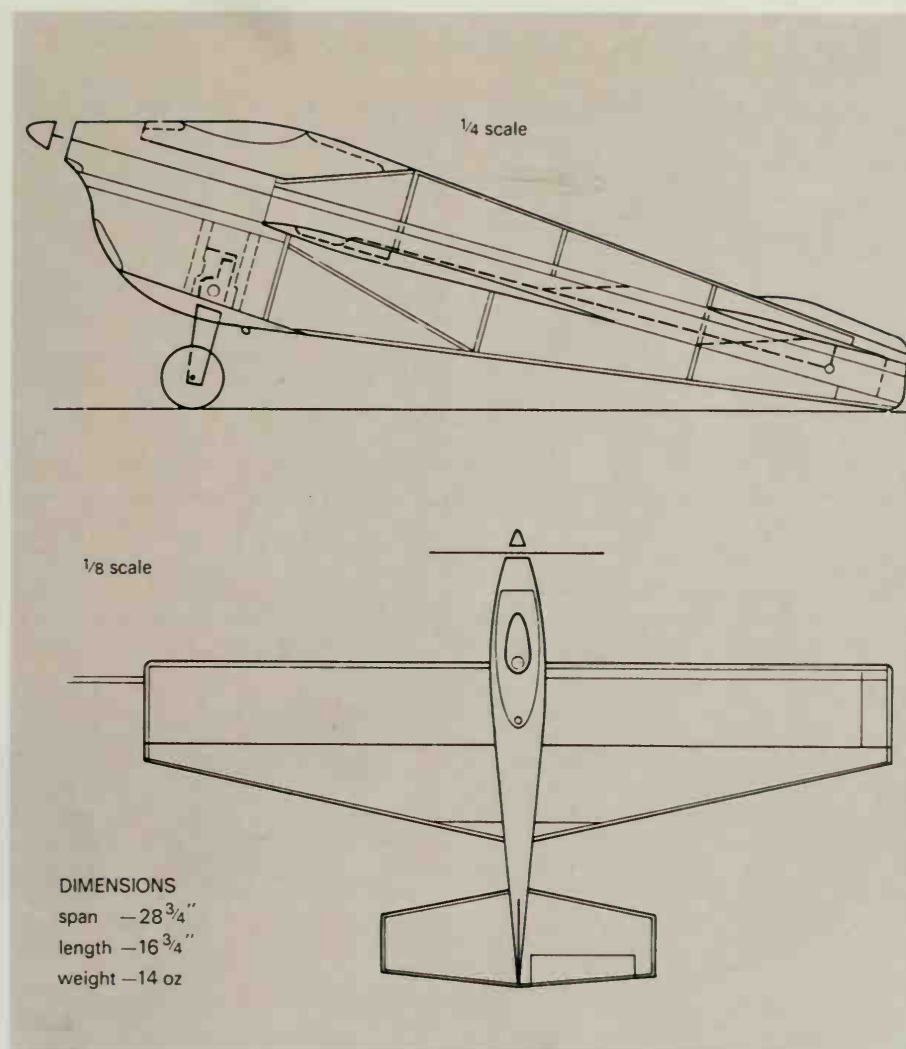
The basics of one of Dave Clarkson's highly successful team racers are shown in this drawing.

the mechanics are standing ready to flick their motionless models into life. The whistle sounds and an instant later the models are airborne.

Flight Mechanics and officials stand around the edge of the circle watching while the pilots try to fly as quickly as possible within the constraints of the rules (no physical assistance, normal flight to be at 2 to 3m (6-10ft) altitude, no interference with other pilots). To fly quickly means that the model must progress along the shortest path possible, so it must fly at the maximum height permitted and have the control handle as close to the centre of the circle as permitted. Also the model must be subjected to the minimum of drag-creating circumstances – control handle as high as the rules permit and the minimum of disturbances to the intended absolutely level flight path.

Pit-stops The mechanic is in control here despite the fact that it is the pilot who has his hands on the flight controls. One lap away from the mechanic, the pilot operates the motor fuel supply shut-off by use of the mostly redundant full-down elevator mode on the model. With the minimum of time-loss, the pilot guides the model to the ground and into his mechanic's hand. Now one lap means about 100m in straight distance, and the air-speed at the start of that lap can be 170km/h, (105mph), so the only way for the model to be stationary at the end of that lap is for the mechanic to catch and stop the model. Another reason for light models is that they have less inertia and therefore slow quicker, resulting in reduced mechanic hand stress. Now in the mechanic's hand, the model is re-fuelled (in Team Races, by using a pressurized re-fuelling system strapped to the mechanic's arm) and the motor re-started; the team-race jargon 'a flick like an elephant' helps here – try to imagine what that means and then try to do it. Practice will ensure that you can, eventually! The sound of his motor going again secures the total attention of the pilot and, on release by the mechanic, a smooth low take-off puts the model back into the traffic for more 'boredom'.

'Practice makes perfect' is the key. In control-line racing perfection is very hard to achieve, but it can ultimately be reached; its pursuit is addictive . . .



KISS (Keep It Simple, Sam). Simplicity is vital, for what is not there cannot weigh and cannot fail; low weight and reliability are both vital in team race models. This principle applies not only to the woodwork (i.e. the airframe) but also to the motor/tank package, where a great aid to lightness and reliability is the elimination of systems by making what systems you have do everything, as typified by the so-called 'Multi-function Valve' where tank filling, in-flight fuel feeding and motor shut-off functions are all performed by one item.

'Light Is Right'. Every ounce removed from the model weight can mean an extra couple of seconds subtracted from the potential race times. It is no coincidence that the top three finishers at the 1978 World Championships had very light models, viz

1st	Metkemeijer/ Metkemeijer (Holland)	384g (13 ¹ / ₂ oz)
2nd	Geschwendtner/ Mau (Denmark)	361g (12 ¹ / ₂ oz)
3rd	Heaton/Ross (England)	418g (14 ³ / ₄ oz)

How these low all-up weights are

achieved is not by 'magic' – there are no secrets. Select the lightest wood, use the minimum of glue by accurate joint fitting, and do not over-engineer anything. In other words, KICK, KISS and 'Light Is Right'.

People matter

Control-line racing by definition is a competitive activity – there is no way for a race to happen without people competing together under the restriction of rules policed by other people. People to check that the models involved accord with the rule requirements, people to ensure that the arena for the spectacle is marked out exactly in accordance with the rule requirements, people to enforce the conduct necessary for a fair result, and, of course, the people on the centre-stage – the competitors.

It has been said that war comprises long periods of boredom interrupted by short periods of intense stress. Viewed in this light, control-line racing is war.

A race features:

The Start Immediately before the whistle, all pilots are crouched with control-handles grounded and

Speed and Combat

Speed is a fascinating subject; take any object you can think of powered by any form of engine and someone, somewhere, will try to make it go faster. That applies to anything from jet-propelled motorcycles to pedal cars where a child is the 'engine'. Not surprisingly, then, control-line speed flying has been in existence for many years. Different capacities of engine result in different classes, and rules cover line lengths and diameters, and sometimes the fuel used. For example, the International class (FAI) calls for a maximum engine capacity of 2.5cc (0.15cu.in), a pair of control lines with a minimum diameter of 0.4mm (0.015in) 15.92m

(52ft 3in) long measured from centre line of handle to the centre line of model, and a fuel consisting of 80% methanol, 20% castor oil: timing is over ten laps, exactly one kilometre.

Most countries have other classes to cover engine capacities from 0.8cc (0.049cu.in) to 10cc (0.61cu.in), flown on either one or two line control systems using lines of stated minimum diameter, or lines capable of withstanding the pull of (for example) 20 times the weight of the model, with no fuel restrictions.

Model design is not governed by the rules, but the requirements of a fast model are quite clear. Natur-

ally, the engine must be the best available, or if you have the expertise and knowledge it must have the *potential* for being the best. Commercially available engines are mass produced to a greater or lesser degree, and frequently skilled workmanship can improve the engine in details where the manufacturer simply cannot afford to spend the time himself.

To achieve its full potential the engine must be mounted on a solid base and the most common method is to bolt it to a cast magnesium or aluminium 'pan' forming the entire lower half of the fuselage, rounded and tapered to provide a smooth aerodynamic shape. Alternatively,



a half pan may be used, forming just the front half of the lower fuselage. The pans are hollowed out extensively to save weight, carry the engine and fuel tank, and are bolted to the remaining structure.

Drag is the biggest enemy of the speed flier, so models are made to reduce it to the minimum. Traditionally mounted upright, the engine's cylinder head is normally faired-in by a tightly fitting cowl, while the wings are of high aspect ratio and have just sufficient area to enable the model to fly in a stable, level attitude.

The control lines themselves create a tremendous amount of drag and to overcome this a system of providing control from just one line has been designed, known as mono-line. In essence, the scheme works by twisting the control line itself, using the Archimedean spiral principle. The pilot holds a special handle in his right hand which has a spirally wound piece of stiff wire, some 600mm (24in) long projecting from it, to which the control wire is attached. In his left hand is a bobbin which, when moved along the spiral, causes it to rotate and twist the control wire, thus moving a torsion bar in the model which operates the elevator via a push rod. Unfortunately control is less precise and a thicker wire is necessary for both safety and adequate control.

An alternative to reduce drag in two-line systems is to fit line groupers holding one control line behind the other using tiny plastic airfoil mouldings or pieces of very fine tube and adhesive tape 'flags' every 150mm (6in) or so along the lines; wind pressure keeps the 'flags' all pointing the same way. Speed increases of 10% are easily obtained in this manner, but they are banned from international competition and also from certain domestic classes.

Again, to save drag, fixed undercarriages are not used, the models taking off from three-wheeled 'dollies', which remain on the ground when the model reaches sufficient speed to take off.

Recently, asymmetric layouts have become popular, with all (or nearly all) the wing area being concentrated inboard of the fuselage. An outer wing panel has to fly faster than the inboard wing as it has further to travel due to the A speed flier places his handle in the pylon, which guarantees a constant-radius circle.

circular flight path, so it creates more drag, while by using a high aspect ratio inboard wing only, more of the control lines are faired-in, so once again drag is reduced. The result may be odd looking aircraft, but they certainly are fast; the 1978 World Champion FAI class model (2.5cc) recorded 255.5km/h.

Apart from modifying the engine and reducing drag, there are other ways of going faster. If fuel is unrestricted, there is plenty of scope for experiment. Nitromethane is the most common additive for increasing power, but other chemicals too are used. Castor oil does not blend so well with high percentages of nitromethane, so modern synthetic two-stroke oils are often utilized.

However, the biggest source of increased power concerns the exhaust system employed, often called a 'tuned pipe', consisting of two cones joined back to back, tuned to suit the engine, and operating on the principle of using the exhaust pulses to extract or scavenge the engine's exhaust port of the previously burnt charge. Properly set up, and matched perfectly to the engine, such an exhaust system can increase power by up to 50%. Unfortunately, it restricts the engine power to a very narrow rpm band, for example, with a 2.5cc engine, perhaps between 26,000 and 28,000 rpm. The problem is then how to get the model airborne and flying level in order to bring the engine rpm up to the power band; the best solution is a centrifugal switch with the engine set 'lean' on the ground, near the desirable rpm range. Then as the model gains speed, so more fuel is fed to the engine, keeping it in its power band. It's tricky to set up correctly, but the system works – ask the top ten fliers in the World Championships.

To make sure that the models fly exactly the right distance without 'assistance' from the pilot, the timed portion of competition flights are made with the pilot's handle held in a pylon, a U-shaped bracket revolving in the top of a metal pole. During a competition the pilot leads the model with the control lines during take off from the dolly, then pulls on the lines to bring the model up to speed. When satisfied that the engine has reached maximum rpm, he places his control handle in the pylon. The timekeepers allow him one more lap, then start the watches. When he has completed the required number of laps (usually ten) they stop the

watches and signal that the flight is over. The pilot then lifts his handle from the pylon and flies continually until the fuel runs out, landing the model at a fast glide on a wire skid secured to the metal pan.

Combat

Combat is a very descriptive title for this form of competition flying. Spend a few minutes watching a combat 'bout' and you quickly appreciate why this branch of aeromodelling has such a vast following, particularly among younger enthusiasts. It has all the essential ingredients for a truly exciting competition; high speed manoeuvring (frequently very close to the ground), the need for lightning reflexes by the pilots, the necessity for first-class teamwork between pilot and pit-crew, and the inevitable crop of broken models as a reminder of poor technique!

Two models are flown together within the same flight circle. Each is fitted with a crepe paper streamer and the pilots, standing next to one another, have to try and manoeuvre their fast flying aircraft so that they can cut their opponent's streamer with the propeller. As points are awarded for cutting the streamers, and lost for time spent on the ground, each pilot must concentrate on keeping his model airborne, avoiding tangling control lines and bringing his model into a good attacking position, without having his own streamer cut.

Countries have differing regulations concerning engine sizes, line lengths and scoring, but most support the *Federation Aeronautique Internationale* (FAI) rules which call for engines of 2.5cc (0.15cu.in) maximum capacity and control lines 15.92m (52ft 3in) long and that is the class of model described here.

Model design is unrestricted, but practical experience over the years has resulted in most top designs being very similar. For success, they have to be very fast and very manoeuvrable. The first requirement is achieved by using a powerful engine, and until the mid 1970s, the diesel engine reigned supreme in the FAI class due to its ease of operation, reliability and reasonable power. Today, racing type glow engines are the most popular choice, frequently operated on high nitromethane content fuel. A top quality glow motor can produce some 200% more horsepower than most diesels.