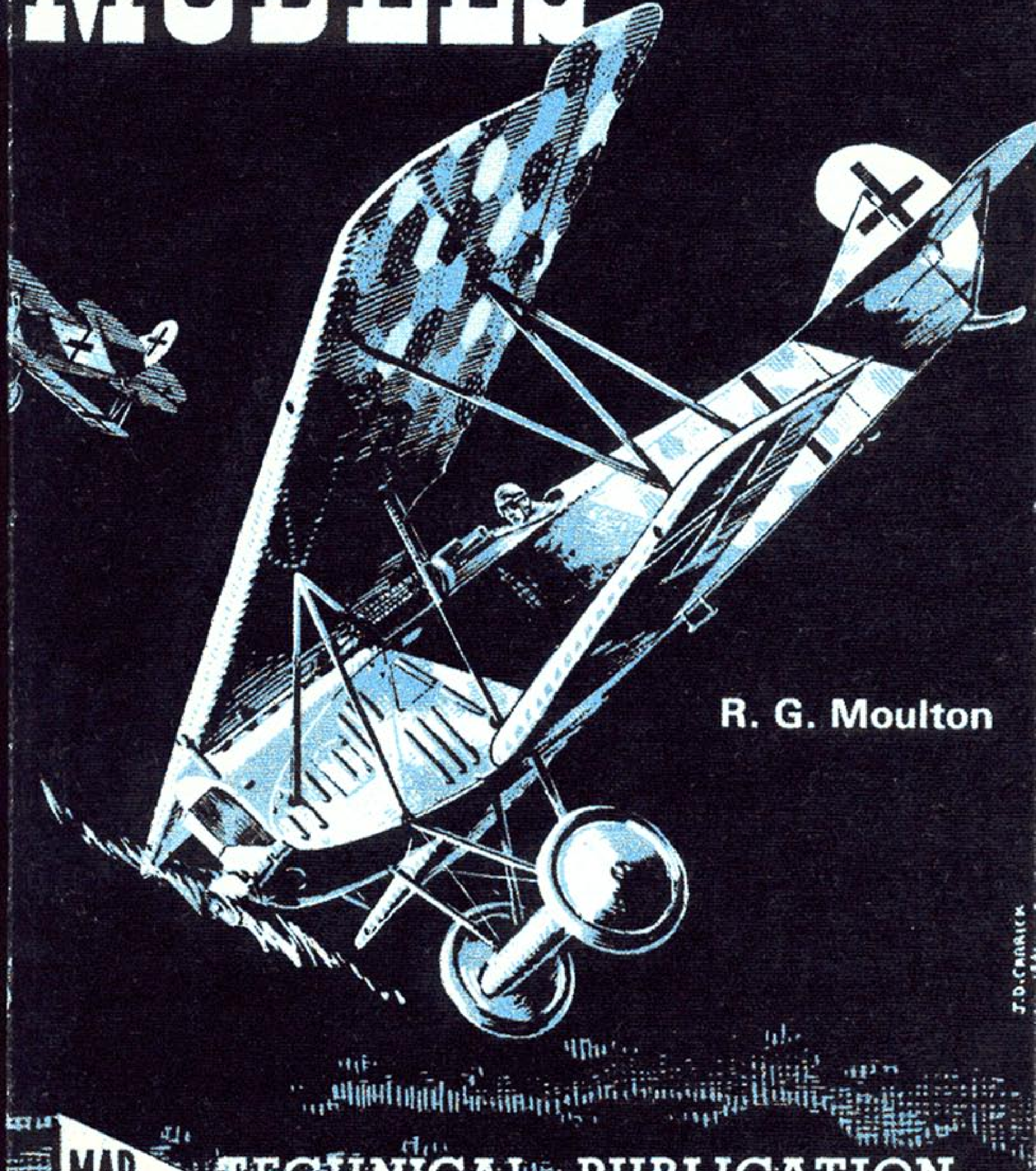
FLYING SCALE MODELS



R. G. Moulton

MAP TECHNICAL PUBLICATION

FLYING SCALE MODELS

By R. G. Moulton

A comprehensive work on all aspects of flying scale model aircraft, from the selection of suitable prototypes, through all stages of building and flying, including detailed information on all kinds of power units, together with invaluable data on authentic colours and markings.

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Preface

When this book was first written in 1956 as a guide for the novice and reference work for the expert, the object was to combine in one volume all of the information likely to be needed for making a successful flying scale model.

It was difficult to decide which of the masses of reference sources available I should use to satisfy the prospective reader and modeller. The print order was a gamble for my publisher, for we were exploring new ground.

Happily, I can say that in either case the book would appear to have met the requirements as intended. This reprint, after a substantial initial impression, and the many complimentary letters received, is issued in the firm knowledge that it will extend its use as the standard reference book on the subject. It is hoped that *Flying Scale Models* will continue to encourage enthusiasm for the building of replicas in miniature of favourite full-size aircraft.

R. G. MOULTON

Chapter One
Types of Flying Scale Model

AN acquaintance, returning from his first-ever visit to a large aeromodelling meeting, passed the remarks that " some of these model planes fly very well indeed, they go very high and travel a long distance ; but they don't *look* much like the real thing do they? " He had, of course, seen only the duration contests of the day—and completely missed the Concours d'Élégance event where the scale entries were to be found.

Some weeks later we had the pleasure of accompanying this same friend to another model rally, and made a special point of showing him the scale section. The look on his face was reward enough for our efforts, especially when he gazed with awe at the qualifying flight of a perfect Heston Phoenix which retracted its wheels after a long and realistic take-off, and then lowered them again for the realistic landing ! There was no longer any doubt in our friend's mind of the fact that models could look like the real thing and still be able to fly, and the aeromodelling movement gained one more convert for the flying scale fraternity.

In all aeromodelling there is no greater sight than that of a true-scale model emulating its full-size counterpart, whether it be jet, lightplane or glider, and the person who enjoys the view most of all is the model-maker himself. It is hoped that this book will help to stimulate further enthusiasm for scale modelling, and will provide the ways and means for many a self-designed aeroplane in miniature.

Now it may seem strange that we should be talking of *designing* our scale model, when, in effect, the outline and general aerodynamic form of the model is a reduced version of something which already exists. But " designing " it is, for although the outline is defined, the modeller has to fill in the detail with considerable skill. The structure must be light in weight, yet strong enough for the loads it is likely to receive in a heavy landing. It has to be authentic in section, yet cleverly blended with a change here and there to minimise " scale effect " and its attendant handicap on the chances of flight. Above all, the final appearance has to be realistic in every degree, and this can only come with perfect proportioning of registration lettering, international markings, etc., all of which hark back to that term " designing " and careful deliberation on the drawing board.

Having established that our scale modeller is something of a genius, capable of surmounting the greatest of problems and possessed of the enviable quality of making a success of all he touches, we shall now proceed to explain how easy it is to make scale models, and, moreover, show how wide is the field of opportunity in this branch of aeromodelling.

Gliders

As always, the easiest introduction to the hobby is via the glider. It offers so little resistance to flight and gives so much satisfaction for a minimum of expense in time and money, that it is always an unqualified success and serves as an ideal encourager for further model building. Unfortunately, this is not always true of the scale glider unless the rather ugly but more functional troop-carrying variety is chosen. We have seen many a fine flight with a scale Waco Hadrian or Airspeed Horsa ; but all too few with, say, an Olympia or Minimoa, and the reason is not hard to find. It lies in the fact that these high performance full-size sailplanes (note that they are elevated from the glider category) have the most minute tail surfaces, in some cases not much more than one-sixth of the wing in area. This problem of tail areas will rear its head in all scale models ; but it is usual for the real thing to give us a fair start

Fig. 1.—Accurate scale version of the Waco Hadrian troop carrier flies well from tow launch or when slope soaring.

by offering a tail approaching the one-quarter wing size, as will be seen in later chapters. So the glider, or sail-plane as such, is not exactly a wide-open field with dozens of handy subjects to select.

Fortunately we are now in the Jet Era, and since such aircraft fly without the impedimenta of a propeller, then there remains no logical reason why we cannot make a gliding version of, say, a Canberra jet bomber, or even a vast B-52. Believe us, we have seen this kind of scale model in the air and holding a thermal upcurrent so well that it might well have been jet-powered! Thus the field widens and we can add "jet gliders" to the troop carriers for the benefit of the beginners.

Rubber Driven

It is a logical step for rubber power to provide the drive for our next model, and with this form of propulsion, dating back to the same system used by earliest experimenters in aviation back in the last century, we are able to select a wide range of full-size subjects.

Those rare and fascinating types with propellers pushing from the tail end like the Mixmaster and Sierra Sue American aircraft, are most suitable for rubber drive with even weight distribution. The twin boom types like the Lockheed P-38 Lightning, even twin-engined aircraft like the Airspeed Envoy and four-engined Handley Page Bomber, are existing model designs in the *Aeromodeller Plans Service* to bear out the possibilities. Thanks to the pioneer work of H. J. Towner, Howard Boys and Rupert Moore, we are presented with ingenious means of transmitting the power of a rubber motor in any shape or size of model. If the nose is short, and we have to keep the weight forward, the Moore drive is the solution. For twins, or multis, we can utilise cranks or flexible drives, while for massing extra power within the space of a small fuselage, there is the "Moore Diaphragm" or a gearbox. We shall be discussing these details in a later chapter, for the moment it suffices for us to know that the rubber-driven scale model can be any subject from a triplane to a multi-engined bomber.

Jetex

Earlier mention of jetplanes now prompts the thought of Jetex as a power unit for fairly simple scale models. Proof of the popularity of Jetex propelled fighters in miniature, like the Sabre, Hunter or Attacker, is to be seen in any model shop where British kits are available in profusion, with wingspan down to less than a foot and construction varied from stringers and formers to moulded prefabbed sheet. The Jetex unit is available in many sizes, and burns a dry tablet of fuel at fast rate to give rocket-like thrust. Some units can be adapted to utilise augmenter tubes rather like the jet pipes of the full-size, and others are clipped into a gulley stepped into the fuselage bottom to give a less realistic clearance for the efflux of the burning gases. Either way, the Jetex model is an ideal beginner's approach to scale, and for the expert it offers tempting possibilities for helicopter scale now that tip-burning rotor-craft are becoming current vogue.

Power Driven

This is the age of the miniature internal combustion engine, and most of us will have the small diesel or glowplug engine in mind when we think of a free-flying scale model. Most existing designs are for the very small capacity units of less than 1 c.c. and this may be taken as a fair barometer of international enthusiasm for the one-eighth or one-twelfth scale model. Low-wing, high-wing, biplane or triplane, the choice is wide open, and the only serious consideration is one of balance. For these engines weigh heavily in some long-nosed selections, like the Auster or Miles Hawk series, and they often do not weigh enough for the ultra-short probosci of the '14-'18 fighters like the Sopwith Camel and Nieuport Scout. Experience tells us what to do, and by careful selection of the engine and the airframe structure, it is possible to build a flying replica of almost any full-size aeroplane. To aid stability we have devices known as pendulum controls, and to take the brunt of an unwelcome hard knock there are many ways of making components shock proof. The power model has special attractions, not the least being the noise it creates, and the speed with which it cavorts about the sky, and these two factors have contributed greatly to the latest of the flying scale developments. . . .

Ducted Fan

This is the " ducted fan "—a system whereby both engine and impeller are hidden within a hollow fuselage and the model flies on the thrust generated by such a flying vacuum cleaner. In this way we can have a Sabre or MiG, a Mystère or a Boulton Paul P.111, and the effect of an apparently engineless jet storming its way across the airfield at 50 ft. altitude needs little elaboration to show how attractive this type of model can be. Nor is this ducted fan principle limited to the free-flying sphere. It originated with electric drive for demonstration round-the-pole models of a De Havilland Vampire, built by the *Aeromodeller* Staff, and it has been used to good effect by K. W. Newbold for a 3.5 c.c. diesel in a control-line version of the Venom.

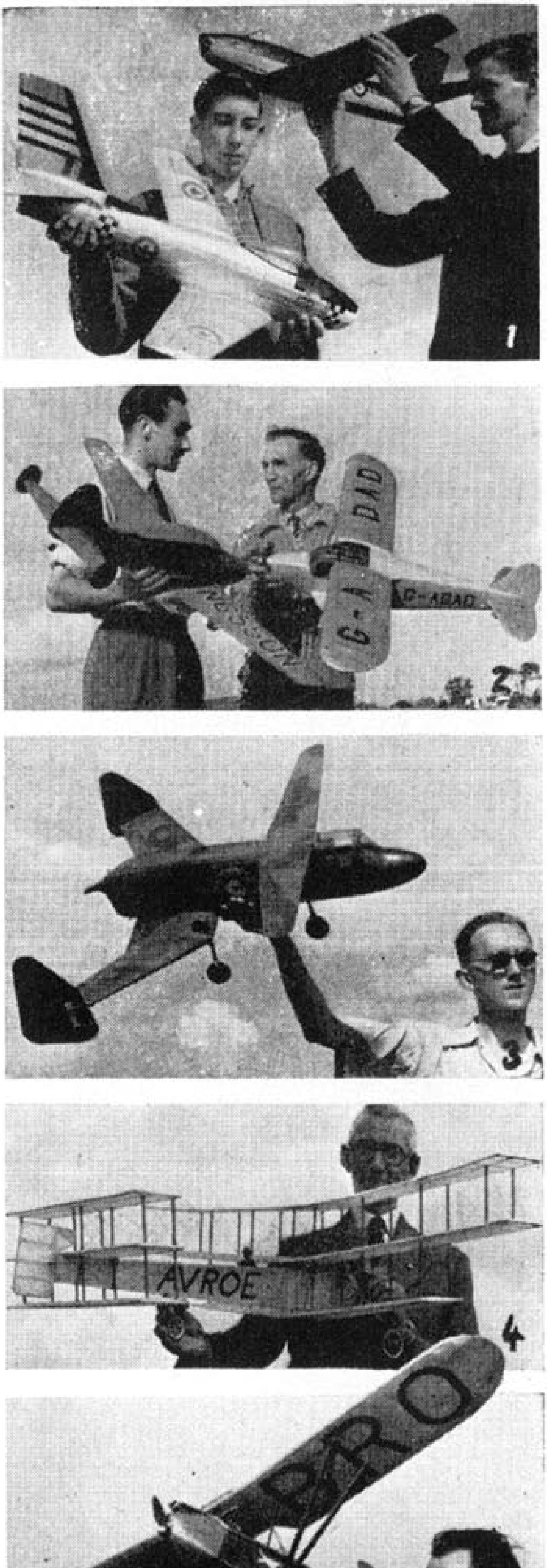


Fig. 2.—Model Types. 1. Veron " IMP " Sabres using ducted fan propulsion. 2. Experts confer over a Bellanca Cruisemaster and Heston Phoenix. 3. Miles M.35 Libellula is remarkably stable in free flight. 4. This builder actually helped to build the Avro Triplane he now models. 5. Westland Widgeon III is an ideal free-flight selection.

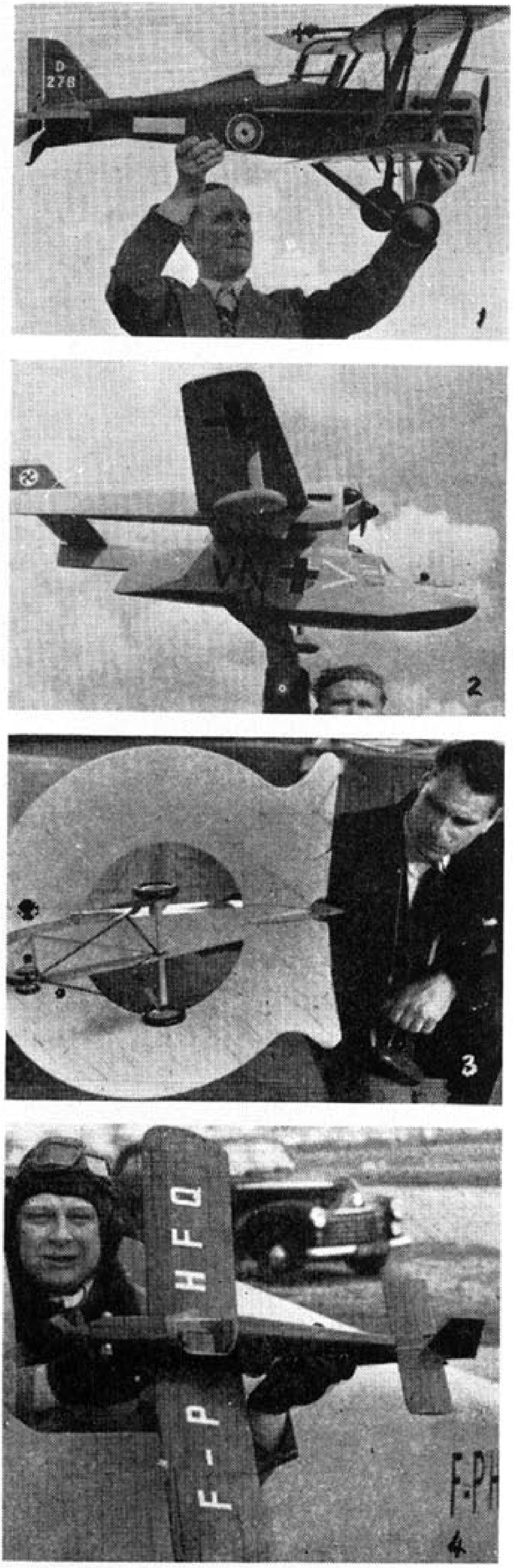


Fig. 3.—Model Types. 1. Free-flight SE5a with full detail but no pilot. 2. Blohm und Voss flying boat with one engine, two dummies. 3. The Lee-Richards Annular Wing is a flying novelty. 4. Author's Druine Turbulent is held by test pilot in the cockpit of the full-size aircraft.

Free flight or control-line, the ducted fan is now more than a novelty, and only the passage of time awaits arrival of the first commercially produced fan that will fit directly to any of the many small engines.

There is one other facet of the free-flying scale model that should be mentioned, and that is the question of realism in flight. One would hardly expect a scale Spitfire to stagger ponderously across the sky any more than anticipate a 60 m.p.h. (model speed) Tiger Moth. We come, therefore, to a "crashproof" barrier, as it were, in our scale modelling. Fast fliers have to be built tough and relatively collapsible without risk of damage, and they usually have to be fitted with powerful engines for their size. The slower models have less power, are more lightly loaded, and in many ways are more akin to the general sport flying power model. It is this latter class which holds greatest popularity, with designs ranging from the '14-'18 biplanes to Piper Cubs and Aeronca Sedans, while the fast fliers remain a devout and seemingly select school.

No one could deny the fact that a free-flight version of the Percival Mew Gull Racer would be ambitious, especially if required to simulate the high-speed antics of the real aircraft. This is but one lone example of the fast flier brigade, and has been successfully repeated in several sizes for a variety of engines by that doyen of the heavyweights, P. E. Norman. Such a model could be said to be capable of surmounting the "crashproof" barrier we mentioned. It is built with the anticipation of high-speed landings in unconventional attitudes, and wings are made fit to stand upon. Such a tough model could also be one of the ducted fan variety, though weight must be kept to a minimum and reliance put upon the power for realism in high-speed flight.

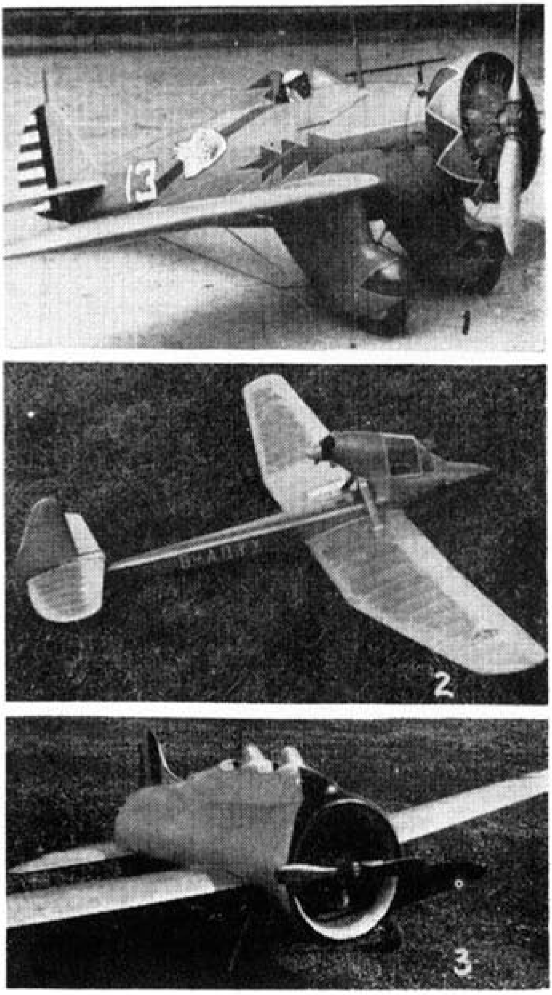


Fig. 4.—Model Types. 1. Control-line Boeing P.26a in full regalia—with pilot. 2. Luton Buzzard for free-flight is a nice lightweight. 3. Caproni-Stipa ducted airscrew (see Chapter 12).

Control-line

Last, easiest, and most convenient of the scale models from many points of view—though perhaps not quite so satisfying—is the control-line type. For the initiate who may have escaped the publicity, good and otherwise, for this form of model flying, we should explain that these aircraft are flown tethered. Pivot point of the circuit is the pilot or operator, and in his hand he controls the tension on two wires which lead to a crank in the model. This in turn operates the elevators so that it is possible to climb or dive at will, and with an experienced pilot and balanced model of right proportions, loops, bunts and figures of eight are among the attractive manœuvres to be executed. Landing lights, cockpit detail in profusion, the absolute in realistic finish and full engine control are finer points of the C/L model that call for ingenuity.

Because there is little to worry about in the event of unequal power output, we can have twin- or even four-engined subjects—and if the neighbours will tolerate the noise, we can produce a scale jet with real fire and venom spitting through the tailplane by using one of the American or Continental pulse jets.

Thus it will be seen that the paths to flying scale are numerous to follow, and from now on we dip into facts and figures to aid us in selection and execution (literally !) of the subject.

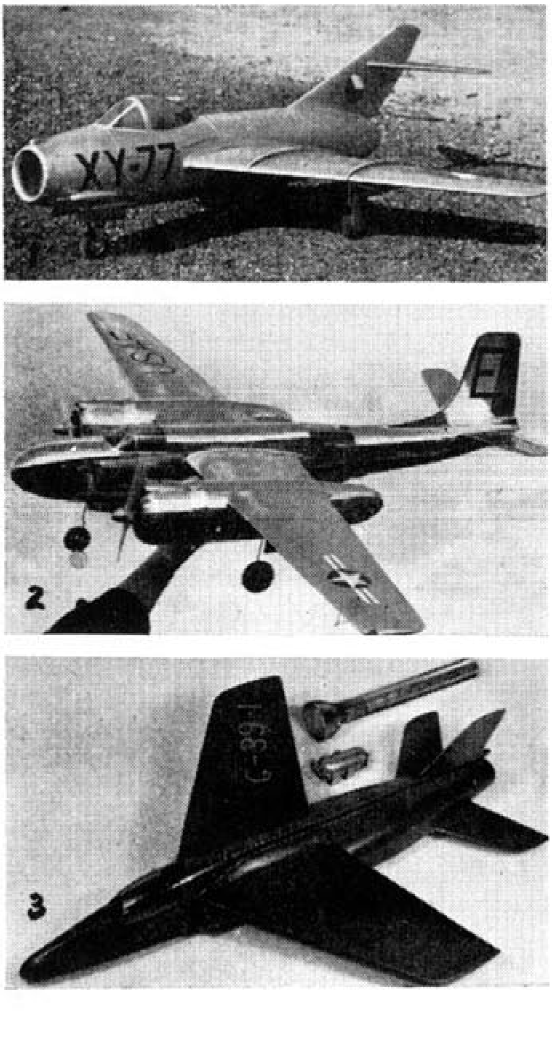


Fig. 5.—Model Types. 1. Czech MiG 15 has real jet power. 2. Douglas A26 Invader, a popular control-line twin—here with silver wallpaper covering. 3. Folland Midge, for Jetex power, see unit and augmenter tube.

Chapter Two

Selection of the Subject

THE vast majority of modellers intent on building a scale design have been influenced in their selection by the sight of some illustration of an attractive subject, or perhaps an actual flying scale example which has been demonstrated on their local field. For the latter there exists an excellent range of plans to suit all tastes, in the *Aeromodeller Plans Service*. This book will concern itself with the adventuresome enthusiasts who prefer to start from scratch and seek out their own subject to conquer.

Is it to be chosen for its " glamour " or for its proportions as a suitable scale model for flying? The Sopwith Camel could be classified under the heading of the glamorous—it carries with it all the fame of air battles over France and memorable air victories in the hands of renowned ace pilots. Likewise one might say that the Ryan Monoplane " Spirit of St. Louis " holds great attraction as the aircraft flown by Charles Lindbergh on that fabulous non-stop flight from New York to Paris. The Gladiator, Spitfire, Tiger Moth, or Lysander all carry a story with them and would be instantly recognisable to anyone with even the remotest interest in aviation. Yet one would hardly consider their proportions to be ideal for a flying model. That they can be flown is common knowledge to all scale enthusiasts, and the ways and means employed to make sure of stable flight will be unfolded in Chapter 4.

On the other hand, one can discover remote types like the Czechoslovakian Praga E.114, a cantilever high-wing monoplane without struts to either wing or undercarriage, and with a box-like fuselage that tends to make it look rather like the reverse process of scale modelling—an enlargement of a model for full-size flying! Choose something like this and scale tends to lose its fascination. Try to be different ; but at the same time make a selection that will look like a genuine reduction of the real thing, and not an aircraft that bears the appearance of being an overgrown and somewhat austere model.

Colouring of the final product can often be a tempting feature of our selection. In that case, some of the popular American lightplanes, the Cessnas, Aeroncas, Pipers and Luscombes, can be made into brightly decorated models, and with good proportions for flying without any stability aids. These lightplanes may not have the glamour of more famous aircraft ; but they are well known and information on them is fairly easy to obtain.

This touches upon the focal point around which all scale models are evolved. Availability of information, or the lack of it, can make or mar any prospect of building many an outstanding scale model. Supposing we choose to build an aircraft of the mid-'30s which we have noticed in a magazine of about that date. Perhaps the aircraft is so appealing in its lines that we cannot resist it, the scale-bug has bitten, yet all there is to work upon is this one photograph and the basic dimensions of wingspan, length, and height.

The first step to take is to seek reference in the local Public Library, where the appropriate copy of *Jane's All the World's Aircraft* should be located. A scanty three-view drawing may appear in this volume, and such an outline may generally be accepted as authentic and accurate. But the chances are that all the information given concerns the structure of the aircraft, its purpose and its dimensions with precious little else to quench our thirst for the vital details needed for making a good model. There will be one thing, however, and that is the address of the manufacturer.

Now it cannot be expected that any aircraft company is prepared to employ

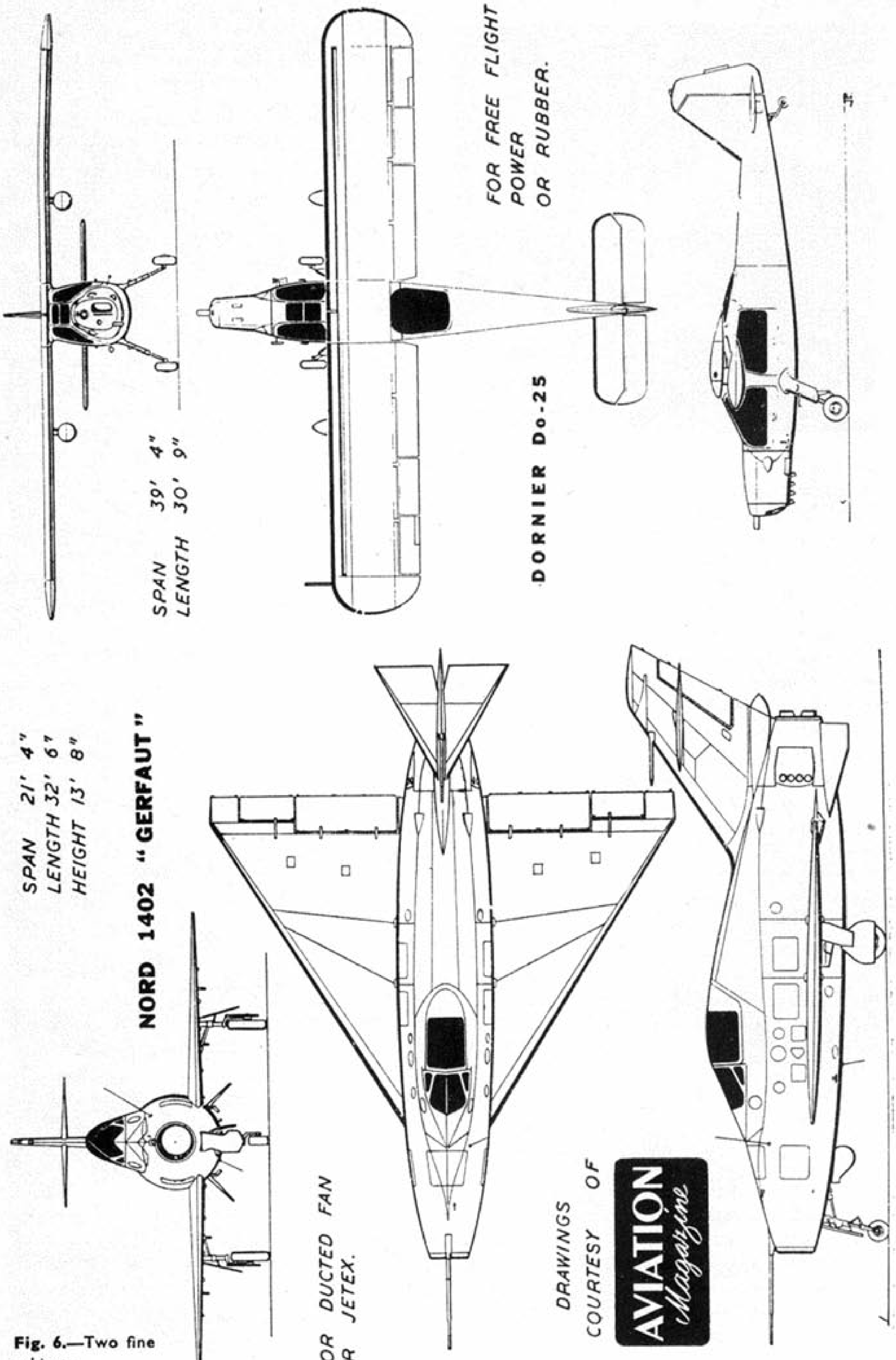


Fig. 6.—Two fine subjects

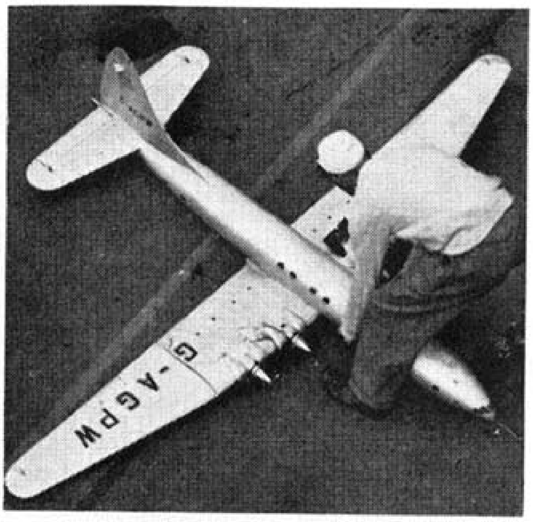


Fig. 7.—Proof that there is no exception to the rule that all scale models can be made to fly is W. P. Holland's huge Bristol Brabazon (see Fig. 60 for u/c details).

people solely for the preoccupations of interested model-makers who will have little to contribute to the manufacturer's welfare. So it is no earthly use writing blithely to the address in *Jane's* and asking for a host of information, photos, etc., and expecting a return post service.

Write to them by all means. Address the enquiry to the Public Relations Officer and outline the purpose of your request for information as briefly and concisely as possible. One may be lucky and get a works three-view, or a reference to a plan company such as *Aeromodeller Plans Service*, where accurate drawings can be obtained. You may have located a company that is no longer in existence, or is no longer in possession of pre-war records. Either way, you will have explored the channels most likely to reveal the material you need, and for further information there are organisations like *Air Britain*, a voluntary band of rabid aviation enthusiasts who would welcome membership of a scale modeller. This particular society has its own panel of experts with specialists for military, civil, or historic aviation. They run a reference service for aircraft markings, etc., and a photographic service at very reasonable charges for *Air Britain* members. Having like interests, these enthusiasts are quick to help a fellow member modeller when he is anxious to obtain particular detail on colouring or identification of a special aircraft, and their photographs are always taken with a helpful view to display the décor, stencilling, or registration marks which are so important to any precise model.

For modern aircraft there are many reference works which include line drawings or reversed black silhouettes to a reasonable standard of accuracy. It is the "old-timer" that becomes rather difficult to locate, and if the local reference library cannot provide the material needed for producing a model design, then a good source of information is the Library of the *Science Museum* (Aviation Section) at South Kensington, London, or the Photo Section, *Imperial War Museum*, Lambeth. The old saying of "Where there's a will—there's a way" was never more true than in the case of an ardent modeller seeking out information on some remote type.

Thus our choice lies in four ways.

Conventional
(Monoplane, high or low)
Old-timer
(Pre-1930)
Unconventional
(Multi-wing, or multi-engined)
Modern
(Lightplane or Jet)

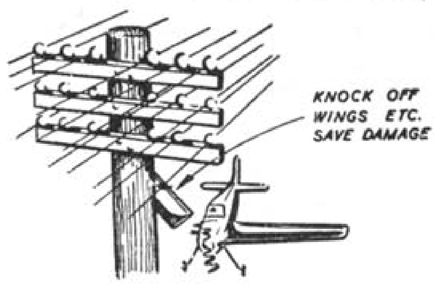
To which we can add the general classifications of "glamorous" or "nondescript", while any of these subjects can be selected for the various forms of model flying outlined in Chapter 1.

Most important of the factors which should sway the modeller in making his choice, is the suitability of the aircraft for the power unit he has in mind. The question of balance is critical in some cases, for example, the pusher aircraft like the F.E.8 and Supermarine Walrus, or the Sierra Sue, with its propeller at the extreme tail. Then again, the airframe must not be too weighty for rubber drive, so one should avoid choosing a type that calls for complicated framework to resemble the real thing unless it is a particular qualification of the modeller to be able to execute lightweight work—so common in the pre-war era ; but no longer a feature of the model exhibitions.

Power Requirements

It would be safe to say that if we are to use a diesel or glowplug ignition engine, then for free flight we have to watch the following points: *The length of the nose* (if short, a heavy engine is advised ; long, then the tail will have to be weighty to balance and a light engine used). *The tail area* (for monoplanes, 18% is a safe minimum for stability in the looping plane—biplanes can be as low as 12% of the total wing area). *The position of the engine* (a pusher requires ballast to bring the balance point, or Centre of Gravity, forward). *Size of the engine* (a large radial cowling can offer reverse thrust to the portion of the airscrew within its diameter, and only the portion of the airscrew outside the cowl has full effect, for example, Fokker D.VIII to a large scale would need a very large diameter airscrew, perhaps beyond the capabilities of the engine chosen). *Dihedral* (a point that can be overcome with stability aids: but an aeroplane without either dihedral or slots is difficult to fly in any but absolutely calm conditions).

Fig. 8.—Decision to make a model flexible and " knock-off " is a wise one.



Rubber

For rubber drive, *the length of the nose* has a bearing on duration (the longer the nose, the more rubber can be stored in the fuselage). *Tail area, Dihedral and Cowling size* are similarly as effective as in a power model, but the *position*

Fig. 9.—Three fine lightplanes, Sierra Sue (Chapter 11), the HK-1 (Chapter 3) and Cessna 172, drawn overleaf.

of the engine is not at all critical (a pusher would have limited motor length, which could be overcome with gears, but if at the extreme tail, the propeller is in an ideal position for rubber drive). *Propeller clearance* is important for R.O.G. take-off. (Rubber demands a larger than scale propeller for efficiency, there must be sufficient undercarriage length or clearance in other directions to allow for slight diameter increase.)

Jetex and Ducted Fans

Since for Jetex, one would only select a jet-propelled aircraft, no problems arise, as the modern form of these flying blowtorches fits in well with model requirements. The ducted fan model does, however, call for *large intake area* (nose intake perferred, since the amount of air made available to the fan or impeller will determine the thrust generated) and medium *Wingsweep* is an advantage in that it allows the engine to be positioned fairly rearward, where the real turbojet would be, and, in consequence, at the point of greatest fuselage cross-section. It also offers a shorter rear fuselage duct, which appears to be an advantage.

Control-line

There remains control-line. Here we have no stability problems, for the

Fig. 10.—A fine subject for free-flight, power.

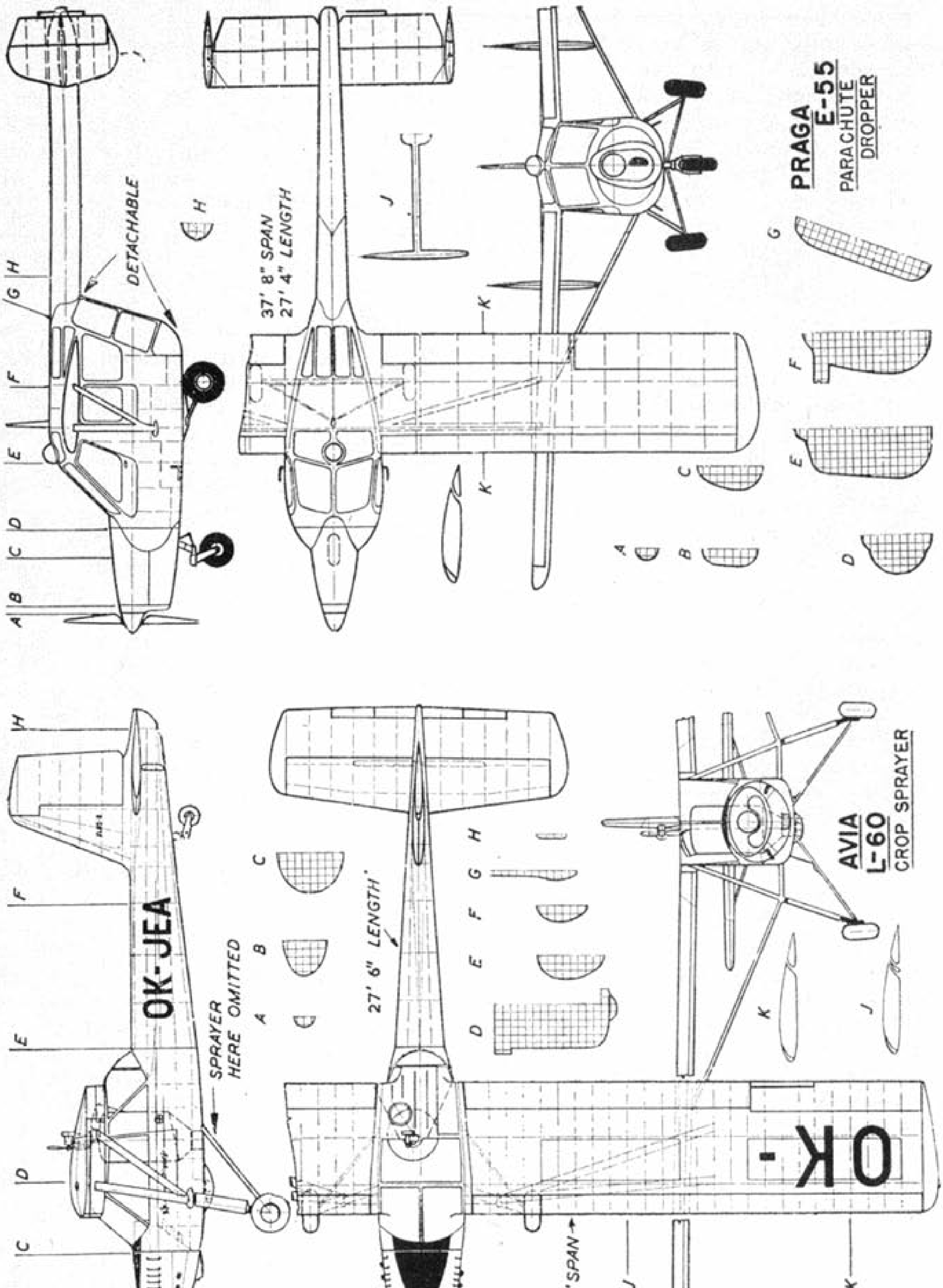


Fig. 11.—Two Czechoslovakian light aircraft with admirable proportions for free-flight scale models using diesel or glowplug power.

model does not have to be inherently stable to be able to fly. It is controlled by the pilot, and the elevator is used to counteract any wayward tendencies that would, of course, spell disaster for a free-flying model. In the control-liner we have, as they say in France, "Carte blanche"—the white card without restriction is given us to make any form of selection we may desire. For this reason, it ought by rights to be the most popular form of flying scale model —yet only in the twin-engined or aerobatic subjects does it really achieve any degree of popularity.

Perhaps the great thrill of seeing a scale model emulating its full-size counterpart in the natural element and without the fetters of control-wires, is the deciding influence. But we should not deride the control-liner. It has little in the way of weight limitations, and much to offer, as we have already mentioned, with the possibility of most realistic finish and working undercarriages. For multi-engined subjects, it is the ideal medium to use, and with various methods of flap and throttle control, it offers many a thrill that could never be repeated by the free-flying (even under radio control) model. One example of its possibilities is the "Carrier" event, where scale Navy aircraft are required to take off from and land on an aircraft carrier in miniature. Throttle control and use of the arrestor hook demands pilot skill as well as a good model. Flight points are awarded for the difference in speed between fast and slow laps in this exacting branch of control-line scale flying.

Before we proceed to draughting our model—having made the choice, and decided upon the power unit, we should reflect on the point raised earlier concerning the "crashproof" barrier and what it implies. Say, for example, we have elected to build an S.E.5a for a 1.5 c.c. diesel. Now this can be in two sizes for free flight. As a large model it can be built to fly at between 15 and 20 m.p.h., but will be vulnerable in the event of a heavy landing. As a smaller model, it could weigh the same, yet fly at more than 25 m.p.h. and be virtually unbreakable in the best P.E. Norman style. Parts could be arranged to knock off in a crash; but would, of course, have to be covered in silk or nylon and made in hardwood structure.

Though each of these models might weigh 2 lb., their wing loading will vary in the order of one being 75% higher than the other. The smaller model, flying much faster, needs a stability aid in the form of a pendulum elevator or rudder to correct any deviation from the desired trim. It looks more realistic, behaves like the fighter it is supposed to represent, and would probably outlast the larger but safer-to-fly big model. The decision has to be made as to which type of model will be built, and it is generally found that this depends upon the experience of the modeller.

The smaller, highly loaded model will be made in a mixture of hardwoods, cane, papier mache, etc., and calls for a myriad other items to complete its strong construction. Much of this will demand ingenuity on the part of the modeller, both in hunting out sources of supply for the ideal material, and in applying the mixture of various materials to best advantage in the model structure.

On the other hand, the larger design will be made entirely from the more common supplies bought from the local model shop, balsa, little hardwood and ordinary covering tissue, etc. With its moderate wing loading of perhaps, at the most, eight ounces per square foot of total wing area, it will be docile to fly, and no special precautions need be taken to render it "fully knock-offable" as all landings should be at a safe rate of glide descent.

The difference in vulnerability between the two types will be obvious when one or the other flies straight into a tree or similar rigid obstruction! In reality—these pro's and con's for fast or slower models are resolved in the choice of the subject when the modeller selects his aeroplane according to the performance of the full-size. The selection table will give some guidance for those who are undecided on which line to take.

SELECTION TABLE

Type of Model.	Desirable Features.	Points to Avoid.	Approximate Weight of Model.	Suggested Aeroplanes.
Glider	Dihedral : 20% tail area.	Small tail area.	5 ozs./sq. ft. total area.	Waco Hadrian, Airspeed Horsa, Fauvel Tailless, Slingsby Type 42.
Jetex	Dihedral, or sweep back.	Bulky fuselage. Too much sweep back.	35—1½ ozs. 50—2 ozs. 100—4 ozs. Jetmaster—5 ozs. 200—5 ozs. 350—7 ozs. 6 ozs./sq. ft.	Hawker Hunter, Supermarine Swift, Grumman Cougar, N.A. Sabre F-86D, Folland Gnat, Dassault Mystère, Fouga Magister, Fokker Mach-Trainer.
Rubber	Long nose : 25% tail area. Simple structure. Room for rubber.	Very short nose ; lack of propeller clearance ; drag producing structure.	Maximum of 6 ozs./sq. ft.	Sierra Sue, Helioplane, Piper PA-18 Super Cub, Hawker Hurricane, Westland Lysander, Lockheed Lightning and Northrop Black Widow twins.
Power ... ... (Free flight) Moderate	Short nose ; dihedral or slots simple rigging.	Four-bay biplanes ; long nose for large engines ; very small tailplane ; thin wings ; large radial cowlings.	20 ozs. per c.c. 7-8 ozs./sq. ft.	Republic Seabee (pusher) SE5a, Tiger Moth, Fokker Triplane, Helioplane, Piper Tri-Pacer, Cunliffe-Owen wing (twin), Fletcher Defender.
Power ... ... (Free flight) Fast.	Medium length nose ; small wings ; no struts.	Weak points in structure. Parasol wings.	20 ozs. per c.c. 10-16 ozs./sq. ft.	Supermarine Spitfire, Percival Mew Gull, D.H. TK.2, Comper Swift, Curtiss Hawk 75.
Ducted Fan ... ... (Free flight)	Nose intake ; slight sweep back ; large fin and tailplane ; delta form.	Small intake area ; large fuselage ; other than circular section fuselage, too much sweep back (30°).	8-10 ozs./sq. ft. 10 ozs. per c.c.	Fokker Mach-Trainer, Gerfaut, Boulton Paul P.111A, N.A. Sabre, MiG 15, Dassault Mystère.
Control-line	Twin engines ; mid wings ; tricycle undercarriages ; colourful subjects ; aerobatic aircraft.	Rearward two-leg u/c ; long nose on single engines ; small cowls ; exposed model engine.	12-16 ozs./sq. ft. 8 ozs. per c.c.	Boeing P.26, Bucker Jungmeister, Gotha 145, Aero Commander, Cessna 310, Dornier 17, North American T-28, Percival Provost, D.H. 88 Comet, Vought Corsair.

Chapter Three

Scaling up the Plan

BY this stage we have decided on the aeroplane we want to model, and have managed to obtain a three-view drawing of reasonable accuracy from which an enlargement must be made. To many modellers this is a stumbling-block that they are not prepared to tackle. Not being trained in draughtsmanship, and perhaps lacking in mathematics, the task is exaggerated in their imagination until it appears to be beyond their capabilities. Such could not be farther from true fact.

All we have to do is to reproduce an "X"-times drawing on a large sheet of paper so that the construction can be filled in and our model commenced. The job is a simple one, and there are several ways in which it can be tackled.

The very first decision to be made is on the actual degree of enlargement required. We know what type of model we want to make, whether it be for rubber drive, control-line or free flight, and we have decided on the power unit. We now want to know the wingspan and area needed to suit the power, and so begin our calculations.

Say, for example, we are using a 1 c.c. diesel and the model is to be free flight. This is likely to be the class of flying scale model demanding most ingenuity in selection of size according to power, so it serves as a good gauge for the other types. Now in our selection table, the column "Approximate weight of model" gives a set of figures for either fast or moderate scale flight. Earlier, we have discussed this definition, and the type of aircraft chosen will illustrate our reaction. Let us suppose we have elected to make a Piper Tri-Pacer from the 1/72nd scale drawing first located in *Aeromodeller Annual* 1952 and reproduced here. Naturally this will be one of the moderate variety, certainly not a fast flier, and one of admirable choice both for appearance and stability in flight.

The table tells us that it should have a power loading of about twenty ounces per c.c. and a wing loading of between seven and eight ounces per square foot of wing area. These two factors will be the yardstick from which the size of the final model is determined, and we start with the power loading.

Our engine is of 1 c.c. Therefore the finished model should weigh somewhere in the region of twenty ounces. This figure is now applied to the wing loading and we divide the figure of eight ounces into it to find the number of square feet needed to carry the weight satisfactorily. It happens to be very convenient at the factor of 2½, so if we work this out in square inches we shall know the actual required wing area. It is exactly 360 square inches.

The next step is to find, either by trial and error or by calculation, how large the model Piper Tri-Pacer must be for it to have this amount of wing surface. The published span is 29 ft. 3 in., and the wing chord 5 ft. 3 in. by measurements from the 1/72nd scale drawing. We can simplify this to 30 ft. and 5 ft. for the moment. Working by trial and error, we know that five times 30 equals 150, and so a one-inch scale would obviously be too small, so we estimate a rough guess at 1½ in.-1 ft. scale and multiply 45 (still assuming span at 30 ft.) by 8 (a little more than 1½ times the wing chord in feet). The answer becomes, as if by magic—exactly 360!

So the trial and error scheme has done its duty, and mathematics have been limited to the simplest of calculations. We have been lucky this time in finding the scale so quickly: but it can be generally assumed that the 1½ in.-1 ft. or "one-eighth" scale is admirable for most aircraft of the lightplane variety, with wingspans in

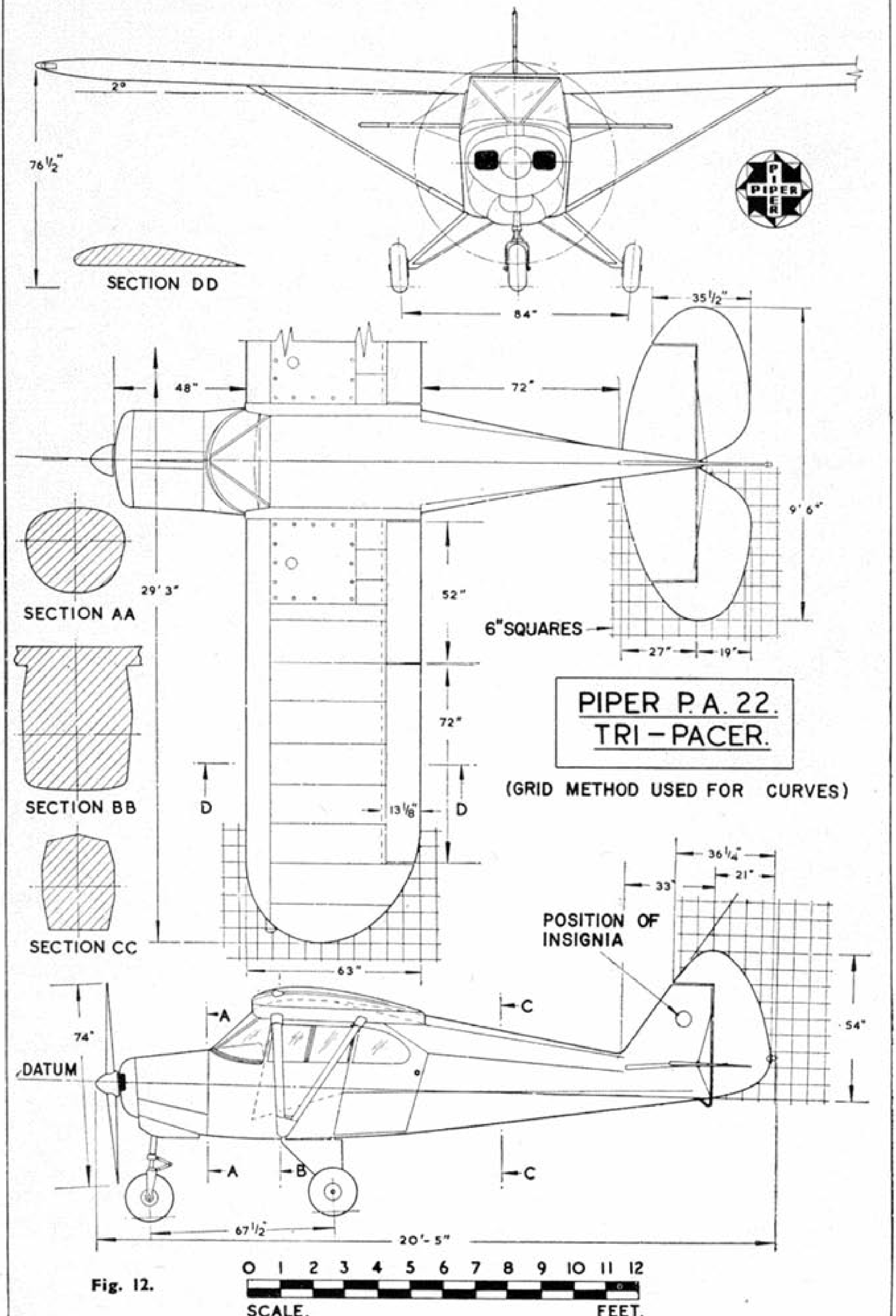

76 1/2"
2°
SECTION DD
84"
35 1/2"
48"
72"
9' 6"
SECTION AA
29' 3"
52"
6" SQUARES
27"
19"
SECTION BB
72"
PIPER P.A. 22.
TRI-PACER.
(GRID METHOD USED FOR CURVES)
D
13 1/8"
D
36 1/4"
21"
33"
POSITION OF
INSIGNIA
SECTION CC
63"
54"
74"
A
C
DATUM
A
B
C
67 1/2"
20'-5"
0 1 2 3 4 5 6 7 8 9 10 11 12
SCALE.
FEET.

Fig. 12.

the region of 30 ft.-40 ft. It is, by far, the most popular of all sizes for scale models, using engines of .5-1.5 c.c. according to type of subject.

Should it be necessary for us to resort to calculation to find the desired model size, we tackle the problem this way:

We have to reduce 29 ft. 3 in. × 5 ft. 3 in. to a figure providing 360 sq. ins. The proportion or "Aspect Ratio" of wing chord to wingspan must remain the same, and this is 29¼ divided by the chord of 5¼—or 5.57. Now we have to find the two figures in the ratio of 5.57, which, when multiplied together, give the answer of 360.

The formula for this calculation is $\text{Span} = \sqrt{\text{Area} \times \text{Aspect Ratio}}$, so we multiply the figures of 5.57 × 360 and find the square root of the resultant 2007.2. The answer is 44.8 and that should be our span in inches for the given area.

We have, however, glossed over the fact that the Piper's wings are not square tipped, and there will be a loss of area where the tip curve occurs. Since our calculation of 44.8 in. for the span has to be related in some way to the size of the 1/72nd scale drawing we have to enlarge, it is better to correct the span to the nearest convenient scale, and so we return to dividing 44.8 into 349 (span of full-size in inches). The answer is not quite eight times, and thus it seems obvious that our final scale should be one-eighth full-size.

Note how long it has taken us to arrive at this figure again by calculation—after reaching it originally in a few moments by the trial and error method! Surely an indication of how easy it is to draw and design one's own scale project—without formulae.

So now we are set to start our enlargement—the model will be to the scale of 1½ in.-1 ft., or exactly nine times the size of our 1/72nd scale drawing.

Easiest (and most expensive) way of producing the enlargement would be by the *Photostat* method. This photographic process of increasing or diminishing plan sizes is a commercial method widely used by industry and most successful where the enlargement is not of too great an order. The Photostat Company has its service station located in London at Photostat Ltd., 1 & 2 Beech Street, London, E.C.1, and one can vouch for the expedience and accuracy with which they dispense their orders. A very large photostat reproduction to 36 in. × 54 in. from a small original measuring 4 in. × 6 in. is likely to cost 28*s*. 3*d*. and one should remember that being a true photographic enlargement, all lines will also be magnified several times their original size and some degree of accuracy thus lost in heavy outlines. So the photostat is really limited in value to the smaller models, where cost is correspondingly lower.

For the man who would like to avail himself of this service, the best procedure would be to detach the drawing from its surrounding pages if it is in a book, and clearly mark the largest dimension needed on the final photostat. This will invariably be the wingspan, and determines the size of the print—and the cost. A request for an estimate or pro forma invoice for payment before the job is tackled will safeguard the modeller from being unwillingly involved in any disproportionate expense.

Perhaps it would be as well to emphasise at this stage that all published material remains the copyright of the publisher, and that whilst no Editor would ever object to having an individual enlarge one of his pages for a single model, he would raise all means within his power to prevent his original from being used for a commercial purpose without prior agreement. So prospective kit manufacturers ought to negotiate for permission if they wish to maintain a happy relationship with the publisher!

Though a photostat may be the easiest way out of our enlarging problem, it is nowhere near as satisfying as a pencil drawing produced by dint of careful work on the part of the modeller himself. There are many ways by which such a drawing can be produced, and they are: *Pantograph, Proportional Dividers, Compasses, Two-Scale-Rule, Proportional Scale* and the *Multiplied Measurement* methods.

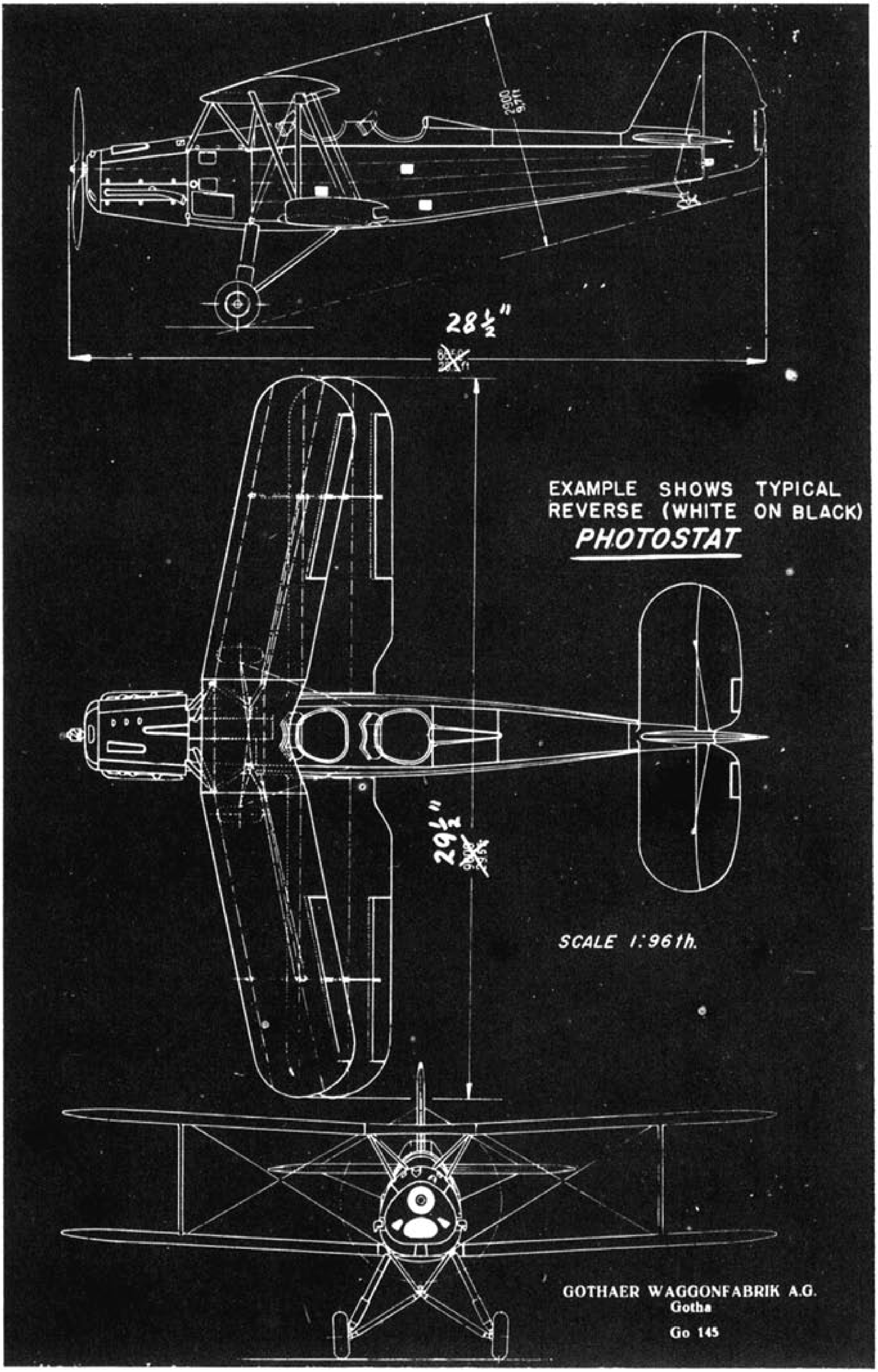

28½"
29½"
EXAMPLE SHOWS TYPICAL
REVERSE (WHITE ON BLACK)
PHOTOSTAT
SCALE 1:96th.
GOTHAER WAGGONFABRIK A.G.
Gotha
Go 145

Fig. 13.

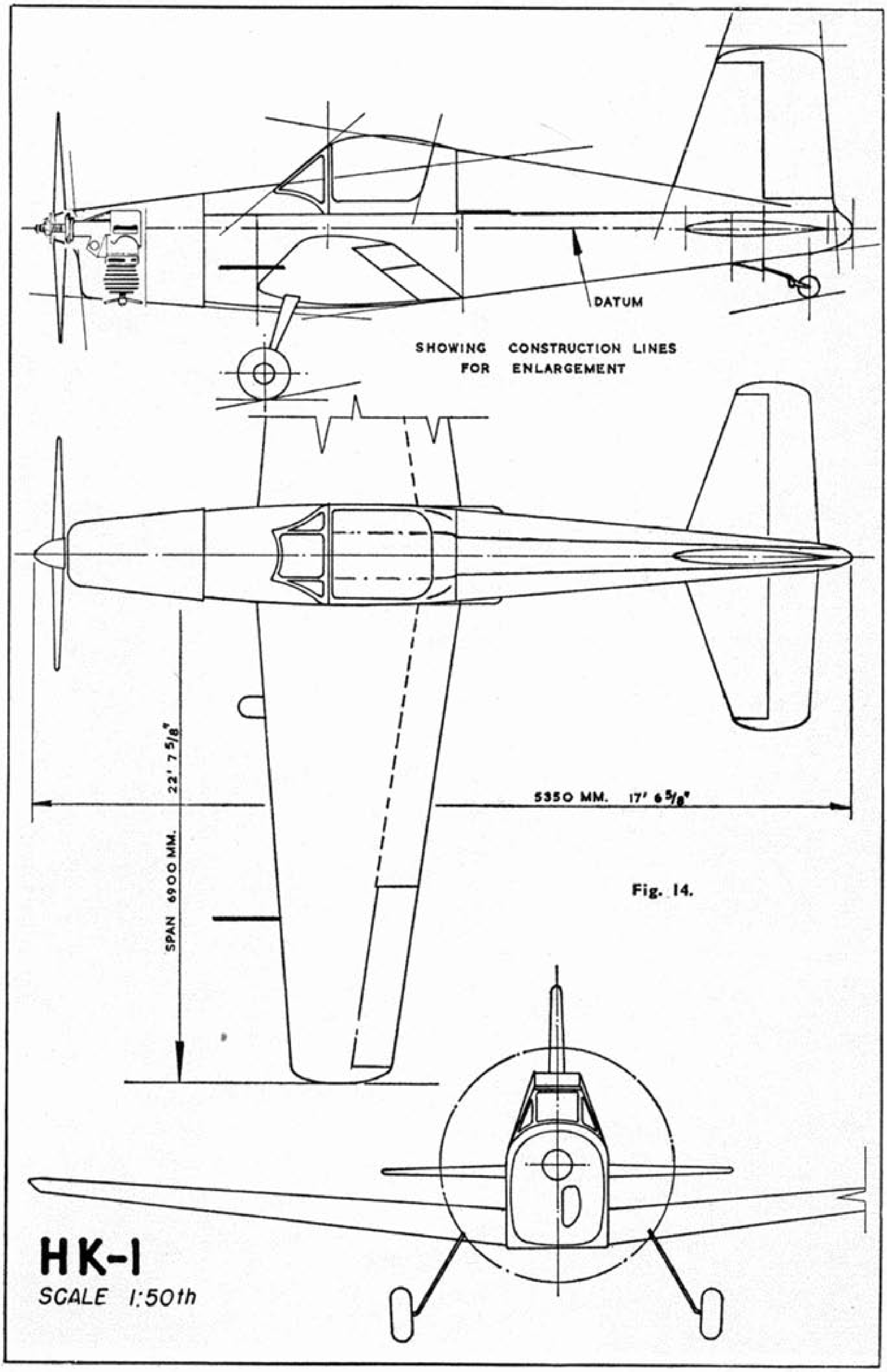
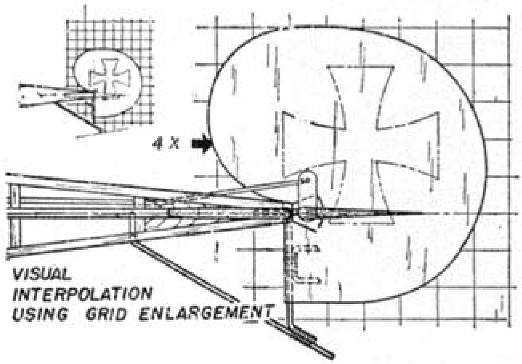

DATUM
SHOWING CONSTRUCTION LINES
FOR ENLARGEMENT
5350 MM. 17' 6 5/8"
SPAN 6900 MM. 22' 7 5/8"
HK-1
SCALE 1:50th

Fig. 14.



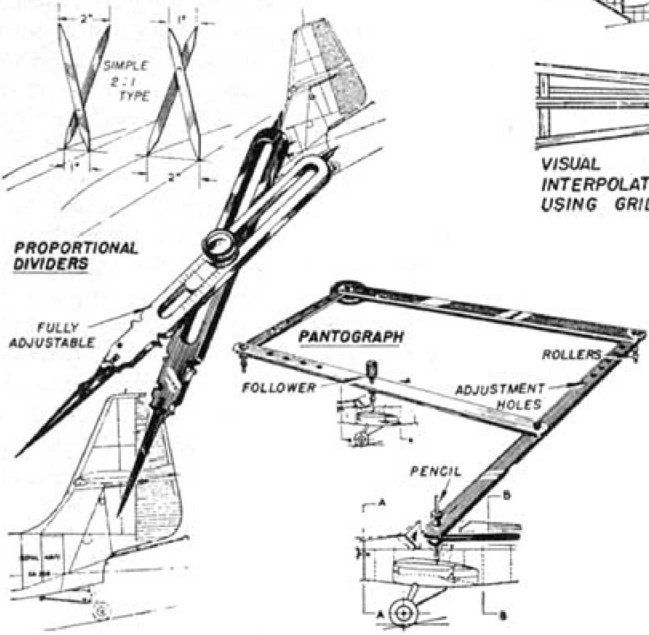


Fig. 15. (left) illustrates professional drawing instruments employed for enlargement and which can be reproduced easily for model-making purposes. **Fig. 16** (above) demonstrates the use of the grid system for positive accuracy in preserving curved outlines.

The first is the simplest, but not the easiest. A pantograph can be set for enlargement or reduction of any object, no matter how irregular in outline, and in the hands of a skilled draughtsman it can produce a scale outline in a fraction of the time needed for the five other methods with their attendant " grid " means of obtaining curved outlines. Pantographs can be bought cheaply—they are to be found in some of the larger " Woolworths " and they can also be made quite easily. To obtain the degree of enlargement we are most likely to need, in the order of nine times, or thereabouts, it is perhaps better to make one's own and a drawing for an excellent example can be obtained from the *Model Maker Plans Service* as drawing MM/188 for 2*s*. 6*d*. The cheaper grade of wooden pantograph is rarely adjustable to the limits we shall require, and the high-grade drawing instrument for skilled draughtsmen is liable to be prohibitively expensive (up to £32) for the amount of work we shall need from it, so a home-made pantograph is the better proposition (a 30*s*. version is illustrated).

For those who have never had occasion to use or understand the pantograph, a few words on its operation would not be out of place. It is a simple lattice-work or linkage that connects a pencil and a pointer in a ratio of motion. One end of the linkage or framework is firmly located on the drawing board so that it cannot move. The pointer, which is in the centre of the linkage, is moved about to follow the contours of the drawing we need to enlarge. As each movement is made with the pointer so the pencil, on the end of the linkage farthest from the fixed end, scribes a similar but enlarged outline. Everything depends on the accuracy of the operator in following the original outline faithfully, for all mistakes are enlarged, and a true shape can soon be lost through an unsteady hand. The most difficult part of pantograph operation for the unskilled is that of keeping the point *and* the pencil follower firm on the board while at the same time maintaining a smooth motion. A practice run is advised before launching forth on an involved project.

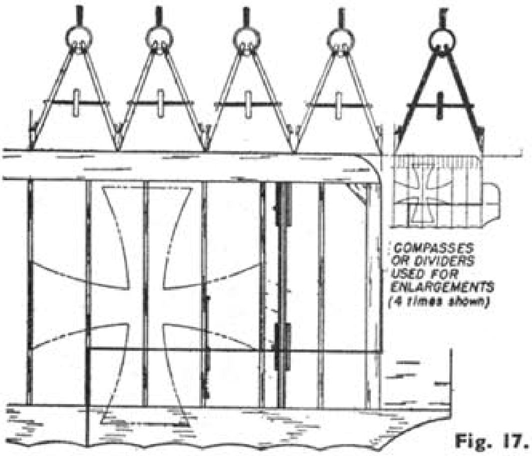


Fig. 17.

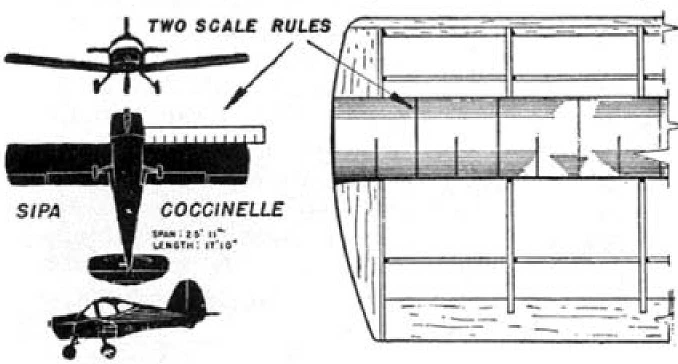
The other methods of enlargement, five in all, are variations of the same basic scheme. This is the use of a datum or base line upon which all measurements are taken so that the enlargement is uniform. Generally, the datum line passes down the centre of an aircraft fuselage in the side view, and is usually indicated on all small-scale drawings by having projections fore and aft. More often than not, it coincides with the engine thrust-line or the upper longeron of the fuselage and it represents practically the only straight line through the length of the aircraft.

On the plan view, the centreline is easy to detect as it bisects the aircraft, while the head-on view merely has the plan view centreline and side datum projected on to it to form a cross.

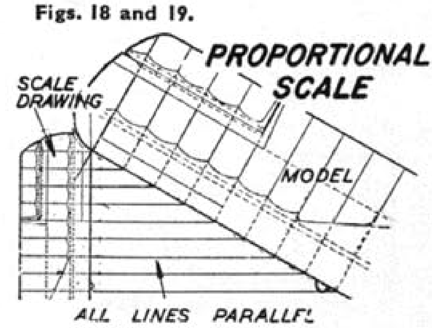
These base lines will be the first to go on our model plan. We measure along them for length and spacing of components. Up and down from them we project distances for fuselage depths, etc. The golden rule is to pin the paper firm on the drawing board, use a tee-square or long straight edge for the datum lines, and an accurate set-square for projecting up or down verticals.

We start with the side elevation, marking off key points along the datum where contours change or components are fitted, and working from nose to tail, we double check that all is accurate in scale before going ahead with the up and down dimensions above or below this first datum. Curves are completed by a system known as " Visual Interpolation " through the grid method. This may not be necessary for the longer and shallow fuselage outlines: but for a fin and rudder, particularly when of " trade-mark " shape like those on De Havilland aeroplanes, it is the quickest means oı ensuring a faithful representation of the full-size.

By covering the original drawing with a network of lines which are equally spaced to form squares, and providing a set of similar squares of scaled-up proportions on the model drawing, it is possible to get an outline simply by " eye ". For example, our 1/72nd scale Piper Tri-Pacer drawing would need a network of lines spaced $\frac{1}{12}$ in. apart on the fin outline and a representative set of lines $\frac{3}{4}$ in. apart on the model drawing. This nine-times enlargement is surprisingly accurate in spite of the rather " coarse " difference in the size of the squares concerned. Points on the curvature are plotted just like map references, and after being connected with a soft pencil lightly sketching a rough outline, the final line is positively scribed, using an " H " or hard pencil drawn around a french curve. Avoid using soft pencils for drawing any final



Figs. 18 and 19.



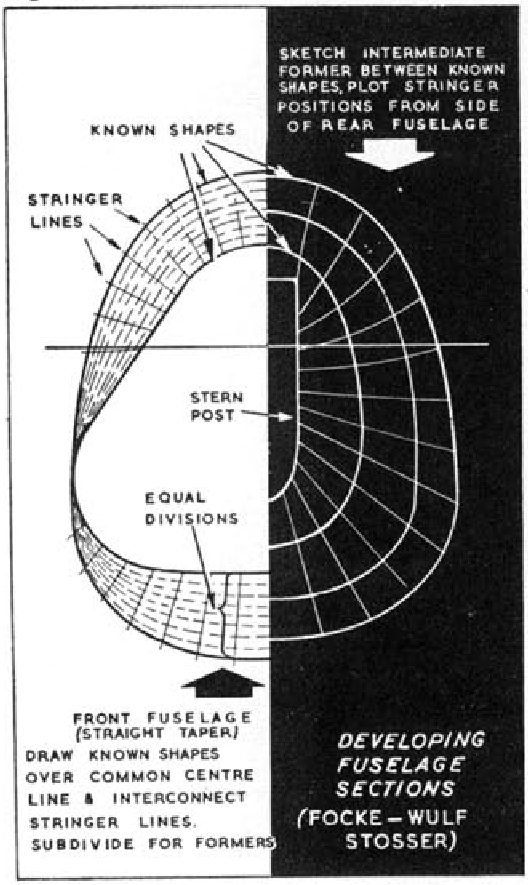
lines, they wear down too quickly, leave lines of varying thickness, and tend to smudge and make the drawing look scruffy. Mistakes with a hard pencil are easily and cleanly erased—those with a "B" or soft lead also erase with ease, but tend to leave a surround of dirty marks that soon render an otherwise good drawing offensive to the eye.

That, in brief, is what we have to do when an enlarged drawing is begun. The means by which we obtain the dimensions are diverse, and depend upon the choice of one of three instruments. They are: Proportional Dividers, Compasses, or the Slide Rule. Add to them the ordinary rule, and slight brainwork needed to construct either a proportional scale, or a pair of scale rules, and we have the lot.

First on our list were the *Proportional Dividers*. These are part of the professional draughtsman's equipment, and being precision instruments, are rather expensive to buy (from £2 10*s*. 0*d*. to £8 10*s*. 0*d*.) just for our purpose. We can, however, make a most effective pair to suit the degree of enlargement needed, and patience in making an accurate instrument will soon bring the reward of providing a fast drawing *without calculation*. All we have to do is to ensure that the proportionals are set right to start with, and any measurement can be transported from the small original to the model size drawing in a moment.

The instrument works on a "scissors" action. Two arms are crossed with a firm pivot, and since the length of the arm is greater on one side of the pivot than on the other, a proportion of motion exists between the extremities of the arms. For example, if the pivot is so arranged that the arms are 4 in. long on one side, and 2 in. long on the other, then the distance between the ends of each set of arms will be 2:1 in ratio for any setting. To make our own set, one could use two lengths o. $\frac{1}{8}$ in. $\times \frac{1}{8}$ in. hardwood for the arms, with gramophone needles or sharpened points of 16 gauge piano wire to make the actual pointers at the arm ends. Since the position of the pivot point

Fig. 20.



is not easy to obtain by calculation, it is simpler to use a practical method of finalising the actual pivot point.

Cross the arms in scissors fashion so that one set of pointers are exactly 1 in. apart, and the other set are proportionally farther apart. In the case of our 1½ in.-1 ft. Piper Tri-Pacer, it would need to be as much as 9 in. At once it becomes obvious that the arms have to be about 10 in. long to obtain this 9:1 enlargement, in fact, the longer the arms, the more chance there will be for error. The author prefers not to take proportionals out more than a 5:1 ratio, so one can actually reduce the possibility of false measurement to a minimum, and would advise anyone to split a 9:1 enlargement into two stages of 4½:1.

So we cross the arms with opposite pointers set at 1 in. and 4½ in. respectively. Now drill through the pair of arms to make the pivot point, and bolt

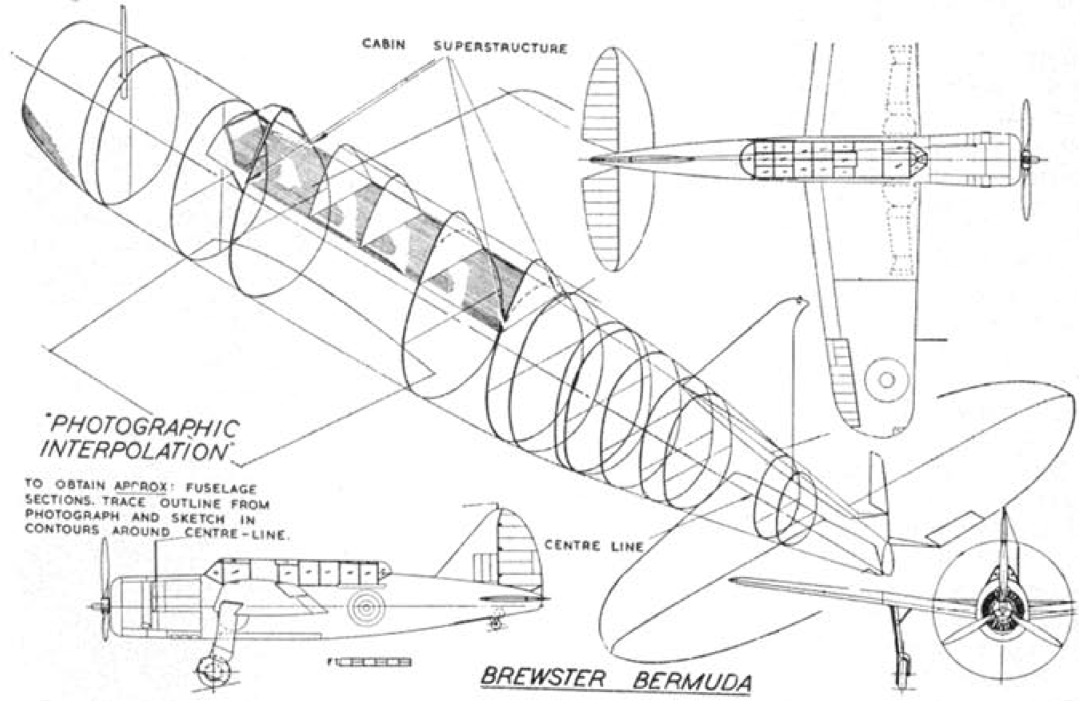


Fig. 21.

up so that the scissors are friction tight. Most important is the fact that when closed, the arms should be exactly over one another, and the points just touching at either end.

Now set the smaller arms on the wing chord of the 1/72nd Tri-Pacer drawing, and the span of the opposite, larger arms will be the actual wing chord of the model.

A more advanced set of proportionals could be made with a slotted centre to each arm so that the pivot can be varied for a change of enlargement ratios. The true value of the proportional divider lies in its ability to give any ratio simply by altering the pivot. Thus, if our model needs to be of an awkward scale of, say, 1.3 in. to the foot, or is being enlarged from a Continental Metric scale drawing to Inch dimensions, the variable ratio is brought into play and, once set, makes the enlargement simple and entirely free of tiresome calculations.

For a " straight-factor " enlargement —such as the nine-times Tri-Pacer, etc. —we can also dispense with calculation, and utilise the simplest of drawing instruments, the *Compasses*. Dividers serve the same purpose, but the pencil mark left by a pair of compasses is neater than a series of prick marks on the type of paper used by the average modeller for his building drawing! The system is as follows. Take the dimension to be enlarged and set the compasses to the exact figure. Now transfer the dimension to the model drawing by marking off so many spans of the compasses. For example, a nine-times enlargement calls for nine spans of the instrument. Unfortunately, this system does lend itself to possibilities of error in that unless the original measurement is precise the final enlargement will be inaccurate—perhaps to a great magnitude. The possibility of error is such that the system is only recommended for enlargements in the order of two of three times.

So far we have discussed the photostat, and three means of self-drawn enlargement. All have been open to error, and since the whole object of this treatise is for the production of true-scale models, we shall now reveal the three acknowledged methods of indisputably accurate enlargement.

The first is our favourite, and it has been called the *Two-Scale-Rule* method. It is just that—we make two scale

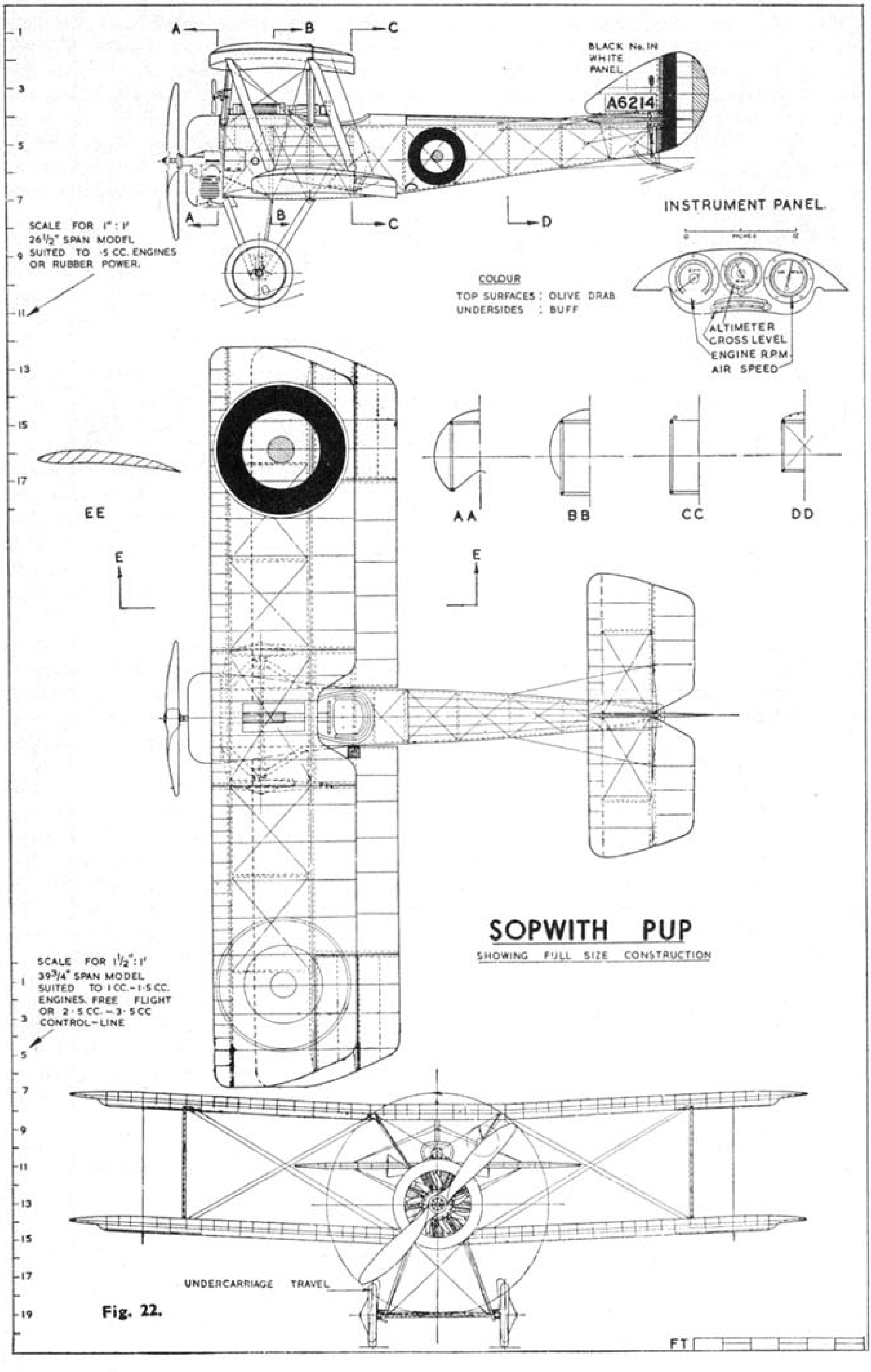

BLACK No. IN WHITE PANEL
A6214
INSTRUMENT PANEL.
SCALE FOR 1" : 1' 26½" SPAN MODEL SUITED TO ·5 CC. ENGINES OR RUBBER POWER.
COLOUR
TOP SURFACES : OLIVE DRAB
UNDERSIDES : BUFF
ALTIMETER
CROSS LEVEL
ENGINE R.P.M.
AIR SPEED
EE
AA
BB
CC
DD
SOPWITH PUP
SHOWING FULL SIZE CONSTRUCTION
SCALE FOR 1½" : 1' 39¾" SPAN MODEL SUITED TO 1 CC.–1·5 CC. ENGINES. FREE FLIGHT OR 2·5 CC.–3·5 CC CONTROL-LINE
UNDERCARRIAGE TRAVEL
FT

Fig. 22.

rules, one for the original drawing, the other for the model, and we simply cannot go wrong. Let us presume that our original is 1/72nd scale, and that we are making a 1/12th size model. This is perhaps the easiest possible example, for 1/72nd is represented by $\frac{1}{6}$ in. equals one foot and 1/12th is obviously an inch to the foot.

We make one scale rule only in this case, and it should show about 12 inches divided into sixths and marked so that each $\frac{1}{6}$ in. is one foot. The 12 in. rule will represent a total of 72 ft. On the end divisions, we can subdivide so that smaller dimensions can be read, such as 3 in., 6 in., and 9 in. For the model scale rule of 1 in.-1 ft., all we need is an ordinary ruler.

To begin operations, measure the original drawing and take the reading in feet and the nearest 3 in. Perhaps the wing chord has been selected as the first item, and this reads 6 ft. 6 in. Now take up the larger scale rule for the model, and read off 6 ft. 6 in. on that, then transfer the figure to the drawing. Awkward scales are just as easy to deal with in this manner: but as the majority of originals likely to be used will be 1/72nd, 1/48th or 1/36th, the task is further simplified by the provision of Architects' rules, or Printers' "Ems" rules which are divided in these fractions. The important thing to remember is that both the original and the model drawing are read in terms of full-size dimensions which, after all, are the common factors.

Next on the list is the *Proportional Scale*—advised for small degrees of enlargement only: but eminently suitable for any ratio of enlargement without resorting to calculation. It is also known as the diagonal ruler method, and for accuracy, a straight-edged Tee-square, set square and sharp pencil are essentials.

Start by selecting the largest dimension likely to be required. This will probably be the wingspan or fuselage length, and might be a matter of 5 in. on the 1/72nd original. Since the model is to be a small one, let us assume we are using a span of 18 in. for Jetex 50, and we now have a degree of enlargement in the order of $3\frac{1}{2}$:1 which is about the limit of the diagonal ruler system.

Draw a line along the Tee-square, and project a 5 in. vertical line at one end to represent the original drawing. Then connect the two extremities with a diagonal line measuring 18 in.

Keep the paper pinned firmly in the same position, and measure off any required figure *down* the vertical line from the top. Then use the Tee-square to draw a horizontal line from the point measured, and the intersection with the diagonal line will be the enlarged measurement. Providing all drawn lines are fine, and that all the horizontal projections are parallel to the base line, this scheme is very accurate indeed.

Last on our list, and most accurate of all, is the system of *Multiplied Measurement.* Readings are taken on the original and multiplied longhand or by slide rule by the determined factor of the enlargement. The slide rule is, of course, the easier way: but not everyone is trained in the use of the instrument. For the man who has to resort to calculation by longhand, the task becomes a brainteaser if the multiplication factor is not simple, and patience is likely to run dry after the first page of notepad paper is covered with odd sums. It is a saving grace of the average scale modeller that he enters into the task with unrivalled enthusiasm: but the newcomer is strongly advised to leave Multiplied Measurement to experts like the *Aeromodeller* draughtsmen, and to use the Two-scale system for even-factor enlargements, or home-made Proportionals for awkward factors.

SCALING UP THE PLAN
(SEQUENCE AND EXAMPLES)

Sequence	Limit Example (Jetex)	Limit Example (F/F Power)	Limit Example (Ducted Fan)	Limit Example (Control-line)
A. Decide on power and subject.	100 unit Fouga Magister.	1 c.c. Piper Tri-Pacer.	2·5 c.c. Fokker Mach-Trainer.	5 c.c. Boeing P.26.
B. Refer to weight required (Selection Table).	4 ozs.	20 ozs.	25 ozs.	40 ozs.
C. Divide weight per c.c., or Jetex, by load factor per sq. ft.	$\frac{4 \times 144}{6}$ sq. in.	$\frac{20 \times 144}{8}$ sq. in.	$\frac{25 \times 144}{10}$ sq. in.	$\frac{40 \times 144}{16}$ sq. in.
D. Answer in sq. in.	96 sq. in.	360 sq. in.	360 sq. in.	360 sq. in.
E. Full-size span and chord.	39′ 4″ and 4′ 7″	29′ 3″ and 5′ 3″	39′ 6″ and 8′ 6″	28′ and 6′
F. Aspect Ratio.	$\frac{39 \cdot 3}{4 \cdot 63} = 8 \cdot 5$	$\frac{29\frac{1}{4}}{5\frac{1}{4}} = 5 \cdot 57$	$\frac{39\frac{1}{4}}{8\frac{1}{2}} = 4 \cdot 65$	$\frac{28}{6} = 4 \cdot 66$
G. Span of model for area.	$\sqrt{96 \times 8 \cdot 5} = 28 \cdot 6''$	$\sqrt{360 \times 5 \cdot 57} = 44 \cdot 8''$	$\sqrt{360 \times 4 \cdot 65} = 40 \cdot 9''$	$\sqrt{360 \times 4 \cdot 66} = 40 \cdot 95''$
H. Nearest scale.	$\frac{3}{4}'' = 1'$	$1\frac{1}{2}'' = 1'$	$1'' = 1'$	$1\frac{1}{2}'' = 1'$
I. Scale span, chord and area.	$29\frac{1}{2}'' \times 3\frac{7}{16}'' = 101$ sq. in.	$43\frac{7}{8}'' \times 7\frac{7}{8}'' = 345$ sq. in.	$39\frac{1}{2}'' \times 8\frac{1}{2}'' = 336$ sq. in.	$42'' \times 9'' = 378$ sq. in. (Minus tip losses)
J. Enlargement factor and advised method.	3 × 1/48th or odd factor times metric original. Use diagonal scale or proportional dividers.	9 × 1/72nd. Use two-scale rules or proportional dividers.	6 × 1/72nd, or 4 × 1/48th. Use two-scale rules or proportional dividers.	9 × 1/72nd. Use two-scale rules or proportional dividers.

Chapter Four Requirements for Flight

HAVING completed the outline of our scale project we are now faced with the most interesting task of filling in the detail and designing the model so that it will fly. There is one very important point to bear in mind—full-size aircraft are not necessarily auto-stable and have a pilot to correct any wayward tendencies while our little model must fend for itself in the fight against the elements.

The model must be automatically stable, that is to say, capable of restoring itself to normal attitude if upset by a gust or faulty launch, and it must be able to retain this virtue with power on or off.

Against us there is one big bogy which we generally call " scale effect ", a term widely used in the full-size and model spheres to cover a multitude of design sins—but which has a smattering of truth in it, sufficient to make our design problem all the more interesting.

One would not expect a small dinghy to compete in terms of efficiency with a large racing yacht, nor can one match a 750 c.c. car in the 8 h.p. class with a 3,500 c.c. V-8. In the same way we do not expect a small aeroplane to be as efficient as a larger one—though there are limits to this supposition as the manufacturers at Bristol and the Isle of Wight have discovered. Just as it obviously pays to build large for efficiency in the airframe, so it can be understood that to reduce the size down to the diminutive ⅛th scale flying model, we must lose something in the process.

A wing depends upon its aerofoil section for lift, and when reduced from 5 ft. 3 in. down to a mere 8 in. in chord, or width, it quite obviously suffers from a loss of efficiency. This is particularly so in the case of most monoplanes where a " bi-convex " section is employed to obtain good performance through a wide speed range and at what are known as high *Reynolds Numbers.*

The Reynolds No. is, in plain language, the measure of air molecules which pass over the wing surface, and we arrive at this magic figure by multiplying Speed (ft. per sec.) and Chord (feet), and dividing by .000157. Now for full-size aeroplanes, flying at 120 m.p.h. with a chord of 5 ft. 3 in. in the case of the Tri-Pacer, the Reynolds No. will be many times higher than for an 8-inch model chord flying at 10 m.p.h. Since the characteristics of the aerofoil change according to this Reynolds No. we therefore have many hundreds of aerofoil contours in use for varying sizes and speeds, and it becomes increasingly obvious that what suits the full-size will rarely do for the model.

There are exceptions to this, of course, and they are the " high lift " aircraft like the Fieseler Storch, Prestwick Pioneer, or D.H.C. Otter and Beaver. Each of these aircraft has been designed for maximum utility and low speed landings with a high safety factor. They use aerofoils much after the type employed in sport flying models, and can therefore be reproduced to exact scale—aerofoil included.

The majority, however, are out of this classification and employ the bi-convex profile for a higher cruising speed. By far the most popular aerofoil with full-size designers and one that is used for multi-engined aircraft as well as the diminutive Druine Turbulent, is N.A.C.A. 23012. We can take this section as a fair example of one that is perfect for wing chords of 48 in. and above, and speeds of more than 30 m.p.h.—which would be the absolute minimum for landing a single-seater lightplane.

Look at the profile and you will see that the upper curvature is approximately 1½ times more than that for the lower surface. For this reason, the section is frequently known as the ⅔rds " Symmetrical " aerofoil, as opposed to the flat bottom variety such as

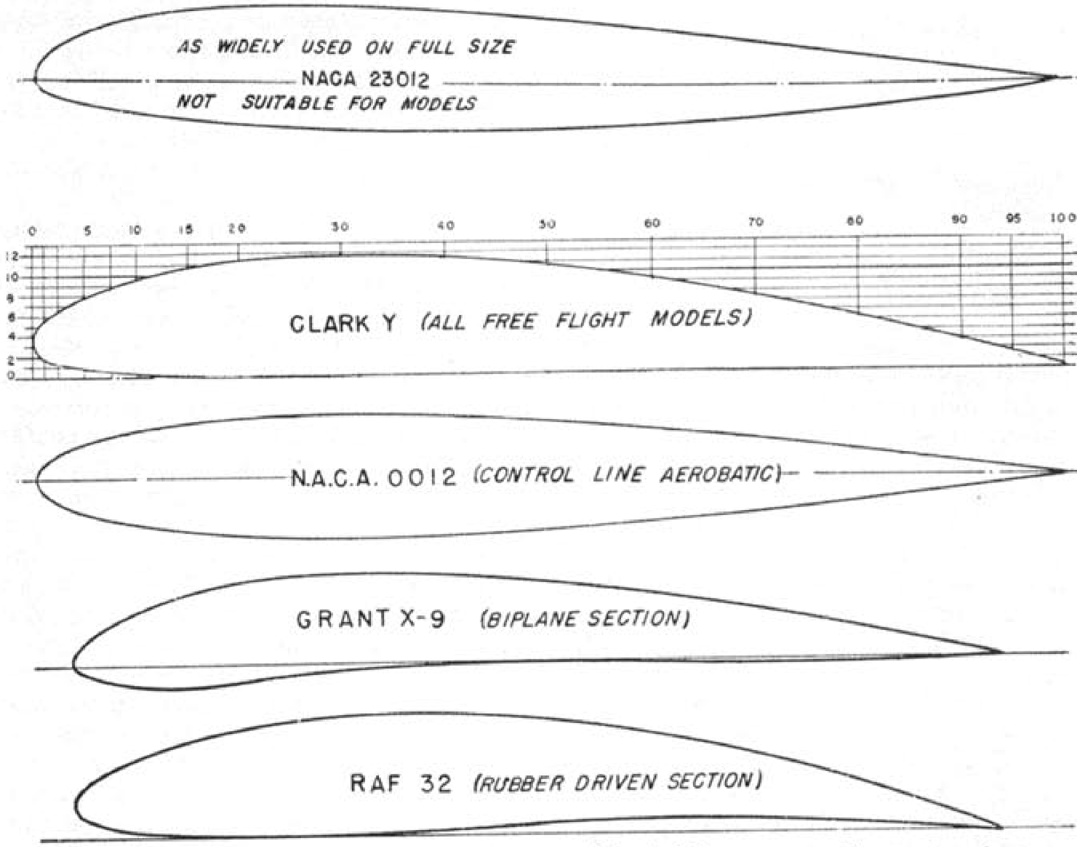


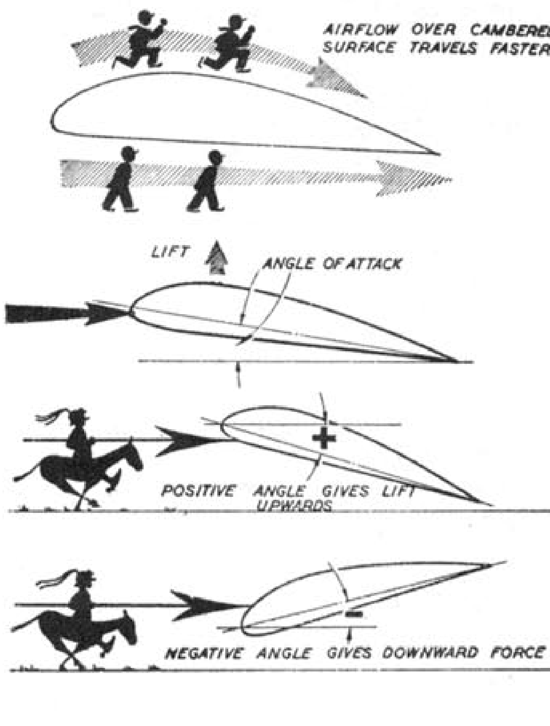
Fig. 23.—Aerofoils most suitable for flying scale models.

Clark Y, or the fully symmetrical R.A.F. 30. Now, without delving deeply into the involved subject of aerodynamics, we can see at a glance that the near-symmetrical aerofoil will either have to fly fast or at a considerable angle to maintain lift.

As the air molecules reach the leading edge of the wing, they part to go over and under the aerofoil, and meet again at the trailing edge or just behind that point. In order that the molecules should rejoin one another in harmony according to a famous Joukowski theory, those travelling the greater distance over the upper surface will have to speed up faster than the lower airflow. By so doing, the air pressure on the upper wing surface is lowered, and this in turn means "lift". At the same time, if the aerofoil is set at an angle to the approaching airflow, then the air molecules striking the lower surface at an oblique angle will provide an increase of pressure on this surface and help to push the wing up.

All of this serves to illustrate what we need for a flying scale model. For it

Fig. 24.—How the aerofoil generates lift.



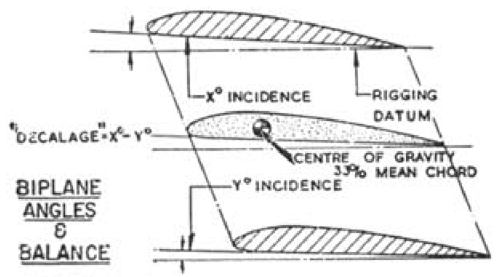


Fig. 25.

should be obvious that the greater the distance over the upper surface of the wing than the same chordwise measurement of the lower surface, then the more lift we can expect for any given airspeed. If the lower surface is completely flat, as in the case of Clark Y, then we shall have the right type of aerofoil for our model, especially if it is a monoplane.

Clark Y will lift at a wide range of angles, and airspeeds. N.A.C.A. 23012 will stall if the *model* airspeed falls even a little below its critical figure, which is usually far too high for our requirements. That is the contrast, and our advice is that the flat-bottomed Clark Y should be used on all scale models with an expected moderate flying speed. If the model is to be one of the fast-flying " crashproof " types, then the thickness of the aerofoil can be reduced to minimise drag, and a 60% Clark Y employed; but the actual thickness of the wing is finally determined by the spar depth required in such cases.

Another different category for aerofoil selection is the biplane. Full-size biplanes use rather thin sections which are not exactly accommodating for model spars, etc., but which are quite good for slow-speed work with a minimum of " biplane interference ". This is what happens when the low pressure area of the bottom wing starts interrupting the airflow over the top wing. Wing stagger, placing one wing in front of the other, is a solution adopted by most aircraft designers, and this also makes for stability in a model, so is a point in favour of types like the D.H. Tiger Moth.

Typical of the biplane aerofoils is R.A.F. 15. If the structure allows it, this section can be retained for the model. Should deeper spars be needed, then there are other sections of similar character, having the little dip in their lower surface, such as Eiffel 431, Grant X-8 and 9, and U.S.A. 27, in that order of recommendation.

So far we have only touched one of the " design " items to fill in our scale model outline: but it has been the most important, and will determine the success or otherwise of our model. Assuming that Clark Y is the aerofoil of our choice, we now have to reconcile its profile with the lines of the model so that the change in section does not offend the eye. To begin with, we must first position the section on the blank side view of the model at the angle of incidence needed for flight. This may be taken to be 3° positive angle (leading edge lifted) and with a flat-bottomed aerofoil, such a measurement is easy work, using a simple protractor. The datum line for the model will be our base level, and the bottom of the section set at 3° to this —keeping the upper surface as near as possible to the position of the full-size camber. This will at least retain the scale outline, the interior detail can be adjusted within the side view. For instance, the bottom of the model wing may come higher on the fuselage than the scale position indicates, and there will be an increased gap between the cabin and the wing. Such a situation is overcome by meeting the problem half-way and making the cabin slightly deeper, leaving paintwork to camouflage the rest.

Just as we have set the wing at an angle of incidence, so we must now determine the tail angle and its section. This is not a particularly easy decision to take, in fact, very few aeromodellers find that their designs fly at the first

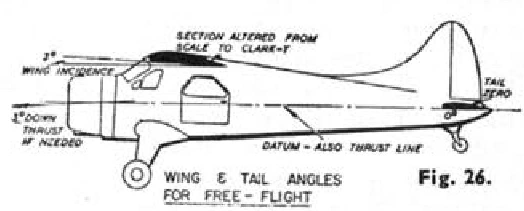


Fig. 26.

position given for the tail, so this important "stabiliser" (as it is known in the U.S.A.) is best left detachable or adjustable for initial trimming tests. We have already discussed the question of tail percentage—or the proportion of tail area to wing area and the actual size of the tail will have a lot to do with the section used.

The choice is threefold. The tailplane can be flatplate, lifting, or symmetrical. As a variation, the lifting section can be inverted: but this is such a comparative rarity used for extremely low-powered models or those with large tail area, that we can dispense with the thought for our purpose.

Invariably, the section of the full-size aircraft tail will be a rather thin symmetrical aerofoil, sufficient in depth only to accommodate the spars needed to support the surface. Light aircraft are less streamlined, and mostly have flat section tails with tubular structure forming a radius at the edges: but as indicated for the choice of wing aerofoil for the model, what goes for the full-size will not necessarily do for our miniature.

The golden rule is to assess the amount of power to be utilised for the model and to consider whether the tail area is sufficient to control it. For the tailplane quite obviously has the duty of supporting the rear end of the model in a normal attitude of flight. Should the model fly fast, and the power be sufficient to cause the model to ascend in a steep climb, then the tailplane should be able to generate enough lift to prevent the climb from developing into a series of loops. For example, a model of the low-wing Druine Turbulent was built with a scale section symmetrical tailplane. It flew very well on

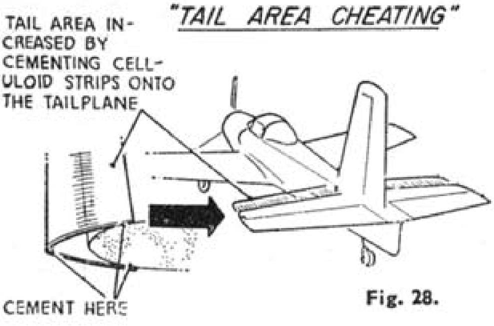


Fig. 28.

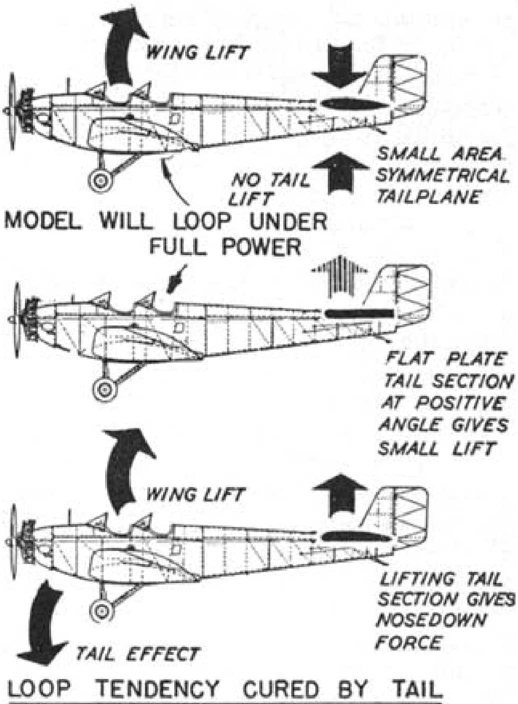


Fig. 27.

reduced power: but each time the engine peaked as the fuel ran out, a loop resulted from the sudden surge of extra power. Now the tail on this model is small indeed. Only some 18% of the actual wing area can be used, and being symmetrical, very little lift derived from it. An experimental lifting tail was made, with exactly the same thickness and area: but with the bottom surface flat and upper profile curved. With this tailplane, the climb was completely controlled, and the steep ascent becomes a left spiral climb instead of a series of loops.

First, check on the area percentage. If it is below 25% of the wing area, then most definitely use a lifting tail with 60% Clark Y or similar aerofoil. If the tail is larger, then try to keep to scale by reproducing a flat surface with sheet balsa, or building up a streamlined section. In all cases, set the tail parallel to the fuselage datum for initial tests, and make it removable for those vital first flight tests.

All of the foregoing will apply to any free-flight scale model. For control-line we have no difficulties, and scale sections can be employed on both wing and tail, though all angles should be neutral to the fuselage datum.

With the wing and tail sections decided, the next aerodynamic question is that of stability. There are three directions in which the model should be auto-stable: Longitudinal, or up and down; Lateral, or rolling from side to side; and Directional, or right and left. We have dealt with Longitudinal in part by our decision on the aerofoils, and the next one to consider is Lateral.

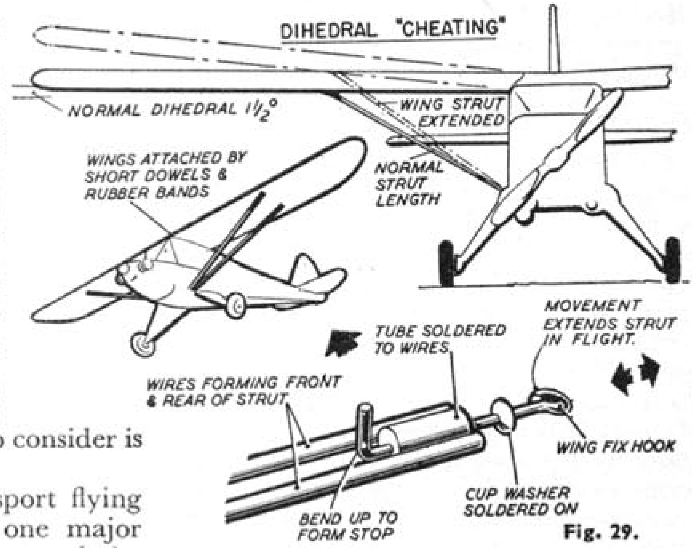


Fig. 29.

Anyone who has built a sport flying model will appreciate that one major difference between his product and the full-size is the upward and outward sweep of the wings. This is called Dihedral, and it governs the lateral stability to such an extent that it enables the sport model to hold an incredibly tight turning radius without losing height. It is normal to use up to 10° of dihedral on a high-wing model, and as much as 15° for low-wing ; but we cannot expect our scale subject to remain realistic with such unnatural angles.

More often than not, the subject of our choice has no dihedral whatsoever !

On the full-size aircraft, the pilot is able to keep lateral stability by diligent use of aileron control, and only a minimum of dihedral is used to aid "hands-off" flying. There is a simple answer to this little problem—cheat ! Everyone does it, so you need not have a pang of conscience at committing a travesty of true-scale. What matters is that you make the alteration so that the dihedral increase is not obvious. Up to 5° is desirable ; but on an aeroplane not intended to have any dihedral, this amount can change the appearance too much, so it is better to restrict the increase to a limit of 3° more than the full-size allows. More dihedral can be used when the wings are allowed to swing upwards under flying loads. This is effected by using two-part wings that plug on to short dowel stubs at the fuselage joint, and have extensible wing struts. When flying, the wings lift from their "at rest" scale position, and in the air the appearance is not unduly affected. Should the wings be completely cantilever, or without struts, then we have no option but to keep within 3° of true angle at all times.

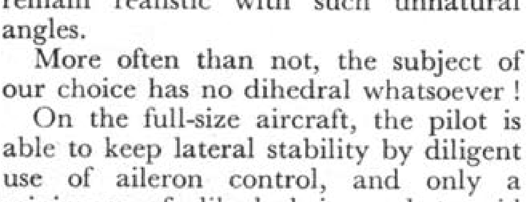


Fig. 30.

Directional stability will result from the function of the rudder, and torque reaction from the airscrew. In general, the natural turn of a power model will be to the left and upwards; but if the nose is long, and wing low, this left turn can be too tight for comfort and has to be compensated with right "sidethrust".

This means that the engine is offset, pointing to the right of the fuselage centre line, and the resultant sidethrust enables the model to fly straight, or with a larger turn.

Since torque reaction will be in proportion to the speed of the engine, we can sometimes control a nasty turn to the left with a change of airscrew with finer or less pitch. The higher revs of the engine will, in most cases, reduce torque effect and provide a different flight pattern. So it will be seen that for the purposes of our initial design, the engine can be positioned to coincide with the thrustline of the full-size aircraft, unless it is a long-nose, low-wing type, which should certainly need right thrust.

Another means of directional stability control is the cambered fin and rudder. By using a lifting section on the vertical tail surface, the increased airflow from the slipstream will cause the tail to counteract torque swing in power flight, while the effect in the glide is considerably reduced due to the lower speed. Again, this is only a necessity for the less conventional type of aeroplane ; but its use led to the development of the pendulum rudder which will be found detailed in Chapter 6, and it is a favourite with those who build the faster flying scale models.

For control-line, the cambered fin is an asset if used to direct the model out of the circle, so keeping the control-lines taut, while use of discreet engine offset is a boon to any aerobatic design.

Thus we have covered the main aspects of our project and catered for the four forces which balance out for safe and stable flight. *Thrust* we provide with the means of our choice, adhering to the full-size airscrew or jet position. *Lift* is derived from our choice of aerofoil, the wing angle and dihedral. *Gravity* will be personified by the finished weight of the model, and *Drag* we must keep to a minimum with clean workmanship.

To balance these forces, our greatest concern will be to see that the weight distribution is so arranged that the model balances at a point between 25% and 40% average wing chord, and this will determine what we have to do in our next stage, which is to fill in the designed structure.

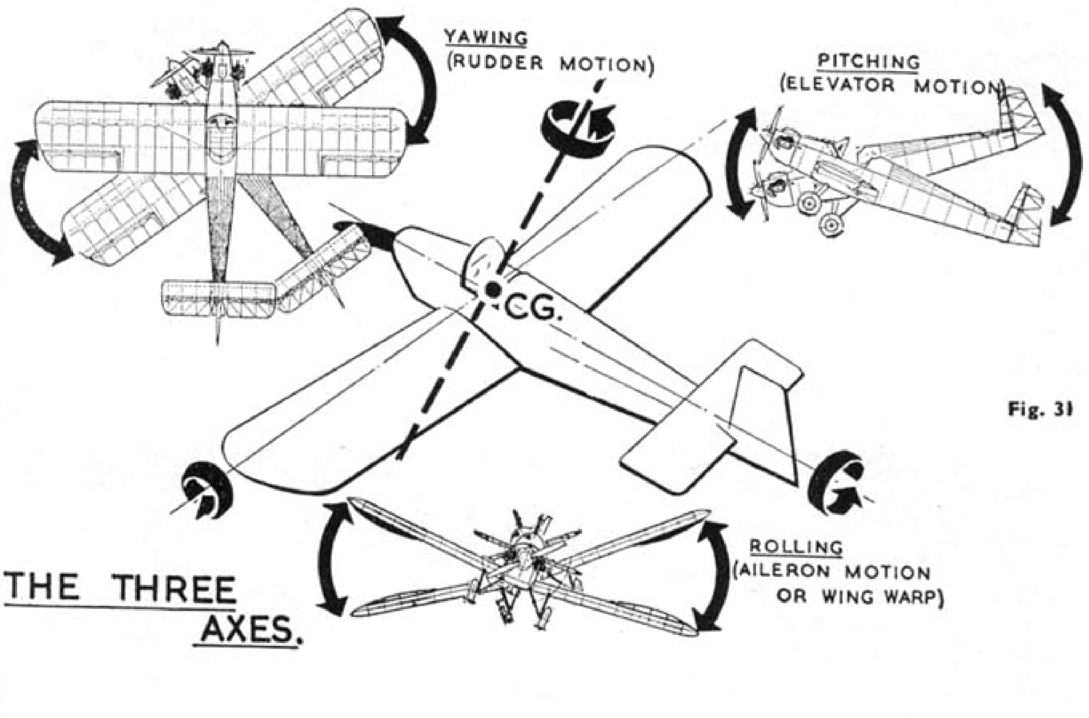


Fig. 31

Chapter Five Detail Design

THE outline of our model is now complete, and we have positioned the lifting surfaces, engine, etc., so that we shall have the minimum of difficulty in making it fly satisfactorily. What we have to do next is to distribute the structure so that the scale contours are retained in a realistic manner combined with ample strength, and the weight is within estimated limits.

It is always a difficult matter for the model maker to provide an accurate weight estimate simply by looking at the construction of a model, and we are in no position to suggest that one should be able to build exactly to an ounce in final weight. One of the Author's models, intended for 14 oz., came out at a scant 11 oz. while another that was supposed to be 16 oz. finally balanced the scale at 18 oz. when the last lick of colour dope had been applied!

We can get within a sensible tolerance in weight by choosing light or heavy structure as the case may be, and using various grades of wood to suit the purpose of each component part. Remember that if a tail unit is four times as far from the balance point as the propeller, then it will take a whole ounce in the nose to cancel out ¼ of an ounce of extra weight in the tail, and similarly an overweight nose unit will need balancing out at the tail.

The shape of our aeroplane will be the deciding factor on its construction. If it is a slab-sided type like the Auster A.O.P. 9, or Short Seamew, it can be made with solid sheet sides, thin for a rubber-driven model, and up to ⅛ in. thick for power. But the slab-side subject is hard to find—full-size designers having an aesthetic eye for more streamline contours, and, more often than not, we have to deal with an elliptical section on the fuselage. This in itself is a source of difficulty for the unwary, and we must be particularly careful to see that the formers or bulkheads blend in a smooth flow of contour throughout the fuselage length.

There are several approaches to the streamlined fuselage, and they are all based upon some form of "crutch" system to key the formers. The crutch can be vertical or horizontal, as a tube through the fuselage centre, or basic box framework, or it can be in the form of a solid stick of hardwood, rather in the manner of a skewer, on which the bulkheads or formers can be temporarily positioned. To understand these many variations, study of the sketches will illustrate the advantages and merits of each system. For light models, Jetex or rubber driven, the vertical crutch is a favourite, especially with the kit manufacturers. Each former is divided into halves vertically, and the crutch is used to build one fuselage half at a time.

First we lay the side outline "backbones" of the fuselage flat over the plan view, and then the half-formers are keyed and cemented in position. It is dangerous, from the warp point of view, to add any more structure at this stage, and the half-fuselage is lifted from the building board and the other former halves added while supported in the

Fig. 32.—The Auster A.O.P. 9 is easily constructed with sheet sides, as on the author's model.

hands. Alternatively, a double set of backbones can be made and butt joined together. Next stage is to add the vital stringers at the widest point of the fuselage, running from end to end and keeping the main backbone straight. These too have to be fitted while the structure is held in the hands, and this basic unit can be set true by eye as each joint is glued. Finally, we add stringers or plank with tapering strips from sheet balsa according to the type. If the full-size is a metal covered monocoque like the Vought Corsair, then it should be planked. A Westland Lysander would be better with regularly spaced square stringers around the fuselage.

The vertical crutch has a disadvantage in that it cannot always be continuous, having to be broken by a cockpit aperture or wing position, etc. In this case we should use a horizontal crutch, again with formers made in halves where a fuselage is nearly symmetrical, or with whole formers " half-turned " in place. The first system is so like the vertical crutch it needs no further explanation ; but the latter is a little more involved. In the first place, only the crutch is built over the plan, and the only construction added to it are the crossbraces which are so placed as to come at each former position.

The crutch is made of stout members, $\frac{3}{16}$ in. square or thereabouts, and, when thoroughly set, is lifted from the board in the shape of a fuselage plan view in skeleton. Each former is cut to shape, and dropped at an angle of 45° or so through the crutch just in front or to

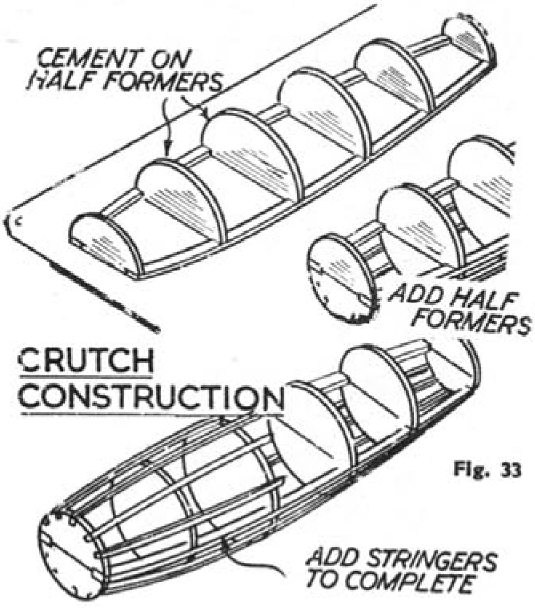


Fig. 33

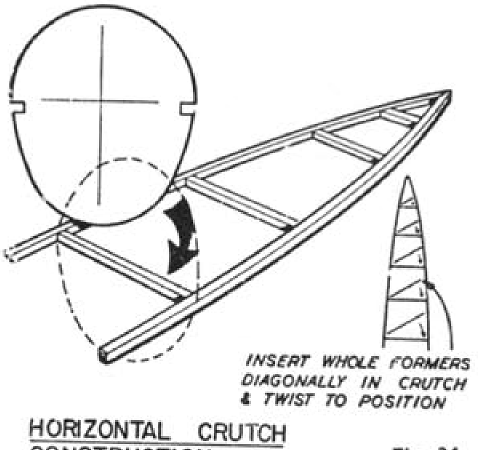


Fig. 34.

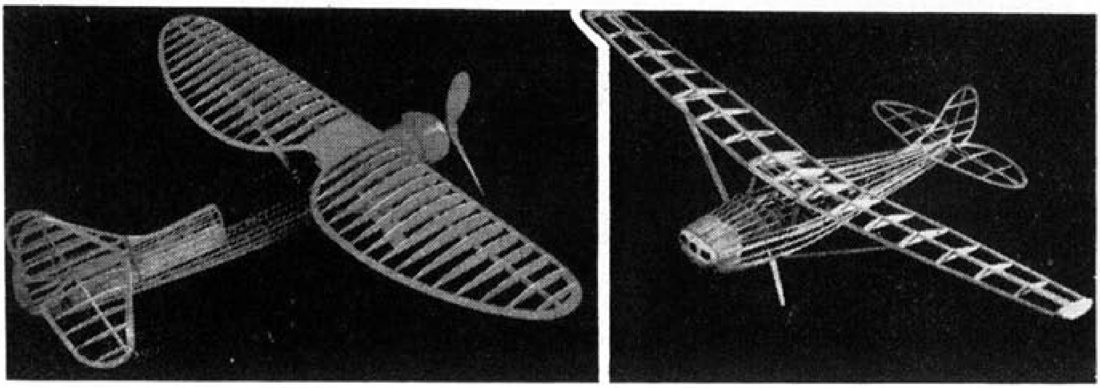


Fig. 35.—Douglas 0.46 at left is for rubber drive, has a central tube of balsa sheet to key formers and protect rubber motor. Cessna 170 at right shows use of stringers on a power model.

the rear of its final position, then "half-turned" to 90° and cemented firmly against the crossbrace and crutch sides. It will be evident that the keypoint of such a fuselage will be the spacing between ıormers to allow them to be fitted. Whichever crutch system is used, one must make sure to get the diagonally opposite stringers in position quickly after all formers are fitted, so that a true line-up can be made and the fuselage does not become twisted out of accurate shape.

For rubber models, particularly those with involved construction likely to call for hours of patient work and specially careful construction, it often pays to take out an "insurance" against the highly probable accident of a broken motor. The impact of a partly wound skein of rubber threshing its way through thin formers and stringers is heartrending and such a misfortune can be rendered quite harmless at the initial building stage. This is by means of the motor tube, a simple parallel winding of thin sheet balsa to make a tube tough enough to take the compression of a fully wound motor, and thick enough in its wall to resist a sudden motor break.

Governing factor of its size will be the shape of the fuselage at its rearmost position where the motor peg is placed. In a Lysander it would be midway between the cabin and tailplane, and the motor tube could be made to come within ⅛ in. of the edge of the former. Assembly is then simplicity itself, each former being threaded on to the tube, and rotated in line fore and aft, then cemented firm. There is no possibility of a twist in plan or side views provided the tube is made straight in the first place and the scheme is to be recommended whenever fuselage cross-section permits on a streamlined fuselage for rubber power.

Speaking of power, the tube system can also be used with a variation for a control-line or free-flight power driven model, substituting the tube with a square section length of hardwood. Set on edge, diamond fashion to avoid whip up or down, the "skewer" system, as we christen this, is rather like a Kebab, that delectable Turkish dish where meats are threaded on a skewer for the enjoyment of inner man. We slide the formers along the skewer until located temporarily and fit the four key stringers to make the basic frame. When the skewer is withdrawn, it leaves a true structure ready to receive the remainder of the planking or stringers.

Crutch or skewer for a streamline shape—what for a near streamline that is not quite slab sided?

Here we use the basic box frame, and select a method which is very close to the full-size method of construction for many types like the Hawker biplanes, the Austers and De Havilland Moths. First we make a side frame over the fuselage drawing, with longerons positioned to take most of the stress without having to adopt small radius curves. For example, we take a cross-section at the deepest and widest position oı the fuselage. Now we draw a rectangle, the largest possible rectangle that will go into the curved shape of the cross-section. Each corner of this rectangle will be our longeron position, and we repeat the process several times through the length of the fuselage to get the intermediate longeron positions from front to rear.

This works well for a fully elliptical fuselage, say a Focke Wulf Stosser, but for a cabin type like the Austers, or open cockpit round top decking aircraft like the D.H. Moths, the upper longeron is better placed lower down, usually as low as the fuselage datum line which coincides often with the thrustline.

Now we make up the fuselage sides in square section balsa, say ⅛ in. sq. for a free-flight power model, and join the two sides just as we would a simple sport model. The square box framework needs a diagonal reinforcement here and there to remain true, and then we are ready to add the embellishments of half-formers and segments of formers to build up the scale cross-section. This scheme is perhaps the most popular oı all, it is certainly not the easiest or quickest; but it brings with it the reward of satisfaction in making the model more or less after the same method as the real thing, and the

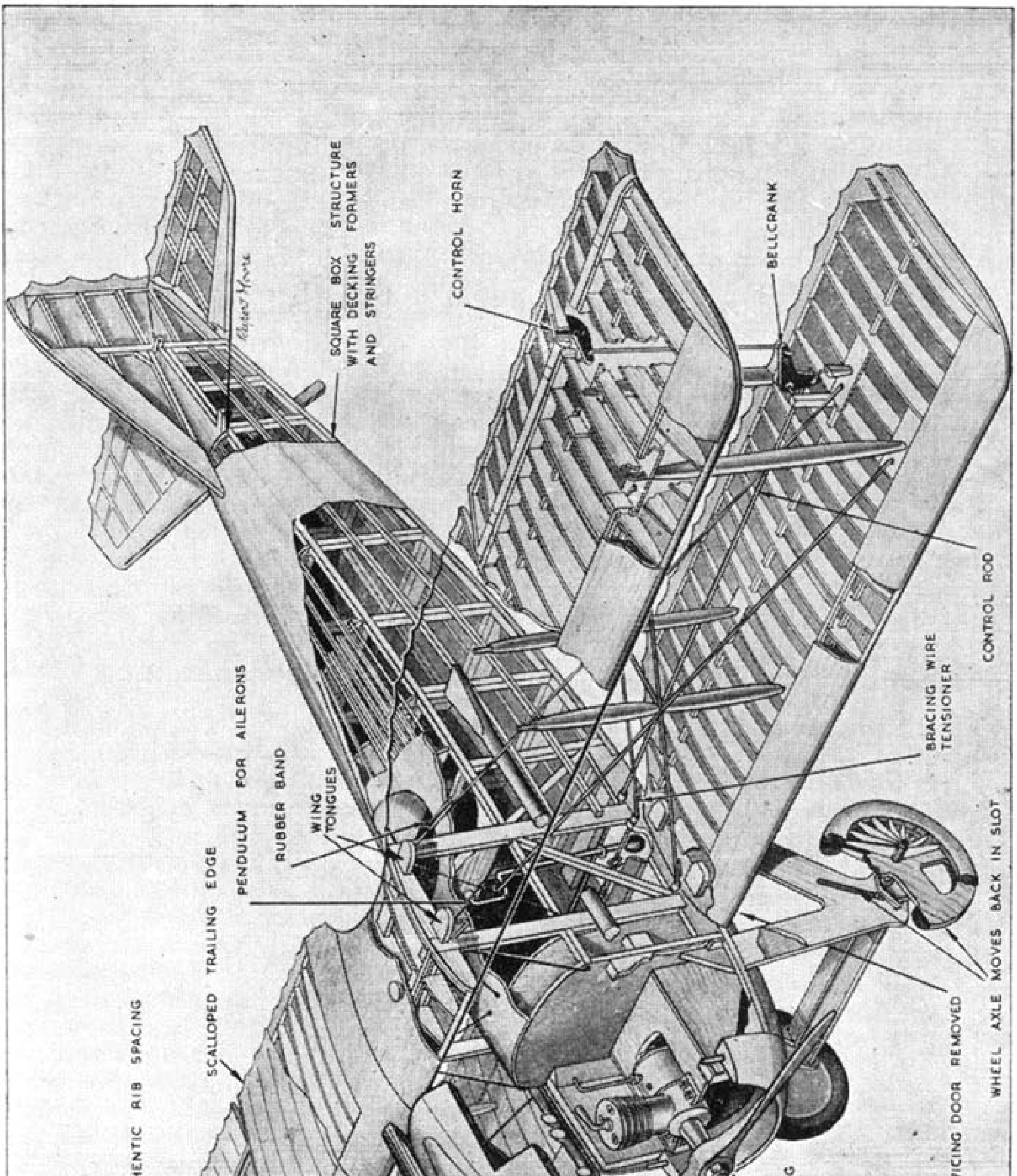

AUTHENTIC RIB SPACING
SCALLOPED TRAILING EDGE
PENDULUM FOR AILERONS
RUBBER BAND
WING TONGUES
SQUARE BOX STRUCTURE WITH DECKING FORMERS AND STRINGERS
CONTROL HORN
BELLCRANK
CONTROL ROD
BRACING WIRE TENSIONER
WHEEL AXLE MOVES BACK IN SLOT
SERVICING DOOR REMOVED
PLY ENGINE MOUNTING PLATE
BELLCRANK
S.P.A.D. S-7C1.
(APS. FSP. 373)

Fig. 36.

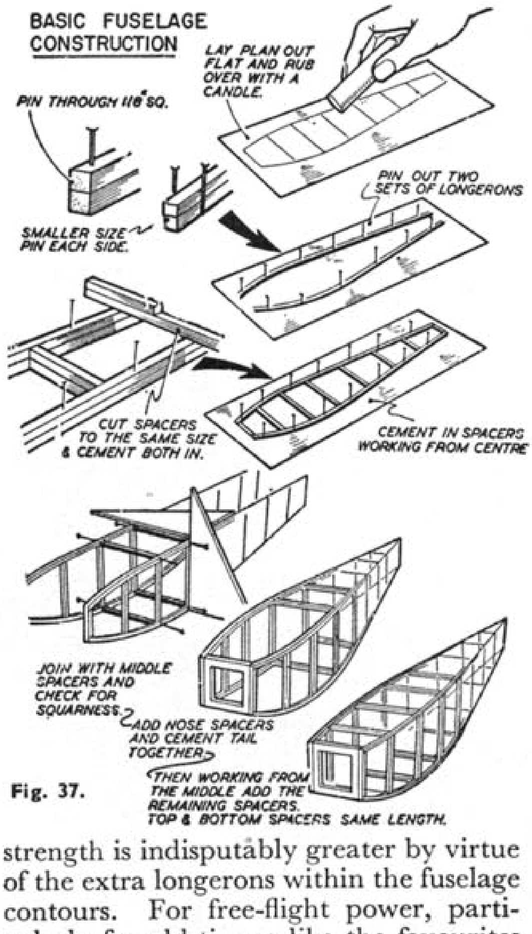


Fig. 37.

strength is indisputably greater by virtue of the extra longerons within the fuselage contours. For free-flight power, particularly for old-timers like the favourites of the '14-'18 War period, and practically all the lightplanes, it has a special

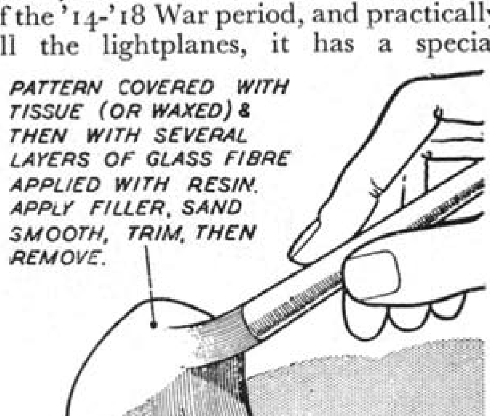


Fig. 38.

recommendation where there are few stringers or other longitudinal members to take the stress of a heavy landing.

Each of the foregoing methods of construction has been in use ever since the model aeroplane first reached the popular kit stage in the early '30s. To-day we have innovations; but few of them can match the lightweight results of the well-established methods.

Consequently these modern introductions are used where weight counts less and strength is a greater need. We refer to glass fibre, papier mâché, and moulded sheet balsa, all of which are particularly adaptable to scale models of modern stressed-skin fighters, including jets which we can now simulate by use of the ducted fan. All of the strength will be in the skin of such a model, and to get this skin to accurate shape without an internal framework, we have to start with a carved block, appropriately undersize of the final model.

Although introduced at this stage as a form of fuselage construction, the methods outlined in the following paragraphs will also cover their application for cowlings, and therefore become an item of interest for all scale modellers for we know of no better means of reproducing the compound curves such as are usually found in a scale engine cowl.

As stated, for all three methods we must start with a dummy fuselage, or cowling, carved from solid block in two halves, vertically or horizontally divided. Though this is a deterrent for most enthusiasts, it really presents no problem other than that of hunting out the original block of wood, and, once carved, we have a regular form from which we can repeat the process many times. The medium we are to use will determine how much smaller, or larger, the block will have to be in order that the final moulding comes out to a scale surface section. For moulded balsa, make it 3/32 in. undersize, for male-moulded glass fibre or papier mâché, $\frac{1}{16}$ in. undersize, or for female or "inside" moulding, exact size. This inside moulding method is the finest and most effective of all, and is well worth the additional effort of the plaster cast it requires. It means that the block is pressed into a box containing freshly mixed plaster of paris so that the impression made is an inside, or female mould, of the original. This is used for the glass fibre or papier mâché which is pressed on the inside surface of the plaster to adopt the scale fuselage shape.

Why go to all this trouble, one might well ask, when the end product is just a streamlined fuselage shell and to get it we have to go through several processes? The answer lies in the word "shell", for the result of our moulding will be a strong skin, not requiring internal structure and with an outside surface as smooth as one could desire. It is the female mould which provides such a surface since it is always the face next to the mould which comes out smoothest when using glass fibre or papier mâché.

So if we dispense with the plaster operation and make our shell directly over the wooden mould, we can expect a beautiful inside surface and a rough outer face, and, take it from us, with Glass Fibre set hard, it is a very difficult job to smooth out irregularities on the outside of a careless moulding.

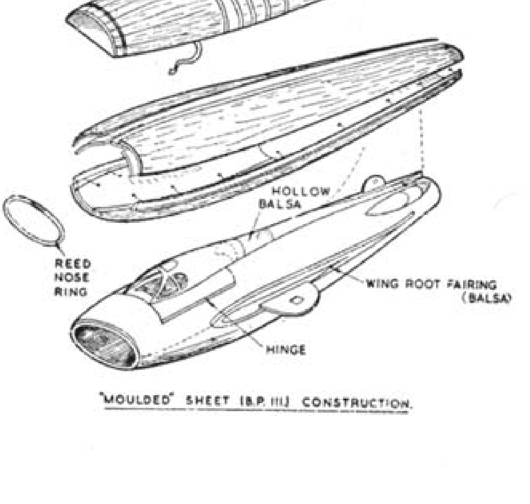
The systems are as follows. Papier mâché is made up of small pieces of newsprint, thoroughly dampened in a cold water paste (wallpaper paste) and applied layer by layer into or on to the mould. The separating agent needed to stop the first layer from sticking to the wood or plaster can be a rubbing of vaseline or beeswax—even a layer of waxed paper will do. Layers are repeatedly applied until a thickness approaching $\frac{1}{16}$th is obtained, and the mould set aside for a day to dry thoroughly. It is surprising how light such a shell can be, and how strong it is after a liberal coat of proofing cellulose varnish, banana oil, etc., is applied. As a general guide, tear the newsprint into 1 in. squares, and use the new type cellulose pastes which are less messy.

Glass fibre requires a little more preparation, but rewards us with greater strength than even the most devastating of crashes would demand. In fact, it is unbreakable if the manufacturers' instructions are followed. Cellophane is the finest separating agent for the mould, and the two liquids, a resin and catalyst, are mixed lin advised proportions and brushed over the form. Then the first layer of glass fibre cloth is pushed down firm on to the mould, allowing the liquid to penetrate through open pores, and more liquid applied. According to thickness required and the amount we can afford either in pocket or in weight, we apply urther layers and in an evening the shell is complete. For cowlings, wheel spats, wing tips, and especially for ducted-fan fuselages, glass fibre is perfect; but please—make the best of it by using an "inside" mould!

The moulded balsa fuselage is the lightest method of stressed-skin construction, and is a refinement to be found in the kits of large manufacturers who possess the expensive presses able to turn out such a desirable prefabrication. Our system cannot, of course, involve a press; but the final result will be as good—even if it does take a hundred times as long to make!

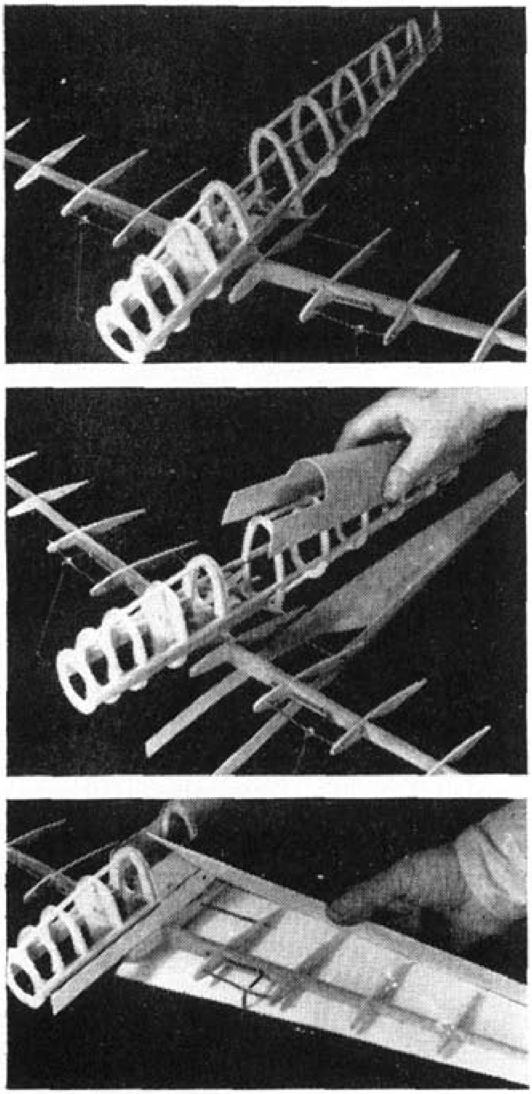
We start with the wooden half-fuselage block, 3/32 in. undersize, and dampen a sheet of straight grained $\frac{1}{32}$ in.

Fig. 39.



"MOULDED" SHEET (B.P. 111) CONSTRUCTION.

Fig. 40.—Author's Nakajima Tony fighter made of basic crutch construction with sheet wrapping for fuselage and wing surfaces, top and bottom.



balsa so that it will easily wrap around the fuselage without cracking, at the largest cross-section. Then we pin or bind this sheet on the mould at the high-point, and proceed to pleat the sheet by cutting out a series of long Vee-cuts and pulling the edges together so that eventually, the $\frac{1}{32}$ in. balsa is as close as possible to the mould surface. The next stage is identical except that this time we must see that the Vee-cuts are in a different position to overlap those of the first layer, and the whole sheet must be tailored to fit, partially dried and then liberally smeared with cement before application on the mould. Lastly, a third layer completes the "ply" and the few deformities on the outer surface are soon remedied with balsa scraps, plastic wood, or cement.

Of course, if we choose an aircraft like the Nakajima Tony fighter with elliptical cross-section and straight taper throughout, we can simply wrap sheet balsa around the fuselage basic structure, having obtained the shape of such a wrapping with a piece of paper for a rough template. This usually applies to the upper fuselage decking of many biplanes and low-wing lightplanes which also have straight taper and can be sheet wrapped.

We have dealt at length with the fuselage, since this is the one component likely to give most difficulty. Wings and tail assemblies follow more regular channels, though their means of attachment vary from type to type. For disposition of spars, one can do no better than follow the arrangements illustrated in this chapter, if possible keeping to full-size spar position where this makes itself evident for scale purposes.

For example, a biplane will have its interplane struts fitted to the spars, and we have to follow this on the model. Spar positions are normally indicated on a detailed three-view drawing of a monoplane as well, and can be used as a guide for the model.

Close rib spacing is a feature of any true-scale replica of the real thing, and to save weight we have to employ thin sheet balsa. Whereas a sport model may have $\frac{1}{16}$ in. ribs at a frequency of 3 in. spaces, our scale model might call for ribs only 1 in. apart, needing $\frac{1}{32}$ in. thickness as there will be three times more than normally used and $\frac{1}{32}$ in. is the minimum practical thickness. In any case, these thin ribs are easier to cut out, so we have a blessing in disguise. Another full-size feature is the panelled leading edge, for at least the first 15% chord, and often back as far as 40%. This, too, should be faithfully reproduced with thin sheet covering, since there is nothing more capable of dispelling the illusion of a scale model than a row of hungry unrealistic ribs pushing through the leading edge covering.

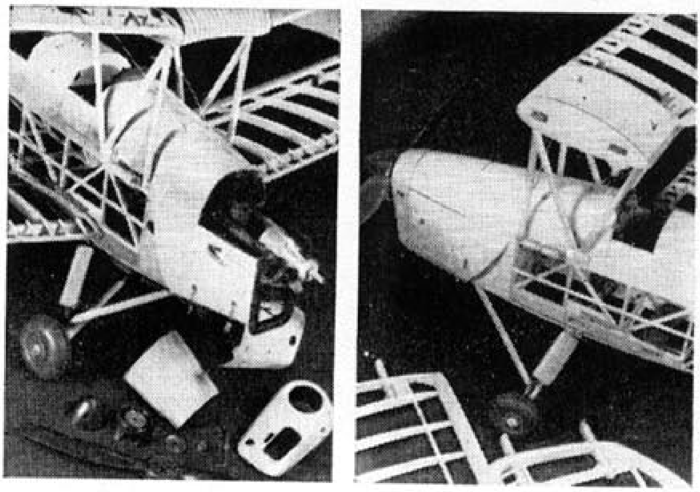


Fig. 41.—D.H. Tiger Moth displaying wing root attachment and engine cowl details

Similarly, try to keep as near scale as possible in the tail construction. We have already decided whether a change is necessary on the question o area, and if flat plate is the choice, then sheet balsa is sufficient. If we are to have a lifting section, then at least see that the leading edge is sheet covered and that ribs do not get that hungry appearance. Movable surfaces for pendulum operation should be hinged with a " shroud " like the real thing, and dividing lines between fin/rudder, elevator/tailplane kept in scale position. More will be found on the pendulum subject in Chapter 6.

The important points about the tail construction will be that the weight should be sufficient to balance the nose moment, forward of the wing, and that the tail be detachable for alterations to its angle of incidence during the first trimming flights.

Wing attachment should be more positive, and depends upon the actual subject rather than personal preference of the builder. For example, large fairings at the centre-section of a Spitfire cannot be detachable, so for this type the centre/section at least should be a fixture on the fuselage. Some high-wing monoplanes, the Auster Autocrat for one, have transparent cockpit roofing as part of the fuselage structure. These, too,

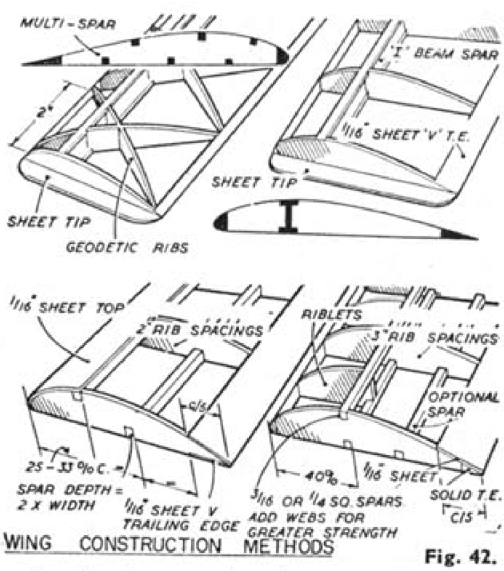


Fig. 42.

need a fixed centre/section on the fuselage with wings detachable from the root position. Then one can find low-wing subjects like the B.A. Swallow, where it is an advantage to have the whole

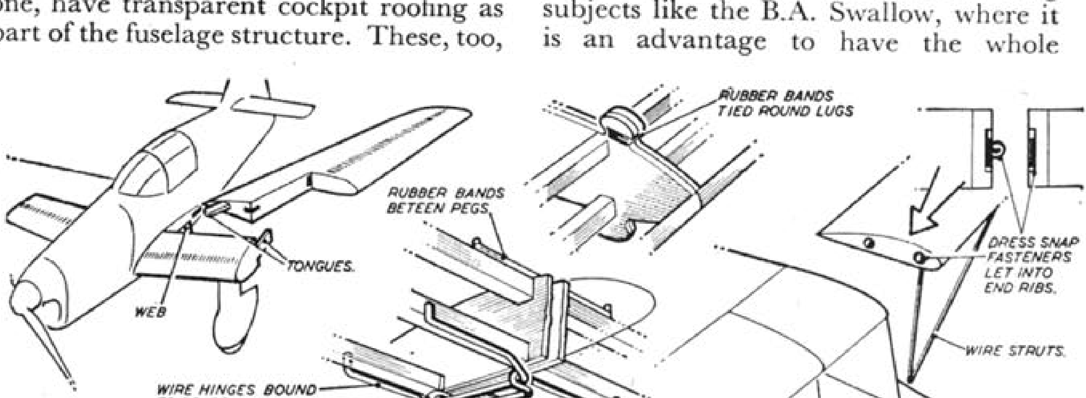


Fig. 43.—Wing fixings.

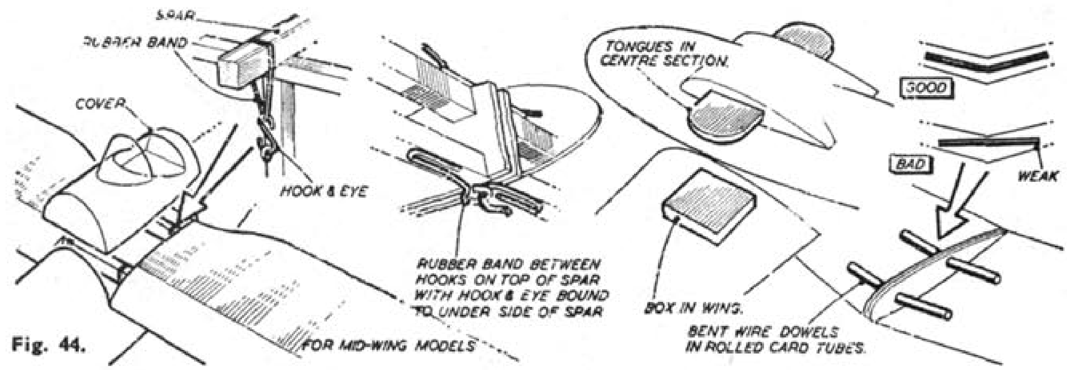


Fig. 44.

wing come away from the fuselage, with undercarriage attached.

The biplane must follow full-size assembly and have a rigid centre-section for the upper wing. Lower wings joining the fuselage will be mostly of the same semi-span, so it is possible to have biplane wings assemble as units before joining the rest of the model. Then, in the event of a heavy landing, both top and bottom wings can be arranged to " knock off " as a pair and alleviate damage.

Such references do, of course, apply to the larger free-flight power model. Control-liners are rarely large enough to present any transport difficulties, and are robust enough to withstand the rigours of an occasional prang. Small rubber-driven and Jetex types are similarly built in one piece regardless of type, as their loading is light enough to permit soft contact with terra firma even in a spiral dive.

So the free-flight power model is our main concern when it comes to detachable wings, and bearing in mind our earlier mention of " crashproof " types, special attention should be given to " knock-off " components.

To obtain this virtue of having wings that remain firm in place under flight loads and yet collapse off the fuselage in a collision, we have a choice of many root fixings. Number one on most people's list is the " tongue and box " scheme. This is a stout fixing for all kinds of model, well established with the gliding fraternity, and the only satisfactory answer for cantilever or unsupported wings.

A tongue of ply or Dural is rigidly fixed in the fuselage or wing centre-section, and it fits snugly into an equivalent box of ply or hard balsa in the detachable panel. Because the tongue is shaped on its leading edge with the radius scribed by swing of the wing as it pivots on the apex of the trailing edge, the wing can detach itself without damage. Should one have fears of the wing coming adrift in flight, then a retaining peg of $\frac{1}{16}$ in. square balsa, or a matchstick, can be pushed vertically through wing, box and tongue to shear off in a crash. There is another system of the vertical tongue and box, suitable only for deep-section wings, and although more satisfying for taking up the flight stresses, it is not so readily detached. To get the combination of " knock-off " and flight rigidity with the vertical tongue (also called vertical brace), we have to split the tongue into many laminations, none of which is attached to the others, and usually cut from 1 mm. plywood or thinner. Bend a pack of playing cards and you'll get the effect of how the tongue can flex back in a crash.

If we have chosen a high-wing type with lift struts, the Piper, Cessna, or Auster types for example, we can do without the tongue and box, so saving weight, and simplifying the construction. Now we employ a means of holding the wings at the desired angle of incidence and can do this solely on a ply-faced root rib. The inextensible wing strut (even if allowed to stretch out for more dihedral it will be inextensible at some stage) prevents the wing from folding up, so flight loads are no longer a worry. Short-radiused ends of two dowels can pop in the root rib from the fuselage to key the angle and the wing will knock off easily. Refinements, with carpet snaps, " Home-Perm " Spinnit snaps, or ball and socket fasteners, help to retain the wing more securely in flight, though in the Author's experience, floppy wings stay put in flight (providing the strut fixing is safe !) and knock off quickest in a crash.

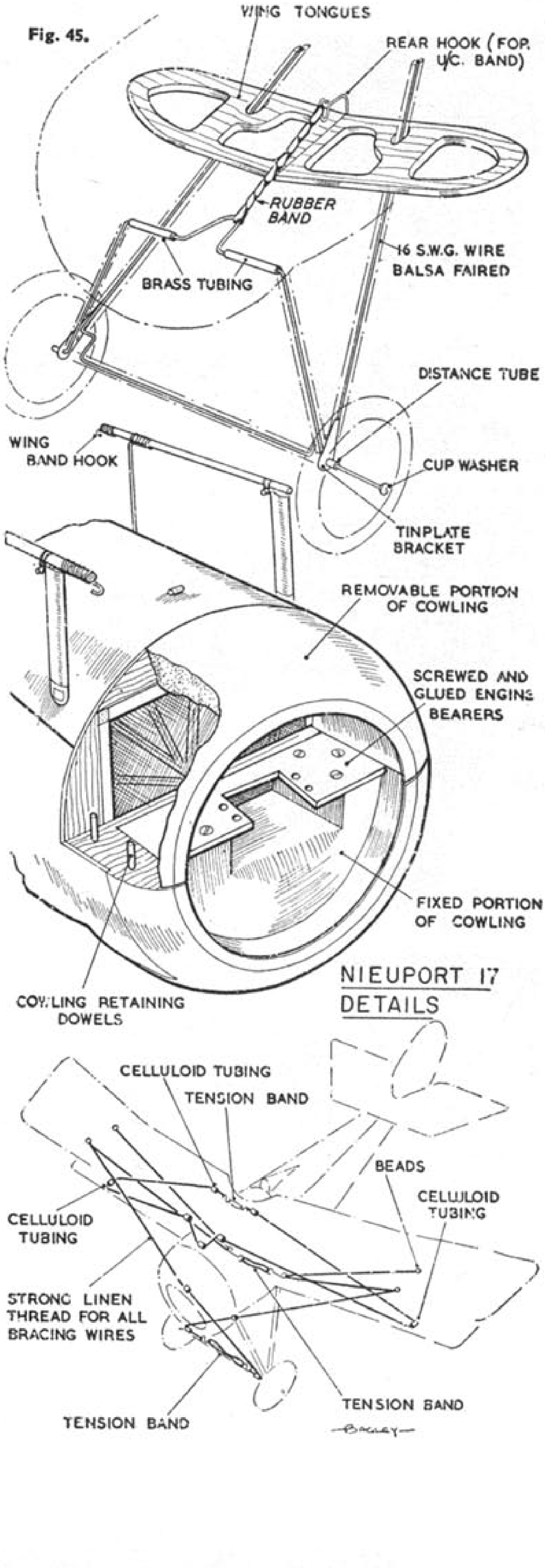
The great thing is to avoid at all costs that horrible rubber band which spoils the appearance of many an otherwise fine scale model.

Biplanes call for a combination of the tongue arrangement for cantilever wings, to be employed for the lower-wing, and the "pop-on" system outlined above for the high-wing monoplane. Quite obviously, we have to ensure some rigidity of the dihedral on a biplane, so the lower wing is used for this purpose, and its junction with the fuselage permits the tongue fitting. We could also use the tongue through a centre-section; but this is not always to be advised, as the tongues might not be at the same angles, or one may be tighter than the other, with the result that one wing detaches before the other and more damage is done in the ensuing tangle.

So the general guide is thus:

One-piece model	Rubber, Jetex, Control-line, small FF Power (30 in.).
One-piece wing detachable	Low wing without root fillet. High wing without struts.
Half-wings tongue and box fitted	Low wing with centre section integral with fuselage. Mid-wing cantilever types. Lower wing of biplanes.
Half-wings "pop" fitted with short dowels or snaps	High wing with struts. Upper wings of biplanes where possible.

Fig. 45.



There are so many forms of strut fitting, most of them unnecessarily complicated, and all serving the purpose with equal effect. Trying to save a fraction of the all-up weight by binding short lengths of wire at each end of a balsa strut is neither strong enough—nor safe enough, except on multi-bay biplanes where the load is spread over a large number of interplane struts.

We have planned the fuselage, wing and tail construction, and now we move to the undercarriage. Bearing in mind that the model is going to weigh upwards of a pound, it follows that the undercarriage is going to be an important plane-saver and time spent on its design will pay dividends. It must be shock absorbing, yet scale. Light, yet strong.

At one time the Author used to spend hours searching for a scale subject with the simplest possible undercarriage, so much was his objection to making anything with more than a couple of struts! Fortunately those days have passed, and we have learned of using the torsion obtained from a length of spring steel wire (piano wire) and later shock-absorbing methods have been uncovered. It is not a bad idea to try to follow the full-size method of springing.

For example, what could be simpler than a Dural plate resembling the Cessna undercarriage, or a floating axle lashed to the side members with rubber bands on an S.E.5a? The single tubular strut on the Auster A.O.P. 9 can be thin enough on a model to spring at any heavy landing, and the wing-mounted undercarriage on a Seamew can be swung rearwards under torsion bar action through the wing.

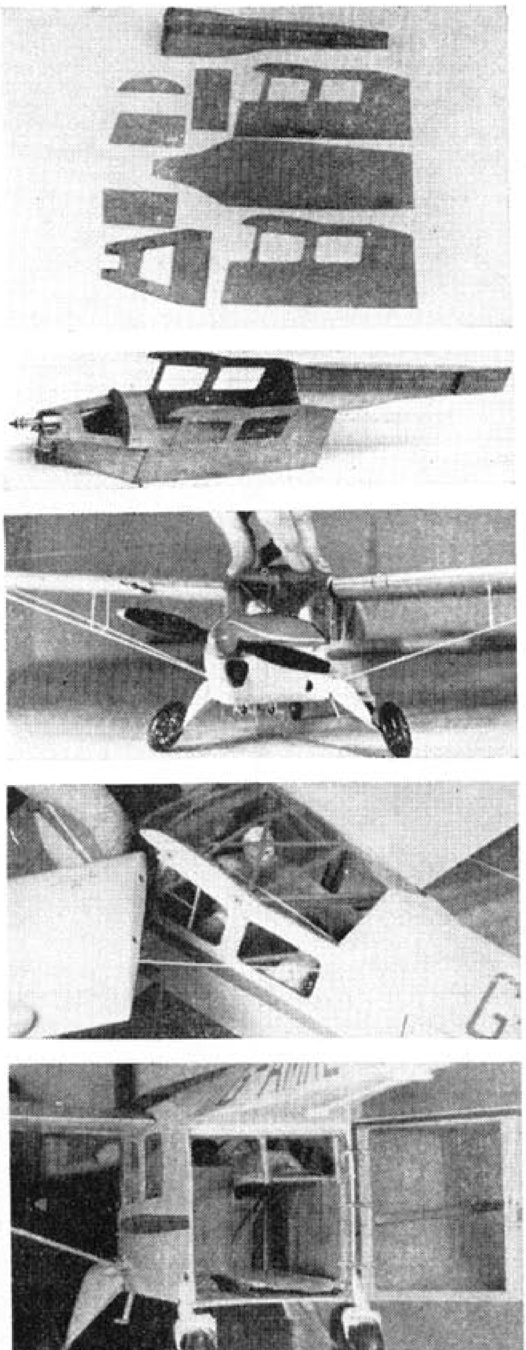


Fig. 46.—Author's Auster B4 Ambulance/Freighter details. Top, basic sheet parts for fuselage. Second, parts assembled. Centre, undercarriage depressed under load. Next, "home-perm" Spinnit root fixing. Bottom, ambulance access through scale door.

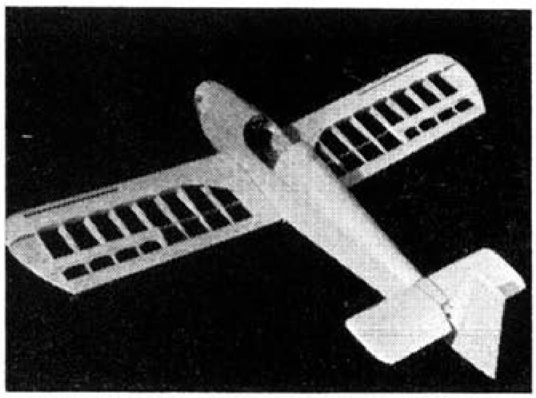


Fig. 47.—Rib-for-Rib construction of Druine Turbulent by the author results in perfect scale effect.

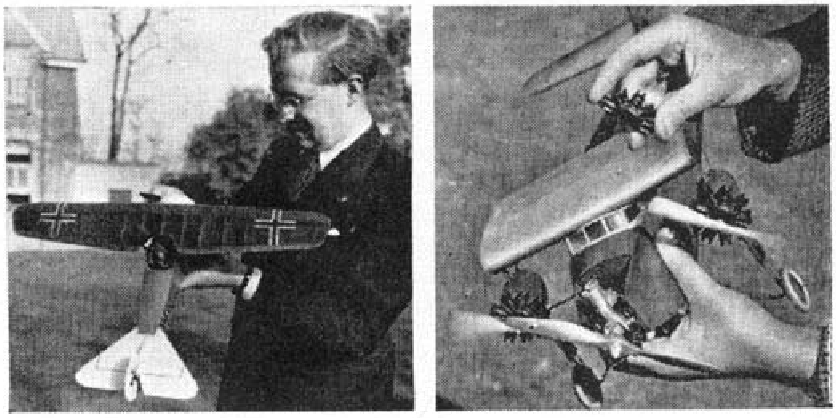


Fig. 48. — Author and his smallest scale power model for free flight, a 22 in. span Fokker D VIII. Right, another Fokker, the F VII, with one real engine, two dummy free-wheelers.

These examples serve to show the variation that exists in undercarriage design.

Fig. 49

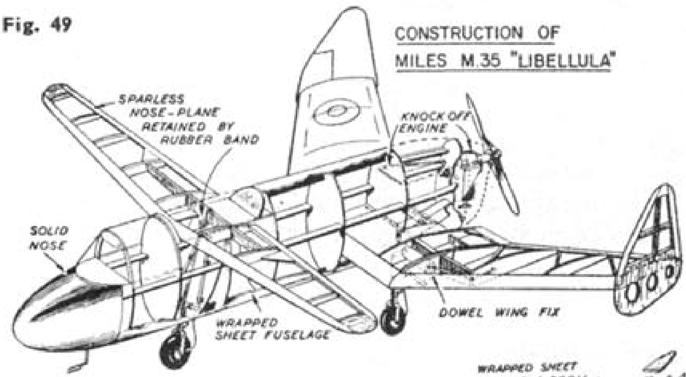


Fig. 49.—Wrapped sheet around the constant section fuselage with crutch mounted bulkheads, simplifies the Libellula. Note use of heavy leading edge to eliminate spar on this small model, and "kock-off" wings.

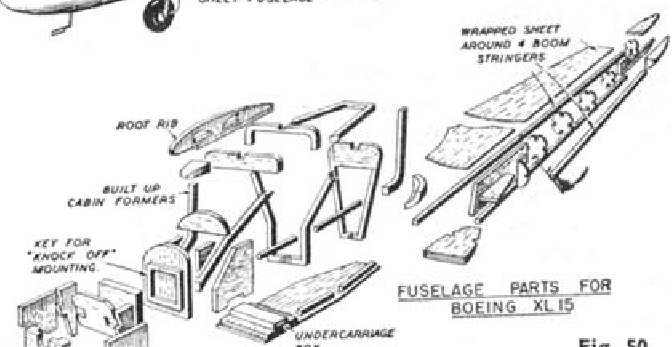
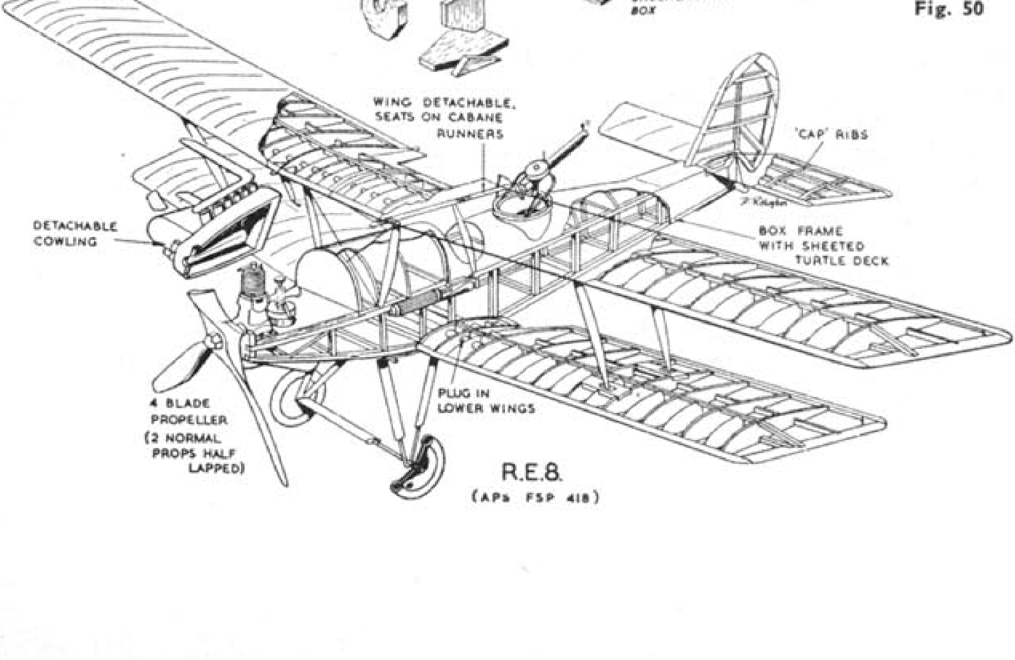


Fig. 50

Fig. 50.—Wrapped sheet is also used for the tail boom of the Boeing XL 15, while "glasshouse" cabin is made up with ply formers, over a sheet base. RE. 8 below is nearer to basic structure of box fuselage and elementary wing construction. Note use of cap ribs over spars for lightness in the tailplane construction.



Chapter Six

Pendulums for Free Flight

OF course you'll fit a pendulum—that plain statement, usually from one uninformed and inexperienced of the subject of scale models is an admission of how much we modellers follow fashion. One season we may be control-line stunt crazy, the next, we switch to radio control. In scale design, we sometimes get a flush of biplanes, then a rush of multi-engine bombers. The pendulum came suddenly as one of these fashion periods, and before long any and every scale subject being tackled was fitted with a pendulum that was supposed to be the magic answer to all stability problems. Most of the models so fitted would have been improved *without* the pendulum attachment.

Make no mistake, we cannot decry the pendulum—for it is an aid to stability when used correctly, and it can make a model perform wondrous aerobatics in certain safety ; but it is *not* the cure-all answer that people have been led by assumption to believe. Let's study its history and why it became popular.

We go back to 1947/48 when the Belgian contest fliers were finding the new diesels extremely powerful for their shoulder-wing designs. With the engine screaming out full revs, the model would require enormous angles of downthrust to cure a looping tendency, and even then, there was a tendency for the climb to twist into a spiral dive. Gaston Joostens thought up a movable rudder idea, with a weight swinging pendulum-fashion at the tail end of the machine so that when climbing, the rudder remained straight as long as the flight was near vertical. If the model tended to veer right, the rudder was shifted automatically to the left and the climb was maintained by correction. The duration of this power run was only 20 seconds, and in the glide, the rudder hardly moved as it was hinged to operate most effectively in steep climb angle.

This Joostens idea caught on with the scale modellers, and, in particular, P. E. Norman applied it to rudder and elevators (separately), C. Rupert Moore and Laurie Bagley tried it on ailerons, and E. C. Martin used a pair of pendulums on a twin-finned Boeing XL 15. All were successful experiments by experienced modellers, believing that " little movement and large area " was the safest means of applying the pendulum as an aid to flight stability.

Apart from Martin's twin-finned model, the others had one item in common, and this was the result of finding things out the hard way—it was that the pendulum itself was situated near to the centre of gravity on the model. Here it had the minimum of effect on the natural trim of the design—half an ounce of lead moving about at the tail end of a model is enough to unsettle some of the most stable designs. Above all, it was not affected unduly by centrifugal effect.

Consider a weight swung forward direct from a rudder hinge line and so balanced that when the model was banked to either side or turned, it moved the rudder opposite to apply correction. This was the system adopted by many would-be pendulum fliers. In flight, two things happened—when the model climbed, the rudder swung over, even in a straight climb, because the weight was higher than the hinge line and gravity wanted it to " get below and behind "—then in the ensuing turn, centrifugal effect on the weight kept it where it was (hard over in the wrong direction) and a spiral dive resulted to the chorus of " Tut-tut, pendulum must have stuck ". So they try again—and get the same result.

The only answer to the simple, forward-projecting pendulum is Vic

Dubery's roller method, where the pendulum has to climb a hill if it wants to go wrong, and in fact it operates only through a small angle, and corrects when the bank or turn is steep.

When people began to learn about the success of the cockpit-located pendulum they met with another obstacle. Instead of the moving rudder or elevators smoothing out the flight and taking care of any inconsistencies in the stability of the design, they enhanced the tendency to drop a wing into a turn or start a series of swooping zooms, and the result was exaggerated instability! Cause of this was twofold. Either they had sticky controls, apt to "hang up" at a crucial stage, or (and most likely) they were using too much movement and over-correcting.

Little motion, very free hinges, and scale moving surfaces were soon found to be the answer, and the finest example of pendulum control likely to be seen for many years, was P. E. Norman's 50 m.p.h., 46 inch Percival Mew Gull, weighing more than 3lb. for its tiny wing area and diminutive tail surfaces. A movable elevator made this model absolutely rock steady in the air, but only after considerable experiment. Other P. E. Norman models use their pendulums for controlled aerobatics, and the flight pattern is consistently predictable. A left turn from hand launch, climbing after an initial swoop down to the launching point, followed by elevator action to level off, another left turn, swoop and more climb, gradually building up height and control reaction to the stage of aerobatics. It is a joy to watch such a model, and to see the corrective power of its elevator.

Although the rudder was first in use with a pendulum, the elevator now rivals it for popularity, and it has the backing of many experienced modellers as the more effective and valuable method of control. If a rudder starts to over-correct, we end up in a spiral dive and sweep the remains away. If an elevator goes wrong, we get snap loops or violent zooms, but rarely hit the ground under power. Elevator action can convert a tight turn, with nose down, into a climb to recovery. If the initial climb is over-steep, it noses down to a reasonable angle. All points considered, the elevator should be chosen—but what for?

Monoplanes rarely call for an extra stability aid other than a few degrees more dihedral providing they are lightly loaded and have low to medium power. Make it a "crashproof" type, fast flying, high powered for its size or weight, and the pendulum is needed. A free-flight Boeing P.26 with 42 in. span, weighing up to 40 ounces with extra tough construction and nylon covering fitted with a fast running 2.5 c.c. engine would fly at more than 25 m.p.h. and certainly benefit from a pendulum elevator to keep it longitudinally stable. Build the same size model to 24 ounces for 1.5 c.c. and flight speed will be almost halved, safety factor enhanced, and pendulum unnecessary.

The average biplane is a different question altogether. Tail area percentage will be low, the nose usually very short and this pair of factors combine to make longitudinal instability. This we can cure with the elevator: but again the pendulum is not necessary if the loadings are low. One example of a biplane that need never be pendulum fitted is the D.H. Tiger Moth. Its sweep back makes up for lack of dihedral, the tail has ample area if made lifting, and the nose is fairly long and stabilising. At the opposite end of the scale, a Gloster Gladiator has little dihedral and no sweep back, a medium amount of tail area, and a short nose. Moreover, it is bulky for its wing area and will present a lot of drag. A pendulum would be an advantage; but for rudder or ailerons to cure the lack of dihedral, or elevator to keep the nose up?

Study the type, and it will be seen that the fixed fin-rudder is generous in proportions. It should therefore help lateral stability, especially if we add a little dihedral over-scale. So the elevator receives our blessing again.

A biplane with absolutely flat wings, and a rather long span for length, would do better with aileron control

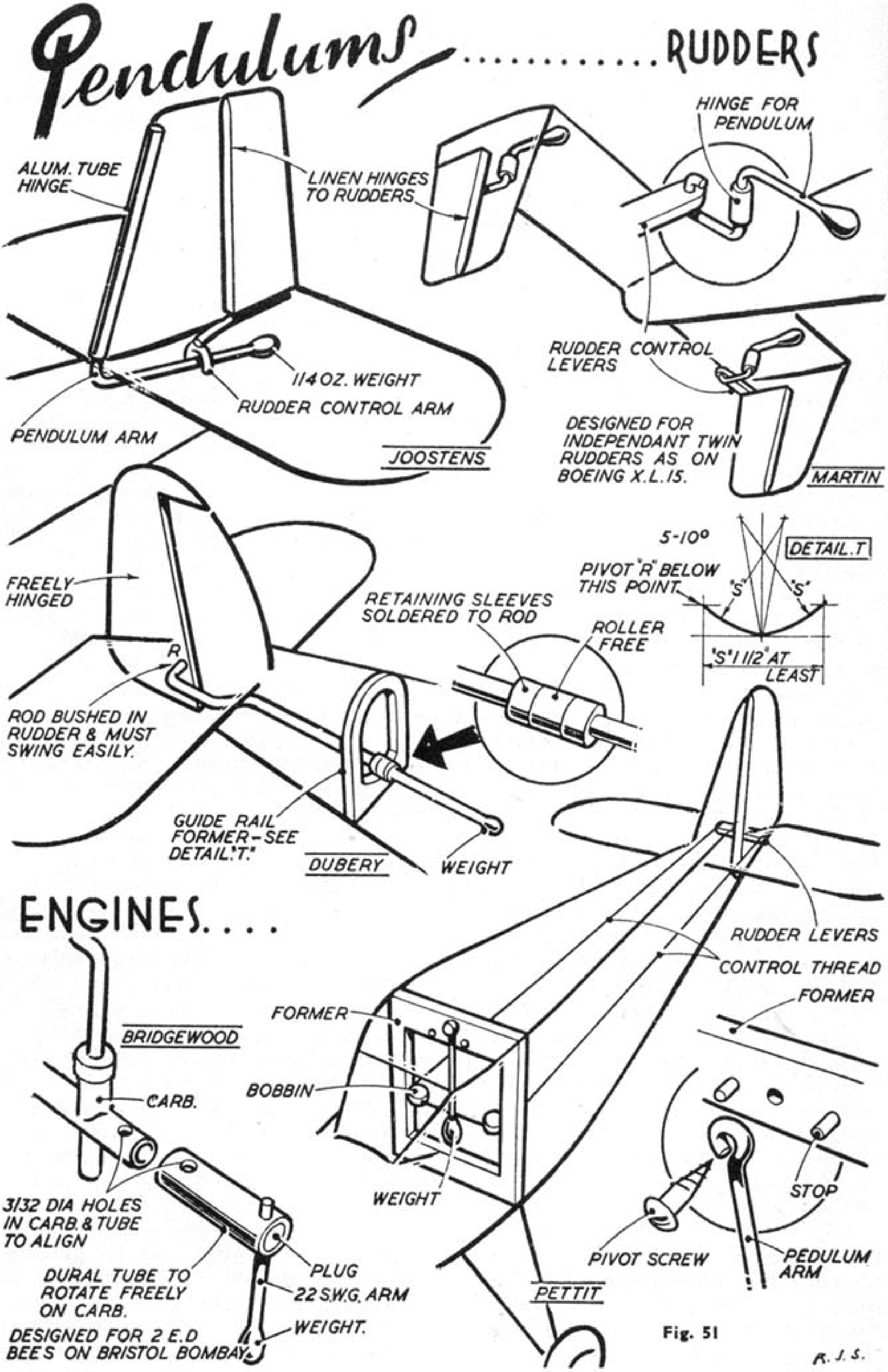

Pendulums .... RUDDERS
ALUM. TUBE HINGE
LINEN HINGES TO RUDDERS
1/4 OZ. WEIGHT
RUDDER CONTROL ARM
PENDULUM ARM
JOOSTENS
HINGE FOR PENDULUM
RUDDER CONTROL LEVERS
DESIGNED FOR INDEPENDANT TWIN RUDDERS AS ON BOEING X.L.15.
MARTIN
5-10°
DETAIL.T
PIVOT "R" BELOW THIS POINT
"S"
"S"
"S" 1 1/2" AT LEAST
FREELY HINGED
R
RETAINING SLEEVES SOLDERED TO ROD
ROLLER FREE
ROD BUSHED IN RUDDER & MUST SWING EASILY.
GUIDE RAIL FORMER - SEE DETAIL "T."
DUBERY
WEIGHT
ENGINES....
BRIDGEWOOD
CARB.
3/32 DIA HOLES IN CARB. & TUBE TO ALIGN
DURAL TUBE TO ROTATE FREELY ON CARB.
PLUG
22 S.W.G. ARM
WEIGHT.
DESIGNED FOR 2 E.D BEES ON BRISTOL BOMBAY.
RUDDER LEVERS
CONTROL THREAD
FORMER
FORMER
BOBBIN
WEIGHT
STOP
PIVOT SCREW
PEDULUM ARM
PETTIT
R. J. S.

Fig. 51

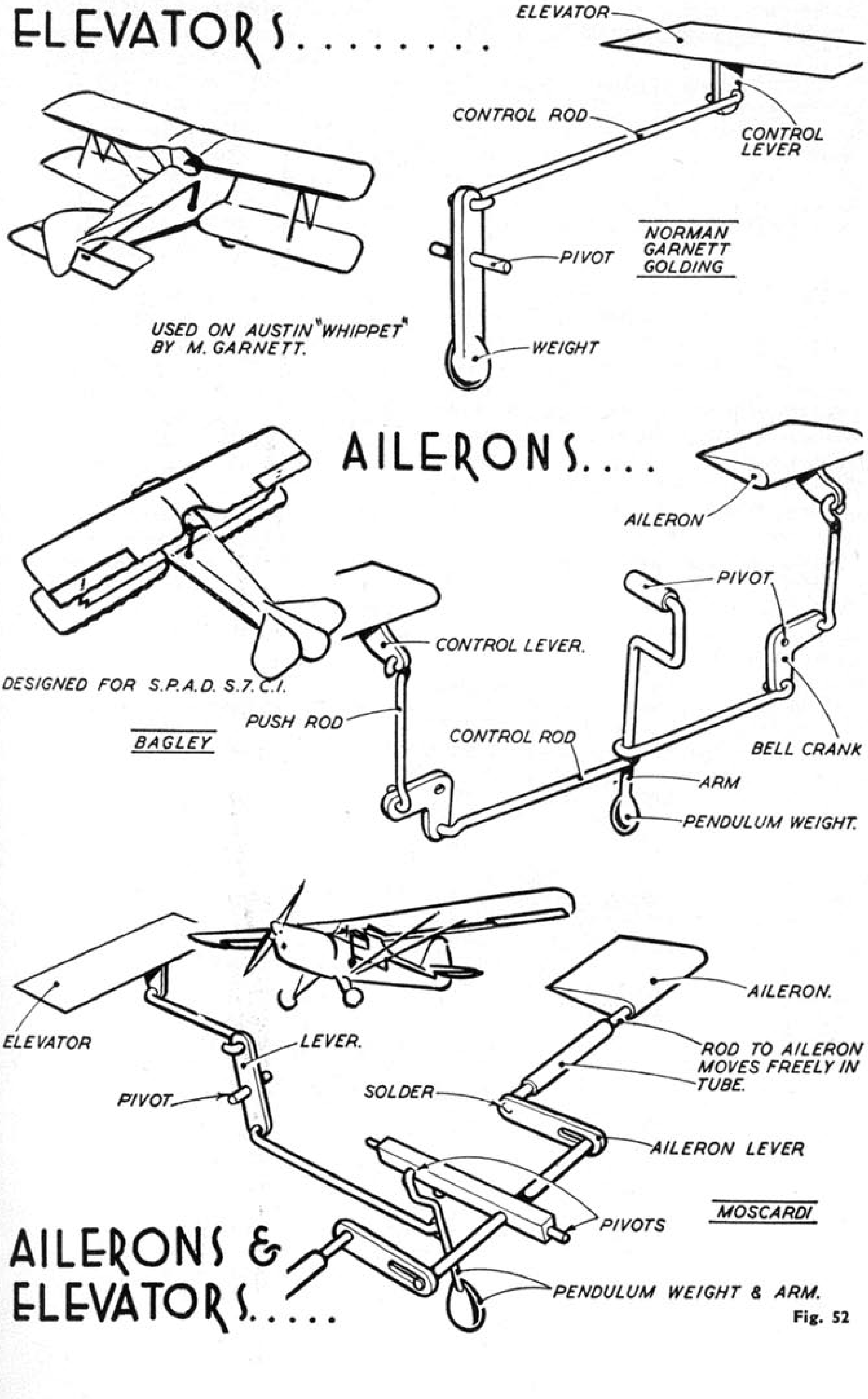

ELEVATORS.........
ELEVATOR
CONTROL ROD
CONTROL LEVER
NORMAN GARNETT GOLDING
PIVOT
USED ON AUSTIN "WHIPPET" BY M. GARNETT.
WEIGHT
AILERONS....
AILERON
PIVOT
CONTROL LEVER.
DESIGNED FOR S.P.A.D. S.7.C.I.
PUSH ROD
BAGLEY
CONTROL ROD
BELL CRANK
ARM
PENDULUM WEIGHT.
AILERON.
ELEVATOR
LEVER.
ROD TO AILERON MOVES FREELY IN TUBE.
PIVOT
SOLDER
AILERON LEVER
MOSCARDI
PIVOTS
AILERONS & ELEVATORS.....
PENDULUM WEIGHT & ARM.

Fig. 52

rather than either rudder or elevator. Two-bay biplanes, the S.P.A.D. Wapiti, Hippo, etc., are examples, and while there are aileron controls that use direct action with the swinging weight near the moving surface, we prefer the Bagley system as it retains the pendulum inside the fuselage. Weight at a wingtip is a disadvantage, and is very prone to centrifugal effect in a tight turn—so avoid it.

How much movement? P. E. Norman once showed us the motion on one of his earlier types, a Typhoon, and we had difficulty in seeing the elevator move at all! Two or three degrees motion either way is quite enough to start with, and if not entirely satisfactory, the range of movement can always be enlarged. To start with a large swing and cut down to safe limits, is to court disaster.

So much for surface controls, there is also an engine pendulum method that can be " tuned " and for a twin there is a workable system that has been safely employed on a Bristol Freighter and a Bristol Bombay. First we must have engines with intakes running level fore and aft. The E.D. Bee and Mills are ideal, and we make a cap, or choke, to fit snugly over the carburettor intake yet be free to swing. To this is directly attached a pendulum, and in the side of the carburettor, we drill an air-intake hole to coincide with another on the choke when straight and level. Now, if the model banks, the choke slows the engine by making it run rich, and if so arranged on a twin, that the inside engine of the turn keeps at full power and the outer one slows, then we can have safety even with unequal power output.

Each of these ideas is outlined in the sketches and, for the ingenious, we offer Moscardi's combination control.

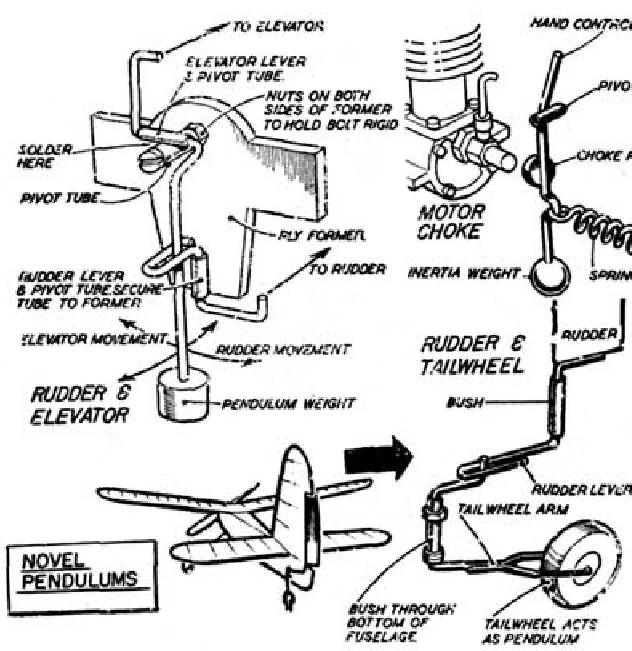


Fig. 53.—Variations on the employment of a single pendulum showing a simple method of combining rudder and elevator for aerobatics, the motor choke which operates to slow the engine in the event of a dive and duplication of a swivelling tail wheel acting as a pendulum.

Chapter Seven

Refinements for Control-line

FLYING on wires, tethered to the handle of the controlling "pilot" the control-line model is free of many of the design restrictions attached to free flight. Make no mistake—the control-line model is not the "brick on a string" some people are apt to call it. You will find that only the people who are so biased in their aeromodelling outlook that they scorn control-line flying and would not deem to try their hand at it, are those who use such an expression. A model has to fly when it is on the lines, just as much as when in free flight. The difference is that it can have a much heavier wing loading (thus relieving us of constructional restrictions)—and it does not need to be laterally stable.

Longitudinally, it must be able to maintain smooth, straight and level flight with a neutral elevator. It must climb when the elevator is pulled "up", dive when "down" is applied, and glide to a safely controlled landing. Therefore it requires lifting wings to support the weight of the model in the air: but so trimmed that only when induced into an angle of increased attack by the elevator, will the model begin to climb. To get this we have a forward centre of gravity position, wing and tail incidence at zero, or even completely symmetrical aerofoils if aerobatics are contemplated.

For general round-and-round sport flying, an aerofoil of the Clark Y type is admirable, the bottom surface being set parallel to the fuselage datum line and thrustline. The centre of gravity should be within a range of from 10% to 25% from the leading edge at the average chord position, and the bellcrank control pivot so arranged that the front line is on or just in front of the C.G. If it is to be a biplane, calling for thinner wings in scale appearance, then it is possible to use a 60% Clark Y section which is about as thin as any wing would need to be.

That, in brief, is our design requirement. The rest will depend largely upon the nature of our selection.

Since the control-line model has no need to be laterally stable, and weight is but a secondary consideration, we can look toward novel and unusual aircraft types that would be virtually impossible to fly as free-flight projects. Multi-engines, Vertical Risers (V.T.O.), Carrier planes, Racers, Autogiros, short-span Fighters and Jets with real pulse units are a few of the classifications now open to us. Then there are the additional facilities of full engine throttle control, retractable undercarriages, lights for night flying, hooks for carrier landing, flaps for slow flying and contraprops for torqueless vertical take-off. If we are going to make a control-line scale model, we might just as well take advantage of these added possibilities and choose an aircraft that is right out of the rut.

The most popular variation on the theme is to make a multi-engined aircraft, as witness the well-worn types like the Mosquito and Invader. Why not try something more refreshing, and inviting as gaudy a paint scheme as any American publicist could devise? The Piper Apache, Cessna 310 and Aero Commander are three ideal types which lay themselves open to a widely varying selection of decorative schemes. Or perhaps if colour is not one's concern, the streamlined form of a Lockheed Neptune in its latest shape with long sting tail, or the wartime Lightning with twin-boomed fuselage and Westland Whirlwind with its high tail, are more attractive. The field is a wide one and it is not difficult to find a type that can be made either with solid sheet or planked fuselage construction. Our main concern will be the operation of two—or more—engines at one time.

Firstly, the engines need not be matched for size or power. The better engine must be fitted to the inboard

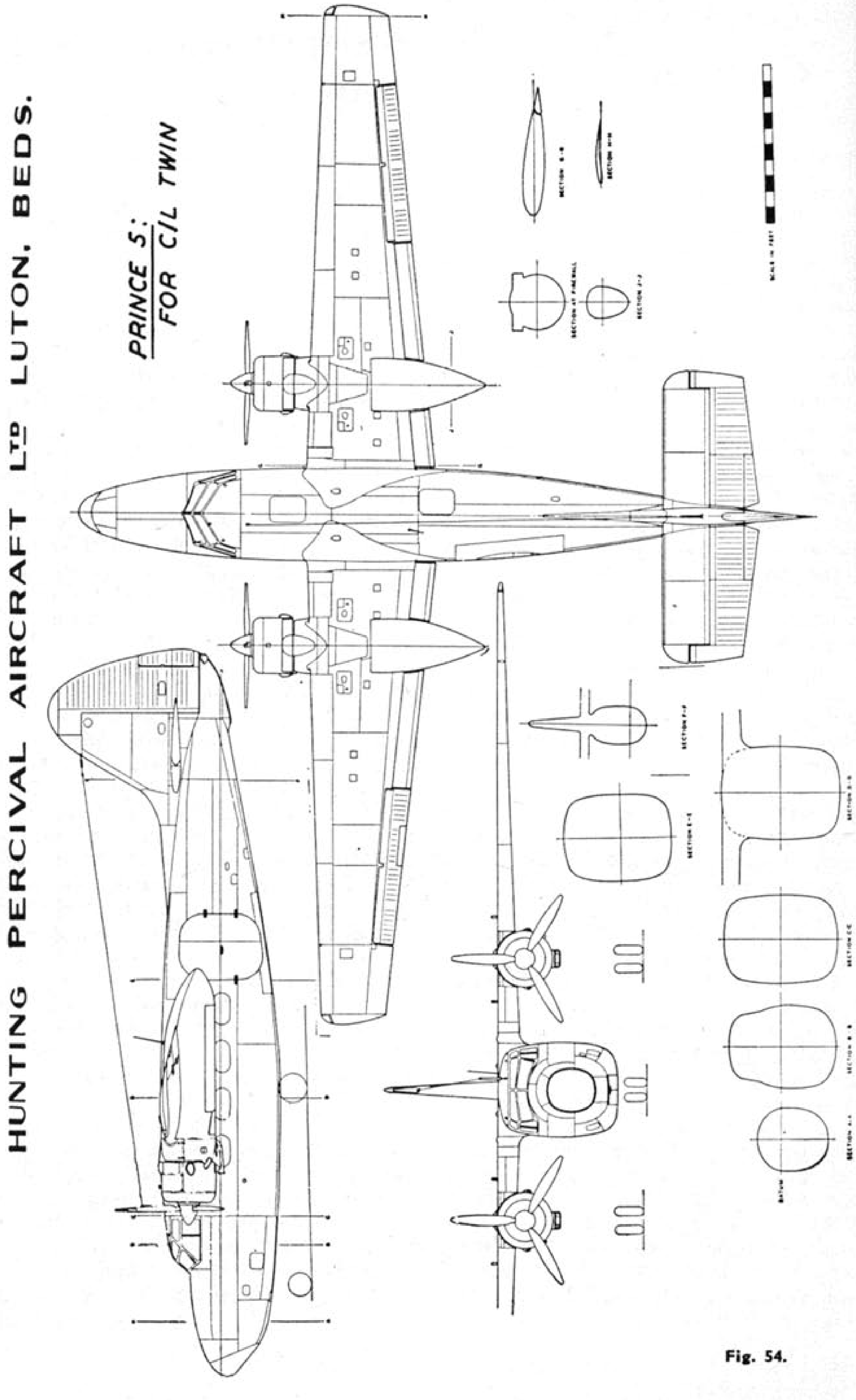

HUNTING PERCIVAL AIRCRAFT LTD LUTON. BEDS.
PRINCE 5: FOR C/L TWIN

Fig. 54.

nacelle, nearest the control handle, and the smaller or less powerful unit on the outside wing. This is because in assymmetrical flight, with one engine pulling more than the other, the drag of the wing opposite to the better engine will combine with the increase of thrust on the other side, to want to turn the aircraft in a circle. Since it would be undesirable for this to happen in the direction of the pilot, we use the offset power to keep the lines taut and make the model want to fly out of the control-line circuit.

There used to be some concern over this subject, and early "twins" had unequal size fuel tanks so that the outer engine always stopped first. While this is desirable, it is not entirely necessary, as many demonstrations have shown. Captain Milani's famous beauty of a Dornier 215 has frequently flown on the outer engine only, the answer to his success being that a few degrees of offset to the right have been incorporated in the engine mount. As for the unequal tank size, all we have to do is to start the engines in the order in which we want them to stop, using the same size individual tanks on each, and the engines will automatically stop in the desired order providing they are properly adjusted.

Note that individual tanks are specified. The communal tank is of little use when situated between engines since, when centrifugal force takes effect during flight, the inside engine will be starved and the outer engine flooded. Treat each engine as though in a single-engined model, and get thoroughly used to starting technique on the work-bench before fitting it in the airframe.

Because we have two lines from the handle to the model, we can use them to operate additional controls. This is effected by passing current down the lines, which must be given a heavy coating of shellac first to insulate one from the other when they touch. In the line length of 50 ft. we shall need about 45 volts at the handle end to get enough volts to the model, where we fit a relay, and use this as an electrical trip to select our third control.

This can be engine throttle, flaps lowered, undercarriage retracted or let down, carrier hook extended, lights switched on or engines stopped. Quite a choice, in fact, and the most *attractive* is the retractable undercarriage.

In a twin, we can afford to carry the weight of up to three of the small modern electric motors, such as the Mighty Midget, Frog Tornado, or Ever Ready TG 18, and these can be battery driven with a 4.5 volt system to operate a tricycle undercarriage by

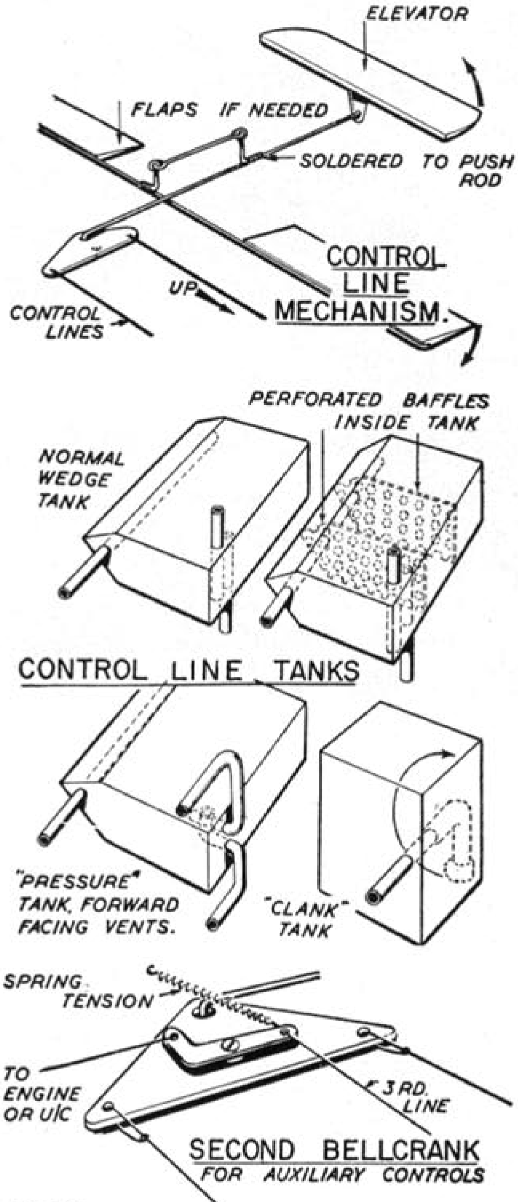
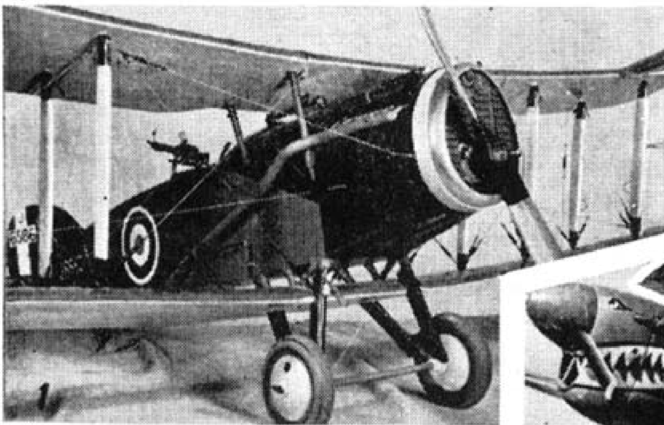
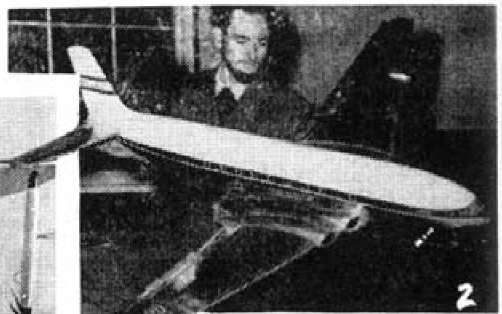
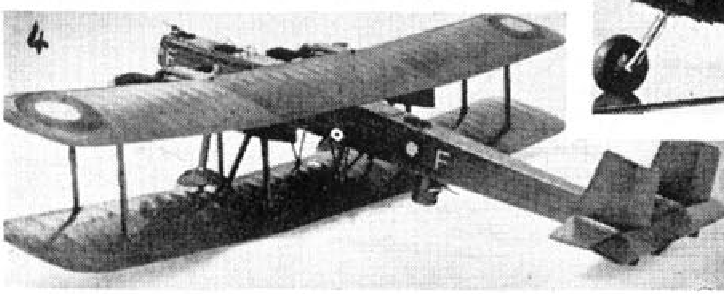


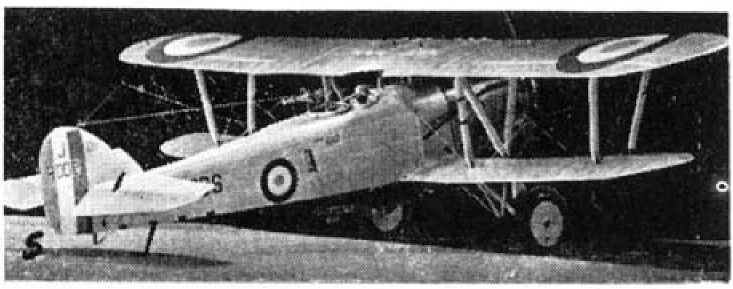
Fig. 55.

Fig. 56.—1. Bristol F2b fighter with all possible detail including scale prop for 10 c.c. petrol engine. 2. D.H. Comet with Ducted Fan Frog 500 has metallised covering and u/c as in Fig. 59.









3. Curtiss P.40 Warhawk has completely enclosed inverted engine, sprung undercarriage. 4. Handley Page Heyford for two engines displays tenacity for detail. 5. Hawker Horsley, complete even to the Torpedo between its shock absorbing undercarriage. These illustrate control-line scale models at their best.

means of a worm gear. The lines from the insulated bellcrank pass to a relay which is in effect a switch for the undercarriage circuit. It can be so arranged with limit switches that the undercarriage motors switch off when the undercarriage is fully up, and when the next signal is passed through the bellcrank, it should direct the current through a reverse polarity circuit to get the undercarriage down again. This is only possible by having a double wiring system, and a two-pole relay, for which polarity is reversed at the control handle. Thus, although most attractive, the undercarriage that will operate both up and down at the flick of a switch, is not quite as simple as it sounds. We can, however, " short circuit " the complications by using a third control-line, and use this to pull a two-stage sliding switch against spring tension. One point need be noted. For a sideways retracting unit, particularly on a large or fast-flying model, the electric motors will have to be of a more powerful type than the plastic-cased variety we have mentioned. This is because centrifugal effect on the rather weighty outboard undercarriage leg and wheel will tend to hold the wheel down and stall the motor, causing it to burn out or heat up to such a degree that it might melt the casing. Equally important for all retracting

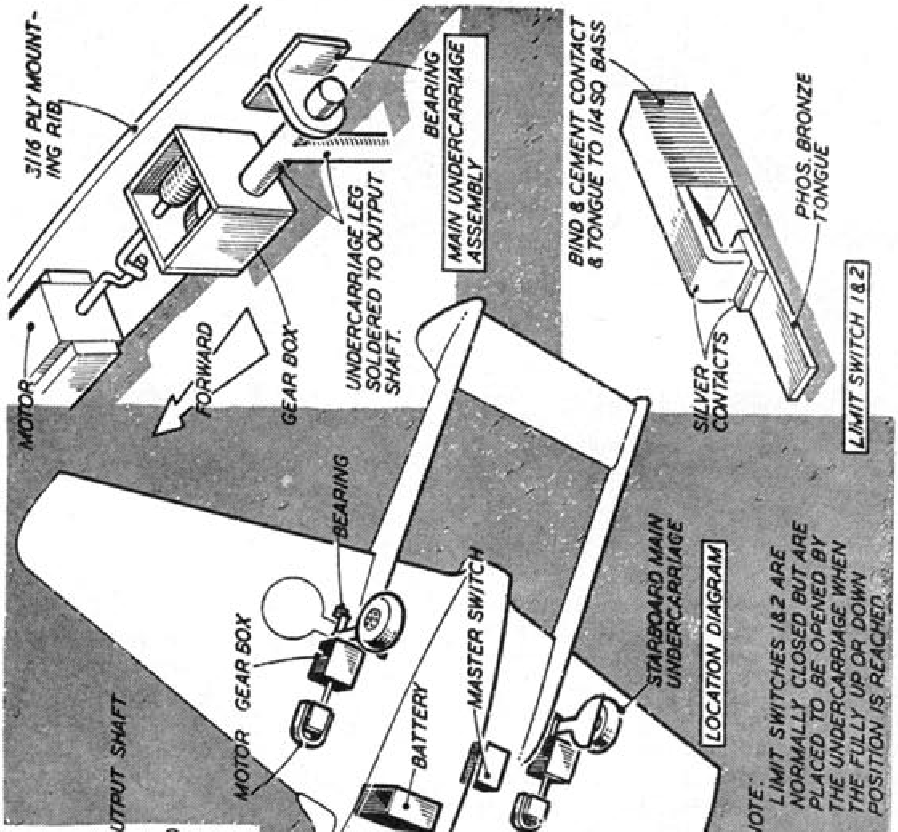


Fig. 57.—Electrical undercarriage retraction gear used on American Dynajet powered scale D.H. Vampire uses miniature motors driving a gear train with limit switches to hold "up" or "down". Master switch is operated by a third line from the control handle and has a spring bias which calls for constant line tension. Should the line break, or slacken, the undercarriage comes down for landing. Total reduction from motor to each leg via double-worm gearboxes is 1369:1. Gearboxes are from model railway locomotives.

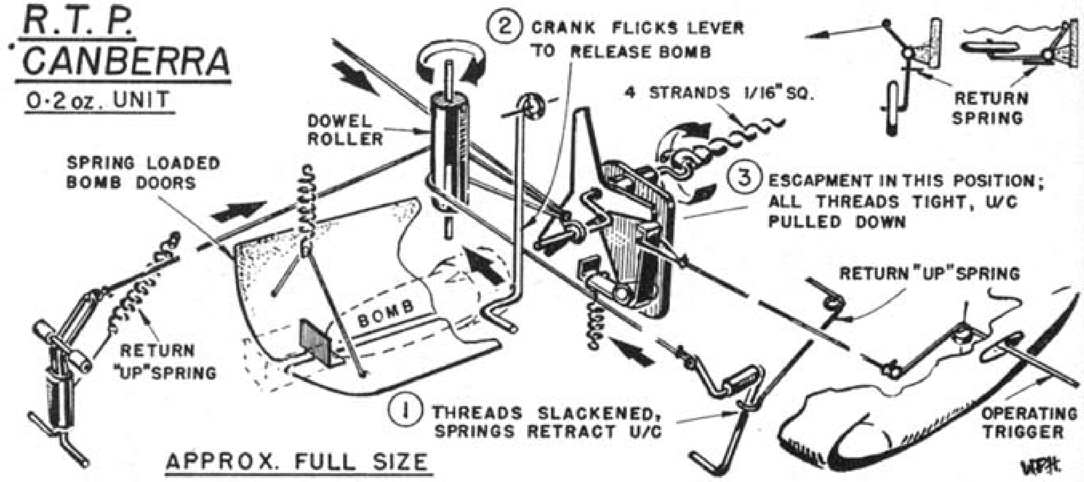


Fig. 58.—Small retracting unit for an airline propelled model has simple escapement operated u/c.

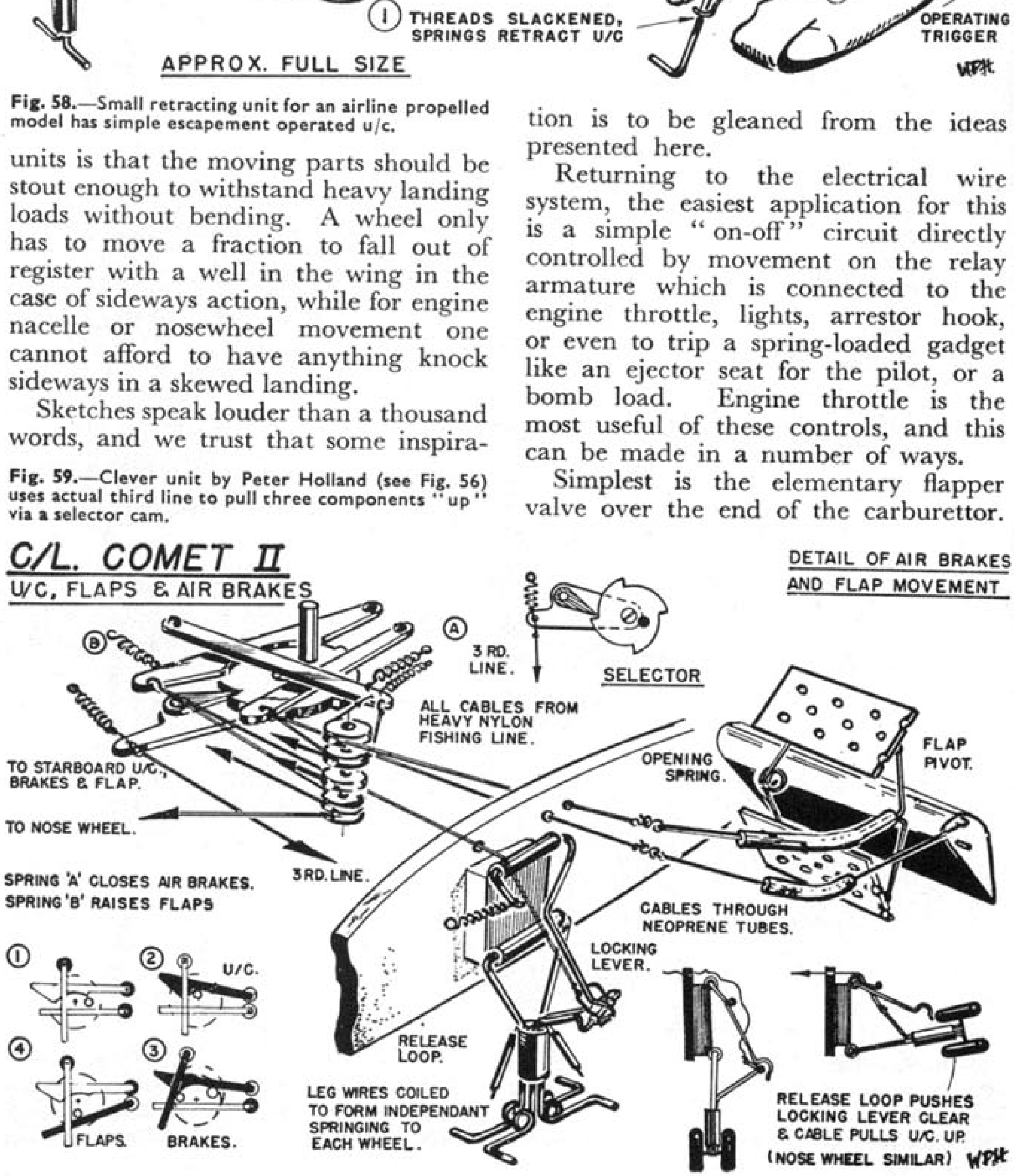
units is that the moving parts should be stout enough to withstand heavy landing loads without bending. A wheel only has to move a fraction to fall out of register with a well in the wing in the case of sideways action, while for engine nacelle or nosewheel movement one cannot afford to have anything knock sideways in a skewed landing.

Sketches speak louder than a thousand words, and we trust that some inspiration is to be gleaned from the ideas presented here.

Returning to the electrical wire system, the easiest application for this is a simple "on-off" circuit directly controlled by movement on the relay armature which is connected to the engine throttle, lights, arrestor hook, or even to trip a spring-loaded gadget like an ejector seat for the pilot, or a bomb load. Engine throttle is the most useful of these controls, and this can be made in a number of ways.

Simplest is the elementary flapper valve over the end of the carburettor.

Fig. 59.—Clever unit by Peter Holland (see Fig. 56) uses actual third line to pull three components "up" via a selector cam.



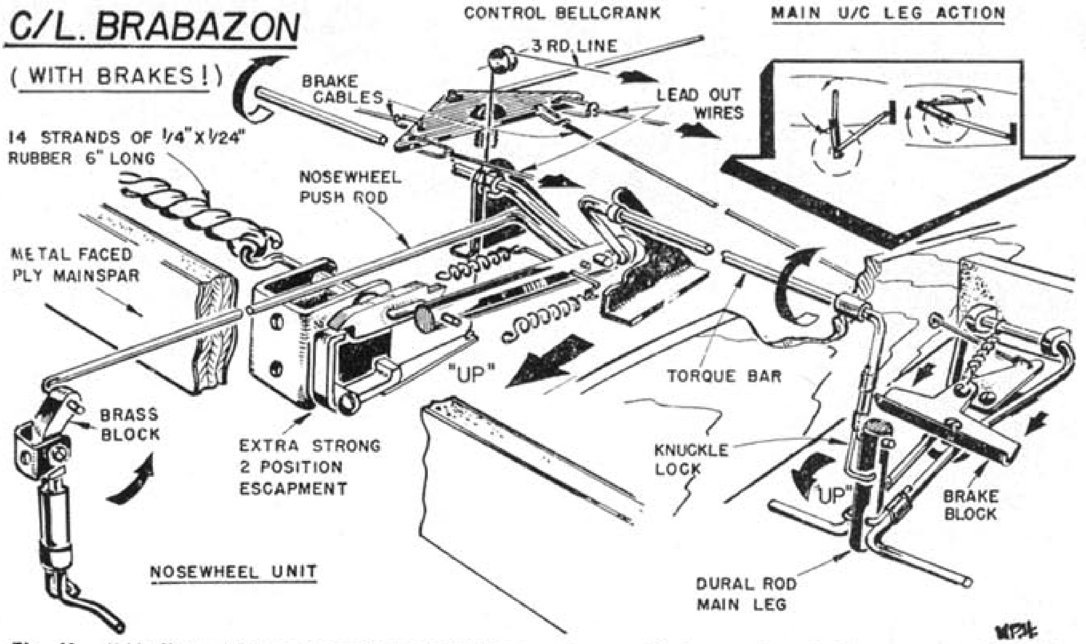


Fig. 60.—" Up " or " Down " at will by this Peter Holland undercarriage using rubber drive on a powerful escapement. See Fig. 7.

This restricts the airflow, causing a rich mixture of fuel and air to enter the engine, and slows the speed of the engine considerably. Although some engines with sub-piston air-intake will run with the carburettor fully choked by a flapper, it is advisable to allow air to pass the flapper through a hole of about 3/32 in. diameter. After a short period of running with such control, a diesel will labour to a stop, so it will be necessary to keep " blipping " the control for continued operation. Glowplug engines are less sensitive to loading up the crankcase with a rich mixture, as they offer more complete combustion, and usually have greater exhaust port area to clear the extra gases and take in a quick gulp of fresh air when the piston is on its return journey. So for glowplug, or coil ignition, the flapper is ideal. It can also be synchronised with a variable choke on the exhaust stack for silencing, and this is, in fact, a feature of one American engine, the Jim Walker " Firecracker " 1 c.c. This latter engine introduces a third method of control operation—air pressure. A bulb is held on the control handle and connected to the engine by means of a long airline. When pressure is applied to the bulb at the handle, the bellows at the model end will expand, and move the silencer/flapper unit, so increasing speed. When at rest the engine is in the slow-running and choked setting. (See Fig. 64.)

For diesels, the difficulty of altering a mixture setting without having to make a change of compression ratio, is overcome by the double butterfly system. This is a flapper within a

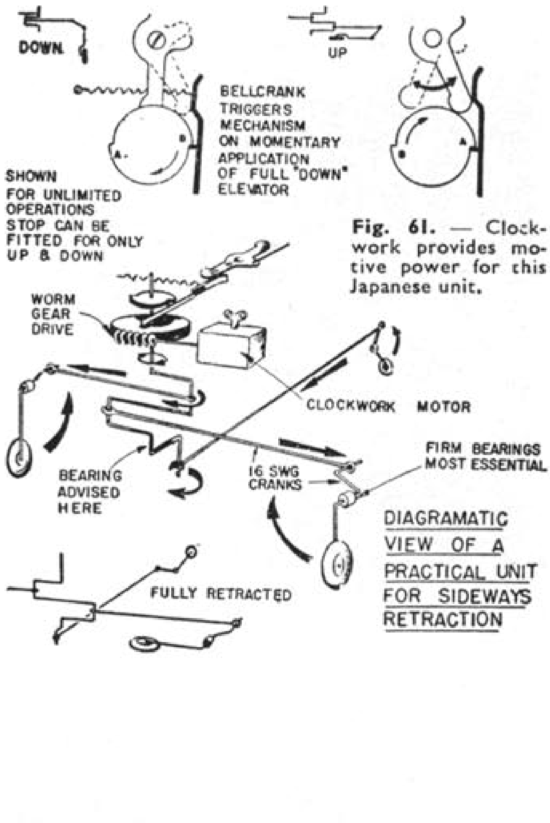


Fig. 61. — Clockwork provides motive power for this Japanese unit.

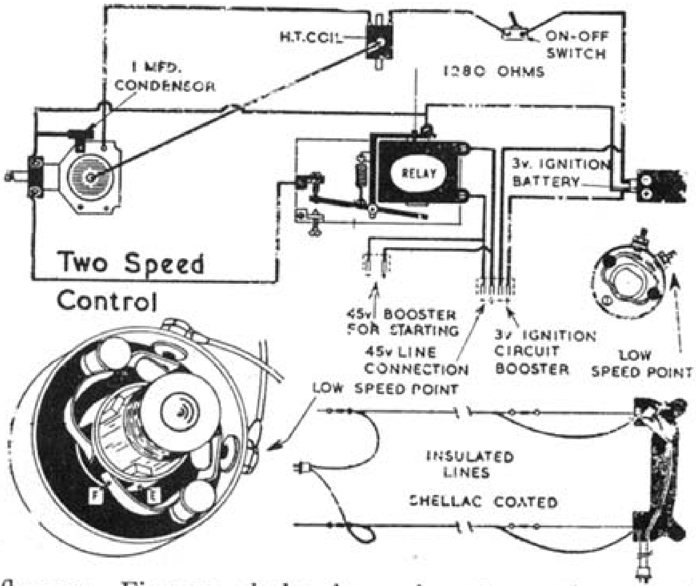


Fig. 62.—Two-speed contro using double ignition points and insulated lines.

flapper. First we choke the carburettor with one restrictor, then we cut down the amount of mixture drawn into the engine by having another restrictor between the needle valve and the crankcase. So that the two can be linked for synchronised motion, it is logical that they pivot inside the induction tube, and so they become butterfly valves. The idea was first used by George Honnest-Redlich for radio control, and has proved so successful that several control-line enthusiasts have adopted it. Engines with detachable carburettor pipes are easy to convert; but, in any case, a tube large enough to slip over the existing carburettor will do the job equally well.

Mills engines can be fitted with their own two-speed throttle control, while some of the American K & B products have two needle valves, one for high-speed, the pair for low-speed, running. This is operated by introducing air into the fuel line to one needle valve, causing it to lose suction, and such a " bleed " system can be worked directly from an electrical relay. When the pair of needle valves are being used, the engine runs rich—and when one is cut out, the engine leans out to high speed. Webra diesels from Germany include a two-needle version in their range, which is an exception among diesels in that it will run satisfactorily without having to alter the compression ratio when on the rich setting, and sub-piston intake is probably the answer to its success.

There is one other form of engine control, and it was the first to be used. This is for coil-ignition petrol engines, and involves altering the ignition timing by advance and retard of the make-and-break mechanism. Some engines, the Forsters and Ohllsons, for example, could be supplied with two sets of ignition points and a simple alteration to the wiring circuit enabling one to switch from high to low speed with a relay such as we suggest with the insulated control-lines. Otherwise, the make-and-break unit could be shifted mechanically; but to do this, we should need either an electric motor, or a third control line.

There is a fascination about flying after dark—and since most model meetings conclude at dusk, a control-line model with navigation lights and a powerful landing light is a distinct novelty. Coloured bulbs at the wingtips, red on the port, and green on starboard,

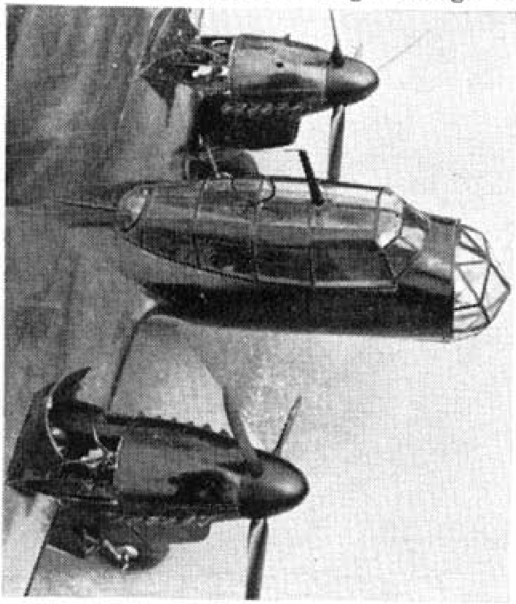


Fig. 63.—Capt. C. Milani's Do. 215 with engine hatches open to reveal throttle carburettor control.

with plain at the tail and under the belly, are easy to wire up and add little weight. Though the 4.5 volt battery that can be arranged to cope with all four bulbs in parallel need not be carried all the time, there is no reason why any scale control-line model should not start life so equipped. The navigation lights need no switch—they can be on for all of the flight. A powerful landing light would have to be an extra—used only at the beginning and end of each flight, switched on and off by the pilot. This can also be arranged by the insulated wire and relay method, with the points of the relay acting as a switch. A small pocket torch reflector unit makes a fine light unit, and if mounted in the nose the batteries can be fitted in a balsa box nearer to the model balance point with remote wiring to the bulb.

Another attractive avenue to follow in the scale control-line field is that of carrier planes. The U.S. Navy instigated a carrier-borne model contest, and over the years it has become so popular that the idea has spread to other countries. Main object is to take off from and land on a model carrier. The size varies according to the transport facilities and material available to the builders, and the original specification called for something in the region of 8 ft. wide by 40 ft. long, curved to suit a 60 ft. radius. Across the aft deck are stretched nylon or wire arrestor lines, and the model is expected to land using these to pull up. In addition, points are given for the difference in speed between several laps at slow speed and more at high speed, so that some versatility is required of the pilot. Further, it is primarily a scale model contest, though semi-scale is allowed at a handicap in points.

It follows that for the carrier contest we should have some form of motor throttle control, and a hook that will droop for the landing but not hinder take-off. Since points for realism are being offered, we might as well make it as near the full-size as possible and arrange the hook to droop when the engine is set at slow speed and this

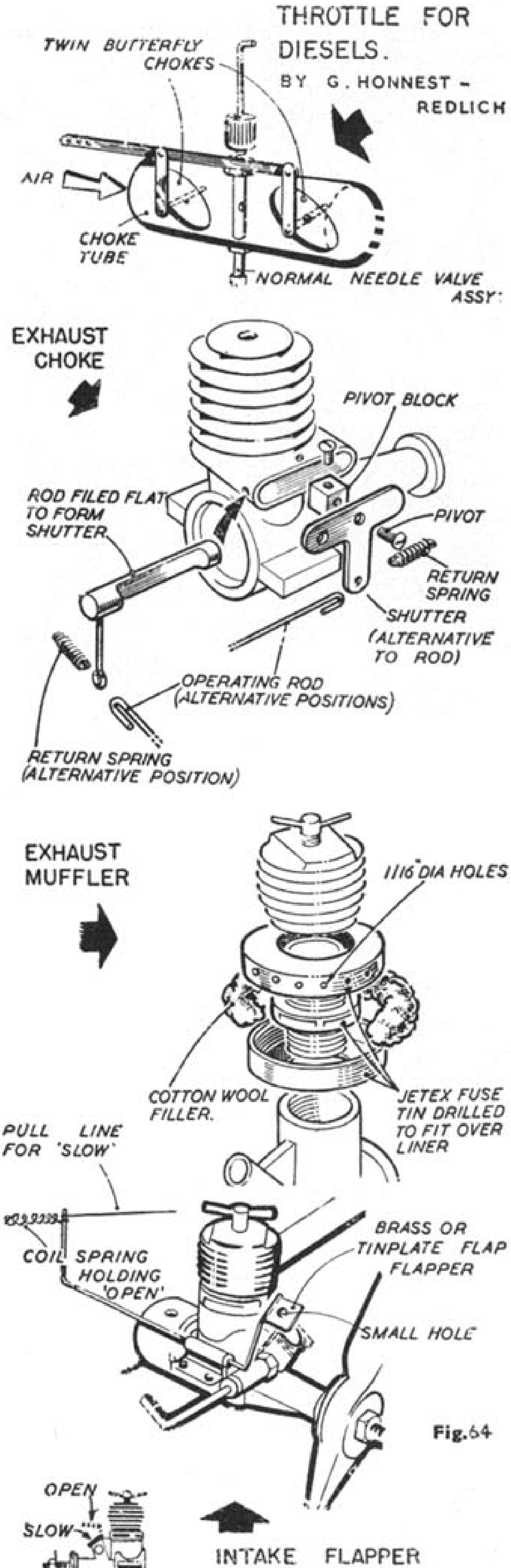


Fig. 64

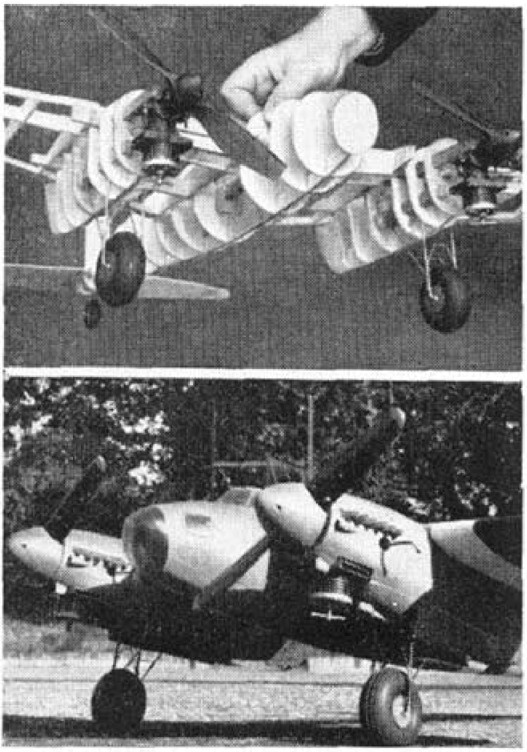


Fig. 65.—D.H. Mosquito before planking, and finished.

can be easily arranged through linkage.

As an added feature, why not a carrier torpedo bomber? This can be fixed by having the spring-loaded torpedo or bomb (with percussion cap warhead !) suspended below the fuselage and released when full " up " elevator is applied. We shall not need the maximum " up " control at take-off, and a mock attack on the object to be bombed (preferably not one's own carrier) will be made at low level, then sudden " up " for evasive action will cause the bellcrank to touch a trigger, release the load—and a few more points are racked up in your favour. Did someone mention a retractable-undercarriage Westland Wyvern—with torpedo slung beneath, arrestor hook to droop, motor control for fast and slow . . . plus navigation lights . . . landing lights . . . and, perhaps, one final touch, an ejected pilot if the lines break through overstrain? Yes—it might be a heavy model, but it is a possibility that could be arranged.

Summarising the controls we have mentioned, we have the three systems, arranged in order of advisability:

1. *Extra third wire control* — to be pulled for use as a switch or direct application of control.
2. *Insulated electrical control wire* — operating a relay for direct control or as a switch for other circuits.
3. *Airline control* — for use of air pressure through a tube to bellows-type actuators.

Besides the application of extra controls, the scale models flown on wires can be a type that would offer difficulties if attempted free-flight. Among them are the small-span types, Fighters and Racers, Jets (for pulse jet motors), and, mixture of the two, the Vertical Risers or V.T.O. aircraft.

The small fighters, Boeing P.26 or Brewster Buffalo, for example, can be a colourful semi-aerobatic project. Racers like the TK-4, Percival Mew Gull, Folkerts Speed King, and Wittman Buster are of suitable proportions for scaling down as team racers to the British Class A specification. Unfortunately, there are all too few other full-size racers that can offer these proportions of small wing and deep nose cowling, so that they fit the team race rules ; but there would be nothing wrong in making a true-scale racer, even if it did not fit the requirements of a team racer. Such a model is a good choice for Concours d'Élégance. A scale racer starts with an advantage in that the character of its full-size counterpart

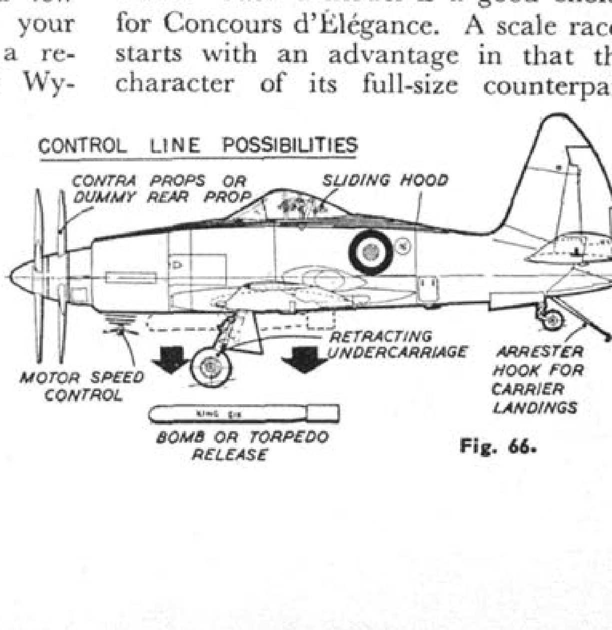


Fig. 66.

calls for good finish, clean lines and a nice paint scheme. If it makes a qualifying flight for the Concours event at a high speed, then it will be certain to impress the judges. For such a choice, combining speed, style and colour, we can think of no better aeroplane than the D.H. 88 Comet G-ACSS, winner of the MacRobertson Mildenhall—Melbourne air race. Finished in bright red with white lettering, the famous racer is elegant and well suited to a pair of fast-running engines.

The jet is unfortunate in life as far as modelling is concerned. We do have home-built and Jap, German, Swiss or U.S.A.-made pulse jet motors, but the fire and personal accident hazard, not to mention the noise nuisance, has hounded the jet from pillar to post. Enthusiasts for this form of propulsion, exciting though it might be, can be numbered as a distinct minority. No one could deny that a Grumman Panther, a North American Sabre or a D.H. Vampire would look superb and those who have been lucky enough to see models of these aircraft in Britain would agree that they give an unrivalled thrill—especially when they catch fire!

But they are not for beginners, nor for men of moderate modelling experience—they are for the expert alone, and, apart from this mention, cannot be detailed in this book.

Latest of the radical interceptor fighters is the Vertical Riser. This aeroplane stands on its tail when at rest, takes off vertically and alights again on its tail by using airscrew thrust to counteract the effect of gravity. To do this, the engine must develop an enormous amount of thrust from the airscrew. At the same time, this thrust must be free of torque, or twisting force, which is the normal reaction to a rotating airscrew. So we have contra-props—a pair of counter-rotating airscrews, each revolving at the same speed, and thus neutralising torque effect. In a model we have an advantage in that we can obtain better power/weight ratios than can the full-size people.

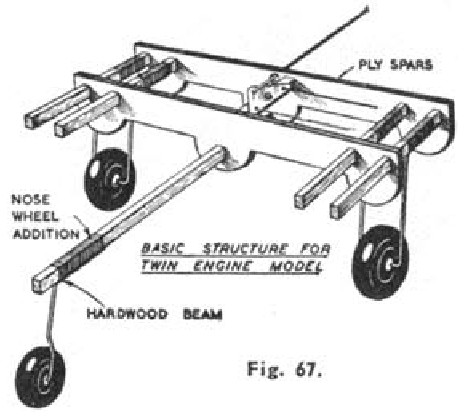


Fig. 67.

For example, we can make a control-line V.T.O. model that will weigh 12 ounces complete, with a fast 1.5 c.c. diesel capable of producing up to 36 ounces of airscrew thrust. Vertical take-off is therefore a simple matter for our model, and we can use the elevator control to make the model fly straight and level after "converting" it from vertical flight. Motor control, applied by third line or the electrical relay system described earlier, can be used to "blip" the throttle and permit a reverse landing . . . at least in theory! We can pack extra weight into the opposite tip to help keep the tendency to topple away from the pilot, and we can offset the engine slightly to pull out of the circuit, but the real answer, and one which appeals for its scale appearance, is a model contra-prop. Though a job for a model engineer rather than an aero-modeller, the contra-prop unit as shown is a workable proposition based on an American commercial unit. Coupled with throttle control, and fitted in a scale Lockheed XFV-1 Salmon, such a combination would typify the extreme possibilities of the control-line model.

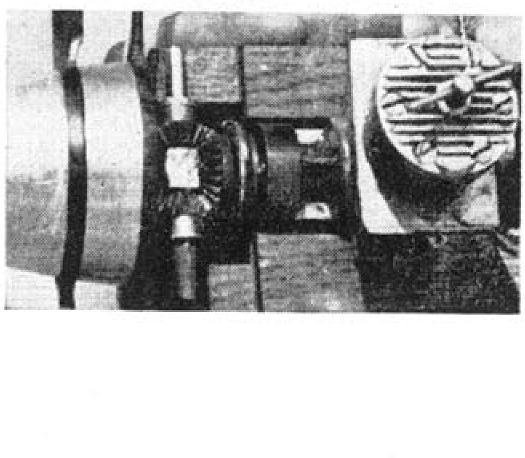


Fig. 68.—Contra-props on an E.D. 2.46 Racer completely eliminate torque.

Chapter Eight The Propeller

THOUGH we can reproduce the full-size aeroplane in detail, keeping true proportion in all the airframe components, we cannot hope to fly our model on a true to scale propeller. The reason for this is a simple one, and if you remember our brief encounter with Mr. *Reynolds* and his number of molecules theory, mentioned in Chapter 4, you will recall what is known as "scale effect". For a propeller blade is like a wing. It generates lift in a forward direction, operating at very high speed and high angle of attack, and because it is more efficient for it to have comparatively small chord (width) for its length, the blade scales down to an impractical size for our model. If we imagine the reverse, and can visualise what is suitable for the model being enlarged for a real aeroplane, then the picture would be quite extraordinary, and either the aeroplane would want to turn around the prop when the engine is started, or the blades would shear off due to their large drag and loading on root end and hub.

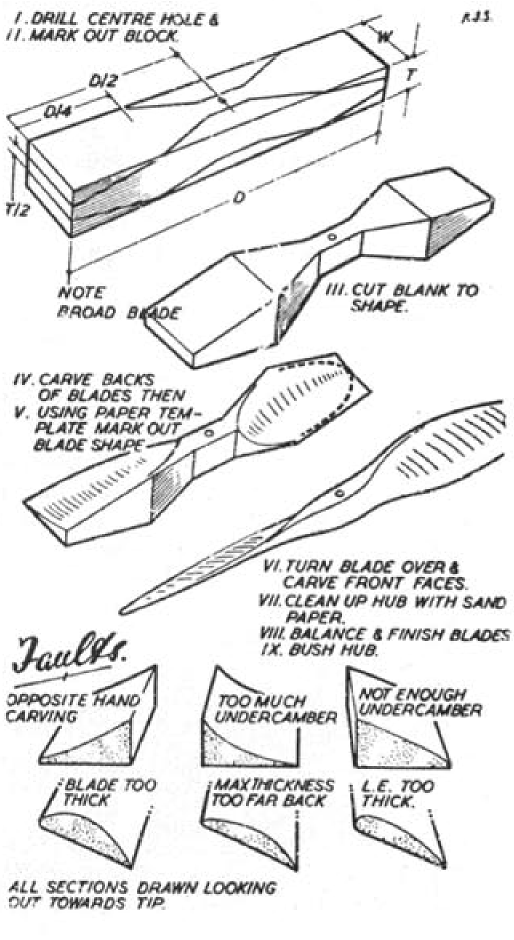


Fig. 69.—Stages in carving a propeller for a rubber-driven model. Note wide blade to take advantage of diameter. Power props have narrower blades.

For a rubber-driven duration-type model, the general rule is that the diameter is about one-third of the wingspan and the pitch is approximately the same as the diameter. What we mean by "pitch" is the distance travelled forward in theory of each complete revolution of the prop. It is just the same as a nut on a bolt, or the cap on the sauce bottle—one complete turn takes the item so far along the threaded portion, and progress is a constant rate. In the air, we are dealing with a less substantial medium, and some "slip" or skidding takes place to reduce the effective pitch to something like 70% of the theoretical designed pitch angle, so we have to allow for this handicap at a later stage when we are faced with selecting the prop for our particular model.

Now, although it is desirable for a 30 in. wingspan duration model to have a 10 in. dia. × 10 in. pitch propeller, our Puss Moth or Piper Cub is going to look darned silly with a fan of that size on the nose. We have to restrict ourselves to the diameter allowed by the undercarriage length, and spill the prop blade area sideways so that we have paddle shapes instead of the customary duration model ellipses.

Only in the rare cases of some very early aircraft, of Blériot and Antoinette vintage, do we find ourselves able to fly on a near-scale prop, and some power-driven control-liners can also get closer to scale for they can afford the concession to thrust. When a three-blade prop is used on the full-size, we can take the advantage of

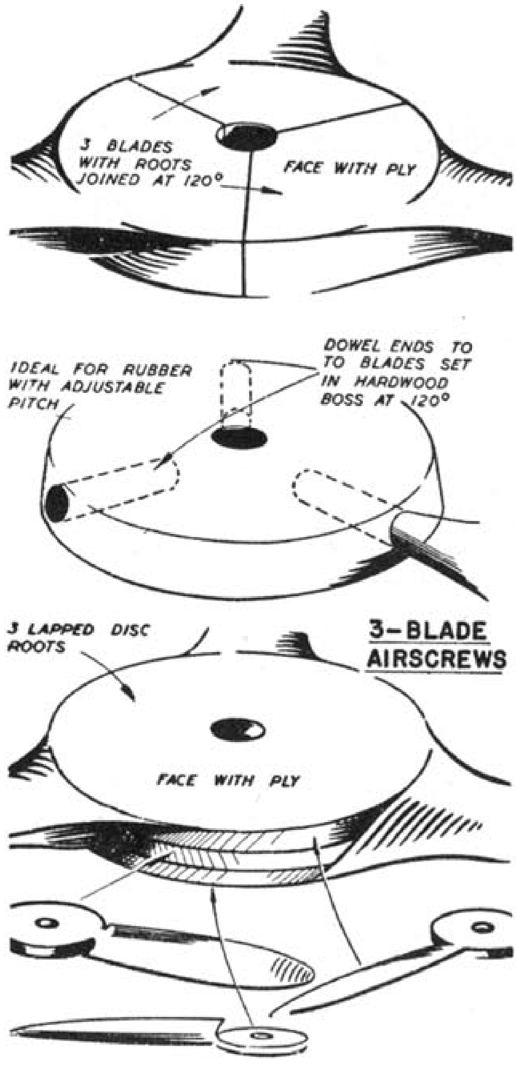


Fig. 70.—Three methods of blade root assembly, the bottom one being preferable for a power model.

copying this for extra blade area on a rubber-driven or control-line design. Free-flight power is a different matter altogether and we will see how the dictates of blade pitch and design make it essential for a non-scale prop to be used.

Firstly, the rubber-driven model. General rules for a suitable scale model prop are that the maximum width of the blank, or block from which the prop is to be carved, is $\frac{1}{8}$th of the diameter and the thickness about $\frac{1}{9}$th. The maximum width is maintained as far as possible along the blade, and full advantage taken of the area to get a generously cambered section for good low-speed thrust. A geared model can employ a slightly narrower blade for higher r.p.m. Sketches show how a typical two-blade propeller is carved, the three-blader calling for one of three different approaches.

Since it is essential for the blades to be made from three separate pieces of balsa, only the construction of the root or hub will show variation. First method is to end each blade root in a 120° Vee-angled spade, so that the three-blade roots combine to make a circular hub. This is then faced on either side with plywood, and tacked if considered necessary, or alternatively a centre " core " of ply can be cut into each blade like a large letter " Y ". Second method is to terminate the roots in the form of circular dowels and plug them into drilled holes at 120° spacing on the hardwood hub—a method which allows changes of pitch setting before final glueing, or even adjustment during initial test flights.

Third on the list is the blade interleaving scheme, where the thickness of the hub is divided into three, and each blade root is shaped into a circle, with one third of the boss or hub thickness. To strengthen such an assembly, the hub should be plywood faced on both sides and the facings extended for $\frac{1}{4}$ in. along each blade from the central disc.

Four-blade propellers are more simple to make, being pairs of two-bladers half-lapped at the centre.

For all these joints, a slow-drying glue is advised. Balsa cement is not suitable as it has little chance to key into the surface, particularly on the end grain joints. Le Pages, Casco, Croid, or the impact glues such as Aerolite are strong enough to withstand the large centrifugal force applied on a built-up prop assembly. This particularly applies to the power model prop, which can be made up in exactly the same joint systems as described for the lighter balsa multi-blader for rubber drive. There is also another method of making a power three-blade prop, which should replace the dowel-ended method described above in view of the increased speed and loading. It is the one-piece plywood version. Actually cut from a disc of ply which must be made up by the modeller, and certainly not be the ordinary commercial ply, the prop should have at least six laminations of hardwood, each successive grain direction being at 120° to the previous one. With six laminations, we thus obtain two direct grain layers from root to tip in each blade, and if the hub is at least ⅜ in. thick, this means each layer can easily be cut to the three-blade blank shape in the first place, so saving the hard work of fretting out a thick disc. If the layers are alternately light and dark, such as mahogany and spruce, or walnut and whitewood, or lime, then the final effect of the "layered" appearance is most pleasing, and permits absolute symmetry in all three blades, simply by comparison when carving, of the division lines between colours.

Carving the propeller for flight will follow the same pattern of procedure whether two- or multi-blade, for rubber or for power. The only difference likely to occur is that for the rubber model we should have "undercamber" or a concave surface on the rear face, while the power prop has the rear face perfectly flat. Actual carving demands a knack which can come only with practice, a number of commercial rubber and power props are available; but since we are most likely to need something different from the ordinary run of design for our rubber or control-line model in the way of a wide-blade "paddle" or a three-blader, we must invariably start carving our own. In any case it is more satisfying, and certainly cheaper, to make the whole model *including* the propeller oneself.

Start with the rear face every time. The blade should remain a rectangular blank shape until this is completed and then, when a template of the blade profile is held over the finished back of the blade, it is trimmed to shape and turned over for the front face to receive its attention in carving to section. A rubber model prop has a thin arched section, a power prop is thicker, and rather like the Clark Y aerofoil in section.

When sanded and given two coats of sanding sealer for last rubbing down, the blade is balanced by pushing a tight-fitting dowel through the drilled boss and allowing this to rest across a pair of razor blades "on edge". This process should be repeated as a rough guide during the carving stage too, but final balance is left until after the last coat of cellulose is applied. If one blade is heavier, then a spot of cellulose at the opposite tip will soon right the balance.

The word "pitch" has so far indicated that it exists in two forms, theoretical and effective. We will be concerned with the effective pitch, for this will determine the flying speed of our model, especially a power model where the output is a constant b.h.p. and not variable as with rubber. Let us assume that the model will be required to fly at 15 m.p.h., which is 1,320 feet per minute. Our engine is a 1 c.c. diesel, and it can turn an 8 in. diameter propeller of 4 in. pitch at 8,000 revs. per minute. Let us assume that its effective pitch is 3 in., then it will pull the model along at the rate of 2,000 feet per minute—faster than we need. But one must also allow for another contribution to slip, and that is the airframe drag, so it is safe to allow this extra margin of 2,000 over 1,350 and to use a theoretical 4 in. pitch. This illustration is typical, and uses the published engine test figures that are always a useful feature of *Aeromodeller* Engine Analyses. In fact, the 4 in. pitch propeller is the most widely used size for free flight, and 6 in. or 8 in. for control-line where 30 m.p.h. to 60 m.p.h. speeds will be needed.

The propeller for rubber drive is nearly always of "square" proportions. That is to say, it has the same inch dimensions for both diameter and pitch. We cannot work on the same basis as for the power prop since (a) we do not have a ready reference to r.p.m. scales, and (b) the power is not a constant output, starting with a sudden burst and terminating with a very low power, finally blending into the free-wheeling stage. So practice comes before theory, and if we have an 8 in. diameter we try a pitch of about 8 in. first, and if too high revving, the solution is to change for a higher pitch.

If gears are employed, it is advisable to reduce the pitch slightly as this will suit the characteristics better, particularly if the gear ratio is not 1:1 and made so that the propeller rotates faster than the unwinding motor. Providing one realises that the propeller pitch/diameter variables are just the same as the changing gear ratios in a car or a motor-cycle, then one gains an appreciation of the practical approach we have to take in selection of pitch.

Having chosen the pitch figure, we ought to know more about it, what it is, and how it is defined on the blades. This is best explained by stating that the blade is so designed to advance, say 6 in. per revolution. To get this figure we project a vertical line 6 in. from a base line on the drawing board, and join the top to the base with a hypotenuse (longest side of triangle) measuring 11/7 times the diameter in inches. The resultant angle between the base line and the hypotenuse is the pitch angle at the point halfway between the tip and boss of the prop, or one-quarter diameter.

Simplifying this method, we can use a little gadget to check our pitch angles, for although we have determined the angle at the halfway mark, the root and

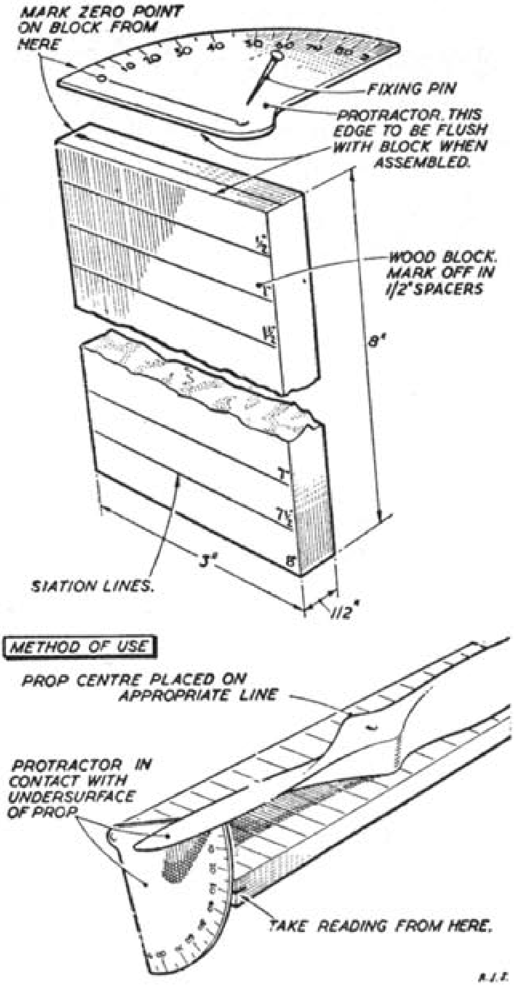


Fig. 71.—Gadget for measuring pitch on a prop, used in conjunction with the table.

Pitch (in.)	Radius from prop centre in inches 7	6	5	4	3	2	1
12 in.	15°	18°	21°	25°	33°	44°	61°
10 ,,	12°	14°	18°	22°	30°	34°	58°
9 ,,	11°	13°	16°	20°	26°	36°	54°
8 ,,	10°	12°	14°	18°	22°	32°	52°
7 ,,	9°	11°	12°	16°	20°	29°	47°
6 ,,	8°	9°	11°	13°	18°	26°	44°
5 ,,	6°	8°	9°	11°	15°	22°	38°
4 ,,	5°	6°	7°	9°	12°	18°	32°
3 ,,	4°	$4\frac{1}{2}$°	5°	7°	9°	13°	25°

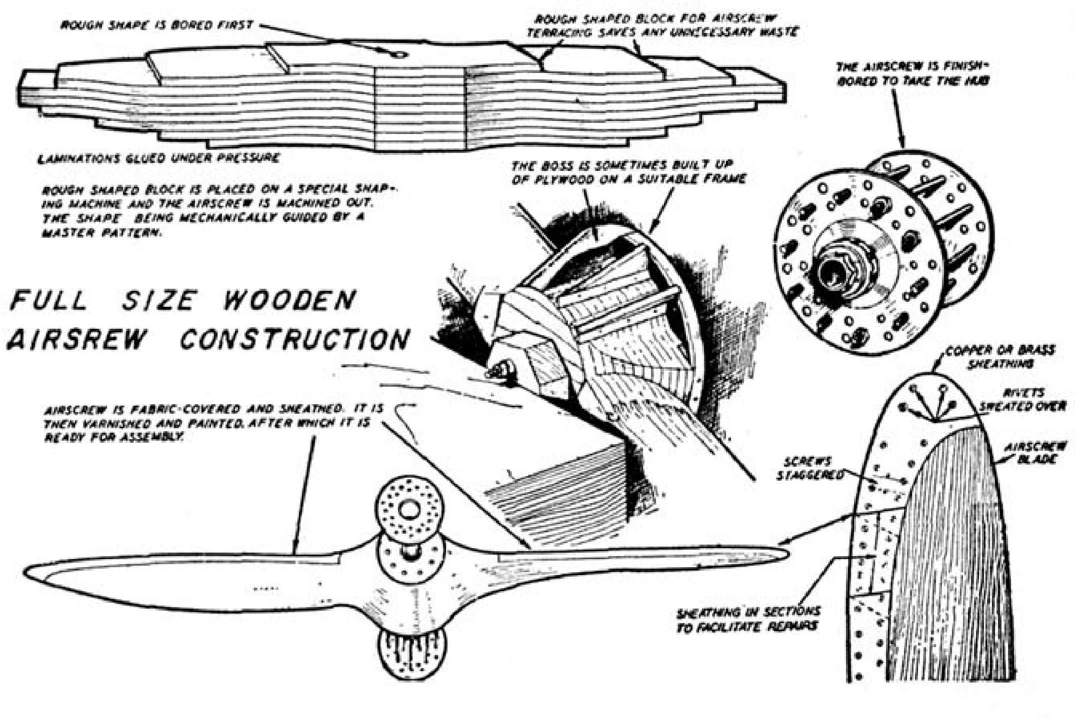
tip will have different angles since they travel relatively slower and faster than the midway position. The gadget is like a protractor on the end of a base-board. It can be made from balsa measuring $\frac{1}{2} \times 3 \times 8$ in. which is marked off in $\frac{1}{2}$ in. spaced lines. By placing the prop centre over the appropriate line to get the correct distance from the root situated over the protractor, we can read off an angle against the chart. For example, if the prop is 8 in. diameter, and supposed to be 4 in. pitch, then with the boss over the 4 in. line, the blade angle at the tip should be 9°. At the 3 in. line it should be 12°, and at 2 in. from centre, 18°. See the sketch and the method becomes self-explanatory. A little thought, and it soon becomes apparent that we can employ the same gadget for working out the thickness of the prop blank in relation to its width. By setting the protractor to the indicated angle on the chart, we have only to place a 90° set square on the base against the rear face of the protractor, and reading the vertical height to the angle when the square is set at the prop width from the base edge will give the required depth. The table provides angles for the possible side range from the little 6 in. × 3 in. power prop used on .5 c.c. engines up to a 14 in. × 12 in. rubber prop.

The modern prop with painted or light grey anodised finish is simple to copy, having dowel-shaped roots entering either a spinner or a laminated boss shaped after the blades are fitted. It is the old-timer which calls for more special effort, and the lamination of mahogany or similar veneers produces a very nice effect.

As a final touch, the leading edge should be "sheathed" with brass or copper foil, held in place with a reliable glue and dimpled with the blunt point of an awl to represent riveting.

There is one other variation on the propeller theme, and that is the counter-rotating prop as mentioned in Chapter 7. Perhaps we cannot make the geared mechanism for our free-flight or control-line model; but at least we can reproduce the scale unit for static display. Or why not use just one prop and have the other permanently feathered? For builders of a control-line Fairey Gannet with double Mamba turbo-props, this would be a fitting approach.

Fig. 72.—Full-size construction can be copied for power models.



Chapter Nine **Aids to Realism**

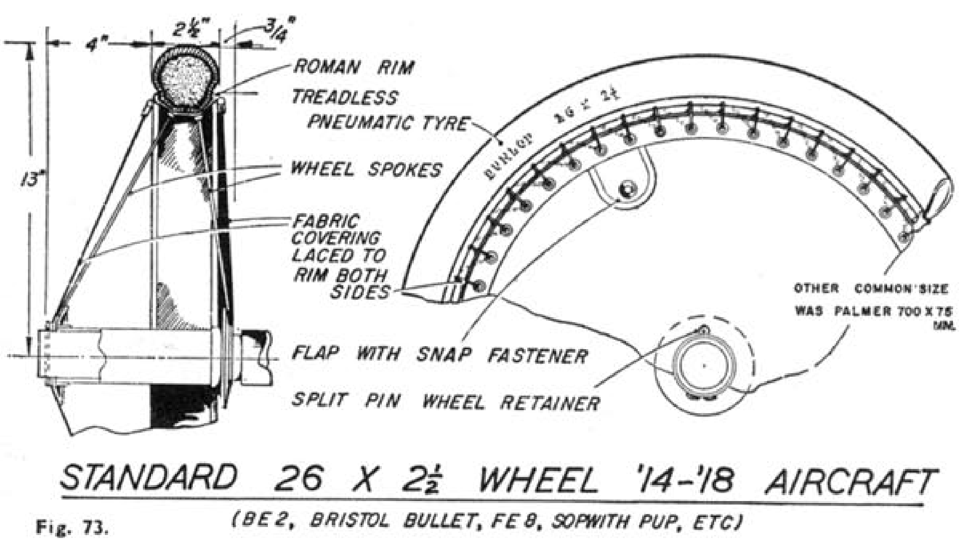
NO matter how accurate a scale model may be in its outline and section, it will still rely upon the very important but small details to carry off the impression of realism. This is particularly so in the case of principal items, which are too often replaced by commercial "over the counter" goods intended for sports models. Wheels, spinners, props, and pilots are the chief offenders, and the latter two are dealt with in Chapters 8 and 13.

A plain airwheel may look reasonably accurate on a modern lightplane ; but its large tyre diameter hardly befits any aircraft of early vintage. Aircraft wheels were, for a long time, spoke and rim constructions just like an ordinary pedal bicycle ; but with the rim offset over the hub so that one side of the wheel was almost vertical and the other at about 70° taper inwards from a wide hub. Most common sizes in '14-'18 were Dunlop 26×2½ in. and Palmer 700×75 or 100 mm., these references being for the *outside* diameter of the tyre and the thickness. (*Not* like a car or motor-cycle.) Although not round in section, the tyre dimensions are sufficient to calculate the actual rim size and the general proportions of the wheel. (See sketch.)

Rather fortunately for modellers, the open network of 10 s.w.g. spokes was an efficient mudtrap and weight gatherer, so a "streamlining" was laced to the rim, being secured at the centre by a metal ring over the hub. Our model wheels can therefore be simple conical discs with small-radius tyres which cannot be expected to help take any landing shocks.

There are several ways of reproducing the conical section wheel, the most accurate being that devised by Rupert Moore using a plaster of paris mould and papier mâché to form the wheel contours. First cut a ½ section of the wheel in tin or stiff card. Pivot this section in the centre of a disc of plasticine, around which is formed the moulding box, then fill with freshly mixed plaster.

By rotating the wheel section, we have carved out an impression for one wheel half, and transferring the process to the "other face" in plaster enables us to make as many papier mâché vintage wheels as we will ever require. Chapter 5 explained how to make up the compressed paper surface by tearing off small pieces ; but in the case of a wheel, the layers can be whole discs. When joining the wheel halves over a



STANDARD 26 X 2½ WHEEL '14-'18 AIRCRAFT

Fig. 73. (BE 2, BRISTOL BULLET, FE 8, SOPWITH PUP, ETC)

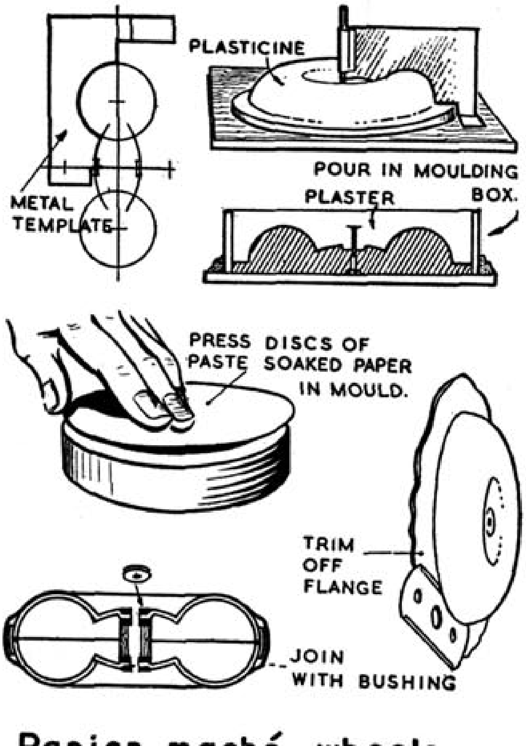


Fig. 74.—Simple method of moulding with newspaper and paste.

brass tube hub, apply a coat of tough model tissue or fine silk to avoid a ridge on the tyre curve.

Acetate moulded wheels are never really satisfactory, although the process lends itself to the flat-sided wheel of the Gladiator era, and there is another alternative in the all-wood wheel, made up in a series of thin layers as sketched. This is easy to make, and because the layers need be no thicker than $\frac{1}{8}$ in., a pair of compasses with a broken piece of razor blade instead of the pencil can be used to scribe out the perfect circle.

The problem now is how to retain the wheel on the axle —for although many aircraft display a large nut which is an obvious answer for us, the majority use a very small axle washer and split pin affair that might just as well not be there as far as we are concerned! One solution is to sleeve the axle with a length of thin-wall tubing, and solder a capping washer on this before fitting the wheel. Then slip the wheel on, and fit the sleeve over the main axle, soldering where it protrudes through on the *inside*. Another method is to make up the wheels actually in position on the axle and solder retaining washers inside the hollow structure.

For realism, there is nothing more certain to impress or delight the eye than a working telescopic leg. Many full-size subjects allow us the opportunity to use this excellent form of springing, yet so many modellers fight shy of the method on the basis of it being " too complicated ". The most suitable type of undercarriage for model telescopics is the sideways swinging three-strut unit. Each wheel is on the apex of an inverted tripod, the inner pair of struts being rigid in length but swinging from their attachment to the fuselage, while the third strut stretches or compresses. This leg is made of aluminium tubing, sliding over a piano wire—or welding rod wire—strut of smaller diameter. Wind a 20 gauge coil spring by binding it tightly round a small section nail held in the vice, and slip this into the tube so that when the model is at rest, the telescopics are at scale position, and when in flight the wheel drops to scale flight position. The compression of the coil spring will take up the travel between these two positions and also allow extra movement during the landing shock when the spring is usually taken to maximum compression.

A feature of early aircraft was the complex struttery around the under-

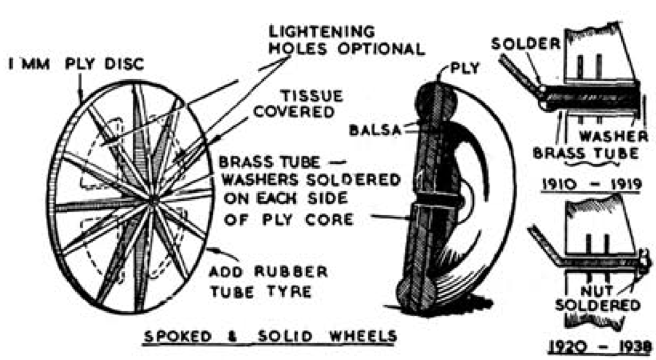
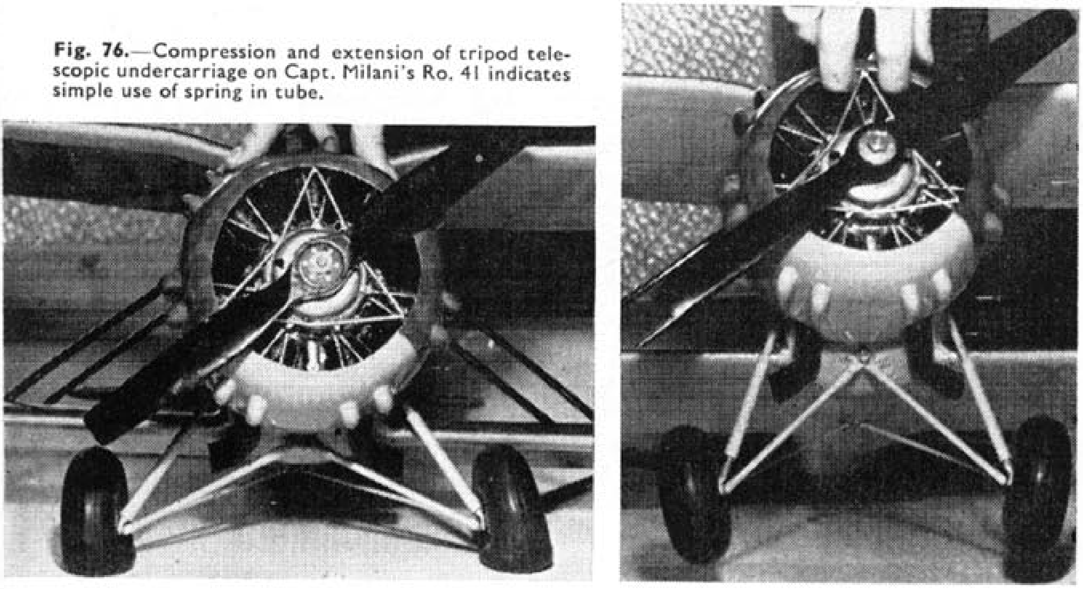


Fig. 75.—Wooden wheels and retaining methods.

Fig. 76.—Compression and extension of tripod telescopic undercarriage on Capt. Milani's Ro. 41 indicates simple use of spring in tube.



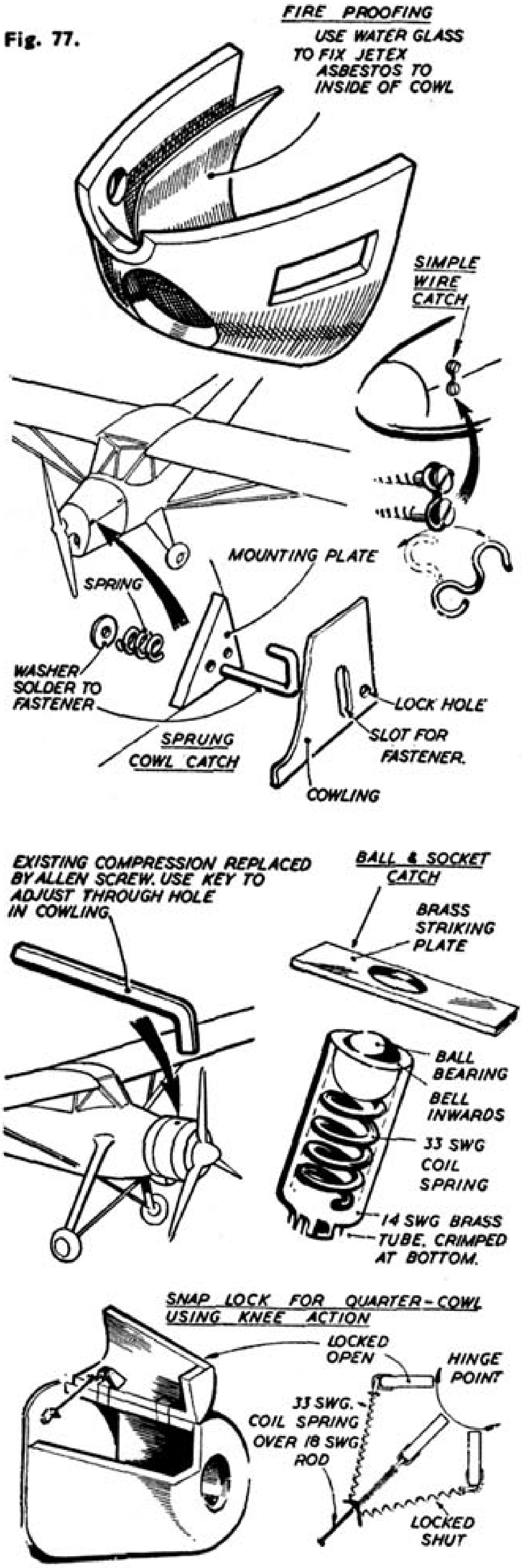
carriage, including large hoop skids out in front to help save the prop in a nose-over. These were either of tubular mild steel or ash, the former we represent with piano wire, the latter with bamboo, and this is a material which has been with the aeroplane and aeromodelling for all time. Some of the early framework pushers had their tail units supported by bamboo, and most early models were silk-covered spruce or bamboo frames, yet we have to look hard to find it on the modern sports model, for its strength/weight ratio is rarely required. In the scale model, the struts, for the wings or undercarriage, can be part of the stressed construction and far from ornamental. Bamboo is the perfect material, since it can be springy or rigid, is hard to break, bends easily in dry heat over a gas flame or candle, and looks the part. When varnished, a bamboo strut is as realistic as one could desire, the fine grain lines representing ash on the full-size to perfection.

It may be that our model will need hatches and detachable sections for internal access. The cowling around the engine, the cockpit, or a hatch to get at hidden tail-retaining elastic bands, can all reproduce the real counterpart and add to realism. Make the hinge lines coincide for these panels as nearly as possible to those on the full-size. If parts are to be hinged, keep the hinges hidden from sight by burying them in the covering or arranging an articulated motion. The "piano" hinge, with a continuous run of tubular bearings over a central core of wire is the officially approved full-size method for a cowl or cockpit cover ; but this cannot be scaled down to model size satisfactorily. A length of silk or nylon taped over the joint is often the simplest and most effective hinge—if camouflaged into the final finish.

To keep a hatch shut, one can use a bent piano wire catch, or a small turnkey flat on the surface: but the spring hatch catches used by J. Sutherland of Dundee deserve attention. No. 1 uses a length of wire running through a lug, and between the lug and moving hatch, there is a spring over this wire, under compression. The lug and attachment of the wire on the hatch are so positioned that when fully open or shut, the spring is holding the hatch firm ; but in the halfway stage, it resists staying in any set position. This gives a "snap" action—either fully open, or shut firm.

A small ball catch can also be made, working on the same principle as the full-size furniture ball catch, only made with a small ball bearing, length of

Fig. 77.



COWLING DETAILS.

tubing and a home-wound 33 gauge spring. Burr the tube end to hold the ball as on a ball-point pen, slip in the ball and spring, then nip the tube to hold the spring. This unit goes in the hatch, and a catch plate, with a small locating hole to receive the ball, in the fixed portion of the fuselage. This gives a "pop" action and is specially valuable when there is no room inside the hatch space for any other type of catch.

In most cases, the detachable cowl or hinged hatch will be carved from balsa: but for some engine cowlings, it is an advantage to use the same type metal as the full-size to get the desired effect. Brass and aluminium are very easy to beat into shape—if a little patience is applied to the process. Many taps, and light ones at that, is the general rule, and for the average model we select 18 s.w.g. metal.

Make a hardwood facsimile of the cowl or hatch, and pre-bend the soft metal so that it adopts most of the curve in one direction. Then start "working" the metal with taps from a ball peine hammer (rounded-end head) and you will find that in no time at all it is possible to make a compound curve—of sorts. The skill comes in smoothing out the multiple ripples left by the hammer action, and patience scores (plus a great deal of elbow grease and emery cloth) in getting the final effect. A short cut to the radial cowling is often found in the local ironmonger's in the blancmange and jelly mould department, where circular moulds or very suitable curvature can be cut to fit the nose of many a model.

The brightly polished aluminium surface of the full-size engine cowl is easy to reproduce if we are using the same metal for the model and even if "engine turned" with myriad whirls of circular buffing, we can get this same effect too by following full-scale practice. Fit a piece of tubing over the shaft of a small electric motor, and pad the end with a hard eraser. Start the motor, and push the spinning "buff" on the cowl—you will find it leaves exactly the same effect as seen on the real thing, from Sopwith Camel to Hawker Fury.

Use of metal also has one great advantage over wood when it comes to an engine cowling, for it is possible to cut louvres and so get a better cooling flow through the engine department, as well as letting out some of the exhaust mess that comes with the power-driven model. To cut louvres, we need a very sharp chisel (that we can risk on soft metal) or a fine drill and fretsaw.

With the drill we make a fine hole at the bottom of the louvre slot position, and then fret the slot out. With the chisel we can strike from the inside of the cowl to make the slot. Whichever way is employed, the next stage is to get a small awl and work the louvre so that it curves outwards, opening the slot yet keeping a smooth, rounded edge to the shroud at top and bottom. Practise on a piece of scrap first.

There may be a radiator in the nose. An SE5a, Bristol Fighter, or SPAD will call for shutters, rather like a venetian blind across the honeycomb of the water radiator. As we have to get some air through this to cool our engine, use a piece of black-painted meat-safe zinc (perforated finely) as the background to the shutters, which can be slats of brass riveted across the zinc face on one edge to catch the air and draw it into the cowl. As for the exhaust, if the engine is a small diesel, then there will be a commendable silence if it is allowed to find its own way out through a hidden drain hole in the bottom. The cowling then forms a kind of silencing box.

If the thought of panel beating does not appeal, we can still obtain the polished metal effect by using one of the Sanderson's Metallised Wallpaper sheets. This is sold by decorators for window display work and can be bought in aluminium, copper, or gold tones, though our particular interest is in the aluminium grade. The beauty of this paper is that it can be worked over a compound curve, and the tricky parts can be cemented on with a good-grade slow-drying model cement.

It is one 3,000th thick (.003 in.) and this

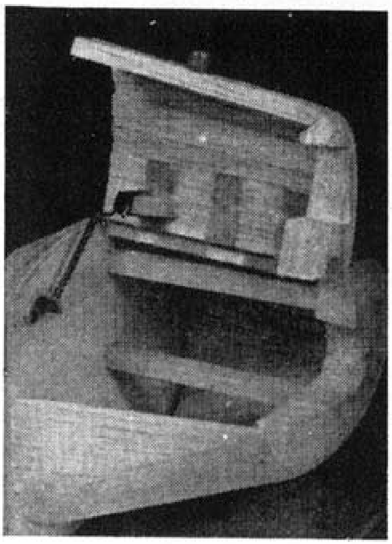
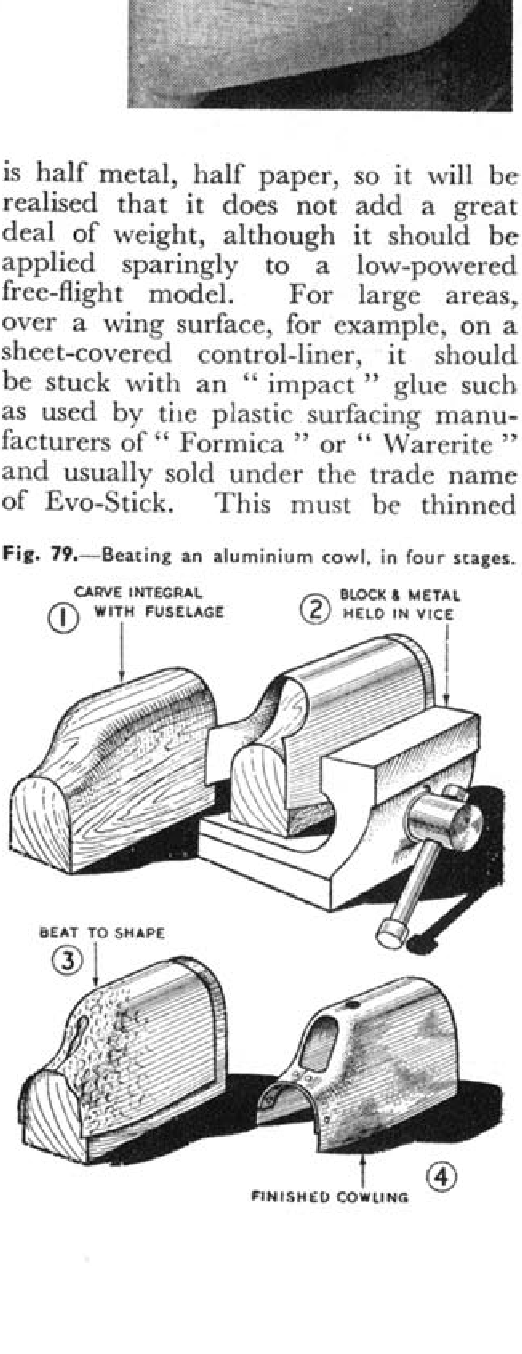


Fig. 78.—Auto-locking cowl hatch, as sketched in Fig. 77.

is half metal, half paper, so it will be realised that it does not add a great deal of weight, although it should be applied sparingly to a low-powered free-flight model. For large areas, over a wing surface, for example, on a sheet-covered control-liner, it should be stuck with an "impact" glue such as used by the plastic surfacing manufacturers of "Formica" or "Warerite" and usually sold under the trade name of Evo-Stick. This must be thinned

Fig. 79.—Beating an aluminium cowl, in four stages.



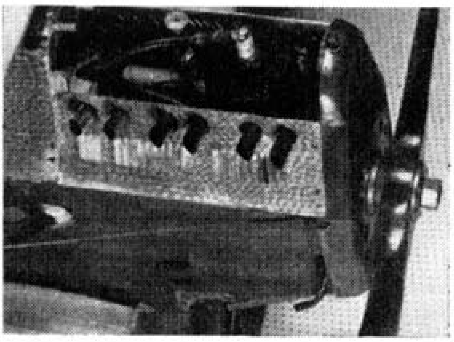


Fig. 80.—Capt. Milani's metal cowls on Fiat and SVA fighters have louvres for engine cooling and are " engine tuned " with eraser rubber on electric motor shaft.

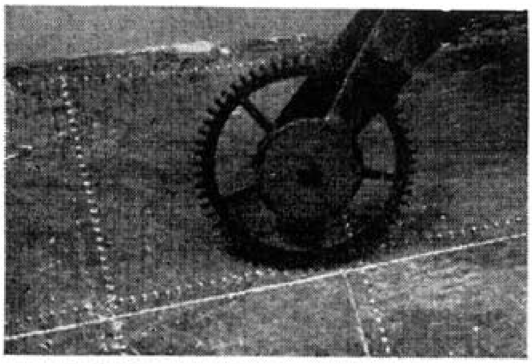
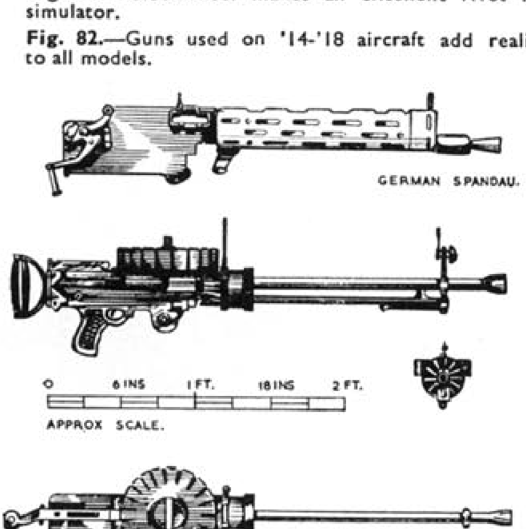


Fig. 81.—Clockwheel makes an excellent rivet line simulator.

Fig. 82.—Guns used on '14-'18 aircraft add realism to all models.



down with acetone, and applied in a thin coat to both the sheet wing or fuselage surface and the metallised paper (cut with small overlap). Just as with a puncture repair on a bicycle tube, we wait for the solution to almost dry, and when the finger-tips can be brushed over the surfaces without sign of tackiness, the two faces can be brought together—and once together, they are there to stay! So be warned, and get the position right first time. To wrap around a curve of leading edge, rub hard with smooth cloth (Butcher's Mutton cloth) and " bone " around the compound curves with the rounded edge of an old toothbrush handle. The metal can be worked in this way to follow any curve, and if intersecting panels are allowed to overlap, a razor blade cut through them will find the right butt joint and give a neat panelling appearance. For the impression of rivets one can make a small " pastry decorator " out of an old clock or watch wheel and a run along the surface with this leaves a line of indentations that looks just like the real thing even though it is actually in reverse. The metallised paper can be polished with one of the impregnated wool polishes such as Dura-glit, and also be " engine turned " as already described for a metal cowl.

Exposed guns on wartime aircraft, especially the early types, call for fine detail if to give the right impression. There were three basic types in use during the '14-'18 war. The Spandau, used by Germany, and the Vickers and Lewis by the Allies. As the drawing indicates, the Vickers can be reproduced nicely in wood, with an alloy tube barrel projecting from the water jacket (painted same as the aircraft) but the Lewis is a wire/card/tube and balsa proposition that calls for care. The whole should be coloured a dull blue/black, and a brown "leather" strap placed across the centre of the loading drum. Spandaus are remarkably like some ladies' hair curlers—if the scale suits—but if one has to make them, the holed barrel shroud should be rolled from a flat piece of 22 s.w.g. brass after this has been drilled and slotted to suit. Plug the end and fit a tube barrel through the bottom, then paint a dull grey to represent the "sand-blasted" effect of these guns. Quite a number of small parts on the guns, as well as details like windscreen frames, strut brackets, rigging lugs and cockpit fittings can be most realistically fabricated from shim brass, about .008 in. thick. This can be bought in small sheets from the garage, cuts easily with an old pair of scissors, and can be stuck in small areas with balsa cement.

The rigging of a model will depend on whether it is a one-piece job, or has detachable wings. For the former, we can use the wires to work like the real thing and stop the wings from folding up, or they can be purely ornamental and shock absorbing. The majority will be in the latter category, and the finest material for the purpose is called shirring elastic, sold for dressmaking. Bought on a spool like thread it is about ·015 in. thick and has the finest of bindings around the central rubber core. It will stretch; but has no great power in the tension, so all wires can be pulled taut, knotted around strut lugs and cemented—the covering makes a good cement joint. As the shirring elastic wears, it tends to fluff, and so it is advisable to run it through Indian ink, to make it perfectly black and to get the odd fluff settled down before use. Other, more rigid wiring material is stranded control-line wire of approximately the same thickness; but with infinitely better scale appearance. This can also be kept taut between struts by spring tension, using a short length of 30 s.w.g. coiled spring at one end. A half-inch, with 15

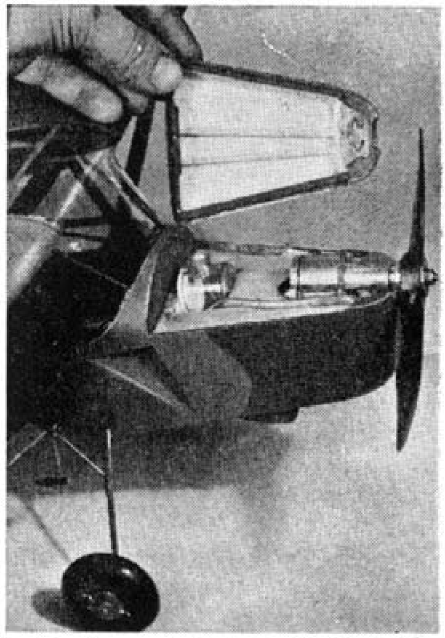
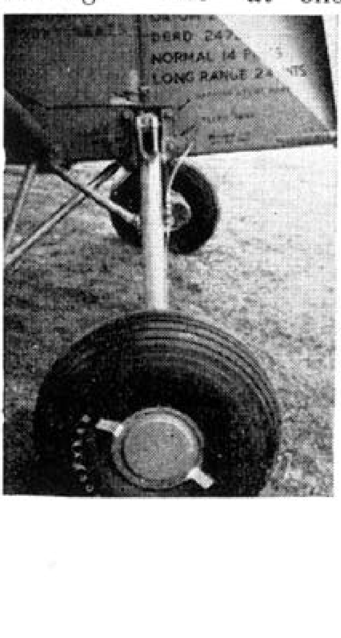


Fig. 83.—Cowl on author's Auster A.O.P. 9 clips on crankshaft. Note how simple wire u/c represents full-size as in Fig. 84.



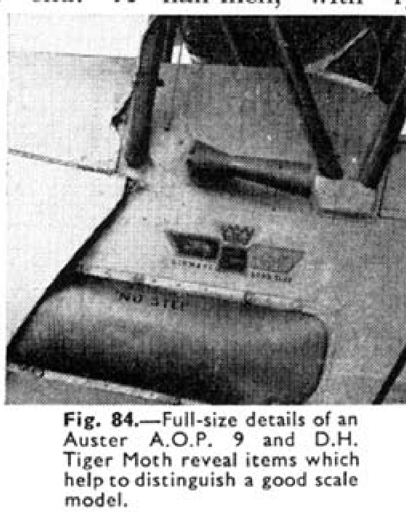


Fig. 84.—Full-size details of an Auster A.O.P. 9 and D.H. Tiger Moth reveal items which help to distinguish a good scale model.

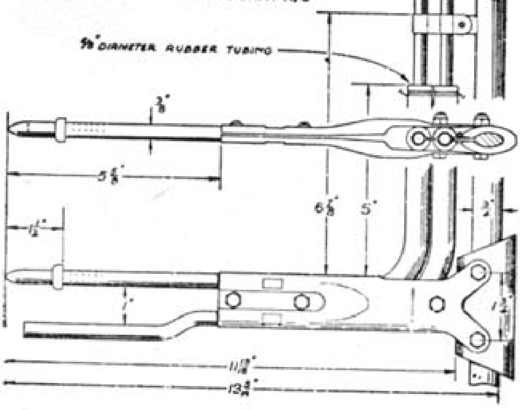
turns in the coil before attachment, is usually enough to keep an 8 in. length of stranded wire straight. The same wire can also be employed for the dummy control wires which pass out of the rear fuselage to horns on the rudder and elevator. Even if they do not work, they do at least impart a degree of confidence in any examining pilot—who will always look to see if the flappers are hooked up correctly.

If the wing unit (a pair of biplane wings, say for the port side) is intended to knock off, then we have to see that the rigging is free of the fuselage and wires that pass to the root ribs are not a hindrance to the knock-off action. On the full-size, these wires would go to the centre section and fuselage, so we have to make a compromise and fit small brass or tin lugs at the root ribs to give a false appearance.

On a streamlined monoplane, we have no rigging to worry us: but instead, there is a long aerodynamically designed root fairing which would take an awful lot of plastic wood—even if we could afford the weight. The answer to this is in silk. First we make a profile of the fairing on the fuselage side, in $\frac{1}{16}$th sheet, and at the juncture of the wing and fuselage we position a flat fillet in $\frac{1}{8}$ in. wood. Mark the curve for the fairing joint to the wing, and by trial and error, cut a paper pattern to fit. Then cut this in silk, leaving a $\frac{1}{4}$ in. overlap all round, and wet the silk thoroughly.

Fig. 85.—Exterior fittings to be found on most light-planes and not often reproduced. Note Venturi in Fig. 84.

PITOT HEAD FITTED TO 'AUTOCRAT' A/C

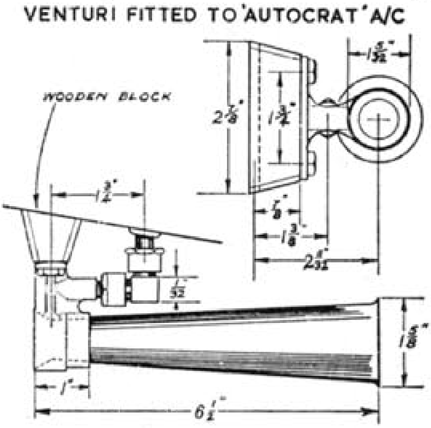


Run thin cement all around the fuselage profile sheet edge, along the wing curve and the fillet. Now pin the damp silk in place, working from the pointed front to the curved rear, and pinning into the fuselage as you go. A pull at the rear end gets the convex shape, and an application of dope keeps the edges of the silk flat and unobtrusive. As it dries, the silk adopts the curve, or " two-way " stretch, and this same method can be applied to other parts as well.

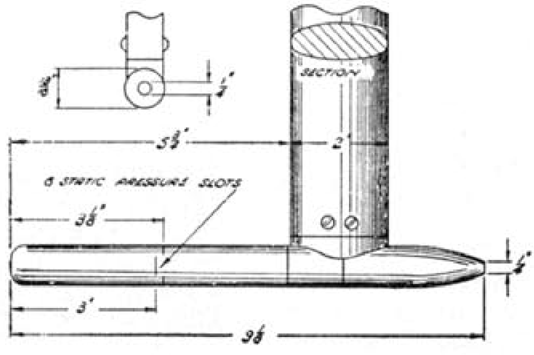
In particular, a stringered fuselage, such as that on the Bristol Bulldog, Westland Lysander or practically any early biplane trainer, can be reproduced at best with silk covering applied wet and adhered with cement. The moisture in the silk causes " blushing " where the cement makes contact, but this is soon removed after the first coat of clear dope.

It is advisable to use scale rib spacing and to employ the little false ribs which only extend back for 15 or

VENTURI FITTED TO 'AUTOCRAT' A/C



ELECTRICALLY HEATED PITOT HEAD FITTED TO 'GEMINI' A/C



20% of the wing chord on the full-size. Weight considerations are often put forward to excuse a sketchy framework with a starved appearance about the wing: but one can always halve the rib thickness and use twice as many!

Then there are the "opposite" surfaces, which are metal on the real aeroplane and reinforced with corrugations or *external* stiffeners. The corrugations can be grooved into soft sheet for a fuselage side, but are hard to reproduce on a wing. In any case these are virtually limited to the few possibilities among the Junkers range (perhaps a W.34) and the problem is hardly likely to occur for wings. The outside reinforcing is common, and very easy to reproduce from fine strips cut out of $\frac{1}{32}$nd sheet which represents a $\frac{1}{4}$ in. in one-eighth scale. Cut the strip in a long length, stroke with sandpaper to get a rounded surface, and adhere to the wing, tail or rudder with a coat of clear dope. The Grumman Seabee, and surfaces of the Pioneer are typical examples of this construction.

Control surfaces should look as though they work. It is normal for an aileron to fit the wing in a shroud of the type named after creator L. G. Frise. This gives a wider chord to the aileron on the bottom surface than on the top, and the air gap between the wing and aileron is like a wing slot. To reproduce this, one must, of course, make the aileron as a separate item and this can be turned to advantage for, at a later stage, we can use the aileron as an aid to trimming the flight of the model. Use the thinnest of sheet for the shrouds so that weight is kept to a minimum (heavy weight at the tips is an unstabilising factor in free flight) and $\frac{1}{64}$th sheet will usually cover the aileron leading edge and the wing shroud without sagging between ribs if no more than $1\frac{1}{2}$ in. apart. And don't forget to hook up with dummy controls!

Continental aircraft designers in the early days were very keen on "fineness ratio" for their aerofoils, and the trailing edges of wings and elevators were no thicker than a wrapping of linen around a fine cord. There was no such thing as a rigid trailing edge on many an aircraft. A rear spar was situated at about 95% wing chord, and the points of the ribs joined by a cord from root to tip. Naturally this was pulled in as the covering shrank, and we were presented with a scalloped effect. The easy way to reproduce this is to take a large rat-tail file to a length of trailing edge: but it is far from effective in "fineness ratio"—or razor-sharp edges.

Like most items we have discussed in this section on obtaining realism, the answer is no more than to take a lea, out of the full-size book and follow the same procedure. Where they use metal—we use metal, where they polish with a spinning buff, we do the same in miniature. So it is with the scalloped edge. Make the wing with an inset trailing edge to retain the strength that is needed and anti-warp construction, and run a stout thread along the apexes of the ribs. The thread should be fairly tight, as it will stretch again when dampened, and the ribs must be tough to stop it pulling through. Now cover with wet silk both surfaces in quick sequence and wrap over at the spaces between ribs. Careful work will give exactly the same effect as on the full-size, and you'll never tire of telling fellow admirers just how easy it was!

Chapter Ten The Engine

THE coming of the miniature internal-combustion engine with self-ignition either by "compression ignition" (Diesel) or by "hot coil" (Glowplug) has revolutionised scale model flying. It is now possible for us to make a free-flight scale model of only 15 in. wingspan and weighing a scant 1½ ounces *complete* with an Allbon Bambi .12 c.c. diesel engine. At the opposite end of the scale, we can fly a radio-controlled 10 feet span monster with any 10 c.c. glow-plug engine of modern design.

Since the operation of these Diesel and Glowplug motors is a complete subject unto itself, it is not proposed to enter into a "How-to-start, how-to-stop" series here. The scale model has requirements of its own, and if you are in difficulty with the engine, then seek another title and the solution may be found between its covers. At any rate, it is expected that the reading scale enthusiast will have some bench testing experience at least on his engine before being so adventuresome as to fit it into his scale model. That is the first approach to reliability on the model field—knowing and understanding the idiosyncrasies of the engine by running it in carefully on the bench mounting, and learning its whims before it becomes buried in a carefully carved cowling.

There we strike upon the particular difference between the ordinary sport or contest model and the scale type. In the former, the engine is exposed and usually very accessible. In the scale model, the engine is absorbed into the framework and unless camouflaged as the one working cylinder of a radial or rotary engine, or perhaps made to represent the exposed part of a flat-four on a lightplane, it is located within a cowling and therefore hard to get at.

The cowling has to be made detachable or hinged to give access to the engine should the need arise: but if the "plumbing", fuel tank feed pipe and vent, the controls, etc., are extended, it should not be necessary to open up everything to start the engine except in certain cases. This will be when the engine requires a "choke"—or full turn with the carburettor blanked off by a forefinger to induce fuel into the feed pipe and engine. Or perhaps if a glow-plug needs replacement—or a trace of vibration becomes evident through a loosening screw.

There are many ways in which a cowl can be hinged or made detachable, and much depends upon the actual nose shape of the aircraft. For an inverted

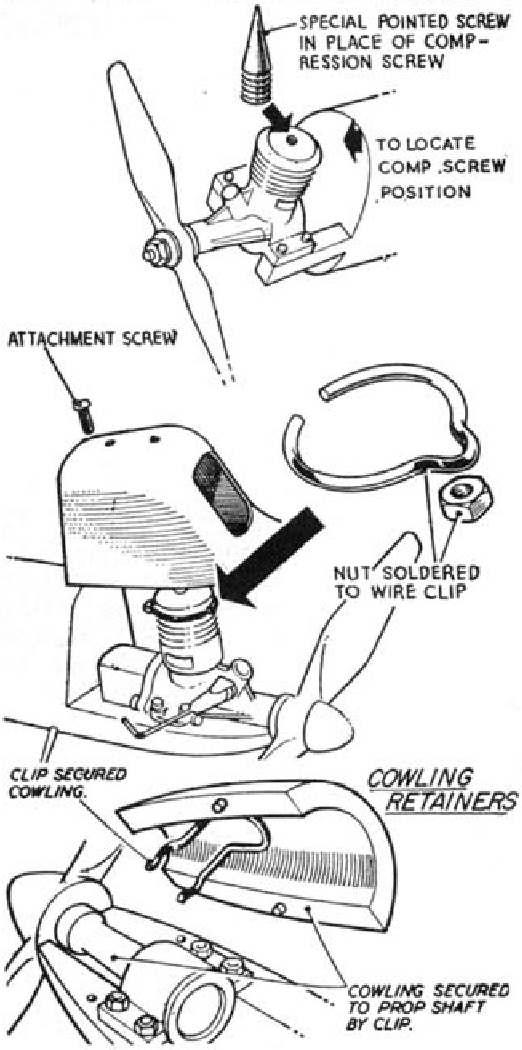


Fig. 86.—Two excellent cowl retainers, using the engine cylinder. Top sketch shows use of a pointed screw to position hole for plug or compression control in cowl.

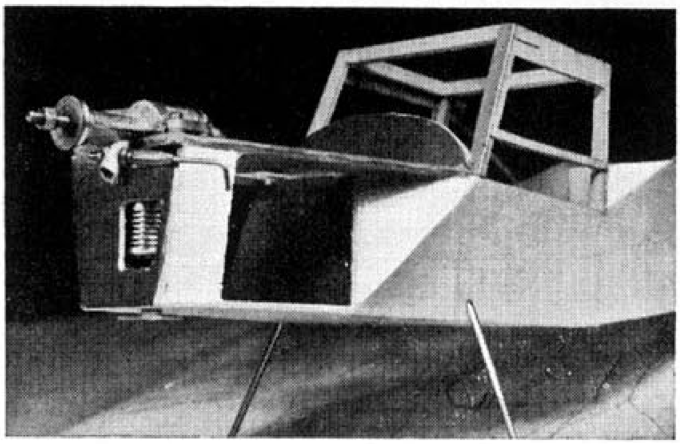


Fig. 87.—Engine mounted on ply plate in author's Auster A.O.P.9.

installation of a Bombardier or Gipsy engine, such as on the Auster series of Autocrat, Autocar, Aiglet and A.O.P.9, the preference is to have only the top half of the cowl removable, with the engine mounted on a ply plate which forms one side of a box construction comprising fuselage sides, bottom and nose, plus the first main former or bulkhead.

Alternatively, say for a Tiger Moth, Puss Moth, etc., the engine can be mounted on hardwood bearers of rectangular section of about $\frac{3}{8}$ in. × $\frac{1}{2}$ in. beech and the side plates hinged just like the real thing so that they swing upwards. The upper cowl or noseblock will still have to be made removable should it be necessary to take out the engine at any time.

For a radial engine installation, the shaft length of the model engine is often too long for the cylinder to become one of the dummies representing the real engine barrels. We are then faced with a small problem of how to make a set of cylinders that will look like the actual engine and support them while the model engine is somewhere at the rear of the cowl. One solution applied by P. E. Norman is to use the rubber cup from a sink plunger (the type used to clear a blocked pipe by forcing air down the drainhole) and stitching separate cylinders to this vertical-crash-resistant dummy crankcase. The rubber plunger is about $3\frac{3}{4}$ in. dia. at its rim, so it can be trimmed down to suit any model of about $\frac{1}{8}$ scale. A scoop out of the rear to go around the model engine cylinder and clear the carburettor is all that is needed to make the job complete. The dummy motor can then be held in place by a keying former inside the cowl, or a pair of wire clips. A " radial " model engine for a full-size radial type is a good rule for scale model design. By " radial " in this case we mean that the engine is not mounted on a horizontal plate or pair of bearers, it is held tight against a vertical bulkhead. This mounting is particularly popular in the U.S.A. for the smaller engines, and it solves constructional difficulties since all we need to retain the engine is a solid ply facing to the nose. If " beam " mounted, the engine still needs this ply nose facing as well as the beams, not only to strengthen the nose assembly but also to form an oil-proof facing to seal off the sludge and exhaust mess from the rest of the air-frame.

As a final insurance against all seepage into the balsa structure it is recommended that a coating of carpenter's " knotting " or thick shellac be painted over all engine compartment surfaces that are likely to be oil splashed.

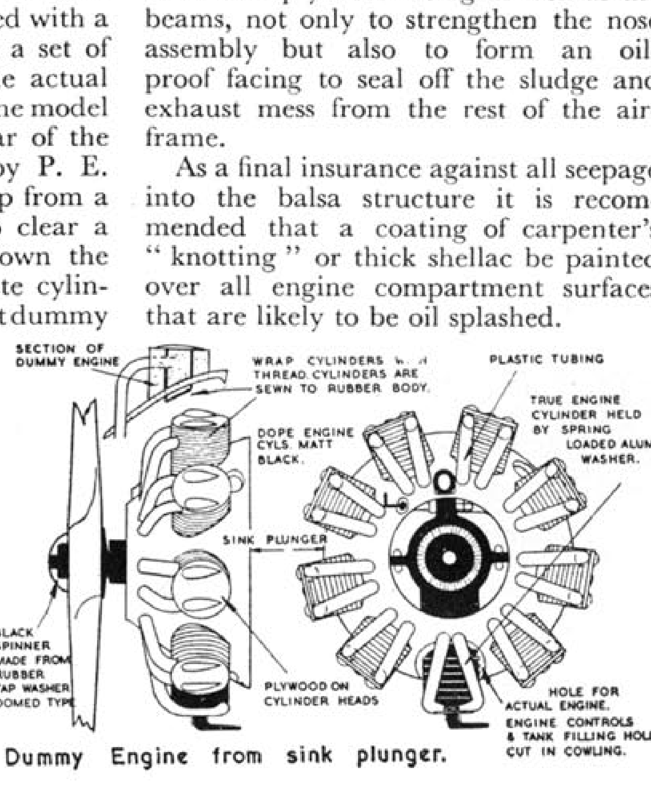


Fig. 88.—Domestic implement makes a fine resilient crankcase for radial engine.

The upright engine presents no problem, since the majority of engines are designed to be mounted that way up, and engine bearer lugs are faced to bed down on top of the beams or ply plate with the thrustline neatly coinciding with the top of the beam. etc. A completely detachable cowling gives easy access, and in some cases of early types, it is quite in order to have an exposed cylinder head to represent the full-size and at the same time allow better engine cooling. This is a point which will need watching in any attempt to tuck the model power unit away from sight, and even though it may not be possible to allow a direct air passage to the engine, it is advisable to use whatever area possible for a free airflow in and around the cowl. If not possible to allow a frontal airflow, then an air outlet is almost as beneficial since the propeller slipstream will give extractor effect and withdraw the hot air from inside the cowl . . . plus the exhaust.

Before we can fly the model, and after the engine has been started, it follows that we shall pass through the stage of setting the engine controls for the performance needed. Test flights are only made with full power by mistake, and to control the speed of the engine we have one main variable, common to all forms of ignition, and that is the mixture control. The fuel/air mixture which is drawn into the engine will vary according to the setting of a needle valve affecting fuel flow. There is an " ideal " setting for maximum power, and closing down from this we " lean " the mixture, or by opening up, we " enrich " the combustible vapour drawn from the tiny jet hole.

So the needle valve is the most important control, and if not long enough to come outside the cowl through a small hole, an extension should be made. This is best if flexible, so a short length of curtain wire of the spiral variety is soldered to the end of the needle valve. To keep the exterior tidy, the control protruding through the cowl can be another piece of 16 s.w.g. wire soldered at the other end of the curtain wire. The flexible link between the two will permit easy removal of the cowl and allow some margin of error in locating the actual hole in the surface.

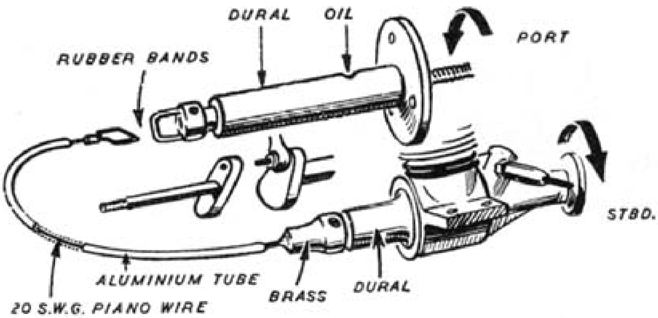
A glowplug engine requires boosting to start, with 1.5 or 2 volts short-circuited across the two components of the plug. To do this on a fully cowled engine, it is better to arrange permanent leads to a two-pin plug point further down the fuselage, or perhaps in an open cockpit, and to have the leads connected by clips to the plug. Then there is no need to take the cowl off—unless to refuel—but there again, one can easily fix extensions to the tank with neoprene or brass tube.

The diesel has another control which is used mostly during the initial starting of the engine from cold. This is the compression ratio, and the average diesel operates somewhere in the region of 18:1 ratio which is about twice that for a glowplug engine. To start the diesel we have to get just that right amount of combustible fuel mixture into the upper cylinder and then the engine has to maintain the flow by suction from the tank. We have seen how the needle valve will control mixture: but the initial starting very often involves extra " priming " and this can be very flexible. Perhaps after a series of attempts to start, without success, the engine begins to show signs of willingness but is hard to flick over.

Once relieved, the compression ratio permits the engine to start, and during the first few seconds the ratio has to be reset to running position. This compression control is usually in the form of a large " T " so that an easy grip can be made upon it, and rather a large slot would have to be cut in a cowling to clear it. As this is not altogether desirable, it is better to detach the screw for removing or replacing the cowl.

An alternative "hidden" approach is to replace the " T " with a cheese head screw of the same thread, and allow a clearance hole in the cowl for a screwdriver to reach through and alter settings. Safer still is the use of an Allen screw, the recessed hexagon on the head being a non-slip fitting with the special Allen key (Fig. 77).

Fig. 89.—Diagram of flexible drive used for "twin" props.

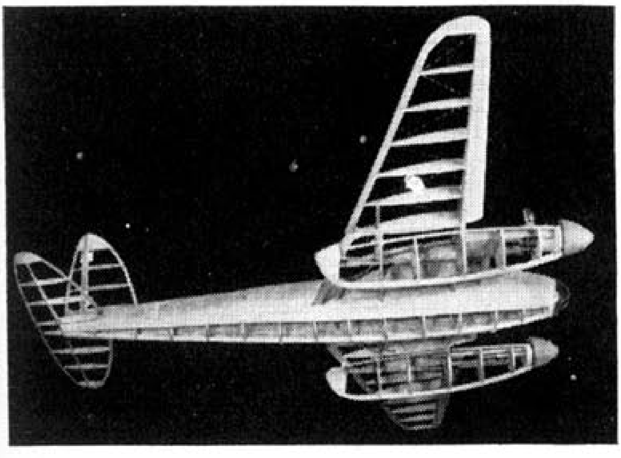


Tanks are largely a matter for personal choice, the transparent moulded shapes being preferred for diesel, and only used for glowplug after a liberal coating of fuel-proofer has been applied. As a general rule, set the top of the tank level with the needle valve so that all feed is "suction" for free flight, and set higher for control-lineso that feed is half "suction" and half "gravity". This gives a minimum chance of fuel flow variation in flight. The tank should always be placed as near as possible to the engine, and the feed pipe from the tank kept in a smooth curve, free of kinks and sharp turns. If a kink seems likely, wind a coil spring in 22 s.w.g. piano wire so that the tube passes through tightly.

For control-line we can have multi-engines, and some ambitious modellers have tackled free-flight twins. The major problem for free flight is one of synchronisation, and unless an aircraft with close-set engines like the Cunliffe-Owen Flying Wing Airliner is selected, the question of assymetric power is difficult to surmount without recourse to pendulums or other devices. Under the "other devices" we could classify the "two-off-one" arrangement used in P. L. Whittaker's Mosquito.

An engine with front rotary crankshaft valve is used, and a new backplate made to take an auxiliary drive from the crankpin. This engages a Bowden flexible cable drive to a second prop in the other nacelle, and by happy coincidence the two props rotate in opposite directions to counteract torque. By this means we can fly many a twin, including "tandems", using only one engine.

Fig. 90.—P. L. Whittaker's Mosquito has only one engine, with auxiliary drive as in Fig. 89, to other nacelle. Calls for drive from crankpin and a specially made engine backplate.



Chapter Eleven
Rubber and Jetex power

THE first scale models to fly were gliders, and soon after them came the rubber-driven-airscrew "expert-only" types. This was way back in the early days of the '14-'18 war, when a few strands of shock rubber unravelled from a crashed Maurice Farman Shorthorn enabled, among others, C. Rupert Moore to fly a scale card-and-veneer D.H.2. Through the '20s and with the coming of balsa in the '30s, the rubber-driven scale model increased in popularity to such an extent that 90% of model kit output was for this kind of flying model.

To-day, we have only the small, 20 in. or less, so-called beginner type scale kits on the market. Whether the manufacturers have taken it upon themselves to assess public demand, and consider the larger rubber-driven scale kit a dead item—or whether the post-war rise in costs of production has ousted the profit from these more intricate kits, is a matter of conjecture. The coming of the diesel at a price that even schoolboys seem to be able to afford, has replaced the one-time rabid enthusiasm for the "wind up and go" Gladiators, Puss Moths, Wickos and Hurricanes that was a feature of the heyday of 1937-39.

For the real enthusiast, the sheer satisfaction of whirring gears, the flutter of a fast-revving prop carved with loving care to a high degree of finish and section—and the enjoyment of those brief but so gentle and smooth flights on a small local common or farmer's meadow—are still possible. The scale rubber model may seem out of fashion, but it will always remain a firm favourite with the discriminating modellers who particularly like to return home clean after a day's flying. No oil except the lubricant, no noise but for the rattle of the winder and the whirr of the model as it leaves one's hands in a smooth launch.

Constructional methods have been outlined in Chapter 5, and selection of the subject shows a need for a long nose, good prop clearance and ability to be built at a light wing loading. The basic problem of the rubber model is that of providing sufficient thrust for a long enough period to get a satisfactory flight. A simple indication of this being a 30 in. wingspan Hawker Typhoon or Tempest which are short-nosed aeroplanes. If built with the light construction needed in a rubber model, the Typhoon airframe—without motor but with propeller—would probably balance not much farther forwards than at $\frac{2}{3}$ mean chord (average wing width). This should be brought *forward* to about $\frac{1}{3}$ of the mean chord back from the leading edge if we are going to make the model fly, and yet we still have to add the rubber motor which will bring the balance even farther from the desired position.

The ideal is for the mid-point between ends of the rubber motor (its Centre of Gravity) to be about 1 in. back from the balance point or C. of G. on the complete airframe. For our tail-heavy Typhoon, we should have to keep the motor very short and restrict it to the nose portion only—leaving the rest of an attractive fuselage vacant and empty of potential power.

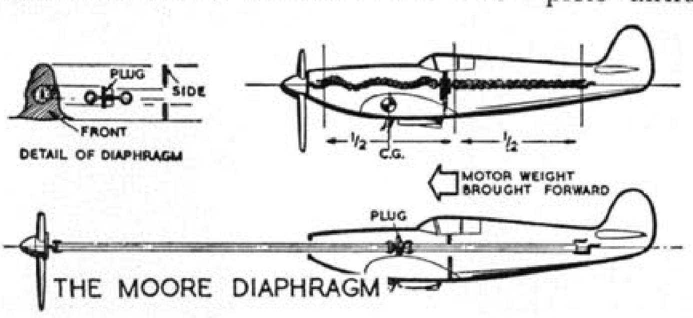


Fig. 91.—Simple invention permits use of more rubber

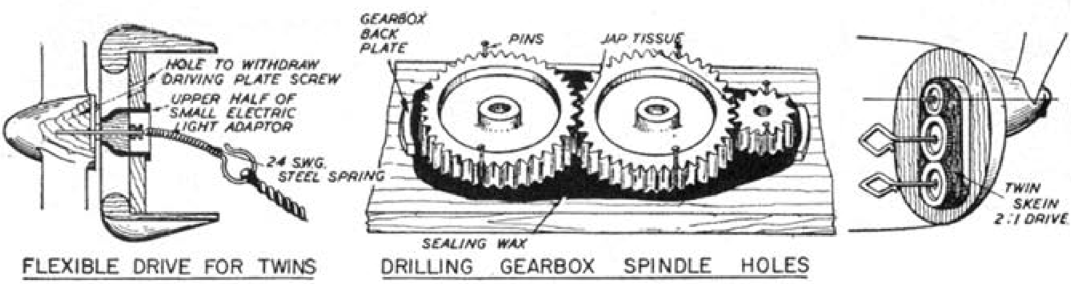


Fig. 92.—Variations on rubber drive, using flexible shaft or gears.

What happens to the Typhoon would be typical of all short-nosed types. The Sopwith biplanes, Fokker D VIII, and Gloster Gladiator. Our requirement is either to make the tail surfaces and rear fuselage specially light, or to employ gears or the Moore Diaphragm (patented). Gears are rather complex, but keep the weight in the right place, provide a long motor run, give less torsion to the fuselage, and, most important, permit a near-scale propeller diameter. The Moore Diaphragm is simple, allows a long motor for improved power duration, is quickly wound, and keeps the weight in the right place, still using all of the fuselage length. Disadvantage is that we have to use a larger-than-scale propeller, both in area and diameter (which is common to most rubber-driven scale models and calls for the good ground clearance).

Gears can be employed in a number of ways. The " Return " gear system as used for duration designs means that, in effect, the motor starts at the noseblock, goes to a gear at the rear peg, turns power through 360° and comes back to the propeller. We still have to employ the same number of strands as for a long single block-to-peg motor, but we can shift the peg forward in the fuselage to help balance the model. Thus we gain balance, with a longer motor and more power run.

By " coupled " gear boxes we can use the same amount of rubber as in the " return " system, yet increase the power run still longer by reducing the number of strands per skein. For example, if a single motor calls for 8 strands of $\frac{1}{4}$ in. rubber, 20 in. long, then with two coupled motors we can divide the single motor into two skeins each of four strands. If three or four skeins are used, we can split the power even more, but not exactly at the same rate of division by the factor of 3 or 4. In this way, the Miles Kestrel Trainer, Harvard, Lysander, and Tiger Moth, have been flown with motor runs of up to 35 seconds despite the fast-revving propeller. Dividing the strands does not decrease power, for the skeins are coupled—it simply gives us the answer to condensing motor weight in the forward fuselage, yet still providing a long power run.

To make a gear box properly, one should first cut a ply nose block profile in front elevation and drill for the main gear and propshaft bearing. With this gear positioned (it can be smaller than the others, and not connected to a skein for increased gearing), the next gear is meshed and temporarily pinned while its centre is keyed on the ply. In this way, with each gear in the train meshed and fitted in turn, the gearbox is soon completed and found no more difficult to make than bending an undercarriage.

Rupert Moore's approach is a division of the desired long motor length into the ratio of 2 : 1 and separated by a plug or " diaphragm " which in no way interferes with the smooth running of the motor from end to end. Actual motor length is about $1\frac{1}{2}$ times that of a taut motor between noseblock and rear peg, and the motor is pre-tensioned to take up some of the excess slack. When wound up, the rear $\frac{1}{3}$ length shortens first and pulls the diaphragm or plug back onto its seating, leaving the forward $\frac{2}{3}$ to knot up and condense in the smaller nose space. Thus, two-thirds of the motor weight is kept in the useful position forward and the centre of gravity shifted quite an appreciable amount to render nose ballast unnecessary. Like most simple discoveries,

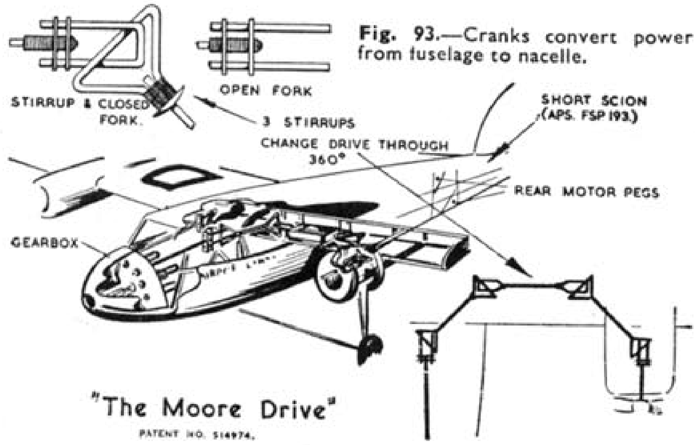


Fig. 93.—Cranks convert power from fuselage to nacelle.

this use of an intervening bulkhead is such an ideal answer to the balance problem of the rubber model, that one wonders why it was not thought of at an earlier stage.

Apart from the balance problem in short-nosed aircraft, and the need for a long motor run, calling for gears in others, there is also the question of multi-engined subject. Rubber is a flexible item, but to extract energy from it we must stretch it in a direct line between two points. On a " twin " or " four " engined model we might find this difficult, except in the fuselage, and we must find a way of connecting the propellers to the remote rubber motors. This can be accomplished by flexible drives or cranks. A length of spiral curtain wire will transmit power through a 90° curve with minimum whip, better still, a home-wound spiral of 24 s.w.g. piano wire, tightly bound around a $\frac{3}{32}$ in. nail (afterwards removed) will give all the flexibility required. H. J. Towner uses this method in his famous Airspeed Envoy, with the rubber motors running from noseblock to the centre of the fuselage just behind the wing in the form of a wide " Vee ". Very little energy is lost in friction providing all bearings are free, and the system is adaptable for aircraft like the Goodyear Duck, Spencer Larson, etc., where the prop is amidships on a pylon which can be made to conceal the flexible drive.

Wire cranks are a little more involved, and call for good alignment if no power losses are to be incurred. In addition, the wires add weight to the airframe, so the system is of the most useful value in a type that can carry the weight with generous wing area and pack in a healthy amount of rubber in the fuselage. The sketch of C. Rupert Moore's Short Scion shows an application of this method, and serves to illustrate the complications involved.

Whether or not our rubber-driven model is going to need any of the variations on method of drive outlined here will depend entirely upon the selection of the subject. A straight drive from noseblock to rear peg, and still utilising all the available fuselage length is still possible if a long-nosed aircraft is chosen. As a guide—why not the Fairey Long Range Monoplane, the Vickers Wellesley, or a Grumman Guardian for a simple cantilever high, low, or mid-wing selection?

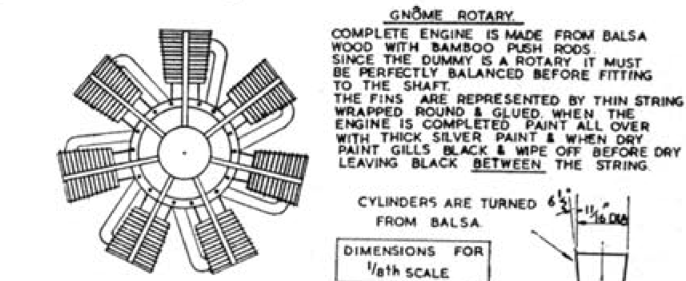
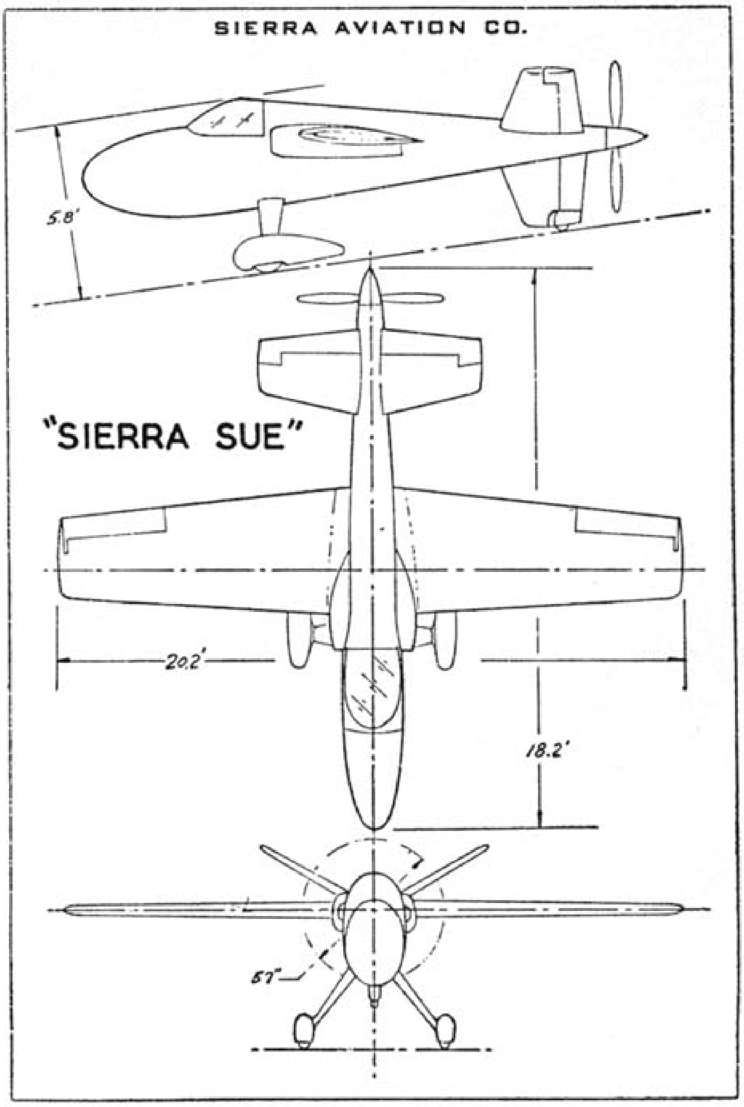


Fig. 94.

Fig. 95.—Neat pusher subject for rubber power allows use of full fuselage length (see Fig. 9.)



Jetex

If the post-war market has been starved of "quality" rubber scale kits, it has certainly seen a move to keep up with the times in the progress of Jetex power, and the products of its parent company in the form of a magnificent range of "tailored" scale kit models. These are made in moulded balsa, the thin veneer being steam pressed and bonded so that compounded fuselage curves are seemingly stamped out of flat sheet wood. Such is beyond the facilities of the home model maker; but these examples from the Jetex people have served to show the application of this rocket power in a true-scale model.

For Jetex is a form of rocket. Solid pellets of fuel are ignited in a specially designed aluminium container, and the tiny orifice prolongs a high velocity gas flow so that thrust is maintained for periods of 10 seconds or more, according to the type of unit. The little "35" weighs only $\frac{1}{4}$ oz. when ready to use, and its .5 ounce thrust will fly a model weighing up to $1\frac{1}{2}$ oz. At the other end of the scale, the Scorpion delivers 6 ounces thrust for its 2 oz. weight and will fly a 9 ounce scale model. With the latest Thrust Augmenter Tubes, these figures are raised still higher, and the Jetex unit becomes even more adaptable for a scale jet.

Before the advent of the Augmenter Tube, it was customary to mount the unit in a trough on the underside of a scale model. In side view, the jet could not be seen and appearance was not unduly offensive. It was safer too, for the unit has to be ignited by a quick-burning fuse, and since the trough could be lined with light asbestos sheet thoughtfully supplied by the manufacturers, there was little danger of fire. Alternatively, on the short nacelle-like fuselages, the SAAB J-29, D.H. Vampire, SIPA Minijet, etc., it was possible to have the unit mounted on an opening hatchway, which could be slammed shut when the Jetex was ready to fire, and the short fuselage allowed a clear passage for the hot gases.

The augmenter tube obviates the trough and the hatch mount by providing a featherweight aluminium tube through which it is possible to ignite the Jetex with safety, and at the same time

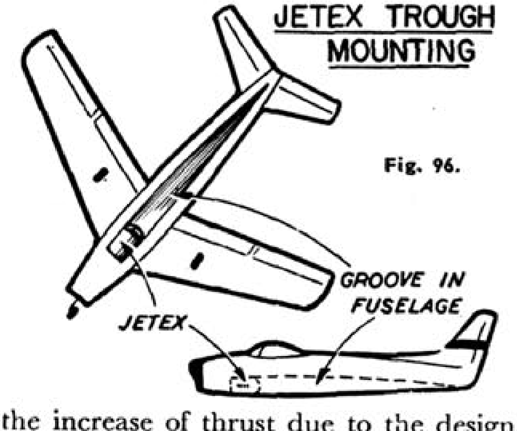


Fig. 96.

the increase of thrust due to the design of the tube and the extremely clean efflux, makes it possible to build perfect scale models of any jet aircraft, from the Midge to the P.1.

That the Jetex "tailored" series includes the delta Skyray, and highly swept North American F.100 Super Sabre is indicative of the possibilities. There are two sizes of tube, and these basic diameters can be employed with any of the range of units, though one especially is recommended—the "Jetmaster". This unit has several advantages. It can take an extra half pellet and give power for 22 seconds, it can fly a model weighing 5 ounces (well within anyone's capability) and it was specially designed for the larger size augmenter tube. Without the tube, it delivers $1\frac{3}{4}$ ounces thrust. With a full-length tube of 13 in. overall, it is boosted to $2\frac{1}{4}$ ounces, and with the short tube of 5 in. length, it is even as high as $2\frac{3}{4}$ ounces thrust. Thus it is obvious that a swept-wing aircraft such as the P.1 which will need the unit in a rear position, or a short-nacelle type like the D.H.110, will take full advantage of the augmented Jetmaster and 5 in. tube.

There are certain advantages in stability with power on if the Jetex can be mounted high, particularly on the very light models for the smaller units. This is to counteract the tendency to loop, since the high unit will give what is known as a "nose-down couple" and this improves as the model accelerates. For this reason, the French Fouga Sylphe is ideal, or the Somers-Kendall Racer, where, in each case, the full-size turbojet is pick-a-back on the fuselage.

To counter the loop in a model with a mid- or under-slung Jetex, the best solution is to mount the unit just forward of the C.G. and trim the glide with an empty motor. The additional weight of the burning pellet, and slight "down-thrust"

RUBBER MOTORS

Approx. Model Weight	Strands (turns per inch)					Gears Advised
	$\frac{1}{8}'' \times \frac{1}{30}''$	$\frac{3}{16}'' \times \frac{1}{30}''$	$\frac{3}{16}'' \times \frac{1}{24}''$	$\frac{1}{4}'' \times \frac{1}{24}''$	$\frac{1}{4}'' \times \frac{1}{30}''$	
2 ozs.	6 (53)	4 (70)	3 (70)	—	3 (65)	—
4 ozs.	8 (42)	6 (44)	4 (55)	3 (45)	4 (52)	—
6 ozs.	12 (36)	9 (36)	6 (42)	4 (39)	6 (40)	Return
8 ozs.	16 (31)	12 (31)	9 (36)	6 (37)	8 (34)	Coupled 2
10 ozs.	20 (28)	14 (30)	11 (29)	8 (31)	10(30)	Coupled 3
14 ozs.	24 (26)	18 (26)	14 (27)	9 (28)	12 (28)	Coupled 4

JETEX MOTORS

Approx. Model Weight	Advised Unit	Weight of Unit (ozs.)	Thrust (ozs.)	With Short Tube	With Long Tube
$1\frac{1}{2}$ ozs.	35	$\frac{1}{4}$	·5	—	—
2 ozs.	50	$\frac{1}{2}$	·6	·6	·6
4 ozs.	100	$\frac{7}{8}$	1·25	—	—
5 ozs.	200	$1\frac{1}{2}$	3	—	—
	Jetmaster	$\frac{11}{16}$	1·75	2·75	2·25
7 ozs.	350	$2\frac{3}{4}$	4	—	—
8 ozs.	Scorpion	2	6	6·25	6
Augmenter Tube	Small Large	Bellmouth Bellmouth	$1\frac{1}{4}''$ dia. × $2\frac{1}{2}''$ $1\frac{3}{4}''$ dia.	Short Tube 4" OA Short Tube $7\frac{1}{2}''$ OA	Long Tube 6" OA Long Tube $13\frac{1}{2}''$ OA

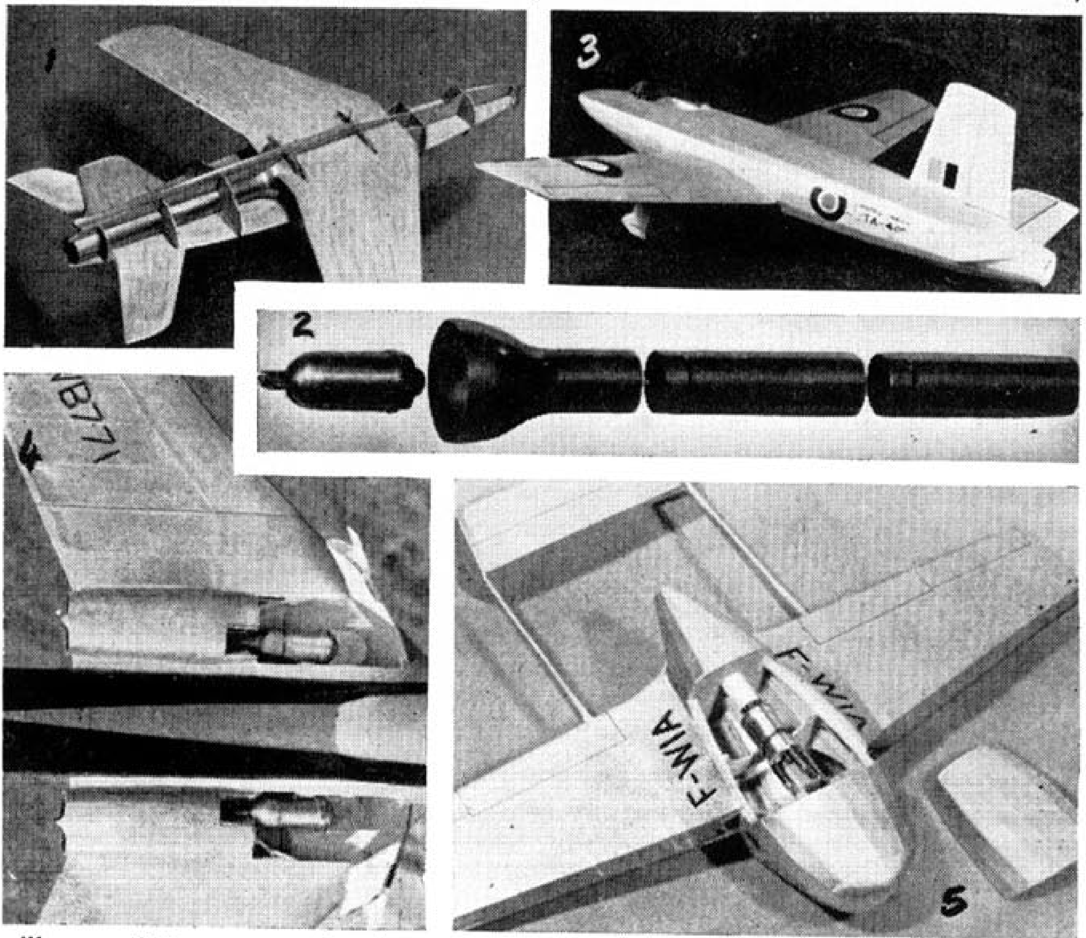


Fig. 97.—Jetex applications. 1. Buried augmenter tube in Folland Midge for 50 unit. 2. Close-up of same unit with tube dissected. 3. Veron Seahawk has belly duct as in Fig. 96. 4. Jetmaster units within a scale Handley Page Victor wing. 5. 100 unit in a SIPA Minijet, using a card tube to extend jet flow.

will successfully stem any looping trends.

Apart from the absolutely true scale model, now made possible with the tuned unit, we should also mention the profile design. Did someone say "Ugh"? Well, one had to begin somewhere, and it might interest readers to know that the author has spied several of the above-mentioned super "tailored" models on test—and they were flat profiles!

A profile is just exactly what it implies—a model made in flat sheet, without section, but otherwise true to shape in side and plan views. It can be made in an evening, tested to destruction and used by the modeller to prove whether or not his scale selection will fly, and it is a system used by a great many famous modellers throughout the world. It is roughly the equivalent of the present-day full-size designer checking the design with a dynamic model.

So why not the profile? If not as a test medium, it is also an inexpensive novelty that forms an ideal basis for the Junior's first powered model. With it one can pick up the fundamentals of flight—the "what happens when we warp this or that"—and learn all about the practical aspect of model flying.

Fig. 98.—Elementary profile model of sheet balsa has Jetex Atom 35 on nose.

Chapter Twelve **Ducted Fans**

WE can fly a jet model without flame or fire. Discounting Jetex, which, after all, is a form of rocket, the ducted fan offers the safest and simplest method of representing a full-size jet aircraft and enables it to fly on the same basis of thrust. Just as a real jet displaces a vast amount of air, and the reaction forces the aircraft forwards, so the rapid flow through a model ducted fan unit will provide the energy or flight. Naturally, the more air we can force through our ducted model, the greater the thrust and more efficient the fan. Unfortunately, at the dateline of this book, the amount of work produced from a fan is approximately 25% of that expected from a conventional airscrew fitted to the same engine—so we are at a disadvantage: but undoubtedly there will be developments and, who knows, in the course of a few years, the fan may reach even higher standards and outmode the airscrew.

As an indication of progress in 1953, the originator of the model ducted fan as we know it, Thomas H. Purcell Jr., of Morton, Pennsylvania, was claiming 3 ounces of thrust from a twisted-sheet fan driven by a .8 c.c. (.049 cu. in.) engine. It was enough to fly a 6 ounce model in all but a stiff breeze. In the same year, K. Newbold, of Hamble, Hants, applied a multi-blade unit to an E.D.3.46 Hunter and produced more than 16 oz. thrust to fly a 54 oz. model control-line D.H. Venom. In 1955, Robert T. DeVault conducted experiments in the U.S.A. which showed thrust up to 8 ounces from .8 c.c. and 26 ounces from 3.25 c.c., while in Britain, Phil Smith's Veron designs for the patent " IMP " fan Sabre and Lavochkin were entering their third successful season as kit models.

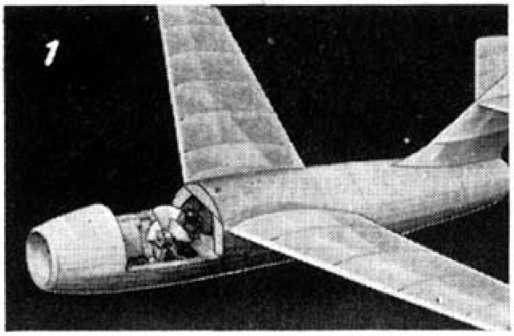
The fan has caught on rapidly; but though many such models have been built, using kits or published plans, there has been relatively little individual development. The success of those mentioned above who have explored variations on the theme indicates a need for more effort in design both of the fan itself, and the duct in which it operates.

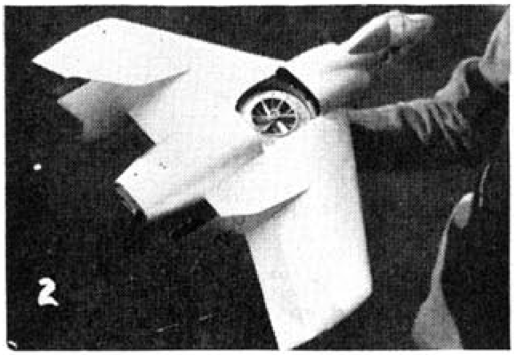
What kind of fan can we use—and which aircraft types are most suitable? That is the big question, and the answer lies in an investigation of the systems in use, and the way in which a fan can produce thrust.

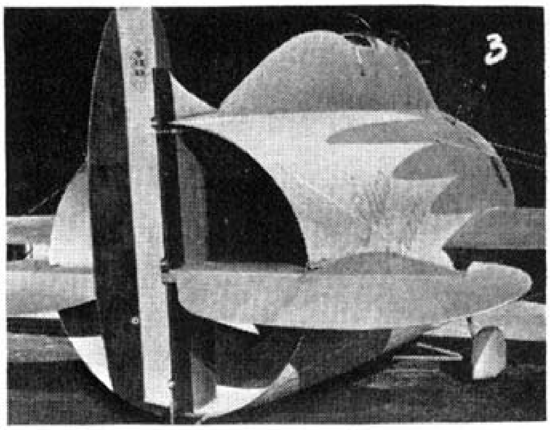
Most of us are familiar with the workings of a vacuum cleaner or hair drier, and have felt the efflux of air that these domestic appliances can blow out. (" Sausage " shape cleaners can be reversed for spray painting and usually have a through-flow only interrupted by the removable dust bag.) They use, in most cases, a centrifugal impeller. That is to say, air is drawn in at the centre of a rotating multi-blade fan, and shoots out at high velocity at the periphery. It is collected in a duct, and the airflow used for whatever purpose befits the appliance. In our case we need thrust, and the centrifugal fan can provide plenty—complete with disadvantages.

Firstly, the centrifugal must, perforce, lie on its side horizontally in the model. This is because it will need a diameter upwards of 3 in. for .5 c.c., and from the edge of that we still have to conduct the airflow back to the tailpipe. If the fan is fitted flat in a centre-section it will absorb itself in the depth of the wing and fuselage, while the ducting can easily become part of the rear fuselage structure. Put the centrifugal fan up on edge facing forwards, and installation becomes impossible except for the most bulky of fuselages. Even then, one has to employ a larger-size model than desirable to get the unit within scale proportions. So the centrifugal *must* lie on its side, and, correctly employed, it becomes neat in application, open for accessibility and starting, and independent of scale intake area.

Against it is the eyesore of an open fan in the wing surface (though this can







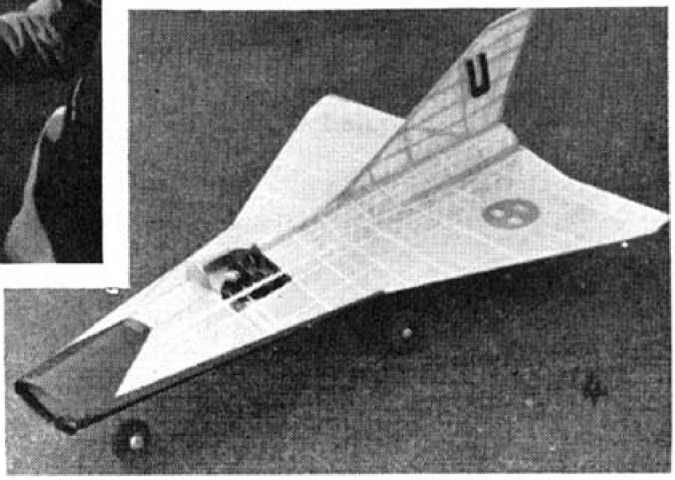


Fig. 99.—Successful Fans. 1. Phil Smith's original IMP-propelled La. 17 with Allbon Dart and five-blade impeller. 2. John Coatsworth's centrifugal unit in a Cutlass showing intake in centre of fan. 3. Full-size Caproni-Stipa shows its duct exit and flow over control surfaces. 4. Wayne Schindler's SAAB Draken has six-blade fan.

be covered with a wire mesh), the more involved construction of the impeller when compared with an axial unit, and for small engines there is the problem of inertia when the engine stops in flight. This unique reaction tends to make the model rotate about the fan as it suddenly stops, and the resultant flat spin is hardly a desirable flight transition from power to glide. With larger engines such an effect would be less noticable and the free-wheeling characteristic of the lower compression ratio used on a glowplug engine would tend to nullify such reversed torque reaction. All credit, though, to John Coatsworth of South London who has pioneered the centrifugal using Dart diesels in a variety of models ranging from the Avro 707A to the Hawker P.1081 and D.H. 108 Swallow. A rabid scale enthusiast, John approached the subject scientifically and can measure his success with the lively performance of these models which ranged from a diminutive 16 in. span to a large (!) 24 in. and weighed only 8 ounces at the most.

If the centrifugal is a trifle complicated, the axial is the opposite, and since the simplest things are more attractive it follows that our ducted fans are all of axial type. Unfortunately it is also another fact that the simplest things are frequently the most difficult to devise, and where there are so many variables to play with, the ducted fan in its most efficient form is still a jump or two ahead of current experiment.

We can follow the Purcell and Phil Smith lead by using an engine of 1 c.c. or less, cutting a disc of .025 in. or .32 in. aluminium with six radial slots and forming twisted blades with the segments at 30° pitch angle. Fit it to a good .5 c.c. diesel and you can expect a thrust of 3 ounces or more if the fuselage duct is clean, and vibration kept to a minimum. That is the simplest approach

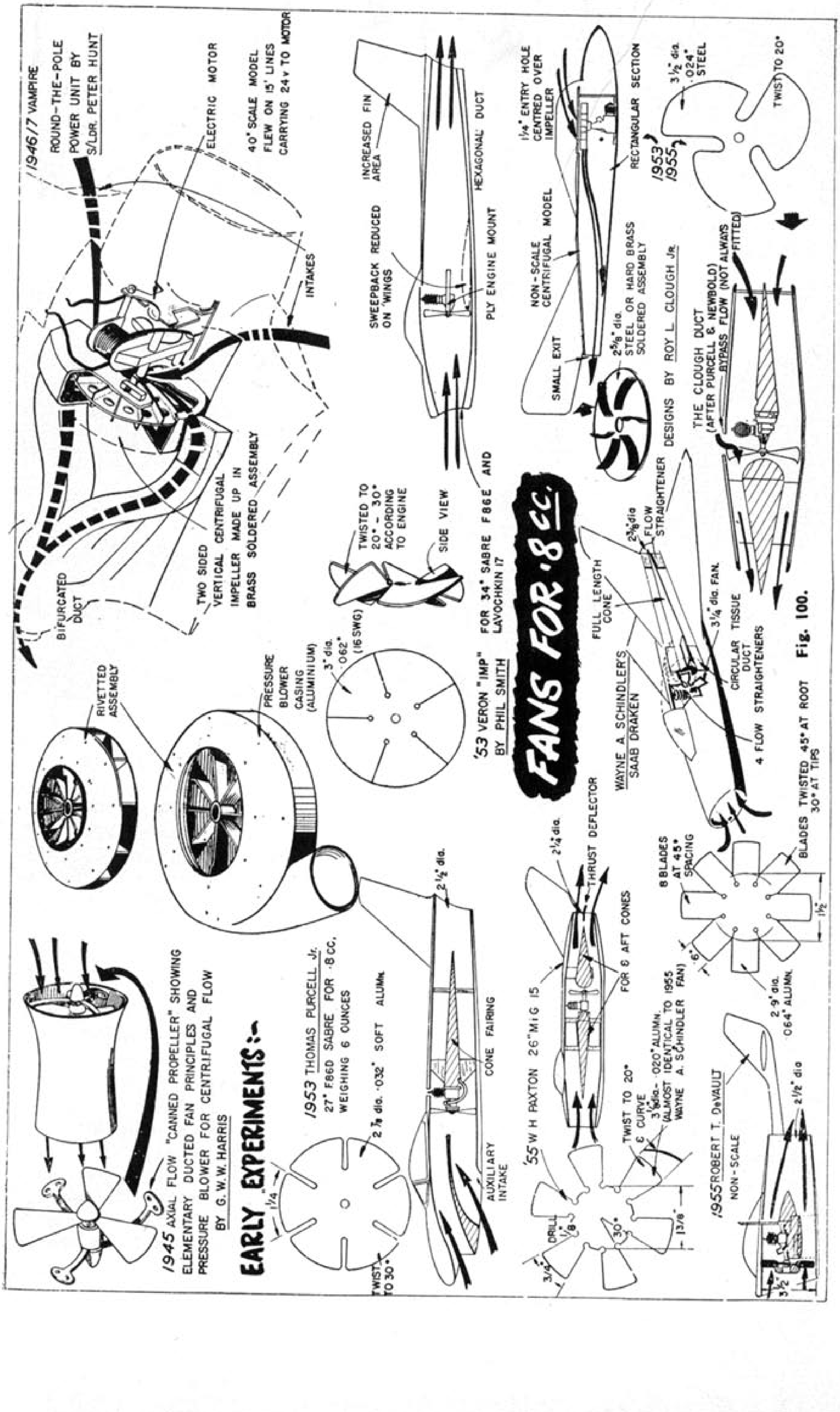

1945 AXIAL FLOW "CANNED PROPELLER" SHOWING ELEMENTARY DUCTED FAN PRINCIPLES AND PRESSURE BLOWER FOR CENTRIFUGAL FLOW BY G. W. W. HARRIS
EARLY EXPERIMENTS:-
1¼
TWIST TO 30°
1953 THOMAS PURCELL Jr. 27" F86D SABRE FOR ·8 cc. WEIGHING 6 OUNCES
2⅞ dia. ·032" SOFT ALUMN.
CONE FAIRING
AUXILIARY INTAKE
2½" dia.
RIVETTED ASSEMBLY
PRESSURE BLOWER CASING (ALUMINIUM)
1946/7 VAMPIRE
ROUND-THE-POLE POWER UNIT BY S/LDR. PETER HUNT
ELECTRIC MOTOR
40" SCALE MODEL FLEW ON 15' LINES CARRYING 24 v TO MOTOR
INTAKES
BIFURCATED DUCT
TWO SIDED VERTICAL CENTRIFUGAL IMPELLER MADE UP IN BRASS SOLDERED ASSEMBLY
3" dia. ·062" (16 SWG)
TWISTED TO 20° - 30° ACCORDING TO ENGINE
SIDE VIEW
'53 VERON "IMP" BY PHIL SMITH
FOR 34" SABRE F86E AND LAVOCHKIN 17
SWEEPBACK REDUCED ON WINGS
INCREASED FIN AREA
HEXAGONAL DUCT
PLY ENGINE MOUNT
FANS FOR ·8 CC.
'55 W H PAXTON 26" MiG 15
TWIST TO 20° & CURVE
3⅛" dia. ·020" ALUMN. (ALMOST IDENTICAL TO 1955 WAYNE A. SCHINDLER FAN)
1⅜"
30°
DRILL ⅛"
¾"
FOR 6 AFT CONES
THRUST DEFLECTOR
2¼" dia.
1955 ROBERT T. DeVAULT NON-SCALE
2½" dia
3½"
2·9" dia. ·064" ALUMN.
6°
1½"
8 BLADES AT 45° SPACING
BLADES TWISTED 45° AT ROOT 30° AT TIPS
WAYNE A. SCHINDLER'S SAAB DRAKEN
FULL LENGTH CONE
2⅝" dia FLOW STRAIGHTENER
3¼" dia. FAN.
CIRCULAR TISSUE DUCT
4 FLOW STRAIGHTENERS
1¼" ENTRY HOLE CENTRED OVER IMPELLER
RECTANGULAR SECTION
NON-SCALE CENTRIFUGAL MODEL
SMALL EXIT
2⅜" dia. STEEL OR HARD BRASS SOLDERED ASSEMBLY
DESIGNS BY ROY L. CLOUGH Jr.
1953 1955
3½" dia. ·024" STEEL
TWIST TO 20°
THE CLOUGH DUCT (AFTER PURCELL & NEWBOLD) BYPASS FLOW (NOT ALWAYS FITTED)

Fig. 100.

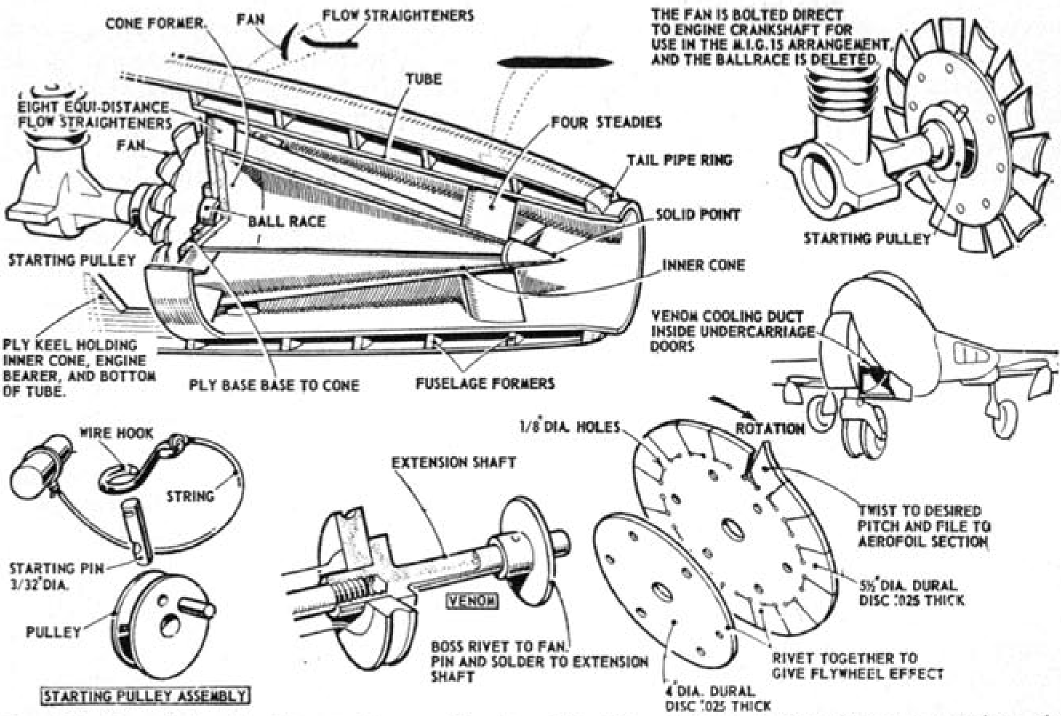


Fig. 100 (Opposite).—Fan history shows origin in article published in *Aeromodeller* 1945 and experiments of 1946. Other six types show different approaches for small engines.

Fig. 101.—First to employ the cone to a duct, the Newbold Fan inspired many experiments.

and it sounds so easy that one wonders why it did not come to light at a much earlier day in power model flying. Yet we should remember that to get this so simple "first stage" approach to the fan or "IMP" impeller, there were many hours of trial and error involved in the Purcell and Smith workshops.

From the twisted disc, with its tapered blades, the next jump was the Newbold unit. Sixteen short-length blades were twisted at the outer edge of a 5½ in. fan for 3.5 c.c. To prevent danger of fracture through flexing, and to give flywheel effect, the centre 4 in. was doubled with an extra disc of heavier gauge dural riveted on. This gave excellent thrust when fitted in a fuselage duct with a central streamline cone and was further improved by use of "flow straighteners". It was discovered by the simple means of shining a torch on the fan unit and watching the exhaust flow while running in the dark, that the airflow left the blades at an angle and did not fill the centre portion of the rear fuselage. Hence the cone to streamline the flow. The "straighteners" were calculated by the process of mounting a pivoted flag immediately behind the fan, and checking the angle of deflection. It was near enough to 30°, and eight straighteners-cum-cone supports were bent to this angle.

These refinements, notably the cone, are essential to the ducted fan if we are to gain maximum efficiency: but whether we should employ the multi-blade system devised by Mr. Newbold or use fewer blades will largely depend on the fan diameter.

At the opposite end of the scale, there is a following for the three-blade "Ship's Screw" shape of fan, notably by R. L. Clough, an American experimenter. This may work well in a short duct, where it is possible that the proximity of the fan to the entry allows it to gain some material direct thrust like that of an airscrew: but in a long duct it does not appear to offer advantages. The fore and aft cones used by Mr. Clough, and the fact that the engine is in front of the fan are definite points in favour. We are most concerned with the fast flow of air after it has left the fan. A cylinder and its exhaust gases can only disturb the airflow and disrupt thrust by offering flow losses. Placing the engine in front of the fan enables use of flow straighteners immediately behind the fan, and the cylinder does, in fact, become a diffuser for the air about to reach the fan. The function of a diffuser is to slow the air down with minimum pressure losses, and since we usually have to draw in from an intake of smaller area than the cross-section of the fan, this is to some advantage—or so the full-size jet experts would have us believe. (Perhaps that is why a look down a real jet entry pipe reveals a startling mass of generators and other unstreamline ancilliaries instead of a nice clean flow to the impeller.)

So far we have established that cones, flow straighteners and a "pusher" layout are best. Now what of the fan? First, the number of blades and their length. It appears to have become a standard rule that a constant chord blade of ⅜ in. (or 7% circumference) is the minimum practicable size and that blades should be of half-radius length. This will define the number of blades according to the fan diameter and size of engine: but for more than 1 c.c., it is strongly recommended that separate fibre blades are mounted and pinned securely in a solid boss. Below that capacity, .040 in. aluminium allows a 45° twist at the blade root, flattening to 30° at the tips, and the thickness permits filing the blade to an aerofoil section for higher efficiency.

One word of warning should be uttered to the bent-alloy fan makers. Ultimately, the fan will require to be "canned", or run inside a peripheral ring of plywood with a close clearance gap between itself and the actual rotating blade tips. This "canning" has two purposes. As a safety item it stops a thrown blade, and a vibrating engine from running wild if it gets out of alignment. As a close fitting to the fan, it saves "spillage" from the blades and utilises all available airflow. If one attempts to run a fan free of the can, then the only limit to r.p.m. will be blade drag, and it is likely that the achieved speed will exceed the safety factor of twisted alloy. So fit the can—even for a bench test. The added air loading will slow the motor to actual running revs when in flight, and if there is a failure, the can will avert a possible accident.

The stresses in the blade root for a twisted aluminium disc will be in the region of 1,600 lb. per square inch—even more for a heavier disc in steel, so it will be realised that at 16,000 to 18,000 r.p.m., where our unit can be expected to "peak", it is important that the twists are crack-free and smooth. On the basis of area, actual loading on a blade root of a 3 in. fan will be up to 24 lb., and breaking factor of a well-made blade has been shown to be up to 20 times that figure. But the safety margin will depend on the workmanship in bending the fan and it becomes readily apparent why, for more than 1 c.c., we should use separate, pinned blades.

We owe the "big" fan to P. E. Norman. He soon found out that for his favourite capacity, 2.5 c.c., a twisted disc was overstressed. His experience with fibre for unbreakable components of his "crashproof" scale models, including multi-blade props, led to use of the same material in the succession of Hunters, MiGs, Yaks, Cougars and Boulton Paul ducted fliers which have been such a feature of British model rallies. Separate blades made either in plain fibre, or fabric impregnated "Turnol" proved to be ideal. An aerofoil section can be filed on the blade,

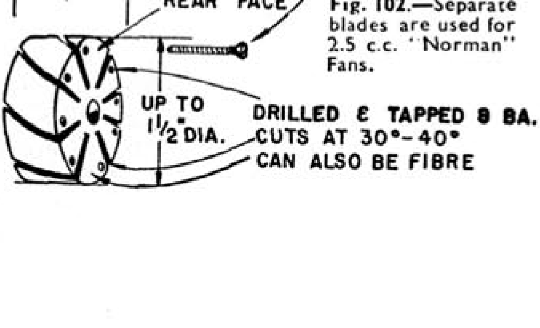


Fig. 102.—Separate blades are used for 2.5 c.c. "Norman" Fans.

application of dry heat can be used to warp a camber if so desired, and the very fact that the blades are detachable means that, for experiment with angles, all we need is a series of hubs, and replacement of a fractured blade no longer involves a complete re-make of the entire fan.

As to the number of blades, this system allows an overlap at the root ends, not possible with a twisted disc, and—happily—P. E.'s development along the hard path of experience rather than theory has ended up with a coincidence that indicates the right approach has been found. For his blade width/circumference ratio is in the order of 1:12 or 1:15, which is identical to that found best by American R. DeVault.

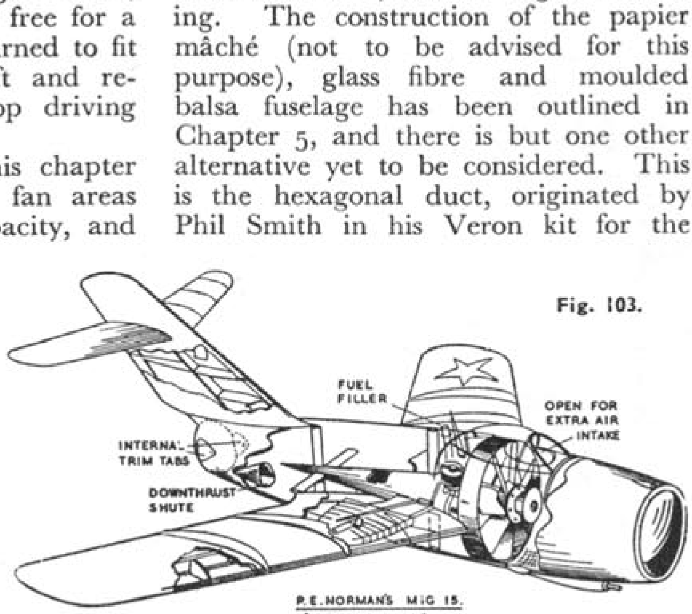
The central hub is up to half radius of the fan. It carries a series of jig-cut inclined slots at angles of between 30° and 40° and the blades are fitted into these and line up with a hole drilled through from front to rear of the hub. In the rear portion of the hub, this hole is tapped to receive a set screw and, consequently, when a screw is passed through both hub and blade, it tightens the slotted section, both clamping and pegging the blade. Shear stress would have to be enormous to throw a blade held by this Norman system. To key the hub tightly on an engine shaft, and allow more shaft length free for a starting pulley, the hub is turned to fit the taper on the crankshaft and replaces the conventional prop driving washer.

A table at the end of this chapter summarises blade sizes and fan areas according to the engine capacity, and now, having dealt with the fan itself, we should consider how best to start the engine. There is only one way—by pulley and cord, unless you are able to devise a flexible drive to enter the duct and connect on the fan shaft. The jerk on a starting cord has worked well enough so far, not only for the ducted-fan people, but also for boats and racing cars, so we need have no fears of difficulty. A knack must be learned. How not to pull the engine out of its bearers, how to get the cord clear of the fan, and how to hold what must be a lightweight structure while pulling against diesel compression. It is easily learned: but teach yourself how to do it on the bench first! For a pulley, one can use the common knurled bottle cap held on the shaft by the nut, or a length of hexagonal nut, with a large-diameter washer held on the front of it. Best of all would be a properly turned and knurled pulley of up to 1½ in. diameter, directly attached to the fan hub.

The procedure should be as follows: 1. Wind the starting cord around the pulley for about 5 turns by reverse turning the fan. 2. Fill up the tank, which should have a slight gravity feed, and check the needle setting. Fuel should begin to drip from the carb, if of the updraught type, or the crankshaft should be arranged to close the intake on a downdraught engine (piston on downstroke). 3. Slacken compression from running setting by at least ¼ turn and with a steadying hand on the compression screw, pull the cord smartly.

Do not prime the cylinder, or allow the engine to flood. Next consideration is the duct itself, and the engine mounting. The construction of the papier mâché (not to be advised for this purpose), glass fibre and moulded balsa fuselage has been outlined in Chapter 5, and there is but one other alternative yet to be considered. This is the hexagonal duct, originated by Phil Smith in his Veron kit for the

Fig. 103.



P. E. NORMAN'S MIG 15.
(APS FSP 603)

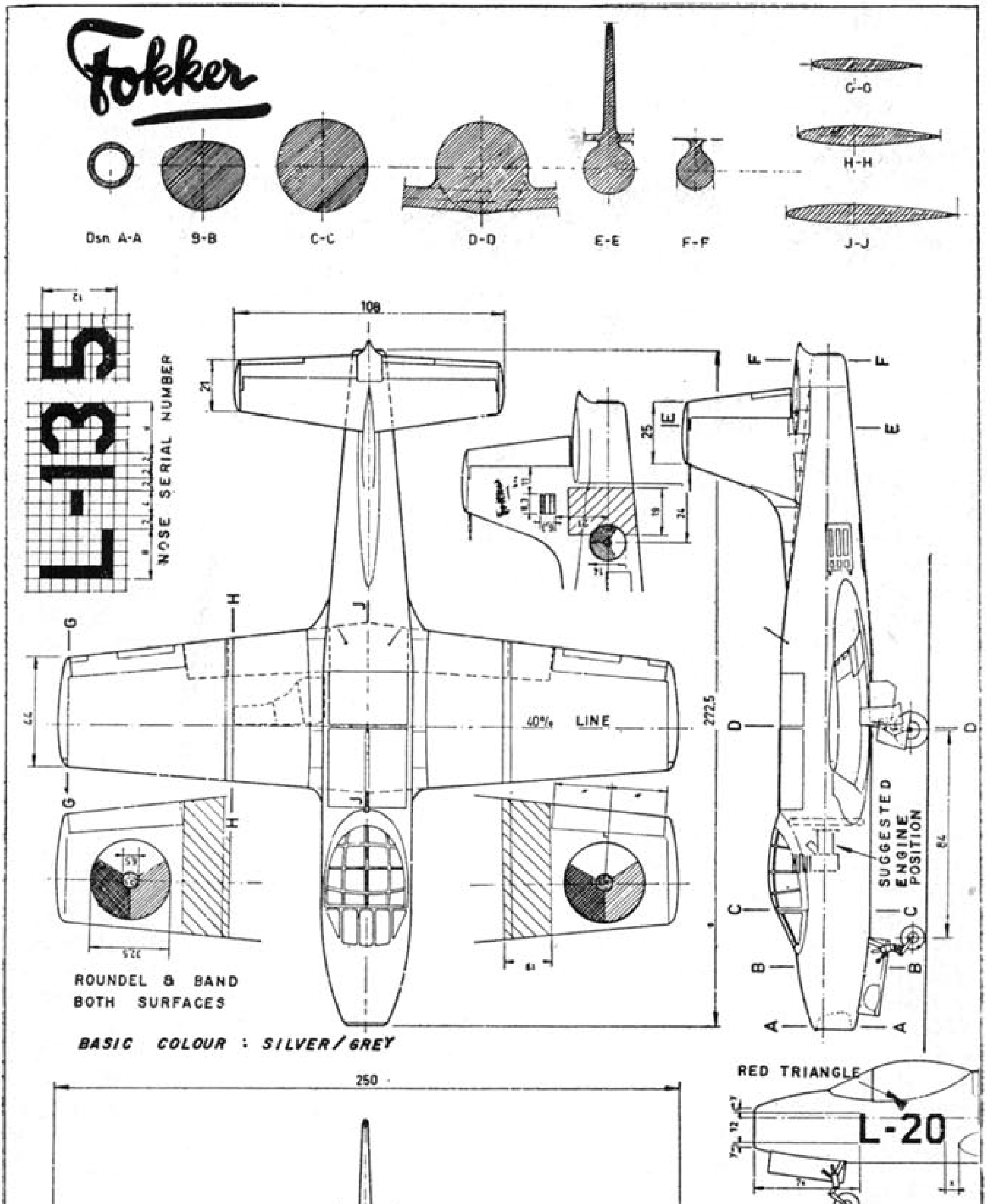

Fokker
Dsn A-A
B-B
C-C
D-D
E-E
F-F
G-G
H-H
J-J
NOSE SERIAL NUMBER
L-13 5
108
272.5
40% LINE
SUGGESTED ENGINE POSITION
ROUNDEL & BAND BOTH SURFACES
BASIC COLOUR : SILVER/GREY
250
RED TRIANGLE
L-20
97
"MACH TRAINER"
FOR DUCTED FANS.
RED
BLUE
YELLOW
ORANGE
Fig. 104.
ALL DIMNS IN MILLIMETERS
SCALE 1/144th.
FOKKER S-14.1
GET: A.L.AARTS 23-2-'55
ACC. T.C.-KNVvL.

Fig. 104 (Opposite).—Ideal ducted-fan subject for any size engine

Lavochkin. Six sides of equal width can easily be made to follow the internal contour of the duct, leaving the elliptical or circular external section to be formed by stringers or planking over small formers. Disadvantage is that we have two lots of structure in using an internal and external " skin " ; but this can be employed to good effect when making unusual shaped fuselages such as that of the French Gerfaut, the Midge, or the Swift, which are not exactly straightforward ellipses in cross-section.

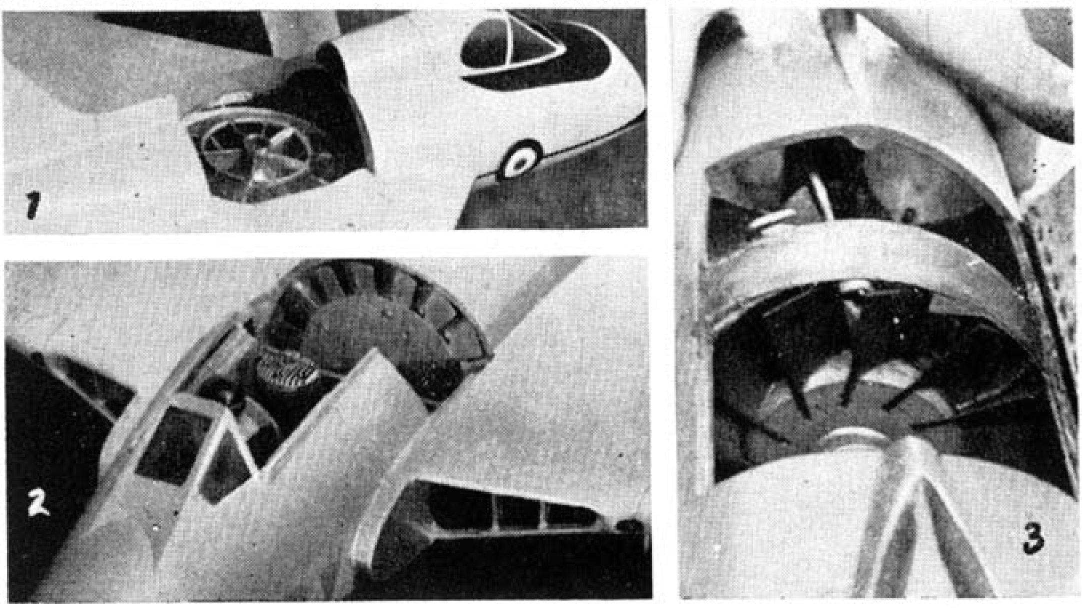
If we choose a favourable type with circular-section fuselage, nose intake and mid wing to clip on extensions of a plywood engine mount, we inevitably rest upon the MiG 15—a well-worn ducted-fan subject. As a change—why not choose the Fokker S.14 Mach Trainer? It has a low wing that can still be knock-offable from a rigid integral centre-section and it avoids the swept-wing that is responsible for the tail-dragging nose-up flight typical of the underpowered fan model. The dihedral is generous, and the engine position easy to define as being in the rear cockpit area. Hence the cockpit can be removed for starting and, moreover, the near-circular form allows a single skin to play the part of both duct and outside surface.

The nose intake is large for scale, the efflux far too small. We must enlarge the tailpipe to suit our fan, and camouflage the deviation from scale as much as possible. It is typical of our design problems likely to arise in selection of a ducted-fan subject, so we will investigate further.

A rough check will give us a scale of 1 in. = 1 ft., area 336 sq. in. length 43 in. span 39½ and weight 25 ounces allowed for 2.25 c.c. The fuselage diameter will allow us a fan of up to 5½ in. diameter if we need it : but this could be limited to 4½ in. in the interests of efficiency and maintaining high engine revs. The intake hole will be about 2¾ in. diameter, and a scale orifice only 1⅝ in. diameter.

Allowing for the fact that this aircraft has a normal, unswept configuration and that the tail structure will be of normal weight, we can decide on the engine position as roughly underneath the rear portion of the cockpit. In this position it could not in any case become part of the wing tongue as on a MiG, so we must devise a rigid mount, with stress distributed through the fuselage. We settle on a beam-mounted engine, facing aft, and fitted to a plate keyed on two main fuselage side members. Next on the list is the duct.

Fig. 105.—Significant Fans. 1. The Coatsworth centrifugal type in BP. III. 2. The Newbold multiblade in a Venom. 3. The Norman fibre blade for 2.5 c.c.



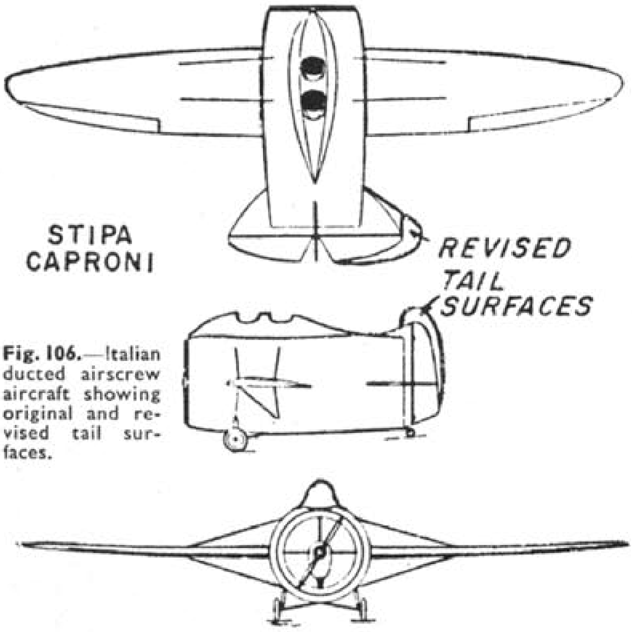


Fig. 106.—Italian ducted airscrew aircraft showing original and revised tail surfaces.

It will be about 30 in. long—and that is *very* long indeed for a ducted fan, so we must keep duct losses to a minimum and use a maximum possible tail orifice. By experience we know that the fan of $4\frac{1}{2}$ in. diameter will have working blades about 2 in. long, meaning a working fan area of 12 sq. in. For a maximum efficiency sport model, with shorter duct as well, this would indicate a tail orifice of 66% fan area, or more than 3 in. diameter (8 sq. in. area), but such an increase over scale size for the Fokker would be too much. A settlement for $2\frac{3}{4}$ in. permits a near-scale tailpipe, blending with model requirements.

Internally we can use the same contours as the outside. A cone, streamlining from the $2\frac{1}{2}$ in. centre boss of the fan and tapering to a point half way or all the way down the duct, will smooth the airflow, and a set of 4 or 6 straighteners at 30° or 40° deflection on their leading edges will speed the air velocity immediately behind the fan. We are ready to build, the ducted fan is "designed"!

For trimming this type of model, we can use airscoops in the tailpipe. One in the bottom will give a nose-down couple, at the top, nose-up, and either side for turn. It is better to use a deflector tab in the actual orifice unless the scoops are absolutely necessary, for the 15 ounces of thrust we can hope to get from the fan will soon be lost in these auxiliary "bleeds" for compensating the aerodynamics of the airframe. Similarly, unless the internal face of the duct is well varnished and proofed, the rear fuselage soon gains a dangerously large percentage of weight in absorbed exhaust waste, which in turn will seriously affect the longitudinal balance.

We cannot leave the subject of the ducted fan without touching a pert little scale selection which was the very first to use a real ducted propeller in the years 1927-1932. Ing. Stipa began investigating the possibility of a venturi-tube fuselage as a means of improving propeller thrust. Results showed that the fuselage contributed to wing lift, and an aeroplane built by the Caproni Co. had the interesting dimensions of 46 ft. 10 in. span, 19 ft. 4 in. length and maximum fuselage diameter no less than 8ft. For the man who wants the very simplest of ducted fans, here is one that utilises a standard propeller at the intake.

FAN DATA

Engine Capacity	Fan Dia.	Construction	No. of blades	Tip angles (degrees)	Tailpipe Dia.	Expected Thrust	Max. Model Weight
·5 c.c.	Axial 3 in.	·025 Almn.	8	30	$2\frac{1}{2}$ in.	5 ozs.	10 ozs.
·5 c.c.	Centrifugal $3\frac{1}{8}$ in.	·020 Almn.	10	Straight	$\frac{7}{8}$ in.	3 ozs.	8 ozs.
·8 c.c.	Axial 3 in.	·040 Almn.	8	30	$2\frac{1}{2}$ in.	6 ozs.	12 ozs.
·8 c.c.	Axial $3\frac{3}{4}$ in.	·040 Almn.	8	25	3 in.	8 ozs.	14 ozs.
1 c.c.	Axial $3\frac{3}{4}$ in.	·040 Almn.	8	30	3 in.	9 ozs.	16 ozs.
1·5 c.c.	Axial $3\frac{1}{2}$ in.	Fibre and Dural	8	30	3 in.	11 ozs.	20 ozs.
2·5 c.c.	Axial $4\frac{1}{2}$ in.	Fibre and Dural	10	35	$3\frac{1}{2}$ in.	15 ozs.	28 ozs.
3·5 c.c.	Axial $4\frac{1}{2}$ in.	Fibre and Dural	10	38	4 in.	25 ozs.	32 ozs.
5 c.c.	Axial 5 in.	Fibre and Dural	12	40	$4\frac{1}{2}$ in.	30 ozs.	34 ozs.

Chapter Thirteen

Furnishing the Cockpit

A TRUE-TO-SCALE model is not completed without cockpit detail, and in the author's opinion, it should also have an occupant if it is going to fly—after all, one wouldn't expect to see the real aircraft dashing about the sky with a vacant pilot's seat! Yet most scale modellers bilk at this last touch of authenticity which so improves a well-finished model. Whether it is the fear of adding too much weight, or the fact that they cannot locate sufficient information, or perhaps that they do not consider themselves capable of getting the furniture and pilot to " look right "—is difficult to decide. In most cases it is a combination of all three fears, with predominance given to the first.

All are unfounded. The average power scale model can well afford the extra ounce or so, even the rubber-driven types can carry head and shoulders of a pilot, with the motor passing through his middle, and the weight in this case can be as light as a few grammes.

The cockpit interior will depend entirely upon the nature of the full-size aeroplane. Military types of all vintages, from 1912 to the present day, are sparsely upholstered, and the construction is visible on the cockpit sides, while the seat will vary from the waist-high wicker " buckets " of World War I to the modern sinister mechanised " bang-seat ". Civil aircraft carry more bright décor, have seats with padding, usually colour toned, and a more flamboyant instrument panel design, particularly in the larger " executive transport " types. On the other hand, the home-built ultra-light will carry the bare necessities of instrumentation according to the purse of the builder and the demands of his civil aviation authority.

The first stage in model-making our cockpit or cabin is to follow up the source of information for the model plan and endeavour to get an illustration for use as an accurate guide. Should this not be possible, then the photographic departments of the manufacturers, the national aviation weekly magazines, or the Imperial War Museum (for military and Air Force aircraft) may be able to assist with a print to order at a reasonable charge of 1*s.* 9*d.* for 6 × 4 in. picture. The Air-Britain organisation and the reference libraries in larger towns are also useful sources of such information.

We must plan our cockpit long before completion of the model, arranging the instrument panel position, placing the rudder pedals, control column, and the seat position in the side elevation of the drawing. The next stage is to estimate the size of a standard man according to the scale we have adopted, and this will call for a tape measure plus Dad's co-operation. Get him to sit naturally on a seat about 12 in. up from the floor, and to push his feet out in front so that they rest on their heels. This will be a normal pilot attitude, and if you tailor-measure Dad and scale him down, you should find that he will fit in that side elevation drawing. The modern pilot has to carry lots of impedimenta in the way of an oxygen mask, " Bone-Dome " or crash helmet, high-altitude glare shield, etc. These will add inches to the overall height, so if it is a ducted-fan jet fighter you are making, the chances are that only the head of the " pipe jockey " pilot can possibly be located in the restricted area of the canopy above the model duct.

Make the pilot first. We start with a block of balsa of shoulder height and bust depth. It is roughly carved to head and shoulder size rather like an upside-down " T " in front view, and then the indents back and front for the neck and chin begin to transform the block into a more recognisable shape. One does not have to be a Jacob Epstein to produce a

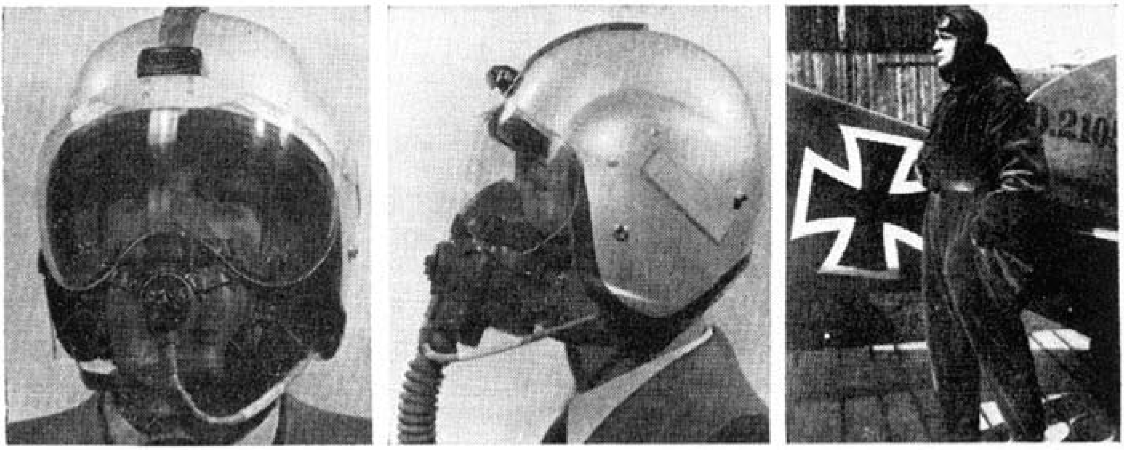


Fig. 107.—Latest Jet pilot helmet (photos courtesy of Helmets Ltd.) and 1917 German pilot illustrate contrast in attire, also the cross pattée used on Albatross D.III (Imperial War Museum photo).

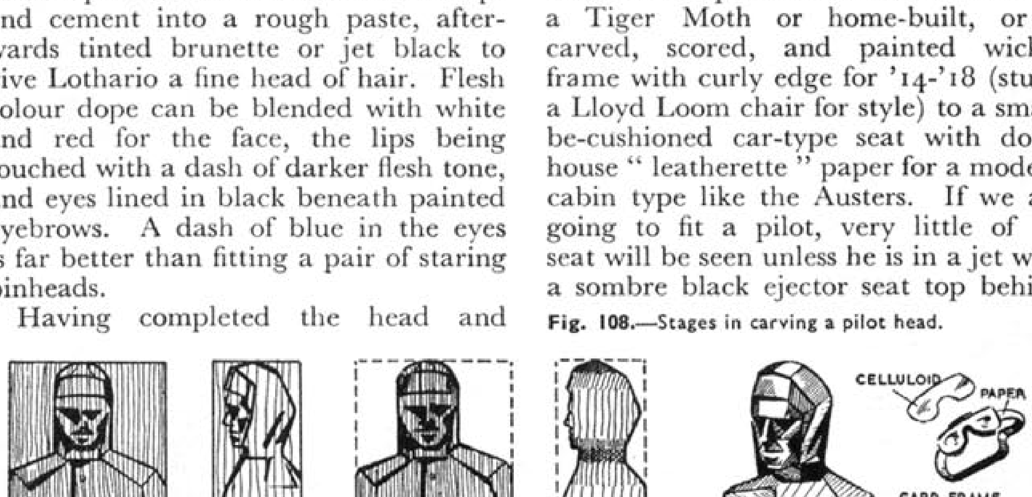
reasonable facsimile of the human face with a sharp point of a razor blade and soft balsa : but there is a best method of approach, which all are advised to follow.

Having carved the very rough shape, sketch on the block in soft pencil, the nose, ears and forehead positions. These will be left untouched, and we now cut away the hollows for the cheeks and sides of nose, the eyes, and around the underside of the chin. Fine-grade sandpaper will round off the lumps, and a smear of cement over the whole will seal the grain ready for painting. A helmeted head must be left smooth, and for a bareheaded cabin pilot, we can make up a mixture of fine balsa chips and cement into a rough paste, afterwards tinted brunette or jet black to give Lothario a fine head of hair. Flesh colour dope can be blended with white and red for the face, the lips being touched with a dash of darker flesh tone, and eyes lined in black beneath painted eyebrows. A dash of blue in the eyes is far better than fitting a pair of staring pinheads.

Having completed the head and shoulders, we are ready to add the rest of the body with a vertical backbone of $\frac{3}{16}$ in. square balsa, a base for sitting upon, and four lengths of soft wire to represent the limbs. On this bare skeleton we wrap lightweight covering tissue of the "hard" variety, with shiny surface outside. Bread-wrapping tissue is also ideal. The figure is loosely formed in the manner of a flying suit, and a coat of dope in an appropriate brown, blue or white overall shade will rapidly give a realistic impression. Paint the helmet, which could be silk for fabric effect, either brown for leather, or silver for a crash hat, and gloves in yellow for pigskin. As a final touch, make a pair of goggles or visor from celluloid, and give the man a small moustache.

The seat can be a wrapping of $\frac{1}{32}$ balsa for the plain bucket to be found in a Tiger Moth or home-built, or a carved, scored, and painted wicker frame with curly edge for '14-'18 (study a Lloyd Loom chair for style) to a smart be-cushioned car-type seat with dolls' house "leatherette" paper for a modern cabin type like the Austers. If we are going to fit a pilot, very little of his seat will be seen unless he is in a jet with a sombre black ejector seat top behind

Fig. 108.—Stages in carving a pilot head.



his helmeted head. The back of the seat need not always be fitted, for the sake of lightness, and most of the base should be hidden by the pilot's legs. What will be noticed are the Sutton Harness safety straps of an aerobatic military type, or the Mills safety lap-strap across the thighs in a more docile civil aircraft. These should be painted brown and given silver quick-release fittings where they join in the pilot's middle. Other unoccupied seats can have these straps lying loosely in flat strips of thin card to represent the stout webbing.

Cabin walls can be lined with the same dolls'-house furnishing paper in the more luxurious passenger aircraft, or left bare and given an overlay of $\frac{1}{16}$ in. square balsa and thin dowel to represent dummy structure in most open-cockpit lightplanes and all military types. Since 1938, R.A.F. "day" machines have been doped a soothing cockpit green, matt and light in tone, but for most other aircraft, and all earlier R.A.F. machines, the colour is left in natural metal or clear varnished woodwork as the case may be. "Night" fighters and bombers had black interiors.

Taking a typical military single-seat cockpit, we had, in '14-'18 vintage, a polished natural wood instrument panel with few dials, most of which had large brass rims. In the centre, a banana shaped spirit level served as a crude bank indicator, and prominent at the base of the panel in the centre was a large compass. To the left were large brass-domed electric light switches—used for the ignition circuit, and a gun breech protruded into the cockpit, handy for reloading, in the case of the S.E.5a. On the walls, a map pocket at left, and control cables or ammunition drums at right helped to fill the tiny space.

Fig. 109.—Pilots by Capt. Milani add character to his models. Bottom, use of electric-motor-driven eraser to simulate "engine turning" on metallised paper.

The pattern was set, however, and with throttles at the left, engine instruments at the right and principal blind-flying dials in the centre, the arrangement is retained to the present day. Refinements include the standard blind-flying panel, standardised on all British military and commercial aircraft, and comprising six of the most important instruments. Always black in finish, the entire instrument panel is designed to give most prominence to the lime-green luminous figures and dial pointers. Only touches of colour are the red covers on emergency buttons, the red rims to boost-pressure gauges and yellow rims

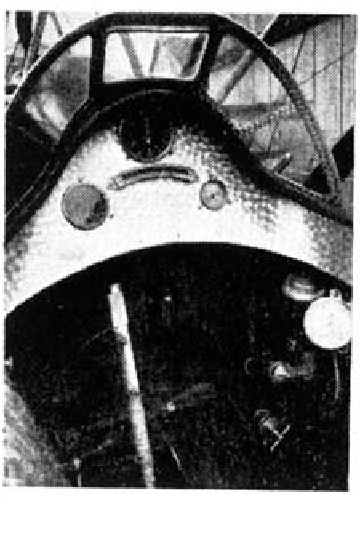


Fig. 110—Full-size and model cockpits of an SVA 4 are scarcely distinguishable. This Milani model has inlaid mahogany covering and scalloped fabric trailing edges as should be.

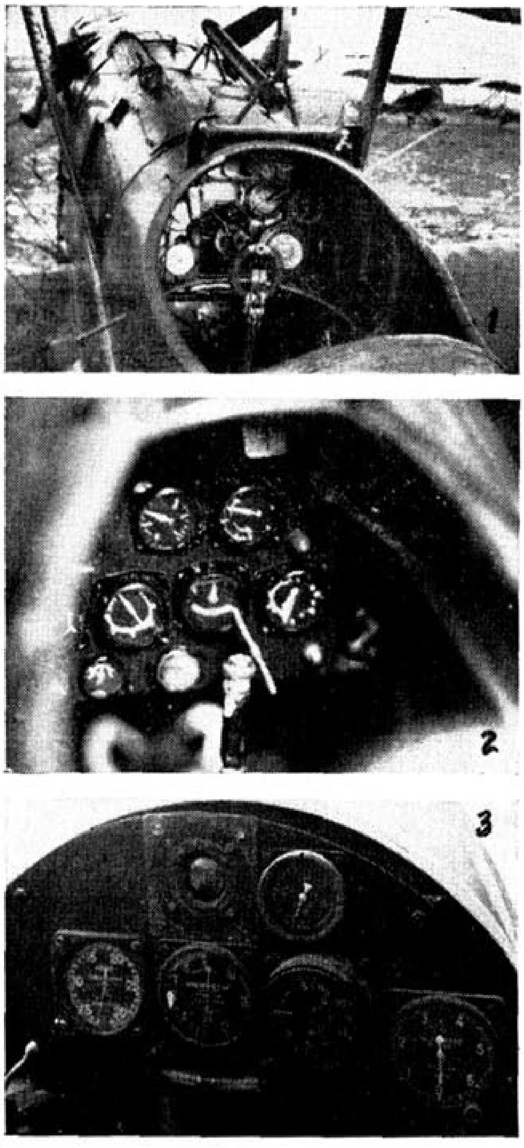


Fig. 111.—1. S.E.5a cockpit showing spadegrip joystick. 2. Model Fiat CR.42—almost actual size! 3. French Jodel Bebe with assorted war surplus instruments.

on oil gauges. On the throttle arms, the actual handling knob is sometimes yellow, otherwise black, and airscrew-pitch control knob, red.

A multi-engined type, or side-by-side dual control arrangement, calls for the engine controls to be mounted centrally on a pedestal. Such is covered with protruding arms, one for each engine control, others for mixture, airscrew pitch, cooling gills, etc. They even run over and extend to the roof in a very large airliner: but that's for the control-line multi enthusiast alone !

In a civilian cabin or open-cockpit type, the instrument panel is colour toned to harmonise with the rest of the schemes, and we find car-like facilities such as dashboard glove compartments, and chromium plating is used to embellish general appearance. Edges of cockpit coaming, found inside cabins as well as around the edge of an open single-seater, are piped with smart leather protective padding, easily duplicated on our model with lengths of electric flex-cover split along its length to fit over an edge.

All instrument panels are made by cutting holes for each dial in a piece of smooth paper, painting it black, or the appropriate colour, and sandwiching a layer of celluloid between it and the black-painted instrument panel former. Luminous figures are symbolised by marks in lime-green dope on the celluloid after the sandwich is made up. Throttles can be made with pins—the heads being just right in many cases, and a dummy map sticking halfway out of a wall pocket adds to the realism, as well as sundry electrical conduits and pneumatic or hydraulic pipes in varied yellow, blue or green colour codes. The latter are grouped together, passing low down along the wall. Most important of all cockpit furniture is the control column or " joy-stick ". This will vary from the simple tube with a rubber-grip top as found in most early aircraft and modern lightplanes, to the large " spectacle frame " used in big bombers and airliners. In between come the " spadegrip " controls as fitted to fighters, and usually hinged at a point halfway up from the base of the column. Make the joystick from bent wire and a length of dowel or balsa. Very often, an oval nail can be bent and painted to right size, and for lightplanes this can look just right with the top 5 in. in scale, painted black to represent a rubber-grip. Most joysticks of this type have to be bent to negotiate the seat and give leg clearance, while the spadegrip and spectacle variety rise straight from the floor or heel-board level to give a direct run for the bicycle chain used inside them to transmit the aileron control.

Put the pilot in his seat, his feet on the rudder pedals, left hand at the throttle and right on the stick.

The cockpit is not yet finished. It needs either a complete canopy or full cabin, at the very least a windscreen. We make these items from Acetate sheet, a transparent plastic obtainable at model shops and handicraft stores and which can be moulded with heat to almost any shape. First, the simple windscreen. This is an item that is always getting knocked, so do *not* cement it firm. Try a paper pattern for size, it is usually a half-moon shape, and when cutting out the pattern in Acetate (about .020 in. thickness), add a pair of lugs at the corners, and another in the centre. Now position these on the fuselage, cut slots for them, and force the screen home without cementing anywhere on the outside. A dab at the lug positions on the inside will not show—and if a crash moves the screen, as it always does, then there will be no effect on the exterior finish.

For a cabin we have no alternative but to cement the glazing firm but there

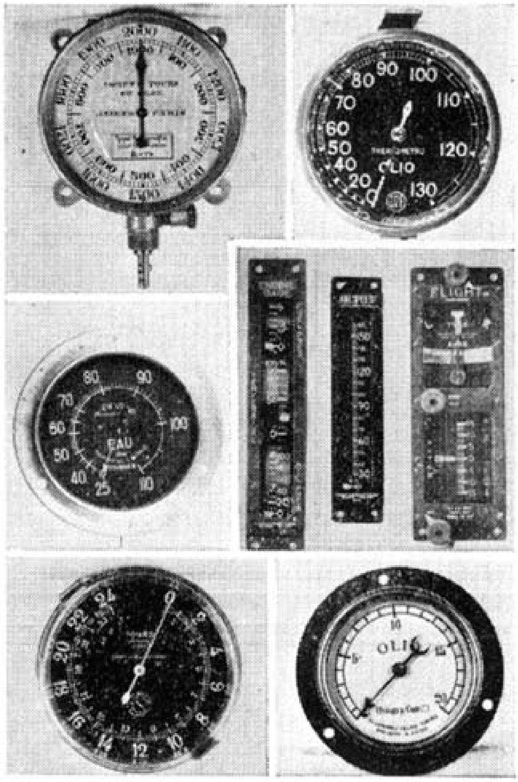
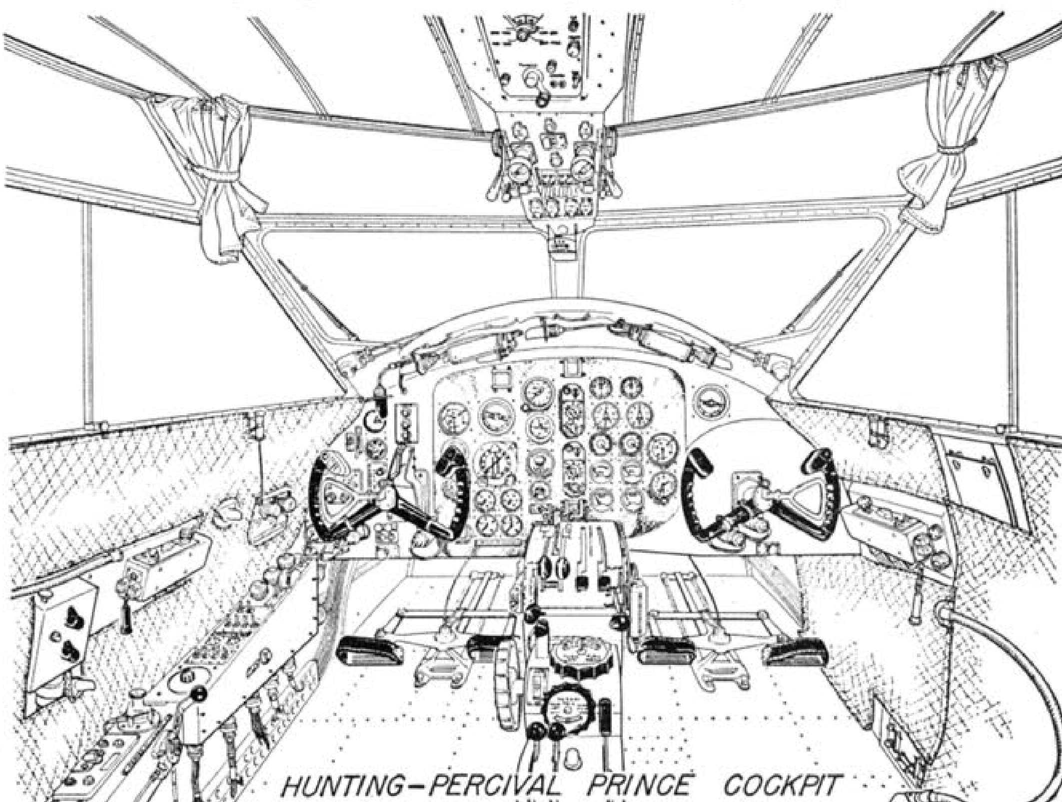


Fig. 112.—Continental instruments used in '14-'18 aircraft, approx. ½ scale.
Fig. 113.—Twin-engined cockpit interior.



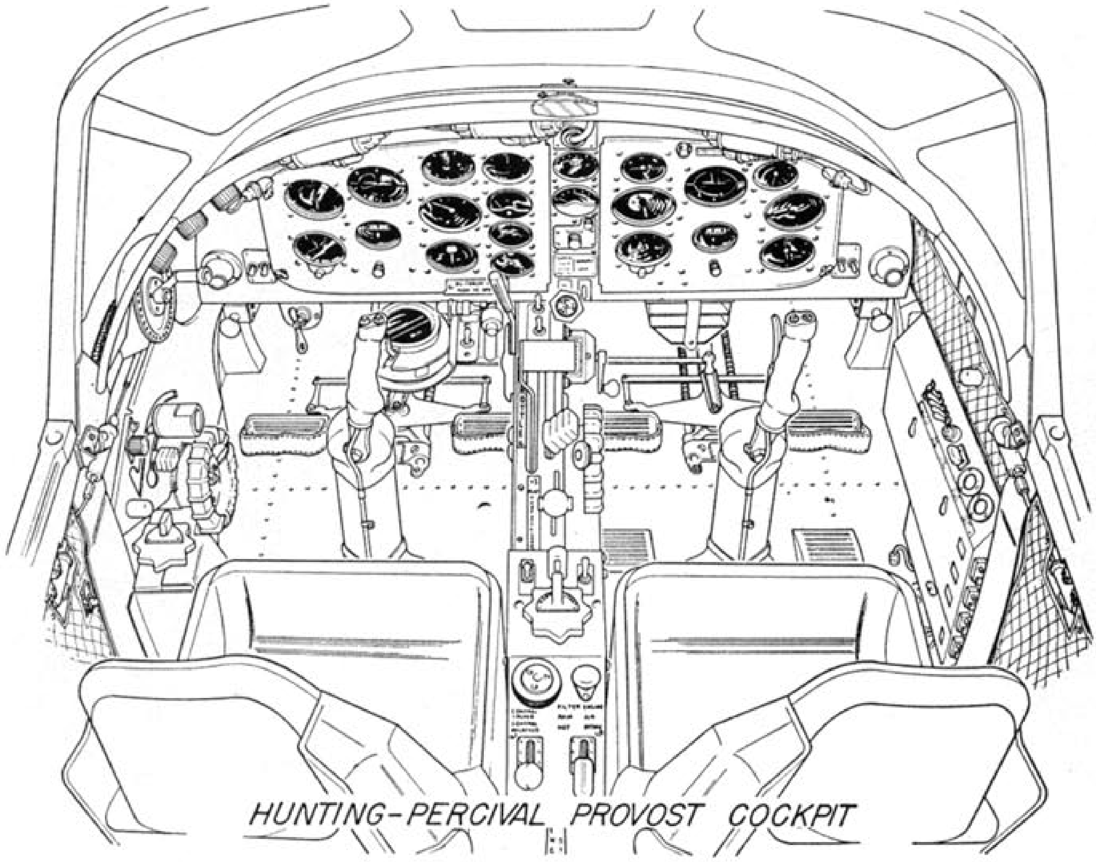


Fig. 114.—Trainer, with duplicated controls (reproduced by courtesy of manufacturers).

is less risk of damage due to the increased rigidity. We hold the moulded shape on the fuselage with small lengths of Sellotape, etc., and a dab here and there soon locates the hood, ready for removal of the tape, and a quick application of very thin cement or thick dope all around the fuselage/cabin juncture. A further refinement is the sliding canopy, with the use of wire rails and short pieces of tubing runners attached to the Acetate. But either way, we must first mould the Acetate, and here is the advised way in which we do it.

Of the many methods of heating the Acetate sheet to make it pliable, dry heat in front of an electric fire is to be preferred since it is the least involved and allows quick moulding action, an essential to success. Heating in an oven is feasible: but the vapour given off by the sheet is not the sort of atmosphere the wife or mother will tolerate more than once in the kitchen. Use of hot oil, over a gas ring, is similarly a smelly process, but one which produces the finest result due to the even heat distribution in the Acetate.

Using the dry heat system, we can tackle the moulding in one of two ways, the size of the job, and the amount of "draw" or depth of mould being the deciding factor. For an Auster cabin, we use the **stretch** method, pulling the Acetate over the mould in two stages, one for the roof, another for the windscreen. For a Spitfire rear-view canopy (Bubble hood) we use the **pressure** method, forcing the Acetate through a hollow jig. Both methods require that the shape to be moulded must first be carved in balsa, and covered with tissue or grain filled, for every indentation will reproduce itself in the transparent canopy. We can use this to advantage by placing card straps on the mould to represent the canopy framework, which will come out perfectly and make painting very easy if

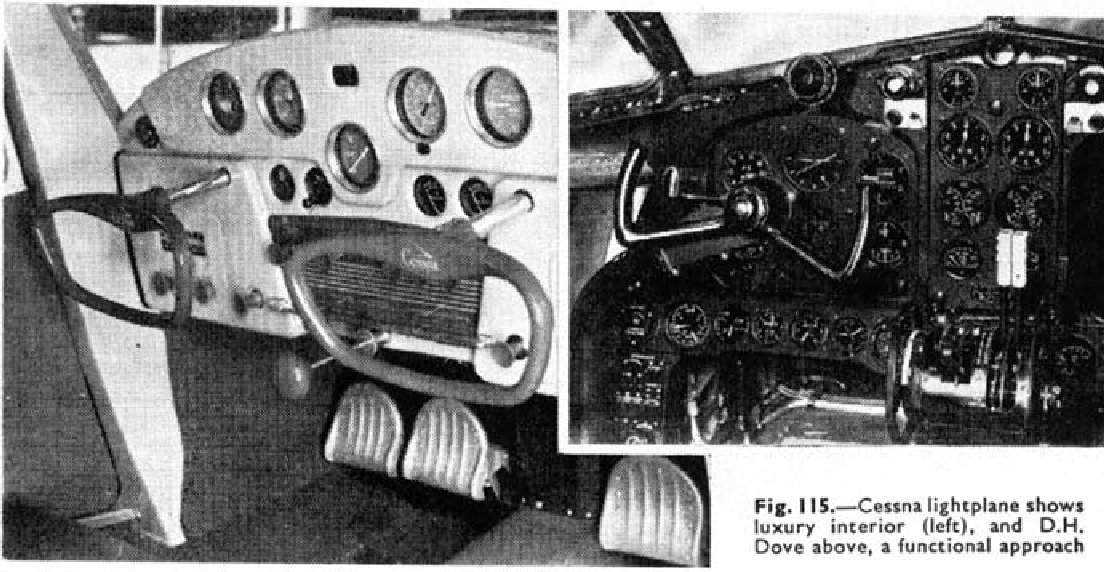


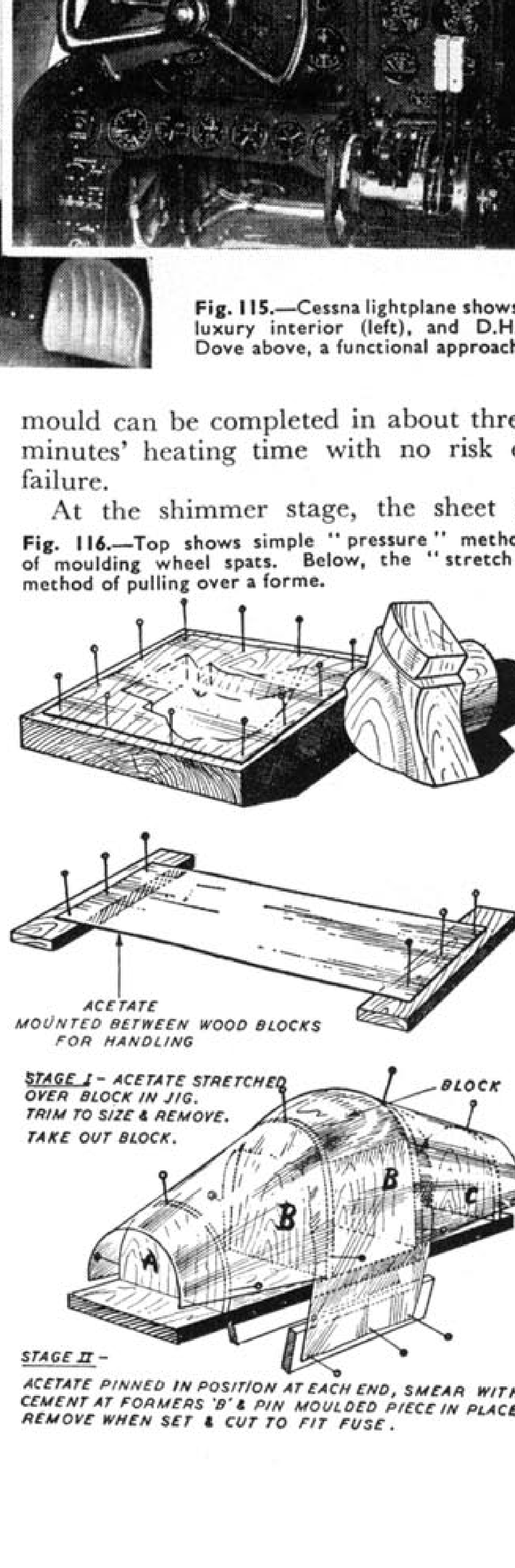
Fig. 115.—Cessna lightplane shows luxury interior (left), and D.H. Dove above, a functional approach

run along the gutter formed inside the final shape. By this same " pressure " method we can mould wingtips, and can leave the front quarter unpainted for the navigation lights, or we can mould landing light covers, wheel spats, wing root fairings and exhaust stubs. The possibilities are endless, and moulding soon becomes a part of every scale model once we get the knack of knowing just when to " make the plunge ".

That is the art of Acetate moulding, to judge the correct moment for either stretching or applying pressure on the heated sheet. For the **stretch** method, have the balsa form held rigidly in a clamp near to the fire, and pin a piece of Acetate, 2 in. oversize all round, across the ends of two stout sticks. Use plenty of steel pins, and keep them at about 2 in. intervals, about ¾ in. in from the edge. Now hold the Acetate in front of the fire at a distance of 15 to 18 in. and keep it moving so that the heat is well distributed. It will soften, go floppy, and give off a steamy vapour. By pulling the sticks we can see exactly how pliable the sheet becomes, and the best moment for making the moulding is when it begins to shimmer. Avoid taking the sheet too near the heat, or allowing one part to receive more heat than the rest. It will blister all too soon, and at 1*s*. 9½*d*. per square foot the experiment can become an expensive one. With patience, a mould can be completed in about three minutes' heating time with no risk of failure.

At the shimmer stage, the sheet is

Fig. 116.—Top shows simple " pressure " method of moulding wheel spats. Below, the " stretch " method of pulling over a forme.



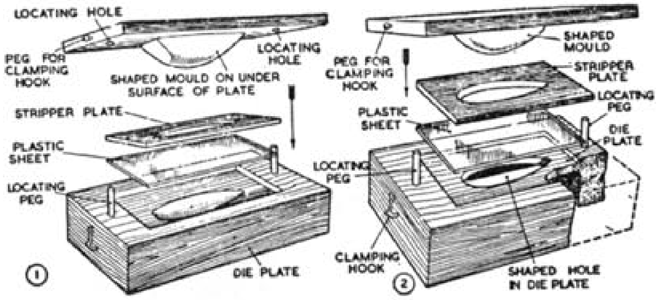
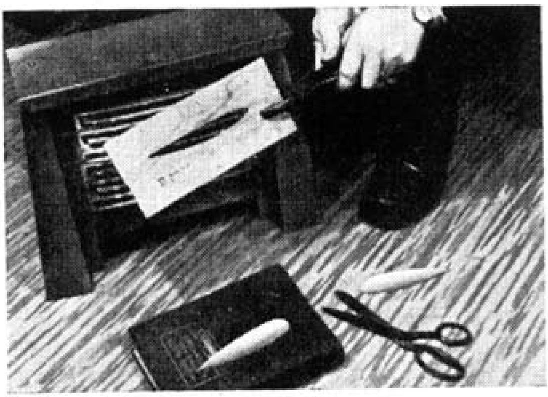


Fig. 117.—Complex method ot pressure moulding used for mass production, in two ways, with female mould or hollow dieplate.

like a piece of polythene plastic. Lines sometimes appear : but disappear during the stretch. We decide to "take the plunge", and in one swift motion force the Acetate squarely over the mould with stretching pressure on both sticks. Get a third hand to wipe firmly over the moulded surface with a soft rag and so make sure that the contact is good. In a moment—less than 10 seconds—the Acetate is set hard again and ready to part from the form.

Pressure moulding for smaller parts is, if anything, an easier operation. In addition to the balsa form, we must cut a hole in stout ply or similar so that the form will just pass through, with clearance for the Acetate all round.

Procedure for heating is as before, only this time the Acetate is pinned over the jig hole at 2 in. intervals around its edge, and with liberal allowance for the stretch. At the "plunge" moment, see that the form passes well inside the hole, forcing the Acetate to follow the curvature in every way.



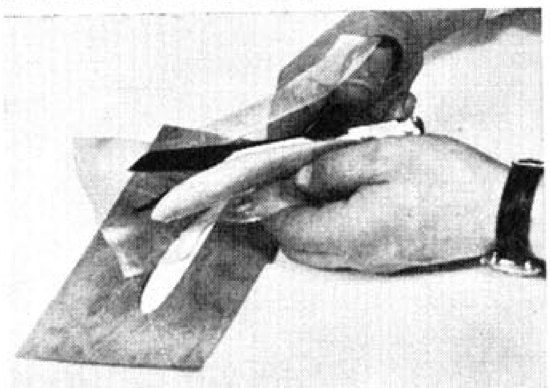
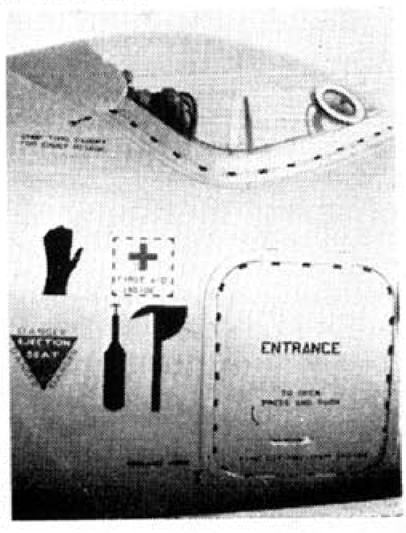


Fig. 118.—Photos at left show easy pressure moulding for author's Auster wingtips. Acetate is heated over dieplate, then forced over balsa form, afterwards trimmed to shape.

Fig. 119.—Below, old and new, an R.E. 8 and Canberra show stencilling detail for accurate modelling. Ejector seat triangle cross, and dotted lines are red on Canberra, all else, black.



Chapter Fourteen **Finish and Colouring**

THE well-worn adage, never spoil the ship for a ha'porth of tar was never more true than in the case of a roughly coloured scale model. Most enthusiasts realise this and, for the majority, the decoration and finish stage is the most enjoyable. In fact, there are some scale modellers who follow this branch of the aeromodelling hobby so that they can display their particular skills in wielding a handy paintbrush.

Nothing is more offensive to the true-scale enthusiast than use of obviously incorrect colouring and markings, and there is no reason why we should see such travesties of truth as an all-red Sopwith Pup, or Lilliputian U.S.A.F. transfers tucked away on both wingtips of a five-foot Cessna Bird Dog, for the correct and authoritative information is easy to obtain through a wide range of excellent reference books. Yet those two examples of inaccuracy were seen at a recent large model rally.

Having covered the model, either with tissue, silk or nylon, and shaped all block and sheeted parts as smooth as possible, we are ready to start our doping. We refer to the process as doping, since all of the cellulose liquids which dry by rapid evaporation and are used for both full-size and model finishing are collectively known as " Dopes ". For the tissue or fabric, we apply at least two coats of good quality clear dope. This shrinks the covering to a drum-like tautness and imparts a coating of thin transparent film on the surface to render it water- and air-proof. Sturdier structures, the fuselage and wing centre-section, would benefit from a third coat of clear to form an additional protection against oil seepage from the engine exhaust.

On the bare wood surfaces we must give due consideration to the need for keeping weight as low as possible and since the commercial primers and grain fillers have heavy paste content, they are not generally suitable for flying models. Instead we use what is known as " Sanding Sealer " which looks rather like a mixture of clear dope and talcum (a good substitute) but which is superior in its ability to " find its own surface ". This liquid is applied liberally, and the first coat will rapidly seal the open grain of balsa. Second application can be applied immediately, even before the first is hard, and then left overnight for solid drying. We must then rub the surface down to remove excess dried sealer and level out the bumps that inevitably appear. This is a simple sandpapering job for small areas, using the finest grades, such as 000 and " Flourpaper ". For a large area, where

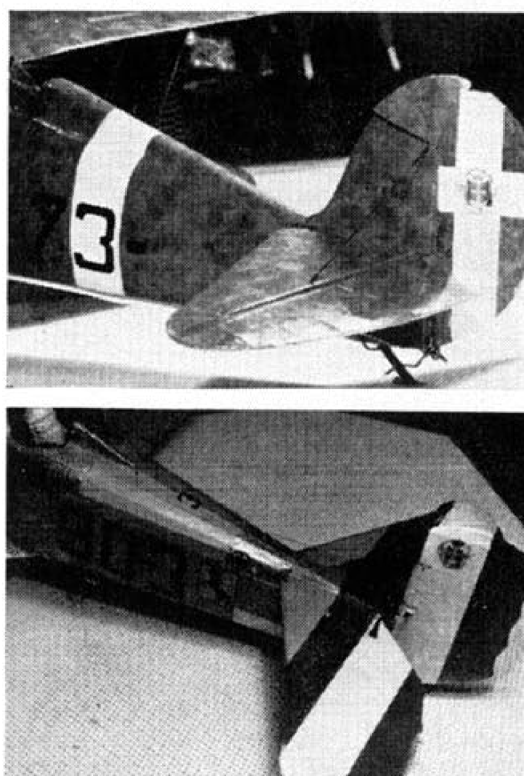


Fig. 120.—Well-finished models of Ro. 41 and CR. 42 Italian biplanes illustrate stippled camouflage, fine lettering and different styles of national insignia. House of Savoy crest is hand painted by Capt. Milani on these rudders.

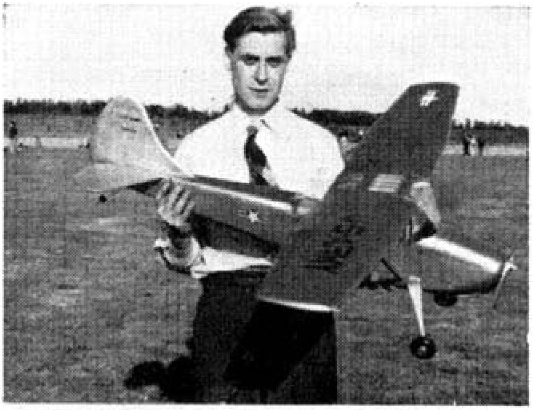


Fig. 121.—Nicely-made model Cessna Bird Dog spoiled by too small markings and inverted fuselage insignia, a trap for the unwary !

grain and undulations will be more noticeable, " Wet and Dry " paper is recommended. This is obtainable at most garages and is used for obtaining that superb finish we see on expensive cars. As the name implies, the paper is waterproof, and its principal asset is that if kept wet and dipped regularly in water or petrol, the grains do not clog, and we get a polished surface rather than one with sanding marks. Wiping down with an absorbent cloth will keep the surface clean and show just how smooth the model becomes. For a large fuselage, calling for exceptionally fine finish, up to eight applications of sanding sealer may be used with increase in weight of the order of 1 ounce per square foot of area. By rubbing down close to the wood surface each time, the grain is filled to perfection and actual sealer thickness kept to a minimum.

With the balsa parts and fabric covering taut and smoothly finished, the next stage is the first application of colour. Weight is most important, and the pigments of coloured dope are heavy, so the rule is to keep the dope thin and rely on a maximum of three coats for the most difficult colour, which is white, and two coats for average primary colours. We need have no qualms over this, as most of the cellulose dope manufacturers in Britain supply their colours of a consistency ready for brushing, which are ready to apply almost straight out of the tin or jar. There are exceptions to this, and in cold weather we should watch for extra viscosity. This means that the dope has been standing in a cold temperature and has become treacly or thick. If placed in a temperature of 75° for 24 hours before use, it regains the smooth flow from the brush and does not drag or show brushmarks. A quick remedy is, of course, to thin the dope ; but this should be done with caution as it is all too easy to reduce the consistency of the pigment so that it will no longer " cover ", and with matt dopes, for camouflage, extra thinners introduce a most unwelcome shine to the surface.

Another weather-effect is " blushing ", common in humid or rainy conditions, and which produces white patches, no matter what the colour of the pigment. It is caused by the rapid evaporation of thinners and solvents in the dope, lowering the temperature on the surface and causing condensation of the moisture in the atmosphere. This moisture on the surface of the wet dope precipitates the cellulose out of solution, giving the white appearance known as a blush. We need to remove this effect to regain the finish, and the simplest way is the application of a solvent such as acetone, quickly brushed over the surface in a warm dry room.

Other detrimental effects in doping are pin-holes. These appear in the surface over an area which has been tissue-covered over balsa, such as a broad trailing edge or sheeted wing surface. It indicates an unprepared base for the colour coats, and the remedy is to rub down with wet and dry paper, give a coat of sanding sealer and start again. Runs are a sign of slap dash work with the brush, which should be a soft squirrel (known as " camel " hair in some cases). Always wipe the brush on the inner edge of the jar or tin after dipping the end of the flat in the dope, this removes the excess and keeps all hairs in place. If you are unlucky and allow a run to develop, wipe it from the surface before it has time to dry—it is easy to repair the damage to the finish : but very difficult to remove the unsightly ridge of the run, if allowed to set dry.

Matt surfaces for scale '14-'18 and

'39-'45 wartime aircraft are not always easy to reproduce with a soft blend between tones, such as obtained by a spray painting apparatus when following the camouflage pattern. Various mouth sprays have come on to the market from time to time, and work with some success until the dope begins to clog the jet and we have to take the unit apart frequently to keep it clean. A simpler plan is to "stipple" the furry edge for camouflage by using an old brush with the hairs cut down short, and dabbing lightly all along the edge of the proposed pattern. The main coat of colour is applied afterwards. Prepare the model for its camouflage pattern by following the contours observed on an actual photo of the full-size type, and chalking the colour dividing lines lightly on the tissue surfaces. This way we can avoid unnecessary weight by not overlapping the colours. Incidentally, the width of the spray effect of one colour overlapping another on the full-size will only be a matter of an inch, so a hard dividing line on any model smaller than one-twelfth scale is quite in order. Post-war camouflage appears to have hard or masked dividing lines anyway!

For a super-glossy finish, we can afford to thin the dope slightly and use an extra coat to "cover". American modellers talk of up to 16 coats of dope on a model: but they must be particularly fortunate with the pigments that are used, for the weight of British dopes would be prohibitive at more than six thin applications. For a final top-coat to obtain a lasting shine and protection against the ravages of castor oil in the model fuel, use a non-shrinking varnish sold as "Fuel Proofer". This is used to protect oil paintings so one can apply it with every confidence that it will not spoil the effect unless it is pure white. In that case, be wise and leave the dope surface alone, for any varnish will tarnish!

The general guide to doping is set out as follows:

Material: Squirrel Brushes. ½ in. Mop (No. 3) for clear doping. ¾ in. Flat for S/Sealer and Colour. Nos. 2 and 5 Artist Brushes for decoration. Clear Dope, Sanding Sealer, Colours and Thinners of same make. Warm atmosphere, approximately 65° Fahrenheit. Separate jar for mixing thinned dope. Sandpaper and wet and dry paper in fine grades. Soft rag and newspaper over work bench. Fuel Proofer or Varnish. Cellulose abrasive polishes.

Application: 2 coats clear on tissue or fabric.

(*a*) 2 coats Sanding Sealer on bare wood.

(*b*) Rub down with fine sandpaper or wet and dry paper.

(*c*) Apply further Sanding Sealer until satisfied, rubbing down between coats.

(*d*) 2 coats each colour, light colours first.

(*e*) Fuel Proofer or Varnish over glossy colours or polish with cellulose abrasives (Titanine, Hendon C. and W.).

Our scale model will still be far from finished even at this stage. It will need international registration lettering or national marking on the wings and fuselage, plus sundry other stencilled notices and marks of identification. These are the titbits that can become so interesting and serve to identify a well-finished model.

Decorative stripes or cheat lines are not the sort of item one would like to tackle free-hand. A stencil must be used, and the self-adhesive transparent tapes of the Sellotape variety are a great asset. First mark the cheat line at occasional key positions on ribs or formers, with a soft pencil (not indelible!). We may be making a yellow outer leading edge for a fighter, an invasion stripe on a bomber, or a smart fuselage flash on a lightplane. The few spots of pencil marking can be joined by the edge of the Sellotape and, with a little patience, one can soon learn the ways and means of negotiating curves or maintaining straight lines on a curved surface. When the Sellotape is pressed down firm at the stencilling edges, brush a single coat of the colour dope around the edges quickly, using a motion that directs the dope away from, and not

R.F.C. AND R.A.F. BASIC CAMOUFLAGE SCHEMES AND INSIGNIA

Command	Upper Surfaces Colour	Upper Surfaces Roundel	Undersides Colour	Undersides Roundel	Fuselage and Fin Colour	Fuselage and Fin Roundel	Examples
Fighter (Day) 1914-15	Natural linen	None	Natural linen	Union Jack flag	Varnished wood and linen	None	B.E.2B. M.F. Shorthorn
1916-19	Khaki or olive drab (Home service-silver)	Types 1 and 2, full chord	Natural linen (Home service-silver)	Type 1, full chord	Khaki or olive drab (Home service-silver)	Type 2 and rudder stripes	S.E.5a. Sopwith Camel Bristol F-2b.
1921-34	Aluminium and Sqdrn. colours	Type 1, full chord	Aluminium, black serial numbers	Type 1, full chord	Aluminium and Sqdrn. colours	Type 1 and rudder stripes	Gamecock Grebe
1934-37	Aluminium and Sqdrn. colours	Type 1, smaller	Aluminium, black serial numbers	Type 1, smaller	Aluminium and Sqdrn. colours	Type 1 and rudder stripes	Gauntlet Fury
1938-40	Dark green and dark earth	Type 4 and Type 3	Aluminium, half light grey, half black	Type 1 None	Dark green and dark earth	Type 4 Type 1, rudder stripes	Defiant PS.264 Gladiator HE.605 Hurricane TP.73 Sqdrns.
1940-42	Dark green and dark earth	Type 3	Sky	Type 1	Dark green and dark earth, sky or grey letters	Type 4, fin flash	Spitfire QV 19 Sqdrn.
1942-46	Dark green and dark sea grey 6" wide yellow leading edge on all types for outer ½ span.	Type 3	Sea grey medium	Type 6	Dark green and dark sea grey 18" band around rear fuselage in sea grey medium or sky, as letters	Type 7, fin flash	Typhoon DP.193 Mustang MT.122 Spitfire EB.41 Kittihawk (Tropical) NS.260 Sqdrns.
(Tropical)	(Dark earth and light earth)		(Sky, or azure blue)		(Dark earth and light earth)		
1946-53	Aluminium and black anti-dazzle	Type 8	Aluminium, black serial numbers	Type 8	Aluminium and Sqdrn. colours	Type 8, fin flash	Vampires Meteors
1953-60	Dark green and dark sea grey E.E. Lightning—Natural metal	Type 8	High-speed silver (2nd T.A.F. cerulean blue) black serial numbers	Type 8	Dark green and dark sea grey Sqdrn. colours E. E. Lightning—Natural metal	Type 8, fin flash	Hunters, Sabres, Venoms
Fighter (Night) 1940-42	RDM-2 matt black	Type 3	RDM-2 matt black	None	RDM-2 matt black, red letters	Type 4, fin flash	Havocs VV.534 Sqdrn. Defiants KP.409 Sqdrn.
1942-60	Dark green and dark sea grey	Type 3 (to '46) Type 8	Medium sea grey black serial numbers	None	Half as upper half as lower Red letters or Sqdrn. colours	Type 7 (to '46) Type 8	Beaufighters AJ.256 Mosquitos YA.125 Sqdrns. Meteors, Javelins

Trainer 1916-21	Aluminium	Type 2	Aluminium	Type 2	Aluminium	Type 2, rudder stripes	Sopwith Pup
1921-36	Yellow	Type 1	Yellow, black serial numbers	Type 1	Yellow, black serial numbers	Type 1, rudder stripes	Avro 504
1937-40	Dark green and dark earth	Type 3	Yellow, black serial numbers	Type 1	Yellow, black serial numbers	Type 1, fin flash	Tiger Moth
(**Overseas**) 1940-44	Yellow	Type 1	Yellow, black serial numbers	Type 1	Yellow, black serial numbers	Type 1, fin flash	Harvard (Overseas)
(**Home**) 1945-59	Aluminium, 24" yellow stripe	Type 8	Aluminium, black serial numbers	Type 8	Aluminium, 24" yellow stripe	Type 8, fin flash	Provost Chipmunk
1960	Aluminium outer 4' 9" of tips and flaps, fluorescent orange	Type 8	As upper, 24" black serial numbers	Type 8	Aluminium, rear fuselage and nose fluorescent orange	Type 8, fin flash	Jet Provost
Bomber 1917-18	Black	White circle, black centre	Black	White circle, black centre	Black	White circle, black centre	F.E-2B, H.P.0/400
1930-37	Dark green	Type 3	Black, white serial numbers	Type 1	Dark green	Type 3	Virginia, Heyford
1937-43	Dark green and dark earth	Type 3	Black or sky (day)	None or Type 1	Dark green and dark earth or black; red letters	Type 4 or Type 7, fin flash	Wellington AA 75 Sqdrn., Blenheim SR. 101 Sdqrn.
1943-45	Dark green and dark sea grey	Type 3	Black (night). Sky, or medium sea grey (day)	None	Dark green and dark sea grey; red letters	Type 7	Stirling MG.75 Lancaster OJ.149 Halifax MP.76 Mosquito GB.105 Sqdrns.
1945-53	Medium sea grey	Type 8	Gloss black, white serial numbers, or cerulean blue	None	Half medium sea grey Half gloss black	Type 8, fin flash	Canberra, Washington WP.90, Lincoln EM.207. Sqdrns.
1953-56	High-speed silver	Type 8	High-speed silver, black serial numbers	None	High-speed silver, 24" black serial numbers	Type 8, fin flash	Valiant, Canberra
1957-60	Antiflash white	Type 8	Antiflash white	Type 8	Antiflash white	Type 8, fin flash	Victor, Valiant, Vulcan
Coastal 1939-40	Dark green and dark earth	Type 3	Aluminium or black	Type 1	Dark green and dark earth	Type 1	Anson XZ.48 Hudson NR.220 Sqdrns.
1940-42	Dark slate grey and dark sea grey	Type 3	Sky or sea grey medium	Type 1 or none	Dark slate grey and dark sea grey	Type 4, fin flash	Blenheim YH.21 Beaufort MW.217 Sqdrns.
1942-44	Dark slate grey and dark sea grey	Type 3	Matt white	None	Matt white, red letters	Type 7, fin flash	Liberator FH.35 Sunderland RB.10 Catalina TR.265 Sqdrns.
1945-56	Sea grey, medium glossy (or U.S. midnite blue)	Type 8	Gloss white, black serial numbers (or U.S. midnite blue)	None	Gloss white (or U.S. midnite blue)	Type 8, fin flash	Shackleton, Seamew (Neptune)
1958-60	Extra dark sea grey (glossy)	Type 8	extra dark sea grey, (glossy) white serials	Type 8	Extra dark sea grey (glossy)	Type 8, fin flash, red numbers	Shackleton MR.3

Command	Upper Surfaces Colour	Upper Surfaces Roundel	Undersides Colour	Undersides Roundel	Fuselage and Fin Colour	Fuselage and Fin Roundel	Examples
Photo Recce (P.R.U.) 1942-53	Cerulean blue	Type 3	Cerulean blue	None	Cerulean blue, red letters if carried	Type 3, fin flash	Spitfire Mks. 12 and 19 Mosquito Mk. 34, HS 109 Sqdrn. Canberra
Observation (A.O.P.) 1942-56	Dark green and dark earth	Type 3 (Type 8 from '48)	Dark green and dark earth	Type 6 (Type 8 from '48)	Dark green and dark earth	Type 7, fin flash (Type 8 from '48)	Auster Series
Target Tugs 1941-47	Dark green and dark earth	Type 3	Yellow, 36" black bands at 30°, 108" apart, black tail-plane	None	Dark green and dark earth	Type 4, fin flash	Maryland, Albemarle Martinet
1947-55	Aluminium	Type 8	As above, black serial numbers	Type 8	Aluminium	Type 8, fin flash	Beaufighter Buckmaster
Pilotless Target 1955	Cream	Type 8	Red	Type 8	Half cream, half red	Type 8	Firefly 8

R.N.A.S. AND FLEET AIR ARM CAMOUFLAGE AND INSIGNIA

Year	Upper Surfaces Colour	Upper Surfaces Roundel	Undersides Colour	Undersides Roundel	Fuselage and Fin Colour	Fuselage and Fin Roundel	Examples
1914-16	Natural linen	None or Type I	Natural linen	None or Type I	Natural linen	None, or type I	Short Seaplanes Sopwith Tabloid
1916-19	Khaki or olive drab (Home service, silver)	Type 2	Natural linen or silver	Type 2	Khaki, olive drab or silver	Type 2, rudder stripes	Short 320, F.2A Flying Boat Fairey IIIB
1919-39	Aluminium	Type I	Aluminium	Type 2	Aluminium, ships' colours	Type I, rudder or fin stripes	Flycatcher Swordfish, Skua, Walrus
1939-40	Dark green and dark earth	Type 3	Light sea grey	Type I	Dark green and dark earth	Type 4, fin flash	Swordfish Albacore
1940-47	Dark slate grey and dark sea grey	Type 3	Sea grey medium (Fighters) Sky (T.S.R. and Bombers)	Type 6	Dark slate grey and dark sea grey. Sky or grey letters	Type 7, fin flash or Type 4	Fulmar, Seafire, Martlet, Avenger
1947-56	Extra dark sea grey or U.S. midnite blue	Type 8	Sky or U.S. midnite blue. Black numbers	Type 8	Top—extra dark sea grey, lower and rudder sky, black numbers	Type 8	Seafire, Skyraider, Sea Hawk, Gannet
1957-60	Extra dark sea grey	Type 8	White, black serials	Type 8	Extra dark sea grey	Type 8	Sea Vixen, Scimitar NA.39

Under EXAMPLES, letter pairs refer to Sqdrn. Code Insignia. Numbers to Sqdrn. No.

GENERAL GUIDE TO
A.E.F., A.S.C., A.A.F., NAVY CAMOUFLAGE AND INSIGNIA (UNITED STATES OF AMERICA)

Command	Upper Surfaces Colour	Upper Surfaces Insignia	Undersides Colour	Undersides Insignia	Fuselage and Fin Colour	Fuselage and Fin Insignia	Examples
A.S.C., Mexico 1915-17	Natural linen	Type 1	Natural linen	Type 1	Natural Linen, black numbers	Type 1 on rudder	Martin TT
A.E.F., France 1918-18	Olive green and fawn	Type 2	Natural Linen	Type 2	Olive green	None, rudder stripes	SPAD, Nieuport 28
A.A.F,, U.S.A. 1918-20	Olive green	Type 3	Aluminium	Type 3	Olive green	None, rudder stripes	Curtiss P.1.
Bombers 1920-34	Olive green fuselage, yellow wing and tail	Type 3	Olive green fuselage, yellow wing and tail, black letters	Type 3	Olive green fuselage, yellow fin	Horizontal rudder stripes	Curtiss B.2
Army Fighters and Trainers 1934-40	Blue fuselage, yellow wing and tail	Type 3	Blue fuselage, yellow wing and tail, black letters	Type 3	Blue fuselage, yellow fin	Horizontal rudder stripes	Boeing P26.
Navy Fighters and Trainers 1930-40	Aluminium, ships' colours	Type 3	Aluminium, black letters	Type 3	Aluminium, ships' colours	Vertical rudder stripes	Grumman F2F-1
*1940-42	Pale grey	Type 3	Pale grey, black letters	Type 3	Pale grey	Horizontal rudder stripes	Grumman Wildcat
1942-55	Midnite blue, white letters	Type 4 or 9	Pale grey, white or midnite blue, white letters	Type 4, 7 or 9	Midnite blue, white letters	Type 4 or 9	Hellcat, Corsair, Banshee, Panther
Army Fighters and Bombers *1940-43	Olive green	Type 3, 4, 5	Pale grey, black letters	Type 3, 4 or none	Olive green, yellow letters	Type 3 or 5	P.40, B.17E
1943-44	Olive green	Type 6 or 7	Pale grey, black letters	Type 6 or 7	Olive green, yellow letters	Type 6 or 7	B.17G, P.47
1944-46	Natural metal	Type 7	Natural metal	Type 7	Natural metal, black letters	Type 7	P.38, P.47, P.51, B.29, A.26
Night Fighters 1944-46	Gloss black	Type 7	Gloss black	Type 7	Gloss black, yellow letters	Type 7	P.61
All Fighters and Bombers 1947-56	Natural metal	Type 8	Natural metal, black letters	Type 8	Natural metal, Sqdrn. colours	Type 8	P.80, F.84, F.86
S.A.C. Bombers 1956	Natural metal	Type 8	Atomic white	Type 8	Atomic white	Type 8	B.47, B.52
Navy Fighters 1956	Gull grey, black letters	Type 8	Gull grey or white, black letters	Type 8	Gull grey, black letters	Type 8	F7U-3 Cutlass F4D-1 Skyray
Army/Air Force † Arctic Ops. 1947-56	White or natural metal, outer tips red, black letters	Type 8	White or natural metal, outer tips red, black letters	Type 8	White or natural metal, fin, rudder red	Type 8	D.H. Otter, Scorpion, Starfire
Air Force Rescue † 1947-56	Natural metal, yellow wing tips lined in black, black letters	Type 8	Natural metal, yellow wing tips, lined in black, black letters	Type 8	Natural metal, yellow band around fuselage, lined in black, yellow floats	Type 8	Grumman Albatross

†The two latter schemes may be combined on one aircraft. Extremities of communications aircraft painted fluorescent orange 1959-60.

*From 1942 onwards, National insignia carried on top of port wing and below starboard wing, both sides fuselage.

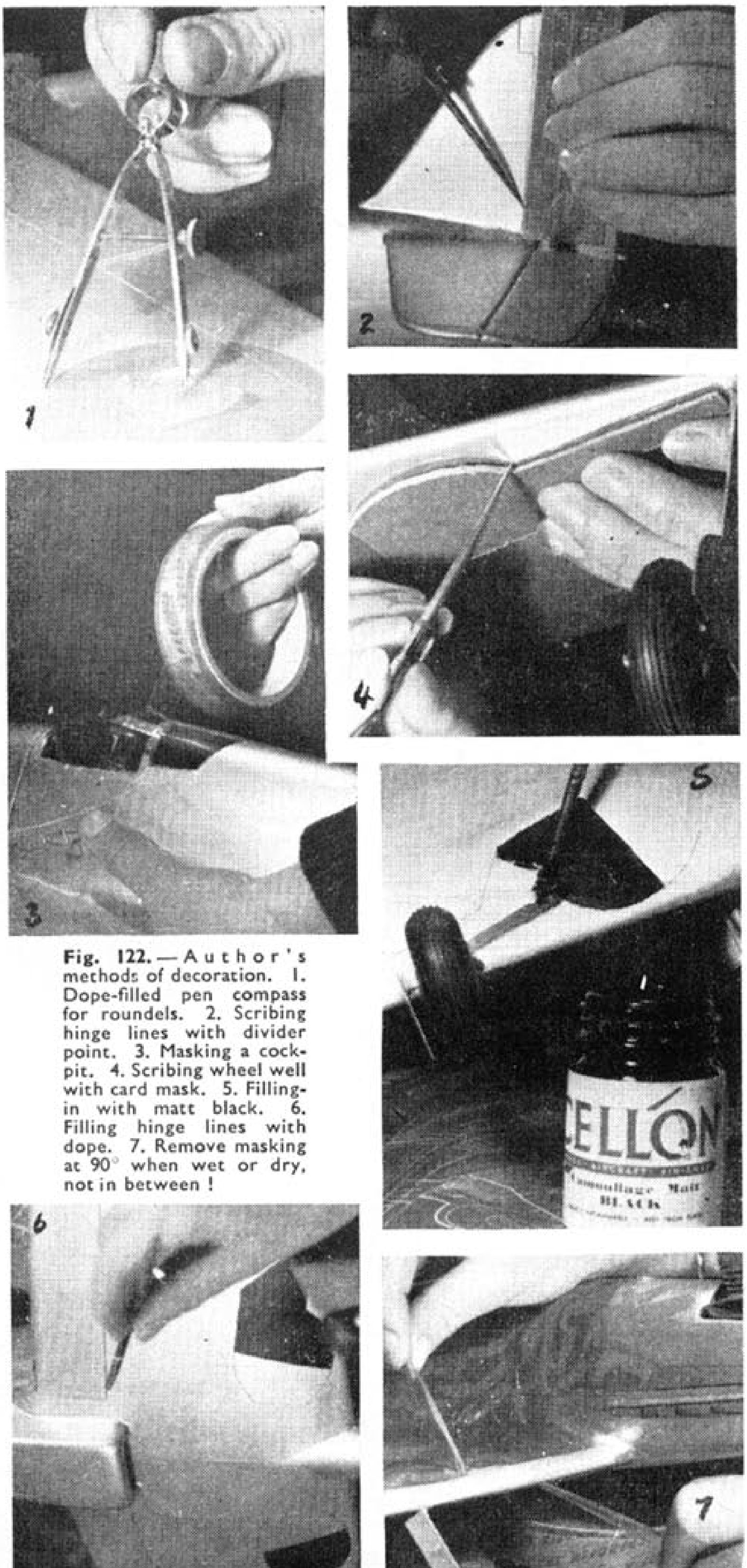


Fig. 122.—Author's methods of decoration. 1. Dope-filled pen compass for roundels. 2. Scribing hinge lines with divider point. 3. Masking a cockpit. 4. Scribing wheel well with card mask. 5. Filling-in with matt black. 6. Filling hinge lines with dope. 7. Remove masking at 90° when wet or dry, not in between !

on to, the tape edge. This makes sure of getting a clear-cut border to our decoration, and when the second or main colour coat has been applied, remove the tape by carefully pulling it away at an angle. This makes sure that the excess dope left on the tape, and still not dry, will be kept clear of the rest of the surface. Since the tape has been removed while the dope is wet, we avoid having "stepped" edges to the decoration, for the dope is now free to contract slightly. In some cases, it is difficult to remove the tape unless the dope has dried thoroughly, and here we should be specially careful not to apply too much at the edges.

To attempt to remove the tape with the dope half-dry is inviting trouble. Local patches will adhere to the tape and pull away, leaving a poorly covered section here and there—so be warned and if unable to get the tape off within 3 minutes of brushing, leave it on for 3 hours.

National markings are obtainable in waterslide transfer form: but only in a limited range of types and sizes. They are simple to apply, being dipped or floated in lukewarm water to soften the emulsion on backing paper, and then the actual colour transfer may be coaxed off and slid into position on the wing or fuselage. A dab with a soft cloth to squeeze out excess water and press the transfer in permanent position is all we need to do to complete the application. Although it is not a sound commercial proposition for the manufacturers to extend their range of waterslide transfers to suit any and every flying scale model, we need not abandon the system, for it is possible to make one's own. For this we need a gummed paper surface, such as a parcel address label. This is given a coat of dope, to which has been added a few drops of castor oil to make it more flexible, and when dry, we mark the insignia on the dope in soft pencil. After filling in with colour, the home-made transfer (decal in the U.S.A.) should be cut out and treated as a normal waterslide. The possibilities are enormous, ranging from the large national insignia, the unusual individual decorations, and squadron markings, to small stencilling and warning notices such as the triangular ejector-seat panel. We can afford to have several attempts at each intricate pattern before applying the decoration to the model, and we do not need to worry about making a mistake.

But whatever the method of painting, either " indirect " on a transfer sheet or direct on the model, we are still faced with the difficulty of painting the perfect circle, or five-pointed star, or even a simple item like a capital letter of the alphabet. Few of us are artists, and even less than few are capable of painting a straight line without Sellotape.

We can overcome the problem by using compasses and ruling pen from a set of drawing instruments. Instead of indian ink, the pen will have to flow a thinned colour dope, and the pen setting will have to be for a line about $\frac{1}{16}$ in. wide to get a fair rate of flow and leave enough pigment to form the decoration edge in one single application. Practise with the colour you are to apply, by ruling straight and curved lines on smooth paper until the right dope viscosity is obtained. Very thin dope is no use as it does not leave enough colour, and thick will give an irregular flow—we have to find the happy medium.

First the outline of lettering or insignia should be scribed in soft pencil

Fig. 123.—Stages in making a transfer for decoration.

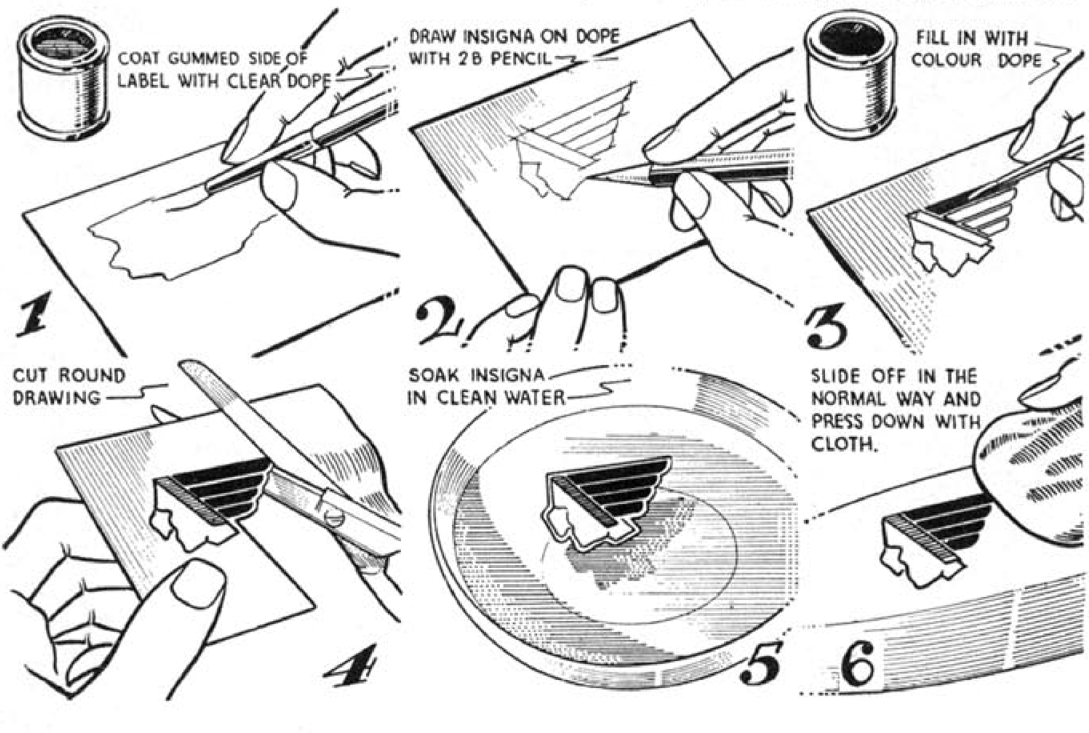


Fig. 124.—Lightplane insignia. 1. Herts & Essex Club badge. 2. Manufacturers' stencil. 3. Racing pilot's badge.

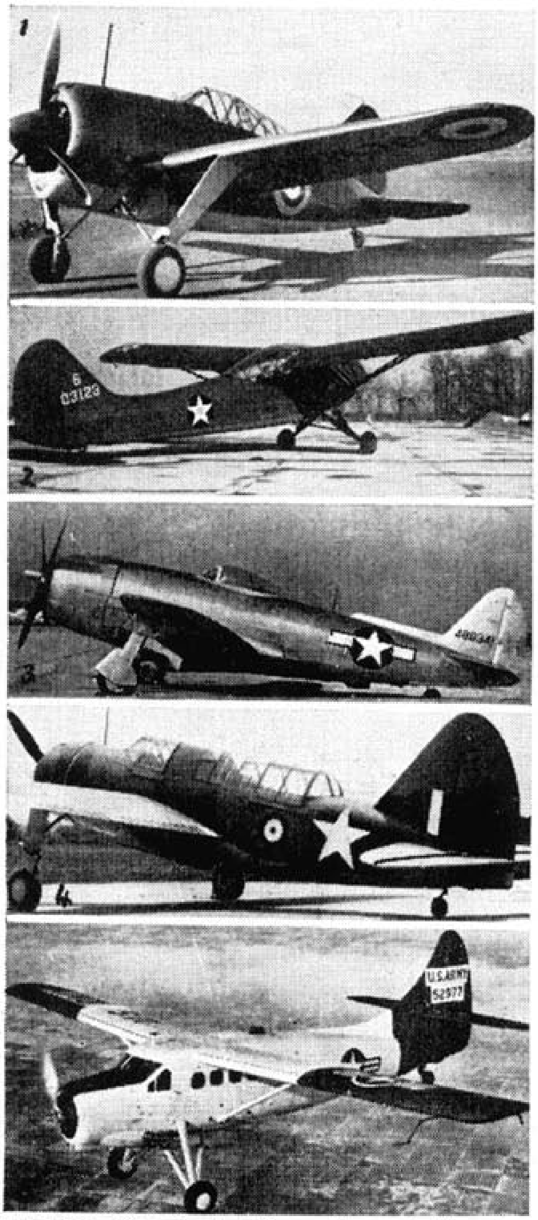


Fig. 125.—Diversion in U.S. markings. 1. Brewster Buffalo with U.S. Civil and British markings. 2. Vultee Vigilant with pre-war insignia. 3. Thunderbolt and latest type. 4. Bermuda in two Air Forces! 5. Red and White Arctic markings on Otter.

on the model or gummed label. Be sure that you have the right proportions by making frequent checks against a photo of the full-size. Nothing spoils a model more than undersize or distorted lettering and insignia, and it is comparatively easy to locate authentic information. One common error is to paint the squadron code letters of a wartime aircraft in wrong sequence on the "other" side of the fuselage. For example, the photo may show the port fuselage with letters DP roundel A on a Typhoon 1. The other side will keep this same order of lettering, only the two squadron code letters (DP) will be on the rudder (aft) side of the roundel. Normal error is to make the other side read, D roundel PA—which would be hopelessly inaccurate.

It is inevitable that when scribing a circle, both for the soft pencil marking and the application of dope with the pen compasses that we should make a hole in the surface. This can be alleviated by using three or four thicknesses of Sellotape as a "pricking" base for the compass point: but in any case, a mark will be made and this has to be filled in before painting the centre. Use a dab of quick-drying balsa cement if it is in a balsa surface, or a filler of less powerful shrinking property (plastic wood) if in a tissue-covered area.

Proportions of roundels and starred international markings are detailed in the sketches, as are principal details of camouflage colours in the tables: but the author could never claim to cover this intriguing side of scale modelling in a single chapter, for it is sufficiently involved to have filled several books on the subject already, and will doubtless provide material for more in the future.

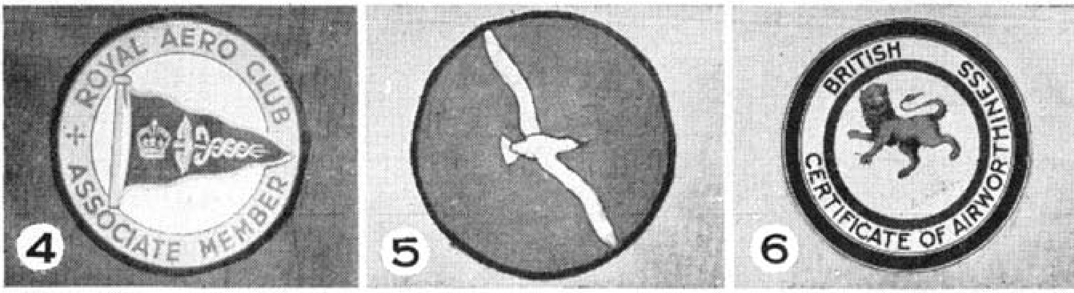


Fig. 126.—4. Royal Aero Club badge. 5. Black, yellow and white Percival "Gull" badge. 6. Insignia seen on few aircraft.

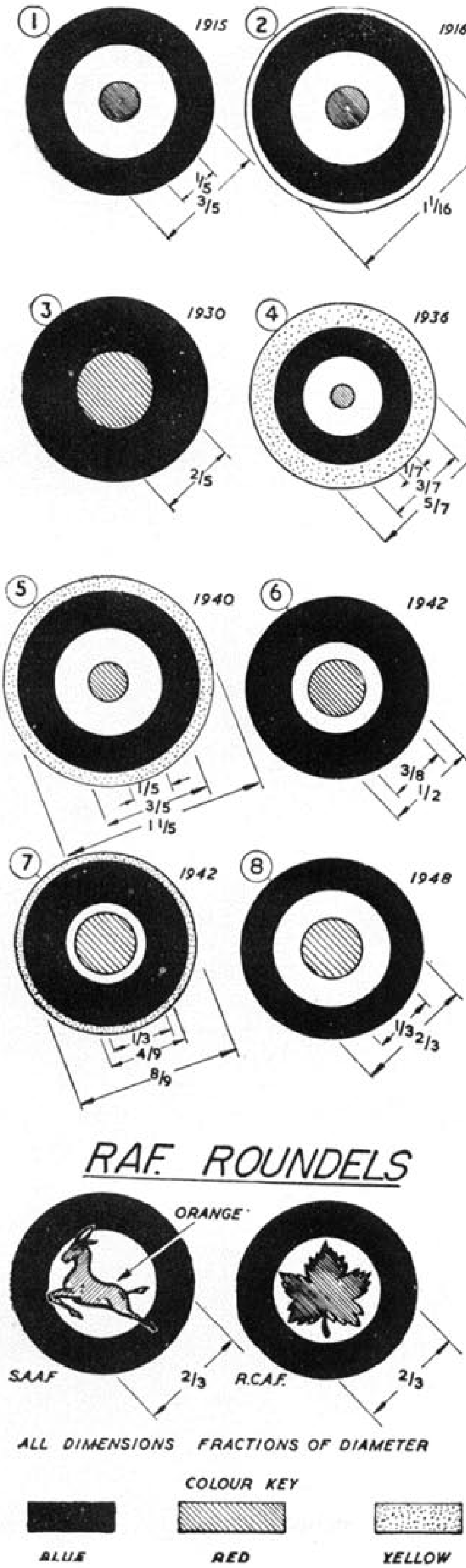
Fig. 127.—Typical "Special" insignia are the Hawker badge and BEA crest, seen here on prototypes.

In every case *except* where we have to dope white over red or yellow over blue, leave the lettering until last. For white letters on a red ground, or yellow on blue, there is a 90% possibility that white will turn pink, or yellow to green, so we have to apply the light-toned lettering first. This is effected by covering the area with the lighter dope, and masking the colour with Sellotape letters cut accurately to shape on the actual surface. When the other colour has dried, we can remove the tape to reveal a perfect colour contrast without the intermixed tint that would otherwise result.

Military Insignia

A military aircraft can be "dated" by its national markings and colouring. Therefore it is essential to get both these items correctly aligned on our model to ensure authenticity and, since the bulk of military aircraft selected for models will be either British or American in origin, the tones are tabulated as a general guide. To cover the complete story, with individual variations, would fill a book. Perhaps one little illustration of how complicated things can get is that at least one Brewster Bermuda (a nice scale stunt subject for control-line) had the honour to carry the 1940 R.A.F. roundel alongside the 1942 United States white star on the fuselage and presumably belonged to both air forces for a short time !

Fig. 128.—1. "Half and Half" Hurricane of 1940. 2. 71 "Eagle" Sqdn. Spitfire with RAF roundel overpainted. 3. Unique individual letter? On night-fighting Hurricane. Note squadron lettering on latter pair.



Naval aircraft have always carried distinguishing marks, usually in the form of large lettering to advertise their service, or, in the French case, with a discreet anchor superimposed over the roundels. U.S. Marines are likewise proud of distinguishing marks, and other special services, Rescue, Coast Guard or Arctic, are clearly defined in their colouring.

As well as such standard insignia, the myriad items of small stencilled instruction that litter the fuselage exterior can all be reproduced to render the model more realistic. Fire extinguishing gear, ejector seat and turbine or propeller position lines (U.S. aircraft only) are in red. Dotted " cut here for rescue " lines are bright yellow. First-aid panels white with the traditional red cross superimposed . . . and so on. To indicate this lettering on a small model, use a mapping pen and indian ink (waterproof drawing ink). A coat of clear varnish over the top will protect it after completion.

Badges of rank and squadron markings can give a model more specific purpose, and the colourful patterns used between wars by the R.A.F., now revived for their supersonic steeds, are interesting and decorative. Ranging from simple checkerboard designs to elaborate tartans, these patterns used to spread along biplane wings as well as on the fuselage. Flights within the squadron carried different colour wheel hubs, red, blue or yellow whether " A ", " B ", or " C " Flt., and coloured tassels of linen streamer were trailed from outer interplane struts in the heyday of the Gloster Gamecock and Bristol Bulldog.

One more military marking deserves mention, for it applies to so many wartime aircraft, and that is the five-stripe " invasion " decoration which derived from identity marks on Typhoons used at Dieppe. Whereas the Typhoons had white noses and three 2 ft. wide white stripes, with four 12 in. black stripes, the invasion markings were of equal width. This was 2 ft. wide for gliders and support bombers, and approximately 18 in. wide for fighters. There were two black stripes and three white—extending in many cases right around the fuselage and the wings.

Fig. 129.—British and Commonwealth roundels Numbers conform with camouflage tables.

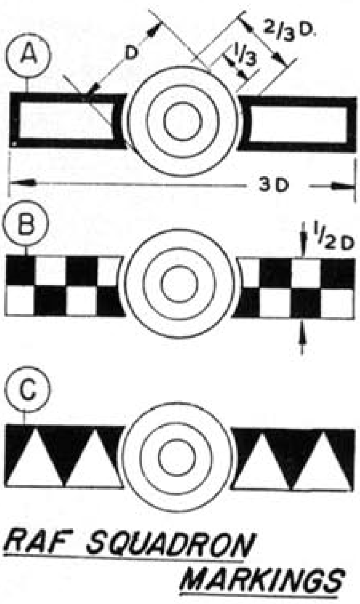


Fig. 130.—Three basic types of R.A.F. squadron markings.

TYPE A.

Squadron	Frame	Centre
1	Red	White
25	Black	White
66	Blue	White
72	Red	Blue
247	Black	Red
504	Red	Green
605	Red	Blue

TYPE B.

Squadron	Checkers (Dice)
19	Blue and White
43	Black and White
54	Blue and Yellow
56	Red and White
85	Black and Red
245	Dark Blue and Yellow

TYPE C.

Squadron	Triangles
501	Black and Gold
600	Red and White
601	Black and Red
604	Red and Yellow
607	Red and Brown
614	Red and Green

1914-1918 Aircraft

Allied aircraft were unusual if not coloured olive drab or khaki on the upper surfaces and had natural linen undersides of a buff tone. French planes, including the SPAD 13 as used by the American Expeditionary Force, had an attempt at shadow shading with green hues intermingled with the khaki, and, of course, the large night bombers, H.P. O/400, etc. were a sombre black.

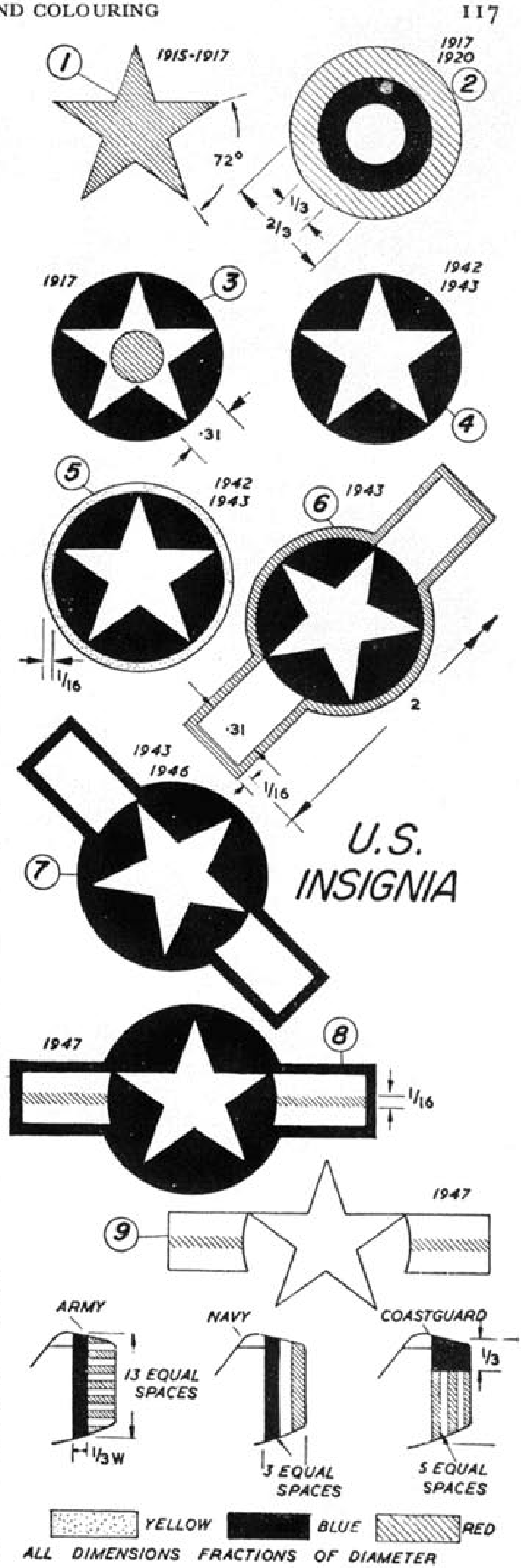


Fig. 131.—American markings.

Fig. 132.—Hardly distinguishable type 3 roundel and red letters on NF Defiant. Float Spitfire carries yellow P for prototype—a nice scale subject?

On the other side of the lines, the German Air Force was a colour conscious body of men, and the fabulous "Air Circuses", as led by Richthofen and others, were as varied in decorative schemes as there are colours in a rainbow. Albatros, D3s and D5s and Fokker DR1 triplanes in the Richthofen Staffel were scarlet with contrasting tail units and ailerons to distinguish individual pilots. The famous Red Baron's tri-plane was scarlet all over, except for the white backgrounds to the pattée (erroneously called "Maltese") cross in black on fuselage, rudder and wings. This national insignia was changed in early 1918 to the plain Latin cross which remains the mark of Germany up to the present day.

Camouflage of German aircraft up to 1918 was—if used—a mottle of pale green and fawn on upper surfaces and pale blue undersides. During 1918, the lozenge pattern camouflage in mauve, fawn and green six-sided figures was to be seen on types like the AEG, Fokker DVII and DVIII, and Hannoverana, with pink replacing mauve on the same pattern of the undersurfaces. To decorate a model in this scheme, one should be prepared to use lots of Sellotape!

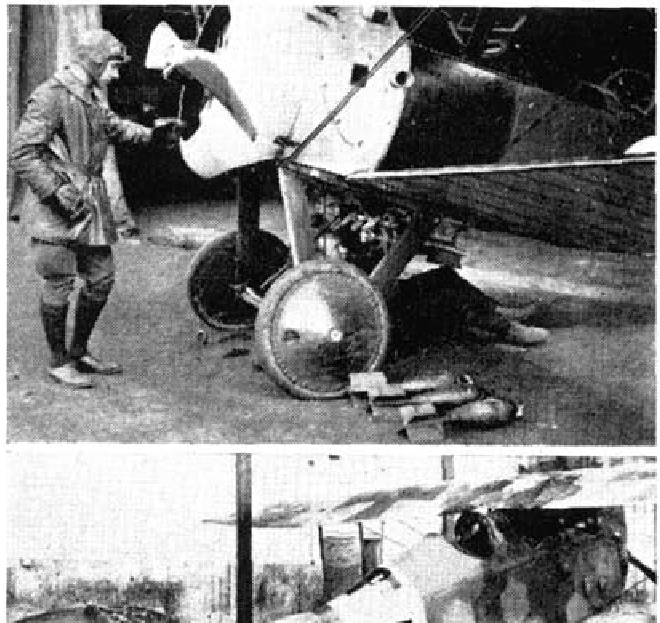
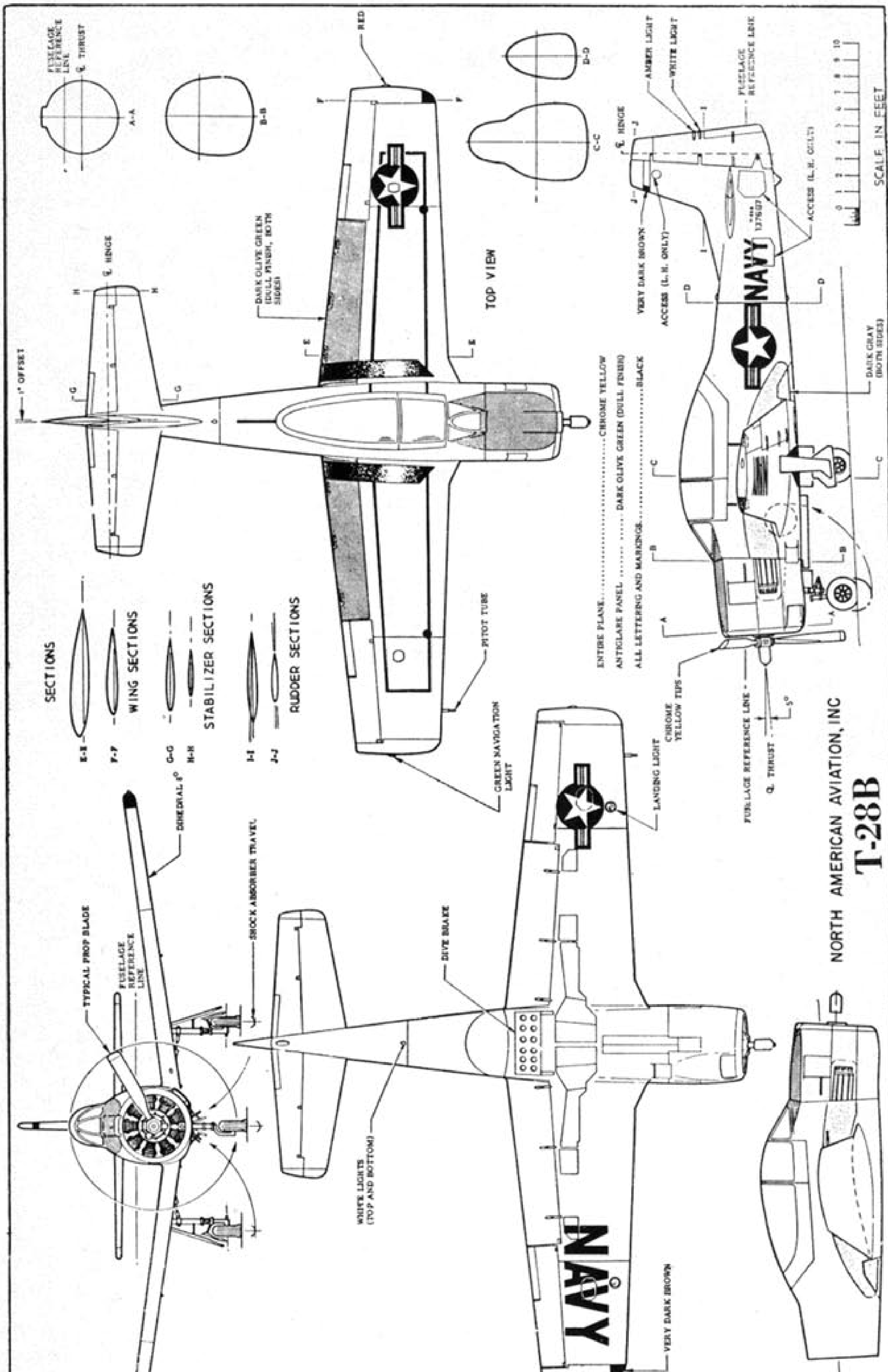
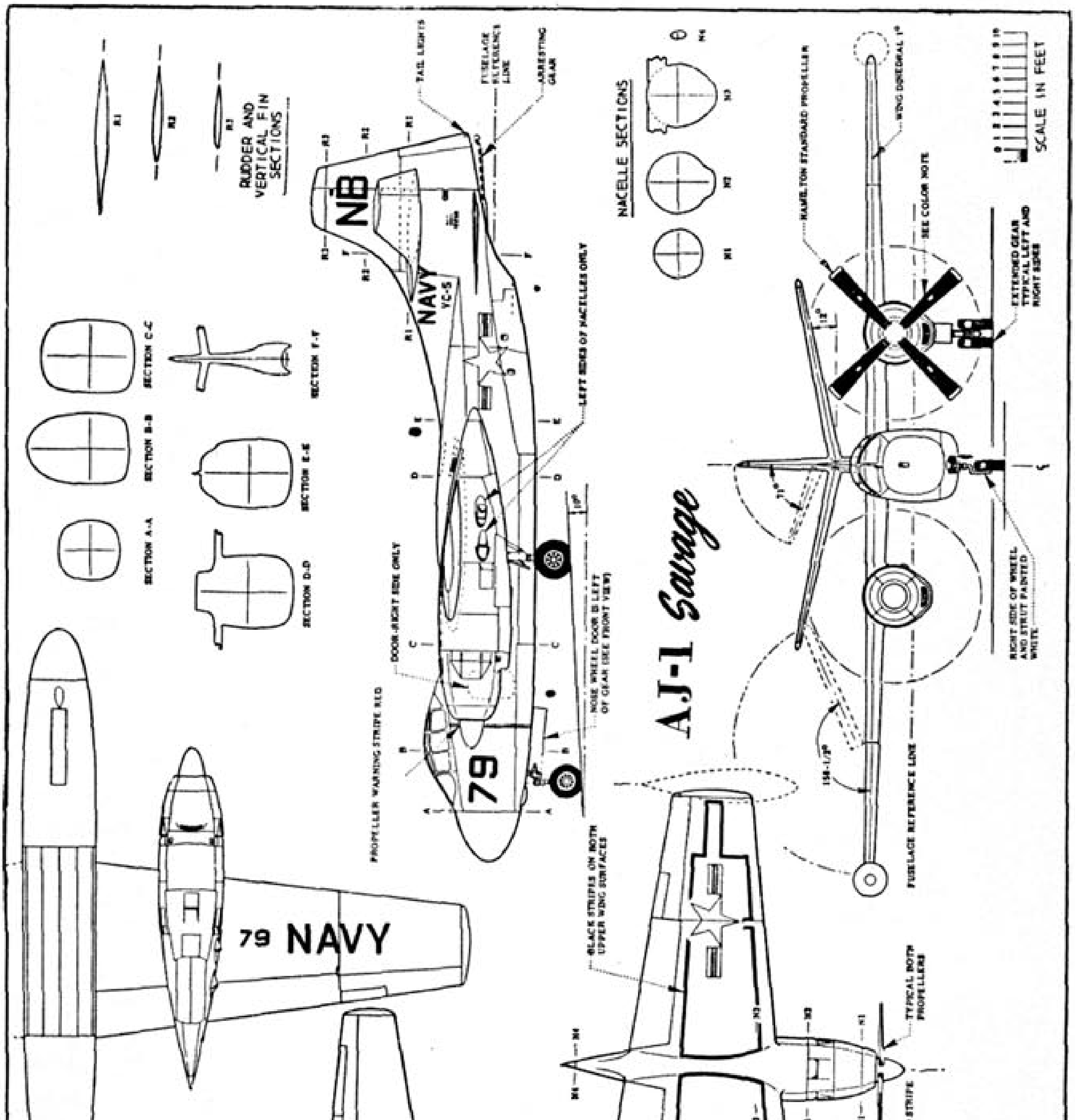


Fig. 133.—Imperial War Museum photo shows Camel pilot of World War I and illustrates clear doped buff undersides of wing, olive drab fuselage, aluminium cowl. Below is Austrian AVG with lozenge camouflage of 1918, and pattée crosses.

Plans on the following pages for the T-28B (to 1/144th scale) and the AJ-1 Savage (to 1/240th scale) serve to illustrate typical insignia positions, colouring and other markings found on U.S. Navy aircraft used for training and operational flying. Each is a fine subject for control-line and the drawings are typical examples of the high standard of work produced for issue through the U.S. Navy Information Dept. by the North American Aviation Co Inc.

Fig. 134.—A method of obtaining five pointed star.


NORTH AMERICAN AVIATION, INC
T-28B
TOP VIEW
SECTIONS
WING SECTIONS
STABILIZER SECTIONS
RUDDER SECTIONS
SCALE IN FEET
ENTIRE PLANE .... CHROME YELLOW
ANTIGLARE PANEL .... DARK OLIVE GREEN (DULL FINISH)
ALL LETTERING AND MARKINGS .... BLACK
DARK OLIVE GREEN (DULL FINISH, BOTH SIDES)
RED
PITOT TUBE
GREEN NAVIGATION LIGHT
LANDING LIGHT
CHROME YELLOW TIPS
DIVE BRAKE
WHITE LIGHTS (TOP AND BOTTOM)
VERY DARK BROWN
TYPICAL PROP BLADE
FUSELAGE REFERENCE LINE
SHOCK ABSORBER TRAVEL
DARK GRAY (BOTH SIDES)
ACCESS (L.H. ONLY)
AMBER LIGHT
WHITE LIGHT
NAVY


AJ-1 Savage
RUDDER AND VERTICAL FIN SECTIONS
NACELLE SECTIONS
SECTION A-A
SECTION B-B
SECTION C-C
SECTION D-D
SECTION E-E
SECTION F-F
NB
NAVY
VC-5
79
79 NAVY
SCALE IN FEET
WING SECTIONS
WING SPAN 75 FEET WITH TANKS 71.4 FEET WITHOUT TANKS
LENGTH 63.1 FEET
HEIGHT 20.4 FEET
WING AREA 835.45 SQUARE FEET
ENGINES 2 PRATT & WHITNEY R2800-44 1 ALLISON J33-A-10
COLOR NOTE:
ENTIRE AIRPLANE GLOSSY SEA BLUE
ALL LETTERING AND MARKINGS (UNLESS OTHERWISE INDICATED) WHITE

Chapter Fifteen **Flying the Model**

THE great moment has arrived, our model is ready for its first airing, and with considerable trepidation we assemble it at the flying field. Many scale models never reach this happy stage although they are supposed to be built to fly, and the reason for this is nothing less than a complete lack of confidence on the part of the builder.

Let us state here and now that if the model has sufficient power, is built carefully, and assembled correctly, it is bound to fly. The author has seen far too many unlikely subjects safely airborne to be influenced by anyone defending a permanently grounded scale model on the basis of being " difficult " to trim. Whether it be a delta Boulton Paul 111, canard pusher Miles M.35, tandem wing Flying Flea or triplane Fokker D.R.1, one need have little fear of writing the model off first flight, providing due care and attention is paid to the testing procedure.

For all free-flight models, the initial tests are common to all types, irrespective of propulsion. **Control-line** is the exception and, as such, will be dealt with first.

First check the balance. When the model is supported on finger-tips so that it balances horizontally, the actual point of balance should be no more than 25% average wing chord from the leading edge. In relation to the bellcrank, the balance ought to be near the front line attachment for sport flying models, further aft for aerobatic designs ; but never behind the actual bellcrank pivot. Lateral balance should indicate that the outer wing (right side) is heavier, to offset the weight and drag of the control-lines.

Check the motor(s) through a full tank run on the ground, holding the model up on edge in the latter stage so that the last drop of fuel is drawn from the tank. During this, we can check for vibration, find the best engine control settings and note the smoothness of the elevator movement with engine vibration. Should the vibration be excessive, alter the prop position on the shaft and check again. Very often an engine calls for an unbalanced prop to cancel the lack of balance in the crankshaft, and the heavy blade should be set at 6 o'clock when the piston is at top dead centre. Vibration is the enemy of a control-liner, it causes lines to tangle, and control in such circumstances is " sticky " to say the least.

Once satisfied with the power, we are ready for the flight. Connect the lines from the handle to the model, with a radius of 25 ft. for low power (up to 1 c.c.), 40 ft. for medium power (2.5 or 3.5 c.c.) and 50 ft. or more for larger models. Take the handle in the hand naturally, point it at the model, calling for the assistant to see that the elevators are neutral. Lift the handle, keeping the whole arm stiff, and check for " up " elevator. Lower the handle for " down ", and finally pull hard on the lines to satisfy yourself that they will not break under flying strain.

When the engine is running, and the model held back by an assistant, go to the handle, at the same time running each wire through left and right hands to see that they are separated and not kinked. Take up the handle, pointing a rigid arm at the model and call to the assistant to release.

The first take-off is always rather a fearsome business : but in reality there is little to go wrong providing the " pilot " back-pedals to take up line tension if need be, and remembers *not* to use wrist movement. This produces too harsh a control motion, and is only suitable for violent aerobatics. By pointing where one wishes to fly the model, keeping the arm rigid, we get a smooth transition from take-off to climb, then level flight and landing.

If, after take-off, the model appears to be climbing too steeply, the tendency is to over-correct with " down " and the

CONTROL-LINE TROUBLE SHOOTING CHART

Symptom	Cure
(*a*) Model "light" on lines, which do not keep taut.	(*a*) Lines too heavy, or, not enough rudder offset, or, lines too long for power of engine—check lines, increase rudder angle or offset motor 3° right.
(*b*) Model banks inwards, showing outer wing panel, especially when into or crosswind.	(*b*) Droop inner aileron, or raise outer aileron (more effective), or add ballast weight to outer tip.
(*c*) Model over-sensitive, difficult to fly straight and level, although lines are taut.	(*c*) Balance point too far aft, add noseweight, or, elevator motion is too fast. Ideal is 15° movement "up" with $1\frac{1}{2}$" pull on line. Move pushrod lower on elevator horn.
(*d*) Model flies "skewed", pilot sees both wheels. Model not at right angles to lines.	(*d*) Balance point too far forward, or, too much rudder offset or, too much engine offset. Check balance point. If forward of front line, add tail ballast.
(*e*) Model tends to climb all the time. Needs downward pressure on handle to fly level.	(*e*) "Up" line shorter than "down", or, wings have incidence, or, tailplane is set at negative angle, arrange for slight elevator deflection down with handle neutral.
(*f*) Model runs around on wheels, tail high, will not take off.	(*f*) You have picked the handle up the wrong way! Paint the "up" line connection on handle to identify it.
(*g*) Engine persists in stopping as soon as speed is built up.	(*g*) Use a stunt (wedge section) tank. Engine must be set rich to allow for centrifugal effect "leaning out" the flow to carburettor.
(*h*) Model slow to react to handle movement—jerky in response.	(*h*) Controls are too stiff—check elevator hinges for free action, see lead out wires are not bent at tip guides. Oil bellcrank pivot, give push rod a clear run through fuselage formers. Elevator should drop when lines are not connected.

flight develops into a series of zooms, none of which are intentional but which arise as the outcome of over-correction. To get in such a state, one must have forgotten the "rigid-arm rule" and employed wrist movement, so the simple answer to stabilising the flight of our zooming model is to be firm and hold the arm out stolidly, pointing 15° or so above the horizon. The model will soon settle down to level flight, and after those first hectic laps, one soon gets used to the idea, until at last the motor cuts and our scale model glides down for a three-point landing with full elevator "up" for the last few feet of flare-out. If perhaps the flight is not as smooth as one would desire, the symptom and cure may be located in the table.

The initial test flights of any other type of scale model must follow the set pattern of hand-launched glides before venturing into flight under power or from a towline. Choose a calm day and a field with soft pasture. Long grass, heather, clover and reeds in marshland have been the saving of many a model, so it is worth while to go out of one's way to find a really suitable flying site.

First check is made after assembly, and the fuel tank or Jetex should be empty. See that the model balances between 25% and 40% back from the leading edge at the average chord. On a biplane, one has to imagine a wing midway between the existing panels, and treat this as the "average" chord. Now, does it *look* right? Squint at the front and rear views for a warp check or maladjustment during assembly, and if all is square, the fin and rudder at neutral and tailplane seated firm, we are ready to baptise our creation.

All launches should be made into wind, then the model achieves flying speed quickly, and the groundspeed is fairly slow. If we launch downwind, the model has to travel at its flying speed *plus* the local windspeed, and we learn very little from the flight.

Hold the model at shoulder height with a gentle grip on the fuselage near the balance point with small models, and by the fuselage just forward of the balance point, and at the extreme tail end for larger models. Poise and wait for any wind gusts to pass, then release the model with a forward throwing

Fig. 135.—How to do it. Free-flight sketches are purely diagrammatic to illustrate desired glide path.

motion, keeping the wings level, nose slightly down, and aimed at a point about 8 paces in front. For the larger model, the hand at the rear end provides that extra " push " at the moment of launch.

From the glide path of this first launch, we can determine whether or not it will be safe to try a powered flight—providing we are satisfied that the actual launch was a good one. If it did not achieve flying speed, then the result is of no value and the launch should be improved on successive attempts. In any case, one should repeat the hand launch procedure indefinitely until thoroughly happy with the glide and general stability.

Ideal is, of course, a straight glide down to a smooth landing or tumble in the soft pasture. We may not get this first time, and the reaction might well be a **stall**, in which the model lifts its nose, endeavours to climb, and falls into a dive, perhaps on to one wingtip. This means that the model is either tail-heavy, or that the tailplane is set at too great a negative angle. Try again with a piece of thin packing under the tailplane leading edge, $\frac{1}{32}$ in. for less than 30 in. span, $\frac{1}{16}$ in. for larger models. If not showing much sign of improvement, increase the packing thickness: but never take the tailplane to an angle greater than that on the wing—if we do, there is a chance that in power flight we have no hope of recovery from a dive. When the stall persists to the state of having the tail at the same angle as the wing incidence, we should start to trim with ballast. This should be added to the nose, and here the disadvantage of a short nose is indicated by the amount of ballast needed to move the C.G. as little as a $\frac{1}{4}$ in.

Another launching symptom might be a **sharp turn**, with one wing lifting high. This is a sure indication of a warp, or rudder offset. At this stage we do not want to have any turn, so the first item to check is the rudder. If the glide still develops into a spiral dive with rudder neutral, and model balanced laterally, then we must have warps somewhere in the wing structure, and these will have to be cured before venturing into powered flight. Look for a trailing edge deflected upwards on the wing which touches down first. This is the more common fault, known as " wash-out " of incidence. The opposite wing might be the one at fault with " wash-in ", or trailing edge drooped, and in either case we have to put matters right by slackening the covering with water and pinning the surface onto a board with blocks arranged to twist the wing past " square ". When unpinned, it will return to the " square " setting: but should be watched in future, for warps have a habit of returning as soon as the model is exposed to the heat of the sun.

Third possible glide symptom is the **dive.** We have no need to explain this one! First cure is to increase the negative angle on the tailplane by packing at least $\frac{1}{16}$ in. under the trailing edge, increasing the amount until the glide becomes flat. Should the dive persist, then the model is nose heavy and calls for a *little* ballast in the tail end unless there is some disposable item in the nose. A Jetex model has the advantage in that the unit can be shifted within reasonable limits to obtain ideal balance: but in reality, these glide test faults are so rare, and design so flexible, that the item most likely to offer difficulty is the warp—a constructional fault.

Now we pass to the climax—flight with power, or from a towline. The scale **glider** should have its towhook on the bottom of the fuselage, about 1-2 in. forward of the balance point according to size of the model. We test it with a towline 100 ft. long, using strong fishing line or nylon, and connecting the end of the line to the model with a small curtain ring. Just like the full-size, our glider is towed into the air like a kite, and when as high as possible on the line the tower relaxes the pull on the line, so releasing the ring from the model, which is now free to descend at its leisure.

Watch for flight symptoms. A spiral dive, a stall or a straight dive have each been covered in our hand-launch faults: but they may still persist when the model has some 80 ft. or so of altitude to play with. It will also be seen that, although the hand glide was straight, the model has a natural turn as it descends, and we can tighten this to a smaller radius by applying rudder. We may have to connect the towhook and rudder so that the towline tension pulls the rudder to neutral up to the moment of release: but since this is only for topline contest performance, our scale model can easily be managed up to 60% of towline height even with permanent rudder offset.

The **Jetex** model must fly with full power right from its very first flight. The main check is to see that the unit is dead straight fore and aft, and that it is properly loaded. Wait for the jet to

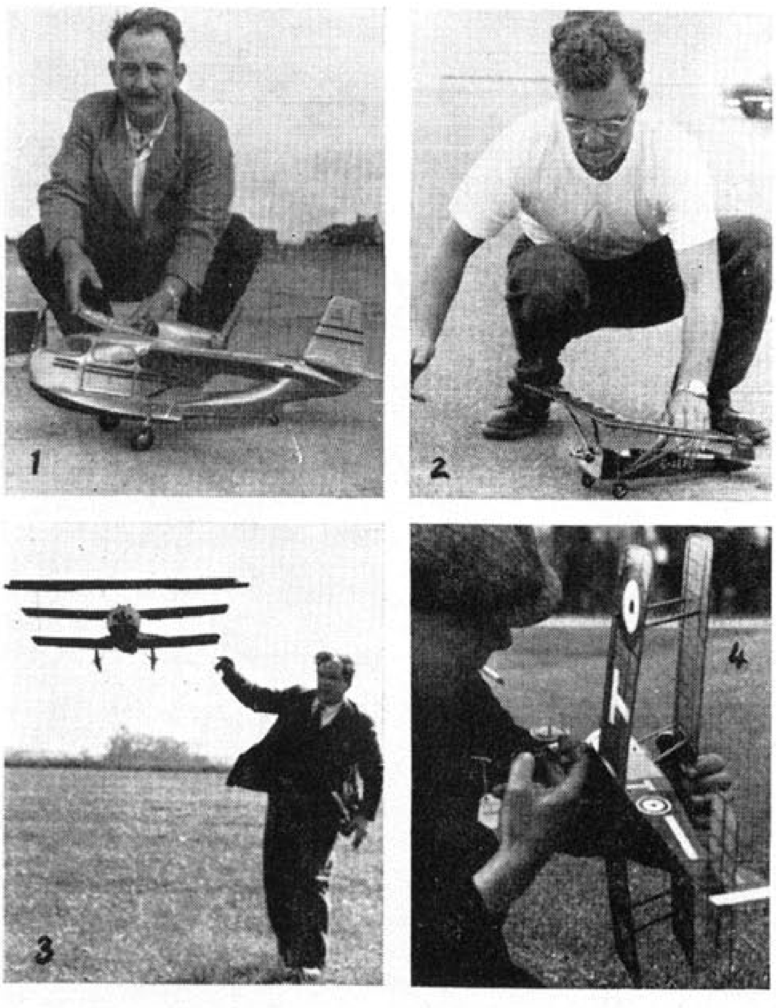


Fig. 136.—Flying scale-models on the field. 1. A perfect Republic Sea Bee, complete with retracting undercarriage. 2. Tiny Luton Minor has an engine of only .13 c.c. 3. P. E. Norman launches his famous Fokker DR.I Triplane 4. Small Camel has 32 c.c diesel.

build up pressure with a steady hiss before launching, and send the model off at a slight upwards angle. A spiral climb is the desired result, and this is the normal reaction. Should it develop into a straight loop, slight rudder turn may cure the model from going over the top, or downthrust (jet nozzle raised) applied in extreme cases. In the author's experience, the only Jetex-powered scale models that do not fly are the grossly underpowered ones which exceed the weights given at the end oi chapter 11 by a 50% margin.

The **rubber-driven** model is the easiest of all types to test. We can wind as many turns as we wish on the motor, and progressively work up to the full number possible to get the longest flight duration. There are one or two rules to follow, and No. 1 is that the model should turn to the right to counteract torque from the propeller. With this direction of turn, the gyro-force of the prop is downwards, also useful in damping out the tendency to stall under the initial burst of full power after release. The right turn is safer in most cases, and a little sliver of packing under the left side of the noseblock is all that is needed to obtain the power turn. For the glide, we can have slight left rudder, and this forms the dual purpose of preventing the model from spinning in under the power turn, and then, as power decreases, there is a smooth transition from right to left turn as the rudder effect takes over from the noseblock offset. Should a stall develop on the glide, check to see if the rubber motor has bunched at the tail end, or if the free-wheel mechanism has worked properly. Conversely, a dive might be due to rubber bunching in the nose: but this is a rare possibility.

The **power** model is advised to turn left, with torque. This keeps the nose up during the turn (the gyro-force again) and also conforms with full-size practice of making a left-hand circuit of the aerodrome after take-off or before a landing!

Fit a plastic propeller for the first flight, and set the engine to run for about 15 seconds at low speed. If the engine is one of those which refuse to run slow, and gives dangerous fast bursts as the fuel runs out, fit the prop on back to front, and render it 50% efficient. Launch straight into wind, the

FREE FLIGHT TROUBLE SHOOTING CHART

Symptom	Cure
(*a*) Slow flight under power, dragging tail.	(*a*) Increase power, or tighten turning radius.
(*b*) Repeated stalls under power.	(*b*) Reduce rubber power, or engine r.p.m. Add down-thrust.
(c) Flies fast and flat—no climb.	(c) Remove downthrust, increase wing incidence if possible.
(*d*) Model side-slips, losing height in a turn.	(*d*) Insufficient dihedral, increase if possible, or use pendulum rudder. Make power model turn left, rubber, right.
(e) Loops	(e) Induce a turn with sidethrust or cure with downthrust, reduce power.
(*f*) Power turn too tight.	(*f*) Cure with sidethrust, do not alter rudder setting for glide.
(*g*) Stall as power ceases.	(*g*) Check rubber for bunching. Trim power model glide turn to "follow through" in same direction.
(*h*) Stall on glide.	(*h*) Lift tailplane leading edge or add nose ballast weight.
(*i*) Dive on glide.	(*i*) Check for rubber bunch in nose, tailplane shift or other alteration to assembly. Add packing under tailplane trailing edge.
(*j*) Spiral dive on power.	(j) If turning right—change to left turn. Check for warps, cure with a tab or drop aileron on inside of spiral turn.
(*k*) Spiral dive in glide.	(*k*) Too much rudder turn—reduce rudder angle. Free-wheeling prop sticking—check mechanism.

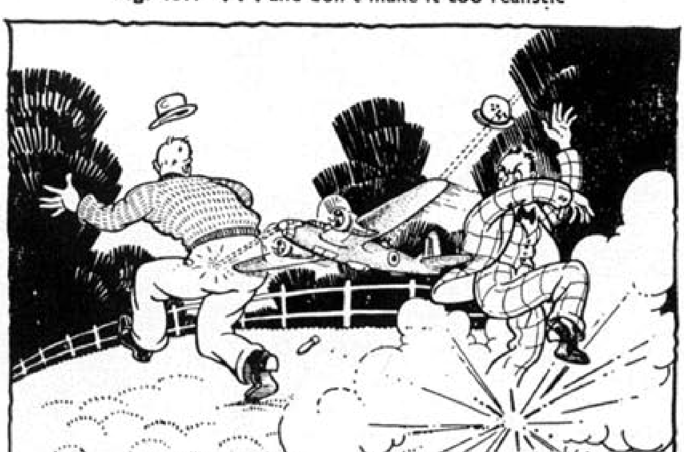
engine making about 5,000 revs per minute. Do not be discouraged if the model sinks tail down and does not fly far. We have at least prolonged the hand-launch, and all we need is more power. Try again with an increase in revs, and watch the radius of turn. Should the flight be a nice safe one—and there is no reason to suppose it will be otherwise, we should gradually work up to full power, and then study the transition from power to glide. Always have the turn of the glide in the same direction as for power. This gives a smoother takeover, and helps alleviate a stall, for unlike rubber drive, where the power is gradually decreasing from the moment of launch, the engine will be delivering constant thrust which is suddenly shut off with the model in a climbing attitude. Having the glide turn in the same direction as power, enables the nose to " follow through " in the same smooth turn.

As we increase power, there may be a need for downthrust on the engine to obviate any tendency to loop : but when we reach this stage we are really in the aerobatic class, and our model should be blessed with the attachment of a pendulum-controlled elevator. For-true-to scale flying, use only the amount of power needed for safe and realistic flight and never tempt fate by launching with a full tank and no timing device to stop the engine.

For the trimming of all free-flight models, the table overleaf will give a general guide to faults and their correction.

And when you dismantle the model after the first test flights have been successfully completed, you will return home a much-satisfied—if not a content—person. For the scale bug will have bitten, and once ensnared with enthusiasm for this kind of model, which can offer so much, the first flying scale effort only serves to trigger off a succession of projected designs for the future. One can be satisfied with a job well done ; but never content with a hobby that offers such an ever-changing variety of subjects to conquer.

Fig. 137.—. . . and don't make it too realistic



FLYING SCALE MODELS
in the Aero Modeller Plans Service

CL = Control line, FSP = Free Flight Scale power, FSR = Free Flight Scale Rubber, FSG = Flying Scale Glider, J = Jetex, MA = Model Aircraft Magazine Plan

Aero Commander 680 Super, CL/733, 85p.
Aichi 99 "Val", MA/349, 60p.
Airspeed Courier, FSP/1016, 45p.
Albatross D.V., FSP/646, 85p.
Ansaldo S.V.A.4, MA/359. 85p.
Arnhem, FSG/263, 45p.
Auster A.O.P.9, FSP/580, 60p.
Avro Avian Sports, FSP/468, 85p.
Avro Lancaster, CL/1081, £1.45.
Avro 504K, FSP/343, 85p.
A.W. Siskin 3a, MA/314, 85p
A.W.FK 8 (Big Ack), FSP/960, 60p.

B.A.C. Super Drone, MA/193, 60p.
B.A. Swallow, FSP/560, 60p.
Barracuda, FSP/RC 1095, 85p.
B.E.2e, FSP/721, 85p.
B.E.12b, FSP/1183, £1.15.
Beagle-Miles 218, CL/874, £1.45.
Beagle Bassett, CL/1140, 85p.
Bellanca Skyrocket, MA/396, 60p.
Bell Airacobra, CL/1203, £1.15.
Bell P.39 Airacobra, MA/251, 60p.
Blackburn B.2, FSP/1028, 70p.
Blackburn 1912 Monoplane, FSP/567, 85p.
Blackburn Firebrand, CL/1189, 85p.
Bleriot Monoplane, FSR/275, £1.15.
Boeing FB4-4, MA/290, 60p.
Boeing B.47, G/1180, 35p.
Brandenburg Sea Monoplane, MA/343, 60p.
Breguet 901, FSG/680, 60p.
Brewster F2A-1 Buffalo, MA/367, 60p.
Bristol Beaufighter X, MA/275, 85p.
Bristol Bulldog, FSP/762, 85p.
Bristol Bullet, FSR/226, 60p.
Bristol F2B, FSR/111, 50p.
Bristol F2B, FSP/1021, 35p.
Bristol Monoplane Scout, FSP/759, 85p.
Bucker Jungmann, FSP/1217, £1.15.
Bucker Jungmeister, FSP/807, 60p.
Bucker Jungmeister, CL/1020, 60p.

Carden-Baynes, FSP/853, 85p.
Cessna 172, FSP/668, 85p.
Cessna 172E, FSP/RC 902, 85p.
Cessna 310, CL/638, 60p.
Cessna Bird Dog, FSP/568, 60p.
Chilton D.W.1., FSP/340, 60p.
Chilton D.W.1A, RTP/1104, 35p.
Chrislea Super Ace, FSP/331, 85p.
Colonial Skimmer, MA/250, 60p.
Consolidated Catalina, CL/606, 85p.
Curtiss Owl, MA/159, 60p.
Curtiss Hawk P-6E, CL/539, 90p.
Curtiss-Wright Junior, FSP/1043, 60p.

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