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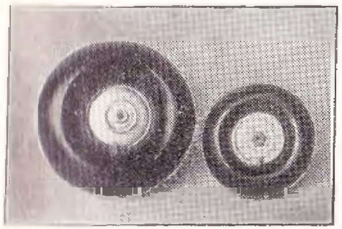

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PETROL ENGINED MODEL AEROPLANES

PETROL ENGINED MODEL AEROPLANES

By

C. E. BOWDEN

A PRACTICAL MANUAL AND GUIDE TO THE BUILDING AND FLYING OF PETROL MODEL AEROPLANES.

With 93 Illustrations

Foreword by F. J. Camm

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FOREWORD

By F. J. Camm

It gives me especial pleasure to write this foreword, for my friend Capt. Bowden has done more than any other man in the world to popularize and develop interest in petrol-driven model aircraft. His work is known throughout the world, and he will go down to posterity as the man who demonstrated the practicability of model aircraft powered by tiny internal combustion engines. Unlike Stringfellow, Langley, and others, he lives to see his work appreciated. The original record for petrol-driven models was held by D. Stanger, and it stood at 51 seconds for almost a quarter of a century before Capt. Bowden eventually broke it. Resulting from his painstaking enthusiasm, to-day you cannot visit a model aircraft meeting of any pretensions at which there are not at least three or four petrol-driven models flying successfully. The limit in duration is decided only by the amount of fuel carried, so reliable are the midget engines now available. A large measure of credit for the encouragement of their production is due to Capt. Bowden.

It is true to say that model aircraft of the future will be almost entirely propelled by midget engines, for it has been shown that it is practicable to make a midget petrol engine of only 1 c.c. (about $\frac{7}{16}$-in. bore by $\frac{1}{2}$-in. stroke), and weighing, complete with coil and batteries, only 7 ozs. A few years ago it was considered that the minimum capacity for a miniature petrol engine was 15 c.c. An American firm demonstrated that reliable engines of only 9 c.c. could be mass produced. An English firm reduced the figure to 6 c.c. Canada replied with a 2-c.c. engine. An Englishman then built a 1-c.c. engine of which, however, only the briefest details are available. This encouraged me to experiment with a 1-c.c. engine, and I have successfully demonstrated that a 1-c.c. engine can be mass produced.

Capt. Bowden has proved to the world that petrol-engined models are equally as reliable as their rubber-propelled counterparts, and he has encouraged therefore the development of even smaller power units so that lighter, smaller, and cheaper petrol-engined models can be built. He has lifted the hobby from the stage at which it was regarded merely as the pastime of youths to that of a scientific art which attracts men in all professions. It is the most fascinating outdoor pastime in the world, combining the pleasures of practical work with those of a healthy outdoor exercise, providing the fascination which results from observing the model in flight. Thus, model aircraft can now be used for scientific experiments, and under conditions which approximate more closely to those obtaining with full-size aircraft. There can be little doubt that model aircraft of this type will supersede the rubber-propelled type which was pioneered by Penaud in 1871.

Capt. Bowden is the pioneer of power-driven model aircraft. He has brought to the pastime a fresh and more intriguing outlook, and the fillip it needed. He has attracted to it a better type of enthusiast and encouraged an improved style of construction. You can discern his influence on design by inspecting any petrol-driven model aeroplane, some feature of which was originated by him. Hence, he has saved the

modeller the heartbreaking experiences of arriving at a satisfactory result only after many failures.

He has generously contributed the results of his experiments to the Press for the benefit of all, and he has enthusiastically attended most of the important model aircraft meetings, often travelling for hours in order to be present. There is no doubt that as a result of his work, a new industry will spring up, and a new generation of air-minded youths.

In this book you have the cream of his experience, with the reasons for using a particular form of construction, a particular wing section, or a style of chassis. A book from his pen was long overdue. Now that it has made its appearance I sincerely wish it well, although I am certain that it will be eagerly purchased by the many thousands of aero-modellers now actively following the pastime, and whose numbers are increasing day by day. Within the compass of his volume he has incorporated almost a lifetime's work, for he has built nearly twenty petrol-driven models.

It would be fitting for me to conclude this foreword with some brief details of his career, for I feel that the reader will not learn them from Capt. Bowden himself. Modesty is always the besetting sin of the skilled!

He has been actively and enthusiastically associated with model aircraft since 1912, and formed a model aircraft club at Radley College in 1913. The war intervened, however, and it was at the end of it that he recommenced, concentrating on original rubber-driven models, chiefly biplanes. It was in 1932 that he beat Stringer's pre-war petrol-model record. Since then he has built over twenty petrol models of all types, including an autogiro and flying boats. He entered a rubber-driven model for the Moffat Trophy Competition in 1934 and put up the second best flight of the British team. He is, of course, the present holder of the power-model record. Lately he has successfully turned his attention to petrol-driven model boats, utilizing a system of construction based on his experience with model aircraft.

Finally, I genuinely hope that this book will bring to its author his due reward, not only for his labours in compiling it, but also for the vast amount of work he has undertaken and with which he has augmented our heritage of knowledge.

PREFACE

During the past few years great strides have been made in the efficiency of the very small petrol engine, chiefly due to the increased popularity of model speed boats. These little engines have in recent years been adapted and re-designed on a smaller and lighter scale, which has enabled petrol-driven model aeroplanes to be produced in reasonable sizes that can be transported to the scene of their flying activities.

As a result, there has been a rapidly growing interest in the petrol-driven model aeroplane in this country, whilst in America literally hundreds of models attend each national contest.

In France and Germany the movement is just gaining ground.

One cannot deny that it is a vastly more exciting and interesting type of model than the rubber-driven type. Added to which it is more realistic both on the ground and in the air.

Even the exhaust note, when warming up the engine, and when the model is passing overhead, adds to the general thrill and interest.

A petrol model also gives its designer greater scope for the display of ingenuity both in general design and construction.

Even the spectator gets more satisfaction in examining a number of petrol models at a meeting than a number of rubber-driven models, for there is the arrangement of the power unit as well as the aeroplane to examine.

There is the amusement of watching the varying skill displayed by the operators with their engines; and finally, the aeroplane itself looks more imposing and purposeful in the air than its smaller rubber-driven brother.

Now that the ice is cut, and people are beginning to realize that the project is reasonably assured of success, and the cost of building a model is not prohibitive, there is every reason to expect the petrol-driven model aeroplane to forge rapidly ahead both in efficiency and in popularity; and besides forming an amusing hobby, it all helps to make the nation air-minded.

Without a strong air sense it is unlikely that this country will keep its leading place amongst the nations of the world in the future.

It is with this hope that I have compiled this little book, and set out my own experiences and conclusions, and those of others who have also been engaged in this fascinating hobby.

I do not wish to suggest that my methods are the only or even the best methods. There are always different ways in life for arriving at the same result. I started flying model aeroplanes in 1912 and I flew what I suppose may be termed the first successful flying post-war petrol model and captured the first post-war record.

Since then I have constructed many petrol models, and up to the time of writing hold the official British power-driven record.

I therefore hope that the book may be a useful guide for those who are contemplating building their first petrol-driven model aeroplane. I wish to thank the following publications for their kindness in permitting me to make use of material of mine that has been published in their columns from time to time: *The*

Model Engineer, *Practical Mechanics* and *The Aeromodeller*. I am also much indebted to the help afforded to me by Mr. E. T. Westbury, Mr. F. J. Camm, Mr. J. B. Allman.

C. E. Bowden.

Birmingham.

CONTENTS

CHAPTER I

A BRIEF HISTORY OF THE PETROL-DRIVEN MODEL AEROPLANE

In 1914 Mr. Stanger produced two successful petrol-driven model aeroplanes in this country.

One was a "Canard" biplane, and the other a tractor monoplane.

The biplane set up a record with a flight of 51 seconds. This machine had a V-twin cylinder engine and weighed $10\frac{3}{4}$ lbs. complete. The engine weight was 2 lbs. 12 ozs., and it revolved at 2,000 r.p.m. with a propeller of 22-in. diameter and 18-in. pitch.

The machine was a "Canard" biplane with a span of 7 ft., chord 1 ft. and gap 13 ins. Elevator span 30 ins., chord 8 ins. The total length of the machine was 4 ft. 2 ins.

The monoplane had a four-cylinder engine weighing $5\frac{1}{4}$ lbs., with the cylinders arranged in V-formation. The machine weighed complete 21 lbs., and it had a wing span of 10 ft.

These two interesting engines are still in existence, although not in use. In most respects, except from the automatic inlet valves, they are modern in design. They operated on the four-stroke principle.

Mr. Stanger's record was not broken until 1932. He actually started his experiments in petrol models as far back as 1908.

Another outstanding early experiment was the Bonn-Meyer engine for model aircraft.

It was a V-twin four-stroke engine, and its weight, with battery and coil, was 11 lbs. 2 ozs.

It drove a 2-ft. propeller at 1,200 r.p.m., but no successful flights were made with it as far as is known. As a contrast engines can now be bought weighing only 4 ozs.

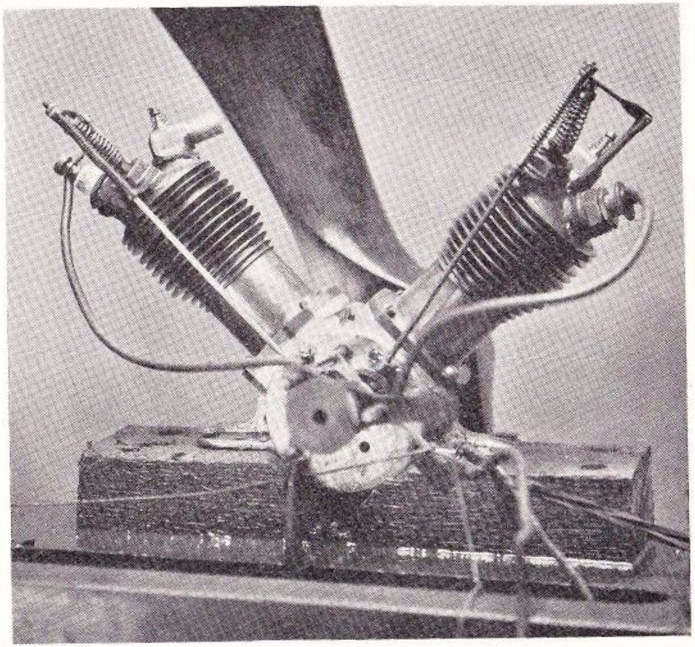


FIG. 1.
The Bonn-Meyer Engine.

Fig. 1 shows the Bonn-Meyer engine on the bench.

The war naturally put a stop to further experiments by model makers.

However, after the war, Mr. Edgar Westbury made

a 52-c.c. two-stroke engine called the "Atom I."

This engine was fitted with a flywheel magneto and a mixing valve carburettor. Its weight was 5½ lbs.

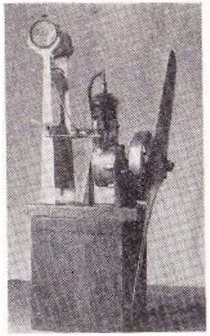


FIG. 2.
The "Atom I" Engine. Note the Flywheel Magneto.

and it drove an airscrew of 2-ft. diameter and 18-in. pitch at 3,000 r.p.m. (See Fig. 2.) The flywheel magneto is noteworthy on such an early model aero engine.

In 1925 the Cranwell R.A.F. Boys' Wing Model Aircraft Society build a half-scale model of the C.L.A.3 single-seater light plane for the "Atom I" engine. The full-sized machine was designed by the now well-known full-sized aircraft designer, Flight-Lieut. Comper. This aircraft was the direct ancestor of the famous "Comper Swift" single-seater aeroplane.

The model had a wing-span of 11 ft. 6 ins., and weighed 14 lbs. Successful taxying tests on the Cranwell Aerodrome were carried out, but the model was not flown owing to regulations to the contrary, and

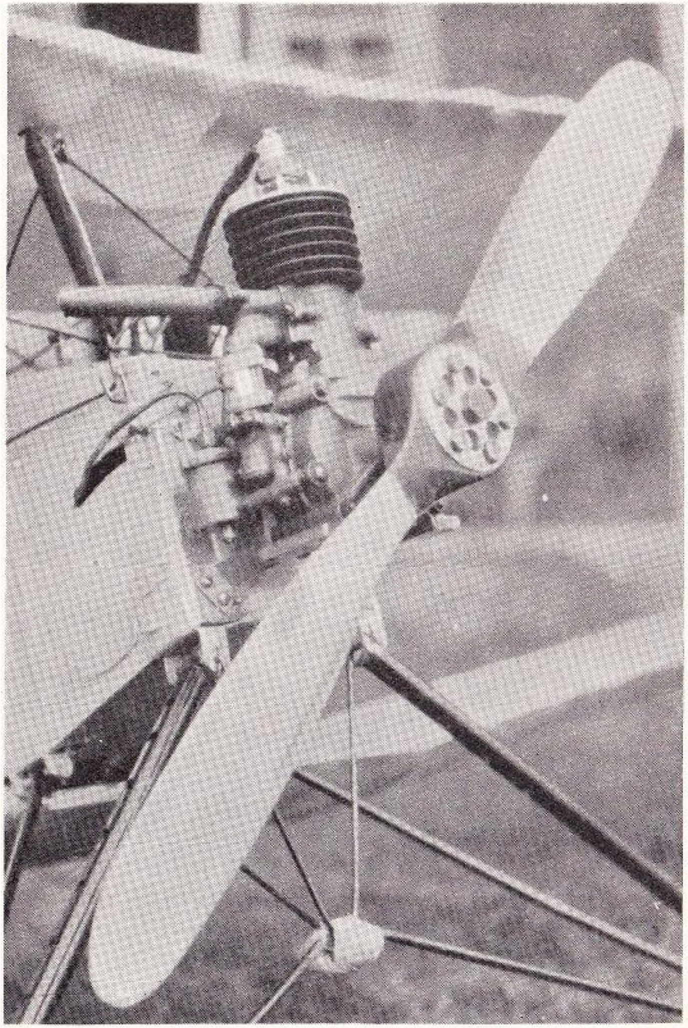


Fig. 3. The 28-c.c. "Wall" Engine.

was eventually acquired for instructional purposes at the Cadet college. The engine is still in existence and in working order.

Another machine then emerged before the public eye, called the "Dowsett Special," details of which were published in *Flight*.

This machine did not do anything of note, however. It was not until 1932 that Mr. Stanger's 51 seconds

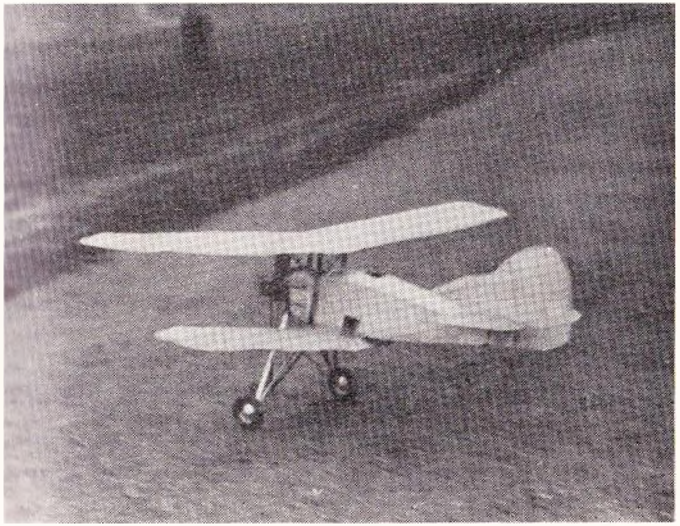


Fig. 4.
"Kanga" taking off on Wimbledon Common.

was bettered. Mr. Stanger therefore held the record for eighteen years.

The writer, who had built model aeroplanes since 1912, decided that rubber-driven and compressed-air models were losing their charm, and that it would be interesting to see what could be done with one of the small 30-c.c. petrol engines that at that time were being developed for model speed boats.

So, in collaboration with Mr. Edgar T. Westbury, an old American two-stroke engine was taken out of a model hydroplane hull, relieved of its fly-wheel, and a wooden propeller of 24-in. diameter fitted. The outfit weighed $2\frac{3}{4}$ lbs., less ignition gear. Fig. 3 shows the " Wall " American engine mounted in its fuselage.

The writer then designed a biplane for the engine with various features that, at the time, were considered

Fig. 5.
The " Bee." A Record-holder in 1933, also winner of the Sir John Shelley Cup.

necessary to control take off, landing, and length of flight. The complete model was called " Kanga " as it was hoped it might hop a little. The model weighed $10\frac{1}{2}$ lbs.

After a few short controlled flights it was found to be moderately stable and free from damage on landing, and so the official timekeepers were gathered together one day on Fairey's Great West Aerodrome, by the

kind permission of Mr. Fairey, and a flight of 71 seconds was made, thus beating the previous record of 51 seconds. The flight was arrested by the clock mechanism controlling the duration of flight, and the model circled round in right-hand spirals at an altitude of about 120 ft.

It was then decided to try a longer flight, but nothing would induce the engine to start.

The next day an ignition fault was discovered, but by then the official timekeepers had, of course, dispersed, and it was decided to rest upon the laurels gained.

Fig. 4 shows " Kanga " taking off on Wimbledon Common.

This success stimulated the writer to further efforts, and it was decided to attempt the production of a smaller and lighter model, as it was felt that the popularity of the model aeroplane would never be assured until a smaller engine and model could be produced.

Mr. Westbury therefore produced the now well-known " Atom Minor " engine of 14·2 c.c., weighing 1 lb. 3 ozs., whilst the writer produced a model called the " Bee " which set up a new record on its first day out. In 1933 this model won the Sir John Shelley Power Cup and set up a record of 8 minutes 42 seconds out of sight.

It actually flew for nearly fourteen minutes until the tank ran dry. This was unofficially timed from a car. The model weighed $6\frac{1}{2}$ lbs. and had a wing span of 7 ft. The ignition gear weighed 15 oz.

Fig. 5 shows the " Bee " in the air, whilst Fig. 6 shows the " Atom Minor " engine fitted to an early low-wing model of the author's. During 1933 great

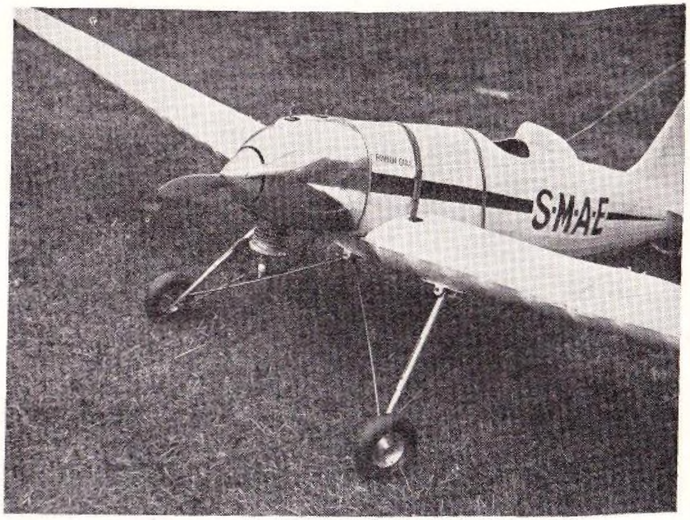


Fig. 6.

Early low-wing Model by the author powered with the original type " Atom Minor " Engine.

strides were made, but by a limited number of people.

Amongst those early successful enthusiasts, Mr. Bishop made a heavily-loaded model of a " Comper Swift." This model made a few short but meteoric flights, and was then followed by a large biplane of light wing loading which proved most successful and flew a great deal. A four-stroke engine of 30 c.c. was used.

Mr. Stalham carried out successful experiments in the Midlands, using a flat twin four-stroke engine of 30 c.c., with overhead valves.

Fig. 7 shows Mr. Stalham's 30-c.c. flat twin power unit mounted in his model " Peggy."

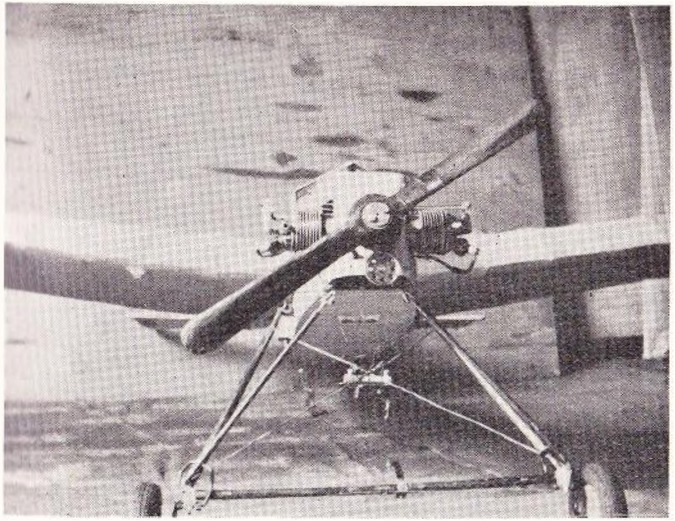


Fig. 7.

Mr. Stalham's flat twin 30-c.c. Engine.

A further 1933 effort was a model made by Mr. B. K. Johnson. It was exceptionally light and with some unusual features. It had a 14.2 c.c. " Atom Minor " engine and weighed only $4\frac{1}{2}$ lbs. complete with an 8 ft. wing span.

In 1934 this model made a number of successful flights, but ended its days through a wing collapsing in the air, followed by a most spectacular spinning nose dive to earth in the best movie traditions during the 1934 power competition.

About this time Messrs. Andrews, Bennett and Collins produced a scale model of a D.H. " Moth." This model carried out a number of short flights and it looked very well in the air.

The year 1934 naturally produced many more petrol-driven models. So much so, that it now becomes impossible to mention the doings of all, and one must be content to remark upon some of the outstanding performers in the 1934 Sir John Shelley power competition.

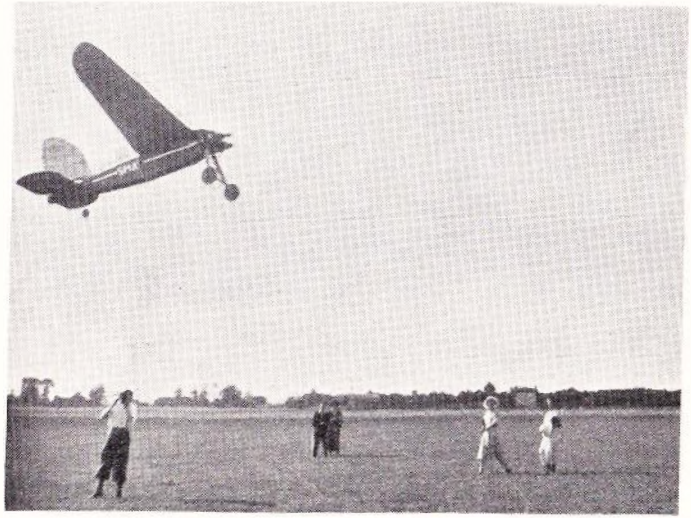


FIG. 8.

" Blue Dragon " Monoplane. Just after taking off in 1934 when machine established record of 12 mins. 48 secs. out of sight.

Five models succeeded in putting up successful flights.

The writer was fortunate enough to win the competition with a high-wing model called the " Blue Dragon."

The model took off under its own power and rapidly

gained altitude, estimated by several experienced flying men at the time, of over 4,000 ft.

It encountered a bank of cumulus cloud, in which it played hide-and-seek. Eventually it was clocked " out of sight " with the engine still running at 12 minutes 48 seconds. This constituted an R.O.G. record for all classes of models. The model was engined with an " Atom Minor " and is described in a later chapter. At the time of writing it holds the existing British petrol record.

Fig. 8 shows the model commencing its climb just after taking off.

The model was found afterwards undamaged eight miles away, after the author had made a search from a full-sized autogiro.

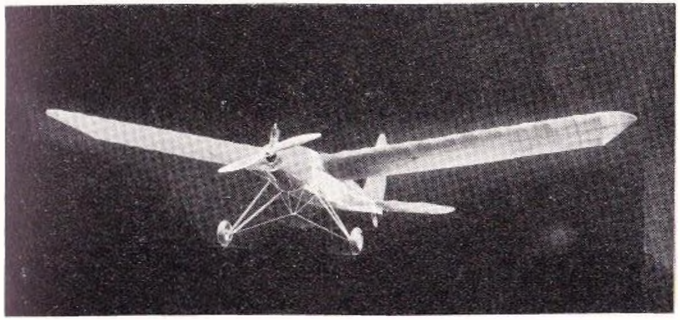


FIG. 9.

Mr. F. J. Camm's oval midwing Petrol Monoplane with " Brown " Engine.

Another successful flight of 3 minutes 42 seconds was made by Mr. F. Harris's " Flamingo II," a 12-ft. span monoplane fitted with a 15-c.c. four-stroke engine, which had been used previously in a boat and had run many laps in the tank at the schoolboys' exhibition. This flight brought Mr. Harris second place.

During 1935 Mr. F. J. Camm, the well-known model designer, produced a pleasant-looking streamlined mid-wing model, with an engine mounting designed to take a number of different types of engine.

The details of this model were published in *Practical Mechanics* and blue prints were made available.

Fig. 9 shows the model's excellent streamline form to advantage.

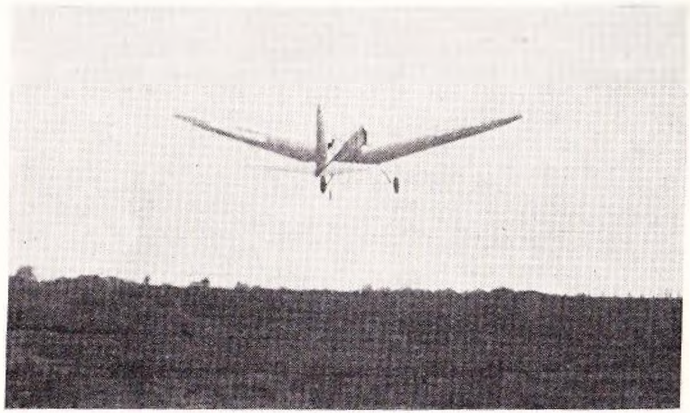


FIG. 10.
The author's low-wing Model Aeroplane caught after taking off at Renfrew, 1934.

Fig. 10 is a photograph of a low-wing model of the writer's caught just after taking off. This was probably the first successful petrol low-wing model. Constructional details of this model were published in the *Model Engineer*.

The high spot of the year 1935 was undoubtedly

when Mr. Willis won the Sir John Shelley power competition, which had now ceased to be a duration competition owing to the ability of models to carry out long flights due to their more reliable engines. The Willis model was 9-ft. span and was very beautifully constructed.

Mr. Baster's model " Comet " from Bournemouth took second place. This model had a single-cylinder four-stroke engine installed.

1936 produced two outstandingly stable models for rough weather flying. Mr. Brooks's " Comet "-engined model has a low aspect ratio contrary to general practice, which undoubtedly helps lateral stability in really bad weather. The engine is an 18-c.c. " Comet."

Mr. Wilson has produced a somewhat similar type of model with a 15-c.c. engine. It also has the same excellent characteristics of stability in high winds.

The writer was unfortunately unable to attend the 1936 power competition, and therefore cannot personally describe the event. The competition was postponed due to bad weather and was flown off on a later date.

Mr. E. Ross eventually won the competition with a very light " Brown "-engined model of approximately 8-ft. wing span, weight $3\frac{3}{4}$ lbs. I am informed that the weather conditions were very bad, but the winning model flew magnificently and landed exactly on the scheduled time of 60 seconds with a flight of left-hand circles. Mr. Ross was unable to complete the right-hand or opposite circles demanded by the rules. Other competitors were in the same position, however.

Whilst 1935 produced the American " Brown

Junior " engine, and set the fashion of even smaller engines and models, 1936 has produced smaller engines still of 6 c.c. and one of only 2·4 c.c. These engines can be obtained commercially and are described in Chapter II. Several firms are now concentrating on the production of 2·5 c.c. engines.

During 1936 the writer has also carried out various experiments in all balsa wood monocoque construction. These are dealt with in Chapter VIII.

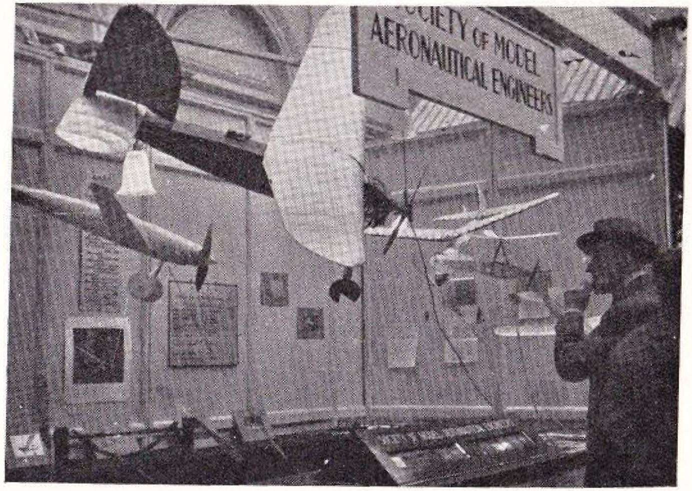


FIG. 11.
The *Model Engineer* Exhibition, 1934.

This brief history would not be complete if mention were not made of the valuable propaganda work done by the " Model Engineer " Exhibition organized each year by the *Model Engineer*.

Fig. 11 shows interest being taken by visitors in the

stand of the Society of Model Aeronautical Engineers at the 1934 exhibition.

It is now quite impossible to trace the doings of all the models in Great Britain, they have become far too numerous and the hobby is forging rapidly ahead.

CHAPTER II

THE POWER UNIT AND ITS MOUNTING

General.

ONE of the first things that anyone contemplating building a petrol-model aeroplane wishes to know is what sort of engine he shall obtain or make for his model.

The matter of expense often decides the problem. It is important, however, if success is to be obtained, to buy an engine that has been thoroughly tested and is well known to be reliable. Extreme low cost unfortunately often leads to disappointing results and eventual waste of money, for the model never flies and a new start has to be made.

There are now a considerable number of reliable engines on the market, and in some cases sets of castings can be obtained by those who wish to make up their own engines.

The price of most modern small aero engines complete with coil condenser and tank is so reasonable that it is doubtful whether it is worth making up an engine from castings, unless the constructor has plenty of spare time and the urge to do so.

In this chapter I propose to classify engines by their cubic capacity, and mention well-known examples in each capacity, that I have either had personal experience of, or have knowledge of in other ways, and I may add that I have actually tried out most of the engines on the market to-day. I would wish to say, however, that there are engines that I have not mentioned that

are doubtless excellent, and because they are not included in this chapter is merely that I cannot personally claim experience of them.

I assume that the newcomer to petrol models wishes to construct a *slow-flying, general purpose petrol model.* In these circumstances the size of the model will therefore more or less be dictated by the size and power of the engine selected. I will therefore give a general indication of the span and weight of the model that any particular class of engine may be expected to fly, provided the model is correctly designed in accordance with the chapter on design, and provided the construction is soundly carried out.

Four-stroke or Two-stroke Power Units.

Either type is suitable for model petrol aeroplane use, and both types have been successfully flown.

For the beginner I feel that it is perhaps best to select a simple type of engine, robustly built and with no frills.

The two-stroke engine therefore suggests itself, for there is less to become deranged, or damaged, by bad landings. The absence of valve gear that can become damaged is a large point. The torque is more even in the case of the two-stroke, and the weight is generally less and the cost is usually less, owing to the simplicity of the type.

It is interesting to note that the majority of engines on the market for aero purposes are two-strokes.

Unfortunately the two-stroke is well known for its temperamental habits, due to the carburation which has to suit more exact requirements.

Nevertheless, careful attention to simplification of carburation methods goes a long way to eliminate

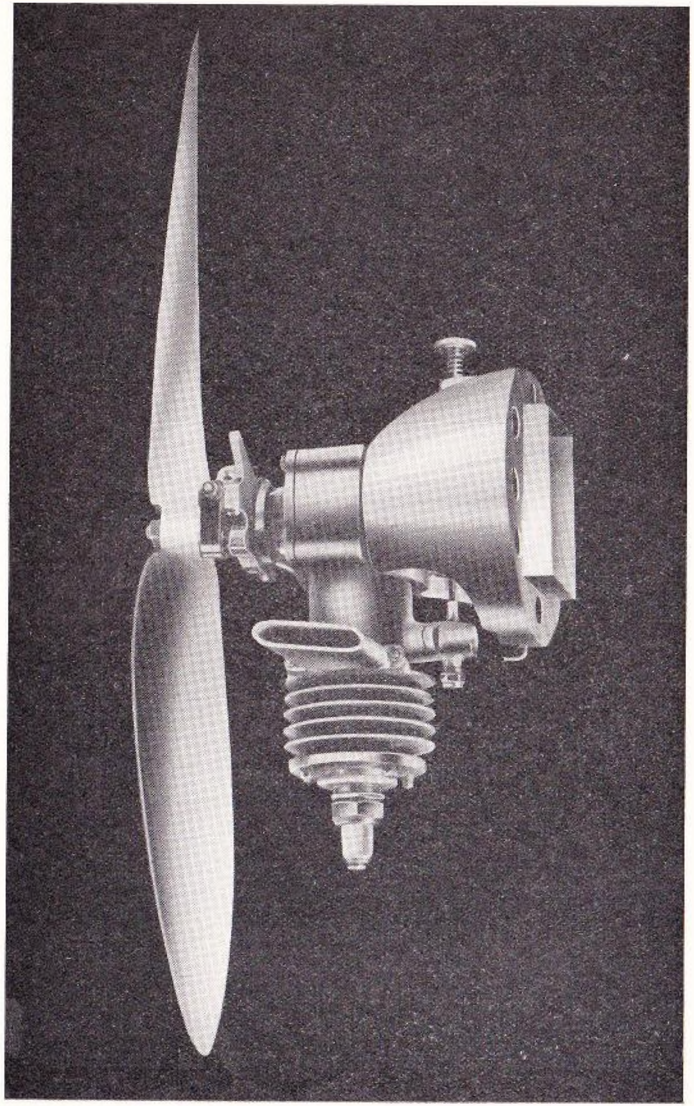


Fig. 12.
The "Comet" 18-c.c. Engine on Bowden detachable mounting.

these troubles. A well-designed contact breaker gear, coil and condenser completes the cure. Most of the modern little engines on the market have had these points carefully considered.

I therefore recommend the beginner for the sake of simplicity and low cost to start off with a two-stroke, but I do urge him to only get a well tried and known example to ensure that he does not waste his money, and so become tired of the petrol model before the disease becomes firmly embedded in his system.

There are some good four-stroke aero engines on the market, and those I have seen have been good starters and, if well balanced, have been surprisingly smooth in operation.

Size of Engine.

Having decided upon the type of engine, the aeroplane designer will have to consider the size of the engine. It is convenient to consider this in cylinder capacity.

This size is dictated, as already mentioned, by the type of performance required and by the size of the model that is considered convenient for transport and operation. *This matter of size then must obviously be a matter for personal decision of each individual constructor.*

Classes of Engine Obtainable Commercially

The 30-c.c. Class.

The 30-c.c. engine is usually adapted from model speed-boat engines. This size, generally speaking, has an ample reserve of power and will stand a lot of hard work, but it is rather heavy and requires a model of at least 10-ft. span and up to about 15 ft., if a monoplane is being considered, and if slow flying characteristics are to be sought after, and I think we can safely say that for a normal general purpose model, comparatively slow flying is one of the most essential features if the model is to be reasonably safe and controllable.

The considerable weight of the 30-c.c. model and its large size will probably rule it out of court for most constructors.

My original biplane "Kanga" which put up the first post-war record, and came approximately in the 30-c.c. category, had a span of 8 ft. (biplane) and weighed about 10½ lbs. after various modifications. It is obvious, of course, that a monoplane to produce similar results would have to be of considerable greater span; somewhere in the neighbourhood of 14 to 15-ft. span.

A model of this size is an imposing sight in the air, but is difficult to transport in a car, and takes up a lot of room in a house, even if it is constructed in sections as in the case of "Kanga."

Messrs. E. Gray and Son produce an excellent 30-c.c. class four-stroke engine suitable for model aircraft.

The 18-c.c. Class.

This class has one outstanding and notable example on the market. The "Comet" engine, designed by Mr. A. E. Brooks is a very reliable and well-designed engine, produced for long life and to withstand hard knocks. It is a moderately slow-speed engine, and will fly models from 8-ft. span up to much larger sizes. A robust model can be constructed around this engine. The cylinder capacity is 18 c.c., and the engine works

on the two-stroke principle. The alloy cylinder casting is fitted with a liner and the alloy piston with one ring. A car-type contact-breaker is fitted, an excellent feature where reliable starting and running is concerned. The engine can be bought either in casting form, or as a unit ready to run, or complete with a detachable streamlined engine-mounting with petrol tank inside and Elektron propeller. (See Engine Mountings at the end of this chapter.)

The weight of my "Comet" engine with propeller, tank and mounting is 25 ozs. Fig. 12 shows the "Comet" engine mounted in this manner.

The mounting was designed by myself and cast in Elektron.

The 15-c.c. Class.

The next capacity in which engines are available commercially is of 15 c.c.

There are a number of these on the market of varying success.

The engine will weigh about 1 lb. 3 ozs., not including ignition gear, and a robust model should be produced at about 6½ lbs. to 8 lbs. all on.

The weight of ignition gear is at present heavy and out of proportion to the engine.

Models in this category have been produced weighing less, but as a general rule have not had a sufficient factor of safety for all-weather flying in our English climate. I know of one model constructed entirely of balsa wood and paper tissue covered, weighing just over 3 lbs., with a 15-c.c. engine, but it bears evidence of much repair work, and I imagine that the average man is not too fond of this type of industry

As far as I know, the first successful 15-c.c. model aero engine that flew a model was the result of collaboration in 1932 between myself and Mr. Westbury, of model speed-boat fame.

We were seeking after lighter and smaller petrol-driven model aeroplanes. The 14·2-c.c. "Atom Minor" engine was the result in the model called the "Bee."

At the moment of writing, my 14·2-c.c. model "Blue Dragon" holds the British duration record, although there is little doubt that either I or other competitors could better the record time if the rule in which the model has to be kept in sight of the official timekeepers at the start of the flight were to be removed.

In fact it is known that a number of flights have been made of greater duration.

Nevertheless, the 15-c.c. and 18-c.c. category is still a most useful one in spite of the lure of the smaller model. There is a reserve of power to get the model off poor ground, and the engine can be made really robustly.

These two categories are excellent for competition work in the English climate.

The "Atom Minor" engine is now out of production, but may shortly be placed on the market again in an improved form, I am informed.

The "Grayspec" is a reasonably priced 15-c.c. two-stroke engine, manufactured by Messrs. E. Gray and Son, Ltd. Either complete engines, or sets of castings and parts for their construction, may be obtained.

Another two-stroke engine in this class is one of 13.5 c.c. made by Messrs. F. J. Hallam and Son, Hamworthy, Poole, Dorset ; this is also available either finished or in the form of castings and parts.

The 10-c.c. Class.

Next on the list comes the 10-c.c. class of engine made popular by the Americans, and now obtainable on the British market, the best known being the "Brown Junior." These engines weigh only 6 ozs., less coil, etc., and are sold complete with coil and condenser on a wooden test base, ready to run. They have proved themselves most successful in competitions in America, and have a surprising power for their light weight. They fly a model of 8-ft. span or more, with an excellent power reserve. I have three of these engines, one of which I have used for experimental fittings. All have been most reliable and excellent little engines.

I have fitted these engines into models weighing from between 4½ lbs. to 7½ lbs., i.e., from a biplane of 5-ft. span to a large low-wing model of 8-ft. span. I have also fitted these engines into a flying-boat and an experimental autogiro. The last-named caught fire just as it was producing interesting results and was completely destroyed.

The 10-c.c. engine may be thoroughly recommended. Its only limitations appear to be that it is not quite so robust as a 15-c.c. engine and there is not quite the same reserve of power, although there is not much in this latter feature.

The "Brown Junior" engine can be obtained from Stuart Turner, Ltd., or from The Model Aircraft Supplies, Ltd.

The "Brown Junior" two-stroke engine may be said to have introduced the really light engine and was the first successful commercial engine produced without piston rings, the piston merely having a groove for oil around its skirt.

Fig. 13 shows a "Brown" engine beside its larger brother, the original "Atom Minor" engine.

The 6-c.c. Class.

Recently there have been placed on the market examples of very small two-stroke engines of about 6 c.c.

These little engines, of which I have several fitted to different models and can therefore vouch for their practicability and excellent power output, are two-strokes, and in the case of the American "Baby Cyclone" engine are sold complete with coil and condenser, weighing 2½ ozs. the pair. The complete outfit with tank, coil and condenser weighs only 10½ ozs., and can be run off a 4-volt flashlamp battery for the ignition. A rotary valve is fitted which appears to be very efficient, whilst no rings are fitted to the piston. The engine is controllable on its simple needle valve petrol control. These little engines can be obtained on the British market and produce a most astonishing amount of power. In America a "Cyclone" has flown a 15-ft. span model of light balsa-wood construction.

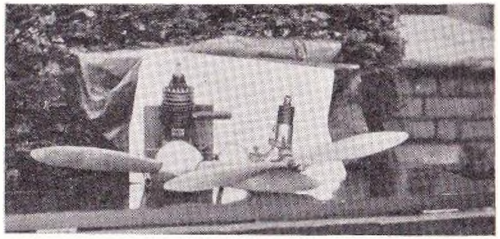


FIG. 13.
A comparison in sizes. The "Atom Minor" 15-c.c. Engine on left and "Brown Junior" 10-c.c. Engine on right.

Models of about 5-ft. to 7-ft. span and 3 lbs. to 5½ lbs. are very suitable for these engines.

Recently a similar-sized little engine has been placed on the British market called the "Hallam Nipper" aero engine. This is an English-built engine, and it can be supplied as a set of castings. This engine embodies some novel features of design and construction, and is fitted with either a cast iron or an alloy piston, which is unusual in being without the usual baffle or deflector on the crown. F. J. Hallam and Son, of Poole, Dorset, are the manufacturers.

The 2·4-c.c. Midget Class.

Finally what is a most interesting and very recent development is the really midget engine of only 2·4 c.c. Although a midget engine was privately produced in England by Mr. Desoutter, there has hitherto been no really midget engine on the market. Recently a Canadian firm, The Vancouver Model Aircraft Supply Co., 2698 Granville Street, Vancouver, B.C., Canada, sent me over a little engine of 2·4 c.c. and weighing 4 ozs., called the "Elf." This little engine has a cylinder liner in a light alloy cylinder casting, piston rings and float-controlled carburettor, with a two-bearing crankshaft. The coil and condenser weigh 2½ ozs., and the coil works on two "fountain-pen" type 1½-volt dry cells which weigh 1 oz. the pair. The petrol tank weighs ½ oz. Thus the whole outfit including ignition and battery weighs 8 ozs. complete!

One would imagine that such a small engine might be a touchy starter and irregular runner. On the contrary, the engine is, normally, exceptionally good at starting and produces powerful, even, and vibrationless running.

Models of between 3-ft. to 5-ft. span suit this engine with its 12-in. diameter propeller, but must be kept light.

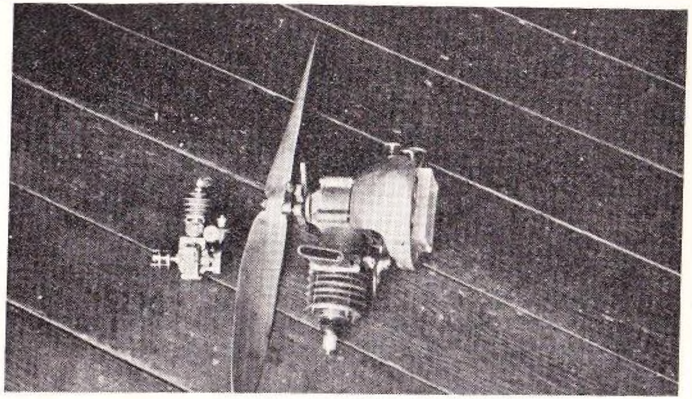


Fig. 14.
The 2·4-c.c. "Elf" Engine beside the 18-c.c. "Comet" Engine.

Fig. 14 depicts the "Elf" engine side by side with the 18-c.c. "Comet" engine. At the time of writing I know of several firms that are experimenting with and probably will shortly produce engines of about 2·5 c.c.

The "Grayson Gnome" 3.5-c.c. engine is just on the market. The "Spitfire" 2.5-c.c. engine, designed by Mr. Brooks is now on the market, with a 1½oz. coil, and I can personally vouch for its exceptionally fine performance and robust design.

Engine Mountings.

If the engine and the air frame of the model are

both to withstand the blows they are sure to get from time to time, it is absolutely essential that some form of engine mounting, that will give to the blow, is fitted.

Early on in my petrol-model experiments I discarded any form of rigid fixing, and I developed a detachable mounting that is held in place to the nose of the fuselage by rubber elastic bands.

Elastic bands are preferable to springs as they do not lose their temper, and just the correct tension can be obtained by adding or reducing the number of elastic bands, so that the engine-thrust will just pull

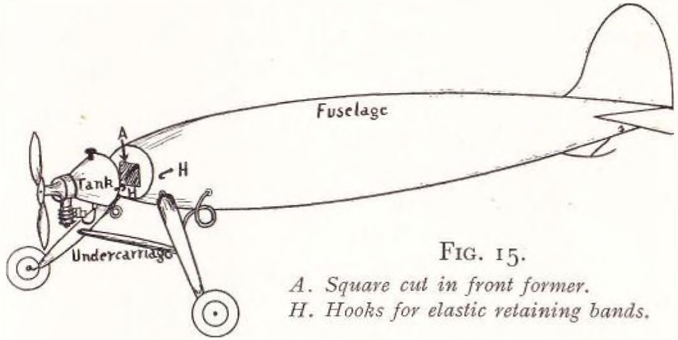


Fig. 15.
A. Square cut in front former.
H. Hooks for elastic retaining bands.

the model through the air and no more. The engine is thus able to be knocked easily off the fuselage if a bad landing is made, and it will be appreciated that the rubber bands will stretch before the crankshaft will bend or the nose of the fuselage crumple, except in very exceptional circumstances.

A detachable engine mounting is, furthermore, very convenient, as the engine can be removed in a moment by unfastening the rubber bands and disconnecting a few ignition wires. Engines can be changed over in this way or attended to in comfort on the bench.

I notice many people are now using my method or variations of it, and yet I still see certain constructors damaging their expensive power units through the use of rigid mountings

One further great advantage of the detachable mounting is the fact that variations of down-thrust or " offset " thrust can be given when tuning the model up during its initial trials, by packing with slips of wood until the desired variation is obtained.

The mounting I advocate can be attached to the nose of a model fuselage in exactly the same way as the nosepiece is attached to a rubber-driven model fuselage.

If the reader will refer back to Fig. 12 he should understand the principle. Fig. 12 is an illustration of

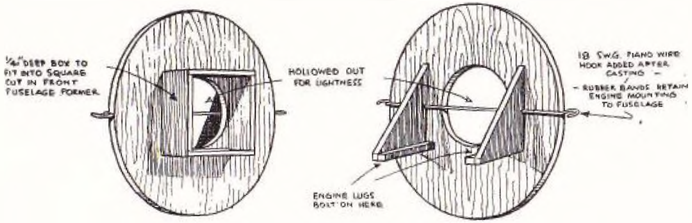


FIG. 16.

Two views of the wooden pattern for a cast ELEKTRON mounting for an engine.

the " Comet " engine mounted on a hollow cone type of mounting. The square at the back of the mounting fits into a square cut in the first three-ply wood former of the fuselage. Elastic bands are placed between the hooks on the mounting and suitably arranged wire hooks on the fuselage.

Fig. 15 is a drawing which shows how the mounting fits into the nose of the fuselage, whilst Fig. 16 is a further sketch of how a mounting may be made up with lugs for the engine-bearers instead of a cone.

This latter type of mounting is made up in three-ply wood glued together. The pattern so formed can be sent away to a casting firm and cast in Elektron, which is a light alloy 40 per cent. lighter than aluminium alloy, but sufficiently strong for the purpose. The Birmingham Aluminium Casting Co. will make these castings very cheaply, and they are practically indestructible.

Fig. 17 shows a casting fitted with the " Cyclone " engine to a small biplane fuselage. The retaining elastic bands at one side can clearly be seen.

Fig. 18 is a photograph of my original cone-type mounting screwed into the rear plate of a " Brown Junior " crank chamber. The cone was turned on a lathe from a solid bar of duralumin. The hollow cone was then used as a petrol tank, with a rear plate screwed into the rear end of the cone. On this rear plate a raised square was fitted in the same manner as on the Elektron casting type of mounting. The " Brown " engine was fitted with an Elektron piston and rings. A small float-feed carburettor was also fitted. The result was very successful.

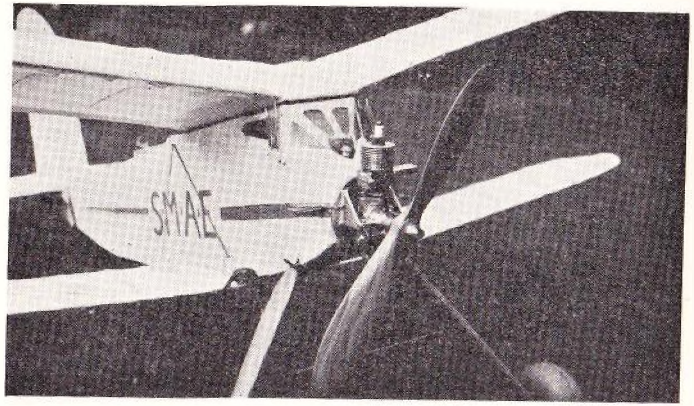


Fig. 17.
A Detachable Engine-mounting fitted to a Model Biplane.

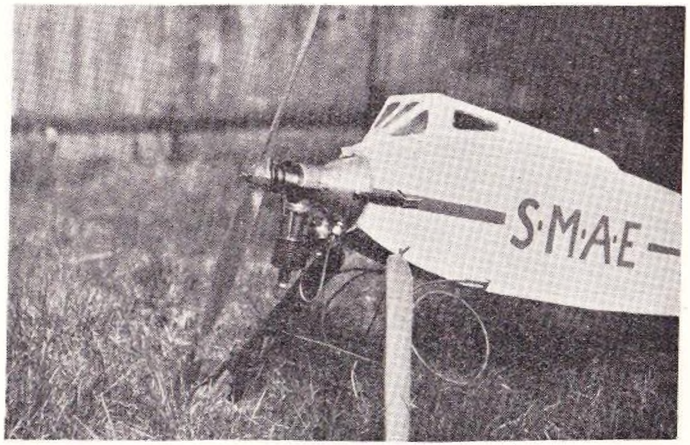


Fig. 18.
"Brown Junior" on duralumin cone, which serves as a tank.

CHAPTER III

THE IGNITION SYSTEM AND CONTROL TO REGULATE DURATION OF FLIGHT

General.

The ignition system on petrol-model aeroplanes is generally by coil and battery. A flywheel magneto would be ideal, but up to the present a suitably light flywheel magneto has not yet been evolved. We therefore have to fall back upon the coil. The trembler coil is ruled out of court where high revolutions are required, for it cannot cope with high r.p.m. satisfactorily. Most of the model aero engines to-day are of the high speed variety, therefore a non-trembler coil has to be used. The Americans have recently produced really light-weight coils weighing about 2½ ozs. with a condenser of ½-oz. for engines of 6 c.c. and less, whilst a 4-oz. coil is used in the 10-c.c. class. A British 1½-oz. coil has recently been put on the market, designed by Mr. Brooks.

Another commercial coil on the British market at the time of writing weighs 4 ozs. and is the "Apex," designed by Mr. Westbury, the designer of the "Atom Minor" aero engine. These coils are cheap and can now be bought from most well-known model engine supply firms. The 4-oz. coil is run off a 4-volt flashlamp battery, weight 4 ozs. The lighter coils on the small American engines mostly operate on 3-volt flashlamp batteries with the exception of the little 2·4-c.c. "Elf" engine, which has a 2-oz. coil that operates on two "fountain-pen" type dry cells weighing 1 oz. the pair. The voltage used is only $1\frac{1}{2}$.

As a general rule all these light-weight coils are very reliable, provided the contact-breaker points are not left closed so that the battery is in circuit whilst the

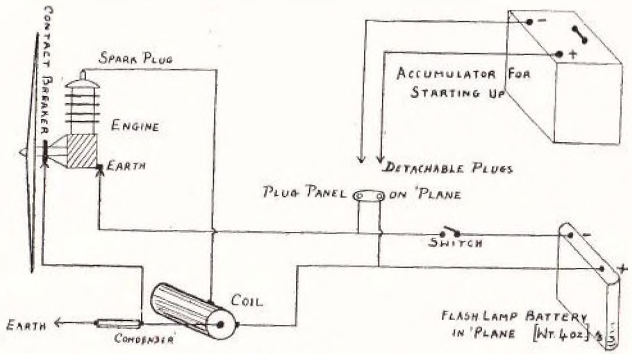


FIG. 19.

Ignition Circuit and Wiring Diagram.

engine is stationary. If this is allowed, the windings are liable to overheat and the coil becomes damaged.

It is an advantage to use a larger battery of the same voltage but greater capacity to start up the engine and run it up. A two-way wiring system should therefore be included so that the plugs and leads of the large ground battery can be removed just prior to flight and the model then takes the air running on the light flashlamp battery fixed in the fuselage.

See Fig. 19 for wiring diagram to attain this feature.

The Battery.

It is essential to keep the ground accumulator well charged, and the flashlamp batteries on the machine

must be absolutely new and frequently changed. Any drop in voltage will cause bad starting and poor running.

Contact Breakers.

The contact-breaker points must be kept properly adjusted and absolutely clean and free from oil. The correct gap when open should be maintained. There are various types of contact-breakers fitted to different engines, but the principle is the same, i.e., when the cam on the engine shaft opens the points a high-tension current is induced and a spark takes place at the sparking-plug points.

If the points become worn and pitted they should be carefully filed up so that they meet each other square and true. They should be frequently cleaned, and if a poor spark is obtained at the sparking plug, dirty or ill-adjusted points may be suspected, provided the battery is well up to scratch. It is essential that the contact-breaker spring shall have sufficient tension to close the points sufficiently quickly to compete with the high r.p.m. of the engine. Otherwise misfiring will take place.

It cannot be emphasized too strongly that the contact-breaker must *function perfectly* to obtain good starting and even running. Loss of power is often due to a faulty contact-breaker gear. Most small engines are very touchy on this point.

Wiring.

All wiring should be kept as short and simple as possible and joints should be soldered.

Insulation must be kept perfect. Half measures will not do and will be the cause of endless trouble.

Time Switch to Control Duration of Flight.

A petrol model may be a dangerous mechanism if some sort of positive control to regulate duration of flight is not used.

This control must be accurate and reliable. To control duration by limiting the petrol supply is not sufficiently accurate and should not be attempted, firstly, because the model may fly for too long a period and so damage itself or property, and secondly, the battery is often left in circuit when the engine stops if the contact-breaker points happen to stop in the closed position. The result, as already mentioned, is that the coil may suffer, and coils are expensive things.

The best method then to regulate duration of flight is to automatically cut the ignition circuit at some predetermined time.

There are two excellent methods. The first that I shall describe is light and quickly made but is not dead accurate to within a few seconds, and may not therefore be suitable for model owners who fly in rather enclosed spaces.

The second method to be described is more difficult to construct but is by far the best method. Flights can be terminated to within any predetermined second, provided the glide of the model is allowed for correctly. This second method was evolved by Mr. J. B. Allman at my request for a clock-controlled switch.

Mr. Allman, it will be remembered, is a Wakefield Cup winner and an expert on gearing for rubber-driven models. He has kindly given me permission to reproduce details of his clock switch in this book.

The First Method.

A " Kodak " self-timer which is used for control of

camera shutters is purchased from a stores that provides photographic material. The timer weighs about 1½ ozs. and operates on the dashpot or airleak principle. This is its weakness, for the airleak which is operated by a milled thumb-screw varies slightly each time.

Fig. 20 shows how this timer is mounted on a three-ply base and operates a pull and push switch which can be obtained at any wireless shop.

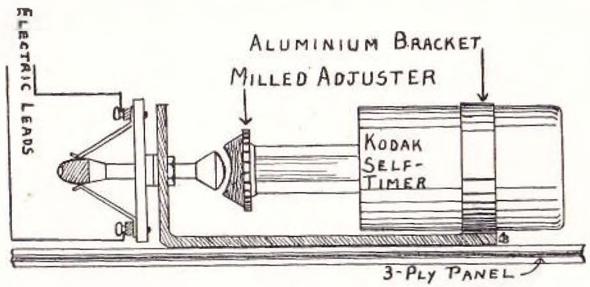


FIG. 20.
Automatic Timing Mechanism to regulate the Duration of Flight (Method No. 1).

The three-ply panel is then mounted in a convenient place on the fuselage and the switch is wired in to one of the battery leads.

On releasing the model the little starting lever on the timer is pressed and the timer operates the switch according to the time that has been set by the airleak screw.

The whole timing apparatus weighs about 3 ozs. complete.

The Second Method: How to Construct the Allman Timing Clock.

The Allman clock device is made up from a small cheap clock costing about half-a-crown from Boots the Chemists or elsewhere.

The mechanism is extracted from the case, and the latter with the dial and hands is discarded. All the projecting shafts, with the exception of the winding shaft are cut off as short as possible.

It will be found that the clock mechanism is held together by three brass nuts. These should be slackened off so that the escapement mechanism can be removed and discarded. This consists of the wheel

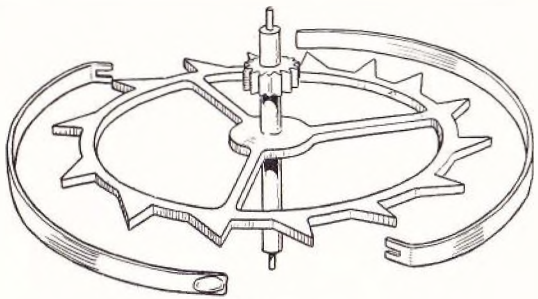


FIG. 21.

that revolves backwards and forwards, the hairspring, the speed-regulating mechanism and the rocker-arm.

The escapement-wheel must also be removed but not thrown away as this wheel is to be converted into the governor (Fig. 21 shows the escapement-wheel).

Two strips of very thin hard brass foil about $\frac{1}{1000}$-in. to $\frac{2}{1000}$ in. in thickness are cut, slotted and curved. The slotted ends of the strips are then soldered to the escapement-wheel on opposite sides so that the strips fit round the escapement-wheel in the same direction as indicated by the teeth.

Two blobs of solder are then put on to the ends of the strips.

Fig. 22 is of a small cylinder constructed of thin tin. It should be just large enough for the escapement-wheel to revolve inside without the strips or the solder weights touching the sides of the cylinder.

The escapement-wheel and the cylinder must then be put back into the mechanism of the clock and the cylinder soldered in position on the same. It is

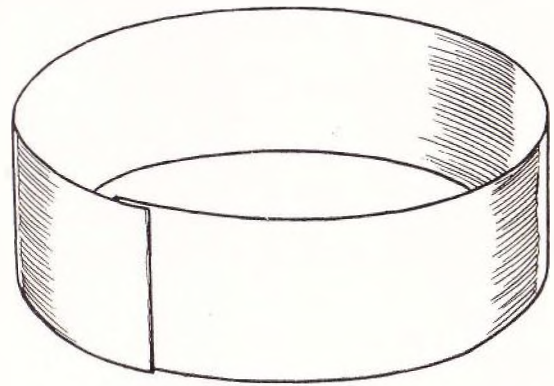


FIG. 22.

important to see that the escapement-wheel is quite free to revolve without touching the cylinder. It may be necessary to cut away parts of the cylinder so as not to foul other gear wheels in the mechanism.

The next thing to do is to construct a starting and stopping device. This can consist of a small lever of heavy gauge brass, to which is fixed a small spring catch of fine steel wire. See Fig. 23.

The lever is mounted on the outside frame of the time-switch on the same side as the winding shaft, and so arranged that when the lever is up the fine steel wire engages with the spokes (not the teeth) of the gear wheel next to the governor.

The time-switch is then screwed to a piece of three-ply wood of suitable size to fit into a recess in the fuselage of the model.

The clock mechanism will be inside the fuselage and through the top of the three-ply will project the winding shaft and stopping and starting lever.

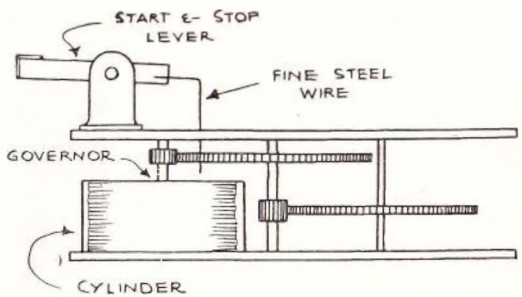


FIG. 23.

Now remove the top portion of the winding-key and insert into the hole a suitably-sized nail, which is then riveted or soldered into position, Fig. 24.

Fix a circle of good paper to the top of the three-ply to form a dial.

The electrical contacts are fixed on the three-ply as shown in Fig. 25. These consist of a plate of thick gauge copper screwed flat onto the three-ply. The movable arm is constructed of thick gauge hard brass, and has the end turned up, so that when the finger approaches "zero hour" it moves the movable arm from the plate and the ignition circuit is broken.

The mechanism is brought to rest when the finger

comes into contact with the set-screw B—Fig. 25.

Before fixing the set-screw B in position, wind the spring until the mechanism is half wound up.

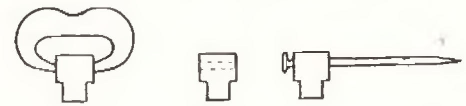


FIG. 24

Now with the aid of a stop-watch calibrate the dial by making a number of tests from different points on the dial, marking each one with a pencil.

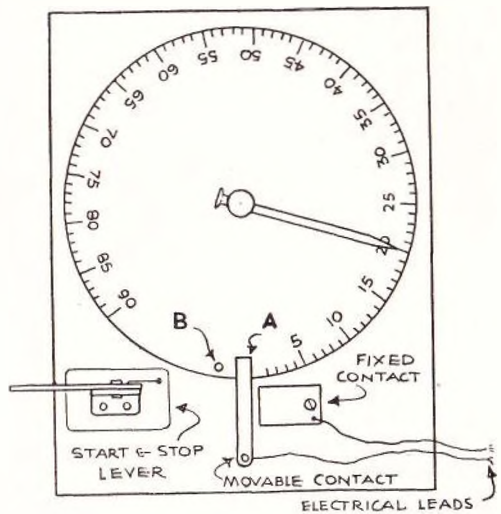


FIG. 25

When the correct position of each second has been found, the dial can be inked in with Indian ink and a sheet of celluloid fixed over the paper to protect the latter from damp and damage. The edges of the celluloid should be carefully sealed with a cellulose cement.

To operate the time-switch the stop and start lever is raised and the pointer finger adjusted to the required number of second's power duration.

The movable contact arm is moved on to the plate contact. The engine of the model is started up. Just before launching the starting lever is pressed and the time-switch does the rest.

With this piece of apparatus it is possible to test out a new model with complete safety, starting with a short hop of, say, five seconds, and gradually increasing the duration until perfect trim is obtained.

It is also possible to fly a petrol model in a comparatively small field without any fear of the model getting out of control.

The clock when mounted in a model can be seen in photographs in Chapter XV.

CHAPTER IV

AUTOMATIC STABILITY AND DESIGN

General.

The question of automatic stability is the *basis of a successful-flying petrol model.*

In this book it will be noticed that I am not considering the question of the non-flying type of scale petrol-model that sits around an aerodrome and does nothing. It seems a very profitless type of model to me and requires no particular designing skill or ingenuity. Merely a flair for copying is required.

A scale type of model that is suitably modified and thereby induced to fly is quite another matter, and requires a considerable knowledge on the subject of stability to know just where to carry out the necessary modifications and yet keep the scale effect of the prototype.

Stability under Two Headings.

Stability can generally be considered under two headings, although each reacts upon the other, and consideration in this light must be given when designing an automatically stable model.

But let us understand the *main principles* of stability under these two headings, i.e., longitudinal and lateral stability.

Longitudinal Stability.

Let me say first that to obtain a really controllable and stable petrol-model aeroplane it should be lightly loaded and have a wing loading of between 6 ozs. to 16 ozs. per square foot.

The nearer it is to the first figure the easier it will be to control, because the model will fly more slowly, and therefore land slower, and in the event of a crash will not do itself so much harm. On the other hand, if one wishes to fly much in windy weather the wing-loading should be rather higher, say 16 ozs. per square foot, in order to obtain sufficient forward flying speed against the wind. If this is overdone, however, and if the model gets out of control on a down wind turn, the best thing to do is to close one's eyes and block one's ears until the whole crash is over!

For normal pleasant weather with light winds or dead calm keep the model a slow flyer and the wing-loading light. It will be a far safer and more enjoyable model.

I am not considering the speed or racing petrol model in these pages, as it is seldom that constructors wish to design these types owing to their uncertainty and the cost of damage to a high-speed model. I have actually made myself two high-speed models but do not recommend them to anyone unless he is an enthusiast after all types of model aeroplane sensations.

But let us return to longitudinal stability—which means that the model will keep a normal keel in a fore and aft direction through air pressure balancing the mainplane against the tailplane, and so that varying speed and thrust of the engine does not upset this equilibrium.

Although, personally, I have a weakness for both the low-wing model and the biplane, I think it will be generally admitted that for model work it is an easier proposition to design a naturally-stable high-wing

model, *and that this type should be the beginner's first model.*

This is due in a great measure to the fact that the centre of gravity can be kept low in relation to the main supporting surface.

But it must be remembered that *the thrust-line has a great effect upon the stability of even a high-wing model.*

Thus, although a parasol or a high-wing set well above the centre of gravity, will add to the stability when the model is gliding, if the thrust-line is well below the main supporting surface, then when the engine is firing there is a tendency to pull the nose up around the resistance of the mainplane and so stall the machine.

This can largely be overcome by giving the engine down-thrust to the correct degree. But it will be appreciated that if the engine is producing a great deal more thrust on one day than is usual, then the amount of down-thrust given may be inadequate and a stall will result. *It is therefore advisable not to place the wing too high in a high-wing model and not to attempt a parasol model* at all unless one is prepared to take risks.

Now look at Figs. 26 and 27. It will be observed that in the case of Fig. 26, the mainplane is not as far above the centre of gravity as in the case of Fig. 27, and therefore does not exert as strong a pendulum effect. But in the case of Fig. 26 the line of thrust and, for the purpose of the argument, let us call it the "centre of resistance," is nearly on the same longitudinal line, therefore there is not any undue tendency for the engine to pull the nose up. A climb is therefore chiefly due to added lift of the mainplane, as the forward speed is raised.

But in the case of Fig. 27, the centre of resistance is well above the thrust-line.

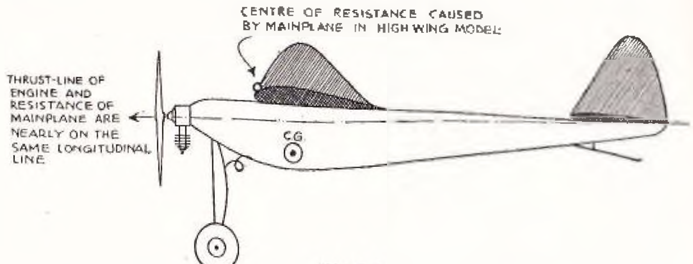


FIG 26

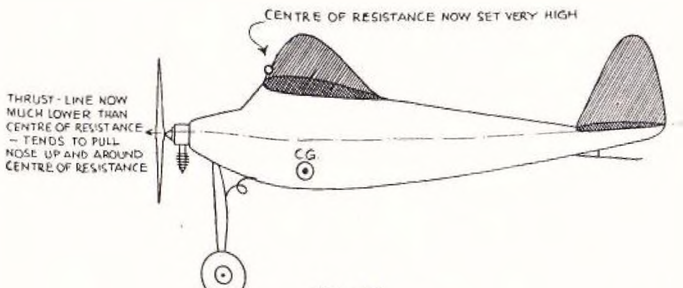


FIG 27

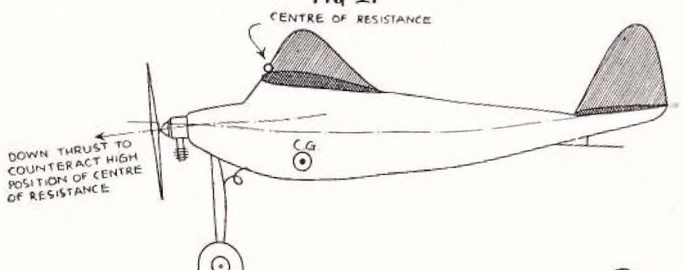


FIG 28

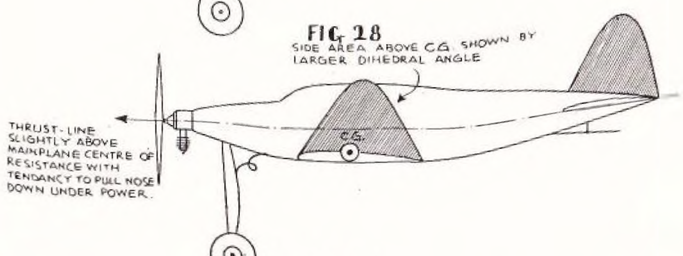


FIG 29

The tendency then will be for the thrust to pull up the nose.

In the latter case we must, therefore, put in sufficient down-thrust by tilting the engine downwards to counteract this tendency to stall, as in Fig. 28.

For the greatest possible stability then in a high wing, where the thrust varies according to throttle opening, it is advisable to keep the mainplane as close to the thrust-line as possible.

Now let us look at Fig. 29 which depicts a low-wing monoplane.

Here we have the thrust-line and the centre of resistance of the mainplane nearly on the same line if we keep our low wing well up to the thrust-line, but the thrust-line is actually slightly *above* the centre of resistance of the mainplane, and therefore there is a tendency of the engine to pull the nose down around the centre of resistance when under power. We can counteract this by a shade of extra negative angle on the tailplane or a little upthrust of the engine.

But, and this is where we must watch the low-wing model, the centre of gravity is dangerously near or even above the supporting surface, and there is little or no pendulum effect.

We can help this by fitting heavy wheels to the model, and we can also help by giving more dihedral angle so that the centre of resistance becomes higher and so that more side area above the C.G. is shown in a sideslip.

Note the shaded area of the wing in Fig. 29. This represents side area above the C.G. which will have a righting effect in a sideslip, tending to push the model back again onto an even keel and so restore lateral balance, but we will go into this side area business shortly under the heading of "lateral stability."

We have now discussed a few of the main elements toward stability in the case of the high-wing and the low-wing monoplane. Let us look into the biplane problem for longitudinal stability.

The Biplane.

The biplane is rather a more difficult model to design satisfactorily, but with the necessary knowledge it can be a perfectly satisfactory flying model.

For years now I have flown my biplanes, and I have built quite a number of rubber and petrol biplanes, somewhat on the principle of M. Mignet's little "Pou du Ciel."

That is to say, I use a large positive "stagger" with a fairly small "gap," and I place the two mainplanes at different angles of incidence, generally called *decalage.*

The top plane I place at a slightly greater angle of incidence than the bottom plane. In this way it will be seen that the bottom plane acts like a large tail-plane, but very near the front or top plane.

Due to its size, it can dispense with the normal long fuselage required on a model biplane to get sufficient leverage for the tailplane, therefore a shorter fuselage can be fitted more like the real thing, together with quite a smallish tailplane.

The bottom plane acts as a longitudinal stabilizer to the top plane, as well as the tailplane.

As most model builders know, *one of the important features of longitudinal stability is that the stabilizing tailplane should fly at a slight angle with the mainplane and so forming a longitudinal V angle if looked at sideways.*

It will be seen by referring to Fig. 30 that this

system of setting the two mainplanes on a biplane at different angles, whilst heavily staggering them, complies with the V angle requirements.

In order that the thrust of the engine shall not upset the stability, the positioning of the thrust-line must be as carefully considered, in fact more so, than on the high-wing or low-wing monoplane.

This will be realized when it is remembered that both mainplanes have their own centre of resistance to be considered and the combined point of resistance

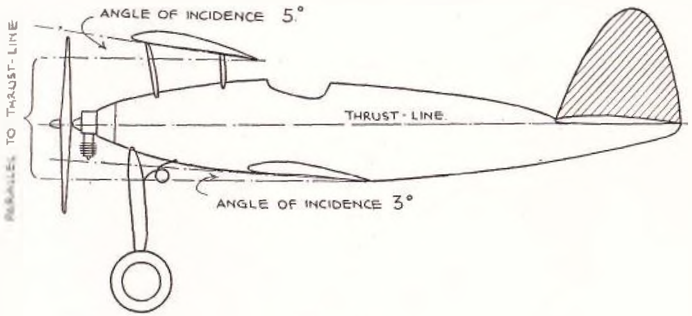


Fig. 30.

must be worked out and the thrust-line placed so that it does not cause a stall or a nose dive when the engine is firing.

Too many model constructors of biplanes ignore the correct placing of the thrust-line with the result that, whereas they may have got away with it in the case of the conventional high-wing or even with the low-wing model, they have usually struck a snag over the biplanes, and then condemned them as tricky things where automatic longitudinal stability is concerned.

Lateral Stability.

Lateral stability is obtained firstly and in a minor degree by having the C.G. low. This can be arranged for in the design, and where necessary a heavyish undercarriage and wheels will help. The low C.G. naturally gives a pendulum effect and uses the point of centre of resistance of the wing to swing on. However, we have already discussed why this must not be too high up due to other reasons. A compromise is therefore required.

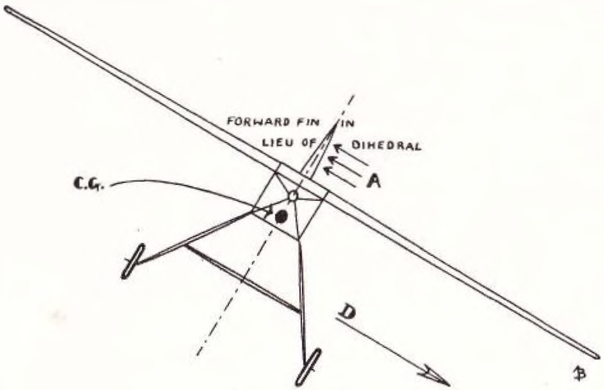


FIG. 31.

Correcting effect of fins placed above C.G.

A. Air resistance on a forward fin above C.G. pushes nose of model on to an even keel. A rear fin looks after the tail. (Now see Fig. 32.)
D. Direction of sideslip when in a banked turn or due to dropping a wing in an air-pocket.

Far more important, however, in connection with lateral stability is the correct proportioning of side areas.

When the model turns, due to an offset fin (a method by the way that is dangerous but often used), or due to engine torque or warped wing, the outside wing travels faster and therefore gains more lift. The model

then banks over onto its side. It then commences to slide inwards and downwards unless something is done to prevent it.

If the centre of gravity is low it will be appreciated that a push from a position above the C.G. will push the model back onto an even keel, as the C.G. is used as the lateral pivoting point.

As the model is slipping down sideways (see Fig. 31) it naturally strikes the resistance of air from the lower side, because it is slipping into it.

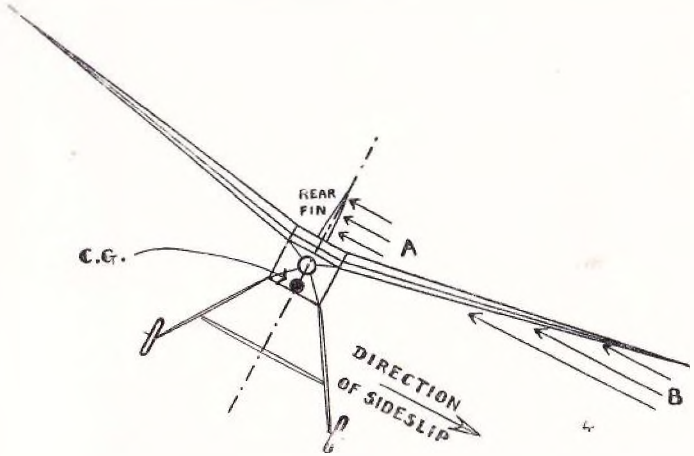


FIG. 32.

Correcting effect of well-proportioned side areas above C.G. during a sideslip.

A. Air resistance on rear side areas above C.G.
B. Air resistance exerting a righting effect on forward side area above C.G. A dihedral angle is now used in lieu of a forward fin.

If we place two fins that are situated above the C.G. pivotal point, one at the stern and one at the nose, then this air pressure will arrest the sideslip of the fins whilst the rest of the model will go on. The two fins will therefore push the model back onto an even keel laterally

Now instead of using an extra fin at the nose end of the model we make use of the mainplane, for if we give it a dihedral angle, which is really only a V angle, we have the same effect of side area as offered by a fin. (See Fig. 32 and Fig. 33.)

We must then take care to balance the side area shown forward *by the dihedral angle and the fuselage area above the C.G.* by the rudder or fin at the rear.

If the rear fin is too large then the rear of the model will be pushed back more rapidly than the nose. The

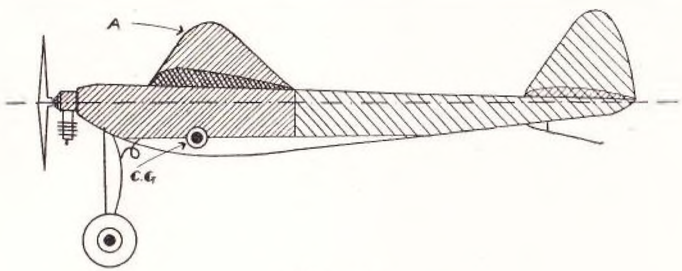


Fig. 33.
Balanced side areas fore and aft above C.G. in order to obtain good lateral Stability.
A—*Side area of mainplane due to dihedral angle.*

result will be the nose will continue to slide inwards and drop, and the model will get into a very steep nose-down spiral or even a spin. If, on the other hand, the dihedral angle is too great, the nose will be held up and the tail will drop sideways, with the result that the model stalls in a sideways position, and this is a most dangerous type of stall.

So decide how much dihedral you want to quickly right a sideslip and then carefully balance the dihedral

by fin area at the rear. Now study Fig. 33, and you will not forget to include the fuselage area *above the C.G.* This is important.

If the reader will also study the photograph of the "Blue Dragon" model taking off, Fig. 34, he will

Fig. 34.
The "Blue Dragon" high-wing model taking off. Note large dihedral and large fin to balance.

notice that there is a very large fin. This was put in to balance the very large dihedral angle. And the very large dihedral angle was used to *quickly* right the model in the gusty weather that I expected might take place during the 1934 Sir John Shelley Cup, which the model won. This pessimistic outlook was justified—the day was very windy and gusty.

Further Points of Design

Aspect Ratio.

A high aspect ratio, i.e., a large span and narrow chord, will give rapid lift and good climb, but a lower aspect ratio will help longitudinal stability, and also in rough weather a shorter span rights itself more rapidly provided the engine torque is taken up by suitably offsetting the engine-thrust line to the opposite direction in which the engine tends to turn the model over.

A compromise should therefore be made as in all mechanical design.

Highly-tapered Wings.

During the last year, in full-sized aeroplane circles, it has been considered that highly-tapered wings stall first at the tips and last at the centre unless the tapered wing is of the type where the leading edge is practically straight and the trailing edge is swept forward. In the latter case the tips stall last as in the case of the parallel chord wing. There seems to be quite a lot to be said for this theory, and it has been borne out in my petrol model experiments.

It is therefore desirable that the petrol model should be fitted with either parallel chord wings, or tapered wings with the trailing edge swept forward and the leading edge kept fairly straight. A slight negative angle or wash-out at the tips helps, and ensures that the tips will not stall until last, thus helping lateral stability.

Wing Sections.

A thick wing section gives good slow flying and excellent lift for a petrol model. A slight under-camber is also an advantage. If the reader will examine the wing section used on my record model "Blue Dragon" he will see what I mean. (See Fig. 35.)

I have tried many wing sections but for my type of

slow-flying models have found this the most useful all-round wing section. If the reader does not like this section, standard "Clark Y" is excellent.

Tailplanes.

Tailplanes should be very large both in span and chord. It is useless to expect good stability by fitting a "scale" type of tailplane.

I personally favour a slightly-cambered tailplane on the top surface. But this is a debatable point and not agreed to by all, although it is becoming increasingly popular.

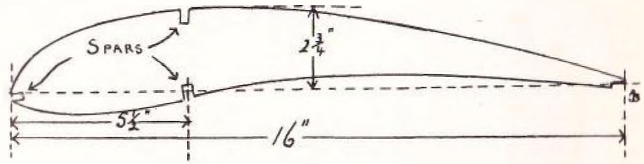


FIG. 35.
Wing Section of "Blue Dragon" at longest rib at Root.

I like my tailplane to normally fly at no angle of incidence or, at any rate, a very slight angle. Then if the mainplane climbs too much, the tailplane comes into a greater angle of incidence and so generates lift due to its slightly lifting section. The tail is then lifted and, due to the leverage on the long fuselage, the mainplane resumes its normal incidence, and a stall is averted. It is this extra lift and righting effect, if correctly used, that makes me favour the cambered top surface type.

The Fuselage.

Many people are worried as to how long their fuselage should be.

As a *rough* guide, a normal parallel wing should have approximately two "chord" lengths between the trailing edge of the mainplane and the leading edge of the tailplane. Slightly less may suffice in the case of a tapered wing with a large root chord, but a large tailplane should be fitted in both cases.

Remember that the main weights should be concentrated well forward and all near one point. The tailplane then has an easier job and does it more quickly. On a petrol model it is easy to group the main components near together, and the C.G. and therefore the wing will be surprisingly far forward and near the nose. This is an advantage provided there is plenty of side area in the shape of dihedral angle shown above the C.G.

I am often asked how I can predict where the wing will be situated when building a new model. After one has built a few petrol models it is very easy from experience to predict to within very small limits where the wing will come. It is best, however, on one's first model to design the wing so that it can slide along the fuselage for adjustment.

The centre of gravity should be about one-third back from the leading edge of the mainplane.

A Model for Maximum Stability.

As a final summary: If one wants to build a model for maximum all-round stability, both on the glide and under power, make a compromise and situate the wing just above the thrust-line but not far above. Keep the span moderate with a fairly wide chord. Situate the tailplane approximately two chords behind the mainplane. Keep the tailplane large. Keep the wing-loading down to about 8 to 10 ozs. per square foot.

Have plenty of dihedral angle and *balance this dihedral with a correct fin area at the back.* (See Fig. 33.) Keep main weights concentrated forward and weight as low down as possible.

Use a thick wing section with slight under camber and a slightly cambered tailplane.

If a tapered wing is to be used see that the trailing edge comes forward and the leading edge is nearly straight like a "Klemm" full-sized monoplane, and give slight wash-out at the wing tips. Give sufficient "offset" of the engine to counteract torque. Set your fin *straight*, and give sufficient "down-thrust" to prevent undue climbing, and you should have a stable model. If you wish to turn, then turn on torque and not fin. See the chapter on "Flying the Model" for reasons.

CHAPTER V

THE CHOICE OF A MODEL TO BUILD—SCALE, ETC.

It is not an easy matter to advise anyone upon what type of model that he shall build, owing to the very diverse desires and ambitions found amongst a number of people.

The subject can be reviewed under several headings, however, that may give the newcomer to petrol model building some indication as to whether his efforts are likely to be successful or not.

The Beginner's Model.

The best model for the beginner is undoubtedly a lightly-loaded, high-wing model as summarized at the end of Chapter IV. This model will fly slowly, be controllable and suffer the least damage. A great deal of fun, interest, and amusement is to be got out of a slow-flying stable model. But the design must be kept *absolutely simple.*

I would recommend the beginner to first of all build a replica of the " Blue Dragon," as described in a later chapter. This model is simple and designed for stability. The " Blue Dragon " can be flown by either an 18-c.c. or 15-c.c. engine or a 10-c.c. " Brown Junior " or its equivalent in h.p. If this model is kept light a 6-c.c. " Cyclone " engine will fly it. Alternatively a scaled-down " Blue Dragon," with a wing span of 5 ft. 6 ins. makes an excellent simple model for a 6-c.c. engine.

Design by Owner.

If the beginner wishes to design a model for himself as a first model and he is not *au fait* with model building, I would suggest that he designs his model on the lines summarized at the end of Chapter IV, and after having carefully digested the points raised in the early parts of the chapter. The important thing to remember is to keep the model simple, strong and yet with a light wing loading of not more than 14 ozs. per square foot. Wings should be made cantilever and not strut or wire-braced if possible, as in the event of a crash or heavy landing, struts and wire-bracing always become deranged and the model is out of true for the next flight. In fact, with bracing one never knows what to expect on the next flight.

The wings, engine-mounting and tailplane, etc., should *always* be made easily detachable and held in position by some form of rubber retention bands, so that these components can knock off in bad landings and possible crashes. No end of damage can be saved in this way. The mainplane should slide for adjustment. The undercarriage should be right up at the nose.

The Scale Flying Model.

Many people take a fancy to a certain full-sized aeroplane and would like to produce a scale model that flies. I fear that quite a number produce the model, and it looks very well, but no thought has been given to the necessary modification in design so that the model will fly. The result is that the owner either becomes discouraged at the resultant damage, or he places the model on various aerodromes for the admiring crowd to view, but the model never takes the air. Neither of these are very satisfactory to the average man.

There are certain types of full-sized aeroplanes that with very little alteration lend themselves excellently to the production of scale flying models.

The scale enthusiast might do well to study his fancies, and see if a slight alteration of thrust-line, a little more dihedral, and a larger tailplane and possibly a little more wing area will fit in without upsetting the general lines and scale effect of the original. In this way a scale model can often be a great flying success and is quite an achievement worth attaining.

I suggest that Chapter IV is borne in mind when looking over the full-sized aeroplane outline drawings. But whatever the loss in scale effect, do not forget that the undercarriage *must* go further forward, or the model will never take off and will nose over on every landing.

The Free-Lance Design.

To my mind the free-lance design is the most intriguing, for it is entirely the result of the designer's own brain-storm. He can make a compromise of flying ability and good looks. He can lay out new shapes and methods of construction, and when the affair flies, he can at least feel that no one else thought of it! It is a part of him, and however dreadful it may look to other eyes, it is his own child; and fathers and mothers are notoriously fond of their own children. The worse they look the fonder they generally are!

CHAPTER VI

A SIMPLE METHOD OF LAYING OUT A DESIGN AND COMMENCEMENT OF CONSTRUCTION

General.

THE budding designer, when considering his first petrol model must, first of all master the main principles connected with the power unit and its ignition, *and he must thoroughly understand the principles of automatic stability*—Chapters II, III and IV should help him in the above. A knowledge of constructional methods and materials is essential, for without it no part of the model can be correctly visualized, nor can any prediction of weights be made. Chapter VII may help here, although experience is the most valuable aid.

The above perhaps sounds complicated to the beginner, but it is necessary, unless a well-known successful design is followed, and even then a sound knowledge of the general principles of stability will make all the difference between good and bad operation of the model.

In this chapter I am only going to suggest one method, and a simple one at that, so that any beginner can obtain a jumping-off point for his designing.

The rest follows as a matter of course, as the individual gains experience and according to his own ability and powers of originality.

There is one golden rule that should always be adhered to, in my opinion, whatever the type of model that is decided upon. All component parts such as wings, tailplane, fin and engine should be designed in

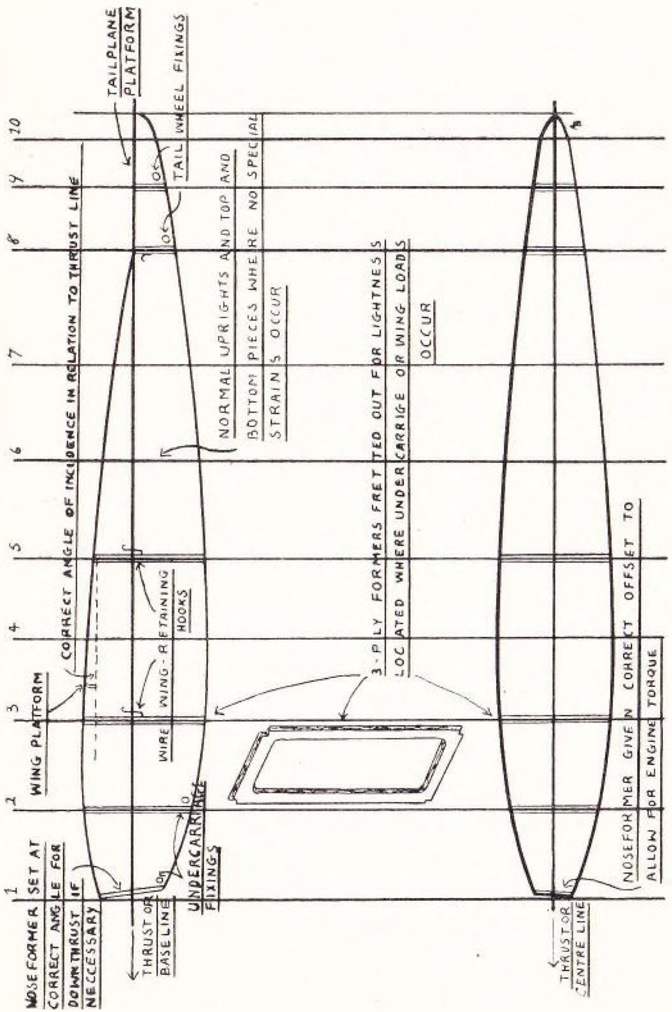


Fig. 36
Method of Laying out Full-sized drawing of simple rectangular Fuselage (High Wing)

such a way that in the event of a bad landing these components can be *knocked off undamaged instead of smashed off and wrecked!* Therefore abandon the idea of wire bracing straight away. Eschew rigidity.

The Method.

First decide upon what general type of model is required, and I strongly suggest a simple one for the first model. Make a rough freehand general arrangement sketch. During this sketch one gets the general arrangement ideas of the model.

Now obtain a roll of white kitchen paper. This is cheap and does very well for the full-sized drawing.

Make a full-sized drawing side elevation of the fuselage. See Fig. 36, which is a simple type high-wing model.

Begin by drawing a central line lengthways and call it " thrust-line." Mark off the length of the fuselage on this line.

One can then arrange the wing and tail positions and other details to comply with the requirements of stability enumerated in Chapter IV, using this base line or " thrust-line " as the basis of the design.

Angles of incidence of mainplane and tail can all be measured from this " thrust-line." These matters are not then left to chance, and each has to be considered in relation to the other.

If no base line is used it is difficult to get angles of incidence, etc., correct in relation to one another. In fact, the whole model becomes a hit and miss affair. " Down-thrust " can be measured as required so that the front bulkhead is correctly tilted. " Offset " of thrust to allow for engine torque can also be correctly given.

The desired outline shape of the fuselage can now be drawn, so that the centre of pressure of the wing will come in the correct position in relation to the thrust line. See Chapter IV.

The undercarriage must be located as *far forward as possible* if the model is not to nose over on taking off and on landing. Never position the undercarriage just about at the C.G. position as in full-size practice. *It cannot be too far forward.*

Now draw in uprights and position the stout three-ply formers where you visualize strains of under-carriage loads and wing fixings will have to be taken. Number these formers and uprights off from the front. See Fig. 36.

Next draw another centre line some 12 ins. or so below the completed fuselage and parallel with the original thrust-line.

Now extend the former lines so that they cut the lower centre line. The top or plan view of the fuselage can then be drawn in to suitable widths for location of the wing and tailplane. Refer again to Fig. 36.

You now have the correct widths of all formers as well as the correct side elevation heights, and you should allow the correct offset of the thrust-line to allow for engine torque. Three-ply formers can be drawn in outline from these dimensions.

Now locate where you consider battery, coil, etc., should be fitted. Draw in all fittings that you consider will be necessary, and you are then ready to start construction of your fuselage.

Construction of the Fuselage.

Obtain a sufficiently large board and place your

full-sized *side elevation* drawing on it. Cover this drawing with greaseproof but transparent paper. You will then be able to see your drawing and yet glue will not stick to the drawing when you eventually glue formers into position.

Pin the whole down with drawing pins to the board.

Obtain a number of these pins and place your two top longerons one above the other on the drawing with

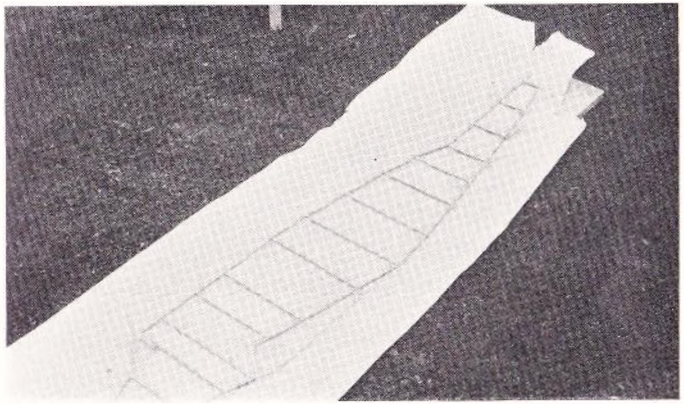


FIG. 37.

The full-sized drawing, side elevation, of the fuselage is laid on a board and the longerons are pinned on either side and steamed.

pins on either side to keep them in position above the outline drawing.

Direct steam from a boiling kettle onto these longerons and bend to the desired shape, gradually pinning the entire length to the board.

Carry out the same procedure for the two lower longerons which should also be one on top of the other.

Allow twenty-four hours to set hard with the pins on either side of the longerons.

Fig. 37 is a photograph of a biplane cabin model fuselage set out in the above manner. Unfortunately the steam has crinkled the drawing and therefore rather spoilt the photograph. But the method should be made clear.

Uprights can now be glued in with a cellulose glue such as Durofix. In order that the top side of the fuselage shall not stick to the bottom, small pieces of greaseproof paper are inserted between the two sets of longerons where the uprights are glued to the longerons.

When the glue has set, the pins can be removed, and the two sides of the fuselage can be separated.

Where complete three-ply rectangular formers have been decided upon, these can now be inserted, bound at the corners, and glued. The nosepiece former is next inserted, followed by the tail end former.

Finish by gluing in the top and bottom cross-pieces.

Wire and other fittings can now be added and bound with thread and glued into place.

No cross-bracing should ever be necessary as the final silk covering when doped will do all the bracing necessary. Any other attempt at bracing is merely added complication and weight.

For methods of covering with silk, and general finishing details, see Chapter VII, "Methods of Construction."

Wings.

Wings and tail unit can be laid out in a somewhat similar manner, the full-sized drawing being made on sheets of kitchen paper as before.

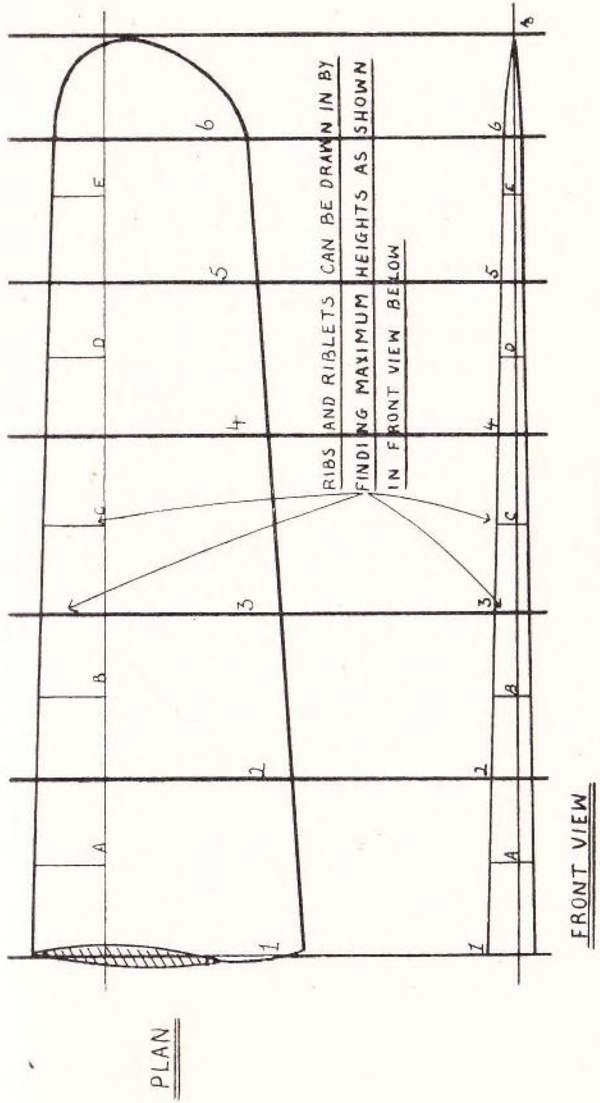


Fig. 38.
Method of drawing a tapered wing and ribs.

If a tapered wing is required the method of making the full-sized drawing, plan form, is shown in Fig. 38.

For actual constructional details of wings, see Chapter VII. Undercarriages and fittings are also dealt with in this chapter.

If the reader desires to construct a streamlined monocoque fuselage in preference to the simple rectangular type fuselage described in this chapter, he should refer to Chapter VII, although he should remember that the actual laying-out of the design, drawing, and method of constructing on boards is the same.

CHAPTER VII

METHODS OF CONSTRUCTION. THE MONOCOQUE FUSELAGE, WINGS, AND THE TAIL UNIT, WITH NOTES ON MATERIALS AND THE UNDERCARRIAGE

Monocoque Fuselage Construction.

THIS form of construction has not often been attempted in the past in connection with petrol models.

The reader who wishes to build his models with this type of construction should undoubtedly be experienced, and will therefore not require the fullest details. I therefore propose to indicate on broad lines the three types of monocoque construction that I have attempted to date, whilst a general constructional description of a successful monocoque low-wing model is given in Chapter XI.

Stringing and Stressed Skin Method.

The first method that I evolved can be seen in Fig. 39, which is a photograph of a low-wing model with the wing removed. The cut away portion for wing location can be seen.

The fuselage has a detachable tailplane. Briefly, the main points of my first type of construction are:

(1) Backbone.

(2) Half oval formers glued on to both sides of the backbone.

(3) Stringing the whole fuselage with balsa stringers $\frac{1}{8}$-in. × $\frac{1}{8}$-in. section.

(4) Filling in the highly-stressed nose with solid balsa wood slightly hollowed out in the centre.

(5) Covering the whole with $\frac{1}{16}$-in. sheet balsa.
(6) Covering the whole fuselage with silk.
(7) Doping and colouring the fuselage.

The Backbone.

The backbone upon which the whole structure is built is composed of three-ply wood at the front where the engine and undercarriage stresses occur. From

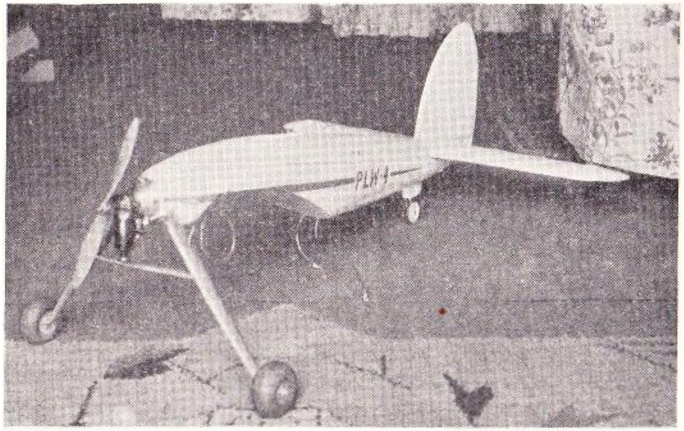


Fig. 39.
Author's Monocoque fuselage for a low-wing Monoplane fitted with inverted "Brown" Engine.

about one-third back, the backbone is composed of $\frac{1}{8}$-in. thick balsa wood cut out to the outline side elevation of the fuselage. The centre is then cut out for lightness. See Fig. 40, which is a backbone for a low-wing monoplane. The cut-away portion for the low-wing location can be seen and also the detachable tail-plane platform is located below the fuselage in this case.

Referring back to the second constructional point,

Fig. 40.
Backbone for Monocoque construction (first method).

the oval formers are cut in two halves, one half is glued onto one side of the backbone and allowed to set hard. Durofix glue is used. The other half ovals are then glued into position on the other side. These half ovals are made of $\frac{1}{8}$-in. thick balsa cut to shape except the nosepiece and where undercarriage fittings are located or wire wing retaining hooks, where the oval formers are of three-ply wood. See Fig. 41.

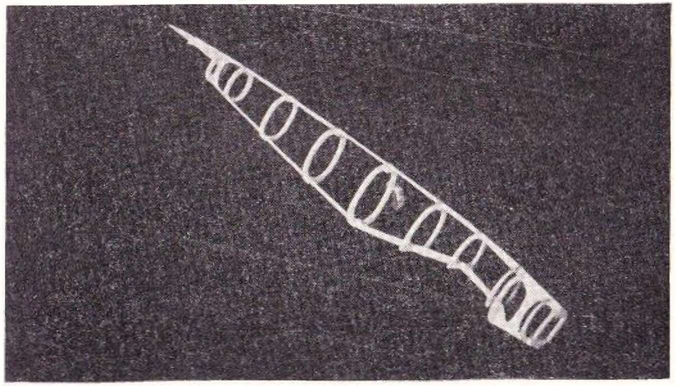


Fig. 41.
The balsa wood oval formers are now glued to the backbone.

In the case of the undercarriage, duralumin tubes are bound with thread across the fuselage to receive the detachable legs of the simple but robust detachable type of undercarriage as now used on all my models. A description of this type of undercarriage is contained later in this chapter.

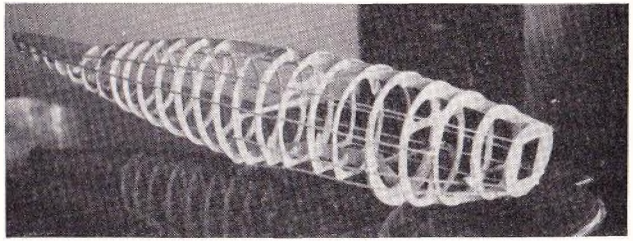


FIG. 42.
The Biplane skeleton with the first few stringers added.

Stringing the Fuselage.

Now examine Fig. 42 and it will be observed that a few $\frac{1}{8}$-in. × $\frac{1}{8}$-in. balsa stringers have been added to the biplane skeleton. The whole fuselage is then strung in this manner until stringers are located at about $\frac{1}{2}$-in. intervals. The stringers are kept in position by small touches of Durofix glue and are kept to the skeleton until dry by a few turns of model elastic wrapped around the whole fuselage.

Covering.

The fuselage is next covered with sheets of $\frac{1}{16}$-in. thick lightweight balsa wood. This balsa should be obtained in sheets of approximately 4 ft. long and 6 ins. wide, for convenience.

Sections are covered at a time, and where there is a double bend a section is left in boiling water for about 5 minutes before being stuck onto the top of the stringers with plenty of Durofix glue.

Model aeroplane elastic is wrapped round the fuselage until the balsa covering is dry. It is then removed and any cracks or poor joints are filled in with touches of plastic wood, allowed to set hard, and the whole is rubbed carefully down with sandpaper until quite smooth.

The fuselage is now covered with silk, of the thin Jap variety, and it is this silk over the balsa covering that provides the exceptional strength of this method combined with light weight. The oval shape, of course, also has a lot to do with the strength.

It will be observed that we now have a fuselage of great strength constructed almost entirely of balsa wood, the lightest and yet most easily broken wood obtainable.

To attempt to obtain the same strength for weight from a rectangular balsa-wood fuselage is impossible.

When covering with silk, Kodak photopaste is *liberally* smeared onto the fuselage.

The silk is then worked taut by the fingers. This photopaste also has another purpose.

It quickly dries and fills up the porous surface of the soft balsa sheet and prevents an undue amount of heavy dope soaking into the balsa.

Finally the whole fuselage is doped with one coat of *full-sized aeroplane clear dope.* Do not use model dope as it is not sufficiently stiff when dry for petrol models.

Monocoque Construction, No. 2.

In my second method I used a well-known type of construction in the American rubber-driven model world, but as far as I know I was the first to try it on a petrol model in this country. It has been perfectly satisfactory although a trifle heavier than in the method just described.

Briefly, the method is merely the hollowing out of a solid balsa-wood block to form a streamlined shaped fuselage.

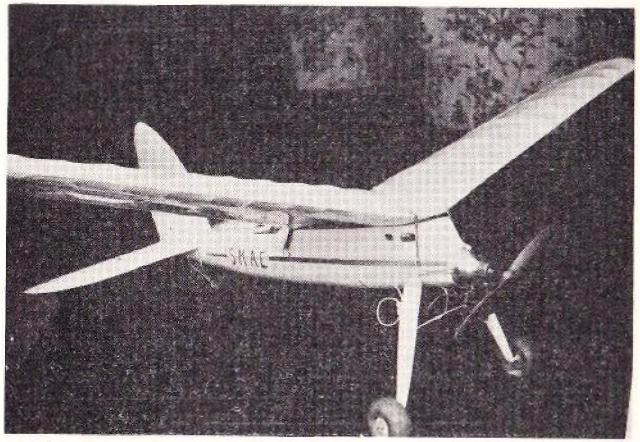


FIG. 43.
The author's 6 ft. 6 in. span Monocoque-fuselaged Model constructed on Method No. 2.

The idea is simple, but it presents certain other problems connected with reinforcement of the balsa where the engine, undercarriage and wing strains occur. The large balsa block is rather expensive, too. Fig. 43 shows a 6 ft. 6 in. model built up on this principle with the mainplane and tailplane kept in position by rubber bands to wire hooks which protrude from the fuselage. The undercarriage prongs are

located in duralumin tubes which are pressed into the hollow fuselage. Where the wire hooks and undercarriage tubes are located, the balsa shell is reinforced with plastic wood to take the stresses set up.

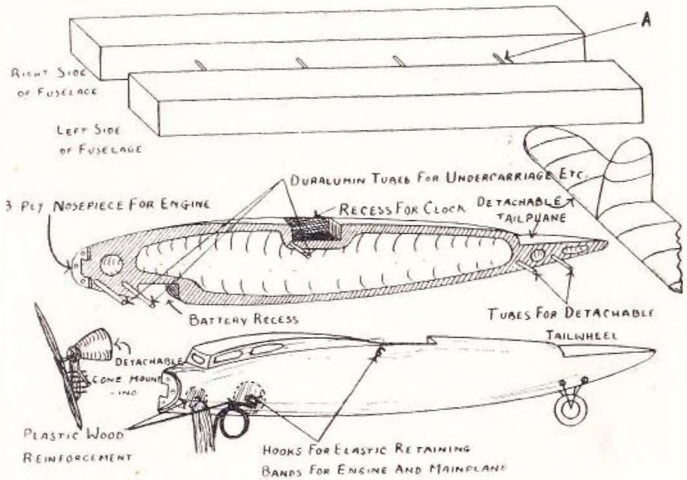


FIG. 44.
Method No. 2. Fuselage carved from two blocks of soft white balsa and hollowed out.

If the reader will carefully study Fig. 44 he will notice that two rectangular blocks of soft white balsa are used.

The blocks are temporarily pegged together with wire pegs and a few blobs of glue that can easily be broken later.

The main shape of the fuselage is then carved out with a sharp knife, and the fuselage is sanded down to shape.

For those with a poor " eye " for shape, outside templates must be used to check up the shape at various points.

The two sides are then separated and the internal hollowing is carried out for lightness. This is done with a gouge with a curved shaft.

Where the detachable undercarriage legs fit into their duralumin tubes, the fuselage is left solid. The tubes then have a solid and firm basis and near the ends of the tubes where they emerge from the sides of the fuselage, portions of the balsa wood shell are cut away and filled in with plastic wood to help to take up landing loads.

The engine nosepiece is constructed of ¼-in. thick three-ply wood and is attached with a series of 2-in. long thin wood screws.

The fuselage halves are eventually glued together, and when dry a final sanding is given to smooth off.

The whole is then covered with Jap silk and Kodak photopaste as in No. 1 method, with a final coat of full-sized aeroplane clear dope, which can be followed with a coat or two of colour if the constructor desires.

The cabin on top of the fuselage is constructed of ⅛-in. thick balsa sheet and covered with silk. Celluloid windows are fitted.

No. 3 Method of Monocoque Construction.

This last method I find most useful for light and small petrol models to suit 6-c.c. engines or the 2·4-c.c. "Elf" engine type.

As the construction is described in detail in Chapter XIII, it is merely necessary here to say that a backbone and skeleton is built as in the case of the first method, but instead of stringing and fitting an outer covering, a great number of ⅛-in. × ⅛-in. section balsa lengths are laid side by side around the skeleton and glued together.

The whole is then sanded down with coarse sand-paper and finished with fine grained paper. The fuselage is covered with silk and doped as before. Fig. 45 shows a little model made up in this way for the 2·4-c.c. "Elf" engine.

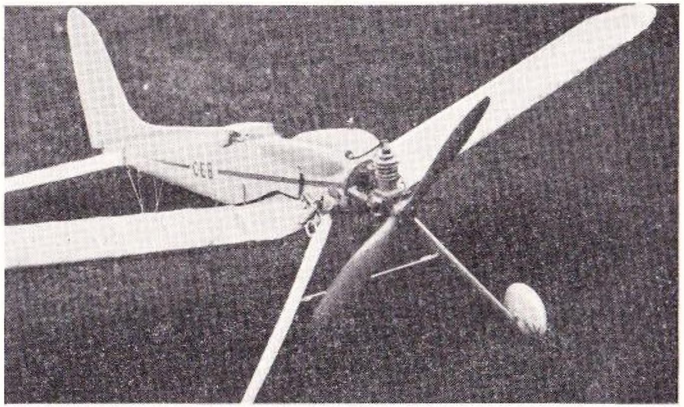


FIG. 45.
A small 1¾-lb. Model for the 2·4-c.c. "Elf" Engine made up by the No. 3 Method.

The Rectangular Fuselage.

This can be constructed as described at the end of Chapter VI. It can either be covered first with sheet balsa $\frac{1}{16}$-in. thick and then with silk, or a silk covering only can be used. The first method is very strong indeed, and does not add much to the weight. Spruce longerons and uprights, etc., can be used, or if only covered with silk, birch is stronger and therefore advisable.

Covering with Silk.

Covering is an art that has to be learnt by practice if no wrinkles are to appear. The secret is to use Kodak photopaste as an adhesive. Then to *lightly* stretch the silk with the fingers so that no wrinkles appear. Then spray with water from a scent-spray. Take out any further wrinkles that appear and stretch finally taut, but not too taut, by working the silk with the fingers. Allow to dry and if any wrinkles or mistakes have been made, re-spray with water and the photopaste will soften and allow the bad section to be pulled up. *This is the value of using photopaste.* Now dope with *full strength aeroplane dope.* I personally obtain this from Cellon Ltd. This full-strength stuff will form a strong weatherproof skin that dispenses with any internal bracing of the wings or fuselage.

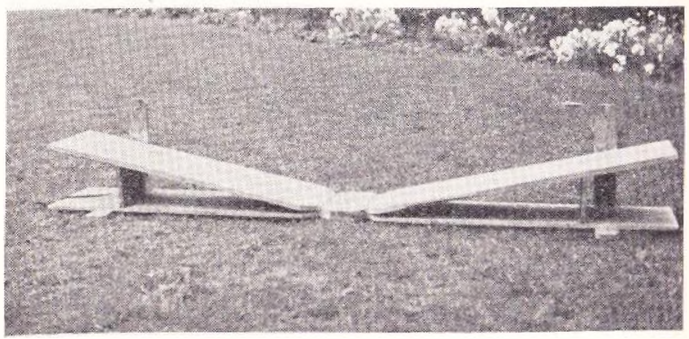


FIG. 46.
A wooden bed to build a wing upon. The dihedral angle is catered for in the bed.

Wings.

The method of making the full-sized drawing for the wing was described in Chapter VI.

A wooden jig or bed should be made as shown in

Fig. 46. This bed has the desired dihedral angle built into it.

The correct dihedral angle can be built into the wing and the wing remains absolutely true with this method.

When the wing is covered and doped it can be left on its bed with weights on it until it is dry. In this way the dope tightens up without distorting the wing.

Wings can be constructed in two halves for portability as described in the description of the "Blue Dragon" in Chapter IX.

Suitable materials for the average large or medium-sized petrol-model wings are a $\frac{1}{4}$-in. × $\frac{1}{8}$-in. spruce leading and trailing edge with two $\frac{1}{4}$-in. × $\frac{1}{8}$-in. birch main spars located one above the other, about one-third back from the leading edge.

The wing tips can be of 16 s.w.g. steel piano wire bound to the leading and trailing edges with thread and glued. A strip of $\frac{1}{16}$-in. thick balsa sheet can be glued under the trailing-edge spar and about 1 in. wide to the ribs. The ribs, except the central ones of three-ply, should be of $\frac{1}{8}$-in. thick balsa wood.

Riblets can be used from leading edge to central spars between the main ribs. Now a solid soft balsa-wood filling is cut to a streamlined shape at the wing-tip. This is then sandpapered smooth, and when the wing is covered with silk the tips become very strong, look well and are practically indestructible in a crash.

The trailing edge should be sandpapered to a sharp edge at the rear.

It is an excellent practice to cover from the leading edge to the central spars with $\frac{1}{16}$-in. thick balsa wood in the case of large wings. The wing becomes very strong to resist torsion, and the extra weight is only a matter of a very few ounces. See Chapter XI.

An excellent and stable wing section is shown in Chapter IV, Fig. 35, for the "Blue Dragon."

I evolved this section after a great number of tests. It has good lift and slow flying qualities and suits most models.

If this under-camber section is used, the wing must first of all be covered from the bottom with damp silk, and each rib must be stitched with thread to the silk covering to prevent the dope destroying the under-camber. This is a laborious process but very necessary.

For detachable wings made in two halves see Chapter IX, the "Blue Dragon."

The wing root of a wing made in two halves should be covered with 1 m.m. three-ply and have $\frac{1}{8}$-in. thick balsa sheet inserted between the main spars for several bays.

Where the dihedral angle occurs it is as well to reinforce the wooden spars by binding 16 s.w.g. piano wire lengths onto the wood with thread and finally glue.

The Tailplane and Fin.

These two components may be built separately, but I have found from experience that more consistent flying results are obtained if they are built as one unit. For good landings after a *straight* glide a model must have neither warp on a wing nor an offset fin. When the engine is running, torque will turn the model. This is often counteracted by an offset fin or warp on a wing, but when the engine stops the model gets into a turn on the glide which will either cause a cross-wind

landing, or a wing-tip cartwheel on landing. A spin can even take place in extreme cases. A far better plan is to offset the thrust-line to take up engine torque and keep the fin straight, thus ensuring a straight glide. If the tail unit is made in one unit it is less likely to suffer from slight alterations of position each time the model is erected.

The tail unit should, in my opinion, be made detachable and kept in position with elastic bands or some type of spring fastening. This will allow it to be knocked off in the event of a crash and also make the model easy to transport. Fig. 47 gives a general

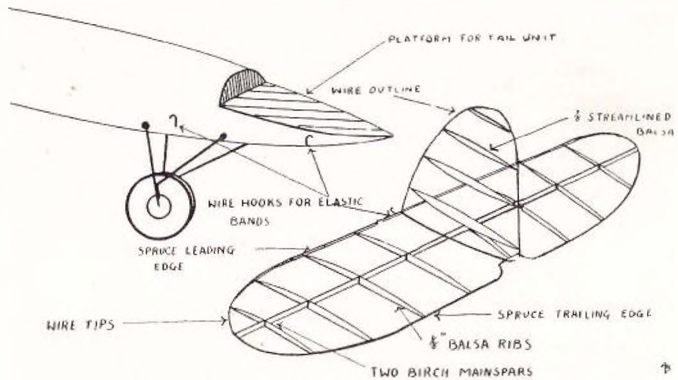


FIG. 47.

Tail and fin combined and made detachable.

idea of a suitable type of tail unit construction. A glance ahead at Fig. 51 will show a completed tail unit.

Wheels.

Wheels are a considerable problem for the petrol model. A certain amount of weight is usually beneficial low down, but if the wheels are too heavy the wing-loading is put up unduly. The diameter must be as large as possible for ease of taking off and landing, and yet if the side area shown *below* the C.G. is too great, the lateral stability of the model will be upset. (See Chapter IV.) For models of about 8-ft. span, $4\frac{1}{2}$-ins. diameter is an excellent compromise for the wheel. For smaller models a certain amount of diameter must be sacrificed.

The greatest difficulty to overcome is the action of a cross-wind landing with drift on, which naturally tends to tear tyres of the inflated type off their rims. I have evolved two different types that are quite satisfactory.

The first is very simple and cheap to construct from three-ply wood and streamlined outside discs of balsa. Fig. 48 will make the construction clear, whilst Fig. 49 is a photograph of the completed wheels.

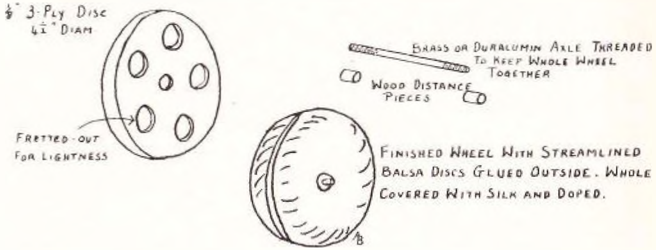


FIG. 48.
A Simple Three-ply and Balsa Wheel.

The second type is rather heavy but otherwise most satisfactory and quite simple to make. If the model has plenty of wing area this type is to be recommended as it cannot give trouble. I approached the Dunlop

Rubber Co. (Aero Section), of Fort Dunlop, Birmingham, and they made me up two special moulds so that $4\frac{1}{2}$-in. diameter and $3\frac{1}{2}$-in. diameter light "Dunlopillo" rubber balls pierced in the centre could be produced. These are now available to the general public.

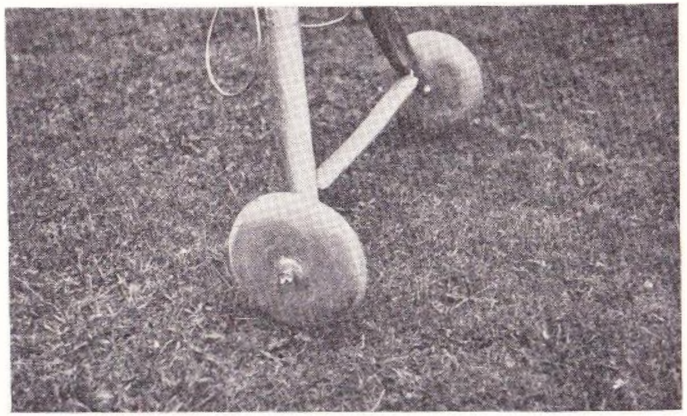


FIG. 49.
Simple type of three-ply and balsa wheels.
Cheap and light.

Two Elektron or duralumin discs are made and threaded in the centre. An axle bush of duralumin is then threaded at each end. The two discs, when screwed into the axle bush, with the ball compressed between, make excellent wheels, and the action of the rubber prevents the discs from unscrewing. The balls being of solid rubber cannot be torn off on landing, whatever the strain. The "Dunlopillo" type of rubber is filled with thousands of little air holes, thus making the rubber reasonably light. Fig. 50 will make the method of construction clear.

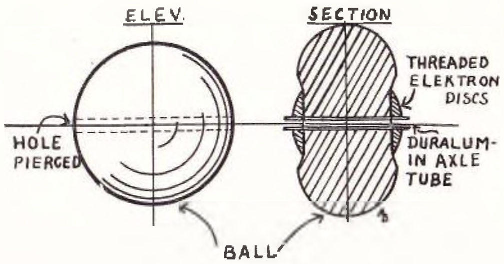


FIG. 50.
"Dunlopillo" Rubber Ball Wheels.

If a very light wheel is required, the American "M. and M." wheel is now available on the market. These wheels can be obtained for petrol models $4\frac{1}{2}$-in. diameter or $3\frac{1}{4}$-in. diameter. Fig. 51 shows a fuselage

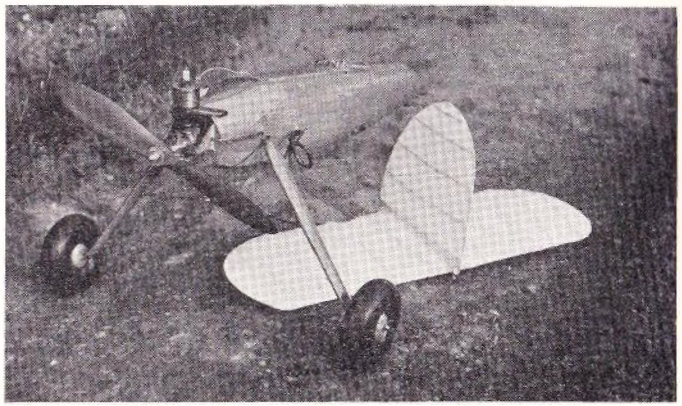


FIG. 51.
American "M. and M." wheels which are exceptionally light. The combined tailplane and fin should be observed.

fitted with these wheels. The tyres can be blown up by a mouth tube supplied with the wheels.

Tail Wheels.

A tail wheel is more useful on a petrol model than a tail skid if the model is meant to take off by itself, for it allows an easy start before the tail lifts. Fig. 52

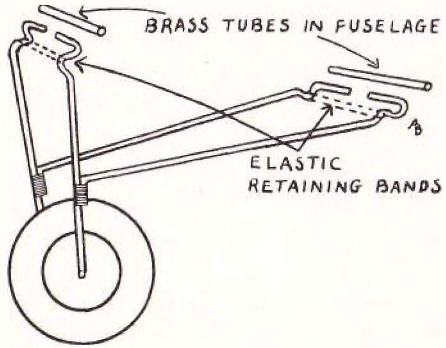


FIG. 52.
A Detachable Tailwheel.

shows a suitable type of tail wheel that is detachable and therefore allows a tail float to be fitted in lieu if flights off water are desired.

Undercarriages.

A petrol model with even a good flat glide does not land in the stalled position as a full-sized aeroplane does, for there is no pilot to hold the model off, and so make a "three-point landing."

The petrol model glides *into* the ground. See Fig. 53. The result is that the normal type of undercarriage as fitted to the full-sized aeroplane will not do, and yet practically all newcomers to petrol models, and a great many old hands, too, try to fit an undercarriage on the lines of full-sized practice.

The petrol-model undercarriage must *first give backwards and then upwards.*

The undercarriage I now fit to all my models complies with the above requirements and is practically indestructible, and also goes a very long way towards saving the model from damage in a heavy landing. Its chief criticism may be that it does not look very beautiful. But it is simple and easily made with the normal tools that an aero-modeller possesses.

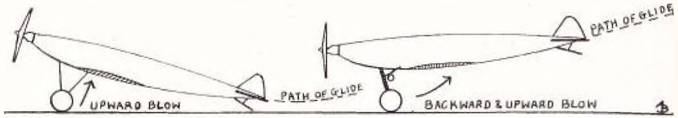


FIG. 53.

Full-size Aeroplane making Three-point Landing.
A Petrol Model gliding *into* the ground.

If the reader will study Fig. 54 and then read the description of the undercarriage he should find no difficulty in construction.

Model enthusiasts are very difficult to convince and therefore most of them who read this book will doubtless fit various types of undercarriage, in fact any type but the one to be described! When their troubles commence I urge them to just give one of my undercarriages a trial, and build it as I do and without alterations! You will note that I really am a believer in the contraption!

Many people try to fit their undercarriages too far back in order to look well. The best, and in fact, *only* satisfactory place for an undercarriage on a tractor model is as far forward as you can get it. If a tail

wheel is fitted there will be no difficulty in taking off, and what is so important, the model will not nose over in long grass during the take off, nor will it nose over on landing.

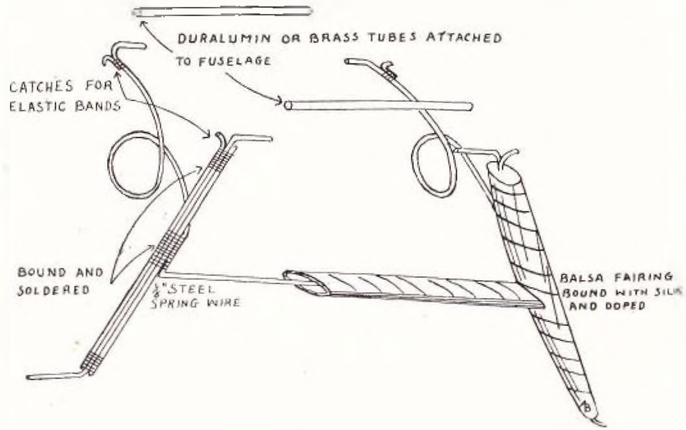


FIG. 54.

Undercarriage for Petrol Models.

Now look at Fig. 54.

The undercarriage for a 6-lb. to 10-lb. petrol model is composed of two main legs of $\frac{1}{8}$-in. diameter *spring steel* wire turned out at the lower ends to form stub axles for the wheels.

The upper ends may be either carried across to join the legs and then eventually bound to the floor of the fuselage by thread and glue, if the undercarriage is to be a permanent fixture; or the ends may be turned in and cut off $1\frac{1}{2}$ ins. after the bend.

These projections can then be fitted into a duralumin or brass tube which has been bound across the bottom of the fuselage.

The undercarriage will then be detachable if the rear circular spring legs are similarly treated.

A cross-bar is fitted between the two main legs. It is located about half-way up. This helps to steady the legs and yet allows good clearance for long grass.

The crossbar is also made of ⅛-in. diameter spring steel wire turned up beyond the right-angle at each end and carried on into the two rear circular spring legs. These turned-up portions are bound with florists' wire to the main legs and soldered.

The two rear legs are formed as continuations of the ⅛-in. steel wire used in the crossbar and are in the form of circular springs. These allow the two main legs to go backwards and then upwards on the forward impact of the model with the ground.

These circular springs are bent by hand in a large vice—not an easy job. The rear legs are then bent inwards at their extremities, to form prongs of 1½ ins. long to insert into the rear fuselage tube.

If it is found that the undercarriage works too easily, then further circles are bent to the same size and bound side by side to the original wire circles with insulating tape. This stiffens up the spring action, of course.

The two main legs are reinforced by two more straight lengths of ⅛-in. diameter wire for each leg.

These are bound with florists' wire and soldered to the legs.

One of the reinforcing pieces on each leg is turned outwards at the top to form a catch to keep the strong elastic bands in position that are used to keep the two legs firmly into the fuselage tube. Small wire catches are also soldered to the rear circular legs to perform a similar purpose.

The final stages of construction are the fairing of the legs and crossbar with balsa sheets, and the covering of the faired legs with silk and dope. Strips of ⅛-in. thick balsa are used on each side of the legs with strips sandwiched in between, both at the front and rear of the legs. Plenty of cellulose glue is used and the fairing strips are kept together, until dry, with model aeroplane elastic.

When the elastic is removed the balsa fairing can be streamlined off with a razor blade and then sand-papered. Thin strips of Jap silk are then bound carefully around the legs, using plenty of Kodak photopaste. When fairly dry the legs are given a coat of *full-sized* aeroplane clear dope. They are then painted in colour to waterproof.

CHAPTER VIII

PROPELLERS FOR PETROL MODELS

General.

It is not an easy matter to calculate the correct pitch and diameter for a petrol model owing to the fact that the model engine varies so much in power and revolutions per minute. Very few model engines even of the same make produce exactly the same results. The full-sized engine can be relied upon to produce almost exactly what it is designed to do. The recent advance in model commercial engine construction has certainly produced far more consistent results due to more or less mass production methods. Where engines are made up by private individuals from sets of castings but from the same design, the difference in performance is often very marked.

The reader may console himself, however, by the fact that it is not important that the very last ounce of efficiency should be obtained from the propeller of a petrol model, due to the increased efficiency of the modern model petrol engine, and that in all cases except for competition work, provided the model flies well, that is all that is required. There is no Air Ministry test or commercial payload to be considered.

Fortunately the petrol-driven model can generally afford to waste a certain amount of power, whereas the rubber-driven model must give away nothing to be successful.

The petrol man is really concerned chiefly with one object, namely, to get his model into the air and keep

it there for one or more minutes, until the timing device shuts off the engine to terminate the flight.

Nevertheless, an approximately correct pitched propeller must be fitted, or the model will not fly.

The American competition is largely concerned with petrol consumption, but at the moment we are not bothered by this rule of doubtful value.

Correct R.P.M.

Our problem then boils down to finding the best r.p.m. of the engine under load to produce the greatest power, and then to produce a propeller that will allow this desirable r.p.m. and yet ensure that *the blades are not stalled.*

Stalling of Blades of Propeller.

The blades of a propeller, as most people know, are merely small aerofoils or wings, and these aerofoils must be of correct section and must be set at the correct angle of incidence to produce thrust without stalling, at the speed at which the engine produces its best power and a compromise between the forward speed of the aeroplane in flight and the slower speed of the take off.

The ideal, of course, is to have a variable pitch propeller which will adjust this angle of incidence of the blades according to the speed of the aeroplane. For petrol-model work where simple flying is only desired, the complication of variable pitch is not worth while. A compromise can be made that will work satisfactorily.

The reader will appreciate that if too great an angle of incidence is given to a high-speed wing, then the even airflow breaks down over the wing and it stalls.

The propeller blade is exactly the same except that it travels at a greater speed than a normal wing, if the propeller is fitted directly to the crankshaft and is not geared.

It is doubtful whether gearing is a feasible problem for the petrol model owing to extra complication, chiefly due to the fact that if a propeller is not bolted up to the engine crankshaft *without play*, then a flywheel must be fitted in lieu.

The *average* model aero-engine of to-day gives off its best power at around 3,000 to 4,000 r.p.m.

The engine that I used in order to set up the British record in 1934 revolved at between 7,000 and 8,000 r.p.m. under the load of its propeller, but this was exceptional for a model aero-engine, and was done in order to create a quick and exceptional climb so that the model would spend as much time as possible circling upwards within the view of the official time-keepers. The existing British rule for records being that the timekeepers must remain at the starting-point, and the model is clocked until it goes out of sight. No binoculars are allowed.

Forward Speed of Model.

The estimated forward speed of the model next comes up for consideration.

At the beginning of a flight when the model has to be moved across the ground the speed is very slow and therefore a very fine pitch is required, i.e., a fine angle of incidence on the propeller blades to prevent stalling of the blades.

A lightly-loaded and therefore slow-flying model will not gather any very much greater speed before it takes off and flies.

Therefore the pitch may be kept low. This suits both the take-off and the flight, and let me add here that a lightly-loaded model for general purposes is the best model to control in all respects.

A heavily-loaded model has a considerable speed to gain before it will fly. Therefore it is a considerable problem to get the correct compromise of pitch for the slow initial movement of the take-off and the high-speed flight.

That is why many full-sized high-speed aeroplanes adopt variable-pitch airscrews, which permit of a fine pitch for the take off.

Grading of Propeller Sizes and Pitches.

My experience has shown me that propeller sizes and pitches fall into classes according to the cubic capacity of the engines and the sizes and weights of the models.

I base my remarks upon fairly lightly-loaded and slow-flying models and give below a table of propeller sizes and pitches.

Fig. 55.

Propeller Table of Sizes and Pitches

No.	Approx. Engine c.c.	Approx. R.P.H.	Prop. Diam.	Pitch	Approx. Wt. of Model	Approx. Span
1	30 c.c.	2500	24″	12″	10 lb.	12′
2	18 c.c.	3000	16″	12″	$7\frac{1}{2}$ lb.	8′ to 9′
3	15 c.c.	3500	16″	$10\frac{1}{2}$″	7 lb.	8′ to 9′
4	10 c.c.	3500	15″	9″	$6\frac{1}{2}$ lb.	8′
5	6 c.c.	3500	$13\frac{1}{2}$″	$7\frac{1}{2}$″	$3\frac{1}{2}$ lb.	5′ 6″ to 6′
6	2.5 c.c.	3500	12″	6″	2 lb.	5′ to 4′ 6″

Note: For c.c. sizes and makes of Engines refer to Chapter II on the power unit.

This has been compiled from my own models and is only approximate, but will at least be a useful guide for experiment and thought.

Provided the engines are up to normal standard of efficiency for their class, success should be obtained if these dimensions are used

Blade Area.

I have always found that far better results are obtained by the use of a generous blade area coupled with a fine pitch.

This allows a good take off and excellent climb on a lightly-loaded model.

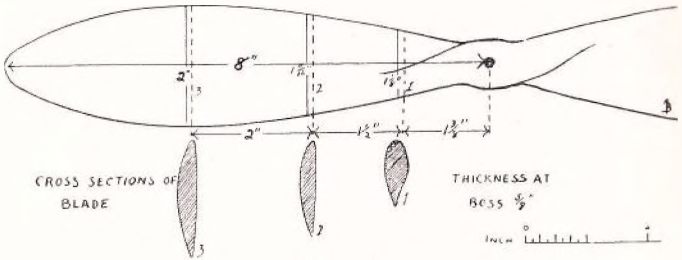


FIG. 56

Propeller for 10 c.c. " Brown Junior " Engine.
Symmetrical shape. Pitch 9 ins. Diameter 16 ins.

I do not favour the very small blade and very high speed for this class of model. A symmetrical-shaped blade is excellent. A good aerofoil section is essential.

The width of the blade around the propeller boss should be kept down, or it will form a useless disc of head resistance when travelling through the air. Fig. 56 is a sketch of the propeller I use for the " Brown " engine and will form a basis for other sizes of engine if the table in Fig. 55 is also consulted with regard to diameter, pitch, etc.

A heavy yet tough wood should be used for a wooden propeller in order to form a good flywheel effect for the engine.

Finally, if in doubt, or you are too pushed for time to carve your own propeller, remember that there are various model aircraft stores that can supply propellers, usually in wood, that are the result of experience gained from their own efforts or through individuals like myself who have expended considerable time and energy on the subject, and have published the results.

Metal or Wooden Propeller.

A word or two should be said on the question as to whether a wooden or cast alloy propeller should be fitted.

The wooden propeller is fairly easily broken and does not form a very good flywheel for the engine, but it is not so dangerous to fingers and spectators and if the engine is rigidly mounted it should always be used in order to save the crankshaft from damage in a crash.

If the model constructor, however, elects to mount his engine in a detachable engine-mounting as described elsewhere in this book, I *strongly advise him to do so.* Then he may use a metal propeller. If this strikes the ground or a tree it will very seldom break, and neither will the crankshaft become damaged, for the mounting which is kept in place with elastic will be knocked out. (See the chapter on engines and their mountings.)

Personally, I almost always use a cast metal propeller and seldom ever break one.

I get castings made up in Elektron from wood patterns by The Birmingham Aluminium Casting Co., Ltd., Birmid Works, Smethwick, Birmingham, who will make one a batch of several spare castings from a favourite wooden propeller for a shilling or two per casting.

I thus have consistent results and seldom require replacements, and in this way save money and time on replacements.

I carefully file up, balance, and finally polish the castings.

Elektron will bend but seldom cracks if moderately thick. It is 40 per cent. lighter than aluminium alloy. If the blades become bent to a moderate and reasonable degree, one can quickly set them true by bending cold by hand.

Instructions for carving a wooden propeller are not given in this book owing to lack of space and because there are so many model aeroplane manuals that thoroughly describe the process. The subject is fully dealt with in *The New Model Aeroplane Manual*, published by Percival Marshall and Co., Ltd., London. Fig. 56 gives outline dimensions for a propeller for a "Brown Junior" engine.

CHAPTER IX

THE "BLUE DRAGON" MONOPLANE—THE 1934 SIR JOHN SHELLEY CUP WINNER AND HOLDER OF BRITISH R.O.G. POWER RECORD FROM 1934 TO DATE OF WRITING IN 1937

General

THE "Blue Dragon" was designed purely as a competition model with exaggerated stability and complete simplicity. It is an easy model to construct and will stand up to a lot of abuse. It would make an excellent beginner's model. Although built in 1934 it is still flying, to-day, in 1937 and has had comparatively little

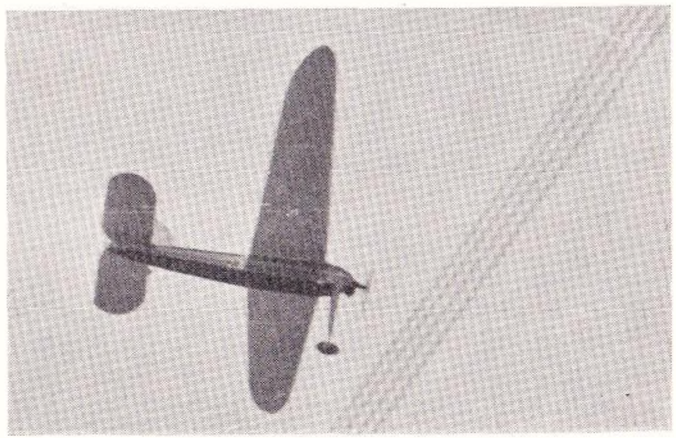
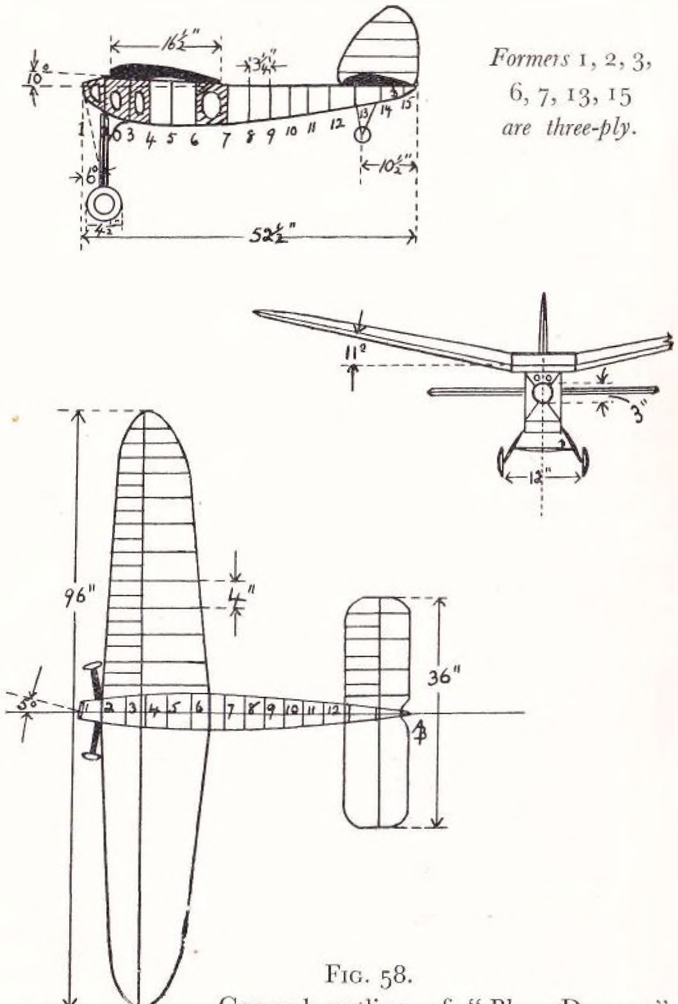


FIG. 57.
Depicts the "Blue Dragon" gliding overhead and narrowly missing some power cables.



Formers 1, 2, 3, 6, 7, 13, 15 *are three-ply.*

FIG. 58.
General outline of "Blue Dragon."
Weight ready for the air, 6½ *lbs.* Note: *Angle of incidence of mainplane shown as* 10° *should be* 8° *and downthrust* 8° *instead of* 6°.

repair work done to it. Beauty of line was not considered when designing the model. Full sized blue prints of the model can be obtained from "Kanga Aero Models," Birmingham.

Fig. 57 shows the model caught by the camera as it glided slowly overhead at the termination of a seventeen-minutes' flight in Scotland. Two friends and myself had followed the model in my car. She narrowly missed the power wires seen in the photograph. The model made a perfect landing. She is an exceptionally slow glider and also flies very slowly and is therefore very controllable. The model is now fitted with a "Brown Junior" 9-c.c. engine, whereas an "Atom Minor" 15-c.c. engine was used to set up the British record. The "Brown" engine is less powerful and more suitable for normal flying. A 6-c.c. Baby Cyclone engine flies this model on full throttle and forms a very satisfactory combination.

Fig. 58 is a general outline drawing of the model and should be used to produce a full-sized drawing as described in Chapter VI if the reader wishes to make a replica of this model.

The Fuselage.

This is a simple rectangular affair. The correct angle of incidence of the mainplane is obtained by sweeping the top longerons upwards at the nose to make a platform for the wing. The longerons are of ⅛-in. × ⅛-in. square birch. The nosepiece is detachable and is an Elektron casting. See Fig. 59. The "Brown" engine has about one-third of the rear end of the petrol tank cut off to reduce overhang. The end-plate is then resoldered into position.

The nosepiece is kept in position by elastic bands from wire hooks on either side of the fuselage.

The thrust-line of the model is kept as high as possible above the C.G. position to look after good fore and aft stability. Down-thrust and offset of thrust are given as shown in Fig. 58.

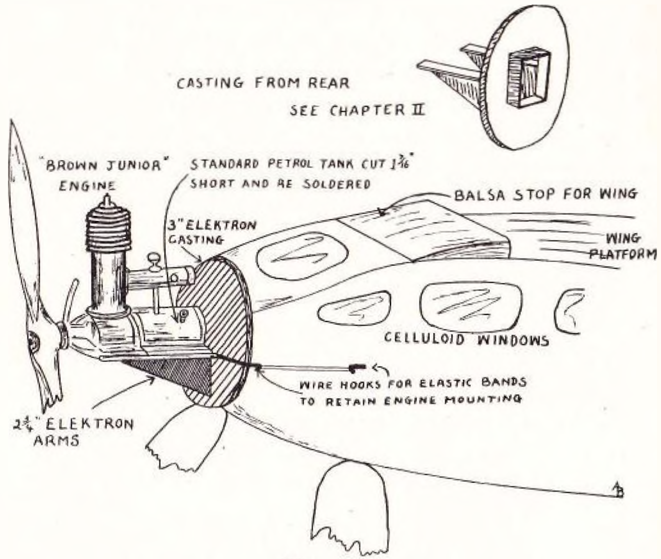


Fig. 59.
Nose of " Blue Dragon " showing Detachable Engine Mounting.

The coil is strapped to the floor of the fuselage by wire just behind the nosepiece, whilst the pocket flashlamp battery is located on the floor of the fuselage, 24 ins. from the nose.

Elastic bands hold the battery in position and a door is situated in the left side of the fuselage to gain access to the battery.

An " Allman " type clock to control duration of

flight is held on top of the fuselage by elastic just behind the wing.

The fuselage should be built up as described at the end of Chapter VI and then covered with damp silk, allowed to dry, and then doped with one coat of full-strength clear dope, and finally painted blue.

The uprights are of $\frac{1}{8}$-in. × $\frac{1}{8}$-in. birch, whilst three-ply $\frac{1}{8}$-in. thick formers are fitted where shown in Fig. 58. These take the strains of the undercarriage and the rubber bands that pass around the fuselage and hold the wing in position.

It will be noticed in Fig. 58 that there are four three-ply side panels fitted in between formers. These, like the three-ply formers, are fretted out for lightness, but help to strengthen the front end of the fuselage. As well as being glued into position with Durofix glue they are bound with thread around the longerons at top and bottom. The fuselage back to No. 7 former is covered with $\frac{1}{16}$-in. thick sheet balsa before the final covering of silk.

The Undercarriage

is constructed exactly as described at the end of Chapter VII. A tail wheel is fitted. See Chapter VII.

The Wheels

can be either the simple wooden wheels or the " Dunlopillo " wheels described in Chapter VII.

The Wing

is of tapered plan, and has a span of 8 ft. with a chord of 16 ins. at the root. This chord tapers to 6 ins. just before the tips. A slight wash-out or negative angle is given to the tips, and the wing is constructed on a wooden bed as described in Chapter VII. The correct tapered shape should be carefully adhered to as the trailing edge comes forward whilst the leading edge is nearly straight. This has been proved in full-sized aircraft to be the most stable type of tapered wing up to the moment of writing.

The wing is made in two halves for portability, and the wing tips are of 16 s.w.g. wire with solid balsa

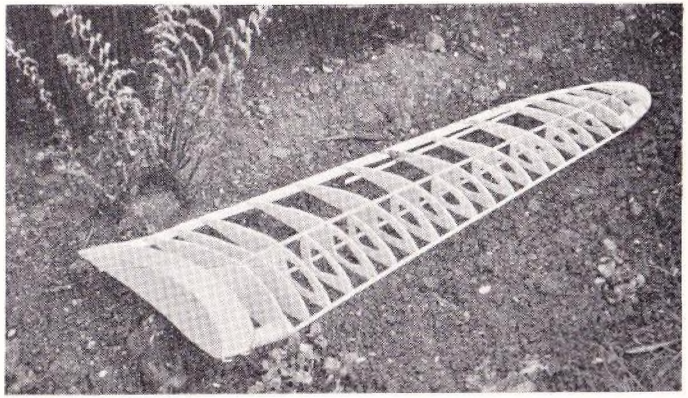


Fig. 60.
A wing half of the "Blue Dragon." Note the 1 m.m. three-ply covering at the root to strengthen.

ends carved to streamline shape. The wing should be constructed of material, etc., as described in Chapter VII. The ribs are situated $4\frac{1}{4}$ ins. apart, whilst riblets from leading edge to main spars are inserted at equal distances between the main ribs.

The dihedral angle is 11 degrees measured from the horizontal wing root, and the dihedral angle of each half wing commences $4\frac{3}{4}$ ins. from the root. The two

wing halves are therefore at 22 degrees to each other.

Fig. 60 is a photograph of a wing half before covering. The 1 m.m. three-ply covering of the root section will be noticed. This strengthens the root where it butts up against the other half wing. The two wing halves are attached to each other for flight by tying thick thread or rubber bands around wire hooks located at the leading edges, trailing edges, and top spars centrally.

There are also four large wire hooks on the under surfaces, which accommodate the stout elastic rubber bands which pass around the fuselage.

These bands naturally keep the bottom portions of the wing roots together and the wing tight up against the fuselage whilst the hooks and thread keep the top of the wing halves together. In the event of a crash the whole wing can be knocked off. No location pegs or other joints are necessary, or even desirable. This method has stood the test of flying for three years, and does away with all the complications seen on so many models that are fitted with detachable and split wings.

The wing section is a very stable and slow-flying type and was evolved by myself. Dimensions are given in Chapter IV, Fig. 35.

When covering the under surface first with damp silk (see Chapter VII, "Covering") it should not be forgotten to stitch the silk to each rib in order to preserve the pronounced under-camber section. The wing is given two coats of silver *full-sized* aeroplane dope, and allowed to set dry on its wooden bed with weights on it to prevent distortion whilst drying.

The Ignition Gear.

A small pocket flashlamp battery of 4 ozs. and

4 volts is situated on the fuselage floor beside the trapdoor in the fuselage side, 24 ins. from the nose. The "Allman" type clock (see Chapter III) is wired to this battery and breaks the circuit. A ground battery is used for starting up. Otherwise the wiring is carried out as described in Chapter III.

The Tail and Fin

are separate on this model. The tail is very large to obtain good fore and aft stability with reasonably short fuselage for transport purposes. It is of the normal type of wooden construction with $\frac{1}{8}$-in. thick balsa ribs

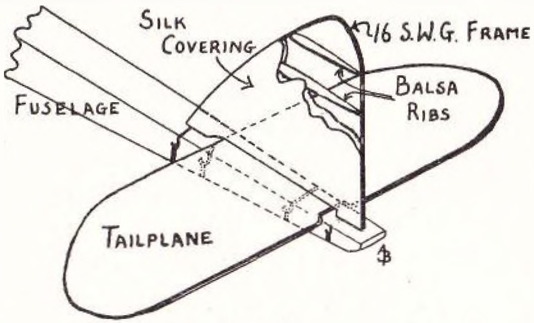


Fig. 61.
Tail Fin of "Blue Dragon."

of a very slightly cambered upper surface. Leading and trailing edge and the two centre spars are of $\frac{1}{4}$-in. × $\frac{1}{8}$-in. spruce.

The tail is set flat on the fuselage and may require a $\frac{1}{8}$-in. thick balsa packing under the leading edge when gliding tests are made.

There is a wire saddle bound to the leading edge. The saddle has a hook at each end, and a rubber band around the fuselage keeps the tail down forward. The leading edge butts up against a balsa stop to prevent

the tail going forward. There is another wire saddle with its hooks for rubber about two-thirds of the chord back. A rubber band from this saddle passes under the fuselage and keeps the rear of the tailplane down.

This rubber band gives a forward pull, as it is placed in front of two stops ahead of the wire saddle. Therefore the tailplane cannot move backwards in flight.

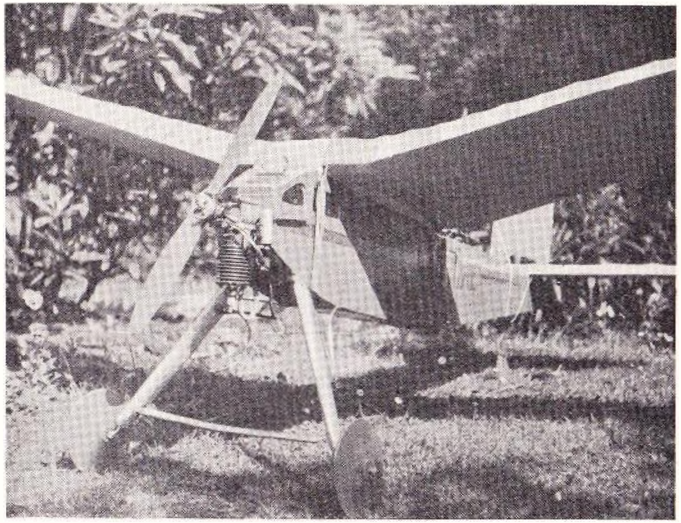


Fig. 62.
The "Blue Dragon" showing wing fixing.

The fin is also kept in position with rubber bands. It is made of 16 s.w.g. wire outline and balsa ribs of a streamline shape. It is, therefore, double surfaced. It and the tailplane are doped with one coat of silver *full-sized* aeroplane dope.

Fig. 61 shows details of tail and fin and mounting.

For flying and preliminary tests see Chapter XIV.

Fig. 62 shows the model and method of holding the wing down with rubber bands.

The photograph shows the old "Atom Minor" engine and competition wheels. These should be ignored when constructing the model.

CHAPTER X

A SMALL PETROL BIPLANE, "THE MOUSE," FOR A 6-C.C. ENGINE

General.

THE little biplane to be described is suitable for 6-c.c. engines, several of which have been placed on the market during the past year (see Chapter II). A 10-c.c. "Brown" engine can also be used provided the correct extra offset to thrust is given to allow for added engine torque. The model then becomes rather like

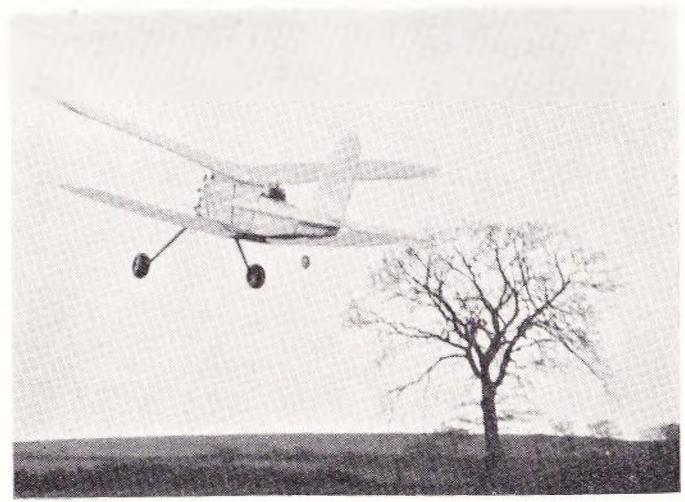


FIG. 63.
"Bowden Mouse" Biplane. The clock to control duration of flight is seen on top of the fuselage.

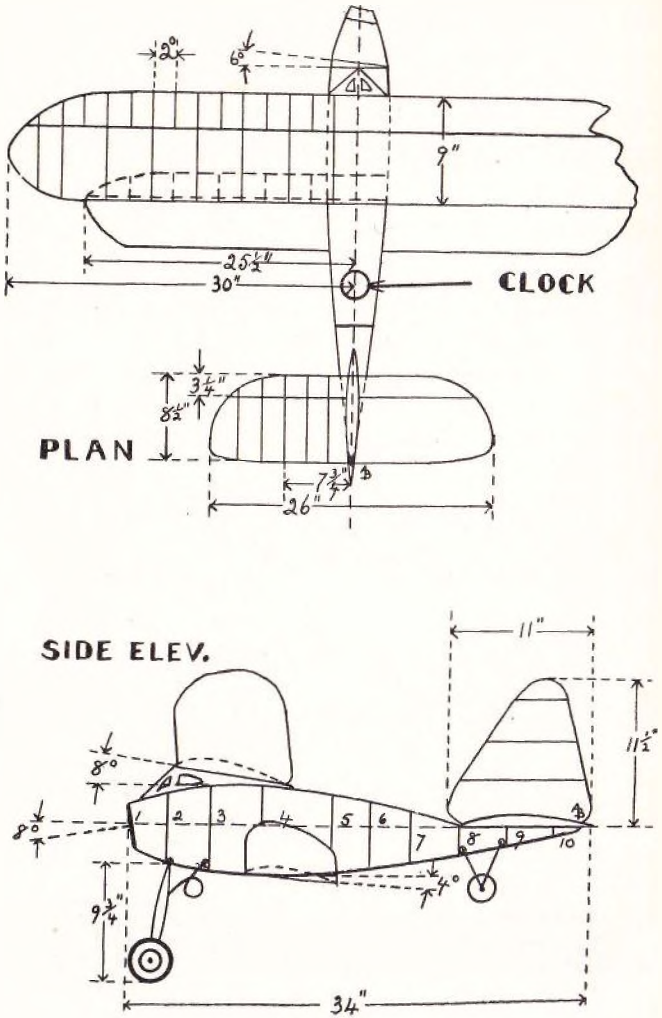


FIG. 64.
The Bowden " Mouse " Biplane.
Engine Offset according to Direction of Rotation.

an interceptor fighter when under full power, but is quite slow on the glide. With a 6-c.c. engine the model is a delightfully stable and slow flyer. The total weight turns out at approximately 4½ lbs., and the model has a span of 60 ins. Fig. 63 shows the model just after taking off. The clock-timing device to control duration of flight can clearly be seen on top of the fuselage.

Methods of construction of the various components, including method of laying out the full-sized drawing

FIG. 65.
The " Mouse " showing " Baby Cyclone " on detachable mounting. Elastic retaining bands can be seen. Wing fixing by elastic and under carriage details are clearly shown.

that should be made from Fig. 64 before construction, are fully dealt with in general terms in Chapters VI and VII. Only a general description is therefore given in this chapter.

The Power Unit.

The engine shown in Fig. 65 is a " Baby Cyclone " (see Chapter II), 6 c.c., and can be seen fitted to its detachable type mounting as described in Chapter II. In Fig. 65 the method of building the cabin onto the fuselage, in order to form a base for the top wing, is also clear. The cabin is made from sheet balsa $\frac{1}{8}$-in. thick with a 1 m.m. three-ply top. The cabin top has a covering of green baize to prevent the detachable wing from sliding about.

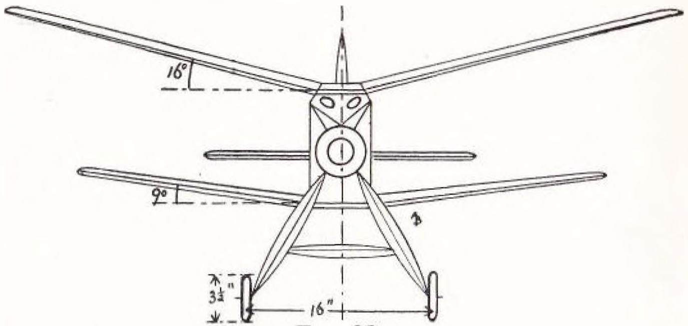


FIG. 66.
Front View of the " Mouse."

The ignition details and clock-controlling mechanism are the same as described in Chapter III. The flashlamp battery for flight is kept out in the open under the fuselage, just behind the engine, by elastic bands. The battery is then immediately accessible and does not require any trapdoor in the small fuselage. When not in flight the battery is taken off and so does not spoil the appearance of the model. When in flight it is not noticed.

The Fuselage

is made up as described in Chapter VI, and is covered

as far back as former No. 4 (Fig. 64) with 1 m.m. three-ply. The whole fuselage is then covered with silk and doped with one coat of clear full-strength aeroplane dope. The longerons and uprights and crosspieces are all of $\frac{1}{8}$-in. × $\frac{1}{8}$-in. section birch, except formers Nos. 1, 2, 3, 4 and 8, which are of three-ply, fretted out for lightness. No cross-bracing is used. The doped silk acts as sufficient bracing.

Tailplane and Fin

are formed into one unit as described in Chapter VII, and this is held in position by rubber bands passed

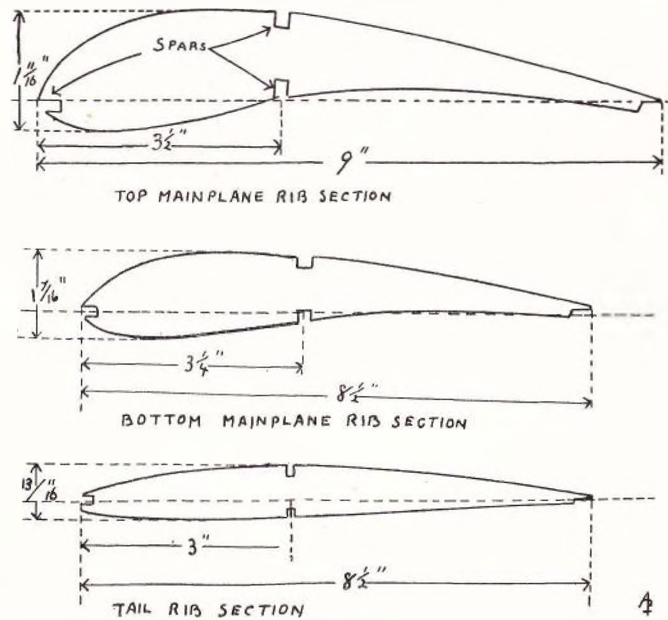


FIG. 67.
Wing Sections and Tailplane Sections of the " Mouse."

around the fuselage with a forward tension to ensure that the tail unit does not slip backwards. The fin is set straight and the engine torque is taken up by offset of thrust-line. (See Fig. 64.) The tail is set flat as shown in Fig. 64. The section is slightly cambered on top only. (See Fig. 67.)

The Wings

are constructed each in one piece and, as described generally in Chapter VII, with the same dimensions for spars. The wing sections are given in Fig. 67. The correct angles of incidence and stagger as shown in Fig. 64 should be carefully adhered to. It will be noticed that the top wing has a far greater angle of incidence. This is important. See Fig. 66.

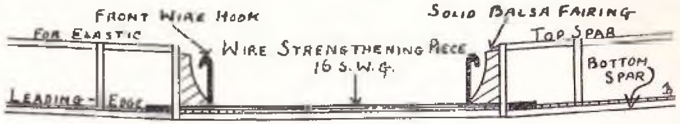


FIG. 68.

Centre Section of Bottom Wing.

For details of lower wing centre section see Fig. 68. The wings are provided with 16 s.w.g. wire hooks so that elastic bands keep them in position. This is made clear in Fig. 65.

The Undercarriage

is similar to that described in Chapter VII, except that a slightly smaller gauge wire is used.

Final Notes.

The whole model is finally doped white and lined with red. For covering methods with silk see Chapter

VII. It is important that the theory of biplane stability should be thoroughly understood as the biplane is not an easily operated model for the uninitiated, although if understood it can be an excellent and stable machine, as this model has proved itself to be. The constructor should study Chapter IV in this respect.

For flying and testing directions a study should be made of Chapter XV—" Flying a Petrol Model."

Fig. 69 gives a general view of the model that will help in general constructional details.

FIG. 69.

A front view of the " Mouse". $3\frac{1}{2}$-in. diameter " Dunlopillo " type wheels are fitted.

CHAPTER XI

A LOW-WING MONOCOQUE MONOPLANE, P.L.W.4

Monocoque Construction.

Now that we have got over the first experimental stages in petrol models, and understand the various difficulties in the way of stable flight on this type of model, we can afford to turn our attention to more ambitious types of construction.

The monoplane to be described has proved to me that monocoque construction offers certain advantages, amongst which greater strength for weight can be obtained, and appearance is much enhanced.

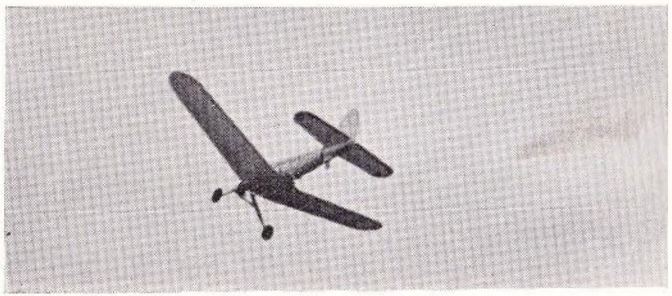


Fig. 70.
The Bowden P.L.W.4 low-wing Model passing overhead on its first day's test flying.

The fact that less drag is set up is a doubtful advantage at the moment, because we do not want our models to fly fast owing to the difficulty of control. On the other hand, a model that offers very little head resistance of the fuselage can afford more wing surface

resistance and can therefore reduce the wing loading, a very desirable feature.

For the man who has built a few simple type rectangular fuselages, the added interest of monocoque construction should offer an appeal.

In Chapter VII I have given a broad outline of the three methods of monocoque construction that I have experimented with and I described the first method in

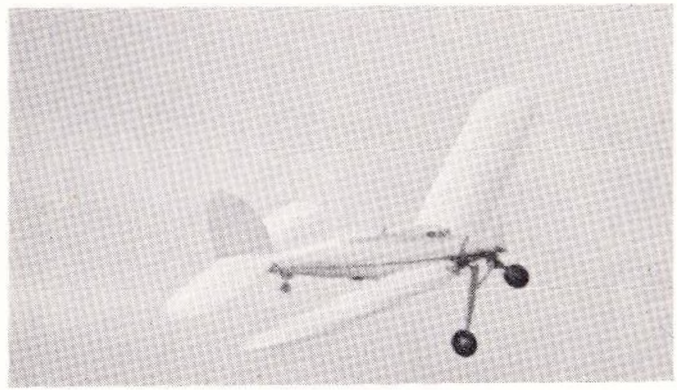


Fig. 71.
The Petrol low-wing Monoplane described in Chapter XI flying slowly around the camera.

some detail. Therefore, in the description of this model I do not propose to go into much constructional detail.

By reading the notes on the *first method* in Chapter VII and the general description of the model contained in this chapter, I feel that anyone interested in the method should be able to construct a similar type of model, or gain sufficient ideas to set out on a modified and possibly better design.

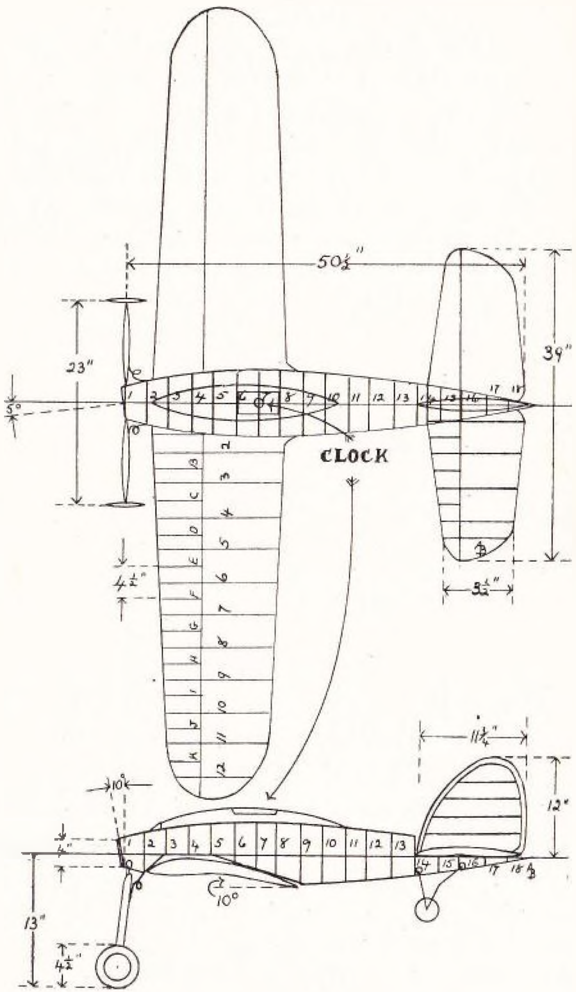


FIG. 72.
Outline Drawing of low-wing Model P.L.W.4.

The low-wing model P.L.W.4 that I have constructed and am describing here has proved itself a stable and slow-flying model in reasonable weather. It looks very well in the air with the light shining on its white polished oval fuselage, whilst it lands slowly and takes off after quite a short run.

Fig. 70 shows the model flying overhead and away from the camera whilst Fig. 71 has caught the model circling around the operator under reduced throttle. Unfortunately these photographs were taken last winter and the result is not very clear, due to the poor light.

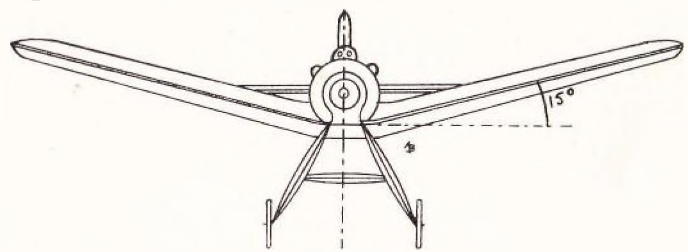


FIG. 73.
Front View of P.L.W.4.

Construction.

A full-sized drawing can be made from Fig. 72 (see Chapter VI for details of laying out a model design), whilst Fig. 73 shows the front elevation of the model.

If the reader will look at Fig. 74 in conjunction with these drawings he will get a good general idea of the model, which has a wing span of 8 ft. and a weight all on of 6¾ lbs.

The Fuselage.

At the first glance at Fig. 72 the reader may wonder why down-thrust has to be given with the wing set low; at least I hope he may if he is a novice and has read the chapter on stability. The reason, of course, is that a very large dihedral angle is given to ensure lateral stability on a low-wing model. This naturally puts the centre of resistance of the mainplane actually *above* the thrust-line which has been situated low on this model.

Therefore down-thrust has to be used in this case in spite of the fact that it is a low-wing model.

The fuselage is constructed on a backbone of $\frac{1}{8}$-in. thick balsa wood and has $\frac{1}{8}$-in. thick balsa, half oval formers glued onto each side of the backbone, as described in Chapter VII. Formers Nos. 1, 2, 3, 9, 15 and 16 are made from three-ply wood fretted out for lightness.

The nosepiece is of $\frac{1}{4}$-in. thick three-ply and has a square cut in it to receive the raised square of the

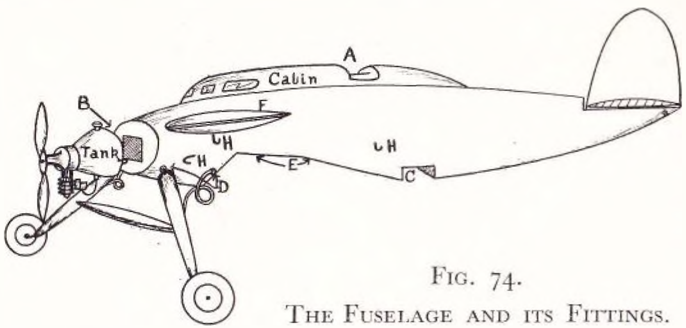


FIG. 74.
THE FUSELAGE AND ITS FITTINGS.

A. Location of clock.
B. Rear cover plate of duralumin mounting threaded into cone.
C. Battery recess.
D. Duralumin tubes taking detachable undercarriage.
E. Cut-away portion.
F. Dummy engine cylinder blocks to strengthen fuselage.
H. Wire hooks to take retaining bands.

detachable type nosepiece fitted. The other three-ply formers are of $\frac{1}{16}$-in. three-ply and accommodate wire hooks for the elastic retaining bands for wings, etc., as shown in Fig. 74.

It will be observed that there is a cut-away portion under the fuselage, and owing to its special shape the low wing cannot vibrate forward or backward, and yet is detachable, as it is held up to this cut-away portion by means of elastic bands to hooks arranged

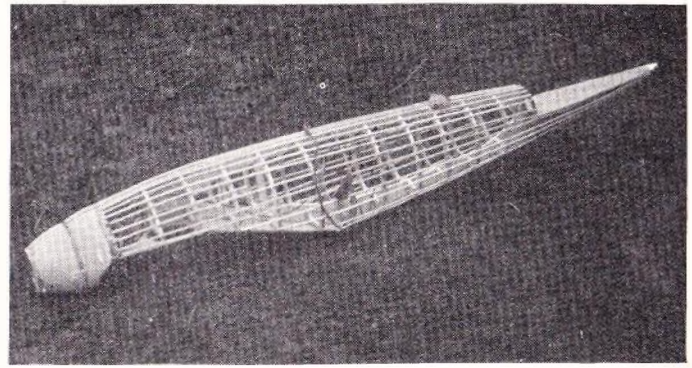


FIG. 75.
The fuselage after fitting with solid balsa nose inserts and $\frac{1}{8}$-in. × $\frac{1}{8}$-in. stringers.

on the fuselage and on the wing. The wire hooks are bound internally to the three-ply formers, Nos. 3 and 9, and protrude through the fuselage skin about half-way up the fuselage.

There are two duralumin tubes bound across No. 1 and No. 3 former. These accommodate the $\frac{1}{8}$-in. diameter wire prongs of the detachable undercarriage.

This undercarriage is constructed in exactly similar manner to that described in Chapter VII. A tail wheel is also fitted as described in Chapter VII.

The fuselage has solid balsa-wood inserts between the nose formers No. 1 and No. 2, also between No. 2 and No. 3 formers, after the above fittings have been attached. This is to strengthen the nose. It should have been mentioned that two wire hooks facing forward are attached to No. 2 former to take the elastic retaining bands for the detachable engine-mounting.

Fig. 75 shows the fuselage with its fittings, its solid balsa nose inserts, the cut-away portion below for the wing. The $\frac{1}{8}$-in. × $\frac{1}{8}$-in. balsa stringers, and finally the tailplane platform.

The next stage of construction as described in Chapter VII is the covering of the fuselage with $\frac{1}{16}$-in. balsa sheet and then silk and doping.

It will be observed in Fig. 74 that the flashlamp battery for ignition purposes during flight has a recess made for it just behind the low-wing cut-away. The battery is merely pushed in here and wedged with a piece of sponge rubber. Thus the battery contacts are easily examined after each flight and there is no need for battery trapdoors. Also it will be seen that balsa hollowed-out dummy cylinder banks are fitted to the fuselage on either side of the nose. This is to strengthen the fuselage where the cut-away portion below comes. Also there is a hollowed-out streamline cabin on top of the fuselage. This serves a similar purpose, and makes a convenient place for locating the "Allman" type clock to control duration of flight.

The Tail Unit

is made in one unit as can clearly be seen in Fig. 76.

It is kept in position by elastic bands. The wire frame for the fin is covered each side with 1 m.m. sheet balsa strips. See Fig. 72.

The Wing

is made in two halves and constructed as described in Chapter VII, except that from the leading edge to the

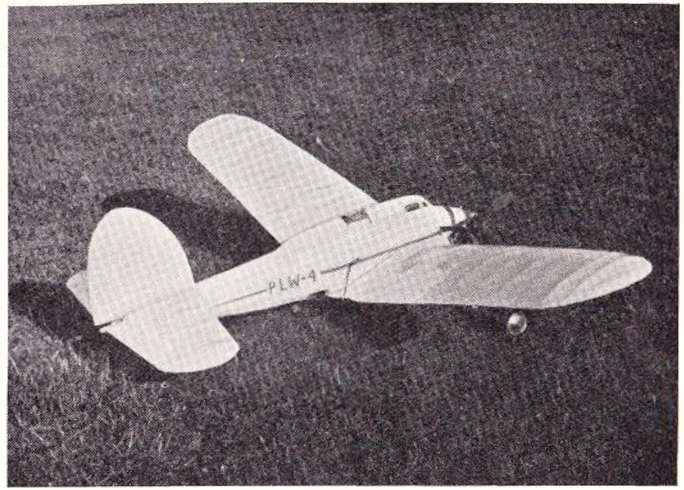


FIG. 76.

The low-wing Petrol Model P.L.W.4. The clock-controlling Mechanism can be seen in the top of the streamline cabin.

main spars it is covered with $\frac{1}{16}$-in. thick sheet balsa before covering with silk.

The two half wings butt up against each other and are held below by wire hooks and thread whilst the tension of the rubber retaining bands to fuselage keeps the top part of the wing roots together.

Also see the description of wing construction in Chapter IX of the "Blue Dragon." The centre arrangement of wire hooks is the same as on the "Blue Dragon" except that it is naturally reversed as it is a low wing, whereas the other was a high wing. Fig. 77

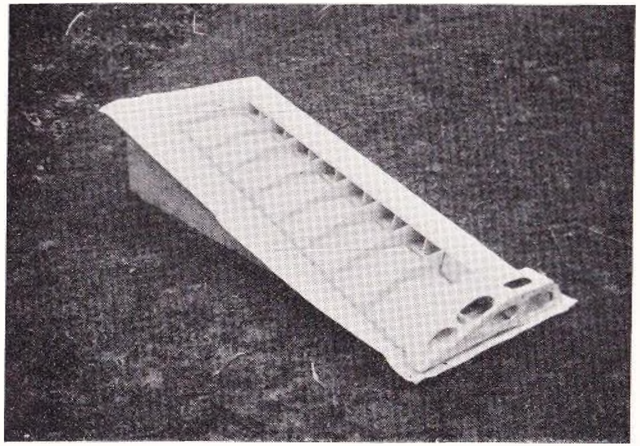


FIG. 77.

One wing-half on its wooden construction bed. Note wing root and leading edge covering of $\frac{1}{16}$-in. thick balsa sheet.

shows the method of construction of the wing roots. They are of well-fretted-out $\frac{1}{8}$-in. thick three-ply, whereas all other ribs are of $\frac{1}{8}$-in. thick balsa.

The wing section is the same as for the "Blue Dragon," but it will be observed that the wing taper in plan form is only very slight on this model. This is in order to keep the centre of resistance as high as possible in relation to the C.G., as the model is a low wing. Thus there is more surface shown near the

tips than on a highly-tapered wing. The dihedral angle causes the tips to be high.

The Engine.

The engine is a "Brown Junior" that has been inverted and screwed onto a hollow duralumin cone, which is used as the petrol tank. The engine has been specially fitted with an Elektron piston and piston rings, whilst a float-controlled carburettor is fitted. These modifications to the "Brown" were very successful but not absolutely necessary for ordinary purposes. They were carried out for interest's sake and due to the fact that an engine when inverted and not fitted with piston rings sometimes gives trouble with fouled plugs.

There is no reason why a standard "Brown" should not be fitted to this model, if a detachable-type mounting as described in Chapter IX is used. In fact, the model has been flown with the upright engine from the "Blue Dragon.' The mounting backplate and raised square dimensions were designed to be interchangeable on all my models.

For test flying the model, see Chapter XV, "Flying a Petrol Model."

CHAPTER XII

A SMALL MONOCOQUE MONOPLANE FOR THE "BABY CYCLONE" AND OTHER 6-C.C. ENGINES

This model can be built with simple rectangular fuselage. This model can also be flown by a 3·5-c.c. engine if construction is kept light.

THE little two-stroke of about 6 c.c. had become an accomplished fact in 1936, and there are examples on the British and American market that are perfectly satisfactory. These little engines permit the model constructor to come another step down in size, although in America a "Baby Cyclone" has successfully flown a 15-ft. span model made entirely of balsa wood.

Except in very good weather a greater flying speed is required, and therefore a more heavily loaded model. Most people prefer the small model owing to ease of transport. The 6-c.c. type engine allows this to be done, but there is the danger of making too small a model that will fly too fast and become unmanageable.

The model to be described has a medium flying speed that will suit average weather in this peculiar English climate of ours.

Fig. 78 shows the model three-quarters rear view. The weight is 3 lbs. all on, and the wing span is 5 ft. 4 ins.

I often am asked for a simple design for the "Cyclone" engine that can be easily built. I suggest that newcomers who want to use a 6-c.c. engine and yet

have not the ability and experience to build a monocoque, should build this model with a rectangular fuselage If they will treat the drawing Fig. 79 as a rectangular fuselage the model will be perfectly satisfactory. Construction should then be carried out as detailed for rectangular fuselages in Chapter VII.

FIG. 78.

The Monocoque high-wing Model showing combined detachable tail unit, timing clock and short elastic retaining bands from hooks on the fuselage to hooks below the wing.

$\frac{1}{4}$-in. × $\frac{1}{4}$-in. balsa longerons, etc., could be used and the whole fuselage covered with $\frac{1}{16}$-in. thick balsa sheet and then silk and doped one coat clear. I have tried this with success.

The Fuselage.

In Chapter VII I described in some detail two methods I had tried of constructing monocoque fuselages and I mentioned a third method that I now

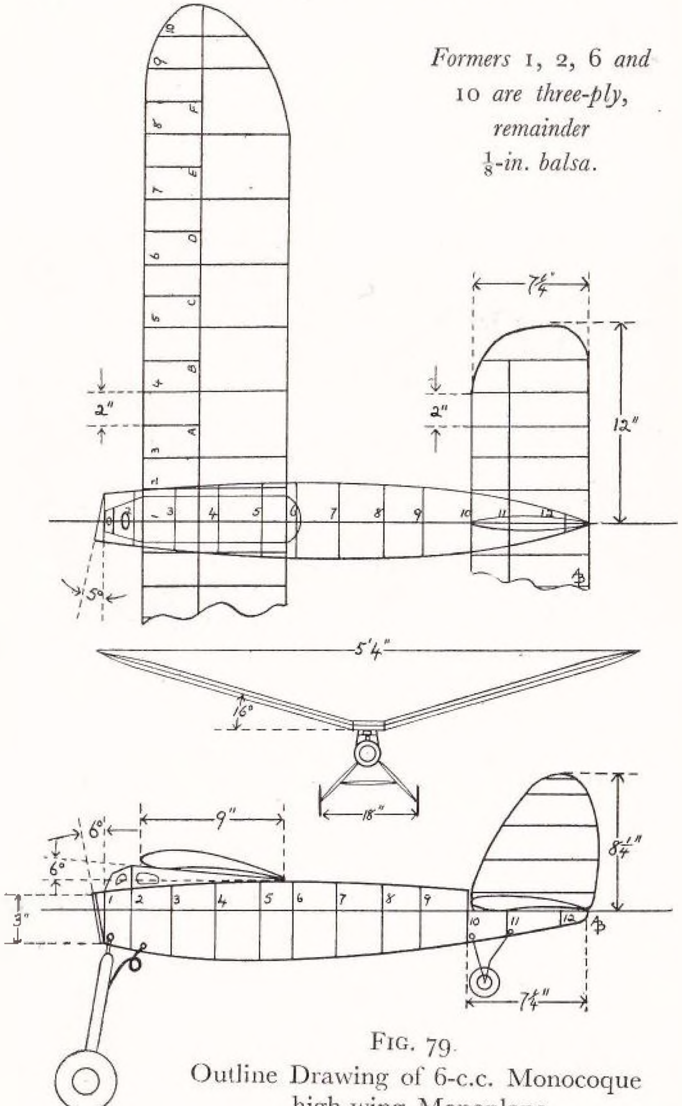


FIG. 79.
Outline Drawing of 6-c.c. Monocoque high-wing Monoplane.

propose to describe in the construction of this model. It is the lightest method of the three and ideal for smaller petrol models. I have also used the method in a very small 4 ft. 4 in. model for the little 4-oz. 2·4-c.c. "Elf" engine. A photograph of this model is given in the next chapter, XIII, "Experimental Models."

A balsa backbone is made up as in the case of the first method described in Chapter VII.

Onto each side of this backbone, half oval balsa formers are glued with Durofix

A great number of $\frac{1}{8}$-in. × $\frac{1}{8}$-in. sectioned balsa lengths are next obtained and are "strung" around the skeleton, touching each other side by side and with a film of Durofix glue between each length. This forms the outside skin, and when the fuselage has been completely covered in this way it is carefully sandpapered down until there is about $\frac{1}{8}$-in. thickness at the nose and about $\frac{1}{16}$-in. thickness or less at the tail. I have also made a rubber-driven model in this manner and it is surprising how light and strong the construction can be, due to its oval shape, and the extreme thinness of the fuselage skin after it has been sandpapered down. In the case of the rubber-driven model the skin was taken down to about $\frac{1}{32}$-in. at the tail.

Before the whole fuselage has been completely covered, fittings like duralumin tubes to take the detachable undercarriage and wire hooks for wing elastic retaining bands, etc., are fitted to the oval formers in the same way as on the monocoque low-wing model described in Chapter XI. Certain formers, where these fittings come, are of three-ply wood fretted out for lightness. Otherwise the entire fuselage is of soft white balsa. See Fig. 79 for details where fittings are located.

When the fuselage has been sandpapered to the desired thickness of skin, the whole is covered with Jap silk and a liberal application of Kodak photopaste, which will dry rapidly and prevent the final coat of *full-sized* aeroplane clear dope from sinking into the balsa, and so putting up the weight. Fig. 80 is a

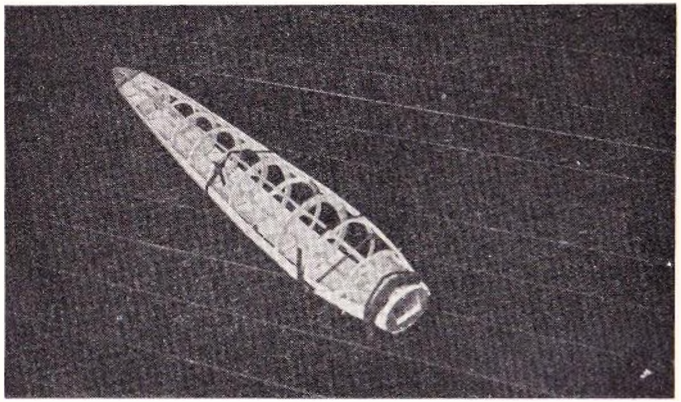


Fig. 80.
The skeleton only partly covered at the bottom.

photograph of the fuselage with only the bottom part covered with the balsa stringers. One or two isolated stringers can be seen. These are the preliminary stringers to keep the skeleton's shape whilst the "barrel"-like construction is going on. Before the skin is entirely put on, solid pieces of balsa are slipped in and glued between the ¼-in. thick three-ply nosepiece and Nos. 2 and 3 formers. These add strength to the nose. The stringers are kept in position by elastic

wrapped around the fuselage until the glue has set firm.

A platform is formed at the tail end of the fuselage to accommodate the detachable tail unit which is on the same principle as described in Chapter VII.

This tail unit is kept in position by elastic bands from the tailplane to little wire hooks that protrude from the fuselage. Wire hooks also protrude from the

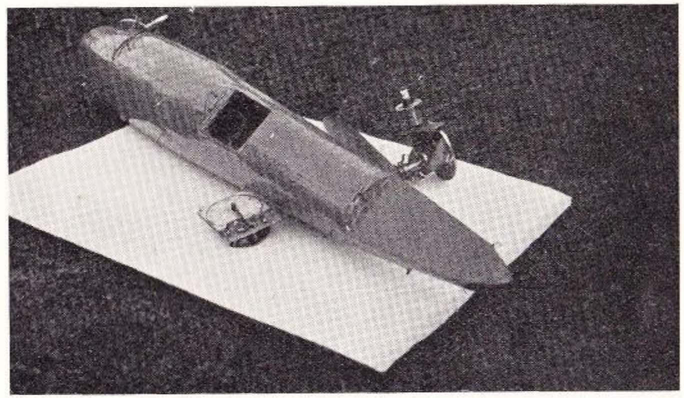


Fig. 81.
The clock and its well and tailplane platform can be seen in this view of the fuselage.

fuselage about two-thirds up to retain the detachable mainplane.

An "Allman" type clock as described in Chapter III is fitted into an opening in the top of the fuselage.

The engine is mounted on an Elektron casting and is detachable as shown in Chapter II. These last features can all clearly be seen in Fig. 81, which shows the fuselage lying on the ground and before the cabin had been built onto its top. A detachable undercarriage with its light American " M. and M." air-wheels and the detachable tail-wheel are fitted. These are all described in Chapter VII.

A cabin is finally added to the fuselage. This is made of $\frac{1}{8}$-in. thick balsa sheet and has celluloid windows. It is merely glued onto the fuselage top, the petrol tank and coil and condenser are situated in the cabin, and it is then given a 1 m.m. three-ply top and covered with silk and doped. The silk covering,

FIG. 82.
Depicting the wing fixing on the cabin. The petrol tank can also be seen.

glue and dope keep the cabin firmly in place. The top of the cabin is set at the correct angle so that it forms a platform for the wing at the correct angle of incidence as shown in Fig. 79. The cabin top and bottom of the wing centre section are both covered with green baize to prevent the wing moving by engine vibration.

Fig. 82 clearly shows the wing fixing and the petrol

tank position. The $2\frac{1}{2}$-oz. " Cyclone " coil is situated directly behind the tank.

The Wing

is built up exactly as described in Chapter VII on a wooden bed except that leading edge and trailing edge are made of $\frac{5}{16}$-in. $\times$ $\frac{1}{8}$-in. balsa wood, and the wing tips are made from cane with solid balsa inserts. These modifications are for lightness.

FIG. 83.
A general view of the 6-c.c. Engined Model.

If transportation is a difficulty, the wing can be made in two halves as described in Chapter IX, in the description of the " Blue Dragon." The wing is a little lighter, however, if made in one piece. The tail unit should be built up as described in Chapter VII, but all spars should be made of balsa and the tailplane tips of bamboo for lightness.

General Details.

Fig. 83 gives a good impression of the model side view. The front tailplane elastic retaining bands can be seen. The ground battery plugs can also be seen below the "Allman" type clock. There is a small recess for the flashlamp battery let into the bottom of the fuselage on the other side as in the case of the low-wing model described in Chapter XI. The ignition details are as described in Chapter III.

Both offset of thrust and down-thrust are given as shown in the general outline drawing of the model, Fig. 79. For preliminary test flying of the model see Chapter XV.

CHAPTER XIII

EXPERIMENTAL MODELS

THERE is not much spare time in the lives of most individuals to experiment with models other than the normal type. Most petrol enthusiasts want a model that will fly. They therefore naturally first of all construct the normal and easily constructed type that can be relied upon to produce flying results with the minimum amount of time expended upon their building and design.

Nevertheless, there is a definite interest in the out of the ordinary type of model, and although I have built somewhere about twenty petrol models in my time as a spare-time hobby, I have managed to squeeze a little extra spare time for experimental models.

In a sense all petrol models are experimental, but I now only classify models under this heading that are completely new in their conception from anything that has been done before in the petrol-model world.

The Petrol Autogiro.

The petrol autogiro has been attempted by very few people to date. I have made two of these models and it may interest those intending to tackle the subject to hear of my trials and troubles.

The first model was powered by a "Brown Junior" engine and weighed $4\frac{1}{2}$ lbs. It had four standard-type very high aspect ratio rotor blades. The essential articulation of the blades in an up and down flapping movement was carried out by mounting the hub ends of the blades on gramophone clock springs. The hub was mounted on a pylon consisting of a duralumin tube, and a ball race was used in the rotor head. The rotor blades were given a slight negative angle which seems to be necessary on model autogiros to cause auto-rotation. The rotors revolved at great speed even when the model was quickly walked into a reasonable wind, and a fierce lift was generated.

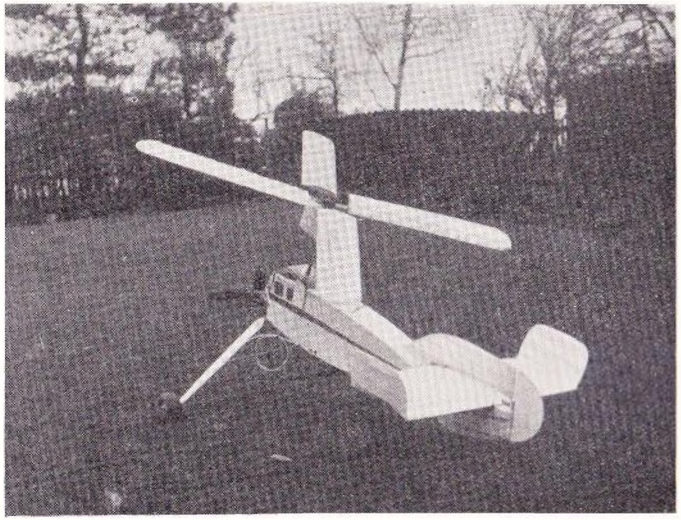


FIG. 84.
The Author's latest experimental Autogiro.

The snag of the whole model was that the advancing blades caused more lift one side and the model insisted in turning over onto one side and smashing the revolving blades.

The model eventually caught fire and was destroyed in a few seconds! I then designed a new model with

shorter and lower-aspect ratio blades (see Fig. 84), and with a very wide track undercarriage fitted with heavy wheels set low down. The idea being that the low C.G. position would more quickly act as a pendulum on the shorter span blades and that the centre of resistance of the blades is as near the rotor head as possible. A much longer fuselage and much larger tailplane was fitted, and if a fair wind is chosen the model will glide into wind from a hand launch without any tendency to turn over. It was not necessary to cant the rotor head. A good down-thrust and offset of thrust was given to the engine to deal with the high centre of pressure of the rotor and the torque of the engine.

The trouble now is that the engine fitted, a " Brown," has not sufficient power to get the model moving sufficiently rapidly to gain lift on the reduced span rotors. It therefore seems that I must at some time build another set of rotors and make a compromise between the large span high-aspect ratio blades which give good lift and the small span low-aspect ratio blade arrangement which is stable.

I tried towing the autogiro on the end of a line from my car, and at about 20 m.p.h. the model rose quite satisfactorily, which indicated that the power of the engine was not sufficient. It is a well-known fact that the rotating-wing type of aircraft requires more power to fly than a similar fixed-wing aircraft.

Fig. 85 shows the spring rotor fixings to the rotor head. There is a duralumin plate with extensions below these springs that prevents the rotor blades from dropping down too far before centrifugal force due to working revolutions keeps the blades out horizontally. The little pulley fitted around the ball-bearing rotor head was intended to start the rotor up with a cord, but actually it was found that normal wind pressure was sufficient. The rotor pylon made from a duralumin tube can be slid along the fuselage top for

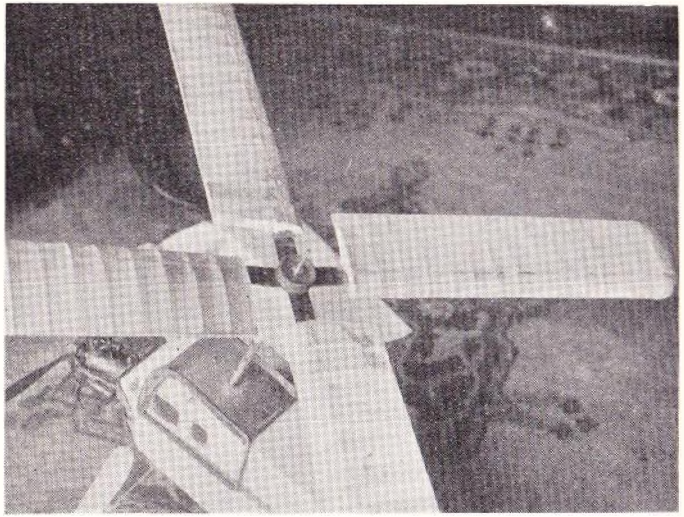


FIG. 85.
The rotor head with its articulated blades and their gramophone spring attachment.

adjustment of C.G. position, and can be knocked off in the event of a crash as its duralumin base is kept to the fuselage by stout elastic bands.

On the full-sized machine, the lateral stability of the rotor system is chiefly ensured by the vertical hinges and, therefore, flapping of the rotors, in conjunction with a low C.G. whilst the engine torque is dealt with by the incorporation of a lifting tail on one side and an anti-lift section on the other.

I have found on rubber experimental models that a fully-hinged rotor system suffers too much damage to the hinges. I therefore rely upon the modified articulation of the gramophone springs and a small rotor span.

It is an interesting fact that the late Senor Juan de la Cierva, the autogiro designer, could only get his models to fly at first whilst the full-sized attempts heeled over directly they moved forward. The autogiro as we know it to-day is often called the " wingless " autogiro. This, of course, is a misnomer as the rotating blades are merely wings that rotate around a fixed axis and gain their lift in the normal way by travelling forward through the air, but in a circular direction. The beauty of the principle is that these wings cannot stall whilst the weight of the machine is hanging on the rotor axis, because the blades *must* rotate at a nearly constant speed.

Now that the 1936 full-sized autogiro can make jump starts, and on landing, the rotating blades take up a negative angle of incidence on application of the rotor brake, and the lift is therefore destroyed and the machine cannot be blown over in a high wind, there is undoubtedly a very great future for this type of aircraft when people become autogiro-minded.

It therefore makes an interesting model to experiment with, and the safest possible full-sized aeroplane to fly

The Flying-Boat.

This is a type of petrol model that intrigues me, and if one possesses a boat a great deal of amu ement can be obtained from it. In 1935 I built a biplane flying-boat. See Fig. 86. This model flew very well and would glide well and flat, and also do good landings on the water, but I had put the step too far back and the high thrust-line of the engine in relation to the water pressure at the step tended to pull the nose down when attempts were made to take off the water.

As the hull was too short to alter the step and yet keep sufficient hull surface in front of the step, I had to

FIG. 86.

An Experimental Biplane Flying-boat.

content myself with hand launches from my boat and gain what satisfaction I could by watching the model settle down after a power flight like a large duck with a satisfying splash.

Recently I have constructed another flying-boat which has the step well forward of the C.G., as I have found this is necessary on all float planes driven by rubber in order to overcome the high thrust-line.

This new hull also has a very generous beam and is made up on my No. 1 monocoque constructional

method (see Chapter VII), almost entirely of balsa wood with a 1-m.m. three-ply bottom.

Fig 87 shows the hull, whilst the platform for the wing and its cabin below it can be seen. The hooks that take the rubber bands to keep the cabin down to the hull can also be distinguished. The tail and fin unit fits onto the platform at the rear of the hull.

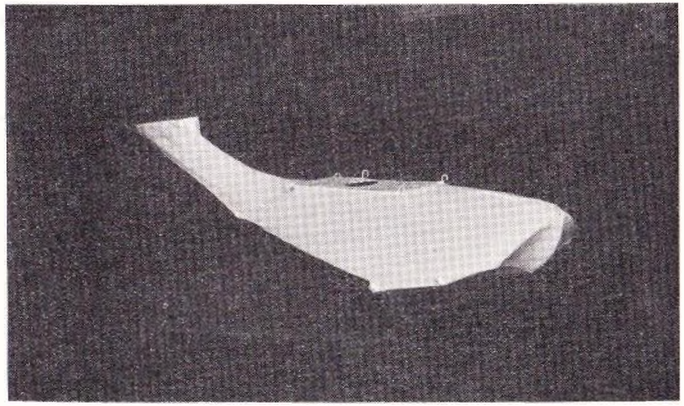


FIG. 87.

The author's latest Experimental Flying-boat hull.

This model is now completed and comes out at $3\frac{1}{4}$ lbs. with a "Baby Cyclone" engine, but has not yet been test flown. It has a span of 5 ft. 6 ins. I am hoping to do the test flying shortly. Fig. 88 will give a general idea of the model, whilst Fig. 89 shows the hull in skeleton form. Two duralumin tubes can be seen in front of the step. These can accommodate a short detachable undercarriage if necessary, so that the model can be used for land flying.

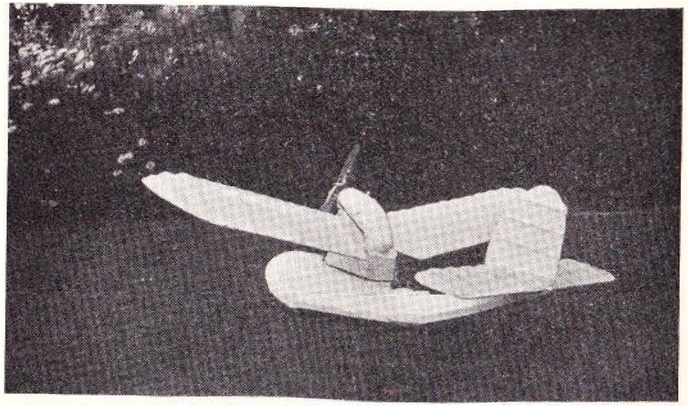


FIG. 88.
The author's Experimental Flying-boat.

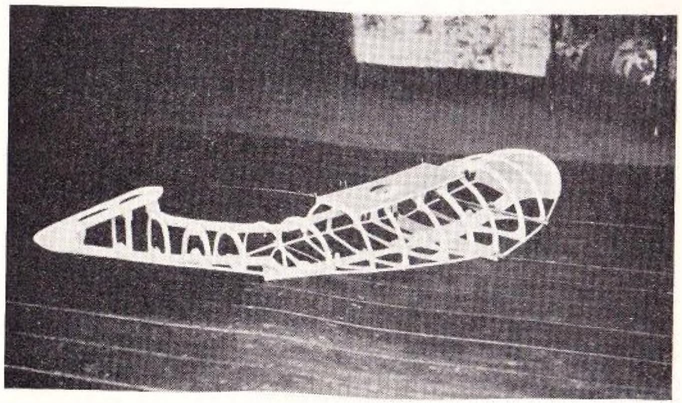


FIG. 89.
The Flying-boat hull in skeleton. Formers are made of balsa wood.

A Midget Petrol Model.

The "Elf" engine of 2·4 c.c. that I have recently received from Canada opens up possibilities for very small petrol models.

Fig. 90 shows a 4 ft. 6 in. span low-wing monoplane with monocoque construction on my third method as described in Chapter VII.

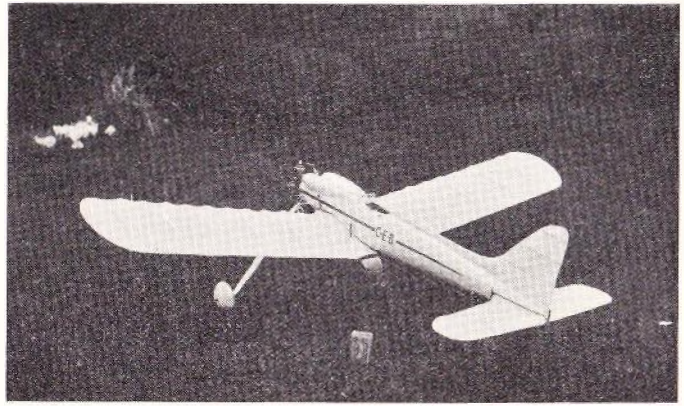


FIG. 90.
A 4 ft. 6 in. span Petrol Model for the 2·4-c.c. "Elf" Canadian Engine.

Both the wing and the tailplane on this model are located under the fuselage and held up to it by elastic bands. The whole model weighs $1\frac{3}{4}$ lbs. as shown, and the two "fountain-pen" flashlamp cells of $1\frac{1}{2}$ volts and weighing 1 oz. the pair, are accommodated in the open cockpit. The petrol tank is inside one of the dummy cylinder-block cowlings.

The matchbox in the foreground makes an interesting comparison. In addition, now that there are several

3-c.c. engines about to be produced commercially, I have constructed a simple high-wing model for this type, but of 5-ft. span. It is called the "Kub" and is described in Chapter XVI.

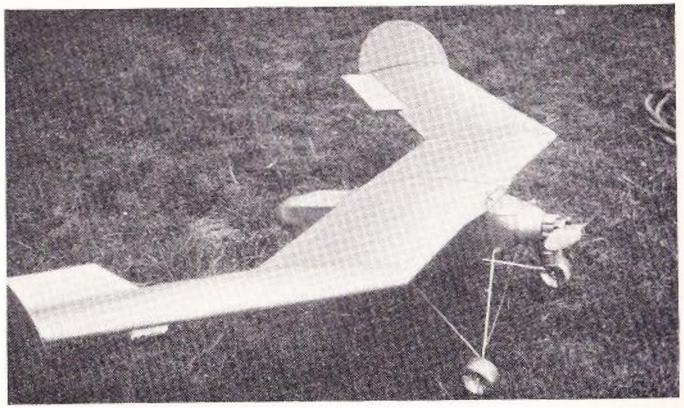


FIG. 91.
A tailless Petrol Model by Mr. Brooks.

A Tailless Model.

Fig. 91 shows an interesting tailless petrol model built by Mr. Brooks, of Bournemouth. This model has a Brooks's 18-c.c. "Comet" engine mounted on one of my type hollow Elektron detachable cone mountings.

CHAPTER XIV

A MODEL FOR 2·5-C.C. ENGINES OR 3-C.C. ENGINES. TOTAL WEIGHT APPROXIMATELY 2 LBS.

THE "MOTH"

General.

THE model to be described was designed for the 2·5-c.c. and 3-c.c. type of engine that will become more and more popular as its convenient size is appreciated.

There may be a tendency to produce a very small model for these little engines, but this may prove disappointing, as it will mean a very fast model if it is to be produced sufficiently robustly to withstand the English climate.

The model to be described has proved itself very stable in the air and is very lightly and yet robustly built owing to the method of construction. It can be covered with thin Jap silk or stout bamboo paper. The model that I have built is covered with Jap silk and doped one coat of clear full-strength glider dope. The extra weight of silk is very little and the model is more durable, although bamboo paper is easier to put on and gives a lovely finish. The weight of the model complete is 2 lbs., and a 2·5-c.c. "Elf" engine is fitted to the writer's model.

Fig. 92 is an outline drawing of the model and can be enlarged and used as in the case of all other descriptions of models in this book. Chapter VII should be studied on general construction methods, and the description of the larger model "Blue Dragon" in Chapter IX will be useful.

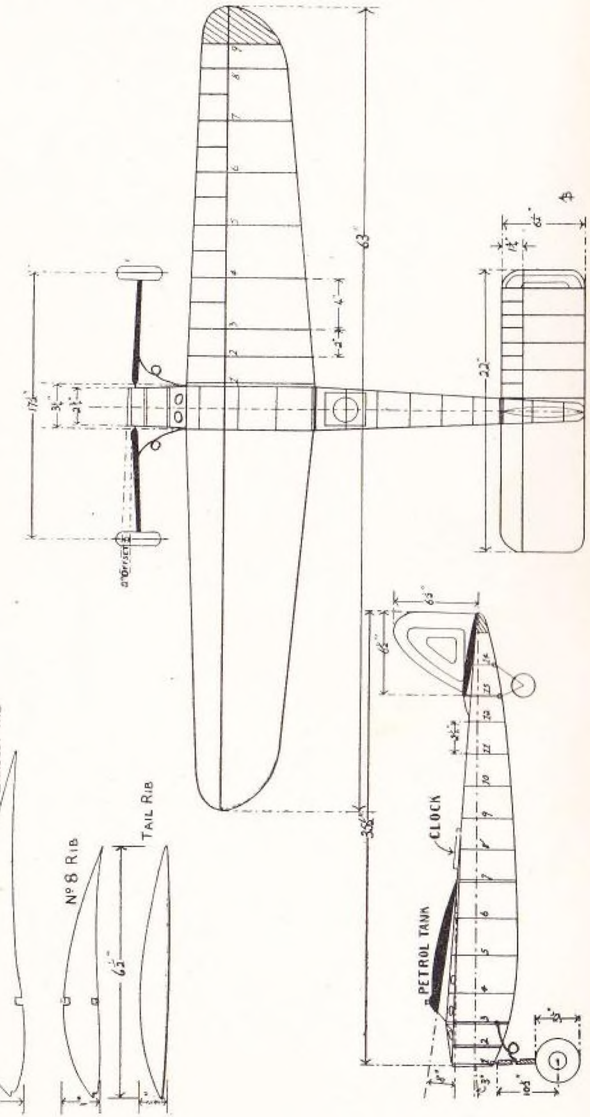


FIG. 92.
Model for 2.5 or 3.0 c.c. Engines.

The Fuselage

is made up by building the two sides first with spruce longerons ⅛-in. × ⅛-in. and uprights of ⅛-in. × ⅛-in. balsa wood, except at formers Nos. 1, 2, 3, 7 and 13, which are of ⅛-in. thick three-ply wood fretted out in the centre for lightness. These three-ply formers take the strain of wire hook fittings and undercarriage tubes for the detachable undercarriage, see Fig. 93. The crosspieces top and bottom are also of ⅛-in. × ⅛-in. balsa wood.

The fuselage has a circular nosepiece, No. 1 former of ¼-in. three-ply wood to accommodate the detachable nosepiece casting of Elektron which is exactly similar to

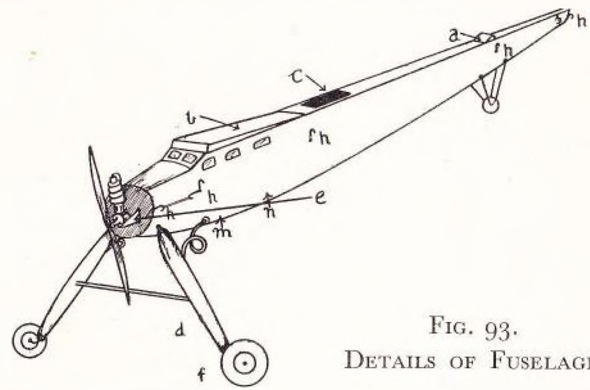


FIG. 93.
DETAILS OF FUSELAGE

a. *Balsa stop for tail unit.*
b. *Balsa wing platform set at correct angle of incidence.*
c. *Location for clock.*
d. *Detachable undercarriage, 14 s.w.g. piano faired with silk-covered balsa.*
f. *3½-in. American "M. and M." air wheels.*
h. *Wire hooks attached to three-ply formers to take retaining bands for the various units.*
m. *Location of 3-oz. 3-volt flash-lamp battery slipped under fuselage and between fuselage and elastic bands that hold rear spring legs of undercarriage together.*
n. *Location of coil and condenser.*

that used on the 6-c.c. "Cyclone" type of model described in Chapter II. To strengthen between this No. 1 former and No. 2 three-ply former, a number of $\frac{1}{16}$-in. × $\frac{1}{16}$-in. stringers of spruce are inserted. The fuselage is then covered with lightweight $\frac{1}{16}$-in. thick balsa sheet, rubbed carefully down with sandpaper and then finally covered with silk. Fig. 93 will make clear where the various fittings to retain the wing and tail unit, etc., are situated. 1 m.m. three-ply is used in lieu of balsa sheet from the nose to former No. 7 at the bottom only of the fuselage. This makes a platform for the coil.

A standard "Allman" type of clock-control mechanism is installed in the fuselage top just to the rear of the mainplane.

A little plastic wood is then pressed inside the nose and around the fittings for hooks and undercarriage. This reinforces the lightly-built fuselage where the main shocks of landing and loads are taken, without adding much weight.

The coil and condenser are attached to the floor just behind former No. 5, with thread and glue. The 3-oz., 3-volt flashlamp rectangular battery used for flight is kept up to the bottom of the fuselage, and outside it, by the rubber retaining bands that keep the rear circular spring legs of the undercarriage together in their tube.

The battery is merely slipped under these bands, and two leads are led from a hole in the fuselage floor. These leads have spring clips on them which grip the flat battery terminals.

The battery is thus always very accessible and yet no door or weakening hole has to be cut in the very lightly-built fuselage.

When the model is on the ground the little battery can be slipped from its rubber bands and the appearance of the model is not spoilt. During flight the battery is not noticed when placed in position.

A platform is built of balsa onto the top of the fuselage to the shape of the under-camber of the wing. This and the tail unit platform are both covered on top with thin felt. The wing and tail unit will not then vibrate out of adjustment.

The undercarriage and tail-wheel are similar to all the previous models but are of very much lighter spring steel wire. 14 s.w.g. is used for the undercarriage. Light American "M. and M." wheels are used of $3\frac{1}{2}$-in. diameter.

A small petrol tank is mounted in the wing and connected by rubber bicycle tube to the engine. This position is necessary to obtain gravity feed.

The Wing

is made up on a similar principle to those of all the preceding models except that the leading and trailing edges are of $\frac{3}{16}$-in. × $\frac{1}{8}$-in. medium hard balsa. The two central spars are of $\frac{1}{4}$-in. × $\frac{1}{8}$-in. spruce. The wing is built up on a bed as previously described with $\frac{1}{8}$-in. thick (soft) balsa ribs and riblets. On my model the wing is made in one piece, but it can be made in two halves exactly as described in the chapter of the "Blue Dragon" if ease of portability is desired

The tips are made from round cane shaped by hand and bound and glued to leading and trailing edge. The tip is then filled in with solid soft white balsa carved to streamline shape. This gives great strength for light weight. The wing is then covered with damp silk or bamboo paper, doped one coat of cellon clear glider dope and left to set on its bed with weights on it to prevent warping.

The Tail Unit

is built in the same manner as already described in the chapter on the " Mouse " biplane, but is entirely made of balsa with $\frac{1}{4}$-in. × $\frac{1}{8}$-in. balsa leading and trailing edge and the two main spars also of $\frac{1}{4}$-in. × $\frac{1}{8}$-in. balsa wood. The chapter on general construction should also be studied.

The fin is made up by laminated sheet balsa $\frac{1}{8}$-in. thick. The outline is cut to shape from a sheet of balsa. The centre is then cut away leaving about $\frac{3}{4}$-in. around the edges.

A smaller outline of about $\frac{1}{2}$-in. less is glued on each side and this outline, and it also has its centre hollowed out. This is followed by an even smaller outline.

The whole is then streamlined off by razor blade and sandpaper. The tail unit complete, covered with silk and doped, weighs $2\frac{1}{4}$ ozs. built in this manner.

CHAPTER XV

FLYING A PETROL MODEL

The Power Unit.

If successful flying is to be obtained, a thorough knowledge of the principle of stability, both fore and aft, and lateral, is essential. Chapter IV should help in this direction.

Whilst the constructor is building his model, he should frequently run up his engine so that he becomes thoroughly *au fait* with it and its peculiarities before the model has to take the air.

A two-stroke engine, and most commercial model aero-engines are two-strokes, is very touchy on the mixture of petrol and air that is supplied to it. If the mixture is too rich the engine will not start, and even if it can be induced to do so, it will four-stroke or eight-stroke badly. With a weak mixture the engine will have no power, and will run hot.

Most model two-strokes make the mixture of petrol and air by a small hand-operated fine adjustment.

It is advisable to open this well up and suck in with the air orifice restricted to start. Now close the petrol supply and flip over the engine with ignition on until a start is made and, as soon as two-stroking takes place, open up the fine adjustment until the running remains even and at the best power. Just before releasing the model make the mixture just a trifle rich. It is all a matter of practice, and only practice will ensure success.

Do not waste time trying to start if the ignition system is not up to scratch. Always test it before wasting further effort, and see that there is a regular and hot spark occurring.

If all is O.K., then get the mixture right, and if the engine is mechanically good the engine must go. The two-stroke is so simple.

Testing a New Model.

When the model is built the critical period is undoubtedly during the first few test flights, and it is as well to have some system.

I personally always adopt the following method:—

First of all glide the model directly *into* a medium wind, by hand launching, after having checked off that the wing is over the C.G. position—i.e., about one-third of the chord back from the leading edge should be approximately over C.G. position or point of balance of the model. See that angles of incidence of mainplane and tail are correct. For general purposes these should be mainplane approximately 6 degrees, and tailplane set flat. See Fig. 45, Chapter IV.

Now get glide correct so that the model glides flat and lands well. If necessary *slightly* alter tail-setting by packing leading or trailing edge with shavings of balsa wood. It is possible that the mainplane will want a little less or more angle of incidence according to the type of wing section used.

Packing up the leading edge of the tail will cause the nose to drop, whilst a packing under the trailing edge of the tail will cause the nose to rise.

Before the power flight be sure to get this glide perfect!

Make sure that there is no turn on the model during these gliding tests. A warped wing or wing not square or an offset fin will cause a turn on the glide. *Do not permit these.*

When the power ceases one wants to get the model to glide *perfectly straight*, so that it does not land with one wing down whilst on a turn.

The engine torque will tend to turn the model over onto one wing and cause a bank and therefore a turn under power.

Some people offset the fin or give wing warp to counteract.

This, in my opinion, is a serious mistake, as it certainly corrects the torque when the model is under power, but as soon as the engine ceases firing the offset fin, etc., asserts itself and turns the model when on the glide.

There is then no chance of landing into wind, whilst a dangerous wing-tip landing is possible, and in extreme cases a spin may even take place.

The best way to counteract engine torque is to *offset the thrust-line.* If it is desired to turn the model in circles down-wind, then only give sufficient offset so that torque only partly turns the model when under power.

Having obtained the correct glide with fin straight and no wing warp, and given what you consider will be about correct offset of thrust to counteract torque, now cant the " detachable " engine-mounting downwards so that *plenty* of down-thrust is given, by placing temporary packing between the mounting and the first nose former. Give 10 seconds' flight on the clock-timing device and release the model on *full throttle.* If the down-thrust is too great the model will not rise before the clock switches off the engine. Reduce the down-thrust packing a bit at a time with 10 seconds' engine-runs until the model starts to rise. Now give a 20-seconds' flight and observe whether more or less offset to thrust is required or whether you consider the model may be allowed to climb either more or less by giving more or perhaps less down-thrust.

Do not under any circumstances alter the correct gliding settings.

If the above method is carefully followed out there is very little danger of damaging the model provided it is fitted with the correct type of undercarriage as already discussed in this book and provided the undercarriage is as far forward as possible.

It is fatal to alter wing positions, etc., to control climb under power.

When I damage my models in reasonable weather it is always due to cutting out the above procedure due to either laziness or haste. It sounds simple, and is simple, if the correct sequence is carried out and the model has been correctly designed for stability as discussed in Chapter IV.

If one sees a model that either dives or stalls after a good power flight it means that the model has only been adjusted or designed for power and not first as a glider. If it is found that too much down-thrust is required to prevent stalling after the correct glide has been obtained without power, it means that the model has been designed with the centre of pressure of the wing too high in relation to the thrust-line. The best thing to do is to try again, and produce another model and benefit by the experience gained!

Finally, do not try long flights over closely-populated

areas. The risk is not worth while and gets the petrol model a bad name.

With the clock-controlling device described in Chapter III there is no difficulty in obtaining controlled duration of flight.

CHAPTER XVI

FINAL REFLECTIONS

WHILST writing a book of this kind, advances are taking place both in one's own methods and in those of others. It is therefore worth while reviewing some of these at the conclusion :

Ignition.—I have recently been making some experiments with platinum points for contact-breakers on model engines, for it has always seemed to me that one of the chief weaknesses of the model aero petrol engine is the touchy spark. This is, of course, due to the limited voltage and capacity of batteries used for flying. I do not wish to give the impression that the standard tungsten pointed contact-breaker as generally fitted will not give successful running. It does. But in many cases it requires careful adjustment, as the points *must* make good contact and be kept *absolutely clean.* A friend and I first tried a type of contact-breaker in which a spring arm slid over an insulated segment of brass (let into a circle of fibre) during each revolution of the engine. If one even put a normally moist finger on this brass segment, either a very weak spark, or no spark, occurred until the propeller had been revolved several times. As the spring arm scraped the segment dry and clean the spark became hot and satisfactory. This proved to us that a very little indeed was necessary to break down a good contact with the low voltages we used on model engines.

I then fitted a " Brown Junior " and a " Cyclone "

engine with platinum points. The general improvement was very marked, and it was found that a good spark was obtained even with the points only touching at one side, and not square to each other ; also that these points seldom ever require cleaning. Starting and general good running was therefore much more reliable and required less effort.

Platinum points are, of course, much more expensive. That is the snag for the commercial engine. Nevertheless I think these experiments are worth recording.

A Light British Coil

There is now a new coil on the market made in Britain weighing only $1\frac{1}{2}$ oz. called the " Comet " coil. So at last we can obtain a British commercial coil lighter than even the average American coil. This is particularly useful for the very much smaller types of engines now being produced, because the weight of the ignition gear has always been out of proportion to the rest of a model petrol engine. This coil was produced for the British 2.3 c.c. " Spitfire " engine, but I find it works equally well with larger engines.

A Light and Simple Time Switch.

The " Autoknips " camera timer has been made up commercially by Mr. Brooks as a satisfactory and simple time switch where durations of not more than about sixty seconds are required, and where light weight is essential. That excellent American book, the 1937 *Model Aeronautics Year Book*, by Frank Zaic, also has a similar device described in the latest edition. I have used these " timers " and they are accurate and efficient.

For those who cannot find time to make them up for themselves, they can now be obtained commercially. Fig. 94 is a sketch of the timer as it can be made. It should be mentioned, however, that the clock type of timer is still essential where longer controlled durations are desired.

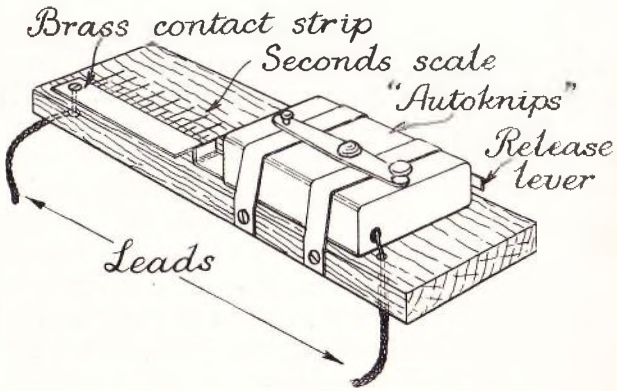


FIG. 94.
Autoknips Timer. Weight approximately $2\frac{1}{2}$ ozs.

A Further and Simple Method of Constructing a Petrol Model: The "Kub" 5 ft. span, chord. 9 in. See Fig. 95

I have recently made up a small model to suit the 2·3 c.c. "Spitfire" engine which is now in full production, and is a very excellent little engine by the way.

This little engine, though only of 2·3 c.c., has a most astonishing amount of power, and when run in, starts up very easily indeed and is not touchy whilst warming up like some of the very small engines.

I find it advisable to run it in upright, but as soon as one understands the engine adjustments and it is run in, it can be inverted if desired, and this engine then runs just as well, provided the plug is taken out after a run, as oil may drain down on to it when the engine is standing. My model, the "Kub," has a rectangular fuselage made almost entirely of sheet balsa.

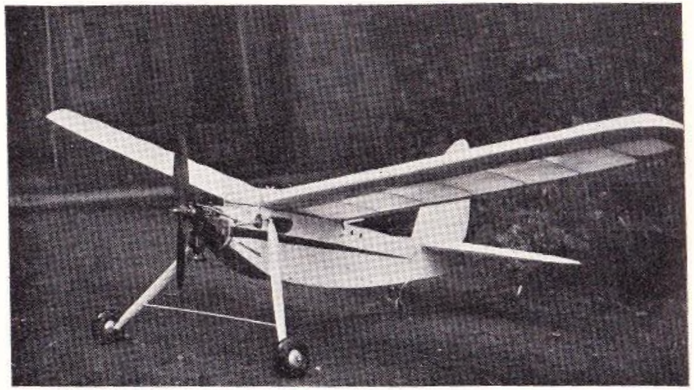


FIG. 95.
The "Kub" fitted with 2·3 c.c. Spitfire engine, inverted and mounted on a detachable elektron mounting.

The fuselage is 32-in. long. Each side is merely cut out from $\frac{1}{16}$-in. sheet balsa to the shape of the side elevation of the fuselage—$\frac{1}{4}$-in. × $\frac{1}{4}$-in. balsa longerons are then glued and temporarily pinned whilst the glue is drying, along the top and bottom of the side sheets. A few uprights are also glued in.

There are only two main three-ply formers to take wire hooks and undercarriage tube loads.

The sides are now glued to these formers and allowed to dry. They also act as jigs whilst setting up the fuselage, and the fuselage cannot get out of square.

Cross-pieces of $\frac{1}{4}$-in. × $\frac{1}{4}$-in. balsa are then glued into position, top and bottom.

The top and bottom also of $\frac{1}{16}$-in. sheet balsa is then glued on and temporarily pinned (with household pins). When dry all pins are withdrawn. A circular

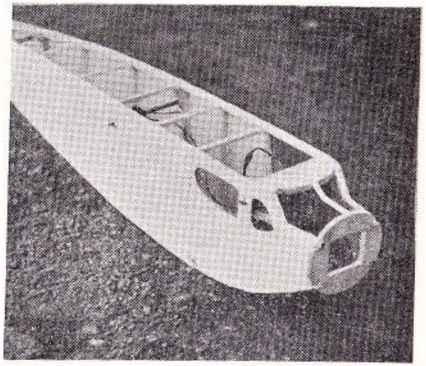


FIG. 96.
Method of constructing simple lightweight rectangular fuselage.

three-ply nose for the usual Electron detachable engine mounting is then merely glued on to the front of this simple fuselage. Plastic *balsa wood* is now pressed and moulded around the rectangular nose to merge the circular nose into the fuselage and give the necessary strength to the fuselage nose. See Fig. 96, showing fuselage before this plastic wood has been applied.

The fuselage is now covered with silk and the job is done in record time! Two or three evenings will produce a fuselage.

Now refer back to Fig. 96 and you will observe my latest undercarriage for very light models. It has the same principles as all those used on preceding models, i.e., it goes back first and then upwards on landing, but it works on rubber bands from the nose to the legs.

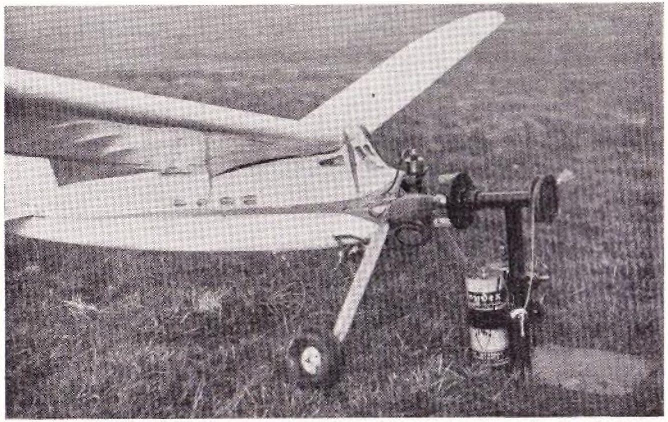


FIG. 97.
A mechanical starter complete with switch and ground battery. The machine is a six-foot span Monocoque high-wing model, built by the author.

The legs are kept from coming too far forward by linked wire. It is lighter to build, and when the elastic bands are removed the undercarriage folds up under the fuselage for easy transportation.

An Engine Starter.

Although well-tuned engines now start quite easily by hand, it is rather nice to have a simple device without gears that will spin an engine round fast and always ensure easy starting with the minimum of effort and possible damage to one's fingers through carelessness.

Fig. 97 shows a starter that I have made up. It is almost self explanatory. The arm that holds the starter dogs is adjustable for any height of model. At the rear of the starter shaft a pulley with a notch is mounted on to the spindle. This is similar to a model speedboat flywheel starter.

A cord with a knot at the end is merely wrapped around the pulley a few times and the end is then pulled rapidly up, thus spinning the engine a number of times. It is a gift starting like this! Undoubtedly the lazy man's way.

Three bell batteries, a switch, and two leads and plugs are carried on the base. Thus, one merely plugs into the ground starting plugs on the model and switches on and off as desired from the starting position in front of the model.

On the model shown in Fig. 97, the latest B.B. air-wheels are shown. They are extremely simple, cheap and effective and are British.

Starting the New Baby Miniatures of 2·5 c.c.

Remember that everything is very small, including the amount of fuel required to pass the valve. Be very careful of the needle opening and treat it delicately. It is very critical and requires practice. There are a few rules that will save people from cursing the engine and giving themselves a lot of unnecessary labour.

Rule 1.

Use a well charged four-volt accumulator (except where otherwise specified by makers) or three bell batteries for starting. Once the engine is warm and ready to fly, switch over to an ordinary flash-lamp type battery. *Always* test for spark by removing the plug lead and holding about ¼-in. from cylinder body whilst turning the propeller. *There must be a regular hot spark that will jump this gap every time.* If not, check up on battery, or contact-breaker points may be dirty, etc. Gap at plug points should normally be about ·015 in.

Rule 2.

Assuming the ignition side to be found correct, open the needle-valve until petrol drips from air intake (on engines mounted upright). Turn propeller two complete turns only and then close jet completely. Flick engine over several times smartly to start. At first the running will be uneven until surplus fuel in the crank-case is used. As soon as even two-stroking commences, open up the needle valve to correct setting, *and not a moment before*, or you will choke the engine.

One spot of fuel is quite sufficient to choke and prevent any signs of starting. I have already seen a number of people claim that these little engines are bad starters, *or will not start at all*, until they have grasped the above method and have realized how easy it is to hopelessly flood them.

Always strain the fuel carefully as a tiny speck of dirt will choke the minute jet orifice.

If these little engines are dealt with sensibly they run and operate delightfully.

Wing Sections for Baby Engines.

Finally, the new little engines around 2·5 c.c. naturally have not the same fierce thrust of their larger brothers. It is advisable therefore to keep the under camber on wing sections moderate, if you elect to use undercamber as I do.

The reason is, of course, that a large undercamber puts up a lot of resistance. A slight undercamber and a thickish wing section I find ideal for the baby engines, for there is more " float " with this type of section and therefore less power required to fly the model.

Correction to Fig. 92, Page 156.

The dimensions of the fin shown in the drawing are too small. They should be altered to $9\frac{3}{4}$ ins. high, and $7\frac{1}{2}$ ins. wide. The tail rib should be $\frac{3}{4}$ ins. instead of $\frac{3}{8}$ ins. thick as shown.