CHAPTER IV

HOW TO START DIESELS, INCLUDING A STARTING DRILL

GOOD STARTING MAKES POWER FLYING, BOATING AND CAR WORK A PLEASURE

BEFORE reading this chapter it is highly desirable to read the previous chapter on the matter of fuel.

Model flying is made or marred by easy or bad starting. This also applies to the good name of an engine. The general principles for starting also apply to boats and cars. I am including a few specialised notes on these at the end of this chapter.

The diesel is a very simple engine to start provided it is of good design and construction, and provided the individual attempting to start it understands certain principles and then applies these with patience in an orderly sequence.

Some time ago, I visited two model engine manufacturing firms, whose engines I had owned and flown, and which I knew to be good starters. I was shown their method of testing every engine that left the factory for good starting and power output. The test was rigorous and engines were sent back for attention by the tester if they did not start up in the specified time by hand-swinging a normal propeller as advised for flying.

Both these firms had a very excellent reputation, and yet there were certain individuals who could not start their products, although these were sent out with " controls set." In a few cases, people had written rude letters and said hard things about the engines. I was perfectly satisfied that these were quite unjustified and that the fault lay at the door of the complainers. Even the best manufacturers suffer these unjust complaints through lack of elementary knowledge on the part of certain of their customers.

One of the most difficult things that a maker has to face is

to get all new owners of his engines to read the simple starting and operating instructions sent out with engines and then to abide by these instructions.

Some new purchasers are too eager to get at the engine, whilst others think they know better. There are people who think they know all there is to know about model engines because they own a car or a motor-cycle. There are also some who are just stupid, and fiddle until they lose the original settings. They cannot then find these settings because they have not marked them or made a note of them.

There are others who have had some engineering training, but fail to appreciate the fact that model engines, although fundamentally the same as full-sized engines, require a different technique of handling. Happily there are also many sensible people who read their instructions and use their common sense. It is my hope that this book will appeal to this type of person, and perhaps win over a few of the others.

Many people have come to me and said in various ways, " This engine is no good, I can't get it to start, and so I took it to Mr. So-and-So, who is a ' full-size ' engine expert, and diesels are his daily fare. He can't get it to go. I cannot think how a huge firm like Such-and-Such & Company can put a thing on the market that will not start. Robbing the poor, I call it." Or words to that effect. A few slight adjustments to undo the heavy hand of the " full-sized " engineering expert, who one sometimes suspects being an apprentice in a country garage, chiefly concerned in sweeping the shop up, followed by a few flicks of the propeller in the right way, and the poor manufacturer's reputation is vindicated through a burst of diesel power that surprises the owner, and sometimes almost annoys him that it should be so simple. The fact is that the modern manufacturers do not put dud engines on the market, and a new owner would be wise to suspect flaws in his own efforts rather than in the engine. This happy state of affairs was not so a few years ago at the beginning of model diesel popularity in Britain. Most of the duds have died a natural death.

One of the most common faults is to screw down the contra-piston on a diesel hard should it fail to start quickly. This faulty reasoning being " because it is a compression ignition engine, and therefore if one raises the compression really high the thing is sure to start." I can assure this type of individual that he is most unlikely to obtain a start because the compression will be too high, and he is most likely to damage his engine !

If we are novices, or even fairly experienced petrol modellers, let us READ THE INSTRUCTIONS AND ABIDE BY THEM. Let us mark or otherwise keep a record of the settings sent out by the makers, of needle-valve and contra-piston—we shall then have a basis on which to start off, and to refer to if we make a mess of things ! It must, of course, be realised that the settings as sent out may vary a little due to a slightly different fuel and other reasons, but they do form a basis from which to work.

NECESSARY PRELIMINARIES

Make sure you have a correct propeller as recommended by the makers. Diesels and glow-plug engines are very much affected by the propeller size, balance and weight. The diesel, generally speaking, is a slower revving engine than the glow-plug engine, which is not of much use unless it can " rev." The propeller controls engine speed by diameter and pitch. Its design is therefore vitally important to get the best performance out of any particular engine type. For each type has its own peculiar characteristics. Maximum horse-power is produced at different revolutions.

Also make quite sure that the engine is firmly mounted and that mounting bolts are tight after each flight or run. This is very important, due to the high compression which causes rougher running than with petrol engines ; and also the swinging of the propeller against high compression. Vibration-free running in the model is necessary ; vibration also upsets fuel mixture strength.

It is most astonishing how many people fit incorrect propellers or mount their engines on some flimsy mounting, very often with the unfortunate engine lugs unevenly supported.

Make absolutely certain that you have the correct fuel mixture with the correct proportion of constituents as recommended by the makers. So many people try weird mixtures and curious lubricating oil substitutes, such as old car sump oil, machine oil, bicycle oil, and so on, often because " an engineering friend " has told them that, being a tiny engine, it requires thin oil. Do not listen to such false prophets and advisers. Unfortunately, I find that they are legion.

Be sure that your fuel is filtered, kept in a clean bottle and well corked so that the ether content does not evaporate, also see that you have a suitable pourer.

Check that the propeller is screwed well home and tight and if possible that a lock-nut is fitted. We should check this tightening of the propeller nuts after each run or flight, as some diesels have a habit of shedding propellers. Do not over-tighten with a vast spanner, as threads can be stripped.

The propeller should be bolted up so that it is coming on to compression just before the top of the starting swing.

THE NEEDLE-VALVE

On a model petrol engine the needle-valve setting is critical.

This is not so critical in the case of most diesels, but there is a definite relation between the needle-valve of the carburettor and the contra-piston—once the needle-valve setting has been found in the case of the diesel, very little alteration need be made, provided the constituents of the fuel are carefully adhered to each time a new supply is mixed up, and provided the fuel bottle is kept corked to prevent evaporation of ether.

We should therefore remember, " DO NOT FIDDLE WITH THE NEEDLE-VALVE."

Get the setting correct and leave it. Make a mark where the needle-valve should be set. You can then always refer to this mark. Should there be no setting given with the engine when it is purchased, or should the operator lose the setting, the drill given in " Procedure B " overleaf should be carried out.

When I used to go in for competition flying and hydroplane racing, I made a rigid practice of finding the best needle-valve setting, or the correct jet in a fixed jet carburettor before the event, and then keeping to this. *I never fiddled with this setting;* as a result I was able to obtain quick starting and reliable performance, when many of the competitors were juggling with adjustments in a wild desire to get that little extra bit out of the engine. This so often results in confusion. Mr. Rankine, the famous hydroplane exponent, adopts a similar attitude, whilst Mr. Curwen, one of the best known car racers in this country, is also a believer in the principle. I will quote the words of a letter he recently wrote to me referring to his petrol race car. " Two or three pulls to choke, and the engine starts every time with the choke half closed. *I never alter the jet setting*—at least, I have not done so for the past four years or so on this engine. Speed has been very consistent for some time now."

On the other side of the picture, at the 1946 " Bowden International Power Trophy " for model aircraft, I have seldom seen so much trouble over the starting of engines, petrol and diesel. From careful observation, I should say that 80 per cent. of this was due to the competitors wildly playing with their needle-valve adjustments, as soon as their engine did not respond at once to the starting swing. The results were chaotic, for " the known best run settings " were lost, and engines became choked or starved, and were often sent off weak or rich in the heat and excitement of the competition fever, when and if they did get started. Almost everyone used their full time limit of three minutes and three false starts which delayed the whole competition. Most of this would not have occurred if the competitors had left their needle-valve settings at the " known best run position," and then choked or doped to suit their particular engine to obtain the start from cold, always provided, of course, that the needle-valve orifice is kept clean.

HOW TO SWING THE PROPELLER

I have watched a considerable number of people who say that they cannot start their diesels, and petrol engines too, and I have noticed that one of the real stumbling blocks is the swinging of the propeller. Some get quite testy if they are told

they are swinging improperly. They are surprised when one gives two or three swings to their " difficult " engine, and off it goes.

There is a right and a wrong way of swinging a propeller. Let us first see how not to do it, the way many newcomers

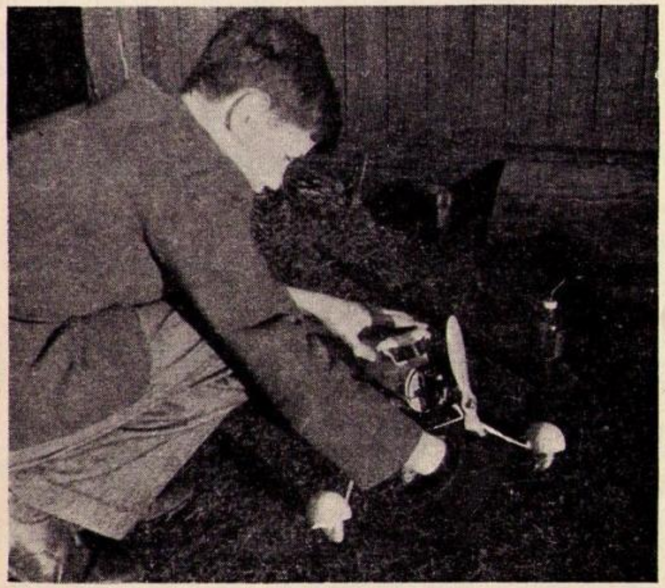

Fig. 60. The starter cramps his style by not facing the propeller properly.

try to do the job. Then let us see how to do it. I have taken a few photographs which I think may help. The methods I advocate are my own and not necessarily the only way, but I can at least recommend them as a way of getting a start. Goodness only knows how many propellers and flywheels I have swung in my life-time!

(1) *The Wrong Way*

Look at Fig. 60 and you will notice that the starter is bending over his engine from the half rear, or side, where he cannot really get at it to swing lustily.

Notice how he pulls up on the propeller and therefore cannot flick it over the top and downwards with a good three-quarter follow through at speed.

He has his swinging finger too far out on the propeller blade. This makes a long arc for him to swing and so reduces the speed of the " flick " over compression, and the speed with which the propeller rotates and the engine sucks in and compresses the mixture. See Fig. 61. It should be realised that *in order to obtain the necessary heat from quick compression to fire the gases the speed of the swing or flick must be great. A weak, half-hearted swing is useless!* Fear of a kick-back sometimes causes this. A weak swing actually encourages a kick-back!

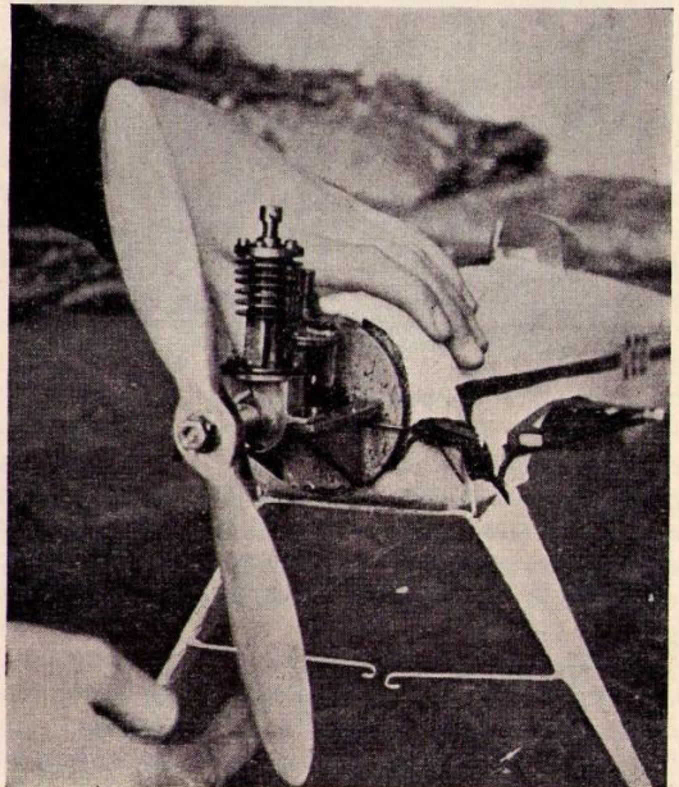

Fig. 61. The starting fingers are too low down the propeller.

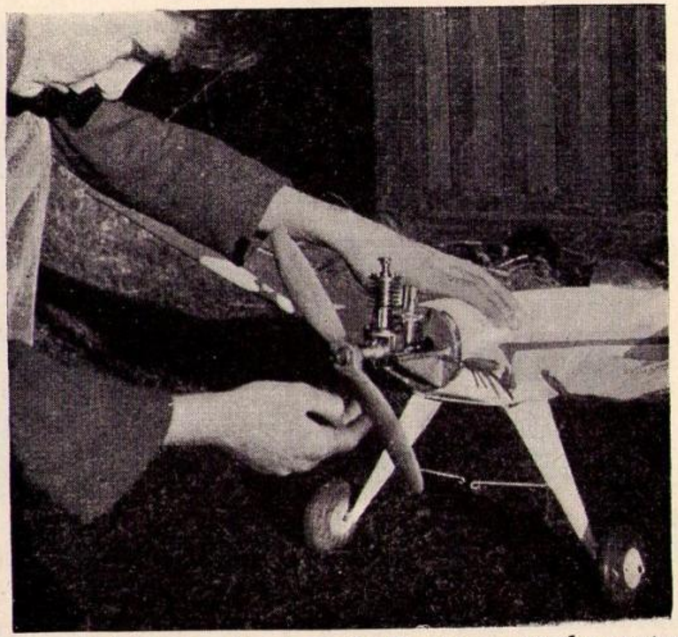

Fig. 62. It is better to place the fingers near the centre of the propeller. This allows a quick flick.

(2) *The Correct Way*

Now look at Fig. 62.

It will be observed that the starter is now *in front of* the engine where he can swing *with a follow through.*

This follow through is most important and the lack of it is the reason for a great many failures to obtain a start. As soon as people are shown how to obtain it, they start their engines. It is like the follow through wrist flick of the golf swing. It adds power and speed to the stroke.

The starting finger of many aeromodellers leaves the propeller when it has swung the propeller for only half a revolution, and in some cases less. This is sometimes due to being afraid of the engine and sometimes due to lack of practice. The follow through flick is a technique that has to be acquired, and the propeller must travel through at least three-quarters of the circle.

The swinger must not be afraid of the engine! The starting finger should be placed about halfway down the propeller. This permits the operator to flick the propeller over more quickly than when the finger is placed at the propeller tip.

Position the propeller correctly. In order to be able to swing the engine properly over compression to ensure easy starting, it is essential for the propeller to be attached to the crankshaft in the correct position relative to the compression point at the top of the piston stroke. Therefore screw up your propeller on the crankshaft so that it is coming on to compression just before the top of the starting swing.

A STARTING DRILL

If we have our preliminaries as mentioned correct, and we have mastered the starting swing as detailed above, we can best obtain success by practising a simple drill. This gives us an orderly sequence. Below I give a simple starting drill (a) *when the makers' settings are known.* This is followed by starting procedure (b), assuming both needle-valve and contra-piston settings have been lost, and (c) for fixed-head engines.

(a) *Starting drill when the settings of needle-valve and contra-piston are known* :—

When the engine is received from the makers, the settings should be noted and marked, so that they are not lost. They then form a basis from which to work.

(1) Fill the tank. (Never leave fuel for long periods in the tank, as the ether evaporates and leaves an incorrect fuel mixture.)

(2) Check that known settings are set as indicated, and make sure that the flight timing device is open.

(3) Increase compression by screwing down compression lever a quarter turn from "running setting," i.e. raise compression slightly. For exceptions, see remarks at the end of this drill.

SEE NOTE AT START OF BOOK
(ON BACK OF HARD COVER)

Fig. 63. Here we see a well-known competitor facing his 1 c.c. "Frog" diesel and starting easily in "The Bowden International Trophy," 1946.

(4) Suck in fuel by swinging propeller smartly two or three times with finger over intake (refer back to Fig. 24, Chapter I, if in doubt of how to do this). Wet fuel on finger shows that fuel is being sucked up. Diesels take a lot of fuel to start. Do not overdo however—gravity-fed engines flood easily.

(5) Swing propeller smartly and when engine fires return contra-piston to original "running setting."

(6) If engine gets "over hard" and will not start as described overleaf in Procedure B, para. (7), unscrew contra-piston one turn—"obtain relief," then screw up contra-piston to "start" position, and swing to start.

(7) Finally, make slight adjustments to obtain maximum power. *Do not over fiddle with adjustments*, as diesels are not as critical as petrol engines—once a sound adjustment is obtained, they run steadily until the fuel is exhausted.

(8) If your model is one that climbs at a steep angle, test

the running fuel adjustments to suit by holding model with nose up. See Fig. 70.

A good diesel will be found very reliable and extremely simple to start. It is all a matter of the correct fuel, the correct needle-valve setting, and the correct compression. *There is no worry about the electrical spark*, for it does not exist. The fuel mixture is ignited by the heat generated by the high compression. As the engine warms up, we obtain an extra source of heat. The fuel will therefore be ready to ignite at a lower compression adjustment. We therefore reduce the compression slightly, as in para. (5) above.

If we do not reduce the compression slightly when the engine is warm, the fuel will ignite too early. The warning symptoms are—at first the engine note sounds less free, and later, the engine will gradually lose speed and sometimes even stop altogether. This puts extra stress upon the engine. *Keep the compression as low as possible for a long engine life.* It may sound unnecessary to say that there is no spark. I have however, had several letters from enthusiastic new modellers saying they cannot get a spark from their diesels! No names, no pack drill.

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With regard to the exceptions mentioned in para. (3) above: there are a few diesels on the market which I have found to require no alteration of the contra-piston between starting position and running position. There are also a few engines which start very " wet " which actually like the C.-P. to be slacked off slightly to start, and then screwed up. The advantage of the contra-piston lever in these cases is that slight alteration can be made to compression ratio should one change the fuel in any way, or should one flood the engine by mistake.

DIESEL KNOCK

This phenomenon is caused by shock from the whole structure of the engine, and should not be confused with local pinking of a petrol engine.

Diesel knock is caused on models by too great compression, as explained above and also by a too weak mixture combined with over compression.

(b) *Procedure, assuming both needle-valve and contra-piston settings have been lost.*

(1) Unscrew contra-piston lever completely. Take right out if there is no stop fitted. If stop fitted, unscrew to stop.

(2) Shut needle-valve.

(3) Turn propeller over smartly, which should raise contra-piston to the top of the cylinder. This usually causes a smart crack to be heard, as though something has fractured. Actually, no damage has been done, but the contra-piston has shot up to the top of the cylinder through the force of compression.

(4) Replace C.-P. (contra-piston) lever, and screw down gently until it meets resistance of the contra-piston itself, or if stop is fitted keep at " unscrewed position."

(5) As no setting is known for needle-valve, it can be found only by experiment, and it is fairly safe to try one turn open. (Some engines require as many as four turns open. This depends largely whether the needle-valve is a fine or coarse taper.)

Try one turn—choke engine by placing finger over the intake and swing propeller smartly twice.

On removing finger, and again swinging, a wet sucking noise is heard if fuel is being sucked up, also fuel can generally be seen on the finger-tip which has been withdrawn. If no sign of fuel is present as above, repeat process, with needle-valve open another turn. If still no result, try another turn.

CHECK UP THAT THERE IS FUEL IN THE TANK!

(6) Fuel is now assumed to be present—swinging the propeller as smartly as possible with the right hand, very gradually screw down the contra-piston with the left hand—when the correct setting has been reached, the engine should begin to fire.

If the needle-valve setting is too weak, engine will run and then stop, and no further turning of the propeller will restart it—open needle-valve approximately a further half turn. On the other hand, *if the setting is too rich, the engine will run with regular bursts of speed up and down the scale.* This indicates that it needs either more compression (C.-P. lever screwed down) or weaker mixture (needle-valve screwed down).

It will be appreciated that it is not possible to give a newcomer to diesel work a completely foolproof explanation of starting when all settings have been lost. Some experiment and " starting sense " is often required, and this can be obtained only by practice *along the right lines,* as laid down above.

(7) *The " over-hard " engine due to excess of fuel.*

One snag must be clearly understood, and be again emphasised—*the compression space, i.e. the space between contra-piston and the piston at top dead centre in diesel motors is very small (often only 1/32 in.) in order to obtain the necessary high compression ratio to create auto-ignition.* It is therefore possible, particularly on the smaller motors, to suck in too much mixture in which the oil content remains, whilst the ether may evaporate—oil is practically *incompressible.* This will make the propeller either very difficult or impossible to get over top dead centre. If the operator attempts to force the engine over top dead centre, he must be prepared to bend or fracture something inside the motor. It is then useless to complain to the manufacturer about such a motor. He knows the reason for the damage—you !

Slight difficulty in turning the engine over compression is perfectly correct, and in fact necessary to start. But there should be no difficulty in recognising when the engine becomes really " over-hard " and the operator is forcing it to breaking point.

Should this " over-hard " condition occur, i.e. when too much fuel has been sucked in, the *contra-piston lever must be unscrewed half to one turn.* The engine is then swung over compression, which raises the contra-

piston and creates relief. After relief the compression can be slowly raised again by screwing down the C.-P. lever whilst swinging the engine, until a start occurs. As one becomes experienced it is quite possible to " sense " an engine with too great a compression to start, although it has not reached the " over-hard " state, which is often known as " hydraulicing."

THE " HOT " HIGH SPEED MOTOR

During the past year or so a number of very high efficiency diesels have been produced for speed competition events. These are sometimes best started by dropping two or three drops of fuel into the open exhaust port from the fuel can's spout, and swinging with vigour to start. The normal running settings are left. A stuck-up contra-piston often worries newcomers to the diesel. This is explained at the end of this chapter.

(e) *Starting engines with " fixed heads," i.e. the engine with no adjustable contra-piston.*

Manufacturers who make engines which are not fitted with the adjustable piston, issue instructions for a fuel mixture. The proportions and ingredients of this mixture must obviously be adhered to because deviations in the fuel mixture cannot be compensated by compression adjustment through a contra-piston.

Should the " over-hard " engine be experienced, as has already been explained, due to too much fuel being sucked into the cylinder, the only rapid cure is to turn the engine backward until the exhaust port is seen to open. Now turn over on its side and drain out fuel from cylinder—then commence starting operations again.

I am giving below an abridged extract of the very excellent starting instructions drawn up by the French " Micron " diesel makers. The 5-c.c. motor, an example of which I have (see Fig. 6), has a fixed head and can be taken as a very sound fixed head design.

If the reader will refer to Chapter III, he will see the recommended fuel by the "Micron" firm; he can then read how to start the "Micron" fixed-head engine below. These instructions will suit many other fixed-head engines where the induction pipe points downward from a crank-shaft rotary valve, as in the case of the French "Micron" and the British "Owat."

Extracts from "Micron" instructions

"Easy starting is mainly dependent on the nature of the oil used. Results can vary *considerably* with different oils. If you encounter difficult starting, change the oil content. For your first trials use more oil, 30 per cent. to 35 per cent. The adjustment of the fuel valve is then less sensitive.

Starting

(1) Close the fuel valve. (Needle screwed right home.)
(2) Fill the tank with fresh fuel.
(3) Set the flight timer control plunger by pulling it upwards until the catch engages, i.e. fuel is allowed to flow.
(4) Open the fuel valve three or four turns. The mixture will run of its own accord and will fall drop by drop from the air intake. If the mixture does not run in this manner (owing to an obstruction), close the air intake opening with the finger and give the propeller one turn.
(5) As soon as the mixture is dripping from the intake pipe, close the fuel valve completely. The mixture, having filled the intake pipe, produces an excessively rich mixture of gas to be drawn into the engine which prevents an explosion.
(6) Swing the propeller (anti-clockwise) until the motor fires.
(7) Now open the fuel valve approximately ¼ or ½ a turn and continue swinging the propeller.
(8) Two conditions may present themselves :—
   (*a*) *The fuel valve may be too far open.* The explosions cease and the compression becomes "stiff" to pass. The mixture flows drop by drop from the intake pipe. (It is gravity feed on these engines unless they are inverted.) Close the fuel valve and swing the propeller until the engine starts a series of explosions of greater and greater length until it runs without stopping.
   (*b*) *The fuel valve is not sufficiently open.* The motor fires but knocks at compression—open *very slightly* the fuel valve and swing the propeller until the engine starts a series of explosions of greater and greater length until it runs without stopping.
(9) As soon as the motor runs, open up the fuel valve and search for the setting which gives optimum results where the motor does not knock.

After a few starts, the knack of cold starting will be acquired. When warm, after the motor has run a little, starting will be instantaneous and the regulation of the fuel valve less sensitive.

Too weak a mixture causes knocking and puffs of smoke from the exhaust.

A flimsy engine mount causes air bubbles in the fuel due to vibration. This creates uneven running."

Should you own a *fixed-head diesel* with the induction pipe upwards or horizontal and where the fuel is sucked up and not gravity fed, the starting instructions are very similar except that the owner cannot watch for the dripping of fuel. The fuel must be sucked in by choking by the finger, but you must be careful not to suck in too much, as there is no contra-piston to unscrew momentarily and give the engine relief for excess of fuel.

The reader has been given three different situations to choose from which have been explained in detail.

First: The drill for starting with a diesel fitted with a contra-piston and where he knows the maker's settings of contra-piston and needle-valve.

Second: The method of finding the settings if they have been lost for an engine fitted with a contra-piston.

Third: A method of starting a fixed-head (i.e. no contra-piston) diesel.

These three situations should cover any diesel starting problem likely to be met with. The main thing being to understand how the diesel works (described in Chapter I) and then to practise starting on sound lines until a " starting sense " is gained. The midget type is dealt with below.

Although it has taken a long time to write about the matter, in order to cover all possible details and troubles, in actual fact starting is quite simple and is soon mastered. If the reader has any form of trouble, I feel convinced he will find the answer somewhere in this chapter.

STARTING THE MIDGET TYPE

The midget type of diesel is not as easy to start as the larger type from 1 c.c. upwards, owing to the small clearances in the cylinder-head, i.e., between contra-piston and piston.

The engine often sucks in neat fuel when choked. The very small space in the cylinder-head becomes full of fuel, and it is therefore absolutely necessary when the engine becomes " hard " to slack back the contra-piston a half to one turn, according to the feel of hardness. When the engine becomes free, *slowly* return contra-piston to the running " setting " whilst swinging the engine.

During this process the engine will most probably begin firing. It is then that experience will show precisely the way to manipulate the contra-piston. It should never be necessary to touch the needle-valve setting, except for minute adjustment for maximum revolutions. Also remember that the contra-piston adjustment must be very delicate because of the very small compression space in the cylinder-head.

We thus have in effect only one adjustment to make for the midget engines, namely, the contra-piston. This simplifies the problem. It cannot be emphasised sufficiently that the least possible fiddling with adjustments, *combined with patience*, obtains results. It is most noticeable at competitions and elsewhere that starting difficulty is usually due to over-adjustment in an effort to get the motor to run before the mixture is properly vaporised and warmed up through the heat generated by turning

the tiny motor over compression a sufficient number of times very rapidly.

Once a diesel, particularly a midget, has started on its first run of the day, subsequent starts are more easily made, and it is frequently the best plan to leave all settings at the best running position, suck in twice and swing until a start is made.

I find that " Mills " fuel is particularly efficacious for my " Mite " engines of 0.7 c.c. once I have obtained the *exact* setting of the compression. I use ½ Mills-½ ether for midget engines because this greater content of ether does not clog up the tiny fuel space around the needle-valve.

There are exceptions to every rule! When the " Frog " 1-c.c. engine is inverted it becomes gravity feed, due to the tank fitting arrangements. When the engine is run upright the feed is suction. In the gravity-fed inverted position, care must be taken that the engine does not become flooded at the start. It is good practice to suck in one or two swings with the needle-valve open to the normal run position. *Then close the needle-valve, start, and when the engine produces a burst of song, open up the needle-valve to the normal best run position*, approx. half one turn open. With the engine in the upright position, and its suction feed, there is naturally no need for these special precautions. A small sleeve is fitted into the induction pipe for upright running of the " Frog 100 " This improves starting in the upright position, but should not be used when inverted.

STARTING BOATS AND CARS

In this chapter, we have discussed how to swing a propeller for aero-engines. Many people will also want to use diesels in boats and cars where a flywheel is fitted.

In Chapter VI, I describe a car that is not fitted with the normal flywheel and can be started by a flick of one wheel, the drive then being taken up by a centrifugal clutch. However, the bulk of modellers will doubtless use flywheels for cars, and will certainly do so in boats. In the case of cars, a centrifugal clutch will most probably be fitted to take up the drive evenly as the car is sent away.

I have done a great deal of petrol hydroplane work, and I have built a number of V-type planing speedboats during which I have found that the most simple and reliable method of starting engines is to turn a groove in the outside periphery of the flywheel, where the leverage is greatest (not at the centre, where starting pulleys are sometimes fitted), and to use a round leather sewing-machine belt. The belt is held in each hand, as shown in Fig. 64. The hull or the car is either held down by a helper, or temporarily held to its starting-stand-cum-tool-box by thick elastic bands if the operator is on his own. By pulling the belt up from one side to the other smartly, and retaining just sufficient pressure for the comparatively large frictional surface of the leather to grip the V-eed groove of the flywheel, the engine can be turned over quickly for a couple to three revolutions, and a start easily obtained.

This simple method is very effective and cuts out special

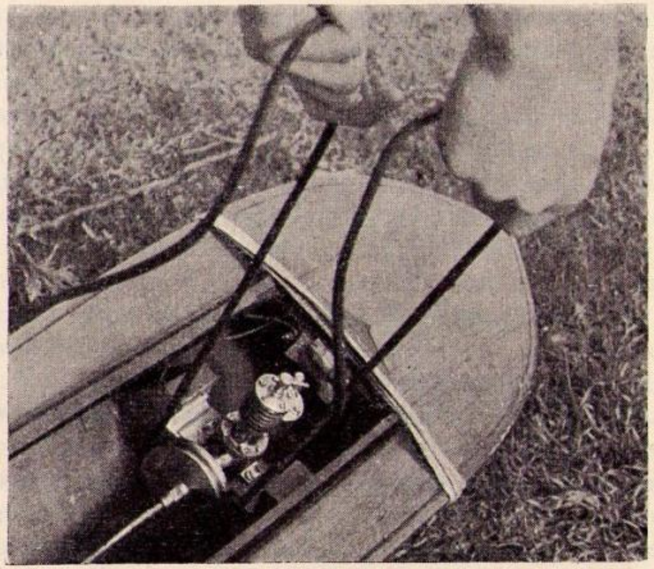


Fig. 64. Starting a boat engine is best done by the simple leather thong method.

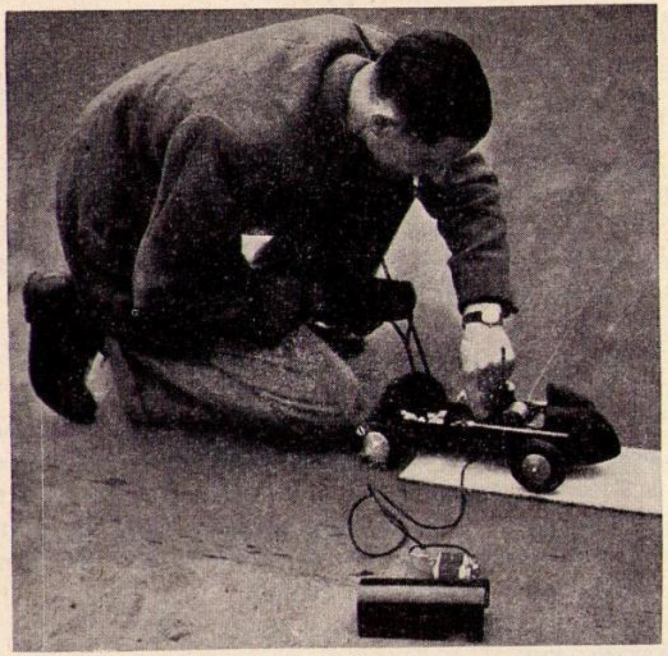


Fig. 65. Mr. Curwen, the well-known car exponent starting up his car (in this instance a petrol engine) by a blind cord. He is noted for his quick starts, and has set up officially observed speeds of over 60 m.p.h. with his diesel car.

ratchet pulleys and other complicated mechanisms that are no more efficient for the main object of starting the engine, but do cause considerably more trouble to make and maintain. In a few cases car starter motors have been adopted with a friction drive to the model flywheel. This method, however, means the carrying of weighty starter motor and storage battery and is more useful for a club.

When starting by oneself, it is found impossible to pull up the thong using both hands, and at the same time to choke the carburettor by finger. I overcome this difficulty by doping the carburettor with two or three drops of fuel, or by fitting a little cork plug which I take out after two or three suck-ins. The cork is not lost, as it is on a string.

A description of diesel cars and boats is given at the end of Chapter VI.

Let us quote Mr. Curwen in his own words contained in a letter I have beside me, " The technique (or drill) is to hold the car down by kneeling on a board fitted with the hooks which register with a cross-member fitted across the bottom of the chassis below the starting pulley, the engine being started in the usual 'diabolo' fashion with a leather cord. Two or three pulls to choke and the engine starts every time with the choke half closed."

FINALLY—TOO HIGH COMPRESSION PREVENTS STARTING

The above is a fact so often overlooked by operators and even designers. If too high a compression is allied to an engine that is " sticky " to turn, then there will never be a start!

If the engine starts and then bounces back and forth, the compression is too high for the amount of fuel in the crankcase. Ease compression slightly and restart.

A STARTING TIP

If a model diesel's compression is not first-class due to wear or imperfect fit of the piston, provided this is not excessive, two or three drops of lubricating oil dropped into the exhaust port before starting will often help to obtain a start.

A STICKING CONTRA-PISTON

The contra-piston sometimes refuses to rise when the lever is unscrewed. This is due to the contra-piston being a very tight fit. A contra-piston has to be a close fit to be effective.

There are two methods of dealing with this trouble :—

(a) Clear out the excess fuel from the cylinder head by turning engine upside down and dribbling fuel out of *open* exhaust port. The engine may then start and the contra-piston go up as the metal heats up and expands.

(b) If the above does not prove effective, fill the cylinder head with oil through the exhaust port and by rotating the engine *gently* force the piston to compress the oil. *Be very careful because oil is virtually incompressible and the engine may be damaged if over forced.* If the contra-piston still remains stuck after reasonable pressure, it will have to be dismantled and the contra-piston eased in the bore. For the average person it is best to have this attended to by the makers.

CHAPTER V

DIESEL OPERATION—PROPELLERS—PROBLEMS—THE TIMING DEVICE—TROUBLE FINDING

THIS chapter contains a certain amount of repetition, as a very great deal of the subject has naturally been covered in the chapter on starting, for they are inseparable. I originally considered the advisability of combining the two subjects of starting and operating together in one chapter ; however, I finally decided to keep Chapter V as a separate entity because it would then perhaps form a summary and a last-minute method of impressing on the new modeller certain things that he should *not* do, in addition to those items that help towards sound management of the engine and the model to which the engine is fitted.

A certain amount of repetition is therefore inevitably combined with new information.

COMPRESSION RATIO PRECAUTIONS

It will be quite evident from the previous chapters that the compression ratio looms up very large in the model diesel's make-up and *life*. The word " life " is the one I wish to lay emphasis upon. If the owner wants his diesel to have a long and prosperous life, he must be careful *not to run the engine with too high a compression.* It is rather reminiscent of the man who cannot resist the extra few whiskies and sodas daily, with the result that his blood compression is raised and his useful life becomes shorter than it might have been !

Too high a compression knocks bearings to pieces, and it is also well to remember that it slows up the engine because it has to overcome excessive compression at the latter part of the compression stroke during the process of compressing the gases. It is like putting a brake upon the engine.

The important point always to remember is that once a start has been obtained (if a contra-piston is fitted), the contra-

piston adjustment should be slacked back slightly until the engine runs best. There are a few engines that will start and run on the same compression ratio once the best setting has been found.

Also make sure that the mixture is not too weak. As stated before, too weak a mixture, and particularly too weak a mixture allied to too high compression, will cause what is known as diesel knock. The knock, in the case of the diesel engine, according to Mr. Ricardo, the expert on full-sized engines, is a shock wave coming from the whole structure of the engine, and not from a localised stress such as that which is known as " pinking " of a petrol engine.

I think it is worth remembering the reason for diesel knock, because the owner will then be *eager to stop this undue stress coming from the whole structure of his engine.* It is quite easy to stop the knock once the causes are recognised.

If a diesel eases up and gradually dies away in its power with a dead-sounding note, you may be sure that the probable cause is that you are running on too high a compression.

The gas is being expanded due to the heat generated by the running of the engine, more than when it was sucked in cold at the start. This is automatically raising the compression. *The answer is to let the engine run for a little while before releasing the model.* If it knocks, check up the compression when thoroughly warm, then reduce the compression slightly. The non-contra-piston engine of course cannot have this adjustment made, but a slightly richer mixture may alleviate matters by making the engine run cooler.

A number of purchasers of a certain diesel noted for its reliability and good starting have written to the manufacturer complaining that their engine will only run backwards. The fault in this case is that of the purchaser, because he is running his engine at too high a compression by screwing down the contra-piston too far. Another engine manufacturer I know has been cursed because his engine bearings wear out. This is due to the same cause, for I have found his engines wear very well !

Whilst on the subject of compression, I generally make a practice of starting up any engine fitted with an air propeller, armed with a stout leather glove on my starting hand. It saves many an unpleasant rap over the knuckles!

If the compression is a little too high when starting, diesels have a habit of sometimes firing and then bouncing backwards on the next compression before one gets the starting finger out of the way. Hence the rap. Slightly slack back the contra-piston and have another try, fortified by the knowledge that you have a well-armoured and shock-absorbing finger due to the stout leather glove. *Bouncing back and forth means slightly too high compression.* Unscrew the compression lever slightly and restart.

I have seen unkind people fit mighty disc flywheels to run in their diesels. This is unfair on the diesel, because there is so much leverage and momentum that it can be easily forced over the " over-hard " compression that I have described, due to too much liquid fuel being compressed. Owing to the leverage and inertia of the large disc flywheel, the owner does not feel the very hard condition. Things then collapse inside the unhappy little diesel and the manufacturer gets the undeserved blame.

It is probable that you have read the chapter on starting and seen my advice in the case of a contra-piston engine, to " give the engine relief " by unscrewing the contra-piston lever one or two turns should you get too much fuel in the cylinder-head and obtain an " over-hard " engine. Maybe you own an engine with two stops fitted to prevent the lever being turned more than three-quarters of a turn. There are several engines of this type on the market, in order to prevent novices losing the approximately correct setting. In these cases all that can be done is to unscrew as far as the stop, and if the engine will not then turn over easily, resort must be made to the old dodge I mentioned in Chapter III, of turning the piston back, so that the excess fuel will dribble out of the now open exhaust port when the engine is placed on its side. Then turn, and if free, put the compression lever back to its normal start position. See Fig. 66. In the case of inverted engines, it will, of course, be necessary to up-end them to allow the fuel to drain from the exhaust ports.

Although a completely free contra-piston adjustment is

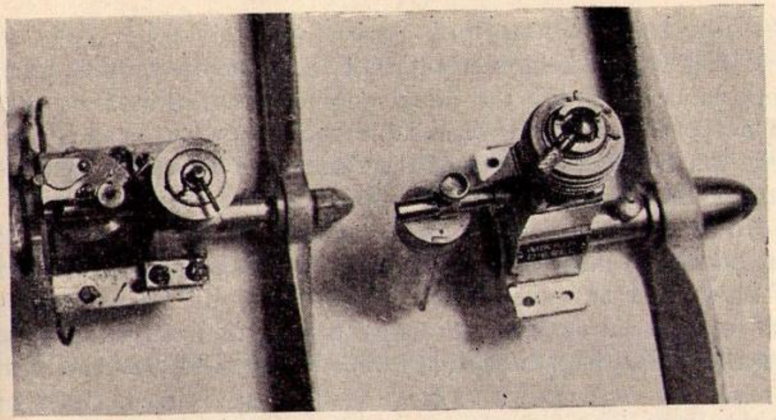


Fig. 66. The compression adjusting levers can be seen with special stops to limit movement on these two diesels.

the ideal for the knowledgeable man, we are seeing more and more engines fitted with contra-piston limiting stops in order to prevent the complete novice from losing all adjustment, or from grossly over-screwing down the contra-piston lever, and wrecking the engine by over-compression on a grand scale! The " Frog " diesels have a simple spring washer between head and adjusting lever which is most effective, for it prevents damage and yet permits of a considerable range of adjustment.

THE DANGERS OF ETHER

Don't smoke near an open bottle of fuel is another point which cannot be over stressed. Ether is very volatile and will flash back easily, and a nasty explosion may take place. If you are one of those uncontrolled chain-smokers, you will just have to stiffen up your controlling mechanism and take this warning seriously. Just because you have got away with it on a number of occasions does not mean that you have some special dispensation.

I need scarcely remark upon the fact that ether is used as an anaesthetic. So if I feel more dopey than usual I suspect the ether and do not think my normal powers are failing early in life. Keep the room well ventilated if running-in an engine on the bench.

THE MOUNTING, A REMINDER

I feel I must remind readers of the very great operational importance of fitting the diesel engine to a really sound and rigid type of mounting if reliable running is to be obtained. This can be rigid and yet of the detachable knock-off type, as already described, if desired.

In spite of many words on the subject, people still fit model engines to the most ridiculously flimsy pieces of wood, thin bits of plywood that wave about in the breeze, and other curious thin metal contraptions that cause a peck of trouble. I have described what happens earlier in this book, and I now end with a reminder to get down to tackling the really vital business of mounting the engine properly, both on the running test bed and in the model. *You will have no lasting success if you do not*!

THE PROPELLER AND THE LUBRICANT

When summing up operating difficulties which I have seen new modellers troubled by, I think that the fitting of incorrect propellers and the use of incorrect lubricating oil account for the two main operational troubles experienced, after the poor engine mounting.

As in the case of the mounting, I have given full reasons earlier in this book and need not recapitulate all these, other than to say that if the aeromodeller does not fit a correct and properly-balanced propeller and use the correct oil as recommended, then the ensuing trouble will be on his own head, and trouble will be sure to overtake him!

The "unbreakable" plastic propeller with flexible blades has now become available in Britain. There is a full range available from Keilkraft, Frog and E.D.

They are just the right weight for diesel engines and practically crashproof. The aerofoil section is kept correct by the flexible blades being flung outward through centrifugal force. I seldom use any other type for general purpose flying and radio flying.

If a propeller from the makers is unobtainable, the following approximate table will help to prevent a newcomer being given

a totally unsuitable propeller. It can only be approximate because engines vary in power and r.p.m., and different models fly at varying speeds.

Remember that the propeller must not only be of the right diameter. It must be a heavyish one, and it must be balanced. It is quite easy to see if a propeller is balanced—put it on a nail or a piece of wire and spin gently by hand. If one blade always stops in one position at the bottom, then that blade is too heavy and the propeller is out of balance. If this is slight, a little sand-papering of the heavy blade will correct. The blades should stop at different positions each time the propeller is spun. There is nothing peculiar in a diesel propeller from that for a petrol engine, except that the diameter, weight and pitch must suit the diesel. A good diesel swings a larger diameter propeller than a similar capacity petrol engine, or glow plug engine.

A low-pitched propeller is the most suitable for a general purpose slow-flying aeroplane, and a higher pitch for a fast control-line model. The latter is suited by an 8-in. pitch for average requirements, in which case a slightly smaller diameter is required. A speed model requires an even higher pitch of approx. 10 in. to 14 in.

DIESEL ENGINES
(Approx.) Guide to Select Propellers

C.C. of Diesel	Diam. of Prop.	Pitch		
		F/Flight	Control Line	Speed
0.7	7 to 8 in.	4 in.	6 in.	Special to suit speed 9 to 14 in. approx.
1.0	$7\frac{3}{4}$ to 9 in.	$4\frac{3}{4}$ to 5 in.	6 in.	
2.0	$9\frac{1}{2}$ in.	5 to $5\frac{1}{2}$ in.	6 to 8 in.	
2.5	$9\frac{1}{2}$ to 10 in.	5 to 6 in.	6 to 8 in.	
3.5	$9\frac{1}{2}$ to 11 in.	5 to 6 in.	6 to 8 in.	
5.0	12 to 14 in.	5 to 7 in.	8 in.	

PROPELLERS MUST BE BALANCED!!
The higher revving engines should have the smaller diameters mentioned above.

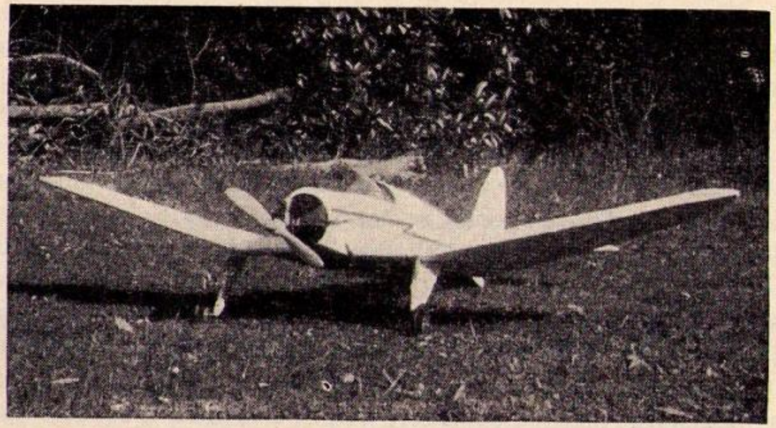


Fig. 67. Flexible plastic propellers which are almost unbreakable were a valuable development of 1949. Here we note a plastic prop on a "Bee" 1 c.c. diesel fitted to the author's small 45 in. low wing model.

I have used slightly larger and slightly smaller propellers on all the above sized engines, but have found from experience that the sizes shown are the most satisfactory for general purpose slow-flying models.

SQUARE-TIPPED PROPELLERS AND THREE-BLADERS

For some little time now I have been using square tips to the blades of my petrol and diesel engine propellers, like the "paddle props." of many full-sized modern machines. I first tried this idea when I wanted to reduce the height at which I positioned my engine above the hull of a flying-boat. I made certain static thrust tests with an "Ohlsson 23" engine, upon which I was running a $10\frac{3}{4}$-in. propeller of fine pitch but normal blade area. I made a propeller of only $8\frac{1}{2}$ in. diameter for the engine and gave it square tips, but with considerably wider blades, so that it looked rather like a fan. I was surprised to find that, in spite of the very large reduction in diameter, the loss in thrust was only about 2 oz.—I had well gained this by reduction of frontal area for my flying-boat.

The same would apply to shorter undercarriages on land

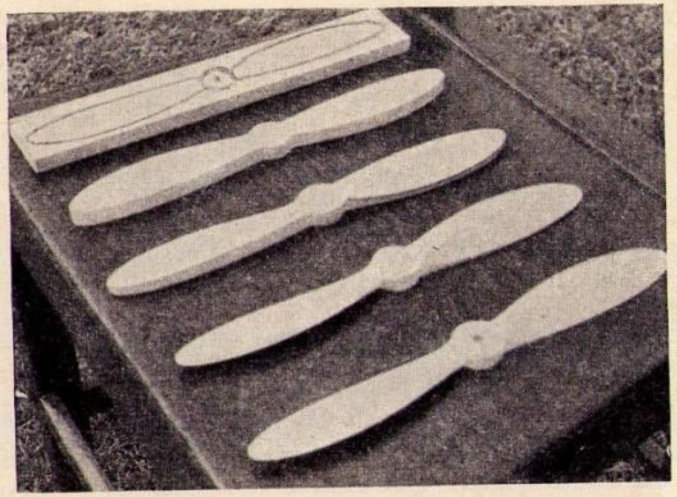


Fig. 68. The stages of propeller carving.

machines. In the case of the flying-boat, I had been able to locate my thrust line in a more efficient place lower down and nearer to the centre of drag, which was a further advantage from the practical flying angle.

I then tried a less drastic cut of an 11-in. propeller as fitted to a 2.2. c.c. diesel. In this case, I squared off the end, which brought the diameter down to 10 in. and a little wider blade. The climb on the model was improved. It appears that the normal elongated tips are of little thrust value and they only cause unwanted drag.

I think the important point to remember is not to overdo matters so that the engine revolutions are unduly raised. Dr. Thomas has some interesting remarks to make on three-bladed propellers for scale models. See Chapter VI where a model of his is described.

AEROPLANE PROPELLER CARVING

The photograph of the different stages of propeller carving (see Fig. 68) should put readers on the right track if they wish to produce for themselves replicas of the original propeller they buy as recommended by the engine manufacturer.

Fig. 68. Stages in propeller carving :—

1. Mark out the top of the blank which must be of the correct depth to obtain the right pitch. Reduce ends to reduce tip angles.
2. Cut around the outline.
3. Cut away the inside faces.
4. Cut away the curved top surfaces of the "aerofoils."
5. Sandpaper smooth, balance, and varnish if desired.

MODEL BOAT PROPELLERS

I found that my speedboat "Flying Fish," described in Chapter VI, would run a 2 in. diameter propeller driven by a 4.5-c.c. petrol engine, whilst a 2-c.c. diesel liked a $1\frac{1}{2}$ in. diameter three-bladed propeller. The blades being in each case $\frac{3}{4}$ in. maximum width and set at an angle of about 45 deg. with the tips given a little washout. A two-bladed propeller is just about as effective for normal speedy running. The three-blader had approximately the same area as the larger diameter two-blader.

These details form a useful guide for speedboat men. My tiny little speedboat "Sea Swallow," also shown in Chapter VI, and fitted with one of the 0.7 c.c. Mills diesels or a 0.8 c.c. "Amco" diesel, runs a two-bladed propeller of $\frac{7}{8}$ in. diameter with blades $\frac{3}{8}$ in. maximum width, a really midget affair which buzzes around at high r.p.m., approx. 7,000. This same hull when fitted with a 1 c.c. "Frog" diesel takes a propeller of 1 in. diameter, and $\frac{5}{16}$ in. blade width. The E.D. "Bee" 1 c.c. diesel also uses a 1 in. diameter propeller.

A BOY'S TROUBLES

I gave my 16-year old boy a diesel, and he built a model aeroplane which I designed for him. It was his first power-driven model and I was interested to see how he would handle the situation.

Like many other boys whom I have watched, including those of between 40 and 50, he tried to swing the propeller incorrectly, as I have already described. Having shown him the

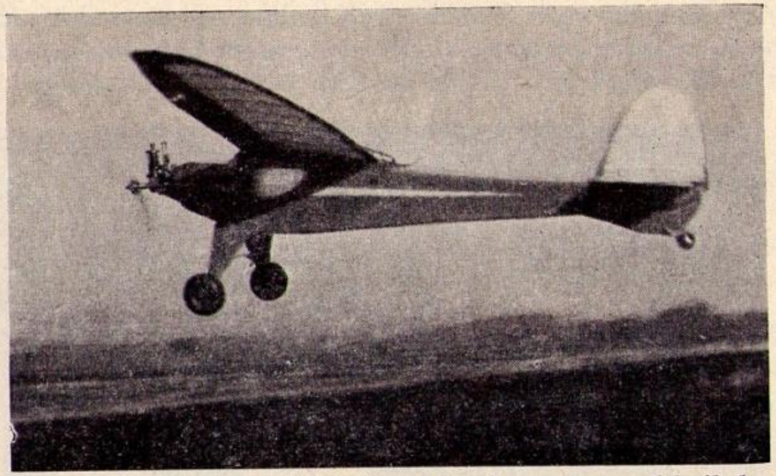


Fig. 69. A simple model designed by the author and built by his son. It is powered by a 2 c.c. diesel engine.

correct way, he at once got over the starting difficulty in exactly the same way that a certain mechanically-minded senior army officer did when shown how!

My boy sometimes fails to obtain a start because he is afraid of over-choking the induction pipe with his finger. I have now taught him a simple way of getting around the difficulty. I can well understand a boy may not be able to judge very well whether the mixture is too rich or too lean to start. My boy now opens the needle-valve half an extra turn. He then drips, with a fountain-pen filler, about three or four drops of *fresh* fuel from the fuel bottle (*which he at once corks up*) into the induction pipe. He increases the compression by a quarter turn. He then starts the motor with a number of swings until the slight excess of fuel clears itself and it fires. As the engine gets going, he returns the needle-valve to its original run position, i.e. half a turn closed, and he slackens off the compression lever the quarter turn he had screwed up to start. He has his perspex tank half full to start and then watches the engine run until the fuel comes down to a red line we have painted on the outside. He then releases the model knowing that there is no timer that can stick and fail.

The engine runs for about half a minute more, and he gets quite a long and exciting flight over a piece of heathland, with a good run after the model to keep him alive and energetic!

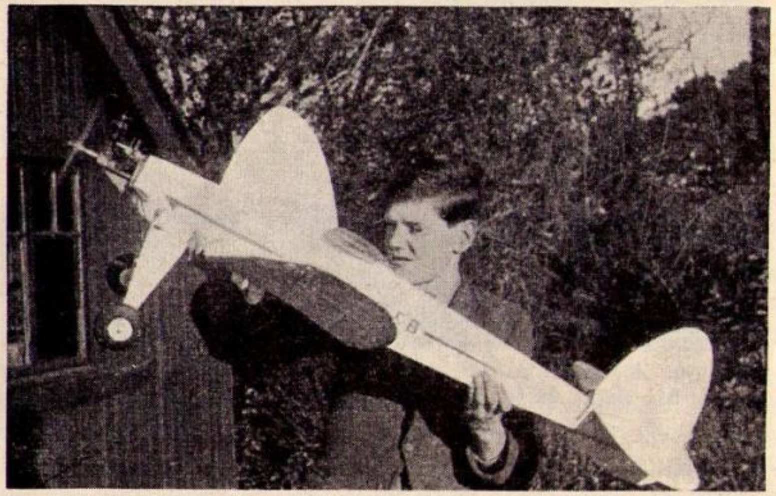


Fig. 70. See if the fuel mixture is adjusted for severe climbs before releasing the model.

I always impress on my son that, if he wants to carry on to a ripe old age, with both eyes intact and no scars on his face, it is a sound plan when running-up model engines *not to stand with one's nose right over the top of the cylinder and not to stand at the side of a running engine with one's face in line with the propeller.*

I do not consider this to be over-cautious, because I have seen things fly off during my many years at the game, and after all is said and done, one is always advised not to stand in line with a full-sized revolving aero. propeller! It is just ordinary common sense, like not looking down the business end of a gun although you think the thing is not loaded. There have been many accidents through the ages because these simple precautions have been neglected. I recently saw a new experimental diesel's cylinder-head blow off.

A point that all competition aspirants should attend to is the simple test of holding the model with the engine running for a

few moments in a stiff climbing attitude, to see if the mixture control is correctly adjusted for such a position which the plane may adopt during a steep climb. (See Fig. 70.)

REDUCED THRUST FOR TEST FLYING

If the propeller is bolted on back to front, it will reduce the thrust of the engine for the first test flights. When trim is found, the propeller can be put on the correct way and full thrust used.

A FEATURE OF DIFFICULT STARTING

Very often a diesel is difficult to start for the first run of the day, whereas once the engine has run, it will start very easily for flight after flight or run after run during the day, in spite of the fact that the engine becomes absolutely dead cold between runs. There is a very simple reason for this that, if not known, may cause considerable trouble to the novice.

Diesel fuel is sticky stuff and when the ether evaporates from the fuel mixture, there is generally a sticky oily mess left in the little tube that runs up from the bottom of the tank to the *very small* orifice that the needle-valve seats upon. When the new fuel is put in the tank for the first run of the day, and the engine is choked by the finger, the suction from the engine is not sufficiently powerful to clear the blocked passage. The remedy is simple. Before starting up for the first run of the day, screw down the needle-valve and note the exact number of turns it was open for the running position on the last occasion if you do not already know this setting. Then unscrew the needle-valve and take completely out. Put a piece of rubber tube about 6 in. long over the orifice and blow down the tube. This will clear any gummy deposits. Replace the needle-valve, and *open it to the "correct run position."*

Now start up in the normal way and fuel can then be sucked up correctly.

When screwing down a needle-valve, do not be heavy-handed, or the seating and needle may be damaged.

PUTTING THE DIESEL AWAY AFTER FLYING OR BOATING, ETC.

There is no sparking plug, as on a petrol motor, for oil to drain into, or ignition points to become saturated in oil, that will give trouble when we next take our diesel-engined model out for a day in the air or on the water.

But we should remember to empty out the fuel tank because the ether in the fuel will evaporate and leave a difficult starting fuel for next time. Also a diesel is a dirty motor and throws out diesel oil and lubricating oil over itself and the model. Therefore a quick wash down with a little petrol and a brush and a rag to dry off is not a bad plan, at the end of a day's fun. Also wipe off the fuel from the wings and fuselage of the aeroplane or the paint and varnish of a boat hull or car, because the fuel stains paint and varnish and rots silk or nylon wing coverings.

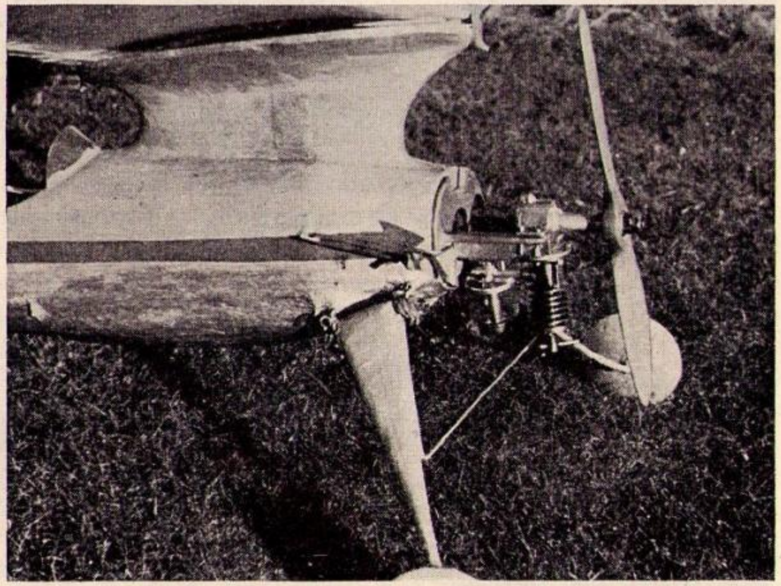


Fig. 71. Diesels can be mounted inverted.

Make sure you cork that fuel bottle securely up each time you use it to keep the ether content in the bottle! Even then it does no harm to add a dash of ether to the fuel and shake, if the corked bottle has been put away for some time—starting will probably be a little quicker.

INVERTING A DIESEL

Many aeromodellers wish to invert their engines because they like having the cylinder positioned low down, partly for realism, and partly because the weight is low, and sometimes because it suits a neat line of cowling. The inverted motor also permits of a high thrust line.

I am often asked, " Can I invert my diesel ? " The answer is, " Yes." I have inverted most of mine at one time or another. There are two possible snags—neither of which are insuperable difficulties.

The first is on a contra-piston engine. The compression adjusting lever is not so readily to hand, although it can be operated with a little practice. The second snag is our old bugbear, a surplus of liquid fuel more easily gets to the cylinder-head and causes the " over-hard " engine, and therefore sometimes causes extra labour in this matter, as described in Chapter IV, " How to Start Diesels "—But forewarned is forearmed.

A clever scale control line model with inverted engine by Dr. Thomas is shown in Chapter VI. Dr. Thomas finds inversion helps his starting. I have found the same thing on several engines. It is equally possible to mount a diesel on its side as the control line enthusiasts do, calling it a " sidewinder."

THE " FIELD GEAR "

We all realise that one of the great advantages of the diesel is the elimination of a booster accumulator and flight battery. Let us look at Fig. 72 and see just what this advantage does mean —on the left of the photograph you will see the box containing booster battery, spare flight batteries, sparking plugs, petrol can, propellers and tools with booster wiring, that I find necessary to fortify myself with when I go out for an afternoon's flying with petrol-engined models. This includes several different " hot " fuels in bottles for varying compression engines. On the right of the picture, I have laid out the gear which I take when the same model has a diesel engine fitted as its power unit ; is it surprising that the diesel is a popular engine ?

The items that are necessary in the latter event are : 1 fuel

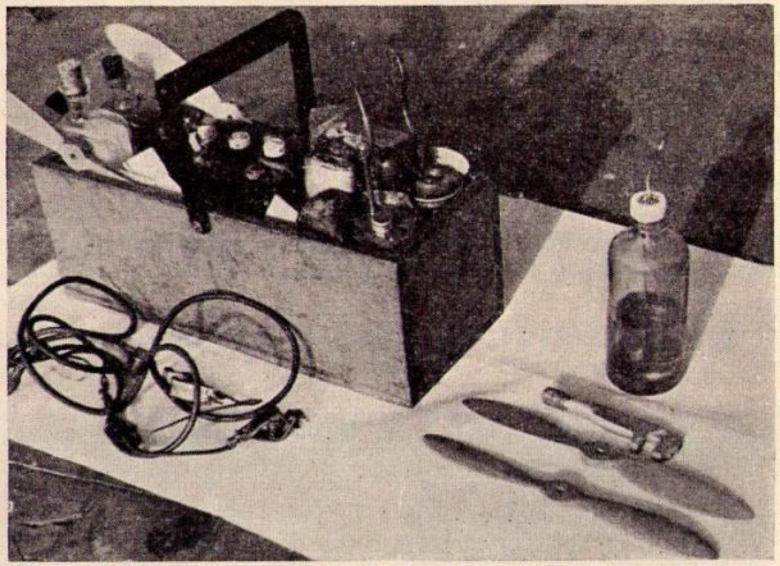


Fig. 72. The field gear carried by the author for a petrol model is seen on the left. The simple gear carried for a diesel is on the right.

bottle ; 1 small spanner to fit propeller retaining nut (possibly a pair of pliers) ; 2 spare propellers, just in case !

CONTROLLING THE DURATION OF RUN OF A DIESEL

When I set up the first officially observed controlled record flight after the 1914-1918 war, I used a weird and wonderful clock device that I had adapted. This clock operated a long arm, which in turn pulled back the throttle lever of the 28-c.c. two-stroke petrol engine that I used. The engine was large and controllable, and was capable of a steady tick over with its 24-in. diameter propeller. This was the first time that a model aeroplane had been controlled to throttle back after a flight of a predetermined time ; in this case 50 seconds.

The extraordinary thing about the whole episode was that it worked well.

In fact, so well that my first record flight was only of 75 seconds, the last 25 seconds being glide with engine ticking over.

The electrical ignition was then cut off by a long arm between the undercarriage legs as the biplane " Kanga " actually touched down. Shortly afterwards I put up a long record flight of over $12\frac{1}{2}$ minutes out of sight. This time I fitted a clock that cut the electrical ignition, because I fitted the first small engine of 15 c.c. to fly, and this engine would not run slowly.

Several of my competitors in those early days relied upon the engine overheating and fading in the air to terminate the duration of their flight ! Later on in the history of power-driven model aircraft it very rightly became a rule that an efficient time-switch must be fitted by all S.M.A.E. members, and also before a model could be insured.

In spite of these precautions, people today constantly allow their models to " fly away " because of inefficient timing devices or because of none at all.

It is immensely important for the model movement in general that aeromodellers particularly should control the duration of their models. A model that flies into the blue is a danger to fellow human beings and property. " An Englishman's home is his castle," etc., and nothing infuriates him more than strange objects, aerial or otherwise, arriving uninvited through his windows or into his garden. No man other than an ardent aeromodeller likes to be pursued by a screaming diesel !

The matter must be taken seriously, and not left as an after-thought, as so many modellers do, if restrictive legislation is not to occur. Apart from the other man's feelings, it always seems to me a foolish pastime to build an expensive model and then lose the creation of one's brainstorm on the first day out. I know I do my best to control mine, and in addition, like the wise virgin, I metaphorically trim my lamp by adding my name and address to the fin of the model with a little reminder that there is a *reward* for the finder who returns the model to me, just in case. As a result, the models do not often fly away !

The petrol model aeroplane that has its duration of engine run stopped short through a time-switch cutting off the ignition to the sparking plug suffers from the great disadvantage of often being in a steep climb when the engine cuts with a suddenness that does not allow the nose of the aeroplane to get into a steady gliding position. The resultant series of stalls is often most distressing for the owner to watch. That was why I fitted my first large record machine with a gradual throttling device. Unfortunately, the smaller petrol engines of recent years will not throttle easily. Hence the ignition time-switch. I now design my models to level out under these circumstances, as this is possible to do.

The diesel has no ignition to cut, therefore designers and owners have evolved various devices to cut off the fuel supply or to choke the air intake, or to admit air below the jet to destroy suction. These methods are superior to the ignition switch of the petrol model because, where the fuel is cut off, a little remains in the feed-line and the engine dies down with pops and irregular running, and in the case of the choke, the mixture becomes starved of air and very rich. Again, the process of stopping the engine takes a few seconds during which time the aeroplane's speed drops, and so does the nose into its gliding angle. Perhaps the best method is to close down the fuel supply by a valve in the line.

There is only one real danger that I have found in the case of the choke or the air-leak method. The engine sometimes manages to draw in just sufficient air to run very badly and keep on running. In this case you really have " had it," because the model, if lightly loaded, carries on flying quietly away for an even longer duration due to the lower fuel consumption. I therefore prefer the positive fuel cut-off, or a limited tank capacity. For radio flying see Fig. 59A.

Besides having a timing device and my name on the fin, *I therefore also see that the fuel tank does not hold too much fuel for a really long flight should the switch fail.* A boy in our local club lost two expensive diesel engines in two days' flying: one cost over £8, and the other over £6 10s. od. This hobby of carelessness is more than the average person can afford.

How does the modeller set about fitting up his engine to stop after a predetermined time?

There are two stages. First, the device on the engine to

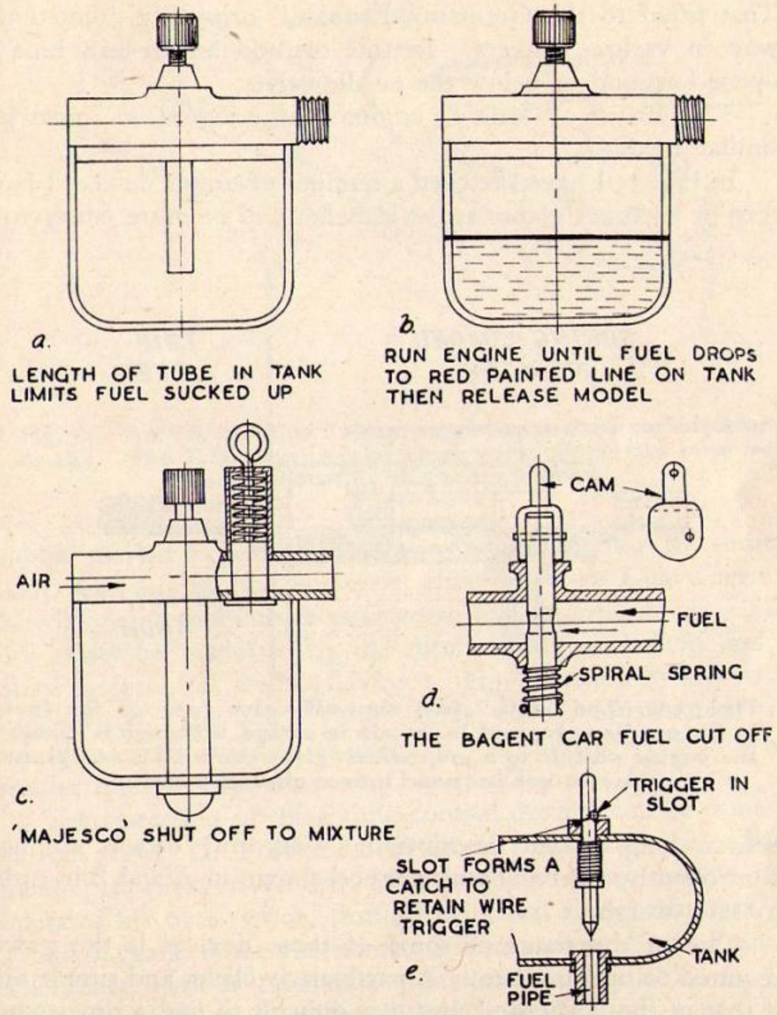


Fig. 73. Methods of stopping a diesel. C, D, E have to be operated by one of the mechanisms shown overleaf.

choke it, cut off its fuel, or destroy the suction on the needle-valve jet, and secondly the mechanism to operate this device. Although not fitted to the early diesels, most modern commercial engines are now being fitted with some sort of stopping device.

That fitted to the German " Eisfeldt," originally pointed the way to various makers. In this method an air-leak hole is opened around or below the needle-valve.

The British " Mills " engine has adopted a somewhat similar method.

In Fig. 73 I have sketched a number of simple devices I have seen or tried. A glance at the sketches will be more satisfactory

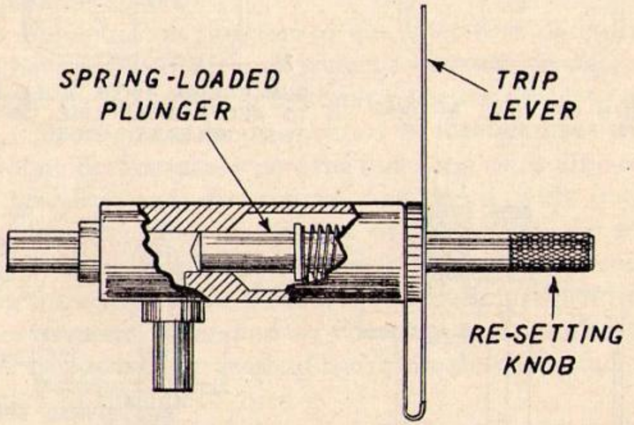


Fig. 73A. The " F.G." fuel shut-off valve cuts off the fuel to the needle-valve and is certain in action, although it makes the engine stutter to a stop which gives the model aeroplane time to get its nose into a gliding position.

than a long-winded description. Very tiny diesels are best controlled by the baby tank method shown in A and B in order to save weight.

One of the snags of some of these devices is the power required to operate them. A particularly clever and simple idea is that of the " Micron," but it is difficult to find a time-switch that has the strength to operate it. In the case of the " Mills," I have seen the return spring removed in order to allow a light-weight " Snip " timer to operate it. The " Majesco " engines are fitted with a very light spring which can easily be tripped by a small airdraulic timer. The " B.M.P." engine has a delightfully easily operated little flap over the induction pipe. This has a

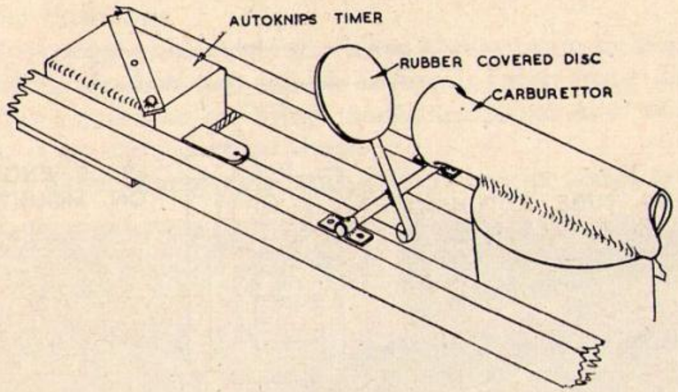


Fig. 74. An " Autoknips " timer rigged up to close carburettor intake. The E.D. commercial clockwork timer can now be obtained to do the above work.

rubber pad on its face to prevent any air leaking past the shutter flap. One of the best and most simple devices I have seen is Mr. Baigent's fuel cut-off as fitted to his 4-c.c. diesel car. This can easily be made up by the mechanically proficient, and is quite foolproof as well as having a light operation by any small time-switch. The new " Frog " diesel cut off constructed with the filler cap is simple and effective. It operates on somewhat similar lines to that shown in Fig. 73 (*e*) or in Fig. 73A.

The operation of these time control devices can be done in various ways. Dr. Forster has devised a simple air vane or little metal propeller driven by the slipstream of his models that operates his time-switch, through a helical screw that sets off a train of gears. Somewhat similar devices are used by the French. There are various airdraulic time-switches available on the British market, such as the light-weight " Snip " timer, the " Gremlin " and the " Majesco " time-switch. These all work on the controlled air-leak principle. They weigh very little and are reasonably cheap, and they are accurate to within a few seconds, but cannot be called dead accurate for competition work in cases where a flight to a certain second is nominated.

An excellent air switch called the " Elmic " has recently been

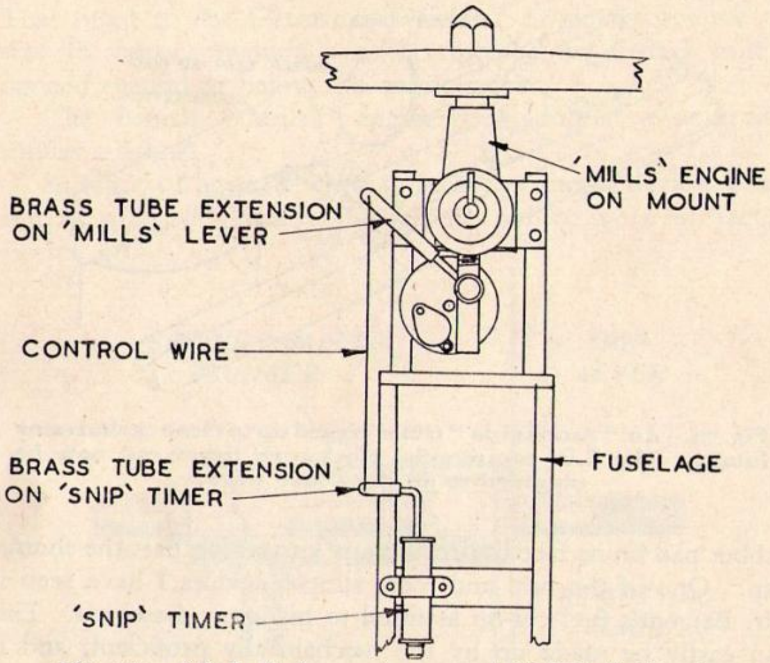


Fig. 75. "Snip" timer to control "Mills" diesel.

put on the market. It has a high degree of accuracy and an excellent device to hold it open until it is released.

The E.D. clockwork time-switch specially made for model work, and on the British market, solves many difficulties where accurate timing is required for competitions. Every second counts! Refer back to Fig. 59A.

The timing devices shown are, of course, also suitable for boat work.

Very small plastic tanks like baby fountain pen fillers are used to give approximately 30 seconds' motor run. I recently saw that an owner had taken three turns of neoprene tubing around his "Frog" diesel tank. A larger tank was used for starting. Just before release of the model, this was withdrawn and the engine run on the tube full of fuel. What could be more simple and a greater insurance against a flyaway.

ENGINE COWLINGS

Most people like cowlings. They always begin by building a cowling for their first model, anyway! Later, many discard them as a nuisance on flying model aeroplanes and working boats. Cars are somewhat different.

The diesel engine runs much cooler than its petrol brother

Fig. 76. Metal spinner and cowlings can be made from aluminium spun or beaten into shape. The cowling on this lovely flying scale "Lysander" adds much to its realism. The motor is a 2.4 c.c. E.D. diesel.

and it has no sparking plug to short to a metal cowling. It is therefore a far more simple matter to cowl a diesel efficiently.

Most sheet-metal firms will spin up a cowling on application for a few shillings. A suitable cowl to suit the nose of one's model can also be beaten out by a panel beater for quite a reasonable sum. I use both these forms of cowling, but must admit I often fly without any cowling!

Cowlings certainly improve the appearance of models enormously. Varied spinners are now on the market.

Rather a beautiful example of cowling a diesel engine on a scale model can be seen in Chapter VI, which shows Dr. Thomas's

" Typhoon " well cowled. This model is a " control-liner " and always flies with cowl in position, which is made from carved balsa wood. A simple metal cowl can be seen fitted to my kit model " Meteorite " in Fig. 88, Chapter VI. Also see Figs. 76, 76A and 76B in this chapter.

TROUBLE FINDING

The diesel is so simple, with its lack of ignition gear, that it is not difficult to pin down faults if they are followed through in an orderly manner. Below is given a summary of the most likely troubles that may be met with :—

(1) *Poor Compression.* This can be heard escaping if the propeller is held halfway against maximum compression, or if bubbles of oil show through exhaust port, escaping between cylinder and piston. I have found this on one or two commercially-made diesels, but it is not usual, as manufacturers with a reputation know how to fit a piston to the cylinder.

This trouble is most usual on amateur-made diesels. Even experts quite used to full-size production do not at first realise the very accurate fit between piston and cylinder that is required for a model engine—cylinder bores must be absolutely round and parallel.

The only cure for this trouble is fitting a new piston to a round cylinder, the piston to be made to finer limits.

(2) *Gumming Oil.* This gums up the needle-valve when the engine is put away, when the ether evaporates. It can also make the motor itself very gummy and difficult to turn.

Cure : Take needle-valve out and clean. Blow through suction fuel tube. It is seldom necessary to clean out the engine and never necessary in the case of fuels I have recommended.

Some of the curious gummy mixtures advocated, particularly on the Continent, cause a lot of trouble in this respect. Dirt in the fuel will also cause a blockage of the needle-valve. Filter all fuel.

(3) *Incorrect fuel mixture of constituents.* Leaving the fuel bottle uncorked will allow the ether to evaporate and so leaving incorrect proportions of constituents. Careless mixing of proportions is another frequent cause. The cure is simple. Be careful !

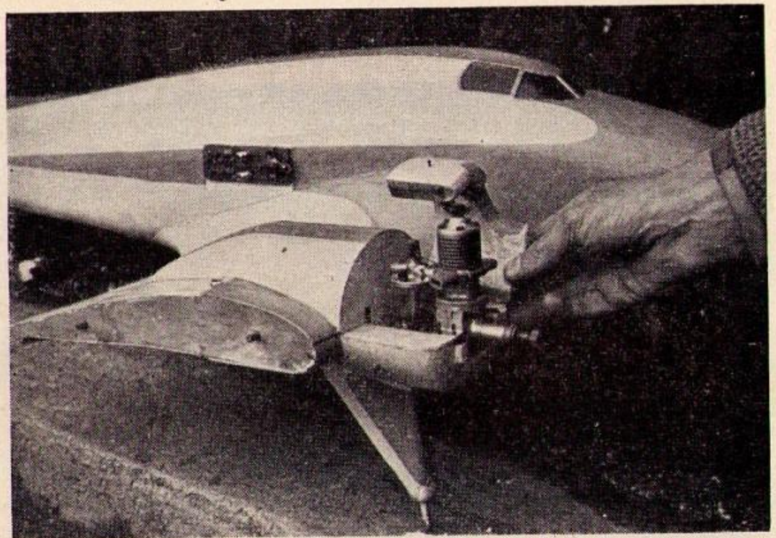


Fig. 76A. A simple carved cowling from balsa wood. Note the hollowed out top cover kept in position by locating dowel pegs and dress snaps, and hinged one side.

(4) *Damage by Acid.* Certain ethers have acid in their make-up. This damages the fuel containers and the engine. Be careful to empty out tanks after use, and blow out as much fuel as possible by rotating the engine a dozen times after use and before putting away. Only buy " anaesthetic ether " or pure " ether meth," as used for anaesthetic work. Neither of these ethers, obtainable from a chemist, have acids in them that will damage an engine.

(5) *Needle-valve.* This may become unsoldered from the thumbscrew top, if made in that way. The operator then turns—what he thinks is the needle-valve—to open or shut, when in fact the needle does not move. This can

be a very puzzling fault and I have known it happen on several occasions.

The cure is to sweat the needle to the brass or other metal thumbscrew. A bent or broken needle can cause trouble. This should not take place if the owner

(*a*) does not screw down too tightly;

(*b*) is careful when taking out the needle-valve.

(6) *Air Leaks.* Due to damaged washers and facings through careless stripping and assembling of the engine. The cure is to renew washers, etc., and not to strip and assemble the engine unless you know how! And leaks can, of course, occur down a worn crankshaft bearing as well as a worn piston.

(7) *Leaky contra-piston.* Amateur constructors do not always realise that the contra-piston must be a perfect fit, on the tight side, or leaks of compression occur *via* the contra-piston and the screwed thread of the adjusting lever.

Sometimes the contra-piston is fitted too tight, with the result that the compression will not force it back to the adjusting lever. One can tell this by finding the lever is loose and slack after it has been turned back and the engine turned several times over compression.

One cure I carry out in such cases is to put some oil in the cylinder and turn *carefully* against compression. The oil being incompressible will force the contra-piston up. *But be careful or you may damage the engine if the contra-piston is really seized up, and you over-force the engine.*

(8) *Excessive vibration when running.* The cause is usually an unbalanced propeller or flywheel, or an insufficiently rigid engine mounting.

(9) *Engine will only fire gently.* On a number of engines there is a device to stop the engine, in some form of cut-off to the inlet pipe. Often this has half closed and is choking the mixture. This is a more frequent happening to the novice than perhaps the reader will believe.

I have seen a very illustrious "petroleer" caught this way when I introduced him to his first diesel!

(10) *Engine becomes stiff.* Use of incorrect grade of oil. A very frequent happening, because people think model engines like very thin oil, or because they want to economise. Lack of adequate lubrication is the cause.

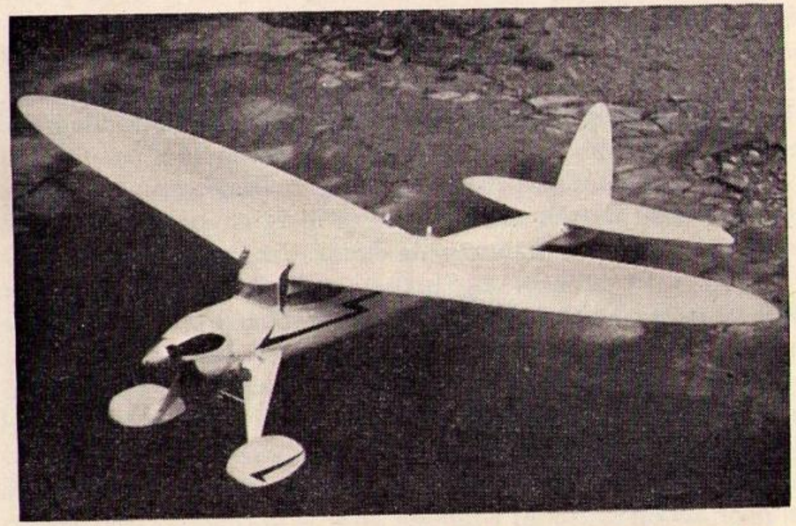


Fig. 76B. A commercially obtained spinner, with hollowed out balsa cowl to blend into spinner and monocoque fuselage is quickly made. Kept in position by dress snaps or quick drying cement which is easily parted and renewed as required. The model is the author's "Satellite" kit monocoque high wing.

(11) *The "Hard Engine."* I have very fully explained this phenomenon earlier in this book, *never force a "hard engine,"* i.e., an engine that is almost impossible to turn over compression due to too much liquid mixture in the cylinder-head.

(12) *Incorrect diameter and pitch propeller.* An incorrect propeller utterly ruins the performance of a model diesel. See my notes elsewhere on this subject.

For full details of propellers, and how to make them, suitable for various types of flying models, these can be obtained from my book, *Petrol-Engined Model Aircraft*, published by Percival Marshall & Co. Ltd.

(13) *Engine slows up after running.* This may be due to lack of adequate lubrication, but in the case of a diesel is more likely to be due to too high compression after engine becomes warm. Try slacking back the contra-piston lever slightly.

(14) *Engine bounces to and fro when starting.* Compression is high; release slightly.

(15) *A puzzling trouble.* The engine starts after choking and then stops after a short burst. It repeats this process and will do nothing else, whatever aids are given. First make sure that the compression ratio is not too high. The fault is almost invariably due to the small hole drilled in the jet tube having become turned away from the air stream in the venturi tube of the " carburettor." There are a number of engines constructed so that the jet tube is rotatable. The carburettor must be taken down and the tube rearranged with the small hole for fuel arranged so that fuel flows evenly through the venturi tube, i.e., the hole must face the rear *and must not be sideways.*

CHAPTER VI

AEROPLANES, BOATS AND CARS AND RADIO CONTROL USING THE DIESEL

There are very few people who buy an engine without the intention of fitting it into a working model. The diesel is particularly versatile. It can be used in model aeroplanes from large models right down to 21 in. span models, and less. It is ideal for flying-boats and seaplanes because of the elimination of electrical troubles due to damp. There is none of the troublesome festooning of long booster battery starting leads around the legs in a dinghy. As soon as a start is made the model can be placed on the water, and off she goes.

Having done a considerable amount of diesel flying off and over water, I consider that the diesel has absolutely revolutionised the model waterplane. It has brought this intriguing side of the hobby within the range of many more people. Now that all the old petrol paraphernalia need not be carried, and the waterplane can be built in really small sizes due to the elimination of ignition weight, should a modeller not happen to own a small boat, there is no reason why he should not hire a dinghy on any inland water or protected stretch of sea water. He can then thoroughly enjoy a day's aquatic flying pleasure.

The diesel is also the answer to the power boat enthusiast's prayer. I have thoroughly tested diesels out in model speedboats of the hard chine class and also in the hydroplane class. They are most successful in the hard chine class of boat, and I believe that in the future they will compete in the round the pole hydroplane racing now that the high speed racing diesel has materialised.

The diesel engine is particularly suitable for the hard chine speedboat because it runs cooler inside a hull than the petrol engine, and because water does not attack the electrical ignition gear that previously had to be carried.

Fig. 77. The author's free-flight cabin low wing monoplane for 1 c.c. diesels.

It must be remembered when operating over sea water that the salt causes corrosive damage to engines if it is left in them, should there be an undue splash on landing or in speed-boating over rough water. If possible, the engine should be run before putting it away at the end of the day and then thoroughly oiled externally. If a dive into the sea has occurred by some mischance, the engine must be dismantled at once and thoroughly cleaned out, with due care taken to remake all joints correctly, as I have emphasised earlier in this book, *unless it starts up at once and dries itself out before condensation sets in.* My experience in such

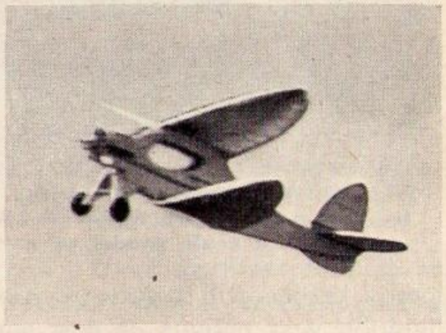
Fig. 77A. Here we see the wing tip slots and a diesel doing their work at a high angle of climb on a low wing monocoque model by the author. The wing span is 4 ft. 4 in. and the diesel a 2 c.c. "E.D. Competition Special."

cases has been that the diesel usually does start up even with sea water still in it! This seldom ever happens in the case of a petrol engine.

In Czechoslovakia a small scooter powered by a little diesel engine has been produced. One would like to suggest that the diesel could very easily be commercially produced as a model, and also a miniature full-sized outboard boat motor.

In order to help individual modellers, whether their inclination is towards aeroplanes, boats or cars, I am devoting this chapter to a survey of experimental models that I know of or have built myself and tested with diesel engines of varying

Fig. 78. The author's 42 in. span biplane fitted with wing tip slots is seen climbing lustily powered by a 2.4 c.c. "Elfin" diesel. The model is exceptionally stable partly due to the "slabsided" fuselage.



capacity. I make apology for the large proportion of my own models that are included. This is partly due to the fact that I naturally have an intimate knowledge of the performance and constructional data of my own models which therefore provide useful comparisons. It is hoped that the release of these details will help many fellow modellists to get going with diesel engines.

All the models shown are stable and successful operating models, and I am giving general details and measurements so that they may form a basis of experience for any of my readers who wish to design their own craft, but are not quite sure of the capabilities of different sizes of engine. Because the diesel has more power, *and a different type of power*, and because it has less weight to carry for its increased power, as a result of the elimination of the electrical ignition gear, it is obvious that our ideas of suitable models for any given cubic capacity of

Fig. 79. This tiny control-line model of 17 in. wing span has flown successfully, powered by a "Kemp" 0.2 c.c. diesel. It is a scale model of a "Westland Widgeon."

petrol engine will require revision. This elimination of the ignition gear permits of new conceptions in regard to even smaller models than we have hitherto considered as the limit of practical projects.

The advent of the diesel has therefore opened up new territory for exploration and given the model designer new fields to conquer.

We have mentioned that France has produced one engine of only 0.16 c.c. which permits the powering of a 4-oz. indoor round the pole model. These microscopic engines, however, cannot yet be called practical propositions for the ordinary mortal, because they are too expensive to produce commercially, and are also too difficult to operate.

A SMALL LOW WING MODEL FOR 1 C.C. TO 1.3 C.C. DIESELS

A stable low wing model looks like the real thing in flight, and if properly designed can be very stable in spite of the

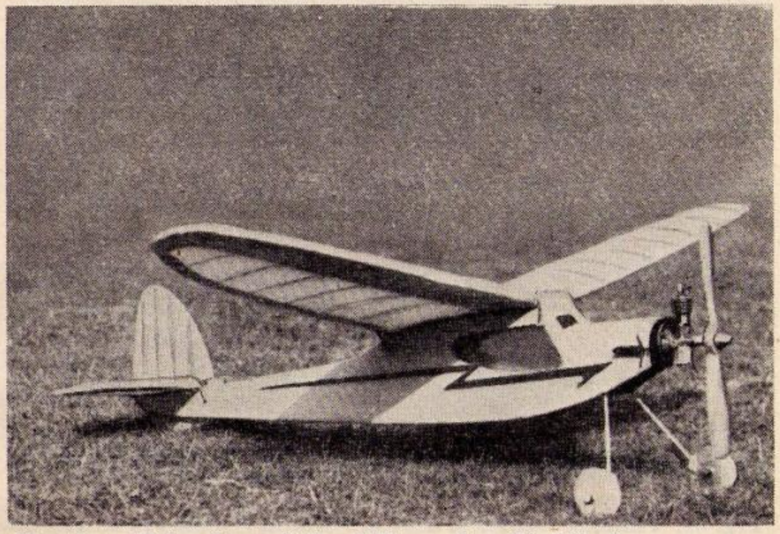


Fig. 80. This view of the "Humming Bird" shows a cone mounted "Majesco Mite" diesel of 0.7 c.c. installed. The fuselage is of sheet balsa.

popular belief to the contrary. It is important to keep the thrust line low to prevent excessive torque reaction upsetting the model's stability. The small 48-in. span low wing model shown in Fig. 77 makes a handy size machine. This model is flown by a 1 c.c. E.D. "Bee" diesel. A low wing model takes off the ground straight after quite a lengthy run, and the "cushioning" effect of the low set wing makes good landings a modeller's dream. They are not noted for a rocketing climb.

Readers of mature age will remember the successful little full-size "Westland Widgeon" light aeroplane of between war years. Dr. Thomas has built a tiny control line model of this craft, which is seen in Fig. 79. It is powered by the midget Kemp 0.2 c.c. diesel, and has the small wing span of 17 in. The length is 12 in., and weight is only $3\frac{1}{2}$ oz. This tiny control liner flies successfully in calm weather on short lines. Naturally there is not enough weight to keep the lines taut through centrifugal force in windy weather.

A well-known full-size aeronautical journal, remarking upon

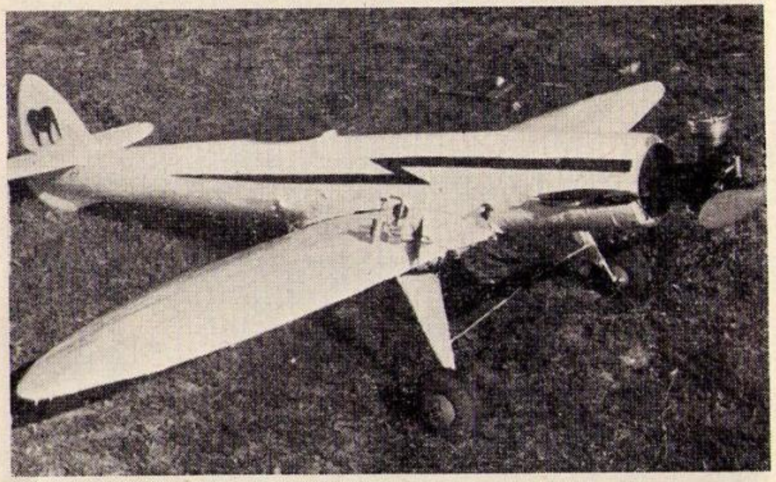


Fig. 81. Find the baby! A 0.2 c.c. " Kemp " diesel is sitting on the starboard wing of this control-line model. It makes an interesting comparison with the large 5 c.c. American " Drone " diesel which powers the author's model.

the capability of the little 0.2 c.c. Kemp in flying a 2 ft. wing span model, pointed out that, scaling this up to full size in proportion, it is equivalent to flying a " Tudor " with an engine of only 12 c.c.! This shows the great power for c.c. these baby model engines produce.

Before the birth of the diesel of very small capacity, the lure of the baby free flight model gave model designers many a headache. If the model was made satisfactorily small the weight made it fly too fast to obtain satisfactory stability. The advent of the tiny diesel changed all that overnight. Fig. 80 shows a little 36-in. span high-wing cabin model which I produced for diesels of around 0.8 c.c. such as the " Amco," the " Allbon Dart " and the 0.7 c.c. Mills. This little machine is called the " Humming Bird " and is now available as a plan from the publishers of this book. The model is very stable and the fuselage is made from balsa sheet in spite of its small size, with the result that it is nearly crash-proof. It will fly in really high

Fig. 82. The new " Hivac " valve radio sets encourage small radio models powered by diesel engines. The author designed his 48 in. span " Radio Brumas " for the latest lightweight radio sets. Engine is a 1.8 c.c. " Elfin."

winds and suffer no damage on landing if reasonably trimmed. Sheet construction allied to light weight see to this.

Fig. 81 may interest readers with an enquiring type of mind. The question is find the diesel. On the starboard wing a 0.2 c.c. " Kemp " diesel is seen sitting as a comparison in size with the 5 c.c. American " Drone " diesel installed in the nose of the model.

BABY RADIO MODELS

The year 1950 has seen the British baby radio sets arrive, due to the latest " thyratron " gas filled mini-valve. It is now possible to fly little models by radio in this country. My little " Radio Brumas " seen in Fig. 82, has a wingspan of only 48 in., and was developed from my larger radio aircraft. The diesel makes the best power unit because of its light weight. Larger radio sets are by no means defunct or outmoded. They and the larger model fly with greater steadiness and easier tuning if the " raised current " system is used, as described at the end of this chapter. Fig. 83 shows one of my medium size radio models powered by the high powered 3.5 c.c. Mark IV

E.D. diesel, with three valve E.D. radio receiver. The wing-span is 78 in.

CONTROL LINE FACTORS

Although a higher wing loading than for free flight is desirable, it is a great mistake to think, as a number of people do, that an excessively high wing loading is desirable for stunt models of the control line variety.

The Americans proved that a lightly loaded model makes for better stunting and indeed speed flying. This is because a lighter model is moved from its path more easily when the controls are altered. The heavy model " sticks in the groove." When one says lightly loaded this should read as reasonably light loading. Therefore reduction of weight is important. Another factor proved in the great American control line boom, and often lost sight of over here, is that a streamline symmetrical section makes for smoother control flying, greater speed, better stunt performance, and far better landings than the " flat plate " thin wing section so often used with wings made of solid balsa.

I have a garden circuit where I can fly whenever the spirit moves, or when a friend with control line aspirations comes

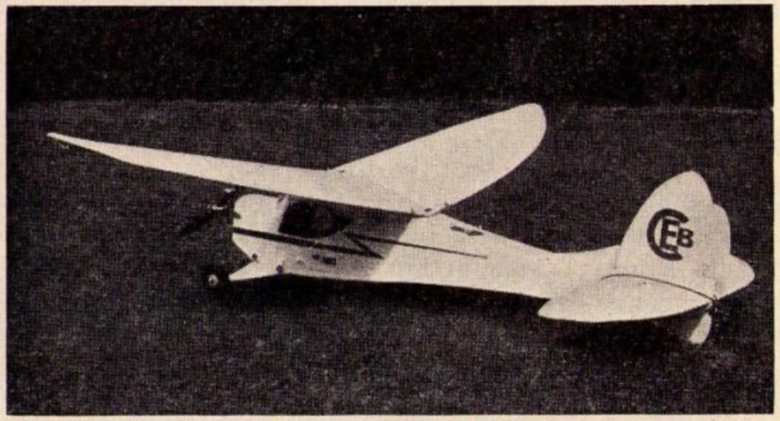


Fig. 83. The larger diesels suit medium sized radio models. The author's 78 in. span radio model is powered by the high performance E.D. 3.5 c.c. Mark IV diesel and controlled by an E.D. radio, modulator three-valve set.

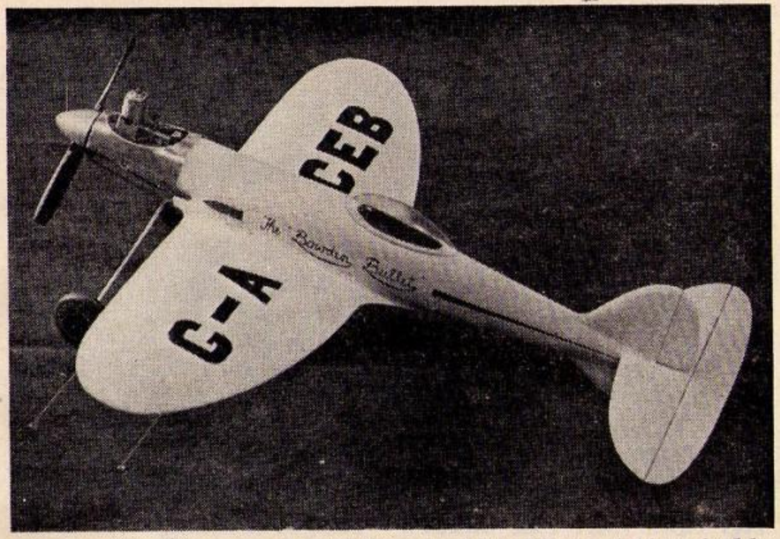


Fig. 84. The " Bowden Bullet " control line kit model is suitable for medium-size engines, such as the " Frog 100 " or " 180 " diesels, the " Elfin " 2.4 c.c. diesel and " Amco " 3.5 c.c. motors.

visiting. As a result I have done a great deal of control line flying and experiment with varying wing sections, propellers, engines and so on. I have found the American ideas outlined above completely revolutionise control line flying. Should a reader have previously flown only a thin wing of the flat plate type, I urge him to try a built-up symmetrical wing sectioned model.

The model shown in Fig. 84 will give an impression of what I mean. It is called the " Bowden Bullet " and has a span of 23 in. with built-up sheet covered wing. It is monocoque and can be built from solid laminated balsa hollowed out, or it may be planked. A model has been made on both principles and both weigh approximately the same, the planked version being a little lighter and, I think, easier to build.

Mr. Phil Smith has designed a delightful series of control line models of the near scale type for the well-known firm of kit manufacturers, Veron. He employs an interconnected wing trailing edge flap with a smaller elevator than is usual, which

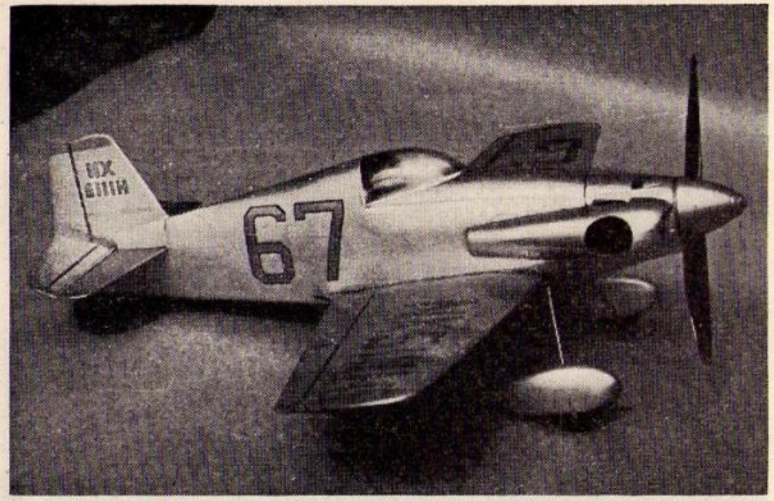


Fig. 84A. Mr. Phil Smith's "Midget Mustang" won the British International Team Race of 1950, powered by a 3.5 c.c. "Amco" diesel, using a 9 in. by 6 in. pitch propeller.

Fig. 85. Another Smith control line model is the Focke Wulf 190, A3, powered by a Mark IV, 3.5 c.c. diesel. Note the trailing edge flaps on the mainplane which go down when the elevator goes up, to assist quick stunt work.

gives smooth but very quick stunt movements. As the elevator goes up the forward flap goes down. Fig. 84A shows one of his models for team racing. This model, the "Midget Mustang," won the first British International Team Race, held at Brighton, in 1950. It is now sold in kit form.

The pure speed enthusiast should remember to get his control line model to fly in an absolutely flat path, with its streamlines in line with that path. A very high pitch propeller will be required, whereas stunt work requires a pitch in the middle ranges.

MODELS SUITABLE FOR DIESEL ENGINES OF 1 TO 1½ C.C.

A Baby Flying-Boat

This is a very popular size of motor because these engines are not quite so touchy for the novice to operate, yet they are cheap to buy and the model can be reasonably small and portable.

My little flying-boat of 36 in. span can be seen in Fig. 86, powered by a 1-c.c. "Frog" diesel, or 1.49 c.c. "Elfin" diesel. The model is called the "Wee-Sea-Bee"; plans are now commercially available.

Small models like these are a joy to operate because they are so handy when starting operations are in progress from a full-sized dinghy, or at the pond-side. The hull of this flying-boat is a "monocoque" and is made entirely of $\frac{1}{16}$-in. sheet balsa. It is fitted with sponsons for lateral stability on the water. The all-up weight with a "Frog" diesel fitted is only just 16 oz., and the model planes very quickly and easily when taking off. I noticed one of these little boats had been converted to a baby amphibian with detachable wheels by a competitor at the 1948 Bowden International Trophy.

It should, however, be remembered that a baby flying-boat is certain to require very delicate trimming of thrust line, etc., whereas a larger boat is far less touchy. I have had a number of exciting and very high flights from this little boat. Not long ago she flew from in front of the Parkstone Yacht Club over Poole Water, and the wind changed after take-off. The model headed with a full tank of the "Frog 100" diesel towards the

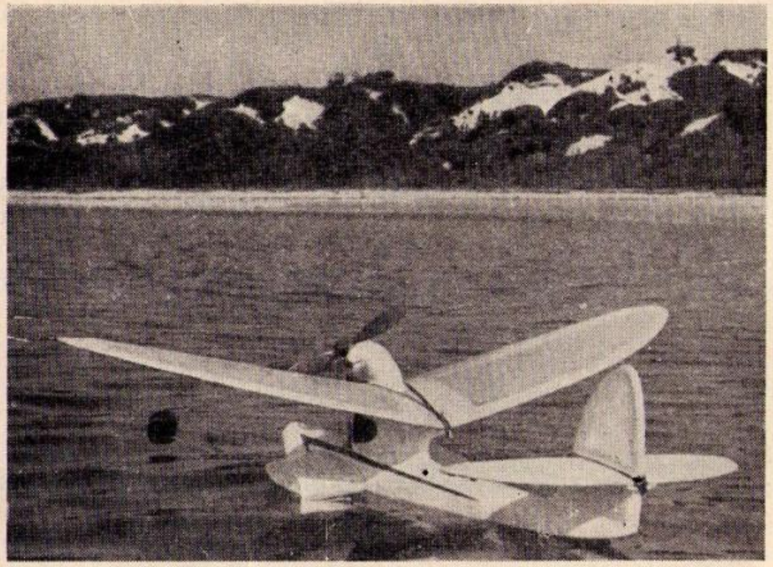


Fig. 86. The author's baby 36 in. span diesel-engined flying boat, " Wee-Sea-Bee."

port of " Poole," climbing fast and, much to my concern, for I could visualise the model landing in various awkward places in the main streets of Poole, perhaps to the fury of the townspeople of this ancient port. I devoutly hoped their spirit of seafaring adventure for which they are famous, would stand me in good stead. However, the thundery wind changed again and I saw with great relief the speck in the sky turn towards the yacht club. After a long slow glide in a huge sweep the tiny flying-boat eventually just skimmed over the boat sheds and actually made a perfect landing on the water. The story has its lessons, and one is that a very small boat must have a fair amount of offset to the thrust line in order to get the model to plane over the water straight. If there is a turn, one sponson will dip and the little craft will slew round. This straight run, with propeller torque more or less cancelled out, gives a rather straight flight under power which may cause exciting moments like the one I have recounted. A considerable number of people have made

this model of the " Wee-Sea-Bee " because of its small size, in spite of my warnings that a baby flying-boat is a far more touchy problem than a larger one. Some have told me of their " wonderful " flights. Others have wondered why they cannot get their model off the water. One man gave his replica upthrust to get it off. I have proved that upthrust will keep a flying-boat firmly stuck on the water. I made some tests on my larger and quite foolproof flying-boat. A little down thrust, contrary to general expectations, gets the hull planing, for it builds up water pressure below the forward step. This is due to the thrust line having to be comparatively high on a single-engined model flying-boat. Disbelievers should try it and see. The same thing applies to jets. It is useless to point the reaction line upwards. It must be pointed downwards, i.e. towards the nose.

Living, as I do, near the water with boats available, I have spent a great deal of time on flying-boats and seaplanes, and have now finished on a book on the subject.

A good number of years ago a boat of mine was the first powered model flying-boat to take off the water in the world's history. It set up an officially observed record at the same time. I still adhere to the usual form of steps that I used in those early days. There are three steps. The nose to the first step is well V'eed to break up shock on landing. This first step is well ahead of the main step which is situated at the C.G. position. The forward step prevents any tendency to nose in during the take-off and if there is any popple on the water, it helps to bounce the nose up and so accelerate planing of the hull. The main step I usually keep flat or only slightly V'eed. The rear step I keep flat on baby flying-boats and V'eed on larger ones. Some few years ago I raised my own record officially with a modern streamlined flying-boat powered by a 3.5-c.c. diesel engine. See Fig. 103. This has since been successfully attacked by a " Mills " diesel engine boat built by Mr. Gregory. There are now new rules for records which limit the engine run and have spoilt the fun !

If the reader will turn a few pages to Fig. 94, he will see a slightly larger 48 in. span flying-boat which I designed for engines like the 2.4 c.c. " Elfin " or 3.5 c.c. " Amco." This size

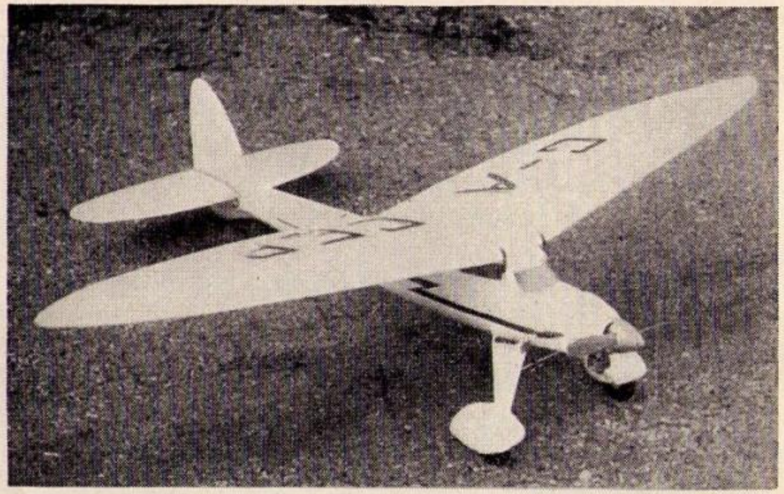


Fig. 87. A small monocoque free flight model for diesel engines of between 1 c.c. to 2 c.c. The " Bowden Satellite " 48 in. span.

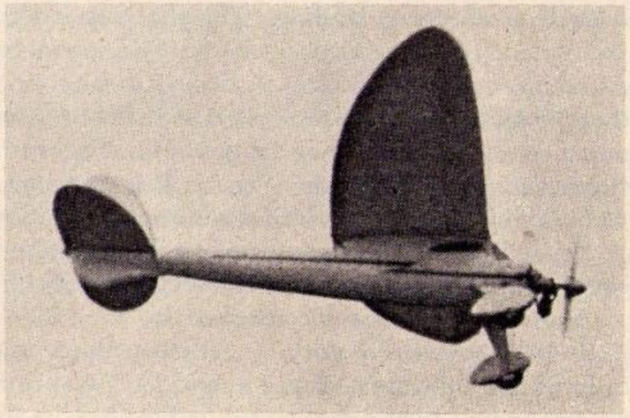


Fig. 87A. The " Bowden Satellite " has been caught by the camera in flight powered by a " Frog 100 " diesel.

boat is very handy to transport and it will doubtless eventually find itself under radio control with one of the new baby radio receivers installed in that capacious cabin. The sponsons are built like a wing and held to a cut away portion of the hull's bottom by rubber bands like a low wing. This prevents damage in the event of a dive in, due to bad trim. Water is very hard stuff and can wreck a rigid structure !

A Small Monocoque Model Landplane

Figs. 87 and 88 show the size of model aeroplanes that I have found most suitable for stable slow flight for the class of engine under review.

I always feel very much against fast-flying models for newcomers to the game of free flight, because fast-flying models suffer much damage and give little satisfaction in the hands of the novice. The problem in design of the smaller type model is to obtain a slowish stable model that is also robustly built. Not an easy combination to obtain, and incidentally, too infrequently attained.

My answer is in the two models seen in Figs. 87 and 88. I have built innumerable models in this class, and have arrived at these two models as a result of what I consider to be the ideal combination to date. Life is always progressing, however, and I may not think so later on ! The first model is of the streamlined monocoque type for those who like them. The wing span is 48 in. This model has been kitted and is probably the first monocoque fuselaged model to be released to the public in this form. The oval fuselage is built by planking on a simple method that presents no difficulty to the average individual. The model really does fly with first-class stability free flight, and has also been fitted with a baby radio receiver for radio control. The side areas and adequate keel surface have been correctly worked out to insure stability. Oval fuselage models are not always renowned for their stability. The rectangular " slab-sider " is easier to get right in this respect, hence their preponderance amongst the designers' choice.

Slow flight is obtainable using a 1 c.c. " Frog " or " E.D.

Bee" diesel, whilst an exciting performance results from fitting a 1.8 c.c. or a 2.4 c.c. "Elfin" diesel. The glide is amazingly flat due to the model's aerodynamic cleanliness.

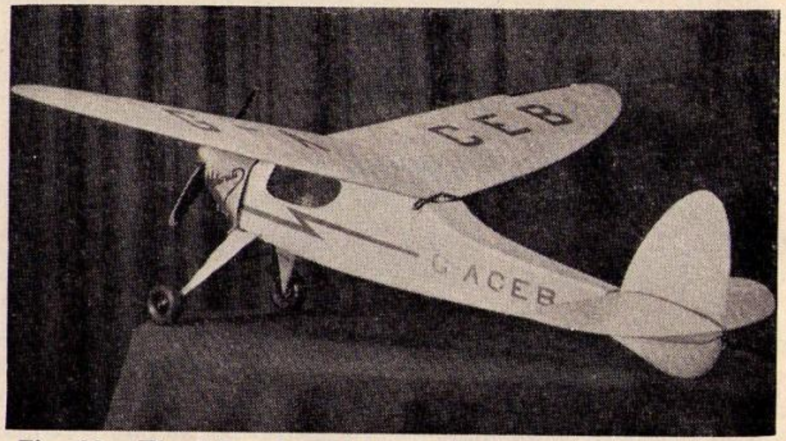


Fig. 88. The "Bowden Meteorite" is a small 45½ in. span plane now commercially obtainable in kit form. It has a great reputation for stable flight. The wing-tip slots can be seen painted in a dark colour. It is suitable for the latest baby radio sets.

A Beginner's Small Model Aeroplane, the "Meteorite"

I produced the second model to suit any of the popular class of 1 to 1½-c.c. diesels, such as the "Frog," the "Mills," and the "Elfin" and also for the "Frog 160" glow-plug engine or the American babies like the "Arden." It is foolproof to fly and to build, having exceptional stability features and great robustness for its small size, and yet it possesses a glide that fills its owner with satisfaction. Many have now been built as the model is available on the market in kit form, and can have a 2 c.c. diesel fitted if desired, in which case a slightly larger wing is fitted.

The fuselage is built up on $\frac{1}{16}$-in. sheet balsa and erected by means of a simple jigging method that ensures accuracy of the vital angles of incidence of wing and tail, a feature that novices so often get muddled over and yet is so vital in a small model. The sheet balsa is covered with paper and is almost indes-

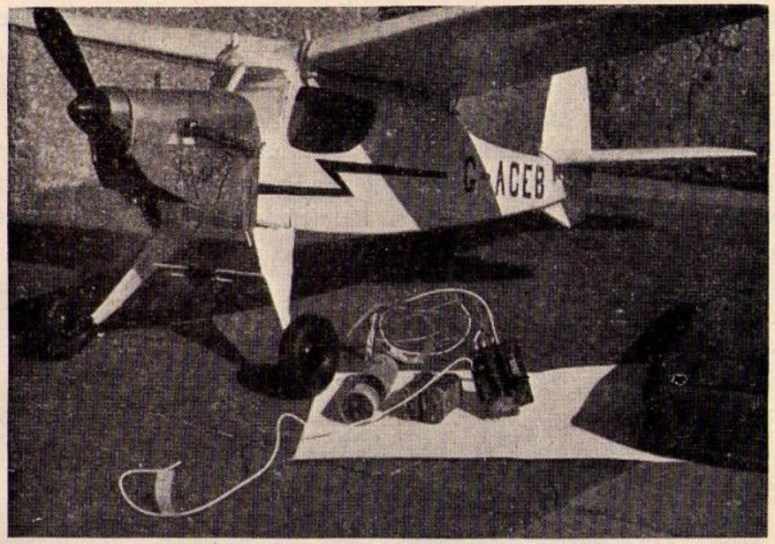


Fig. 88A. A modern baby radio receiver with its batteries fits very well into the "Meteorite."

tructible. I personally dislike the more usual balsa longeron machine covered with paper only. Such a machine often spends most of its time being repaired. The type of construction I advocate weighs only an ounce or two more in this size of model, which is more than allowed for in the wing area provided, and the model then lasts for ever. Due to the elliptical wing, it will be noted that the model has no greater wing span than the normal model for this size of engine, and yet it has a greater area and therefore slower and less dangerous flight.

Flying, and not repair work, is the thing that should be aimed at, especially for the novice, and for the competition fan, who must have reliability if he is to win events.

The wing span is 45½ in., and the central chord 10½ in. Wing-tip slots of a very simple design are fitted for super stability. The fuselage is 34 in. long and the tailplane has a span of 19 in. The flying capabilities of this model are definitely what the doctor ordered for the novice and the competition man who pins his faith to the small model. It has recently been fitted with a baby " E.D." radio set.

Scale Control line Models

The diesel is particularly suited to control line flying because the engine keeps cool when well cowled, and because cowling does not short an H.T. lead, as it is inclined to do in the case of a petrol engine. The H.T. lead and all the other electrical

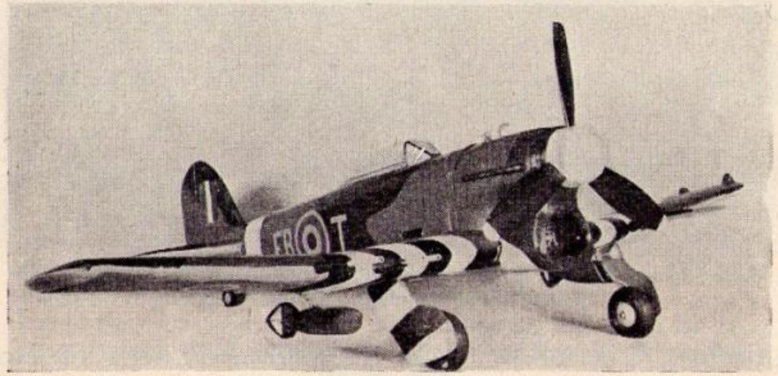


Fig. 89. This is a very nice-looking but practical control line flying model, by Dr. Thomas. The undercarriage retracts and bombs are dropped by a third control line.

leads are always a difficulty to dispose of neatly in the case of a cowled petrol engine if they are also to be accessible. The diesel requires none of these things.

Dr. Thomas is a keen British exponent of the control line model and his scale models not only look well, but they are also practical flying models. Fig. 89 shows a very nice scale " Typhoon " fitted with a 2.2 c.c. " Majesco " diesel, the inverted cylinder-head of which can just be seen lurking inside the cowling below the three-bladed propeller. The contra-piston is " get-at-able " through a small hole in the bottom of the cowling. This model is 35 in. wing span and has a weight of 30 oz.

I should perhaps explain to the uninitiated that wing loading can be comparatively high for scale control-line models because a

spot of speed is considered permissible and safe even for non-racing control-liners. The wing loading of this model is 20 oz. to the square foot, which, of course, would be far too high for a stable free flight power-driven model, which should have a wing loading ranging between 8 oz. to 16 oz. per square foot. Dr. Thomas considers that the wing loading for his " Typhoon " seems to be the optimum for control line models other than racing models. He made the three-bladed 10-in. diameter airscrew from sycamore, and obtains a static thrust of $1\frac{3}{4}$ lb. This is interesting because the reader will remember that I obtained $1\frac{1}{2}$ lb. static thrust from the 2-c.c. " Majesco " with a two-bladed propeller. It therefore appears that there is really nothing to choose between a two-bladed and a three-bladed propeller, except that the three-blader permits the advantage of a shorter undercarriage. As explained elsewhere, I use wide shorter blades for flying-boats for the same reason.

Dr. Thomas's model has a ratchet selector mechanism in the

Fig. 90. The author's simple low-wing free-flight model is here seen flying with a 2.5 c.c. diesel.

centre section, and a third slack control line is used to work the gear, which on the first pull retracts the undercarriage, the second releases the two 500-lb. model bombs, and the third pull lowers the undercarriage, whilst a fourth pull cuts off the engine. Nice work! And it works!

The fuel filler cap and needle-valve are both extended to the top of the engine cowling.

Inverted engine enthusiasts will be pleased to note Dr. Thomas's final remarks, which substantiate my earlier conclusions *re* inversion of diesel engines. He says, "I am very pleased with the engine. It starts very much more easily in the inverted position, and often starts first swing even from cold." That is because the fuel gets to the cylinder head quickly.

Low-wing Diesel Model Aircraft

Low-wing design for power models has always intrigued me immensely: a well-designed low-wing model, provided the operator is experienced, flies with just as good stability as the popular high-wing model. A medium sized low-wing model of mine is seen flying in Fig. 90, during wintry weather. This model was built specially for diesel engines of 2 to 3 c.c.

The model is now powered by an "Elfin" or "E.D." diesel, which in this case can be seen mounted in the upright

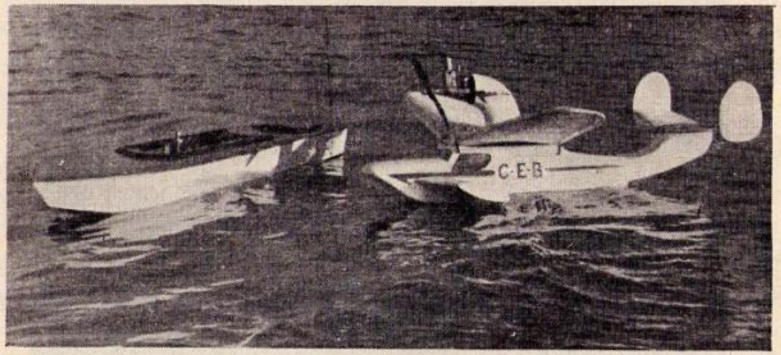


Fig. 91. The author's 38 in. long planing 2 c.c. diesel power boat is seen sitting peacefully on the water with its diesel brother flying-boat.

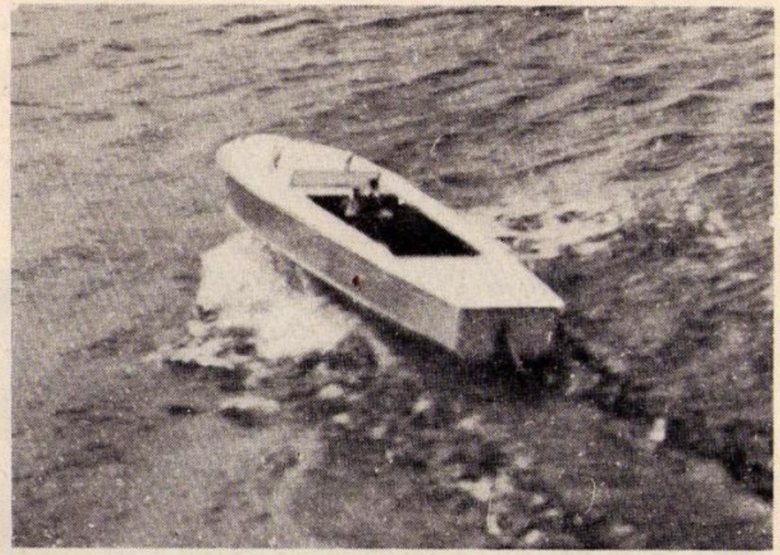


Fig. 92. The "Flying Fish" is here seen planing well powered by a 3.5 c.c. diesel, in wintry weather.

position. The model is fitted with wing-tip slots (as described in *Petrol-Engined Model Aircraft*); these slots are simple and they give extraordinary stability. The wing span is 4 ft. $8\frac{1}{2}$ in., with an elliptical wing having a central chord of 11 in. The fuselage is 45 in. long and the tailplane is elliptical, span 25 in., chord $7\frac{1}{4}$ in. The fuselage is of $\frac{1}{16}$-in. sheet balsa and has a turtle top decking with slab sides.

The Diesel Speedboat

The diesel engine is the most trouble-free power unit imaginable for boats. For years I have fitted my speedboats and hydroplanes with petrol engines. Now, I have gone over to diesels, and I doubt whether I shall use a petrol engine again in this form of model, except for some special purpose like hydroplane racing or boats in the larger class.

The most useful of my power boats is the "Flying Fish," shown in Figs. 91 and 92. It is 38 in. long, with a maximum beam of 9½ in., and is of the hard chine, Vee bottom planing-hull type. The 2 c.c. diesel fitted, planes this boat nearly as fast as most of the 4.5 c.c. petrol engines I have also used in the hull.

For an exciting maximum performance the 3.5 c.c. " E.D." diesel or a 5 c.c. " Eta," or a glow-plug motor of up to 5 c.c. makes the best power unit. For normal pond work the 2 c.c. diesel gives an ample speed with good planing.

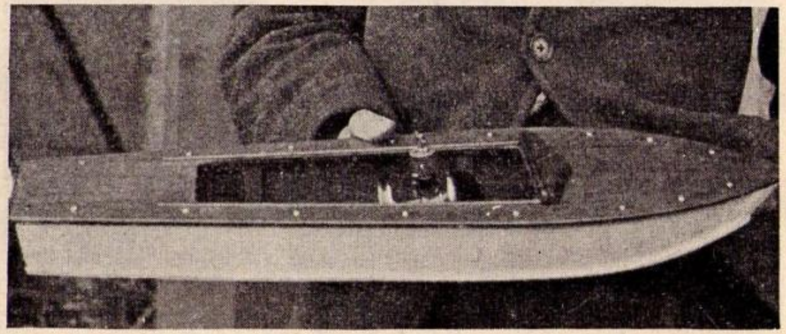


Fig. 93. A 0.7 c.c. midget " Sea Swallow " speedboat hull 19 in. long that planes fast when fitted with a diesel. It was designed by the author. A 1 c.c. diesel gives a racing performance.

The boat is constructed mainly from three-ply, and owing to the demand by people who have seen this rather unusual and yet practical type of model in action, the hull is now obtainable commercially in built-up form or plan form. It is surprising what a very considerable interest has grown up amongst the general public for I.C. power-driven boats during recent years. I have built myself larger and smaller speedboat models of the planing cruiser type, but my favourite has become the boat I have just described, because of its convenient size to carry and operate on pond or sea. For those whose interest lies in a large sea water planing hull capable of dealing with rough weather conditions, Figs. 108 and 109 show the " Swordfish " hull. I now have this hull fitted with " E.D." radio control and a long range fuel tank.

Some people are not quite certain in their minds what a

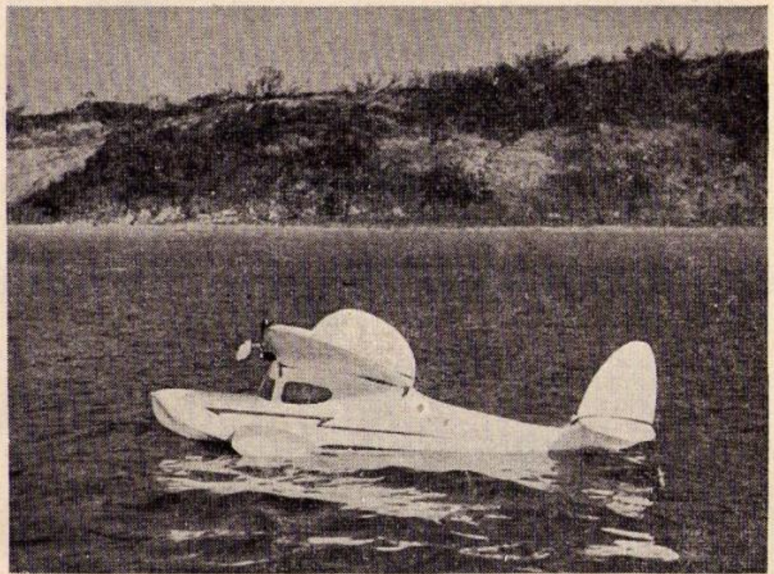


Fig. 94. The author's 48 in. span cabin flying boat designed for 2.4 c.c. diesels such as the " Elfin." Suitable for radio control with a baby receiver in the cabin.

planing " Vee " bottomed hull means. They visualise a stepped racing hydroplane. This is not, of course, correct. The " Vee " bottomed hull is similar to the familiar and well-known air-sea rescue launches of the war, and the normal pleasure speedboat of peace time, and it has a progressively " V'eed " bottom that becomes nearly flat at the stern. This type of hull automatically and correctly banks on turns and does not skid outwards as in the case of a stepped hydroplane. The baby 19 in. long " Sea Swallow " is shown in Fig. 93. This hull planes well when powered by a 0.8 c.c. " Amco " or " E.D. Bee " diesel. A " Mills 0.75" diesel has recently been fitted into this little hull. These motors give high speed and employ a small propeller.

MULTI-ENGINED MODEL AEROPLANES

The diesel's simplicity of equipment, and as a result light weight, makes the type very suitable for multi-engined enthusiasts. Fig. 95 shows Mr. Crabbe's unusual three-engined model,

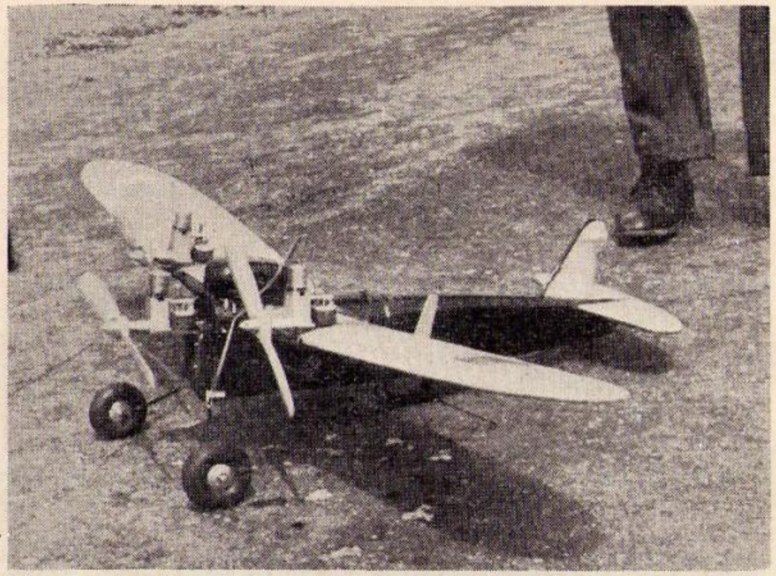


Fig. 95. A tri-motor control-line model by Mr. Crabbe. Three "Mills" diesels are installed.

which I have seen him fly control line. It looks impressive in the air, except that so many naked and uncowled engines rather spoil the effect. Small balsa fins had to be located just aft of the outboard motors so that when one cut before the other the model resisted any tendency to turn inwards. One of these fins can be seen on the port wing. The engines are three Mills diesels. It is quite an exciting moment when all three are started and the model takes off. It is a wonder that more modellers do not build multi-motored control line models, for there is little danger when one motor cuts, as there would be in the case of a free-flight multi-motor model. Colonel Taplin has solved the free-flight problem in an ingeniously simple way. He connects his two "E.D." diesels together with a cross-shaft and gearing so that both engines must run at the same speed. He proved the practicability of his method by flying this multi-motored model in the "Bowden International Power Trophy," 1948. A photograph of the connected engines is given in Fig. 96. This model has since been flown under radio control and must be the

first of its type to fly in this way successfully. The first flight was one of 8 minutes.

The Pylon Type Model

In America and on the Continent the most popular type of power-driven model aeroplane seems to be that with its wing mounted high on a pylon. This is largely due to the competition rules in those countries, which favour a corkscrew climb on a limited motor run. It always seems to me to be the least interesting type of power model, partly because it is so very far away from full-sized machines in appearance, and further because it has a very unrealistic type of flight. Even the Americans, who introduced the type, are now making critical remarks about its unrealistic flight appearance, in their model

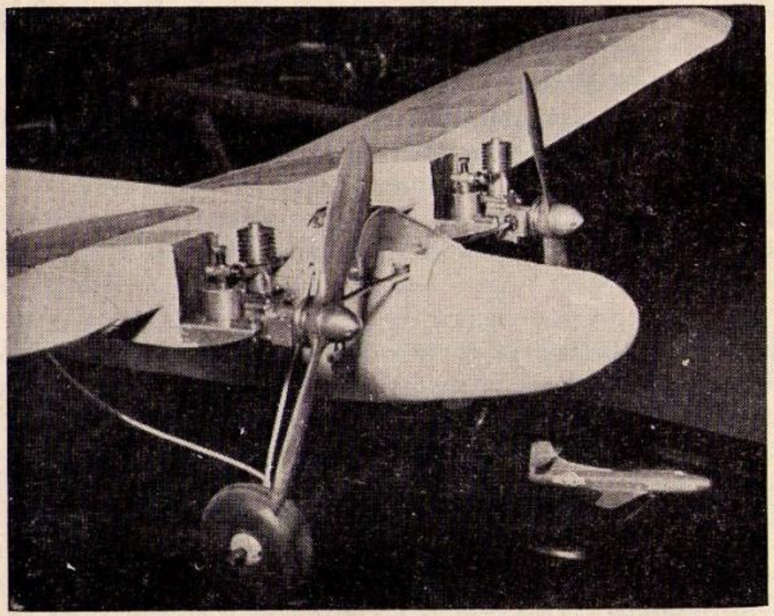


Fig. 96. Colonel Taplin's two-motored model has the two E.D. engines connected together by cross-shaft and gearing which ensures constant speed and thrust from both propellers for this radio-controlled machine.

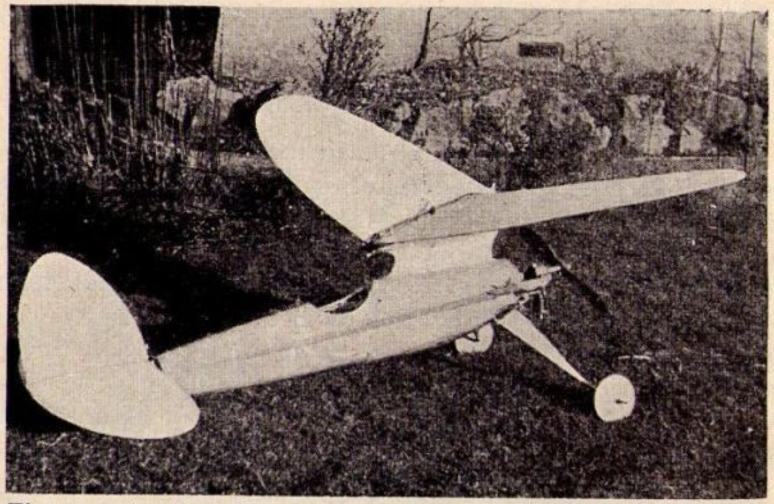


Fig. 97. An American type pylon diesel model designed by the author, with monocoque fuselage.

journals. Nevertheless, there are a number of people who build this type and I must therefore be careful what I say! The type has found very considerable support in Britain recently, and a number of manufacturers have put kit models on the market. A glance through the advertisements in model aeronautical journals will supply the needs of modellers interested in the type.

Fig. 97 gives a picture of a "pylon job" fitted with a streamlined balsa-planked monocoque fuselage, and with its diesel engine inverted. The dimensions of this model, which has the usual pylon performance, are wing span 4 ft. 6 in., central chord 11 in.

Flying Wing Tailless Type is very suitable for Diesels

The tailless model has very little drag for an engine to contend with, therefore quite a small power unit will fly this type of model. That seen flying in Fig. 98 is an 8 ft. 10 in. span model which is fitted with a 3.5 c.c. diesel.

Tailless machines are very critical as to weight distribution. This is made simple by using a diesel, because the weight of the

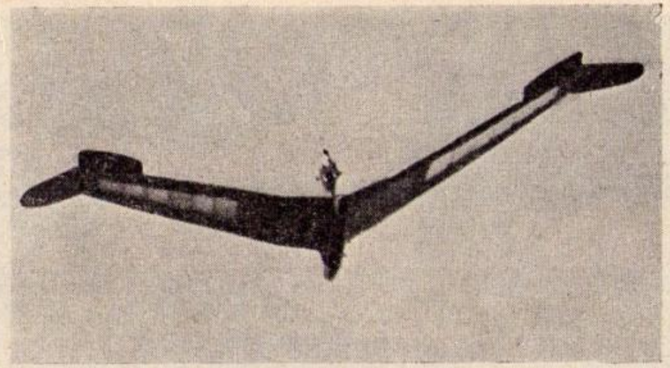


Fig. 98. A large flying wing powered by a small diesel. This model, which was designed by the author, has a wing span of 8 ft. 10 in.

engine is concentrated, and this weight can be located exactly where required. The machine seen in flight has a pusher propeller fitted, in order to get the weight back. Owing to the reduced drag of the tailless model, it is also surprising how fast they fly even when given a very low-wing loading.

The Biplane

Biplanes are still popular in the model world in spite of their having become defunct for full-sized work. They certainly look intriguing in the air.

This type is the exact opposite to the tailless model with regard to drag. Biplanes are truly said to have a "built-in headwind." The small model shown in Fig. 99 is flown by a 2.4 c.c. "Elfin." This model is unshakably stable due to excellent keel surface. The glide is slow and landing excellent, due to the wingtip slots.

The top wing span of this model is 43 in., and it is built with a sheet balsa fuselage.

The Diesel Float-Plane

The 2.5 c.c. class is most useful for the medium-size flying-boat, the hydroplane and the float-plane. I have tried out a

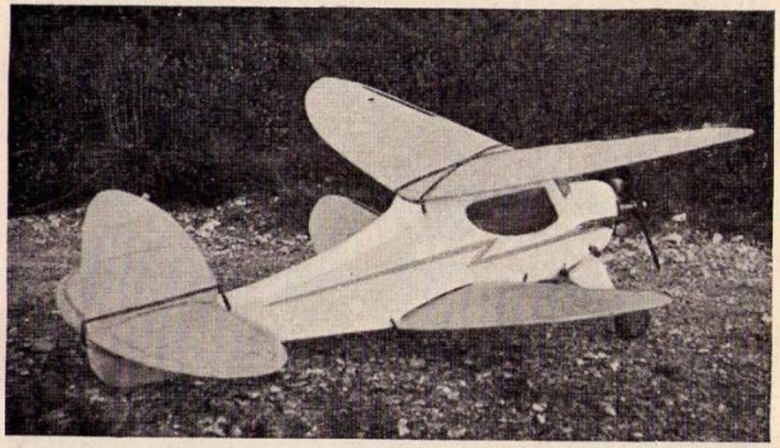


Fig. 99. A small Bowden biplane that flies with rock-like stability powered by a 2.4 c.c. "Elfin." Note wing-tip slots on both top and bottom wing, also very large tail.

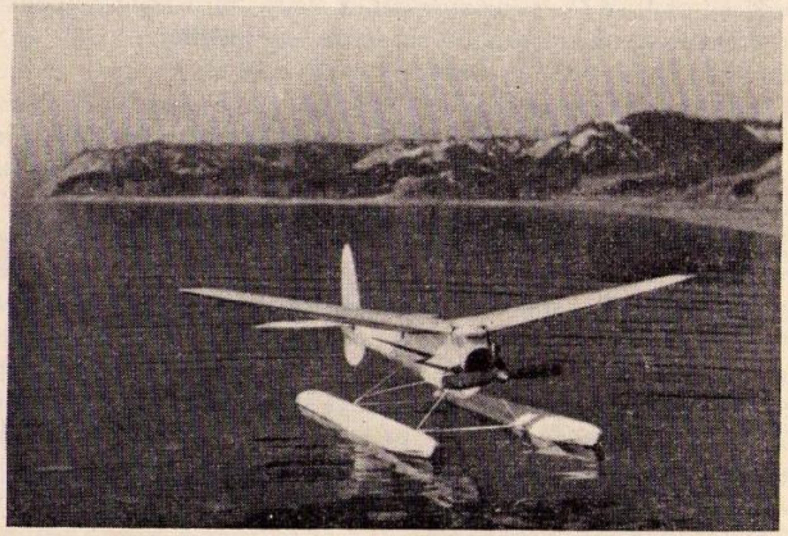


Fig. 100. The author's 2.4 c.c. E.D. diesel powered monocoque twin-float plane flies with remarkable stability. Span 48 in.

hydroplane and flying-boat for this size of engine with success. A small float-plane may interest readers, and is seen in Fig. 100. The wing span is 48 in. with central chord of 11 in. The twin floats are planked monocoque and have an extra forward step to assist take-off. I find that the easiest practical method of obtaining a take-off under limited horse-power is to fit floats of a generous buoyancy and large planing surface. This means that the floats do not sink low into the water when at rest, which would necessitate great power to make them rise on to the surface. It is on the same principle that a light wing loading permits flying on low horse-power. A large planing area also makes for easy landings. It is best to forget "wetted surface" in model work!

The diesel engine has an immense advantage for float-plane work because the total weight of the model tends to mount up, due to two or three floats and their strut gear. The diesel's low overall weight therefore prevents too high a wing and float loading.

The engine is a "Mark III" E.D. diesel of 2.4 c.c., and this model looks particularly pleasant in the air, due to its long twin floats.

AERO MODELS AND BOATS FOR 3.5 C.C. TO 5 C.C.

Large model aeroplanes are justifiably noted for their excellent steady flying characteristics, and they are imposing in the air. They require longer to build and are naturally more expensive to produce. Although they fly with great steadiness, the glide must be good, otherwise the weight of the model will cause considerable damage if bad landings are made. Water is a very hard medium if struck at high speed at the wrong angle by sponsons!

The Large Diesel-engined Flying-Boat

An old flying-boat with planked monocoque hull which was originally powered by a 9-c.c. petrol engine, now that it is stripped of batteries and coil, flies well powered by a 6 c.c. German "Eisfeldt" diesel. Large flying-boats require a considerable excess of power to take-off the water.

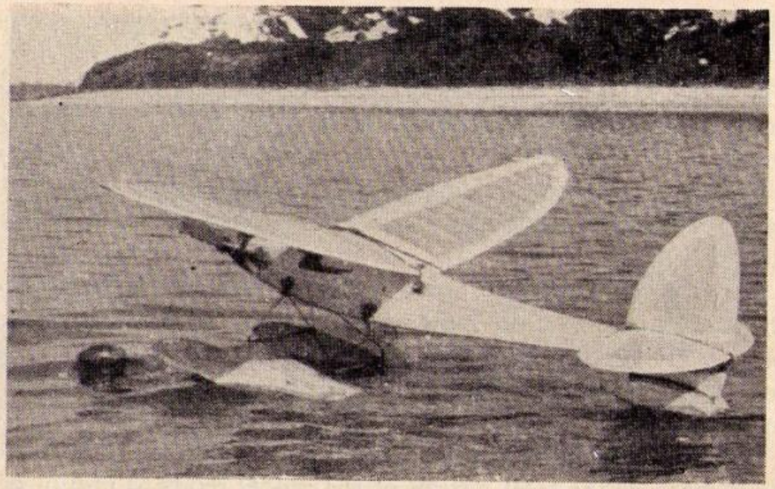


Fig. 101. A little 36 in. span float plane of the author's which has been flown by a number of baby engines, such as the 0.8 c.c. "Amco" and the 0.7 c.c. "Mills." Three floats are used in this case.

Fig. 102 shows the model in the air flying over Poole Harbour. The model had circled several times around my dinghy in the calm air and finally it came within close enough range of my camera, which for sharp photographic purposes was not quite correctly focused ; the light was also failing, hence the somewhat blurred outline. Nevertheless, the extra forward step is quite clearly seen, also the stepped sponsons.

Since taking this photograph I have fitted new and improved sponsons, reverting to my original non-stepped type, but using a swept back leading edge and a deeper and more buoyant trailing edge section. I now set these new sponsons at a greater angle of incidence. The new set-up has improved lateral stability on the water, and clean take-off is much improved because rougher water does not build up and sometimes get over the leading edge as it did in the case of the old sponsons.

The wing span of "Blue Goose," which was exhibited at the 1946 *Model Engineer* Exhibition, is 7 ft. 6 in., with a central chord of 14½ in. to the elliptical wings. The model has a delight-

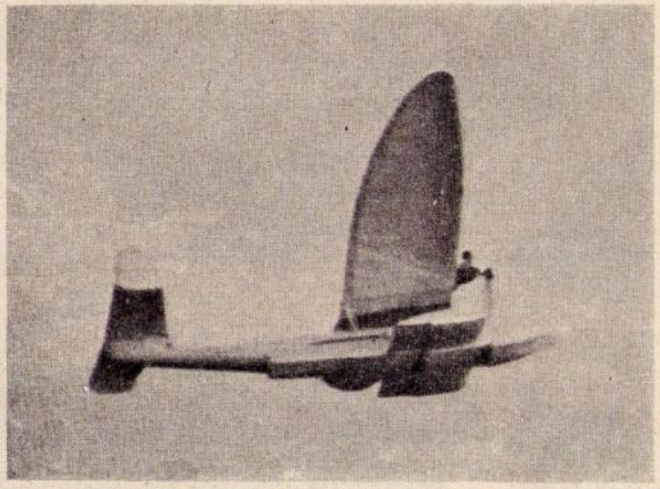


Fig. 102. The author's 7 ft. span flying boat snapped whilst flying over Poole Water. It is powered by a German "Eisfeldt" diesel of 6 c.c.

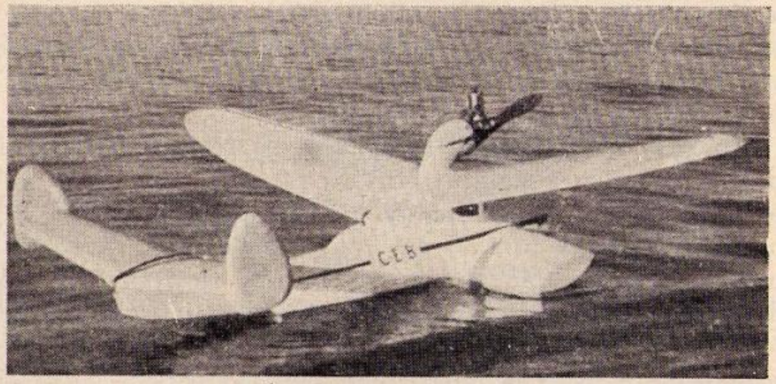


Fig. 103. The 3.5 c.c. flying boat "Goose" shown, raised the author's original British flying boat record, and was designed for stability on and off rough open water at Poole. Note the long waterline to ensure the tail not being blown under when at rest in a wind.

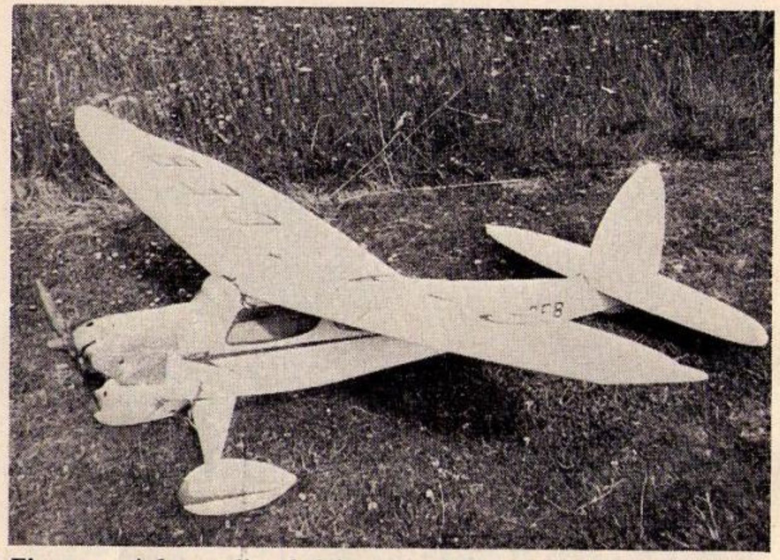


Fig. 104. A large diesel-driven model of stable flying characteristics suitable for free flight or radio control known as "Bowden Whitewings."

fully steady flight over water and a very flat glide with a type of landing that is a pleasure to watch. I feel sure that more people will indulge in power flying-boats and seaplanes now that smaller and more portable models can be built with diesels like the little ones described earlier in this chapter.

In 1947 I made myself a medium-size flying-boat expressly designed for diesel engines of from 3.5 c.c. to 5 c.c. and capable of taking-off from the roughest possible water, also with the necessary stability to ride out rough water after landing. I decided upon these requirements because I had found so many days during our English summer weather when it was impossible to fly off open water such as Poole Water. The result can be seen in Fig. 103. This photograph makes clear the long water-line which prevents the tail being blown under when the model is at rest, and also the enormous sponsons which give unassailable lateral stability both at rest and when planing for the take-off. The great angle of the sponsons' leading edges ensures that

quite large-scale waves do not climb on top of the sponson at take-off, which is the swiftest way to ruin a take-off. It will be observed that the model floats on top of the water and therefore the engine has not a great deal to do in raising the model on to its usual three steps. This model raised my original record for a while, powered with a B.M.P. of only 3.5 c.c. The duration of flight was curtailed by the small tank fitted to the engine. This model has led me to further and better designs for other engine capacities. The weight of boat "Goose" is 3 lb., wing span 4 ft. 8½ in. A new E.D. "Mark IV" diesel of 3.5 c.c. now powers this boat with increased vigour.

A Large General Purpose Flying Model

Fig. 105 is of interest in that it shows my large "Bowden Whitewings" starting on its take-off run powered by a 3.5 c.c. diesel. The tail has just come up and in a few more yards the model was airborne. The same model can be seen in Fig. 106 flying steadily around the camera, and also at rest on the ground in Fig. 104.

This model was heavily loaded with a coil and battery to

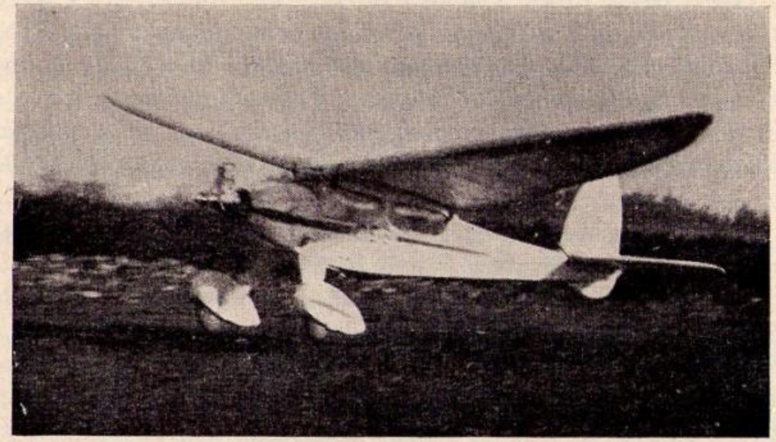


Fig. 105. The "Bowden Whitewings" large power model now produced in kit form, is here seen taking off. It is powered by a 3.5 c.c. diesel, or a 5 c.c. glow plug motor for radio control work.

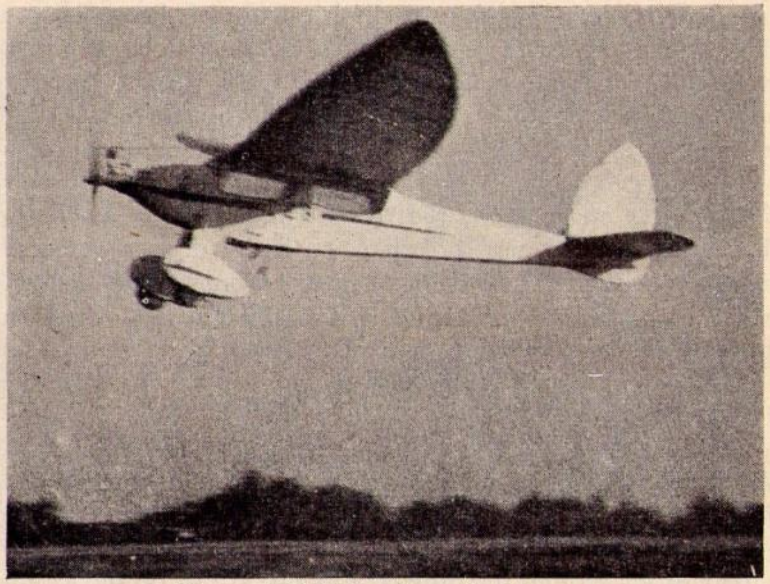


Fig. 106. "Whitewings" airborne.

keep its normal balance for petrol engine flying as well as diesel. A $3\frac{1}{2}$-oz. clock timer was also fitted. The model has a large wing area, but the wing span has been kept reasonably short for a large model by giving the elliptical wing a very large chord of 16 in., the span being 6 ft. 6 in. This type of wing has the advantage of compactness and yet has the area of a normal parallel chord wing of about 7 ft. 6 in. It is also very stable laterally.

Those who are interested in what is known as the Reynolds' number and "scale effect" will realise that a large section is more effective than a small one of the same outline. Therefore the large chord is better as a weight carrier than a small chord. The only way to attain this with a short span is to use an elliptically shaped wing which keeps a low aspect ratio wing efficient. Hence the reason why so many of my models have this shaped wing outline.

There is not the slightest doubt that a 3.5 c.c. *petrol* engine of any make *would fail* to take this model off the ground under

Fig. 107. Mr. P. Smith designed this nice-looking 7 ft. span "Stentor 6," fitted with parallel chord wings. A number of these models have been fitted with radio after slight modification.

its own power and it would only just fly it. A 4.5 c.c. motor flies it comfortably in the air, but requires a bit of a push for R.O.G. work, but a 3.5 c.c. diesel makes the model rise off ground when loaded with all the spare electrical equipment of a petrol model. The evidence is in Fig. 105 and answers the question, does a good diesel produce more power than a good petrol engine?

The model "Whitewings" has had a great variety of petrol and diesel engines installed, because I designed it for a constructional kit of parts for the average aeromodeller and I wanted to make certain that it was capable of taking all sizes and power outputs of engines. The model is rock steady in the air and will fly in heavy winds that usually cause a paper or fabric covered plain longeron model of this size to retire due to damage. The fuselage is the sheet-balsa and fabric-covered type that I have already mentioned.

The prototype seen in the photograph is covered with nylon by the " wet system " of covering.

This model has proved itself a great weight carrier, and due to this and its great stability, I have flown various radio sets in this model.

A Fast Cabin Cruiser for Larger Diesels

Although a large boat is a nuisance to transport, there is something very attractive about such a craft on the water. It looks purposeful and can travel really fast over quite rough water

The hard-chined Vee-bottomed planing boat " Swordfish " gives a great thrill when travelling at speed. She is a little too fast for pond work unless throttled down, but is really first-class fun when let loose with a full tank of fuel from a dinghy on the sea. Fig. 108 shows the boat in action, but not flat out, because the waves were considerably larger than appear in the photograph on the day upon which the snapshot was taken.

This model has recently been fitted with an " E.D." three-valve radio receiver. Although the model is normally used for long runs on Poole Water, which has an alluring 140 square miles or so for this purpose, a special tankage system is being incorporated together with waterproofing of the radio so that if opportunity permits, the model will attempt to cross the English Channel controlled by radio by Taplin and myself from the deck of a full sized boat. This will require calm weather but should afford considerable fun, besides being a new model venture. This boat was originally built when I was stationed at Gibraltar before the last war, where it did much free running at speed in the harbour. I sometimes wondered what the ancient besiegers of this bastion would have thought if they could have seen into the future—a tiny boat speeding over the waters they had fought for beneath the towering old " Rock," leaving behind a thin trail of magic blue exhaust smoke and emitting a hitherto unheard of exhaust howl.

A number of engines have been tried in this boat. The hull planes quite well with a 5 c.c. diesel. If a larger diesel were on the market she would " take it," as she has run at great speed

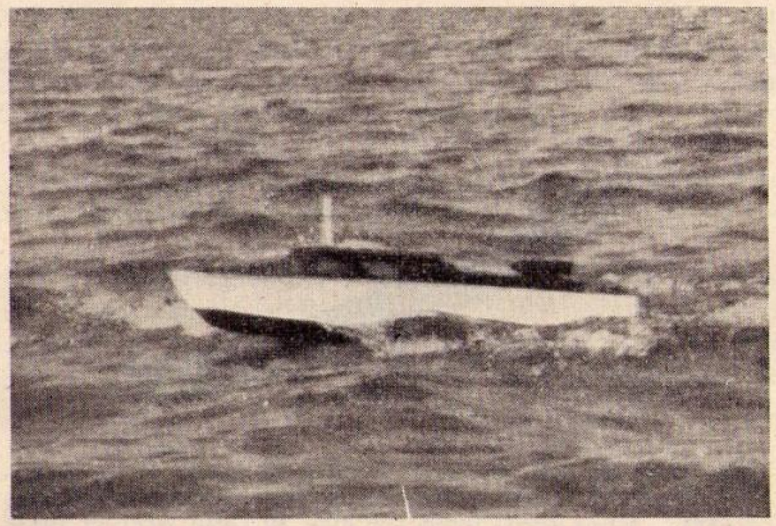


Fig. 108. The author's large planing boat " Swordfish " travelling well in a rough sea. The model has since been installed with radio steering equipment.

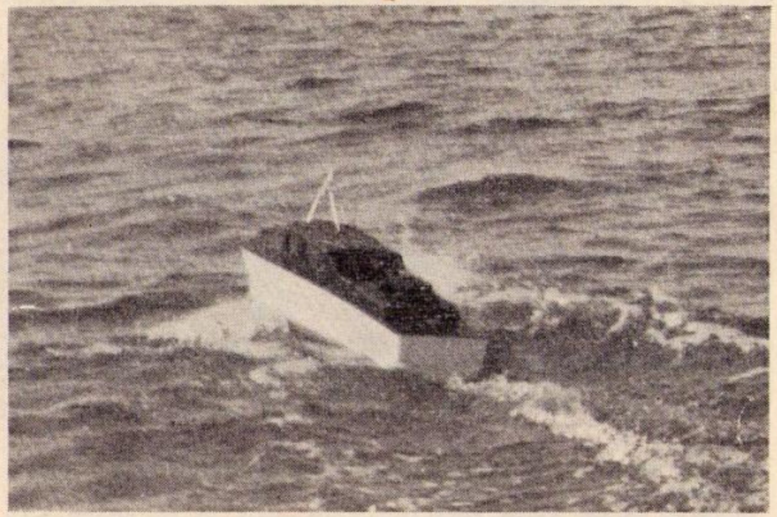


Fig. 109. The " Swordfish " on half throttle runs into a choppy sea. The hull is 3 ft. 10 in. long.

powered by a 13 c.c. water-cooled petrol engine. A 9 c.c. glow-plug motor of the " hot " American type is most suitable too.

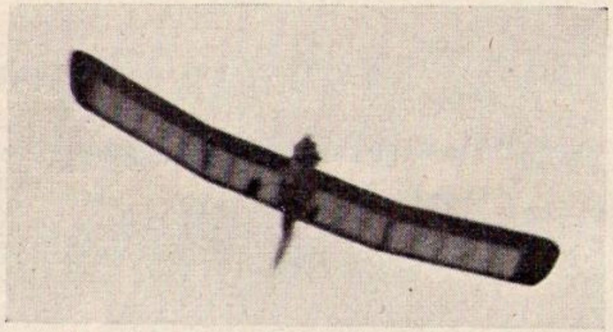


Fig. 110. An odd spectacle is afforded when the author's "flying plank" with reflex trailing edge wing, powered by a "Frog" 1 c.c. diesel takes the air. In calm weather these "planks" are very stable.

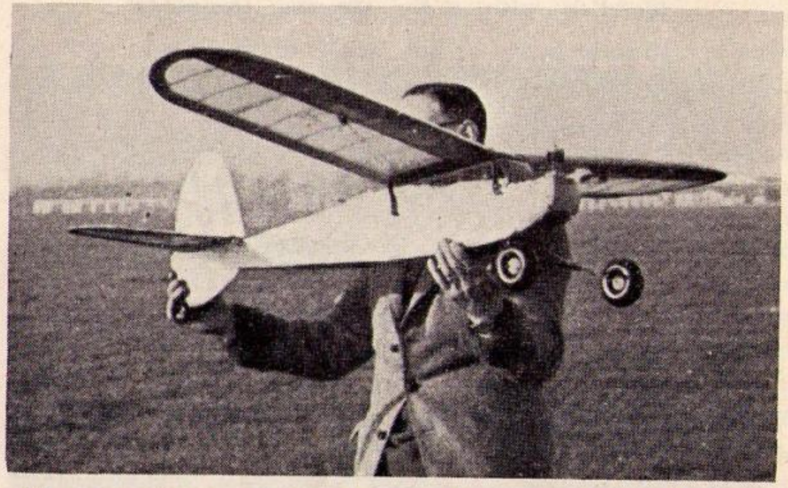


Fig. 110A. A powerful diesel installed in a small model heavily loaded with radio equipment is the ingredient for reliable stunt flying on rudder control alone. Here is Colonel Taplin running up his Mark IV E.D. diesel to test the radio against vibration prior to releasing the model to give a demonstration of stunt flying.

EXPERIMENTAL MODELS

Experiment is the spice of life to many of us in model work. The diesel makes an ideal engine for such work because it is self contained and the weight is concentrated. It can be clapped on to a model in a minimum of time, and give the maximum of flying time without disturbing engine adjustments, for observing the flying behaviour of one's brainstorm in the air or on the water.

The Swiss and German idea of a " flying plank " or rectangular wing without any stabiliser tailplane is an intriguing problem, and forms an unusual spectacle in the air. The secret is in the reflex trailing edge section which looks after longitudinal stability, whilst the fins at front and rear of the nacelle

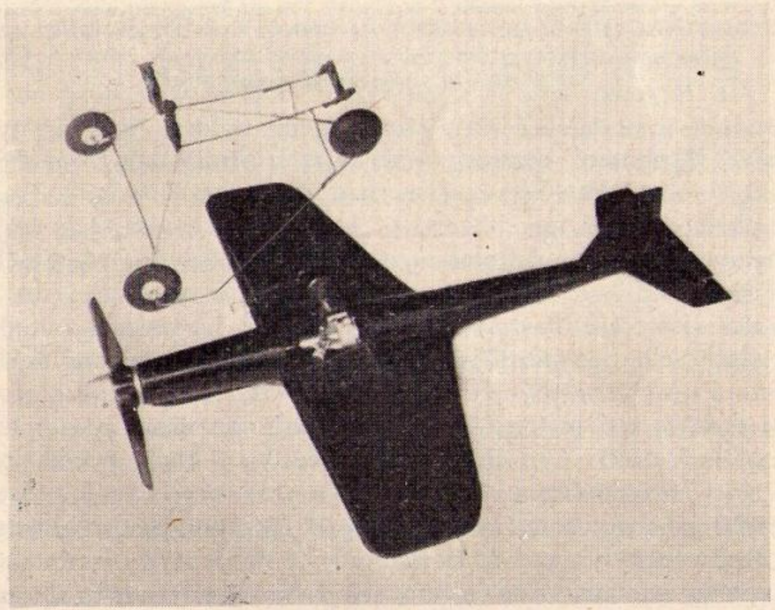


Fig. 111. The Baigent speed control model has a very low frontal area with "E.R.E." diesel engine buried in the wing, driving the propeller of 8 in. diameter and 10 in. pitch, through an extension shaft. A cover snaps into position over the engine.

hold the model up in steep banked turns. These fins must be above and below the nacelle. I do not recommend the type in bad weather, although it flies well in calm air.

A SHAFT-DRIVE MODEL AEROPLANE

Fig. 111 shows a novel streamlined racing control-line model made by Mr. Baigent, housing one of his E.R.E. racing diesels of 2.4 c.c. The engine is buried in the wing with a small cooling slit. An extension shaft from engine to propeller is fitted. This provides a long streamlined nose with a thin circular fuselage giving a very low frontal area and the minimum of drag. The model is mounted on a dolly undercarriage which drops off when the aircraft becomes airborne. It lands upon a dorsal fin below the fuselage nose. Why are there not more speed models on these lines?

AUTOMATIC CONTROL BY PENDULUM USING A DIESEL ENGINE AS POWER UNIT

Mr. Norman, who is a sculptor of note as well as an outstanding aeromodeller with many ingenious ideas, flew a tiny scale "Typhoon" complete with cannon protruding from the wings in the 1948 "Bowden International Power Trophy." The tailplane elevator and dihedral of mainplane were all scale and unaltered. The model was powered by a "Frog 100" diesel which would have normally turned over in the air such a small model with scale dihedral. Norman's model, however, took off perfectly, climbed steadily but fast like the prototype, and flew around under control as though a pilot who understood high-speed flight was at the controls. All this was done by simple pendulum controls to elevator and ailerons. Many people in the past have predicted failure of pendulum controls, saying that centrifugal force at turns would upset the controls. Norman proved otherwise, and what is more, he did it with absolutely simple pendulums. The elevator pendulum was mounted about the C.G. position in the fuselage under the bubble cockpit. It acted on the elevator like a control line handle. The ailerons had their pendulum mounted in the centre section of the wing, which was detachable.

Fig. 112. Mr. "Natznees" Norman flies a scale "Typhoon" under perfect control at the "Bowden Power Trophy," 1948, by pendulum control to scale elevators and ailerons. The model was powered by a "Frog 100" diesel and flew as if a pilot who understood speed was at the controls. The ailerons and elevator sizes can be seen in the photograph of the model, which has a wing span of only 3 ft.

This eventful flight proved that free-flight scale models can be flown satisfactorily without any specially severe dihedral angle added if the controls are operated by pendulum. This model had a high wing loading and was fast, and completely confounded the theorists regarding centrifugal force dangers, which in theory should have occurred due to the high speed! Belgian competition models had previously used pendulum control to the rudder in 1947 in order to bring their high-climbing models out of a turn at the top of the climb.

A few details of the Norman "Typhoon" pendulum-controlled model will doubtless interest readers. The propeller is a three-blader made from fibre, and almost unbreakable. The blades are interchangeable, and bolted into the centre hub. The guns are mounted in rubber to avoid damage. Fibre wheel covers and fibre nose cowling are used. The nose with cowling is knock-off. The simple pendulum control has a patent pending, but there is no reason why any modeller should not design and make himself a satisfactory control for private use using simple lead pendulums, as has been done by Mr. Norman. The wing

Fig. 113. The author's control line flying boat, which successfully takes off and lands on water with the operator standing at the water's edge. A special forward fin is required to resist the inward pull of lines at take-off.

span of the model is 3 ft. Why should we not use aileron pendulum control on radio models, in order to prevent excessive bank on turns? I have used elevator pendulum control.

A CONTROL LINE FLYING-BOAT

It often happens that there is a beach or a pond for flying off water but not a suitable stretch of water for landing on after a free flight. Furthermore, there may not be a boat handy for recovery operations. A control line water-plane in these circumstances permits the modeller to enjoy most of the fun of flying off and over water. It further gives him all the thrill of taking off water and the landing, which are controlled by his skill. In fact, I find it by far the most interesting and intriguing type of control line flying, which tends to become dull after much repetition, for there are more hazards and difficulties to be overcome in water control line flying.

It sounds a simple matter just to attach control lines to a flying-boat or a float-plane and fly. I have found that the chances of this happening successfully are slight. The first flying-boat I tried as a control liner invariably pulled in on the lines at the take-off before the boat could get going at sufficient speed to plane. The left sponson submerged and the boat slewed round out of wind. I found the solution in the boat shown in Fig. 113. It will be noticed that the following points are incorporated.

(1) The hull is exceptionally long in front of the wing, so that a small three-ply fin offset to turn the boat outwards from the centre of the control circle at the beginning of the take-off run before planing speed has been attained, can be fitted well forward. This gives adequate leverage.

(2) The 3.5 c.c. "E.D." diesel is given a large offset outwards, and has plenty of spare power for the light weight of the boat, which sits on top of the water's surface.

(3) The planing surfaces are very generous and have *exceptionally large and wide sponsons*. The longitudinal flotation base is rather extreme and gives an effect like a tea tray which skids over the surface of the water, therefore facilitating take-off.

(4) A little down thrust is given. Up thrust prevents easy planing.

To fly, the operator stands on the bank of a pond, or, better still, a little way offshore in the sea off a sandy and easily-shelving beach. A helper releases the model from the shore with the model sitting on the water, facing sea or pondwards. The pilot then has a half-circle in which to get airborne.

For solo operation, I have rigged up a long wire prong which drives into the sand near the shore, with the top just above the water's surface. The wire has loops at the top through which a pin passes. A loop at the model's stern also goes around the pin. A line from the pin to the pilot allows him to start the tethered model in shallow water. He starts up his engine, walks to the control handle which is stuck into the sand on its prong, picks up the handle, wades into the water a few yards if possible,

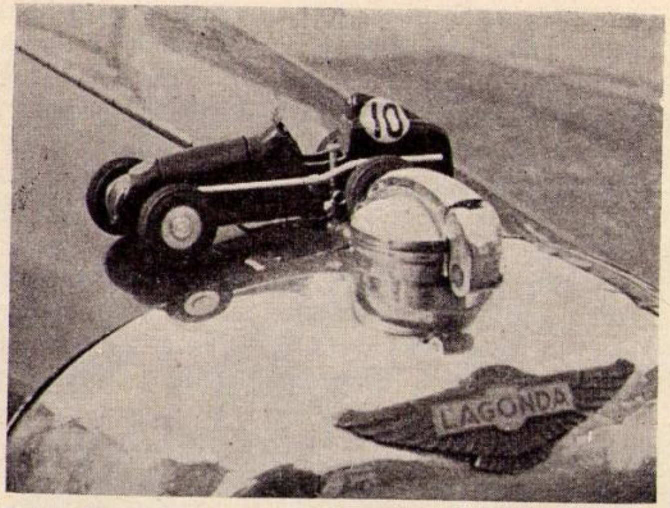


Fig. 114. The Baigent 0.9 c.c. diesel model car is here seen behind the radiator cap of the author's 4½ litre Lagonda. Barely 1 c.c. makes friends with 4,900 c.c.!

for this gives a larger " half-circle," gives the pin a tug by the line which releases the model, and flies the boat off water, taking care to keep the boat low for the first half-lap after becoming airborne. The landing is great fun and requires a little skill in judgment should the engine cut over land. In this case, a " whip " of the wrist is required to carry the boat on to a flat glide, landing with a slight lowering of the tail just before touch down.

I personally use thin fishing line for the flying lines and give a dope of special fisherman's waterproofing mixture so that the lines do not become soggy and sink into the water at take-off time before the lines tighten.

MODEL DIESEL CARS

The diesel is suitable for the light-weight class of car.

The diesel engine is particularly suitable for the smaller types of model cars because, as in the case of aeroplanes and boats we can reduce weight by elimination of the electrical gear and its complication of wiring.

The diesel is cool running and therefore lends itself to good streamlining of the body work.

A LITTLE DIESEL RACE CAR

The 2 c.c. class of diesel is excellent for a beginner's race car of a very simple type, built up with a wooden chassis and balsa body. The power unit, less flywheel, will have an all-up weight of approximately 6 oz., and the excellent power output affords scope for the design of a medium speed model. The " E.D. Mark III " 2.4 c.c. diesel set up a record for its class with a speed of 41.7 m.p.h. in 1948.

The very simplicity of the diesel has produced some outstanding and unconventional designs in countries abroad, and in at least one case in this country. These designs have broken away from the more normal arrangement of the model car which has the engine driving front or rear axle *via* a longitudinal propeller shaft and a right-angled drive to the driving axle. Designs of this standard type are easily obtainable on the British and American markets.

A centrifugal clutch is generally fitted in the drive on model cars in this country, but this is often omitted in designs abroad. The diesel engine in the unconventional designs drives directly through the front or rear axle, thus doing away with the complication of right-angle drive. One of the fastest men in this

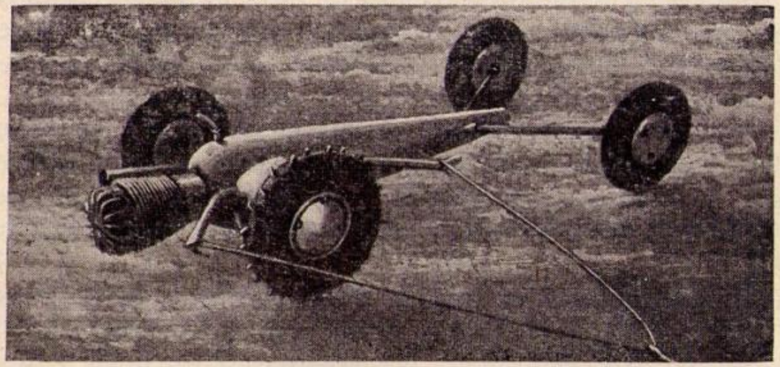


Fig. 115. Simplicity of design is the keynote of this Swedish car, the " Myran." It is powered by a 10 c.c. diesel, drive being on the front axle. *Photo : " Model Cars."*

country is Mr. Cruickshank, who uses direct drive without clutch. He starts by pushing with a walking-stick. A direct drive diesel unit can be seen in Fig. 38, Chapter II.

A CAR FROM STOCKHOLM

The most elementary car is surely that from Stockholm called the " Myran " (Fig. 115). It is powered by a 10-c.c. diesel engine of " fixed-head " design. The drive is through the front axle, which is an extension of the crankshaft. The crankcase is then extended rearwards in the form of a streamlined shell to carry two wire extensions which form the rear axle, as in the case of the American " McCoy " Teardrop light alloy cast car, which created an American record for petrol cars.

A DIESEL CAR WITH A MULTI-PERSONALITY

Recently I examined Mr. Curwen's clever diesel car, having an engine with a detachable head which permits it to be run as a petrol motor, a diesel, or a glow-plug engine. The power from the diesel set up has proved superior to the petrol combination. The car also runs very well as a glow-plug motor.

This car has since become quite famous in the model car world and has demonstrated the high speed potentialities of the diesel engine as applied to racing cars. The powers of a diesel for car racing were much doubted by some people in the early days of diesel development. The car was run at the 1948 *Model Engineer* Exhibition.

Besides its multi-personality as a diesel-cum-petrol, cum-glow-plug motor, the engine has a dual mission in life, for it also drives a racing hydroplane. The best speed to date has been 24 m.p.h. on the water. The best official speed on land for the car is 62 m.p.h. These figures are most impressive for a capacity of only 5 c.c.

The engine has a bore of $\frac{3}{4}$ in. and a stroke of $\frac{11}{16}$ in. There are two exhaust ports and four transfer ports. Admission of the gas is by rotary disc valve. The cylinder head is fitted with a contra-piston which gives a variable compression ratio. It also has a sparking plug or a glow-plug. A contact-breaker is fitted

which is used for starting from cold by spark ignition, for the engine has been found to be a difficult starter when cold, although perfectly normal when warm. The reason for this difficulty in starting from cold is the extremely high bore stroke

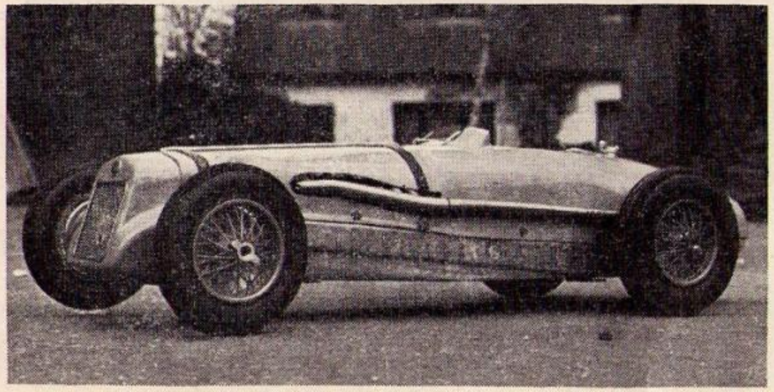


Fig. 116. A beautiful Delage diesel car by Mr. Baigent. The model is $13\frac{1}{2}$ in. long and powered by an "E.R.E." 2.48 c.c. diesel unit with two centrifugal clutches in the rear brake drums.

ratio which produces a combustion space in the cylinder head having a high ratio of area to volume, and therefore high heat losses. Starting is done by using an external power pack which consists of a 3 volt dry booster battery and coil. Connection to the car-type contact-breaker being quickly made by a telephone jack. This method makes starting dead easy from cold, and is not needed when warm. Mr. Curwen has always been noted for his quick and reliable starting. His methods in dealing with a racing diesel are therefore interesting and also unique. The performance as a diesel is : Peak, 0.405 b.h.p. at 11,500 r.p.m., falling to 0.33 b.h.p. at 14,000 r.p.m. Maximum r.p.m. is approximately 18,000. Glow-plug performance is particularly good. The above figures are obtained from Mr. Curwen's well-known test apparatus and are not " guesstimation " !

I am always intrigued when I visit Mr. Baigent, of 10 Beverly Gardens, Bournemouth, who has set up a small works to produce model racing cars of scale appearance which actually do work at high speeds. Baigent uses his clever but very simple E.R.E. 2.48 c.c. diesel-cum-back-axle-unit (see Fig. 38, in the second chapter), containing two centrifugal clutches installed in dummy rear brake drums. This unit drives Maseratis, "Bugs," Delages, and other exciting cars at speeds around 60 m.p.h. Many "full-sized" car enthusiasts get their favourite car modelled by Baigent and use it around the pole as a working model.

In Fig. 116 we see a model of the late Dick Seaman's Delage with perfect wire wheels and tyres, with full cockpit equipment including spoked steering wheel and driving mirror, whilst in Fig. 118, we see a "special" with tubular chassis and independent front suspension with rear leaf springing that works, powered by a 1 c.c. diesel offset and on its side to fit into the coachwork seen in the next illustration. A back axle reduction

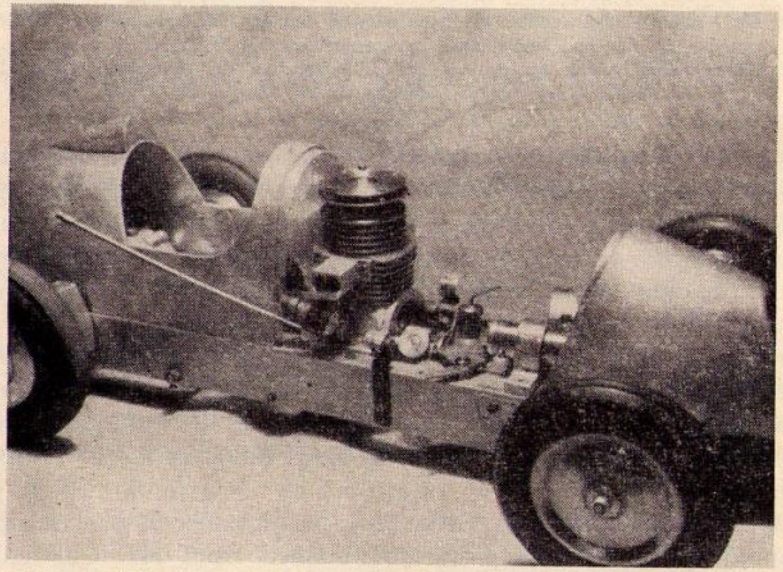


Fig. 117. Mr. Curwen's 5 c.c. diesel chassis. The engine is convertible to petrol or glow-plug by changing the cylinder head. The car has officially lapped at over 62 m.p.h. as a diesel, showing increased power over the petrol set-up.

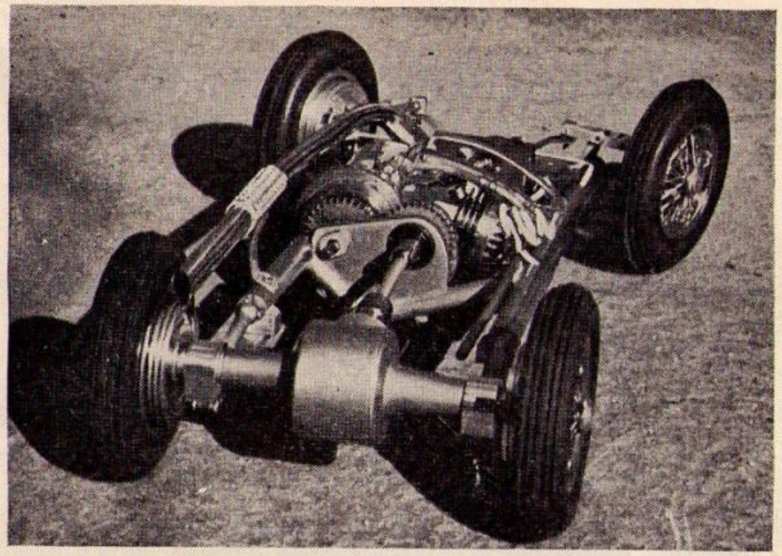


Fig. 118. This "special" Baigent chassis is $11\frac{3}{4}$ in. long and powered by a 1 c.c. diesel geared 2 to 1 in the back axle. The engine is offset on its side to suit the body. Independent front suspension is fitted with leaf springs at the rear.

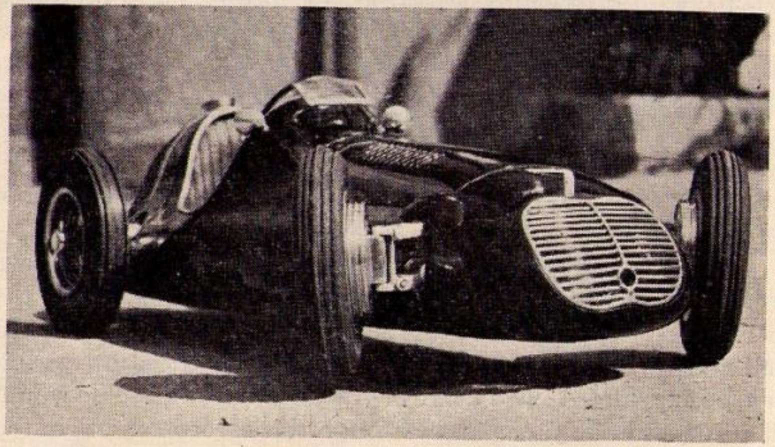


Fig. 118A. The "Special" seen in Fig. 118, has its realistic body in position. The exhaust "works."

gear is used on this model instead of the standard E.R.E. unit. The naked gearing seen in the centre of the chassis is merely to permit an offset engine and is 1 to 1. This car is a " runner " but is not meant for high speed racing as in the case of normal Baigent racers. It is 11¾ in. long.

PLANS AND KITS OF MODELS FOR DIESEL ENGINES

I hope that the foregoing descriptions of different sizes and types of model aircraft and boats will give the reader a very fair idea of the capabilities of diesel engines as we know them to-day. I also hope that the data given will inspire many people, trembling on the brink, to make the plunge into designing and constructing their own diesel craft. There is a great deal of fun, scheming and occupation to be obtained, not to mention the thrill of seeing the resulting models perform in the air or on the water. Experimental work can never be dull.

For those who like to start off with designs, either in kit form or plans, some of my models shown in this book have been produced either as kits or as plans. These can be obtained from B.M. Models, 43, Westover Road, Bournemouth. The boats " Sea Swallow," " Flying Fish " and " Swordfish " are obtainable in plan form. The " Flying Fish " is also produced in made-up hull form with suitable transmission, propeller and flywheel. The little " Meteorite " aeroplane for baby diesel engines, and the large model " Whitewings " are obtainable as kits or plans. The " Humming Bird " and the little 36 in. flying-boat " Wee-Sea-Bee " as plans. The control line model " Bullet " and the monocoque free flight " Satellite " are now available as plans or kits.

Since I wrote the first edition of this book in the early days of diesel development, a full range of excellent plans and kits to suit diesel engines has been placed on the market by all the well-known manufacturers, and suitable plans for construction have been published by the model press. A survey of these would fill a further book. A glance through the advertisements in the model journals will whet the appetite of all enthusiastic modellers or make enthusiasts of modellers !

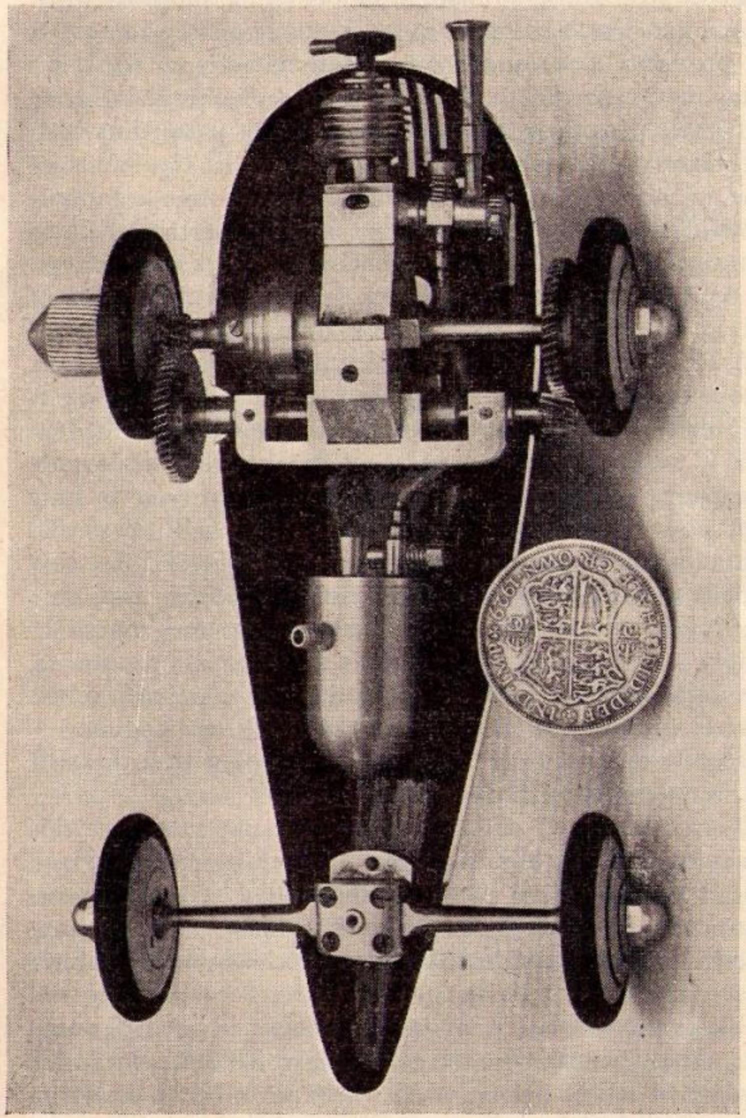


Fig. 119. Mr. Fjellstrom's car with cowling removed to show the mechanism. The engine, with a capacity of only 0.25 c.c. drives the front wheels through double helical reduction gearing.

RADIO CONTROL AND THE DIESEL

Radio control is the ultimate in model flying and boat work for most modellers, and now that it is not necessary to have a licence provided a permitted wavelength is adhered to, radio is gaining many adherents. The early commercial sets have gone through their period of development growing pains, in which the satisfactory ones have proved themselves in the hands of the user. The diesel (and glow-plug engine) forms a particularly useful motor for radio control models of the small to medium size. For instance, the new baby radio sets can be flown by the more powerful of the smaller diesels in little models of around 45 in. wingspan such as my little " Meteorite " and " Radio Brumas " shown in this chapter, or the larger sets can be operated with engines ranging from the powerful 3.5 c.c. " E.D." diesel to the selection of 5 c.c. diesels described in Chapter I. One would like to see some well-known engine manufacturer produce a 10 c.c. diesel as has been done in Italy with success, for the larger radio model which will always fly more convincingly than a small model. The diesel is so very convenient for radio work as it saves extra battery, coil, etc., weight for ignition, which added to radio batteries may mount up alarmingly when spark ignition motors are used. Furthermore, there is quite sufficient electrical equipment to cope with in the radio itself without the extra electrics of the petrol engine.

It is quite simple to get two-speed control with a diesel if desired, by a simple throttle control.

A short explanation of radio equipment may introduce this most exciting and ever alluring form of operating diesel engined models. I am convinced that once the reader has got successfully into radio control he will seldom operate any model without it ! The trouble has been, that there were too many early failures amongst enthusiastic modellers when using certain tricky and unreliable sets fitted into unsuitable models with overpowered engines. Many people gave the game up, which did harm to the good name of radio. None of this need now occur. Having tried every well-known radio set on the market, I now know the most suitable for my own requirements, which, like those of most

modellers who are not essentially radio fans, are :—(1) To tune the receiver quickly by one simple operation. (2) Rely upon flying or boating without further " fiddling " with the radio gear. (3) Knowing that the radio can not cause a crash through the old bugbear of a stuck on " relay " and therefore rudder control.

I now have six of my models rigged up for radio flying, and one speedboat, and hope shortly to be sailing my model yacht by radio. All my gear can now be relied upon to comply with the requirements stated above, with reasonable luck, but I have thrown away quite a lot of the early radio equipment in disgust !

THE USE OF RUDDER ONLY

Many modellers contemplating radio control for the first time imagine that the actual flying is merely a matter of turning the model by rudder from left to right, or making it climb or dive by giving the machine up or down elevator. I strongly advise the newcomer to start off with the rudder only, for even this will tax his flying control ingenuity, and he should remember it is possible to do up to loops with rudder control alone. The leading Americans, who started radio long before we did, have won their National contests for many years past with simple rudder control. Doubtless we are coming to the time when the " experts " use a greater number of controls, but how often does one yet see such a one flying with more than rudder and, perhaps, engine control. There is one proportional control that I know is working satisfactorily. Model radio has so far been in sequence of controls, and not selective, by which I mean that left rudder is followed by centralise and then right, and one must go quickly through right if further left is desired. Proportional control means that half left or right rudder can be given, followed by full rudder, or full rudder skipped rapidly through. It is quite hard enough to remember which rudder you gave last time when an emergency occurs and the model is flying away from you in the far distance, without getting mixed up with going through elevator controls to get at opposite rudder. My advice to the newcomer is to " take it easy " and start off with rudder, being sure that you arrange your rudder *so that it holds on whilst you hold the signal button down, and automatically returns to neutral when you release.* Any other system will cause a crash if the next signal does not arrive, as I will explain in the next paragraphs.

A STUCK ON RUDDER CAN CAUSE A SERIOUS CRASH

Modellers who have not tried radio forget that a full-size aeroplane and model, however automatically stable, will increase its bank, eventually getting into a spiral dive of increasing intensity, if the rudder is kept hard over for more than a short time. Should the radio stick on, due to the relay failing to " come off " the rudder will remain hard over and the model will increase its bank until it is eventually on its side in the air. The nose will drop because the rudder now becomes an elevator in the *down* position. A crash usually results. *Therefore we must not keep turning too long and we must not have a radio set that is prone to " stick on."* This has been the besetting sin of fliers and radio sets in the early days, and caused many a stable model to end up as matchwood, to the amazement of its owner who had flown it free-flight without damage. It also means a well designed model and a perfectly reliable radio set. One well-known model writer maintained that almost any model could be fitted with radio and fly well. I could not disagree with any man more, and most of the leading American radio men support my view that a radio model must be stable, so that when you have got it into an odd position in the air through your playing with controls, if you centralise your rudder, the model will *quickly* iron out its unstable attitude by rapid recovery of its own. Except for stunt work a pylon model is not suitable, for the thrust line is too low in relation to the centre of lift and drag. This gives great variations of trim as the model is turned from left to right. The best set up is either a high wing with engine mounted so that the thrust line is not far below the wing, or a low wing with plenty of dihedral. It is very easy to zoom a radio model all over the sky and call it stunting, but very hard to fly one with real precision around a course and then do a

spot landing. In my opinion the latter type of radio flying should be encouraged.

In short notes such as these it is obviously not possible to go into the movements of flying or the radio itself in detail, but I hope I can give the newcomer some fundamental facts that will save him a lot of wasted money and much disappointment.

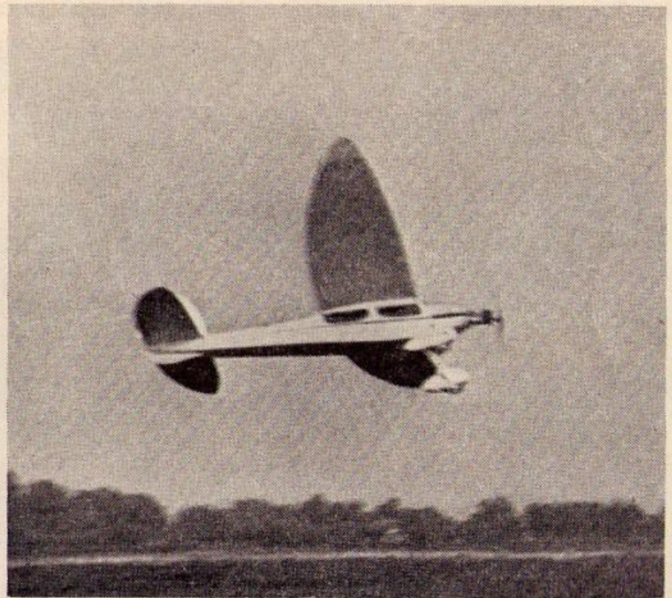


Fig. 120. The author's " Whitewings " is turning to the left under radio control. The nose is held up by area low down due to spats and filled in undercarriage legs, which act as forward keel.

FLYING THE MODEL

For example, if we start turning the model to the left, bank will automatically increase as the turn is persisted in, for there is no pilot to hold off bank by opposite aileron or to give some elevator in a tight turn. The model will begin to lose height rapidly with nose down, so in good time we take off our signal, for it takes time for the model's nose to come up with its increased speed as the machine straightens out. As soon as its nose is up after the resulting shallow dive we can give a very quick flick to the right rudder because it will be remembered that earlier I explained we have to go through controls in sequence. We can now restart our left turn if we want to bring the model right round, and we can turn in these " instalments " remembering *that the engine torque reaction will always assist a left turn and resist a right turn*, and that on the glide we turn without torque. We therefore have given our motor a right offset to

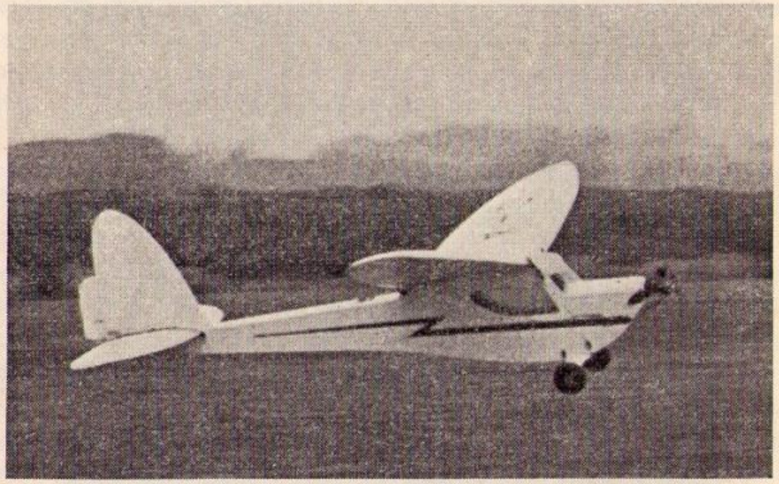


Fig. 121. The author's large radio model " Poole Puffin " with deep underbelly for stable turns, is here seen ruddering into wind after take-off, by a series of short sharp movements of the control button

make it eliminate torque effect as much as possible and give as straight flight as possible under power with rudder centralised. We have also made certain that the engine is not too powerful for the model and that a little " down thrust " is built in to prevent stalling under power as the model is turned from left to right. Far too many newcomers to radio fit an engine of too great power and find themselves all over the sky more out of control than in it! They forget that *in a free flight model they may have prevented undue climb and stalling under power by making an overpowered model hold its nose down by turning in circles.* Others

who have very powerful motors try to control this by fitting a rudder with very minute movement for radio. This does not work out in practice, for such a rudder control will turn the model well to the left without losing much height, but if there is a cross wind when trying to turn to the right against torque the model will merely fly straight ahead out of the ken of the operator.

On the other hand a reasonably powerful motor is required

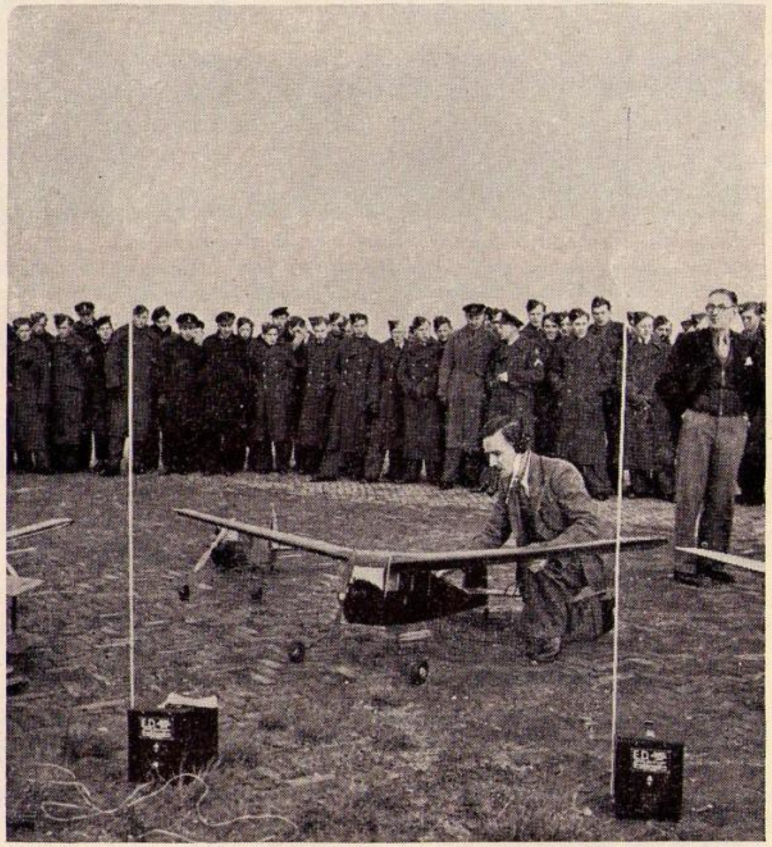


Fig. 122. Mr. Honnest-Redlich, the designer of the E.D. " modulated " radio set, tunes in his receiver before giving a demonstration of radio flying to the Dutch Forces.

to gain height after turns. I can not stress too strongly that a correctly powered engine is required with the right amount of offset and down thrust, and with the thrust line passing not far below the centre of lift and drag of the wing.

From what has been said, it will be evident that it is dangerous to turn for more than a short way just after take-off, for if a mistake is made and too much height lost with a subsequent dive at speed on the turn, the model may not have time to recover before it hits the deck in that most devestating of all manoeuvres, a cart wheel crash. Therefore, keep the turns very short and sweet until height is gained. (Fig. 121, to remind the reader.) The reader will also probably realise that if he wants to lose height when the model is climbing too fast he merely spirals down in a tight turn, but the wings must be robust and very well fixed, for there are big stresses in this manoeuvre, as the model comes out with a mighty zoom, which can be checked

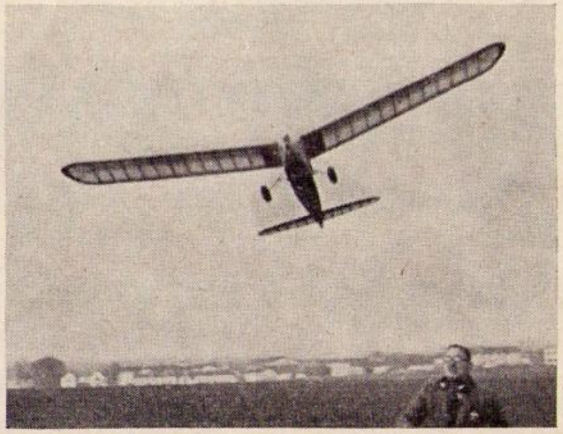


Fig. 123. Colonel Taplin, a well-known radio flyer, sends off his "Radio Queen" for an impressive demonstration flight at Manston aerodrome. The engine is an E.D. diesel and the receiver a "modulated" three valve E.D.

by flicking it over for a very short turn of rudder as the zoom is half completed. If great speed has been gained, it is possible to loop the model if it is left to recover on its own. This is

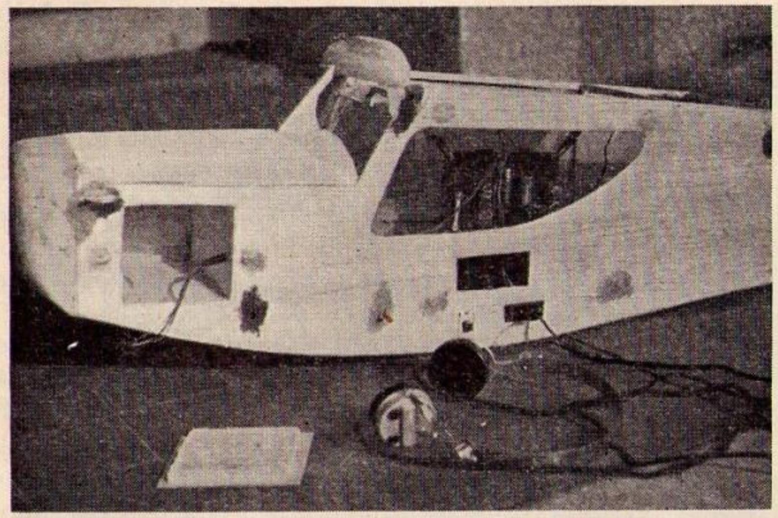


Fig. 124. The author's layout has a forward battery compartment with receiver and servo behind. The receiver is held in position by rubber bands to four cross members in the fuselage. The white tuning arm on the receiver is reached by forefinger through opening in fuselage side. Below are mainswitch and tuning socket for headphones, or meter.

how we stunt when desired. It is best to use an overpowered machine with clipped wings for stunting.

STABILITY FEATURES

For quiet normal flying, a deep bellied fuselage or an undercarriage with legs well filled in to form area low down forward like the keel of a boat, will help to hold up the nose on turns. It will be observed that most of my radio models shown in this book, have a deep belly. Where this is not done, I provide the desirable keel area, as seen in my more normal looking "Whitewings," by fitting large wheels or spats allied to longer filled in undercarriage legs. These two methods can be seen in Fig. 120 which shows my "Whitewings" being turned nose up under radio, whilst Fig. 121 shows my large "Poole Puffin" which sports a large underbelly reminiscent of a bird with a belly full of fish. The well-known American radio modeller, Dick Schumaker, admits that he has fitted under fins to the belly of some of his leaner looking models to gain this desirable holding up the nose on turns.

THE NORMAL COMMERCIAL RADIO SET TODAY

Most radio sets have a similar general set up. This takes the form of a transmitter on the ground with a high tension and low tension "wireless" battery bought at any radio shop. The L.T. is sometimes in the form of an accumulator of two volts, which can be trickle charged, as in the case of the "E.D." set. A receiver and servo motor with their batteries are installed in the model. The receiver detects the signal, and switches on and off the servo motor by the aid of a "relay." The servo motor operates the rudder or other controls and has a clockwork motor or twisted rubber motor to do this. The receiver has H.T. and L.T. dry batteries, of the deaf aid type or flash lamp, and the servo motor has a flash lamp battery. Some call the servo motor an actuator. See Figs. 124, 125, 126 and 127, which explain pictorially the general set up.

THE TWO MOST USUAL PRINCIPLES UPON WHICH SETS WORK

(1) The first principle of "dipping" the current is used by several of the older sets and many of the modern baby sets using the new mini-valve. With radio switched on, but receiving no signal, a "standing current" is registered in the valve of the receiver, and the "relay" arm is therefore attracted down or "in." This "in" position switches off the servo motor's battery. The servo is therefore not operating the rudder or other control, i.e., the "relay" contact points positioned at the other end of the relay arm are *open*. The arm is pivoted at its centre. On receipt of a signal from the transmitter the current in the receiver valve is reduced or "dipped." This current drop can be read by a plugged in meter, The "dip" at best is very small, being measured in milliamps (one-thousandth of an amp.).

As the current is reduced or "dipped" the attraction to the relay arm dies and the arm is released, thus closing the points

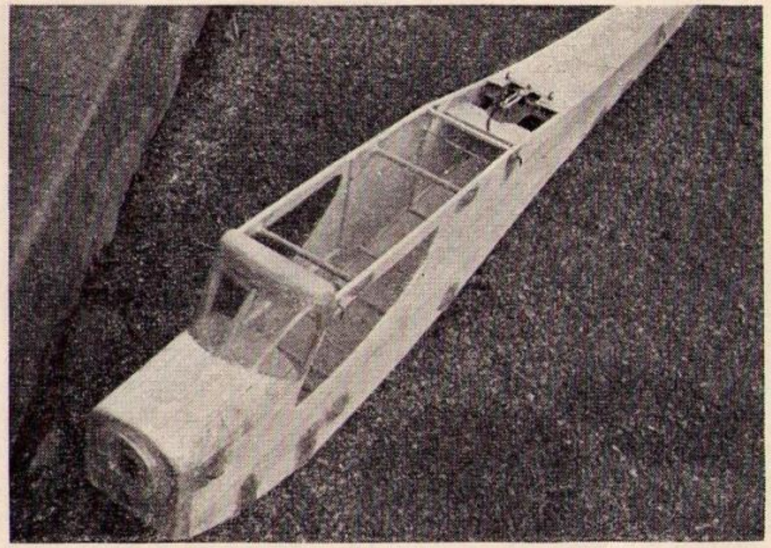


Fig. 125. The fuselage under construction shows the four cross dowels upon which the receiver is slung. Servo is behind the wing platform

at the other end by spring tension. This closing of the points makes a circuit for the servo battery which switches on the servo, which in turn pulls over the rudder. To operate against air or water pressure, the servo finds power in a clockwork spring or a twisted rubber motor.

The relay is therefore released as long as the signal is on and the current dipped. As soon as the signal is stopped the full standing current again passes through the valve, and down goes the relay arm, thus opening the points which switch off the servo. There are various variations of this theme, but that is the main principle.

It will be realised that with this system, *if the battery voltage drops, the current may be insufficient to open the points by attracting the arm down again*, in which case the rudder will stick on hard over and the disastrous spiral nose dive will most likely end the model's days. This is the weakness of the principle, and precautions must be taken, by fitting a good relay and keeping

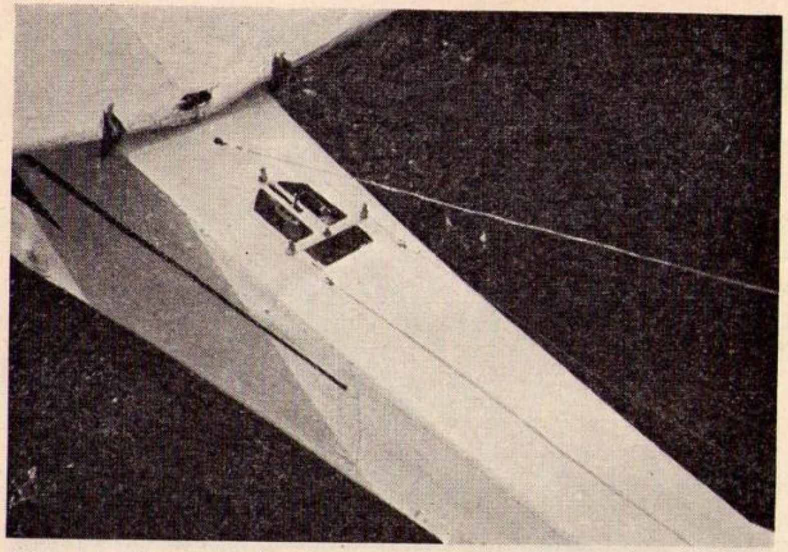


Fig. 126. The servo is as near the centre of gravity as possible with fishing lines to rudder. Wires would upset the reception. The aerial is led to the fin tip and attached by a rubber band to a wire hook.

battery voltage up, and also signals from the transmitter powerful. This system is cheap to construct and the wiring very simple. The latest mini-valve made by Hivac which is a gas filled " thyratron " valve has a lower battery consumption and a larger " dip " than its larger predecessors of the early days, which, together with good manufacturing methods of relay and care by the user that his transmitter is well up to scratch, and the batteries in the model are " up," all help to obtain reliable operation. Unfortunately all these points were not obtained in many of the early " dipping " sets, which gave the radio control game a bad name for crashes of valuable models due to sticking on controls. It must, however, be clearly recognised that the " dipping " principle, however carefully looked after, can never be quite as " safe " as the principle described below. However, owing to its light weight with the new mini-valve and its lower battery consumption and therefore smaller batteries, the " dipping " principle is very suitable for small models,

or boats where an occasional on control does not spell trouble.

(2) *The second principle of " rising current "* :—as used by the well tried three valve " E.D." receiver with its special transmitter giving off a " carrier," works on an exactly opposite system. On receipt of the signal the current in the receiver is raised instead of being dipped. This principle has various undeniable advantages which preclude danger of stuck on relay and therefore rudder, but it costs a little more to produce and works out a trifle heavier as regards receiver weight. For instance, the E.C.C. and the E.D. firms make baby and cheaper but very good " dipping " sets which all up weigh approx. $7\frac{1}{2}$ oz. These suit the baby model admirably. The three valve receiver and batteries weigh just over double this load. In the future this will doubtless be reduced when the mini-valves and their smaller batteries are ultimately employed for the three valve " raised current " system. This safer system should then be sufficiently light for even the baby models, although it will still doubtless cost more. From much personal experience of all the past sets of all makes I have come to use the three valve " rising current " set in all my models over 5 ft. wing span. Naturally, I use the little " dipper " for my baby models around 45 in. span for weight considerations.

This three valve " rising current " " E.D." set gives utter simplicity of tuning, virtual immunity from stuck on controls, and a very outstanding range due to the three valves, etc. Range is very desirable, and was very poor on the early " dipping " sets. With the " E.D." " raised current " set one can fly the model in range as far as, and farther, than it can be seen at ground level. Range at height is always even greater. With this principle the worst that can happen is a flyaway under normal centralised rudder stable free flight conditions, should batteries drop or a signal fail to be received.

Let us follow through the operating sequence. A high frequency " carrier " is permanently radiating from the transmitter as long as it is switched on. (Incidentally, this means that such a transmitter *can not* operate a " dipping " receiver. For their little " dipping " receiver the E.D. firm provided the

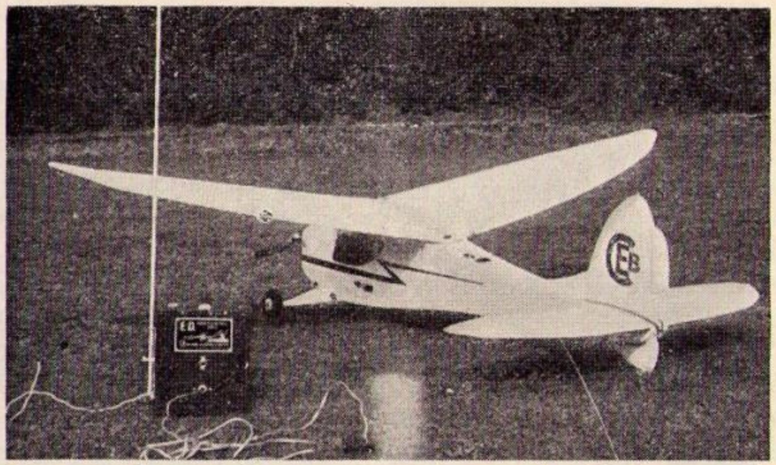


Fig. 127. The complete set up can be seen in this photograph. The rudder tab is attached to the fin by fabric hinges like the elevator of a control line model.

first powerful commercial 4 watt transmitter which makes for reliability. In the past the "dipping" sets suffered from low power of approximately 1 watt in Britain, whereas the Americans all used about 4 watts.) E.C.C. now use high input.

With the "rising current" principle the "carrier" is "modulated" on the transmitting of a signal. This modulation can be heard through headphones plugged temporarily into the model for tuning. In fact this is the only tuning necessary. The operator slightly moves a small tuning arm (which can be seen in Fig. 124) until he hears the loudest note in his phones, whilst an assistant holds on a signal by press button. The set is then ready for operation. It is as simple as that! It is, therefore, suitable for a beginner or someone who enjoys flying rather than radio adjustment. A small boy can tune this set.

This modulation of "carrier" allows a greater current to pass through the valves. *The increased current operates the relay.* Our old friend the "standing current" is kept low before signal to approximately only ½ Ma (milliamp). This is done by the holding down of the current by a 6-volt grid-bias battery, which has no drain upon it other than loss of energy through

old age. The grid-bias therefore need not often be changed, but it is a very important battery, and must be up to its six volts. The "relay" is set at the works to click in at 2 mA. *This setting should never be touched by the owner*, a very good feature for the beginner. As the signal comes in and the current rises, it goes up to between 3.4 and 4 mA, and on its way it passes the point of 2 mA at which the relay operates the servo motor, and so the rudder.

It will be noted that there is a very wide tolerance in this principle, should the batteries drop in voltage or the receiver be a bit off tune. The only possible danger of a sticking on relay could occur if the grid-bias battery (*which has no drain*) becomes low due to neglect, when the "standing current" will obviously rise too high and perhaps pass the magic 2 mA at which the relay clicks in. But this could only happen through gross carelessness, and need not be considered seriously, provided the operator understands the principle. For instance, if he were to fit a 4-volt battery in error this would not hold down the standing current sufficiently low. It is the only system, where I definitely know that if my model spirals in, it is due to my own fault of operation or design of the model.

Perhaps I should mention here that in all types of sets, whatever principle is used, residual magnetism can form at the relay and hold it on, causing a stuck on control. This often happened on some of the earlier sets, but today modern manufacturing methods of tinning the relay arm and using suitable materials, should have eliminated this defect, when a set is bought from a reputable manufacturer. We can therefore dismiss the trouble. Naturally a "dud" relay will cause a stick on.

Purely as a matter of interest, and not of necessity, it is possible to watch the "E.D." three valve receiver in action by plugging in a milliampmeter to the headphones socket (normal tuning can be done entirely by headphones) when the alteration of current can be observed as follows.

(a) With transmitter switched off, the meter will show approximately 1 mA "idling current."

(b) With transmitter switched on but no signal sending, the "standing current" will read approximately $\frac{1}{2}$ mA.

(c) As signal is sent from transmitter, the meter will show the current rise up to 3.5 to 4 mA. On the way, as this passes the point at 2 mA, the relay will be heard to click in and the servo seen to operate.