Diesel Model Engines

G. E. Bowden

Marshall

The starting procedure on page 110 (3) caused me problems when starting my first engine, an E. D. Bee diesel because it told you to increase the compression for starting and then reduce it when running, the exact opposite of what was required (should have read the instructions that came with the engine as the book states). The book does mention rare exceptions on page 112. However all six of the diesel engines I eventually owned* turned out to be "rare exceptions" and required the compression to be reduced for starting. Possibly this was because when the book was written most of the engines available were long stroke, i.e. stroke longer than the bore while all the engines I had were short stroke where the bore and stroke dimensions were similar.

*E. D. Bee, Allbon Dart, Allbon Javelin, Allbon Merlin, Allen Mercury 10 and Allen Mercury 25.

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D. Sharp

Denis Sharp, Hailsham, East Sussex.

DIESEL MODEL ENGINES

DIESEL
MODEL ENGINES

By

LT.-COL. C. E. BOWDEN, A.I.MECH.E.

By the same author
" Petrol Engined Model Aircraft "
" Model Jet Reaction Engines "
" Model Yacht Construction and Sailing "
" Model Glow Plug Engines "

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FOREWORD

When I wrote the first edition of this book the model diesel was in its infancy. The speed at which the book sold has been an indication of the very great interest in the diesel engine. Diesels are seen on every flying field and at every pond. During the past few years the diesel has made great technical strides in development in Britain, becoming the most popular type of power unit for model aeroplanes and boats, whilst the car enthusiasts are now embracing the type.

Low cost and low weight, allied to the lack of complication, has been the secret of the diesel's rapid success, and brought power modelling within the range of vast numbers who held back before its advent.

In America the growth of the diesel has been far less spectacular, for American modellers seem to favour very high r.p.m. and often large cubic capacity. As a result the existing petrol motor has developed along the lines of the glow plug engine which, like the diesel, eliminates the necessity of carrying weighty ignition gear out of all proportion to the weight of the motor. The glow plug engine thrives on high r.p.m., whereas the diesel, generally speaking, develops its power at slightly lower speeds with good torque characteristics. A very great advance in power output was made during the year 1949, as the result of control line flying influence and demands. Radio controlled models are now encouraging the larger capacity diesel.

This book is designed to put the newcomer to power modelling into the picture of the diesel. It explains how it works and the snags that many people may experience; and I hope will iron out any difficulties of starting, fuel, and operation, besides giving a survey of suitable models for diesel engines. Modern diesel engines are also reviewed.

I want to thank the following publications for kindly permitting me to use certain material—The *Aeromodeller*, *Model Aircraft*, *Model Cars*, *The Model Car News*, *The Model Engineer*, *Practical Mechanics*.

Bournemouth, 1951. C. E. BOWDEN.

CHAPTER I

HOW THE MODEL DIESEL WORKS, ITS DESIGN AND INSTALLATION

THE INTERNAL COMBUSTION ENGINE AND THE DIESEL

THERE is a good deal of misconception concerning the model diesel engine. For instance, many people ask how the injector mechanism operates, although in fact there is no such mechanism fitted to a normal model diesel.

It is therefore not out of place, bearing in mind that this book is written to help the complete novice as well as the more knowledgeable man, to describe at the outset the model diesel in elementary terms.

The model diesel as we know it at the time of writing this book is a development of an offshoot from the two-stroke model petrol engine, which, of course, is an " internal combustion " engine, i.e. it derives its power from a series of expansions of gas. The gas is created from liquid fuel which is atomised and mixed with air in the " carburettor." The expansions of gas are usually termed " explosions " by the general public. It is as well to explain that the word diesel is not strictly correct. It is the popular term for a " compression ignition engine," or " C.I. engine." A Dr. Diesel originally developed the C.I. engine, hence the well-known term " Diesel engine," which is now universally used in the same way that " propeller " is universally used to describe a tractor airscrew. These terms are so universal that they are used in official Service textbooks. Let us therefore call it the diesel engine in this handbook. The name is simple, and it suits everyone except the pedant.

To return to our expansion of gases or explosions in the internal combustion engine; the model internal combustion engine, like its full-sized prototype, can be a " four-stroke " or a " two-stroke." A four-stroke usually has poppet valves and fires on every fourth stroke of the piston. There are very few commercial four-stroke engines at present for model work. The two-stroke is almost universally sold for this purpose, because of its simplicity of construction. The normal two-stroke eliminates mechanically-operated valve gear (except in certain very advanced designs of full-sized engines) and it fires once every revolution of the crankshaft, i.e. each time the engine turns one complete revolution, or every second stroke of the piston.

IGNITING THE GASES

The petrol two-stroke engine fires its charge of gas by an electrical spark produced by means of a sparking plug when the piston is at the top of its stroke and has compressed the gas that it has sucked in.

The model diesel, at present, may be loosely likened to a petrol engine two-stroke without the electrical spark gear. It also fires the charge of gas when the piston is at the top of its stroke and has compressed the gas, as in the case of the petrol engine. Now, why does it do this when there is no sparking plug and no spark?

That is the crux of the whole matter.

The model petrol engine compresses its charge of gas to approximately one-fifth or one-sixth its original volume. The gas is compressed into a small space in the cylinder head as the piston comes up to the top of its stroke. This gas is then ready to " explode " *if it is ignited.* The electrical spark from the sparking plug produces this ignition and explosion follows. The piston is then driven down and the engine turns round. This action is shown in Fig. 1 and Fig. 2.

The model diesel engine compresses its gas in the same manner, but to approximately one-sixteenth the original volume, when the piston arrives at the top of its stroke. This top of the stroke is called " Top dead centre," abbreviated to T.D.C.

Now you well know that if you rapidly pump up your bicycle tyre, the quick compression of the air makes the bicycle valve and the bottom of the pump hot. This is because the air itself becomes hot due to the rapid compression and friction of

the particles of the air. The diesel compresses the air it draws in even more rapidly, and at a greater pressure. In fact, it becomes so hot that if there is a suitable fuel mixed with the air it " explodes " from the heat *without a spark.*

In the full-sized diesel, pure air only is compressed by the piston and, as the piston arrives at the top of its stroke, a small carefully metered amount of diesel fuel oil is shot through a very tiny nozzle into the very hot compressed air. This forms a

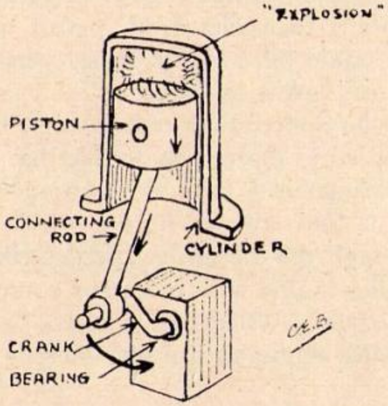


Fig. 1. The first principles of the internal combustion engine.

gas and explodes. The fuel injector gear to shoot the fuel into the cylinder against great pressure is complicated and expensive to produce, and far too heavy for a model; in addition, the amount of fuel to be injected in a model engine is so small that few craftsmen could make so small a pump. To overcome this, some clever individuals on the Continent thought of the idea of increasing the ignitability point of diesel oil and other fuels by adding ether to them. The model engine then sucked in its charge of air together *with the fuel containing ether*, and when the piston compressed this air and fuel mixture at its very high " compression ratio " of 16 to 1, the mixture became so hot as it arrived at the top of the stroke (T.D.C.) that it " exploded " *without any spark.*

It would obviously not be an economical practice for a full-sized diesel to burn ether because of the expense. But the model uses very little, and the cost does not enter the picture. However, it is interesting to note that in Czechoslovakia there is a little diesel scooter that runs on an ether mixture.

I need not explain that the compression must be exactly right to get the mixture at the correct temperature to suit the "flashpoint" of the fuel used. "Flashpoint" means the point at which a fuel ignites spontaneously, and ether ignites at a very much lower point than diesel oil, petrol, paraffin and other distillations of crude oil. Hence it has what is called a "low flash point," and "great ignitability."

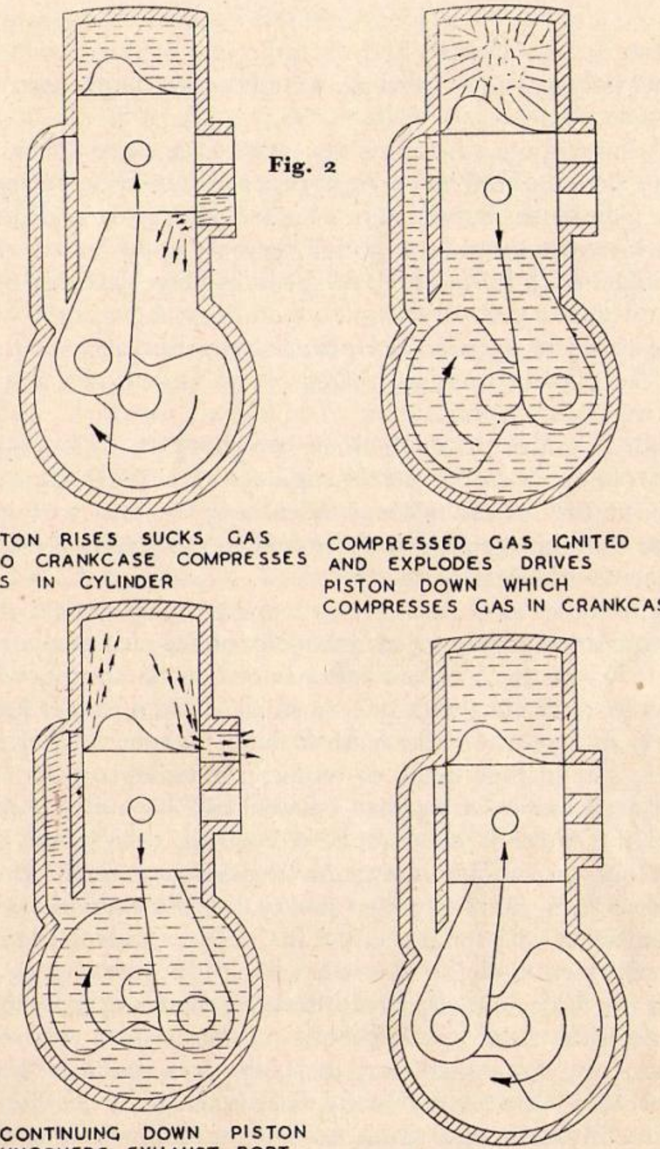
It will also be appreciated at once that if the compression ratio is to be raised to more than double that of a petrol engine, i.e. from approximately 6 to 1 to 16 to 1, there will be vastly increased strains and stresses in the whole engine structure, therefore, although the diesel may be described as similar to a petrol two-stroke engine with increased compression, it *must be more robustly designed.* When I give 16 to 1 as the ratio, this is only approximate, as diesels fire on different ratios from about 12 to 20 to 1.

ADVANTAGES OF THE DIESEL

What advantage do we get from using a diesel instead of a petrol engine, because we know that we have the considerable disadvantage of these higher stresses and strains due to the very much higher compression ratio?

There is the elimination of all the trouble of electrical ignition gear and therefore of producing an ignition coil, a condenser, make and break gear, and sparking plug; and the trouble of wiring; cleaning and adjusting of the gear, etc., goes by the board. There is the saving of the weight of this gear, which in the case of the really midget petrol engine means a great deal, because the weight of the ignition gear on a petrol engine cannot be reduced below a certain minimum figure that is entirely out of proportion to the weight of the engine in the very minute sizes. The larger petrol engine scores in this

Fig. 2



PISTON RISES SUCKS GAS INTO CRANKCASE COMPRESSES GAS IN CYLINDER

COMPRESSED GAS IGNITED AND EXPLODES DRIVES PISTON DOWN WHICH COMPRESSES GAS IN CRANKCASE

CONTINUING DOWN PISTON UNCOVERS EXHAUST PORT RELEASES BURNT GAS TRANSFER PORT OPENS CRANKCASE GAS RUSHES INTO CYLINDER

PISTON RISES COMPRESSES GAS AND RESTARTS CYCLE OF OPERATIONS

N.B. THE DEFLECTOR HUMP ON TOP OF THE PISTON IS NOT USUALLY FITTED TO MODEL DIESELS respect, and has the power to fly the weight of the ignition gear without being troubled by it. In the case of the speedboat, the lesser weight allows planing to take place more easily with a smaller hull.

Admittedly the diesel must weigh a little more than a similar petrol engine of the same c.c. in order to stand those stresses we have mentioned, but it is not as much as the lost ignition gear. This loss of ignition gear weight is most important in the case of midget engines, and it allows us to produce perfectly practical and reliable diesel engines of 1 oz. all up, including fuel ready to operate! A reliable and practical electrical gear at the very best for a similar engine weighs many ounces over and above the engine's weight.

For instance, the engine may weigh 1½ oz. The coil 1½ to 2 oz. (as much as the whole engine). The flight accumulator 2 oz. at the lowest. The condenser ¼ oz. and wiring ½ oz. These ignition weights are the same for a large 10-c.c. petrol engine or a midget of 1½ c.c.

The diesel also enables us to operate our models with far less equipment to be carried in the field, on the race-track or on the pond. There are no spare batteries or booster starting accumulators to cart about with one—a small bottle of diesel fuel is all that is required, together with a small spanner to change propellers should they break or require tightening on the shaft.

I need hardly stress that a model can be built much more quickly if there is no complicated wiring of ignition gear to carry out with its booster plugs and electrical time switch and so on. This simplicity also makes the diesel model a better beginners' model for boys, and it therefore widens the field of power-driven models. But it has its snags; particularly is this so in the larger diesels, which have to be swung over the high compression we have talked about in order to start. It is a simple matter for even a small boy to bump over the little diesels to start them. One further very great advantage of the diesel is its use for flying-boats, seaplanes and speedboats—there is no electrical gear, which usually gives endless trouble when faced with damp and water.

THE EXTRA POWER OF A DIESEL

The diesel has more power per c.c. than the petrol engine. This is a well-known statement made by a number of people who write about diesels. The question that one does not see answered is, how much more power?

I recently carried out a little experiment with a model engine manufacturing friend in order to obtain a good practical comparative test. We rigged up a static test machine on a ball-bearing slide rail, mounted on a base secured to the bench. We used a slide rail mounted on ball bearings to eliminate friction as far as possible in order to secure readings that would be sufficiently accurate to draw worthwhile comparisons. To one end of the slide rail we attached one hook of a spring balance. The other hook of the spring balance was attached to the rail guide on the bench. At the opposite end of the slide rail we had an engine mounting fixed, so that a running engine could pull the slide rail along its guide and extend the spring balance. It was therefore possible to take readings of thrust in ounces.

One realises that static thrust does not show the full thrust that an engine is capable of, when the propeller is screwing its way through the air, because a static engine has the blades of the propeller largely stalled, but if the best possible propeller to suit each different engine is fitted, useful comparisons can be made between different types of engines.

We first fitted a well-known example of a 4.5 c.c. petrol engine that could be called a very sound example of power producer of that particular cubic capacity. This engine gave us two pounds of static thrust on our test apparatus. A 2 c.c. diesel, also a good example of its size and type, was next fitted. The diesel gave nearly 1¾ lb. of thrust. Both engines gave their best thrust with 11 in. diameter propellers.

This test showed (*a*) that the diesel of less than half the c.c. of the petrol engine would swing a similar size prop to the petrol engine. An important point to remember when fitting propellers to diesels, because their torque is greater at slightly lower r.p.m.—and not, as is frequently stated, at very high r.p.m. The same applies to the full-sized engine.

(*b*) That although the diesel was of less than half the c.c. of the petrol engine the thrust was not far off that of the petrol engine, thus giving a very good indication of the extra power produced by a diesel engine of any given c.c. in comparison with that of a petrol engine. The petrol engine makes more noise, which impresses many people.

The above facts, of course, are borne out in practical flying models. For instance, we may say that a 2 c.c. diesel will fly a 5 ft. 6 in. span model with the same vigour as a 3.5 c.c. to 4.5 c.c. petrol engine. This is even more marked in the case of the very minute engines. A 0.7 c.c. diesel will, for instance, fly a model that at least a 1.75 c.c. petrol engine is required to fly. The diesel gains in the smaller weight of power unit that the model has to fly, because of the lack of electrical ignition gear. Exactly the same applies to boats and cars of the small type. The efficiency of the diesel is bound up in a suitable propeller or gear ratio, as we shall see later in this book.

Further useful comparison is gained by tests I made using a hard-chined planing speedboat hull which I originally designed for 4.5 c.c. petrol engines. After a few minor alterations to the propeller I found that a 2 c.c. diesel would plane this hull almost as fast as the 4.5 c.c. petrol engine, of over double its capacity.

A large elliptical-winged model aeroplane that I have will fly well, powered by 4.5 c.c. petrol engines of various makes, but will not normally rise off the ground unassisted by push. When fitted with a 3.5 c.c. diesel with suitable propeller, this model takes off easily without assistance. The subsequent climb in the air is more rapid than with the 4.5 c.c. petrol engines.

Practical comparative tests like these give a far more accurate picture than records of r.p.m. and h.p. so often quoted. The proof of the pudding is undoubtedly always in the eating. Mr. Curwen's diesel car described in the final chapter bears out these tests, in another field.

Some people claim that the diesel is immensely more powerful than the petrol engine of similar capacity, others openly doubt if it is any more powerful. Neither of these extreme views is correct. Those who decry the power of the diesel have either not tested a good example, or have tested it with an incorrect propeller, poor transmission, inefficient model, or they habitually run the engine on too high a compression.

When reading of static thrust results, and similar performance data, including design details, it is as well to remember that manufacturers and amateur constructors are always making progress, which has already improved upon the results mentioned.

The diesel has a characteristic graph curve ; that is, the steep rise to maximum output, followed by an equally steep drop. The curves of the larger sizes of engines are generally steeper than those obtained from the small diesels of 1 c.c. to 2 c.c. A marked point is that the maximum B.H.P. usually lies at a lower reading with the larger diesels.

PROPELLERS FOR DIESELS

It is very important to realise that the diesel likes, and in fact requires, a larger diameter and blade area propeller than the petrol motor. It is a good point, I find in practice, to keep the diesel propeller of large diameter with a *low pitch*.

Before I leave our static thrust test apparatus, it is of interest to record that my friend and I put on six 1½-oz. diesel motors of only 0.7 c.c. All these six motors produced a static thrust very near each other in the neighbourhood of 8½ oz. Some produced this thrust at higher r.p.m. with a smaller propeller of slightly greater pitch, the diameter being 7 in., whilst others used 8 in. diameter propellers of larger blade area and a finer pitch and lower r.p.m. We favoured the larger propeller at lower r.p.m. because it gave easier starting due to its flywheel effect during the operation of swinging the propeller.

A very important point that should always be remembered in connection with model diesels is that due to the higher compression to be overcome, a propeller of heavy wood or plastic material is most desirable. Laminated wood is perhaps one of the best wooden types. The new plastic “ unbreakable ” props are excellent.

This feature helps the starting and running of a diesel, because the weight gives a good flywheel effect to overcome the high compression. It is also, of course, most important to fit a properly balanced propeller. See Chapter V for suitable propeller sizes and shapes. Many people actually do run their diesels with lightweight petrol propellers. The fact remains that starting and running is improved if a heavier propeller is used on aircraft and a heavy flywheel in boats or cars. One well-known modeller drills holes in his diesel propeller blades and fills these holes with little rounds of lead !

THE DIESEL'S PISTON

A normal two-stroke petrol engine usually has a deflector hump on the top of the piston to deflect the flow of gas from the transfer port up to the cylinder-head, whilst the exhaust gases escape through the exhaust port (see Fig. 2); on the other hand, most model diesel engines fit a plain flat-top piston which compresses or squeezes the gas up against the cylinder head or contra-piston. A flat top piston is fitted because of the difficulty of making a humped piston with the very small space available in order to obtain the high compression ratio required. This difficulty has been overcome in the "Morin" French engine in a rather novel manner. In this case a humped deflector piston head is used and it fits into a specially-shaped head (see Fig. 11).

The flat-topped piston works quite satisfactorily on model diesels, and is normal practice. Fig. 5 shows the flat-topped piston of a normal engine. The transfer port should not directly face the exhaust port.

The contra-piston and its function is explained a little farther on under the heading "The Contra-Piston," see also Fig. 3.

Pistons on small model diesel engines are normally plain and without any piston rings. They have to be an absolutely perfect fit with no appreciable tolerances. Many people talk gaily about the tolerances between piston and cylinder walls—the fact is they do not exist for practical purposes if the engine is to be of any real use !

It has been found recently that diesel engine pistons without any oil grooves cut in them are usually superior to those with grooves.

A rather staggering fact that may interest the slide-rule enthusiasts is that due to the short stroke of a midget motor of about 1 c.c. the piston travels only at the very slow *average* speed of $6\frac{1}{2}$ m.p.h. at 7,000 r.p.m. The wear of these miniatures should therefore not be as great as a full-sized car engine with its very much higher piston speed.

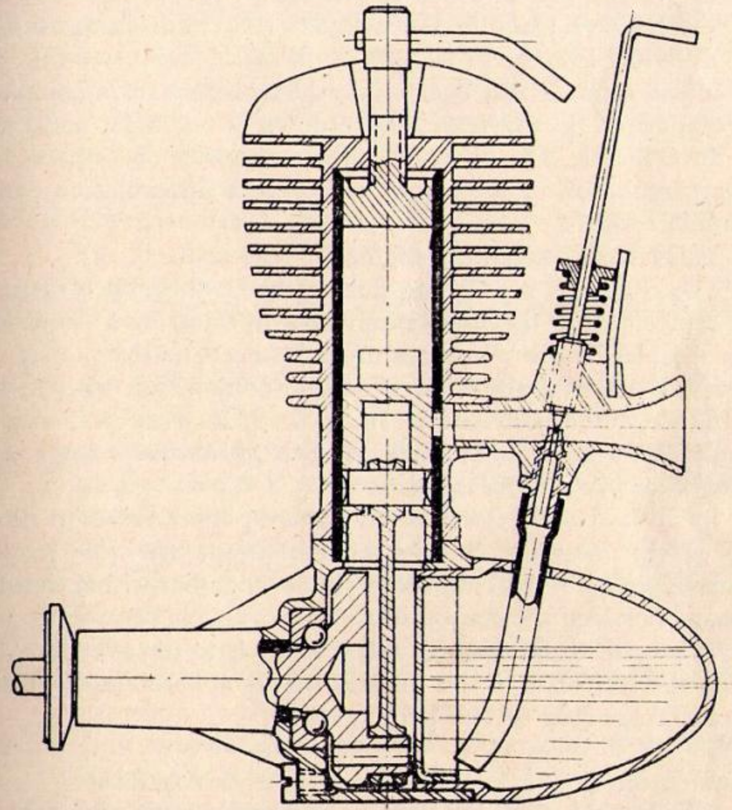


Fig. 3. A typical two-stroke model diesel engine fitted with a contra-piston to alter compression. The contra-piston can be seen at the top of the cylinder.

THE TWO-STROKE CYCLE OF OPERATIONS

Before we proceed further with the design features of the diesel it is as well to understand clearly the cycle of operation of the two-stroke engine. See Fig. 1 and Fig. 2. In spite of its simplicity and the fact that it has only three moving parts, the two-stroke and its method of working are not too easy to grasp.

The main essentials of a single cylinder engine are a piston that slides up and down inside a cylinder, a crank, and a connecting rod, which connects the piston with the crank. We have only to imagine the piston pushed downwards to realise that when an explosion takes place in the cylinder the crank automatically revolves just like the pedal and crank of a bicycle (see Fig. 1).

It will be seen that every time the crank makes a complete revolution the piston travels once down the cylinder and once up the cylinder. The piston therefore completes two strokes for every revolution of the crank, and there is an explosion every second stroke.

This is why we call the engine a " two-stroke."

The engine is kept going during the strokes when there is no explosion, by the momentum of a flywheel or a propeller. For aeroplane work we do not use a flywheel and that is why we must use a heavy propeller, which, in conjunction with its air resistance, acts as a flywheel. *In the case of the diesel this should be heavier than a petrol engine because we have to overcome a larger compression than in a petrol engine.*

In a two-stroke engine we do not use poppet valves to allow the gas to enter the cylinder and to escape after the stroke. Instead, we use ports cut in the cylinder together with a transfer passage between the crankcase and the cylinder, because we use the crankcase to take in gas and transfer it to the cylinder. By using the crankcase in this manner we are able to cut down the strokes from four to two per explosion.

THE ACTION OF A TWO-STROKE ENGINE IS AS FOLLOWS

This should be followed through step by step with Fig. 2. The sketch shows the normal petrol two-stroke engine as fitted with a " deflector " hump to the top of the piston, because this makes the flow of the gases easier to follow. Many model diesels are not fitted with this deflector-headed piston, as already explained, but the action is similar, although the ports do not face one another.

(1) Assuming that the engine is being rotated by swinging the propeller (or the flywheel in the case of a boat) ; the piston ascends in the cylinder and causes a powerful suction in the crankcase (which is hermetically sealed by good fitting bearings and joints).

(2) When the piston almost reaches the top of its stroke an inlet port in the cylinder lower wall is uncovered by the bottom edge of the piston. Atmospheric pressure then forces a full charge of mixture from the carburettor (" mixing valve ") to the crankcase, because of the partial vacuum in the crankcase due to the suction mentioned above.

(3) The piston immediately closes this port upon commencing its descent, and the charge in the crankcase is then compressed.

(4) When the bottom of the stroke is almost reached and the crankcase compression is at its maximum, the top of the piston uncovers a transfer port in the cylinder wall (somewhat above the inlet port). This transfer port communicates with the crankcase from which the compressed charge is instantly transferred to the combustion chamber (i.e. the cylinder proper).

(5) The transfer port is closed again by the further ascent of the piston, and the charge compressed ready for the " explosion " to take place.

(6) *In a petrol two-stroke engine* the spark is timed to occur at approximately the top of the stroke, and the piston again descends by the force of the explosion.

In the model diesel engine the temperature of the mixture is raised to a sufficient height by compression to fire the charge at approximately the top of the stroke, and the piston again descends by the force of the explosion.

(7) Before the piston has fully descended, its top edge

uncovers a large exhaust port in the cylinder wall and the burnt-up gases escape by reason of their own force reducing the pressure in the combustion chamber to approximately that of the atmosphere, helped by the " extractor effect " of the exhaust snout or pipe if fitted.

(8) Immediately this condition has been reached the transfer port is again uncovered (it being almost at the bottom of the stroke) and as explained in paragraph 4 a fresh charge of explosive mixture fills the combustion chamber.

The cycle of operation then proceeds again as explained in paragraph 5 and onwards. It will be appreciated that when the engine is running the induction takes place simultaneously with the compression of a previous charge (paragraph 5). Similarly, the compression of a crankcase charge (paragraph 3) takes place simultaneously with the explosion of a previous charge (paragraph 6).

Thus there is one power stroke to every one revolution of the crankshaft, or two strokes of the piston.

Two-stroke engines of the normal type of porting as shown in Fig. 2 and the " Majesco " engine, Fig. 5, can run in either direction—engines with ports such as the " Micron " can only be run in one direction ; usually counter-clockwise.

THE CONTRA-PISTON

Should he not have already done so, I hope that the reader will now understand how the two-stroke functions, and also that the model diesel works as a two-stroke with a very much higher compression than the petrol two-stroke, in order to fire the mixture without any electrical ignition equipment.

The next important point to be fully appreciated is how the compression ratio can be altered and why we should want to alter it.

If the fuel used never varies at all in its composition when mixed, then we can decide upon the exact compression ratio that is required to ignite it. There are engines on the market with fixed heads that cannot be altered. These are in the minority because of this very difficulty of always ensuring that the correct

proportion of fuel constituents is available, and because people are not always accurate in measuring out fuel constituents ; also because when the engine warms up, the gas expands and alters the compression ratio.

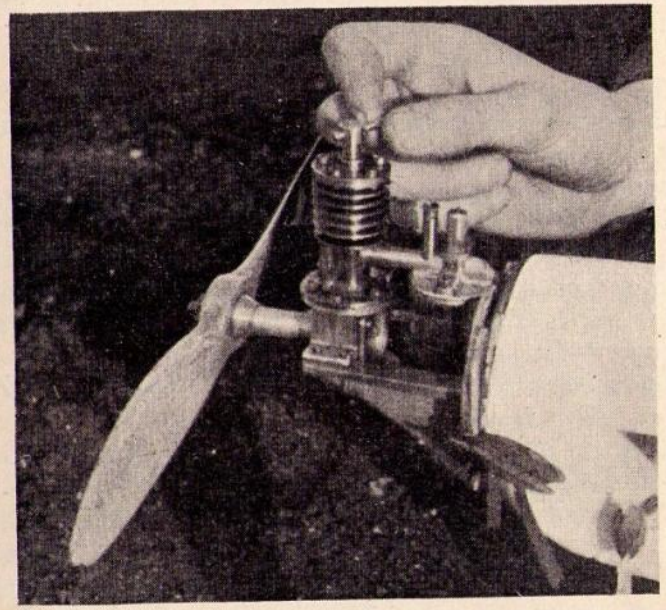


Fig. 4. Operating the contra-piston adjusting lever.

If a fixed-head diesel is owned, the operator must be very careful to adhere to the exact proportions and the type of fuel laid down. He cannot, of course, make minor adjustments to suit a different fuel or even loss of compression due to wear. Such an engine is naturally more simple to manufacture, but is limited in the fuel that it can burn, and is penalised by any carelessness in mixing up the fuel as laid down to be used. There is one further limitation in connection with an over-rich mixture that may be accidentally sucked in, but we will deal with the overcoming of this difficulty later on in the book.

The majority of engine designs are provided with an adjustable compression by the means of a lever or "tommy bar" fitted to the cylinder-head which screws an adjusting rod up and down through the cylinder-head. This adjusting rod either pushes down or allows the "contra-piston" to rise. When the tommy bar is screwed in a clockwise direction looking down on to the cylinder-head it pushes the contra-piston down. See Figs. 3 and 4, and Fig. 20.

The contra-piston in this case comes nearer the piston, and so raises the compression because there is a smaller space at T.D.C. for the gases to be compressed into. On the other hand, if the tommy bar is unscrewed in a counter-clockwise direction the contra-piston is allowed to be forced up towards the cylinder-head by the compression, thus allowing more space between piston and contra-piston and so reducing the compression.

It is absolutely vital that the reader should understand the working of the contra-piston and why it is used, so that later, when we come to the chapters on starting and operating the diesel, he will appreciate what is being said and what he is doing.

There are three main reasons why we may want to raise or lower the compression of a diesel—

(1) If we use a slightly different fuel mixture that requires a higher compression to ignite it and run it. People are also often careless of the exact proportions of constituents when mixing fuel. This is human nature and difficult to overcome. In this case, within limits, a slight alteration of the compression will usually overcome the difficulty.

(2) Many engines prefer a slightly raised compression ratio to start, with a slackening off of the compression when they become warm, the fuel then being more easily vaporised and the gas therefore more "expanded." On the other hand, I know of two engines, one foreign and one British, which prefer the operation in the reverse order, but this is unusual.

(3) Should too much fuel be sucked into the engine during starting operations, liquid fuel will often become compressed in the very small space between piston and contra-piston (frequently as small as 1/32 in.). This

liquid fuel is practically incompressible and the engine will become impossible to turn. *It will be damaged if it is forced over.* The contra-piston can be slackened back, and more space provided, the engine can then be turned until the liquid fuel is blown out of the cylinder. The compression can be returned to normal and a start made.

The reader will be reminded of the above three very important points when we come to the chapters on starting and operating the diesel.

A further form of compression adjustment is used in the case of the French "Ouragan" 3.36 c.c. diesel and the British "Airstar" diesel of 2.15 c.c. The cylinder-head is fixed, but the crankshaft is mounted in an eccentric crankshaft bearing. The shaft can, therefore, be moved towards or away from the cylinder-head by rotation of the eccentric bearing sleeve, which alters the space between piston and cylinder-head at T.D.C.

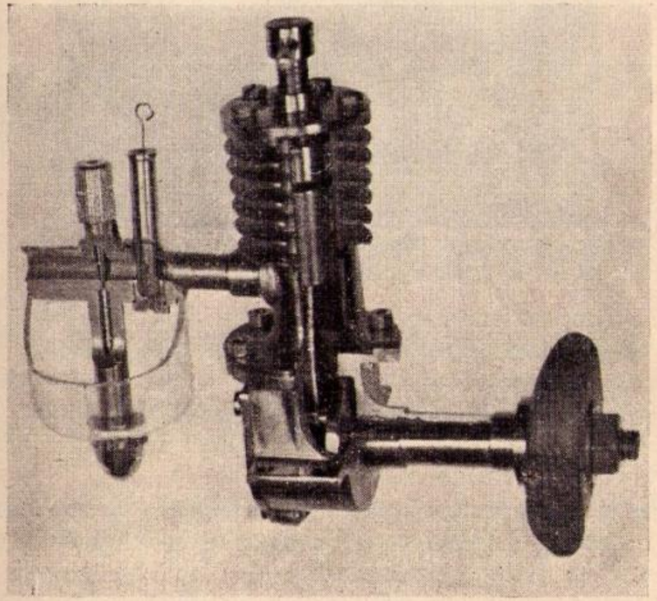


Fig. 5. Sectionalised "Majesco" diesel of 2-c.c. showing piston and contra-piston above it.

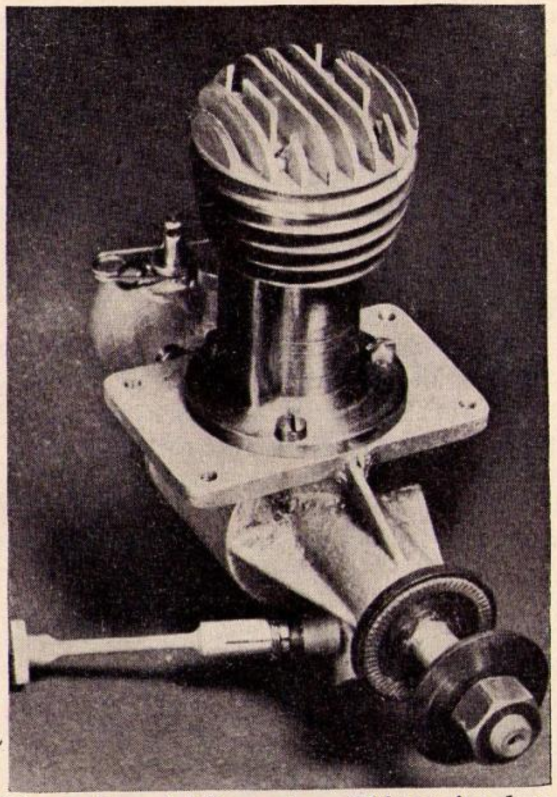


Fig. 6. French Micron 5-c.c. This engine does not incorporate a contra-piston.

The control lever appears similar to the variable ignition lever of a normal petrol engine. The advantage of this system lies in the reduction of the height of the engine. The " Airstar " which is in my stable works extremely well. Fig. 39.

THE VALUE OF THE CONTRA-PISTON

The operator can, with a contra-piston engine, be sure that he is obtaining maximum performance as his engine warms up by reducing the compression to its optimum value for warm running before releasing the model. It has been noticed on a number of occasions that fixed-head engines have faded out as

they have warmed up and actually stopped before their fuel tanks have emptied. This, of course, is due to the rise of compression owing to the greater expansion of the gases as the engines warm up, which automatically raises the compression, which in turn acts as a brake to the engine.

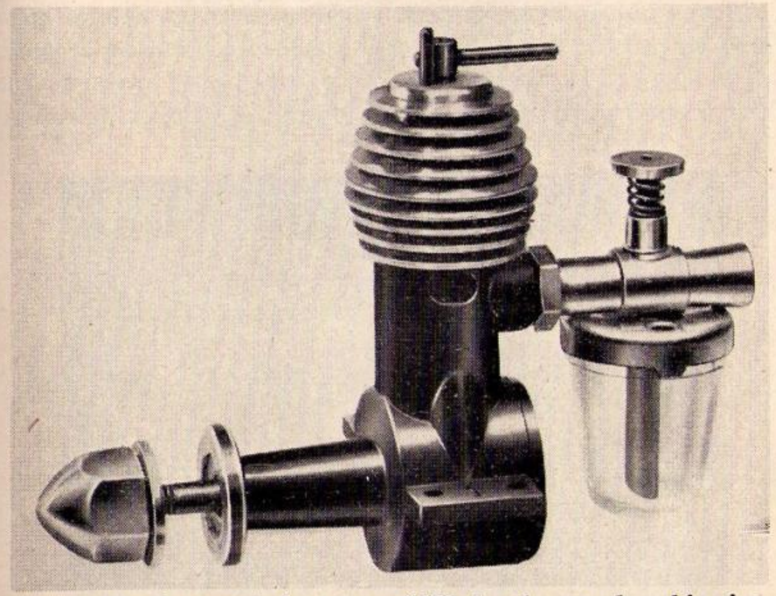


Fig. 7. The famous baby 0.7 c.c. Mills has been reduced in size and price but increased in power. Note large exhaust port and clean robust design for only $1\frac{3}{4}$ oz. in weight.

COOL RUNNING OF DIESELS

The model diesel engine runs very cool; in fact far cooler than its petrol brother. I have seen several experimental diesels run perfectly without any cooling fins on the cylinder, and with only one fin on the head. Fins are eventually often fitted for the sake of conventional appearance because purchasers do not like curious and unusual things, a fact that has been proved in the full-sized motor-cycle, car and boat world. One can usually place the hand upon a diesel cylinder when the engine stops running. This cannot be done on a petrol engine cylinder unless the individual has a very hard and horny hand!

The Italian "Helium" diesel has vertical fins which make it look different, even though the performance may not be improved.

FRICTION IS THE BUGBEAR OF MODEL DIESELS

The elimination of friction as far as it is possible is most important to the diesel, even more important than on a model petrol engine, because any undue "stickiness" prevents the operator swinging rapidly over the high compression, and so

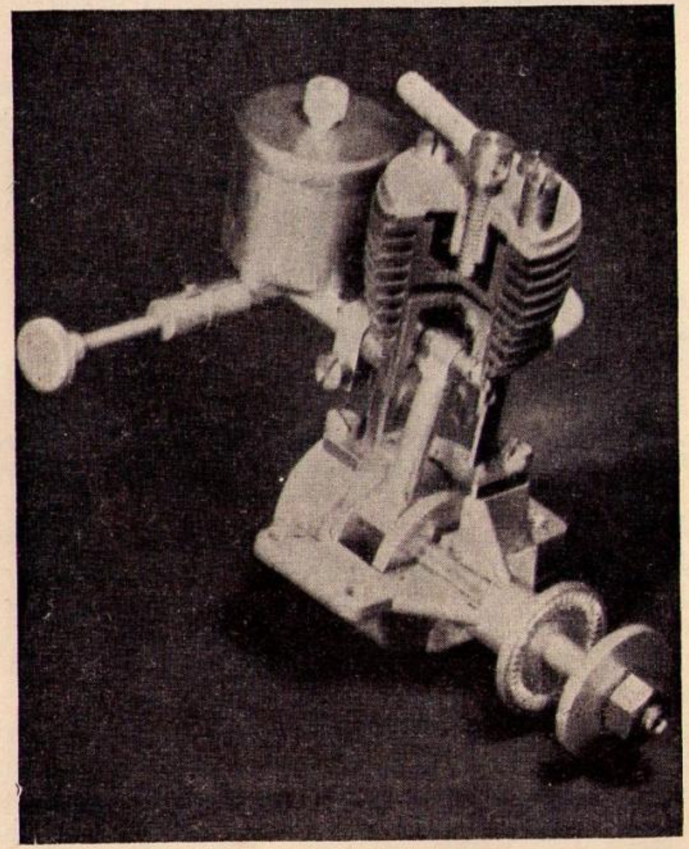


Fig. 8. The French 2.8 c.c. "Micron" sectionalised.

allowing the engine to carry on the swing with sufficient momentum for the first "explosion" to overcome the subsequent compression.

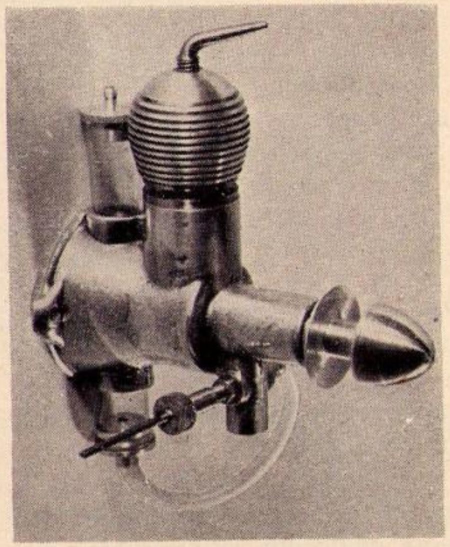


Fig. 9. The British Elfin fitted with a contra-piston and an adjustable compression ratio. Note the adjusting tommy bar protruding from the cylinder head. Weight $3\frac{1}{4}$ oz.

The problem is not an easy one for the manufacturer, because the piston and cylinder must be a perfect fit, and so must the mainshaft bearing in order to prevent leakage of the gas, *and yet the engine must be free to turn without any stickiness and still have good compression.*

It can be done, I know, because well-known manufacturers do it. If I were purchasing a new engine and spending "my all," I would not accept a diesel engine that was "sticky" to turn. I have had them, and they are the very devil to start. Neither would I accept an engine with poor compression.

HOW TO TELL A GOOD DIESEL WHEN MAKING A PURCHASE

When examining a new diesel, turn it round with propeller fitted, see that it turns nicely and easily, but when it comes up against compression it must be difficult to bump over. Then try turning it against compression again, and hold it steadily with the compression half overcome. Now listen if there are any hissing noises of rapidly escaping compression, also observe if there is undue escape around the exhaust port from the piston; shown by a rapid bubbling of oil. The piston should hold compression for an appreciable time without the above signs of excessive escaping compression. Slight escape is permissible.

As I have already mentioned, the piston on most model diesels is of the plain ringless type and must be fitted "just so," with practically no clearance at all, and certainly not clearance that you can detect. Some of the latest American speedboat and racing petrol engines have piston rings fitted, to keep good compression when light alloy pistons are used in order to permit extremely high r.p.m. But the smaller diesels made abroad and in this country have plain pistons, because the r.p.m. of diesels is not so extreme. A good manufacturer knows how to fit a ringless piston to a cylinder bore, and he has the necessary machines to repeat the process in quantity. It is quite easy to make up one good engine by hand and think that the problem is solved. It is quite a different kettle of diesels when a number have to be made up for sale, and this is where many a budding new manufacturer failed in the early days of development.

Do not be misled by people telling you that a model engine should be really tight and difficult to turn when new, because it will free up when run in, and will therefore be a better wearing engine. This means that the manufacturer has shirked his business of obtaining a perfect fit and carefully lapping and running-in for you. The American engines of repute *all arrive free to turn, and yet with excellent compression.* Of course, I do not mean to say that a new engine will not be a little tighter than an old one, and that it will not benefit by careful running in; that would be incorrect. But the old idea of a new engine having to be stiff and "sticky" to turn is not now acceptable. *On the other hand, do not be caught by the engine that is easy to turn the whole way round the clock.* This means that the engine has not got

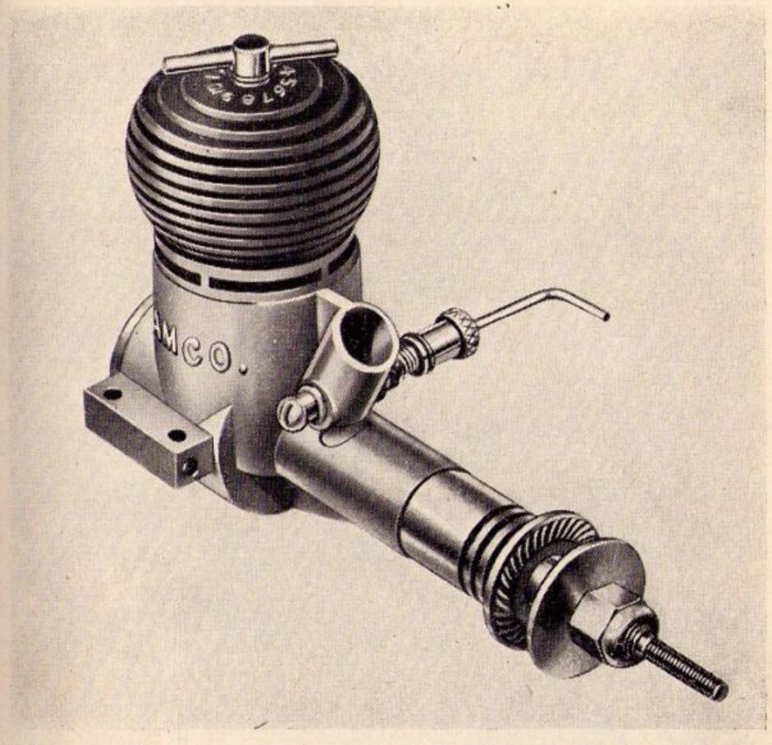


Fig. 10. The 3.5 c.c. Amco is a modern example of high efficiency, having a short stroke and big bore allied to large ports. This combination spells high r.p.m. Note ring of exhaust ports around the cylinder.

good gas seals and compression in the cylinder and crankcase. This engine will be very difficult, if not impossible to start, and it will be a poor runner if it does start.

One very soon learns to recognise a free-turning engine and yet one with good compression to be overcome. Provided that the purchaser knows that he has to look for these points, he will not accept the over-tight or the sloppy engine.

Many American and British manufacturers are now fitting ball and roller races to main bearings in order to eliminate friction as much as possible. This is a good point, provided

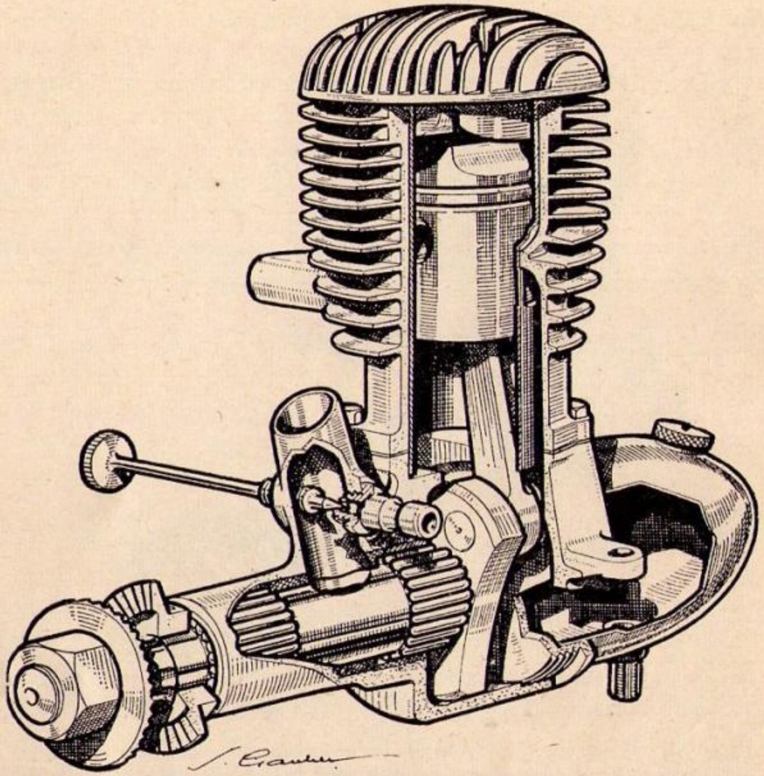


Fig. 11. The French "Morin" design has a piston deflector with recessed head. Note the roller main bearings.

there is provision made to keep good gas seals. This does not mean that a well-fitted plain main bearing is poor, for a carefully designed plain bearing gives every satisfaction for reasonable revolutions.

GAS-TIGHT SEALS

We therefore have the sliding up and down friction of the piston to keep down, yet we must keep a good gas-tight fit. We also have rotational friction to eliminate as far as possible, particularly in the main shaft, and yet keep a good gas seal to

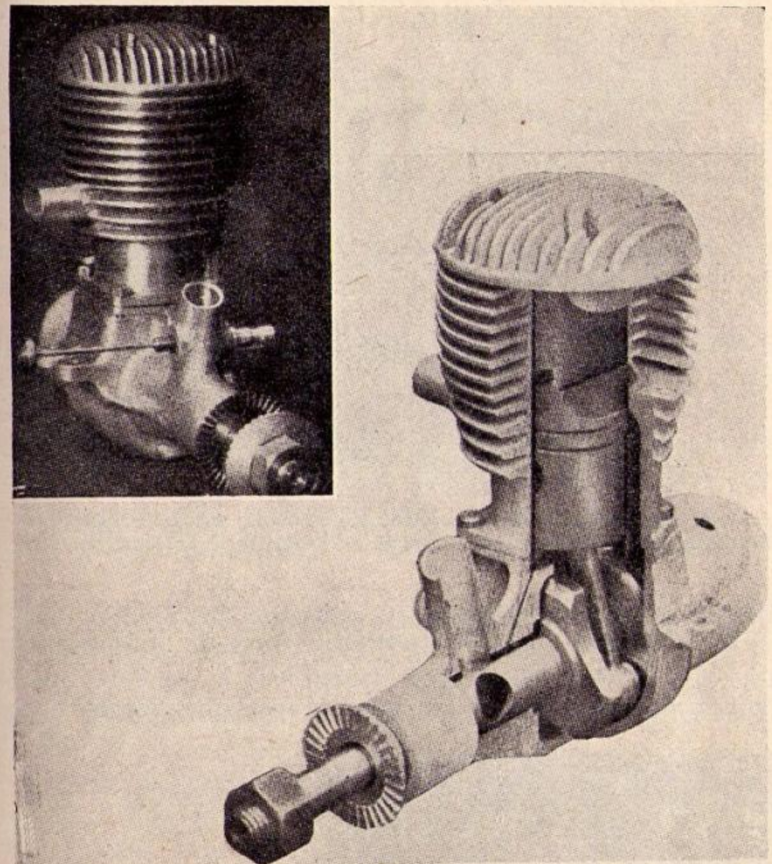


Fig. 12. Monsieur Morin, of France, is responsible for this interesting engine fitted with a deflector hump and recess in the cylinder head.

prevent leakages of air into the crankcase, for you will remember that in Fig. 2 we saw how the crankcase on a two-stroke has first to receive the mixture and then compress it, and finally the descending piston pushes it up through the transfer port to the cylinder. If there are leaks of air to the crankcase the correct explosive mixture will be diluted. If there are leaks past the piston and cylinder wall the piston will not create a vacuum in the crankcase to suck in the mixture, nor will it pump it up from the crankcase to the cylinder *via* the transfer port.

It will readily be grasped that a two-stroke cannot abide air leaks, and apart from the piston and main bearing, there are also certain washers or gaskets and joints between cylinder and head, cylinder and contra-piston, cylinder and crankcase, crankcase door and sometimes detachable transfer port joints. *All these must be perfect and allow no leaks.* That is why I so heartily recommend the newcomer *not to take his engine to pieces or even allow an "engineering friend" to take it to pieces to have a look at the works.*

When he really knows what he is doing and how to make joints, it is a different matter. In the early days after purchase it is better to let the manufacturer have the engine back if it does not run properly. The French "Micron" engine instructions sum up this point very nicely—under the heading—

"*The life of your motor depends on this*:—The less you dismantle your motor, the longer it will maintain its quality."

RUNNING-IN THE DIESEL

How often one sees the wearisome spectacle of a new aeromodellist fiddling with a new engine in a new model on the flying field, whilst originally interested spectators become bored

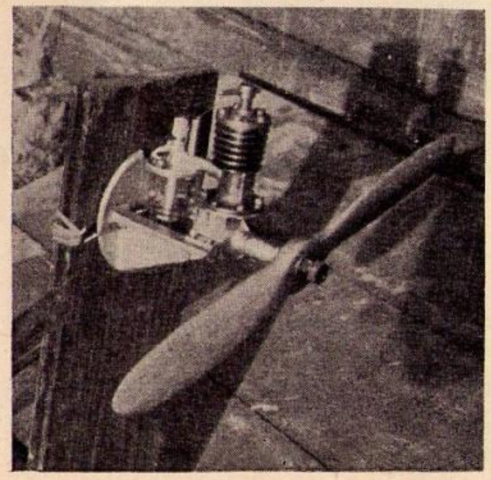


Fig. 13. Running-in on a test stand.

Fig. 14. Testing the installation and running the engine on the fuselage, whilst the wings and tail are being made.

because of the abnormal time the poor fellow takes to start up his engine, and when it does start it constantly stops, and the laborious business of a restart has to be gone through again and again. All this is bad propaganda, and these discouraging results for the owner are due to :—

(*a*) not having a starting drill at his fingertips. This is given in Chapter IV—"On Starting."

(*b*) Lack of practice with the engine.

There is no advice so good as "know your engine." This can be done during the building period of the model aeroplane, boat, or car, firstly by mounting the engine on a test block of wood or a stand, and learning its tricks whilst running it in during the preliminary stage of building the model, and later by running the engine in when mounted in the completed fuselage, hull or car chassis, whilst the constructor is building the remainder of the model.

When running in an engine on the bench for a boat or car, an airscrew should be fitted for the purposes of cooling and load. Under no circumstances should an engine be gripped direct between the jaws of a vice. The crankcase is not designed to take this crushing strain.

It is far better to learn your engine in these two definite stages, because starting an engine in a fuselage near the ground is a very different thing from starting one comfortably swinging away high up on a bench! It also brings out any faults found in the mounting and general get-at-ability of the installation and controls, before the proud owner makes his, probably somewhat harassed, first flight under power, or his first voyage across the pond.

Figs. 13 and 14 show these two stages of running in, and will perhaps remind the new diesel modeller to carry out his running in and knowing his engine in two stages.

MOUNTING THE DIESEL

Owing to the high compression of a diesel, as a rule it runs more roughly than its petrol brother, and it will, therefore, shake itself loose unless well mounted. Swinging over high compression is also a severe strain on the mounting. It is therefore important to mount the engine rigidly and well with adequate bolts that will not shake loose.

Flimsy mountings cause vibration which upsets the mixture due to air bubbles in the fuel. Uneven running then ensues, and rapidly knocks bearings to pieces.

With regard to aeroplanes, although perhaps rather an ugly method, I know of no more practical way than the one I adopt. The mount for an aeroplane can be seen in Fig. 19. This is in the form of an elektron casting *that any engine can be firmly bolted to*. Elektron is a very light metal about 40 per cent. lighter than aluminium. The mount has a raised square cast on its rear. This fits into a square cut in the first three-ply former of the fuselage. The engine mount is then held on to the fuselage nose by elastic bands from wire hooks on the mount to wire hooks on the fuselage. These bands are made sufficiently taut to give in the event of a crash, and thus save engine and fuselage when the engine and mount are knocked off the fuselage, and yet prevent vibration of the power unit when it is running.

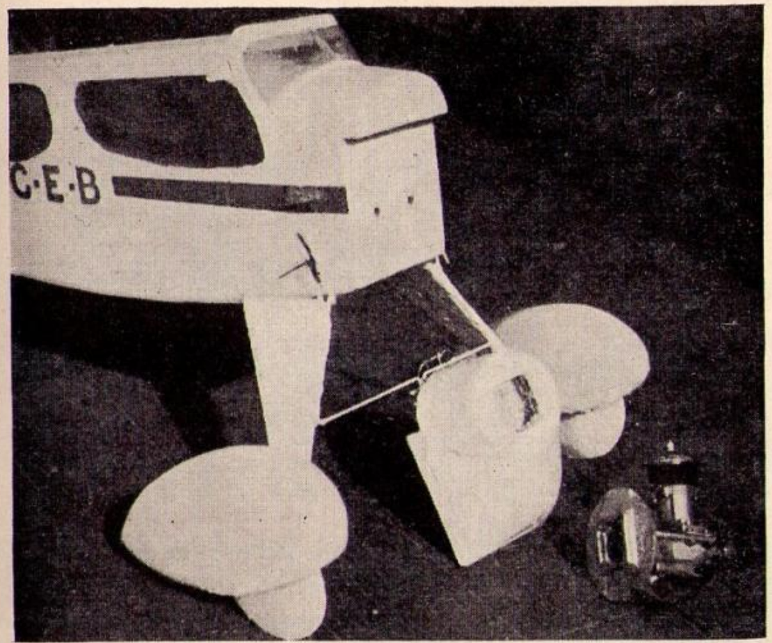


Fig. 15. The author's simple method of mounting a diesel. An elektron casting is screwed on to a solid laminated detachable balsa nose. This "distance piece" can be altered in length to suit various engines.

The mount, with its engine, can be detached quickly to change fuselages, or take to the bench. Down thrust or side thrust can be given or changed quickly when test flying a new model by simply inserting strips of packing wood between fuselage and mount. These can later be permanently secured by glue, silk and dope, when found to be correct.

I designed this mount many years ago and very many people have adopted it, or variations of the theme. The mount can easily be cowled in, to hide its ugliness, or left naked, if desired.

I frequently get letters asking me how a mount can be obtained. To forestall some of these—an elektron mount with a 3-in. circular backplate that will take almost any engine on the market today, can now be obtained from "BM" Models, 43, Westover Road, Bournemouth.

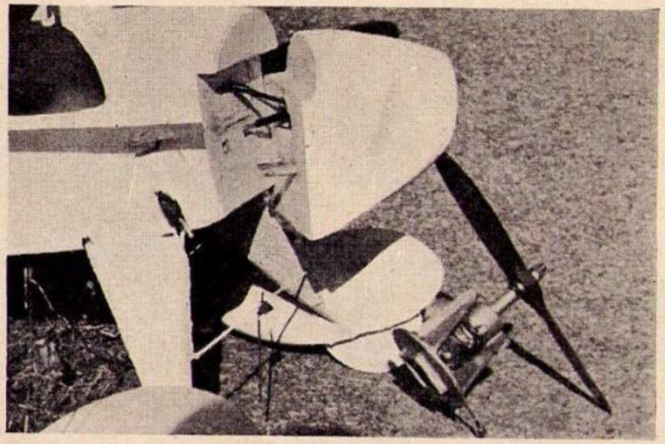


Fig. 16. Another view of the " distance piece " showing how it fits up to the rectangular nose of the fuselage.

Figs. 15 and 16 show another method that I often adopt whilst using one of these mounts. I screw an elektron mount on to a solid laminated and streamlined balsa nose. This in turn fits on to a square or rectangular fuselage nose. The balsa laminations can be made long or short to suit the weight of the engine fitted to obtain the correct c.g. position of the model. The whole is then held up to the fuselage by rubber bands. The mount knocks off in the event of a severe crash and will save damage to the engine.

If the reader elects to mount his diesel on wooden bearers in a rigid fixing to the fuselage in the American fashion, he should make sure that the bearers are square to the engine lugs and are really rigid, and do not give or distort the engine crankcase itself. The same applies to the wooden bearers in a boat or the bearers in a car. In a boat, oak bearers are generally used. See Fig. 17.

For those who like to use a simple wooden mount, but one that has the virtue of being detachable, I devised a scheme shown in Figs. 18 and 19.

The detachable engine mount is built up of plywood with a metal facing over the actual bearer arms. The two photographs

will make the idea clear. It works very well in practice, although it is not quite so robust and firm as the elektron mount idea.

THE NEEDLE-VALVE CONTROLLED " CARBURETTOR "

The majority of model petrol and diesel engines have a very simple type of mixing valve in lieu of a carburettor. A full-sized carburettor is usually an instrument of chokes, tubes, jets and compensating devices to alter the mixture's strength under varying engine speeds and loads. The model diesel runs flat out, or nearly so. Its r.p.m. is nearly constant when it is flying

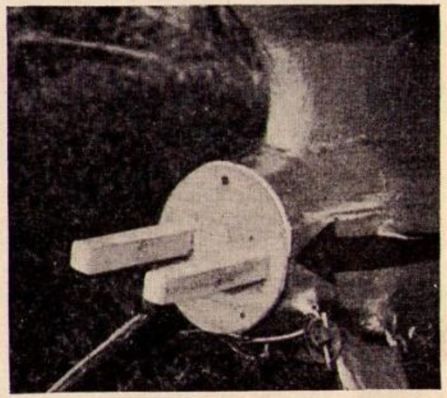


Fig. 17. A simple American type beam mount of wood. It is rigid and cannot be detached either by hand or crash. The wooden bearer arms pass through the front bulkhead and second bulkhead in the fuselage.

an aeroplane or propelling a boat or car. The question of compensating devices therefore does not enter into the problem except for radio-controlled models. A simple induction tube is therefore generally used with a jet projecting into the tube, the amount of fuel being regulated by a tapered needle-valve which seats in the jet orifice. When the thumb-screw of the needle-valve is turned clockwise, i.e., screwed down, the jet is progressively closed, and when the thumb-screw is unscrewed the tapered needle is raised from the jet seating and therefore allows more fuel to be sucked from the jet. See Fig. 22.

As already explained, the piston in the cylinder causes a vacuum or low pressure in the crankcase. This in turn sucks air in through the " mixing valve " intake tube to the crankcase. The air flowing at speed past the jet picks up fuel and atomises

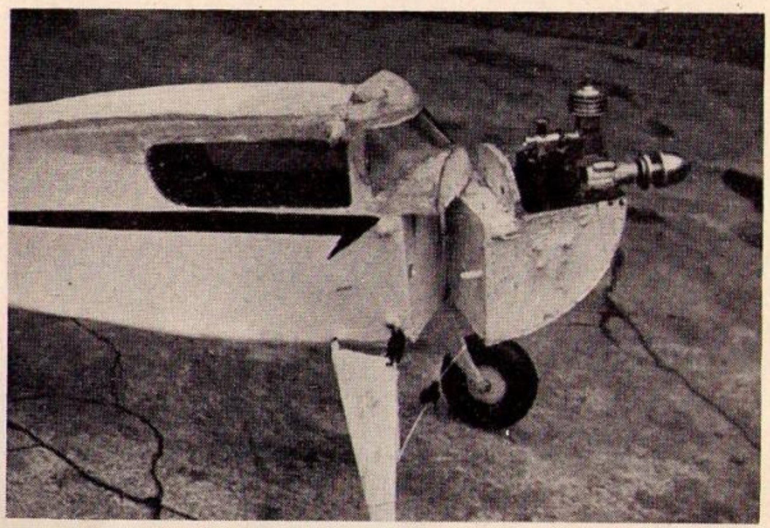


Fig. 18. The author's detachable mount made from 3-ply, balsa fairing, and sheet metal, shown half detached. If the motor is inverted a hinged balsa top cowl can be added.

it on the way. An explosive mixture is produced which eventually is transferred to the cylinder and compressed. It then explodes or expands, and provides the power stroke.

The task of the mixing valve is to mix the correct quantity of air and fuel together to form a suitable explosive mixture which can be fired by the heat of the high diesel compression. In order to achieve this, the operator can alter the fuel to air ratio by the fuel needle-valve. (See Figs. 22 and 23, and refer back to Fig. 5, which shows a sectionalised carburettor.) It is possible to fit these miniature engines with a fixed jet, and so cut out all the bother of making a correct mixture each time. I have fitted up several engines with little carburettors with fixed jets and find it the best method for racing hydroplanes, but a considerable amount of patient fitting of, and experimenting with, various sized jets is required. Of course, once the correct jet is obtained, there is no further trouble over making the right mixtures. A fixed jet carburettor also must have a constant feed float chamber fitted, and the oil content in the fuel be rigidly adhered to.

All these complications require too many man-hours of production time for commercial engines built to a price, therefore the reader will almost surely buy an engine with the simple needle controlled mixing valve. This is satisfactory and therefore the instrument that we will discuss.

The secret of this type of carburettor is to find the correct opening of the fuel needle-valve, and then to mark the setting. The engine will always run at this, provided the fuel and oil content are kept the same. Only slight adjustment is required to correct the mixture to obtain maximum power, after the engine has been started, and when it is warm. If a different oil content is used this alters the amount of combustible fuel that can pass the needle and thus alters the fuel content of the mixture.

It should be remembered that dirt can clog or partially clog the needle-valve and seating. Fuel should therefore be filtered

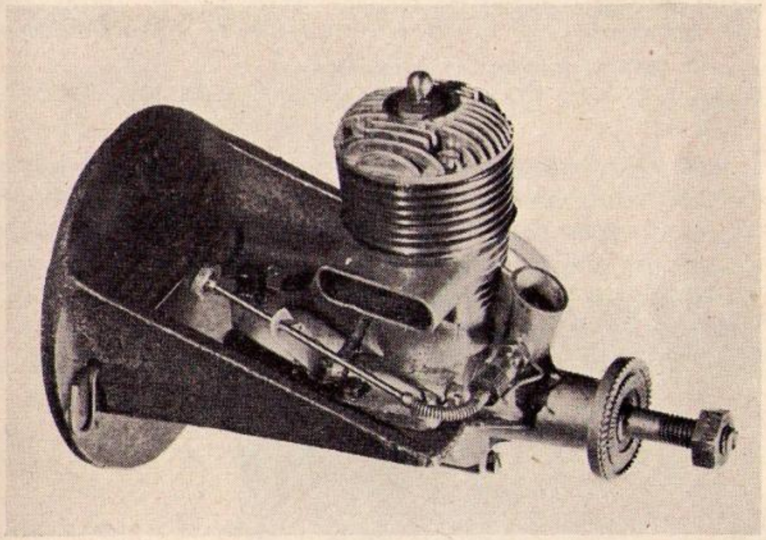


Fig. 19. The author's elektron cast detachable mount can be fitted to a front bulkhead and cowled if desired. Compare this 5 c.c. Frog glow-plug engine's lesser height with diesels shown in this book of similar capacity, due to extra height of contra-piston of the diesel.

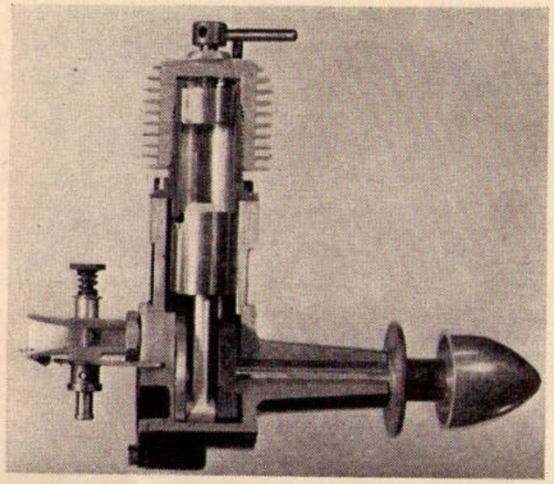


Fig. 20. The Mills 2.4 c.c. diesel sectionalised. Note the induction on this engine is by rotary disc valve at the rear of the crankcase. The transfer port can be seen at rear bottom of cylinder.

carefully and kept in a very clean container. If dirt is suspected in the needle-valve, unscrew it and blow through the jet and pipe, *but do not forget to return it to the correct setting for running*, i.e., the correct number of turns open.

FUEL FEED

It is poor practice to rig up a fuel tank with gravity feed, because the pressure of fuel, and therefore the flow of fuel, will vary as the tank empties. Fuel also dribbles into the engine when at rest and the crankcase may become flooded.

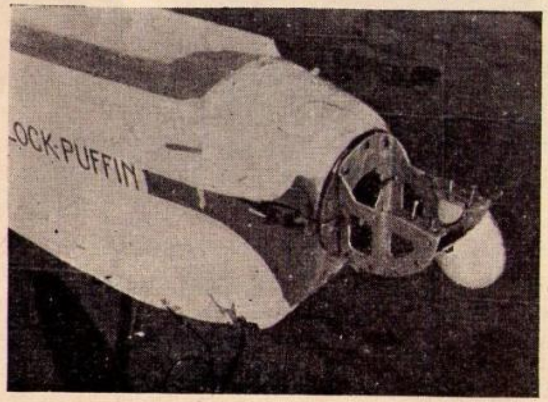


Fig. 21. Detachable mount of sheetduralumin.

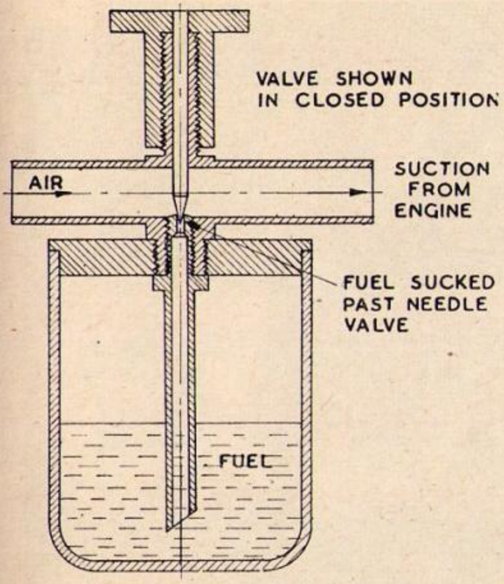


Fig. 22. Simple needle valve controlled carburettor.

The best method is to suck up the fuel from a small shallow tank located below or near the needle-valve.

The engine cannot flood itself when stationary, and because the fuel is near the needle-valve jet, the level of fuel and therefore the amount of fuel, will not vary appreciably when the model dives or banks, etc., in the air or gyrates upon the water. Because the tank is small, the level of fuel will not drop seriously.

See Fig. 25 to make clear the wrong and the right way of constructing and fixing the fuel tank. Control line flying requires a special tank to cope with the action of centrifugal force. This is fully dealt with in my book *Model Glow Plug Engines*.

Jim Walker, the father of control line flying and inventor of the famous " U Reely " control handle in which the lines are wound in and out as desired during or after flight, has recently produced a fuel regulator which is fitted between a special rubber tank shaped like a miniature hot water bottle and squeezed between two plates by a rubber band, thus giving pressure feed

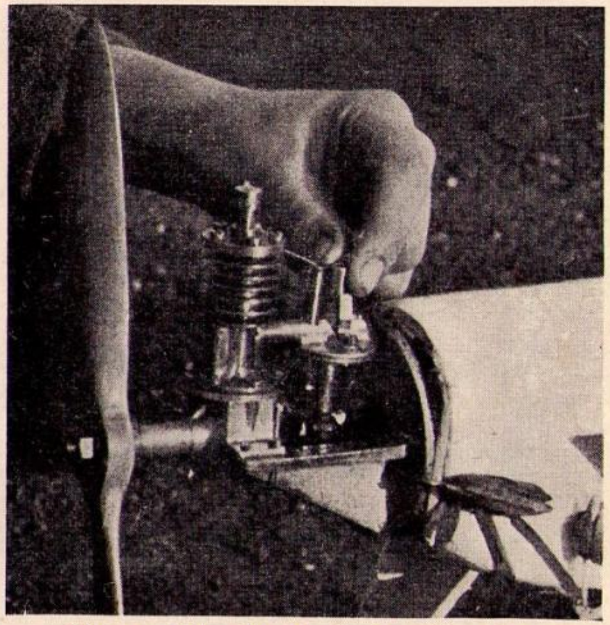


Fig. 23. Adjusting the fuel needle valve.

to the motor. The regulator meters the fuel by a diaphragm which insures absolutely regular fuel flow whatever the position of the model when stunting or radio controlled, and however great the action of centrifugal force on a circular path. This new feed is patented in America, and should eventually revolutionise model fuel feed reliability, thereby cutting out balky motors.

POINTS TO REMEMBER

Points that the novice should remember are that a suitable quick-burning explosive mixture of gas has to be made through the air being sucked past the jet, so that the right proportion of fuel and air is taken into the engine. He controls the amount of fuel by means of the needle-valve. He should keep to the best running setting once it is found, i.e. when the engine is two-stroking at its best performance. He should keep the

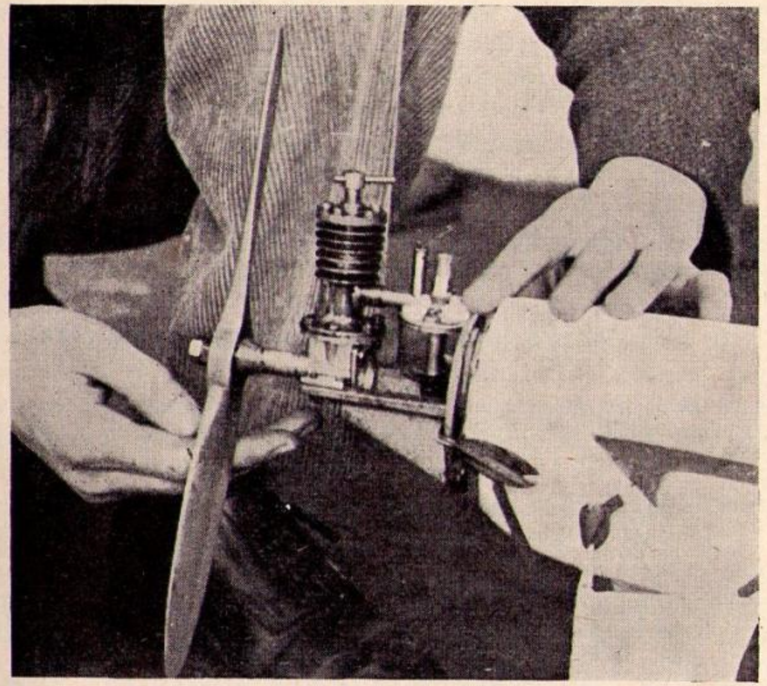


Fig. 24. When "sucking in" or choking the carburettor intake, the finger covers the induction pipe as shown.

needle-valve clean, and he can increase the amount of fuel taken in to start the engine by placing a finger over the induction pipe orifice and swinging the propeller once or twice. This must not be overdone or the engine will be flooded with liquid fuel (see Fig. 24).

SIZES OF MODELS CAN BE REDUCED THROUGH THE ADVENT OF THE MIDGET DIESEL

The diesel, with its elimination of electrical ignition gear, has recently brought the size of practical I.C. engines down with another bump. It is of interest to note that in 1914 Mr. Stanger's engine—which set up the first record free flight (petrol)—weighed around 2 lb. 12 oz. In 1932 I used a $2\frac{3}{4}$-lb. 28 c.c. engine to set up the first post-1914-1918 war record, and in 1933 I collaborated with Mr. Westbury, who produced a 1¼-lb. 14.2 c.c. engine, with which I set up the first really long record flight in history of 12 minutes 40 seconds "out of sight."

In 1934 the Americans produced the first real miniature engines of 9 c.c. and 6 c.c., the "Brown" and the "Baby Cyclone."

In 1935 the "Elf" people of Canada produced the first really baby commercial I.C. engine of only 2.4 c.c., weighing about 8 oz., with electrical gear and wiring.

The above were all petrol engines.

In recent years petrol aero-engines like the "Mighty Atom" and "Arden" from America and the British 1.7 c.c. "Frog" have been produced, weighing around 2 oz. bare, but had to add the weight of the coil, condenser, flight battery, and wiring, before flying could take place. These extras totalled up to considerably more than the engine weight.

Now, we have got down to diesels of 1 oz., and baby glow-plug engines with no other impedimenta, ready for flight. Fig. 26 shows my old 28 c.c. 2¾-lb. engine, that set up the first post-1914-1918 war record, side by side with a little commercially obtainable diesel weighing only 1½ oz., made by Mr. Colyer, which I have flown a considerable amount in different models, and also fitted an example to a tiny speedboat.

There are now a number of 2 oz. diesels obtainable. These are mentioned in Chapter II. Also see Fig. 7—The Mills 0.7 c.c. diesel. The new Albon Dart of 0.5 c.c. weighs only 1.2 oz.

The diesel has made the really midget internal combustion engine and model a practical possibility. Thus we have another milestone in the history of model I.C. power-driven craft.

The smallest known commercial engine, at the moment of writing, is the 0.16 c.c. French "Allouchery," which is alleged to run at 12,000 r.p.m., and can fly a model of under 4 oz. all up weight. This engine is too expensive to produce as a successful mass-produced commercial project. The "Allouchery" people produce a practical little engine of 0.7 c.c. This engine is also made with a specially lengthened crankshaft for those who like building scale model aeroplanes with a long streamlined nose.

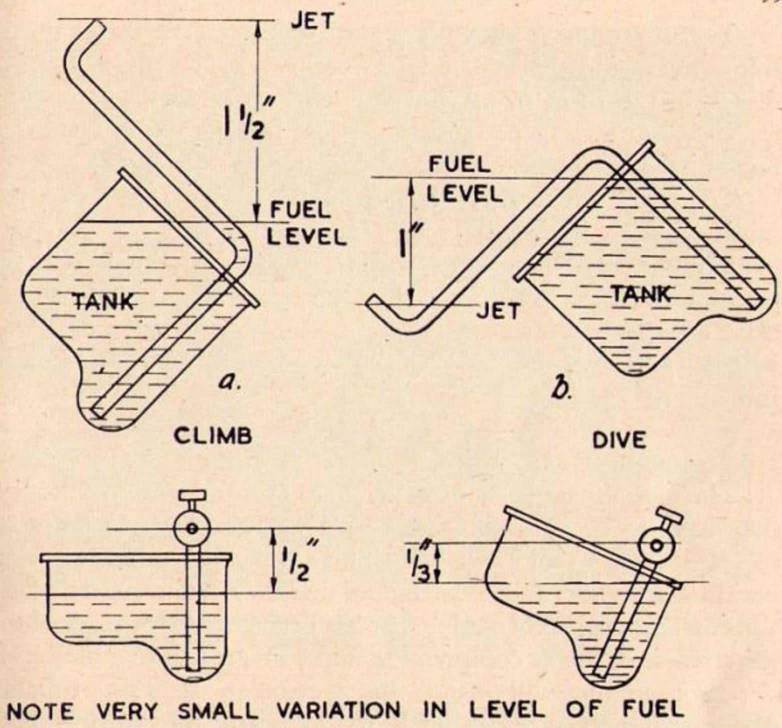


Fig. 25. The right and the wrong way of fitting suction fuel feed to model aeroplanes. Wrong method above, correct method below.

A phenomenally small diesel engine of only 0.04 c.c. was shown at the 1948 "Model Engineer" Exhibition by Mr. Fjellstrom, of Sweden. He demonstrated the engine in action. It ran so quietly that onlookers had difficulty in hearing its exhaust note above the noise of the exhibition!

THE LARGE-CAPACITY DIESEL

I have remarked upon the virtues of the very small diesel, and how the advent of the diesel has allowed us to make smaller model aeroplanes, boats and cars. I have also explained how, in my opinion, the petrol and glow plug engine scores in the larger sizes.

There is one aspect with regard to the larger diesel that I think we would do well not to overlook. The multi-cylinder diesel, in the form of a twin or even " three in line " engine, makes an attractive proposition, provided the compression of each cylinder can be accurately adjusted.

The chief advantage, apart from the added interest of the multi-cylinder, is that each cylinder will have the advantage of being in the small diesel class, with its ease of swinging over compression to start. There are already aero-twin model diesels in existence that work satisfactorily. Notably, a flat twin designed by the sponsor of the " Micron " and a vertical twin fitted to an Italian race-car.

THE COMPONENT PARTS OF A TWO-STROKE DIESEL

The component parts of a diesel are few and simple although they have to be very accurately made. They have to be more robust than a petrol engine of similar c.c. It is worth warning budding designers and constructors that they cannot usually fake a normal model petrol engine that has been correctly designed for the stresses of lower compression and convert it into a diesel. If a petrol engine will stand this treatment, it was probably designed unnecessarily robustly for its petrol mission in life.

DO DIESELS WEAR WELL ?

I often hear this question asked. It is naturally a difficult one to answer because it entirely depends upon the design and the manufacturer, also how the engine is run after manufacture.

The diesels which I own that are what I call well-designed and made have improved with age, and as they naturally become the favourites, because of their sound starting and reliable running, they have had several years' use.

Provided a manufacturer builds his engine so that it is adequately stiffened up through the construction of crankcase and cylinder, and it has the correct metals in its design, with really adequate bearings, crankshaft and connecting-rod, there is absolutely no reason why the diesel should not last as long as its petrol brother. Connecting-rods should normally be made

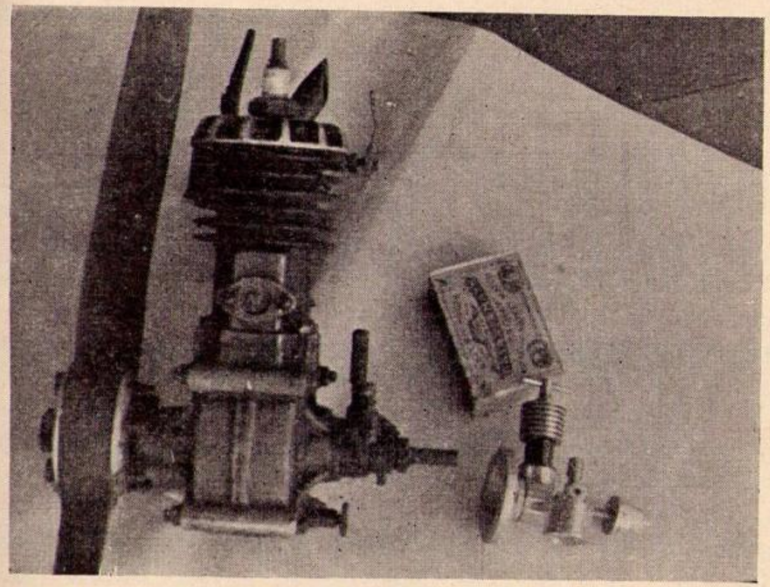


Fig. 26. Dignity and Impudence ! The " Wall " 28 c.c. beside the " Majesco Mite " 0.7 c.c.

from steel with hardened bearings. Some are made from duralumin, but, generally speaking, are better not cast.

If, on the other hand, the engine is not stiffly robust, and bearings and connecting-rod more suitable to the lower compression of a petrol engine are used, the life of a diesel will be short. The answer is quite simple. Buy a diesel made by a manufacturer with a reputation, and *then be careful not to run it with too high a compression setting.*

With regard to the main bearing, lapped cast-iron is often recommended in preference to the more usual bronze. It may, however, interest readers to know that I have an engine which has done a great deal of running with the crankshaft running direct in the aluminium alloy crankcase, and I believe that this will eventually become a normal practice in many model engines, because the softer and more porous bearing metal holds the oil and improves lubrication, apart from the very important advantage in reducing production costs. There are several firms now adopting this practice with perfect success.

WHY DOES A MODEL DIESEL LOOK TALLER THAN A PETROL ENGINE?

The great majority of diesels are fitted with a contra-piston. This adds to the height.

Many diesels at present are of the long stroke variety in order to incorporate a long piston seal to obtain good compression and facilitate obtaining the high compression required. This long stroke naturally also demands a larger crankcase to allow for the longer crank throw. There has been a recent trend towards the short stroke "square" engine for high speed "hot" performance to suit control line models. A short stroke and bigger bore engine has many advantages. The well-known and popular "Frog 180" diesel is a good example, also the "Elfin" and the "Amco." These engines run at very high r.p.m. for diesels. A newcomer is the Davies-Charlton 350.

One of the main advantages of the "square" big-bore short-stroke engine is the shorter distance that the piston has to travel. The piston speed is therefore not so great, which helps the mechanical wear factor and the attainment of high rotational speeds. The overall height of the engine is naturally not as great, which is an advantage for those individuals who favour engine cowling on their model aeroplanes.

The shorter stroke engine, being reduced in size, also means a reduction in weight. There is a lower inertia of the connecting-rod, and the gas flow into the cylinder is improved.

The main disadvantage of the "square engine," with bore and stroke approximately equal, is that the stroke being shorter, it makes the attainment of high compression more difficult than in the case of the long-stroke engine, because the combustion space is less compact. As a result, many model enthusiasts condemn this type of diesel. The secret seems to be a very carefully fitted piston, and vast exhaust ports. The 3.5 c.c. "Amco" seen in Fig. 10 forms a good example of a very high performance diesel. The long stroke diesel (such as the E.D.

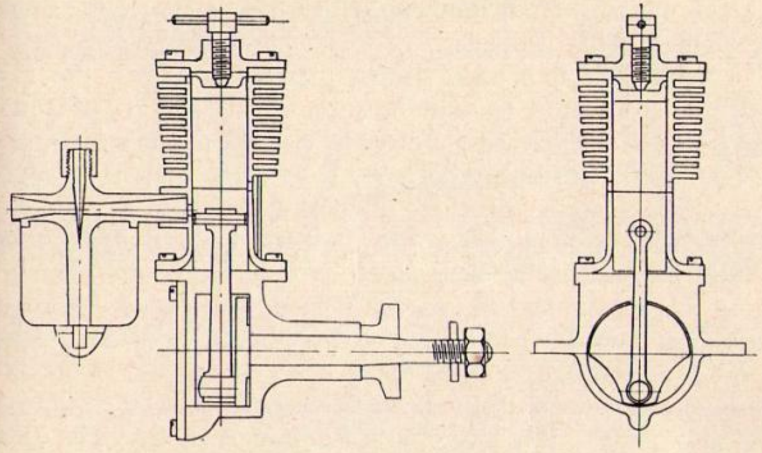


Fig. 27. The original 2-c.c. "Majesco."

Mark IV 3.5 c.c. engine) is a better "puller" as opposed to high speed "revver." (Fig. 50)

DIESEL DRAWINGS

Some readers with designing instincts will wish to study drawings of diesels. It is not possible in a book of this nature to reproduce the drawings full size. However, the reduced drawings of the simple 2.2 c.c. "Majesco" will give readers with a designing instinct some clues to get started with. (Fig. 27.) This engine has the simple cylinder induction port layout, whereas the engines seen in Figs. 10 and 11 are of the rotary induction crankshaft port type. The latter suits the high speed racing type of engine used for control line models of great speed.

SPINNERS AND FLYWHEELS

In the very early days of the diesel, it was considered necessary in many cases to fit a flywheel or a spinner with a groove in it to take a starting cord. This is now unnecessary and I would not own a diesel nowadays for aero work that could not be started by the simple swinging of the propeller.

The fact is that all the best British diesels start quite easily by swinging the propeller.

I remember one little British diesel that, when the first prototype was made, ran with most impressive power but would not start reasonably easily. I used to visit the manufacturer, and at one period, in those very early days of diesels, we thought that the only answer for these midget types was to fit a spinner with starting groove for a cord. This was being done by other people in England at that time on some larger diesels. We fitted this device and the engine started with reasonable regularity, but a cord is not really practicable on a model aeroplane. It is a nuisance, except in the hands of an expert, and inclined to become entangled with the propeller because it is so close to it and also tends to tear a very light fuselage to pieces. The value of fitting a baby diesel is lost if a heavy fuselage has to be made to resist the starting efforts!

We therefore decided that if one could not make a midget type start without such a handicap, the midget would be ruled out of court as a really practicable engine, and be relegated to the freak class. It was evident that the fuel did not become atomised and pumped up to the cylinder-head in that form from the crankcase. The whole problem was suddenly and very quickly solved by fitting a much smaller venturi tube to the carburettor, and hey-presto, the engine started like a big-un, or very nearly so, and yet the power did not stop. I should mention that the engine was already an easy one to turn and therefore friction did not enter into the problem.

Now there we have a most valuable tip, for the man who fancies his chance at making diesel engines and who finds he must use a flywheel to start. I have experienced this in the case of other engines and am now quite satisfied that if any aero-engine *must* have a flywheel spinner to start by cord, it is an admission of failure in at least one direction.

The reader will probably have noticed that a number of the early diesels were fitted with these starting cord spinners. I can well remember in the early days of petrol engines, many years ago, having to fit starting pulleys. No one does this

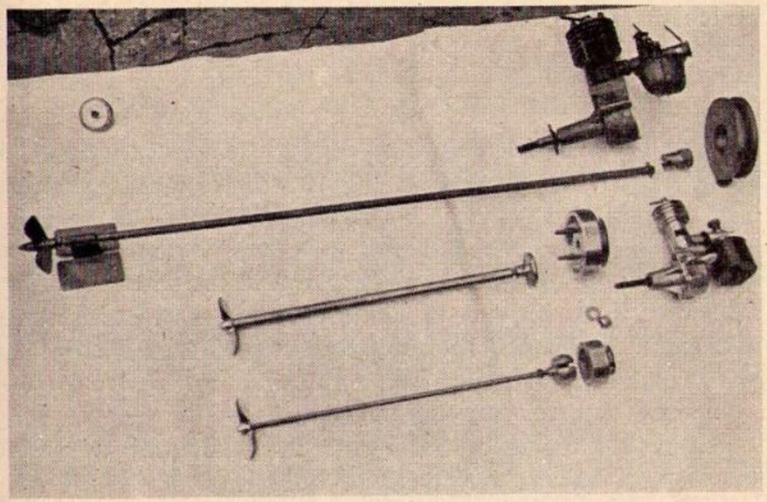


Fig. 28. A selection of boat transmissions. The stern tube is located through the hull floor with plastic wood. All flywheels have grooves for the starting belt. Universal joints are by nut and pin, or pegs and slotted disc, or by ball joint inside a recessed flywheel as in the "E.D. Bee" transmission seen at the bottom of the photograph.

nowadays. History has repeated itself apparently in the case of the diesel!

The cure is a combination of a good piston fit, easy turning of the engine, correct transfer port and correct venturi tube size of the carburettor, and, of course, sound port timing.

The flywheel I have developed for boat and car work for engines between 2.4 c.c. to 5 c.c. is made from brass. It weighs $\frac{3}{4}$ lb. and is $2\frac{1}{2}$ in. diameter and $\frac{1}{2}$ in. across the rim. It is not turned out in the centre other than to take the special coupling nut. (*See Fig.* 28.) A steel propeller shaft with a small steel ball and cross pin on the end fits into the coupling nut.

In Chapter IV I have included a photograph which shows how to start up a boat or car by cord. It is advisable to use a small driving peg fitted to the backplate on the engine shaft, otherwise a flywheel tends to come loose if a diesel backfires. On the other hand, I have found a large peg is too rigid for a wooden propeller, as it often causes it to fly to pieces, which can be dangerous.

MAKERS' RATINGS

I am never particularly impressed by advertisements or statements that the so and so engine will do 6,000 or 10,000 r.p.m. or is rated at 1/6 h.p. or 1/10 h.p. These statements mean little. Under what load did they do these "r.p.m." and how was the h.p. calculated? I prefer practical thrust comparisons or practical feats of flying model aircraft of certain wing spans and weights of propelling boats and cars of certain sizes and types at given speeds. Such data give a practical answer to what may be expected from an engine on purchase.

The most extravagant and meaningless claims of r.p.m. and h.p. are often made by makers, particularly overseas, and when I hear protagonists discussing these claims in supporting their favourite engines I am reminded of Mark Twain's remark, "Be honest. This will gratify some people and astonish everybody."

I am giving examples, in Chapter VI, of models that have been operated by different capacity engines.

"DIESELS RUN SLOWER"

It is most important for the user of diesel engines to realise that these engines develop their power at lower revolutions than the glow plug motor. The smaller the engine, however, the higher the r.p.m. of which it is capable, and the minute size diesel engines do actually revolve at speeds comparable with the average petrol engine. As their size goes up the maximum revolutions of which they are capable go down and it is quite easy to notice the difference in speed between a 0.7 c.c. engine and one of 2 c.c. Engines between 3.5 c.c. and 5 c.c. produce their power at considerably lower r.p.m. and swing a proportionately larger diameter propeller.

When 10 c.c. is reached, the r.p.m. is still further reduced and we are approaching the slow speed and high torque combination which is the characteristic of the full-sized diesel motor.

The very tiny engines have so small a combustion space that

combustion quickly spreads throughout the combustion area. The larger engines with their larger space take longer for the flame of combustion to spread. This feature is important, as it has a direct bearing on the propeller size which is employed (see Chapter V). A lower speed of revolutions and higher torque if properly applied through suitable propellers, etc., does not mean a lower power output. This has been explained earlier in the chapter under the heading—"The Extra Power of the Diesel." The recent development of the "square" short stroke big-bore diesels for racing models remarked upon in this chapter, brings this special type of diesel nearer the high r.p.m. of the petrol or glow plug engine.

THE THREE TYPES OF INDUCTION

The first is the normal cylinder port, as shown in Fig. 2, and also in Fig. 36, of the small Mills diesel in section.

The second is the rotary disc induction through the rear of the crankcase as seen in Fig. 20, showing the Mills 2.4 c.c., a long induction period can be arranged on this type. The "E.D. Bee" and the larger "Mark IV" also use this method. (See Figs. 47A and 50.)

The third method is the rotary crankshaft inlet port, much used by high revving motors. See Fig. 10, the "Amco" 3.5 c.c. diesel and also Fig. 9, the "Elfin" diesels which employ this type of induction.

CHAPTER II

BRITISH AND CONTINENTAL DIESEL ENGINES—PLANS AND CASTINGS

THE BIRTH OF THE DIESEL

The Swiss "Dyno I" was the first practical commercially-produced model diesel, which set the model world going on this type. It also set a fashion that is seen in a number of diesels made in different countries, namely, the long rectangular extension of the crankcase of Egyptian architectural appearance. As examples, the reader will see this feature in the Danish diesel "Mikro," the early British "Mills," the German "Eisfeldt" diesel, photographs of which are given in this chapter. There is something attractive in this shape but, of course, it is not vital to success, although it is a convenient method of stiffening up the engine. There are various other ways of attaining this object.

The war appears to have kept the glad tidings of the diesel's birth segregated to Europe, where development spread through France, Germany and Italy, and later to the Scandinavian countries.

The first serious British experiments seem to have occurred after the war, when the "iron curtain" of the Continent was raised. I was interested to learn that Mr. Lennan, of Scotland, first built a diesel in 1943, which was slowly developed over a period of two years. Mr. Sparey started experiments in 1944.

Mr. R. Trevithick is an amateur well known for his beautiful workmanship and novelty of outlook in designing model I.C. engines. Fig. 29 shows a very beautiful little engine made by him. The following are notes he has kindly sent me in connection with this engine, which shows amateur construction at its best.

"Engine, $\frac{1}{4}$ in. bore × $\frac{5}{16}$ in. stroke.

"Cylinder, alloy steel, machined from solid screwed into

crankcase 40 T.P.I.

"Transfer port and inlet brazed on.

"Crankcase, from solid dural, main bearing centrifugal cast-iron, burnished to size, as it is impossible to eliminate lapping compound from cast-iron.

"Crankshaft, from solid, 5/32 in. dia. in housing, tapered to $\frac{1}{8}$ in. at front. Screwed 60 T.P.I. pin. case-hardened.

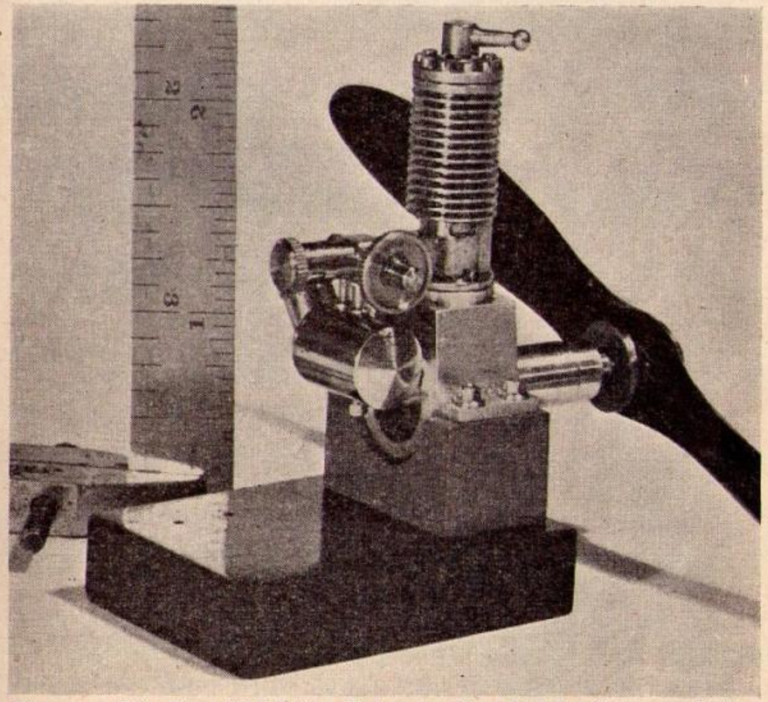


Fig. 29. Mr. Trevithick's miniature diesel, $\frac{1}{4}$-in. bore × $\frac{5}{16}$-in. stroke. An example of beautiful amateur construction.

"Pistons, first quality mild steel, case-hardened in electric furnace.

"Head adjustment, 3/32 in. dia. × 60 T.P.I.

"Connecting-rod, tool steel hardened.

"Carburettor intakes, venturi diameters, jet 0.003 in. hardened. Jet (adjustable), 3/32 in. × 60 T.P.I. hardened.

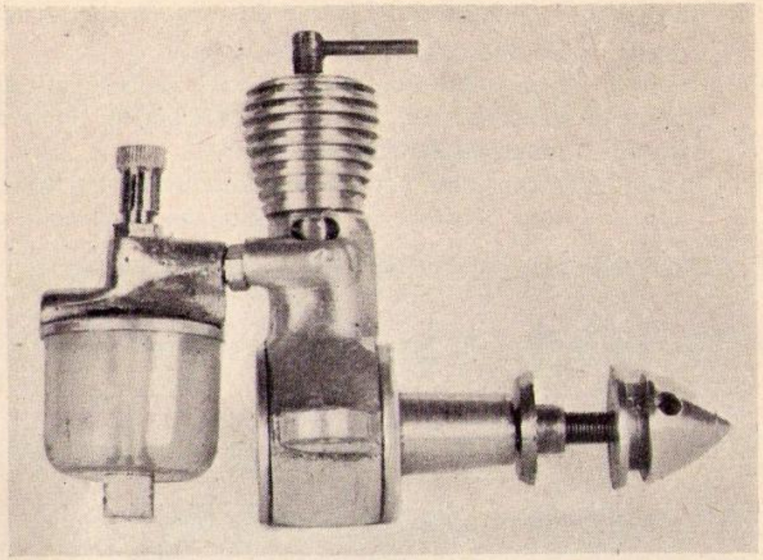


Fig. 30. A tiny commercial diesel with a reputation is the 0.3 c.c. Kalper, which drives a propeller of 7 in. diameter and 4 in. pitch.

"All lapping finished with magnesium oxide 0.0003 mm. grain, boxwood laps: rough lapping cast-iron or brass adjustable laps. All the work on this engine was carried out on a 3½-in. centre English lathe, now 16 years of age —except drilling the jet, which was done on a Wolf-Jahn watchmaker's lathe of 40 mm. centre."

Mr. Trevithick has some points to make which I will quote, because I feel sure the amateur constructor will consider them of interest, coming from such a well-known amateur authority, also because his remarks substantiate those I make farther on in this chapter in connection with amateur construction.

Mr. Trevithick says in his letter to me, "Last evening I got this latest effort running on 'Mills' fuel. At present it is touchy, but very fast—a little further work will have to be put in before it will 'pass,' I fear. There is a very tiny leak between barrel and the crankcase—apparently this should have been a lapped fit. The amount of lapping on these, and

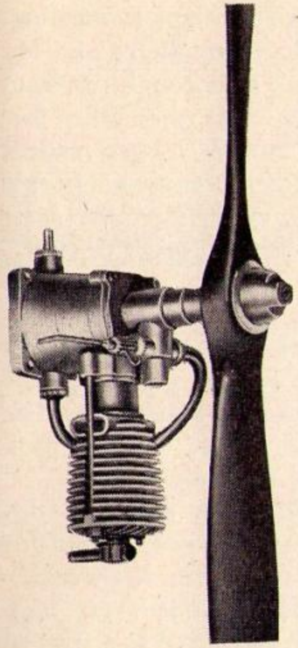


Fig. 31. The "Frog 100" is a 1 c.c. diesel fitted with a 9 in. diameter plastic propeller. The price is low and the performance is high. Weight bare 3.25 oz., static thrust 12 oz. +. A modified carburettor has recently much enhanced the performance. It is known as the "Spray-bar."

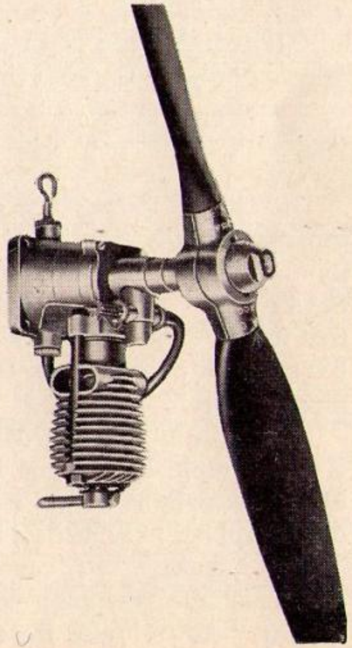


Fig. 32. The "Frog 180" has a larger capacity than the "100." Bare weight is 3.75 oz., static thrust 20 oz., 10 in. diameter adjustable pitch airscrew fitted.

the time taken upon truing and making fresh laps is startling. The bore is $\frac{1}{4}$ in. and the stroke 11/32 in.; weight $1\frac{1}{4}$ oz. My lathe is now sixteen years old and I think a thorough overhaul of the alignments and headstock bearings seems to be called for, as the limits of these tiny engines are 'close.' I have made a very free-running rev. counter for these tiny engines—people are apt to be optimistic over engine revs. My experience suggests that engines with lower revs. are much easier to start."

BRITISH COMMERCIAL ENGINES

From the commercial angle, as far as I am aware, the first engines to be produced in this country for the general public were by the firms "Leesil," "Mills" and "Majesco." The latter two firms in considerable numbers. The "Leesil" took their engine off the market shortly after its inauguration.

Although we were late starting with the diesel in this country, we have already forged ahead. Our power output for weight of engine is, generally speaking, the best in the world.

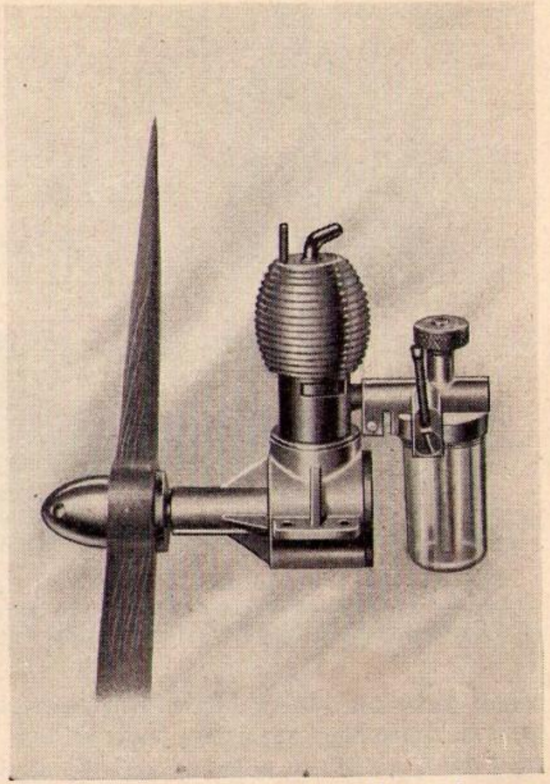
The control-line craze in Britain has demanded very high power output for speedy models. This has acted as a spur to engine designers—as a result power output of model diesel engines in Britain has been raised to a very high pitch during the past two years.

The baby "Kalper" weighs a little over 1 oz., and has a capacity of only 0.3 c.c.—I have one of these delightful little motors. They have become very popular in the midget class. See Fig. 30. A 7 in. diam. by 2 in. pitch propeller is used for free flight. The Allbon Dart of 0.5 c.c. weighing only 1.2 oz. has superior power to the fractional c.c. midget American glow plug motors.

The British "Majesco Mite" of 0.7 c.c., weighing only $1\frac{1}{2}$ oz., is an example of extreme lightness for its 8 oz. static thrust. Owing to its light weight it is a suitable power unit for models of the rubber "Wakefield" size—(Free flight). See Fig. 34.

The "Amco" 3.5 c.c. diesel is an ultra modern engine developed for very high speeds to suit control-line flying. I use my "Amco" also for free flight. It is one of the highest

Fig. 33. The 0.87 c.c. Amco is a well known baby engine with a fine performance and $2\frac{3}{8}$ in. high.



speed diesels in existence. Exhaust porting is located completely around the cylinder with supporting bridges. There is an imposing inlet port via the crankshaft. On first viewing this diesel it is difficult to realise that such a comparatively large capacity as 3.5 c.c. in. can be housed in such a compact and small design. This motor must be allowed to do its work with a suitable propeller that permits high revolutions, for slower speeds kill output. The reason, apart from the porting mentioned above, for high power output with exceptionally high revolutions is that the stroke is short in relation to the bore. Thus with a short stroke the engine can rev. without excessive piston speed. The power curve reveals an output practically constant from 9,000 to 13,000 r.p.m., which is exceptional for a model

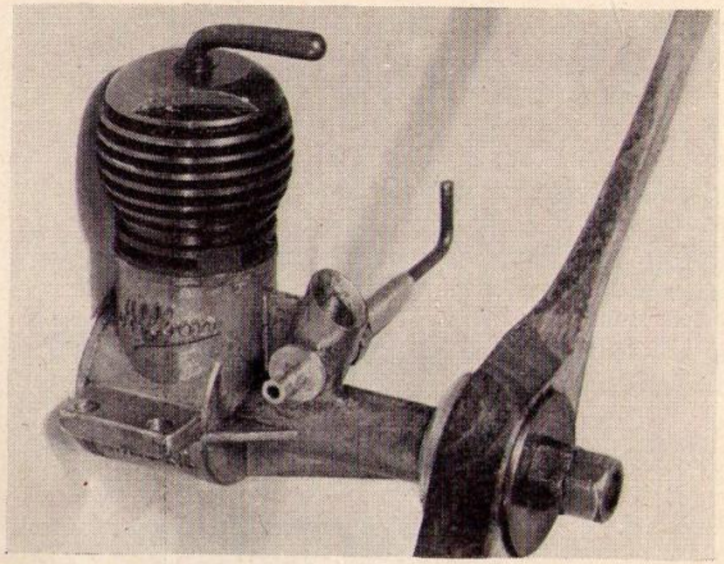


Fig. 34. The "Allbon Dart" of only 0.5 c.c. has exceptional power, capable of flying models up to 48 in. span. It is the British reply to the American Midget Glow-plug motors.

diesel and more in keeping with a glow-plug engine. A 9 in. by 8 in. propeller suits stunt control line work, whilst 10 in. by 6 in. is suitable for larger and lighter loaded C/L models. Speed models are suited by an 8 in. by 10 in. prop. The weight is 3.75 oz. without tank. Bore, .675 in. Stroke .5625 in., which makes a nearly "square engine." Refer back to Fig. 10 which shows this interesting engine.

The 0.87 c.c. Amco 87 has now firmly established itself as a particularly impressive little power producer and a good starter. A large number of these engines are already in circulation. Fig. 33 shows the clean design of normal 3-port type.

The "Frog" range of diesels are noted for their power, the introduction of plastic propellers, and their extraordinarily reasonable prices. I have used these diesels in many of my models, and watched their development from the early days of British diesels. They are first-class value for money.

The combined cone tank and engine mount makes them easy to bolt to a fuselage nose former. The tank permits upright or inverted mounting by simply changing the filler cap and the fuel line plug. A timer fuel cut-off can be provided integral with the filler cap. Control-line fans can mount their "Frog" motors, including the glow-plug "160" version, as "sidewinders" with the cylinder on its side, and inverted flight can be indulged in, without resort to a special fuel tank, if the neoprene fuel line is taken one complete turn around the tank. This prevents surge of the fuel. For normal free flight, I personally mount my "Frogs" inverted. They are particularly good starters in this position as soon as one realises that flooding of the motor does not pay. I open the needle-valve one turn, suck in once only when fuel should be found on the choking finger, close the needle-valve, start up, and as the motor clears itself of fuel, open up to the normal run position of approximately half a turn open. A slight adjustment of the compression lever completes a sure operation.

The "Frog 100" has a capacity of 1 c.c. and drives a 9 in. or 8 in. diameter plastic propeller. The bare weight of engine is 3.25 oz. The static thrust is well over 12 oz. This has been much enhanced recently by a modified and improved "carburettor" and fuel feed to needle valve, known as the "Spray-bar." The rear of the cone tank has been thickened so that there is no difficulty in removing the filler cap. I fly my little 45½ in. span "Meteorite" and baby flying boat "Wee See Bee," described in the last chapter, powered by Frog engines. The firm have recently introduced an 8 in. high performance "unbreakable" propeller, also made from plastic material. Owners should always check balance of propellers as an unbalanced propeller causes bad vibration.

The "Frog 180" is a larger and more powerful engine than the "100," the capacity being 1.66 c.c. The motor swings a 10-in. diameter propeller, which in this case is adjustable for pitch by a simple clamping boss. This is a useful feature for changing to a higher pitch for control line speeds, which are usually higher. Appearance and dimensions are almost identical to the "100."

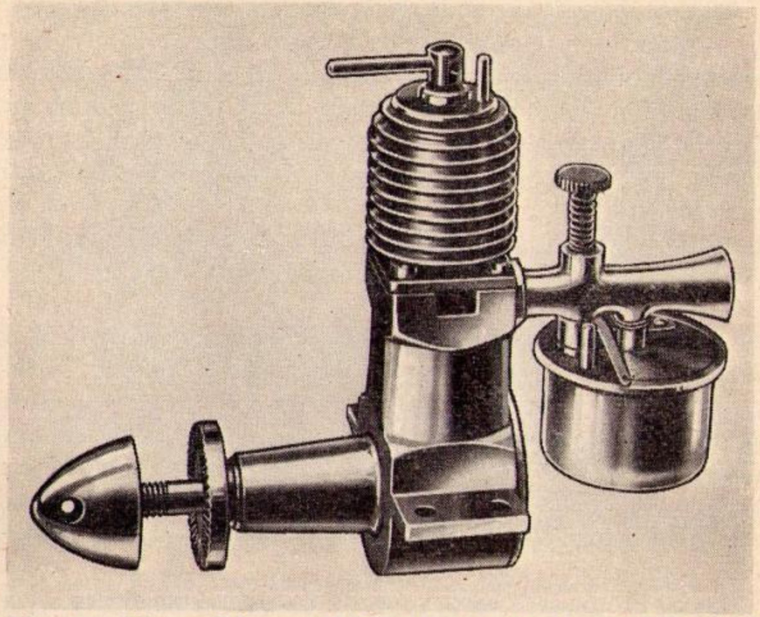


Fig. 35. The well-known " Mills " 1.3 c.c. diesel of British make has recently been much improved in appearance and performance, with a weight reduction to only 3½ oz. The static thrust is claimed to be up to 20 oz.

Figs. 31 and 32 show these engines. The adjustable pitch propeller will be noticed in Fig. 32. The " Frog 160 " glow-plug engine, which has an impressive performance is described in my book *Model Glow-Plug Engines.*

The new " Frog 250 " diesel is a particularly good looker with an excellent performance of the high speed variety. I particularly like the remote control needle-valve which saves possible damage to the fingers and makes for better fuel adjustment because the operator's mind is at rest. I also highly approve of the fitting of a fuel tank, which so many manufacturers evade under the umbrella that the owner will be only control line flying in all probability, and therefore can make his own tank. This is false reasoning, for even a control line fan likes to place his new motor on the bench and run it in with

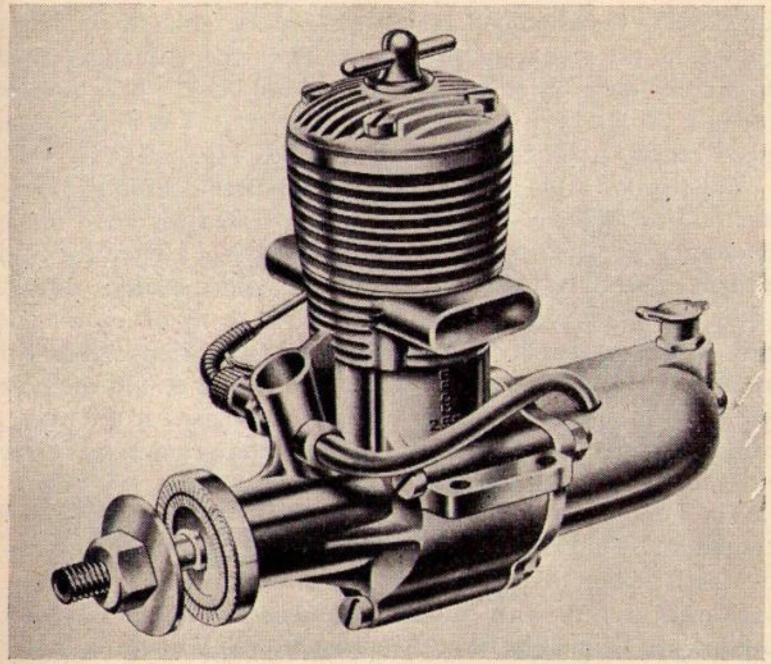


Fig. 35A. The new " Frog 250 " diesel has a capacity of 2.49 c.c. Note the neat tank design and remote needle valve control.

tank conveniently *in situ.* The free flight enthusiast, and there are many still in existence together with radio fans, naturally wants a fuel tank ready built in. Furthermore, many a new modeller who buys his first engine has not the experience to build a tank or fit a commercial extra in the correct position for good flow of fuel. As a result bad fuel flow often gets an otherwise excellent engine a bad name. A tankless engine must reduce sales far more than some manufacturers imagine, and it is doubtful if the few pence saved is a sound policy.

Frogs do not fail in this respect, although their engines are sold at the most competitive prices, and what is more the tank is made so that it can be disconnected in a moment to connect up to a larger control line tank if desired. The fuel line is merely pulled out of the existing "250" tank, and the tank removed by a screw from the rear crankcase cover. The finish and appearance of this engine is good and on American lines. The bore is .580 in. Stroke .575 in. Cubic capacity, 2.49. Weight $5\frac{1}{2}$ oz. Speed range, 2,000 to 10,000 r.p.m. See Fig. 35A.

The firm of Mills have a first class reputation from the early days of British diesels. The engines are noted for good finish and sound workmanship allied to easy starting. They are sold in three sizes. The baby, the middle size, and the larger 2.4 c.c. motor. Like every modeller, I have fitted many of my models with Mills engines. Last Christmas I was responsible for organising a five week demonstration of indoor round the pole flying and car running. I chose a 0.75 c.c. baby for the flying, and a 1.3 c.c. motor for the car. Those engines ran every day without a fault with absolutely reliable starting every time.

The famous 1.3 c.c. Mills seen in Fig. 35 started the firm's reputation. This engine has steadily been improved in appearance and power, over the years. Power exceeding 0.10 h.p. gives 9,000 r.p.m. with standard propeller. Weight is $3\frac{1}{2}$ oz. Engines are claimed to be at their best after 400 hrs. running.

The baby 0.75 c.c. type makes an ideal little motor for small model aircraft and boats. The weight is only $1\frac{3}{4}$ oz. Bore .33 in. Stroke .52 in. Propeller 8 in. by 4 in. Max. power at 10,000 r.p.m. A new "popular" version of this motor is now produced without cut out at a cheaper price. See Fig. 7.

The larger Mills "Universal" 2.4 c.c. diesel departs from the firm's normal practice of induction system, adopting a rotary disc at the rear of the crankcase which can be seen in Fig. 20 and Fig. 43. This engine has an excellent performance with flexibility, making a good free flight engine for medium size aircraft and boats, as well as control line and cars. The bore is $\frac{1}{2}$ in., stroke $\frac{3}{4}$ in. Speed 8,000 r.p.m. (10 in. by 5 in. prop.). Thrust 32 oz. Power 18 h.p. Max. power at 9,000 to 10,000 r.p.m. I have one of these engines fitted to my speed boat "Flying Fish" seen in the last chapter.

It would scarcely be expected that a diesel of the minute size

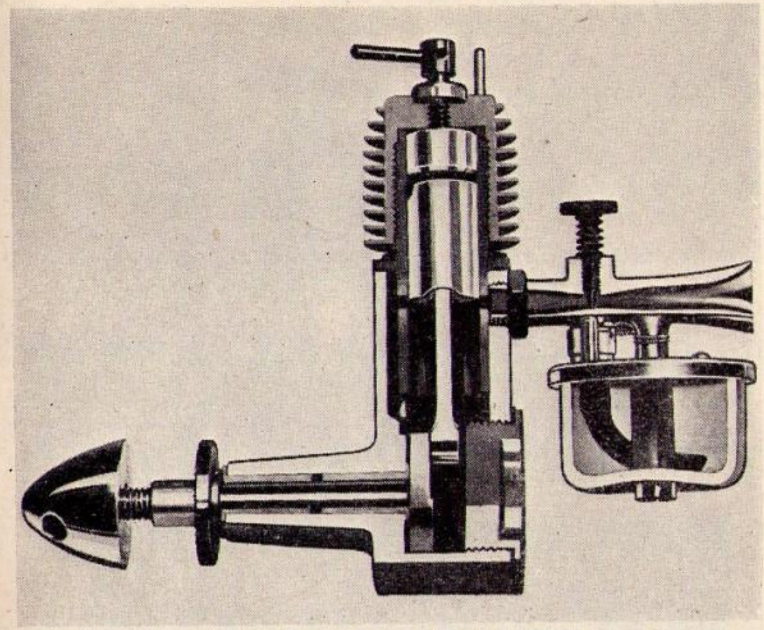


Fig. 36. This sectionalised view of the "Mills" diesel emphasises robust construction combined with light weight and clean design.

of only 0.2 c.c. could become a reliable commercial proposition at a reasonable price. And yet I have such a motor in my possession. It runs like an angry little insect to the end of each tank full of fuel. The makers suggest that a starting cord around the groove of the spinner should be used to start as the propeller weight, etc., is so small. After the first few days starting in this manner, which tends to wreck a very small and lightly-built model of the rubber duration class suitable for such an engine, I found that with reasonable care I could reliably start by swinging the propeller, which, by the way, is of only 5 in. diameter. It is a lovely little motor and is known as the "Hawk K" 0.2 c.c. diesel. The engine weighs 1 oz., having a bore of $\frac{1}{4}$ in. and stroke of $1\frac{1}{4}$ in.

The "E.R.E." (English Racing Engines) was specially designed for speedy control line work. This 2.48 c.c. diesel has

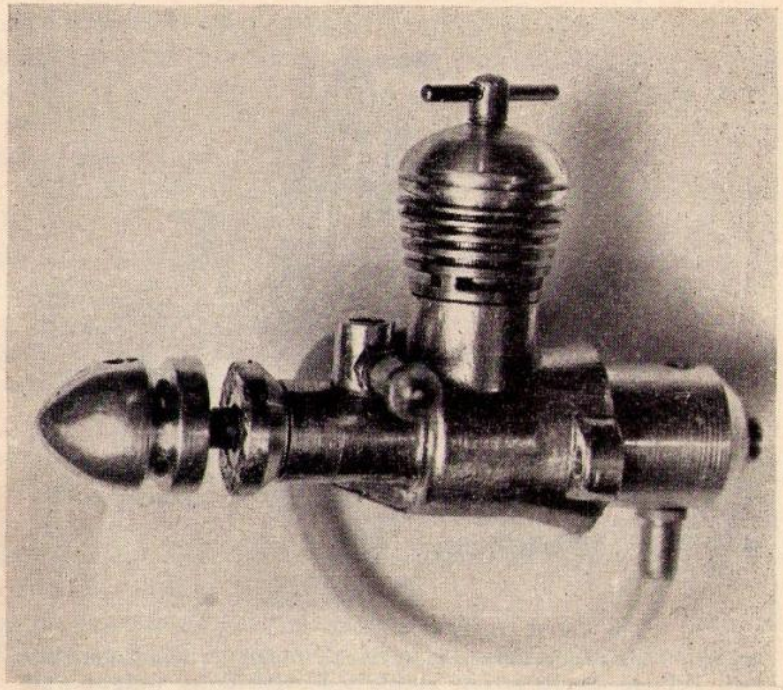


Fig. 37. Can you beat this? It is a practical commercially produced diesel of only 0.2 c.c. and drives a 5 in. diameter propeller with an exhaust note like an angry insect. The "'K' Hawk," Mark II.

an exhaust note not unlike a petrol motor in crackle. It has twin exhaust ports of very generous size and twin transfer ports. An air filter is fitted to the forward facing inlet. The carburettor can be changed to either side of the motor, thus making easy the mounting of the engine on its side, which has become a popular habit for control liners. There is a positive contra-piston stop lever which locks the contra-piston lever after the correct position has been found. The transfer of mixture from carburettor to combustion chamber is in an almost straight line. I have seen this little engine performing in a control line model with great zest.

The E.R.E. is also produced as a car unit complete with

back axle and two centrifugal clutches of great simplicity and effectiveness fitted into dummy rear wheel brake drums. The unit can be clamped straight on to a car chassis tray, and except for arranging a suitable fuel tank, that is all there is to it! Several of the Baigent cars shown in Chapter VI, are fitted with this unit which has been developed from the original B.M.P. by Mr. Baigent. Fig. 38 shows the car unit cum back axle. The clutch drums are attached to the back wheels, and therefore do not appear in the photograph.

A British engine having the feature of compression adjustment by eccentric crankshaft bearing is the "Airstar." This engine has a number of interesting features. No nuts or bolts are used in the assembly. Although the motor has a

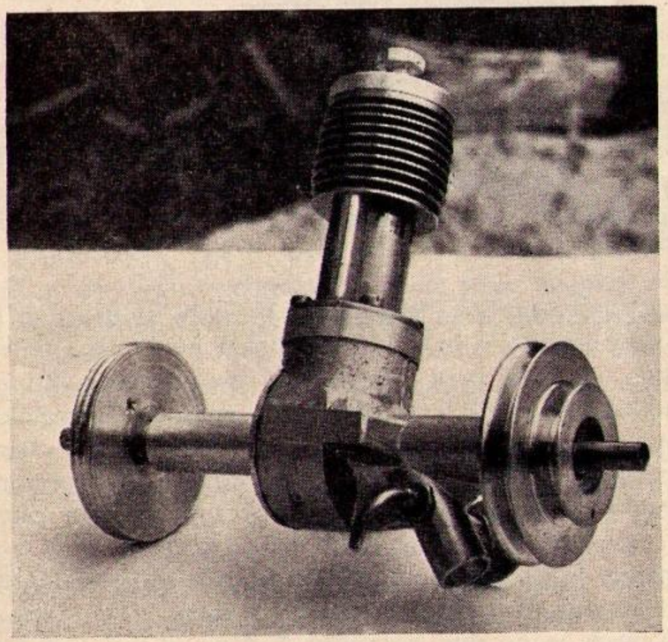


Fig. 38. The "E.R.E." 2.48 c.c. diesel car unit comprises direct drive with two centrifugal clutches in the dummy rear wheel brake drums.

Fig. 39. The new "Airstar" of 2.147 c.c. has adjustable compression by means of the lever seen behind the propeller boss, which alters the crankshaft bearing mounted on an eccentric. The height of the motor is only 3¼ in., and it has a number of unusual features, including a fixed jet and adjustable air supply.

capacity of 2.147 c.c., the height is only 3¼ in., due to the eccentric bearing, which is made from gunmetal. The compression is altered by a lever behind the propeller, reminiscent of the variable spark lever of a petrol engine. This system eliminates the danger of breaking the connecting-rod or crankshaft by screwing a contra-piston too far down; furthermore, the contra-piston cannot leak or jam, because there is not one! Two tanks are provided. One suits ordinary work, and the alternative has gradations marked upon it to provide accurate measurements of fuel for competition work. There should be no flyaways using this method. A drain plug is fitted to the bottom of the crankcase. What a pity this is not a universal feature on all commercial engines. The German "Eisfeldt"

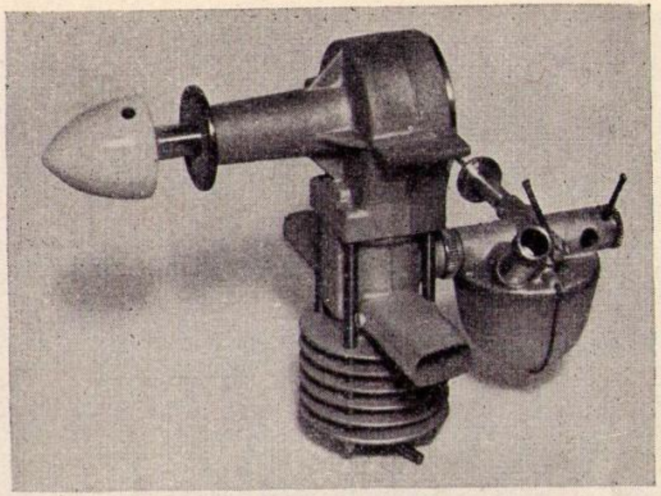


Fig. 40. The British 5-c.c. diesel "Eta" has contra-piston control, choke, and fuel cut-off, and a very fine "finish."

which I own is similarly fitted. Should one make a mistake and suspect an over-rich mixture, it is a moment's work to drain the crankcase and know how the mixture is when restarting operations commence. The "Airstar" has a fixed jet and an air throttle screw. The weight without its 10-in. diameter 6.5 in. pitch propeller is 5 oz. Altogether a most interesting engine. My "Airstar" is a good starter and a reliable performer. The unusual feature of a fixed fuel jet and controllable air supply works well in practice.

The E.T.A. "5" is a very well-finished British diesel of 4.9 c.c. Bore 0.6781 in., stroke 0.8593 in., weight 9½ oz., height 4.25 in. Consumption tests by the makers show an average running time of 1 min. per 3 c.c. of fuel. The tank holds 21 c.c. The induction has integral a sleeve choke fitted for remote control, and a fuel cut-off, for connection to a flight timer. Exhaust stacks and filler tubes are available in various lengths to suit cowling on a model. The contra-piston has a developed contour, giving a high efficiency combustion chamber.

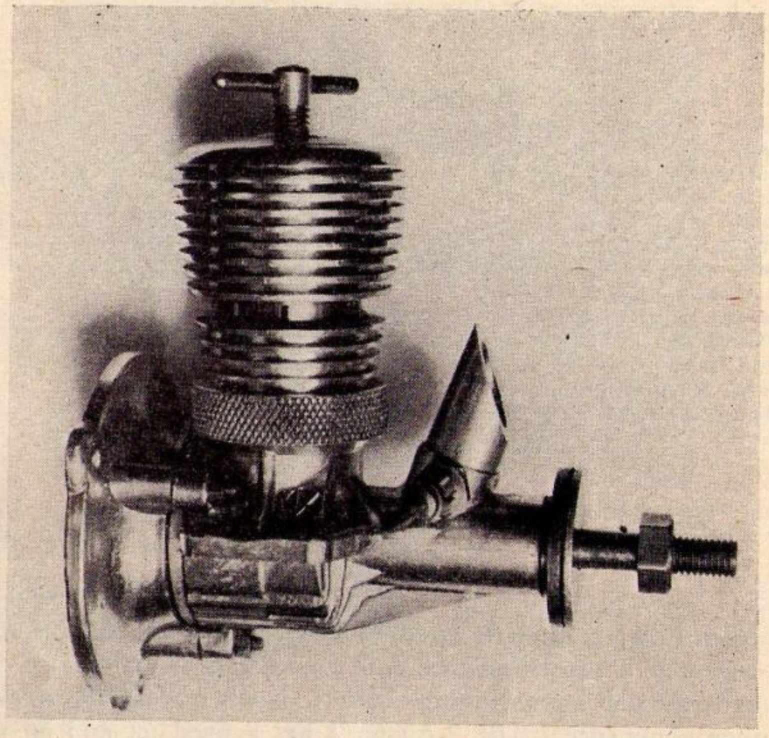


Fig. 41. The "K" 5-c.c. "Vulture," Mk. II, has a high performance and was designed for radio control and speed C/L models, cars and boats. Note the easy mount flanges, large induction port and ring of exhaust ports around cylinder.

A static thrust of 32 oz. using a 13-in. diameter propeller of 7 in. pitch, is claimed for this engine.

The new "Eta" type R has a most attractive appearance with red cylinder head and a carburettor having the "new look." A belled mouth is provided, but the usual tank is lacking, and in lieu a suitable tube for the fuel line from a stunt tank is arranged. The owner can therefore fit whatever tank he favours for control line flying. This engine is one of the best-looking and largest capacity British diesels. I have found my "Eta" fly large free-flight models up to nearly 7 ft. span with unfailing

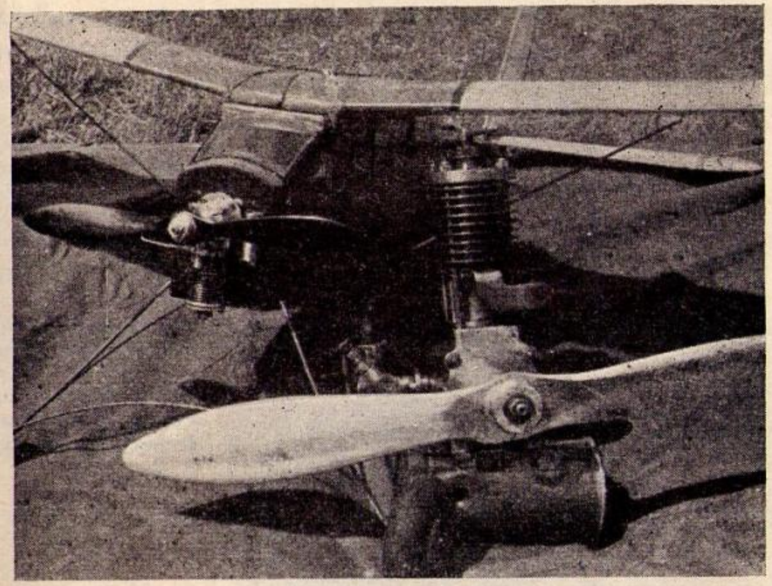


Fig. 42. This large 20-c.c. diesel was made by Mr. Court and is seen beside a "Frog" 1-c.c. The large engine is fitted to a full size dinghy hull of 10 ft. length, which it drives at approximately 3 knots. It answers the question—Can a model diesel be made successfully with a large capacity?

reliability. The same engine has now done a very large period of running, and starts as well, if not better, than when I had it new. The maximum brake horse power of the "Eta" has been discovered by an *Aeromodeller* test to be at 6,250 r.p.m. when a reading of 0.1805 b.h.p. was taken. The compression ratio is 12/1 to infinity. Airscrews: Free flight, 14 × 7 in.—12 × 8 in. Control-line, 12 × 10 in., 11 × 10 in.—10 × 12 in.

The "K" series of diesels include the tiny 0.2 c.c. already shown in Fig. 37.

The 5 c.c. "Vulture" seen in Fig. 41 is a high performance motor for speed models and also for radio control models, selling for a very reasonable price. The bore is $\frac{3}{4}$ in., stroke 11/16 in., height $3\frac{5}{8}$ in., weight $7\frac{1}{2}$ oz., r.p.m. with 10 in. by 6 in. prop. is 10,000 r.p.m. or 10 in. by 8 in. prop. 8,000. H.P.

at 9,000 r.p.m. is claimed to be ¼. Mounting by beam or radial.

The "K" Falcon 2 c.c. and the 1.9 c.c. "Kestrel" are practically identical in design details, having made their names control line flying.

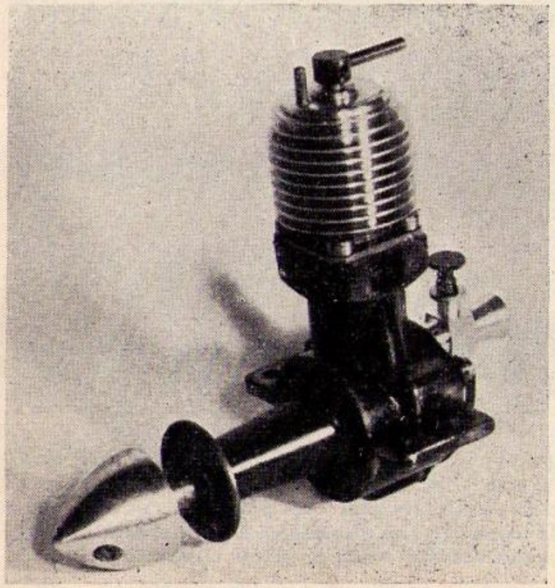


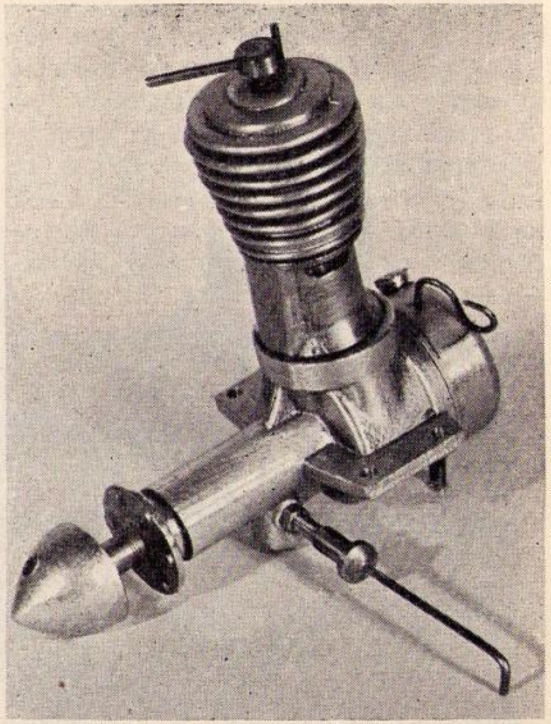
Fig. 43. The disc valve "Mills" 2.4 c.c. engine is noted for its high performance and reliability. This engine can be seen in section in Fig. 20.

The "Falcon" has bore $\frac{9}{16}$ in., stroke $\frac{9}{16}$ in., height 3 in., with radial or beam mounting. I wish more designs would incorporate this choice of mounting, which is most useful and praiseworthy.

The "Kestrel" has bore ½ in., stroke $\frac{9}{16}$ in., height 3 in., weight 3½ oz. Both these motors do 9,000 r.p.m. on an 8 in. by 6 in. propeller or 8,000 r.p.m., using an 8 in. by 8 in. propeller.

The 2.24 c.c. M.S. is a lightweight of 2.8 oz. and claims to be the lightest of its kind. I have tried one of these engines and found it a good starter and reliable runner. The unusual tank around the crankshaft is neat and lends itself to easy mounting, particularly as the radial mounting lugs make it a simple matter to bolt the engine up to a firewall. If the reader will study the

Fig. 44. The Reeves diesel of 3.4 c.c. has a rotary crankshaft valve and a good speed range from 2,000 to 7,000 r.p.m.



photograph of this engine he will note that the overhang is small, and the engine very compact.

The Foursome C.I. engine is made in limited quantities, but has a very good reputation and a clean appearance, as will be seen in the accompanying photograph. A contra-piston is fitted and the capacity is 1.2 c.c. The weight is 5 oz. and the claimed r.p.m. is 6,000 to 8,000, with an 11 in. diameter propeller. All bearing bushes, etc., are hardened, ground and lapped steel, as also is the cylinder and piston. I note with satisfaction that the makers wisely say in their instruction book, "Don't run your engine with contra-piston screwed down too far. You may get a few more revolutions, but a sweetly-running engine is impossible if you do."

The 1.2 c.c. "M.E.C." is a very light motor weighing only

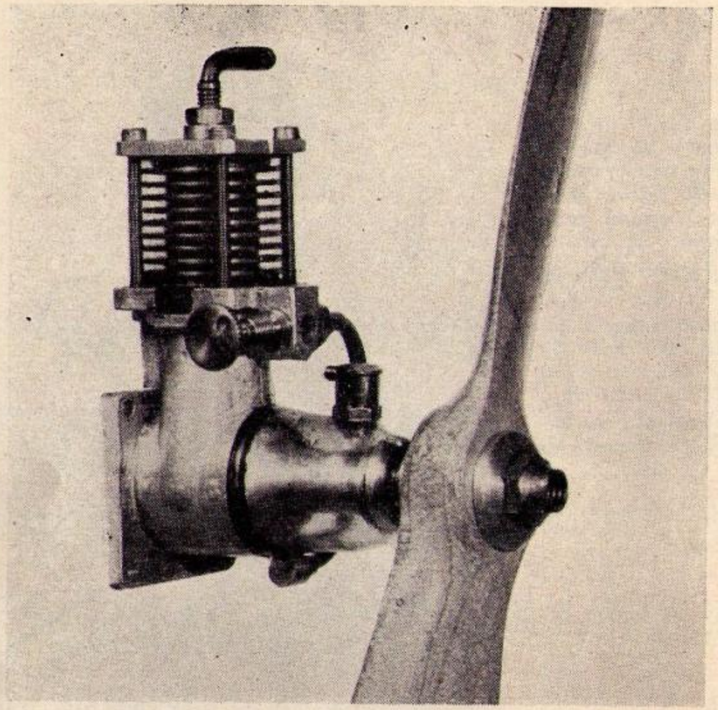


Fig. 45. The new M.S. 1.24 c.c. diesel weighs only 2.8 oz. and has a neat tank located around the crankshaft. The mounting is radial and permits quick and easy bolting to a firewall.

1½ oz. The makers claim it weighs one-third less than the lightest of its approximate c.c., and can be used on sailplanes without any other alteration than for fixing. The engine has a high power weight ratio. It has even flown a lightly-loaded 7 ft. span model with success. Only M.E.C. fuel is supposed to be used with this motor. The bore is 0.450 in., stroke 0.460 in. Height 1⅞ in., length 3⅛ in., width ¾ in., diameter of bulkhead fixing flange 1¼ in.

The " Elfin " competition diesels of 1.8 c.c. and 2.4 c.c., have a very attractive layout and appearance rather reminiscent of the famous little Arden. The exhaust ports are in similar manner located completely around the cylinder. These engines

have already gained a reputation for exceptional performance. The power of these motors can truly be called " terrific," and yet they are easy to start once one knows the technique.

The 2.4 c.c. " Elfin " is only a trifle heavier and larger in bulk than its brother of 1.8 c.c., but there is a big step up in power output. See Fig. 9. Both engines have done extremely well in control line events. I have used them much for high performance free flight and flying-boat work, as well as float plane models. One can not speak too highly of the " Elfin " engines. I now fly my little kit model monocoque high wing

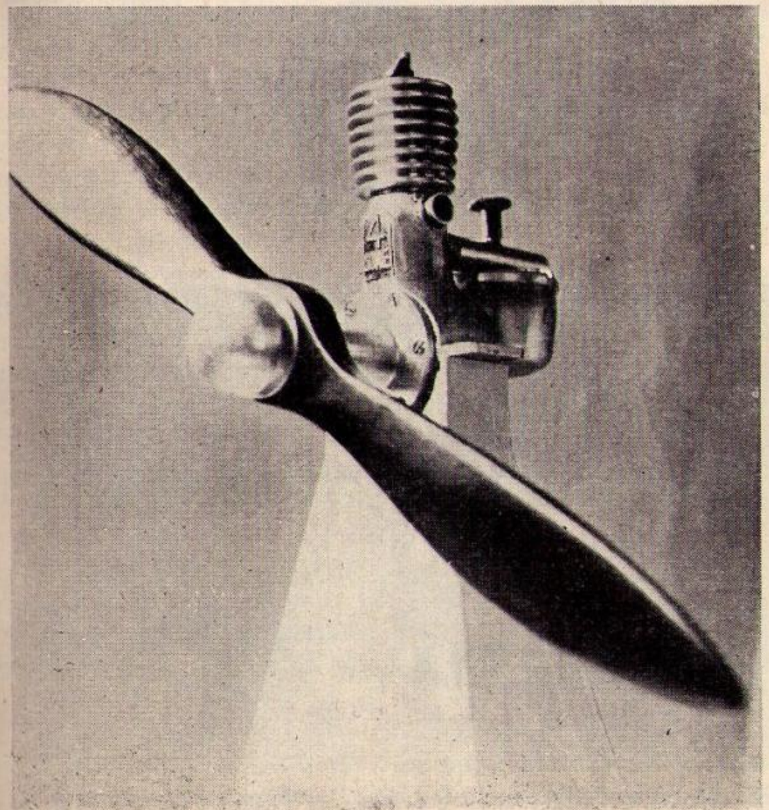


Fig. 46. The Foursome is a nice looking engine with a sound reputation. The capacity is 1.2 c.c. and weight is 5 oz.

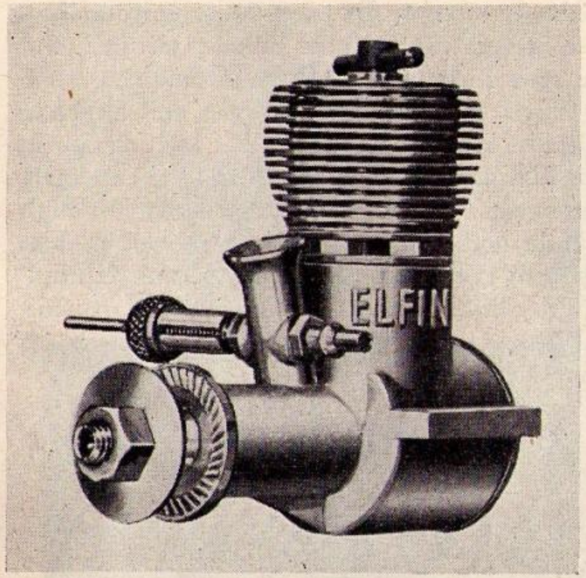


Fig. 47. The latest "Elfin" to suit Class I Competitions has a capacity of 1.49 c.c. and is fitted with the induction above the crankshaft. Engine weight is only 2½ oz. for very high power output.

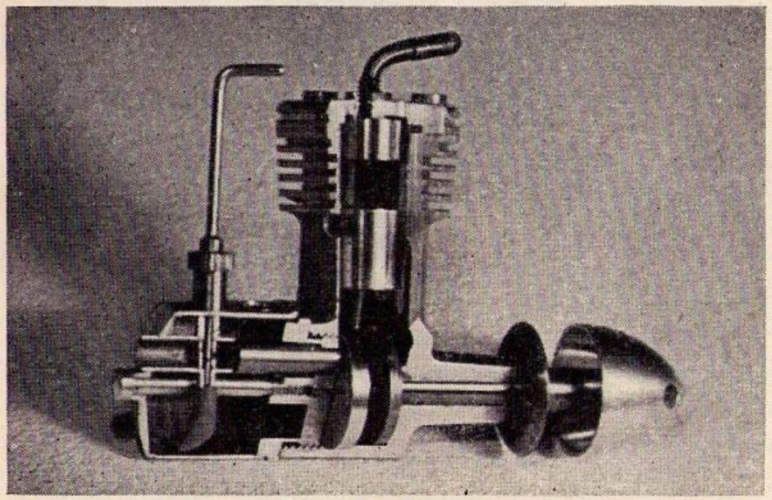


Fig. 47A. The little 1 c.c. "E.D. Bee" is here seen in section. Note compact design, and the disc inlet port with induction pipe, needle valve and fuel tank located at the rear of the crankcase.

"Satellite" with an "Elfin" installed. The model can be seen in the last chapter. The latest range to the "Elfin" family is the new 1.49 c.c. motor for "Class I" competition work. See Fig. 47. This little motor has its induction arranged on top of the crankshaft, and naturally retains the highly successful feature of a ring of exhaust ports around the cylinder which is a family feature of these motors.

The capacity is 1.49 c.c., bore 0.503 in., stroke 0.460 in., weight 2½ oz., height 2¼ in., length 2½ in. A cast iron piston and main bearing are fitted.

The E.D. has become a most popular name amongst modellers, with a very successful sporting and competition reputation to its credit. The standard and first E.D. of the line is 2 c.c. and has a contra-piston adjustment made by means of a slot in the cylinder head. The head can be screwed up or down by a coin or screwdriver inserted in the slot. This feature looks neat, but in practice can prove rather a trial when the coin tries to jump out of the slot due to running vibration on a light model aircraft. The next engine is known as the "Competition Special." This is also 2 c.c., but has an enhanced performance. The compression adjustment is made in the more orthodox manner by means of a hand tommy bar. The ports are larger for increased r.p.m. Colonel Taplin's son set up an official control-line record for speed in the class using one of these engines. His speed was 89-95 m.p.h., which is no mean performance for only 2 c.c.! At first he could only get 55 m.p.h., but by careful trimming and other developments he gradually improved the speed capabilities of his model, until he arrived at the record speed, which was done in the still air of a hangar, so that a "flat" flight path could be maintained. The propeller had a pitch of 14 in., which naturally made the take-off rather slow. Speed had to be built up gradually. This model of the E.D. range also won the "Control Line Flight Competition" at the British Nationals, 1948. The static thrust is 23 oz. as opposed to the 18 oz. of the standard Mark II engine. I have used the competition E.D. a great deal fitted to a flying-boat of small dimensions. The model seen flying in Fig. 77A is powered by a "Competition Special."

The Mark III diesel is suitable as either a glow-plug motor or a diesel by merely changing the head. I have found that when using a propeller of 9½ in. diameter, 8 in. pitch, I get a very hot performance on my control line model. As a diesel I also power my control line flying-boat with this engine, which takes the model off water easily. The engine is capable of high r.p.m., and has special porting to that end. It created a record for class "C" cars of 41.7 m.p.h. in 1948 as a diesel. The capacity is 2.4 c.c.

An E.D. of only 1 c.c. has recently been developed which sells at a highly competitive price and has already become a best seller. It is known as the E.D. Mark I (BEE). It has a bore 0.437, stroke 0.400, weight 2¾ oz. This little engine has proved itself to be a very fine and reliable member of the baby class, with exceptionally easy-starting virtues.

The latest member of the growing E.D. family is known as the "Mark IV" diesel or "Three-Forty-Six." The capacity

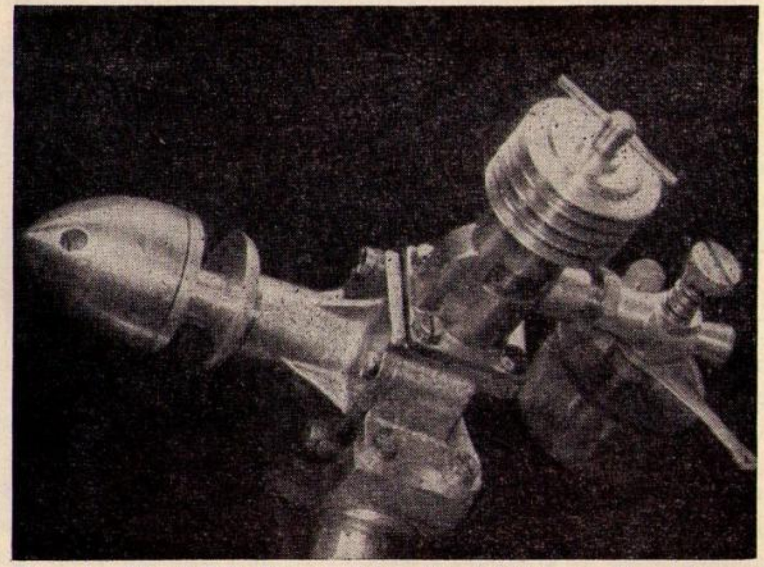


Fig. 48. The "E.D. Competition Special" 2 c.c. diesel has a line of competition successes. Larger porting is employed than on the standard 2 c.c. Mark II engine.

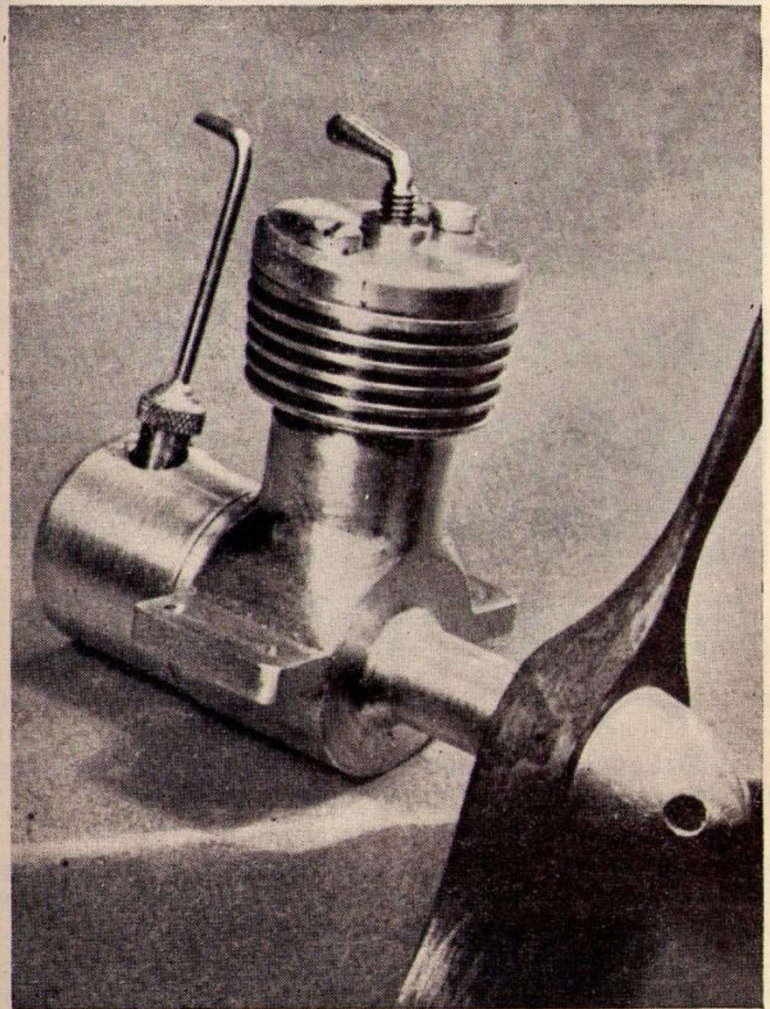


Fig. 49. The new E.D. Mark I weighs only 2¾ oz., and is 1 c.c. The engine has made a great name for itself owing to its robustness and high performance at a low initial cost.

is 3.46 c.c. See Fig. 50. This engine has a phenomenal amount of power for this medium capacity, and is a puller as well as a revver. A variety of propellers can be used to suit

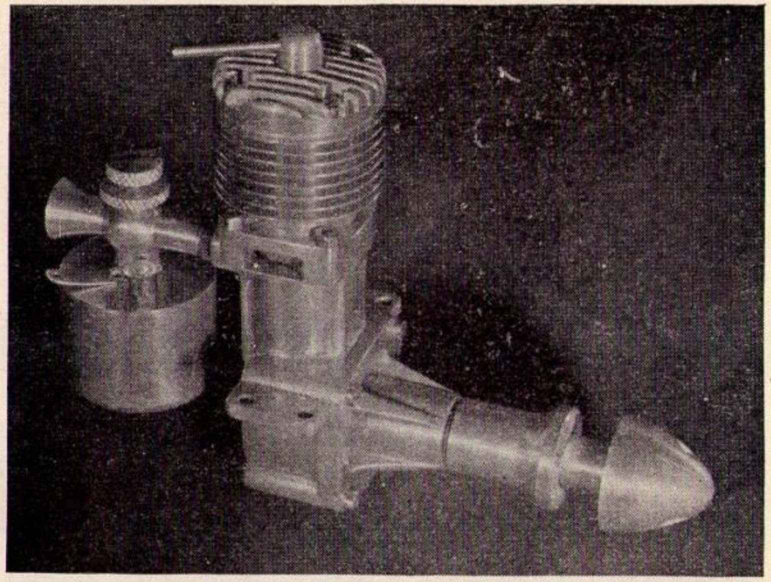


Fig. 49A. The "Wildcat" is a Lancashire engine of practical layout, having a desirably long shaft to suit streamlining of the model's nose. An unmachined kit is also obtainable.

the job, which may be from control line to radio models, boats or aircraft. I have used one of these motors to fly a heavy radio model weighing 6½ lb. It makes an ideal medium size flying-boat motor.

A disc rotary inlet valve is used, arranged at the rear crank-case cover, and the exhaust porting is really generous allowing for very quick evacuation of gases. This is altogether one of the most useful diesel engines of the year. The bore is 0.656 in., stroke 0.625 in., weight 5¾ oz., height 3 in., width, 1 in., length, with extended propeller shaft, hub and spinner, 4⅞ in. The makers claim 10,000 r.p.m. and 0.250 b.h.p., which one would imagine is no idle boast. Propellers, free-flight, 10 in. by 5 in., stunt C/L 9½ in. by 6 in., speed 8¼ in. by 9 in.

The E.D. firm also manufactures one of the most reliable three-valve radio receivers, with transmitter giving off a constant "carrier" modulated by signal. I have used this set a great

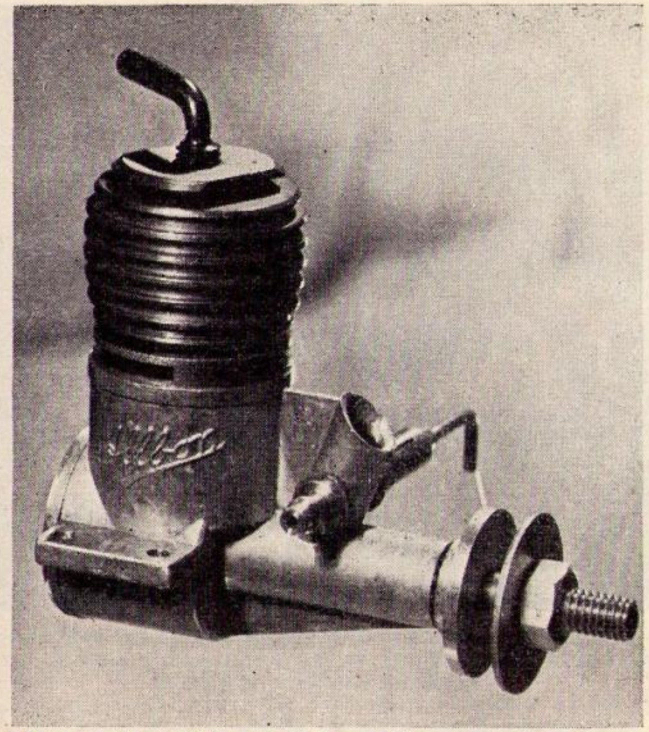


Fig. 49. The Allbon Javelin, with a capacity of 1.49 cu. in. has proved itself a very "hot" little power unit of exceptionally low weight.

deal. It is the most simple for the novice to tune, and operates on the rising current system on receipt of signal to operate the relay, which can be made entirely foolproof if the operator will but trouble to ensure that his grid-bias battery is well up. See Chap. VI.

The D.C. 350-3.5 c.c. diesel is a newcomer on high speed, short stroke, big port lines. The induction is via rotary crank-shaft valve. A fuel tank is located at the rear.

The "Reeves" 3.4 c.c. has a rotary crankshaft valve, and is suitable for planes from 2 ft. 6 in. span control-line to medium size free flight. The bore is 0.570 in., stroke 0.760 in., weight

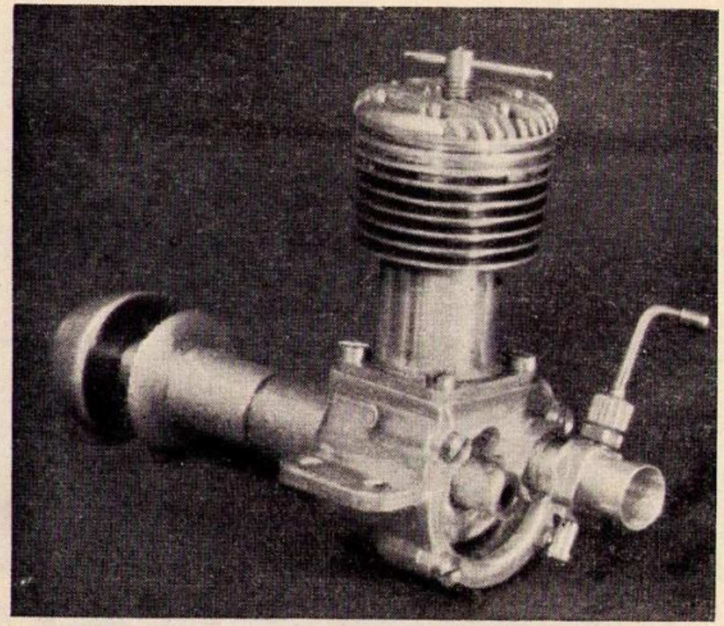


Fig. 50. The E.D. Mark IV is a useful engine for radio control models and boats owing to its outstanding power for the medium capacity of 3.4 c.c.

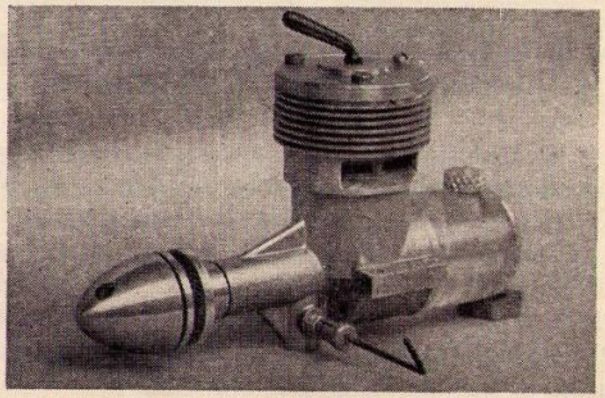


Fig. 50a. The D.C. 350 diesel has a capacity of 3.5 c.c. It is very modern in design. The rotary induction valve, large ports and very short stroke all denote high performance at high r.p.m.

approx. 6½ oz. The cut out is of the positive valve type, and the tank is located at the rear of the crankcase. This motor has a good speed range. See Fig. 44.

The 5 c.c. " Wildcat " Mark III diesel has a greatly improved appearance to match its enhanced performance since inception. Design is orthodox employing well finished die castings. The two port exhaust system is used with direct entry inlet. This system usually produces reliable performance with good starting and power output at the medium speed ranges. This type of performance is particularly suitable for free flight, boats, and radio controlled models. On test the " Wildcat " was found to be an excellent example of its type and very well balanced. The useful speed range appeared to be between 4,000 and 10,000 r.p.m., using a 13 in. by 6 in. propeller. Weight with tank is 9.2 oz., bore, 0.687 in., stroke 0.875 in. Capacity 5.24 cu. in. See Fig. 49A.

The " Allbon Javelin " was developed from the very " hot " little glow plug engine, the " Allbon Arrow," an example of which I possess. The " Javelin " diesel comes into the competition Class 1, with a capacity of 1.49 cu. in. It is a pretty little engine, in appearance rather reminiscent of the " Amco " 3.5 c.c. motor, shown in Fig. 10. The weight is 2¼ oz., height 2⅜ in., bore 0.525 in., stroke 0.420 in. Free flight prop. is 9 in. by 4 in., C/L stunt, 8 in. by 5 in.

The " Javelin " is considerably more powerful than its glow plug counterpart, and develops 0.1 b.h.p. at 10,000 r.p.m.

CONTINENTAL AND AMERICAN DESIGN

The following diesels shown are a selection of typical continental practice which, together with those seen elsewhere in the book, will give the reader a fair idea of the trend of design overseas.

The first engine has an interesting history. It is the best known of the German designs, and was acquired after the war during the occupation of Germany from a Nazi youth leader who used the engine during the war for the inculcation of airmindedness in the German Youth under Hitler's regime. I now have this "Eisfeldt" diesel of 6 c.c. in my possession. It is a very powerful motor, and flies my large flying-boat of 7 ft. 6 in. span very nicely over Poole water. (See Chapter VI.) When in Germany, I discovered that the Mercedes car firm made a special model diesel engine for Goering.

The Swiss "Dyno I" is alleged to be the father of commercial diesels that led the way. Details of this engine have been copied by various designers, the most notable being the Danish "Mikro."

The French, like the Scandinavian countries, have exploited the diesel motor to the full, and have produced some very successful engines, also suitable working models for their diesels. One of the best known is the 5 c.c. "Micron," a photograph of which appears at the beginning of this chapter. The "Micron" is also made in two other sizes, a 2.8 c.c. and a 0.8 c.c.—Fig. 55 shows the little 0.8 c.c. engine. "Allouchery" is another well-known French firm who are renowned for their excellent workmanship and sensible design. Various sizes of engines are made, and some have special long shafts to obtain a streamline effect in scale-type model aircraft with extended noses. Fig. 56 shows the 1½ c.c. "Allouchery." Monsieur Morin is responsible for a number of very interesting diesels of the fixed head and also adjustable compression type. The "Type 76" is on the market. His other designs are available for amateur construction. The Italians have made diesels of varying design.

In America the sales and manufacture of model petrol and glow-plug engines have been prodigious and more than in any other country in the world. For some unexplained reason, the development of the diesel has lagged.

Fixed heads seemed to be popular at the beginning of American diesel effort, as the Drone and the "Mite" were two of the first to be advertised in American model journals. It is interesting to note that the 0.30 cu. in. displacement Drone weighs 11 oz. and has a compression ration of 18 to 1, whilst the "Mite" of 0.099 cu. in. weighs 2.6/10 oz., and has a compression ratio of 13½ to 1. Another of the first diesels to be produced commer-

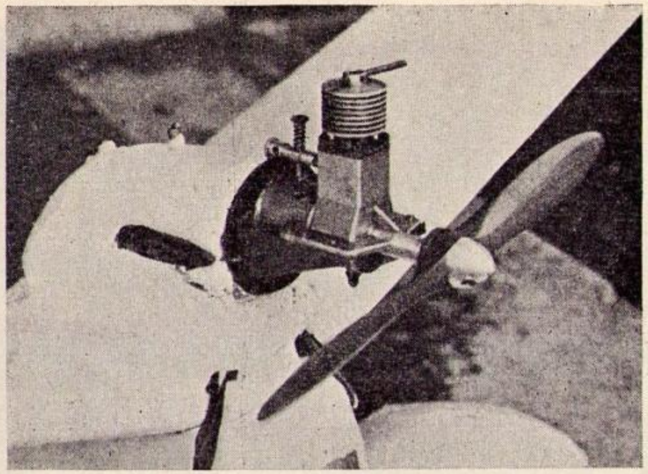


Fig. 51. The author's German 6 c.c. "Eisfeldt" diesel.

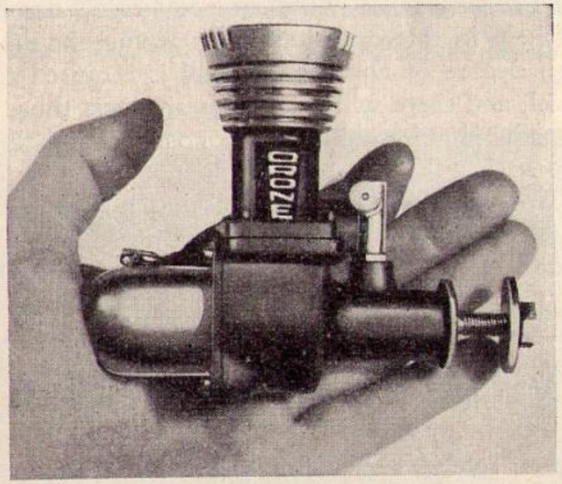


Fig. 52. An early American representative, the "Drone," which weighs 11 oz., and has a displacement of 30 cu. in. with an 18 to 1 compression ratio and a fixed head. Compression ratio can be altered by fitting cylinder-head washers of varying thickness.

cially in America, but fitted with a contra-piston, is the " C.I.E." diesel which comes in the American baby class " A," for models around 48 in. wing span. See Fig. 52, which shows the " Drone." This engine has a really " hot " performance and the usual American outstanding finish. An alternative variable compression head is now supplied if desired. The new head gives first-class starting when using British fuels. The engine flies my 8 ft. span free-flight model, which is very good going for a 5 c.c. diesel. The Drone is the winner of many American " stunt " competitions (control-line), and won the 1948 radio-control contest of America. The latest Drone has a ball-bearing mounted crankshaft. Different thicknesses of detachable cylinder-head washers are used to vary compression ratio in order to suit varying fuels.

AMATEUR CONSTRUCTION

Certain readers will undoubtedly wish to make their own diesels. It is therefore advisable to examine what facilities there are on the British market at the time of writing this book that will be of help in this direction. A warning should be given that a high degree of engineering skill is required to build a model diesel, and there will be failures amongst those who try. A petrol model is quite a difficult proposition, and the diesel is even more so.

These words of warning will doubtless not deter the determined man. Indeed, I hope they will not do so, because even if there are failures a great deal of interest will result and a lot will be learnt. Those who succeed will be all the more satisfied with their achievement. I merely wish to warn the boy who has little spare cash and no experience, and few facilities, so that he will not be disappointed if he fails. In his case I believe it is cheaper to buy a made-up engine by a reputable manufacturer. Some of these are now sold at such very reasonable prices.

Mr. L. Sparey has produced a drawing and building instructions for a 5-c.c. diesel that can be obtained from the " Aero-modeller Plans Service." Mr. Sparey is a well-known engine designer, and was one of the first pioneers in this country to

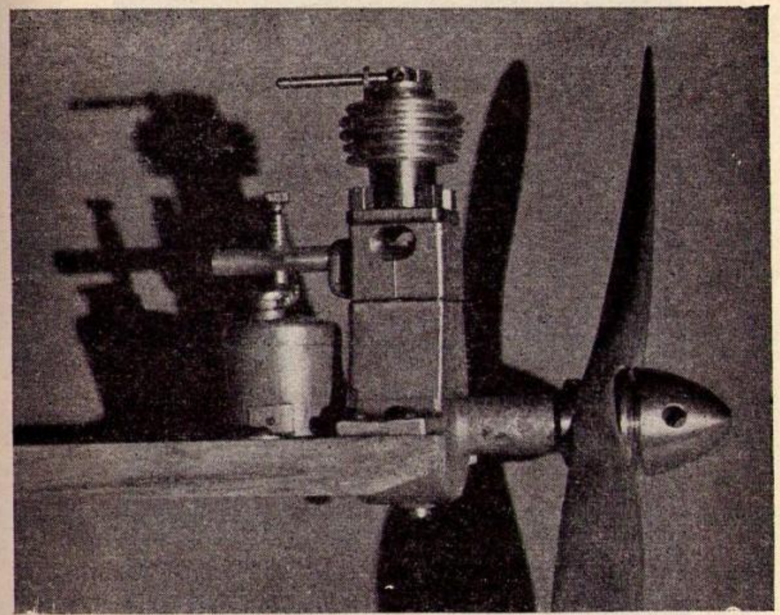


Fig. 53. The Swiss " Dyno " alleged to be the father of all model diesels.

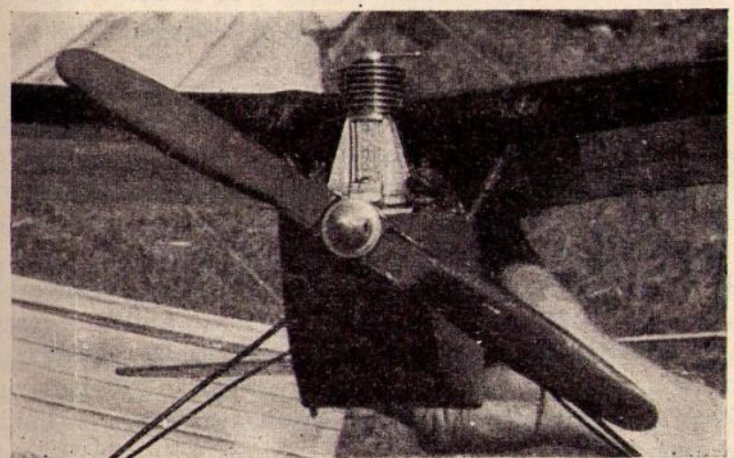


Fig. 54. The well-known French " Delmo " diesel, noted for its easy starting, 2.65 c.c.

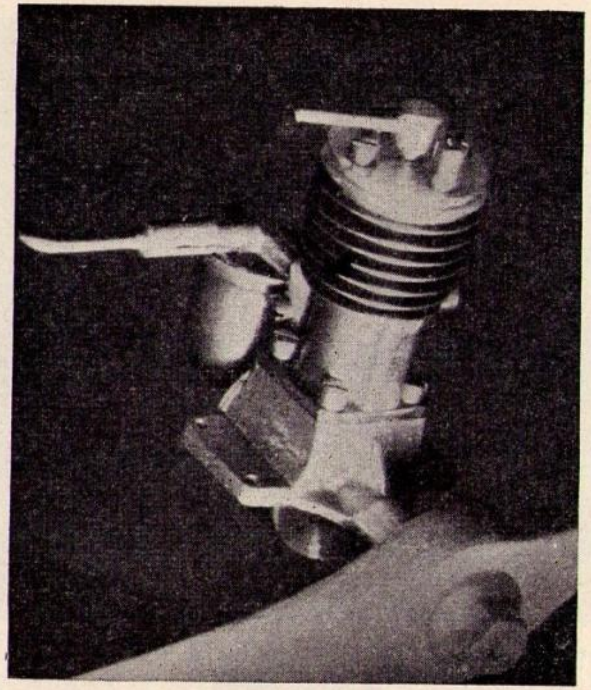


Fig. 55. The baby 0.8 c.c. " Micron " of French design.

build a diesel with which he gave a number of lectures and working demonstrations to various well-known model clubs and societies. As far as is known, he was the first one to design and make a model diesel in Britain early in 1944. He built this engine from " rumours " he got about continental diesels through soldier friends returning from abroad.

Recently, the " Masco " 0.8 c.c. diesel has been made available as a set of castings and working drawings. This little motor was designed by Mr. L. H. Sparey. The 2.8 c.c. Masco Buzzard diesel was designed by L. H. Sparey and D. A. Russell, and amateur constructors are offered diecastings comprising cylinder head and crankcase, etc.

A large number of Mr. Sparey's engines have already been

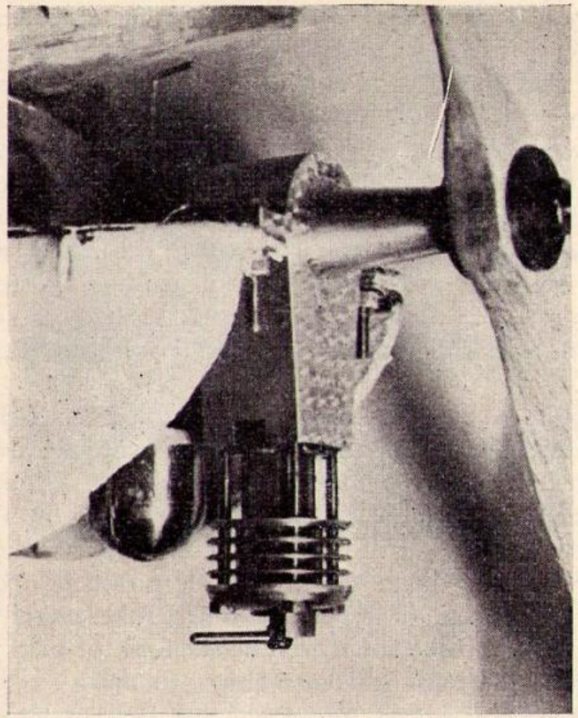


Fig. 56. The French 1½ c.c. " Allouchery," a very well-finished engine.

tackled by amateur constructors, and he is the first person to warn budding diesel builders of the pitfalls.

Although the parts are few and simple in a model two-stroke diesel, a high degree of accuracy is absolutely essential, particularly in the case of the cylinder, and the fit of the piston and the contra-piston. These latter components must be really perfect. Mr. Sparey's engine was made on a 3½ in. lathe and a drilling machine, therefore complicated machinery is not necessary. It is skill and care that is required.

Many amateur constructors will want to buy a set of castings, together with a plan. In this case, there is the 2.2 c.c. " Majesco " diesel which I have used so much in aeroplanes and boats. This firm are well known for their excellent and very complete set of 4.5 c.c. petrol engine castings which have sold in large numbers. The 2.2 c.c. diesel is kept fundamentally the same as the examples I have shown in photographs in this book, because it has proved so satisfactory. The only change is a cast cylinder-block, so that certain difficult operations for the amateur will be eliminated. Port timing, shape and size are exactly the same in order to retain the proved characteristics of the present engine.

There are now several other sets of castings on the market. Rapid progress of some manufacturers and the demise of others are two of the difficulties of writing books on engineering subjects.

Finally, there is really no reason why a thoroughly knowledgeable man should not have a cut at designing his own diesel and then making it. Keep it robust and remember the fit of piston to cylinder should be the theme to keep in mind. There are many reasons in favour of designing multi-cylinder diesels and also a four-stroke diesel where cost of production does not influence the choice of type. A four-stroke diesel with its positive exhaust stroke could well be silenced for boat work on ponds where the local residents object to noise.

NOTES ON THE CONSTRUCTION OF A 2-C.C. DIESEL

For those equipped with a reasonably accurate lathe of 3½ in. centre or more, the construction of a diesel motor is by no means beyond the capabilities of the model enthusiast. An amateur who has successfully made a petrol motor need have no qualms about attempting a diesel, bearing in mind that the higher compression ratio and violent detonation demands greater strength and soundly-constructed components. In addition, as the necessary compression of the fuel to firing point must be attained in the cylinder-head, it follows that little or no leakage down the piston can be allowed. Therefore the quality finish and fit of the cylinder bore and the piston must be excellent. The actual clearance between these two parts must also be as small as possible, and it can only lead to disappointment in the final performance of the motor if these points are not attended

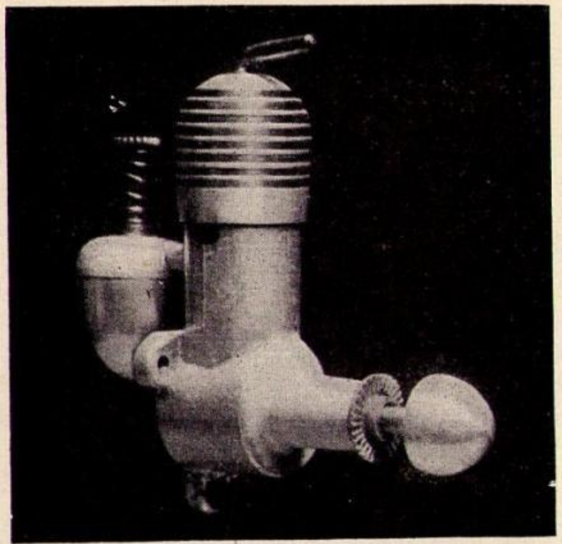


Fig. 57. A neat Czechoslovakian diesel, the "Standard" 1.8 c.c. "Super Atom"

to. It is also necessary to use suitable metals for the cylinder liner and piston that will permit the above close clearances at working temperatures. For instance, cast-iron piston and steel liner.

Bearing in mind the above remarks, let us tabulate the main components that make up the diesel motor, with some suggestions as to the way to set about their construction. These remarks apply to the "Majesco" method of design, in connection with the Home Construction Set, which has been evolved especially for amateur craftsmen, employing as many diecast parts as possible. It is by no means the only way to construct a diesel, but will form a basis for discussion.

Crankcase

A diecasting which can be machined in two operations, drilling and tapping. The bearing should be reamed and lapped to ensure a good fit. Bronze or cast-iron bearing.

Crankshaft

This can be built up from stock material by screwing and silver-soldering. All joints should be absolutely clean and a low melting point solder used to avoid scaling.

Carburettor

A diecasting requiring very little machining. Three operations in the lathe, drilling and dieing the threads.

Cylinder

A diecasting with tubular liner insert. Three lathe operations, facing and boring to size. The liner is skimmed and shrunk into the cylinder casting, giving about 0.001 in. interference. Ports are cast in the cylinder, which should be arranged to align with those in the liner. Lapping the bore is left to last, and should be continued until a fine finish is obtained, together with roundness and parallelism. A series of brass plug gauges machined to a tight push-fit in the bore as lapping proceeds is the best way to test the condition of the bore. Thoroughly rinse the bore after lapping, and if possible blow out all traces of lapping compound. Be careful no compound remains in ports, otherwise it may become dislodged later and quickly ruin the engine.

Piston

Machined from the solid. Cast-iron. Remove the material inside and screw for mandrel. After drilling and reaming gudgeon-pin hole, screw on mandrel and turn to within 0.001 in. of finished size. (Obtained from size of the last plug gauge made for bore.) Lap piston with copper ring lap until it is a tightish slide-fit in the bore.

Contra-piston

Machine to a *light tap-fit* in the bore. Counterbore the top.

Connecting-rod

Machined from square steel to a tapered round section between big and little end. Drill and ream big and little end

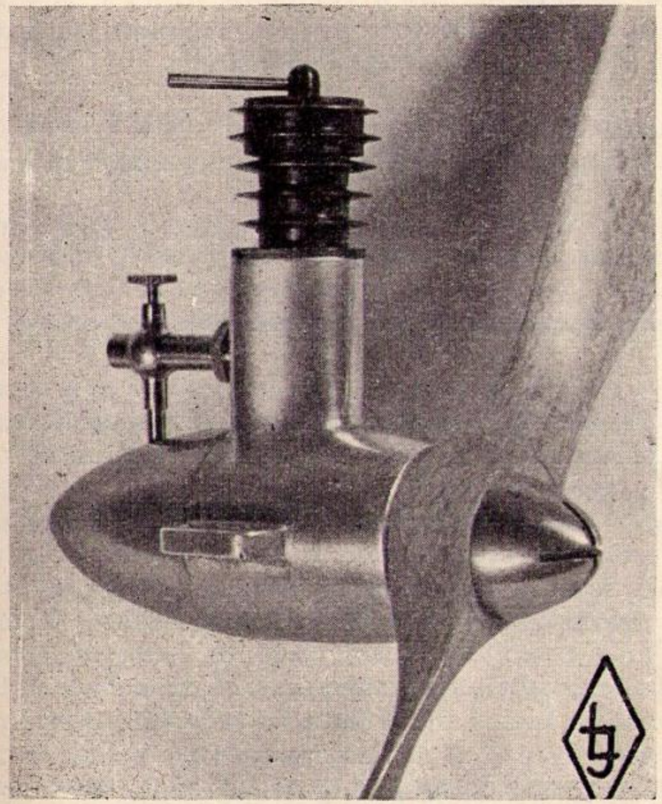


Fig. 58. A Scandinavian diesel, the "Monsun Standard," shows attractive design layout, and an eye for line.

about 0.001 in. small, finally lapping after hardening. This latter process can be carried out by heating to cherry-red and quenching, afterwards cleaning with emery cloth and tempering to very dark straw colour. If mild steel is used, this can be case-hardened only.

Cylinder-Head

Steel or aluminium threaded to take the contra-piston adjusting screw, and drilled clearance for holding down screws.

Propeller Backplate

Steel with taper hole to fit taper on crankshaft, and arranged to give clearance between crankcase bearing.

Crankcase Cover

Diecasting. This requires one lathe operation to machine spigot. Drilled clearance.

CHAPTER III

THE FUEL, LUBRICATION AND FUEL ACCESSORIES

GENERAL FUEL MATTERS

THE question of fuel for the model diesel is just as important as the subject of the compression ratio. In fact, it may be said that these two subjects go hand in hand, for one reacts upon the other.

It was the clever idea from the Continent of adding a suitable mixture of ether to the fuel that made the model diesel a possibility. Before this idea had been thought of, the model diesel in small sizes had been dismissed as impracticable owing to the weight and difficulty of fitting a fuel injector gear. Ether, as explained in Chapter I, increases the ignitability of the fuel, and permits auto-ignition without all the complication of injection of fuel at a predetermined point of the power stroke.

Having sacrificed the mechanically exact timed injection, it would be pardonable to expect that it would be impossible to obtain regular explosions when the piston arrived at the correct position at the top of the compression stroke. It might be thought that this would vary, but in actual practice it has been found to be completely consistent *provided the correct fuel, and a suitable compression ratio for that fuel, are provided.*

In fact, I would say that one of the outstanding features of the model diesel that particularly impresses itself upon my mind after many years of model petrol engine experience, is the extraordinarily even running of a well-adjusted diesel. Once started and running well, there is less tendency to change note and power output than in the case of the petrol engine, and the setting of the fuel needle-valve is definitely less critical than in the case of the petrol engine.

On the other hand, it is very important to correctly mix the proportions of constituents in the fuel, and to set the compression right.

The full-sized diesel is not fussy about what fuel is injected into its cylinders. It will stand almost anything. As most readers know, the normal diesel (full-sized) uses a crude oil that is refined far less than the spirit used in a petrol engine. The fuel is generally known as " diesel oil " or " derv." It is much cheaper than petrol, and also gives a better mileage per gallon when used in conjunction with a diesel engine.

We can use this " diesel oil fuel " in our models, but we must add a percentage of ether and a percentage of lubricating oil.

Paraffin and other fuels can also be used in lieu of diesel oil as the basis of the fuel, and there are special concoctions on the market sold by engine manufacturers.

My experience has been that the commercial mixtures which I have tried are highly satisfactory. On the other hand, almost all model diesels with adjustable compression will run reasonably well on a diesel oil fuel basis given later in this chapter.

I am considering the normal modeller's lack of facilities for obtaining ingredients, and also for measuring difficult percentages, when I sum up the situation in this chapter.

To cut a long story short, there are a considerable number of fuel mixtures that have been tried here and abroad. Many are most complicated, and the subject is shrouded in mystery by many people, with the result that there has been a lot of ballyhoo talked about these curious mixtures. Many, one suspects, have resulted from the difficulty of obtaining the simple ingredients that are obtainable in this country. I have tried most of these mixtures and found none better, and some not as good as the mixtures given in this chapter. This is not to say that we shall not improve our fuels for model diesels as time goes on, as there is a great deal to learn about the subject.

There are four well-known diesel fuels commercially blended, all of which I use at the time of writing. These fuels are blended by one or other of the large petrol companies, and each has an additive to promote easy starting and smooth running. They are known as (1) Mills Fuel; (2) Frog Diesel fuel; (3) E.D.; (4) Mercury diesel fuels. There is one Mercury fuel that requires no ether added. This is known as " Mercury No. 6," and is

as easy to start as the normal etherised fuels. Normally, ether must be added to all diesel fuels. There are also a number of special blends made up by model shops which are quite satisfactory. Whenever I have examined damaged engines due to corrosion, this has usually been traced to the use of improper ether. The reader will do well to take to heart the advice given later in this chapter regarding ethers, *and under no circumstances whatsoever to use what is known as " commercial ether."* If unable to obtain any of the above fuels for any reason, I use my simple mixture as a second choice. It works very well but has no additive such as amyl-nitrate.

It is important, however, that, if the reader has a " fixed head " engine, he should use only the fuel laid down by the makers, because the *unadjustable compression ratio* has been designed to suit that fuel and no other. There are, however, few " fixed head " engines on the market.

One must admit that some of these " fixed head " mixtures have rather difficult percentages to measure out.

Let us examine these fuels so that the reader can use whichever he fancies, or can easily obtain. We will then end up by giving the " fixed head " fuel of the well-known French " Micron " engine, as an example for a " fixed head " engine, remembering that each " fixed head " engine has its own special mixture. One of the advantages of the variable compression engine, to my way of thinking, is that it is far more accommodating as regards the mixtures which may be used.

" Mills " fuel may be taken as an example of a commercial fuel, for it was first on the market, and will show the reader how he should mix his fuel with the correct proportion and type of ether. Other commercial fuel blends are sold with instructions on the container. These may slightly vary in the proportion of fuel to ether, but the principle is the same.

FUEL MIXTURES

(Shake the mixture well and keep corked.)

No. 1 " *Mills* " *Fuel* (*Blue Label*):

Obtainable in small containers. Mix 1 part ether, 2 parts " Mills " special fuel. Shake well and keep the bottle corked. Ether is normal 0.720 " Ether Meth," or " Anaesthetic Ether," *obtainable from a chemist.* (Not commercial ether.)

Remember that " Mills " fuels must have ether added to them, and will not operate properly by themselves. They have the correct lubricating oil already mixed in the fuel.

The resulting mixture of fuel and ether should be perfectly clear. If it is cloudy, the wrong ether is being used.

Very minute diesels often run best on 1 measure " Mills " fuel, 1 measure ether.

No. 2 *The Simple Fuel (" My Mixture ") : If commercial fuels not obtainable.*

5 measures " Ether Meth," or " Anaesthetic Ether," *obtainable from a chemist* (see end of chapter *re* ether).

4 measures diesel oil, obtainable from a garage.

1 measure lubricating oil. This must be of a good motor-cycle air-cooled grade such as Castrol XXL.

Add 2 per cent. amyl-nitrate if obtainable.

Never use any thin machine oil, old sump oil, bicycle oil, or other substitutes as a lubricant.

(N.B. Assuming the measure is the same size.)

No. 3 *E.D. Fuel* uses a castor based lubricant, and is bottled with ether incorporated. It therefore merely requires the bottle being shaken. The container top must be kept on when not in use to preserve the highly volatile ether content.

No. 4 *Mercury Diesel Fuels*

Mercury No. 6, " All-in-One," requires no ether to be added, and does not have ether incorporated. It is very easy starting with great power output, but runs rather hotter than etherised fuels. It is therefore best to " run in " a new engine with etherised fuels, and No. 6 can be used when nicely run in. I seldom use any other fuel for all but the baby motors, because it saves so much trouble, and there is no ether to evaporate. It is rather too thick for my very small motors. *Mercury No.* 3 is blended with Essolube Racer lubricating oil and is a cool running fuel, which *must* have ether added. This may be from 1 part ether to 1 part fuel, or 2 parts fuel to 1 part ether according to requirements and maker's instructions. *Mercury No.* 8 is a ready-mixed castor lubricant based fuel for diesels.

No. 5 *Frog " Power Mix " fuel* is blended with " Aeroshell " oil, and must have ether added, in the proportion of 1 part ether to 2 parts fuel. (See page 101.)

No. 6 *A " Fixed Head " fuel as recommended by the " Micron " French manufacturers, (with extracts of their remarks in italics). Other " Fixed Head " manufacturers specify different fuel mixtures to suit the compression they use.*

" The motor has been designed to function with the following mixture :—

Paraffin (*medicinal*) 15%

N.B. Do not use ordinary lamp paraffin.

Lubricating oil 10%

Ether 75%

" This is the mixture which gives the best results from the point of view of both maximum power and ease of starting.

" If medicinal paraffin is not available you can use vaseline in the same proportions.

" If it is not possible for you to obtain either medicinal paraffin or vaseline, you can make use of the following mixture :—

Motor lubricating oil 20%

Ether 80%

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

N.B.—A good alternative home-made mixture to No. 2 is that used by the "E.D." diesel. 1 measure each castor oil, ether, paraffin (commercial), or diesel oil. Mix castor oil with ether, than add paraffin or diesel oil. Shake well when mixing.

POINTS OF INTEREST

I may as well explain here that diesels are dirty to operate. They fling out a large proportion of the oily nature of the fuel from their exhaust ports. At the end of the day's flying it is desirable to clean up the engine and the plane or boat to prevent dust and grit collecting on the model. Diesel oil should be washed carefully from the hands after use, as it affects some skins adversely.

A diesel model often leaves an interesting trail of smoke behind it, which in the case of the model aeroplane sometimes gives a picture of the airflow behind the wing. I remember on one winter's day, one of those very calm frosty days, a high-wing model of mine was flying with the sun behind it, and I obtained the most perfect silhouette view of the model and the diesel smoke trail against the sun. I noticed that the down wash from the wing carried the smoke in a long sweeping curve down from the wing so that it missed the tailplane "by miles." This free flight test was far superior to any wind tunnel tests, which are often subject to tunnel wall interference, etc. The practical view I had, proved to me the fallacy of the so-called interference with the tailplane on a *slow flying* model of the high-wing type, provided the tail is mounted in line with the wing or only slightly below.

REMINDERS

1. Always keep your fuel bottle well corked to prevent the ether from evaporating and leaving the other constituents in a greater proportion. This does not apply to Mercury No. 6.
2. Keep the bottle away from fires and cigarettes. Also remember ether is not only dangerous because of its explosive and "flash-back" qualities, but also its anaesthetic propensities. If you run the engine indoors, see that the room is adequately ventilated.
3. Carefully strain fuel when mixing to extract fluff and impurities.

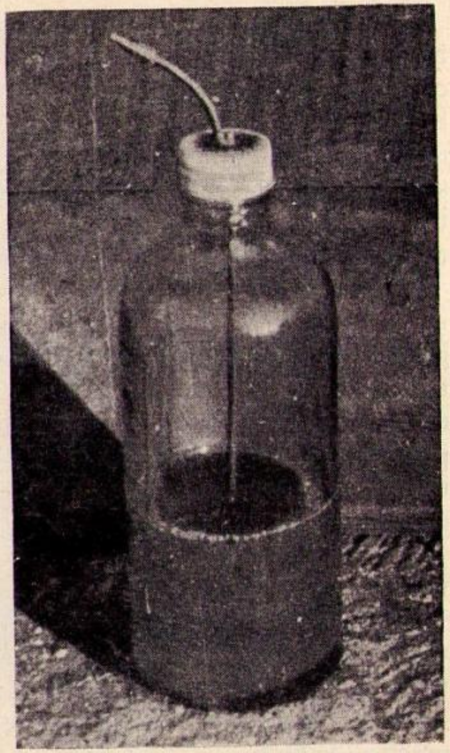


Fig. 59. The fuel bottle for the field of operation may have a "turned up" pourer spout with a tiny hole. This prevents the ether unduly evaporating.

A FUEL BOTTLE FOR OPERATION ON THE FIELD, AT THE POND-SIDE, OR RACE TRACK

An old "Dettol" graduated disinfectant bottle, or a graduated medicine bottle will make an excellent container, because it is simple to measure the proportions to be used, as one can see the fuel and the graduated markings.

A little filling funnel can be used and the fuel poured from the bottle into the tank *via* the funnel. *In this case the bottle must have its cork replaced every time to conserve the ether content.*

An even better plan dispenses with the cork, the filler spout being so very small that the ether does not appreciably evaporate, consists of a simple pouring spout of thin model aeroplane brass tube soldered into a metal bottle cap, as shown in Fig. 59. A tiny spout must be turned up from brass, as shown, with a very small hole. This brass spout is soldered to the brass pouring tube. A metal screw-on top for the bottle is obviously necessary to permit the brass tubes to be soldered into it.

The "Alton Valvespout" oil-can is obtainable at most ironmongers and has become very popular with modellers, because the spout has a quick screw-threaded stopper that seals the open end instantaneously without any danger of losing the top. The top remains *in situ* even when the spout is open to pour from its convenient-sized opening to suit the average model tank. When closed, the ether content of the fuel cannot evaporate.

FUEL TECHNICALITIES

Do not be frightened or put off the model diesel by long-winded discussions over fuel. Leave this to the genuine fuel technicians to sort out, and also to the armchair experts—the latter derive a lot of fun from their discourses but very little of practical value.

The fact that stands out is that the fuels that I have mentioned will run your engines perfectly satisfactorily, and that is what matters to the keen modeller who requires running results. In any case, one short chapter on the intricate matter of fuels could never cover what is a life's study of the fuel expert.

PRE-IGNITION

The term "pre-ignition" that is sometimes used in connection with a *model* diesel is rather inaccurate, because it refers to ignition in the petrol engine *before* the ignition spark takes place, due to varying reasons. In the full-sized diesel the ignition is definitely timed to take place when the fuel is injected.

In the model there is no absolute timed ignition point. The gas "explodes" when it is ready, due to the heat of compression.

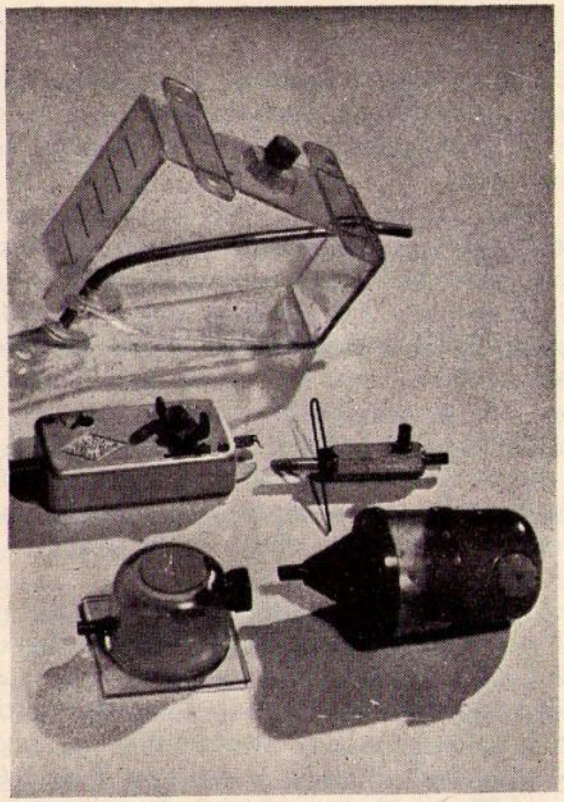


Fig. 59A. Useful Fuel Accessories. At top the large E.D. tank with graduated fuel level marks for radio flight of long duration. Note the well at lower corner to retain even flow when stunting. In middle, the E.D. clockwork timer to operate a switch on the F.G. fuel cut off seen beside it. Below two very useful plastic tanks for free flight and control line flying

There cannot, therefore, be pre-ignition in this sense. There can, however, be early or late ignition. There can also be detonation or combustion lag.

Detonation is produced by too rapid burning of the mixture and is caused by too weak a mixture or too high compression or both. Combustion lag is caused by too rich a mixture and its attendant slow combustion, together with a low compression, or an unsuitable fuel.

I have a sting in the tail to hand out lest I shall be accused by the technically-minded of making fuel matters sound too simple for Mr. Everymodeller, and therefore taking all the kick out of the problem.

There is no denying the fact that we may not have arrived at the ultimate fuel for model diesels. There are other accelerators besides ether which are suitable and which can be ready mixed.

As an instance of a non-etherised fuel, the new " Mercury No. 6 " diesel fuel has been blended by the Anglo-American Oil Company and starts very well. This fuel is composed of six components and literally does not function correctly if any one of the ingredients is not included. It has a lower fuel consumption than the normal etherised fuel, and I have found it start a diesel engine surprisingly easily, producing outstanding power. I use it a great deal because of the trouble saved in obtaining ether.

To prove how near we are to being able to run on normal diesel fuel oil by itself, I have tried a simple little experiment. I have filled my 3.5 c.c. B.M.P. engine tank with pure unadulterated diesel fuel oil. The engine will not start on this, but if one squirts a little of a normal etherised fuel into the induction pipe, the engine starts up, *and it then runs out the tank load of pure diesel fuel oil.* That makes one think! It means that once the engine is started it keeps warm enough to run on the pure diesel oil. The compression has to be raised a little and the fuel needle-valve opened a good deal more. The exhaust is rather smoky and the power is less, nevertheless the engine runs and swings its normal propeller at quite a good turn of speed.

I have also seen a " hot " square 4 c.c. model diesel engine fitted in a model car do the same but at a higher r.p.m. and giving greater power, probably due to the extra heat generated at the higher r.p.m.

For slow speed running on large diesels, a mixture of only 5 per cent. ether has been found to give starting and good running. A mixture of only 2 per cent. of ether will give good running

if a little extra ether is dropped into the induction pipe to give a start.

Let us, therefore, for a few brief moments delve into the simple facts of fuels, without being too technical over names that may fog the issue.

ETHER

I have seen it stated that one should not use " methylated ether " in model diesels, or dire results due to the presence of the corrosive influence of sulphuric acid may occur, and that the modellist must therefore use only " anaesthetic ether." In actual fact, the doctor sometimes uses methylated ether and sometimes anaesthetic ether. *Both* " methylated ether " and " anaesthetic ether " are pure, and there should not be acids in them to burn out the vitals of your diesel.

A chemist and I carried out a litmus paper test of both ether meth and anaesthetic ether. Neither showed the slightest trace of acid, whereas a drop of sulphuric acid from another jar turned the blue litmus paper a lovely shade of pink. I think the misconception about ether meth has grown up because ether meth is a distillation of sulphuric acid. As a result, some people have jumped to the conclusion that there is acid remaining in ether meth. This is not so, provided it is the pure type.

There is, however, a third ether called " commercial ether," which may severely damage your engine by corrosion. That is why I recommended earlier in this chapter that you should go to a chemist to obtain your ether. There is practically no difference in price between methylated ether, or anaesthetic ether. The only difference is that methylated ether has a small tolerance allowed in its specific gravity from 0.720 to 0.750, whereas anaesthetic ether has to be 0.720. The diesel does not care which you use.

HIGH AND LOW OCTANES

There are many fearsome names in the fuel groups which we need not worry about unless we are becoming a director of a petroleum company, or its chief chemist, but we might perhaps mention that low octane fuels will cause detonation—which is the cause of engine knocking. Ethers and paraffins are usually low octane fuels. High octane fuels burn evenly under compression and do not readily detonate. They are therefore not suitable for model diesels as an only fuel.

The detonation of low octane fuels must, however, be controlled, because fuels for model diesels must not have too short or too long a combustion lag. In the latter case it may be that the fuel detonates, drives the piston down, and when it is coming up again, the piston receives the full force of the delayed explosion that has by then arrived at its maximum effort. No engine will stand much of that sort of thing. Too short a combustion lag on the other hand will obviously give violent detonation and knock the engine to pieces.

It is generally accepted that the ether in the fuel ignites and fires the diesel fuel oil, which with the lubricating oil tends to decrease the combustion speed of the ether. This is another way of saying they quieten down the violence of the detonation. The lubricating oil at the same time attends to its work of lubrication, and also acts as a further damper on the combustion speed.

According to the fuel experts, the addition of 1-2 per cent. of amyl-*nitrate* to diesel oil, noticeably increases the ease with which such a fuel will self-ignite in a diesel engine, but once combustion has started it has no significant effect upon its speed. In practice, I find the engine runs more smoothly. Do not use amyl-*nitrite*.

The low flashpoint of ether is incidental to its effect of increasing the ignitability of a diesel fuel in an engine. Petrol would also lower the flash point but would decrease the ignitability.

Ether combines high volatility with ignitability to a remarkable degree.

I have found in practice that paraffin and petrol are not so effective as diesel fuel oil. That is why I use diesel fuel oil in my simple mixture rather than the other two fuels that are sometimes recommended. Paraffin or petrol may cause misfiring, knocking, excessively smoky exhaust, and generally rough running.

A LOWER ETHER CONTENT

I have recently started up with complete regularity, and run with the same power, a certain 2-c.c. British diesel, using a 12 per cent. ether content and Mills diesel model fuel. It confirms my belief that the model diesel should be developed for power lawn mowers, baby outboard boat motors, and similar full-sized " utility machinery."

As this book goes to press, Frog " Power-Mix " has been placed on the market as an ether-less ready mixed fuel in a special metal container with screw-spout top. A test sample appeared to start easily and run well.