The Starter Battery.

Having grasped the working of the carburetter and how the gas is produced, we can turn to the engine and start it up, being careful to use the correct starter battery and the right voltage.

The glow plug is heated by a battery *which must not be of a greater voltage than 2.* Any increase in voltage will burn out the plug. The battery for British plugs is best in the form of a two-volt radio accumulator. Certain American plugs will not stand more than $1\frac{1}{2}$ volts, in which case either a heavy duty bell battery must be used or an accumulator with a resistance in one lead.

The glow plug takes a very heavy drain from the battery, therefore dry batteries are often exhausted in one afternoon's starting. They are expensive items and it is

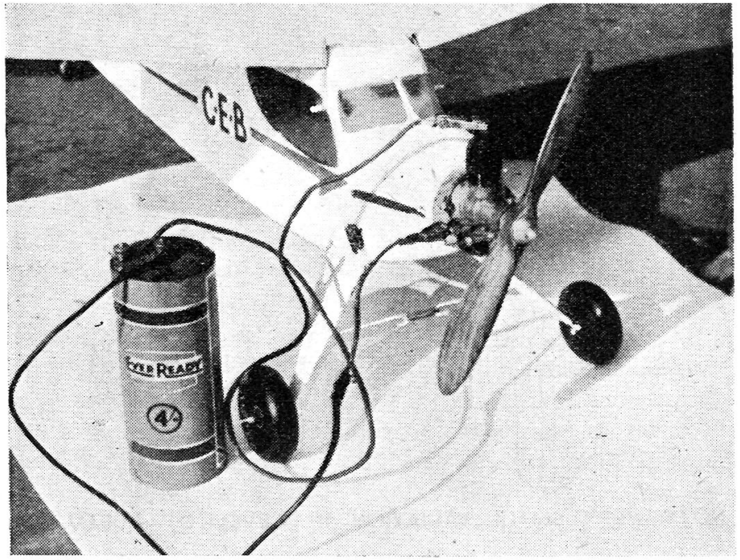

Fig. 11—Starting the American baby Arden with a $1\frac{1}{2}$ volt dry cell. Immediately the engine starts the battery must be disconnected.

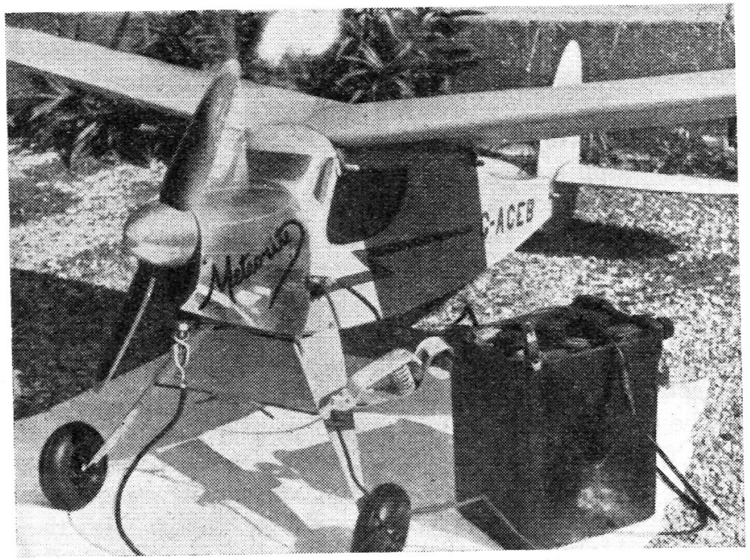

Fig. 12—The author's Meteorite model fitted with a British glow plug that can safely take a 2-volt accumulator for starting.

far more satisfactory to buy a two-volt "wireless" accumulator from the local radio shop. This should preferably be at least 45 amps. Smaller accumulators require too frequent charging. A good accumulator as described can then be recharged or freshened up periodically, either by a home trickle charger from the lamp circuit, or by taking to the radio dealer. I cannot too strongly advise modellers to use an accumulator rather than a battery. It is far cheaper on the pocket and far more reliable and generally satisfactory. A good 2-volt accumulator will last for years if periodically given a charge, and distilled water added as necessary.

When it is realised that the average glow plug has a consumption as high as 8 watts—4 amps. at 2 volts, it will be realised a dry battery is not satisfactory. The owner will so often damn the engine for not starting when, in fact, it is the failure of starting current that is to blame. In order that the reader shall grasp the problem clearly, I am including three photographs of starting engines showing various forms of starting electrical source. The first shows an engine being started by a bell battery of $1\frac{1}{2}$ volts as used for certain American plugs. The same engine could be served by the second method if a resistance of 1/8 ohm at 4 amps. is place in circuit, thus ensuring a reasonable life for the plug. The second photograph shows a model of mine being started up by 2 volts from a 6-volt accumulator. Modellers often have a 6-volt motor-cycle accumulator for petrol engine work. In this case the leads can be attached to the positive terminal and the adjacent negative terminal which will give only 2 volts. The third photograph shows the method which is best for the average new modeller. In this case a 2 volt radio accumulator is used with two stout heavy-duty leads which pass the current easily, attached to the engine by crocodile clips. These clips are easily attached and quickly detached. The positive clip can be attached to the glow plug and the negative clip can be attached to any clean part of the engine's metal body. This makes the necessary circuit to cause the plug's element to glow. The crocodile clips on plug and engine can be taken off as soon as the engine starts, one being snapped on to the other's lead so that they cannot short by touching each other on the ground.

Starting Procedure.

(1) Most engines run anti-clockwise, so swing propeller or flywheel from right to left.

(2) Open throttle needle valve several turns, place finger over the air intake to choke, as glow plug fuel is sticky stuff. Turn engine over once or twice and see if fuel shows on finger. This proves that fuel is flowing. If no signs, blow through fuel line after detaching. Also blow through needle valve to clear gummy oil. I use a

piece of bicycle valve tubing which I keep with my starting accumulator for this purpose.

(3) Close fuel needle valve to the " best run position ", which is usually stated when buying a new engine. If a converted petrol motor is being started for the first time, remember that the running opening of the needle valve will be greater than when the engine is used with "petroil" mixture. Glow plug fuel (see Chapter on fuels later) generally burns at a greater consumption and has a thick castor lubricant to pass through the needle valve orifice.

Glow plug motors therefore usually require a greater opening of the needle valve and a good choke on starting. The castor oil lubricant is inclined to make the engine " sticky " to swing when cold, so it may be necessary to suck in several times to free it. This will have the effect of flooding the engine. The plug may then be heard sizzling, and vapour will be seen at the exhaust ports. Any attempt to start may cause the engine to oscillate its propeller rapidly back and forth. In this case close the needle valve and allow the excess fuel to burn away, then repeat the starting procedure.

(4) Having sucked in, connect one lead to the glow plug and the other to the frame (earth) of the engine. This is done by crocodile clips as previously mentioned.

(5) Swing the engine *smartly* to start.

(6) As soon as the engine fires reasonably well *disconnect the battery leads.* This is vital to prevent burning out the plug which will not stand the combined heat of electrical energy and combustion of the engine. It will be noted that a properly suited plug to engine will cause the engine to rise in r.p.m. as soon as the battery is disconnected. Ignition is too soon when battery and combustion heat are combining together to create too fierce a glow. If, on the other hand, the plug is too "cool" for the engine, there will be no improvement in running, in fact the engine may not carry on firing.

If the engine hesitates but runs, it is permissible to touch the plug a few times to pick up the adjustment, as long as the battery is not kept in circuit for any appreciable length of time.

The glow plug engine is more critical than the petrol motor to correct mixture strength. This is because a rich mixture cools off the plug and douses the glow. It is absolutely vital that the correct mixture strength shall keep the heat of combustion high and constant so that the plug will carry on glowing properly by itself and without electrical aid, when the starter accumulator is disconnected. Control line models and circular course hydroplanes often bring a glow plug engine to a standstill through alteration of the mixture strength as the speed rises and more fuel is flung by centrifugal force into the intake fuel pipe. It is therefore most important on these mosels to fit a suitable tank as described in Chap. IV which ensures a constant

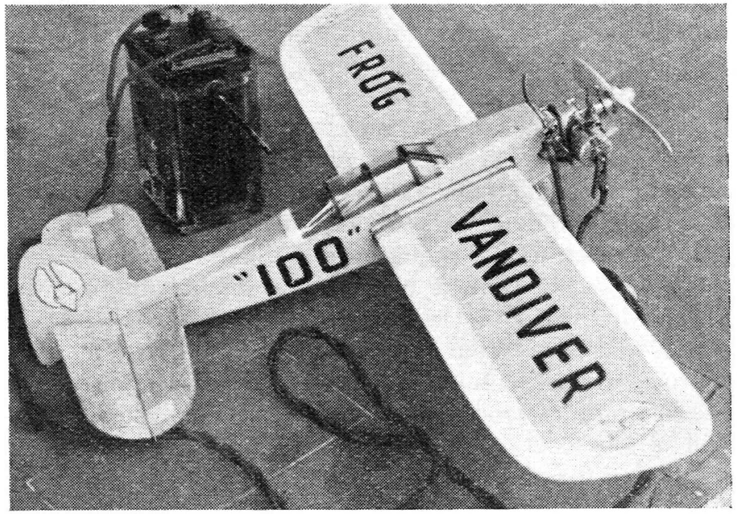

Fig. 13—The best battery for starting. A 2-volt radio accumulator of large capacity. The model is a Frog "Vandiver" powered by a "Frog 160" glow plug engine.

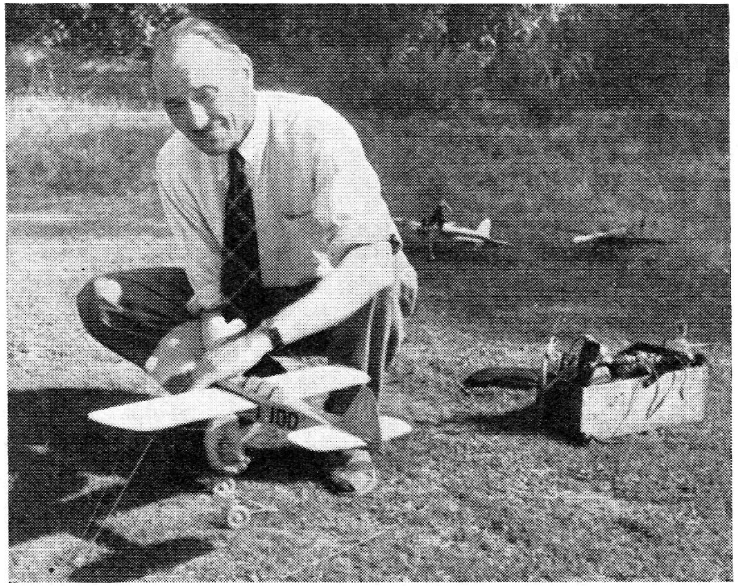

Fig. 14—Mr. Cathcart getting his mixture right with rapid and practiced hands prior to a control line flight with a "Frog 160" glow plug engine.

mixture strength irrespective of speed in alteration.

Readers who are used to the diesel's easy going nature regarding mixture strength adjustments of the needle valve, will at first find the glow plug motor rather disconcerting if they have not been forewarned. Once the engine has started it is therefore advisable to tune the needle valve to get the best mixture. *This does not mean fiddling with the mixture until the engine has emptied its tank as some people do. It means quickly and with practised fingers making a sound adjustment and leaving it.* Those who fiddle with adjustments on model motors never have success, whilst the spectators get utterly bored watching their tiresome efforts.

Fig. 14 will remind the reader to run up his motor before release.

(7) If the engine will not start, check up that the plug is glowing properly. This may be done by taking out the plug, *using a spanner and not a pair of pliers*. When the plug is connected to battery and touching the motor frame, with the other lead clipped to " earth," the plug should glow brightly and red. It is however seldom necessary to take out the plug, as it can be seen to glow red in the cylinder if the piston is turned back so that it uncovers the exhaust port. NEVER USE MORE THAN TWO VOLTS.

(8) If the mixture is too weak the engine will misfire and slow down. If the mixture is too rich the engine will " Four-stroke," or cut out completely as though the ignition had been switched off in a spark ignition motor.

(9) When you have finished running for the day, remove fuel line and drain tank, or otherwise empty tank, as sticky oil will clog up the fuel lines if the fuel is left. Castor oil lubricant tends to separate from the fuel. *Therefore the fuel should always be shaken up before use.*

(10) It is a good practice to squirt a few drops of castor oil into the cylinder after use. The motor should then be turned over.

(11) Remember that a special fuel as described in the chapter on fuels must be used.

Essentials of Hot Point Ignition.

(1) A special fuel.
(2) A suitable compression ratio.
(3) A plug to suit the compression ratio.
(4) Cylinder head design which prevents "shrouding" of the heater plug.

The American firm of Ohlsson and Rice, who make the famous Ohlsson range of engines, make the following sage remark. "For successful glow plug operation it is necessary to accomplish a very definite and careful balance between the heat of the plug, the fuel used, and the compression ratio". This precisely sums up why certain combinations of plug and engine do not function satisfactorily. When a modeller

puts "any plug" into his ancient petrol motor, although he may use one of the recignised special fuels, it is quite possible that the engine will run badly or even stop altogather.

I have found that many of my old petrol engines will run quite well if I fit them with a make of plug that suits them, but there are no results with another make of plug. Plugs are made to suit different heats of compression.

When the starter battery is switched off, a glow plug ignition engine is in effect running in a similar manner to a diesel, except that the fuel is ignited by the "hot-coil" plug instead of by compression only. Because of the necessity of keeping the plug glowing, the speed range is limited. It is not normally advisable to run such an engine at speeds less than 6,000 r.p.m.

High compression and a glowing plug fire the charge early, therefore a fuel that will prevent too early burning and detonation is necessary, or the piston will be driven back in the wrong direction or pull up the motor's speed by offering great resistance before the top of the stroke is reached, in similar manner to the diesel when it is run at too great a compression adjustment. In other words the fuel must burn with a slight time lag and have anti-knock features. Alcohol is generally used for the above purposes. Fuel is therefore given a chapter of its own, because a glow plug engine will not run properly on any but a special fuel.

Almost all engines will run on glow plug ignition if the compression ratio is sufficiently high, and the plug is not overcooled by shrouding. A compression ratio of approximately 8 to 1 is very suitable. Shrouding of the plug's element keeps the flame of combusion from heating the plug. If the plug gets cool, it does not then fire the next charge.

The American speed fiends even go as far as "winkling" out the plug element with a pin so that it stands out proud. They try different lengths until the highest r.p.m.

are obtained. What a lot of plugs must be damaged!

In the petrol engine the designer times his spark to ignite the gases so that a late push is given to the pistom at starting and slow running, and an earlier explosion or push as the engine speeds up. The glow plug engine can–not do this. The only control is by burning a slower burning fuel. The engine must run flat out once it is started except for a very small variation due to a richer mixture that does not actually cool off the element sufficiently to stop the engine running. How compression ratio affects fuel is discussed in the next Chapter II.

Advantages of Glow Plug Engines.

This book gives the advantages of using the glow plug engine, such as weight reduction, etc., but there are, of course, the very real advantage of simplification in building the model for the engine. Just think of all the scheming and the actual labour that spark plug ignition creates. All the wiring of booster battery, the battery box, and time switch and so on, which takes so much time to do, not to mention the gear that has to be carried to the flying field. All this is done away with. Models can be made far more quickly and with less expense, and carried to the field of operation with far greater ease. In fact, it is very much the same story as the diesel which brought in so many people to power flying who had been wavering on the brink. The glow plug engine seems to be a bit more exciting than the average diesel. I think this is really more due to noise than anything else? The large capacity diesel in the 10 c.c. class scarcely exists, and here is where the glow plug engine comes to the fore, although I for one can not resist the snappy performance of the little glow plug motor either. The fact is, *all* model internal combustion engines including the jet motor have a vast interest, and one leads to the other. They all have their uses, and I have no doubt that many of my readers will keep the lot in their hangar to suit varying moods and models.

CHAPTER TWO

The Fuel for Glow Plug Ignition.

The Requirements.

EARLY experiments with fuel in America led to the "ignitionless" operation of normal spark ignition petrol engines. Spark ignition was used to start up. It was then removed after about one minute's running to thoroughly warm up. A fuel having certain chemicals added to lower the flash point and add to ignitability were used. It was found that the normal spark plug's electrode, when thinned down, remained sufficiently hot to cause self ignition. The model was then launched without ignition gear and flight battery. The fuel contained 35% petrol, 20% nitro-methane, 10% ether, 10% spirits of turpentine, 25% castor oil.

From these experiments Mr. Arden developed his "Glo-plug", which eliminated the high tension spark equipment altogether.

High compression and a glowing plug fire the charge early as the piston rises on its compression stroke. Therefore a fuel that will prevent too rapid burning and detonation is necessary. Even then high revolutions will be the order of the day, and a fuel that will fit in with this characteristic of the glow plug engine is required.

If an incorrect fuel is provided, the rising piston will be driven backwards, or will be pulled up, and the speed of the engine retarded, causing excessive strain and stress on the engine. Also undue wear is imposed upon bearings. In other words, the fuel must burn with a slight time lag and have anti-knock features.

Alcohol is generally used for the above requirements, therefore we will discuss its properties. A high compression ratio is required to cause heat when the gases are compressed at the top of the stroke.

Alcohol.

Alcohol is less subject to knocking because of its higher resistance to preignition than possessed by petroleum in a spark or glow plug engine. It is a suitable fuel for compression ratios between about 7 to 18 to 1. Alcohol fuels are known as cool fuels, and cooling fins can be less when it is used. The reader may have noticed how small the cooling fins are on the popular dirt track racing J.A.P. motorcycle single cylinder engines using alcohol racing fuel.

Methanol fuels contain a major percentage of this light, volatile, inflamable fuel. Methanol is derived from a distillation of wood. It is suitable for engines having a compression ratio ranging from 7 to 14 to 1 (dirt track motorcycles engines have a compression ratio of about 14 to 1). The average glow plug model engine has a compression ratio of approximately 8 to 1, rising to 10 to 1 or even 12 to 1 in special cases.

A methanol base fuel is used for most glow plug engines.

Methanol keeps engine temperature moderate. Whereas it takes about $15\frac{1}{2}$ parts of air by volume to burn one part petrol efficiently, it requires $8\frac{1}{2}$ parts by volume of air to burn one part of alcohol. *Alcohol fuels therefore have a higher consumption figure than petrol.* A model enthusiast brought his new glow plug engine to me convinced it was faulty because it had to have the needle valve open much further than his diesel by the same maker. He was also sure that the engine was not up to standard because it " used so much more fuel."

My answer was of course contained in the above facts regarding air fuel ratio. We may therefore say that alcohol fuels have a higher consumption than petrol, and that is why the model man who requires a long engine run must make a larger tank than he has been used to when running on a "petroil" mixture with his spark ignition engine.

Some readers may perhaps have run a motor cycle or a car on alcohol racing fuel for a while during the petrol shortage. They will have been worried by not only the heavy price per gallon, but also by having obtained only approximately half the mileage per gallon they were accustomed to. This extra fuel consumption is of no great moment to the model man for his fuel bill is so small !

The Americans use nitro-methane extensively, added to the methanol basis of their glow plug fuel. This additive definitely gives what they term a "souped up performance". For instance, I and other people in this country, who have used nitro-methane added to our fuel, have all agreed that it provides between 500 to 1,000 extra revolutions per minute on most engines of a reasonably high compression ratio and having the porting to permit high revolutions.

Nitro-methane is almost unobtainable in Britain today, and when it can be got it is fantastically expensive. This makes it out of the reach of normal commercial fuel blends for glow plug engines. Perhaps in the future the situation may alter in this respect.

The loss of nitro-methane need not cause us undue alarm however, for even straight methanol with glow plug ignition will usually give a better performance than the average spark ignition engine, especially taking into account the fact that the weight of ignition gear has not to be carried by the model.

Furthermore, there are substitutes such as cellulose solvents in Britain which give a very similar effect, although perhaps not quite so outstanding. British commercial glow plug fuels are now ready blended with that "little something" which helps a slight extra urge and keeps down any tendency to detonate, nitro-benzine being one of them and acetone another.

Other chemical additives which we can obtain are Amyl-nitrate, Amyl-acetate, Ethyl-nitrate. The latter is nearly as effective as the American nitro-methane when added at 5 to 10%. Amyl-acetate is the least effective, but a slight improvement on straight methanol is found if added at 2%.

Our fuels give all the speed and power that we can reasonably wish for, and they are "safe", which nitro-methane may prove not to be when mixed with certain ingredients. We are all in the same boat over here even for our speed machines, so why unduly worry! Anyway, there is so little in it, and we can get all the practical fun we want with our special fuels.

Nitro-methane is extremely hazardous from the fire standpoint, the flash point being 112 degrees F. If used as a fuel additive there is a definite risk, and under no circumstances should the modeller add anything but castor oil and alcohol to nitro-methane. Some chemicals when added to nitro-methane make it *sensitive to detonation from shock.*

If the modeller wishes, he can mix his own fuels as laid down below, and these will give him more power than he is used to with his "petroil" fed petrol engine.

Commercial Fuel Blends.

There are two concerns already blending glow plug fuels in a large way. International Model Aircraft provide a ready mixed fuel, blended by Shell, B.P. This fuel has the correct amount of castor oil for lubricant added to the fuel. It also has a 2% anti-knock component. The fuel is called FROG "Red Glow".

Henry J. Nichols has two fuels for glow plug engines. These are blended "with the co-operation of the research staff of the Anglo-American Oil Coy", by the High Flash Petroleum Oil Co. Ltd. Each fuel contains what is advertised as an "Ignition Fraction". The first fuel is called "Mercury Competition Glow Plug Blue Label", for engines with a compression ratio up to 8 to 1. This has a *gasoline* base with Essolube Racer lubricating oil. The second has the normal methanol base and castor oil lubricant, and is known as "Mercury Racing Glow Plug Magenta Label". It is for compression ratios over 6-5 to 1.

Home Mixtures.

Most engines will run well on the very simple mixture of one part "Castrol R" (Wakefield's) to three parts Methanol. The methanol can be bought from a chemist. It should be to B.S.S. Specification No. 506/1933.

Castor Oil can be either Wakefield's "Castrol R" or Shell super heavy (castor). Either can be bought from a garage.

If either castor oil or methanol contain impurities, they will not mix together properly, but will turn milky.

Another mixture is: Methanol 80%, Benzol 10%, Aviation Petrol 10%. Add "Castrol R", 25% by volume.

An American Mixture.

Castor Oil, 2 parts. Methanol, 3 parts. Nitro-methane, 3 parts.

Lubrication.

Two very different types of lubricant are in existence. Castor oil is vegetable. Other oils for cars and motor-cycles are mineral. Mineral oils will not mix with alcohol fuels such as methanol. In this case castor oil must be used.

It will be noted that where methanol is shown in mixtures given above then a castor oil is used as a lubricant so that it will mix properly. Even good castor oil has a tendency to separate from the fuel if left standing for any length of time. *Therefore the fuel bottle should always be shaken before use, and the tank drained after use.*

Castor oil can be recognised by its neutral clear appearance, and also that wonderful smell when it is burning, which stirs the enthusiastic race fans or the early aeroplane pilots. The old rotary aero engines used it, and incidentally flung most of it out upon the person of the pilot. I can never sniff burning castor oil from an exhaust without getting a nostalgic kick from my early flying life. It is very sticky stuff, and becomes more so when subjected to great heat. It therefore tends to gum up fuel and oil lines which require care in respect of cleaning.

Mineral oil is usually a greenish colour, and is used in most standard road machines whether they be cars, motorcycles, or lorries. It is therefore familiar to many people. It mixes well with petrol, and will remain mixed once well shaken up. There is an authentic case of a two-stroke motor cycle being laid up for the war with some mixed "Petroil" in its tank. At the end of hostilities the machine was started up and run till the tank was emptied, thus proving how well mineral oil can be mixed and remain mixed with petrol. I often leave my model petrol engines' "petroil" mixture for months at a time in the fuel bottle, whereas I always find a castor oil methanol mixture requires a good shake before use even if it has been used only the previous day.

Methanol Damages Tanks Made of Celluloid, Also Dope or Paint Finishes.

That lovely finish you have taken so much trouble to obtain will be ruined in one day's flying or use when a methanol fuel is used, unless a special protective finish is doped over the normal finish. There are several protective finishes on the market specially produced for the model glow plug engine fan. These can be bought from good model shops. Some are coloured as well as clear, such as "Uncle Oswald's Marjonos".

Celluloid tanks dissolve under the influence of methanol, therefore metal tanks are used, made from thin sheet brass or tinplate, and soldered. Some people maintain that brass corrodes. I have not found trouble in this respect.

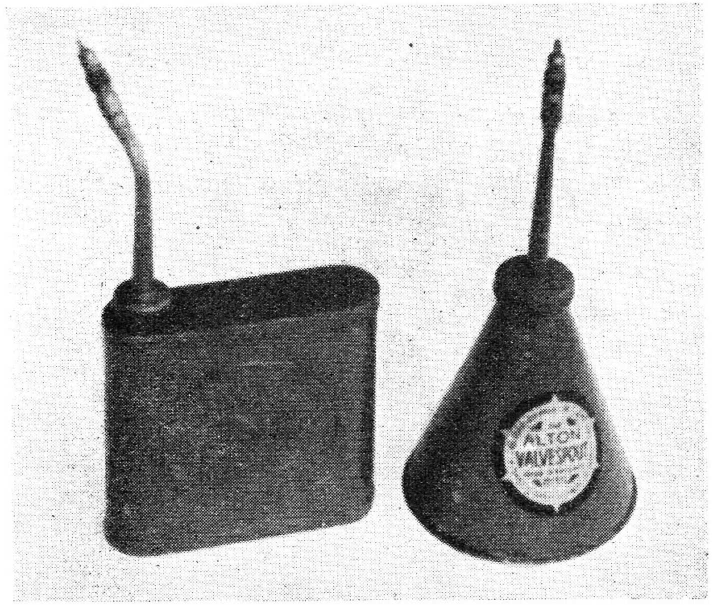

Fig. 15—A very useful can with screw top obtainable at any model shop or ironmonger. The round base is the more stable

A Simple Way to Carry the Glow Plug Fuel.

Obviously a metal or glass fuel bottle for the field is required, for celluolid containers will not do. I have found nothing better to date than the ALTON "Valvepout" oil can. These can be bought from model shops or ironmongers, and are painted red. The type which has a round and wide base seems preferable to the narrow rectangular can, for the wide circular based can is easily put down after filling the model or "doping" it, and the base keeps the can upright without toppling over. The secret of these cans is in the spout top, which is sufficiently small to pour fuel into the average model fuel tank orifice. The top also has a quick screw thread which permits the can to be opened for pouring or closed after use when it becomes leak proof. The screw top is integral with the filler tube. There is therefore no top to be lost in the flying field grass.

Castor Oil Lubricant Keeps Rubber Bands in Good Order.

Those sensible aeromodellers who attach their engine mounts and aeroplane noses, wings and so on, by the means of rubber bands, will be delighted to find that the rubber bands have a long and useful life when they use a glow plug engine and a castor based lubricant. The castor oil keeps rubber supple.

Methanol attracts water and therefore an engine which is being left unused for a long period should be well oiled or certain parts may rust.

CHAPTER THREE

Glow Plug Engines.

ALMOST every American engine manufacturer has turned his attention to at least one special glow plug engine in his range.

In Britain various firms are getting down to the problem with vigour at the time of writing this book. It must, however, be remembered that the glow plug engine is well established in America, and is only now getting under way here. Readers are reminded that they can make a start if desired by first converting one of their more modern petrol engines, or they can start off with one of the already successful British glow plug motors.

In the next chapter I describe how to convert an existing petrol motor, and also how to weigh the chances of success. Not every petrol engine is worth converting, as some of the older ones run roughly and have no increase in performance.

The engines that have already been specially produced by manufacturers for glow plug ignition are already highlv satisfactory in most cases, and I feel convinced that more and more manufacturers will take to glow plug ignition in Britain, just as the American market has developed in this direction, as soon as we over here have had time to assimilate the very real advantages of the system and its few shortcomings. We always take our time to develop something that another country has started, but once we get going things usually move rapidly.

This book has to be limited in length, and therefore I have selected a few examples of existing glow plug engines from America and in Britain, which will serve to show the general trend of design to those interested in the type.

Fig. 16 shows the well known OHLSSON 23 glow plug engine from America. This firm has been making petrol engines for many years, and has set the pace with regard to price reduction in that country, allied to progressive design and high efficiency. I have had many OHLSSON engines over the years and found their standard very high, with exceptionally easy starting.

The engine shown in Fig. 16 has been seen in section in the previous chapter. (Refer back to Figs. 2 and 3.)

Readers will note the vast induction intake located in front of the engine. This is a good point in glow plug engine design, because the type, as already remarked, must be able to turn at high revolutions. Good "breathing" and an easy transfer of the charge, followed by quick and free exhaust of the burnt gases, are largely the secrets of a first class glow plug engine. This has to be backed up by a very free turning engine. Most of the American engines, including the OHLSSON, have ball races to help this last feature. It will be observed that the exhaust port on the OHLSSON is almost large enough to crawl into !

It will doubtless interest readers to note the above points in the other engines illustrated. Naturally, some are better provided with good features than others. That is the way with all design, but it will be observed that all engines shown conform in general to these features so necessary to satisfactory glow plug operation. When choosing a glow plug motor, look for large ports and a free turning engine, but one with reasonably good compression.

Perhaps the first glow plug engine to be produced in quantity in Britain was the FROG 160 RED GLOW engine. It is a very powerful motor for its small size of only 1-6 c.c.

Besides making an excellent high performance free flight power unit or a small speed boat engine, it has such a fierce performance when well run in that it provides a new type of easy stunt control line flying. Not long ago,

it was necessary to fit a large petrol engine into a large model to stunt really well. This was due to the necessity of keeping the lines really taut throughout a stunt movement, thus keeping proper control. The little diesel would not do this without a certain amount of stepping

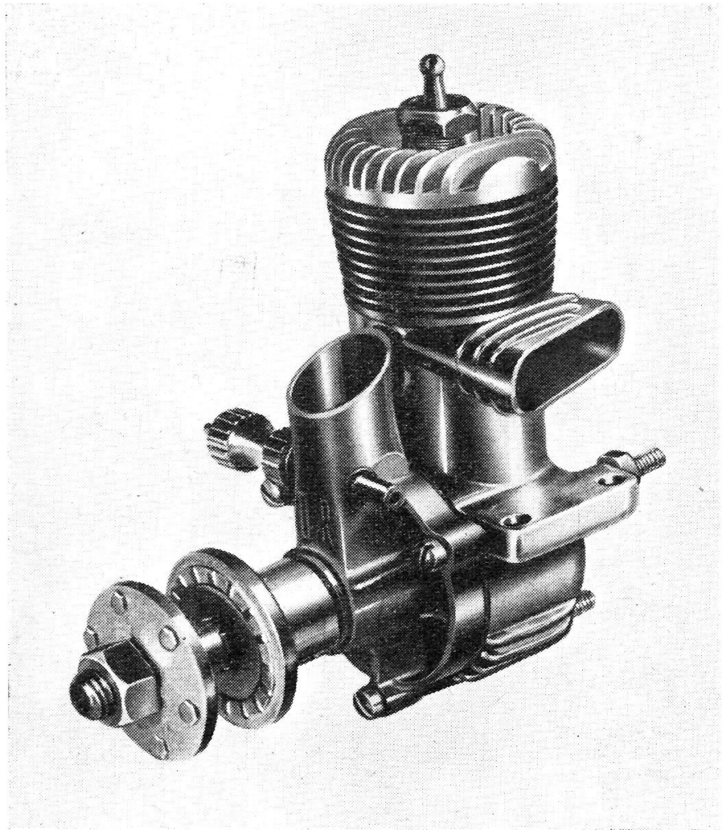

Fig. 16—The famous "Ohlsson 23" glow plug engine from America. Note very large ports which assist high revolutions so necessary in good glow plug operation.

back, etc., and the model had to usually be one of the very unrealistic type having only two main longerons for lightness. The FROG has made it possible, with its fierce power output, to make little models having a balsa sheet rectangular fuselage looking something like the real thing, and yet having the virtue of really easy stunting. The FROG VANDIVER model aeroplane can do any "stunt in the book". With the engine properly tuned for mixture strength, the lines are like "rods", and stunting becomes absurdly easy. The undercarriage is dropped after taking off. The price of the engine and the aeroplane kit are very low and will encourage many a boy to enter into control line flying with a zip.

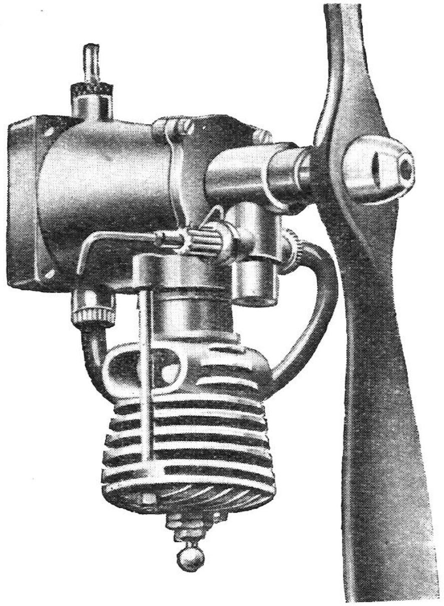

Fig. 17—The " Frog Red Glow 160 " engine was one of the first glow plug engines of small capacity to go into production in Britain.

Lines of approximately 45 to 50 feet are suitable for these little models. Two suitable models are shown in the last chapter.

The FROG RED GLOW engine has a static thrust of 20 to 22 oz. at 9,000 r.p.m., under load of the FROG plastic propeller. Readers will probably realise that static thrust can be misleading as to what an engine can put out when it is flying at speed, and when the propeller blades are really gripping the air and not slipping. Nevertheless, static thrust figures are a useful indication, in spite of what some people may say on the matter. Naturally, a brake horse power test is the best, but this is by no means always possible to obtain accurately in the model world.

The weight of this engine is 3-25 oz. There are two propellers available made from plastic, which have the great merit of being constant in performance, as they are not subject to the variations of hand carved propellers. They are also cheap to replace and they have a sufficient weight which makes for easy starting and smooth running. The blade section may suffer somewhat from the ideal, but from much personal experience I have found that the plastic propeller suits a FROG engine far better than many much talked about carved propellers. It is performance in the air that matters, and FROG engines excel in this.

One propeller has a diameter of 8 in. and pitch 5 in. for free flight, and the other has a diameter of 8 in. and 6 in. pitch for control line work. The FROG uses a K.L.G. MINI-GLOW plug, and likes the FROG "RED GLOW" fuel. The engine has a cone tank-cum-engine-mount, which is easy to bolt up to a forward bulkhead of an aeroplane or a cross bulkhead in a boat.

Like all glow plug engines, the FROG performs best when fully run in.

The Americans have developed the large 10 c.c. motor to a very high degree. Britain has lagged behind in this respect until recently. The 10 c.c. engine gives great

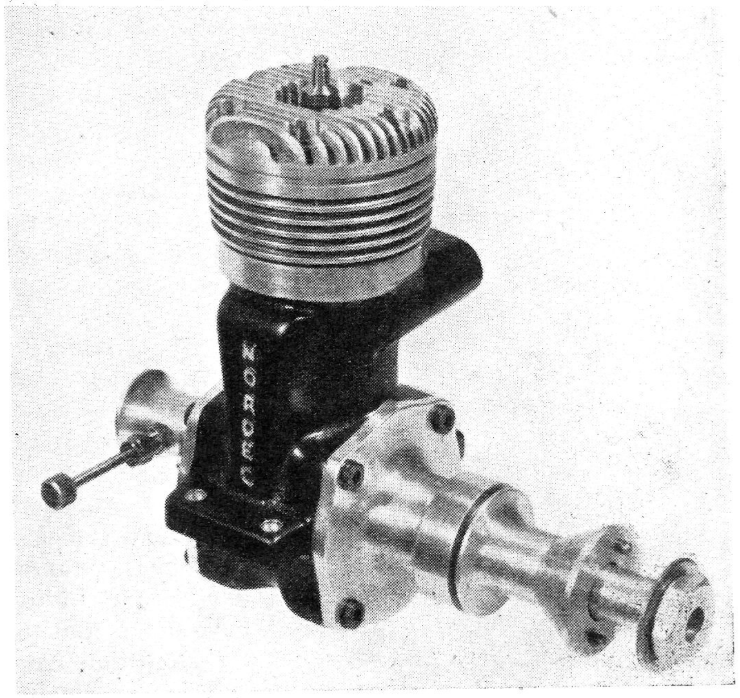

Fig. 18—The British "Nordec" 10 c.c. is a much needed really "hot", large capacity motor on well proved American lines. The engine has piston rings, disc rotary inlet valve and two ball races.

power and is suitable for racing model cars, hydroplanes, speed boats of the vee bottom planing type, and, of course, the really hot speed control line model aircraft. It also makes an excellent capacity for large radio control models, but many will consider that spark ignition is better for variable speed control in this latter case.

A British firm has produced a really powerful racing glow plug engine of 10 c.c. on American lines. This engine is called the NORDEC, and has already put up a British

control line record in its class, the speed being 95·3 m.p.h. A glance at the photograph in Fig. 18 will give a clue to the secret of this engine's success. Note the large ports, the rotary disc inlet valve, the robust construction that ensures a "stiff" engine in the sense that high power will not distort the structure and so cause friction. Ball races are also used, and piston rings are provided, as they should be on all engines of this capacity given to high revolutions. It will be noticed that the intake is situated at the rear, and gives an easy path for the incoming gases through the disc inlet valve. The NORDEC is produced as a glow plug engine without contact breaker gear, or as a petrol timed spark ignition engine when a sensible car type contact breaker is fitted. The engine I use is well finished

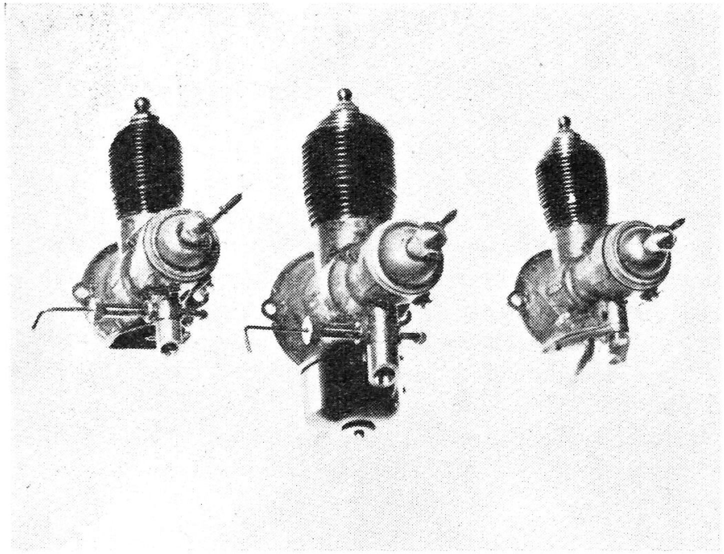

Fig. 19—Very outstanding glow plug engines are made by Arden, who was a pioneer of this type . The engine in the centre is the larger 1.99, those on the outside are 0.99 cu. in.

as in the case of American engines, and American engines have a deservedly good reputation for finish. The engine has a very hot performance, too. The makers claim it turns round at 12,000 r.p.m. when fitted with a 9 in. diameter 10 in. pitch propeller, or at 22,000 r.p.m. when running light with a flywheel. Personally, I am more impressed by actual performance than in makers' claims of revolutions, etc. But certainly the NORDEC comes up to expectations as regards performance when fitted to models. The engine should have a big future in front of it in Britain. Although not cheap, for there is obviously a great deal of careful fitting in such an engine with piston rings, etc., it fills a long felt want in this country.

ARDEN American engines have a great reputation all over the world for small capacity, light weight, fine finish and integral design, also a terrific performance for size. Their exhaust note alone is most inspiring! This is doubtless due in part to the unusual feature introduced by Mr. Arden of a ring of ports completely encircling the cylinder. These engines are well worth studying by all enthusiasts interested in high efficiency glow plug engine design. They are really very wonderful engines. I am fortunate in possessing two of the baby .099 cu. in. engines and the larger .199 cu. in. motor. It will be noticed that the engine is formed in one casting with its mount so that it is very easy to bolt up to a nose bulkhead, and it looks extremely neat and workmanlike. The Arden is perhaps the most obliging glow plug motor that I know. It runs on almost any fuel and any plug. This is perhaps not surprising, as Mr. Arden was a glow plug pioneer, a fact that I mentioned in Chapter I. Starting is the easiest I have experienced, requiring one squirt of fuel into the exhaust ports and off she goes with that ear splitting but exciting exhaust note. These engines are, of course, fitted with ball races. The baby does a good 10,000 r.p.m. with propeller. In fact it produces its best power at this speed. A maintained 20,000 r.p.m. is claimed when running light with flywheel. An official American flight of 76 m.p.h., and unofficial flights of over 90 m.p.h. have been made with the baby ARDEN of .099 c.c. The 199 c.c. engine has officially done 109 m.p.h. in 1948.

The .099 engine uses an 8 in. by 4 in. propeller, and a 10 in. by 5 in. is used by the larger .199 engine. These propeller sizes permit the necessary revolutions to be developed. A slightly higher pitch may be used for fast control line models.

Mr. Arden has the interesting conviction that a diesel engine to be dependable should have a greater stroke-to bore ratio, but this however does not hold true with spark ignition or glow plug ignition. As he has designed and produced so many winning baby engines right back from the early days of the model internal combustion engine, his remarks on the subject will command respect.

ARDEN engines have the piston joined with the connecting rod by means of a ball and socket bearing which permits the piston to rotate as it reciprocates. It is claimed that this feature assures the maintenance of perfect cylindrical surfaces on both piston and cylinder with even distribution of wear. The 360 degree exhaust and intake porting construction is an innovation in model two stroke design. As a result, the exhaust gases are expelled radially from the cylinder at the bottom of the piston's stroke, and are replaced by incoming fresh fuel, in the form of a jet spray, through spaces between the piston and cylinder wall, resulting in high efficiency operation and exceptional starting.

E.D. are well known for their excellent diesels made in Britain. This firm has produced a combined diesel-cum-glow-plug engine. It is known as the MARK III, having a capacity of 2-4 c.c. I use one of these engines in a flying boat. For its light weight this small engine is very powerful as a diesel, and has the capacity for high revolutions.

Apart from forming an excellent power unit for small to medium size models, the engine has the interesting feature of being sold with two detachable cylinder heads. One of these allows it to be run as a diesel. The other can be quickly changed over and the engine becomes a glow plug motor. Fig. 20 shows the engine fitted up as a diesel, with the alternative glow plug head lying on the ground beside it. I have found this engine is best as a glow plug engine when it is very well run in and quite free. It will be no surprise to readers of this book, for I have gone to some pains to emphasise that a glow plug motor must be really free and capable of high r.p.m. It will be noted that the exhaust porting is large. The high revolutions are assisted in the engine by what the makers term "induction boost".

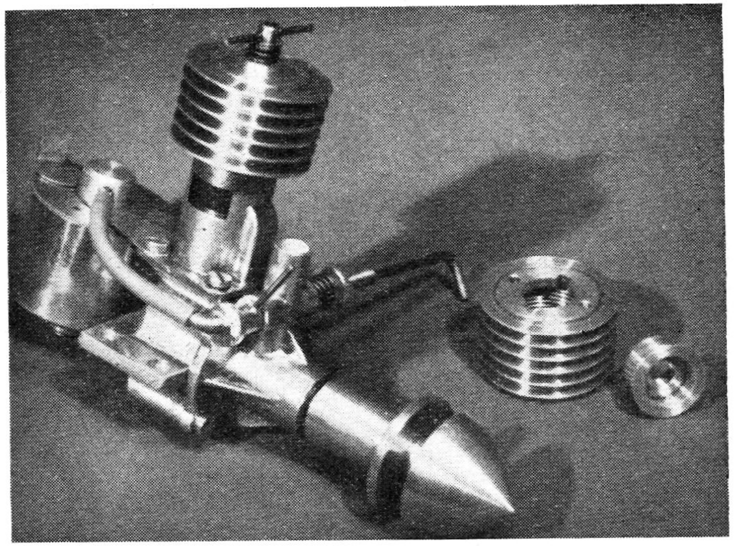

Fig. 20—The " E.D. Mark III " engine can be run as a diesel or a glow plug motor. Changeable cylinder heads are provided. Note the exceptionally long crankshaft.

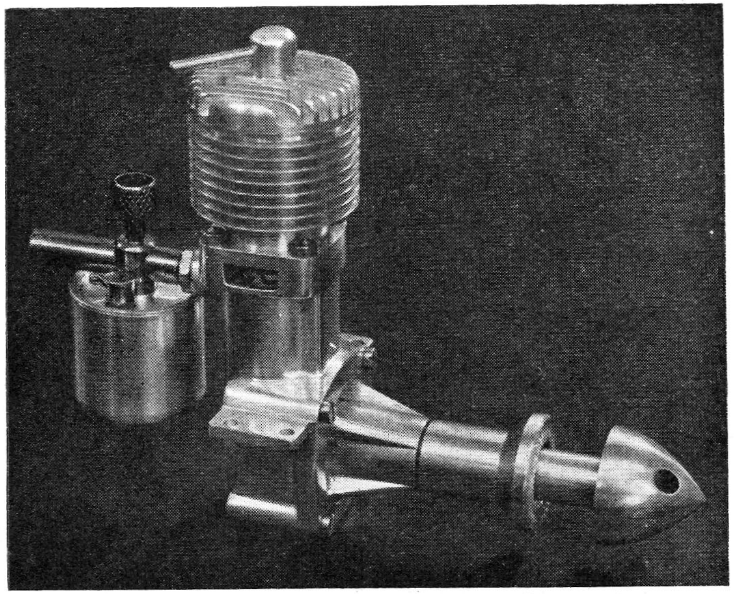

Fig. 21—The " Wildcat " diesel can also be used as a glow plug engine after being well run in and freed up with larger running clearances. A special head is used.

This is created by a space at the lower end of the large exhaust port which remains open when the piston is at the top of its stroke. The space is then between the skirt of the piston and the bottom of the port. It allows extra air to get into the crankcase, or in other words assists "breathing". Naturally, a richer mixture for starting than normal can be given. The makers' recommended fuel for the glow plug version is Methanol 3 parts, Castor Oil 1 part. The makers claim that the engine is capable of 9,000 r.p.m. with airscrew fitted.

The propeller is 10 in. diameter. There is an exceptionally long crankshaft, which keeps the owner's operating fingers comfortably out of the way of the revolving airscrew when adjusting the fuel needle valve. This long shaft also makes a long streamlined nose on a model aircraft simple to attain. The tank is made of metal and is suitably large for the extra consumption of glow plug fuel.

Another dual purpose diesel-cum-glow-plug engine is the 5 c.c. WILDCAT made by Davies-Charlton & Coy. They state that considerable experience has been gained on the glow plug version of their engine. This firm also

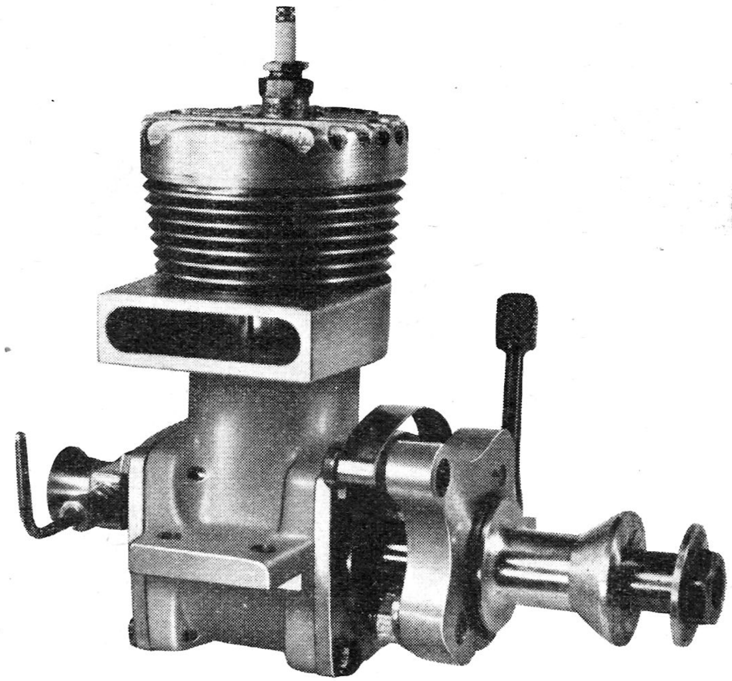

Fig. 22—The British "Rowell Racing 60" ball bearing high efficiency engine of 10 c.c. is also supplied as a glow plug engine with plain front housing. This engine has been officially timed at 85.4 m.p.h. in a model car.

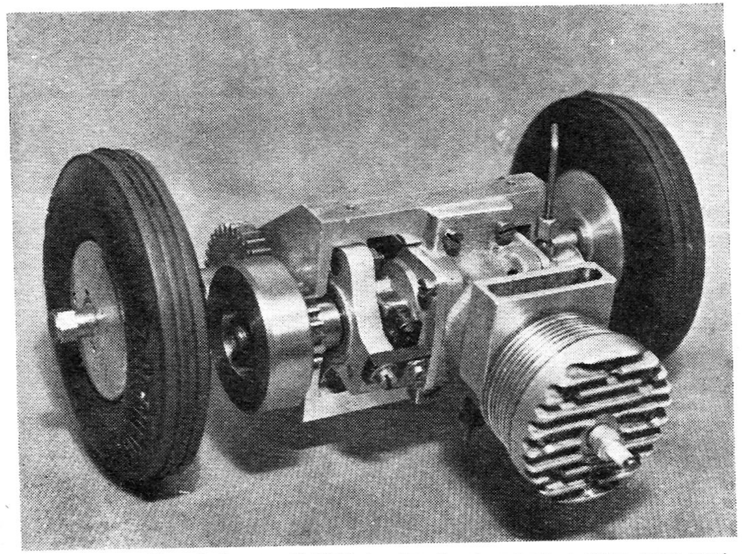

Fig. 23—The Rowell Racing "60" is also produced as a spur gear unit ready to bolt into a model car.

state: "As expected, best results are obtained after the engine has been first run as a diesel for some time. This is due to the fact that it runs much hotter than as a diesel and therefore requires larger running clearances. We advise all modellers to run their engines as diesels in the first instance, and to fit a glow plug head after a few hours total running". This firm also advise the use of "Mercury" Glow Plug Fuel.

Rowell Motors of Dundee make a large capacity 10 c.c. motor called the ROWELL 60. This engine is reminiscent of American ten c.c. class practice, and has been operated as a glow plug engine. The engine has put up an officially timed speed of 85.4 m.p.h. in a model car. Fig. 22 shows the motor with spark plug contact breaker gear, but it is also supplied with a plain front housing for glow plug ignition.

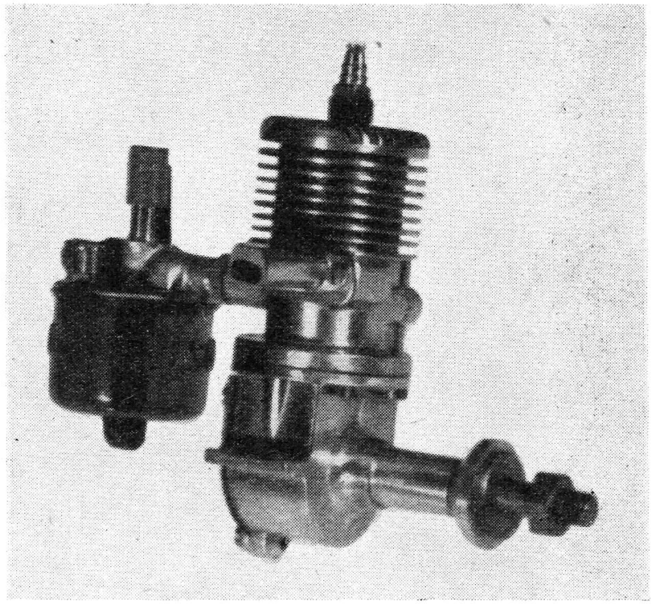

Fig. 24—The 4.5 c.c. " Majesco " engine makes an excellent medium powered glow plug engine when fitted with a McCoy plug.

The weight is 17 oz., and the compression ratio is 12 to 1. The Rowell motor has been designed "with one aim in view—ultimate performance as a racing engine". Piston rings are fitted and a rotary inlet valve is employed. A ball bearing crankshaft is fitted. A methanol fuel mixture is used in the engine, whether it is employed as a glow plug engine or a spark ignition motor. The manufacturers also make an interesting spur gear unit for model car work. It is the first high duty power-transmission spur geared unit to be made this side of the Atlantic, and is ready to be bolted into any constructor's car chassis.

The well known and well tried MAJESCO 4.5 c.c. petrol engine has recently been redesigned for glow plug

ignition, which gives a medium capacity engine the advantage of lighter weight. This engine is fitted to one of my model aircraft and has an excellent performance combined with its usual features of reliability and easy starting characteristics. The engine also makes an excellent

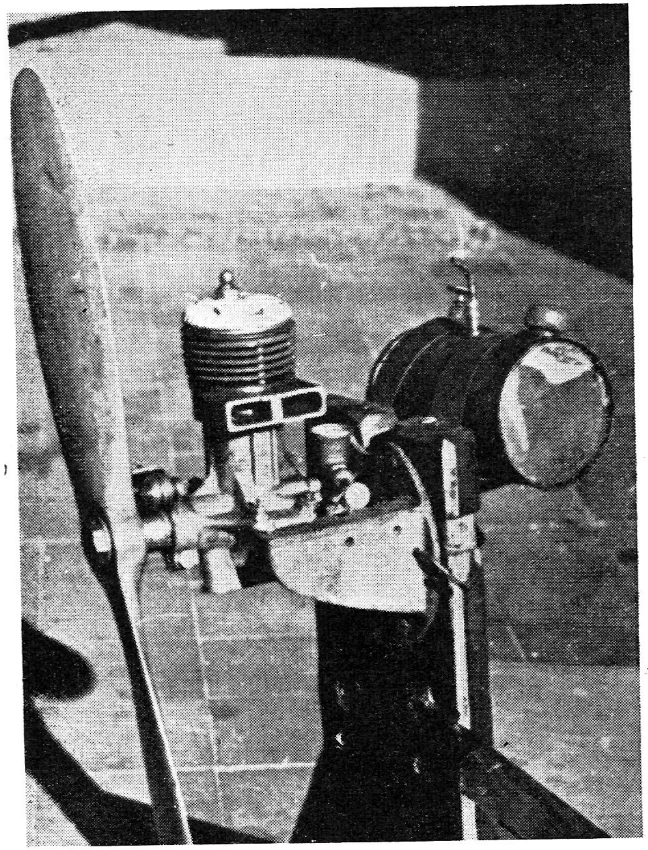

Fig. 25—The 10 c.c. American Atwood Champion is seen here. The twin rotary inlet ports will be noted. The latest glow plug engine is called the " Glo-Devil."

medium sized speed boat power unit for the planing type of craft such as my "FLYING FISH" hull seen in the last chapter. The McCoy glow plug is best suited to the engine.

The American ATWOOD Engines were designed by that well known designer Bill Atwood who was responsible for the original 6 c.c. "Baby Cyclone" which set a new standard in small size internal combustion engines many years ago in the early days of model power flying.

The ATWOOD CHAMPION has twin inlet ports via rotary valves. These are situated at the front of the engine and also at the rear. If the reader will refer to Fig. 25 he will see a photograph I took of this 10 c.c. engine. I now operate the engine on glow plug ignition. The makers produce a special model called the GLO-DEVIL (Model D.R.) with a .624 displacement. The compression ratio is 8 to 1. It is similar to the engine shown, except for the rear induction inlet orifice which has been modified. Twin inlet rotary valves are retained.

Bill Atwood has also recently produced two new engines of high efficiency called the TRIUMPH 49 and the TRIUMPH 51 : both are suitable for glow plug ignition.

Atwood has a long history of obtaining great power from engines of the larger range capacity.

In America, the land of high speed records in the 10 c.c. class, the DOOLING has gained a tremendous reputation. Records have fallen to models in the car, the aeroplane and boat fields, with DOOLING engines installed. In Britain, where a few DOOLING engines have filtered in, Mr. Stone of the Malden Club used a DOOLING with a McCoy "Hot-Point" glow plug when he broke the British Hydroplane Record with a speed of 58.44 m.p.h. This is a great speed for water in this country and faster than the best speed put up by engines of 30 c.c. I am showing a DOOLING engine in Fig. 26. This has a spark plug fitted with its contact breaker gear. But Mr. Dooling tells me that this

engine is used for glow plug work with a cylinder head providing a slightly higher compression ratio. and of course the contact breaker gear is removed. He has some interesting remarks to make in regard to this particular engine which contrary to general procedure does not provide quite so much power with glow plug ignition as with timed spark ignition. On the other hand there is the lesser weight to consider. I will quote his remarks which I feel sure will interest readers, for they affect such an outstanding power producer in the large class.

"When Nitro-methane is available the performance of the DOOLING 61 engine with a glow plug is excellent and gives approximately 95% of the power with a standard ignition system. If nitro-methane is not available (for the DOOLING) then it would be better to retain the ignition system for highest performance *unless it be for an aeroplane.* It will be necessary to decide whether the loss in power is offset by the saving in weight. One possible source of supply for nitro-methane in your country is the large photographic film manufacturing companies".

The DOOLING 61 appears to run a little too cool to obtain the ultimate in power from glow plug ignition. This has been suggested by the fact that when the starter battery was kept in circuit and the plug's temperature kept high, the power loss, slight though it is, was restored. As a result a special glow plug head is being manufactured for DOOLING engines. In spite of this very small loss in power we should remember that a DOOLING engine has created the fastest time in a hydroplane in this country !

On the other side of the picture of "hot" 10 c.c. engines the American BUNGAY 600 engine claims a free speed of over 26,000 r.p.m. and enhanced performance with glow plug.

The DOOLING weighs 14 oz., and has roller bearing connecting rod and ball bearing mainshaft with rotary disc induction valve. The bore is 1.015 in., stroke 0.750 in.

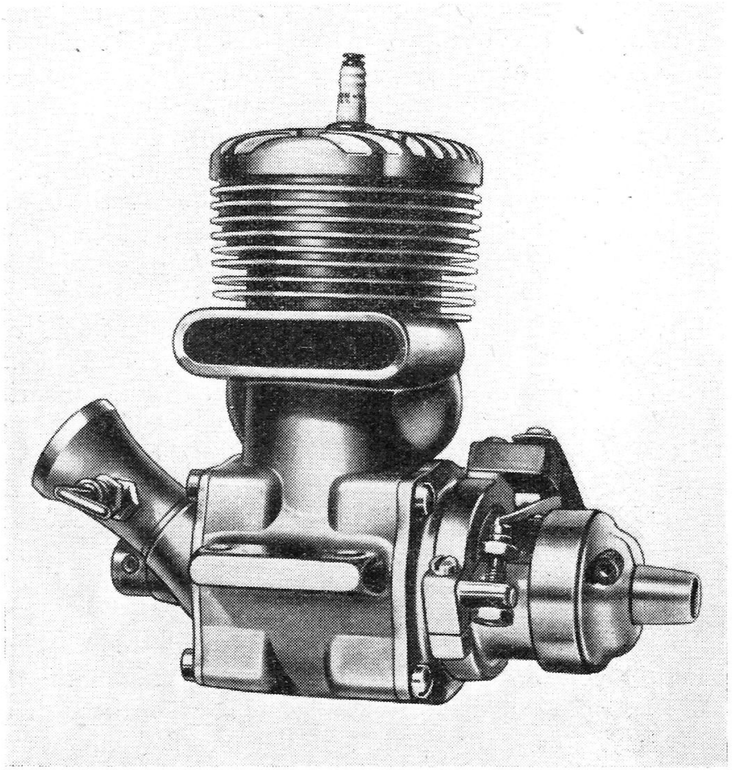

Fig. 26—The 10 c.c. " Dooling 61 " has a long line of high speed successes in the model car, boat and plane fields. The glow plug version has the contact breaker removed and a slightly raised compression ratio.

The manufacturers claim that no known engine of any size or manufacture—even the finest full scale aircraft engines—compare with this engine in horse power per pound weight. Its history would appear to bear out this claim at the moment of writing. It is interesting to note that the DOOLING was produced after manufacturing 42 different engines—thirty-three of which were of original designs and nine were rebuilt from previous models. Of

the unusual types, there were several with rotary valves in the head, rotary discs, rotary sleeves, tube rotaries, step pistons and inverted pistons. One was a twin cylinder engine with rotary valves and dual ignition, and two were equipped with superchargers, one operating at 80,000 r.p.m. ! The "61" was finally decided upon for the average hobbyist. A special dynamometer was one of the most important pieces of laboratory apparatus in the development of the engine. It indicates horsepower to three decimal places.

This short story shows the reader unversed with model engine production, what effort goes into producing the engine of his choice. All successful manufacturers go through the mill !