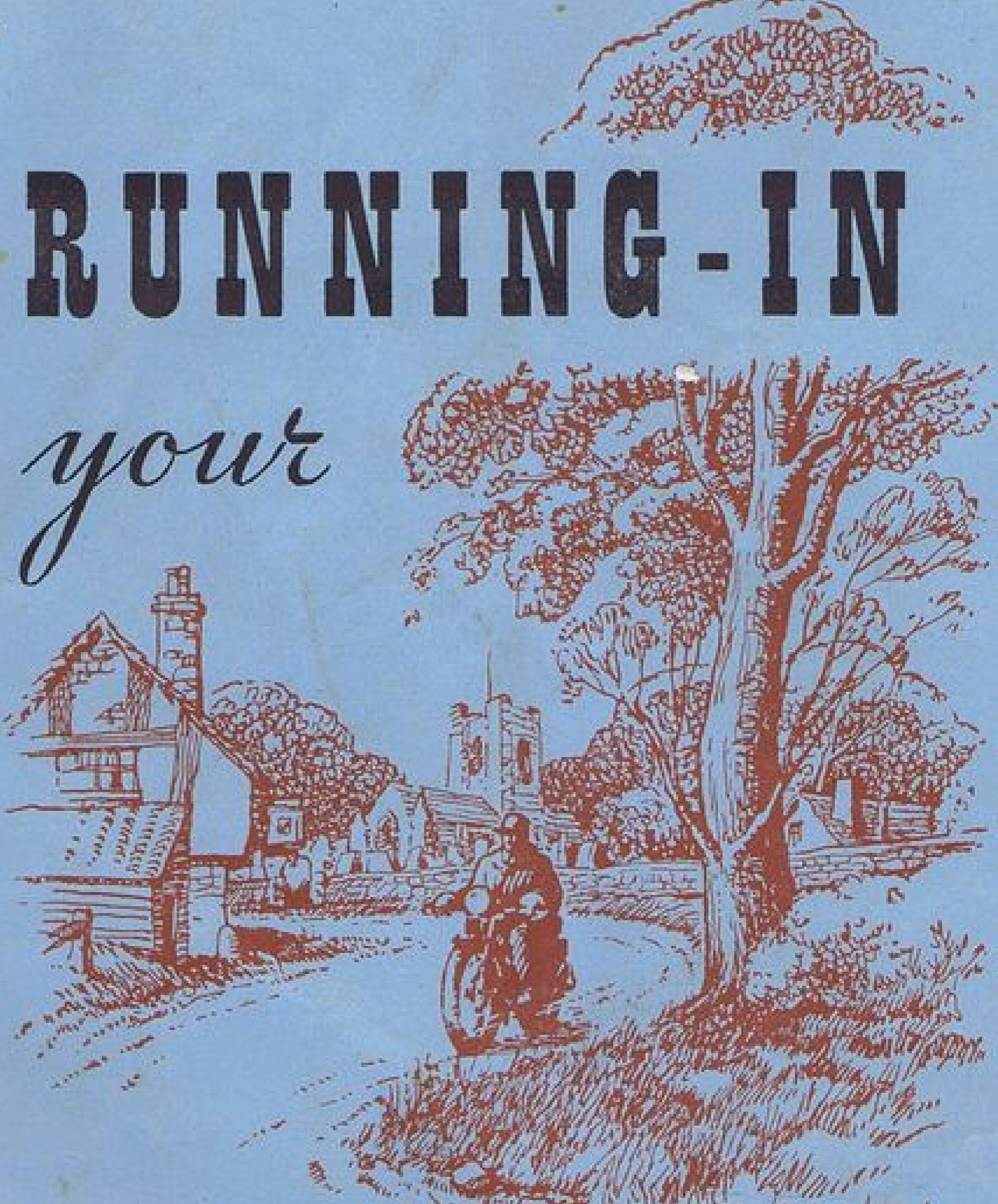
RUNNING-IN

your



Royal Enfield

MOTOR CYCLE

THIS little booklet on the lubrication of new engines has enjoyed unusual success since it was first issued. It is still in great demand, and for that reason, this new edition is offered by Acheson Colloids Limited, in the belief that it will be as warmly welcomed as the original issue.

ACHESON COLLOIDS
LIMITED

Manufacturers of "dag" colloids

9, GAYFERE STREET, WESTMINSTER
LONDON, S.W.1

RUNNING-IN

BY A. H. STUART, Ph.D., B.Sc.

SOME PRINCIPLES OF LUBRICATION

Since the subject of running-in centres round the question of lubrication let us be clear in the first instance as to the functions which a lubricant is expected to perform. Its main function is to reduce the friction of the mutually moving parts to a minimum. No matter how good a lubricant may be, however, it never entirely eliminates friction, and the overcoming of the residual friction results in the formation of heat. The second function of the oil is to carry this heat away and to allow it to radiate at a point where its presence will do no harm.

THE FUNCTION OF VISCOSITY

Some, at least, of the residual friction which is present in a well lubricated bearing is due to the resistance to relative movement of the layers in the film of oil. It is obvious that the higher the viscosity of the oil the greater will be this resistance, yet if the viscosity of the oil is not sufficiently high the oil film will be broken when the oil is squeezed out by the pressure of the bearing surfaces. In addition to these conflicting claims on a lubricant it must not be overlooked that the oil will be working at a relatively high temperature and the viscosity of all oils falls off very rapidly with a rise of temperature, a typical example being shown in Fig. 1.

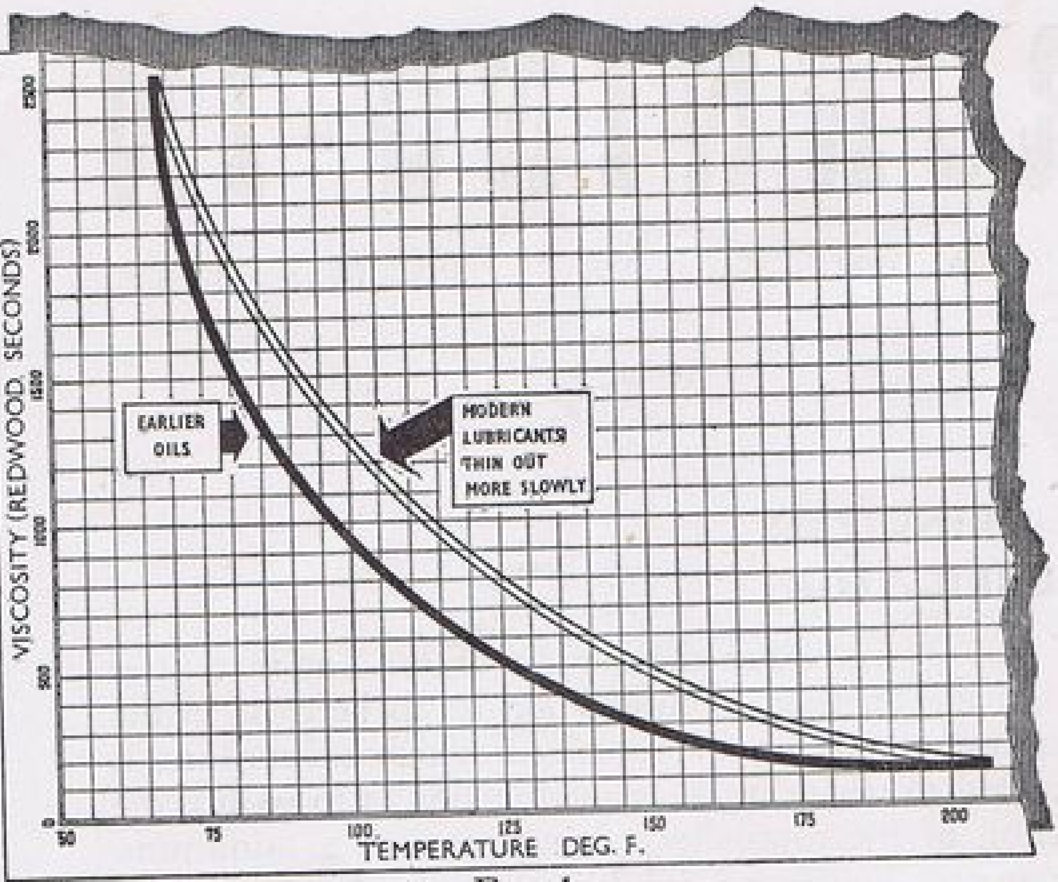


FIG. 1.

THE WORKING TEMPERATURE

This working temperature is a very important matter, since any error in its estimation may result in the selection of an unsuitable oil. All bearings, whether subject to the heat of an engine or not, will rise in temperature, when running, until the heat radiated from the bearing, or carried away by the oil, is just balanced by that which is generated by overcoming the friction.

It has recently been pointed out that the temperature of the oil within a bearing is not necessarily the same as the temperature of the bearing itself, since the oil film is at the seat of the friction and is, therefore, very near the origin of the heat generated.

The designer must take this into account, for excessive heat at the immediate surface of the bearing would mean that the oilfilm is thinned out to such an extent that it fails to keep opposite rubbing faces apart. Undue wear would follow with, possibly, seizure.

THE NATURE OF A BEARING SURFACE

Now, a bearing which has been machined by the best possible processes may feel smooth and look smooth to the naked eye, yet under microscopic examination the surfaces are not only irregular in shape but covered by a multitude of minute cracks and fissures. Keeping this in mind, let us consider, in detail, the conditions prevailing in the big end bearing of any internal combustion engine. During the power stroke the pressure of the crankpin will be exerted on the upper half of the bearing, and no matter how tight this bearing may be there is some clearance, the bulk of which will occur between the crank pin and the lower half of the bearing. On the induction stroke these conditions are reversed, and the clearance is transferred to the upper half.

With force feed lubrication the oil will obviously pass into the bearing where there is most clearance, and thus it happens that there is always the least oil where it is most wanted, that is, where the pressure is highest.

BEARING STRESSES

Engineers make a practice of expressing the load on a bearing in lb. per sq. in. of projected area. This is a very comforting fallacy for it leads one to assume (subconsciously, maybe) that the load is uniformly distributed. In a freshly-machined bearing the surfaces are microscopically rough and may possess very slight irregularities in shape. There will certainly be high spots where a minute particle of metal stands up above the level of its neighbours. When this spot comes into the line of the thrust of the load the pressure in lb. per sq. in. of projected area has nothing to do with the case, for the whole load is transferred to a minute area and the stress at this point mounts up to a considerable figure.

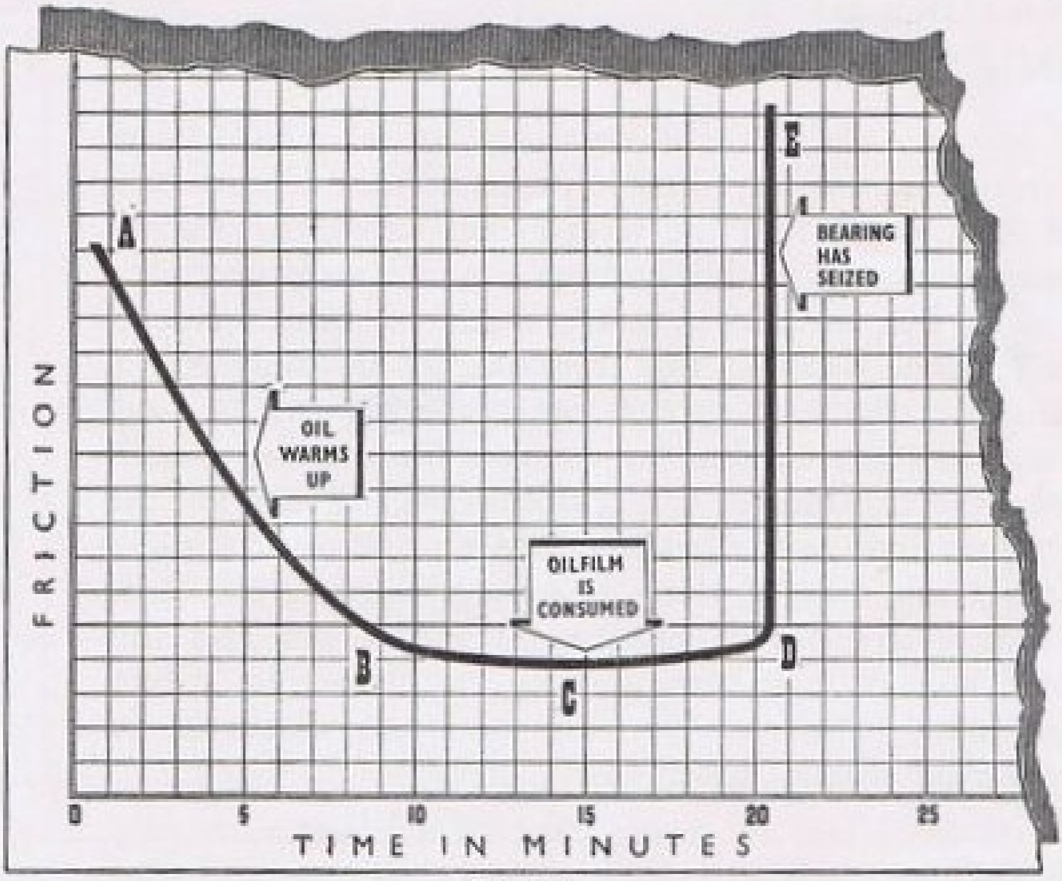


FIG. 2.

WHEN THE OIL FILM IS BROKEN

The oil which is being used in this bearing is quite unable to withstand such a pressure and the oil film will certainly be momentarily broken over this small area. This increases the friction which, in turn, produces a rise in temperature, thus making the matter worse still for the surrounding oil. All metals suffer a loss in tensile strength with a rise in temperature and this high spot will be worn down under the conditions now prevailing.

While this may be a desirable state of things in moderation, it is imperative that the high spot shall not be pulled up by the roots, so to speak, and destroy the surface in its immediate vicinity. To perform the necessary operation with as little injury to the patient as possible we must aim at maintaining the lubrication so that the rupture of the oil film shall be extremely local and every effort should be made to restore it without delay.

A BEARING WITHOUT OIL

It is interesting to watch the process of seizure of a bearing in which facilities are provided for measuring the forces operating. Fig. 2 shows the results of a test carried out at the National Physical Laboratory, on an experimental bearing in which the steel shaft was 2 in. in diameter and running in a white metal bearing at 500 r.p.m., under a load equivalent to 240 lb. per sq. in of projected area. Forced lubrication was used, employing an oil suitable for this load. The coefficient of friction was measured at frequent intervals of time, and it will be noted that the friction fell from A to B as the bearing warmed up and the viscosity of the oil fell. Shortly after the point B, the best conditions of lubrication were reached, and at this point the oil supply was cut off and the ducts plugged. The shaft was then run with no other lubrication than the oil film it retained at the moment of cut off.

THE CONDITIONS OF SEIZURE

As there was now no oil flow to carry away the heat generated, the temperature rose and the viscosity of the oil fell. At first this caused a very slight reduction in the coefficient of friction, until the point C was reached. After this the further fall in the viscosity of the oil due to the rising temperature caused a slight rise in the friction, the oil now being too thin for efficient lubrication at the prevailing pressure. At D the oil film definitely broke and the bearing was subject to metal-to-metal contact, causing the coefficient of friction to rise abruptly to E. In a normal bearing seizure would take place about this point, but in the experimental bearing the conditions were indicated by the belt being thrown off the pulley.

We have here reproduced on a large scale precisely what is happening on a small scale at numerous points in every bearing of an engine during the running-in period. The combined effects of these numerous small failures will be negligible only if we can confine their influence to the locality of the high spots, but if we allow a general rise of temperature so as to get an extensive rupture of the oil film, or if the film having only a small rupture is delayed in its restoration, seizure is practically certain. What steps can be taken to prevent this serious trouble?

FIRST PRECAUTIONS

To keep the load and speed of the new engine below normal is an elementary precaution which should be obvious to anyone. A plentiful supply of well-cooled oil also suggests itself. Since, as the high spots wear down, the metal removed has to be carried in the oil, a complete change of oil after the first 15 or 20 hours' running removes the danger of fine clearances being occupied by dirt where oil is most needed.

THE IDEAL LUBRICANT

If a lubricant could be found which would not be affected by temperature (within the range likely to be met with in an engine) and which could not be squeezed out of a bearing by excessive pressure, our problem would be solved. Such a lubricant exists in the form of colloidal graphite. One thing, however, colloidal graphite will *not* do. It will not carry away the heat generated in a bearing, which is one of the functions required of a lubricant. A suitable combination of lubricating oil and colloidal graphite, however, leaves nothing to be desired and meets all the demands which may be made upon a lubricant under the exacting conditions of running-in.

COLLOIDAL GRAPHITE

"dag" colloidal graphite is composed of graphite of more than 99 per cent. purity, and through the Acheson colloidalizing process of manufacture, is of such extreme fineness that it will disperse perfectly in good mineral oil.

When the recommended proportion of colloidal graphite has been added to a good quality mineral oil of viscosity suited to the engine, an ideal lubricant is obtained. In the case of mineral oils, and under certain conditions, this lubricant not only reduces by some 15 per cent. the coefficient of friction which the untreated oil would offer, but it produces on the metal what may be called a graphoid surface. This is a slippery surface too thin to measure which is held to the metal by molecular attraction, and cannot be washed or scraped off without the metal being taken with it.

THE GRAPHOID SURFACE

This graphoid surface may almost be regarded as a permanent safeguard, for its presence yields three important functions. First, under boundary lubrication conditions, it reduces the coefficient of friction. Next, should the oil film be broken, even on a quite extensive scale, it will provide sufficient lubrication to enable the bearing to continue running without undue overheating until the oil film is restored; and lastly, an oil film reforms over a graphoid surface much more quickly than is the case on an untreated metallic surface.

ANOTHER EXPERIMENT ON A BEARING WITHOUT OIL

To estimate the extent of the second advantage mentioned above an experiment was devised at the National Physical Laboratory using the shaft and bearing already mentioned. The shaft was run under the same load and at the same speed but an oil treated with "dag" colloidal graphite was used. The coefficient of friction was measured at intervals, as before, and the first part of the graph of these results was similar to the portion AB in Fig. 2, but somewhat lower down the scale, owing to reduced friction. At the point B, or thereabouts, the supply of lubricant was cut off as before. Now, instead of the graph falling to C, rising to D and then turning vertically upwards to indicate seizing conditions, as it did in the case of plain oil, it flattened out into a horizontal straight line indicating uniform friction, and continued, not for a matter of minutes, but for seven hours, when the test was closed for the day. The next day it was run, without any further lubricant, for 3¾ hours and on the third and fourth day for 8 hours each, making 26¾ hours in all.

For the first 23 hours of this running there was no measureable rise in the coefficient of friction. For the last 3¾ hours there was a gradual rise, but at no time was there any indication of conditions developing which would have resulted in seizure, and it was not thought worth while to continue the test longer. It is seldom that test results are as positive and conclusive as this, any comment on them being superfluous.

A film of extreme thinness (usually called a graphoid surface) which is held so tenaciously by a bearing surface, and which possesses such truly astonishing anti-friction properties, is of more than passing interest, and one is naturally curious to know something of the conditions which produce these highly desirable properties.

A STIFF ENGINE

Reverting, for a moment, to the running-in of an engine, it is readily understood that one of the most critical periods in the life of an engine is experienced during the first few revolutions after assembly. At this stage an engine is very stiff ; at least, it should be stiff, for if it is free before running-in, it will certainly be too loose after the various bearings have bedded down. The problem is to relieve this stiffness in such a way that the bearing surfaces are left in the condition necessary for a long and efficient life. One can hardly imagine any means better suited to this end than the formation of a good graphoid surface. Nor can this graphoid surface be developed too early. It is folly to ease the stiffness of a new engine by methods of sheer attrition and then to consider how best to lubricate the damaged surfaces.

RUNNING-IN

It should not be forgotten, however, that putting a supply of colloidal graphite between the bearing surfaces in only a part of the process. It is imperative that the graphoid surface should be formed by running-in under the most favourable conditions.

The skilled automobile engineer is able to reduce the running-in period by lubricating the engine, at this stage, with oil containing colloidal graphite, since the more gentle manner with which "high spots" are worn down enables him to increase the speed and load of the engine more rapidly. It is important, however, for the motor cyclist to realise that he should not attempt to follow this example. It requires great care and skill and experience to run an engine near the safety limit during its early life, and liberties of this sort should only be taken by the expert. On the other hand, during the whole process of running-in, including the running by the purchaser until the engine is free enough to be considered normal, the use of colloidal graphite will not only render the engine less stiff than it would otherwise be but will develop a surface on all the bearings, which will assure for them the maximum life.

THOSE FIRST REVOLUTIONS

In the best practice a new engine, for instance, placed on the running-in bench, is first "motored" by external power, the amount of power used to rotate the engine being registered. This process is continued until the power required drops to a pre-determined level. It is a good plan during this period to stop the engine after each 15 minutes of running-in and allow it to cool for 5 minutes. Another desirable precaution against overheating is to run the engine with a dry sump and allow the pump to take its supply of graphited oil from a separate tank of at least 5 gallons capacity, with adequate cooling facilities.

THE POWER ABSORBED

As an example of what takes place during this preliminary "motoring" of an engine, the case may be quoted of a well-known 9 horse power 4-cylinder engine which, after being assembled with a coating of colloidal graphite in oil on the bearing surfaces was mounted on a running-in bench and "motored" at 800 r.p.m., the power absorbed being 4½ h.p. After 2 hours on this bench it was being "motored" at 1,200 r.p.m. with absorption of only 2 h.p.

The rate of fall in power absorbed and of the rise in the revolutions during these two hours are shown by the graphs in Fig. 3. It is obviously desirable that both graphs should show unmistakable signs of flattening out before an attempt is made to run the engine under its own power.

NOW A LIGHT LOAD

After the engine has been sufficiently motored, it is run on light load at low revolutions under its own power, the load and revolutions being gradually increased until the normal is reached. After a few hours of such running the best practice exposes the main and big end bearings for inspection, after passing which the engine is re-assembled.

A purchaser receiving an engine which has received this treatment will find the worst of the running-in troubles over. Nevertheless, the machine should be used with care for the first 1,000 miles, using graphited oil throughout with a change to new oil at 500 miles.

GEAR BOX

Attention to lubrication of the gear box will be repaid by silent running and minimum losses in the power transmitted.

The graphoid surface which is formed on the teeth with colloidal graphite protects them from pitting and undue wear. A test carried out at the National Physical Laboratory on the Lanchester worm gear testing machine showed that "dag" colloidal graphite reduces friction by 15 per cent. and raises, by about 68 deg. F., the maximum temperature at which oil can lubricate with safety.

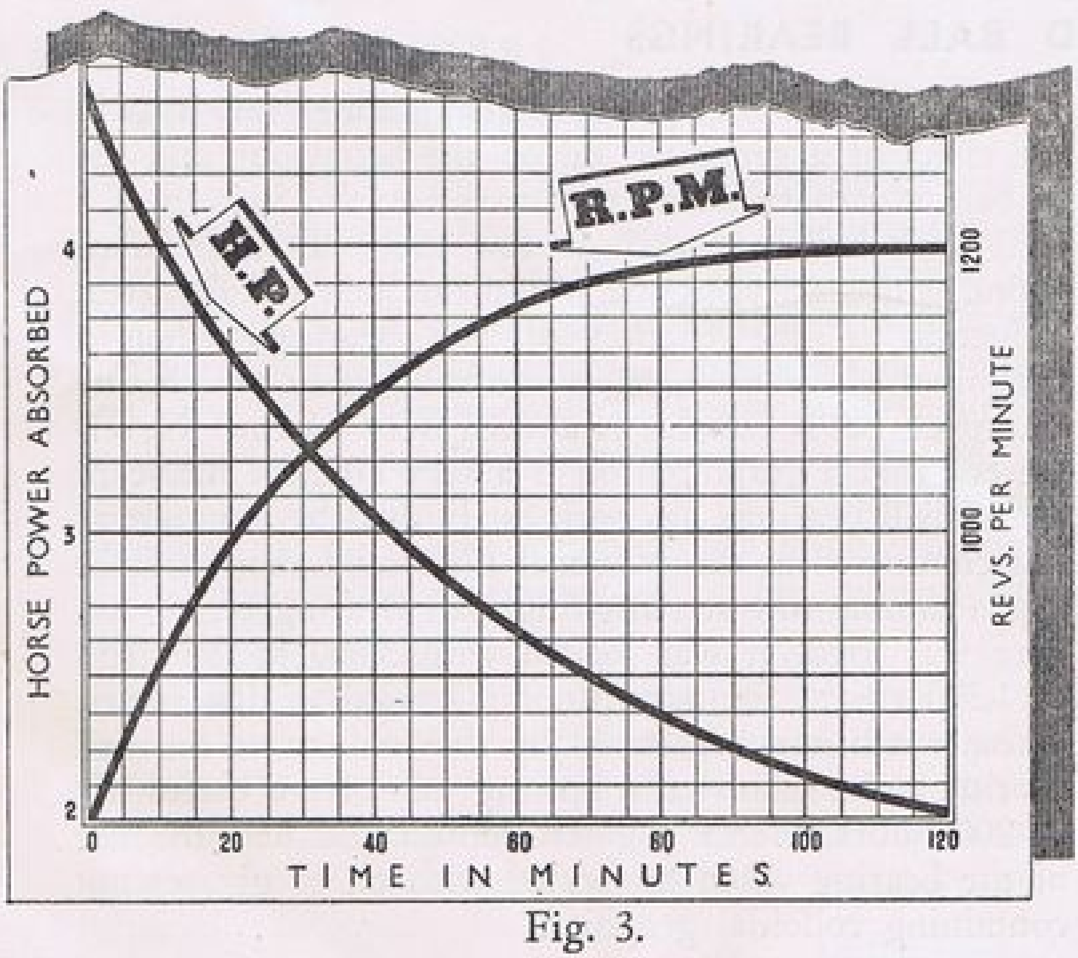


Fig. 3.

CYLINDER WALL TEMPERATURES

Again, when an engine is working under load, the cylinder walls are exposed to temperatures which are not always realised. Recent investigations have been made by means of thermo-couples, into the temperatures reached in the combustion chamber. With compression ignition engines, now so common in heavy vehicles, the temperatures are, of course, higher, 2,500 deg. C. having been recorded at the peak. No oil can withstand temperatures even approaching those recorded and under the high pressure prevailing at this stage of the cycle much of the oil which is present is "cracked" and the evidence of recent investigation points to the formation of carbon deposits being a result of this cracking process. A graphoid surface is capable of retaining its slipperiness at high temperatures indeed.

COLLOIDAL GRAPHITE AND BALL BEARINGS

The question is sometimes raised as to the effect of a graphited oil on the behaviour and life of ball and roller bearings. Of course, the friction of a well-made ball bearing is so low that very little lubrication is necessary, so one would not look for any great reduction in the friction of ball bearings when a graphited oil is used, since the margin in which any improvement is possible is already very narrow. Nevertheless, that a graphited oil is a very efficient lubricant for all ball bearings has been established by a searching test conducted at the National Physical Laboratory. In this a double row self-aligning Ball Bearing of 2½ in. bore was used. It was loaded with 3,600 lb. and run at 1,300 r.p.m. for a continuous period of 100 hours. These conditions are stated by the makers of the ball bearing to be such that a bearing will give a useful life of 200 hours. Hence the test represented half the life of the bearing when lubricated with oil or greases not containing colloidal graphite.

The bearing was lubricated with a suitable oil with which "dag" colloidal graphite had been incorporated. Throughout the test the temperature of the bearing ranged from 37.5 deg. C. when the temperature of the air was 19 deg. C. to 42 deg. C. The coefficient of friction was 0.00085 at the higher temperature and 0.0009 at the lower temperature and otherwise remained unchanged throughout the test.

The balls and races were examined and weighed before and after the test and showed no sign of wear and no change of weight. As the weighing was made to the nearest 0.005 gramme, and a loss of this amount on the balls would indicate a reduction in diameter of 2-millionths of an inch, the wear, if any, was of quite negligible proportions. The presumption is that the bearing could have been run on the graphited oil for another 100 hours without undergoing appreciable wear. In other words, the life of the bearing under these arduous conditions of load and speed would be greatly prolonged.

REBORED CYLINDERS AND OVERSIZE PISTONS

All the advantages attending the use of colloidal graphite in the running-in of a new engine are highly desirable in the initiation of an old engine which has had its cylinders rebored and fitted with oversize pistons. The excellent facilities which many garages now possess for carrying out this reconditioning process on engines are attracting more and more attention. To obtain the full benefit, however, of this relatively cheap restoration of an engine it is necessary to observe many of the precautions recommended in the running of a new engine.

The best results will be obtained if the new pistons have colloidal graphite in oil applied to them before they are inserted in the rebored cylinders, and for the first 1,000 miles after reboring a graphited oil should be used in the sump and a graphited upper cylinder lubricant employed.

An engine initiated to its task in the way indicated has all its bearing surfaces conditioned so as to give not only more efficient service but to maintain this high standard of efficiency for a longer period than would otherwise be possible. Moreover, the risk of serious trouble such as seizure or the running of a big end bearing is practically impossible without ill-use of a very grave order, or some mechanical defect.

THE MAINTENANCE OF THE ENGINE AFTER RUNNING-IN

In conclusion, it is useful to know that colloidal graphite may be used in the oil after the running-in period, the quantity required being about one-half of the proportion used during running-in. Whilst this practice maintains the graphoid surface formed during the running-in period, it is important to bear in mind that good quality oil should at all times be used in the engine. Moreover, to obtain the maximum benefits, and to maintain the engine in good condition, the oil should be drained and renewed and the filter cleaned at regular intervals as specified by the manufacturers.

TESTS PROVE THE VALUE OF COLLOIDAL GRAPHITE

A series of tests have been carried out by the Institution of Automobile Engineers, Research Dept., which have shown that "dag" colloidal graphite in the oil of a new engine reduces cylinder wear by one half.

The conditions of the tests brought out the factors which contribute largely to cold starting and running wear in an engine. Accurate measurements were made throughout the tests so that it was possible to say that at all times the wear with the graphited oil was approximately one-half of the wear with plain oil under similar conditions.

Photographs of the piston rings used in the engine revealed that the graphited oil had protected the piston rings from corrosion. As this factor is prominent in an engine operating under cold starting and running conditions, it is apparent that colloidal graphite is the logical lubricant for petrol engines which have to operate in large towns where stopping and starting is frequent.

TEST ON GRAPHITED UPPER CYLINDER LUBRICANT

A water-cooled single cylinder engine of 500 c.c. capacity was operated by the same Research Department, for alternate periods of fifteen minutes run and fifteen minutes rest. During the first five minutes running the load was light and the temperature in the water jackets kept low. The load, speed and temperature were then increased during the ensuing ten minutes, after which the engine was shut down for fifteen minutes. This procedure was repeated, giving an equivalent mileage for the whole series of tests of approximately 5,370 miles, using alternately, plain petrol and petrol to which "dag" colloidal graphite had been added.

The reduction in cylinder wear ranged from 27 per cent. to 50 per cent. and in piston ring wear, from 12 per cent. to 37 per cent., with colloidal graphite in the petrol. Of particular interest was the way in which the graphoid surface formed on the cylinder walls and piston rings, maintained a lower rate of wear after the supply of colloidal graphite was discontinued. Thus, when a run on graphited petrol was changed over to plain petrol, the beneficial effect continued to be felt until the graphoid surface was worn off the cylinder walls and piston rings.

HOW TO USE COLLOIDAL GRAPHITE

It is available in the form of Running-in Compound and Upper Cylinder Lubricant (graphited) obtainable at garages, service stations and principal accessory stockists.

Add one pint of Running-in Compound to each gallon of lubricating oil. A pint tin will enable you to treat the initial tank of lubricating oil, and also to treat the new lubricating oil after the first oil change, during running-in. If the new machine is delivered without colloidal graphite in the oil add Running-in Compound at the earliest opportunity.

It is not necessary to add Running-in Compound when topping-up. This special lubricant should be added, preferably, when the oil has been warmed up by running the engine.

Upper Cylinder Oil containing Acheson's colloidal graphite is usually added in the proportion of one ounce to four gallons of petrol, when an engine is new.

Form 83—100—648