MAGNETOS

SIMPLY EXPLAINED

A Practical Guide to the Construction, Management, and Uses of the Modern Magneto

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FOREWORD

BEFORE the war the monthly output of British magnetos was 100; at the date of the Armistice it was 18,000.

But these bald figures, eloquent though they are, tell no more than half the story; for, in addition to the fact that the output of complete British magnetos in 1914 was practically a negligible quantity, not one of the chief component parts of a magneto was at that time manufactured in the country, all having become German products. Such was the position when war broke out, and the Government, having in the past entirely neglected this vital industry, began to clamour loudly for magnetos, not only for use on motor cars, but also for the more complicated types required for aeroplanes—a much more difficult proposition. The story of how the foundations of the magneto industry were laid by a few energetic firms; how the subsidiary manufactures of necessary materials such as tungsten, enamelled copper wire, varnished silk and paper, "stabalite" moulding, etc., were established; how foreign magnetos were at first copied with little success; how persistent original failures were gradually overcome; how improvements in design were introduced and new designs for aeroplane types evolved; how success was finally won, and vast quantities of magnetos turned out, far superior in design and workmanship to any pre-war machine, constitutes one of the brightest pages in the history of British industry. For it must be remembered that all this was accomplished in a few years and under the stress of war conditions. The British magneto industry is now firmly established in a flourishing and active condition, turning out machines which are unrivalled as to quality. Indeed, it is one which seems to suit the national characteristics very well, thoroughly sound workmanship of the highest class being essential.

The magneto depends entirely on the principle which was discovered in 1831 by that most distinguished English scientist

and electrician, Michael Faraday. The son of a blacksmith, and himself starting life as a bookbinder's apprentice, he became engrossed in the study of pure science, becoming associated with another great English scientific man, Sir Humphrey Davy.

Among the numberless discoveries made by Faraday, upon which many of the amenities of civilised life depend, was that one which we are now concerned with, and which is called electro-magnetic induction, or simply induction for short. Faraday's discovery was that by moving a magnet within a coil of wire, a tiny electric spark could be produced between the ends of the wire; and this principle, worked out in detail, is that which is used in the present-day magneto to produce the spark at the plug. It is the principle of induction, by which is meant the production of electricity by the influence of magnetism, and the reverse. It occurs, not once only, but several times, at each sparking operation of the magneto.

Faraday having discovered the principle in 1831, the next event of practical importance was the construction of a dynamo based on this idea, in 1860. It is a curious fact that this dynamo has a very close resemblance to the fly-wheel magneto used in the Ford car to-day.

The first H.T. magneto was made by a Frenchman, M. Boudeville, who unfortunately spoiled his invention, from a practical point of view, by neglecting to use a condenser.

The magneto then unfortunately lapsed into German hands, where it was worked up to a successful commercial machine, and Stuttgart remained the home of the magneto industry for many years.

The dramatic (and nearly disastrous) events since 1914, as outlined above, have resulted in bringing the magneto industry to Great Britain, where it should have been established from the first.

Another instance of our curious habit of letting other nations work out our inventions into commercial productions occurs in the case of a later kind of magneto, known as the inductor type, of which more is likely to be heard in the future. The invention was due to Dr. T. B. Murray, who, with the Albion Motor Car Company, took out a patent for it in 1906. Beyond making magnetos for their own cars, however, the invention was not proceeded with here, and it was left to America to develop it, large quantities of inductor magnetos being produced there. During the war, however, one British firm specially devoted itself to this type of magneto for use on aeroplanes, bringing out some new designs giving four sparks per revolution instead of two. These machines have proved successful and have been very largely used in the Air Services for 8- and 12-cylinder engines, among other records held being the historic event of the first successful airship crossing of the Atlantic by H.M. Airship, R 34.

F. H. H.

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CHAPTER I

HOW A MAGNETO WORKS

THE principle of induction as discovered by Faraday may be positively demonstrated by the simple experiment illustrated in fig. 1. An ordinary magnet is fixed upright on a wooden base. A short length of stiff copper wire has two flexible leads fastened to it, the other ends of which are taken to the terminals of a very sensitive galvanometer, this instrument being capable of detecting minute currents of electricity. When the wire is moved sharply upwards between the ends, or "poles," of the magnet as indicated by the arrows, a deflection of the galvanometer needle will be noticed, showing that a current of electricity has been induced in the circuit composed of the copper wire, the flexible leads, and the galvanometer. This is the first important fact to observe. Now repeat this movement at different speeds. It will be found that the faster the wire is moved, the greater is the effect on the galvanometer needle, showing that the strength of the current induced in the wire depends partly on the speed. Now try moving the wire downwards instead of upwards, that is to say, begin with the wire level with the top of the magnets and move it quickly down between the poles. The galvanometer needle will be deflected, but will move in the opposite direction to what it did previously. By moving the wire up and down continuously, we can keep the needle deflecting first to one side then the other. From this, we gather that the direction of the current induced in the circuit depends on the direction in which the wire is moved, either up or down. By continuously moving the wire up and down, it is possible to keep the current alternating in the circuit.

Now, keeping the wire between the arms of the magnet, try the effect lower down, that is, nearer to the wooden base. It will be found that as we get lower, further away from the

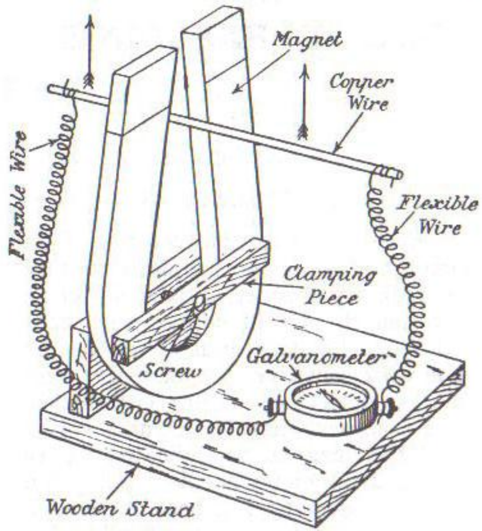

FIG. 1.—The Simplest Form of Magneto Generator.

" poles " of the magnet, the effect on the galvanometer rapidly decreases and soon ceases altogether. Next remove the magnet from its fixing and take it right away. Move the wire about now in any direction, or at any speed, and we get no deflection of the galvanometer needle ; it remains quite unaffected.

From this simple experiment we can gather together some extremely important fundamental facts as follows :—

(1) That a wire moved up or down between the poles of a magnet has a current of electricity induced in it.

(2) That the direction of this current depends on whether the wire is moved up or down.

(3) That the strength of this current varies with the speed at which the wire is moved.

(4) That the induction effect is only obtained by moving the wire when it is near the ends (or poles) of the magnet, where the magnet evidently has a well-defined sphere of influence.

It is, in fact, just on these principles that all electricity is generated for practical use, for lighting or power ; a dynamo being simply a machine for moving the wires between the poles of a magnet.

It is in this way that the original current is produced in a magneto.

Now, in our experiment we have only employed one short length of copper wire, and the current induced in it has consequently been a very small one ; in fact, it is necessary to have an extremely sensitive galvanometer to detect such currents. Delicate instruments like these were, of course, unknown in Faraday's time.

In order to increase the effect we will take a length of wire, wind it up into a coil, and again try the experiment. This time we find that the inductive effect is much increased, the deflections on the galvanometer needle being more violent. We will also get an iron rod about the thickness of a pencil, wrap a layer of paper over it, and then wind our coil over that. Again trying the effect, we find still stronger deflections produced ; in fact, we shall now probably have to change our galvanometer for a less sensitive instrument to avoid damaging it.

From these events we deduce the facts that the inductive effect is largely increased by (1) using a longer length of wire, wound up into a coil for convenience ; (2) by providing an iron core inside the coil, which allows the magnetism to pass through more easily.

An arrangement of a coil, or coils, of wire wound in this manner on an iron core is called an armature. In practice the armature core of a magneto is made of H-section iron, like a shuttle, and the wire is wound in the channels so formed, as shown in the illustration (fig. 2). Instead of moving the wires up and down between the poles of the magnet, the armature is, for convenience, rotated, this motion having practically the same effect as regards the relative movement between coils and magnet.

We have now arrived at the stage shown in fig. 3. The magnet is illustrated with the addition of pole-pieces (or pole "shoes," as they are generally called); these do not alter the principle, but merely concentrate the magnetism where it is wanted, and so increase the effect. The armature has an H-section iron core on which is wound the wire, and this wire we will in future call by its proper name — the primary coil. The ends of this primary coil are taken out to a switch (or contact-breaker), which being closed, and the circuit being therefore complete, a current will flow in it which will alternate in direction for the reason explained above.

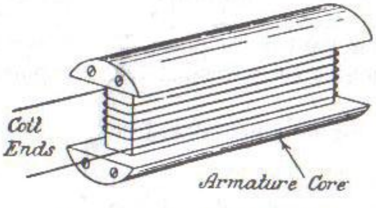

FIG. 2.—The Winding of a Shuttle Armature.

The current in this primary coil alternates or changes its direction twice in every revolution of the armature; its strength gradually rising to a maximum and falling again, first in one direction and then in the other. This rising, falling, and reversing of the current continues so long as the armature is revolved. There are, therefore, two points in each revolution at which the current is at its maximum value. These points occur when the primary coil is passing through the strongest sphere of influence of the magnet, and are only of momentary duration.

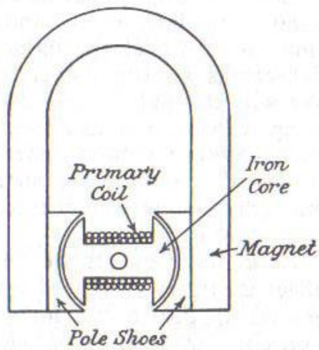

FIG. 3.—The Early Stage of the Magneto.

Now, the purpose of a magneto is to produce a spark at the points of a plug in the engine cylinder in order to ignite the gas. A gap of a definite length is arranged between the points of the plug, and, in order to make the current jump across the gap in the form of a spark, electricity at a high pressure (or voltage) is required. Electric pressure is often compared to hydraulic pressure, and in many ways the two are alike.

On the one hand, we have a flow of water in a pipe driven along by the pressure created at the waterworks; if this pressure is a high one, the walls of the pipe will be liable to burst unless they are made very strong; the volume or quantity of water that will flow under the force of this pressure depends on the diameter of the pipe provided. There are various kinds of water systems: some supply large volumes of water under a low pressure; others supply a small volume at a high pressure. Each system of supply may be capable of doing the same amount of work, and may require the same amount of power to produce it; the choice depends on what we want to use it for. With electricity, the case is very similar: we may have small quantities of electricity at very high pressure, which necessitates having substantial insulating material round the wire (corresponding to thick walls to the hydraulic pipe) to keep the current from escaping; or we may have a large current which will require a thick wire to carry it (corresponding to a large pipe), though the pressure may be quite low. Electric pressure is measured in "volts" and the flow of current in "ampères."

Now, as mentioned above, in order to produce a spark by jumping the gap at the plug points, electricity at a high pressure is required, though the amount of current need only be very small; and although it is not impossible to obtain such high pressures direct from a dynamo, actually it would not be practical to do so for ordinary use. Fortunately, there is an easy way of overcoming this matter, for owing to the application of induction, we are able to transform large quantities of electricity at a low pressure into small quantities at a high pressure, which is exactly what is required in this case. We generate comparatively large quantities of current in the primary coil at a low pressure, and convert this into minute quantities at a very high pressure by means of induction. How is this accomplished? For the answer, we must go back to experiment once more.

Faraday discovered in 1831, that, by moving a magnet in or out of a coil of wire, an electric current was induced in the wire; but about eleven years previously, it had been determined that the converse was also true. That is to say, besides magnetism producing electricity, electric currents also produce magnetism. It was found that when a current was sent into a wire, the wire spread out all round itself a sphere of magnetic influence which had just the same qualities as that from an ordinary magnet. To increase this effect, the wire was wound up into a coil as before.

We have two coils of wire lying close to each other, but not actually touching (see fig. 4). The ends of the first coil are connected through a switch or circuit-breaker of some kind so that the circuit can be opened or closed at will. Now, suppose that the contact-breaker is closed and a current of electricity is flowing in that circuit, as indicated by the arrows. A magnetic sphere of influence will be set up round the coil which will embrace the second coil, as the two are close together. Suddenly open the contact-breaker; the current ceases, and with it the magnetic sphere of influence round the coil; but this magnetic sphere, or "magnetic field" as it is called, in subsiding, cuts across the wires of the second coil, producing the effect of induction as before, and causing a deflection of the galvanometer to which the ends of the second coil are attached. This is the principle to remember—when a coil of wire carries a current, it is surrounded by a magnetic field similar in all respects to that which surrounds an ordinary magnet; so long as this field remains steady no inductive effect is produced on another stationary coil, but as soon as the magnetic field begins to collapse it cuts across the wires of the second coil and induces a current in them. The great convenience, however, of the arrangement lies in the fact that for a given current strength in the first coil, the electric pressure induced in the second coil depends on the length of wire composing it. We may arrange matters as in fig. 5, where the first coil consists of a few turns of thick wire and allowing a large current to flow through it; the second coil may consist of a vast number of turns of very fine wire, the ends of which are taken to a gap of say ¼ in. In the first coil we may have a current

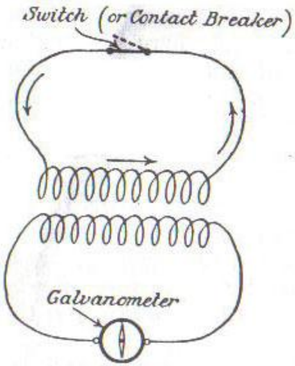

FIG. 4.—Induction from one Coil to another.

When current in the top circuit ceases a deflection is caused in the galvanometer.

of about three ampères flowing at a pressure of ten volts. This current suddenly being broken at the contact-breaker, by its inductive effect on the second coil may produce in that coil a pressure of 5000 volts, which will be capable of jumping across the gap in the form of a spark. This is actually what happens in a magneto. The first coil is the primary coil on the armature, as previously described; it is wound on an iron core and revolved between the poles of a magnet; a comparatively large current is induced in this winding, which increases to a maximum twice in each revolution; at these maximum points the contact-breaker is made to open, interrupting the current and so inducing a very high electric pressure in the secondary coil, as just described, which causes a spark at the points of the plug. In practice the secondary coil of fine wire is wound over the primary coil, both coils being made of insulated copper wire.

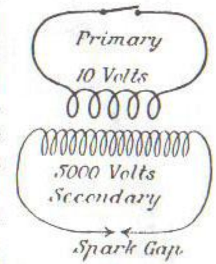

FIG. 5.—Transforming Low Voltage to High Voltage by Induction.

These events are a general outline of what occurs in a magneto each time it produces a spark at the plug. But other electrical reactions also take place, some of which we must examine. The first and most important of these reactions concerns the condenser and the reason for which it is required. The manner in which one coil acts on another by induction has just been shown. But, further than this, a peculiar action called "self-induction" also takes place at the same time. That is to say, the primary coil not only affects the secondary coil by induction, but even acts on itself in the same manner. Self-induction is a somewhat peculiar phenomenon, and one that is not easy to grasp at first; but it plays an important part, and would render the magneto impracticable unless measures were taken to counteract its effects. What happens is that when the contact-breaker opens and interrupts the current in the primary coil, the magnetic field, in collapsing, cuts across the windings of its own coil, thus inducing in them a large current. This self-induced current we will call the "extra current." Now, these self-induced extra currents in a coil always act in opposition to the main current: if a current is beginning to flow in a coil, the extra current opposes and therefore weakens it ; if, as in this case, a current is being interrupted, the extra current tends to continue and strengthen it. The extra currents, in fact, make themselves as objectionable as possible. When the contact-breaker opens in the primary coil, we want the current to die away with all possible speed in order to produce the greatest inductive effect on the secondary coil. But the self-induced extra current opposes this, and tends to make the main current continue and to cause a hot spark across the points of the contact-breaker which would soon cause them to burn away.

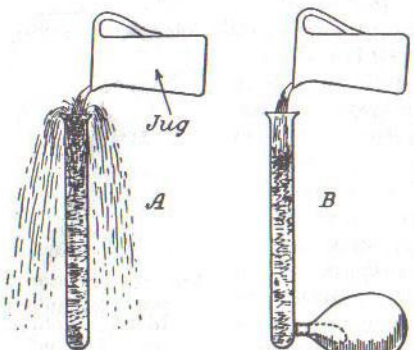

FIG 6.—Hydraulic Analogy of the Condenser.

It is in order to counteract these bad effects that a condenser is used. In order to understand the function of a condenser, we may again conveniently turn to the water analogy.

Imagine a long, slender vessel, like a tall flower-glass, being filled with water from a jug by someone in a great hurry (fig. 6, A). The jug, on being tilted upwards, shoots the water into the glass, the water level quickly rising and flowing over the top of the glass, spilling over the side, wasting itself and causing damage. Take another flower-glass of the same shape and dimensions as before, but having an outlet at one side to which can be attached a small indiarubber toy balloon, deflated, as indicated by the dotted line in fig. 6, B. Let the water be poured in as before. This time, instead of spilling over the top and causing damage, the water pressure spends its energy by distending the indiarubber balloon, which becomes strained but does not burst so long as it is made of good material. In this way the rush of water is absorbed and prevented from overflowing. The condenser acts in a very similar manner towards electricity as the balloon does to the water ; it absorbs the rush of the extra current and prevents it overflowing at the contact points and doing damage in the form of a spark,

corresponding to the water overflowing at the top of the glass. Like the balloon, it becomes strained (electrically), but is able to resist the strain if the insulating material is good. By reason of its large surface it can provide accommodation for a large amount of electricity, or, in more scientific language, it forms a " capacity " for the current to flow into. The water analogy must not be pressed too far, but up to a point it forms a good illustration of a condenser, and makes the action more comprehensible.

When there is room, condensers are generally made of a sheet of glass coated on either side with tinfoil, as in fig. 7, A. They are charged by connecting the opposing sides to a source of electric pressure of some kind. On a magneto the available

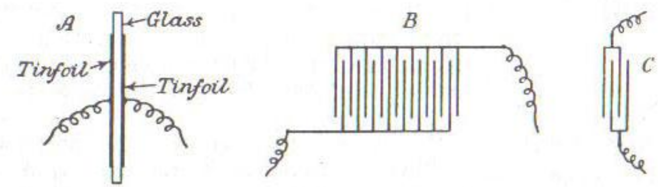

FIG. 7.

A, Ordinary Electric Condenser.
B, Condenser constructed as a Number of Small Plates. Mica Insulation (not shown) is inserted between each Plate.
C, Conventional Method of Representing a Condenser.

space is very limited, and there is no room for large sheets, so these are cut up into small pieces and placed one over the other like a pack of cards. Alternate pieces are connected together and mica insulation is placed between each piece of tinfoil. Each of these series of pieces connected together then forms one side of the condenser, the arrangement being as shown in fig. 7, B. The conventional method of representing a condenser is indicated at fig. 7, C, as though it consisted of two plates only. The whole device has to be made very compact and well insulated, a considerable amount of skill and experience in that particular work being required.

The condenser is connected in the magneto circuit as shown in fig. 8, being placed " in parallel " with the contact-breaker, to which it forms an alternative path. Although the condenser is unseen by the user of a magneto, it nevertheless forms a most important part of the anatomy. It is located at one end of the armature, under a brass cap provided for its protection.

The next working portion is the contact-breaker, which forms part of the armature and revolves with it, consisting of two contact points, one fixed and the other capable of being rocked on a pivot. The primary winding is connected to the fixed point, while the rocking point is connected to earth. The other end of this rocking arm has a fibre heel which strikes against two steel cams in the course of its revolution, matters being so arranged that this happens when the current in the primary coil is at its maximum. When either of the cams strikes the fibre heel, the contact points are knocked open, thus breaking the circuit and bringing into operation the inductive effects we have been considering, and which culminate in producing a spark at the plug.

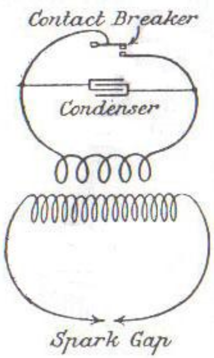

FIG. 8.—Connections in a Magneto. Elementary Form.

We have now reviewed the principal operations that take place within a magneto and the causes that bring them about: the magnet, the primary and secondary coils, the contact-breaker, and the condenser, which, together with the iron core, combine to form the armature. We have seen in fig. 8 how these parts are connected. To come a little closer to actual practice, while still retaining the diagrammatic form, we give the illustration (fig. 9). At first sight this diagram appears to be fundamentally different from the last one, but in reality it is not so. Probably the first difference noted will be that, instead of all the circuits being completed by wires, some of them end up at points marked with the symbol E. This symbol, in electrical jargon, stands for earth, which in motor engineering means the metal framework of the car or magneto, so that all parts of the diagram marked E are in electrical contact with each other. Dotted lines in the diagram indicate this connection through the framework. Take, for example, the primary (or low-tension) circuit. The commencement of this winding is marked E because it is connected to the iron core of the armature, which is in metallic contact with the frame of the car through the body of the magneto. The primary

circuit passes on to the contact-breaker, throwing off on the way a connection to one side of the condenser. The rocking arm of the contact-breaker is connected to earth so that when the points are closed there is a complete circuit through the primary coil to the contact-breaker and so back through earth to its starting-point. Again, take the condenser and note its connections. In the former diagram it was seen to be connected between the primary coil and the contact-breaker, in parallel with the latter. Following up the connections in fig. 9, it will be found to be connected just in the same way through earth.

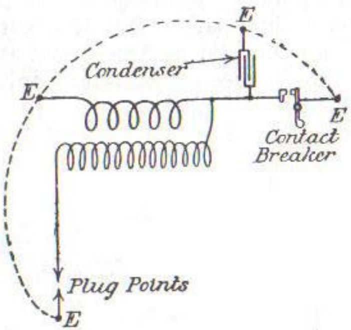

FIG. 9.—Diagram of Magneto Connections. Second Stage.

A slight alteration will be noticed in the secondary (or high-tension) circuit. Whereas in the former diagram both ends of this winding were brought out to the spark gap, in this diagram one end is shown connected to the finishing end of the primary coil. This is merely done for convenience, and makes no difference to the working. The current in the HT winding passes to the plug by way of a well-insulated cable provided for it; there it jumps the gap in the form of a spark, enters the framework of the car E, finds its way back as per the dotted line to the commencing end of the primary winding, goes through the primary coil, which offers practically no resistance to such a small current, and so completes the HT circuit.

A few more connections still remain to be added to the magneto diagram. Looking at fig. 10, one addition is seen to be the "earthing switch," used to prevent the magneto from producing sparks when not required. A connection from the fixed member of the contact-breaker points leads to a switch placed on the instrument board of the car, the other terminal of this switch being connected to earth as shown. When the switch is closed it is evident that the LT circuit is complete, whether the contact-breaker points are open or closed. No inductive effect, therefore, will take place when the contact points open, and no spark will be produced at the plug.

Another addition is the safety spark gap, consisting of two points, one connected to the HT circuit and the other to earth. These points are set at such a distance apart that in ordinary working the current will find an easier path across the points of the plug, and so the safety gap does not interfere with the spark. But if a wire should become disconnected from the plug so that there is no path for the HT current, then the electric pressure would rise to a very high figure, and

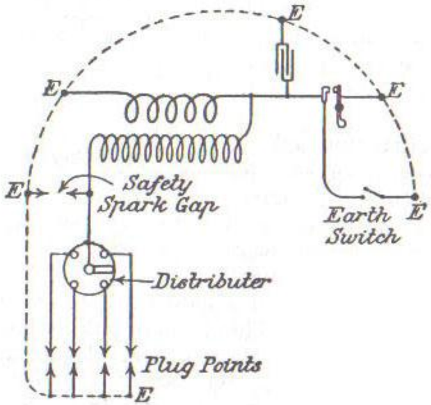

FIG. 10.—Magneto Connections. Complete.

if no safe outlet was at hand it would find some weak place in the insulation and would spark through it, causing permanent damage. It is for such circumstances that the safety gap is provided. When the electric pressure rises up to a certain figure, a spark passes across this wide gap and so relieves the situation. Next comes the distributer. This is merely a revolving switch which distributes the HT current to the cylinder whose turn it is to fire, but, since it deals with current at high pressure, the insulation is an important matter and has to be carefully considered. The distributer is driven by a gear-wheel on the armature shaft, and is placed immediately over the contact-breaker.

Passing on from the diagram stage and approaching still

nearer to concrete facts, we have in fig. 11 a good illustration of the magneto connections in practice. The compact nature of the armature will be noticed, including as it does so many

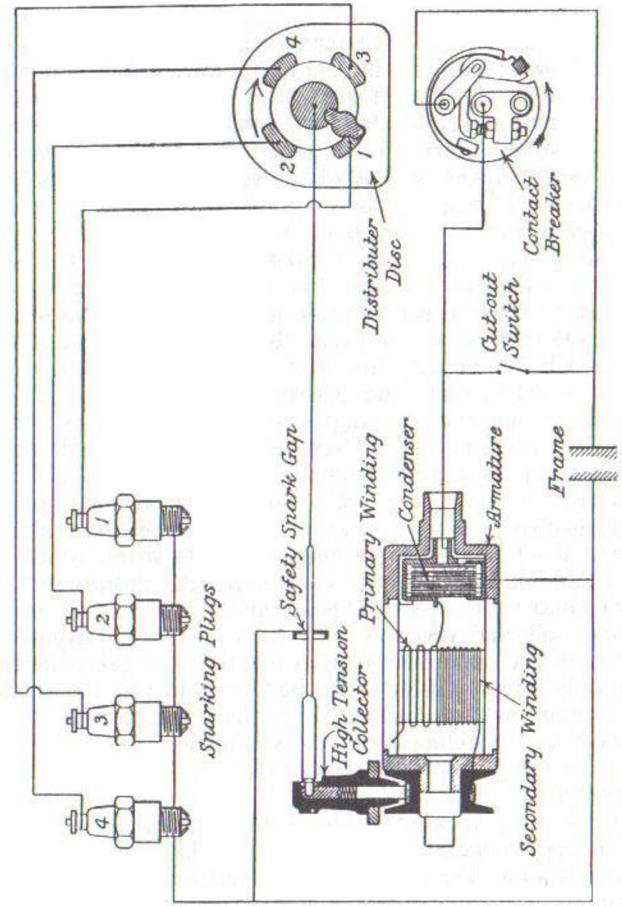

FIG. 11.—Diagram showing the Connections of a Magneto in Practice.

important parts in a small space. The primary and secondary coils are here shown side by side, though actually they are wound one over the other, the primary being underneath. The beginning of the primary is earthed, as shown, on to the armature core, the common connection between the other end of the primary and the secondary being led off on the opposite side, as shown, towards the contact-breaker; this connection is taken on by an insulated metal plate to the centre boss, into which the end of the long bolt from the contact-breaker screws. The head of this bolt may be seen in the centre of the contact-breaker, shown separately further to the right. The condenser is housed at the right-hand end of the armature, one side of it being insulated and connected to the plate joining armature to contact-breaker, and the other side being earthed as shown. At the left-hand side the end of the secondary coil passes out to the brass slip-ring, which is embedded at the bottom of a deep V-shaped groove in a block of insulating material. The high-tension collector brush is pressed down on to this slip-ring by a spring, and collects the HT current, which is then conveyed by a metal rod to the centre of the distributer. It will be noticed that all the parts about the slip-ring and collector brush are heavily insulated.

The contact-breaker and distributer are, for the sake of clearness, shown at right angles to their normal position in relation to the armature. That is, the armature is shown in "longitudinal section," while the contact-breaker and distributer are in "end elevation." In practice, also, these parts are much closer to the armature, being combined with the magneto itself. It is, however, impossible to show all the parts clearly if they are put in their normal positions. The contact-breaker is, of course, held rigidly to the armature by the long bolt and revolves with it, while the distributer is revolved in the opposite direction by means of gear-wheels.

The only parts which cannot be shown in this illustration are the cams and cam-ring. This, however, can be easily imagined as encircling the contact-breaker, with the two cams projecting inwards and acting on the heel of the rocker-arm.

The magneto, working on the lines indicated, forms on the whole a very satisfactory and practical machine for the ignition of petrol engines, being simple and reliable in use, although a good many problems are compressed within a very small space, rendering the highest class workmanship essential.

Two drawbacks are inherent in the normal design. The effectiveness of the spark produced depends very greatly on the strength of the current flowing in the primary coil at the

moment of "break." This in turn depends on the speed of rotation and on the position of the armature at the moment. The position of maximum current occurs twice in each revolution of the armature, and is only momentary. If the break occurs later than just at the maximum position, the spark at the plug will be considerably weakened. The further off from the maximum position that the break occurs, the weaker will be the spark. But in order to obtain the best result from a petrol engine at high speeds, the spark should occur early; that is, well before the previous upstroke of the piston has been finished. In a magneto this result is achieved by moving round the cams so that the rocker-arm strikes against them sooner, the timing being so arranged on the magneto that, when the cams are in the "advanced" position, the current is broken at (or about) the maximum position of the armature. But if the cams are moved far away from this position, as they must be when a late timing is necessary, the spark will be considerably weakened.

That is one of the inherent defects. The other is that the spark is also weakened by low speeds of rotation. It is unfortunate that, at starting an engine with magneto ignition, both these inherent defects come into operation. The speed is very low, as the engine is only being hand-operated, this in itself tending to a weak spark; but, on account of this low speed, the timing of the spark must be retarded, and therefore the armature at "break" is not in its maximum position. At that low speed a spark occurring on the previous upstroke of the piston would result in a back-fire. The spark, at starting, cannot be timed to occur early on account of backfiring, and it must not be timed very late or no spark would be produced at that low speed. Consequently, a compromise between early and late timing has to be effected, which, like most other compromises, is not entirely satisfactory to either side. The same conditions apply also, in a modified degree, to slow-speed running after a start has been effected.

Starting and slow-speed running are therefore the weak points of an ordinary magneto; reliability and running at normal and high speeds are where it shines.

Many devices have at different times been incorporated with the magneto to overcome these natural defects, and the most important of these we shall deal with later on. In the meantime, it may be said that modern improvements in the design of British magnetos have very considerably improved its slow-speed sparking.

We have now run over the main points in the working of a magneto of the ordinary type, having followed up the development of the original discovery of induction by Faraday. Many other reactions occur in the operation of a magneto, but in a small treatise like this we cannot enter into the more subtle points, interesting though they are. Anyone wishing to pursue the subject further, and to learn something of its fascinations, will find much information in a book called *Magnetos*, by A. P. Young. The present small handbook might be called the ABC of the magneto, in which case Mr Young's book would be the D to Z of the subject.

CHAPTER II

THE CONSTRUCTION OF A MAGNETO

TURNING from the theoretical to the practical side, we will discuss briefly the component parts of a standard-type modern magneto. In fig. 12 the various parts of a Thomson-Bennett armature are seen: first, the armature core in its rough state; next, the core with the insulating strips in place and the primary winding of enamelled copper wire. Following this is the armature, with primary and secondary coils wound ready for assembling. When it is realised that the diameter of the wire used for the secondary coil is usually four-thousandths of an inch, and that nearly a mile of it has to be very carefully wound on to the armature, it will be admitted that magneto armature-winding is a skilled and highly-specialised job, not to be lightly undertaken by amateurs without the necessary appliances.

In the same illustration are shown the steel cam-ring in the rough state and after grinding out the cam shapes. This is a point which cannot be very clearly illustrated, as the shape of the cams now used diverges very gradually and slightly from the circular ring itself. By close examination of the figure, however, the cam may be observed inside the ring.

At the bottom right-hand side may be seen two views of the condenser, before and after assembling, the latter being

ready for insertion under the brass cap at the end of the armature. The position of this cap may be seen in fig. 15,

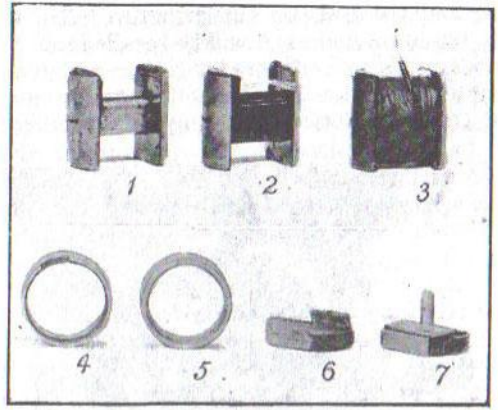

FIG. 12.—Component Parts of a Thomson-Bennett Armature.

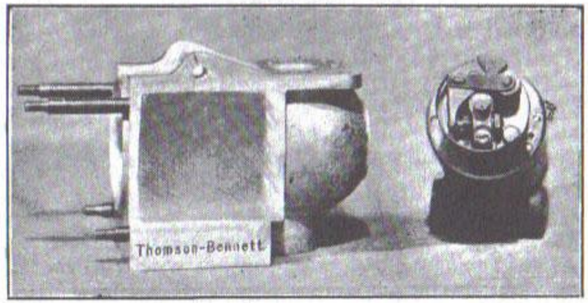

FIG. 13.—Body Casting and End View of Contact-Breaker of a Thomson-Bennett Magneto.

being placed on the armature next to the gear-wheel which drives the distributer.

The next illustration (fig. 13), shows an end view of the contact-breaker on this magneto and also the main body casting and pole-pieces. Fig. 14 shows a view of the contact-breaker used on the M-L magneto, and these two illustrations of contact-breakers should be studied together. In the centre of each may be seen the head of the long bolt, which not only holds the contact-breaker plate in place, but also has the important function of forming the electrical connection between it and the coils on the armature. By reference to Chapter I., figs. 9, 10 and 11, it will be recalled that the primary and secondary coils are connected together, and at the junction of the two a connection is taken off to the contact-breaker. This is effected in practice by a long bolt, the head of which

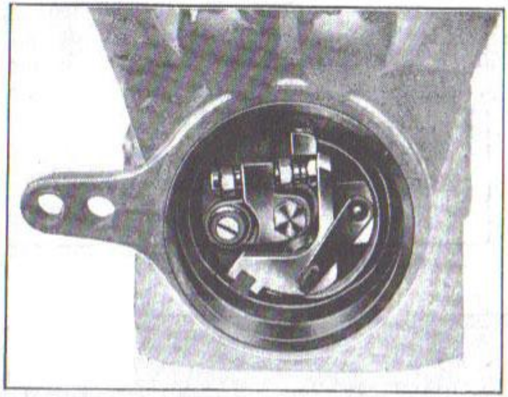

FIG. 14.—End View of Contact-Breaker of an M-L Magneto.

appears in the centre of the contact-breakers (seen clearly in fig. 14).

It is to be noted that this long bolt is carefully insulated from the body of the magneto, in the space between the coils and the head. The head is in contact with the metal block carrying one of the platinum points, this block also being insulated. The current generated in the primary circuit passes up the long bolt, across the platinum points to the rocker-arm, earthed through the curved spring blade, seen edgewise in the illustrations, and so passes back to the other end of the primary coil, which is earthed on to the spindle at the beginning. By comparing these illustrations with the diagram, fig. 9, Chapter I, the action will be at once evident.

On looking at fig. 14, it is clearly seen that the contact-point carried on the insulated block can be adjusted and locked in any position, the reasons for this adjustment being

given in the following chapter. The contact-points themselves used always to be made of platinum, but now tungsten and iridium are sometimes used instead, or in combination. The contact-point, which is not adjustable, is carried at one end of the rocker-arm, which has a pivot at its elbow, the head of which is covered by the flat spring in fig. 14. This pivot cannot be lubricated, and is therefore provided with a bush, for which purpose fibre is generally used. This fibre absorbs moisture in damp weather, and has frequently caused trouble in this way by swelling and so holding the rocker-arm from working properly. In nearly all modern machines, as in the case of the two examples illustrated, great care has been taken to avoid this trouble, special fibre or new materials being used, and in the Thomson-Bennett design (fig. 13) it will be seen that a special form of arm has been constructed which also has the virtue of great lightness. It must be remembered that this rocker-arm has to operate at very high speeds, so that its inertia must be carefully taken into account. By unscrewing the long centre bolt, the contact-breaker plate may be entirely removed, and at the back of it will be found a small carbon " earthing-brush," to ensure that the plate is properly earthed and that the current shall not pass through the oily bearings for this purpose. A key is provided on the little spigot at the back of the plate, which makes sure of the contact-breaker being correctly replaced.

The other part of fig. 13 shows the main body casting of a modern magneto, generally "die-cast" in aluminium, a process which saves much machine work and gives a very neat appearance. Here also are shown in position the laminated iron pole-pieces which have so greatly improved the performance of modern magnetos by the avoidance of eddy currents. The ends of the laminations can be seen in the illustration in a vertical position, ready to connect with the magnet which is placed over them.

In fig. 15 we have the parts of a Thomson-Bennett magneto ready for assembling. On the right hand is the armature, complete with contact-breaker, ball-bearing, gear-wheel, and at the other end, the slip-ring in a deep V-shaped insulating groove; in the centre, the main body of the magneto with distributer-shaft laminated pole-pieces, and cam-housing in place; on the left, the magnet ready to slip on to the main casting; and below, the distributer cover with terminals and the cam-ring.

In the two other illustrations (figs. 16 and 17), the various parts of two types of M-L magnetos may be clearly seen,

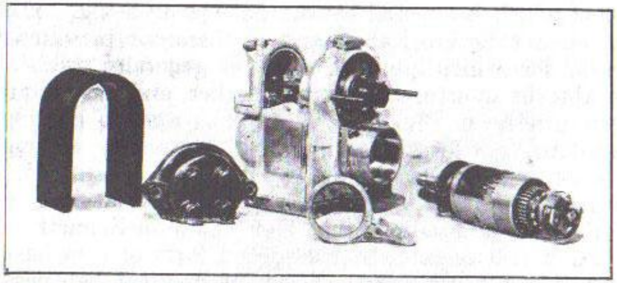

FIG. 15.—Component Parts of a Thomson-Bennett Magneto ready for Assembling.

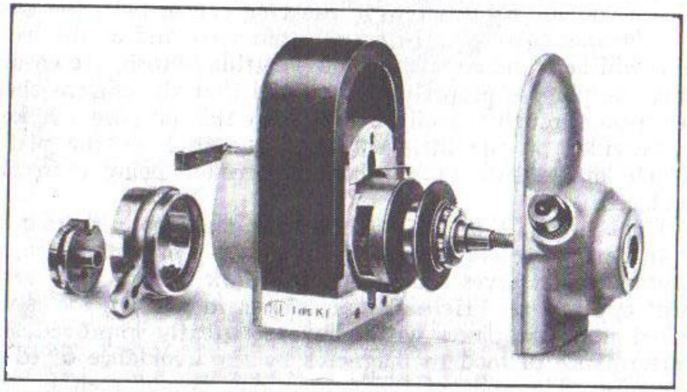

FIG. 16.—Component Parts of an M-L Single-Cylinder Magneto.

fig. 16 being a single-cylinder magneto without distributer. In this view the small "earthing brush" at the back of the contact-breaker is distinctly shown, and also the slip-ring or current collector at the other end of the armature, where the HT current is picked up by a brush and taken to the plug by means of a cable connecting to the large terminal shown projecting through the cover. In fig. 17 we have a similar

view of the M-L standard 4-cylinder type, known as G 4. The HT current, being collected from the slip-ring, is taken back by a metal rod passing through the moulded insulator seen on the top of the front cover, and connects with the centre arm of the "jump-spark" distributer, and thence in turn to the four points visible inside the cover. The cam-ring with its timing-lever is seen ready to put in position; then the back view of the contact-breaker, on the spigot-bearing of which may be noted the small key for registering the correct position, as previously mentioned. On the extreme left-hand side comes the contact-breaker cover, in the centre of which may be seen the contact, which is pressed on to the head of the

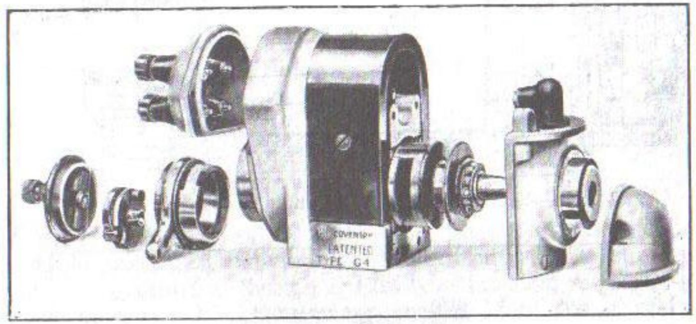

FIG. 17.—Parts of an M-L Standard 4-Cylinder Magneto.

long bolt by the springs seen on either side of it. This contact is connected to the terminal on the outside of the cover, and is taken to the "earthing," or magneto, switch near the driver's seat, as shown in the diagram, fig. 10, Chapter I.

In figs. 18 and 19 we have two complete sectional views of magnetos, showing all the parts very clearly. Fig. 18 is a line drawing of a Conner magneto, the type being known as 418. Every mechanical detail can be seen, and it is unnecessary to point out the parts separately. It will be noticed, however, that in this machine the carbon-brush type of distributer is used; ball-bearings, self-lubricated, are employed for the distributer shaft as well as for the armature, and a felt washer is provided on the driving end of the spindle to keep out moisture. The magnets and the whole of the driving end are completely enclosed by a one-piece aluminium cover.

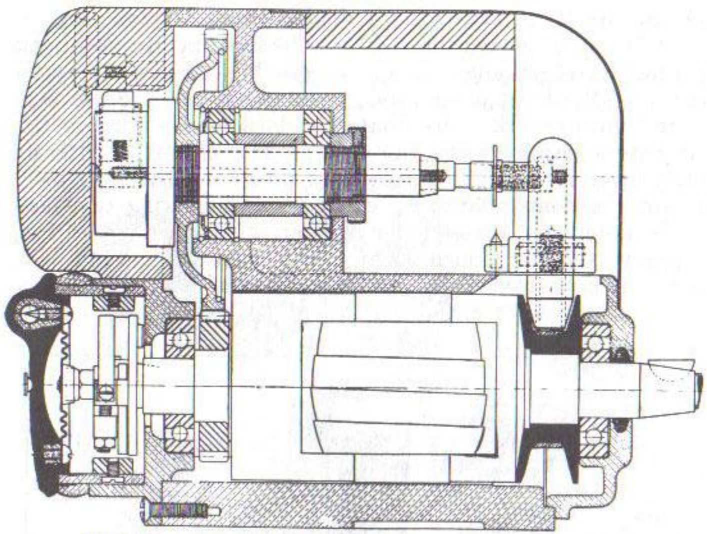

FIG. 18.—Sectional View of a Conner Magneto.

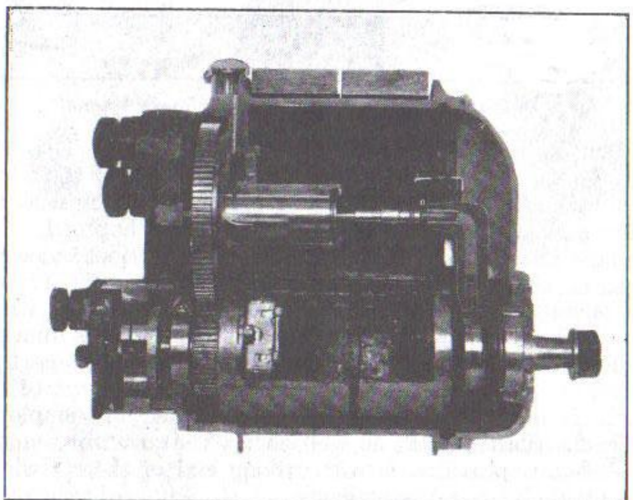

FIG. 19.—Sectional View of an Ericsson Magneto.

A magneto of this type (but for a 6-cylinder engine) is shown complete in fig. 38.

The other illustration, fig. 19, is a photograph of a part section of an Ericsson magneto, which gives a very good idea of the vital organs and how they are arranged. In this view the magnets and main body are shown in section, but the other parts are shown whole; for example, the armature with its various components, such as the condenser, contact-breaker, and slip-ring, are all complete, as are the gear-wheels. The distributer-bearing in this machine is of the journal type, and the oil-way leading to it may be seen.

These two sectional views, studied together, reveal many of the secrets hidden inside a magneto of the standard type.

CHAPTER III

CARE OF THE MAGNETO

A BRITISH magneto of modern type is perhaps one of the most reliable parts of a car, and should certainly not be interfered with unnecessarily, though naturally a little attention of the right kind is better than none at all. Moreover, there are many thousands of foreign-made magnetos of old types about, in which from time to time faults and breakdowns occur—some due to old age or crude design, and others due to neglect and ill-treatment. It is to be remembered also that some repairs—such as armature-winding, condenser-building, etc.—are really specialists' work, requiring special skill, tools, and appliances, and that work of this kind should not be attempted by anyone not possessing the necessary qualifications and facilities. In a magneto armature, a great deal has to be condensed into a very small space, and this kind of work requires specially trained hands. If repairs of this kind become necessary, it is far wiser to have them done by the manufacturers of the machine, if possible, or by a firm who make a speciality of magneto repairs.

The chief points to which attention should be given by the motor-owner are—the working of the contact-breaker, the lubrication of the bearings, the condition of the various connections and rubbing contacts, and to see that the necessary degree of insulation is maintained throughout to resist the high electric pressure.

Lubrication is sometimes the source of trouble, not as a rule from being neglected, but just the opposite, from the excessive amount of unsuitable oil often administered. The only bearings are those of the armature shaft and the distributer spindle. The former are always ball-bearings, and the latter very often so, especially in later-type machines. Ball-bearings of any kind require very little lubrication, and that more from the point of keeping away rust than from any need of an actual film of oil between the surfaces. In the case of a magneto bearing the pressure is extremely light, which also reduces the need for lubrication. The usual occurrence in a garage is that the owner has at hand a drum of oil for his engine which, rightly for that purpose, is thick and heavy, since it is intended for use inside the crank case where the temperature is high, and where it has to maintain a film between the surfaces of such parts as the big ends of the connecting rods, where the pressure is very great. The oil must have sufficient "body" to avoid being squeezed out of such places and leaving them dry. The motor-owner, having no other oil handy, fills a small oil-can from this drum, and proceeds to apply it to all the oil-cups he can find about the engine, including those on the magneto, which, being in a convenient position, often get an extra share. The cups at each end of the armature shaft and the distributer therefore become flooded with this thick oil, which naturally finds its way on to the adjacent parts, and before long appears on the contact-points or the collector-brush, on the slip-ring or on the distributer face.

These are not at all desirable locations for oil, especially on the contact-breaker points, where the spark soon carbonises the oil, which seriously interferes with the primary current. The collector-brush may become gummed up in its guide so that it does not make proper contact with the slip-ring, and on the distributer face a mixture of oil and carbon dust may be formed which leads to cylinders firing in wrong order, or to misfiring. All that the magneto requires in the way of lubrication is a few drops of a light high-class oil about once a month for a car in average use. Oil of this kind may be conveniently bought in small bottles or tins as supplied for sewing-machines

or bicycles.* But even this attention is not called for in the case of some modern magnetos, for, where ball-bearings are used throughout, they are packed with grease by the manufacturers, and this treatment will be sufficient for several years, and before the end of this time the whole chassis will no doubt be overhauled and the magneto inspected.

The contact-breaker is the most important part of the magneto that the motor-owner has to deal with. On the correct working of this part depends very largely the efficiency of the machine as a whole. It must be remembered that it is nothing unusual for the contact-breaker to operate 5000 times a minute, and in some cases more than this. Consequently, many things happen which would not occur at lower speeds; centrifugal force, inertia of the moving parts, etc., must be taken into consideration at these high speeds.

The object of the contact-breaker is to allow the maximum current to pass through it when closed, and to break the circuit as quickly and effectually as possible at the exact moment of time required.

When one considers what a very small fraction of a second that moment is, one begins to realise how accurate the movement of the contact-breaker must be. It is important that the current in the primary should be as large as possible at the moment of break, so as to produce the greatest inductive effect. For this reason the contact-points must be kept in good condition, so as to reduce the resistance between them to a minimum. They must meet squarely together and be absolutely clean. If the contacts only touch at a small point of their surface, considerable resistance will be offered to the current in the primary, which will consequently be reduced in proportion, with bad effect on the sparking, especially at low speeds. Any dirt, and especially oil, will have the same result. It is most important, therefore, to look after the condition of these contact-points and attend to them if they become pitted or dirty. The general instruction is to file them into shape; but this procedure should only be taken with great caution, for it is by no means so easy as it sounds to file two contact-points so that they meet together perfectly all over their surface. A piece of white paper held behind them will reveal many high and low spots after a first attempt.

* One large firm, dealing in motor accessories, is now selling bottles of oil specially for magnetos.

Special jigs can be made for the purpose, into which the contact-point is screwed, with the end just projecting through; the surface of the jig then forming a guide for the file. Or the points can be placed in a special chuck in a small lathe and filed; in that case the points may be left with a very slight amount of camber towards the centre. Only a special file should be used for this operation. A good one is made by Messrs Brown Bros., Great Eastern Street, London, and is appropriately called the "Spark" file. But it is much better to avoid filing the contacts unless absolutely necessary, for considerable experience and skill are required to make a really good business of it.

If the contacts are merely dirty, they can be effectually cleaned by drawing a piece of very fine emery cloth (or carborundum cloth) between them. This operation can be done without removing the contact-breaker from the magneto, and should be followed by washing the points with a little petrol on a fine paint-brush to make sure of all the particles of emery being removed.

But in addition to the points being clean, smooth, and meeting squarely together over as large a surface as possible, it is necessary that they should be set so that the correct distance is maintained at the gap between them when they are opened to the fullest extent by the heel of the rocker-arm resting on the highest point of the cam. If they did not separate far enough, a small "arc" would be maintained between the points and the circuit would never be really broken at all; if they separated too far, the points might not have sufficient time to close again when required in the very small fraction of a second in which this must take place at high running speeds; moreover, a hammering or bouncing action would be encouraged, which it is very desirable to avoid. A definite gap-distance is therefore settled by the manufacturers of each magneto which gives the best results with that machine, and this distance must be kept at the correct figure by the user, one of the points being adjustable for that purpose; a lock nut is provided which must be loosened before the point can be moved. Owing to wear and burning of the contacts, the gap is liable to alter after some time, so that this point should be attended to occasionally. The distance is not the same for all magnetos, as it depends on other features in the design; but a very usual figure for standard machines is

·015 in., and in the absence of particular instructions for a certain machine the gap may be set at that figure, using either a magneto gauge or an engineer's "feeler" gauge. If there is any discrepancy, the latter is more likely to be accurate than the average gauge sold for the purpose, which often forms part of a combination tool and is not too reliable. In the absence of a better gauge, it may be useful to remember that a Gillette razor blade is ·006 in. thick, so that two of these together make ·012 in., and three make ·018 in. If we arrange the gap so that it appears to be about half way between these two distances, it will not be far away from the measurement of the standard gap.

Some magnetos, especially later types for high-speed work, are designed for smaller gaps, such as ·012 in., or even ·010 in.

In the case of foreign magnetos the distance is generally given as ·4 mm., which is equivalent to ·016 in., or $\frac{1}{64}$ in. approximately. When setting the gap the distance should be gauged in connection with both of the cams to make sure they are exactly alike, or else one spark may be timed earlier than the other, giving uneven running of the engine and possible misfiring at low speeds.

After altering the gap, make sure that the small lock nut on the adjustable point has been tightened up.

Another item that requires attention is to see that the rocker-arm is working quite freely on its pivot; a bush, which in some machines is made of fibre but in later types is made of other substances, is inserted in the rocker-arm, and in damp weather this bush if made of fibre may swell and cause the rocker-arm to stick. This is, in fact, the most frequent source of trouble in older machines. The remedy is to remove the rocker-arm, which can easily be done by pushing to one side the spring clip which holds it in place, the rocker-arm can then be pulled straight off and the bush eased very slightly with a broach or reamer; a very slight amount will be sufficient, and care should be taken not to do too much.

The fibre heel at the other end of the rocker-arm is also subject to wear, and should be inspected at intervals. If much worn, the circuit will not be broken at the maximum position of the armature, and the contacts will not separate to the correct distance; a new fibre heel should be substituted in that case.

The hexagon in the centre of the contact-breaker is the head of a long bolt which performs the two functions of holding the contact-breaker plate in place and conveying the current to one side of the contact-points. By unscrewing this long bolt the contact-breaker plate may be entirely removed from the magneto, and it is necessary to do this when examining the contact-points, etc. A key provided on the taper spigot at the back of the plate ensures its correct replacement. At the back of the plate also will be found the "earthing-brush," which is provided to form a good electrical connection between the base plate and the body of the magneto. This brush makes a rubbing contact, and should occasionally be inspected to see that it is working properly and the track cleaned.

The distributer, if it is of the carbon brush type, should also be inspected periodically. It is subject to the disease called "tracking," that is, the formation of a layer of carbon dust on the path of the brush over the insulating material between the metal segments. The HT current will leak over these conducting tracks and so cause sparks to occur in the wrong cylinder. Oil or dirt in the distributer-case is the usual cause of tracking troubles, and the remedy is a wipe-out with a cloth dipped in petrol. The distributer-brush should work freely in its holder, and should present a bright polished surface to the face holding the segments. The collector-brush at the other end, which presses on the slip-ring, should also be examined to see it is working freely in its guide; any accumulation of carbon dust should be cleared away and the ring itself polished up with a cloth held on the end of a pencil. Distributers of the "jump-spark" variety, where there is no actual contact, need no attention.

The foregoing are the main points for an owner to attend to; they may be summarised as follows:—

Do not interfere unnecessarily with the magneto; remember that it is made by highly skilled specialists with proper appliances, and that others less favourably situated cannot possibly do the same work. More harm may be done in a few minutes by unskilled hands than in years of ordinary running. On the other hand, a few simple attentions regularly given will be well rewarded.

Keep the contact-breaker points clean, especially free from oil. Use fine emery cloth for this purpose, and only file when really necessary.

Oil the bearings cautiously with a high-class fine oil.

Do not run the engine with a lead disconnected from a plug.

Occasionally inspect the various terminals and contacts about the magneto: the earthing-brush, distributer, collector-brush, etc., and see they are clean and in good order.

See that the correct gap is maintained between the contact-breaker points, that it is the same for both cams, and that all screws and nuts about the contact-breaker are tightened up.

If any further attention appears to be necessary, it is better to send the magneto to the manufacturers, who have proper facilities for dealing with it, and whose interest it is that the machine should have a good reputation. For example, if severe sparking should appear at the contact-points, and it cannot be cured by the methods given above, it is probably due to a defective condenser, and this part can only be dealt with satisfactorily at a magneto works. Any fault in the armature, slip-ring, etc., should be treated in the same manner.

Remagnetising the magnets is also an operation requiring considerable skill and experience, and special apparatus is necessary to obtain really good results, although there are rough-and-ready means of doing it which are seldom satisfactory. It would certainly not be worth while for a motor owner to make or buy apparatus for this purpose for his own use, as it is so very rarely required. If it is proved that the magnets want remagnetising, it is an easy matter to send them to a specialist, and the result will be more satisfactory in every way.

The magnetic circuit of a magneto is so good, provided that the armature is not removed, that the magnets very seldom deteriorate unless subjected to unusual ill-treatment. Some motor owners are inclined to attribute all ignition troubles that cannot be immediately solved to weak magnets on the magneto, though in reality this is probably the most unlikely cause of failure. The sparking-plugs and the connecting-leads should first be minutely examined, and not until these have been proved faultless should the magneto be suspected. Then the contact-breaker, collector-brush, and distributer may be examined as mentioned above, and the fault will most likely be located.

As a rough test of a suspected magneto, one of the leads may be disconnected from a plug and the end of the lead held as close as possible, without actually touching, to the framework of the car at any convenient spot. Another person should then crank the engine, and a small spark should appear regularly at the end of the lead if the magneto is in order. Only a small spark will be given at that low speed in any case. An alternative method is to remove a spark-plug and lay it on the top of the engine, reconnect the lead, taking care that the terminal is not in contact with the metal framework of the engine, and crank as before, when a spark should appear at the plug points.

If no spark is obtained in this manner, and the contact-breaker and other parts about the magneto appear to be in order, then a careful examination should be made of the earthing-switch and its connections. It may be earthing the magneto, in spite of the fact that it is in the "off" position; there may be a fault in the switch itself or the wiring connecting it. To prove this, disconnect the wire altogether from the terminal on the contact-breaker cover, and again test for a spark.

Failure to spark at the plug when first starting up an engine on a damp day has been sometimes traced to a film of moisture on the distributer, especially when, as in some of the earlier magnetos, the cables were run straight down to the terminals in such a way that moisture could run down and collect round the terminal base. Occurrences of this kind are often difficult to trace to their cause unless this is suspected beforehand. If any doubts arise on this score, take off the distributer cover and dry it thoroughly before a fire.

If no signs of a spark can be obtained by these methods, take the magneto off the car, put it on the bench, and twist the armature-spindle quickly round with the fingers, being careful to do this in the proper direction of rotation as marked on the machine. Sparks should then occur at the safety-gap, and, if so, then the fault clearly lies somewhere between the collector-brush and the plugs, probably in the distributer. If no spark appears at the safety-gap, and everything about the contact-breaker, etc., is in order, then there is a serious fault, probably in the insulation of the armature, which should be sent to the manufacturers.

If the armature of the magneto is to be taken out, the collector-brush must first be dismantled; but before withdrawing the armature from the magneto it is most important that a "keeper" or bridge-piece of iron should be placed across the magnets so as to form a path for the magnetic field instead of the iron core of the armature. Any piece of iron

will serve if it makes good metallic contact with both pole-pieces, and this "keeper" must remain in position until the armature is replaced, the armature being pushed in as the iron is taken out, no interval being allowed between the two. If this precaution is not taken, the magnets will lose a considerable amount of their strength.

A fault which in the past was not infrequent was due to distortion of the cam-ring in course of time, which, though very slight, has the effect of causing one cam to open the contacts slightly in advance of the other. In a 4-cylinder engine, when this defect occurs, two cylinders will give less power than the others, causing uneven running and possibly misfiring at low speeds. It can be discovered by carefully measuring the gap at the contact-points for either cam and comparing them. In the case of misfiring, and the magneto being the suspected cause, a very useful hint is to run the engine in the dark, carefully examining the magneto all over for short-circuit sparks, especially at high speeds. These sparks would often be undetected in daylight.

Timing the Magneto.—Engines vary in design and require slightly different timing of the spark in order to obtain the best results, but the following arrangement gives the standard timing from which variations can be made as desired.

We will suppose that a 4-cylinder engine of standard type is to have a magneto timed to it.

We will call the cylinder nearest to the radiator No. 1.

First ascertain the order of firing of the cylinders.

This may be either

1, 3, 4, 2, or 1, 2, 4, 3.

The former is the most common.

If there is any doubt, the order may be verified by watching the operation of the valves.

See that the wiring is correctly carried out from the distributer terminals on the magneto to the plugs, having regard to the direction in which the distributer revolves when the magneto is driven by the engine. See fig. 20 for an engine firing in the order 1, 3, 4, 2.

Do not take for granted that the wiring has been correctly carried out by someone else, for a mistake in this respect is easily made.

Having checked the wiring, turn the engine by hand until the piston of No. 1 cylinder is on the dead centre at the top of its *compression* stroke (not the exhaust stroke).

This position in most engines is marked by a line on the fly-wheel, and occurs when this line is at the top.

Holding the engine in this position, slacken the coupling on the armature-shaft of the magneto, but keep the engine side of the coupling fixed. Turn the armature-spindle slowly until the distributer-brush is on the segment connected to No. 1 cylinder. Many magnetos are provided with a small window at the distributer end, under which a number appears corresponding to the cylinder to which the distributer is sending the current. In this case No. 1 should appear at the window. If no window is provided, the distributer cover must be removed and the position of the brush noted.

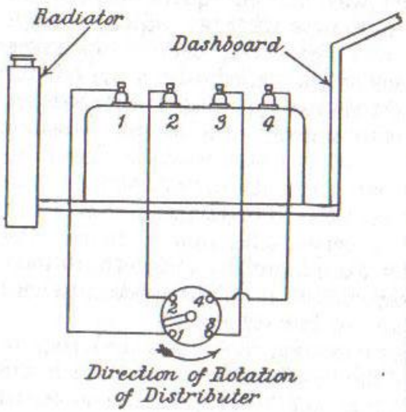

FIG. 20.—Wiring from Distributer to Plugs for an Engine firing in the order 1, 3, 4, 2.

Move the timing lever connected to the cam-ring into the position of maximum retard, that is, as far as it will go in the direction of rotation of the armature. This direction is usually indicated by an arrow on the machine.

Remove the contact-breaker cover and slowly turn the armature to the position where the contact-points are just beginning to separate. Then, keeping everything in the same position, tighten up the magneto coupling, and the timing will be set correctly for standard engines. It is as well to check over the various positions to make sure that nothing has slipped.

Some engines, especially motor-cycle engines, are timed later, that is, with the piston at its dead centre and the timing lever about a third of its distance from the end.

It is not always easy to see just when the contact-points are breaking, and two methods of determining this accurately

are employed. One is to insert a piece of very fine paper between them and to pull slightly on this paper, the spring pressure on the rocker-arm holding the paper tight until the cam hits the heel of the arm. The paper will then be released. For this purpose the paper must be the thinnest procurable—cigarette paper answers the purpose fairly well.

The other method is more accurate. In this method a battery and bell are used to give warning when the circuit breaks. One wire is connected to the fixed contact-point through the terminal on the cover, the other wire being earthed on the body of the magneto. It is necessary to disconnect the contact-breaker from the armature electrically by removing altogether the long central bolt. In its place a steel ball is used, which completes the circuit between the terminal and the fixed contact, and also holds the contact-breaker in position after the cover has been replaced. A diagram of the arrangement is shown in fig. 21.

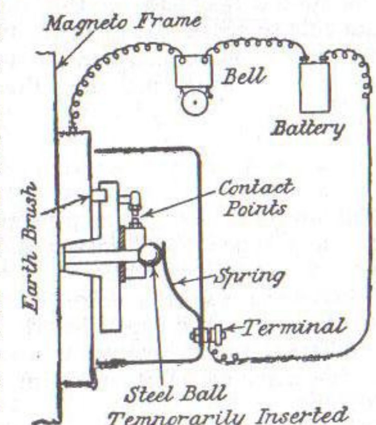

FIG. 21.—Diagram of Connections, using Battery and Bell for indicating Break at Contacts.

It is obvious that the bell will cease to ring when the contacts separate.

CHAPTER IV

THE INDUCTOR MAGNETO

IN addition to the magneto of standard design with a rotating armature another type is used known as the Inductor. Although originally a British invention, as mentioned in the Foreword, this type before the year 1914 was principally developed in America. Subsequently British firms took it up, and one firm, the British Thomson-Houston, made a special feature of this type, introducing many developments and supplying it in very large numbers for aeroplane engines. Owing to the fact that four sparks can be produced per revolution instead of two as with the ordinary type, the inductor magneto lends itself particularly well for ignition on aeroplane engines, as these are generally of the multi-cylinder type, eight, nine, or twelve cylinders being commonly employed. Some of the special magnetos of this type made by the B.T.-H. firm are able to spark satisfactorily at the enormous rate of 16,000 sparks per minute. They hold some remarkable records in Air Service work, including the crossing of the Atlantic by H.M. Airship R 34, which was fitted with five Sunbeam engines, on each of which ignition was provided by two B.T.-H. inductor magnetos of the type known as AV12S.

The question then arises—What is an inductor magneto, and how does it differ in principle and construction from the ordinary type? The answer is, briefly, that the principle of electro-magnetic induction as discovered by Faraday, and to which we have so often referred, is the foundation of the inductor as of the standard type; but the manner in which this is used is different, and it involves an entire change in the construction of the machine, which in many respects is a change for the better.

In the standard type the armature revolves, and so induction is caused by its movement through the magnetic field. In the inductor type the armature is stationary, but the magnetic field is made to move through it by the agency of iron arms (or pole-pieces), which revolve and, owing to their shape and disposition, convey the magnetic field, first in one direction and then in the other, through the armature core.

This form of construction allows the armature to be stationary, which is certainly a good feature, since the armature with its two coils and condenser is the most delicate part, and, if stationary, is not subject to the effects of centrifugal force, which are very considerable at high speed. Since the HT winding is stationary, clearly no slip-ring and collector-brush is required, and therefore one working part is eliminated. Also because the armature-coils are stationary a form of contact-breaker can be used in which the contact-points do not revolve as in the standard types; instead of this, a small central cam is the only revolving part in the type generally used on inductor magnetos. In fact, the only revolving

portion at all in this type consists of a metallic structure composed of iron arms (or pole extensions, as they may be called) fixed on a non-magnetic shaft and carrying a small cam at one end to operate the contact-breaker.

One feature, perhaps the most important, is that it is possible in this type of construction to make the whole magnetic path laminated. Upon this, to a large extent, appears to depend the rate at which the voltage rises in the secondary circuit at the moment of break in the primary circuit. Facts are now being investigated about the nature of the spark and how ignition is caused by it, and the rate at which the voltage rises seems to be all-important. It is probably for this reason that the spark from an inductor-magneto has been found more effective for ignition in some cases than that from a standard magneto, although the spark given by the latter is much more energetic in appearance, or "fatter," as it is generally termed. Much, however, is being learned on this subject of electric-spark ignition, and much still remains to be determined before definite results can be made known. It seems highly probable, however, in the light of modern observation, that the "fat-" spark theory is quite fallacious.

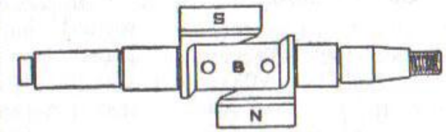

FIG. 22.—The "Rotor" of a Dixie Magneto.

Although the inductor-type magneto is fairly simple in practice, it is not easy to describe its working accurately in a few words. The description, therefore, is inclined to give the idea of a more complicated machine than is actually the case.

The following is the operation of the principle as used on the American Dixie magneto, the illustrations 22 to 25 being reproduced by permission of the Splitdorf Electrical Company:—

The rotating portion or "rotor," as it is called, is shown in fig. 22. This rotor consists of two arms, or pole extensions, N and S, fixed rigidly on either side of a shaft the centre part of which (B), between the arms, being made of bronze, is non-magnetic.

These arms in reality form revolving pole-pieces to the magnet, the latter being placed at right angles to the line of the rotor, as shown in fig. 23. Thus the arms revolve with their shoulders close up to the magnets and always retain the same polarity. They convey the magnetism from the magnets to the lower extremities of the armature core. The armature core itself is an arch-shaped structure placed under the larger arch of the magnet, and at right angles to it.

On the horizontal member of the armature structure are wound the low- and high-tension coils together with the condenser. The path which the magnetic field traverses at that position of the rotor is shown by the dotted lines in fig. 23. It will be seen that when the rotor moves further round, the N arm will then be facing the opposite leg of the armature structure, and that the magnetic field will then traverse the armature core in the reverse direction. This action will be more clearly understood by reference to figs. 24 and 25, which are purely diagrammatic. They are supposed to be sections cut across the centre line of the magneto. In fig. 24 the position of the rotor is such as to conduct the magnetism from the N pole of the magnet to the left leg of the armature, from whence it passes across the top member, on which the coils are wound from left to right hand. When the rotor has moved further round, as shown in fig. 25, the arm conveying the magnetism from the N pole is now in front of the right leg of the armature, so that the magnetism now flows through the armature core from right to left, *i.e.* in the reverse direction to the former figure. It is obvious, therefore, that between these two positions the magnetic field must have ceased flowing in one direction and started again in the reverse direction, and that this occurs twice in every revolution of the rotor. When the magnetic field reverses, it cuts across the coil wound on the armature and so produces a current in this coil, as the contact-breaker points are then closed and the LT circuit is complete. At that moment, when the current is greatest in the coil, the contact-points open by the operation of the cam which is fixed to the end of the rotor-shaft, and

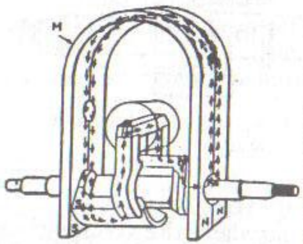

FIG. 23.—Showing the Path of the Magnetic Field in a Dixie Magneto.

therefore induction is set up and a spark produced, as previously described in other magnetos.

The foregoing is the broad principle, and is employed in other inductor-magnetos—that is, a revolving rotor which reverses the direction of the magnetism in the armature core; but the method of carrying it out naturally varies considerably in different machines.

The Dixie magneto includes a special feature by which the spark is rendered equally effective at any position in the timing range. That is to say, the spark is just as good whether fully advanced or fully retarded or at any intermediate position. This desirable feature is brought about by constructing the

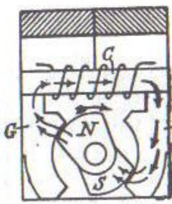

FIG. 24.—Flux flowing in one direction through core C.

When the arm N is opposite G, the flux flows to G, and through C to F, back to S of opposite polarity.

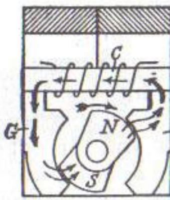

FIG. 25.—Flux flowing in reverse direction through core C.

The pole N has moved over to F, and the direction of the flow of the flux is reversed, as shown.

machine so that the contact-breaker and the armature structure move together. Therefore, when once the contact-breaker has been set to open at the maximum point of the operation, it will continue to open when the rotor and armature core are in the same relative positions, whether the spark is timed early or late. This is a very useful feature, and overcomes in a simple manner one of the inherent defects of a magneto. The type of Dixie magneto generally used on 4-cylinder engines allows an advance of 40°, which corresponds to the same amount on the engine, as in this case engine and magneto run at the same speed. A range of 40°, with the spark equally effective over the whole range, is therefore provided for in a standard 4-cylinder engine.

A special form of "impulse coupling" called the "Sumter" is made to use with the Dixie to ensure a good spark at starting. This kind of coupling is described in Chapter V. among accessories.

The Dixie can be easily taken apart if necessary, and parts such as the coils or condenser replaced. If the magnets are taken off, a keeper should always be placed across the poles and kept there all the time they are off, and care should be taken to replace the magnets as they were originally, *i.e.* not reversed as it is possible to do.

In addition to the 4-cylinder type mentioned above, the Dixie magneto is made in over twenty different models for engines of all types, from single-cylinder to 12-cylinder. Some of these have a single-point cam giving only one spark per revolution; others are made with a four-arm rotor giving four sparks per revolution, and are used on 8- and 12-cylinder engines.

The correct gap at which to set the contact-points is given as ·020 in., and the maximum point at which the break should occur is when the gap between the receding arm of the rotor and the edge of the pole-piece is from ·015 in. to ·035 in. This applies to rotors with either two or four arms.

As the contact-breaker itself does not revolve like the ordinary type, it is possible to lubricate the rocker-arm bearing, and this should be attended to regularly, the maker's instructions being, "one drop of oil applied with a toothpick every 200 hours of operation."

Another magneto working on the inductor principle, made in America, and which used to be imported to this country on a fairly extensive scale, is the K-W. In this a rotor is used carrying four arms at right angles to each other. The stationary coils in this case are wound in a cylindrical form and situated in a central position surrounding the shaft, which itself forms the armature core. The magnet poles are placed at an angle of 90° to each other, and the magnetism is carried backwards and forwards alternately through the rotor arms and armature core. Thus four impulses are set up at each revolution, and can be made use of. The magneto is always run at crank-shaft speed for 1-, 2- or 4-cylinder engines, and one and a half times crank-speed for 3- or 6-cylinder engines, the number of impulses used being settled by the number of lobes on the cam—one for a single-, 2- or 3-cylinder engine, two for a 4- or 6-cylinder engine, and four for an 8-cylinder engine. A special feature of the

K-W is the very long magnets used, which are claimed to give greater efficiency.

An impulse-starter (see next chapter) is often combined with the K-W magneto, a special type being sold in conjunction with it.

The inductor type of magneto has been actively taken up in England by the British Thomson-Houston Company, and is made for 8- and 12-cylinder engines, which, while primarily intended for aeroplane work, are quite suitable for car or other engines.

The main type is known as AV8S or AV12S, according to the number of cylinders catered for, the only difference being in the gear-wheels and distributer. The following notes

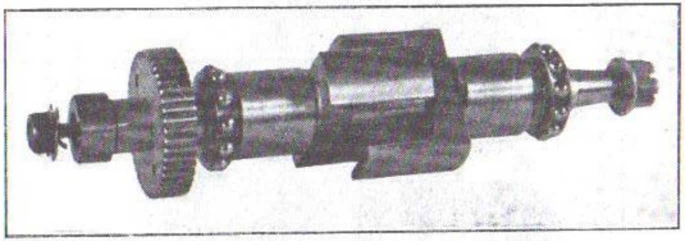

FIG. 26.—Rotor of a B.T.-H. Inductor Magneto.

and illustrations which refer to the AV8S machine, therefore, are equally applicable to the 12-cylinder type:—

This inductor magneto is essentially a four-spark machine, *i.e.* it gives four sparks per revolution. The rotor seen in fig. 26 has four arms on it at right angles to each other, these arms being pressed on to the shaft, which is a continuous piece of 25 per cent. non-magnetic nickel steel, making a very robust and sound construction. In the next illustration (fig. 27) the whole machine is seen dismantled, all the working parts being visible. The rotor is seen in the centre, projecting out of the armature tunnel. The laminations of the armature core run vertically up to the coil block, above which, again, is the condenser with its lead running down to the contact-breaker, seen further to the right, ready to be attached to the front end of the armature shaft.

The magnet, the distributer housing containing the large gear-wheel and revolving arm, and the distributer cover are

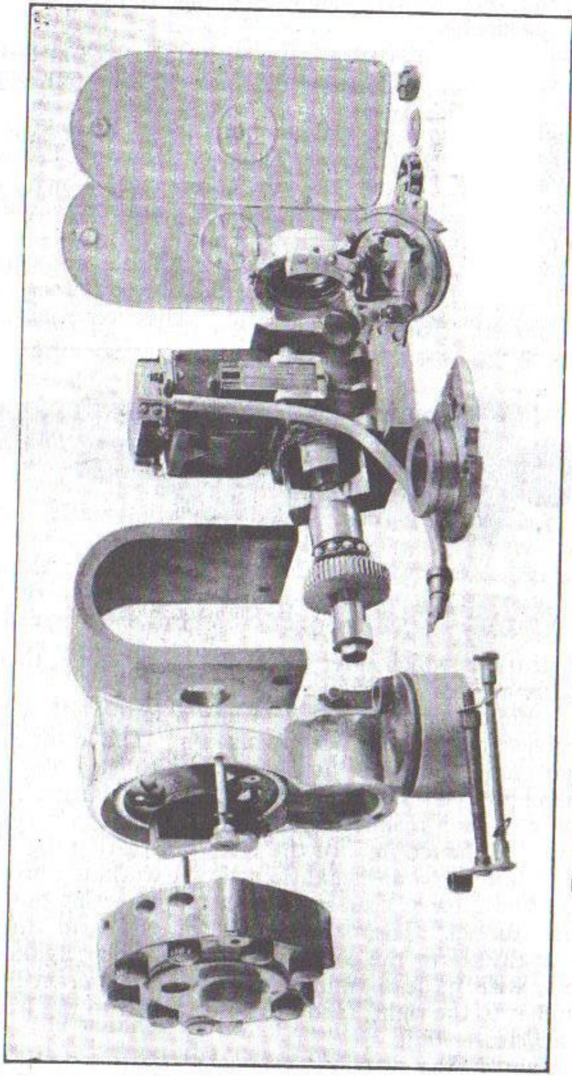

FIG. 27.—Dismantled Parts of a B.T.-H. 8-Cylinder Inductor Magneto.

seen in their relative order; the other portions consisting of bearings, end-plates, etc.

The contact-breaker of this magneto is actuated by a four-point cam carried on the end of the rotor spindle, this being the only part of it which revolves. The points of this cam strike the fibre heel of a lever arm, and so open the contact points as required. This gives a very robust form of design,

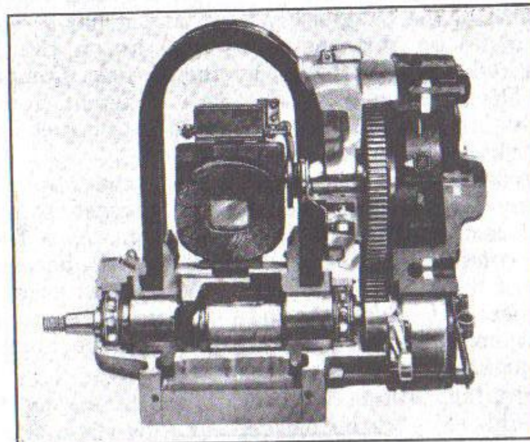

FIG. 28.—Sectional View of a B.T.-H. Inductor Magneto.

which operates successfully up to 4000 r.p.m., corresponding in this magneto to 16,000 sparks per min.

A sectional view of this magneto assembled is shown in fig. 28.

In a letter to the writer, Mr Young, the designer of this magneto, says: "During the past two years some 25,000 machines of this type have been manufactured for the Air Services, and the type AV8S has been used exclusively on the Hispaño-Suiza engines. More recently the type AV12S has been extensively used on 12-cylinder engines, and notably the Napier Lion engine, which was designed to take the B.T-H. machine as well as the Rolls-Royce Falcon and Condor engines, the Siddeley-Deasy 12-cylinder engine, and the Beardmore 12-cylinder engine. The type AV12S magneto was the first and only machine of its kind to be manufactured in this country, and at the present moment it is the only 12-cylinder magneto being manufactured in England."

In addition to the above machines, the British Thomson-Houston Company manufacture another inductor magneto known as the AQ type.

This type was specially designed in 1918 to meet the requirements of the Air Force for a light-weight 9-cylinder magneto. It was designed originally for use on the 9-cylinder radial engine of the Dragon-Fly type, and it has given satisfactory results on this engine, as well as on the Jupiter 9-cylinder radial engine made by the Cosmos Company of Bristol. The design of the inductors is different from those used in the other type, and the axis of the magnet lies in a plane at right angles to that of the spindle.

One special feature of this construction is that the inductors are entirely laminated as well as the magnet pole-pieces, which are cast into an aluminium housing. As a result of this, the complete magnetic path interposed between the two poles of the magnet is entirely laminated at every point, in consequence of which the rate of rise of the secondary voltage at break is particularly rapid, and the magneto is able to work satisfactorily at very high speeds.

CHAPTER V

SPECIAL MAGNETOS: COMBINATIONS: ACCESSORIES

By far the best known of special magnetos is the peculiar type used on the Ford car. This magneto generates low-tension current, which is distributed by a revolving switch to four separate coils, each having its own trembler or vibrating interrupter.

Sixteen horse-shoe permanent magnets are attached to the flywheel in such a manner that like poles of adjacent magnets come together—that is, the North pole of one joins the North pole of the next magnet, and so on. Thus the effect is of a large magnet with sixteen poles. Immediately opposite to this are situated the sixteen coils, wound on bobbins and threaded over iron cores, these cores being directly attached to a stationary steel plate. Only $\frac{1}{32}$ in. separates the faces

of the magnet poles from the coil spools, so that when the magnets revolve their magnetic fields pass through the coils and induce currents in them. The coils are connected all in series, one end being earthed and the other taken up to a terminal at the top, from which the current passes to the induction coils, being distributed to them in order by means of a revolving switch, commonly called the "commutator." The current generated in the magneto coils alternates sixteen times per revolution, and the voltage varies very much with the speed, being about six or eight volts at cranking speed, rising to about thirty volts at full speed. It will be noticed that in this magneto the usual order of things is reversed as the magnets revolve, while the coils corresponding to the armature are stationary.

The large size, compared to the ordinary type, is also remarkable. There are practically no working parts to attend to, but care must be taken to keep the coils clean and free from metallic particles, which are apt to be collected by the magnets and thrown off on to the coils. The revolving switch must also be kept in order, or misfiring will result; strange as it may seem, this switch should be oiled to keep it in best condition and from becoming rough. The rubbing contact caused by the strong spring will ensure that proper connection is made with the four segments. It is obvious that, by providing another contact point on the main switch, the current from a separate battery may be sent through the induction coils instead of the current from the magneto, and thereby a much easier start obtained

The Ford ignition is really a particular example of what is called the transformer-coil magneto system, which was formerly commonly used in America. A typical example of this system is the Splitdorf, in which a low-tension magneto is used having an armature of the conventional type, but with only one winding on it. The low-tension current is taken to a separate induction coil situated on the dashboard. It is there converted to HT in the usual manner, when the interrupter on the magneto breaks the circuit. From the coil the HT current is led back to the distributer, which is combined with the magneto, and is thence distributed to the plugs. A battery is usually employed in connection with these systems, and operates through the magneto contact-breaker, being used for starting purposes only.

Another special magneto made on the Continent before the war was known as the "Mea." The special feature was to overcome the defect of the intensity of the spark varying according to the timing position, and it was accomplished by rocking the magnets themselves in harmony with the cam-ring. To facilitate this movement, the magnets were placed horizontally instead of vertically as usual, and were bell-shaped. Over all was a frame or casing supporting the two trunnions in which the magnets rocked. Whenever the cam-ring was moved to alter the timing, the magnets themselves moved through a corresponding angle and so kept the relative positions of magnet and armature constant at the moment of "break." Although answering the purpose fairly well, it was a somewhat clumsy method.

A more refined method is adopted in the latest type of Watford magneto, sliding pole-pieces being employed moving simultaneously with the cam ring, thus giving the maximum magnetic condition for any degree of timing. This construction necessitates the highest class of workmanship, and Messrs North & Sons claim that their magneto is the first of the kind that has been successfully produced commercially. The contact-breaker used is also of special design, the rocker "arm" being a very light and strong triangular structure. The whole machine is very well thought out, and has proved most satisfactory in air service during the war.

Special magnetos are made for V-type engines as used principally in motor cycles; in these the magnet-poles and the armature core are made unsymmetrical in order to produce the maximum points at uneven intervals, as demanded by the engine. When timing these magnetos, care has to be taken to do this in connection with the cylinder which fires first of the two, which, in motor cycles, is generally the rear cylinder.

In order to prolong the maximum position and so give a wider range of timing, many different experiments have been tried as to varying the shape or contour of the pole-pieces. The most effective of these appears to be the practice of making saw cuts or "comb" edges to the poles. No very great difference in practical results can, however, be effected by these means.

Special magnetos have been made for two-point ignition to obviate the necessity for special plugs. With this system

ordinary plugs are used, two in each cylinder, and the spark goes in series from one to the other. The magneto has both ends of the secondary winding brought out, neither end being earthed. Two collector-rings and also two distributers are necessary on the magneto.

A somewhat similar idea is carried out in the special magneto made for firing two plugs in series but in different cylinders.

The object in this case is to simplify the magneto, no distributer at all being necessary. Two pairs of collector-brushes are required, pressing on two rings, each ring having one segment on it, the segments being 180° apart. At each half revolution the high-tension circuit is completed through the two collector-brushes and through two plugs. One of these plugs is in the cylinder which is ready for firing, and the other is in the cylinder which is at the top of the exhaust stroke, where the spark has no effect and is merely an idle spark.

So long as the spark-timing is not retarded past the dead-centre position, no harm is done by this idle spark. A similar system has been used for 2-cylinder engines, in which the pistons move up and down together.

A novel idea in connection with the magneto is found in the machine called the "Magdyno," produced by the Lucas Electrical Company. In spite of the somewhat ungainly name with which it has been endowed, it is likely to find much favour among motor cyclists and small-car users. The machine is a combination of the Thomson-Bennett magneto; as made by the Lucas firm, and a special dynamo which is housed within the enlarged arch of the magnet, as illustrated in fig. 29. The dynamo is driven by gear-wheels from the magneto spindle, but otherwise the dynamo and the magneto are entirely separate concerns both electrically and mechanically. The dynamo can be easily removed from the magneto by slackening the thumb-screw in front and moving round the lever.

The output of the dynamo is 4 to 6 ampères at 6 volts.

It is obvious that only one driving connection to the engine is necessary for the two purposes of lighting and magneto ignition. The illustration shows a magneto for a 2-cylinder engine, but other designs are made with a distributer for a 4-cylinder type.

Hand-starter magnetos have been used to some extent for cars, and are also commonly employed for aeroplane work, being especially suitable for the latter purpose. A miniature magneto is installed which can be rotated rapidly by hand through a chain of gears, and so produces an intense spark. This spark is taken to the cylinder through the distributer on the main magneto, and if this cylinder is full of compressed gas, which has arrived there by previously rotating the engine or by other special means, an explosion will result and the engine will start up. In the Continental model a special

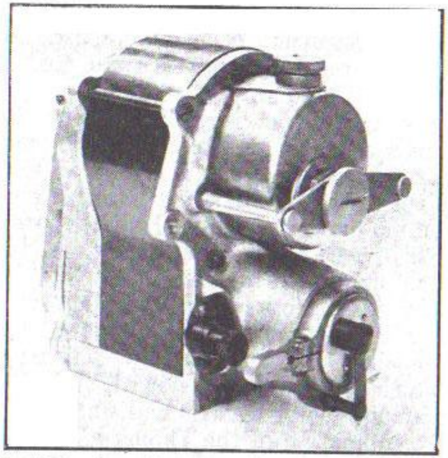

FIG. 29.—The "Magdyno." A Combination of a Standard Thomson-Bennet Magneto and a Cylindrical-shaped Dynamo.

high-tension switch was employed which automatically connected the starter magneto cable to the distributer on the main magneto, and earthed the main magneto cable while the starter magneto was being used. This resulted in considerable complications, and in British models for aeroplane work a different system is adopted in which the hand-starter magneto is connected to a separate point in the distributer-arm, called the "trailing point." This trailing point follows the main distributer-brush at an angle of about 30°, so that when the starting magneto is being used the spark occurs in a cylinder whose piston is about at the dead-centre, thus avoiding any chance of back-fire.

Many and various have been the schemes devised to com-

bine the magneto with battery ignition, the latter either for starting purposes only or else for slow running and as a stand-by, the magneto being used for general running. Probably little will be heard of such arrangements in the future; they belong rather to a bygone period. The best and most useful of these combinations was that known as "dual" ignition, in which a double form of contact-breaker was provided on the magneto, the ordinary type for the magneto itself, and another one actuated by the same cam-ring (though not the same cams) for the battery circuit. A combined coil and switch of rather a complicated nature was placed on the dashboard of the car, and two high-tension leads had to be taken to this from the magneto.

The switch provided three positions—"battery," "magneto," and "off." In the battery position the engine could generally be started "on the spark," *i.e.* without cranking, by pressing down a button, which brought a trembler coil into action and so produced sparks in the cylinder, which had remained more or less full of compressed gas. It proved, however, rather an uncertain method of "self-starting," and has given way to newer methods.

Another rather curious device was known as the "duplex" system, which was a somewhat simpler arrangement for using a battery in conjunction with the magneto windings for starting "on the spark" with a press button on the dashboard, and also for running on the battery if necessary. A "commutator" was combined with the contact-breaker to convert the battery current into an alternating one corresponding with the current in the magneto primary winding.

The duplex form of combination, however, never came into general use in this country, and is of historical interest only.

In order to bring about the desired result of altering the timing of a magneto without weakening the spark, an idea which naturally occurs is to insert a variable coupling between the driving shaft and the magneto, so that the relative displacement of the two can be altered at will by the driver. In that case the whole armature is moved, and the break occurs always at the maximum position.

This system has been tried and carried into effect, having been used especially on some well-known heavy vehicles many years ago. Though correct enough in theory, and effecting its purpose, the system has never become popular owing to the expensive construction necessary in the coupling, which generally depended on keys sliding in helical slots, and to the wear which developed in it. However, it seems to be one of those notions which are periodically "re-invented" by people who are interested in the subject, but who have not kept a close eye on past events in the magneto world.

One or two ingenious forms of automatic coupling have been introduced for bringing about the same result without the driver's intervention, centrifugal force being the moving spirit, acting through levers on helical or spiral grooves; but here again complication and cost were too great to render the idea practical in ordinary use.

A magneto accessory fitting which seems likely to be heard of a good deal more in the future, when its merits become known, is the "impulse starter." By this device the magneto armature is thrown forward at a high speed at the moment of starting, quite independent of the engine speed; in fact, the magneto may be turned as slowly as it is possible to do so by hand, and yet a spark is delivered as if the engine was running at high speed in the ordinary way.

This result can be effected without any great complication or expense. The principle is as follows:—The impulse starter consists essentially of two main parts, one revolving portion fixed to the armature, and the other one stationary fixed to the body of the magneto. A catch or pawl attached to the latter part can be put into a position where it engages with the rotating part and therefore holds it stationary for the time. But when the engine is being cranked, the magneto driving shaft continues to rotate, and this movement is made to compress a strong spring forming part of the device. The compression goes on till a certain point in the revolution is reached, where a trip-gear comes into action releasing the spring, which then unwinds, driving the armature with it at a high speed and so causing a good spark. Moreover, this spark occurs late, being automatically retarded by the nature of the device, without any attention from the driver. Two forms of this impulse starter are in use—one automatic, in which the spring action comes into operation every time at starting without being re-set, and the other in which a trigger has to be moved before starting. It will be understood that the device is put out of action by centrifugal force after a

certain speed has been reached, and the magneto then operates as usual in the ordinary way.

The illustration, fig. 30, shows the M-L impulse starter coupling supplied by Messrs S. Smith & Sons for use with the M-L magneto. Its small size and neat appearance are at once evident. It is of the automatic type, setting itself each time the engine comes to a standstill, ready for re-starting. The coupling is fixed to the magneto-spindle in the normal manner, and can be connected to the driving-shaft from the engine either by a flexible leather disc or by a solid coupling. The manufacturers point out that by its use a much smaller magneto can be employed than would otherwise be necessary for the purposes of starting, the sole reason for the use of large magnetos being to overcome starting difficulties.

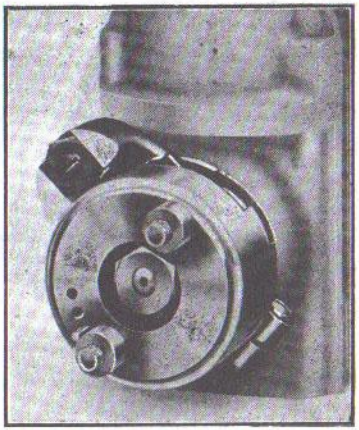

FIG. 30.—The M-L Impulse Starter Coupling.

A very practical and useful accessory has been brought out by Messrs Simms Motor Units, and called the Simms Patent Vernier Magneto Coupling. Its mission is to provide a connection between the engine and magneto which can be easily and very accurately adjusted in combination with a drive which is sufficiently flexible to avoid strains on the magneto shaft and bearings. This straining has been one of the chief troubles met with in the past, for it is far from easy to ensure really correct alignment of the two shafts when cars are being turned out under ordinary commercial conditions. Consequently, abnormal friction occurs in the magneto bearings, causing undue wear or even fracture of the shaft in cases where the want of alignment is excessive. The Simms coupling consists of three parts—two metal bosses with serrations or teeth cut on the faces, and a central connecting portion or disc made of a patent composition having a rubber basis and fitting in between the metal bosses. The coupling in its complete form is shown in fig. 31, while the other illustration, fig. 32, shows the coupling dissected, and the centre portion held in the hand.

The idea of the coupling, as the name implies, is based on the principle of the vernier, with which most readers are acquainted. This principle involves the fact that there shall be a difference of one in the number of teeth on the two flanges. On the standard flanges of this coupling the teeth number nineteen and twenty respectively. Suppose we wish to alter the timing of a magneto very slightly, we proceed as follows:—Remove the bolt and slide the engine half of the coupling out of engagement with the rubber centre-piece. We turn the magneto spindle together with the centre-piece a distance equal to one tooth of the engine-half coupling (*i.e.*, $\frac{1}{19}$th of a rev.) in the desired direction. We then mesh the centre portion with this engine-half coupling and turn back the magneto spindle *by itself* in the opposite direction a distance of one tooth (*i.e.* $\frac{1}{20}$th of a rev.), and then refix the coupling together. Clearly we have now altered the setting by one-nineteenth, less one-twentieth of a revolution. Putting this in figures,

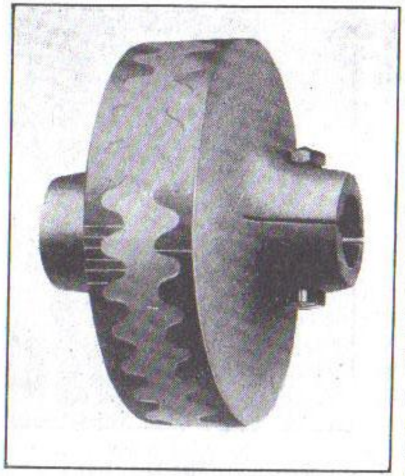

FIG. 31.—Simms Vernier Magneto Coupling, complete.

$$\tfrac{1}{19}-\tfrac{1}{20}=\tfrac{1}{384} \text{ of a rev. approx.,}$$

which is less than 1°. It will thus be seen that any desired amount of alteration can be effected by these very fine steps.

The material of which the centre part is constructed is called Hivoltsit, and anything with such a name should possess some peculiar qualities. It is claimed to be oil-, acid-, and

petrol-proof. It is sufficiently flexible to take up all shock and end-thrust on the armature, and to allow for any ordinary amount of error in alignment between the two shafts, being also noiseless in operation.

Another departure from pre-war practice is the adoption in many cases of "spigot-mounting." The object of this is to get over the difficulties arising from want of alignment between driving and magneto shafts as mentioned above in connection with the Simms coupling. In the ordinary way, when the magneto is base-mounted, the machining of this base and drilling for the driving-spindle bearing constitute two separate operations. Inaccuracies then very easily creep in during commercial production. But if the magneto is designed for flange (or spigot) mounting, as shown in an illustration of a B.T.-H. magneto in the next chapter (fig. 44), then the bolt holes and driving-spindle hole are all drilled at one setting of the same machine, so that no room for error is left. The objection is the large amount of overhang which necessarily occurs, but if the flange is made of generous proportions no harm ensues. This form of mounting has been largely used for aeroplane magnetos, and will probably be increasingly employed for cars.

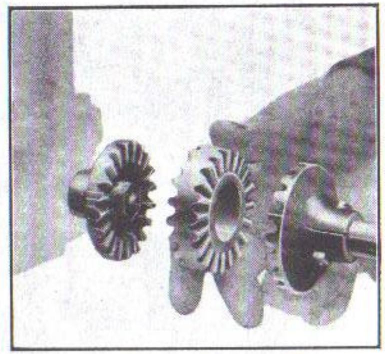

FIG. 32.—Simms Vernier Magneto Coupling, dissected.

CHAPTER VI

SOME TYPICAL MAGNETOS

THE following illustrations show a selection of modern British magnetos. It is not, of course, intended or desirable to include every magneto on the market, but good examples of the main types are reproduced. In nearly all cases other types besides those illustrated are turned out by the same manufacturers.

"BLIC"

One of the BLIC magnetos made by the British Lighting and Ignition Company of Birmingham is shown in fig. 33.

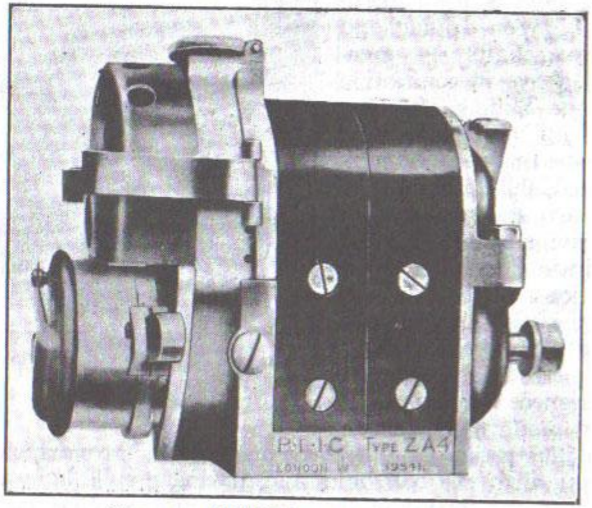

FIG. 33.—BLIC Magneto, Type ZA4.

The type illustrated is known as ZA4, and is intended for use on 4-cylinder light-car engines running at crank-shaft speed and having a timing range of 20°. The approximate weight is 9 lbs. 8 oz.

The neat arrangement of the distributer with concealed terminals is a point to be observed.

THOMSON-BENNETT

The illustrations, figs. 34 and 35, show two out of the complete range of Thomson-Bennett magnetos manufactured by the Lucas Electrical Company of Birmingham, and it should be noted that the Thomson-Bennett magneto was actually being made in England for several years previous to the war.

The particular types illustrated show a single-cylinder machine and a standard 4-cylinder type.

Many detail improvements are included in these machines, and a very good new design of contact-breaker has been in-

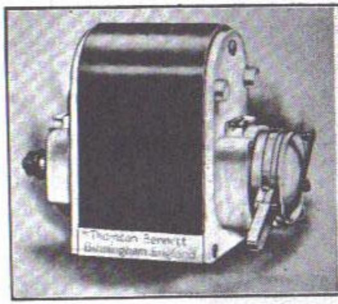

FIG. 34.—A Thomson-Bennett Single-Cylinder Magneto.

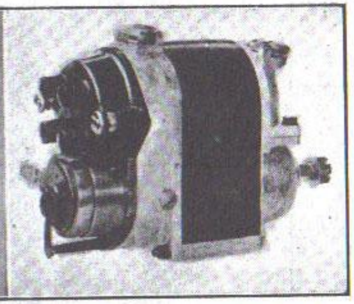

FIG. 35.—Thomson-Bennett Standard 4-Cylinder Type Magneto.

corporated. The distributer-shaft runs in plain bearings to which ring oilers are fitted. Laminated pole-shoes and a jump-spark distributer, combined with the safety spark-gap, are other features. Base- or spigot-mounting is optional.

"M-L"

The M-L magnetos are very up-to-date machines. Some 100,000 were produced during the war, both for car and aeroplane work. Laminated pole-shoes, cams ground to special shape integral with the cam-ring, jump-spark distributer, and self-lubricated bearings are standard features on all the M-L types.

Specialities are the very strong mechanical construction of the condenser, in which part troubles have been not infrequent in foreign machines; a pivot bush made from material which is absolutely damp-proof, and therefore cannot swell and cause sticking of the arm; and absolutely waterproof construction magnetos, having been exhibited running in a water tank and sparking consistently all day.

The illustration, fig. 36, shows the K2 and KV types for 2-cylinder engines, in line, opposed, or V-type. The

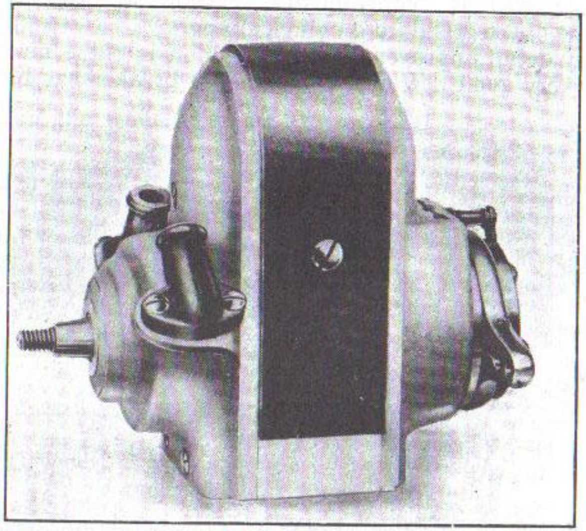

FIG. 36.—A Standard M-L Magneto. 2-Cylinder Type.

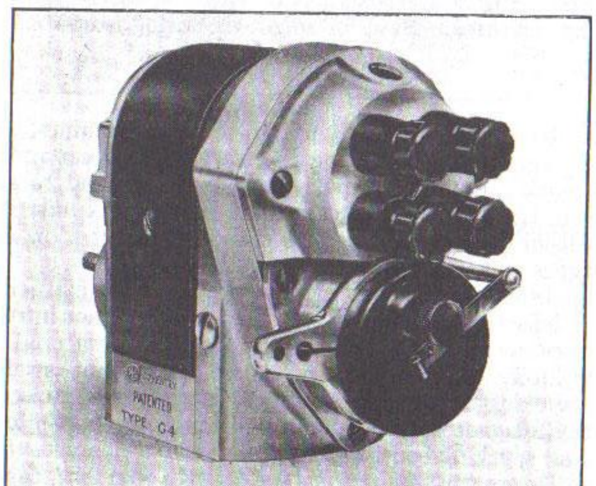

FIG. 37.—A Standard M-L Magneto. G4 Type.

terminals are a special feature. Designed to keep the overall width to a minimum, an ordinary wood screw projects up the centre of the terminal, being moulded in; the cable has merely to be screwed into this, and the shape of the wood screw expands the insulation tightly against the side of the hole, making a watertight joint, while the screw itself makes good electrical contact with the stranded core inside.

The other illustration, fig. 37, shows the standard G4 magneto, similar machines being made for 3- and 6-cylinder engines.

They are designed for engines up to 90 mm. bore and to work satisfactorily over a range of speed from 75 to 5000 r.p.m. A special feature is the employment of aluminium for the shell of the distributer in place of the usual moulded material. Much greater strength is claimed, and also ease of repair in case of damage. A timing range of 30° is standard, and either base- or spigot-mounting.

C.M.I.

The C.M.I. magneto, made by the Conner Magneto and Ignition Company of Stoke, Coventry, has a remarkably good reputation. Possibly ancestry has something to do with it in this case, for the present Company is a lineal descendant of one which can trace its reputation for high-class electrical work back to quite ancient times, as times go in electrical matters. However that may be, there is no doubt that the magneto turned out by this firm at the present day is a very high-class production. A glance at the illustration, fig. 38, will convey a better impression of its distinguished appearance than any description. Perhaps "thoroughbred" is the most appropriate word. A sheet aluminium cover completely encloses the magnets and collector-brush end, imparting a very pleasing finish to the machine, besides serving a useful purpose in excluding dirt and moisture. Laminated pole-pieces are used in an aluminium body casting of which the distributer-bracket forms an integral part. The distributer and contact-breaker are designed on standard lines.

By way of comparison and to illustrate the refinement of design which has been effected by British manufacturers during the war period, an example of an earlier model by the same firm is shown in fig. 39. This magneto, which was manufactured in large numbers for the Air Board, is a fair sample of the best practice in that day and pre-war types

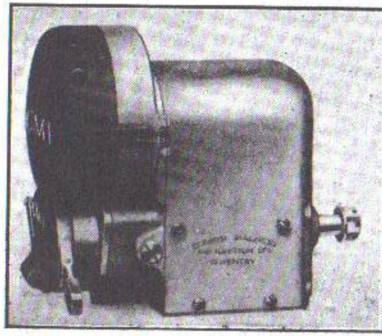

FIG. 38.—One of the latest Types of C.M.I. Magneto.

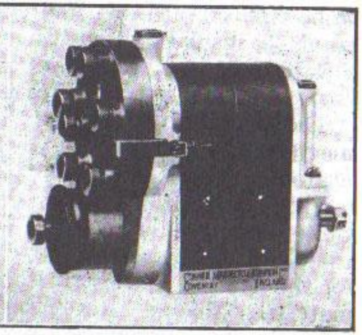

FIG. 39.—An Earlier Type of Magneto by the C.M.I. Coy.

in general. Comparison with the illustration of the present-day C.M.I. magneto (fig. 38) is most striking, and no comments are needed.

ERICSSON

The Ericsson magneto made by the British L.M. Ericsson Manufacturing Company of Beeston, Notts, who are widely known for their telephone work, is shown in fig. 40. It is a very substantially built machine, calculated to resist hard usage, and while it is based on standard lines, it also includes some special features of considerable interest and importance. A sectional view of the Ericsson magneto is shown in Chapter II. fig. 19.

One of the components which has received special attention in respect to mechanical strength is the condenser, which can be dropped 40 ft. on to a concrete floor without breaking up, and will withstand the application of an alternating current of 1000 volts (peak value). But the outstanding feature of the design is the shape of the pole-pieces, shown in fig. 41. It is seen that small auxiliary pole-pieces are used extending from the main pole-pieces, but separated from them by a small air-gap. When the contact-breaker points open at the fully advanced position, the tip of the armature is just leaving

the tip of the main pole-piece, as shown in the diagram, fig. 41, " full advance."

When the timing lever is moved over towards the " full

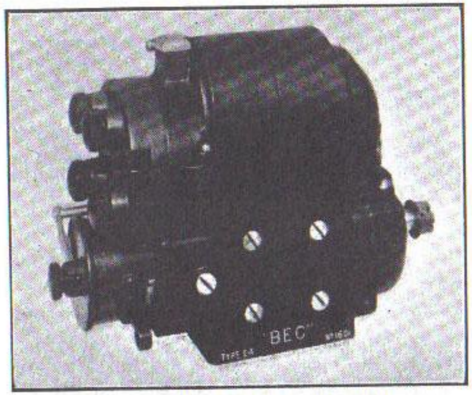

FIG. 40.—The Ericsson Magneto.

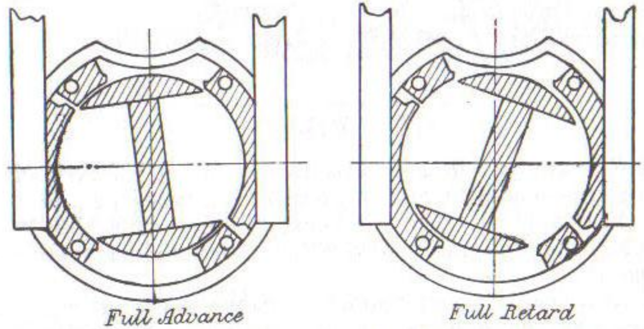

FIG. 41.—Auxiliary Pole-pieces of an Ericsson Magneto.

retard " position the operation of the auxiliary pole-pieces comes in. The reaction of the armature causes the magnetic field to be greatly distorted, so that it is carried through the auxiliary pole-piece. When the break occurs, the effect of the armature reaction ceases, and the magnetic flux immediately reverses in the armature-core, thus producing the induction previously described. The magnetic flow with retarded timing is practically the same as in the fully advanced position. The efficiency of the magneto is thus retained throughout the full range of timing control. The contact-

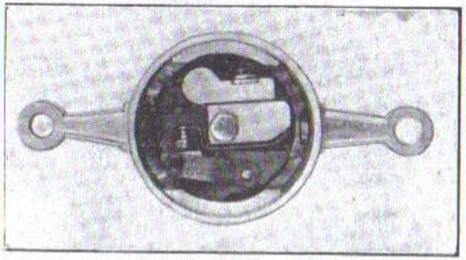

FIG. 42.—Contact-Breaker of an Ericsson Magneto.

breaker shown in fig. 42 is also a special feature possessing some valuable qualities. The moving contact is carried on the spring itself, instead of a rocker-arm controlled by a spring as usual, giving a quick "snappy" action, the same at all speeds. Obviously the spring itself cannot stick and the fibre operating block can be an easy fit on its pivot.

SIMMS

The Simms magneto is illustrated in fig. 43, the type shown being known as SR6, one of the two main types manufactured by the firm, the other one being exactly similar but for a 4-cylinder engine and called SR4. Both are for engines up to 50 h.p.

When writing about Simms magnetos, the word reliability seems to occur quite naturally and to be entirely fitting, at any rate to anyone who has had experience with them in the past. They are essentially sound and trustworthy machines which have stood the test of time and have much experience behind them. All Simms magnetos are fitted with extended pole-pieces giving a high efficiency in all positions of the timing range and facilitating easy starting of the engine. They are waterproof in construction, so that water may be sprayed on to them without detriment to the working; and the work-

manship is of the best. Particular attention is paid to the winding and insulation of the armature, the resistance

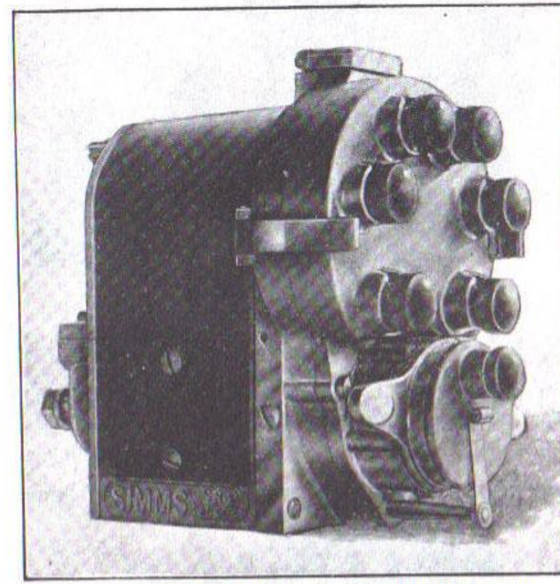

FIG. 43.—A Standard Type of Simms Magneto.

between windings and shaft being approximately 100,000 megohms.

The present magnetos are the result of the experience gained in the manufacture of over one million machines.

BRITISH THOMSON-HOUSTON

The British Thomson-Houston Company of Coventry, who have had such a large experience in aeroplane magnetos of the inductor type, as described in Chapter IV., also produce a highly developed machine of the standard type. Two of these, known as G3 and G6, are illustrated in figs. 44 and 45. They are intended for 3- and 6-cylinder engines respectively, and G3 is shown arranged for spigot-mounting.

These are light-weight machines scaling about 9 lbs. and are on standard up-to-date lines. A single magnet is used

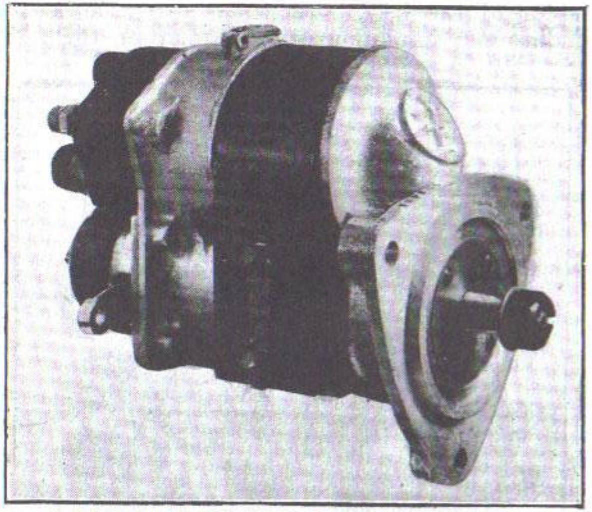

FIG. 44.—A spigot-mounted B.T.-H. Magneto for a 3-Cylinder Engine.

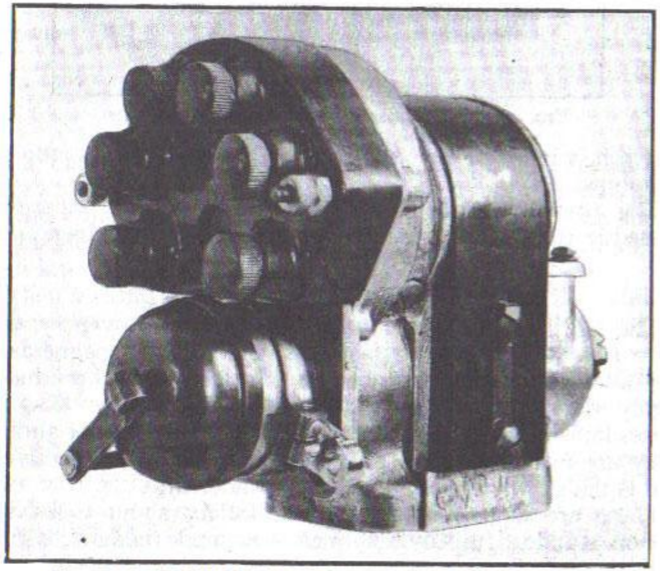

FIG. 45.—A B.T.-H. Magneto for a 6-Cylinder Engine.

which, although containing 40 per cent. less steel than pre-war types, is claimed to give higher efficiency.

Particular care is given to armature construction and winding, many special instruments being made use of to facilitate the work and avoid damaging the insulation. A jump-spark distributer is employed, the safety-gap being combined with it, and therefore rotating, the principle being to disperse the products of ionisation or silent-brush discharge which is continually going on between the points. These products, consisting of ozone and nitric acid, might be deleterious if confined within the body of the machine. A similar type called G4 is made for 4-cylinder engines, interchangeable, so far as mounting is concerned, with the pre-war ZF4 type.