High Tension Ignition by Magneto.

By Roger B. Whitman.

The builders of internal-combustion engines realized from the first that the problem of ignition was of paramount importance, and its solution has required careful study and exhaustive experimental work. The task to be achieved is the positive ignition of the charge at such a point in the compression stroke that complete combustion will result when the piston reaches its inmost point in the cylinder. On the variable-speed automobile engine it must in addition be possible to alter the point of ignition according to the volume of the charge and its quality.

The early "hot-tube" ignition system was soon displaced by the Ruhmkorff coil, which was so modified that the high-voltage current from the secondary winding passed across a gap located in the combustion chamber, where it formed a spark of sufficient intensity to ignite the charge. While this system was and still is in very general use, it is not entirely satisfactory because of the possibility of interruptions arising from the multiplicity of wires and connections, the corrosion of the vibrator contacts, and the instability of the batteries.

To avoid the use of batteries, experiments have been made with various types of mechanical generators. The development of the magneto has been the result. This type of apparatus originated with Faraday, who revolved a coil of wire in a magnetic field, and discovered that changes in the degree of magnetization of the iron core on which the wire was wound resulted in the development of electric currents in the wire, an effect which is in accordance with the laws of induction.

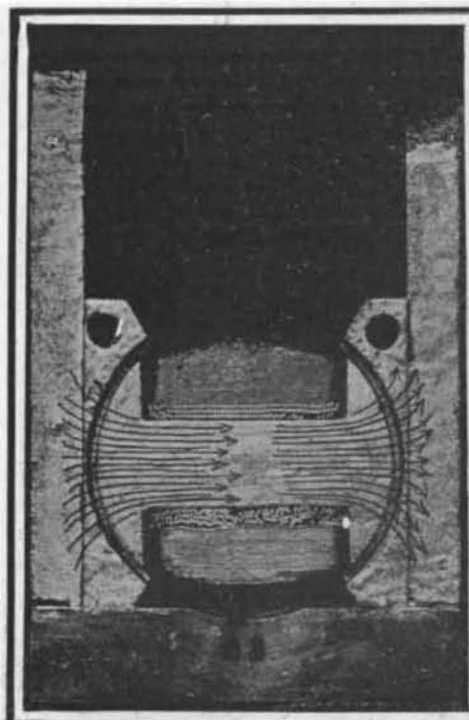


Fig. 1.—Magnetic flow through the cross bar.

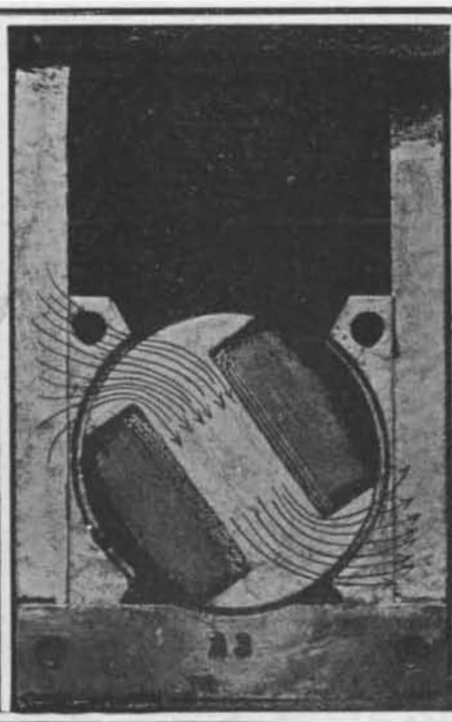


Fig. 2.—Cross bar partially turned with magnetic flow through it.

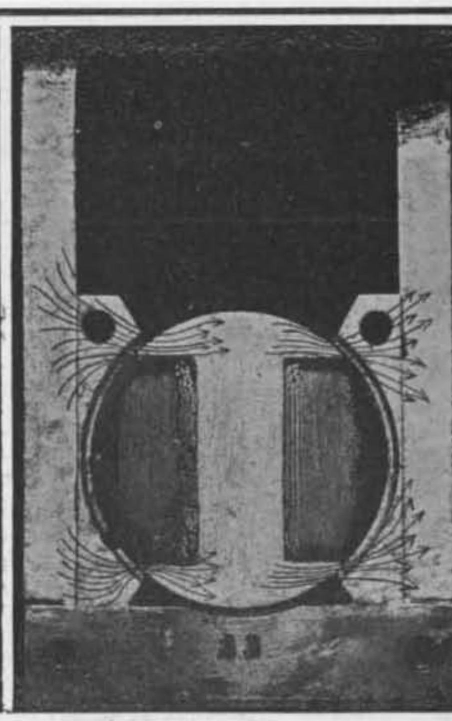


Fig. 3.—The field thrown out by the cross bar disappears in this position.

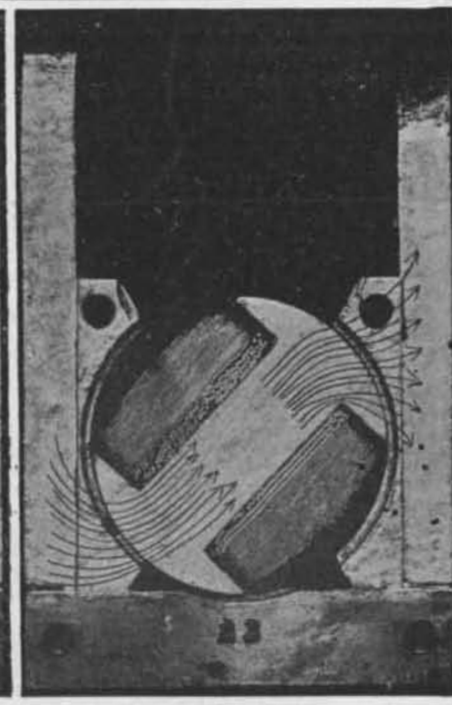


Fig. 4.—The cross bar again becomes magnetized as the magnetism resumes its flow.

CHANGES IN THE STRENGTH OF THE MAGNETIC FIELD THROWN OUT BY THE CROSS BAR AFFECT THE ARMATURE WINDING AND ELECTRIC CURRENTS ARE INDUCED IN IT CORRESPONDING IN INTENSITY WITH THE EXTENT OF THE CHANGES AND THE RAPIDITY WITH WHICH THEY OCCUR.

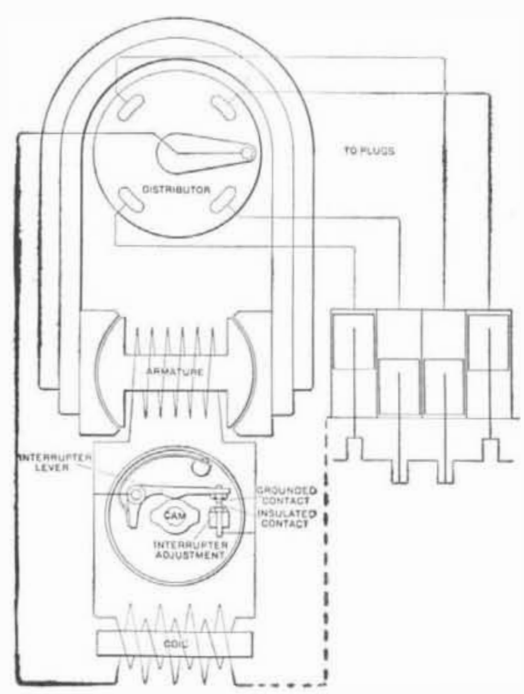


Fig. 6.—The Eisemann system.

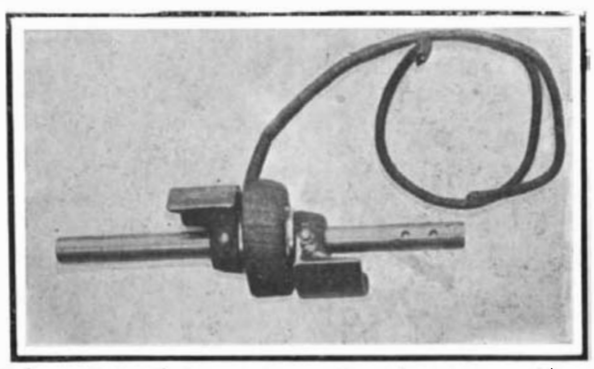


Fig 7.—The Remy armature with stationary winding and revolving core.

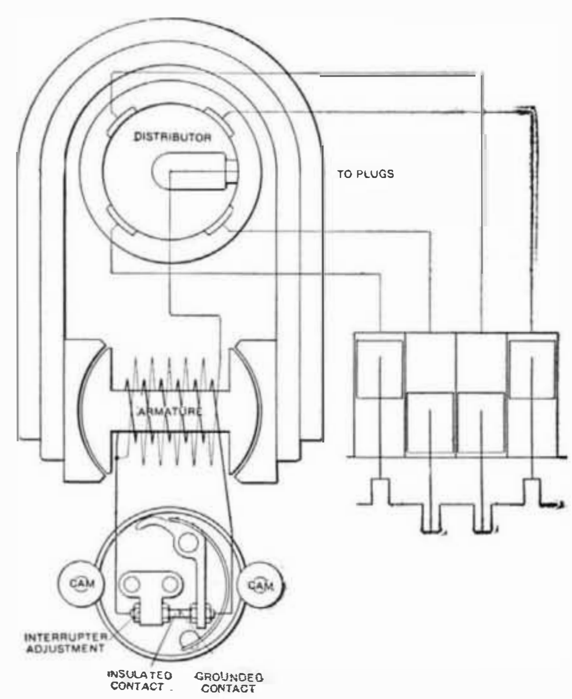


Fig. 9.—The Bosch system.

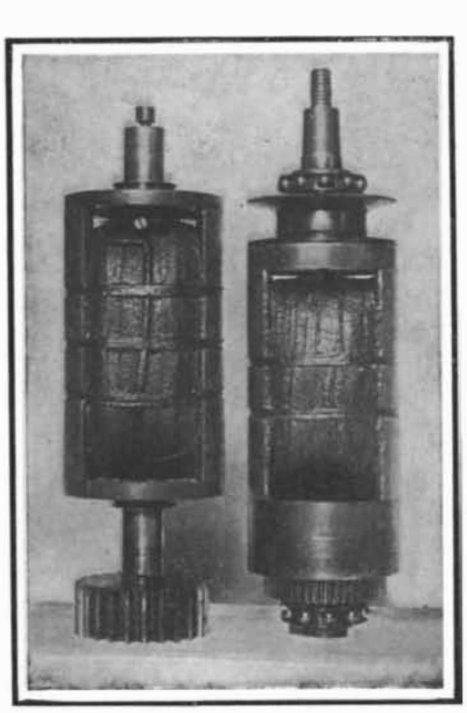


Fig. 5.—Typical magneto armatures.

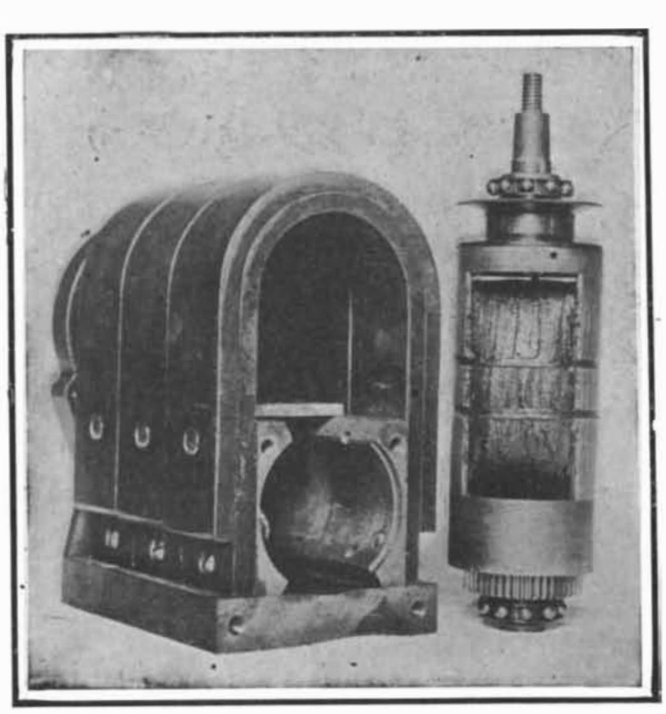


Fig. 8.—Field and armature of Bosch high-tension magneto.

In the modern magneto, the magnetic field is formed between the poles of powerful U-shaped magnets, the coil that revolves in it being wound on an iron core of which the cross section is shown in Figs. 1 to 4. These parts are known as the armature (Fig. 5). Whatever the position of the armature in the field may be, the core serves as a conductor by which the magnetism may flow from one pole to the other. In the positions of Figs. 1 and 2, the magnetic flow is through the cross bar, a condition under which the cross bar becomes magnetized and throws out its own magnetic field. When the armature assumes the position of Fig. 3, the magnetic flow abandons this path in favor of the two shorter paths offered by the side pieces, and the field thrown out by the cross bar disappears. On the further rotation of the armature, the cross bar again becomes magnetized as the magnetism resumes its flow through it. These changes in the strength of the magnetic field thrown out by the cross bar affect the armature winding, and electric currents are induced in it corresponding in intensity with the extent of the changes and the rapidity with which they occur. The greatest changes in the strength of this field will occur as the armature passes from the position of Fig. 2 to that of Fig. 4, for in that interval the magnetic field thrown out by the cross bar will be destroyed and then reproduced.

During the greater part of the revolution of the armature, the changes in strength will be slight and the induced currents correspondingly small; but at the instant when the cross bar becomes remagnetized as the armature leaves the position of Fig. 3, the current will be of sufficient intensity to produce satisfactory ignition. This condition will exist twice during each revolution of the armature, and it is necessary for the armature to be driven in such relation to the crank shaft that each production of maximum current coincides with the ignition point of the cylinder to be fired.

Magnetos were first applied to the ignition of automobile engines on Mercedes cars, the system employed becoming known as low tension, or make-and-break. The maximum pressure developed by these magnetos being in the neighborhood of 100 volts, it can not overcome the resistance of the gap existing in the spark plug, and use is made of a device known as an igniter. This projects into the combustion space, and is connected with the magneto in such a manner that the circuit is made and broken as its two points touch and then separate. By breaking the circuit at the instant when ignition is desired, and having this action coincide with the production of maximum current by the magneto, a spark or flame of high igniting power is obtained. The advantages of this system were recognized immediately on its introduction, but the frequent adjustment made necessary by the wearing of the igniter parts, and the mechanical difficulties to be overcome in making an igniter that is reliable and proof against leakage of compression, prevented its general adoption.

While the make-and-break system as a whole did not solve the ignition question, it showed the magneto to be greatly superior to a battery as a source of current. This advantage does not lie alone in the mechanical production of current, but also in the simplification of engine operation; for with a magneto it is unnecessary to alter the point of ignition with each change in engine speed, as is required with a system employing a battery. The intensity of the current being in accordance with the armature speed, and this being in direct relation to the speed of the crank shaft, an increase in the speed of the engine due to opening the throttle will result in the production of a current of greater igniting value. Except for extreme changes in speed, or under special conditions, the effect of advancing or retarding the spark is obtained without the use of the spark-control lever.

The advantages of the magneto have led to its application to high-tension or jump-spark ignition, and to a development that has made the ignition system one of the most trustworthy parts of the car. This evolution has developed two distinct types of magnetos, both of which are driven synchronously with the engine by gearing. One type generates the high-tension current direct from the magneto armature and the other uses an induction coil for raising the voltage to the potential necessary for jump spark ignition. All commercially successful systems are along one or the other of these lines.

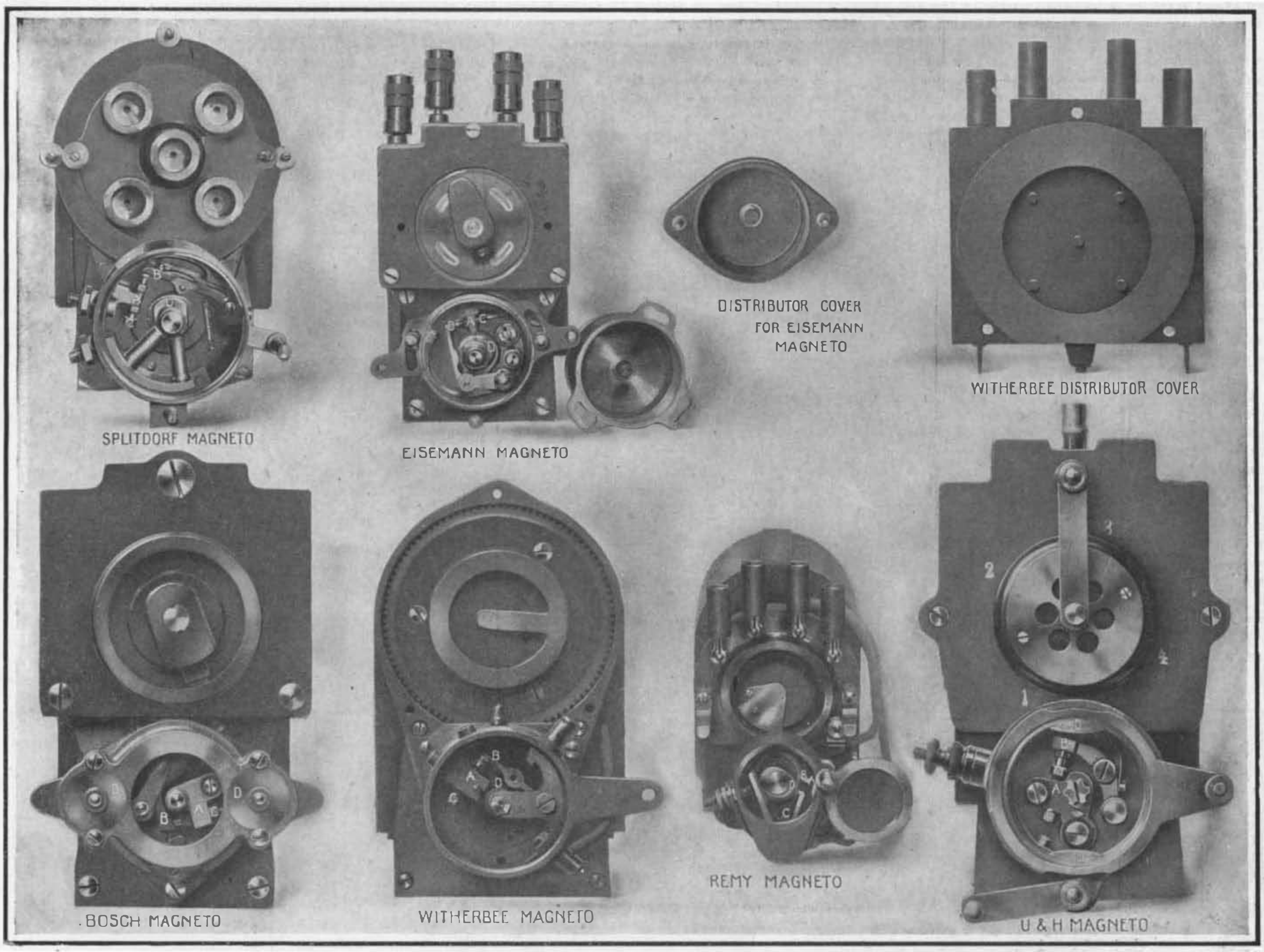
The Eisemann and Remy and similar systems are a development of the logical attempt to make use of a magneto as the source of current for a high-tension or secondary coil. Their direct connection with the primary winding of the coil would not give satisfactory results, for the gradual rise in the intensity of the current would give correspondingly gradual changes in the magnetization of the core of the coil. Good results will be obtained only when the magnetic field thrown out by the core of the coil changes its strength abruptly, and to attain this end use is made of a device known as an interrupter or circuit breaker. Fig. 6 illustrates the general principles of the Eisemann system.

The magneto itself is of the low-voltage type, giving a current at from 20 to 40 volts only. One end of the armature winding is grounded, the live end passing to the insulated contact of the interrupter, which is located at the end of the armature shaft. From this point the circuit continues to one terminal of the primary winding of the coil, the other terminal of which is grounded. The grounded part of the interrupter, a pivoted lever, is operated by a cam carried on the armature shaft, and makes and breaks contact with the insulated part. The cam is set in such relation to the armature that the breaking of the circuit by the interrupter coincides with the production of maximum current in the armature winding. When the interrupter is making contact, the magneto current is offered two circuits by which it may flow to ground, one being through the interrupter and the other through the primary winding of the coil. The resistance of the former being low, the current takes that path in preference to the other, which is of higher resistance. When the current reaches its maximum the cam breaks the interrupter circuit, and the only path by which the current can then flow to ground is that offered by the primary winding of the coil. This sudden and intense flow causes the core of the coil to throw out a powerful magnetic field, which induces a current in the secondary winding of from 20,000 to 40,000 volts. This current is passed to the proper spark plug through the medium of a distributer located on the magneto and driven by the armature shaft. A condenser is connected across the interrupter contacts to reduce the sparking as the circuit is broken, and to effect a more abrupt change in the magnetic field of the coil.

In the Remy magneto the winding, which is stationary, is connected through the magneto circuit breaker with the primary of the spark coil. The circuit is mechanically broken during the current wave or impulse generated by the magneto. The current wave generated, due to design of the magneto, retains practically its maximum strength for over 45 deg. of the inductor's revolution. It is claimed for this construction that it permits of a very large timing range for advancing and retarding the ignition point without weakening the spark. The timing of the spark is accomplished by shifting the circuit breaker around the armature shaft, to which is attached the circuit-breaker cam.

This arrangement is frequently confounded with the true high-tension magneto system, and spoken of

(Continued on page 63.)



A. Insulated interrupter contact. B. Grounded contact on lever. C. Contact adjusting device. D. Cam.

TYPICAL MAGNETOS USED ON AMERICAN CARS.

tor is exposed, an egg-cup full of gasoline or kerosene will keep the oil from becoming too thick and from causing trouble by clogging the small ball checks in the oil pumps.

Before putting on a new clutch lever it is advisable to soak it for 24 hours in water. When fastened to the clutch it should be given a liberal coating of castor oil, or better still, neatsfoot oil. It will take quite a time for the oil to soak into the leather properly, as the water must first evaporate, which takes quite some time.

To prevent the multiple disk clutches (metal to metal) from dragging after disengaging the clutch by the foot pedal, use only a very thin oil (spindle oil) mixed with kerosene. Good results have been obtained by taking ¼ cylinder oil (light) and ¾ kerosene.

Lubricating oils should always be strained before using, as grit and ground-up materials will obstruct oil-holes, pipes, etc.

Blue smoke issuing from the muffler denotes excessive cylinder lubrication or worn cylinders and has nothing to do with the mixture of gas.

THE COMMERCIAL TRUCK VS. THE HORSE.

(*Concluded from page 43.*)

to heavy vehicles, and it must be admitted that it possesses advantages in the smoothness with which the power may be applied and in the reserve power that may be called upon in emergencies. In the United States, however, this field is practically untouched.

The initial expense of an automobile equipment seems high to the man who is familiar with horses, and to reduce it many concerns are purchasing second-hand pleasure cars and fitting them with delivery bodies. There is no risk in making the purchase if the purchaser will have the chassis examined and properly overhauled, but he must realize that the car is suitable only for the delivery of light packages, and that it must have careful attention and handling. With the addition of suitable braces and trusses a fair load may be carried, but there can be no comparison, of course, with the cars that are designed and built for trucking purposes.

To get the fullest benefits from an automobile delivery service, it must be realized at the outset that everything about it is new, and that a stable foreman is rarely competent to give it the intelligent management that it requires. There must be regular and systematic inspection of the mechanism, correct adjustments maintained, and supervision exercised over every detail of handling, repair, and care. The ultimate cost of neglect and mishandling is out of all proportion, and it should therefore be possible to place full responsibility for a failure to lubricate or to attend to any other essential of the upkeep. Two weeks at the factory is not sufficient to change a stable hand into a competent driver, and a lack of smoothness in the handling of the car will be paid for in tires, bearings, and strains in the entire mechanism.

It is usual to see automobile trucks carrying loads far in excess of their rated capacity, and this is the most prolific cause of high repair bills. It is the custom of some manufacturers to protect their vehicles by underrating their capacity, and this also operates to protect the purchaser. Knowing that the car is likely to be overloaded, a truck that is capable of carrying a load of five tons will be rated at three tons; another method of protection that is practised is to limit the size of the body.

A business man will not purchase an electric lighting plant without engaging an engineer to tell him what he wants, to select the apparatus, and to supervise its installation. Yet he believes himself competent to purchase an expensive truck, and to evolve a system for its operation and maintenance. The exigencies of the situation are producing experts who are competent to examine into the conditions under which deliveries are made, who can report on the make and type of car best adapted to perform the work, and who can establish rules for its care. It is to a man of this class that a prospective purchaser should turn for assistance. There are many houses operating automobiles successfully, but the price that they have paid for experience is far in excess of the fee that would have been charged had an expert been employed at the outset.

The construction of pleasure vehicles is approaching a condition of standardization, and the designs undergo only slight changes from one year to another. That the automobile truck is likewise emerging from a formative condition is shown by the reduced importance of the alterations required for the elimination of the weak points that develop in service. The 1909 types are far superior to the earlier models in every respect; and if their purchasers exercise common sense and business judgment in their management, there should be no difficulty in obtaining from them the swift, efficient, and economical service that is so greatly to be desired.

HIGH-TENSION IGNITION BY MAGNETO.

(*Concluded from page 45.*)

as such, but this is an error; for while it produces a high-tension current, the magneto itself delivers a current of even lower voltage than the magneto used for the make-and-break system.

While the Remy and Eisemann systems are similar in that they use separate coils, the magneto construction is different. In the Remy the winding is separate from the armature core and is stationary, the core revolving within it. The core and winding are shown in Fig. 7. When the core is revolved within the pole pieces of the field magnets, the cylindrical portion within the winding becomes magnetized and demagnetized, currents being developed in the winding to correspond with the degree and rapidity of the changes.

The Bosch high-tension magneto differs from the Remy or Eisemann in producing a current of high voltage in the armature winding, and without the use of a separate coil, this construction being also common to the U. & H., the new Eisemann, the Witherbee, and Komet. Instead of but one winding, the armature carries two, the inner or primary consisting of a few layers of coarse wire, and the outer or secondary of a great number of layers of fine wire. The disposition of these windings may be seen in Fig. 1, and the complete armature with the field magnets in Fig. 8. One end of the primary winding is grounded on the armature core, and the other passes to the insulated part of the interrupter, Fig. 9. While in the Remy and Eisemann magnetos the interrupter is stationary and operated by a revolving cam, in the Bosch the two fiber wheels, serving as cams, are stationary, and the interrupter revolves with the armature. This arrangement makes it possible to conduct the current from the primary winding direct to the interrupter without the use of a commutator or of sliding brushes, the action of which might be interfered with by dirt or oil.

In the Remy magneto and in another type of Bosch the primary current is conducted direct to the interrupter without the use of a commutator or sliding brushes, on account of the use of the stationary winding, which is used in its construction.

During the revolution the grounded lever makes and breaks contact with the insulated part, offering the primary current a short circuit while the contact is closed. As may be seen from the diagram, the secondary winding is grounded on the live end of the primary, its live end being connected with the revolving part of a secondary distributer.

In order that a current may flow it must have a closed circuit, and this will be the condition of the primary winding while the interrupter lever is in contact with the insulated part. For all points in the revolution of the armature except from the position of Fig. 3 to that of Fig. 4, and, of course, the corresponding position a half revolution later, the primary circuit is closed, permitting the feeble currents to flow. When the current reaches its maximum, a cam operates the interrupter and the short circuit is broken. In the meantime the secondary circuit has been open while the distributer has been moving from one contact to another, and therefore there has been no flow of current in the secondary winding. The electrical pressure will rise in it as the armature approaches the position of Fig. 3, but there will be no flow even when the distributer is making contact, because the pressure will not be sufficient to overcome the resistance of the spark plug gap. When the interrupter operates, the maximum primary current will be diverted from its short circuit, and can then flow to ground only through the secondary winding and spark plug circuit. The high pressure already existing in the secondary winding will be greatly increased by the sudden flow of the primary current, and the spark plug gap will be bridged by a current of such intensity that an arc rather than a spark is produced at it.

In another Bosch type, the armature, while identical in winding with that already described, does not revolve, but is fixed in the position of Fig. 3. In a space between the armature and pole pieces revolves a shield formed of two pieces of soft iron similar in size and curvature to the side pieces of the armature. The magnetic flow is from one pole of the field to one of the segments of the shield, to the armature core, and to the other pole by the second segment. With this construction complete magnetic changes in the armature cross bar occur not twice, but four times to each revolution of the shield, resulting in the production of four maxima of current. The advantages are that the winding is stationary and therefore operating under better conditions than when it is revolving, that the magneto runs at half the speed that is required for the other type, and that for a 4-cylinder engine the distributer may be placed on the magneto shaft instead of on an auxiliary shaft driven at half the speed of the armature.

The high voltage of the current makes it essential to provide a circuit for it, for if by chance a spark plug lead wire were to become disconnected, the pressure would be quite sufficient to break down the insulation of the armature winding in seeking another path to ground. To guard against this a high-tension magneto should be fitted with a safety spark gap consisting of two points, one connected to the secondary circuit and the other to ground. These are set apart at such a distance that the current will pass across them before the pressure will rie sufficiently to rupture the armature insulation. A pressure of 12,000 volts will usually permit the current to pass across a spark plug gap, and on the Bosch magnetos the safety spark gap is set to operate at 16,000 volts. In the Eisemann system the gap is located on the coil box, and will be bridged by a pressure of from 20,000 to 25,000 volts.

In the Bosch magneto, the condenser that is connected across the interrupter contacts is located in the armature and revolves with it. In the Eisemann, U. & H., and Witherbee the condenser is in the interrupter housing or under the arch of the magnets, which permits its easy replacement in case of rupture. The construction of condensers has been perfected to such a point that there should be little trouble from this source, however, and it would seem advantageous to locate it in the armature, for then there is no need of sliding contacts. The limited size of magnetos and the unfavorable conditions under which they must operate, require perfection of design and construction in order that they may not give trouble, and the elimination of sliding contacts is of importance because of the difficulty of keeping them clean and in adjustment. This feature has been perfected to a high degree in some makes, while in others it seems to have been entirely overlooked.

In comparing the high-tension magneto with the high-tension system employing a low-tension magneto and secondary coil, much may be said on both sides. The chief claim for the latter system is that the small size of the armature makes it difficult to insulate the secondary winding properly, and that it is therefore liable to rupture. The coil being separate is not limited in size, and ample insulation may be provided. The argument against this is that with proper design, workmanship, and materials, no difficulty need be experienced from this source, and that a double-wound armature greatly simplifies the wiring and reduces the number of parts.

In order to give proper ignition, a magneto must be set in such relation to the crankshaft that it is delivering its maximum current at the instant that a piston is at the firing point with the engine running at normal speed. In automobile engines this point varies from ⅜ inch to ¾ inch below the top of the stroke, the average being ⅝ inch. When the firing point is known, the crankshaft should be revolved to bring a piston to that position, and then, the spark control being advanced, the armature should be turned until the interrupter is just breaking, when the driving gear should be meshed. It is possible to make the setting by bringing a piston to the top of the stroke, and meshing the gear when the interrupter is breaking with the spark control retarded, but this gives no assurance that on advancing the spark the production of maximum current will coincide with the firing point. If this method is used, it will be necessary to make trials and to shift the gear one tooth at a time until the best operation is secured.

The automobile user who is familiar with the operation of the battery and coil system will find several points of difference in the use of a magneto system of either of these types. In starting the engine on the magneto, it is necessary to revolve the crankshaft at a much higher speed than is required for a battery, in order that the current may rise to an intensity that is sufficient for ignition, and to utilize it at its maximum the spark control must be advanced to a point that would be dangerous with a battery. At the slow speed attained by cranking, the current will be sufficient for ignition only as the armature moves out of the position of Fig. 3, and the interrupter must break at that point. At high speeds the current at its maximum will be more intense than is actually necessary, and will not drop below the point at which it can give ignition until the armature reaches the position of Fig. 4. The interrupter may therefore operate at any point within this range, its time of breaking being controlled by moving the housing to alter the instant at which the cam touches the lever.

A feature of the U. & H. magneto is that it will give an ignition current with slow rotation of the crankshaft. The magneto driving gear is not applied to the armature shaft, but to a stub shaft in line with it, the two being connected through a ball clutch and helical spring. On cranking the engine the ball clutch prevents the rotation of the armature, and tension is put on the spring. The spring is wound up as a piston nears the top of its stroke, and at the instant of ignition the clutch releases and the unwinding of the spring drives the armature at high speed across the point of maximum magnetic change. When the engine takes up its operation, centrifugal force holds the ball clutch out of engagement, and the magneto drives in the usual manner.

The plugs made for battery and coil systems are unsatisfactory for magneto ignition, for the high amperage rapidly burns their slender points. Plugs with heavy electrodes should be used; and while the gap may be as wide as 1/32 inch, better results will be attained if it does not exceed 1/64 inch. The widening of the gap from burning will introduce resistance that is too high to be overcome, and an interruption of the circuit from this cause will be indicated by sparking at the safety spark gap.

The most important point in the care of a magneto is its lubrication. It is usual to provide the oil cups with overflows to prevent an accumulation of oil that might work its way into the armature, and the lubricant is conducted to the bearings by wick feeds. These oil cups should never be permitted to run dry, for the clearance is so small that a worn bearing will permit the armature to strike the pole pieces.

The interrupter and distributer covers should be tight to prevent the entrance of dust, but should these parts become fouled they must be wiped off with a rag and a little gasoline. Where carbon brushes are used, as in the distributer, the carbon dust that will collect must be removed, or it will tend to cause a short circuit.

The most reliable and satisfactory ignition for automobile engines is obtained through the use of magnetos, but their full benefits are realized only when they are kept clean and properly lubricated. Attempts to improve them by altering adjustments or making changes will only result in dissatisfaction, and the maker may be relied upon to have worked out the details and made the settings with a knowledge based on deeper study and wider experience than is possessed by the average automobilist.

OUR LEGION TIRES AND THEIR TROUBLES.

(*Concluded from page 47.*)

as much as a new tire would cost. Such protectors add to the thickness and consequently to the heating of a tire. There is also bound to be more or less friction between the outer covering and the tire. If the outer covering is of the right size and is properly adjusted, this friction is not excessive. Such a protector, however, frequently stretches if it is not put on sufficiently tight, and very great wear takes place between it and the tire. Another form of tire cover consists of what is really a chain armor (Fig. 11). These covers are held on in a variety of ways, very much the same as leather and fabric and rubber tire protectors. They are very heavy, and to be durable they must be made of hardened steel. They rust badly, and most forms of them wear between the links, so that they soon become loose, for which reason it is necessary to take out a row of links in order to tighten them up.

Another method of seeking to avoid trouble is to provide self-heating materials designed to close a puncture. Gummy, sticky substances of various kinds placed in a leaky tire frequently cause it to hold air temporarily, but the usual experience is that the tire holds air only when it is comparatively cool, and that as soon as the tire heats up in running, the material becomes more soft, and air escapes. In addition, these compounds usually have a bad effect on rubber and fabric, and a tire which has been thus "doped" is soon completely worthless, for the reason that the materials usually make it impossible to vulcanize and repair the tire. Various forms of self-healing inner tubes have been devised. Sometimes the thickness and softness of the rubber is employed (Fig. 12), sometimes a plastic material and fibers, and sometimes by the introduction of fabric in the construction of the inner tube. Other inventors have constructed two, three, and sometimes four inner tubes inside of one another with valves, so that when one tube is punctured another can be immediately inflated without removing the tire or inner tube.

None of these devices solves the problem satisfactorily, and many are failures. Automobilists of the widest experience usually agree that the best and cheapest form of pneumatic tire is the ordinary plain round-tread clincher tire and inner tube on the regular one-piece clincher rim.

Solid tires are used almost exclusively on comparatively slow-moving business vehicles. Many people think solid tires never cause any trouble; but in this they are mistaken, for solid tires also are subject to many ills. They are, on the whole, much more dependable than a pneumatic tire, but a cut in a solid tire is apt very soon to pound itself into a great flat place that destroys the tire. Perhaps the greatest difficulty with solid tires is found in attaching them to the wheel. Fabric bases with cross wires, diagonal wires, and wires running lengthwise are employed. Solid tires are sometimes put on by hydraulic pressure, and other forms are held on by flanges bolted up on either side. Solid tires may be classified as plain, cushion, sectional, and special. Plain solid tires (Fig. 13) do not afford very much in the way of resiliency. They serve chiefly the purposes of being a silencing band, and of giving traction upon the roadway. Their width and thickness vary according to the loads they are designed to carry, and when used on heavy trucks or omnibuses, it is found more satisfactory to use two and sometimes three narrow tires side by side than one very wide single tire (Fig. 14). The plain solid tire is rolled continually between the wheel and the pavement, which rolling has a tendency to make the tire stretch and become longer, just as a piece of metal expands in a rolling mill. This lengthening or stretching of the tire causes particular difficulty in securing the tire firmly to the rim of the wheel.

Cushion tires are not manufactured for as heavy work as the plain solid tire, and are designed to give a greater degree of resiliency, an end which is attained by making the tire of a softer composition of rubber, and also by making the tire thicker in proportion to its width. Many special forms have been designed to increase the resiliency (Fig. 15). Sometimes there are holes through the tire parallel to the axle of the wheel (Fig. 16). Sometimes the tires are manufactured with holes in them in the direction of the spokes of the wheel (Fig. 17). All of these cushion tires depend for their resiliency upon the bending of the rubber. The resiliency is therefore limited considerably. If the tire is overloaded or is improperly designed, so that it bends too much, the tire not only consumes a great deal of power and is "slow," but there will soon be a destructive breaking down of the rubber, which will destroy the tire. At speeds of from twelve to eighteen miles per hour, cushion tires give satisfactory service if they are properly designed for the work they have to do, provided the vehicle is designed to stand a sufficient amount of vibration.

Sectional solid tires have been used with considerable success, particularly abroad, on the heaviest forms of trucks. Each tire is made up of small sectional segments shaped very much like bricks, one of the main advantages of this form of tire being that an injured segment can be readily renewed.

In the class of special solid tires may be included many forms of tire which are at the present time largely experimental. We may mention tires made up of wooden blocks, fiber blocks, and tires made up of sectional steel plates with a cushion of rubber beneath, as well as many other combinations. None of these have come into very general use.

In classifying tires as pneumatic, solid, and special, we place in the last classification filled tires, spring wheels, and wheels which have pneumatic hubs or pneumatic cushions within the circumference of the wheel. A tire filler is an elastic solid substance which takes the place of air in any form of penumatic tire (Fig. 19). The filling must be introduced into the tire under pressure in just the same manner as the tire is filled