SECTION SIX

APPLICATION OF MAGNETO IGNITION

BASIC REQUIREMENTS

The analysis of the ignition requirements of internal combustion engines made in Section Three deals with the problem from the theoretical viewpoint of the engine designer. In adapting a magneto ignition system to a specific engine many other factors must also be considered.

A general survey of standard magneto application practices as well as of certain outstanding special variations has been made in the following paragraphs. It should be noted that many important details of the construction of the magneto itself are often determined by the type of service in which it is to be used.

The extent to which facilities must be provided for field changes or adjustments also has a definite influence on application plans. There appears to be some trend recently toward limiting the amount of adjustment permitted on carefully engineered applications.

PRACTICAL CONSIDERATIONS

There is a definite tendency to build magnetos to comply with the adaptation specifications set up by the individual engine designers and manufacturers, and as a result there are thousands of variations in the field. Some effort has been made to standardize the mountings of magneto ignition units, but it appears that most of the factors which cause the variations are beyond arbitrary control.

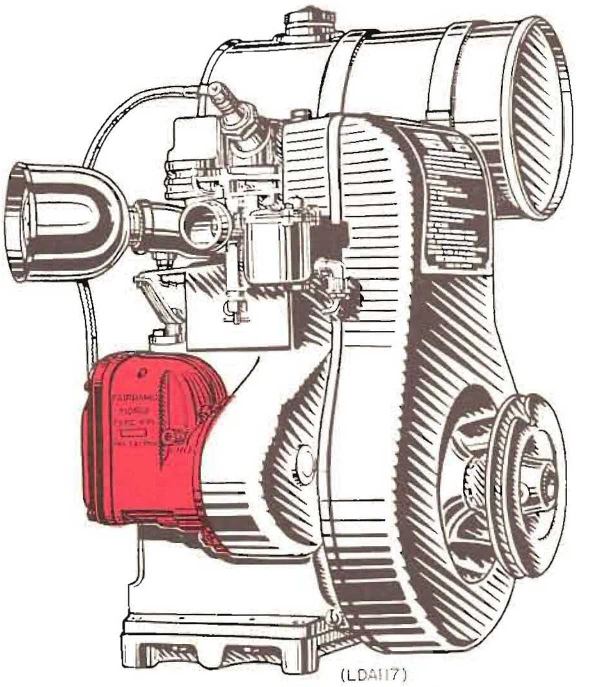

Figure 66—Single Cylinder Wisconsin Engine

A number of items enter into the specification of a magneto for application to an engine:

(a) The number of cylinders

(b) The spark interval between consecutively-firing cylinders

(c) The timing relation between starting and running ignition

(d) The speed and compression of the engine

(e) The magneto mounting

(f) The magneto drive arrangement

(g) The necessity of protection from oil, dust or moisture

(h) The necessity of radio-shielding

(i) Facilities for stopping the engine

It cannot be emphasized too strongly that best engine performance is obtained when the magneto is engineered for the particular installation, especially in its original application.

SINGLE CYLINDER ENGINES

The ignition unit required by a single cylinder engine (Figure 66), either two or four cycle, is relatively simple in construction since the high tension secondary circuit of the magneto can be connected directly to the spark plug terminal and the entire distribution system thereby eliminated. Magnetos for single cylinder engines are usually built with one lobe breaker cams, the magneto then producing only one ignition spark per complete revolution of its rotor. On two cycle engines such a magneto would have to be driven at crankshaft speed, while on a four cycle engine it could be driven at camshaft speed (½ crankshaft speed).

Arrangements are often made on four cycle engines, however, to drive the magneto at crankshaft speed, allowing alternate ignition sparks to occur during the exhaust strokes. In special slow speed engine applications magnetos with geared distributors have been used in order to obtain only one ignition spark per two revolutions of the magneto rotor (See Paragraph "Unequal Spark Intervals" Page 33). In such a case the magneto is driven twice engine speed in order to increase the strength of the ignition spark at normal speeds and also to provide the speed range necessary for satisfactory impulse coupling operation.

MULTI-CYLINDER ENGINES

A large proportion of the internal combustion engines built have more than a single cylinder, the usual combinations being two, four or six cylinders. In effect a multi-cylinder engine smooths out operation, for while

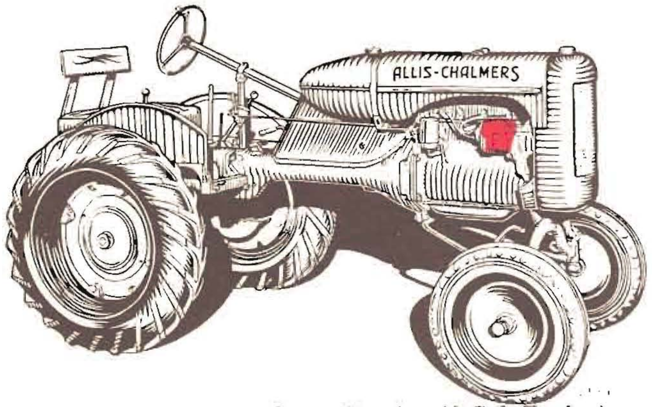

Figure 67—Allis-Chalmers Tractor (4 Cyl. Engine)

power is being supplied to the crankshaft by one of the pistons, others are going through different parts of the engine cycle. As the result a four cylinder engine, for example, with a 180° firing interval (Figure 67) has two complete power strokes during each revolution of its crankshaft. Various designs of multi-cylinder engines have different firing orders for the cylinders, as well as different crankshaft arrangements.

To supply ignition to a multi-cylinder engine a magneto with a distributor must be used, such an assembly usually consisting of a rotating electrode which contacts leads to each of the spark plugs in the proper sequence and at the correct intervals.

MAGNETO SPARK INTERVAL

The spark interval of a magneto refers to the angular degrees rotation of the magneto drive shaft between the production of consecutive ignition sparks, and covers a complete cycle of operation of the magneto.

The required spark interval is established by the engine on which the magneto is to be installed. The minimum angular degrees of crankshaft rotation between any two consecutively firing cylinders divided by the ratio of magneto speed to engine speed determines the minimum spark interval which must be obtained.

A two-pole magneto of conventional design with a two-lobe breaker cam produces two equally spaced ignition sparks per complete revolution of the magnetic rotor; the spark interval is therefore 180° (Figure 68). If alternate sparks are grounded out, the spark interval becomes 360°.

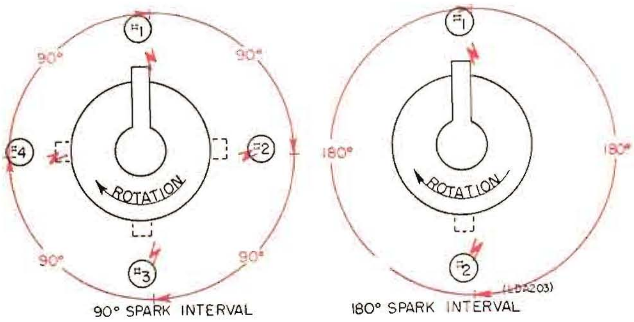

Figure 68—Diagrams of Spark Interval

A four-pole magneto of conventional design with a four-lobe breaker cam produces four equally spaced ignition sparks per complete revolution of the magnetic rotor; the spark interval is therefore 90° (Figure 68).

The spark interval of a magneto depends upon the number of poles of the magnetic rotor and the number of lobes on the breaker arm cam.

UNEQUAL SPARK INTERVALS

As an inherent characteristic of rotary magnetos, ignition sparks are produced at regular intervals. In many applications all of these ignition sparks are not needed and it is common practice to allow the spark plugs to fire during the exhaust strokes. In some cases, however, this means of disposing of unused ignition sparks is not desirable, and a special grounding device must be built into the distributor assembly. In Figure 69 a standard four cylinder unit firing each 180° has been converted

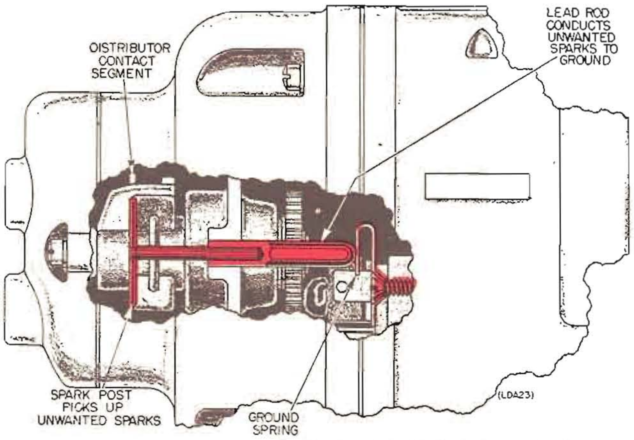

Figure 69—Ignition Spark Grounding Device

into a two cylinder unit with a spark interval of 180°—540° by a grounding device, which conducts the ignition sparks from two consecutive distributor posts to the ground connection. A similar arrangement (three distributor posts grounded out) could be used on the same magneto to obtain a one cylinder unit firing 720°.

BREAKER CAM CONTOUR

An ignition spark is produced when the breaker contact points open the primary circuit at a point of maximum current. The breaker points are actuated mechanically in accordance with the path the breaker arm rubbing block follows on the breaker cam. The design of this cam must be carefully determined in order to provide the desired movement of the breaker arm throughout the speed range of the magneto. Since a slow break in the primary circuit results in arcing between the contact surfaces as well as reducing the rate of flux linkages occurring in the high tension coil, the lobes of the breaker cam must act quickly to provide a clean break in the primary circuit. This action must be secured without causing breaker arm chatter or undesirable vibration.

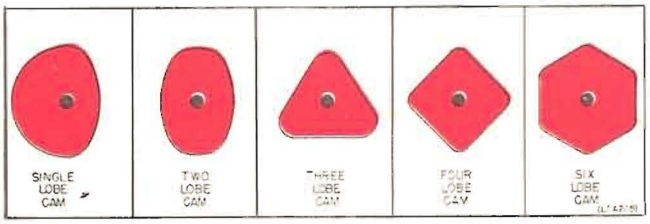

Figure 70—Commonly-Used Breaker Cam Contours

The number of times the contact points open per complete revolution of the breaker cam is determined by the number of lobes which the cam has. Commonly used breaker cams (Figure 70) have from one to six lobes depending upon the spark interval of the magneto and upon the ratio of the rotative speeds of the breaker cam and magnetic rotor.

MAGNETIC ROTOR POLES

Magnetic rotors are built with two or more poles, nearly all standard commercial magnetos being based on the two-pole design. While the number and size of the magnets in a rotor does not determine the number of poles, the arrangement of the magnets and the lamination assemblies is the decisive factor. The necessity of using a rotor with more than two poles arises primarily from consideration of the rotative speed of the magneto and the minimum spark interval required. The two-pole rotor produces an ignition spark each 180° of its rotation, while the four-pole rotor gives a 90° spark and the eight-pole rotor a 45° spark. The use of a geared-distributor in connection with doubling the rotative speed of the rotor gives the same results as doubling the number of poles of the rotor, but it is obvious that this method of reducing the spark interval is limited by the excessive rotative speeds required.

The simplified diagram of a two-pole magneto (Figure

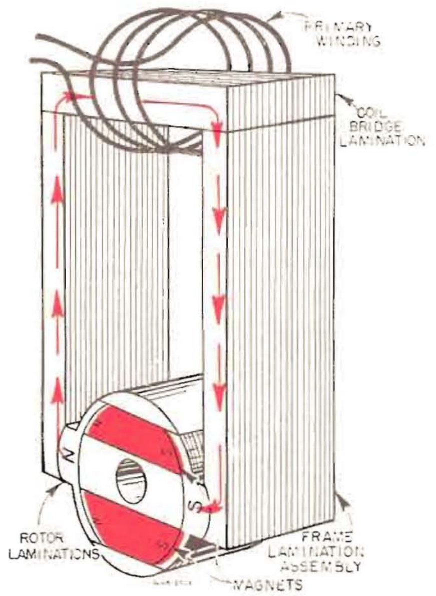

Figure 71—Magnetic Circuit of Two-Pole Magneto

71) illustrates a magnetic rotor with two bar magnets, set into the rotor with their magnetic axis at right angles to axis of rotation. This arrangement is completed by placing lamination assemblies across the like ends of the magnets, concentrating the magnetic flux within the limits of the desired type of pole piece. Since these pole pieces are 180° apart and of opposite polarity, rotation of the magnetic rotor causes two complete flux reversals in the magnetic circuit per revolution. Each complete reversal of flux provides the basis for the production of an ignition spark; two sparks spaced 180° can therefore be obtained per complete turn of the rotor.

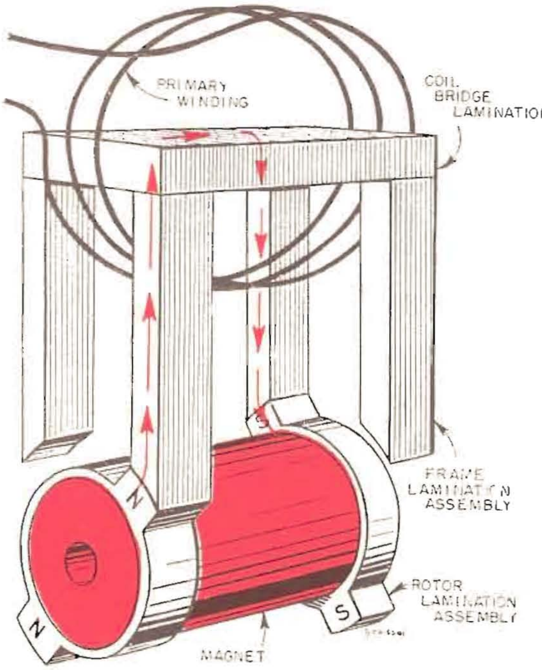

Figure 72—Magnetic Circuit of Four-Pole Magneto

The four-pole magneto shown similarly (Figure 72) is built with a magnetic rotor having a single cylindrical magnet, the ends of which are its poles. Over each end of this cylindrical magnet is placed a lamination assembly having projections each 180° of its circumference. The projections of the corresponding laminations at the ends of the magnet are turned 90° to each other and locked in place. The rotor operates in a frame having a four-legged field lamination assembly so placed that four complete reversals of the magnetic flux through the coil occur per revolution of the magnetic rotor. Consequently, four ignition sparks spaced 90° apart can be produced per complete turn of the rotor.

CARBON-BRUSH DISTRIBUTION

Since sliding contact is made by the carbon-brush distribution system, high voltage sparking is reduced to negligible proportions and it is possible to seal the distributor into the same housing as the magneto without danger of corrosion.

The two general types of carbon-brush distribution

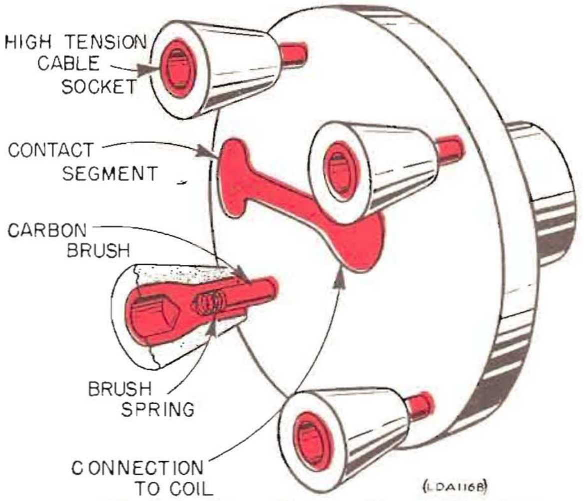

Figure 73—Disc Type Carbon-Brush Distributor

systems are the disc type and the drum type, according to the rotor used. The principle is identical and operation similar.

In the disc type distributor (Figure 73) the brushes track on a flat, revolving surface made of insulating material into which a contact segment has been imbedded The contact segment extends from the center of the disc, where contact is made to the secondary lead of the coil. to the outer edge of the disc, where contact is made during rotation with each of the brushes leading to the individual spark plug cables.

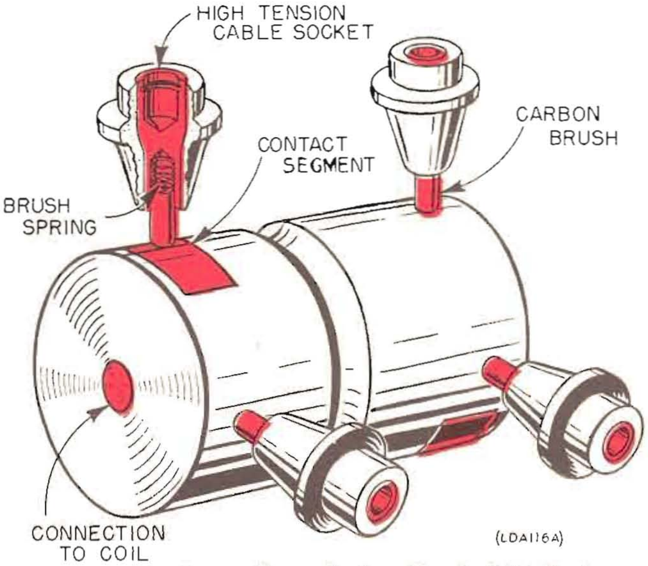

Figure 74—Drum Type Carbon-Brush Distributor

In the drum type distributor (Figure 74) the brushes track on a revolving cylinder made of insulating material into which one or more contact segments have been imbedded. Each contact segment is connected within the cylinder to a central point from which connection is made with the secondary terminal of the coil. The drum-type distributor makes it possible by alternate placing of brushes to extend the separation of consecutively firing contact positions.

JUMP-SPARK DISTRIBUTION

In the jump-spark system of distribution (Figure 75) the contact segment of the distributor passes very close to each contact post, although no actual contact is made. The distributor rotor is so timed to the magneto that its electrode approaches each spark post at the exact instant secondary voltage reaches a maximum; this voltage is sufficient to break down the resistance of the distributor air gap as well as the spark plug point gap. Since the distributor gap is subject only to atmospheric pressure, its resistance in comparison with the point gap is small and very little additional secondary voltage is required.

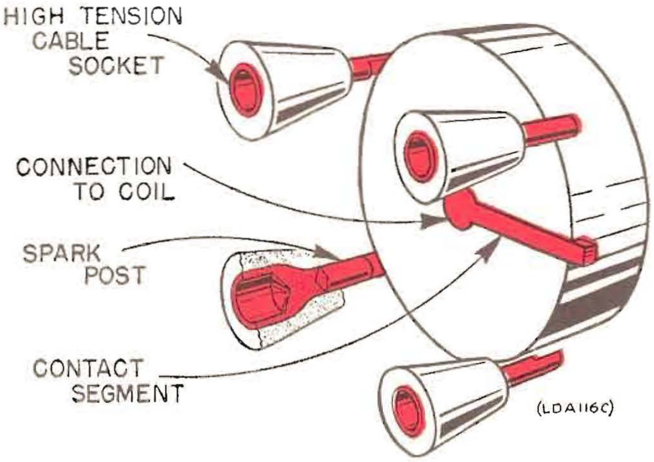

Figure 75—Jump-Spark Distributor

The action of the jump-spark distributor system functions to some extent in preventing pre-ignition due to fouled spark plugs. The additional air gap in the secondary circuit forces the secondary voltage to build up until it reaches a value great enough to break down the combined resistance of the two gaps. Under such circumstances there is less chance that leakage current at the plugs will be sufficient to interfere with normal ignition.

Jump-spark distributors must be operated in a ventilated housing since an active oxidizing agent (ozone) is formed as a result of the sparking across the distributor gaps.

SEALED AND VENTILATED UNITS

Magnetos completely sealed against the entry of dust and moisture are used to advantage in many sections of the country and in many different types of service. Built with carbon-brush distributors, such units provide highly dependable ignition over long periods and require a minimum amount of attention.

Under certain operating conditions improved performance can be obtained from the ventilated design magneto, especially in localities where there is little possibility of the entry of dust or moisture. Ventilation appears to be of considerable advantage in cases where the magneto is subject to excessive engine heat during operation, together with the resultant possibility of condensation when cooling occurs.

Jump-spark systems of distribution necessitate ventilation, since the electro-chemical reactions of the open spark result in the formation of ozone, which in turn is an active oxidizing agent. Some designs of jump-spark magnetos, such as the Fairbanks Morse Types FM-J4 and FM-R, separate the distributor assembly from the magneto proper, thereby permitting adequate ventilation of the distributor compartment, while still maintaining the dust and moisture-proof sealing of the remainder of the magneto.

The problem of recommending a sealed or ventilated magneto for a specific application is a difficult one because it depends to such an extent upon the actual operating conditions encountered in the field. As a result the decision can usually best be made by the experienced operator or serviceman.

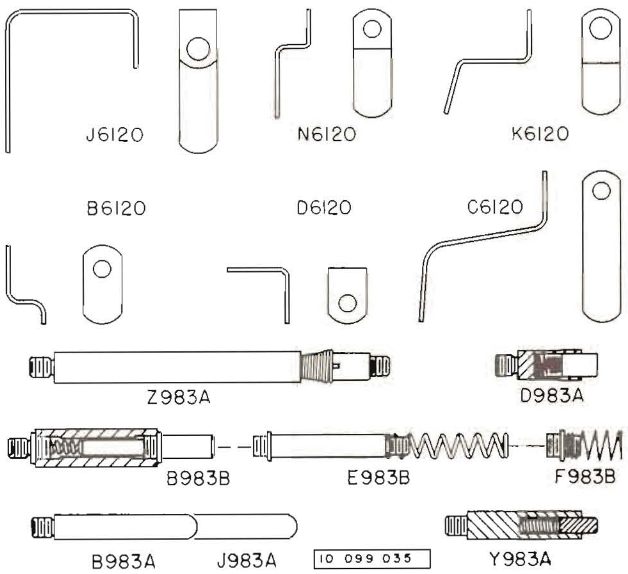

Figure 76—Coil Clips and Lead Rods

COIL CLIPS AND LEAD RODS

The development of the entirely new encapsulated molded high tension coil of epoxy compound has altered somewhat the manner in which the high tension voltage from the coil is transmitted to the distributor rotor or disc and on to the high tension outlets.

Application of this new type of coil to the various magnetos in the field and to the new units being developed has evolved a variety of coil clips, Fig. 76 which are attached to the coil by means of a flat head screw or coil clip button.

Similarly a variety of lead rods and lead rod assemblies have been developed to use in connection with the new coil clips.

Regardless of the combination of coil clips and lead rods used, the contact surfaces of these two parts must be smooth and tight at all times to prevent high voltage arcing at this point which would result in damage to all component parts.

This precaution is also necessary to protect the windings of the coil, since an interruption of the circuit might cause a secondary circuit discharge from the windings of the coil thru its insulation to the ground thus damaging the coil windings beyond use.

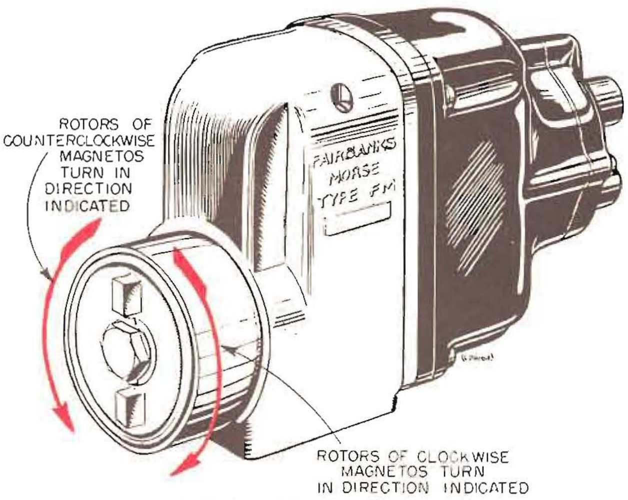

Figure 77—Rotation Diagram

ROTATION OF MAGNETO

The rotation of a magneto is indicated by the direction in which the rotor turns when viewing the unit from the drive end (that is, from the end which is mechanically-coupled to the engine). Magnetos are built for either clockwise (righthand) or counter-clockwise (lefthand) rotation (Figure 77).

The rotation of a magneto fitted with an impulse coupling can usually be ascertained by turning the coupling by hand; the coupling pawls engage the stop pin when the magneto rotor is turned in its proper direction.

Changeover of rotation of many service models of magnetos is not a difficult operation, usually consisting only in changing the impulse coupling, the breaker points and breaker point mounting plate.

MAGNETO MOUNTINGS

Magnetos must be mounted rigidly on engines in order that accurately-timed, positive drive arrangements can be used. A number of entirely different types of mountings have been widely used, special adaptations by individual engine manufacturers resulting in hundreds of variations of the basic designs.

Until recent years all magnetos were of the base mounting design. To provide for this type of mounting engines were built with a small platform bracket on the side of the cylinder block to which the magneto could be fastened. Commonly used base mounting magnetos have either a 35 millimeter (Figure 78) or 45 millimeter (Figure 79) shaft height, this distance being measured from the level of the mounting surface to the centerline of the magneto rotor shaft. An adjustable, flexible coupling is generally used to connect the engine drive shaft to the magneto.

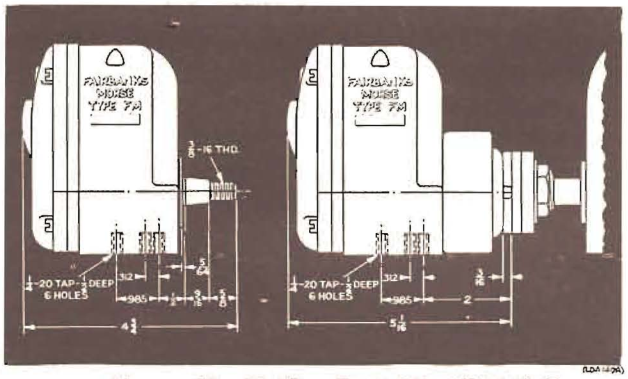

Figure 78—35 Mm. Base Mounting Unit

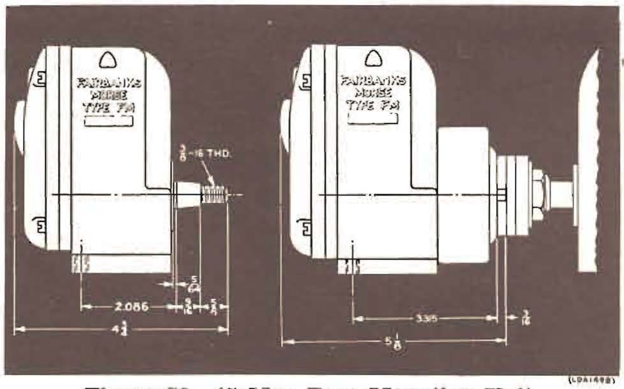

Figure 79—45 Mm. Base Mounting Unit

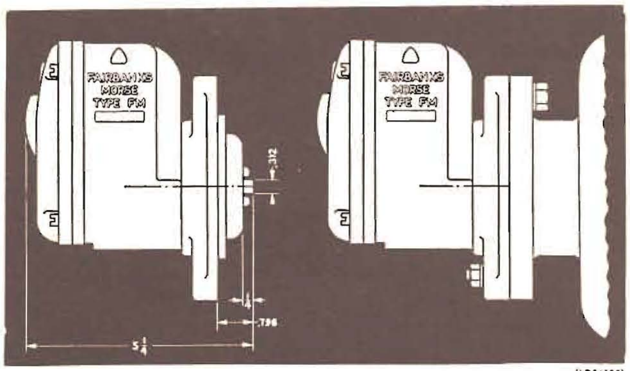

Figure 80—Flange Mounting Unit

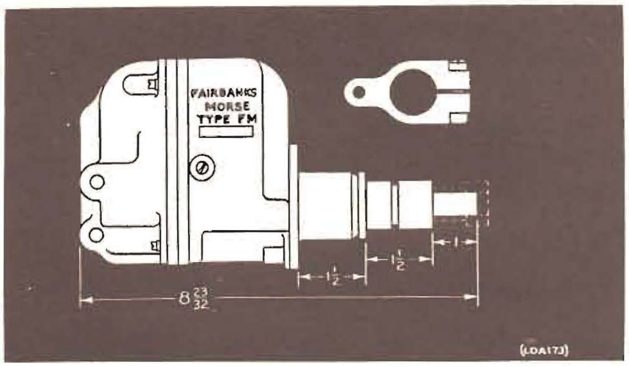

Figure 81—Vertical Mounting Unit

The flange type magneto (Figure 80) has been introduced as an improved method of mounting, being especially adapted to tractor and power unit engines. The flange of the magneto fits directly to a mating flange on the governor housing or crankcase of the engine, thereby enclosing the entire magneto drive assembly within a dust and moisture-proof housing. The machined fit of the mounting flange eliminates the necessity of a flexible coupling and simplifies timing the magneto to the engine.

Some tendency toward a vertical mounting for magnetos has lately become apparent, especially in applications where engine manufacturers desire to offer as optional equipment either battery or magneto ignition. The vertical design mounting (Figure 81) is sometimes referred to as a distributor mounting, since it replaces the complete distributor assembly used on the standard battery ignition engine.

ROTARY DRIVE ARRANGEMENTS

Since a magneto must be precisely timed to an engine in order to furnish ignition sparks exactly in accordance with the sequence of engine operations, provision must be made for a positive drive arrangement. Furthermore, in some instances, it is desirable to provide some means of adjusting the timing of the running spark to compensate for unusual operating conditions.

Rotary magnetos are driven either by a gear train from the crankshaft or camshaft, or directly off the end of the camshaft or crankshaft. The spark interval of the engine is usually the decisive factor in determining the ratio of the rotative speed of the magneto to that of the engine. In cases where the magneto must operate at engine speed, it is driven from the crankshaft; while if it need turn at only half crankshaft speed, it is driven from the camshaft.

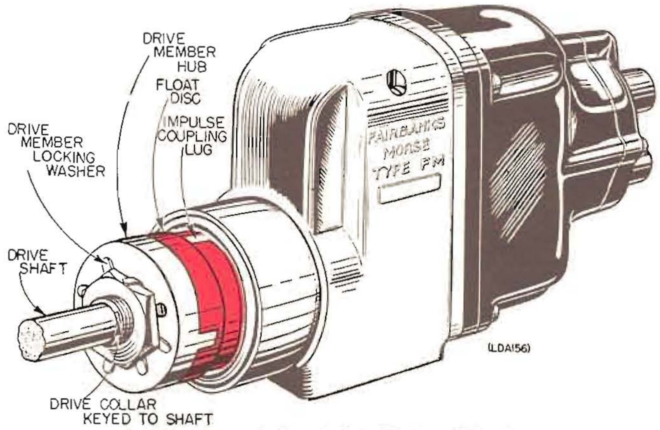

Figure 82—Adjustable Drive Member

Base mounting magnetos are usually connected to the engine drive shaft by means of an adjustable drive member (Figure 82), which also serves as a flexible coupling. The drive member consists of a drive collar which is keyed to the engine drive shaft, a hub with drive lugs to engage the float disc which in turn engages the impulse coupling lugs of the magneto, and a nut and lockwasher for locking the assembly. Since the relative position of the drive member hub and drive member collar can be changed as desired, the assembly permits full adjustment of the magneto spark to meet engine requirements.

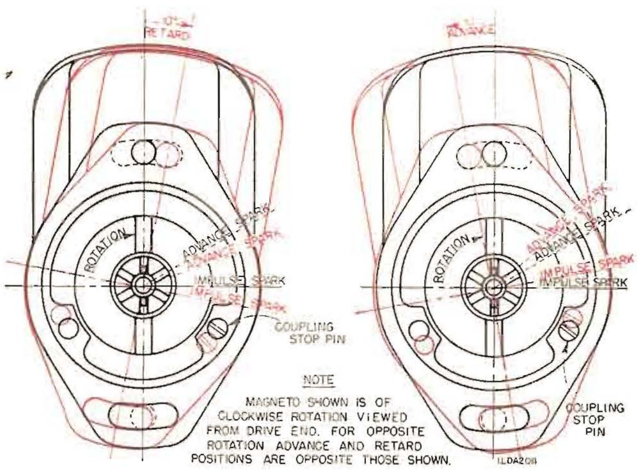

Figure 83—Turning Flange Magneto to Change Spark

The amount of adjustment of the ignition spark of a flange mounted magneto is limited to the extent the magneto can be turned in its mounting. Special slots in the flanges usually provide the possibility of advancing or retarding the spark about 10° (Figure 83). The adjustment can be easily accomplished by loosening the mounting bolts and turning the entire magneto assembly to the desired position, then tightening down the mounting bolts.

FLYWHEEL MAGNETOS

A number of manufacturers of small internal combustion engines, notably in the washing machine engine, garden tractor and outboard motor fields, build the magneto into the flywheel of the engine. The basic magneto assembly, however, is usually purchased from an independent magneto manufacturer. While most widely used on single cylinder engines, flywheel type magnetos have also been adapted to two and four cylinder engines.

The construction of the flywheel magneto depends to a large extent upon the individual engine design, but the theory of operation is identical to that of the rotary magneto. Many of the same developments which have influenced the design of rotary magnetos have been equally effective in respect to flywheel magnetos, and much of the descriptive material covering the self-contained units can also be applied to the flywheel magneto.

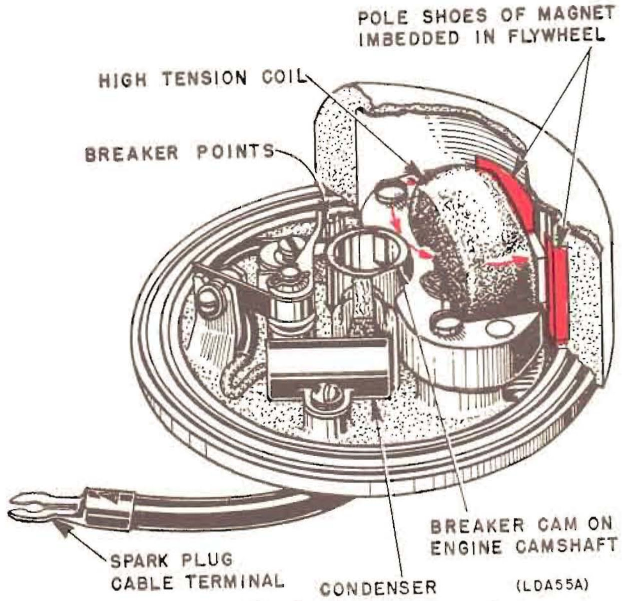

Figure 84—Flywheel Type Magneto

In the typical flywheel magneto (Figure 84) the magnet is located in the outer rim of the flywheel, which revolves around the stationary coil, condenser and breaker point assembly. As the ends of the magnet pass by the pole pieces, an alternating magnetic flux is established through the coil and primary current is generated as long as the contact points remain closed. These points are opened by the cam located on the crankshaft at the instant maximum primary current is obtained, causing the complete collapse of the primary field within the coil and inducing a very high secondary voltage. An ignition spark occurs across the points of the spark plug when the induced secondary voltage becomes sufficiently great to bridge the point gap.

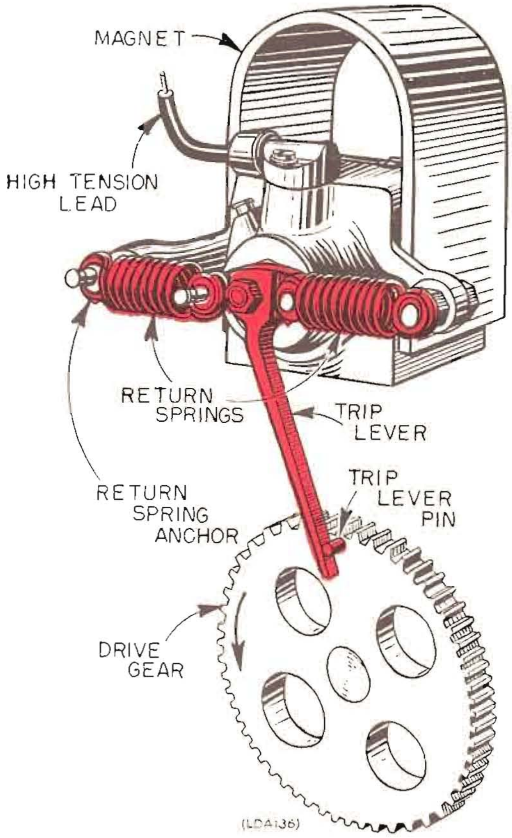

Figure 85—Oscillator Drive Magneto

OSCILLATOR MAGNETOS

Oscillator design magnetos were developed specifically for slow speed, single cylinder engines and differ from conventional magnetos chiefly in the drive arrangement. The construction of the oscillator magneto proper is identical, or nearly so, with that of a standard rotary magneto and can be of the shuttle-wound armature type, inductor type or rotating magnet type.

The important difference in the action of the oscillator magneto is that the rotor is rocked rather than turned. The action can be classed as a form of impulsing, since the engine drive gear (Figure 85) engages the magneto trip lever once each revolution and, as movement continues, extends the springs which establish the normal position of the rotor. When the trip lever is released by the drive gear, these springs act instantly to pull the lever and the rotor back into their normal position. Since this quick rocking of the rotor is designed to occur across the point at which maximum change of magnetic flux takes place, maximum primary current is induced. Simultaneously the cam functions to open the contact points and break the primary circuit, causing a very high voltage to be induced in the secondary winding, which furnishes the ignition spark in completing its circuit to ground.

The use of oscillator magnetos is limited to slow speed engines, because of the mechanical lag in the tripping device. This mechanical lag must also be accounted for in timing the magneto to the engine.

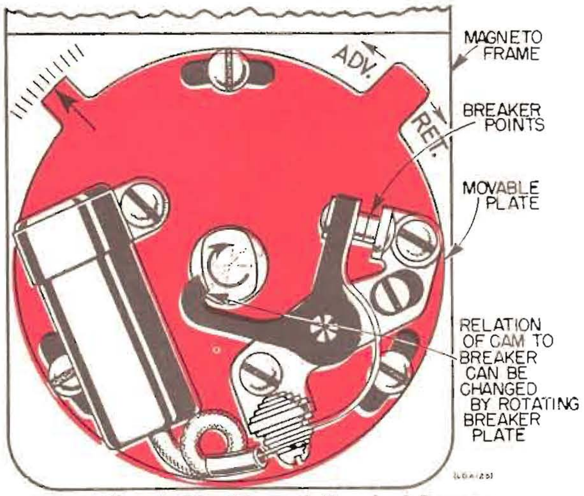

Figure 86—Manual Spark Advance

MANUAL SPARK ADVANCE

Since a magneto produces an ignition spark at the instant its breaker points open, it is reasonable to assume that the time-relation of the ignition spark to the engine cycle can be controlled to some extent by shifting the point at which the breaker contacts begin to open.

To illustrate this principle a simple, movable breaker point mounting plate, concentric with the breaker cam, is shown in Figure 86. Turning the plate so that the points would open before the optimum position is reached would produce a spark earlier in the engine cycle and is commonly referred to as "advancing" the ignition spark, while turning the plate in the opposite direction produces a spark later in the engine cycle and is known as "retarding" the spark.

The amount of advance or retard which can be actually obtained by this method is definitely limited since the strength of the ignition spark falls rapidly as the points open farther away from the point of maximum primary current.

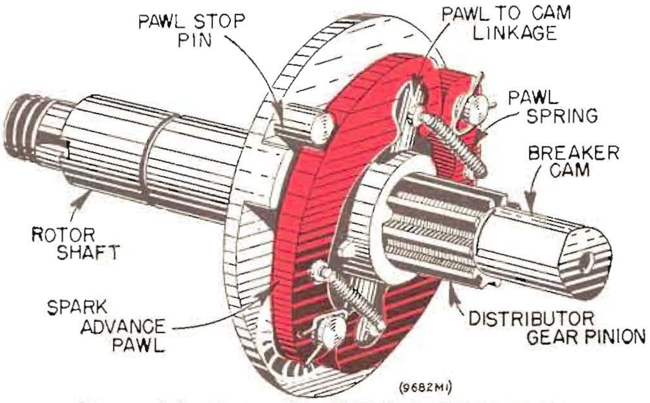

Figure 87—Automatic Spark Advance Rotor

AUTOMATIC SPARK ADVANCE

In certain applications the necessity arises for automatically advancing the ignition spark as the rotative speed of the engine increases. This can be accomplished by using a centrifugally controlled spark advance rotor.

The automatic spark advance rotor (Figure 87) depends upon two spring-loaded pawls for its action. These pawls, which are held close to the center of the rotor at low speeds (Figure 88 "a"), swing gradually outwards as the speed increases (Figure 88 "c") until the pawl stop is reached.

The outward movement of the pawls is transferred by a mechanical linkage to the breaker cam shaft with the result that the cam changes its relative position in re-

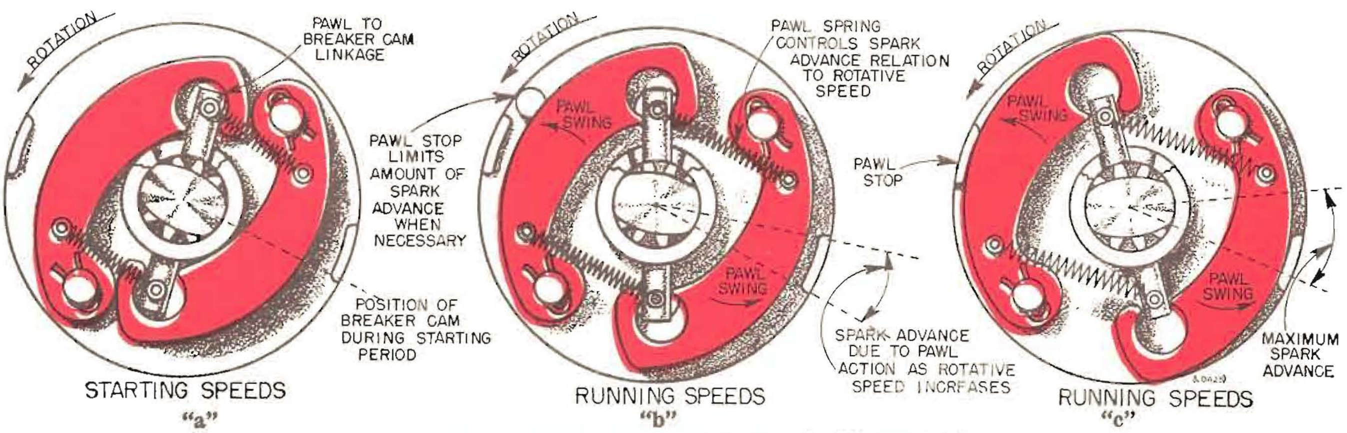

Figure 88—Operation of Automatic Spark Advance Rotor

spect to the drive shaft. Since the shift in the cam to shaft relation as the engine speed increases causes the breaker points to open earlier in the engine cycle, the ignition spark is said to be advanced.

CONTROLLING IGNITION SPARK ADVANCE

The maximum amount of spark advance which can be obtained with a rotor of this type is controlled by the position of the pawl stop which is located on the outer circumference of the rotor. Smaller advances are secured by stopping the pawl movement before it reaches the outer circumference stop (Figure 88 "b"). It is also possible through the selection of proper pawl springs to predetermine the speed at which maximum spark advance will be obtained and also the amount of spark advance obtained per unit increase in rotative speed.

IGNITION SYSTEM WIRING

The efficiency of any ignition system can be immeasurably reduced by poor or inadequate wiring. In both original applications and service work care should be taken to be certain that suitable ignition cables and terminals are used.

The absolute necessities of a suitable wiring harness are high tension cables of sufficient capacity and with proper insulation; clean, tight electrical contacts and terminals adapted to their specific use, and soldered joints. Often overlooked is the low voltage cable (primary ground cable on magnetos); the same care should be given its condition as is given other parts of the system.

A clean, neat arrangement of the high tension cables is of great value in securing top-notch performance. If possible, long ignition cables should be avoided because of the inductance effect involved. Cables should not, however, be so shortened that contact is made with the engine head or block.

Theoretically, high voltage currents travel on the surface of a conductor in what is known as "skin-effect." In practice this accounts for the use of cables of finely-

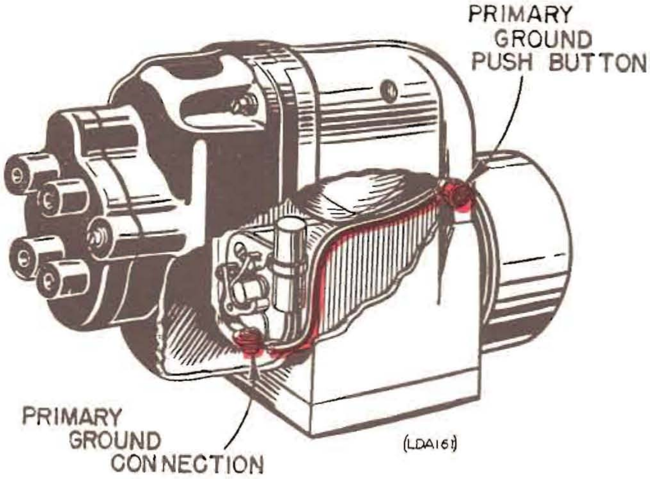

Figure 89—Self-Mounted Primary Ground Switch

stranded wire because of the increased surface thus obtained, as well as the flexibility. Recent experimental results indicate the desirability of stainless steel ignition cables for certain applications. Because of the greater strength of the stainless steel wire, the individual strands can be reduced in cross-section and the effective surface thereby increased. If the effective surface is kept constant, the number of strands can be reduced with a noticeable reduction in the capacitance effects of the cable.

PRIMARY GROUND SWITCHES

Engines are stopped either by closing off the fuel supply to the carburetor or by cutting or grounding the ignition circuit.

The disadvantages of closing off the fuel supply are that an immediate engine stop is not secured and that restarting of the engine is sometimes difficult since the carburetor must completely empty itself before the engine stops, the final intake charge of each cylinder being plain air. In some cases, however, where distillate is used as fuel, it is considered desirable that the engine be stopped by burning out the fuel in the carburetor and cylinders.

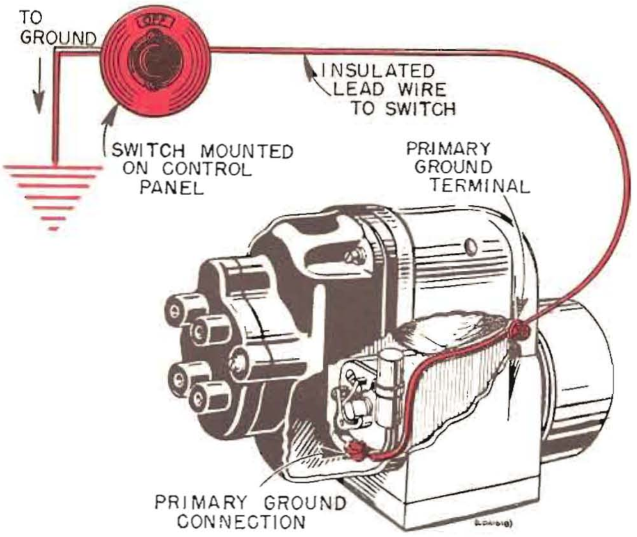

Figure 90—Remote-Mounted Primary Ground Switch

Battery ignition circuits are opened for engine stopping, while magneto ignition circuits must be grounded. The switches must be located in the primary circuit of either type, but their action is instantaneous and the engine fuel system is left ready for re-starting.

There are many types of primary ground switches, but in general they may be divided into two groups: (a) those located directly on the unit and (b) those located some distance away, as for example, on the engine control panel.

On a self-mounted ground switch (Figure 89) a wire is run from the primary terminal of the coil to a spring switch on the metal frame; so arranged that when the switch is actuated the primary circuit is grounded out and no high voltage sparks are produced. On a remote-mounted switch (Figure 90) the same wire from the primary terminal of the coil is extended to the control panel, usually through an intermediate terminal mounted on the magneto.

It should be noted that, in stopping an engine by grounding the ignition circuit, the switch must be held closed until the engine is motionless.

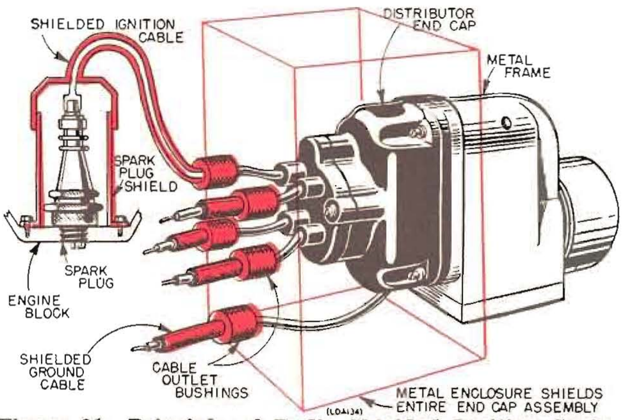

Figure 91—Principle of Radio-Shielded Ignition System

RADIO-SHIELDED IGNITION SYSTEM

The high voltage spark discharge which provides ignition for the engine is an oscillatory surge of electricity and as such causes considerable interference in nearby radio receivers, especially those operating on high frequency bands. In many cases it is therefore necessary or desirable that this interference be eliminated at its source. There is a definite trend toward radio-shielding the ignition systems of all engine-driven light plants and power units.

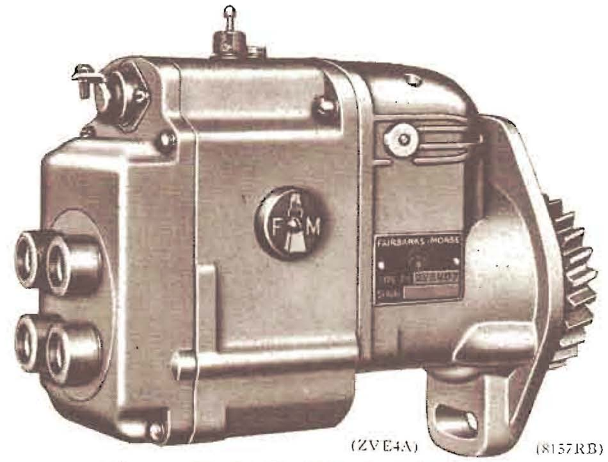

Figure 92—Radio-Shielded Magneto

The principle on which ignition systems are radio-shielded is shown in Figure 91. A metal cover has been so arranged as to completely enclose the plastic end cap, metal sheaths encase the ignition cables and the spark plugs are mounted within metal housings. All of this exterior metal housing is interconnected and grounded and functions as a shield, since it absorbs the interference-causing waves.

In practice a metal cover such as that shown is not used, but the entire end cap of the magneto is made of metal with a plastic distributor block mounted on the inside (Figure 92). Lead gaskets are used to seal joints between the metal housings of the unit. All cables are enclosed in metal sheaths, the ground or switch cable must be shielded as well as the high tension cables. While standard spark plugs mounted in metal enclosures are used in some applications, spark plug manufacturers have developed a special type of spark plug which has an all-metal exterior.

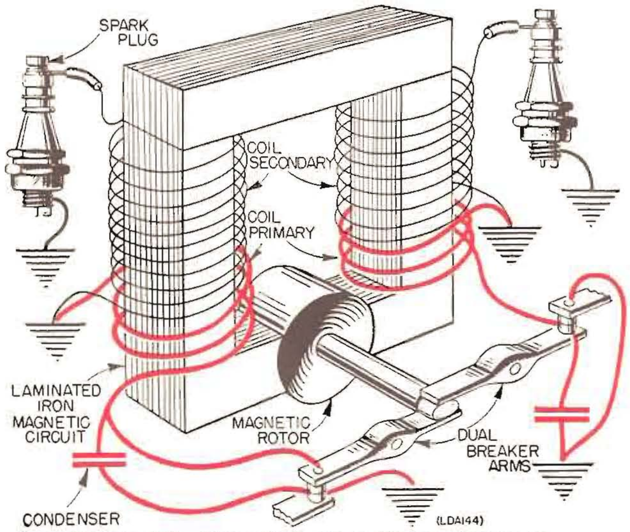

Figure 93—Two-Coil, Two-Spark Magneto

TWO-SPARK MAGNETOS

Occasionally engine designers try to increase the dependability or performance of the ignition system by locating two spark plugs in each cylinder head instead of the customary one. In cases such as this two separate magnetos, timed to spark simultaneously, can be used, but more often a two-spark magneto is specified.

There are two general types of two-spark magnetos. In the first system (Figure 93) two separate coils, con-

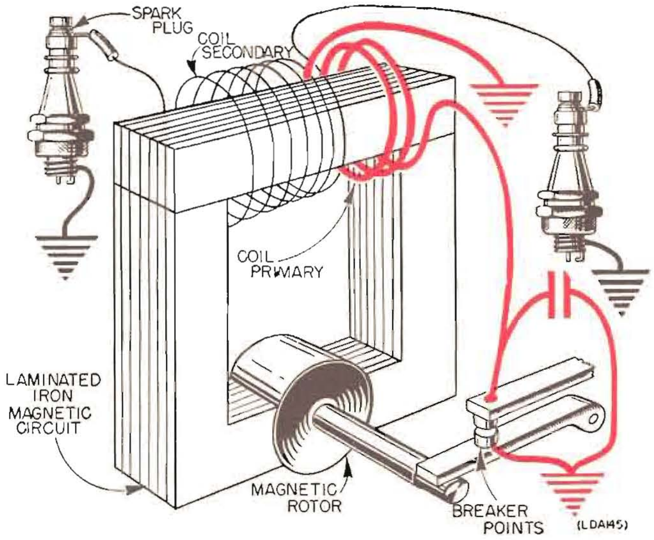

Figure 94—Single Coil, Two-Spark Magneto

densers and breaker point sets are super-imposed upon the same magnetic circuit. Since the same magnetic break produces maximum primary current in each of the coils, the breaker point sets can be so synchronized that two simultaneous ignition spark discharges are obtained. In the second method (Figure 94) only a single coil, condenser and breaker point set are used, the important variation being the fact that each end of the secondary winding of the coil is brought out to a spark plug terminal. To complete the secondary circuit the ignition spark must bridge both spark plug point gaps.

In the event of application of a two-spark magneto to a multi-cylinder engine, two complete and separate distributor systems are required.

DUAL IGNITION

A number of ignition systems can be classified as dual ignition, as, for example, either of the two-spark magneto arrangements described above.

It seems advisable in most respects, however, to think of dual ignition systems as systems which are made up of two complete sets of ignition apparatus. Often such an arrangement is comprised of a complete battery ignition system and a complete magneto ignition system, installed in such manner as to provide the engine operator the possibility of switching from one to the other. Many dual ignition systems, especially on aircraft engines, use two identical magneto ignition units.

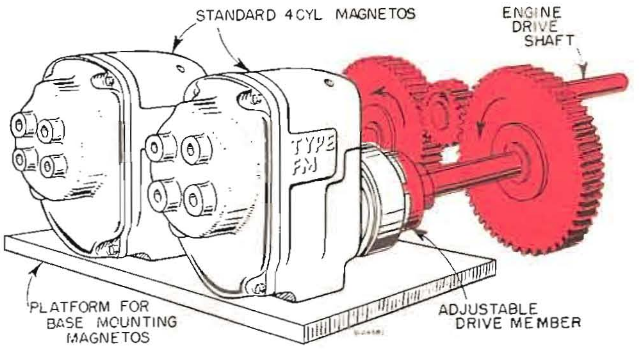

Figure 95—Multiple Installation for 8 Cyl. Engine

EIGHT & TWELVE CYLINDER UNITS

The use of spark-ignition engines of more than six cylinders is uncommon in the tractor and power engine field and most installations encountered are likely to be special adaptations. Magnetos specially built for these installations can be obtained, but because of their infrequent use and increased mechanical intricacy, their cost is relatively high and service facilities limited.

Multiple installations of standard four and six cylinder magnetos have certain advantages, chiefly in their universal service and replacement. An eight cylinder engine is fitted with two four cylinder units, while a twelve cylinder engine requires two six cylinder magnetos. In such installations the two units are interlocked with a gear drive (Figure 95) which permits flexibility in timing.

USE OF MAGNETOS

Even men who work with magnetos and magneto service are likely to overlook part of the tremendous field in which magnetos are used. From the tiny single cylinder gasoline engines used with generators, pumps or washing machines to the huge, multi-cylinder engines of the modern bombers and airline transports, the magneto serves its vital purpose of supplying engine ignition.

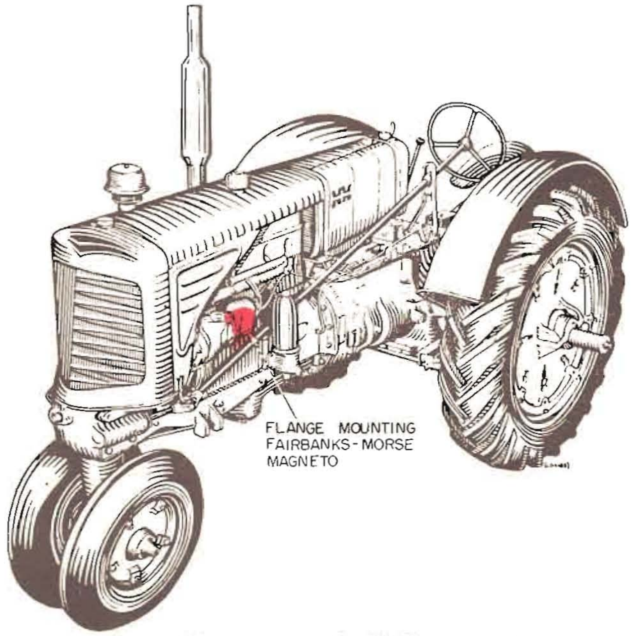

Figure 96—Minneapolis-Moline Tractor

A partial list of the applications of engines equipped with magneto ignition is as follows:

Tractors	Oil Burners	Outboard Motors
Combines	Gas Burners	Washing Machines
Trucks	Cement Mixers	Air Compressor Units
Buses	Pumping Units	Generating Sets
Hoists	Portable Saws	Airplane Engines
Power Units	Marine Engines	Natural Gas Engines

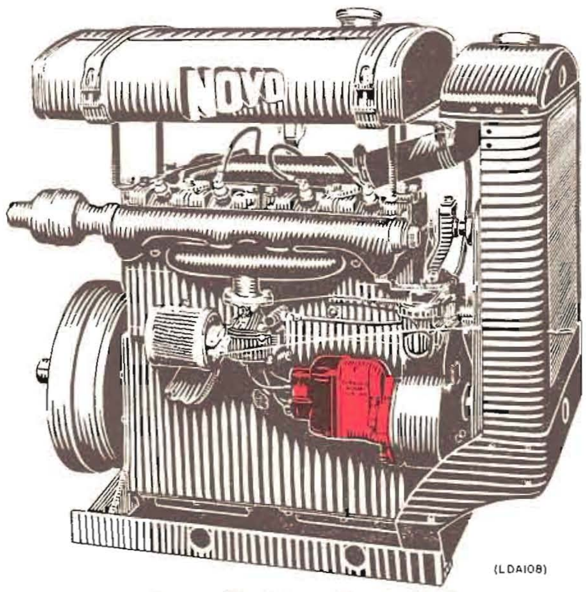

Figure 97—Novo Power Unit