# INSTRUCTION No. 16

## LUBRICATION: Purpose of Lubrication; Engine Lubrication Systems; Oil Gauges; Oil Pumps; Oil Purifying Devices; Correct Lubrication of Engine; Oil Specifications; Correct Use of Oils; Engine Lubrication Troubles; Relation of Carbon to Lubricating Oil; Lubrication of Transmission, Rear Axle (Differential), Clutch, Wheels, and Chassis

### EXAMPLES OF SOME OF THE EARLY ENGINE LUBRICATION SYSTEMS

**Note: The illustrations below are not intended to exemplify the latest approved engine lubrication methods.** In order that the reader may clearly understand the advantages of the modern engine lubrication systems, it is necessary that he understand the early systems. Furthermore, he may have occasion at times to work on engines equipped with some of the early systems. Moreover, some of the systems shown below are now used on tractor, marine, and stationary engines.

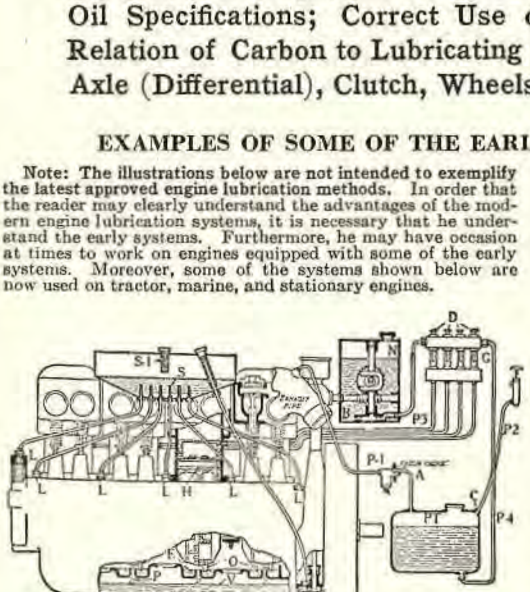



Fig. 1. **A composite illustration showing some of the early methods of engine lubrication:** There are four different systems shown on this engine in order to clearly explain each system. The systems are enumerated and described below.

**Splash system:** The mechanically operated pumps (B) are driven by belt, chain, or gears. There are several small pumps in the oil reservoir box (N), in fact a pump for each feed; the delivery pipe is from (B) to (D) through pipe (P3) and each separate feed is piped to the different parts to be lubricated.

The oil passes through a sight glass (G). The oil then passes to the bearings and cylinders and falls to the bottom of the crank case. The oil reaches such a level or height in the crank case so that the connecting rods give an additional lubrication by splash. The amount of oil fed is regulated by drops, through the sight glasses, by the regulation of the screws (D), and depends upon the size of the engine and on the speed.

This system would be termed a "non-circulating, all-loss" type. The type of oiling device would be termed a **multi-feed mechanical oiler,** a type sometimes used on tractor engines.

(Note that pipe (P4) is not connected with this system, nor is the reservoir (V) used.)

**Re-circulating gravity system:** We will assume that the splash system just described is a part of this system. The overflow passes to reservoir (V); it is then forced by pump (M) to a gravity feed reservoir placed on top of the engine. The passage is then through the different pipes (S to L) to the bearings, thence back to the troughs (E) and reservoir (V). This system would be termed a re-circulating gravity system, as the oil is in circulation.

**Exhaust pressure feed and splash:** This system consists of an air-tight oil tank or reservoir (PT). A small pipe (P1) connects the tank with the exhaust pipe. A check valve (A) permits the gas pressure to pass into the tank but not to flow back.

The initial pressure is given to the tank by a small hand pump through pipe (P2). After the engine is started, the pressure from the exhaust is sufficient to force the oil through pipe (P4) to the sight-feed glasses, thence to the various parts to be lubricated—thence to the crank case.

This system requires oil to be fed by drops, as it is not pumped over and used again, and would be termed a "non-circulating system" of the all-loss type.

### PURPOSE OF LUBRICATION

**The purpose of lubrication** is to prevent metal-to-metal contact.

When two parts of a mechanism rub together, it is necessary to use some means of preventing excessive friction, and this is usually done by applying a **film of lubricating oil** between them. Without a lubricant the friction would cause heating, and the result would be cuts or scratches on the surfaces of the two parts and also excessive **wear** and a great loss of power.

Two parts intended to rub together, like a shaft in its bearing, should **be made as smooth** as possible, for roughness would cause friction that lubrication could not prevent. The **more rapid the movement** of the parts against each other and the **greater the pressure,** the more they must be lubricated, the kind of lubrication must be varied to suit these conditions.

**The functions of a lubricant as applied to an engine can be briefly stated as follows:** (a) to provide an oil film to separate friction surfaces; (b) to seal piston rings; (c) to assist in transmitting heat.

### ENGINE LUBRICATION SYSTEMS CLASSIFIED[1]

**The parts of an engine to be lubricated** are all moving parts.

**Methods of engine lubrication** may be divided into two general classifications: the **circulating** and the **non-circulating** systems.

**The circulating systems** would be represented by systems having a continuous circulation of oil returning it to the original reservoir, and these are frequently termed the "pump over" systems. For instance, a system using a force pump for pumping the oil from the lower part of the crank case to the upper part, with a drain back to the lower part again, would be termed a "circulating system."

**A non-circulating system,** such as a drip or gravity system, or a mechanical feed, supplying so many drops per minute, depending upon the speed and size of the engine, with no provision for circulating the oil back again to the original reservoir, would be termed a "non-circulating system."

**The major classifications of the different engine lubrication systems can be grouped under the following headings:** (1) gravity-feed; (2) splash; (3) splash-circulating; (4) force-feed; (5) force-feed and splash; (6) full force-feed.

#### (1) Gravity-Feed; All-Loss System

**Definition:** This system feeds fresh oil to the friction surfaces in drops, by gravity to various bearings. No provision is made to splash the oil. This system is an **all-loss,** non-circulating, non-pressure system. It is used on some stationary engines.

[1] See pages 1058-1062 for **types of lubrication systems** used on different **passenger-car engines,** and pages 998-1000 for **tractor engines.** The truck specifications on pages 965-977 do not give the type of lubrication system, but are similar to those for passenger cars, that is, some few are splash-circulating, quite a number full-force-feed, and a majority force-feed.

### (2) Splash System (Non-Circulating)

**Definition:** Fresh oil is supplied from a separate oil reservoir or tank to crankcase, and in some instances to the crankshaft main bearings, by means of a mechanical oiler, gravity oil cups, or adjustable feed pump.

The **connecting-rods dip** into troughs and splash oil to all parts of the engine.

Adjustable oil feeds are used on mechanical oilers to control the supply which maintains the splash level. A sight feed is usually employed to indicate the operation and rate of feed.

This system is sometimes known as the **splash-all-loss** type, because the oil is not returned to the reservoir (from where it originated) for circulation.

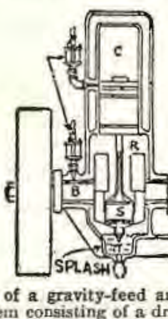



Fig. 2. **Example of a gravity-feed and splash system:** A non-circulating system consisting of a drip or gravity-feed oil cup placed over the bearings and also on the side of cylinder. Special oil cups are required for the cylinder which will prevent the compression interfering with oil entering the side of the cylinder wall. The oil drips by gravity and is adjusted to a certain number of drops per minute. The surplus flows to the oil trough, from where it is picked up by the connecting-rod and splashed to parts above. The oil cups are filled as required, by pouring the oil in by hand.

**This system is used to some extent on two-cycle marine engines, and stationary engines.** Two-cycle engines are also sometimes lubricated by mixing the oil with the gasoline, the mixture being approximately about one part of oil to sixteen of gasoline.

Fig. 3 Fig. 4 Fig. 5

Figs. 3-5. **A splash system without oil troughs would be impractical,** although it was at one time used. As long as the engine remains level, this splash system would probably give fairly good satisfaction; that is to say, so long as the level of the oil is kept up to the lowest point of the connecting-rod where it can be picked up and thrown to the upper part. If, however, the car is in such a position that the engine will be tilted, as shown in Fig. 4, then the oil goes to the rear cylinder. The rear cylinder is over-lubricated and the others are under-lubricated. Even though a **baffle plate** is placed, as shown in Fig. 5, still there are two cylinders minus oil. Therefore some other means must be employed so that all cylinders will receive their proper share of oil.

**One method of overcoming the objection just mentioned is to provide troughs under each connecting-rod,** which is usually done with true splash systems.

**The troughs** retain the oil, even though the engine is at an incline. Some provision must be made to keep the oil at a **constant level** in the troughs. This is done either by means of (1) a hand pump connecting the crankcase to an oil tank, or (2) by oil cups that drip a certain amount of oil into the crankcase every minute, or (3) by filling through a breather pipe.[1]

[1] **A "breather" for an engine** is a pipe opening connected with the crankcase, and extending slightly above it. The opening is closed by a cap which does not fit tight, but allows the air to enter, to allow for "crankcase breathing" when the pistons tend to compress the air in the crankcase, and at the same time prevents oil from working out. Some engines have a separate tube for this purpose, while others combine the breathing feature with the oil filler pipe where oil is poured into the crankcase.

### (3) Splash-Circulating System

**Definition:** Oil is supplied from the reservoir, or sump, by means of a pump, or by the centrifugal force of the revolving flywheel, to splash-troughs and, in some cases, direct to the wells over the crankshaft bearings. After lubricating the surfaces and bearings, the oil returns to the reservoir or sump. (Note that oil is not forced by pressure to any of the bearings; The pump or flywheel serves only to circulate the oil.) The **connecting-rods dip** into and splash the oil to all parts of the engine.

A constant level is maintained in the splash-troughs by an overflow to the sump, or reservoir below, whence the oil is circulated again.

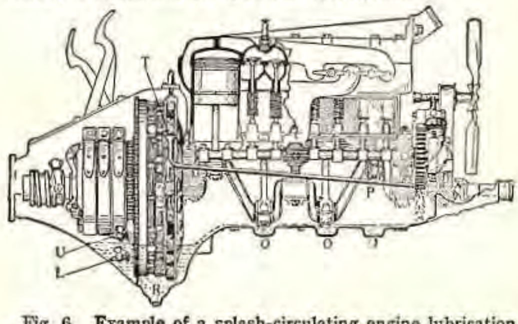



Fig. 6. **Example of a splash-circulating engine lubrication system where the flywheel serves as a pump to circulate the oil** (the Ford model T). The level of the oil in the crankcase governs the amount of oil thrown by the flywheel.

The oil is thrown to the top of the transmission case, where part of it is caught by a funnel **(T)** and then flows by gravity through oil pipe **(P)** to the timing gears, and flows back through the dipper troughs **(O)** to the large oil reservoir **(R)**; thus it is **a circulating** system. (On the improved Ford a connecting-rod dipper trough is also supplied under the fourth cylinder.)

**This system is termed a splash system because** oil is splashed to cylinder walls, piston-pin bearings, main and cam bearings by the **connecting-rod**; the **flywheel** splashes oil for the transmission gears and clutch. The troughs are kept at a **constant level,** or nearly so, by the excess oil flowing from timing gears back to oil reservoir.

**The oil-level** should be maintained as follows: Pour oil into crankcase until it runs out of upper pet cock **(U)**. After engine has become thoroughly limbered up, carry the oil at a level midway between the upper pet cock **(U)** and the lower one **(L)**. Oil should never get below the lower one. The recommended amount of oil is 4 quarts.

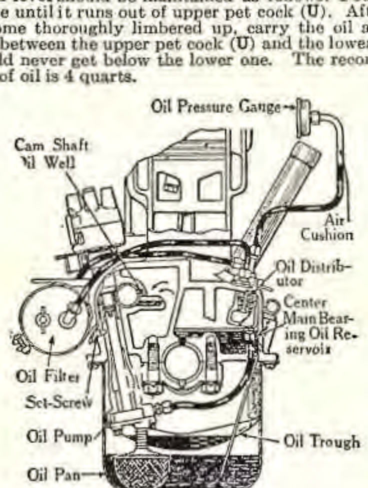



Fig. 7. **Example of a splash-circulating engine lubrication system where an oil pump is used to circulate the oil;** the Chevrolet (Series AA).

**The oil pump** inside of crankcase is elevated above the oil. Pump is a rotary vane type driven from camshaft. It lifts the oil from oil pan and forces it to the **oil distributor,** where the flow is divided and passes through pipes to oil troughs located under each connecting-rod. (Note that oil is not forced under pressure direct to bearings; that is why it would not be termed **a** force-feed and splash system.)

**The oil dippers on the ends of connecting-rods** strike the oil and a portion of it passes up into the connecting-rod bearing. The rest is broken up into a fine spray or oil mist which penetrates to all moving parts of the engine, lubricates them, and then drains back to the oil pan where it is picked up by the pump and circulated again.

**The main and camshaft bearings collect oil from the splash** in oil reservoirs or wells located over each bearing and oil is fed to these bearings through oil holes.

**The oil filter** removes dirt, carbon, and abrasive particles from the crankcase oil. A percentage of the oil passes through it and returns to oil distributor. After about 10,000 to 15,000 miles, the filter cartridge is renewed. Instructions are **not to use a heavy oil as it will not atomize properly,** and may cause **under-lubrication.**

**The oil gauge is an indicator only,** and merely shows whether pump is working or not. The pressure (8 lbs.) shown on gauge does not necessarily tell the condition of the oil in crankcase. **The oil level indicator determines the amount of oil in crankcase.**

### (4) Force-Feed System

**Definition:** Oil is forced by pump **pressure,** direct to the crankshaft main bearings, thence through drilled holes in the crank webs to the connecting-rod crankpins and bearings.

The **piston pins,** pistons, and cylinders are supplied by oil thrown from the crankshaft and connecting-rod bearings (sometimes by drilled holes in lower part of connecting-rod which squirt oil up as shown in Fig. 38, page 795, footnote 3).

The oil returns to the sump, or reservoir, and is circulated again. **The connecting-rods do not dip.** A system of this type is shown in Fig. 10.

**In some engines the oil is also forced to and through the camshaft bearings,** either through drilled passages in crankcase (Fig. 11), or through a hollow camshaft, or through separate leads from oil distributor pipes directly to camshaft bearings.

### (5) Force-Feed and Splash System

**Definition:** Oil is forced by pump **pressure** direct to all crankshaft main bearings.

The oil from the crankshaft bearings falls to splash-troughs in the crankcase, into which the **connecting-rods dip** and splash oil to all other parts of the engine.

A constant oil level is maintained in the splash-troughs by an overflow to the sump, or reservoir, below, whence the oil is circulated again.

**An example of a force-feed and splash system** is not shown.

### (6) Full Force-Feed System

**Definition:** Oil is forced by pump **pressure** direct to crankshaft main bearings and thence by means of drilled holes in the crank webs, to the connecting-rod crank pins and bearings, thence through oil pipes attached to the connecting-rods, or through hollow connecting-rods **to the piston pins.**

The pistons and cylinders are supplied by oil which is thrown from the crankshaft and connecting-rod bearings. In some instances, auxiliary lubrication is supplied to the cylinder walls through the piston pins. The **connecting-rods do not dip.** The oil returns to the sump, or reservoir, and is circulated again.

**This is the only lubricating system in which the oil is forced directly to the piston pin.** Thus the difference between the "force-feed" and "full-force feed" systems will be apparent.

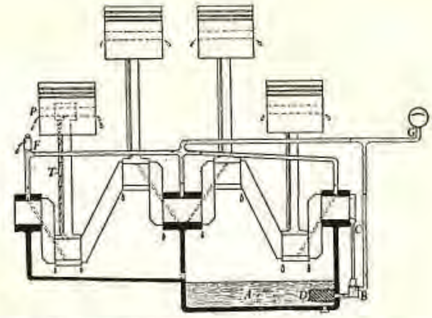



Fig. 9. **Diagram of a "full-force-feed" system.** Note that the path of the oil leads up the connecting-rod through (T) to piston pin (P).

## EXAMPLE OF A FORCE-FEED ENGINE-LUBRICATION SYSTEM WHERE OIL IS FORCED TO THE MAIN AND CONNECTING-ROD BEARINGS

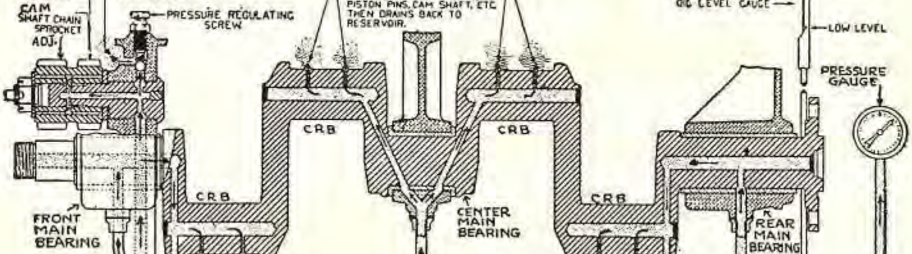



Fig. 10. **Example of a force-feed lubrication system showing a drilled crankshaft. Oil is supplied from oil pump through distributing pipes or tubes to crankshaft main bearings,** thence through drilled passages to **connecting-rod bearings.** Oil pump in this example is a gear type and **is submerged.**

### Path of Oil Circulation

**Oil poured into the filler tube** flows down into the oil pan, filling it up to a height indicated by the oil-**level gauge.** From the oil pan the oil is drawn up through the **oil pump,** which is driven by a vertical shaft from spiral gears on the cam shaft.

**The oil pump is a submerged gear-type surrounded by a screen,** so that all oil entering the system is thoroughly strained to remove the dirt or lint that might stop up the oil ducts. By following the arrows the flow of oil can be traced from the oil pan.

### By-Pass or Relief Valve

**Principle of the by-pass or relief valve which regulates the oil pressure:** The ball is placed in the path of the oil line with a spring tension behind it, and performs the same function as a safety valve on a steam boiler. When the pressure of the oil circulation is reached, to which the spring tension is adjusted, the ball is forced open and oil overflows past the hole—in this instance, **to the chain sprocket.** In other words, it is merely a "relief-valve," and permits the oil to return to the oil pan without passing through the bearings. The pressure in the system is indicated by the oil pressure gauge.

**The oil pressure gauge can be placed anywhere on the system, preferably at the farthest point away from oil pump.**[1] There are certain positions of the crank shaft when no oil channels register and pressure would build up excessively high, were it not provided with some means of release.

**If this regulating screw were set at too low a pressure,** then the oil would pass out under the ball and the crank pins might become dry. **If set too high,** the oil feed would be too great and smoke, carbon, and fouled plugs would be the result.

### Adjustment

**To increase pressure:** The pressure-regulating screw (Fig. 10) can be screwed down after releasing the lock nut, which increases the tension of the spring against the ball. Thus more oil pressure is required to force the ball against the spring tension so that it will open the overflow opening.

**To decrease pressure,** the regulating screw is turned counter-clockwise, which lessens the spring tension on the ball.

**It is best to make adjustment when the engine is warm and running at a speed equivalent to about 25 miles car speed. The scales on various gauges differ,** some reading from 0 to 15 or 25; some from 0 to 40 or 50. In general adjust so that needle reads about 1/3 of points on scale. **If possible, get manufacturer's recommendation.** Be sure to tighten the **lock nut.** Always adjust oil pressure when the **engine is warm.**

## EXAMPLE OF A FORCE-FEED ENGINE LUBRICATION SYSTEM WHERE OIL IS FORCED TO MAIN AND CONNECTING-ROD BEARINGS AND CAMSHAFT BEARINGS

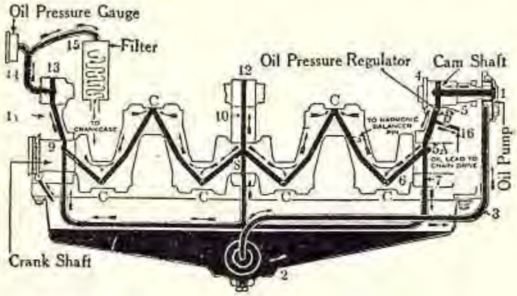



Fig. 11. **Example of a force-feed lubrication system showing drilled crankshaft. Oil is supplied from oil pump, through distributing pipes to crankshaft main bearings, connecting-rod bearings, and camshaft bearings.** Oil is delivered under pressure to all bearings in the engine except the piston-pin bearings. (Oldsmobile six, series E). Oil pump is a gear type and is **elevated.**

### Path of Oil Circulation

**Tracing the course of the oil: An elevated gear type oil pump** (1) is attached to the front end of the engine on the timing gear cover, and is driven by a projection of the camshaft extending through this cover.

**The pump draws oil from a pocket or depression in the center** of the oil reservoir (2) by means of a pipe (3) on the outside of the engine and forces it into the **camshaft** (4), which is drilled hollow to the front journal.

**At this point, the oil passes out of the camshaft** into an annular groove around the journal which coincides with a hole drilled in the crankcase (5) for conveying the oil to the **front crankshaft main bearing, (5A).**

**From this point** (5A) **the oil follows two courses;** into the **hollow crankshaft** (6), and into the **oil pipe** (7), leading from the front bearing cap to the **center** (8) **and rear main bearing** (9).

**A portion of the oil passes out at the crank pins (C) to lubricate the connecting-rod bearings.** (On earlier jobs a hollow camshaft formed the auxiliary oil passage to the center and rear main bearings.)

**From the center** (8) **and rear main bearings** (9), **the oil passes through drilled passages** (10, 11), **in the crankcase to the center** (12) **and rear** (13) **camshaft bearings.**

**The oil which seeps out of the main, connecting-rod and camshaft bearings is whipped into a vapor which floats throughout the engine, depositing a film upon such parts as the cylinder walls, pistons, piston-pins, valve lifters, and valve-stems.**

[1] For **oil pumps,** formerly on this page, see pages 162–163.

### Oil Pressure Gauge

**The oil-pressure gauge** (14) **on the instrument board registers** its pressure from the supply furnished the rear camshaft bearing (13) which is the farthest point in the system from the oil pump (1). This assures oil pressure in all points of the line if pressure is shown on the oil gauge.

**When the engine is warm and supplied with fresh oil, the pressure as indicated by the gauge** should not be less than one pound for each mile per hour on high gear at low car speeds.

**Any excessive drop in oil pressure** would tend to indicate thinning of the oil or an extremely loose bearing in the engine.

**The regulating screw for adjusting the pressure should not** be reset to raise the oil pressure when either of these conditions exists, but **the oil should be changed** or the **bearings taken up,** which will correct the difficulty. No amount of oil under pressure will successfully take the place of metal which has worn away.

**Loss of pressure:** If after oil has been replaced and engine started, the oil gauge on the instrument board fails to register pressure, it is an indication that **the oil pump has lost its prime.** Stop engine, remove plug from fitting on the oil pipe at top of oil pump and pour in sufficient oil to fill pump body. Replace plug and start engine.

### By-Pass or Relief Valve Adjustment

**Midway between the camshaft and crankshaft front bearings** is a by-pass channel (16) for the purpose of relieving the oiling system of any excessive quantities of oil (also leads to and **lubricates the front-end drive chain).**

**This by-pass is normally closed by means of a ball and spring,** the tension of which is regulated by a screw projecting into the channel at the front left side of the engine. Additional tension on this spring will cause **an increase of oil pressure** in the system. Decrease of tension on the spring will cause **a decrease** in pressure.

### Filling

**Oil is poured through an opening (E, Fig. 12).** The amount of oil in crankcase can be determined by an **oil-level indicator** (D. Fig. 12). Attached to the top of the oil level indicator is an air cleaner which serves to extract all foreign matter from the air passing into the crankcase.

### Crankcase Ventilation

**Approximately one-third of the air that passes through the carburetor** is drawn through the crankcase through a pipe (F) leading from an opening in the valve cover to the carburetor air intake (Fig. 12). This air, after having been cleaned by the air cleaner (E) in the filler cap opening, unites with the more volatile parts of the lubricating oil (the unburned gasoline and water vapor which leaks down past the pistons as the left-over product of the combustion taking place in the cylinders) and carries **a portion** of it into the carburetor to be again admitted to the engine and burned.

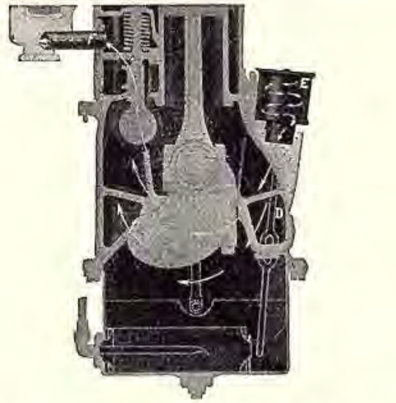


Fig. 12. Crankcase ventilation; Oldsmobile six, series E as an example.

This method relieves the oil of water vapor and enough of the gasoline and other volatile matter to eliminate the probability of oil sludging, freezing, or solidifying in cold weather. The materials carried from the crank case are also an aid to more efficient combustion in the cylinders.

### Oil Filter

**An oil filter** (15, Fig. 11) assists still further in cleaning the oil used in the lubrication of the engine. It is attached to the front of the dash and receives through a by-pass a portion of the oil from the line leading to the oil gauge (14).

**If filter becomes dirty or clogged,** no oil will flow through it. Replace with a new cartridge. In some cases, stoppage of oil flow may be caused by lint, etc., collecting in the small brass fitting at the top of the filter body and not because of clogging of filter itself. Remove and clean.

### Renewing Engine Oil

**Renew oil** at the end of the first 300 miles and at periods not in excess of 2,000 miles thereafter on cars equipped with crankcase ventilation and oil filter. On cars not so equipped oil should be changed every 500 miles in summer and 300 miles in winter.

## EXAMPLE OF A SPLASH-CIRCULATING ENGINE LUBRICATION SYSTEM USING A PISTON OR PLUNGER TYPE OF PUMP

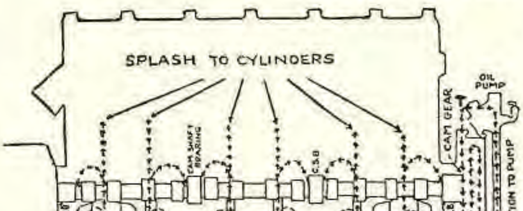



Fig. 13. **Example of a splash-circulating lubrication system,** showing the path of oil circulation (Hudson and Essex).

### Path of Oil Circulation

The oil is taken from the oil reservoir at (A) through a filter or metal screen (Fig. 13).

**The oil is fed** directly into the front compartment containing the timing gears at (T) and their bearings, and flows from this into the first oil trough immediately under No. 1 cylinder. The dipper on the end of the connecting rod practically empties the oil trough at every revolution, throwing the oil into suitable channels or gutters on the side of the reservoir and crank case.

**The upper gutters** feed the main bearings in a continuous stream. The lower gutter feeds the oil directly into No. 2 oil trough (Fig. 13).

**The splash** from No. 2 oil trough feeds No. 3, and so on until No. 6 oil trough is reached, at which time the oil flows back into the reservoir.

The two center bearings are fed by two troughs each. The front bearing is fed from the timing gears and one through, and the rear bearings are fed by two large troughs. It is apparent that all oil which enters at the front end must circulate through the various troughs to the reservoir again.

### Oil Pump

**Operation:** The piston or variable stroke plunger-type of oil pump (Fig. 14) is operated by a cam (G) with an eccentric movement. The cam (G) is driven by a vertical shaft from the crankshaft. The pump is elevated.

The cam forces the plunger in and a spring (S) forces it out again, thus creating a suction effect which draws oil from the lower oil-reservoir or oil pan.

[1] **The Studebaker light six lubrication system,** formerly on this page, and referred to in Index was taken out. The standard six replaced the light six car and uses a regular force-feed ubrication system.

**Throttle control of oil pressure:** The plunger (P) is also under the control of another eccentric (E, Fig. 14A) which is connected with the foot accelerator and throttle control. Thus the quantity of oil pumped to the engine varies with the demand made upon the engine.

**At slow engine speed** the plunger is held in by the eccentric (E). Thus a shorter stroke is the result when the cam comes around. At a car speed of 18 to 20 m.p.h. the gauge should show 1 to 1½ lbs. of oil pressure.

**As the throttle is opened for higher engine speeds,** the eccentric (E) is turned away from the plunger, thus permitting a longer stroke of the plunger (P), and the gauge should register 3 lbs. to 4 lbs. at high speeds. Thus it will be observed that the pressure is governed by the throttle opening.

**If the gauge does not register the amount in the manner described above, the pump mechanism should be investigated.** On indication of a pump being inoperative, or if the gauge needle shows no movement, make sure that there is plenty of oil in the reservoir and that the engine is getting lubrication by splash, and can be run irrespective of the pump. Then you can drive in carefully and have the system examined.

**Failure of the gauge to register** indicates: (1) lack of oil in reservoir; (2) dirty oil preventing pump valves from working properly; (3) air leak in oil pipe line; (4) improper adjustment; (5) improper tension on spring; (6) foreign matter under valve seats.

**Priming the pump:** In case you think that the pump is clogged, it is a good plan before taking it down to try priming it with the same kind of oil that you put in the crank case. To prime the pump, remove the cap, spring and plunger and pour in oil until it fills, replace the plug, and start the engine. If priming does no good, then it will be necessary to clean the pipes in order to find the obstruction. It is also advisable to clean the oil strainer occasionally. When the pump is taken down it must be primed with oil, after replacing.

**The spring above the delivery valve does not control the pressure of oil fed to the engine.** The gauge merely performs the function of showing that the pump is delivering.

### Evidence of Poor Adjustment

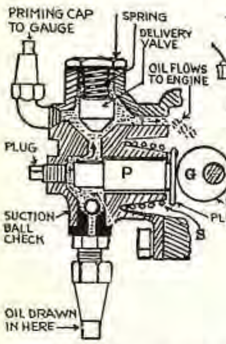
1. **Excessive and continued smoking at slow speeds.** Sooty plugs. This indicates that the adjusting eccentric does not shorten the stroke of the pump sufficiently. Adjustment of adjusting eccentric is necessitated.
2. **Oil-pressure gauge readings** other than from 3/4 lb. to 1 lb. when idling or 2 lbs. to 2½ lbs. at 30 m.p.h. speed. Eccentric adjustment necessary, or there is possibly a leak in the oil pipe lines.
3. **To check adjustment:** Measure stroke as shown in Fig. 14A, by removing the plug and insert a match or nail in the hole, bringing it into contact with the plunger head. The pump can be felt going through its stroke. (Care must be taken in doing this, as the fan runs very close to the plug and offers opportunity for injury.)
4. **When the engine is idling,** with the throttle closed, the stroke of the plunger should be minimum ⅛", maximum 5/32".
5. **Be sure the oil is not thinned out** and is in good condition.
6. **Reassemble pump,** start engine, and notice pressure readings.

7. **Should the gauge read less than 2½ lbs.** at high speed, stop the engine, remove the spring, as shown in Fig. 14, and stretch it slightly in order that there may be more spring tension on the delivery ball, thus increasing the reading on the gauge; but this does not increase the oil pressure. The pressure of the oil is increased only by the stroke of the plunger. Replace spring and again test.

8. **If pressure is more than 2½** lbs. at 30 m.p.h. squeeze the spring shorter and test; couple up the throttle lever with (B), as shown in Fig. 14.; start the engine and let it run with **closed throttle.** The gauge should read from ¾ lb. to 1 lb.

9. **Engine hot.** Dirty oiling system, necessitating cleaning and change of oil, with possible readjustment.

10. **A pressure reading at slow speeds—none at high speeds.** Caused by the adjusting cam permitting the plunger to work at slow speeds, but stopping it at high speeds. Adjustment of cam (E) necessary. It is usually advisable to remove the oil pan, and to clean and refill with new oil in case of any oiling troubles before making any adjustments. A draining and replenishing of the oil supply is advisable every 500 miles; or after the first 250 miles with a new car.



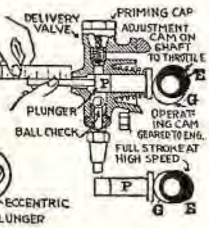




Fig. 14A

Fig. 14 (left). On outer stroke of plunger (P) oil is drawn from oil pan through a 50 mesh screen up through the ball check. On inner stroke of (P) oil forces delivery valve open and flows to engine. Fig. 14A (right). Adjusting oil pump. (Hudson and Essex.)

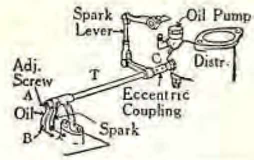



Fig. 15. **Control mechanism of oil supply.** Note position of adjusting screw (A) at the left end of the cross-rod. The stroke of the oil pump is decreased by turning this screw (A) in a counter-clockwise direction. (B) is a crank connected with a shaft which passes through an outer tube (T), and the inner end of this shaft is connected with the adjusting cam (E, Fig. 14A) which governs the amount of stroke of plunger (P, Fig. 14A). The arm (B) connects with the foot accelerator and throttle control; thus as the throttle is opened for higher speeds the adjusting cam (E) is moved to a position which gives a greater stroke of plunger (P); consequently the quantity of oil pumped to the engine varies with the opening of the throttle.

### To Adjust Oil Pump

1. Loosen the throttle arm (B) on the pump-control eccentric (E) at the left side of the engine.
2. Turn the control eccentric arm (A, Fig. 15) with a screwdriver until, with the engine idling, the stroke is minimum ⅛", maximum 5/32", measured as shown in Fig. 14A.
3. Speed the engine up; note oil pressure. It should be as stated.
4. Lock adjusting screw (A) to lever (B, Fig. 15) by means of the clamp nut provided.

### Dodge Engine Lubrication System

The Dodge four-cylinder engine (not illustrated) is another example of a splash-circulating system.

The oil gauge on the dash should show a pressure of 2 to 4 lbs. at 20 m.p.h. If the pressure is too low or too high and investigation shows that adjustment is required, remove the springs in the by-pass, stretching it for more pressure or cutting it off for less pressure.

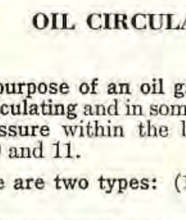
**To determine whether oil is flowing through the feed pipe inside the crank case when the gauge does not work,** it is best first to remove the oil inspection plug. If oil spurts out with the engine running, it shows that trouble is in the gauge.

## OIL CIRCULATING OR PRESSURE GAUGES, OIL-LEVEL INDICATORS, OIL PUMPS, OIL PURIFYING DEVICES

**The purpose of an oil gauge is to indicate if the oil is circulating** and in some systems it also indicates the **pressure** within the lubrication system, as in Figs. 10 and 11.

**There are two types:** (1) "sight-feed" (2) "pressure."

**The sight-feed gauge** is seldom used. Generally, when used, it is with a "splash-circulating" oil system, where oil is only forced to the timing gears and to the oil troughs. The sight-feed gauge mounted on the dash has two pipes connected to it, and the oil can be seen circulating (not illustrated).



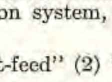



Fig. 16A

Fig. 16. Internal view of oil gauge showing the **Bourdon tube B,** the principle used on many other kinds of gauges.

Fig. 16A. External view of oil gauge.

**The pressure oil gauge** has one pipe connected to it, and oil is not supposed to reach the gauge.

At low speeds of the pump the oil will probably go one-quarter the height of the pipe leading to the gauge, and at high speeds about three-quarters.

**The oil as it rises compresses the air in this pipe up into the thin metal expanding tube (B)** (Fig. 16). **The greater the speed of oil pump, the greater the air pressure in (B), which causes it to tend to straighten out, thus operating (R), (P) and (N).**

**The scale readings on the dials of the various types of oil-pressure gauges** may read anywhere from 0 to 15 or 25; some from 0 to 40 or 50.[1]

**The high-range gauges** are usually used on force-feed lubricating systems, whereas the **low-range gauges** are used on splash systems; however, it is really unnecessary from an operating standpoint to have a high reading on the scale, so long as some pressure shows. If the needle is well up on the scale under normal driving conditions, it is safe. Very few gauges are calibrated so that the scale reading indicates the actual pressure in pounds with any degree of accuracy.

**The amount of pressure as registered on the gauge[1] is dependent upon** the speed, temperature, body or viscosity or thickness of the oil, and the mechanical condition of the engine with regard to wear.

**Maximum pressures** will be indicated at given speeds when the engine is cold and the oil is fresh; the pressure will be higher when the engine speed increases; **minimum pressures,** when the engine is hot and the oil becomes thin; or when the engine speed decreases, or when the oil becomes diluted. Bearing wear will also decrease the oil pressure where force-feed or full force-feed systems are employed.

Practically all engine lubricating oils become less viscous from use, even under normal conditions. Running the engine too long with the "choker" control lever pulled back will cause the oil to be thinned more rapidly, owing to the condensation of gasoline from the rich mixture.

**Too high a pressure will cause abnormal oil consumption.** This should be adjusted according to the pressure recommended by the manufacturers. Always **adjust when the engine is warm.**

[1] See p. 160 under "Adjustment" for an **average adjustment.**

**An excessive pressure** on the gauge may also indicate the clogging of the system. If after the engine is warmed up the pressure is excessive and the regulation does not vary it, then it can be attributed to clogged pipes.

### Oil-Gauge Indications

**If the needle fails to indicate or drops to zero:** This indicates that the oil level is low, or that for some reason oil is not circulating. (1) See if there is oil in the oil pan, the oil-level indicator may be stuck. (2) If there is oil, then disconnect the union leading to the oil pump; run the engine. If oil flows, then look for air leaks, in piping, or in tube (B), Fig. 16. If oil does not flow, then look for the clogged strainer, pump, or pipes, faulty or broken pump shafts, or spring, or pump connections loose, or pump not primed (this last-mentioned condition could result from lack of oil or washing crankcase with kerosene).

In cold weather it may be an indication that the cold test of the oil you are using is not sufficiently low, and that the oil has congealed to a point where the pump cannot draw it from the oil pan. Do not continue to run the engine if the hand on the gauge vibrates excessively, or returns to zero, or if it remains at zero after starting the engine.

**Note:** The oil gauge needle vibrates with each impulse of the plunger when used with a **plunger type** of oil pump. With a **gear type** of oil pump it should be **steady,** or nearly so.

Sometimes, when tube (B), Fig. 16, is expanded out of normal shape by too high a pressure, the needle fails to return to zero. In some instances, this tube can be pressed back into shape with the fingers. It is usually made of light spring copper.

**If the needle reads lower than usual:** (1) Look for air leaks. (2) Loose bearings permit oil to pass freely, reducing the pressure. (3) Thin oil or oil diluted with gasoline, due to excessive priming may be the cause. (4) Pressure adjustment at pump, or at "ball and spring" relief valve not properly adjusted, or weak, or broken spring, or seats worn on ball or cracked, may account for the trouble. (5) Worn pump gears.

**If the needle reads higher than usual:** (1) Heavy or cold, congealed oil, which produces back-pressure, due to slow circulation; (2) obstruction in oil pipes; (3) new and tight bearings after overhauling engine, will all produce higher pressure, as the oil will not circulate as freely as when loose. If the oil gauge shows full pressure when running at a slow speed, foreign matter has become lodged in distributor pipe.

### To Test Oil Pipes or Tubes

**If an air leak is suspected,** remove the oil pipe at the couplings and test them carefully with air pressure, submerging them in water to make the test.

**If the pipe is clogged,** remove it, and use air pressure.

### Oil-Level Indicator

**The oil-level indicator is for the purpose of determining the amount of oil in the oil pan or reservoir,** and is the only sure method.

**There are three types in general use:** the **float** type as shown in Fig. 10, page 159; the **bayonet** type as shown in Fig. 17; and the **pet cocks** in the oil pan, as on the Ford (Fig. 6, page 158) and on some truck engines.


Fig. 17. **Oil-level indicator of the bayonet type.** It is inserted in the side of the crank case. To determine the quantity of oil in the reservoir, pull the rod out (engine not running), wipe free from oil, and insert into the case again. Pull the rod out a second time, and the amount of oil in the base can easily be determined by **noting the height at which the oil shows on the rod.** Empty, half-full and full positions are usually shown by grooves in the rod.

### Oil Pumps

**There are three types of oil-circulating pumps** in general use: the gear type (Fig. 18), the plunger or piston type (Fig. 19) and the rotary or vane type (Fig. 20).


Fig. 18


Fig. 19

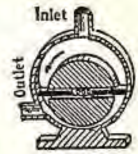



Fig. 20

### Gear Pump

The gear pump is usually driven from the cam shaft or the crankshaft. The oil is drawn into the spaces between the teeth and then forced out to the distributing pipe.

**There are two methods of mounting a gear pump:** One, by having it **submerged** in the oil, and another, by having it **elevated** above the oil level. In the latter case it is necessary that oil be drawn up to the pump before it will circulate, and quite often, if the oil level reaches a point where the pump loses its suction-effect, it will be necessary to **prime** it.

The submerged gear-type of oil pump is **self-priming.** The submerged pump with a large screen will lend itself to the circulation of heavier-bodied lubricants with greater ease than the system with the elevated pump and small screen.

### Plunger or Piston Pump

**The plunger or piston pump** (Fig. 19), quite often used with circulating-splash oiling systems, consists of a plunger in (P) which draws the oil into the pump at (D) on the suction stroke, through a ball valve (B). On the return stroke, the ball valve is closed and oil is forced into the oiling system. The rod (R) of the piston pump (Fig. 19) is connected by an eccentric strap (E) to an eccentric on the cam shaft, which moves the piston in (P). On some systems the plunger is driven directly by a cam.

**The adjustment of the piston pump** (Fig. 19) is made by shortening or lengthening of the stroke which has the effect of regulating the flow of oil. The longer the stroke, the more oil flows, and vice versa.

### Rotary or Vane Type Pump

Another type of pump, as used on the Chevrolet is a rotary pump similar to that in Fig. 20, which is not submerged.

### Priming the Elevated Oil Pump

**If the gauge fails to operate, after finding that the reservoir contains oil,** then all oil-line joints and gaskets should be checked for tightness and the **pump primed** by removing the plug from the fitting on the oil pipe at top of oil pump, and pour into the hole a quantity of oil, sufficient to fill pump body. Replace plug and start the engine.

**Sometimes the gear-pump gasket in head of pump may be loose,** owing to loose screws. This may not only cause a leak, but may permit end play in the pump, causing **local circulation** in the pump but not in the oil line, and the oil gauge will not indicate.

### Oil Strainer or Screen

**An oil strainer** is usually located at the lower end of the oil-suction pipe for the **purpose** of straining the oil before it enters the oil-circulating system. Should this screen become stopped up with foreign substances, it can be removed and cleaned. Too fine a screen impedes suction when oil is cold. Screens run about 20 to 40 mesh for best practice.

**When draining oil, remove the screen and clean thoroughly.** See page 167 discussing frequency for draining and renewing oil and cleaning screen.

### Oil-Purifying Devices

**In conjunction with the circulating type of lubricating systems,** various devices are sometimes employed to remove the fuel, water, carbonaceous, and other foreign material which collect in and contaminate the lubricating oil.

These devices may be either **heaters or rectifiers** which evaporate the fuel and water, or **filters** which strain out the solid material circulating with the oil. In some designs, both operations are performed by a single unit or device. See pages 1006, 159, 161.

## CORRECT LUBRICATION OF AN AUTOMOBILE ENGINE

**In order to provide correct lubrication, the oil in service must perform the following functions:** (1) separate the friction surfaces with an **oil film** to prevent metal-to-metal contact; (2) **seal the piston-rings** against leakage of compressed gases or burned gases; (3) assist in **transmitting heat** from piston to cylinder walls.

### Determining the Correct Grade of Oil

**Experience has proved that it is just as important to use the correct grade** of oil as it is to use a high quality of oil.

**The selection requires scientific knowledge and practical experience,** not only with lubricating oil, but with engines, a combination which the average person is not likely to possess. For this reason it is suggested that the correct oil for an engine be selected, **not by specifications, but by recommendations** of oil refiners who, by scientific knowledge and engineering experience, have worked out charts with brand names and grade designations for the various cars for winter and summer use; usually this information can be obtained at the oil stations.[1]

### How Engine Lubrication Requirements are Analyzed

**The purpose of the discussion which follows** is to give the reader an idea how the recommendations of an oil to be used for a certain make of engine were arrived at by the engineers.

**Experience has shown that there are four basic lubrication factors which must be considered** in analyzing the lubricating requirements of an engine. These factors are: (1) operating temperatures; (2) method of oil distribution; (3) piston-ring seal; (4) carbon sensitiveness.

### (1) Operating Temperatures[2]

**All oils tend to thin out with an increase of temperature,** and the extent to which an oil will thin out will depend not only on the temperature but on its original body and character. After heating, the oil regains its original body when cooled. **It does not remain thinned out unless diluted by liquid fuel.**

**The heavier and more constant the load,** such as with airplane and tractor engines, the more fuel is burned, and consequently, the higher the **operating temperatures.** Therefore **heavy-bodied** rich lubricants would be desirable. This heat, which is usually greatest at the piston, must be conducted through the oil and metal walls before it reaches the water jacket, therefore liberal cooling surface is necessary.

**Automobile service seldom requires more than a small fraction of the available engine power** for any length of time. Therefore it would operate under **low temperatures,** and oils of **lighter body** would probably be necessary.

[1] A chart of automobile recommendations

is issued by the Socony-Vacuum Oil Company, Inc. (makers of Gargoyle Mobiloil), Advertising Department, 26 Broadway, New York, N.Y. These will be sent free to readers of this book on request. The chart specifies the correct grade of oil for each car and model for the last four years.

[2] The maximum temperature in the cylinders, at the top of the explosion stroke is approximately 2700° F.; the minimum temperature during the suction stroke, about 250° F.; average temperature during the four strokes, about 950° F. These are temperatures in the cylinders to which the outer side of the oil film is exposed.

The oil which is between the cylinder walls and pistons is kept below the flash point (about 500° F.) by being in contact with the metal which conducts the heat away through the water circulation.

Cooling the lubricating oil. On some racing cars and high-speed marine and aeronautical engines of high compression and speed, where heat is excessive, due to operating under full power for long periods of time, the oil is cooled by leading the oil out of the engine base, where the temperature can be lowered, before pumping it back into the engine.

The reason for cooling the oil is the fact that an airplane engine usually runs at full power for long periods of time and considerable heat is generated. The oil also loses its heavy lubricating film that is so very necessary between the bearing surfaces, and thins down to a point where the lubricating film is reduced. Hence the advantages of keeping oil at a low temperature. Cooling oil on passenger car engines is seldom, if ever, necessary.

[3] When speaking of **winter temperature,** this means a temperature of less than 32° F.; **summer** means a temperature of more than 32° F. These temperatures are a guide as to when to change the oil. Oils usually become chilled and start to congeal at a temperature of 0° F. for winter oils and 25° to 40° for summer oils. Another term sometime used is **sub-zero temperature,** meaning a temperature below zero.

**The higher the engine speed,** the more frequent will be the heat impulses, and the higher will be the operating temperature.

**With sleeve valve engines, the heat flow from the piston** is restricted as shown in Fig. 21A, by the added oil and metal walls which it must traverse before it reaches the water jacket. Consequently with sleeve valve construction, higher piston operating temperatures are normally encountered than in **poppet valve engines** where the heat has to flow through but one oil film and one metal wall before it reaches the cooling water, as shown in Fig. 21.

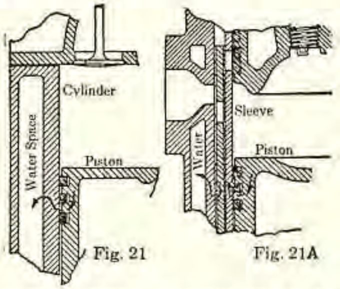



Fig. 21 Fig. 21A

**The design** of the engine materially affects the operating temperature. **Air-cooled engines** run hotter than water-cooled engines. The pistons of **sleeve-valve engines** attain higher temperatures than those of poppet valve engines.

### (2) Oil Distribution

**Lubricating oils vary widely in fluidity,** that is, in thickness or body. Some flow freely in cold weather through small passages; others will not circulate under such conditions.

**Systems in which oil is distributed by splash** must use an oil **light** enough so that it will readily **atomize** in order that it reaches all of the parts to be lubricated. A **heavy** oil might fail to do this.

**Systems in which oil is forced to the crankshaft and connecting-rod bearings by a pump** could use a **heavier** oil in many instances, as it will be mechanically broken up in a fine mist or spray regardless of its body and character by its being thinned when forced through the bearings.

In a few instances, however, due to special features of operation and design, heavy-bodied lubricants cannot be used in force-feed systems.

**Other factors which affect the distribution of lubricating oil in winter and summer**[3] **are,** the type of oil pump, design of oil screen, and dimensions and location of the oil piping.

If the **oil pump** is located below the oil level in the crank case and does not have valves which may fail to operate, it will ordinarily circulate a **heavy**-bodied oil in cold weather. On the other hand, if pump is located far above the oil level or has valves which may not act properly in the presence of chilled oil, as with some plunger type of pumps, an oil of **lighter** body and which will remain fluid at low temperatures will be necessary in order to establish oil circulation as soon as the engine starts.

If **oil screens** have a large area and **coarse** mesh similar to that which surrounds the **submerged gear pump,** a heavier oil could be used than one with small area and **fine** mesh; only a very fluid oil could be drawn freely through the fine screen at low temperatures.

Where the **oil piping** of the suction line is of considerable length and located where it will chill rapidly in **cold weather,** the oil pump may fail to lift the oil unless it is exceptionally fluid at low temperatures. Consequently on designs embodying **elevated pumps** requiring long suction lines, a **fluid** or free-flowing oil is necessary in cold weather.

### (3) Piston-Ring Seal

**The ability to spread, stick, film, and seal varies with different oils.** These properties depend somewhat on the body of the oil. Effective sealing of the piston rings against loss of compression, as explained on page 169, is one of the major functions of a lubricating oil.

### (4) Carbon Sensitiveness

**All oils and fuels, when burned in the combustion chamber of the engine, are likely to leave a residue which may not be entirely expelled through the exhaust and becomes carbon.** Carbon may come from either the fuel or lubricating oils.

**Carbon deposit from lubricating oil in the combustion chamber will depend upon four things as follows:** (1) the character of the oil (if clean burning)[1]; (2) the body of the oil (usually oils of a heavy body tend to leave more carbon under the same operating conditions); (3) engine operating temperatures; (4) the amount of oil reaching combustion chamber.[2]

**The tendency toward carbon formation must be analyzed from three distinct standpoints as follows:** (1) Whether operating conditions promote carbon accumulation, such as intermittent running for long periods of time under varying power; (2) Whether the engine construction is such that an excessive amount of oil will work past the piston-rings into the combustion chamber; if so a **clean-burning oil**[1] of light or medium body is usually preferable; (3) Whether engine is a type in which a slight amount of carbon interferes seriously with its performance (such as engines developing high compression and with a tendency to knock).

## OIL SPECIFICATIONS

**Oil specifications,** such as its flash-point, burning-point, viscosity, cold test, etc., are valuable data to the oil refiner or to the laboratory, but mean virtually nothing to the car owner or garage man.

**As previously stated, the user should be guided by brand names and grade designations of the kind of oil to use, rather than by oil specifications.**

**In order, however, to give the reader an idea as to what some of the specification terms mean,** the following is given.

### Flash and Burning-Points of Oil

**By flash-point and burning-point (also termed fire-point),** is meant the temperature at which the oil, when heated, will flash and burn, explained as follows:

**Oil when heated generates gas,** just as gasoline does when heated. The best gasoline engine oils generate little or no gas at ordinary temperatures, but at high temperatures of, say, 350° to 450° F., they would generate a sufficient amount of gas so that it could be ignited with a match and would thus produce a flash and go out instantly. This is termed the **flash-point.**

**If the heat is increased to,** say, 400° to 500° F., and the match applied, the generation of gas would be so rapid that it would continue to burn until the oil was nearly all consumed, unless extinguished. This is termed the **burning-point.** A low quality of oil would perhaps flash at 300° F., and burn at 350° F.

**The flash and burning-points are lowered soon after the oil is put in use,** from fuel dilution. The initial flash and burning-point, if they are within a reasonable range, have little influence on the effectiveness of the oil as a lubricant.

### Pour-Point, or Cold Test of an Oil

**Another test is the cold test which determines the ability of the oil to withstand extreme low temperatures without getting solid,** or the temperature at which the oil congeals. Some oils finish with a cold test of as high as 60° above zero, others ranging lower and very few as low as 15° to 30° below zero.

**A cold test can be made** by placing some of the oil in a long narrow tube and inserting a low-reading thermometer. Pack the tube in a freezing mixture of salt and ice. After the oil has frozen, remove the tube and incline it at an angle of 60°. When the oil starts to run down the tube, read the thermometer. This reading is known as the **pour-point.** It should be low enough so that the oil will be readily circulated in the lubricating system in any engine under consideration.

**The use of lubricating oils at low temperatures will depend upon its remaining fluid,** otherwise the oil congeals, with the result that the engine will be **difficult to start, the oil will fail to circulate properly through the lubrication system, and all parts of the engine may not be lubricated.** Climatic conditions are considered in selecting an oil from this point of view.

### Viscosity of Engine Lubricating Oils[3]

**Viscosity** refers to the body or fluidity of an oil or any other liquid. The viscosity of oils and liquids varies when heated. The viscosity of an oil does not indicate its lubricating quality, but only determines its fluidity. By this term is understood the flowing property of the oil at a standard temperature, and it is usually measured by determining the rate at which the oil will flow through a small tube of standard dimensions.

**The method adopted in this country to determine the viscosity of oils is known as the Saybolt method,** which is the passing of a certain quantity of oil (60 cubic centimeters) heated to a definite temperature, through a standard orifice or port; the time it takes the oil to run through, expressed in seconds, is the viscosity.

**To make a viscosity test,** a viscosimeter is used. One type generally used is known as the Saybolt Standard Universal Viscosimeter. In order to give an idea as to the principle involved in the test, a simplified illustration is shown in Fig. 22.

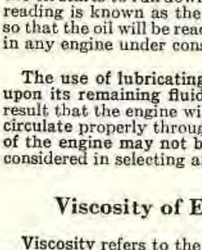



Fig. 22. The test is made by filling the can (A) with oil to be tested and heating it to 100° F. A stop-watch is then used to determine the number of seconds required for the oil to run through the nipple (N). The same process is repeated with the oil at a temperature of 210° F.

**No definite viscosity can be stated here as a standard test for an oil,** as poor oils can be refined to fill nearly any viscosity specifications.

**Viscosities of oils,** to give an idea, and at 100° F., would be approximately as follows: Light oil 200 to 260 sec.; medium 260 to 400 sec.; heavy 400 to 800 sec.; extra heavy 800 to 1,300 sec.

At 212° F., light oil 43 to 47 sec.; medium 47 to 55 sec.; heavy 55 to 70 sec.; extra heavy 70 to 100 sec.

**The above is not at all standard** with refiners. The refiner's recommendation of his own grade for any car should be followed.

**A simple "feel" test of the viscosity of an oil being used in** the engine is to rub a small quantity of the oil between the thumb and finger, and compare it with the feel of new oil under the same test.

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[1] **A clean-burning oil is one that will be completely consumed in the combustion chamber** of the engine without leaving a carbon deposit.

[2] **Bear in mind that carbon deposits are dependent on carburetor adjustments to a large extent.** Rich mixtures tend to promote carbon, as the heat in the engine is less and all the fuel is not burned.

[3] Federal Specifications VV–L–791a covers the methods for sampling and testing lubricants and liquid fuels, including detailed instructions **for determining viscosity by the Saybolt viscosimeter.** The specifications can be obtained by writing the Superintendent of Documents, Government Printing Office, Washington, D.C., and inclosing Post-Office Money Order for 15 cents.

## ENGINE LUBRICATING OILS

**Crankcase lubricating oils** suitable for automobile engines are sometimes classified as extra-light, light, medium, medium-heavy, heavy, extra-heavy. Some oil-refiners give brand names to specify oils of different viscosities. See page 1062B for the S.A.E. *viscosity numbering system* for classifying crankcase lubricating oils as to body or viscosity in place of such terms as "light," "medium," etc.

**The selection of the viscosity of oil** depends upon the temperatures at which it will be used, the clearance space, the general character of the lubricating system, and the oil economy required.

**Heavy oils** are generally used with high temperatures, large clearances, unrestricted circulation systems, and where maximum oil economy is desired. **Lighter oils** are used with low temperatures, small clearances, restricted circulating systems, and where oil economy is not such an important factor.

**Many factors must be considered in selecting the proper oil to use, some of which are:** if the engine is new or reconditioned; easy starting in cold weather; hard driving in warm weather; has the engine a splash or force-feed lubrication system, or a combination of the two; etc.

**From the foregoing it can be seen that it is a difficult problem** for one not thoroughly informed on the subject to determine from his own knowledge the best viscosity of oil to use in all cases. It is for these reasons that operators should **follow the car manufacturers' recommendations.** Owing to changes in engine design with closer fits, etc., also changes in oil refining methods, the **engine oils now recommended** by many car manufacturers **are of lighter viscosity** than formerly.

### Breaking in a New or Reconditioned Engine[1]

**The process of breaking in a new car or reconditioned engine** by gradually glazing or burnishing the bearing surfaces, by careful initial use, has much to do with the length of the life of the parts that come in contact with each other before wear makes replacement necessary.

**The breaking-in process consists of:** (1) *using a good, very light oil* having a pure mineral or petroleum base, for the first 300–500 miles; then drain when hot, and flush the oil pan and crankcase with flushing oil to remove any abrasive or grit that may be present, either from production or initial wear. Refill with fresh *oil of the body recommended by the manufacturer;* (2) *do not drive in excess of* 25–30 m.p.h. during the first 500 miles, or at long continued high speeds for the first 1,000–2,000 miles (varies); (3) *immediately after starting a cold engine (new or not),* engine should be allowed to run at idle speed for a few minutes before driving, and then should not be driven faster than about 20–25 m.p.h. until a normal operating temperature is reached. Warming-up methods in cold weather, such as racing the engine, etc., producing excessive speeds of the rotating and reciprocating parts, may cause damage to the frictional surfaces of the engine if practiced before the engine has reached normal temperature. Manufacturers may vary on these instructions, owing to factors pertaining to different engine designs, too lengthy to mention here; therefore *follow manufacturers' instructions.*

**Special tune-up oils** can be obtained which, it is claimed, can be added in each cylinder before spark plugs are replaced, or fed through the carburetor air intake, which will remove gum and carbon, thus giving quick relief from sticking valves.

### Graphite in an Automobile Engine

**The use of specially prepared graphite mixed with cylinder lubricating oil** when properly used, it is claimed, will improve compression, fill up the scores in the cylinder walls and prevent valves and rings from sticking.

According to the manufacturers of graphite, it is the softest solid mineral known and forms a sleek firm mirror-like film on the bearing surfaces which fills up all the small pores and irregularities in the surfaces and prevents metal to metal contact.[2]

Some authorities object to the use of graphite in the crank case oil as it may clog some of the oil passages.

Graphite should not be mixed with the engine oil on engines equipped with oil filters as it would fill the filter prematurely. A graphite manufacturer suggests that for engines so equipped, graphite may be introduced through air intake of carburetor.

### Castor Oil

**Castor oil** has the property of retaining its oiliness under very high temperatures and severe conditions, but it also has the property of gumming and forming a black coating or film on the inside of engine, resulting in sluggish engine operation after a time. It has been used in racing and airplane engines, but engines used for this purpose are usually dissassembled and every part thoroughly cleaned at frequent intervals, hence this coating or gumming is not a factor to be considered. A high-quality mineral lubricant is now considered more satisfactory.

## CORRECT USE OF ENGINE LUBRICATING OILS

**It is just as essential that proper care and attention be given in using the lubricating oil as it is for that oil to be of high quality and of the correct body.**

**The oil should not be allowed to drop to a low level. Crank case** should not be **over filled,** as this promotes excessive oil consumption, smoking, and carbon deposit, due to the piston rings not being able to take care of the excess, thus permitting the oil to pass to the combustion chamber.

### Dilution and Sludge

**Dilution of the crankcase oil by unburned fuel is always present,** in summer as well as in winter. It is found in its most aggravated form during winter. This condition has led engineers to adopt several different means of heating the mixture so as to change the fuel mixture to a gas in order to obtain more complete combustion.

**In addition to heating the mixture by means of hot-spot exhaust manifolds and other means, the engine jacket water temperature is important.** When this temperature is normal (about 170° F.), some of the fuel that has become mixed with the oil is thrown off, but in winter cars are operated in the majority of cases only for short periods of time and low jacket water temperature prevails and dilution continues.

**As the fuel in the crank case oil is driven off by heat, the oil becomes thicker,** more nearly approaching the body of the fresh oil. It is evident therefore that the original oil body would be restored if all fuel is driven off and this is very closely approached in a true oil reclaiming system.

**Crankcase ventilation,** by permitting a circulation of air through the crankcase, forces out water vapors and unburned gases while it is still in a vapor state, before it condenses and dilutes the oil.

**Water in the products of combustion.** The percentage of water formed depends upon the proportion of gasoline to air; a rich mixture or a large percentage of fuel to air will form more water than a lean mixture. In summer this water vapor passes out with the exhaust, but in winter it enters tne crank case and condenses. Its presence there is a menace to the engine, because it either freezes in the oil pipes, before the heat of the engine melts it, or it forms an emulsion, a thick pasty sludge substance which clogs the oil screen and oil pipes.[3]

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[1] **Instructive literature on the use of "dag" colloidal graphite,** for breaking in new engines, lubrication of the upper portion of automobile cylinders, and crankcase lubrication, can be obtained by writing Acheson Colloids Corp., Port Huron, Mich.

[2] **Instructive literature** on the use of graphite for automobile lubrication may be obtained by writing to Joseph Dixon Crucible Co., Jersey City, N.J.

[3] **Oil filters** prevent the accumulation of dirt and sludge in the crankcase oil. One well-known make is the *Purolator* made by Motor Improvements, Inc., Newark, N.J. The sealed filter unit through which the oil flows continuously as the engine operates collects all dirt and fine particles of foreign substances that find their way into the oil or lubricating system. After 8,000 miles of operation the Purolator should be replaced with a new one because it has become loaded with this mass of dirt and can no longer function. The connections are such, however, that the oil would continue to circulate independent of the filter but would not be filtered. **Other makes are:** *Briggs and Stratton Oil Cleaner,* made by Briggs & Stratton Corp., Milwaukee, Wis.; *Cuno Auto-Klean filter,* made by the Cuno Engineering Corp., Meriden, Conn.; *Handy Oil Conditioner,* made by the Handy Governor Corp., Detroit, Mich.; *Klemm Filtrator,* made by the Klemm Automotive Products Co., 1718 N. Damen Ave., Chicago, Ill. **Literature free.** Mention *Dyke's Auto Encyclopedia.*

**Thinned, diluted oil may cause a number of lubricating difficulties.** In a number of cases the thinned oil will pass the piston rings, resulting in **fouled spark plugs.** Thinned oil is squeezed more easily from between the bearing surfaces resulting, in time, in **bearing wear.** It does not provide as complete a piston-ring seal, permitting a **blow-by,** which not only increases the dilution already present, but may become so bad as to carry with it the major portion of the oil film on the cylinder wall, thereby causing **scoring of cylinder walls and piston.** See page 1075 "Dilution test."

### Precautions To Assist in Preventing Dilution

1. **Avoid excessive use of the carburetor choke;** after starting give engine time to warm up somewhat before driving.
2. **Avoid too rich a mixture adjustment;** use as lean a mixture as possible; too lean, however, may burn the valves on hard driving.
3. **Do not operate engine when it continues to misfire;** some of the unburned gasoline finds its way to the crankcase.
4. **Keep ignition system in order;** its efficiency affects dilution; interrupter points should be kept clean and the proper gap maintained; spark-plug gap should not be too wide, in order to promote easy starting in cold weather; battery should be kept fully charged because with a cold engine the pull is so great the voltage drops to as low as 4 volts, weakening the spark, thereby causing missing of explosion and more raw gasoline to be drawn in.
5. **Maintain good compression** by keeping valves, pistons, and piston rings from leaking. **Maintain proper bearing clearances.** See item (9) page 171.
6. **Avoid excessive idling and slow driving in cold weather;** at very low speeds objectionable suction sets in.
7. **Keep front of radiator closed up in cold weather;** until engine is warm (see also pages 150, 644).
8. **Drain oil frequently,** especially in winter, and refill with correct grade of oil recommended by the manufacturer.
9. **Keep oil filter and air cleaner** in good operating condition.
10. **Replenish oil supply frequently in small quantities,** rather than in large quantities after long periods of operation.
11. **Use a high quality oil** that resists dilution to a maximum.

### When To Drain and Renew Oil

**The frequency of oil changes depends upon operating conditions.** It is impossible to give definite rules that will satisfy all classes of equipment and all conditions of operation. It is obvious that operation on dusty roads without air cleaners and without properly functioning oil filters will require more frequent oil changing than operation on clean hard-surfaced roads with good air cleaners and filters. Other factors to consider are the condition of the engine itself, such as leaky piston rings, and if engine has crankcase ventilation and if the oil breather pipe is equipped with an air strainer.

**In general, the frequency of changing oil is a compromise** dictated by best judgment between the cost of changing oil and the increased maintenance cost produced by failing to do so. The best plan is to **follow manufacturers instructions.**

**Oil should be changed more often in the winter** than in the summer, owing principally to the reasons given under "Dilution." **A lighter oil should be used so that it will heat up and circulate quicker,** also permit easier starting, thus requiring less current to start. Another suggestion for cold weather—in fact, any time—is to **declutch when starting,** and thus save the current required to plow the transmission gears through cold congealed oil.

### Draining the Crank Case

**Draining the crank case can be incorrectly done though the operation may seem simple.** Draining should always be carried out immediately after the engine has run, while the oil is hot and fluid. If this is done the rapidity of flow will be sufficient to carry with it all of the sediment and solid matter actually in suspension in the oil and it may be unnecessary to flush crank case after draining.

Fig. 23

**Do not flush with kerosene,** for in the majority of engines a portion of the kerosene will become trapped either in splash troughs in the many pockets found in the crank case under the timing gears, over bearings, etc., and will remain to dilute the fresh oil.

**To flush:** Open plug at bottom of crankcase to allow the old oil and sludge to drain out thoroughly. Remove **oil screen and clean.** Replace plug and screen, and add about two quarts (or half the oil capacity) of fresh **light engine flushing oil,** which is similar to engine oil but much lighter and less expensive. Start engine and run it at idling speed for about two or three minutes. Step on the running board and rock the car back and forth to allow the fresh oil to wash the interior of the engine thoroughly. Remove drain plug again (also the screen if engine design permits), drain off, and refill with the proper grade of fresh oil.

**The oil pan and oil screen** should be removed and cleaned according to the **manufacturers instructions.** If screen is clogged, no oil can circulate properly. The importance of this operation increases in dusty territories.

**The cylinder oil which is drained from the crankcase** of an engine is usually diluted with gasoline, dirt, and sediment, and should not be used again unless **properly reclaimed.**

### Heavier Oils in Worn Engines

While heavier oil may in some instances soften the noise emanating from worn parts for a time, it is not advisable to use it for this purpose alone.

**No oil can take the place of metal that has been worn away.**

**No oil can seal piston rings that have become worn or are a misfit in their grooves.** Blow-by will take place with any oil—even the heaviest bodied oil—under these conditions. In some cases it may not circulate properly and may thus fail to reach all moving parts.

**The only remedy is to fit new rings, and pistons also if necessary.** If, however, the cylinders are out-of-round, tapered, or scored (see page 814 on this subject), the cylinder must be enlarged and oversize pistons and rings fitted. New rings and pistons are not sufficient if cylinders are not round and true. See pp. 828, 814B on *expanders* and *when to enlarge* cylinders.

**If oil is too light in body,** an excess quantity will be used; the piston rings may not be able to provide sufficient seal and oil will work through into the combustion chambers, where it deposits carbon.

## ENGINE LUBRICATION TROUBLES[1]

**Effect—too much oil:** Smoking at exhaust; carbon in cylinders; pre-ignition and knocking; carbon on valves necessitating grinding (piece of carbon on valve seat, holding valve open, will soon burn and warp valve); spark plugs become fouled; excessive consumption of oil.

**Cause—too much oil:** Oil pan too full; oil pressure adjustment too high; piston pumping oil or rings leak oil.

**Effect—not enough oil:** Overheating; seized bearings or pistons; scored or cut cylinders; knocking.

**Cause—not enough oil:** Oil level in oil pan too low; oil pressure improperly adjusted; oil pipes clogged; oil screen is clogged; pump not operating.

### Scored Cylinders, Pistons, Burned Bearings

**Burned bearings** on a crankshaft or elsewhere mean that the bearing surface is cut, caused by friction from lack of oil.

A **"scored cylinder"** means that there are scratches or cuts in the cylinder, caused by lack of oil, which permits the compression and also oil to leak through the cuts. A "scored piston" and rings is due to the same cause as well as to other causes. Scored cylinders may be caused by the wrong grade of oil, and by dirt in the oil, as well as by lack of oil.

[1] See page 163 for oil gauge indications.

[2] See pages 166, 171, 824B and 833A for a discussion of the importance of running-in a new or reconditioned engine, in order to assure a highly polished or glazed surface.

**If the engine is not getting enough oil,** the cylinder will become so hot that a hard metallic knock will start and the excessive heat will finally cause the piston to stick or "seize" in the cylinder. (Running without proper water circulation will also cause excessive heat, knocking, and finally seizing.)

**Another common cause of a scored piston and cylinder wall is the dilution of the lubricating oil by gasoline.** The heavy-grade fuel is difficult to vaporize, especially in cold weather. To get an explosion, priming is resorted to—and right here is where much damage is done to an engine. If ignition is good, the engine probably will start because a little of the fuel has become vaporized at that particular engine temperature. But most of the gasoline remains unvaporized and **washes the oil from the cylinder walls.** It does not take long for a piston or cylinder to score under such conditions, or where the oil is highly diluted.

**Many drivers forget to release the choker,** and a vast amount of unnecessary fuel is drawn into the cylinders for a long period. This raw fuel mixes with the oil on the cylinder walls and gradually finds its way into the crank-case sump, with the result that the oil is reduced to the consistency of a thin liquid and has no lubricating value whatever.

**It is well to bear in mind, too, that a cylinder which "misses"** allows fuel to get into the oil in even greater volume than when the cylinder fires, because none of the fuel is burned.

**Another cause of scores is that the piston pin** sometimes works loose and cuts the walls of the cylinder.

**If the piston sticks or "seizes,"** stop—wait until it cools, and then fill the oil pan to correct level; also fill the radiator with water after the engine has cooled sufficiently.

**The engine should then be inspected before driving,** to see if any damage has been done. If no obvious damage has been done, a thorough examination should be carried on to determine whether or not the running without oil has burned the bearings or caused other trouble. This can be ascertained by starting the engine, and if it pounds or knocks, it is a certain indication of bearings burned or cylinders scored. See, also, Index under "Seized piston."

## Water in Crank Case

**Principal causes of water in the crank case** are leakage in cylinder head gasket, or **moisture condensation or sweating** in cold weather.

**To demonstrate moisture condensation,** hold a piece of cold metal near the end of the exhaust pipe of engine and note how quickly condensation will collect in drops of water on the cold metal. This is due to the exhaust gases, which are charged with water vapor, striking the cold surface.

A certain amount of these gases pass the piston and rings even under favorable conditions, and there will be a **formation of water in the oil reservoir in a greater or less degree until engine becomes warm,** at which time the crank case no longer acts as a condenser and this water is either expelled in the form of vapor through the exhaust, or else is evaporated in the form of steam through the crank case breather pipe.

**Short runs in cold weather will aggravate this condition,** but even under the best conditions a small amount of water may always be expected in the oil reservoir. Sometimes when engine is standing, the water settles to the bottom of oil pan or reservoir and freezes in cold weather, thus clogging the oil leads and covering the pump screen with ice and leaves bearings and cylinders unprotected.

**About the only remedy,** if there is a tendency of water condensation is to drain the oil more frequently and select good fuel.

In cold weather drain a cupful of oil from crank case after engine is run and warmed up, but allowed to stand idle for about fifteen minutes to settle. If there is any water present, this will remove part of it at least.

**Sludge formation:** Even high-quality oil, which, in its fresh state, will readily separate from water, may form a thick pasty "sludge" when contaminated with the dirt and carbon dust always present in the engine crank case, and mixed with this water and the unburned portions of fuel from the combustion chambers. Such sludge may **form an obstruction in the lubricating system, or accumulate on the surface of the oil-pump screen,** preventing circulation.

**In renewing oil supply, be sure all sludge is removed.** If this is not done, sludge will be formed in the new oil with surprising rapidity.

## Smoke Indications and Cause

**If the vapor is black and foul smelling,** it is caused by too "rich a mixture" (too much gasoline); this can be remedied in the carburetor adjustment.

**If the smoke is white or blue,** the engine is supplied with an excess of oil.

**If the smoke is grey,** there is too much fuel as well as lubricating oil.

**The reason an engine excessively supplied with oil smokes** is that there is too much in the crank case; the entire lower portion of the connecting rod will dip into it and the lubricant will be forced into the cylinder to work by the rings on the piston, then into the combustion chamber, thence out through the exhaust. The same applies to a pressure feed or force system where the pressure is too high.

**If there is a black gummy deposit on the spark plug** it will indicate which cylinder is getting an excess of oil.

**Leaky piston rings are quite frequently the cause of excessive smoke.** It can also be caused by **the piston or piston-rings pumping oil** (see also page 832).

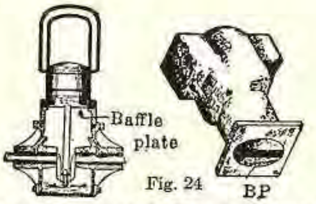

Fig. 24

**A method formerly used, and still used on some marine and stationary engines, for preventing trouble caused by excessive oil, was a baffle plate,** as shown at (BP) in Fig. 24. This is a simple plate of sheet metal in which a slot is cut, through which the connecting rod works, thus preventing an excess amount of oil finding its way into the cylinder. This method has also been used in some automobiles.

**Oil-control piston rings,** explained on page 826, constitute a modern method of reducing excessive oil consumption.

## Oil Drips from Engine

Oil drips can come from **cap screws being loose on the crank case;** from **worn bearings,** out of the ends of the crankshaft; from the **push rods or tappets** above the camshaft; through the **valve cover plate** (not tight); where **generator fits to crank case** (if not tight).

On some cars the fan often picks up the oil oozing from bearings and throws it over the inside of the hood.

## Oil Pumping

**Oil pumping** is a term used where oil is pumped from below the piston to the combustion chamber. When this occurs, it produces excessive oil consumption, a smoky exhaust, and carbon accumulates in the combustion chamber, resulting in sooty spark plugs, which in turn causes missing of explosion.

**When an engine misses explosion,** a part of the unburned gasoline usually passes to the crank case, thinning the oil film on cylinder wall and diluting the lubricating oil in the oil pan. This results in wear.

After wear occurs, burning gases will blow by the rings removing part of the lubricating film, resulting in further wear of rings and cylinder walls. The leak past the piston rings then increases, causing a loss of compression, dilution of the oil, and oil passes around the rings out through the exhaust, causing smoke, all of which results in a loss of power.

**Oil pumping is usually attributable to leaking past the piston rings,** and this may be due to several causes, such as enumerated below:

1. **Worn piston rings or cylinder walls,** which permit the ring to expand and enlarge the ring gap, permitting oil to pass the gap.
2. **Piston ring tension or expansion force insufficient,** permitting oil to pass between the ring and cylinder wall.
3. **Worn ring grooves, or rings improperly fitted to grooves,** permitting the ring to possess perceptible up-and-down movement, causing a **pounding** action of the rings on the sides of their grooves which tends to increase the enlargement of the groove at a very rapid rate. This permits oil to pass around the ring; in fact, this is where oil pumping usually commences. As the piston travels down, the ring moves up and oil collects under and behind ring, in its groove. As the piston travels up, the ring moves down and the oil is forced or pumped out above the top edge of ring and into combustion chamber. (See Fig. 25 explaining this action.)
4. **Pistons fitted with too much clearance** permit oil pumping, even though the rings are properly fitted, because the rings cannot take care of the excess oil between cylinder wall and piston.
5. **Too high an oil pressure** will produce an excess amount of oil which will overtax the capacity of the rings.

6. **Too much oil,** especially in splash-lubricated engines, tends to promote oil pumping.

7. **Vacuum** is another cause of oil pumping, as explained below.

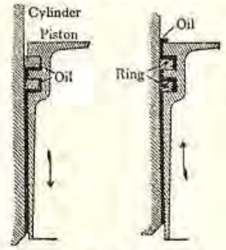


Fig. 25. When ring pounding sets in, piston-ring slot clearances enlarge to such an extent that no oil will seal the piston rings. See item 3 under oil pumping on page 168 for explanation of these illustrations; see also page 832.

### Vacuum Cause of Piston Pumping Oil

When you see blue smoke issuing from the exhaust, it indicates that too much lubricating oil is being consumed.

**If this occurs regularly at all speeds,** it is generally due to piston rings.

**If it occurs only when the engine is run at low speeds** for long periods, or idling at the curb, it is due to either cause as follows:

**When the engine is run fast less vacuum is produced in the cylinder,** because more gasoline and air is drawn into cylinder.

**When the engine is throttled down, only a little air is allowed to enter, therefore more of a vacuum is produced,** the tendency being for the vacuum to suck up oil from the crank case past the piston rings.

No doubt you have seen many a car start off from a standstill after the engine has been running slowly for a time, and have watched clouds of smoke coming from the muffler. Gradually, as the car gets under way, the smoke gets less, and finally no smoke is evident unless the mixture should be too rich, in which case the smoke is black. See Index for meaning of the word "Vacuum."

### Prevention of Excessive Oil in Combustion Chamber

**If the piston rings are properly fitted** to the grooves in the piston and have equal expansion pressure at all points of their circumference in the cylinder walls, and the pistons have the proper clearance—and the **correct oil** is used which **seals** the piston rings—very little oil pumping will occur, that is, providing the cylinder walls are not out-of-round or scored.

**Oil-control piston rings** are used extensively to control oil pumping. Various types are explained on page 826.

**Some of the other methods** employed that have been and are still employed to prevent oil pumping are shown in Fig. 26. It is not the writer's intention to recommend any particular one of these methods, the idea being merely to show some of the various methods.

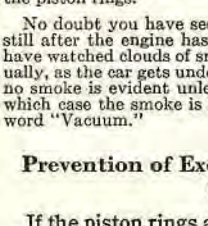


Fig. 26. In 1 at (A) is shown one method for overcoming some of the troubles due to an excess of oil. Note the chamfered lower edge of the second ring groove (B); $\frac{1}{32}$" holes are drilled from the chamfered edge to the inside of the piston. This is for the return flow of the excess oil. An extra large hole in each side over the piston-pin bearing and running into it will improve its lubrication and insure long life. The number of small holes around the chamfered edge should be determined by the extent of the fouling.

At 2, is shown the chamfered lower edge of the second ring groove and the small holes drilled through the piston in the recessed space about the middle. Here, as at 1, the number of holes should be determined by the extent of the fouling.

At 3 is shown the chamfered lower[1] edge of the bottom or oil ring.

Fig. 26A. Showing a method of chamfering the lower[1] part of the lower ring. To "chamfer" means to bevel the part as shown above, with a file or emery wheel. The illustration gives an idea of the amount and angle of the chamfer. This will permit cylinders to get oil, but will prevent oil working past the rings into the combustion chamber, providing, of course, that the cylinder walls are not "scored" and ring fits the groove properly. The treatment applies only to those cylinders in which the spark plugs are constantly oil-soaked, usually No. 1 (front), and often No. 4 (rear).

### Piston Ring Seal[2]

**Effective sealing of the piston rings against loss of compression** is one of the major functions of a lubricating oil.

**Even though the piston rings fit the grooves of the pistons and cylinder walls properly,** there is a possibility of a leak by the rings unless **oil of the proper body and character** is used, in order to seal **the rings** under the temperature and pressure conditions which prevail inside of the engine.

**The chief factors affecting piston-ring seal** are the number and type of rings, the engine speed and load, the operating temperatures, and the tendency of the engine toward fuel dilution.

**With an adequate number of rings** the tendency toward blow-by is minimized, and light-bodied lubricants provide an adequate sealing effect.

**If the engine speed is high,** there is insufficient time for the gases to displace the oil film. On the other hand, **with slow-speed engines,** the greatest possible sealing ability in the oil is desired, particularly if the engine operates under heavy loads.

**With high operating temperatures,** the sealing ability of the oil is reduced, but a much more serious reduction takes place if the engine characteristics are such that unvaporized fuel continually acts to dilute and thin out both the oil film[3] on the cylinder wall and the oil supply in the crank case.

Where such action is likely to take place, the utmost possible sealing effect is desirable in the oil, providing that some other detrimental result is not brought about by a lubricant possessing those sealing characteristics.

It is important that, under normal conditions of design and operation, too **heavy** an oil should not be used, as it tends to create an excessive friction drag, thereby reducing the engine efficiency.

**In engines where too heavy and viscous[4] an oil is used,** the loss due to the excessive friction of the oil alone often amounts to several horsepower. Consequently it is essential that the possibilities for such losses be taken into consideration in selecting the correct grade of oil to meet the piston seal requirements of an engine.

**The oil film**[3] which protects the friction surfaces in the engine is hardly thicker than the page you are now reading. It makes no difference how much oil is poured into the crank case. The only oil that protects the engine is this thin film between the moving metal parts.

And this thin film is not the cool oil you pour into your crank case. In use, the oil heats quickly, and all oils will thin out under heat, but permanent thinning of the oil by dilution with the fuel is what causes most troubles.

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[1] **Although the piston ring here is shown chamfered on the lower edge,** it is oftentimes chamfered on the **upper edge,** so that the ring rides the oil film on up-stroke and pushes it down on down-stroke.

[2] **Piston-ring seal** means the prevention of compressed gases above piston from escaping. Piston and rings form part of the seal, but the oil film must take care of the space between cylinder wall and piston.

[3] **Oil film** is the thin coating of oil between bearing surfaces, which separates them from actual contact.

[4] **Viscous** means a thick or heavy body, like molasses; of high viscosity.

Part of the oil goes off in vapor, just as hot water gives off steam. With an oil film only .003" or less thick, this vaporization must be reckoned with.

To get full protection, you must have a constant, full, even oil film. You must have an oil which will stand the heat of service, and oil which is not diluted excessively with gasoline. Hence the reason for changing the oil in the crank case often.

## RELATION OF CARBON TO LUBRICATING OIL AND FUEL

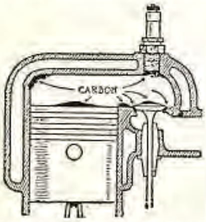
### The Cause of Carbon Deposit

**Carbon** itself may come either from the fuel or from the lubricating oil, usually from both.

**Carbon deposits** tend to accumulate whenever more oil passes the pistons than can be burned up by the fuel charge.

**All oil that gets to combustion chamber should burn up,** as a new film is constantly being worked to the upper cylinder walls by the piston. In a heavily loaded[1] engine, heat is sufficient to consume heavy oil, but a lightly loaded[2] engine does not run hot enough to consume heavy oil; hence a residue is left which stews into a carbon formation.

**Some oils are clean burning, others turn to gummy, sticky masses,** and still others (coke) to hard and dry but abundant carbon formation.



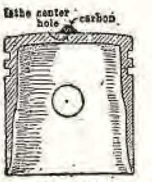




Fig. 27A

Fig. 27. **Showing points in the combustion chamber where carbon deposits are most likely to gather.** It bakes on the cylinder heads, pistons, and valves by the heat of explosion. This carbon deposit will build up very much more quickly if it has a bed to build up on, such as would be produced by a lubricating oil, which, when exposed to the heat of explosion, would leave a gummy deposit, or if parts are rough. Carbon collects rapidly. One starting point at which carbon begins to collect is shown in Fig. 27A; soon there is a mound at this point. The rapidity with which carbon collects can be greatly reduced by smoothing the walls of the combustion chamber, especially the top of the piston. The surfaces should be polished with emery and crocus cloth.

**All fuels and lubricating oil contain carbon,** since they are formed by the chemical combination of carbon and hydrogen in various proportions.

**The heavier and richer the lubricating oil, the greater the amount of carbon entering into its chemical structure,** but the amount which will be deposited in an engine depends not only upon the amount and character of the oil passing the pistons, but also upon the **conditions of combustion** or burning of the fuel mixture.

When an engine is operating under **heavy load,** there is ample flame to consume cleanly, large quantities of rich lubricating oil; under **light loads** and if the **mixture is over-rich,** tending to burn with a sooty flame, carbon will accumulate rapidly, even with an exceptionally clean-burning oil which passes the pistons in very small quantities.

**If the amount of air entering the carburetor is not sufficient to insure complete combustion, we have what is known as a rich mixture.** This is a slow-burning mixture, rather than an explosive one, and will cause excessive carbon deposit.

For example, if the wick of an oil-burning lamp is turned too high, too much oil will be drawn through the wick for the amount of air entering the lamp to form complete combustion. The lamp will smoke, and soot (which is carbon) will be deposited on the chimney.

**In selecting the correct grade of oil for an engine from the carbon standpoint,** it is necessary to determine accurately its **tendency to knock,** its **ability to burn up** the lubricating oil cleanly, and the possibilities for an excess of **oil passing the pistons.**

**The service in which the engine is used** largely determines its ability to burn up the oil while the amount which actually passes the pistons depends upon many features of the engine design and construction.

**If the engine is one which is likely to be sensitive to carbon deposits, a clean-burning, light-bodied oil must be used,** unless the method of controlling the oil supply is exceptionally effective.

**On the other hand, if the engine is not sensitive and the working conditions are severe, a rich, heavy-bodied lubricating oil** may be used without encountering any detrimental carbon deposits, if other factors make its use advisable.

### Bad Effects of Carbon Deposit

**Carbon deposit will cause knocking, missing of explosion, and burned valves,** a part, a combination, or all of which will result in a **loss of power.**

**Knocking:** It was at one time thought that **"pre-ignition"** was the cause of **"carbon knocks,"** that is, by highly heated carbon particles becoming red-hot and igniting the charge before the spark occurred and before the piston was on top of its stroke, thus forcing the piston back against its momentum. This however, has been disproved to a certain extent, as it has been found that the knock comes **after** the spark has fired the mixture and therefore it is not necessarily due to pre-ignition.

Two factors, acting either alone or together, tend to promote knocking or detonation of the fuel: first, high **compression;** second, abnormal **heating** of the fuel charge in the cylinder.

**Carbon tends to induce knocking,** because, being **a non-conductor of heat,** it becomes **overheated** and prevents the free flow of heat from the burning fuel charge to the metal surfaces.

**General overheating due to lack of water or other causes acts in the same way.** Any part of the combustion chamber not properly cooled has a similar effect; hence the presence or absence of such parts, commonly termed **"hot spots,"** has an important bearing on the tendency of an engine to knock.

**Where the engine compression is high or when hot-spots are apparent in the design, carbon accumulations must be reduced to a minimum;** on the other hand, in an engine which is **not sensitive,** they may give little indication of their presence.

**Missing of explosion may be caused by the carbon collecting in the spark-plug shell** or at the points and short-circuiting the high-voltage electric current across the gap. A part of the unburned fuel then passes out the exhaust and a part of it passes to the crank case, washing off the oil film and **diluting** the oil.

**Valves are often held open by pieces of carbon in the seat** with the result that the **valve is burned,** as explained on page 769. Carbon also collects under the head of the valve where it is joined to the stem;

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[1] **Heavy load** means that an engine is normally required to deliver a large portion of its available power, for example, a tractor, airplanes, marine engines, racing automobiles.

[2] **Light load** means that an engine is normally required to deliver a small portion of its available power, for example, a passenger car.

and, due to its being a non-conductor of heat, the **valve head and stem warp,** owing to excessive heat. The valve stem also becomes gummed from unburned carbon residue, and a **sticking valve** results.

### Precautions to Minimize Carbon

**Carbon cannot be prevented entirely, but it can be reduced in formation by following precautions mentioned below:**

1. **Avoid too rich a gasoline mixture** by properly adjusting carburetor.
2. **Avoid the use of the wrong grade of oil,** as well as a poor grade. An oil that is too heavy for the engine will form excessive carbon, even though it be of high quality. Use only an oil that is recommended for your engine by a reputable oil manufacturer. See paragraph, "In selecting the correct grade of oil for an engine from the carbon standpoint" (page 170).
3. **Avoid unnecessary idling.**
4. **Avoid too much oil** and too high a pressure.
5. **Avoid operating an engine when it continues to misfire.**
6. **Drain the oil often,** as explained on page 167.
7. **Poorly fitted piston rings,** as explained on page 168, such as worn grooves, etc., also improper piston clearance should be remedied.
8. **Avoid allowing the oil in the crank case or oiling system to deteriorate** to the point that it becomes **so thin** that even a well-fitting piston ring will not prevent a surplus of oil from passing into the combustion chamber.
9. **Poor bearing fits** or excessively worn main and connecting-rod bearings, in a force or pressure-feed system, will allow an excessive quantity of oil to pass through the bearings. This is thrown to the cylinders, causing over-oiling and carbon. Bearing fits should be checked occasionally, and adjusted (see pages 783–785 on bearing adjustment and tests).

## OIL GROOVES IN MAIN AND CONNECTING-ROD BEARINGS

**Bearing grooving** should follow the practice of the leading manufacturers.

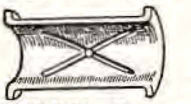


Fig. 28 (left). Cross-groove often used for **splash-lubricated** engine bearings.

For **force-feed** lubricated engine bearings the grooving should be held to a minimum in order that the actual bearing area may be kept large. The grooving in Fig. 28A (right) is a type which is fairly common in force-feed bearings. Usually a short spiral groove or longitudinal channel at point where oil is fed is provided. Cross-grooving in a force-feed system allows too much oil to leak from the bearings (see also page 782).

**Keep oil grooves out of the pressure side of your bearing,** whenever the pressure is one sided, as in the crank-pin or lower connecting-rod bearing.

### "Running-in" a New Engine

**Fine grooves** (not visible to the eye) are left on the piston by the cutting point of the lathe tool when originally made. Also pear-shaped pits are left by the grinding machine on the cylinder walls. When the engine is new the projections are in the fine-line stage.

With an ordinary temperature, at say, .003" piston clearance, the projections will pass one another. When the temperature of the engine is raised, the projections will touch from expansion, and if the speed is excessive, the temperature is raised which, in turn, increases expansion, and friction takes place. The projections then imbed themselves in the recesses opposite them, which will cause a stuck or "seized" piston, with the attendant condition of a "scored" or cut cylinder wall.

Care is necessary to use plenty of oil and to run at normal rates of speed until the projections gradually change shape, and are bent over in such a way that the high points fill the recesses. Avoid driving more than 25 miles per hour for the first 500 to 1,000 miles in a new car.

After **the engine has** been run 1,000 miles with care, the **piston and cylinder** surfaces become very smooth and polished. See also pages 833A, 824B, 633.

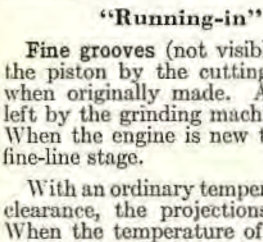
**When the engine stands over night, don't immediately race the engine to warm it up,** because the oil has drained from bearings, cylinder walls, etc. Consequently it is going to take a few minutes to lubricate these parts properly; more so, if the oil is cold and congealed it will require warming so it will circulate freely. Therefore at first let it run slowly for a minute or so.

**Glazing cylinders** is an important operation when running-in a new or reconditioned engine (see page 824B). **Running-in after reconditioning an engine** is discussed on pages 833A, 833B.

## LUBRICATING ENGINE ACCESSORIES

**Some of the parts under this heading** are included in chassis lubrication, but will be discussed here.

Fig. 29



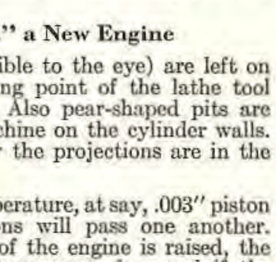




Fig. 30

**Fan bearings** are frequently neglected. These bearings are all isolated from the lubricating system of the engine, and so need separate and periodic attention.

On many engines the fan hub is hollow and serves as a reservoir for the lubricant. On some engines the fan hub is provided with an oil hole that is closed by a ball check, and on some others an oil or grease cup is at the rear of the fan spindle.

Every 500 **miles** lubricate these bearings, using either **light** grease or a **heavy engine oil,** according to the design of the bearing and the lubricating fitting provided.

**Generator:** As a general rule, the generator requires little attention. However, unless the bearings are periodically lubricated excessive wear and costly bearing replacement will result.

Generators in all instances are provided with small oil holes or cups for the **armature bearings.** When the drive of a generator is by means of a chain which is enclosed, this end is usually lubricated with the chain and the other end is lubricated by hand. In Fig. 29 both ends would require lubrication.

Every 500 **miles** fill these oilers with **four or five drops of light engine oil.**

**The starting motor** is not in constant operation, like the generator, and does not need as frequent attention to lubrication. Like the generator, oil holes or cups are usually provided for the **armature shaft bearings.**

Every 1,000 **miles** fill these oilers with **four or five drops of light engine oil.** See also pages 209, 212, 219 for lubricating distributor and interrupter.

**The ignition distributor shaft bearings** are designed either for oil or grease lubrication. In either instance, however, periodic attention is very necessary.

Every 500 **miles lubricate** with either **engine oil or grease** according to the connection. Guard against over-lubrication. Oil or grease should not work up into distributor housing.

**Control connections,** such as for ignition levers and joints, carburetor throttle levers, and joints, accelerator, etc., should be lubricated every 500 **miles** with **light engine oil.**

**Water-pump shaft bearings** are usually provided with grease cups or grease connections. Unless a grease of the correct viscosity and quality is used, as soon as the water gets hot, the grease melts and water will sometimes leak out the grease cups.

Every 300 miles screw down the grease cups one or two turns, and when empty refill with a high quality light grease. Some water pumps are provided with oilless packings which require no lubrication.

**Rocker arms and parts:** In engines of the valve-in-head type, these parts are usually automatically lubricated by engine oil. Where these rocker arms, however, do not receive lubrication from the engine it is very essential that they should be periodically lubricated with **engine oil.**

Either oil cups or wick-filled oil wells are usually employed. Every 500 **miles** fill or soak these oilers with **engine oil.**

**Engine support arm:** Many engines are of the three-point suspension type. In such designs the manufacturer provides for the lubrication of the center engine support **arm** bearing, usually at the front of the engine.

Every 1,000 **miles** lubricate this bearing with either **oil** or grease, according to the design.

**Timing chains or gears** are usually lubricated automatically by the oil relief or by-pass valve (see page 160), or from the front camshaft bearing, and sometimes from the main bearing.

**Oil rectifiers or filters:** Clean periodically as recommended in instruction book of car manufacturer. Renew strainer or cartridge on oil filters **every year,** or as recommended by manufacturer.

**Gear-shift lever bearing:** Lubricate every 500 miles.

**Door handles, door hinges, locks, and windshield working parts, starting-motor button, brake rods and joints, clutch and brake pedal shafts, top of steering-gear post,** should be given a few drops of oil occasionally.

**Horn lubrication:** See page 444.

## TRANSMISSION LUBRICATION

**Drain and flush out twice a year, spring and fall.** Drain after having run car, or when in warm garage, or under conditions where lubricant is most fluid, so that it will drain out readily.

Refill with **correct** transmission lubricant, as recommended by the car manufacturer or oil refiner of established reputation.

**There are several grades of gear lubricants** available, and the manufacturer's recommendation is based on the ability of the oil to be **properly distributed,**[1] **to lubricate and cushion** the teeth of the gears under pressures encountered, and to prevent metal-to-metal contact, and to **avoid leakage** which might oil-soak the brake bands.

**A heavy-bodied, fluid gear oil** is usually required. In some instances a **more fluid** oil is necessary to assure distribution. On the other hand, a **semi-fluid** lubricant may be essential in some designs to minimize leakage. The lubricant should remain fluid in winter and not get too thin in summer. Stiffness in the gear-shifting is an indication that the lubricant has congealed, the result of cold weather.

**The quantity to use** is generally determined by filling until the lubricant overflows from an oil-level plug hole on the side of gear box. Higher levels tend to cause leakage from the bearings.

If there is no oil-level plug, fill those types where countershaft is below the transmission shaft, until the lubricant just covers the body of the countershaft. Where the shafts are side by side, the lubricant should touch the underside of the countershaft.

**Leakage** is usually caused by **over-lubricating,** and the oil works out from the bearings. Worn bearings, loose bearing packing rings, and oil that is too thin will also cause leakage. **Under-lubrication** will cause noise and wear.

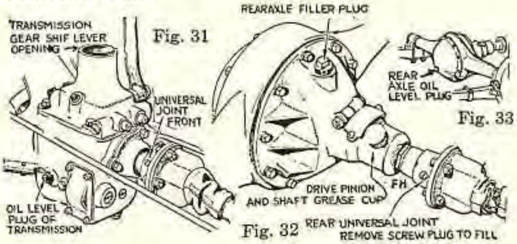


Fig. 31 Fig. 32 Fig. 33

## REAR AXLE (DIFFERENTIAL) LUBRICATION

**What is said relative to the draining and lubrication of the transmission also applies to the rear axle,** with some exceptions, as follows:

**The drive pinion,**[2] **differential, differential bearings, and axle shafts** are enclosed in the rear axle housing which is usually designed to be oil tight.

**The lubricant to use** depends upon the type of rear axle. Since the drive pinion and differential ring gears, like the transmission gears, operate under heavy pressures and are subjected to severe shocks, their lubricating requirements are similar in many respects. The lubricant must **coat and cushion the gear teeth under pressures encountered.** It must flow perfectly to all parts, and at the same time minimize leakage on to the brake drums, so far as this can be done by the lubricant itself.

**A semi-fluid lubricant** is desirable for **summer** in those types of **bevel-gear rear axles** where distribution of this type of lubricant is assured by the arrangement of the axle parts. For **winter,** in most bevel-gear rear axles, a **fluid** lubricant is used.

**A fluid lubricant** is desirable for the differential bevel drive gears and differential for **double-reduction rear axles** where the final drive gears are located in the wheels and are not enclosed (see Fig. 42, page 929 for an example), while **a semi-fluid lubricant** must be used for the internal gears and pinions in the wheels.

**A fluid lubricant** is almost invariably required for year-round use in **worm-gear rear axles** and in other types where proper distribution of the lubricant requires that it flow very easily.

**The quantity of lubricant to use** is generally determined by filling until it overflows out of an oil-level plug hole (see Fig. 33, showing a typical example).

**Where oil-level plug holes are not provided,** the correct level with a fluid lubricant is that at which the lower edge of the bevel-driven (ring) gear dips into the lubricant sufficiently to cover the length of the lowest gear tooth. If a semi-fluid lubricant is used, the axle housing should be filled until the differential case dips into the lubricant for a depth of from one-half to one inch.

**Leakage** on to the brakes is usually caused by over-lubrication. Leaks can also occur through special packing, felt washers, leather oil seals (see page 883), and other means to prevent leaks, and these parts should be examined.

[1] On some transmissions, where dry disk clutches are used, there is an oil hole in the clutch shaft which permits **oil to pass** to the clutch release bearing. With this type, oil that does not remain fluid would result in non-lubrication of these parts. On the other hand, an oil too thin would find its way to the clutch plates and cause slipping.

[2] On some rear axles the **drive pinion shaft outer bearing** is lubricated by a grease cup or connection, and being in an isolated position is sometimes neglected (see Fig. 32). In many rear axles this bearing is lubricated by the throw of lubricant from the ring gear in differential case, thus the importance of maintaining the proper oil level.

*Note.* **See page 1062B for viscosity of lubricants now generally used in transmissions and rear axles.** See also page 867 and footnote 3 on page 1062B.

## CLUTCH LUBRICATION

**Some plate and disk clutches are designed to run in oil.** With such types, **a light-bodied, free-flowing oil** (mixed with kerosene in some instances) is required, so that while lubricating the friction surfaces, it will quickly escape from between the plates as pressure is applied, thereby providing smooth engagement without excessive slipping.

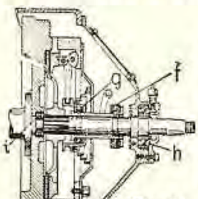


Fig. 34

**In clutches of the dry type,** lubrication is required in practically all cases for the clutch **release bearing** (f, Fig. 34), also for the clutch **thrust bearing,** (g) clutch **shaft bearing,** (h) and clutch **shaft pilot bearing,** (i) in designs where these are used.

**Different methods are employed for supplying lubricant to these bearings.** In some cases they are lubricated from transmission[1]; in some instances, by grease cups that are reached by removing the clutch cover; on other cars an extension is provided for grease cups or high-pressure fittings. When grease or oil must be supplied by the operator regular attention is essential every 500 **miles** (see also "Chassis lubrication").

**The clutch-pedal shaft** is lubricated by grease cups or high-pressure fittings (every 500 **miles**), or by tubes in centrally controlled systems (see chassis lubrication chart).

## WHEEL LUBRICATION*

**In some instances the wheel lubrication is a separate and distinct operation** from the chassis lubrication, and in other instances connections are provided on hub caps for high-pressure grease lubrication.

**Replenish** lubricant every 2,000 **miles;** remove wheels; clean and **repack** every 5,000 **miles.**

### Rear-Wheel Bearings

**Rear-wheel bearings,** in most all designs, are **not** lubricated from the differential supply, but are either designed to be **packed in grease** or supplied with **oil or grease** through special connections (see also "Chassis lubrication").

### Front-Wheel Bearings*

**Front-wheel bearings** are usually lubricated with **grease.** Usually it is only necessary to remove **hub cap,** fill with grease, then screw it back in place. This will force grease throughout the hub and into front-wheel bearings.

Sometimes there are **plugs or fittings** in the wheel hubs (to accommodate the pressure gun); fill these with grease, and in addition, remove hub cap and fill.

When repacking, remove wheels and **clean** the bearings (front) with kerosene. Use care to **adjust** bearings and replace wheels so as to prevent leaks.

If bearings are worn and leak, use heavier grease. If leak continues, replace worn bearings with new ones.

## CHASSIS LUBRICATION

**Chassis lubrication** refers to the lubrication of all parts of the car other than the engine, transmission, rear axle (differential), clutch, and wheels. See chart, page 174, which shows the parts included in "chassis lubrication."

**Note:** While the **clutch** itself is not included, parts of the clutch, such as the clutch-pedal bearing and clutch-release bearing, are included in the chassis lubrication. Also observe that while the **engine** itself is not included, some of its accessories, such as the water pump, fan, and distributor shaft, are included in the chassis lubrication.

**There are two very important essentials** to observe in chassis lubrication.

**One is, not to overlook any of the parts to be lubricated.** There are 17 to 60 (or more) vital bearings on the chassis of every car. If one or more are overlooked, they will run dry and may cost the owner a repair bill.

**Second, use correct lubricants.** The correct lubricant functions in hot weather or in below-zero weather. Inferior lubricants get too thin in summer or freeze in winter.

**The kind of lubricant to use for chassis lubrication** varies with different makes of cars and lubricating systems. There is a divergence of opinion as to whether **oil or grease** is preferable.

**It is best to follow the car manufacturer's recommendation,** in the instruction book, or the **chart recommendation** of well-known lubricant refiners of established reputation in determining the parts to lubricate, and the kind of lubricant to use.

### Steering-Gear Lubrication*

The slow-sliding motion of the surfaces in contact under heavy **pressure** tends to scrape off the film of lubricant and cause metal-to-metal contact, and therefore wear and hard steering result. Consequently lubricants which will resist these heavy pressures are desirable.

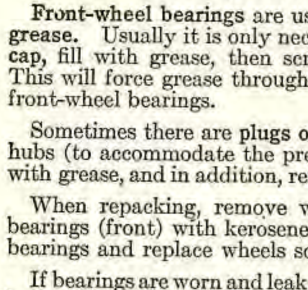


Fig. 35

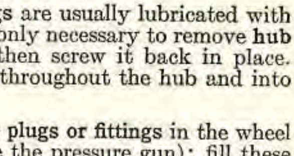



Fig. 36

**The usual method of lubricating the steering gear** is to fill the case with a viscous or heavy-bodied **gear oil or grease.** The kind of lubricant to use depends upon whether or not the steering-gear case is **oil tight.** Lubricate every 1,000 **miles.**

**In winter difficult steering results from congealing of the lubricant.** This can be remedied by cleaning out the old lubricant and using a fluid lubricant recommended on the charts of well-known lubricant refiners.

### Steering-Gear Connections

**The steering-gear connecting-rod (h,** Fig. 35) **also called drag link,** which connects the steering-gear arm (e) with the steering-knuckle gear-rod arm (k) on the front-axle left steering knuckle is provided with adjustable ball socket joints (j) at each end. These should be packed with **light cup grease** about every **1,000 miles.**

[1] See footnote 1, page 172.

* For revised information see *Supplementary Index* for "Wheel bearing lubrication" and "Steering gear lubrication."

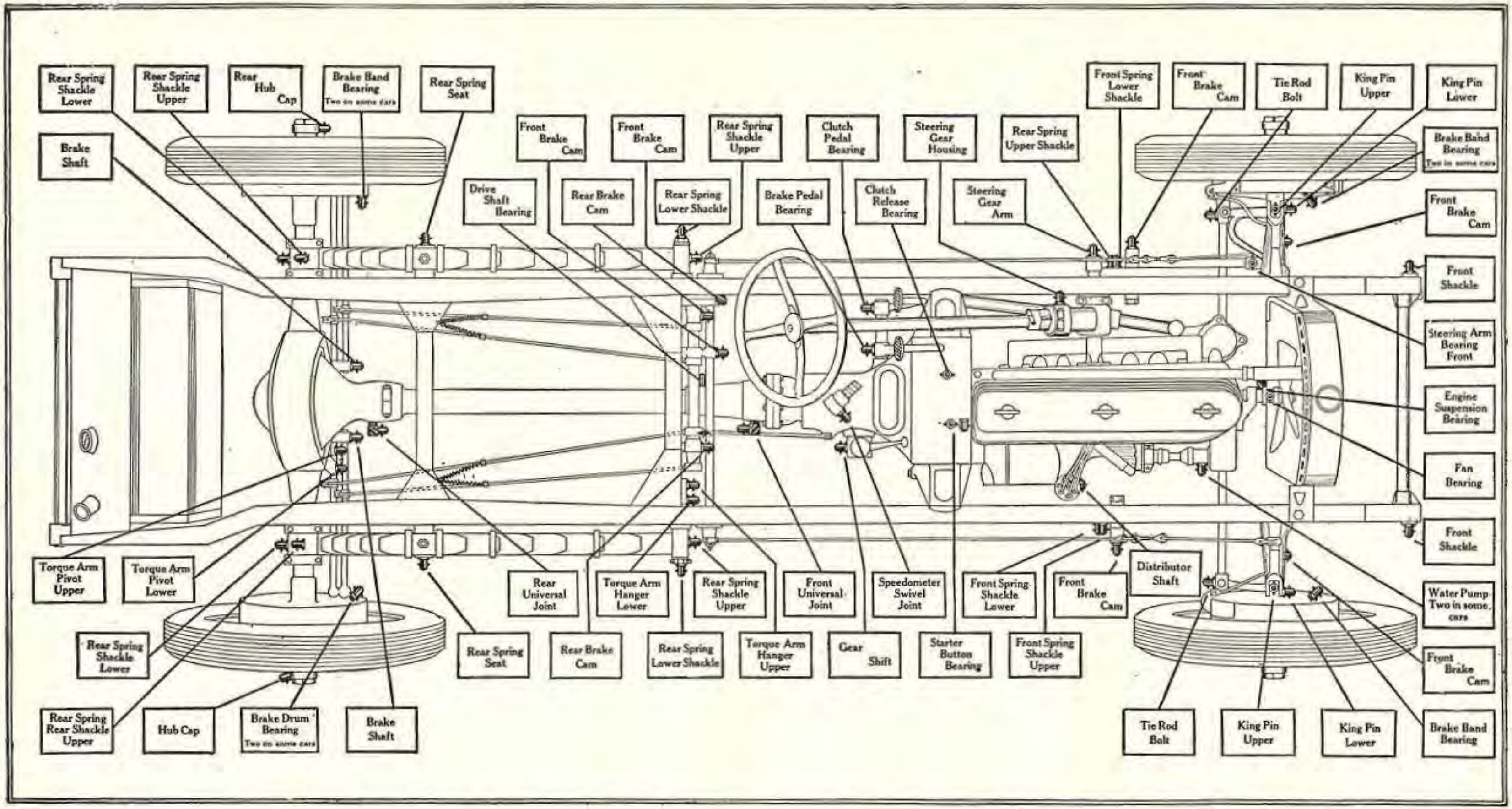



Fig. 37. **Chassis lubricating chart:** This chart is a composite of many cars. It was prepared by the manufacturers of the Alemite and Alemite-Zerk high-pressure lubrication system, which is in use on many cars.

**Few, if any, cars have all the points of lubrication shown here.** Your car has many of them, another man's car may have others. In order not to overlook any bearings, **check** the fittings you lubricate against this chart and see if you have overlooked any. **One neglected bearing may cause a big repair bill.**

**Lubrication of the engine, clutch, transmission, and rear axle (differential), and in some cars, wheels are not included in the operation of chassis lubrication, and must be considered separately.**

Note. This chart was prepared several years ago. See footnote 3 page 1062B.

To pack them properly they should be taken apart. Remove the cotter pin in the ends of the sockets and screw out the sockets (i) with a large screwdriver. Great care must be taken in reassembling to see that they are tight and recotterpinned.

Some steering-gear connecting-rods are hollow and are filled with engine oil which feeds out of each end through wicks. Some cars have high-pressure fittings at points (i).

The steering-knuckle tie-rod (Fig. 36) is usually fitted with grease connections.

### Steering-Knuckle Lubrication

Since the steering knuckles turn on the knuckle pivots as the car is steered (Fig. 36), while at the same time carrying the weight of the car on the thrust bearings, it is highly important for easy steering that these bearings and other steering connections be correctly lubricated, otherwise hard steering, wear, and wobbly wheels will be the result.

Application of the lubricant is usually provided for by the same type of device as employed for spring-shackle lubrication. Lubricate every 500 miles.

### Spring Lubrication

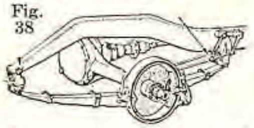
Sometimes springs are enclosed by flexible covers, filled with lubricant (see page 762). It is important to use a lubricant which will not dry out or separate.

Where the springs are not enclosed, they may be most conveniently lubricated by painting them with engine oil at intervals of 1,000 miles.

At some of the lubrication service stations, compressed air is used to force a spray of penetrating oil and graphite between the spring leaves, which lubricates the spring leaves, dissolves rust, and stops squeaks.

Tightening springs: When lubricating the springs, it is a timely opportunity for observing defects of loose nuts or broken leaves, etc. See page 762.

Fig. 38



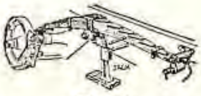


Fig. 39

One example of lubricating the spring leaves (Fig. 39) is to lift the car by placing a jack under the spring seat or frame, and not under the axle, and allow the weight of the wheels and the axle to pull the spring leaves apart. It will then be possible to force graphite grease between the spring leaves with a chisel or screwdriver. The graphite will remain between the leaves and continue to act as a lubricant after the grease itself has become dry. Graphite penetrating oil applied by an air spray gun is often used to lubricate spring leaves.

### Spring Shackle Bolt and Seat Lubrication

Since there is a slight oscillation of the spring upon the shackle bolts, it is customary to insert bronze bushings in the spring ends or eyes which are rolled up for this purpose, and to make the shackle bolts of hardened steel.

Lubrication is provided by means of oil cups, grease cups, connections for pressure-type oil or grease guns, or in some instances by means of an oil reservoir or magazine located adjacent to the wearing surfaces, oil being fed by capillary action through felt wicks to the wearing surfaces.

A few designs provide for the supplying of oil from a central reservoir (centralized system) to all the chassis parts through flexible connections.

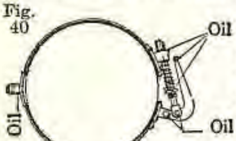
Where lubricated periodically by means of oil cups, grease cups, or connections, lubricate the bolts every 500 miles and seats every 1,000 miles.

To eliminate the wear and noise resulting from the shackle-bolt bushings not being properly lubricated, rubber-spring shackles are being used in some instances, particularly for taxicabs and motor trucks where the service is extremely severe (see page 763). These require no lubrication.

### Brake Lubrication

Brake-pedal bearing, hand-brake lever shaft, brake cams, brake shafts, and brake-drum bearings are usually provided with oil holes or grease connections or grease cups for grease lubrication, which are lubricated every 500 miles.

Fig. 40




Brake-rod yokes and clevices, brake arm or levers on the brake bands and where no grease or oil connections are provided are usually sprayed, or given a few drops of engine oil when the chassis is lubricated.

Brake parts and connections should be kept cleaned and oiled with a solution of oil and graphite, such as graphite penetrating oil. In lubricating service stations this is applied by air through an air gun. See also page 887.

### Clutch-Control Members

Parts such as the clutch-release bearing and clutch-pedal bearing are provided with connections for chassis lubrication. Lubricate every 500 miles. See also page 173.

### Wheel-Bearing Lubrication

The rear-wheel hub cap and also the front-wheel hub cap are sometimes provided with connections or grease cups for chassis lubrication. See also page 173.

### Torque-Arm Lubrication

The torque-arm pivot upper and lower bearing and torque-arm hanger upper and lower bearing used on some cars are usually provided with connections or grease cups for chassis lubrication. Lubricate every 500 miles.

### Universal-Joint Lubrication

Filling and kind of lubricant: Depending upon whether or not the joint casing is oil tight, a fluid oil or grease of a sticky composition will be required. The lubricant used must not separate under the high-speed centrifugal action in the joint, and must withstand heavy pressures. Lubricate every 1,000 miles.

Universal-joint splines at end of propeller shaft are lubricated, when Spicer joints are used, from the universal joint. They are sometimes lubricated by pressure fittings, or by packing the spline joint with grease. If pressure fittings are supplied, they should be attended to when the universal joints are lubricated. If packed with grease, lubricate in your semiannual overhaul.

Neglect of lubrication of the universal joints permits excessive play, which in turn develops lost motion between the engine and rear wheels, causing jerking and undue strain on the transmission and differential gear teeth.

For designs where the angle at which the propeller shaft usually operates is slight, a joint of the fabric type, as shown in Fig. 50, page 861, is often employed. This requires no lubrication and compensates for the shaft angle by the flexing of the fabric.

### Propeller or Drive Shaft Bearing

Very important bearing on a Ford; also on some truck chassis with long wheel base.

### Miscellaneous Chassis Parts to Lubricate

Speedometer cable: Remove flexible shaft core from casing, and as it is put back into casing, run it through a handful of grease. This should be done about every 2,500 miles. A lubricant recommended by the speedometer manufacturer should be used. If a substitute is used, a grease that will not melt and run out of casing and will not get too stiff in cold weather is recommended. The shaft should not be near the exhaust pipe. If a grease is used that becomes too stiff and hard it may break the shaft.

Speedometer head should be lubricated about every 10,000 miles; use oil. It is advisable to have this work done at the speedometer service station, as an excess of oil getting into the head will unbalance the speed dial and may necessitate disassembling.

Speedometer swivel joint is usually fitted with a grease cup or grease connection; grease every 500 miles.

For lubrication of fan bearing, generator, starting motor, water pump, etc., see page 171, and chart on page 174.

## CHASSIS LUBRICATION SYSTEMS

For lubrication of the chassis there is, as previously stated, a divergence of opinion as to whether grease or oil is preferable.

The lubricant is supplied to the bearings by either low pressure or high pressure.

The low-pressure methods would consist of hand-type grease cups, oil cups, wick feed with reservoirs.

The high-pressure methods would consist of connections or fittings where the lubricant is forced into the bearings by pressure. These connections are either individual connections supplied by high-

[1] See footnote 1, page 172.

pressure guns or compressors, or they are all connected to one source of supply and supplied with oil from a **centrally controlled** tank.

**An example of a wick-feed low-pressure oiling system** is the Myers magazine oiling system, used principally on spring shackles and steering-knuckle pivot (king pin), and operated on the principle of capillary action (Fig. 41).

**An example of a high-pressure method where the lubricant is forced through individual connections** to the bearings is the Alemite (Fig. 42) and Alemite-Zerk grease compressors (page 671).

**Elbow or straight fittings are substituted for the old-style grease cups** on all parts to be lubricated. The compressor is then filled with grease or oil and coupled to the fitting with a special coupling which is easily attached. With a slight turn of the compressor handle, fresh grease or oil is forced into the parts to be lubricated and the old grease or oil is forced out. The compressor is capable of exerting a high pressure.

**This system can be applied to old cars,** not so equipped, and the time saved in labor alone will soon pay for the installation.

**One of the fundamentals of this system** is that because of the high pressure developed, all old lubricant as well as any grit or other foreign matter is entirely removed and the bearing is completely packed with fresh lubricant.

**In most cases it is advisable to force lubricant into bearing until the old lubricant is forced out and new lubricant appears.** There are exceptions to this, however. For example, too much lubricant on the **fan bearing** would cause fan belt to slip. Too much on ignition **distributor shaft** may cause trouble. Care should be taken to avoid over-lubricating the **wheel hubs** and **universal joints** which tend to throw grease.

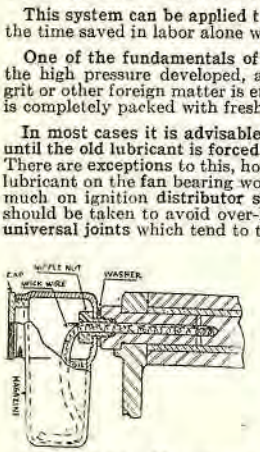




Fig. 41 (left). **Magazine or reservoir is attached to spring** bolt, steering knuckle, or other chassis parts to be lubricated by means of a nipple-nut. Fill every 1,000 **miles.**

Fig. 42 (right). **Alemite high-compression grease gun forcing grease into a fitting located on rear axle.** With the Alemite-Zerk high-pressure grease gun, connection is made wholly by contact with the special fitting, no coupling or flexible hose being used. For lubricating work at service stations a pneumatic compressor such as shown in Fig. 28F, page 671, is more suitable, because it has greater pressure and will force out all of the old grease.

**Examples of high-pressure methods where the lubricant is supplied from one centrally controlled tank** are the Bowen, Bijur, and Alemite. With these systems oil can be delivered to the chassis bearings from a single central reservoir connected by tubing.

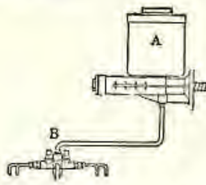



Fig. 43. **The Bowen system of chassis lubrication,** also known as the "One Shot" system, consists of an oil reservoir (A) installed on the dash or under the floor board. When pump foot button (C) is depressed, oil is forced under pressure into the supply lines (tubing) leading to the bearings. A predetermined, measured quantity of oil is delivered through the control headers (B) every time the pump plunger is depressed to such chassis bearings as spring bolts, shackles, front-wheel brake shaft, steering-knuckle bearings, fan, ignition distributor shaft, etc. Under normal operating conditions use heavy cylinder oil, such as Mobiloil B in warm weather; Mobiloil Arctic in freezing weather (Bowen Products Corpn., Auburn, N.Y.).

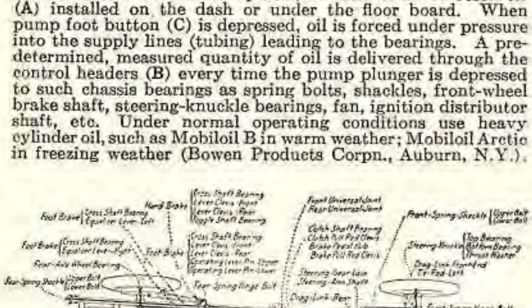



Fig. 44. **The Bijur system of chassis lubrication**[1] showing where 64 places are oiled at one stroke of the pump. The black, heavy lines represent copper tubing $\frac{3}{16}''$ outside diameter, which is fed from a reservoir on the dash (see Fig. 9B, p. 761). Normally, the oil is not under pressure until a pump handle in front of the driver is pulled out and released, when a uniform pressure of 60 lbs., imposed by a compression coil-spring in the pump, gradually forces a measured charge into the pipe line.[2]

**Another example of a centrally controlled chassis lubrication system** (not illustrated) **is the Alemite automatic continuous chassis lubrication system.** The road motion or vibration of the car actuates a delicately balanced weight suspended by springs in such a way that it is free to oscillate vertically in response to the slightest bobbing motion of the car. The movement of this weight actuates a pump developing pressure up to 100 lbs. per square inch in the oil lines, and discharges one drop of oil at each stroke. The mechanism is enclosed in a small oil tank. Oil is forced to various parts to be lubricated through tubing. Resistance units located at the bearings control the rate of flow (Alemite Corporation, Chicago, Ill.).

## EQUIPMENT FOR LUBRICATION SERVICE STATIONS

This subject is discussed on pages 671, 672, and 673. Equipment for washing cars is discussed on page 645. See also page 761.

Some of the equipment would consist of a **pneumatic compressor** for injecting grease into the chassis parts to be lubricated. A **service rack** for elevating cars to a convenient position is also part of the equipment. The modern method of elevating a car is by means of a pneumatic or hydraulic lift, one that will revolve being preferable. An air compressor is also required. Miscellaneous equipment, such as spray gun, oil dispensers, oil cabinets, etc., are some of the other equipment required, also a stock of lubricants of the best quality.

Some of the concerns manufacturing pneumatic, hydraulic, or hand auto lifts are: Curtis Pneumatic Machinery Co., St. Louis, Mo.; Weaver Mfg. Co., Springfield, Ill.; Manley Mf'g Co., Bridgeport, Conn.

[1] Illustration from *The Journal of the Society of Automotive Engineers.*

[2] **Bijur system of automatic chassis lubrication which operates constantly while the car is operating is a later development.** An automatic diaphragm pump connected to and operated by the vacuum in the intake manifold feeds continuously a tiny stream of oil into the chassis lines which distribute it to the drip plugs. Information dealing with Bijur lubrication will be sent gratis to inquirers who mention *Dyke's Automobile and Gasoline Engine Encyclopedia* (Bijur Lubricating Corp'n., New York, N.Y.).

## INSTRUCTION No. 17

## ELEMENTARY PRINCIPLES OF ELECTRICITY AND MAGNETISM: Purpose of Ignition; Ignition Methods; Low-Tension Coil Ignition; Principle of a Low-Tension Coil

### ELECTRICITY

**Electricity**[1]: No one can tell you what electricity is. Electricity is in everything—in your body, in your clothes, in this paper, in the chair; and the only reason you do not know of its presence is because it is not in **motion.**

If you put a water-wheel in the middle of a pond, the wheel will not revolve. To make the wheel revolve, in order to get any work out of it, you must place the wheel in such a position that the water may flow from a high to a low level and thus produce pressure of the water against the wheel. Thus when the water is in motion we can obtain work or energy from it.

Just so with electricity: when it is put into motion you can obtain work from it.

Before the water-wheel will move, a current of water is necessary. So in electricity, there must be a "current," or a "flowing" of electricity before you can get any work out of it, and a circuit must be provided for it to flow in.

**Amperes:** The current, or rate of flow, of electricity is termed "amperes." Just so is the flow of so many gallons of water per second or minute. The ampere is the unit of electric current, or the rate of flow, as, for example, so many gallons of water per second.

**Electro-motive force:** Before a current of electricity will flow in a circuit, there must be a force or pressure to move it. The something which is necessary to put it into motion is an electro-motive force, abrreviated e.m.f., and often referred to as "voltage."

Electro-motive force can be generated "chemically," by means of a battery, or "mechanically," by means of a generator.

When water is pumped into a tank, a pressure is required to force the water to the tank through the pipes. Just so with electricity. When a current of electricity from a generator is sent through a circuit to charge a battery, a pressure (e.m.f.) is required to force the current of electricity to the battery.

**Volt:** The unit of e.m.f. is the "volt." For instance, we could say a generator had an e.m.f. of 8 volts at the brush terminals at 1,000 revolutions, and at this speed, e.m.f. would force an output or rate-of-flow of current of 15 amperes through a circuit.

To make this clear, take the analogy of water flowing through a pipe under pressure. That which causes the flow is "pressure," which corresponds with e.m.f.; that which resists the flow of water through the pipe is "friction" of water against the pipe, due to the size of the pipe and the rate of flow of water through the pipe.

Just so with electricity, there is resistance offered to the flow of the electric current through a conductor forming a circuit.

**Conductors:** A conductor is anything that readily carries electric current, such as copper wire, carbon or gauze generator brushes, the frame of a car, the metal part of the car such as the engine, etc. All metals are conductors.

Some conductors offer less resistance to the flow of electric current than do others. The less resistance a conductor offers, the better a conductor it is.

**The best conductor** is silver, the next best, copper, then aluminum, zinc, brass, platinum, iron, nickel, tin, lead, German silver, antimony, mercury, bismuth, carbon, water. Thus it will be seen that iron offers more resistance than copper, and carbon and water more resistance than iron. **Non-conductors** are slate, marble (if there are no metallic veins), oils, porcelain, glass, rubber, dry paper, silk, gutta percha, shellac, ebonite, etc.

Hence the reason for using copper wire. Silver, as observed above, is the best conductor, but is too expensive. Copper is next best, and not as expensive, and is universally used.

Iron wire offers 6½ times the resistance to the flow of current that the same length and size of copper wire does; therefore if either the iron wire or copper wire is not of sufficient size to permit the free passage of current, the wire will heat. The resistance of the lamp filament is such that it heats and gets quite hot. The greater the resistance, the less total current can pass; hence the pressure or voltage will drop.[1]

**Ohm:** The ohm is the unit of electric resistance. We speak of a certain size of copper wire of a certain length having so many ohms-resistance.

Electric current flowing in a circuit, is therefore dependent upon something besides pressure (e.m.f., voltage) and that is the **resistance** which opposes the flow of electric current in a circuit.

**Resistance** is that property of an electric conductor by which it opposes the flow of an electric current. For instance, carbon, iron wire, German

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[1] It is said that **atoms** of which everything is made, are composed of two different elements called **"electrons"**: one a **positive**, the other **negative**. They neutralize each other when together. Thus if electricity is to be utilized, it is necessary to separate the negative from the positive electrons, and then electricity will flow. It is easier to separate these electrons in copper than it is in hard rubber, glass, etc. Thus copper is used as a conductor and glass and rubber as insulators.

There are several methods of setting electricity in motion. One method is to pass a copper wire across a magnetic field or a magnetic field past a wire. Thus e. m. f. (electro-motive force) is generated in the wire, causing electricity to flow.

Electricity, and a current of electricity, are different. For instance, we do not notice the atmosphere we are living in until a pressure arises and the wind is caused to move. Then we feel it. Thus with electricity, it is in almost everything, but we do not notice it until it is set in motion by pressure (e.m.f.).

[1] Termed a "potential difference" or "energy lost." For instance, "two volts lost on a line" means this much pressure is lost in sending the current through the line.

silver and water will permit current to flow through, but it opposes, or offers resistance to, the flow. **A rheostat** is a device for the purpose of varying the resistance of an electrical current, and is usually made with coils of iron wire or German silver wire, etc. A lamp filament of an electric lamp bulb offers resistance; in fact, it offers so much that it heats white hot.

Resistance opposes the flow of electric current in any circuit it may travel in. The amount of resistance offered depends upon the circuit, size of wire, etc.

As the pressure (e.m.f., voltage) increases, the rate of flow of electric current increases proportionally; as the resistance increases, the rate of flow of electric current decreases.

The greater the resistance which opposes the flow of electric current in a circuit, the less current a certain pressure will produce.

The less the resistance of the circuit, the greater the current a certain pressure will produce.

For example, if the pressure, say, is 6 volts and remains constant, the rate of flow of current will vary if the resistance varies; that is, if the resistance of the circuit be doubled by adding more lamps, etc., the current in the circuit would decrease one-half.

If the resistance of the circuit be decreased, say, one-fourth, by cutting off lamps, the current will increase four times.

**Ohms law:** One volt will force a current of electricity through one ohm of resistance at the rate of one ampere.

Volts ÷ ohms = amperes
Volts ÷ amperes = ohms
Amperes × ohms = volts

Thus, if any two terms are known, the third can easily be found by means of this rule.

For example, suppose the pressure of a generator is 6 volts and the resistance of a lam,) is 6 ohms. What amperage or current is necessary?

Current (amperes) = pressure (6 volts) ÷ resistance (6 ohms) = 1 ampere.

Again, suppose the pressure of a generator is 6 volts and there is a current of 4 amperes passing in a circuit. What is the resistance in ohms of the circuit?

Resistance (ohms) = pressure, 6 volts ÷ current, 4 amperes = 1½ ohms.

Again, suppose the resistance of a lamp is 3 ohms, what pressure would be required to produce 1 ampere through the lamp?

Pressure (volts) = resistance, 3 ohms × current, 1 ampere = 3 volts.

**Coulomb** is the unit of electrical quantity, or such a quantity of electricity as passes in one second in a circuit in which one ampere is flowing. We are not interested in the quantity of electricity alone, but in the ampere, which is a rate-of-flow of one coulomb per second.

**The watt** is the unit of electric power. 746 watts is equal to 1 horse power (h.p.). Amperes × volts = watts.

**Ampere-hour:** 1 ampere of current for 1 hour = 1 ampere-hour.

### How Electricity Is Transmitted

**Electricity produced in one place may be transmitted to another place,** providing a path or circuit is arranged so that it may return to where it started. If the circuit is broken, the flow will immediately stop and will not start again until the circuit is completed.

**A switch** is usually placed in all electrical circuits to stop the current from flowing when not desired.

Electricity flows from the **positive (+) terminal** through the circuit back to the **negative (−) terminal.** Therefore in tracing a circuit, always start with the source of electric supply at the + terminal. The copper wire in which the current starts is called the "lead" (pronounced "leed"), and the return path is called the "return."

**Insulators:** Substances such as rubber, china, porcelain, glass, wood, fiber and mica are called non-conductors or insulators.

A wire is insulated to prevent leakage of current into any metallic substance it may touch, by wrapping it with cotton or silk, which is soaked with rubber to prevent dampness from getting in.

When dry, cotton and silk are insulators, but as water is a conductor, damp cotton and silk cease to be insulators.

**Ground:**[1] This word is used to express two meanings. It has nothing to do with the ground.

One meaning of a "ground" is a leak. For instance, if there is any way by which the current may "leak" from the wires conducting the current, and return to the starting point without going through the entire circuit, this is termed a "bad ground" or "short-circuit." If the leak is only slight, and not enough to short-circuit the path, then it is termed a "ground," and part of the current may reach its destination and return, but part of it will leak through the "ground," such as damp or oil-soaked insulated wires, or wires too near the hot engine, etc. See Index for the meaning of "grounds" and "short circuits."

Another meaning of "ground" is where a wire is intentionally "grounded" or connected to the metal part of the car, such as the frame, engine, etc. One wire of an ignition coil, contact-breaker, and one terminal of a generator and storage battery are often "grounded" to some metal part of the car. This permits using the frame as a return path, and also less wire is used.

**Ignition coil terminals** often have one of the terminals marked "GRND," meaning that this terminal should be grounded.

When a battery negative terminal (−) is grounded, the generator − terminal must also be grounded, and vice-versa, if the positive terminal (+) is grounded. The − terminals are usually grounded; however, on some systems, the + terminals are grounded.

**When electricity has two or more paths to follow, most but not all of the electricity will follow the path of least resistance.**[2] Air offers considerable resistance to the flow of electricity. This is the reason why such a high pressure (voltage) is required to cause current to jump across the gap of a spark plug (see Fig. 1, page 188, for a spark plug).

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[1] **For meaning of open-circuits and short-circuits,** see pages 451–453.

[2] **The velocity of electricity through a copper wire is said to** be 186,000 miles per second. See footnote, p. 237.

## HYDRAULIC ANALOGY OF CONNECTING CELLS

In order to explain the meaning of voltage and amperage more clearly, and how these vary through making different connections, we shall use a hydraulic analogy as follows:

Suppose an ignition coil was wound with a certain number of turns of wire, and that a pressure of 6 volts was required to force a current of 5 amperes of electricity through the wire; and suppose we wanted to use dry-cell batteries for this purpose.

A dry cell usually gives about 1¼ to 1½ volts and its rated output or capacity is from 20 to 25 ampere hours, that is, it will deliver 1 ampere for 20 or 25 hours, or 20 or 25 amperes for 1 hour.[1]

If we connected one dry cell to the primary winding of the coil, the pressure of the one dry cell would not supply sufficient electromotive-force to carry the required current through the winding of the coil. It would be necessary to increase the pressure (voltage). As the pressure (voltage) increases, the rate of current (amperage) flow increases. Therefore it would be necessary to add more cells.

If one cell gives 1½ volts pressure, 4 cells would give 6 volts. Therefore if we connected 4 cells in series, we should obtain 6 volts, but inasmuch as the voltage of a dry cell drops quickly to 1¼ volts or less, we should then use 5 cells connected in series.

It is not advisable to use more cells in series than are needed, because the excess of pressure (voltage) would force the electricity through the circuit at too great a rate or amperage, and this would cause sparking at the vibrator points of the contact-breaker of the coil ignition system and would also likely cause such an increase of voltage in the secondary winding that it would puncture the insulation of the secondary winding (if a high tension coil).

### Meaning of "Series," "Parallel," and "Multiple" Connections

This can be explained by referring to our hydraulic analogy, as follows: Suppose we had three pails of water, each of them 1 foot high (giving 1 foot pressure), as shown in Fig. 1, and suppose we had three dry cells, each of them giving a pressure of 1 volt. By connecting them in different ways we obtain different pressures.


Fig. 1. Comparing dry cells or storage-battery cells with pails of water.

[1] A dry cell, in actual practice, would not deliver current steadily for any great period of time, due to the fact that its voltage would drop on continued use; but if used intermittently, such as for such service as ignition starting, and then being switched off, and used off and on for short periods of time, it would deliver somewhere near its capacity as mentioned above. In other words, it is so constructed that the ampere-hour capacity is greater when producing small current than when producing large current. If a dry cell exceeds 25 ampere capacity of the usual standard size, it will likely polarize and set up a counter-electromotive-force. Thus the terminal voltage would drop more quickly than one of normal capacity (20 to 25 amperes).

Where several dry cells are connected together, if there are weak cells in the circuit, they will absorb the strength from the strong ones, as they will then offer resistance to the good ones, thus bringing the capacity down to that of the weak ones. A storage-battery cell which delivers 2 volts pressure would hold its pressure nearer to a constant value until discharged.

**Series connection:** In the illustration (Fig. 2), three dry cells are connected in "series," similar to pails of water placed one above the other; the pressure (voltage) is three times as great as if only one pail or cell is used, or 3 volts. The capacity would be that of one cell.

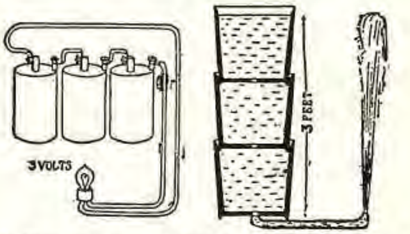



Fig. 2. Dry cells connected in "series," similar to pails of water placed one above the other.

When connecting dry cells mentioned above in series, the carbon terminal (+) is connected with the zinc (−) terminal of the next cell. Thus at the final two terminals, we have one (+) and one (−) terminal, and the voltage at these terminals would be 3×1 volt, or 3 volts.

Note. Illustrations of dry cells are represented as giving 1 volt, and each pail of water as 1 foot pressure, as a matter of easy comparison.

**Parallel or multiple connection:** The three dry cells are connected in "parallel" or "multiple," similar to pails of water connected one with the other as shown in Fig. 3. The pressure (voltage), is equal to only one pail or one cell. The capacity would be that of three cells.


Fig. 3. Dry cells connected in "parallel" or "multiple," similar to pails of water connected one with the other, as shown, to increase the capacity. Voltage is reduced to one cell.

The (+) terminals are connected together and all of the (−) terminals are connected together. The circuit is then between the (+) and (−) group, and the voltage at the terminals would be that of one cell, or 1½ volts.

**"Series-parallel" or "series-multiple" connection:** Two sets of cells are connected in "parallel." Each set of three cells is connected in "series." This connection is termed "series multiple" or "series-parallel." The pressure is equal to three pails or three cells. The capacity would be that of two cells.

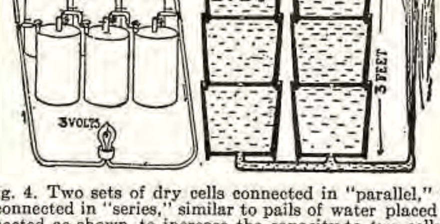



Fig. 4. Two sets of dry cells connected in "parallel," each set connected in "series," similar to pails of water placed and connected as shown, to increase the capacity to two cells and the voltage to three cells.

The two sets of three cells are connected in "series"; then the two series sets would be connected in "parallel" or "multiple." Each of these two sets would then have a (+) and a (−) terminal. The two (+) terminals are connected together, and the two (−) terminals are connected together. The voltage at the terminals would be 3×1½ volts, or 4½ volts.

When connecting two sets of cells in "parallel" it is important that they have the same internal resistance and produce the same pressures, in order that they divide the total current equally. The same thing is true of storage batteries.

If one set has a lower voltage than the other set, then there will be a current through the lower voltage set from the higher voltage set, in a direction opposite to its own pressure. The one of higher pressure will send a current through the one of lower pressure and also the current through the main circuit.

**Where dry cells are used for ignition,** it is advisable to use two sets of 5 or 6 cells connected in "series." One set is used for a while, then the other set. If both sets give out, as an emergency, connect the two sets in "series-parallel" as shown in Fig. 4.

## METHODS OF GENERATING ELECTRICITY

**Electrical energy** or e.m.f. which forces electric current to flow in a circuit, **can be generated by two general methods,** as used on the automobile. One method is by a **chemical action,** which is the principle of the battery; the other is the conversion of mechanical energy into electrical energy by means of **electromagnetic induction,** which is the principle of the generator and magneto.


Fig. 5

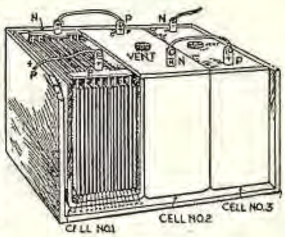



Fig. 6

Fig. 5. Dry cell; a primary cell; a chemical generator.

Fig. 6. Storage battery; secondary cell; a chemical generator.

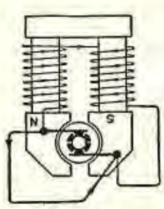


Fig. 7

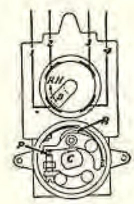


Fig. 8

Fig. 7. Dynamo; a mechanical generator; direct current.

Fig. 8. Magneto; a mechanical generator; alternating current.

**Direct current** (D.C.), means electric current which flows in one continuous direction.

**Alternating current** (A.C.), means electric current which alternates in its flow.

### Chemical Generators

**Chemical generators** are of two kinds, "primary cells" and "secondary cells." Only direct current is produced by a chemical generator.

**Primary cells**[1] (Fig. 5) are usually referred to as "dry cells," and electrical current in a circuit is produced from them by converting chemical energy into electrical energy by a consumption in it of some substance, such as zinc.

[1] Wet cells (not the storage-battery cell) are also referred to as primary cells, but are not used for automobile work.

**Secondary cells**[1] (Fig. 6) refer to the cells of a storage battery, where a current of electricity must first be sent through the cell to cause a chemical action, called "charging," which will put it in such a condition that it is capable of producing a current on "discharge," or whereby it will convert chemical energy into electrical energy.

On most cars three cells of 2 volts each, are used thus making a six-volt battery. On some cars, six cells of 2 volts each, or a 12-volt battery, are used.

There is a set of positive (+) plates and a set of negative (−) plates to each cell, and the cells are usually connected in series. The (+) terminal is usually a dark-brown color, whereas the (−) terminal is gray.

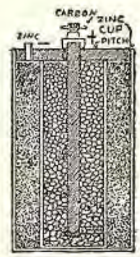



Fig. 9

**A dry cell** (primary cell, Fig. 9) consists of a zinc cup (−) in which a carbon stick (+) is placed as shown. The space between the carbon and zinc is packed with bits of carbon and the necessary chemicals.

The dry cell contains no liquid, but merely moisture, hence its name—"dry cell."

The chemicals used vary, one formula being chloride of zinc, sal-ammoniac, sulphate of lime, and powdered charcoal.

When the circuit is closed from one terminal to the other, a chemical action takes place between the carbon (+) plate and zinc (−) plate, thus generating an electromotive-force which causes the current to flow.

A dry cell has a pressure or voltage of about 1¼ to 1½ volts, and the capacity or volume of current it will produce, called amperage, depends upon the size of the cell. The average is 20 to 30 amperes.

When in use, a primary cell becomes exhausted, and the voltage drops gradually. It will, however, recuperate if disconnected for a period of time. When it has reached a point where it does not recuperate to give sufficient current, it must be discarded and replaced with a new one.

It should be remembered that dry cells are intended for "intermittent" service, as for ignition starting where a magneto is used, after starting the engine, but for continuous service the

[1] Secondary cells are also called "storage-battery cells" or "accumulators." One cell, no matter how large or how small, will show a voltage of a little over 2 volts when fully charged, and will drop to about 1.8 volts when discharged.

dry cell is not a suitable source of current. After the engine has started, dry cells for ignition are not very satisfactory, for they become exhausted in a short time. The less continuous current is used from a dry cell, the longer it will last, and the more efficient it will be.

**For continuous-current service,** the most efficient means of obtaining current is by means of a **storage battery** consisting of a battery of "secondary cells," or, as it is sometimes called, an "accumulator." This chemical type of electric generator, in connection with a dynamo, is in more common use for ignition than the dry cells.

### Mechanical Generators

A mechanical generator of electricity on an automobile is usually driven by the engine and thus produces electromotive-force in the armature coils. This causes electric current to flow out of the armature through the (+) brush, through the external circuit to the (−) generator brush. This action depends upon **electromagnetic induction,** which will be explained farther on.

There are two general types of mechanical generators for automobile work:

1. **The alternating-current magneto-generator** (Figs. 10 and 8) is driven by the engine and is used **only for ignition** purposes, and can be a low-tension (voltage) or a high-tension (voltage) generator. It generates alternating current; therefore it would not charge a storage battery.

Fig. 10

Fig. 11

Fig. 10. A magneto. Generates alternating current.

Fig. 11. A direct-current generator (dynamo). Both magneto and generator are driven mechanically by the engine.

2. **The direct-current electric generator** or dynamo (Figs. 11 and 7) is driven by the engine and generates alternating current. In fact, all mechanical generators generate alternating current in their armatures, but this is changed to direct current at the commutator. Thus, from the brushes the current is direct. This direct-current generator is used **to charge the storage battery and to supply current for the lights and ignition.** When it is running at its normal speed its voltage is higher than that of the storage battery. At other times, the storage battery supplies current for the lights, ignition, and also the starting motor. Approximately, the **generator** gives only from 15 to 20 amperes at 6 or 12 volts. The **starting motor** requires from 150 to 450 amperes of current, depending on how stiff the engine is. Thus only the storage battery could supply this great quantity of current.

## PRINCIPLES OF ELECTRICITY AND MAGNETISM

In order to understand the action of an **ignition coil, magneto, and generator,** it is necessary to understand: (1) magnetism; (2) magnetic induction; (3) electromagnetism; (4) electromagnetic induction.

### Magnetism

**Magnetic circuit:** Magnetic lines-of-force are invisible waves that pass from one pole of the magnet to the other. The lines-of-force pass from the north (N) pole to the south pole (S), *outside* of a permanent magnet, and from (S) to (N) *inside*, thus forming a closed magnetic circuit. Magnetism cannot be transmitted through wires like electricity.


Fig. 1

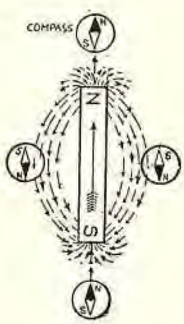



Fig. 1A

Fig. 1. A horseshoe type of permanent magnet.

Fig. 1A. A bar type of permanent magnet.

**Polarity of a magnet:** If a compass (Figs. 1 and 1A) is placed at the (N) pole end of a magnet the (N) end of needle will point away from the (N) pole, or with the direction of the flow of lines-of-force, which is always *out* at (N) and *in* at (S) pole. This is why the (N) pole of a magnet attracts the (Se pole of a compass needle, and why the (S) pole of a magnet attracts the (N) pole of a compass needle.

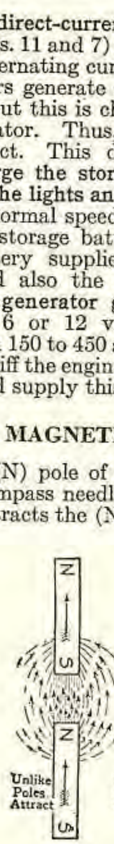



Fig. 2

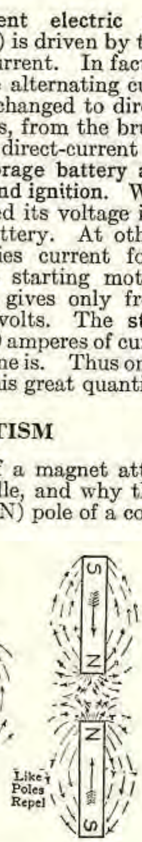



Fig. 2A

Fig. 2. Unlike poles attract.

Fig. 2A. Like poles repel.

This is also the reason why the (N) pole attracts the (S) pole of another magnet (Fig. 2), and why the (N) pole repels the (N) pole (Fig. 2A). Like poles repel, and unlike poles attract, because other lines-of-force pass in a circuit (N) to (S), outside, and (S) to (N) inside of a magnet.

A **bar magnet** is shown in Figs. 1A, 2, and 2A. Note that the **magnetic circuit** is the same as in the horseshoe magnet (Fig. 1). The magnetic lines flow through the air from (N) to (S) pole outside of the magnet and through the magnet from (S) to (N).

If an iron bar is placed between the poles of a magnet, as in Fig. 3, the lines-of-force will flow freely through the iron bar, because the air-gap between the poles offers 280 times the resistance


Fig. 3

that iron does. The iron bar tends to gather and collect stray lines-of-force and to concentrate the lines. Thus we obtain a great many more lines-of-force by using the iron bar.

Soft iron is generally used for the armature core on a magneto and also on generators, and for cores of ignition coils also, because soft iron will not retain its magnetism after the magnetic effect has been removed. In generating electric current this is an important factor, that is, the iron bar must become magnetized and demagnetized quickly, as this change of action, explained farther on, is desirable.

**Permanent magnet:** If hard steel is used, it tends to retain its magnetism, just as the magnets in Figs. 1, 2, and 3 do. Thus they are called permanent magnets on this account. Permanent magnets are used **principally on magnetos.**

When permanent magnets are heated, the iron has a tendency to soften; thus, the more it is heated, the more it loses its magnetism.

### Magnetic Induction

**Magnetic induction:** If a piece of iron or steel is placed in a magnetic field of a magnet, it will become a magnet. Magnetism is "induced" into the iron

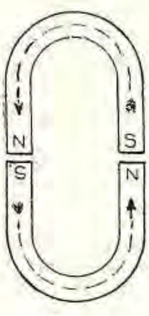



Fig. 4

or steel. See Fig. 4 and note how one magnet will induce magnetism into another magnet if unlike poles are placed together so the lines-of-force will flow from (N) to (S).

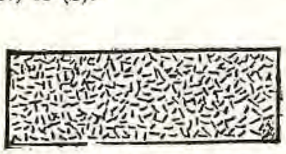


Fig. 5. Not magnetized.

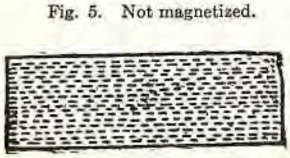


Fig. 5A. Magnetized.

**An explanation or theory why hard steel retains the magnetism, and why soft iron does not,** is that steel or iron composed, like all matter, of small **molecules,** is made up of minute magnets. If the steel or iron is not magnetized, the molecules have no definite arrangement (Fig. 5). If, however, it is magnetized (Fig. 5A), the molecules, like small magnets, all arrange themselves with the (N) pole of each pointing (N), and thus these molecules or little magnets all point in the direction from which the magnetizing force is being applied, and thus form one large magnet.

When all of the molecules or little magnets have been turned around, the iron or steel is then said to be completely magnetized or "saturated," and cannot be further magnetized.

**Soft iron** permits these molecules or little magnets to return to their original position, and almost all of its magnetism is lost when the magnetic influence is removed. This condition is termed "de-magnetized."

There is, however, always some magnetism left in a soft iron core, called **"residual magnetism,"** on generators, where the field poles are wound with wire. When the generator first starts, enough **residual** magnetism is in the iron to supply lines-of-force for the armature wires to cut and thus build up. This is a very important factor when generating current in a dynamo with electromagnetic fields.


Fig. 5B. Keeper.

**Steel** requires more magnetic force to magnetize it, but the molecules retain their position if a "keeper" (Fig. 5B) is placed on the end of the poles; otherwise the molecules will eventually return to normal condition and the permanent magnet will gradually lose its magnetism.

A permanent magnet would be suitable for magneto field poles, but not for an armature. It is not suitable for any part of a generator or ignition coil, but lines-of-force are very necessary, and, owing to the fact that the lines-of-force must change in value from zero to maximum, soft iron is used for magneto armatures, generator armatures, and field poles and cores of ignition coils.

**Magnetic-field-of-force**[1] is the space around or between the magnet where the magnetic lines-of-force pass.

**Electricity** is in almost everything, but requires force to move it in order to produce energy or work.

**Electromotive force** (abbreviated e.m.f.) is the force or **pressure** which moves electricity, and the unit of electromotive force is a volt. When current is sent through a wire or coil from some source, the e.m.f. is supplied from that source.

### Electromagnetism

**Electromagnetism** differs from magnetism in that the magnetism exists only when the current is flowing through the conductor or wire.

[1] "Magnetic flux" is a term often used to express the total number of lines-of-force flowing through a magnetic circuit.

**If electric current is sent through a straight wire,** as in Fig. 6, a magnetic field will be set up around the wire. Its strength or intensity will be in proportion to the amount of electric current flowing through the wire.

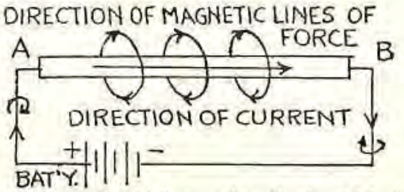



Fig. 6. Magnetic "whirls" around a wire in which direct electric current is flowing.

**Electric current always flows from positive (+) to negative (−).** Therefore, in Fig. 6, the current is flowing from (+) of the battery, through wire, to (−) of the battery. The magnetic lines-of-force will whirl around the wire in a right-hand or clockwise direction *with* the flow of electric current.

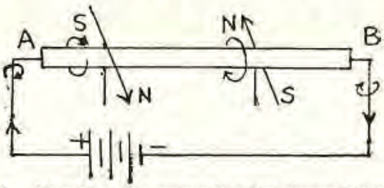



Fig. 6A. Note that the magnetic whirl above the wire is in one direction, and underneath in the opposite direction.

**Direction of magnetic whirls around a wire:** If a compass is placed above the wire (Fig. 6A), when looking at the end **A**, where the current is going *in*, the lines-of-force will whirl clockwise as in Fig. 6B, and the (N) end of the compass needle will point *with* the direction of the flow of the lines-of-force. If the compass is placed *below* the wire, the (N) end of the compass needle will point in the opposite direction, thus proving that there is a magnetic field circling around the wire.

If the compass is placed above the wire, when looking at the end (B) (Fig. 6C), where the flow of current is coming *out* instead of going in, the lines-of-force will be whirling around the wire in a counter-clockwise direction, but the magnetic whirls are still clockwise following the direction of the flow of the current in a clockwise direction.

In other words, the lines-of-force are in the same direction, but we are looking at it from the other end; just as the engine of an automobile revolves in a clockwise direction if we look from the front, but it revolves in a counter-clockwise direction if we look from the rear.

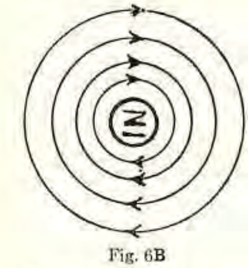



Fig. 6B

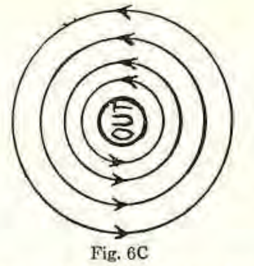



Fig. 6C

Fig. 6B. Note that the magnetic whirls are clockwise when the current is going in the front end of the wire, and counter-clockwise when leaving at the rear end (6C) where the current is coming out.

If electric current is sent through a wire at end **(B)** instead of **(A)**, the magnetic whirls would be clockwise, or in a right-hand direction with the flow of electric current, but in the opposite direction to what they were formerly, because the current has been reversed.


Fig. 7

If an electric current is sent through a wire in **the form of a coil** (Fig. 7), the direction of the magnetic whirls of lines-of-force is clockwise with the flow of electric current in the wire. Note that the whirls are in an opposite direction on either side of the wire. However, the whirls are clockwise with the direction of the flow of current at all points of the circle. Start at (+) and follow the circle in a right-hand direction all the way around, and the explanation will be made clear..

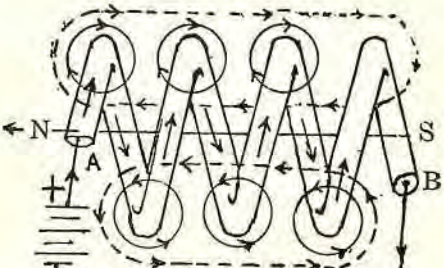



Fig. 7A

If an electric current is sent through several turns of wires or coils (Fig. 7A), which would be termed a **"solenoid"** or "helix," the lines-of-force would join together, because when current flows in two wires side by side (Fig. 7B), in the same direction, the lines-of-force join, because they are circling around the wire in the same direction.

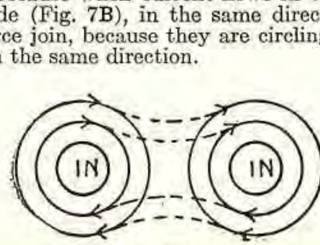



Fig. 7B

Where there are several coils side by side, as in Fig. 7A, note the (+) current is going in the wires at (A) and coming out (−) at (B), at the other end of the coil. The lines-of-force would then whirl clockwise with the flow of electric current, but in doing so they would whirl at the top, in one direction, and in another direction at the bottom. This is due to the current flowing around a circle. However, if the magnetic whirl is followed in its path around the circle, it will be observed that the direction is right hand or clockwise with the flow of current at any point of the circle.

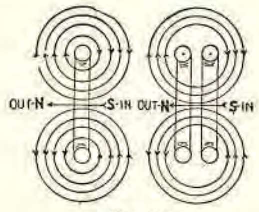



Fig. 7C

**Polarity of a helix or solenoid:** In Fig. 7C, one coil of wire is cut in half to make the explanation clearer, because the point we wish to arrive at is the advantage of the lines-of-force joining and passing around all of the turns of wire of the coil, which is to make one end of the coil (N) pole, and the other end (S) pole.

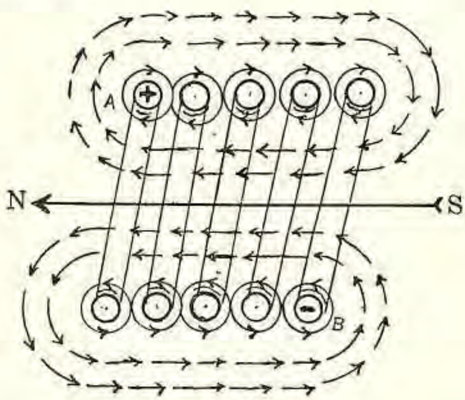



Fig. 7X

We observed in Fig. **1A** that on a permanent magnet, the lines-of-force passed *outside* of the magnet from (N) pole to (S) pole, then from (S) to (N) *inside*. The same effect is taking place in this coil of wire or helix (also called a solenoid), because when the lines-of-force whirl clockwise with the current going in at (A) (Fig. 7A), the lines would whirl *out* of the (N) or left end of the coil, pass over and under and around the coil, and go into the other end (S) (see Fig. 7X), through the inside of the coil, back to end (N) again. Thus we have the lines whirling *out* at (N) pole and *in* at (S) pole, and we have established a (N) and (S) pole **polarity** of the coil, which is clearly shown in Figs. **7A** and **7X**.

If the electric current was sent into the end at (**B**) of the coil (Fig. **7A**) instead of at (**A**), the whirl would be in an opposite direction. Thus the end (**B**) would be (N) pole, and the end (**A**) would be (S) pole.

The next question is, What is the advantage of having these lines-of-force passing around a coil of wire in this manner? The answer is, To form an electro-magnet.

**Electro-magnets:** If we place a soft-iron wire core (Fig. 7Z) inside of a coil or helix which is carrying current, the iron core will offer a great deal less resistance to the passage of the lines-of-force through the center of the coil than does the air. This is due to the fact that the iron will collect a lot of stray lines-of-force and produce a great many more, and thus strengthen the magnetic field (lines-of-force

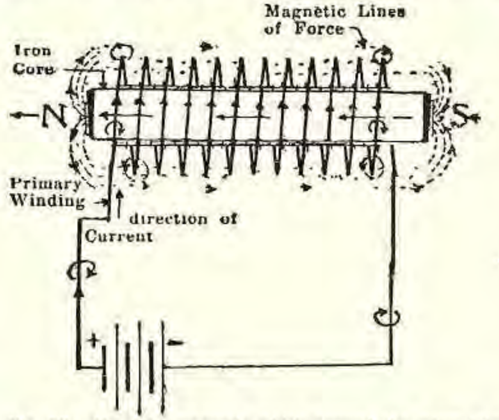



Fig. 7Z. How the magnetic whirls around the wires join forces to produce an electro-magnet.

around the coils of wire), as it is this magnetic field which, when the circuit is opened, collapses and passes back into the core and, in doing so, cuts the coils of wires and produces a greatly increased electromotive force. In other words, the magnetic lines-of-force produced from the current flowing through the turns of wires are going to be utilized to transform the primary low-voltage current passing through the turns of wires (primary winding) into a high-voltage current for ignition purposes, as will be more fully explained farther on.

**The strength of an electro-magnet** is dependent upon the number of ampere **turns**[1] of wire on the coil. The number of amperes flowing through the turns, multiplied by the number of turns, will determine the magnetic strength of the core.

For instance, if one ampere is carried around the core for 100 turns (100 ampere turns), it will equal in effect ten amperes flowing through ten turns. The effect of the turns decreases as the distance from the core increases. A rule is to wind wire 1 inch deep on a core of about 1 inch in diameter.

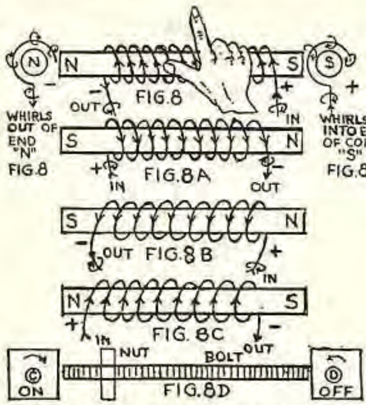
**Polarity of electro-magnets:** In Fig. 8, the (+) current is going in at the right-hand end of the coil, and lines-of-force around the wire would whirl **into** (S) end of the core and then pass through the core and come **out** at the other end of the core (N), thence around the core and coil outside to (S) end again.

The end *into* which the lines whirl would be (S) pole end, and the end they whirl *out* would be (N) pole end.

In Fig. **8A**, the (+) current is going into the coil at the opposite end from that of Fig. 8. Therefore the magnetic lines-of-force would whirl *in* at end (S) and *out* at end (N). Thus the polarity would be reversed from what it was in Fig. 8, owing to the electric current flowing in the wire in an opposite direction.

In Fig. **8B**, the electric current enters the wire coil at the same end as in Fig. 8, but the wire is wound *under* instead of *over*. Thus if we follow the magnetic whirl in a right-hand direction where it enters wire (+), we note that the whirl is *out* of

[1] "Ampere turn" is one turn of a winding through which a current of 1 ampere flows.




Figs. 8, 8A, 8B, 8C, and 8D. Explaining how the direction of the current through the wire and the direction of the wire wound on the iron core produces different polarities of an electro-magnet.

core instead of *into* core; thus it is (N) pole at the right-hand end and (S) pole at the left-hand end.

In Fig. 8C, the electric current enters the wire coil at the same end as in Fig. 8A, but the wire is wound *over* instead of *under;* thus the magnetic lines-of-force around the wire at the left end whirl out of core and the left end is (N) and the right end (S).

A good way to remember the direction of the whirl of the lines-of-force around a wire, when the current is flowing in the wire, is to think of a rod with right-hand threads on it (Fig. 8D). If, for example, the current enters *in* the end of rod where nut (C) would be screwed on, the nut would turn in a right-hand or clockwise direction with the flow of current. If, however, you were looking at the end where the nut is screwed off, and where the current came *out*, the nut (D) would still be turning clockwise with the flow of current, but the nut would be turning counter-clockwise when looking at that end.

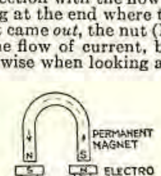



Fig. 9

**The difference between a permanent magnet and an electro-magnet** is shown in Fig. 9. Note in this instance that the electro-magnet is being used to induce magnetism into a permanent steel magnet. Note that the flow of magnetic lines-of-force is out (N) pole into (S) pole. The permanent magnet of hard steel will retain its induced magnetism, whereas the soft-iron core of the electro-magnet will lose its magnetism when the electric current flow is open. This is an important point to remember in connection with the principle of the action of a coil.

**The principle of the ignition coil, magneto, and generator is based on electromagnetism and electromagnetic induction.**

How are we going to apply this information to the production of a high electromotive force in an ignition coil, and to the generating of electric current in a magneto, and the generating of electric current in a dynamo or generator?

The reverse-current cut-out, the electromagnetic vibrator type of generator regulator, in fact very nearly all parts of the electric system on a car, have their fundamental principle based on magnetism in some form, especially electromagnetic induction.

### Electromagnetic Induction

Electromagnetic induction refers to **an electromotive force, or electrical pressure, set up by induction** at the terminals of a conductor, such as a wire, which is moved in such a way as to cut across the magnetic lines-of-force, or magnetic field, at right angles.[1]

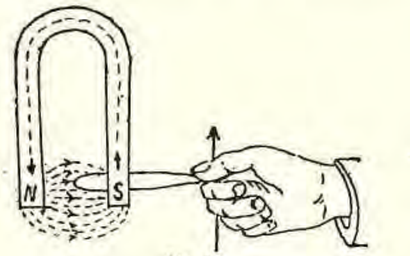



Fig. 10

If the wire is a closed loop the electromotive force (voltage pressure) produced in the wire loop will cause a current of electricity to flow in the circuit. Thus we can produce electric current in a wire by merely moving it across a magnetic field, as in Fig. 10.

How and why the electricity is in the wire we do not know, but if electromotive force is applied to the electricity in the wire, and the wire forms a circuit, the electricity will be made to move.

Copper wire offers less resistance to the flow of electric current, therefore it is used most. Electric currents thus produced are termed **induction currents,** and the principle or method is termed **electromagnetic induction.**

The question then is, How can the e.m.f. be obtained, in order to cause the electricity to move?

**The e.m.f. induced in a wire by a magnet** is one method of producing electric current in a wire.

For example, if a wire is quickly moved down, so that it will cut the magnetic lines-of-force which flow from the (N) to (S) pole of magnets, a momen-

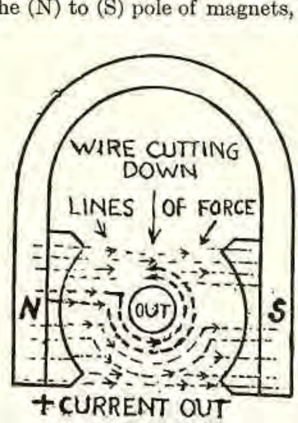



Fig. 10A

[1] We might also say that whenever a loop of wire forming a closed circuit is placed in a magnetic field, an e.m.f. will be generated in the wire, causing electric current to flow whenever the strength of the magnetic field changes.

tary current will flow in the wire (as in Fig. 10A) which is in a direction *out* of the wire or toward the surface of the paper. This is because the lines-of-force, when forced *down*, will act like rubber bands, i.e., first stretch, then loosen from the (S) pole (the weakest point), and tend to wrap around the wire and whirl counter-clockwise.

These magnetic whirls of lines-of-force around the wire, which are taken from the magnetic field of the magnets flowing from (N) to (S) induce an e.m.f. in the wire which causes electric current to flow which was already in the wire but not in motion.

This momentarily induced e.m.f. is greatest when the wire is moved so that it will cut the magnetic lines-of-force at right angles, or across the magnetic field, the position the wire is cutting, as shown in the illustrations.

An e.m.f. would also be induced in the wire when moved, even though it did not form a closed circuit, and the e.m.f. would be at the terminals the same as on the terminals of a battery on open circuit.

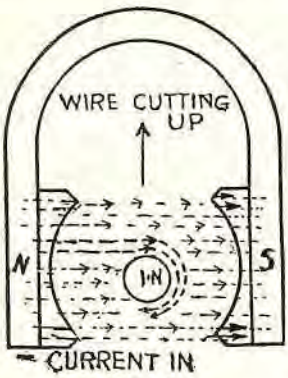


Fig. 10B

When the wire is quickly moved up, as in Fig. 10B, the magnetic lines-of-force will tend to circle around the wire in an opposite direction to that when moving down. Therefore another momentary current will flow *into* the wire. Thus if the wire is moved up and down rapidly, the flow of current in the wire would be first in one direction, then in another direction, or **alternating** in its flow.

### Principle of Low-Tension Coil

**The e.m.f.[1] induced in a wire of an electro-magnet** is another method of causing electric current to flow in a wire. Instead of moving a wire so as to cut the lines-of-force, the lines-of-force, or magnetic field, moves and cuts the wires.

For instance, take an electro-magnet (Fig. 11), which would represent a primary coil, also called a "self-induction coil," or "low-tension coil," which is used to produce a spark or flash inside of an engine cylinder or in the combustion chamber, when the circuit is suddenly opened. This primary or low-tension coil consists of a core made of a bundle of soft iron wires, around which is wrapped about 200 turns and several layers of No. 19 to 24 B. & S. gauge copper insulated wire. When the circuit is closed, the lines-of-force start to build up, and in doing so they spring from the center of the wire and cut the wire up.

[1] If it is difficult to understand the meaning of e.m.f., just consider it as voltage or pressure, or the electric force which moves electric current or causes electricity to move in a wire.

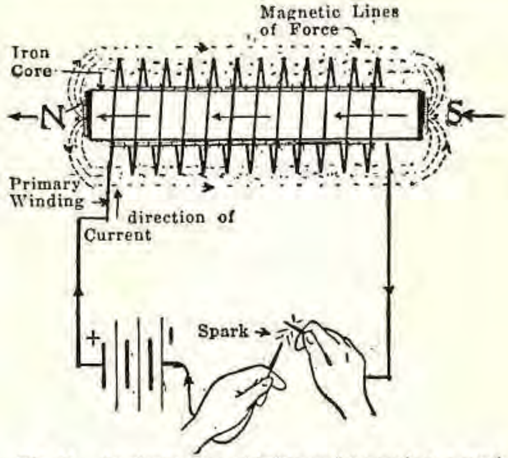


Fig. 11. An electro-magnet being used to produce a spark, by the circuit being opened, thus causing the magnetic lines-of-force to collapse into the core. This generates a self-induced e.m.f. in wires caused by the collapsing lines-of-force cutting the turns of wires. Such a coil is termed a "low-tension coil," or "self-induction coil," or "primary coil."

The **principle or action** is the same as that shown in Fig. 10A, where the wire was moved down to cut the lines. Therefore this electromagnetic induction or self-induction would tend to cause the lines-of-force to whirl around the wire in a counter-clockwise rotation, causing the generated e.m.f. to buck or oppose the battery e.m.f., called "counter-electromotive force." In other words, we have two electromotive forces to deal with in the same wire: the induced e.m.f. produced by the magnetic whirls caused by current from the battery passing through the wire, and a generated e.m.f., caused by these same magnetic whirls, cutting the coils of wires as they build up around the coil.

The generated self-induced e.m.f. or counter-e.m.f., however, is only momentary, as the steady e.m.f. from the battery will force its current through, and in a brief interval of time the lines-of-force around the wires will have been established at their normal value.

The point to remember in connection with the above is that **when the circuit is closed, the e.m.f. or voltage would not be as great as when the circuit is opened,** principally due to the fact that the action of magnetizing the core when the circuit is closed is slower (due to this counter-electromotive force just mentioned) than the action of demagnetizing the core when the circuit is opened.

The question then is, What effect does the magnetizing and demagnetizing of the core have on producing a higher voltage (e.m.f.) in the wires which will cause a spark or flash at the wires when suddenly separated? This is answered as follows:

The amount of voltage (e.m.f.) and of current induced in a coil depends upon three factors:

1. **The strength of the magnetic field** (number of lines-of-force per unit area).

2. **The speed or rate at which the lines-of-force cut** through the windings or coil.

3. **The number of turns of the wires** that are on the coil into which the e.m.f. is to be induced.

When the circuit was closed, the lines-of-force were established around the turns of wires, which pass outside, from (N) to (S) of the core and inside (S) to (N), thus forming a magnetic circuit around the turns of wires (see Fig. 11).

We can greatly increase the rate of speed with which the lines-of-force will cut the turns of wires if the battery circuit is opened, so that the iron core will become demagnetized and thus permit the lines-of-force to die down or collapse more quickly into the iron core.

Thus, when the lines-of-force collapse, they cut the turns of wires at a much more rapid rate than when they were built up; this "self-induced" action causes a greatly increased e.m.f. to be generated in the turns of wires, and is the basic principle of all ignition coils.

The third factor mentioned above, relative to the turns of wires on the coil, also assists in increasing the e.m.f.

For instance, when a conductor is cut by the lines-of-force at the rate of 100,000,000 per second, a pressure of 1 volt is set up at the terminals.

If a single straight wire is cut by a certain number of lines-of-force per second, causing a certain pressure, say 1 volt, and if three wires joined in series are cut by the same number of lines-of-force as the single wire, three times the pressure or 3 volts would be the result. Therefore where there are many turns of wire in a coil and several layers of wire, the induced pressure will be greatly increased, as very nearly all of the lines-of-force produced by each turn of the coil will cut all of the other turns, and the total number of lines-of-force are therefore greatly increased.

From this we learn that when the circuit is opened on a primary coil, we have increased the number of lines-of-force and also the rate of speed at which the lines-of-force cut the turns of wires as they collapse, greatly increasing the "self-induced" pressure in the wires.

Furthermore, the "self-induced" generated e.m.f. in the turns of wires, when the circuit is opened, is in the same direction as the original battery current was. This current from the battery through the primary winding, when opened, did not instantly stop flowing, and with the high "self-induced" e.m.f. flowing in the same direction, the result was a very bright flashy spark at the points of the break, as in Fig. 11. This is what is often seen when a flash follows from the switch-blades when a switch connected with a motor or generator is opened.[1]

This principle might be compared to holding your hand over a water nozzle when water is flowing. At the instant of release, the pressure is greater, due to momentum, although the original pressure which set the water in motion was several times less.

The "self-induced" e.m.f. or voltage (pressure) in a low-tension coil in series with the battery voltage may reach from 150 to 250 volts, owing to the number of turns of wires, length of wire, and strength of current in the wires to build up the original lines-of-force.

### Low-Tension Coil Ignition "Make-and-Break" System

**The low-tension coil,** described in the preceding pages and illustrated in Fig. 11, was formerly used with early ignition systems, such as the "make-and-break" igniter shown in Fig. 12. The principle is clearly shown.

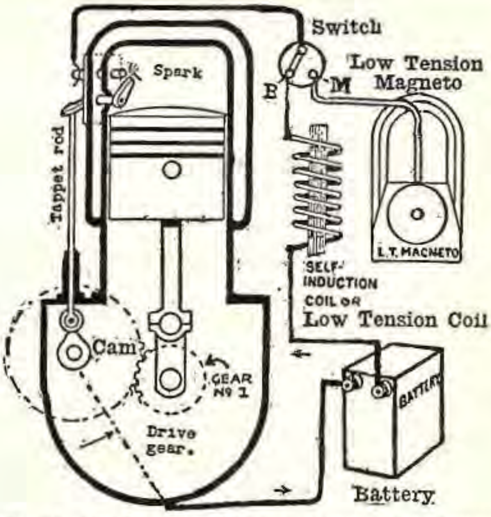



Fig. 12. A "make-and-break" ignition system using a battery (chemical generator) as a source of electric supply. The current is intensified, or the voltage raised, so as to produce a spark at the break of the igniter points.

Although the low-tension coil ignition system is not now used for ignition on automobile engines, it is very important that the principle be studied carefully, as the low-tension or primary coil is used on the cores of high-tension coils and magneto armatures, but with another winding over the primary, called the secondary winding. Therefore the primary winding is the foundation of high-tension coil and magneto ignition.

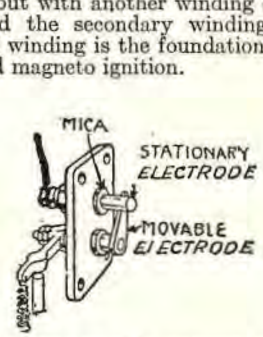



Fig. 13. A clearer view of the make-and-break igniter.

**The make-and-break igniter** (Figs. 12 and 13) consists of a stationary and a movable electrode insulated from each other and connected with a low-tension coil.

**The "movable electrode"** is operated by a cam arrangement, exactly as the exhaust valve of the engine is operated. As the spark is needed only once during two revolutions of the crank shaft, the cam is attached to the half-time shaft, and operates the electrode by a rod called a tappet rod, in a manner similar to that in which the valves are operated on a side-valve engine.

**The "stationary electrode"** is insulated from the cylinder with mica, and one wire of the circuit is connected to it. The "movable electrode" is operated by a cam, which is in contact with the current from the grounded wire of the battery and which allows the current to pass from it to the metal of the cylinder.

**When the two points are in contact,** the current flows from the positive pole of the battery by a wire to the low-tension coil, through a switch (B), to

[1] This is why a condenser is used in connection with a high-tension coil, as will be explained farther on. While the flashy spark is desirable on a low-tension ignition coil, as in Fig. 11, or as used with a "make-and-break" low-tension ignition system, it is very undesirable at contact points in connection with a high-tension system.

the stationary electrode, then to the movable, because the two are in contact, and back to the battery by the ground.

**When the two electrodes are separated** by the cam acting on the movable one, the circuit is broken, and a spark is formed between them.

Fig. 12 shows the make-and-break ignition system connected with a low-tension coil and battery through the (**B**) side of the switch and with a low-tension magneto when the switch-blade is on the (**M**) side of the switch.

**When the battery and low-tension coil are used,** the magneto is cut out entirely in this example.

### Purpose of Ignition

There are three things required before a gasoline engine will run. These are absolutely essential.

First, it is necessary to have a mixture of gasoline and air in the engine cylinders.

Second, this mixture must be compressed.

Third, there must be a spark to set fire to the compressed mixture at the correct time.

In order thoroughly to understand the principles upon which the various ignition systems are built up, and how these systems are operated and maintained, it is well to start at the beginning.

**The original and first method for igniting** the gas in a gasoline engine was by means of a **"hot tube"** or flame, but this method being now obsolete, we shall deal only with the electric ignition.

**The ignition systems used on automobile engines** at the present time are all electrical systems giving an electric spark which passes in the cylinder of the engine and sets fire to the compressed mixture. As you will be dealing with electricity and electrical apparatus in these systems, the first thing to know is how electricity acts and how you can make it do work for you, all of which has now been explained and should be studied carefully.

### Ignition Systems

**There are two general systems of ignition** used for automobile engines: the "low-tension system" and the "high-tension system"; the source of electric supply being either by "chemical" means, as dry cells, or a storage battery; or "mechanical" means, as a magneto or dynamo (also called a generator). (The magneto is explained farther on.)

The word **"tension"** means pressure or voltage; high tension being high voltage, and low tension low voltage.

**The low-tension system of ignition** is not now used on automobiles. The low-tension system was formerly used to a great extent on boat engines, and is still used to a great extent on stationary engines.

The low-tension system uses a low-tension single-wound primary coil as in Fig. 11, page 184, and its source of electric supply can be a dry or storage battery, or dynamo. Low-tension magnetos are also used, but the coil is wound on the armature (treated under "Low-Tension Magnetos.")

**The high-tension system of ignition** is the approved system now in use on very nearly all makes of cars. The high-tension system may be either by a high-tension coil and a battery; a high-tension coil and low-tension magneto; a high-tension coil and dynamo in connection with a battery, or by a high-tension "magneto" alone.

Thus we have four principles underlying the production of a spark in a gasoline engine, as follows:

1. **Low-tension coil.**
2. **Low-tension magneto.**
3. **High-tension coil.**
4. **High-tension magneto.**

These four fundamental principles are used either singly or in combination. Thus when the reader masters these four principles he will understand all ignition systems, although the construction may vary in different makes.

In this instruction and in Instruction No. 18, we deal only with coil ignition, both low-tension and high-tension. Low-tension and high-tension magnetos will be treated farther on.

**When a low-tension magneto is used with a make-and-break igniter** (Fig. 12), the engine is usually started with the battery and low-tension coil, by turning a switch-blade on the (**B**) side of the switch.

After the engine is started, the switch-blade is turned to the (**M**) side and the low-tension (single-wound armature) magneto supplies the current, which, by the way, is alternating current. The low-tension coil is not used with the magneto, as the armature of the magneto, which has a single primary winding, serves in place of the low-tension coil.

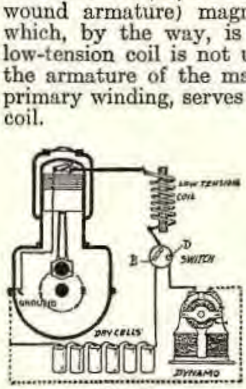



Fig. 14

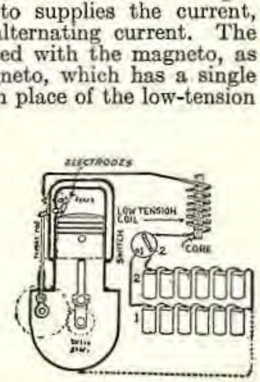



Fig. 15

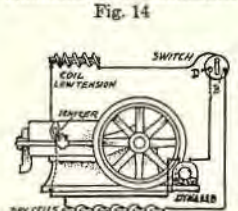



Fig. 16

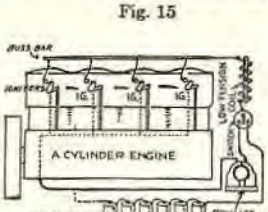



Fig. 17

Fig. 14. Make-and-break ignition, using dry cells to start on when the switch is on the (B) side; after the engine is started the switch is placed on the (D) side and a direct-current dynamo supplies the electric current and the dry cells are cut out of service. The low-tension coil is used with either the dry cells or the dynamo.

Fig. 15. Make-and-break ignition using two sets of dry cells. Set No. 1 is used when the switch-blade is on 1, and No. 2 set is used when the switch-blade is on side 2. Low-tension coil is used.

Fig. 16. Make-and-break ignition on a stationary engine. This principle is similar to that shown in Fig. 14.

Fig. 17. Make-and-break ignition on a four-cylinder engine. The principle is similar to that shown in Fig. 16. Note that the igniters are operated by tappet rods on the side by cams on a cam shaft, similar to a cam shaft operating the valves. The shaft with the cams on are driven by the gears, as in Fig. 12.

### Low-Tension Coil Ignition "Wipe Spark" System

The wipe spark igniter, Fig. 18, is another form of ignition used considerably on large slow-speed stationary gasoline engines.

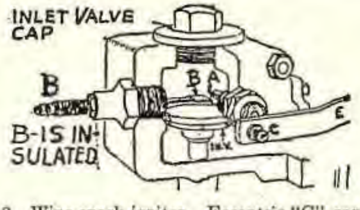



Fig. 18. Wipe-spark igniter. Eccentric "C" can be shifted forward to advance and backward to retard.

Wipe spark ignition is similar to the "Make and Break" in every respect, except that it makes a wiping and rotary motion as the electrode (A) of the igniter revolves; being operated by an eccentric rod (E) from the cam gear.

The other electrode (B) is stationary and looks very much like a spark plug. This type of ignition is never used on the automobile; but is here shown so that the reader can master the elementary principles of the different ignition systems. This system is used mostly on stationary engines.

### Remarks On Low-Tension Ignition

**The true low-tension ignition system** would consist of a make-and-break igniter, as shown in Fig. 13, page 185, or a wipe-spark igniter **arrangement,** shown in Fig. 18.

**The make-and-break igniter** was at one time used on automobile engines, and is now used on many stationary and marine engines. It is practically obsolete for automobile use.

**The wipe-spark igniter** was never used on automobile engines, but was and is now used on many stationary engines.

**The low-tension coil** is used with both igniters when a direct-current source is used, as a battery or a dynamo, as in Figs. 12 to 17.

**Where the low-tension magneto, which delivers an "alternating" current, is used,** the low-tension coil is not used, because the primary winding on the armature of the low-tension magneto serves in place of the low-tension coil, and the magneto current is alternating in flow, that is, first in one direction, then in another, as explained on pages 250, 253, and 254.

In Fig. 12, a low-tension system of ignition is shown, whereby a storage battery is used for a source of direct electric current for starting, by the switch lever being placed on the "B" side of the switch. After the engine is started, the switch lever is placed on the "M" side of the switch; thus the battery and low-tension coil are cut out of service and the low-tension magneto (explained farther on) takes the place of both the battery and the low-tension coil.

**An oscillating type of low-tension magneto ignition system,** using a make-and-break igniter and arranged different from that mentioned above, is shown on page 255 (see Fig. 48).

**A magnetic plug, instead of an igniter,** could also be used for a low-tension ignition system, as shown in Figs. 49, 50, and 51 (page 255).

**The Ford magneto** (pages 248 and 249) **is also a low-tension magneto, but is not a low-tension ignition system,** because the low-tension current of the magneto is transformed to a high-tension current by means of a high-tension coil, all of which will be explained farther on.

**Where a dynamo, which delivers a "direct" current of low-tension is used,** as in Figs. 14, 16, and 17, note that the low-tension coil is used in connection with the batteries or with the dynamo, because the dynamo delivers a direct current flowing in one direction and at a low voltage, or approximately the same voltage as the batteries and thus merely acts as a mechanical source of electric supply instead of a chemical source.

**Disadvantage of the true low-tension ignition system,** using a make-and-break igniter and a low-tension coil: It would appear that this system would be a very simple and effective ignition system, as it requires less care in wiring than a high-tension or jump-spark system, but while this feature may predominate, there are several disadvantages.

For example, the word "make-and-break" refers to the igniter as shown in Figs. 12 and 13 (page 185). The movable electrode first makes contact with the stationary electrode, and after "making" contact, it then "breaks" the contact (due to the action of the tappet rod); thus the derivation of the name, "make-and-break."

On each of the electrodes there are platinum points. When the contact "breaks," a spark occurs just as it did as shown in Fig. 11 (page 184). This spark soon pits the points, burns them off rapidly, and they often stick. Platinum is used because it withstands this action better than any other metal, but even so, where the mechanical arrangement is all within the cylinder, exposed to the combustion heat, it is a difficult matter to keep the points from pitting.

Then another difficulty was in insulating the stationary spark point or electrode, and making an easy working but tight joint for the movable electrode.

Still another disadvantage was in the great advance and retard range of ignition as required on **variable-speed automobile engines,** where the engine varies in speed from 200 to 1,500 r.p.m. This action is limited with the make-and-break system.

**Where a slow, constant-speed engine** is used, this system serves fairly well.

**The low-tension ignition systems are not now used on automobile engines,** but were formerly usea in the early days of motoring.

**The reason for explaining these early systems of ignition** is the fact that the **underlying principles** of the more modern systems are founded upon the principles of these early days. Therefore it is essential that they be mastered first in order more clearly to understand the modern systems treated farther on.

**The next subject will be that of a high-tension coil ignition system using a magnetic vibrator.** This system is now seldom used, but must be understood before the modern battery and coil-ignition system can be thoroughly understood.

# INSTRUCTION No. 18

## HIGH-TENSION COIL IGNITION: Vibrator Type Coil; Condenser Principle; Master Vibrator Coil; Distributor Principle

### The Jump Spark

The voltage produced by a low-tension coil as used for the "make-and-break" ignition system, explained on page 185, would not have enough pressure to jump across the gap of a spark plug. It must therefore be intensified (or the pressure must be increased) still more.

Where simple low-tension coils are used for the make-and-break system, coils of another kind, called "high-tension induction coils," are used to intensify or transform the current to a high voltage in order to force the current to jump across the open space or gap of a spark-plug point (Fig. 1). Therefore it is called the "jump spark" or "high tension" (meaning high pressure).

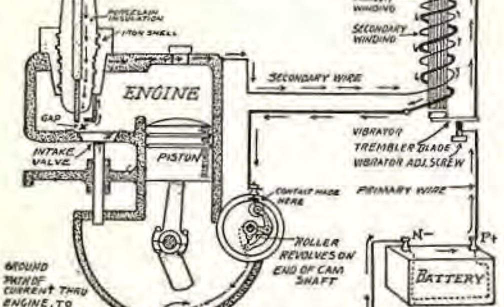



Fig. 1. Relation of the spark plug to the cylinder and to the commutator.

**A spark plug** (Fig. 1) is screwed into the cylinder of the engine, and when the piston is in the right position to receive a spark, a high-tension current of electricity is sent along the metal center rod (called the "electrode") of the spark plug and across the small air-gap (X) at the bottom and into the outer sleeve or iron shell of the spark plug which screws into the cylinder.

Although this air gap (X) is only about 1/64" to 1/32" wide, the air in the gap offers such a tremendous resistance to the current that it requires in the neighborhood of 5,000 or more volts' pressure to force a very small quantity of current across the gap. In other words, the current must be of such high pressure that it will jump across a space between two points, forming a spark as it passes.

**The amperage of current** across this gap is so small a quantity that it cannot be measured with a meter, but is measured with an instrument called an **oscillograph** and the current is measured in terms of **milliamperes** (one-thousandth of an ampere).

To give an idea of the quantity represented by a milliampere, suppose we have a high-tension coil with 5 amperes at 6 volts pressure flowing through the primary winding and the voltage at the secondary terminal or gap is 10,000 volts, what would be the amperage of the secondary?

5 amp.×6 volts=30 watts. 30/10,000=3/1,000 part of an ampere.

**K-W ignition coils** are constructed to operate on a current consumption in the primary from the battery of 1 to 1 2/10 amperes at 6 to 8 volts. The "self-induced" voltage in the primary has a sufficient number of turns to give 145 volts when the circuit is broken. *Voltage at secondary is 6,000 to 10,000 volts, depending on the number of turns. High-tension coils which give a ½" spark, in the open air, require about 10,000 volts at the secondary, and if the coil is of a vibrator type, the voltage can be still further increased when the spring tension on the vibrator spring is increased, so that the coil will draw a heavier current (amperage). This, however, should not be made a practice, inasmuch as the insulation is not designed to stand current values above those recommended by the manufacturer. Always adjust according to instructions. See Index for Ford vibrator coil adjustments.

**Note that the battery or primary current does not jump the spark-plug gap.** It is used to magnetize the iron core; and when the circuit is opened and this core is suddenly demagnetized, a high voltage is induced from the primary winding into the secondary winding. This is due to approximately 12,000 turns of fine wire used in the secondary winding, wound over the primary winding.

### Construction of a High-Tension Vibrator Coil

**The high-tension coil** (also called a "jump-spark coil," "secondary coil," "transformer coil," etc.) differs from the low-tension coil in that there are two windings on the coil core; one, a coarse wire winding, called the **primary** winding, just the same as in a low-tension coil and the other, a **secondary** fine wire winding which is wrapped over the primary winding, both windings being insulated.

*There are usually about 200 to 250 turns of No. 20 to 18 B. & S. gauge insulated copper wire for the primary winding, and about 13,000 to 18,000 turns of very fine No. 38 B. & S. gauge enameled silk-covered thin insulated copper wire in the secondary winding, so that the layers can be close together and with as many turns as possible. The ratio of the primary winding to secondary is about 1 to 60.

The windings can be in either direction. They are usually in the same direction, because it is more practical from a manufacturing standpoint.

The original and early form of a high-tension coil ignition system consisted of the parts as shown in Fig. 2. This system is termed a **"magnetic vibrator-coil"** ignition system.

**A commutator,** which is nothing more than a revolving switch, has a roller (R) connected to an arm which is connected to the cam shaft. This roller, therefore, makes one revolution while the crank shaft makes two revolutions. Thus on a

*Also applies to the "non-vibrating" type coil.

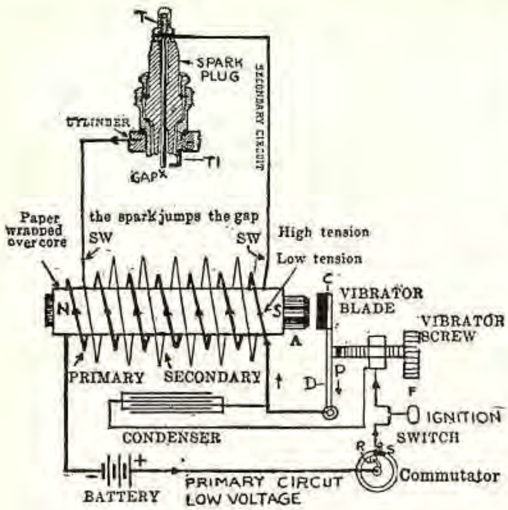



Fig. 2. A high-tension coil using a magnetic vibrator.

single-cylinder engine, there would be one insulated commutator contact segment (S), and one spark would occur during two revolutions of the crank shaft.

**Primary circuit:** The current flows from the positive terminal (+) of the battery, through the roller (R) and segment (S), through the ignition switch, vibrator screw and points (P), through the trembler or vibrator blade (D), through the primary winding wrapped around the coil iron core, to the (−) terminal of the battery.

If the roller (R) is on contact with the commutator segment (S), and the ignition switch is "on," the current would then pass through the entire primary circuit.

The moment the primary circuit is completed, the vibrator blade (trembler blade—D) is drawn to the soft iron core (A), because the soft iron core becomes magnetized the moment the primary circuit is completed.

When the vibrator blade (D) is drawn to the soft iron core (A), the primary circuit is opened between the platinum points (P) on the vibrator blade and on the vibrator screw. Thereupon the core loses its magnetism and the vibrator blade is released; on account of its spring tension, it rebounds, closing the primary circuit again at the point (P).

**This action takes place** repeatedly and the blade vibrates back and forth, so long as the circuit is closed by the roller (R) of the commutator being on contact with the segment (S).

The moment the roller (R) leaves contact with the segment (S), the coil is out of action. Thus we have what is termed a "magnetic" method of making and breaking the primary circuit, instead of a "mechanical" method. The mechanical method, however, is a popular method and will be explained farther on.

**Secondary circuit:** When the primary circuit is opened and closed by the magnetism of the core (A), which is produced by the current flowing through the primary winding, a very high electromotive force is induced into the secondary winding, which is wrapped around the primary winding. This induced e.m.f. in the secondary winding causes current of a very high voltage to flow in the secondary winding, of sufficient intensity to jump a gap (X) of about 1/32″ at the points of the spark plug, which is screwed into the engine cylinder and to cause a spark which ignites the compressed gas.

**To develop a high voltage** (e.m.f.) at the secondary terminals it is necessary that a very large number of turns be used. For instance, if the primary winding consisted, say, of ten turns of wire and the secondary consisted of one hundred turns, the "induced" voltage in the secondary would be ten times as high as that in the primary, but the current value (amperage) in the secondary would be ten times less than in the primary.

**The secondary winding is insulated wire,** as is also the primary winding. One end of the secondary winding leads to the metal rod connection of the spark plug which is insulated from the engine by porcelain, then passes through it, jumps the gap (X) to the metal point of the spark-plug shell, which is an iron shell screwed into the cylinder, and then passes through the frame of the engine back to the other end of the secondary winding. As the vibrator on the coil vibrates, a "succession of sparks" is produced at the spark-plug gap (X). Bear in mind, however, that there is but one spark produced at each break of the contact points (P). Sometimes the secondary and primary windings are connected together inside of the coil, and one wire leads from both, to a ground connection on the engine. But it should be noted that the secondary circuit and the primary circuit are two independent circuits. Of course the secondary circuit, which is of a very high voltage, is dependent upon the primary circuit, not by means of metallic connections, but only by induction, as will be explained farther on.

The magnetic vibrator blade (D) (Fig. 2), as previously stated, vibrates rapidly and opens and closes the circuit a great number of times, during the time the commutator roller is in contact with the segment (S).

This is the principle of the **Ford ignition coil,** and by adjusting the tension of the vibrator, by screwing the adjusting screw in or out, the number of times it opens and closes the primary circuit can be regulated. The more times it opens and closes the primary circuit during a given period of time, the higher the voltage (see Index under "Ford ignition coil").

**Time of spark:** The commutator roller is set so that it makes contact with the segment (S) when the piston is at the top, or slightly over the top, of the compression stroke. This is termed "ignition timing" and is treated farther on.

**Condenser:** A condenser is always used with high-tension coils, by placing it across the interrupter points, to prevent a spark at the interrupter points, which would otherwise occur as shown in Fig. 11, page 184, if a condenser were not used. The condenser is not shown in Fig. 1, but is shown in Fig. 3. The condenser is fully explained farther on.

How and why the **high tension, or voltage is induced into the secondary winding** of sufficient intensity to jump the spark-plug gap (X) is explained in the text following.

Note. In Fig. 1, the circuit is slightly different from that in Fig. 2. The principle is the same. Fig. 1 explains the relation of the spark plug to the cylinder and also how the current flows through the engine frame. The connections from the battery to the coil, etc., could be as in Fig. 1 or 2. The connections shown in Fig. 2, however, are in conformity with the general practice.

Note that, as shown in Fig. 2, the (−) terminal of the battery is usually grounded. The secondary and primary windings are also usually grounded together. For instance, if the left ends of both primary and secondary winding were connected together in the coil and then grounded, and if the (−) terminal of the battery was grounded, the circuit would be a "grounded" system instead of an "insulated" system, as shown in Fig. 2.

### Principle of a High-Tension Coil

How a high-tension current is induced in the secondary winding can best be understood after first reading the explanation of the principle of the low-tension coil on pages 182, 184; since the self-induction action of the primary winding is the base for building up the high-tension voltage in the secondary, by what is termed **mutual-induction.**

The difference between "self-induction" and "mutual-induction" is that self-inductance is produced in the same coil in which the current was allowed to flow, as the primary winding. Mutual inductance is where an e.m.f. or current is induced into a separate coil of wire, as in the secondary winding.

We learned on page 184 that the greater the number of lines-of-force and the greater the rate of speed at which the lines cut the turns of wires, the greater the induced e.m.f. for voltage.

Therefore, as we have several thousand turns of wire in the secondary and a few hundred turns of wire in the primary, we thus have a greater number of cuttings of lines-of-force, because very nearly all the magnetic lines-of-force produced by each turn in the primary will cut all the turns in the secondary coil, hence the total number of cuttings of lines-of-force will be greatly increased. The lines-of-force will cut the turns of wires at a greater rate of speed when contact is broken than when contact is made, thus the voltage developed at the "break" of the circuit is enormously greater than at the "make." This is explained as follows:

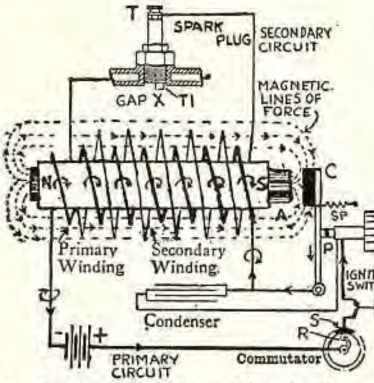



Fig. 3. Showing how the lines-of-force build up around the windings when contact is closed, and how they collapse and cut the turns of wire when the circuit is opened.

**When the primary circuit is closed** by the commutator (Fig. 3), the primary circuit is completed through the points (P) on the vibrator screw and blade (C), and the lines-of-force spring from the primary turns of the wires, and a magnetic field is built up around the wires, as explained on page 181. This magnetic field in building-up forms an electro-magnet, with lines-of-force flowing from (N) to (S), therefore these lines must necessarily cut (*up*) through the turns of wires on the iron core as they build up. In doing so, they generate an induced e.m.f. which has a tendency to create a counter-voltage, or counter-electromotive force, which bucks or opposes the incoming current from the battery (see page 184). Consequently the magnetic field is momentarily retarded and builds up with comparative slowness, and thus we do not obtain a very high rate of speed of the lines-of-force cutting the wires during the building-up process.

In building up this field, the lines-of-force cut through the secondary as well as through the primary. In doing so, an e.m.f. is generated in the secondary which flows in an opposite direction, due to the movement-up of the lines-of-force, which is an operation similar to that of moving a wire *down* in a magnetic field (Fig. 10A, page 183).

The induced voltage in the secondary is thus not great enough to jump the spark-plug gap (X). Therefore we must make use of another action. This is accomplished by breaking, or interrupting or opening the primary circuit. In other words, the moment the lines-of-force build-up, the core (A) becomes an electro-magnet and draws the interrupter blade (C) to it, thus interrupting, or opening, the primary circuit.

**When the primary circuit is opened or interrupted quickly,** an entirely different action takes place. The magnetic field of lines-of-force, which have by this time built-up around both windings and reached maximum value, collapse or recede into the iron core. In doing so, the lines-of-force cut at a great deal more rapid rate than when being built up. Therefore, as the lines-of-force collapse or recede to the iron core with great rapidity, they cut the secondary turns of wire in an opposite direction to that in which they did so in building-up, and the current then flows in the same direction as the dying primary circuit. They thus assist in causing self-induction[1] in both the secondary and primary circuits, which generates a very high voltage, but still not as high as necessary.

Bear in mind that the primary circuit is now open. Thus we are dealing with "self-induced" current, produced by the lines-of-force cutting the turns of wires as they collapse or recede to the core.

The point to be noted is, that if this iron core is demagnetized, so that the lines-of-force can pass back to it at a greater speed, the turns of the wires would be cut at a greater rate, correspondingly increasing the induced e.m.f. in the turns of the wires.

Owing to the fact that this primary circuit is now carrying a self-induced current, caused by the line cutting its own turns of the wires, this prevents the rapid demagnetization of the iron core, and a heavy spark will occur at the interrupter points (P), just as it did on the break of the low-tension coil (Fig. 11, page 184).

**The condenser assists in demagnetizing the core.** Therefore, if we could absorb this spark at the interrupter points (which comes from the self-induced current in the primary winding) in some way, and thus cause a more rapid demagnetization of the iron core, the lines-of-force would then pass back to the iron core more quickly and would thus cut the secondary turns of wires at a still greater rate of speed. In other words, it is the secondary winding into which we wish to induce a very high voltage. Therefore, by placing in the coil a **condenser** which

[1] **"Self-induction"** means induction produced in a circuit at the moment of starting or stopping the currents flowing therein, by induction of the current on itself. For instance, when starting current to flow through the primary circuit, if the circuit is closed, lines-of-force spring out from the center of the wire through which the current is flowing, and thus produce a temporary "self-induced" current in an opposite direction, thus momentarily retarding the building-up of the lines-of-force.

When stopping or opening the circuit of the primary, the lines-of-force collapse into the core and, in doing so, cut in an opposite direction, or in the same direction as that in which the battery current was flowing.

is connected across the interrupter points (P, Fig. 3), we can absorb or suppress the spark across the interrupter points (P) of the primary circuit and stop the flow of self-induced current which is still trying to build up lines-of-force in the core, and thus aid the primary current to fall to zero value more quickly. Hence the reason for placing the condenser (Fig. 3) across interrupter points (P) of the primary circuit.

### Purpose of the Condenser

1. To **absorb** the self-induced current of the primary, thereby allowing the magnetic field to collapse with the greatest possible speed, and also eliminating the spark at the contact points.

2. To **discharge** in an oscillating (alternating) manner back and forth into the primary circuit, thus completely neutralizing or demagnetizing the iron core and thereby preparing it for repeated action.

### Condenser Construction

**The condenser** consists of a series of sheets of tinfoil separated from each other by a good insulator, such as mica, or several sheets of wax paper.[1] These

Fig. 4

Fig. 4A

are built up in a pile, somewhat as shown in Fig. 4. The even-numbered sheets of tinfoil, 2-4-6, etc., are connected, making one terminal (T) of the condenser. The odd-numbered sheets, 1-3-5, etc., are likewise connected, making the second terminal (T1) of the condenser. There is no connection between the two series of sheets. These connections are then made across the primary circuit at the contact points, as shown in Fig. 7.

### Condenser Action

**With contact points (P) closed** (Fig. 5), the current flows as shown by arrows through the primary winding. The condenser and secondary winding are not considered, as they are inactive. A current of low value is induced in the secondary in a direction opposite to that of the primary-current flow.

**With contact points (P) open** (Fig. 6), the condenser is charging. The spark of highest value is now at the secondary terminals. Note that when points (P) open, the magnetic field of lines-of-force collapse, and the induced current in the secondary is then flowing in the same direction as that in the primary. This spark is greatest just as the points open, because the condenser absorbs the self-induced current of the primary and thereby stops its flow, thus preventing it building up lines-of-force in the core. On the other hand, it neutralizes the core, and also eliminates any flow of current or of sparking at the contact points.

[1] **Never attempt to open a condenser,** as this will destroy it. In the manufacturing process the tinfoil and insulating sheets, with the aid of an insulating compound, are pressed closely together under heat, with high pressure (Fig. 4A). Obtain a new one when necessary.

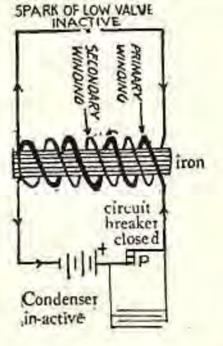


Fig. 5

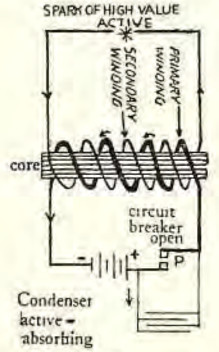


Fig. 6

On account of this action the lines-of-force or magnetic field can collapse with greater rapidity and cut the turns of wires faster, thus inducing a current in the secondary winding of a much higher voltage.

The current flows into the condenser in one direction when charging, which action takes place immediately the points are opened.

When the condenser is charged with the (+) positive current flowing into the (+) side, it will establish a (−) negative charge on the other side.

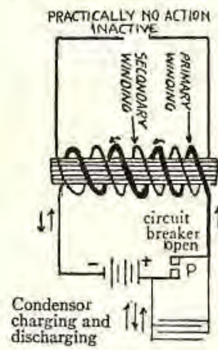


Fig. 7

**The condenser, after being charged, makes an oscillating discharge** of high voltage and frequency through the primary winding and battery (Fig. 7). That is, the discharge is first in one direction and then in the other, the strength of this current gradually decreasing (owing to the resistance of the circuit) until it dies down to zero. This alternation or reversal of the current flow is very rapid, sometimes reversing from one direction to the other as many as two hundred thousand times every second, and its discharge can therefore be considered almost instantaneous.

The main purpose of the alternate discharges shown in Fig. 7 is to completely demagnetize or neutralize the iron core, thereby preparing the core for a repeated action of building-up again as shown in Fig. 5, and collapsing, as shown in Fig. 6.

As this is written out, or as it is read, it seems a rather long action. The process, however, does not require one-thousandth of a second, inasmuch as the current alternates at an extremely high frequency, sometimes having as many as 100,000 cycles per second.

### Meaning of Cycle and Frequency

**A cycle** means a series of events which continually reoccur. In the case of a condenser, for example, the current discharge at one instant is a maximum (+), as shown at (C) (Fig. 7A). It gradually declines to 0 at (A), then builds up to a maximum (−) as shown at (D), again declining to 0 at (B), reversing in direction and building up to a maximum (+) at (E), which is the same condition as at (C), thus reversing the direction twice at (A) and (B) and completing the cycle evolution, which is repeated over and over again until the discharge dies down to 0 (zero).

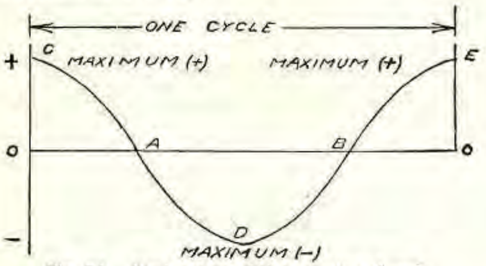



Fig. 7A. Explanation of the meaning of cycle.

**Frequency** means the number of cycles completed per second. As mentioned above, it is 100,000.

### The Ignition Commutator

Because **the secondary current is only needed when it is time for the spark to pass and ignite the mixture**, the primary current is switched into the primary winding only once during two revolutions on a single-cylinder engine. The switching is done by a commutator, which might be termed a revolving switch.

Where there are four cylinders to an engine, then it would be necessary to have four segments (S) on the commutator, because four sparks are required during two revolutions of the crank shaft.

**A four-cylinder ignition commutator** is shown in Fig. 8. An ignition commutator is used only with a vibrator-type coil, as on the Ford. The vibrator-type coil and commutator are seldom used on any other make of car.

**The spark timing device** (commutator) is so named because it "times" the spark at the right time. In other words, the roller makes contact with one of the segments (1, 2, 3, or 4 on a four-cylinder engine). Each segment controls one of the spark plugs (through a coil) in one of the four cylinders. When the right cylinder is ready to fire, the timer makes contact and starts the vibrator on the coil, which causes a spark at the points of the spark plug. This device is called a "commutator," and is used only with a high-tension coil using a vibrator.

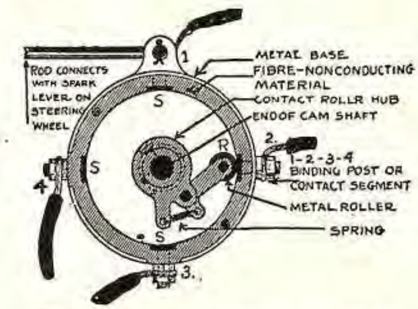



Fig. 8. A four-cylinder ignition commutator.

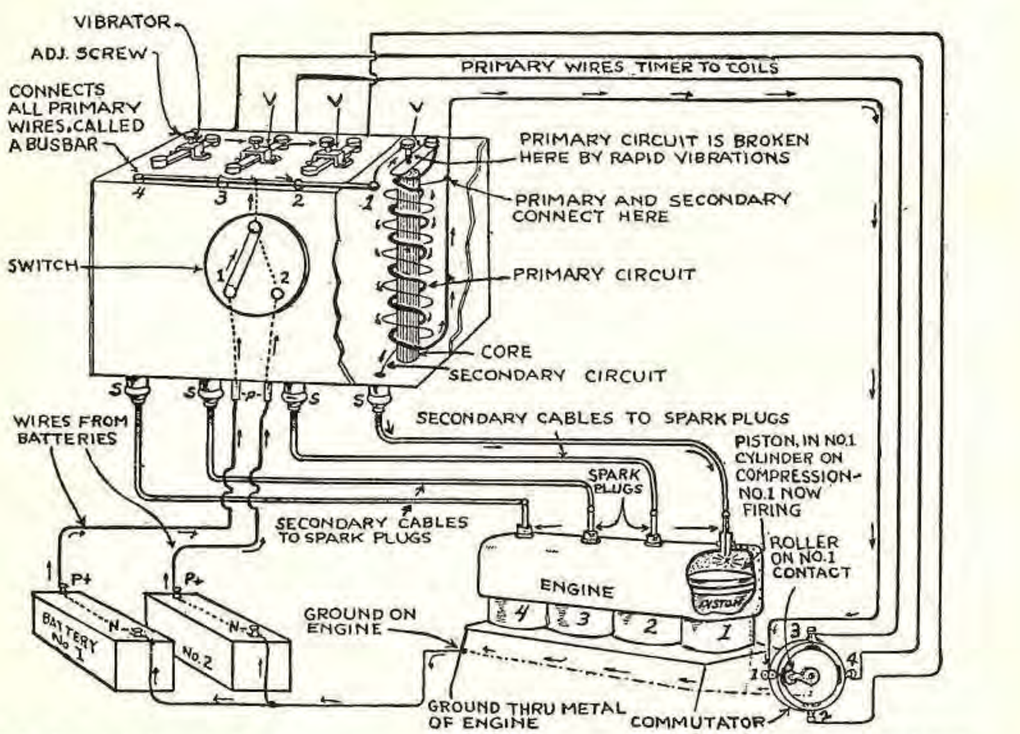



Fig. 9. Circuit of a four-cylinder vibrator coil ignition system using a commutator (exaggerated) and two sets of batteries.

**Commutator construction:** There are many different constructions. One which will explain the principle of a commutator is shown in Fig. 8.

**The metal roller hub** is connected to the cam shaft of the engine. A roller (R) revolves in a housing lined with an insulated, non-conducting material, usually fiber. Metal segments (S) are placed 90° apart for a four-cylinder engine. These segments are connected with one terminal of the primary winding of the coil. There are as many segments on the commutator and as many coils as there are cylinders. Since the cam shaft makes one revolution while the crank shaft makes two revolutions, then the roller (R) would revolve the same number of times as the cam shaft, because it is connected with it. Thus roller (R) would make contact with each of the four segments during one revolution, and so would produce four sparks in the engine cylinders, or one spark for each cylinder during one revolution of the roller (R), or two revolutions of the crank shaft of the engine

### Electric Circuit of a Four-Cylinder Vibrator Coil Ignition System

The illustration (Fig. 9) explains how a commutator is driven from the cam shaft of a four-cylinder engine and how it is connected with the primary windings of four-vibrator type coils contained in one coil box.

The illustration also shows the primary wiring connection from the battery, through one of the coils and connections to the other three coils and to the commutator, back to the battery; also the secondary circuit from coil to spark plugs, back to the coil.

**Primary circuit:** Place your pencil on the drawing at the positive pole (P+) of No. 1 battery, and follow out the circuit.

We will begin with the positive pole connection of No. 1 battery; there are two sets of batteries, but only one set is used at the time. If one runs down, the other one is thrown into service by a switch on the coil.

The switch is now on No. 1 contact, and the circuit is from No. 1 battery to the switch, through the switch lever to the bus-bar on the front of the coil, which connects to the contact screw (V) of the coil, thence through the platinum points, through the magnetic vibrator spring, to the primary winding which is wrapped around a core or bundle of soft iron wires.

The other end of this primary wire of coil connects with the segment on the commutator; the current is closed here at the proper time. The commutator roller-contact revolves as explained previously. When this contact is completed, the primary circuit is closed on one of the four coils (it is now closed on No. 1 coil). When this circuit is closed, the bundle of iron wires (core) becomes magnetized and draws the vibrator down, but the moment the vibrator is drawn away from the contact with the vibrator screw, the circuit is broken and the vibrator springs back and makes contact again, but is immediately drawn down again; this, of course, is quick and rapid. This vibration is kept up as long as the contact is made on the timer, which, of course, is only for a moment, but during that time the vibrator makes several vibrations or "buzzes" as explained previously.

**Secondary circuit:** When these vibrations, or interruption of current, occur, a current is "induced" into the secondary winding of fine insulated wire wrapped around the primary winding of the coil, called a "secondary winding." (How and why this current is induced into the secondary winding without any metallic connection was explained.

This secondary winding, of course, has two terminals; one end goes to a spark plug, and the other end connects to one side of the primary wire, which grounds it through the commutator roller to the engine, when the roller makes contact; thence the circuit is to the metal shell of the spark plug in the engine, across the spark-plug gap, to the insulated part of the spark plug, back to the coil. A separate coil unit is provided for each cylinder.

**The duty of the commutator,** therefore, is to make contact at a certain time in order that the right coil will operate and supply an electric spark to the right cylinder at the right time.

Note. When one wire (on any wiring diagram) passes over another wire without making contact, a half-circle is made, as shown above.

### How the Commutator Helps Control the Speed

The commutator is connected to the spark lever on the steering wheel (Fig. 10). When the spark-lever is pushed forward, the commutator is shifted forward so that the metal roller makes contact earlier with the contact segment. This is called "advancing" the spark.

If the commutator is shifted back instead of forward, the contact is made later. This is called "retarding" the spark.

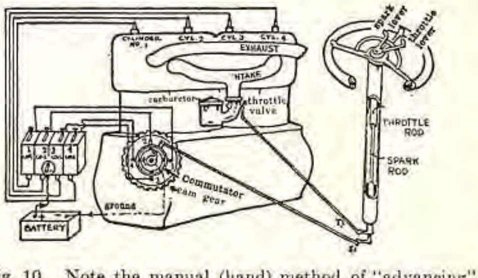



Fig. 10. Note the manual (hand) method of "advancing" and "retarding" the commutator. (Four-cylinder engine as example.) If the roller is revolving to the left, by shifting the commutator housing to the right, contact would be made earlier. This would be called "advancing" the spark. If the commutator is shifted to the left, contact would be made later—called "retarding."

When using a vibrator coil (which is the case here), the time of the spark is set earlier than when using the single-spark system, because plenty of time must be given the spark to ignite the gas so that it will ignite and combust when the piston is at the top of its stroke instead of after the top. (Note the connections to the commutator for firing order of 1, 2, 4, 3.)

**The setting for the time of spark to occur** is done by placing the contact roller at a certain position, as will be explained under "Ignition timing."

**The gas-throttle lever** is the lever used to run on, and is used to increase or decrease the speed of an engine. This is done by opening and closing the throttle, as explained under the subject of Carburetors.

**It is well to run with the spark lever as well forward, or advanced, as possible,** as it will tend to keep the speed of the engine up and consume less gasoline and create less heat. If the spark lever is too far advanced, then the engine will pound or knock, because the ignition will take place before the piston is over the center. A retarded spark produces heat.

The amount of advancing and retarding of the spark by hand must be learned by actual practice, in order to get the best results.

### High-Tension Vibrator Coil Using a Commutator as Used on One, Two, and Four-Cylinder Engines

As previously stated, the vibrator-type coil is now seldom used on automobile engines. It will often be found on small marine and stationary engines. A few examples of connections are shown below.

There are as many coil units and as many commutator segments as there are cylinders.

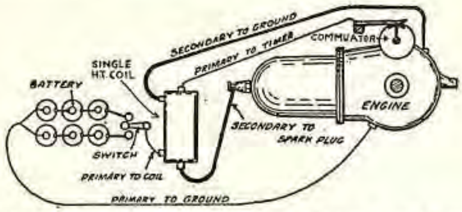



Fig. 11. One-cylinder engine with a vibrator type of jump-spark coil and two sets of dry batteries for ignition. Only one set of batteries is in use at the time. The commutator revolves at one-half the speed of the crank shaft. Note that there is one commutator segment.

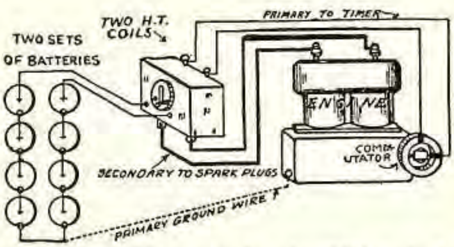



Fig. 12. Two-cylinder vertical engine (180° crank shaft) with a vibrator-type of jump spark coil and two sets of dry cells for ignition. Note the position of the segments on the commutator. The commutator revolves at one-half the speed of the crank shaft. (This type of engine is seldom used.)

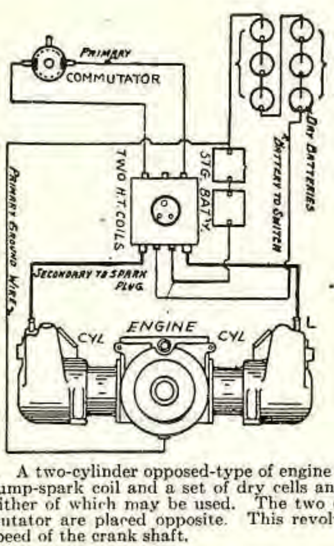



Fig. 13. A two-cylinder opposed-type of engine with a two-cylinder jump-spark coil and a set of dry cells and a storage battery, either of which may be used. The two contacts on the commutator are placed opposite. This revolves at one-half the speed of the crank shaft.

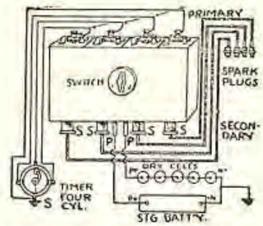



Fig. 14. A four-cylinder vibrator-type coil, using a commutator with four segments and a set of dry cells and a storage battery, either of which may be used. (S) are secondary terminal connections to the spark plugs.

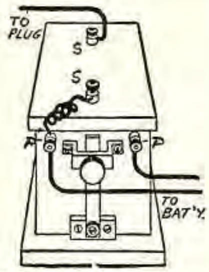



Fig. 15. A single-cylinder vibrator-type of jump-spark coil. This type is usually called a "box coil," and is only used on small marine or stationary engines. Quite frequently a single-cylinder box coil has but one secondary connection on top. In this case the secondary connection shown at the front of the coil is connected inside of the coil to the primary wire which connects to binding post (P).

### The Master Vibrator Coil

With the "high-tension" vibrator coil system, just described, as many coil units, each with vibrators, would be provided as the engine had cylinders. If a four-cylinder engine, four vibrator coil units would be necessary. If a six-cylinder engine, six vibrator coil units would be necessary.

It will be noted that with this number of vibrators, one or more would be constantly sticking, unless a great deal of attention was given to them.

Therefore, by using a **master vibrator,** only one vibrator coil is used, which is connected with the other coils as shown in Fig. 16 (page 195).

The master vibrator coil has but a **single primary winding,** and is connected in series, so the primary current must travel through it before reaching any of the coils. The usual commutator is employed.

**The master-vibrator coil** can be connected with a "multiple" of coils, by screwing down the vibrators on all coils and short-circuiting them, by connecting as shown in Fig. 16A. Note that the coils are the regular double-wound, high-tension coils.

The advantage of such a system is that there is but **one vibrator** to keep in adjustment, since this vibrator serves for all the cylinders; whereas, with several vibrator-coil units the difficulty of keeping several adjustments is a considerable factor.

The disadvantage is the great amount of wiring necessary with the multiple-coil system. Although the master vibrator is easily connected and requires very little wiring, the "distributor" system, which will be explained next, requires considerably less wiring. The master vibrator is an excellent addition to be applied to a multiple system of ignition, already installed, which uses vibrator-type coils.

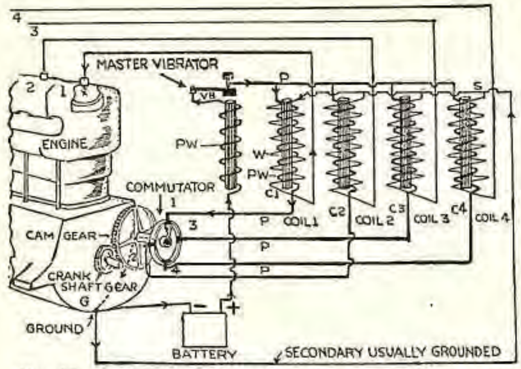



Fig. 16. A simplified illustration of a **master vibrator coil** on a four-cylinder engine, as an example. (W) secondary winding; (PW) primary winding; (P) primary wire; (VB) vibrator; (C) coils; (G) secondary ground wire; Fig. 16A, shows how the vibrator on the coils **C1, C2, C3,** and **C4** are short-circuited.

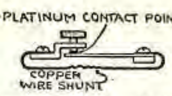



Fig. 16A. How to short-circuit vibrators on coils.

The firing order is 1, 2, 4, 3. No. 1 segment of the commutator is now connected; therefore coil (C1) is firing No. 1 cylinder. Note that the master vibrator is in series with this coil. The primary circuit in this instance is from (+) battery, through the winding of the master vibrator, through the vibrator points, through the primary winding of coil (C1), to the commutator segment, through the metal roller, through the ground of the engine, to the other terminal of the battery.

The secondary circuit is from wire (S) to the spark plug, through the engine, back to the other end of the secondary winding on the coil.

The next cylinder to fire will be No. 2, and coil (C2) will be the next one connected by the roller on the commutator. The next to fire will be cylinder No. 4 through coil (C4), then cylinder No. 3. through coil (C3).

### The "Distributor" or Synchronous System of Ignition

In the foregoing examples it will have been noted that the amount of wiring required for engines having more than one cylinder becomes increasingly complicated. A system now generally used, known as the "distributor system," very considerably simplifies the wiring, and at the same time a more accurate timing of firing of the respective cylinder is obtained. (See Fig. 17).

**One vibrator coil only is necessary,** this having the high-tension terminal joined up to the "distributor," which is a special form of rotating switch highly insulated, which directs the high-tension current to the cylinders in the required order.

**The secondary distributor brush** (B) rotates at the same speed as the commutator roller contact-maker, and in perfect unison with it; that is to say, when the low-tension circuit is completed, the high-tension circuit is completed likewise. The diagram should make the system clear, it being borne in mind that the distributor is rotating as well as the contact maker, and in perfect "synchronism" with it.

The secondary distributor is made in combination with a commutator, each with as many contacts as the engine has cylinders, and with the moving parts of each attached to the same shaft and revolving. (See Fig. 18).

**The battery** is connected to the single coil in the usual manner, and a wire is run from the primary terminal of the coil to the commutator, where it is connected to the four segments of the commutator. Thus when the commutator revolves, the current is passed through the one coil every time that contact is made.

If with this arrangement a wire was run from the secondary terminal of the coil to the four spark plugs, sparks would pass in all four cylinders whenever the timer made contact. Instead of this, one secondary wire is run from the secondary terminal to the moving part of the distributor, termed the "distributor brush," or "rotor," and from each contact point, or distributor segment of the distributor to the proper spark plug.

**When the commutator makes contact, and the secondary current is formed,** it flows to the secondary distributor, which at that instant has made contact with one of its segments, so that that secondary current flows across the contact and to the spark plug that is connected.

The advantage of this system is that there is only one vibrator to keep in adjustment, and only one coil, thus fewer parts. The disadvantage is that the constant action of the vibrator is liable to burn the vibrator points, and destroy them. Electrical lag is also a factor to be considered, as is also a greater consumption of current.

The more modern ignition system uses a distributor for distributing the secondary current to the spark plugs in a similar manner, but instead of using a coil with a magnetic type of vibrator, or interrupter, a coil without a vibrator, termed a "non-vibrating" high-tension double-wound coil, is used, and instead of using a commutator, a timer or "interrupter," which is mechanically operated from the engine, is used. This system will be treated in the next instruction.

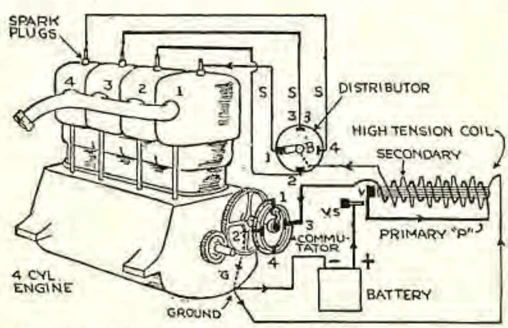



Fig. 17. A simplified illustration showing the principle of a high-tension **distributor** or **synchronous system** of ignition using a vibrator type of coil. Not in general use. (P) primary winding; (S) secondary. Note that one end grounds to the engine (usually grounded on the coil). (VS) vibrator screw.

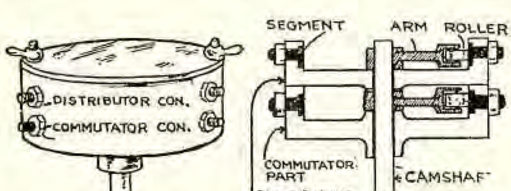



Fig. 18. Simplified illustrations to explain the principle of a **distributor and commutator** in one housing and operated by one drive shaft, used in connection with a vibrator type of coil. This method is obsolete, but a similar principle, of different construction, is the modern method, as will be explained farther on. Note that the distributor and commutator are together. The wiring diagram (Fig. 17) shows the two separated merely to explain the action.

## INSTRUCTION No. 19

# MODERN BATTERY AND COIL-IGNITION SYSTEMS: High-Tension Coil (Non-Vibrator Type); Open and Closed-Circuit Ignition System; Distributor; Resistance Unit; Safety Gap

### THE MODERN BATTERY AND COIL IGNITION SYSTEMS

In order to understand the modern "coil and battery" ignition systems, it was necessary that the reader study the elementary principles of the early forms or methods used for ignition, such as the low-tension coil, the high-tension vibrator coil, the commutator and the distributor, which have all been explained. It ought not therefore to be difficult for the reader to grasp the principle of and the difference between the various modern ignition systems now to be treated.

**The battery and coil system** is the modern ignition system, such as used on the Atwater-Kent, Delco, Remy, and others which are supplied with a "constant" source of electric supply when used in connection with a storage battery which is kept charged by the generator.

"Constant source of supply" means that the ignition apparatus is not dependent upon a mechanical method of generating current, as in a magneto, but the supply of electric current is constantly supplied by a storage battery and the storage battery is constantly supplied with current (direct) by a generator.

#### The Non-Vibrator Coil Ignition System

The same underlying principle of operation of a vibrator-type coil, explained on the preceding pages, applies to the non-vibrator coil. The only difference to be noted is that the commutator is dispensed with, and instead of having a "magnetically operated vibrator" or "interrupter" on the coil, a "mechanically operated timer," or "interrupter," is driven from the same shaft as the secondary distributor and is used for exactly the same purpose.

Fig. 1

Fig. 2

Fig. 1 represents the **"single spark"**—a hot one at the right time, which causes the gas to ignite quickly without lag, and consumes very little current, as produced by a high-tension coil ignition system of the non-vibrator type.

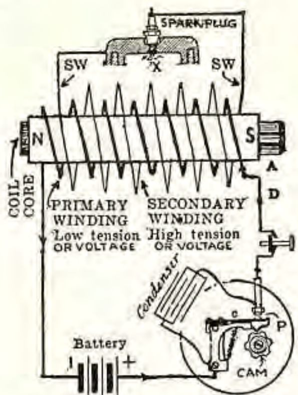
Fig. 2. Note the **succession of sparks.** This represents the sparks as they occur on the old-style magnetic vibrator coil—several after top of stroke. The hottest one ignites the gas, but usually late.

**The non-vibrator coil** uses a mechanical interrupter and gives but one "single spark" (see Figs. 3, 4 and 5).

#### Open and Closed-Circuit Interrupters

**The non-vibrator coil system of ignition** can be classified as an **open-circuit** system and a **closed-circuit** system. It gives a "single spark."

**The open-circuit system** consists of a single non-vibrator coil, timer, and distributor (if a multiple-cylinder engine).




Timer.

Fig. 3. A non-vibrating high-tension coil ignition system, using an **open-circuit** timer.

**The open-circuit timer contact points** (Fig. 3), used in connection with this system, are normally **open.** The cam is attached to a shaft, usually driven from the cam shaft, and must therefore be set so that the high point or lobe on the cam will raise the arm (**C**) so that it will make contact at the proper time. The spark does not occur at the spark plug when the contact is made, but when the contact is opened. This is therefore, a double operation, which causes "electrical and mechanical lag," and this is eliminated by the use of a contact arrangement which is normally **closed.** Thus the improved method (Fig. 4) is termed a "closed-circuit" system, and is the system in general use today.

**"Electrical lag"** means that the spark will not occur in the same position as regards piston travel at any and all engine speeds. With a very high speed the piston might have a tendency to travel past the point of ignition before the open-circuit timer made and opened contact, whereas with the closed-circuit principle it merely opens the contact.

While all lag factors deal with time in seconds, their effect on the engine is the number of degrees they cause the spark to occur off the point where it should. Consequently a time factor of only one-thousandth of a second means only a variation of 3° at 500 r.p.m., yet means 12° at 2,000 r.p.m., and 18° at 3,000 r.p.m.

**Mechanical lag** is eliminated much for the same reason, and the quicker and simpler the mechanism to "interrupt" the flow in the primary, the quicker the spark.

Compare the **timer** in Fig. 3 with the **interrupter** in Fig. 4.

Note that in Fig. 3 the cam raises the arm (C) which makes contact at points (P), which are normally open. The strong spark does not occur when contact is made, but when it is opened.

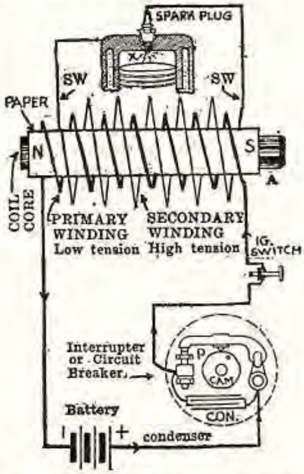



Fig. 4. A non-vibrating high-tension coil ignition system, using a **closed circuit** interrupter (also called contact-breaker).

Note that in Fig. 4 the contact points (P) are normally **closed,** and the high point on the cam raises the interrupter arm, thus opening the points (P) with one single operation. Thus the closed primary circuit of the coil is interrupted; hence its name "interrupter," or "contact breaker" as it is also often called.

**The closed-circuit ignition system** using a non-vibrator coil and a closed-circuit "interrupter" in connection with a distributor is more clearly shown in Fig. 5. This represents a modern "battery-and-coil" ignition system.

**Note that the distributor shaft,** which is driven from the cam shaft of the engine, operates the interrupter cam which opens the interrupter contact points. The same shaft operates the distributor brush which distributes the secondary high-tension current to the spark plugs.

**The cam** has as many high places, or lobes, as there are cylinders. On the cam in Fig. 5 there are four high places. This would, therefore, be suitable for a four-cylinder engine. It is fastened to a shaft which is driven at cam-shaft speed. It is set or timed so that the high point on the cam pushes the moving contact blade point away from the stationary contact point, thus opening the primary circuit of the coil. By this method the operation of first closing the circuit, then opening it, as on the open-circuit timer is eliminated, and makes the action much quicker.

### Circuit of the Modern Closed-Circuit System

**The primary circuit** of the closed-circuit system (Fig. 5, below), is from (+) of the battery, through the ignition switch, through the resistance, through the primary winding, through the insulated stationary contact point, through the movable interrupter or contact points, through the frame of the interrupter, to which it is grounded, to a ground connection of the frame of the car, to (−) ground of the battery.

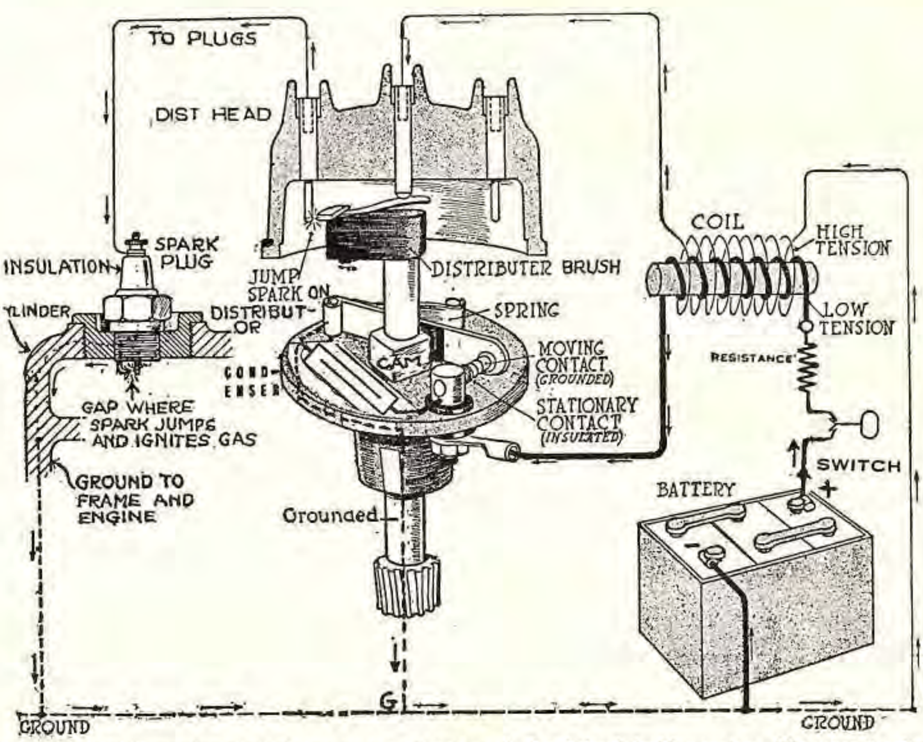



Fig. 5. A simplified illustration of a high-tension non-vibrating coil, closed circuit ignition system. The outer circuit, in light lines, is the secondary; the inner circuit, in heavy lines, is the primary circuit.

**The condenser** in this instance is placed across the contact points of the interrupter and in the interrupter, one end being connected with the insulated stationary contact and the other end grounded to the frame of the interrupter. The condenser could be in the coil, which it is, in some systems; in such cases it must connect directly across the contact points, as explained on page 189.

**The secondary circuit and distributor:** One terminal is grounded. The other leads to the center terminal of the distributor, and makes contact with the metal spring on the insulated rotating distributor brush, also called the "rotor."

The other end of the spring on the rotor passes close to, but not touching, the metal distributor terminals of the distributor head (made of insulated material) which leads to the spark plugs (termed the "distributor gap"[1]); thence through the center terminal of the spark plug; it then jumps the gap at the spark-plug points, thence to the shell of the plug to the engine, back to the grounded connection of the secondary.

The distributor rotor, of course, is synchronized or set so that the rotor spring makes contact with the spark plug in the cylinder to be fired; at the same time the interrupter cam opens the circuit.

**The ignition switch** of course is supposed to be opened when the engine is idle. However, the operator may not always think to open the ignition switch, and therefore an **ignition resistance unit** is placed in series with the primary winding on very nearly all closed-circuit battery and coil-ignition systems, to take care of any possible damage that might occur.

### Ignition Resistance Unit

The purpose of the ignition resistance unit is twofold, one being to protect the battery from discharging back through the primary winding and thus overheating the winding and discharging the battery,i f the switch is left on and engine is not running and interrupter points are closed.

The ignition resistance is made of iron wire, usually mounted on a porcelain spool on the ignition coil. It turns a cherry red when the primary current flows through it for any length of time. When iron heats it offers resistance; thus the discharge through the primary winding is greatly decreased. If current is left on for a long period of time when the engine is idle, the resistance may burn out and open the circuit and a new resistance unit becomes necessary. This sort of thing happens frequently.

When the engine is running, the circuit is continually opened and closed and thus the heating effect is not as great.

In the instruction on the principle of the ignition coil (page 190), we learned that the coil core is slow in its action of "building up" lines-of-force, or in being magnetized, when the circuit is closed. This being the case, it would appear that at high engine speeds the interruption or opening of the circuit would take place before the iron core of the coil was fully magnetized, thus producing a weak spark. This is quite true and possible.

To overcome this, the coil is wound so that it takes an excess of current, or more than is required in order to compensate for this slow action of magnetizing the core. The question next to arise is, if the excess of current takes care of high speeds, what is the situation in the case of low speeds? At low speeds, the points are closed for a longer period and the excess of current would injure the coil.

The answer is, that the resistance unit heats when the circuit is closed for a longer period of time and offers resistance which cuts down the flow of current to normal. At high speeds it does not heat so much and the resistance is less, and the current is permitted to pass at full value through the winding at high speed, thus assisting in quickly building up magnetism in the core.[1]

### High-Tension Safety Gap

**Safety gap:** The fact that the distributor spring does not make full contact with the distributor terminals leading to the spark plugs brings up the subject of safety gaps.

**The safety gap** on the ignition coil is always a "shunt" gap placed across the secondary circuit, usually on the coil. If the external secondary circuit is open, the safety gap provides another path to ground (see Fig. 6). It is used more on high-tension magnetos than it is on ignition coils. It is practically a safety valve for the high-tension current. The safety gap is usually set slightly farther apart than the spark-plug gap, or about 5/16". As long as the wires to the spark plug are connected, the safety gap is inactive, but if the spark-plug wire should come loose, then the safety gap becomes active by a spark jumping across its gap instead of trying to jump from the end of the loose wire to the engine. If this were a greater distance than ½", which it might well be, it might cause the high-tension current to force a circuit through its own insulated winding to its ground, thus damaging the coil, or cause sparking at interrupter points.

## CONNECTICUT IGNITION, CLOSED-CIRCUIT SYSTEMS: MODELS 16, 14, AND 15

As an example of an ignition system using a "safety gap" and a "thermostat resistance," the Connecticut ignition system as used on the Dort and also on the "model 89" Willy-Knight six, is shown in Fig. 6. The diagram represents that of the Dort.[2] The Connecticut ignition system using the Connecticut automatic thermostat switch, is clearly shown in this illustration. This ignition system is known as the model "16."

**The purpose of the thermostat switch.** It must be understood that the timer, or interrupter (Fig. 7) is a closed-circuit type; therefore if the engine is not running and the switch is left "on," a waste of current and heating of the ignition coil results, therefore this automatic switch is used to open the circuit.

There are **two types of Connecticut thermostat switches:** one which is operated by **magnet coils,**

[1] The gap between the distributor brush and the spark-plug terminals (Fig. 5) is about .010". It may vary .003" or .004" either way.

The prime advantage of this gap is the fact that no rubbing parts are employed; therefore there is no friction or wear.

The high-voltage secondary current is able to jump the gap, and as soon as the gap is broken down its resistance becomes very low and the secondary discharge passes without noticeable loss.

[2] See page 208 for Dort-six ignition.

[1] It is a very easy matter to check the resistance unit, by observing its heating when the ignition button is out and the contacts of the interrupter are closed. If it is shorted out, it will not heat up, and will cause missing at low speeds.

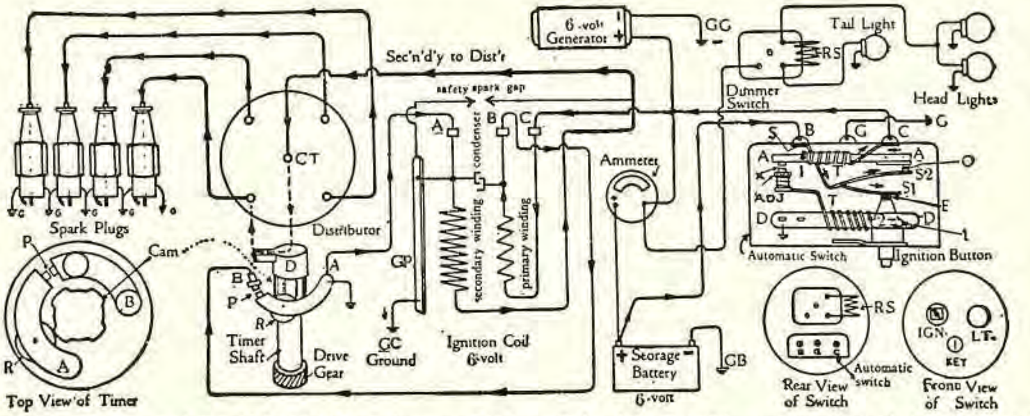



Fig. 6. The Connecticut model "16" high-tension non-vibrating coil closed-circuit ignition system. Note that a thermostat of the **thermal** type, termed "automatic switch," is used to open the circuit if the ignition switch should be left "on." Type "GA" coil is used in this system. Note that the interrupter is grounded at (A). (See page 232 for a later type coil.)

which is an early type described in Figs. 13 and 14, and a later model where a thermal, or **thermostat blade** (**D**), (Figs. 6 and 8) takes the place of the magnets. We shall describe the later model, using the thermal blade. "Thermal" refers to heat.

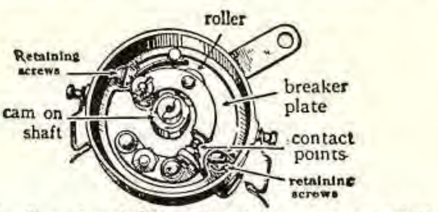



Fig. 7. Top view of Connecticut interrupter or contact-breaker. See also page 232 for later model 18 interrupter.

**Thermostat action** (see Figs. 6 and 8). The battery current flows from battery (+), to (**B**), then through insulated spring (**S**, Figs. 6 and 8). If the ignition button is pushed in, then an insulated plunger (**E**) on the switch button presses against spring (**S1**) causing spring (**S2**) to close points (**O**). The current then travels through (**A**) to (**1**), through resistance wire ribbon (**T**) (thermostat wire which is insulated from **A**, except where grounded to **A** at 1), to insulated connection (**C**), to (**C**) connection on the coil.

So long as the engine is running, the intermittent opening and closing of timer contact points prevents (**T**) from heating blade (**A**).

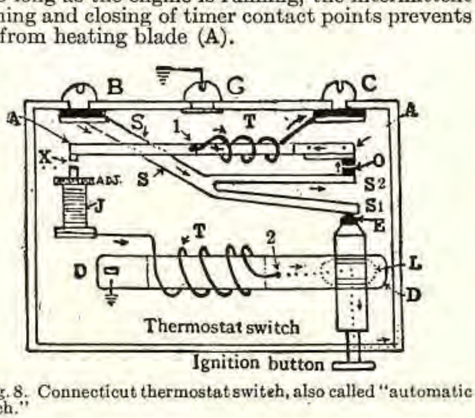



Fig. 8. Connecticut thermostat switch, also called "automatic switch."

If the engine stops with ignition switch "in," then the timer points are closed, and within for 30 or 40 seconds the continuous current passing through resistance wire (**T**) heats spring blade (**A**), causing it to bend down, thus making contact with (**J**) at (**X**). The current then flows through (**J**) to (**T**) on blade (**D**), through (**2**) to ground connection of switch box at (**G**).

Blade (**D**) then becomes heated and bends up, releasing a wedge-shaped lug (**L**) which is attached to under part of (**D**), from a groove in the ignition button shaft. The spring (**S1**) then easily forces the ignition button "out," thus opening the circuit at (**O**) and (**X**).

**The primary ignition coil circuit** can be traced by starting at (+) of battery (Fig. 6) to thermostat connection (**B**) through spring (**S**) to connection (**C**) (when ignition button is "in"), thence to the primary winding of coil (**C**), through the coil, out coil terminal (**B**) to stationary contact (**B**) on model 16 timer, through points (**P**) to movable contact (**A**) (which is grounded), to the grounded terminal of the coil primary winding at (**A**), through ground plate (**GP**) to ground (−) of battery (type **GA** coil).

**The secondary ignition-coil circuit** is from the secondary winding to center terminal (**CT**) of the distributor, to distributor arm (**D**) which passes the secondary current as it revolves, to spark plugs, thence through center terminals of spark plugs across spark-plug gaps to the shell of the spark plug to the engine frame, thence back to ground plate (**GP**) on the coil to the grounded terminal of the secondary winding.

**The safety gap** is shunted across the secondary circuit of the coil, as shown in Fig. 6, and explained above.

**The condenser** (Fig. 6) is shunted across the contact points of the timer, but is located in the coil.

**The lighting and ignition switch** (type K.V.B.) is combined with the Connecticut automatic thermostat ignition switch; a front and rear view is shown in Fig. 6. It has two buttons.

**When the button at the left is pushed in,** the ignition is "on." **When it is pulled out,** the ignition is "off."

**When the button at the right is pushed all the way in,** the headlights will burn "dim," as the dimmer resistance (**RS**) is in series with the circuit. When **pulled all the way out,** the headlights will burn "bright," as the resistance (**RS**) is then cut out of the circuit. When **placed in the center,** the lights are "out."

**The fuse** for the lights is under the hood on the right side, and a fuse for the horn is on the left side. If all lights fail to burn or the horn fails to operate, see if the fuse is blown. The fuses are 7 volt, 10 ampere enclosed No. 1 type, di. 1/4" x 5/8" glass tube.

**Timing ignition** (Dort-4). Open priming cocks. Turn starting crank until 1 and 4DC (cylinders No. 1 and 4 are on dead center of compression stroke) appears on the flywheel and is in line with the center mark on the crank case; then turn flywheel 1" past this dead-center line.

**Retard the spark lever** and loosen the set screw on the distributor shaft.

**Push in the ignition-switch button.** Disconnect the spark-plug wire on cylinder No. 1, and place it so that the terminal may be about 1/16" from the metallic part of the spark plug.

**Turn the distributor shaft very slowly,** in a clockwise direction, till a spark is seen between the spark plug and the wire terminal, and stop.

Screw securely the set screw on the distributor shaft, put the handles of the priming cups in a vertical position, and the spark is correctly timed.

The firing order is 1, 3, 4, 2, and the wires to spark plugs should be attached to the distributor in this order. No. 1 cylinder is the one next to the fan. Spark plug is 7/8–18 thread, and the gap should be .022" to .025". See also page 208 for Dort-six ignition.

**The generator** shown in Fig. 6 (which is the electric diagram on the Dort) is the Westinghouse, using a third-brush regulation with a cut-out switch (reverse-current type) contained in the generator. Note that one terminal of the generator is grounded, likewise the (−) terminal of the battery. When **starting,** the ignition current is taken from the battery. **After starting,** and generator gains sufficient speed (8 or 9 miles per hour car speed), and then the generator supplies current for ignition and charges the battery. The generator produces 12 to 15 amperes at 18 miles per hour. At higher speeds the charging rate decreases slightly.

**The starting motor** (not shown) is located on the left side of the engine, at the rear. It is fitted with a Bendix drive which automatically engages and disengages the fly-wheel gear, as explained in the instruction on starting motors. One terminal of the starting motor is grounded, the other terminal connects with the starter switch, from the starter switch to battery (+), through the battery to ground.

### Renewing Interrupter Points

**To dissassemble interrupter (timer), model 16:** first, unclamp the spring and remove the distributor cover (Fig. 9); second, remove the distributor arm (Fig. 10); third, unscrew the retaining screws (Fig. 11); fourth, lift the breaker-plate, unscrew nut and loosen the primary wire. Install new breaker plate (Fig. 12). After **installing a new breaker-plate, which is always necessary when renewing interrupter points,** reassemble and adjust.

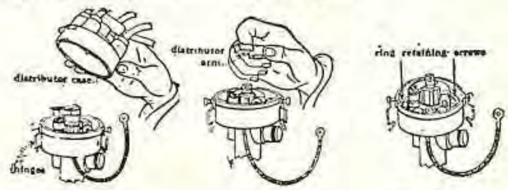



Fig. 9 Fig. 10 Fig. 11

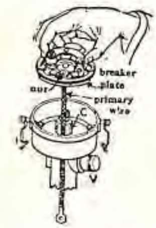



Fig. 12

### Interrupter (Timer) Adjustment

**The opening of contact-points** on 4- and 6-cylinder engines should be .016" minimum to .024" maximum; on 8-cylinder engines, .012" minimum to .015" maximum. When adjusting, the roller should rest on the point of the cam. Set **spark-plug gap** .022" to .025" on 4-, 6-, and 8-cylinder engines.

### Connecticut Ignition; Models 14 and 15; Closed-Circuit System

This ignition system was used on many of the Overland cars. The thermostat switch was controlled by **magnets** and enclosed in rear of a switch mounted on the dash. In many of the Overland cars this switch, called a "combination switch" box, was placed on the steering column.

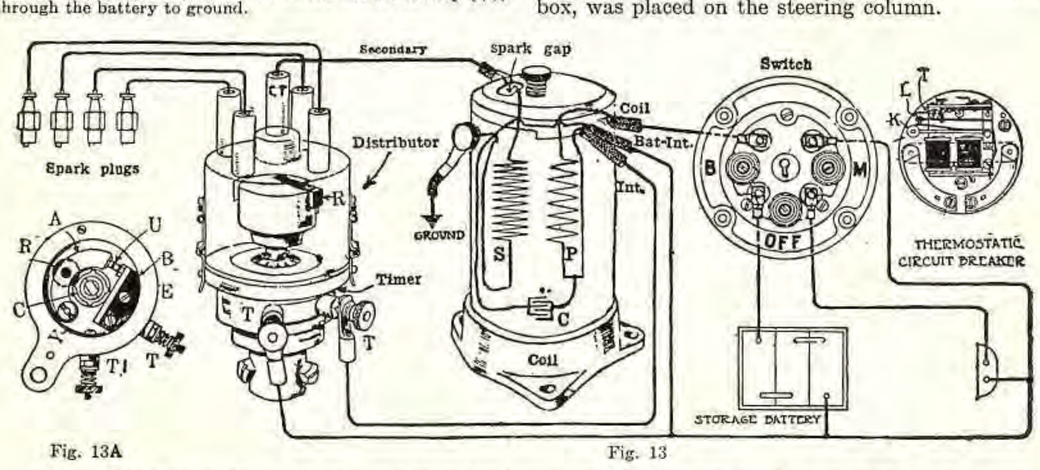



Fig. 13A Fig. 13

Fig. 13. The Connecticut models "14" and "15," high-tension non-vibrating coil, closed-circuit ignition system, using a **magnetic** thermostat switch.

Fig. 13A. Top view of the closed-circuit interrupter or contact-breaker. Note that the interrupter is not grounded, as in Fig. 6, but insulated.

**The timer or interrupter** (Figs. 13 and 13A) is the model 14 and 15, where both contact points (U), one on arm (A), the other on arm (B), are insulated from each other and two wires connect with terminals (T) and T1) from coil, battery, and switch. (R) is a fiber roller and (C) a cam, which turns at one-half the engine speed and has as many lobes as there are cylinders. Both contact-points are normally closed until separated by cam (C). It is thus a closed-circuit type.

**The distributor** sets above the timer, and the rotor or distributor arm sets on top of the cam shaft and revolves at the same speed as the timer cam. The rotor in models 14 and 15 is of the "brush-type" contact (R), which makes a wiping contact.

The model 16 timer-distributor (Fig. 6) is very similar, except, instead of having two binding-posts to the timer, there is one binding-post and a wire, and the distributor rotor (or arm) is of the "gap-type."

**The coil is a non-vibrating type.** A safety-gap is provided to protect the coil from liability to a puncture of the winding insulation if the spark plug or secondary wires come loose.

**The switch** on this system is the model G. When (B) button is pressed, the storage battery supplies current for ignition. When (M) button is pressed, the magneto supplies current for ignition. When the lower button is pressed, it will release either of the above, whichever may be in.

**The thermostat,** as explained below and also shown at the right in Fig. 13, is contained in the back of the switch. This switch is now seldom used except where magneto ignition is employed. The switch below is the model 41Y ignition and lighting switch with thermostat. Where a generator is on the car, it is connected with a separate cut-out, between battery and switch.

The thermostat consists of blade (T) (see Figs. 13 and 14), which heats when current passes through it for from 30 seconds to 4 minutes without interruption, and causes it to bend to contact with (L).

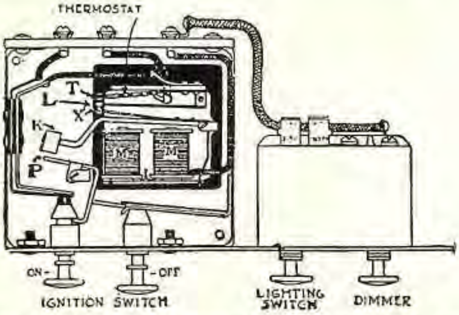



Fig. 14. Connecticut magnetic thermostat switch (early model, as used in Fig. 13). An automatic thermostat in the Connecticut system breaks the circuit in the event that the switch is left in the "on" position with the motor idle. The light switch and dimmer are housed at the right.

This completes an electrical circuit which energizes the magnets (M), causing releasing hammer (K) to operate like the clapper in an electric bell. This arm strikes against a plate (P) which releases whichever of the two ignition switch buttons in switch may be depressed or "on." The thermostat can be set to act from ½ to 4 min.

**An adjusting screw** (Fig. 13, right illustration) is provided directly over the thermostat spring (T) which regulates the time. If the thermostat was made to disconnect in less than 30 seconds it would probably "kick-off" when putting on ignition, before the engine could be started.

**The condenser** (C) (Fig. 13) is located in the coil, but by tracing the coil primary circuit it will be observed that it is shunted across the timer contact points.

### Example of Timing Connecticut Ignition[1] System

**To time the breaker and distributor** six-cylinder engine as example): When replacing, if for any cause it becomes necessary to remove the breaker and distributor, crank the engine by hand until the piston of No. 1 cylinder (first from front end of car) comes up on its compression stroke, and stop when the 1-6 mark on the flywheel is on top in a line with the flywheel indicator. At this point the piston is at the uppermost point of the compression stroke or "dead center." You can determine when the piston is coming up on the compression stroke by opening the relief cock on the cylinder and holding your finger over the opening.

Now advance the spark lever on the steering wheel one-quarter of the way. Remove the distributor cap, then set the combination breaker and distributor on the driving shaft with set screws loose; connect the advance lever, turn the hub on the shaft in the direction of rotation (counter-clockwise) until the contact points are just opening, which is the point at which the spark takes place; then tighten the hub set screws.

**Now replace the distributor cap,** carefully noticing which segment of the distributor brush is opposite, for this is the connection to the spark plug of No. 1 cylinder. Now connect up the balance of the spark plugs in their firing order—1, 5, 3, 6, 2, 4.

**The Chevrolet timing:** Place the piston on top of the compression stroke. Retard spark, loosen set screw and turn igniter unit until contact points are just opening, which is the point for spark. Tighten the set screw. The firing order is 1, 2, 4, 3. Therefore connect the plug terminals accordingly.

See also Index under "Lexington ignition timing," which is another example of the Connecticut system.

### Testing Ignition Circuits and Parts

**Testing coil:** In order to determine if the coil is operating properly, secure a piece of wire and, holding one end to the frame of the car, engine casting, or other metallic "ground," bring the other end to within one-quarter inch from the point where the high-tension wire (running from the coil to the central terminal of the distributor) leads from the coil, and turn the engine over by hand with the switch on. If a spark occurs at this point and not at the distributor, the trouble is in the high-tension wire which leads from the coil to the distributor. If, however, no spark occurs at either point, see if the safety gap in the top of the coil is wet. In this case dry out the coil for several hours in a warm oven. The safety gap may be observed by removing the cover on the top of the coil.

[1]To suit individual requirements it may be necessary to advance the ignition slightly when timing, if greater speed is required, or to retard it slightly for very slow running. This is done by loosening set screw and turning timer with rotation of shaft if it is found to be timed early—or against rotation if it is found to be timed late.

**The thermostat** (or ignition resistance unit in other systems) would cause missing if burned out.

**The condenser,** if shorted, will cause a weak spark. These subjects are treated farther on.

If this does not correct the trouble and the primary circuit is intact, it is evident that the coil should be replaced or returned for repairs.

It is a good plan regularly to examine the clamping rods holding the coil to the generator, tightening when needed to prevent vibration from loosening the terminals or breaking them.

**Test of primary circuit:** When testing the primary circuit, there are practically only two things to be taken into consideration, namely, the condition of the contact points in the breaker box and the wiring.

When tracing the primary circuit, first see if any of the fuses have "blown," then trace all the wiring of the ignition circuit.

**Testing ignition switch:** In order to test the switch and determine if current flows through it, attach a wire to the negative terminal on the storage battery and remove the wire from the terminal on the coil. Then push the ignition button on the left end of the switch in and make and break the circuit with the two wires by touching their free ends together. If a spark occurs, there is a circuit through the switch. If a spark is not obtained, there is doubtless an open circuit in the interior; therefore it should be returned for repairs.

(The address of the Connecticut Tel. and Electric Co. is Meriden, Conn.)

## ATWATER KENT OPEN-CIRCUIT IGNITION SYSTEM

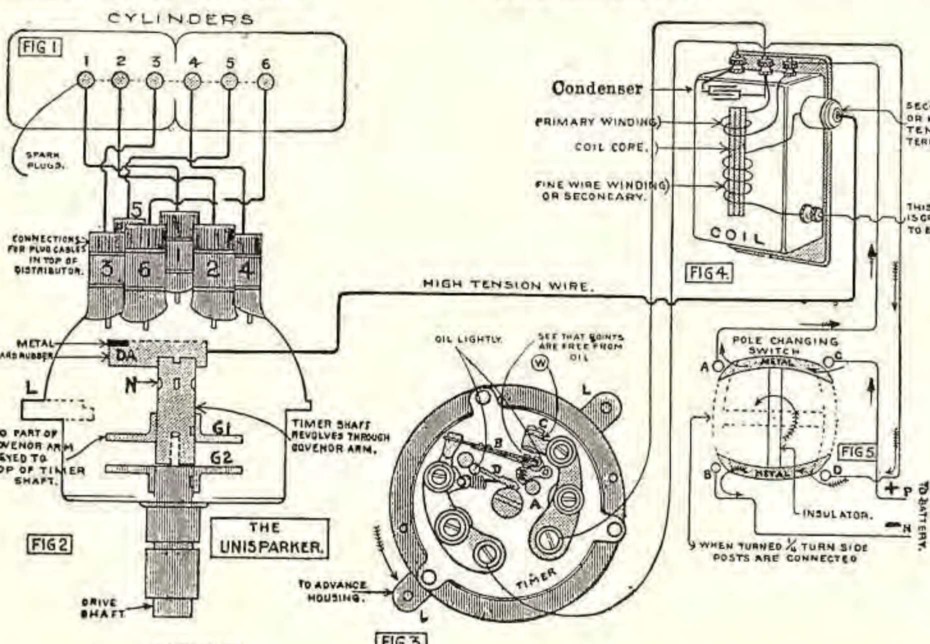
As an example of a **coil and battery ignition system, using an open-circuit timer system of ignition,** we will take the Atwater-Kent type K2 open-circuit system. (This concern also manufactures a closed-circuit system, as illustrated on page 205.)

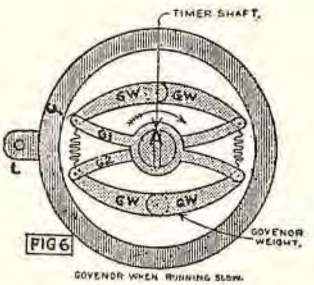
**The distributor and timer** (called the Unisparker) is illustrated in Figs. 1 to 7. It consists of a timer with its contact breaker, or "maker," which would be more appropriate, mounted on the timer shaft, but independent of each other.

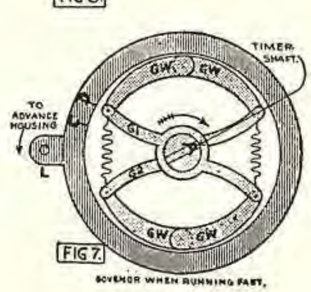
The timer is illustrated in Fig. 3.

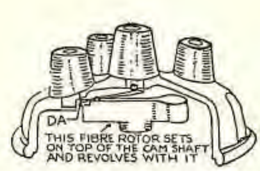
**The parts** consist of: (1) the distributor and timer, which is called the Unisparker; (2) the coil, which consists of a simple primary and secondary winding, sealed in an insulated cylinder; the coil has no vibrators, contacts, or other moving parts; (3) the depolarizer switch; (4) the automatic spark advance.

**The function** of the Atwater-Kent ignition system is to produce a single hot spark for each power-impulse of the engine, accurately timed to occur at the right instant to produce the greatest possible power and efficiency.




View showing distributor cap and rotor. Note how the secondary jumps the gap from rotor point (DA) to spark-plug terminal points.

The timer shaft is a half-inch shaft, driven usually from the cam shaft and at cam-shaft speed. It is also quite often mounted on the generator and driven from it, as shown on page 210. It should always be installed in the coolest location available.

**The contact points** in the timer (Fig. 3) do not touch except during the brief instant of the spark. The ignition circuit is therefore normally open and no current flows, even though the ignition switch be left "closed." This dispenses with the use of a resistance unit, or thermostat.

**Where the hand-spark control lever is also used,** it should be so proportioned as to give not more than one-quarter to one-half inch of movement for the entire range of the spark lever on the steering-wheel sector.

**Range of spark advance:** The high-tension distributor is carried on a central shaft, which connects below the governor, so that the distributor block is not moved by the automatic advance mechanism. This permits of a wide range of spark advance without affecting the synchronism. The maximum advance is about 45° of crank-shaft travel, at 2,400 r.p.m.

**The source of electric supply** for this system, also all other systems of this kind, is from the storage battery. The storage battery, as previously explained, is charged from an electric generator run from the engine.

**The current consumption** is very small, but the strength or pressure of current as required by the coil is necessary for a single-spark system. Therefore keep the battery fully charged at all times.

In case of an emergency, dry cells can be used connected six in series.

### Adjusting A.K. Open-Circuit Timer

**Adjustment of the gap between contact-points** should be .010″, when the lifter (D) (Fig. 3), is in the notch. This adjustment can be made by placing more or less thin shim washers (see W), (Fig. 3) on the contact screw.

When taking up this distance between points, arising from natural wear, remove both screws and dress with a very fine file; then replace and shim up to .010″. The points are made of tungsten steel, which is very hard.

Remember that when the points are working properly, small particles of tungsten will be carried from one point to the other, forming a roughness of a dark gray color. This, however, does not in any way affect the working of the points, as the rough surfaces fit each other perfectly. The spark-plug gap should be .025″.

Do not think that the parts of the timer (Figs. 8 to 11) do not work properly because you cannot see their movement. The contact maker of the Unisparker may be likened to a watch, which, because of the small size and extreme accuracy and hardness of its moving parts, is subject to very little wear. Don't change the tension of spring or alter the parts.

### Polarity Switch

**The polarity switch,** also termed a "pole-changing switch" and "depolarizing switch," is intended to prevent the points on (B) and (C) (Fig. 3) from becoming worn and pitted. "Direct" current is used, which has a tendency to burn and pit the points, whereas an alternating current is much easier on the points. Therefore the purpose and principle of this style of switch is to alternate the flow of current from (N) to (S) and (S) to (N), or from positive to negative and negative to positive.

As stated above, "direct" current is used with all battery systems; therefore a steady flow in one direction has a tendency to deposit the metal from one point to the other—but by changing this flow of current occasionally, the deposit will be put back to the other point again, as in electroplating.

**Note the action of the polarity switch** (Fig. 5): (C) to (A) is now flowing positive, and (D) to (B) is flowing negative. By turning the switch one-quarter turn, the poles are changed; (C) to (D) will become positive and (A) to (B) will become negative. This change is made occasionally when running, and has a tendency to keep the contact points clean.

### Automatic Ignition Governor

**The governor** (Figs. 6 and 7) is mounted directly under the timer. One arm of the governor (G1), is attached to the upper part of the timer shaft which is free to advance with the action of the governor. The other arm of the governor automatically advances the time of spark as the speed of the engine increases, by centrifugal action of the governor weights (GW), as shown. Note the position of the end of the timer shaft (A), at retard (Fig. 6), and advance (Fig. 7). Note that at "retard," the governor arm (G1) is at (C), whereas at full speed it has advanced to (D) (marks shown on left-hand side of housing).

### Explanation of Automatic Spark Advance

**Governor:** The Delco, Remy, Atwater Kent, and many other systems employ a mechanical governor for advancing the spark when the engine is speeded. A governor of the centrifugal type is usually employed, but of slightly different construction on different systems. The purpose of the governor is to cause the timer notched shaft[1] to turn in the direction of rotation, causing the contact points to make and break earlier as the speed increases.

For instance, refer to Fig. 6, page 202. Assume that the engine is running slow and that the governor is in retarded position. Note the position of the notch (A) and the governor weights at the top of the timer shaft. If the engine is speeded up, the governor weights (GW) fly outward (Fig. 7), causing the timer shaft to turn a farther advance in the direction of rotation. It is clear that the contact would be made earlier at contact points. The top of the timer shaft is driven through the governor arm—(G1) (Fig. 2); thus as weights (GW, Fig. 7) are forced outward by centrifugal force, (G1) moves the timer shaft (Fig. 2) in the direction of rotation.

**The automatic spark control** is for the purpose of securing the proper control due to variations in speed alone, and all that is required for normal driving is to secure the proper spark control for slow driving from 10 to 15 miles per hour (set the spark lever about two-thirds advanced), and the automatic feature will give the proper spark position for all higher speeds and for all lower speeds, excepting when the throttle is wide open, at which time the spark lever should be slightly retarded.

**The advantage of the automatic spark advance,** as further explained is this: With the spark lever set at the running position on the steering wheel, the "automatic" feature gives the proper spark for all speeds excepting a wide-open throttle at low

[1] The notched shaft would be termed the "cam," and when it is advanced by the governor action the rotor (DA, Fig 2, page 202) is also advanced.

speeds, at which time the spark lever should be slightly retarded. When the ignition is too far advanced, it causes loss of power and a knocking sound within the engine. With too late a spark there is a loss of power (which is usually not noticed excepting by an experienced driver or one very familiar with the car), and heating of the engine and excessive consumption of fuel are the results.

### Manual and Hand Advance of Spark

In addition to the governor advance—**the distributor housing can also be advanced by hand,** the two working independent of each other (see Fig. 3). (**L**) is connected with the spark lever on the steering wheel. This is termed "manual control."

**The manual or hand control** is for the purpose of securing the proper ignition control for carburetor adjusting, slow idling, retard for starting, and variable conditions which cannot be held constant.

**The reason for using manual (hand) control of spark,** where system is the automatic advance, is as follows: a highly compressed charge burns quicker than a light one. For this reason the engine will stand more advance with a half-open throttle than with a wide-open throttle. The hand control is therefore installed in order to secure the proper timing of the ignition due to these variations and to retard the spark for "starting," "idling," and "carburetor adjusting."

The automatic advance mechanism varies slightly in construction on different makes, but almost all are of the centrifugal type. See also page 212.

When starting the engine, where ignition is manual and with automatic advance, the spark lever should be retarded. After starting, move the hand spark lever to a position on the quadrant on top of the steering wheel, known as "driving position." It can then be advanced or retarded as occasion demands. Usually the **automatic advance starts to operate** at about 600 r.p.m. of engine.

**Semi-automatic advance** is where automatic and manual advance are provided.

**Full-automatic advance** is where automatic advance alone is provided.

### Operation of A.K. Open-Circuit Timer

**The operation of the timer:** This consists of a pair of contact points, normally open, which are connected in series with a battery and the primary circuit of a simple non-vibrating induction coil.

A hardened steel latch, against which the trigger strikes on its recoil and which in turn operates the contact points, completes the device (see Figs. 8, 9, 10 and 11).

**The distributor** forms the upper part of the Unisparker; the high-tension current from the coil is conveyed by the rotating distributor block arm (**DA**) (Fig. 2), thence to the spark plugs in their proper order of firing.

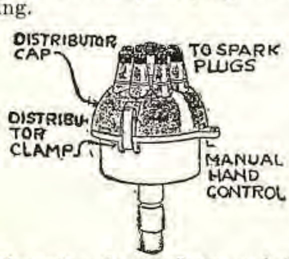



Fig. 7A. Illustrating the distributor and timer unit as shown in Fig. 2. Termed the "Unisparker."

The distributor, which distributes the current to the spark plugs (six, in this instance) in their respective firing order of 1, 4, 2, 6, 3, 5, is mounted on the upper end of the shaft. The distributor arm (**DA**), revolves with the timer shaft and passes the high-tension current to the terminals of the distributor. As six sparks are required per revolution, there are six notches on the timer cam, and the distributor points are spaced 60° apart. Fig. **7A** shows the parts of the distributor. A secondary cable of 5/16" outside diameter is used for the secondary circuit.

**Gap type distributor:** The distributor arm (**DA**, Fig. 2) does not touch the contacts above it, but passes close to them (gap .010 in.) as it revolves, and the high-tension current jumps the slight gap. It is therefore termed a "gap-type" distributor.

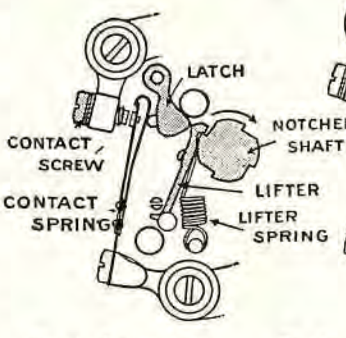



Fig. 8. Contact open.

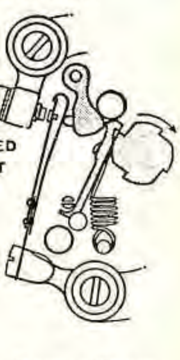


Fig. 9. Contact still open.

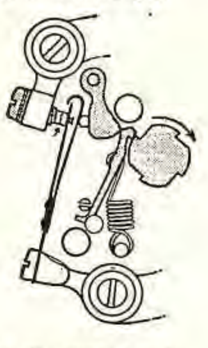


Fig. 10. Contact made.

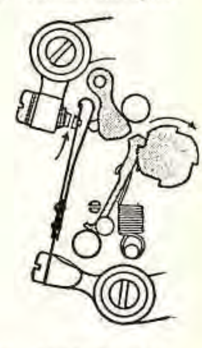


Fig. 11. Contact broken.

Figs. 8, 9, 10, and 11. Atwater Kent open-circuit timer operation.

Figs. 8, 9, 10, and 11 show the operation of the Atwater-Kent open-circuit timer clearly. It will be noted that in Fig. 8, the lifter is being pulled forward by the notched shaft. When pulled forward as far as the shaft will carry it (Fig. 9), the lifter is suddenly pulled back by the recoil of the lifter spring. In returning, it strikes against the latch, throwing this against the contact spring and closing the contact for a very brief instant—far too quickly for the eye to follow the movement (Fig. 10). Note that the circuit is closed only during the instant of the spark.

Fig. 11 shows the lifter ready to be pulled forward by the next notch. There are as many notches in the timer shaft as there are cylinders, and as many leads from the distributor to the spark plugs as there are cylinders.

**The ignition coil** (Fig. 4) is a box-type coil with a secondary and a primary winding. The primary current (6 volts), coming from the battery or generator, is carried through a pole-changing switch (Fig. 5) through timer contacts, where the current is opened and closed at the proper time by the contact arm (**D**) (Fig. 3) coming in contact with notches (**N**, Fig. 2), which raises latch (**E**), causing contacts (**B** and **C**), which are insulated from each other, to come in contact, thereby closing the primary circuit in the coil. This causes a secondary current to be set up in the secondary winding of high voltage. This secondary current is then distributed to the spark plugs by the distributor. (Cylindrical type coil is now used.)

**The condenser** in this system, using the box-type coil, is mounted in the coil, as shown in Fig. 4. The condenser is connected or shunted across the timer contact points.

Where a cylindrical type of coil is used, the condenser is mounted on the timer (Fig. 12**A**), and connects across the timer contact points.

**A box-type coil** is the type as shown in Fig. 4, page 202.

**A cylindrical type coil** is the type shown in Fig. 14, this page.

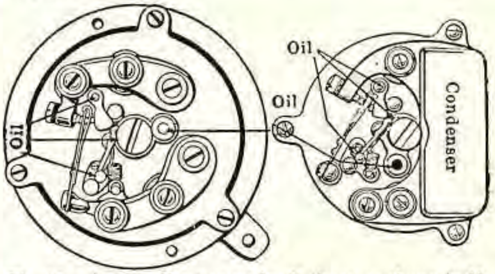



Fig. 12. Atwater Kent open-circuit timer, as shown in Fig. 3. The condenser is in the coil box (Fig. 4).

Fig. 12**A**. "A.K." open-circuit timer with condenser mounted on the timer. In this instance a cylindrical type of coil is used.

## THE ATWATER-KENT CLOSED-CIRCUIT IGNITION SYSTEM

**The closed-circuit system** is similar in many respects to the open-circuit system, except that the timer, or interrupter, is constructed differently. The points are normally closed instead of open. This system is termed the type "CC." When it is equipped with a governor or automatic advance it is termed the type "CA."

When using a closed-circuit timer, it is necessary to use resistance in connection with the primary winding of the coil, else the coil might be damaged if the switch was left on when the engine is not running, as the timer points are normally closed. The resistance unit also protects the coil during variations of speed of the generator, which slightly increases in voltage at high speeds, when the generator supplies current for ignition. At low speeds the battery (6 volts) supplies current for ignition.

At medium and high speeds the generator supplies current for ignition (about 8 or 9 volts).

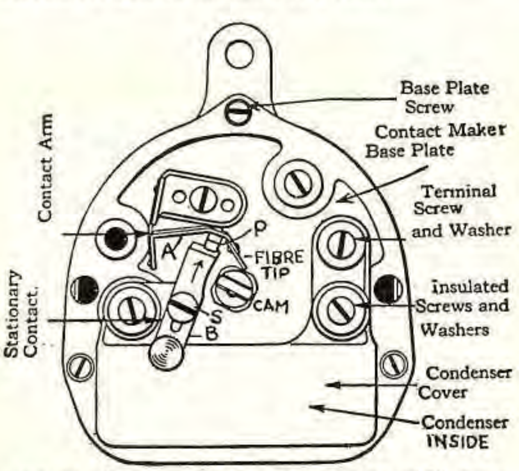



Fig. 13. Top view of Atwater Kent type "CC" closed-circuit timer (also called interrupter and contact-breaker).

**The closed-circuit timer** (we will term it an "interrupter," because it interrupts the flow of current in the primary winding instead of first closing and then opening) is shown in Fig. 13. Contacts are normally closed by a spring on the contact arm. Rotation of cam brings it in contact with a fibre tip on contact arm (**A**), thus separating contact-points (**P**) and breaking the circuit, at which instant the coil delivers the strongest current).

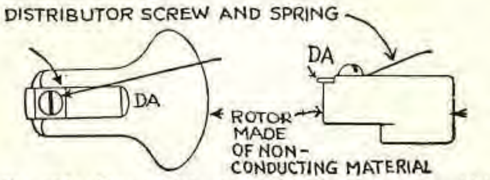



Fig. 13**A**. Top and side view of the distributor rotor which is placed on the top of the cam (Fig. 13), and serves to distribute the secondary current to the spark plugs in a manner similar to (**DA**) (Fig. 2, page 202).

**Adjustment of the interrupter points** on a closed-circuit system can be made by loosening screw (**S**) (Fig. 13) and moving arm (**B**).

**The gap** between contact points should be .009" for 4- and 6-cylinder and .007" for 8-cylinder engines. The spark-plug gap, .025".

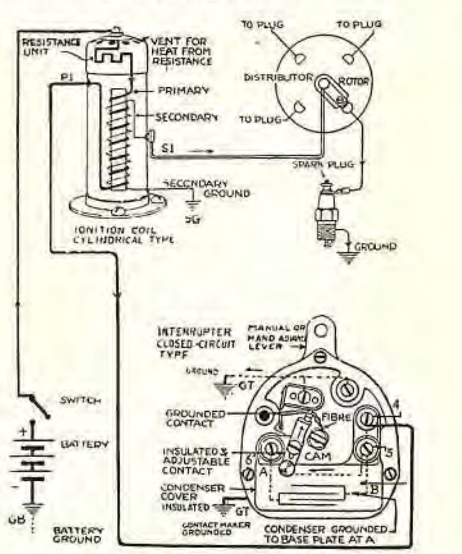



Fig. 14. Wiring of the Atwater Kent closed-circuit ignition system. Note that a cylindrical type of coil is used. Note: The secondary (**SG**) is grounded to the primary winding.

**Circuit of the AK closed-circuit interrupter and distributor** (Fig. 14): Note one wire from the timer and one wire from the battery is grounded; therefore it is a "single-wire" system. The open or closed-circuit system could also use either a "single" or "two-wire" system.

**To trace the primary circuit,** start at the switch, follow the black line to the insulated terminal (4), then to the insulated contact point through grounded contact point to grounded terminal, to ground (GT), to ground on battery (GB). (Note that the condenser connects across the contact points.)

**To trace the secondary circuit,** start at (S1) thence to distributor rotor, through spark plug to ground (SG).

**Note:** The secondary is now grounded to the primary winding

### Atwater-Kent "Style 46" Contact Maker

**On some of the type "CC" and "CA" interrupters a contact-breaker shown below is used.** A contact screw (S) is used instead of (B) (Fig. 13) and a different arm (M) instead of (A) (Fig. 13). This type is known as "Style 46" for a ½" cam and "Style 80" for a ⅝" cam. **The adjustment of the interrupter point gap is .015".**

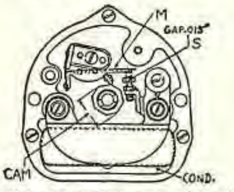
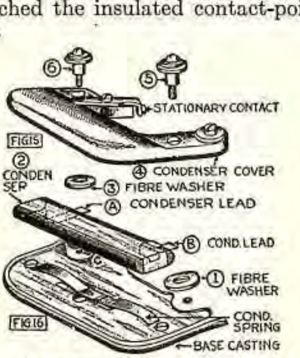



**Fig. 14A.** Style 46 contact-breaker, adaptable to the regular Type "CC" and "CA" interrupter.

### The Atwater-Kent Condenser

**The condenser** on the type "CC" closed-circuit system, instead of being in the coil, is located on the interrupter (Figs. 13 and 14). Note the circuit in Fig. 14. The condenser short-circuits across the timer contact-points for reasons stated on page 190.

To understand how the condenser is connected, see Figs. 14, 15, and 16. A metal cover (Fig. 15) is placed over the condenser to protect it, and to this is attached the insulated contact-point of the interrupter.




Figs. 15, 16. Sequence of operations in installing condenser: (1) insulated washer placed in position; (2) condenser placed in pocket; (3) insulated washer laid on top of condenser terminal; (4) condenser cover placed in position; (5 and 6) insulated screws put in; (7) adjust contact points.

This condenser cover is insulated from the base of the interrupter by screws 5 and 6 which have insulated washers on them.

Note the terminals (A) and (B) of the condenser (Fig. 16). Terminal (A) is grounded to base (C) of the timer below it, then an insulated washer (3) is placed over (A). The other terminal (B) has an insulated washer (1) under it to insulate terminal (B) from the base. Cover (4) is then placed over the condenser and terminal (B) makes contact with the cover. We then have one terminal (A) of the condenser grounded to base (C) and the other terminal (B) connected with cover (4) which is insulated from the base. The circuit would then be as shown in Fig. 14.

It is seldom necessary to remove the condenser, but if ignition fails in case the timer should become water-soaked, feel the coil, with switch on. It should show some heat from current passing through resistance unit in the coil. You will then know that current is passing through the coil all right; therefore open the switch. Then remove the distributor cover and condenser cover and clean all contacts and screws and replace the condenser cover; also wipe water from the other parts and wires. The ignition may also fail by these screws coming loose; however, this seldom happens, but if ignition fails, and you know that current is passing through the coil, and if no spark can be obtained, then this might be investigated.

**Oil:** Use light machine oil at points shown by the lines on the open-circuit timer (Figs. 12 and 12A). Oil lightly about every 1,000 miles. See that **the contact-breaker points are free from oil.** A small amount of vaseline can be applied to interrupter cam.

### Testing

**If the engine misses without regard to speed,** test each cylinder separately by short-circuiting the plug with a screw driver, allowing a spark to jump. If all cylinders produce a good, regular spark, the trouble is not with the ignition.

**If any one cylinder sparks regularly,** this will indicate that the system is in working order, so far as the Unisparker and coil are concerned, and the trouble is probably in the high-tension wiring between the distributor and plugs, or in the plugs themselves. Examine carefully the plugs and wiring. Leaky secondary wiring is frequently the cause of missing and back-firing.

Frequently, when high-tension wires are run from the distributor to the spark plugs through metal or fiber tubing, trouble is experienced with missing and back-firing, which is due to **induction between the various wires in the tube.** This trouble is especially likely to happen if the main secondary wire from the coil to the center of the distributor runs through this tube with the spark-plug wires.

Wherever possible, the **distributor wires should be separated by at least half an inch of space,** and should be supported by brackets or insulators rather than run through a tube. In no case should the main distributor wire be run through a conduit with the other wires.

**If irregular sparking is noted at all plugs,** examine first the battery and connections therefrom. If the trouble commences suddenly, it is probably due to a loose connection in the wiring. If gradually, the batteries may be weakening or the contact points may require attention. See that contacts are clean and bright, and also that the moving parts are not gummed with oil or rusted.

### Timing Atwater-Kent Ignition System—Open and Closed-Circuit Types

**Open-circuit type when hand-spark control is not used** (automatic advance): **First,** place the piston of No. 1 cylinder on top of the compression stroke. **Second,** slowly turn the Unisparker backwards until a click is heard, which is the exact instant of the spark. **Third,** tighten the set screw on the timer shaft which was loosened when starting to time. Be careful not to change position. **Fourth,** remove the distributor cover and note the position of the distributor block or rotor. It should be on the terminal for No. 1 cylinder. Then see if the wires from the distributor are connected properly, in accordance with the firing order of the cylinders, keeping in mind the direction in which the rotor turns.

**The spark set thus, is on top-dead-center retarded,** and the governor action will take care of the advance as the speed increases.

**The closed-circuit type when the hand-spark control is not used** (automatic advance): The timing is the same as above, except that the timer should be turned backwards until the contact-points commence to open. As they open the spark occurs. A good way to test is to have spark plugs on top of the cylinders and current on, so that the spark can be seen at points of plugs. If the timer with automatic advance is used in connection with the regular spark lever on the steering wheel, then do not give over five-eighths or three-quarters of an inch movement of the timer from full retard to full advance.

**Open-circuit type with hand-spark control:** The setting is the same, except that the position of the spark-advance lever on the steering wheel should be within half an inch of full retard and the lug on the timer should have three-eighths to one-half an inch movement from full retard to full advance. After retarding the spark lever to within one-half an inch full retard, then with the driving member loose, and piston on top of the compression stroke, turn backwards until a click is heard, at which point set the timer. Then see "Fourth" procedure, page 206.

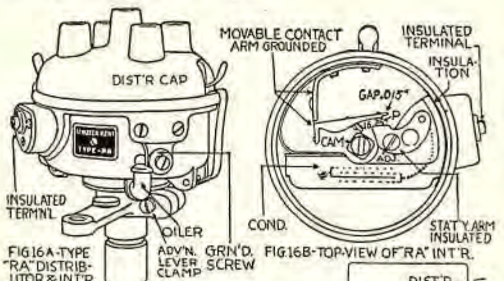
**Closed-circuit type with hand-spark control:** Same as above, except that the timer is turned backwards until contact points commence to open, at which point set the timer by set screw or clamp, or if driven by a shaft on which the timer cannot be loosened, then the setting can be made with the advance lever shaft or drive gears loosened. The lug on the timer should have seven-eighths to one inch movement from full retard to full advance.

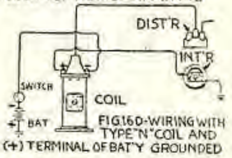
### Atwater-Kent Type "RA" and "LA" Interrupters

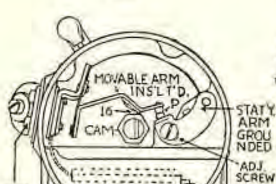
**Type "RA" distributor and interrupter** is shown in Figs. 16A, 16B. **Type "LA" interrupter** is shown in Fig. 16C. These models are later than type "CC" (page 205). They are equipped with automatic governor and hand control and are of the closed circuit type.

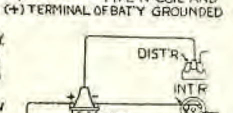
**Type "LA" differs from "RA"** in that the stationary contact arm is grounded and the movable arm is insulated, whereas in type "RA" this is just the reverse. **Adjust contact points (P)** to open .015" when (16) is on high point of cam.

**Ingition coil** type "N" is used with this system, and has a straight iron wire resistance enclosed in the coil. Connections are shown in Fig. 16 (D and E), for type "RA" system.



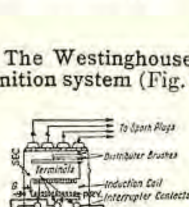




(The address of the Atwater-Kent Mfg. Co. is Philadelphia, Pa.)

## THE WESTINGHOUSE IGNITION SYSTEMS

**The Westinghouse battery and coil vertical type ignition system** (Fig. 17) is of the closed-circuit type.



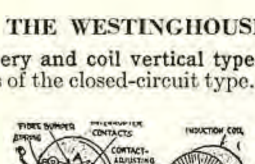




Fig. 17. Westinghouse high-tension non-vibrating coil, closed-circuit ignition system, the Vertical type is now replaced with the type "SC" ignition system.

Fig. 18. Contact-breaker or interrupter with condenser.

Fig. 18A. The double-wound, high-tension ignition coil winding shown in Fig. 17.

**We can thus tell that this is a closed-circuit ignition system by observing the interrupter points or contacts and the cam—** because, normally, the contact points are closed and are opened by the cam, whereas with an open-circuit system, as explained on page 204, the contact points are first closed, then opened.

**Interrupter and distributor** can be operated from cam shaft or attached to generator. **Distributor brush** is carbon. **Switch** is of the pole-changing type.

**Ballast coil or resistor** is the same as an ignition resistance unit (page 198).

**Adjust interrupter points** .012" gap when cam raises arm (**A**); adjust spark plugs gap .025".

This is only one example. Manufacturers are Westinghouse Electric Co., Springfield, Mass.

**The Westinghouse type "SC" ignition system is** shown in Figs. 18B, C, and D.

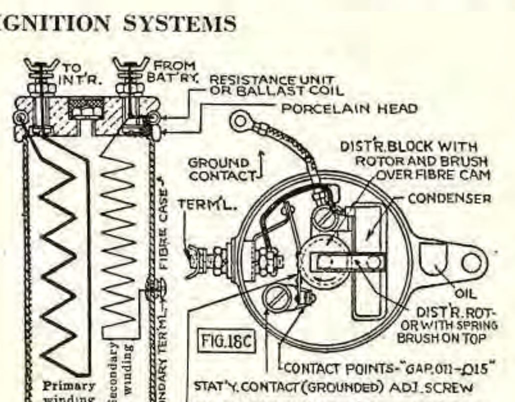
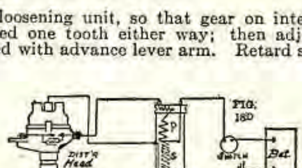



Fig. 18B. Internal of type "SC" coil; Fig. 18C. Top view of interrupter.

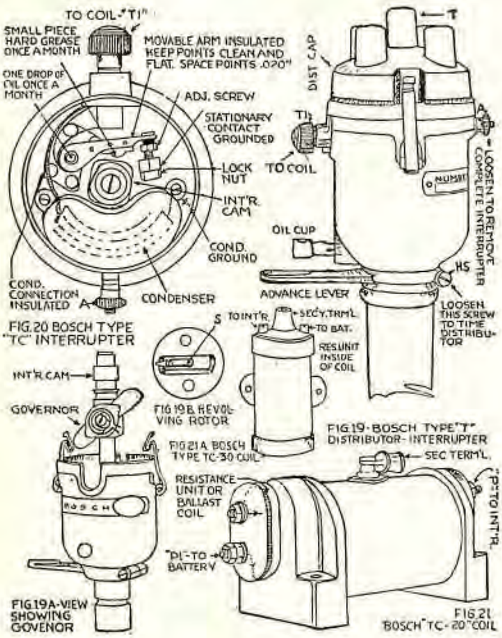
**Adjust interrupter tungsten points** by loosening adjusting screw and move up or down until points are .011" to .015" apart when fully separated by cam.

**Time** by loosening unit, so that gear on interrupter shaft can be moved one tooth either way; then adjust length of rod connected with advance lever arm. Retard spark lever.



## THE BOSCH BATTERY IGNITION SYSTEM (Model "TC-20")

Model "TC-20" is the type used on Essex, Hudson, Dort-Six and other makes of cars (see Specifications of Passenger Cars).




**Distributor connection from coil secondary term'nal** (Fig. 21) is with center terminal (T) of distributor (Fig. 19), which connects with rotor metal part (S, Fig. 19B) by means of a carbon brush. The **rotor** revolves with the cam shaft, and there is a gap of approximately .010" from point of (S, Fig. 19B) to the distributor terminals, thus termed a "gap type of distributor."

**The automatic governor** advances the interrupter cam and rotor (Fig. 19A.) The Hudson and Essex have an advance range of governor of 28°, and the manual advance lever arm 22° (flywheel degrees).

**The interrupter** terminal (T1, Figs. 20, 19) connects with primary winding terminal (**P,** Fig. 21). The movable contact arm is insulated and connects with (T1). Stationary contact screw is grounded. **Adjustment of interrupter gap is .020"** when on highest point of cam.

**Condenser** is connected across the points. One end is insulated and connects with (T1), the other end is grounded. Condenser is insulated with mica.

**Coil primary winding circuit** is from battery to (P1, Fig. 21), through resistance unit (ballast coil), through primary winding, to (P), to (T1) on interrupter. (See page 198 for purpose of resistance unit. Resistance unit is **inside** of the later model TC-30 Bosch coil.)

**Secondary** winding: One end is grounded to primary winding. The other end connects with the secondary terminal, which leads to the center terminal (T) of distributor.

**Timing Essex-Bosch ignition** (also Hudson): Place advance lever in **full-advance** position (top of quadrant). Place No. 1 cylinder piston on top dead center of compression stroke. In this position the pointer on observation hole on flywheel case should be directly over mark "DCI-4" stamped on flywheel. (This mark is **"A"** on the Hudson). Remove distributor cap and rotor and **loosen clamp screw** (HS, Fig. 19) in **advance-lever timing arm.** Turn housing to left until interrupter points just start to open and tighten screw (HS). Replace rotor and determine under which terminal of distributor cap the point of metal segment (S) (Fig. 19B) will rest. Replace distributor cap and connect this terminal to the plug of No. 1 cylinder. Connect the rest of the terminals to the plugs in rotation according to firing order, 1-3-4-2 (on Hudson, 1-5, 3, 6, 2, 4). **Spark plug** gap is set at .025". Parts requiring lubrication are shown in Fig. 20, and the governor and its shaft (Fig. 19A).

**Dort-Six timing** is similar except that spark lever is **retarded** and piston is placed on top d.c. compression stroke (which mark on flywheel is "1 and 6 DC" when in center with inspection hole).

Address of manufacturer is American Bosch Magneto Corpn., Springfield, Mass.

## REMY DISTRIBUTOR, INTERRUPTER, AND IGNITION COILS

**The waterproof type of Remy distributor and interrupter,** as used on many different cars is shown in Fig. 22. The Remy automatic advance distributor is shown on pages 211 and 212. The systems are of the closed-circuit type.

**Parts** are as follows: **(A)** Distributor for the center terminal connecting with the secondary terminal of coil; **(B)** one of the spark-plug terminals of the distributor; note that the lower part **(Z)** is not in contact with (Y), but 1/64" from it; **(C)** rotor or segment insulated; **(D)** lock nuts holding interrupter cam in place; **(E)** reference pin; **(F)** interrupter on the contact-breaker cam; **(G)** fiber block on the breaker lever arm; **(H)** spring with a carbon button on the rotor which connects the secondary circuit coming in at **(A)** with the rotor metal plate **(Y)**; thus as the rotor **(C)** revolves, the secondary current jumps an air-gap clearance of 1/64" to the spark-plug terminal **(Z)** and other spark-plug terminals as it revolves; **(K)** end of the shaft above the cam which the distributor rotor fits over; **(L)** pin in cam **(F)** which fits into the under part of the rotor to drive it; **(S)** shaft driven from the engine which drives the interrupter cam **(F)** and rotor **(C)**. Note that cam **(F)** is fitted on top of this shaft **(S)** which is tapered; thus lock nuts **(D)** force it down; **(Y)** adjustable metal plate on rotor or segment **(C)**.

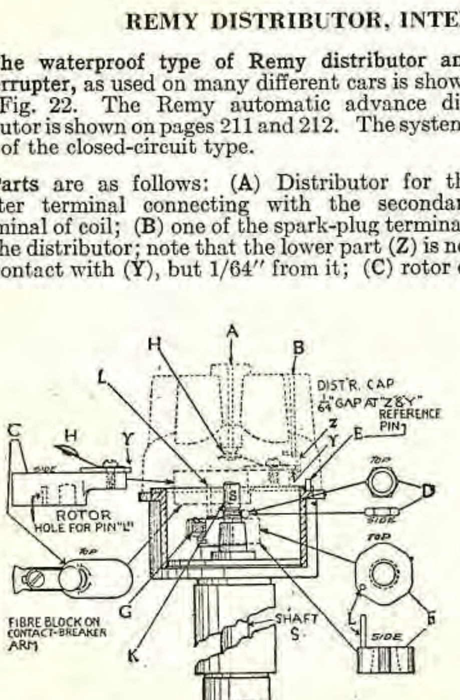



**Fig. 22.** Remy distributor and interrupter (contact-breaker).

### To Check Distributor Settings and How to Time When Putting in New Parts

**For distributors with counter-clockwise rotation:** In observing Fig. 22A, from the top, the cam appears to be revolving in a clockwise rotation; however, by referring to the standard practice of determining rotation (looking from the drive end), it is seen really to be rotating counter-clockwise.

**The spark-control lever** (I) (Fig. 22A) connects with the lever on the steering wheel and should be in a fully retarded position after having located the

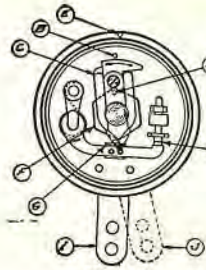


Fig. 22A

Note. "Clockwise rotation" is from right to left, in the same direction as the clock hands rotate. "Counter-clockwise" (or "anti-clockwise") is in an opposite direction to clockwise. When considering the rotation of ignition devices or generators the drive end is the point from which to consider rotation.

cylinder attached to the terminal (B) (Fig. 22) on top of the dead-center compression stroke with the distributor coupling connected up.

(E) is the reference pin (Figs. 22 and 22A) over which the reference slot of the distributor cap is set; (B) is the exact location of the pin in the distributor cap when the distributor cap is installed; therefore, always time by bringing the piston in the cylinder on top of dead-center of the compression stroke, which is attached by high-tension lead to the terminal (B), or to the terminal opposite reference pin (E).

Remove the segment or rotor and cam lock nut (D) (Fig. 22), and lift the cam. Replace the distributor segment (C) in its original position over shaft (K) and cam pin (L) with the cam loose. Then turn cam (F) around (with distributor shaft stationary) in the direction of rotation until the distributor segment (C) is opposite the reference pin (E) with one point of the cam (F) against the fiber block (G), and the breaker points are just ready to separate.

Again remove the segment (C) without disturbing the setting of the cam, install the cam lock-nut (D), tightening it up securely, then install the rotor or segment (C) and the distributor cap, being sure that all high-tension leads are connected to it, in accordance with the direction of rotation and of firing-order.

**For counter-clockwise distributors** use the instructions just given, transposing the control position so that the segment and cam rotate in the opposite direction.

**When installing new high-tension wiring** always connect cylinder No. 1 to high-tension terminal (B), connecting the rest of the cylinders in accordance with the direction of rotation, and as per the segments and firing order (unless the distributor cap is marked otherwise).

**Spark-plug gaps** should be .025″ to .030″.

**If the engine misses** when idling or at light loads, the gaps at the plugs should be wider. If the engine misses at high speed or when pulling hard, the gaps should be narrower.

**The oiler** on the shaft should be kept filled with medium cup grease and screwed down two or three turns occasionally. On some instruments a wick oiler is used. In this case use pure vaseline instead of grease.

Serviced by United Motors Service Branches and Delco-Remy Service Stations.

## Remy Ignition Coils

**Coils** are usually classified as **"two-terminal"** and **"three-terminal"** coils. The designation applies to the **primary terminals.** In a coil without a condenser, either of the primary terminals **could** be connected to battery or interrupter (best however to connect as marked). A coil with condenser in it **must** be connected properly (see page 229).

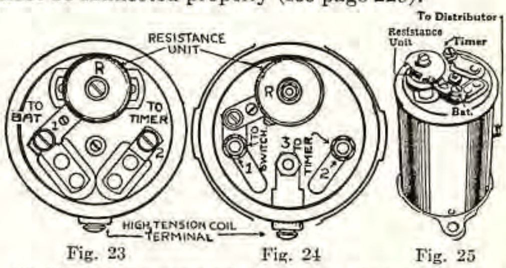



Fig. 23 Fig. 24 Fig. 25

Fig. 23. Remy two-terminal coil; Fig. 24. Three-terminal coil.
Fig. 25. Side view of Remy ignition coil (cylindrical type).

**A two-terminal ignition coil,** top view, is shown in Fig. 23, a wiring diagram in Fig. 26, and a top and side view in Fig. 25. This coil is known as model 284B, F, G, and A, and has a condenser in the coil.

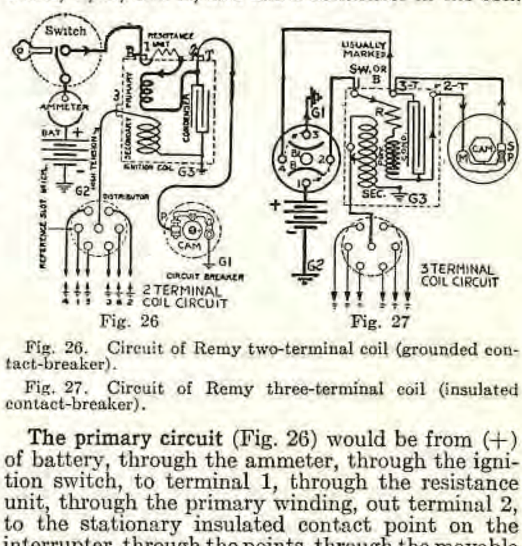



Fig. 26 Fig. 27

Fig. 26. Circuit of Remy two-terminal coil (grounded contact-breaker).

Fig. 27. Circuit of Remy three-terminal coil (insulated contact-breaker).

**The primary circuit** (Fig. 26) would be from (+) of battery, through the ammeter, through the ignition switch, to terminal 1, through the resistance unit, through the primary winding, out terminal 2, to the stationary insulated contact point on the interrupter, through the points, through the movable arm, to ground (G1), to ground of battery (G2), thus completing the primary circuit. (This is termed a "grounded" system.)

**The condenser** is connected across the contact points, one end being grounded at (G3).

**The secondary circuit** is from the secondary winding which is wrapped around the same core as the primary, to the center terminal of distributor, to the rotor arm of the distributor, to the spark plugs, through the frame of the engine to ground (G3) of the coil.

**Marks on coils vary.** Note that terminal 1 is marked "B," meaning to battery, or sometimes "SW," meaning to switch. Terminal 2 is marked "T" or "INT," meaning to timer or interrupter. Where a coil has a mark on the terminal as "MAG," it usually means that it is intended to be used in connection with a magneto.

**When testing a coil,** by connecting with (B) and (T), the primary circuit can be tested, including the resistance unit.

**The resistance unit** can be cut out of the test by placing the test point on the screw or terminal (R) (Fig. 23).

**When testing the condenser,** terminal (T) and ground (G3) would be the circuit across the condenser.

**A three-terminal ignition coil** is shown in Figs. 24, 27. Many of the three-terminal coils were used with "pole-changing" switches, and "insulated" ignition systems (meaning that the primary circuit is fully insulated, or with two wires to the contact breaker).

**The primary circuit** (Fig. 27) would be from (+) of battery to 1 on switch, through "pole-changing switch" blade (B) which, if turned in one direction, would connect with 1 and 2 of the switch, thence to terminal 1 of the coil, through resistance unit (R), through the primary winding, to terminal 2, to movable interrupter-contact arm (M), through points (PS), back to terminal 3 on coil, thence to 4 on the pole-changing switch, through blade (B1) (now disconnected), connecting 4 and 3 together, out 3 to ground (G1), to ground terminal (G2) of battery (−), thus completing the primary circuit. This is termed an "insulated" system.

**If the pole-changing switch** was turned in the opposite direction, so that blade (B) would connect with 1 and 4, and blade (B1) with 3 and 2, the primary circuit would then first go to the stationary contact point (S) on the interrupter instead of to the movable arm (M). For instance, the primary circuit would then be from (+) of battery to 1 on the switch, through blade (B) to 4, to terminal 3 of the coil, to the stationary contact point (S), through the points, out movable arm (M), to 2 on the coil, through the primary winding, through resistance (R), to coil terminal 1, to switch terminal 2, through blade (B1) to 3, to ground (G1), to ground (G2) of battery.

Thus the flow of the primary direct current through contact points could be reversed so that it would flow first in one direction and then in another by moving the switch first one way and then the other. This is termed a "pole-changing switch" or "depolarizing switch," and a three-terminal coil is often used with it. See also Index under "Wiring diagram, Oakland 32," which clearly shows a pole-changing switch.

**The purpose of a pole-changing or depolarizing switch** is explained on page 203.

The pole-changing switch is not used very much at the present time, because tungsten metal is now used for points. It is very hard and does not have the electrolytic[1] effect to such an extent as the silver points which were formerly used. Note that the condenser is connected across the points with either direction of the flow of the current.

## DRIVING THE INTERRUPTER AND DISTRIBUTOR

**One modern method** of driving the timer (interrupter, also called "contact breaker") and distributor, is from the generator shaft, as shown in Fig. 8.

**The generator shaft** is driven by gears or by a silent chain, encased. The timer shaft is driven from the generator shaft by a spiral gear, and is geared so that it will run the distributor and timer usually at one-half the speed of the crank shaft.

Quite often the timer and distributor shaft are operated from the cam shaft. In fact, there are various methods employed, but in most every instance it runs at cam-shaft speed (one-half the speed of the crank shaft).

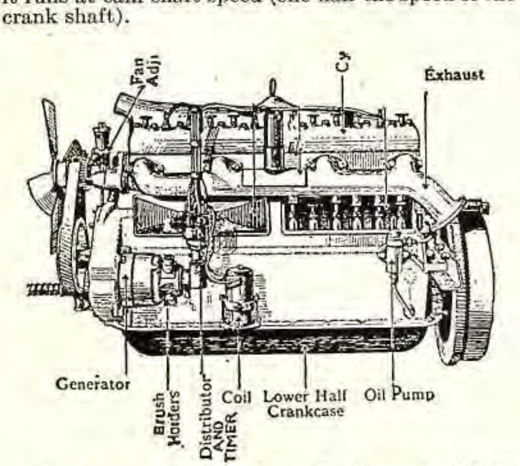



Fig. 8. method of driving the timer and distributor through the generator shaft.

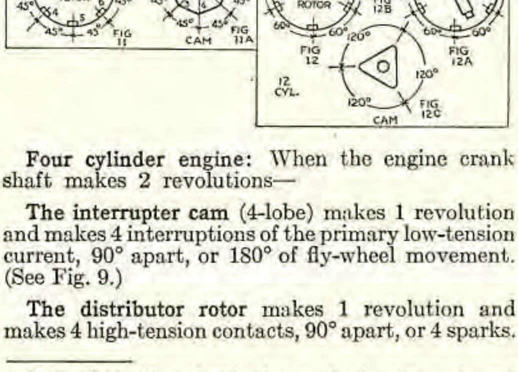
On the double distributor, explained farther on, the cam operating the double set of interrupter contact breakers is driven at crank-shaft speed, but a three-lobe cam is used.

### Relation of Speed of Distributor-Rotor, and Interrupter Cam to Crank Shaft of Engine

**The crank shaft of the engine** must make two revolutions (720°), to complete its four-cycle revolution.

**The distributor rotor** always revolves at cam-shaft speed, or half the crank-shaft speed.

**The interrupter cam** in all instances except one, as on the twelve, revolves at cam-shaft speed, or half crank-shaft speed.




**Four cylinder engine:** When the engine crank shaft makes 2 revolutions—

**The interrupter cam** (4-lobe) makes 1 revolution and makes 4 interruptions of the primary low-tension current, 90° apart, or 180° of fly-wheel movement. (See Fig. 9.)

**The distributor rotor** makes 1 revolution and makes 4 high-tension contacts, 90° apart, or 4 sparks.

[1] Electrolytic (electrolysis) refers to the depositing of metal from one point to another, as in electro-plating.

**Six-cylinder engine:** When the engine crank shaft makes 2 revolutions—

**The interrupter cam** (6-lobe) makes 1 revolution and makes 6 low-tension interruptions, 60° apart, or 120° of fly-wheel movement. (See Fig. 10.)

**The distributor rotor** makes 1 revolution and makes 6 high-tension contacts, 60° apart, or 6 sparks.

**Eight-cylinder engine of the "V" type:** When the engine crank shaft makes 2 revolutions—

**The interrupter cam** (8-lobe) makes 1 revolution and makes 8 low-tension interruptions, 45° apart, or 90° of fly-wheel movement. (See Fig. 11.)

**The distributor rotor** makes 1 revolution and makes 8 high-tension contacts, 45° apart, or 8 sparks.

**Twelve-cylinder engine of "V" type:** When the engine crank shaft makes 2 revolutions, or 720°—

**The interrupter cam** (3-lobe) makes 2 revolutions (720°), or revolves at crank-shaft speed instead of cam-shaft speed; therefore it makes 6 interruptions of the low-tension primary circuit 60° apart. There being two contact-breaker arms instead of one, connected with two separate primary coils, then each breaker arm would make 6 interruptions, or 12 interruptions 30° apart, or 60° of fly-wheel rotation, during 2 revolutions of the 3-lobe cam. (See Fig. 12.)

**Distributor rotor:** Note that there are two distributors driven at half the speed of the crank shaft; therefore each rotor would make one revolution, or 360°, while the crank shaft made two revolutions. Distributor segments are 60° apart, therefore each distributor rotor would make six high-tension contacts during one revolution, or twelve sparks during one revolution with both distributors, during which time the crank shaft makes two revolutions.

With these explanations we have dealt with single distributors and single contact breakers, with the exception of the twelve-cylinder engine, as explained above.

Attention is called to the Delco double distributors and double interrupters, as explained under "Delco ignition coils, distributors and interrupters."

## REMY IGNITION ON STUDEBAKER "LIGHT SIX"

As an example of a method of driving the generator and ignition system, the Studebaker "Light Six," model "EJ" engine is used.

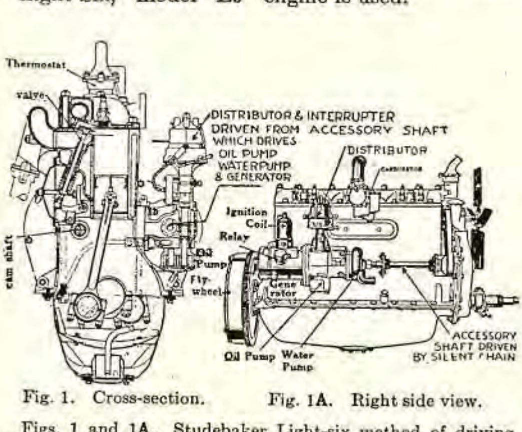



Fig. 1. Cross-section. Fig. 1A. Right side view.

Figs. 1 and 1A. Studebaker Light-six method of driving ignition system.

**The distributor and closed-circuit interrupter** are connected with a vertical shaft which is driven from a shaft called the "accessory shaft." The accessory shaft is driven by a silent chain (see page 51), which also drives a water-circulating pump and generator.

**The speed of the distributor shaft** is 1 revolution to 2 of the crank shaft of the engine, or at cam-shaft speed.

There are six high points or lobes on the interrupter cam, and six terminals on the distributor (Figs. 2 and 3); therefore, there are six sparks, one for each cylinder during two revolutions of the crank shaft.

**The distributor and interrupter** (Figs. 2 and 3) are advanced by a manual control connecting from the spark-control lever to the spark lever on the steering wheel. An automatic advance is also provided.

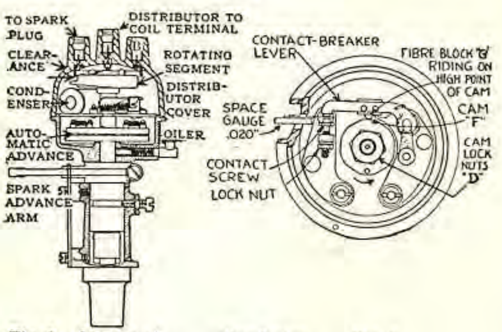



Fig. 2. Section of distributor. Fig. 3

**The interrupter** is of the closed-circuit type.

### Adjustment of Interrupter Points

**To check the opening of the breaker points** on the interrupter, remove the distributor cover, then turn the crank shaft over by hand-crank until the contact-breaker lever (Fig. 3) rides on one of the high points of the cam, then slip a thickness gauge through the space between the points. If the opening is greater than .025", loosen the lock nuts and turn the contact screw until adjustment is not less than .020" nor more than .025". Be sure to tighten the lock nut.

**Contact points should always be flat,** and make good contact with each other. When they have a frosty appearance all over their surface, it indicates good contact. If they are not making good contact, the surfaces can be smoothed up with a fine file or with No. 00 sandpaper and can then be readjusted.

See also pages 221 and 224 under the subject of "contact-point surface and removal" and "dressing and testing platinum points."

## REMY SEMI-AUTOMATIC IGNITION SYSTEM

**The Remy semi-automatic ignition system** type 606 is shown in Fig. 4.

**The condenser** is mounted on the breaker plate.

**The type of advance used is known to the trade as "semi-automatic,"** which means that part of the advance is performed automatically and part is taken care of manually. Under all ordinary driving conditions the advance mechanism adjusts the spark position to the engine requirements. The hand advance need be used only when a wide-open throttle at very low speed, or at maximum speed, is desired. See page 204 for meaning of "full automatic advance."

**The automatic advance** mechanism: Three centrifugal weights (**W**, Fig. 8) advance the cam as speed increases. The cam shaft (**S**) carries a star-shaped punching (**P**) against which rest the tangs (**T**) on the weights, and as the weights fly outward, due to increase in speed, the interrupter cam and rotor are advanced.

From retard position the weights move and the **spark starts to advance at 600 r.p.m.** of the engine.

**The primary circuit** is from the battery (+) grounded battery terminal, to the grounded contact lever or arm, through the points, to the ignition-coil terminal marked "Timer," through the primary winding, through the resistance unit, to "IGN" on the switch, to the battery (−) terminal. Note that this is a two-terminal ignition coil, and the condenser is mounted on the breaker plate, placed across the points, one end being grounded. The cam which raises the breaker contact lever, or arm, has six high points; therefore the one shown in this illustration would be for a six-cylinder engine.

**The secondary circuit** is from the ignition coil of the secondary winding, to the distributor rotor, to the spark-plug terminals (note that the gap between rotor and terminals in the distributor cap leading to the spark plugs is 1/64"), to engine ground, to grounded secondary winding at metal base of coil. Note that there are six terminal leads from the distributor cap to the spark plugs; therefore it would be for a six-cylinder engine.

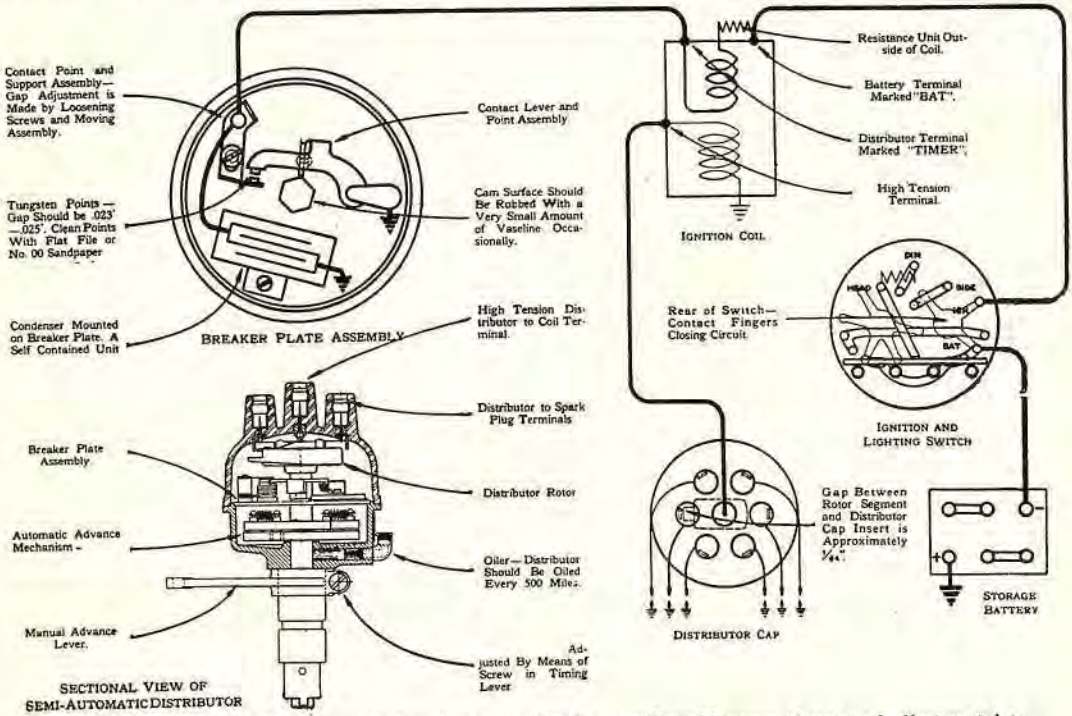



Fig 4. Wiring chart of the Remy "type 606" semi-automatic ignition, together with names of parts and adjustment data.

**The "type 626" Remy ignition system** (Figs. 5 to 8) is a **semi-automatic** type of distributor and supersedes type 606 (Fig. 4). Note that the **manual advance** (Fig. 5) is obtained by moving the interrupter plate instead of rotating the entire distributor. The type 626 **interrupter** (Fig. 6) also differs from the type 606 interrupter, as will be observed. A **condenser** is carried on the interrupter plate.

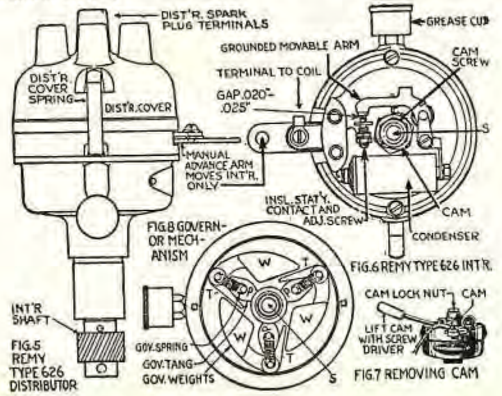
**The automatic governor advances both the rotor and cam** on types 606 and 626. However, on another type, 614, used on the Chevrolet "copper-cooled" car, the automatic mechanism advances the cam only, the rotor being carried on the main shaft.

**The automatic advance begins to advance at 600 r.p.m. of the engine.** The automatic advance is 20° on all 606 and some 626 models. On others it is 30°.

**The manual advance varies** according to the model distributor. Usually this advance is 15°, 20°, 25°, or 32°.

**Timing ignition** (Remy model 606): The timing of this system is explained under Fig. 4, page 302, and is by loosening the advance lever clamp screw, as used on the Studebaker "Light-six" model "EJ," 1922.

**Timing ignition** (Remy model 626): The timing of this system is by loosening the interrupter cam (Fig. 7), in a manner similar to that explained on page 302, under Figs. 3, 3A. The "Studebaker model" "EM," 1923, uses the system shown in Figs. 5, 6, 7, 8.



## INSTRUCTION No. 20

# DELCO IGNITION: Coils; Distributors and Interrupters[1]

**The Delco distributor** might be classified in three ways:

1. **Single distributor, with one set of timing contact points** on the interrupter, using one ignition coil.
2. **Single distributor, with two sets of timing contact points** on the interrupter (connected in parallel), using one ignition coil.
3. **Double distributor, with two sets of timing contacts,** using two ignition coils.

The following explanations will serve to make the foregoing classification clear.

### Delco Ignition Coils

Four general types of non-vibrating, single-spark ignition coils have been used. They are:

1. **Round type with straw-colored shell.** This type does not incorporate either the resistance unit or the condenser.
2. **Round type with black shell.** This type does not incorporate the condenser, but the resistance unit is mounted on the outside of the coil shell.
3. **D-type with bakelite shell.** Certain of the coils carry the resistance unit mounted upon the end of the shell. This type does not incorporate the condenser.
4. **D-type with black shell.** This type incorporates the condenser within the shell and the resistance unit on the end of the shell.

Note: The most popular types of Delco coils are 2159 (Fig. 2 below) and 2178 (see Nash, page 402) and the 2176 used on the Buick-six (1923) which is similar to 2178. These coils do not have condensers. The condenser is on the interrupter plate. The internal connections of these coils are the same as in 2159, Fig. 2.

Figs. 1 and 2 show the internal circuits in typical coils. Note in Fig. 1, that the resistance unit is mounted on the right end of the coil and in Fig. 2, it is on top at the right end.

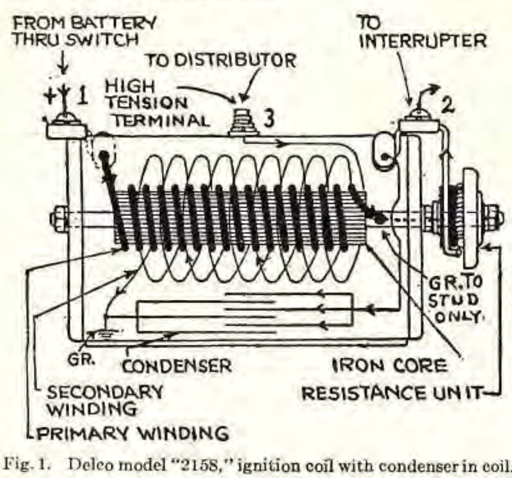



Fig. 1. Delco model "2158," ignition coil with condenser in coil.

In Fig. 1, note the condenser in the coil which is connected across the interrupter points, one end of the condenser being connected to terminal 2, and the other end grounded. The primary-circuit terminals are numbered 1 and 2; the secondary terminal is No. 3.

Fig. 1A illustrates a grounded ignition circuit using a condenser in the coil and a single distributor and interrupter.

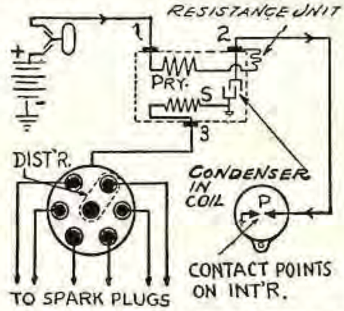



Fig. 1A. Circuit when using coil shown in Fig. 1.

**The primary circuit** (Fig. 1A) runs from (+) of battery, to ignition switch to terminal (1) of the coil, through primary winding, through "resistance unit," to coil terminal (2), to the insulated interrupter contact point, across contact points (P), to grounded interrupter contact, to grounded (−) terminal of the battery, thus completing the primary low-tension circuit.

**The secondary circuit** runs from the secondary terminal (3) on the coil to the center terminal of the distributor, through the rotor, to the spark-plug terminals of the distributor, to the spark plug, through the spark-plug gap, to the spark-plug shell grounded to the engine, through the ground of the engine and frame, to the grounded terminal of the secondary in-coil, thus completing the secondary high-tension circuit.

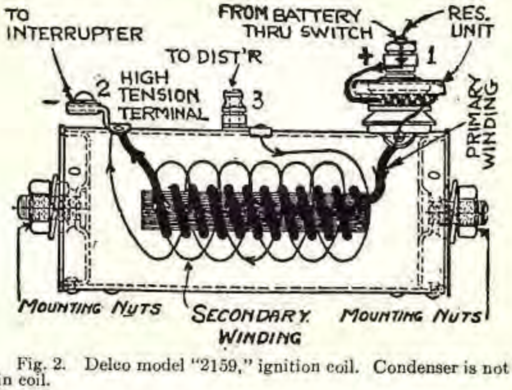



Fig. 2. Delco model "2159," ignition coil. Condenser is not in coil.

In Fig. 2, the condenser is not in this coil. It is located in the interrupter housing, either inside or outside, and is connected across the interrupter points (P). (This is the coil used on the Buick.)

**The primary circuit** (Fig. 2A) runs from (+) of battery, to the ignition switch, to the resistance unit (1), through the primary winding (P), to the terminal

[1] See also page 307.

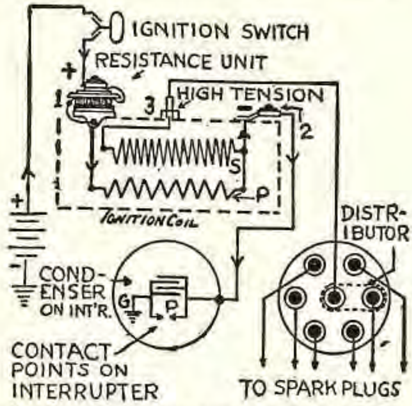



Fig. 2A. Circuit when using coil shown in Fig. 2.

(2), to the interrupter points (P), to ground, to (−) ground of battery, thus completing the primary low-tension circuit.

**The secondary circuit:** runs from the secondary terminal (3) to the center terminal of the distributor, to the spark plugs, to ground on engine and frame, to the battery ground (−), through battery (or generator, if generator is supplying current instead of battery), to the terminal (1) of the coil (+), through the primary winding (P), to the secondary connection to the primary winding at (S), thus completing the high-tension secondary circuit.

**Delco Interrupter with a Single Contact-Breaker Using One Coil**

The top view of a Delco closed-circuit interrupter with a single contact breaker is shown in Fig. 3. The cam in this instance, has 8 high points or lobes and revolves at cam-shaft speed; thus 8 interruptions, or 8 sparks occur during two revolutions of the crank shaft of the engine. One spark plug per cylinder is used.

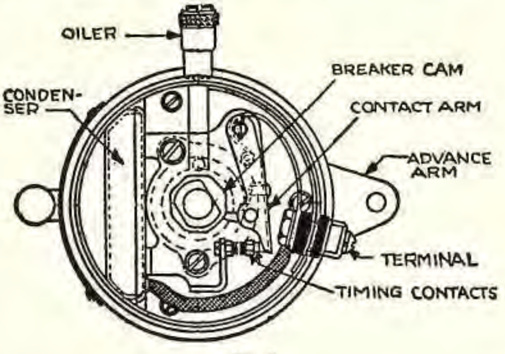



Fig. 3

**Delco Interrupter with Two Contact-Breakers Connected in Parallel, Using One Coil**

In Figs. 4, 5, 6, and 6A, note that the closed-circuit type interrupters have two interrupters or contact breakers operated by one cam.

One spark plug per cylinder is used and also one coil, but two contact points are connected in parallel, both of which open at one time. The primary ignition current which could otherwise flow through only one set of points is divided between the two sets, and the resultant wear upon the points is less and an additional factor of safety is provided. The Marmon, Cadillac, and Cole use this principle.

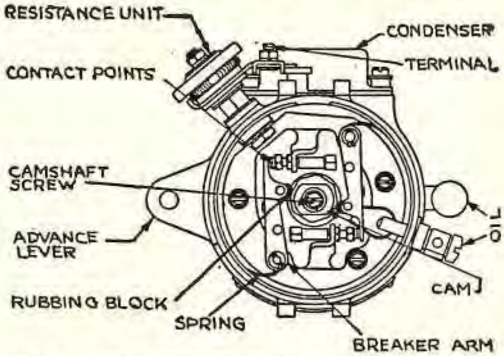



Fig. 4. Delco interrupter with two contact-breakers in parallel (top view).

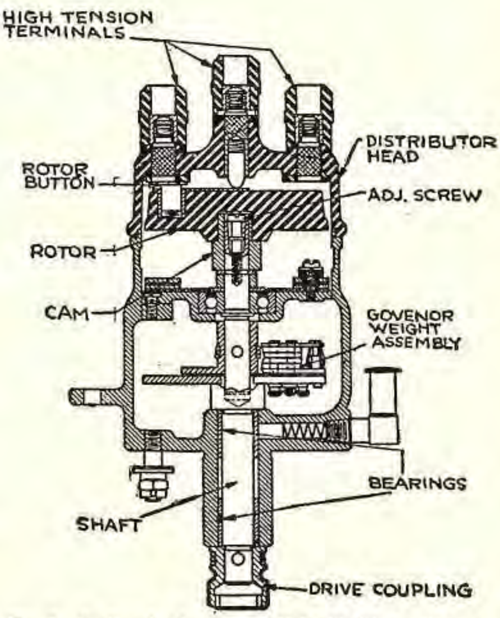



Fig. 5. Sectional side view of Delco ignition unit, a top view of which is shown in Fig. 4.

**The distributor,** interrupter, automatic spark advance mechanism and the ignition drive shaft are shown in Fig. 5. Manual advance of the spark, as shown in Fig. 5. Manual advance of the spark, controlled by a lever, as well as by an automatic advance, are provided for.

**Delco-Cadillac Distributor and Timer**

**The Cadillac** electric system consists of a Delco starting motor and generator in one unit, which is explained in the later discussion of electric systems. **The wiring** is a "single wire" or grounded return system. See Index under "Cadillac wiring diagram."

**Ignition: The distributor and timer** are carried on the fan-shaft housing, and are driven through a set of spiral gears attached to the fan shaft. The distributor consists of a cap or head of insulating

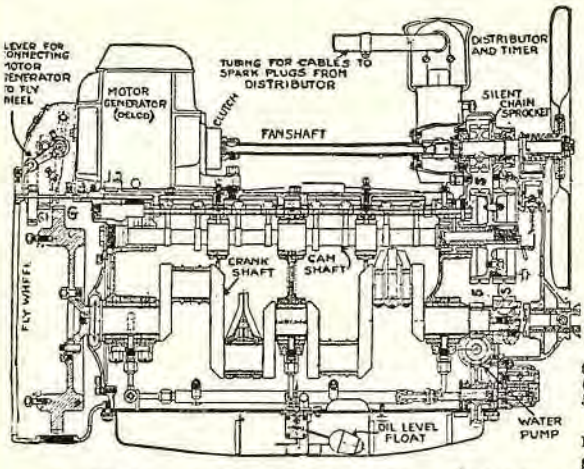



FIG. 5A—Location of the distributor and timer, and of the motor-generator on the Cadillac (Type 55).

material, carrying one contact in the center with eight additional contacts placed at equal distances about the center and a rotor which maintains constant communication with the center contact.

**The rotor** carries a contact button which serves to close the secondary circuit to the spark plug in the proper cylinder.

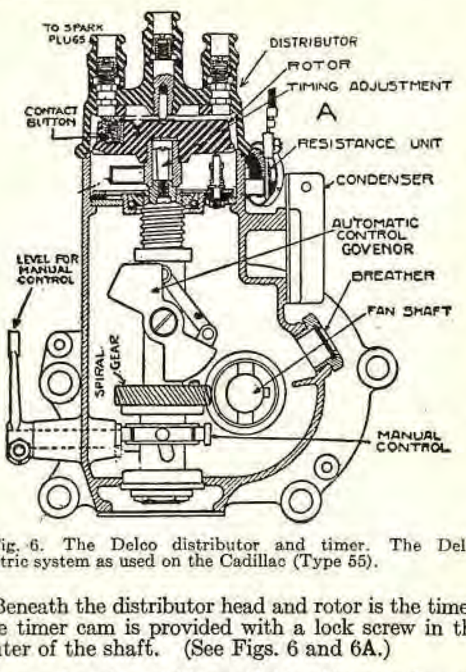



Fig. 6. The Delco distributor and timer. The Delco electric system as used on the Cadillac (Type 55).

Beneath the distributor head and rotor is the timer. The timer cam is provided with a lock screw in the center of the shaft. (See Figs. 6 and 6A.)

**A manual spark control** is provided in addition to the automatic spark control. The manual spark control is for the purpose of securing the proper ignition control for variable conditions, such as starting, differences in gasoline, weather conditions, and amount of carbon in the engine. The automatic control is for the purpose of securing the proper ignition control necessary for the variation due to engine speed alone.

**The timer,** more properly termed an interrupter, is shown in Fig. 6A. It is of the closed-circuit type. Note that there are two contact-breaker, or interrupter points. The object for using two contact-breaker points, is to distribute over two sets of points the cur-

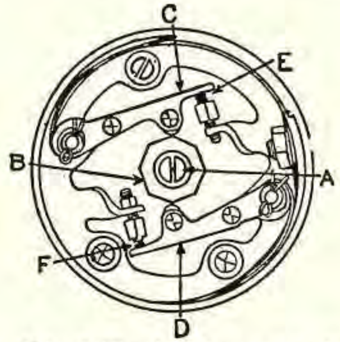



Fig. 6A. Delco-Cadillac timer (interrupter) with two contact-breakers. (A) is the adjusting screw; (B) cam; (C) and (D) contact-breaker arms; (E) and (F) breaker points (Type 55).

rent which would otherwise pass through one. This greatly lessens wear and burning of the points.

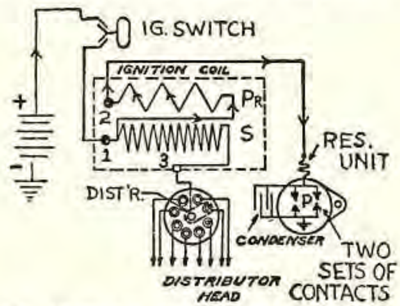



Fig. 6B. Illustration showing circuit where two sets of contact-breakers (connected in parallel) are used.

**The primary circuit** (Fig. 6B) runs from battery (+), to switch, to (1), through the primary winding (P), to (2), to the ignition resistance unit mounted on the interrupter housing, to the interrupter points (P) connected in parallel, to ground, to (—) ground of battery. Note that the condenser is shunted across the two contact points.

Note. Cadillac and Marmon have the positive (+) of the battery grounded.

**The secondary circuit** runs from terminal (3), to the distributor, to the spark plugs, to ground of engine, to (—) ground of battery, to (1) on coil.

### Delco-Cadillac Distributor Connections

**Distributor connections** on the Cadillac—Delco ignition system are shown in Fig. 6C. The cables lead from connections on the distributor to the cylinders in the order which they fire.

Note that the brush (B) makes contact consecutively, but cables from the distributor are connected to the plugs in their respective firing order. (This firing order is on types up to "61.")

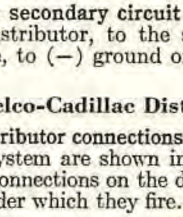



Fig. 6C

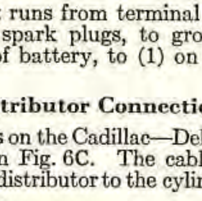
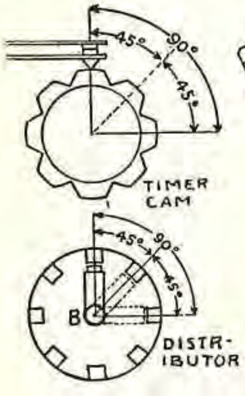



Fig. 6D

The **firing order** is shown in Fig. 6D. The cylinder marked (1L) fires first, then 2R, 3L, 1R, 4L, 3R, 2L, 4R. Follow the black figures on the side of the cylinders which show consecutively how the cylinders fire.



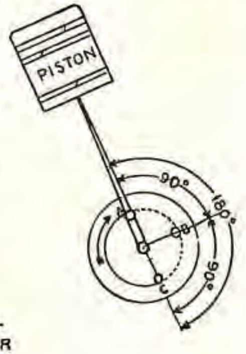




Fig. 7 (upper). Fig. 7B (right).
Fig. 7A (lower).

The relative movement of timer cam, distributor, rotor, and piston is shown in Figs. 7, 7A, 7B. The movement is shown in degrees. There is an impulse or firing spark at every 90° movement of the crank shaft, which is approximately one-half of a stroke of the piston, or one-quarter of a revolution of the crank.

When the crank shown in Fig. 7B travels 90° (A to B, the timer or distributor brush (B, Fig. 7A), being run at cam-shaft speed, or one-half crank-shaft speed, it then moves 45°, as does also the timer cam (Fig. 7).

When the crank makes two revolutions, or 720°, the timer cam and distributor brush (B) move 360° or one revolution. Therefore there are 8 sparks to two revolutions of the crank.

### Delco-Cadillac Ignition Timing (Type 55)

**The timer contact points** are set as follows: Turn the engine over until the contact arms (D) and (C), Fig. 6A are directly on top of the lobes of the cam (B). (Note that there are eight lobes or high points on the cam.) Then adjust the contact points at (E) and (F) so that they stand .020" (twenty-one-thousandths of an inch) apart. Both sets of contact points should be adjusted alike.

**To time the ignition** proceed as follows: Move the spark lever to the extreme left on the sector; open the compression release cocks on the cylinder blocks, and crank the engine by hand until the piston in No. 1 cylinder is on firing center. (No. 1 cylinder is the one nearest the radiator in the left-hand block of cylinders.)

Next remove the distributor cover, also the rotor, and loosen the lock screw (A) just enough to allow the cam (B) to be turned by hand after the rotor is fitted. (The lock screw should not be loosened enough to allow the cam to turn on the shaft when the engine is cranked by hand.)

Then replace the rotor and turn it by hand until the distributor brush in the rotor is directly under the terminal marked No. 1 on the distributor cover. Replace the distributor cover, and move the spark lever to the extreme right on the sector.

Then switch on the ignition; hold the high-tension wire to the spark plug in No. 1 cylinder about one-eighth of an inch away from the cylinder casting, and turn the engine slowly by hand in the direction in which it runs. Stop turning immediately a spark occurs between the wire and the casting. (It will be necessary to turn the engine nearly two complete revolutions before the spark occurs.)

If the cam (B) is properly set, a spark will occur when a point on the fly wheel 1 21/32" (one and twenty-one thirty-seconds of an inch) in advance of the center line for No. 1 cylinder is directly under the pointer or "trammel" attached to the crank case of the engine. This point for each cylinder is marked on the fly wheel by the letters "IG/A."

If the spark occurs before this, rotate the cam (B) slightly in a counter-clockwise direction to correct the adjustment. If a spark occurs later than this, rotate the cam slightly in a clockwise direction.

After the adjustment has been properly made, lock the cam securely to the distributor shaft by the lock screw (A).

After locking the adjustment, it is a good plan to check the timing by fully retarding the spark lever; in other words, by moving it to the extreme left on the sector, holding the high tension wire to the spark plug, in No. 1 cylinder about one-eighth of an inch away from the cylinder casting, and again turning the engine slowly by hand in the direction in which it runs, stopping immediately when a spark occurs.

If the ignition is properly set, the spark will occur under these conditions when the center line on the fly wheel for No. 1 cylinder is directly under the pointer attached to the crank case, or has passed the pointer.

**Caution:** Do not set the ignition so that the spark occurs before center with the spark lever at the extreme left on the sector.

**Resistance unit and ignition coil** are explained in the discussion of the subject "Ignition."

Note. See Index under "Synchronizing two sets of interrupter points." Type 1 connection under this heading applies to the Cadillac.

### Delco Double Distributors Using Two Distributors, Two Contact-Breakers, and Two Ignition Coils and Two Sets of Spark Plugs

Figs. 8 and 9 illustrate the Delco distributor used on the six-cylinder Pierce-Arrow "38–48" models. It is termed a "double ignition system" and consists of double distributors, double contact breakers (closed-circuit type) and a double set of spark plugs. Two coils are used. Automatic and hand (manual) advance of spark is provided. There are two distributor heads: one contains the two contact breakers and the other the condensers. There is a distributor head for each set of spark plugs. One single six-lobe cam, driven at cam-shaft speed, is used. Either the "single" or "double" ignition system may be used.

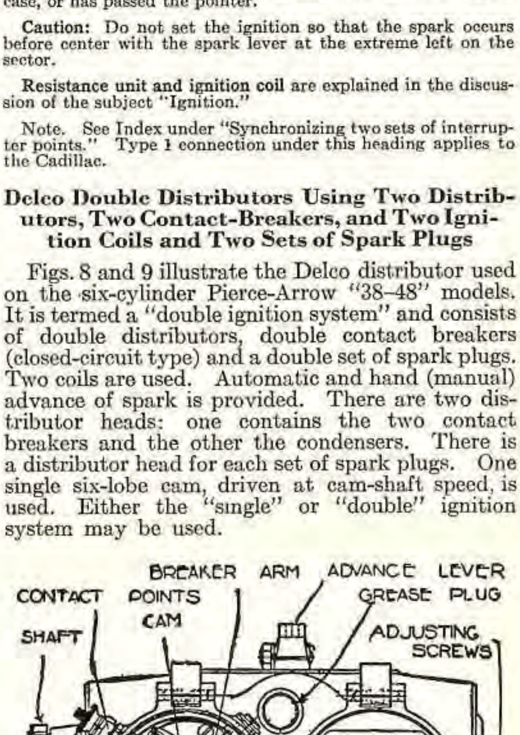



Fig. 8. Top view of Delco-Pierce-Arrow double distributors.

Two sparks occur at slightly different times in each cylinder; one coil furnishes high-voltage current to **the plugs over the intake valves,** while the other coil supplies the **plugs over the exhaust valves.** The Stutz uses a Delco distributor which is similar, except that interrupter points open simultaneously.

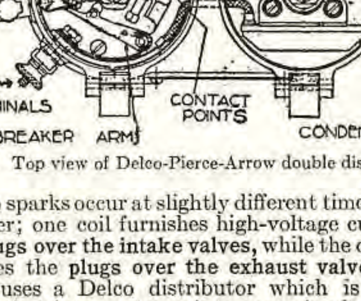



Fig. 9. Side view of Fig. 8.

Attention is called to the method of adjusting the relative time of separation of the timing contacts in the No. 5216 Pierce-Arrow double distributor. The left-hand set of contacts, viewed from the driving end of the distributor, and operating with the ignition of the plugs on the exhaust side of the engine, must be adjusted to separate 3° (flywheel) or 1½° (distributor) ahead of the other set of contacts. To make the adjustment accurately and easily, a method must be used very similar to that described on page 221 for the use of testing lamps. The firing order is 1, 5, 3, 6, 2, 4.

See Index for "Pierce-Arrow wiring diagram."

### Delco-Packard (Twin-Six) Ignition

Figs. 10 and 11 are top and vertical sections of the Delco-Packard ignition distributors and interrupters of the closed-circuit type (Twin-six models "3–25" and "3–35").

**The interrupter contact-breaker mechanism** consists of a separate set of timing contacts for each low-tension circuit. These are operated by a single three-lobed cam mounted on the top of a vertical shaft which is driven at crank-shaft speed. Thus each low-tension circuit is broken three times during each revolution of the crank shaft.

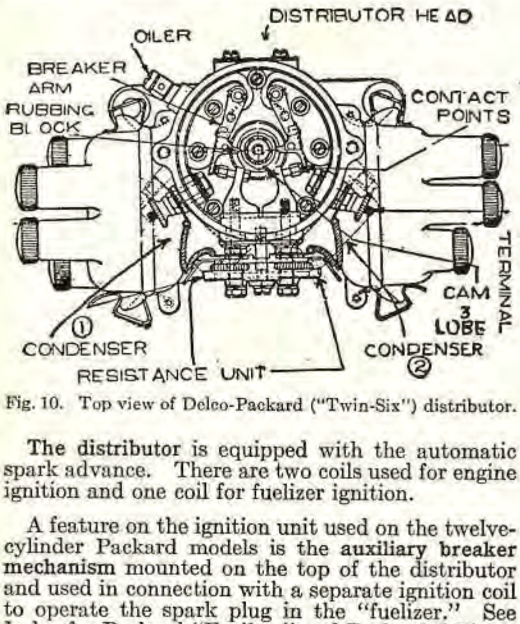



Fig. 10. Top view of Delco-Packard ("Twin-Six") distributor.

**The distributor** is equipped with the automatic spark advance. There are two coils used for engine ignition and one coil for fuelizer ignition.

A feature on the ignition unit used on the twelve-cylinder Packard models is the **auxiliary breaker mechanism** mounted on the top of the distributor and used in connection with a separate ignition coil to operate the spark plug in the "fuelizer." See Index for Packard "Fuelizer" and Packard "Wiring diagram." The wiring diagram will more clearly explain the principle.

It should be observed that the 5220 and 5238 distributors use a 15249 auxiliary breaker, while 5161 and 5220 distributors use a 14805 auxiliary breaker.

Note that in the system described above a three-lobe cam is used which revolves at crank-shaft speed, whereas with most all other systems it revolves at cam-shaft speed.

The fact that twelve interruptions, or sparks, can take place in the two six-cylinder blocks of cylinders during two revolutions of the single three-lobe cam is explained by the fact that there are two interrupter arms with separate contact points operating against opposite sides of a three-lobe cam. Note that the **cam is triangular in form**, with the sharp

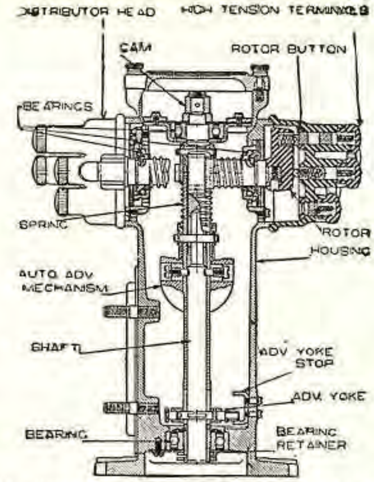



Fig. 11. Side sectional view of Delco-Packard ("Twin-Six") distributor.

corners rounded off; thus the lobes are 120° apart. Therefore when one contact arm is raised at the highest point on one of the lobes of the cam (which is the wide-open position of the contact points), the interrupter arm on the opposite side of the cam will be exactly between the two lobes (which is the closed position of the contact points).

Because there are three lobes 120° apart, three sparks would be produced per revolution of 360° for each set of contact points, or six sparks during one revolution for both interrupter contact points. Since the cam travels at the same speed as the crank shaft, then for two revolutions of the cam, there would be twelve sparks.

**The high-tension distributor,** like all distributors, revolves at cam-shaft speed, or one revolution to two revolutions of the crank shaft, and distributor terminals on the two distributor heads, each with six segments, leading to the twelve spark plugs, have the segments 60° apart.

**Separate high-tension distributor heads** are provided for each cylinder block. These are mounted on either side of the ignition apparatus housing and are operated by rotors on a cross-shaft driven from the vertical timer shaft.

**The firing order** in each block is: 1, 4, 2, 6, 3, 5. The impulses alternate between the two blocks. If we number the cylinders in succession, beginning with number one at the front of the right block, the firing order would be: 1R, 6L, 4R, 3L, 2R, 5L, 6R, 1L, 3R, 4L, 5R, 2L, the R and L designating the right and left cylinder blocks.

Arcing across the contact points when they are separating is minimized by the use of **separate condensers** for each set of breaker points, located in the rear side of the ignition timer and distributor housing. Indirectly these condensers also serve to intensify the high-tension current wave.

**Resistance units** in both low-tension circuits, and located on either side of the common ground return terminal on the timer housing, serve to keep the low-tension current down to the proper rate of flow at various car speeds. These also prevent excessive discharge from the battery when the ignition switch is left on and the engine is not running.

See Index for "Packard wiring diagram."

**The Delco-Lincoln Ignition System (1921)**

Figs. 12, 13, 14 show the **interrupter and distributor** used on the Lincoln. The vertical shaft viewed from the top turns counter-clockwise at one-half engine speed, and carries the manual spark advance mechanism, governor assembly controlling the automatic spark advance, the four-lobe breaker cam, and the rotor. The four-lobe cam produces eight sparks during one revolution of the cam, due to the two interrupters.

Each of the two sets of contacts are connected with the primary circuit of a separate ignition coil. In this manner the right-hand set of contacts (when viewed from the driver's seat) connected with the right-hand ignition coil, controls the ignition in the right bank of four cylinders. Likewise the left-hand set of contacts connected with the left-hand ignition coil controls the ignition in the left-hand bank of cylinders.

**A rotor** (Fig. 15), carried on upper end of distributor shaft, carries two steel rotor brushes, both electrically connected. One of them connects with the small carbon brush, which makes contact with the slip-ring in the distributor head. The other rotor brush connects with the center plunger contact in the distributor head.

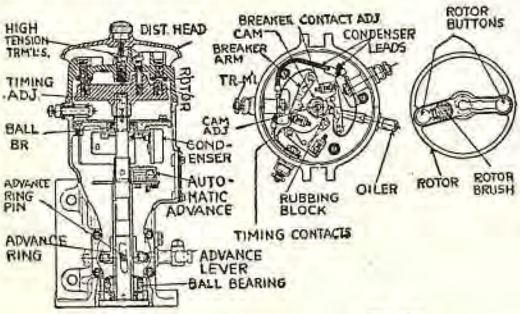



Fig. 12 Fig. 13

Figs. 12 and 13. Side and top view of Delco-Lincoln distributor.

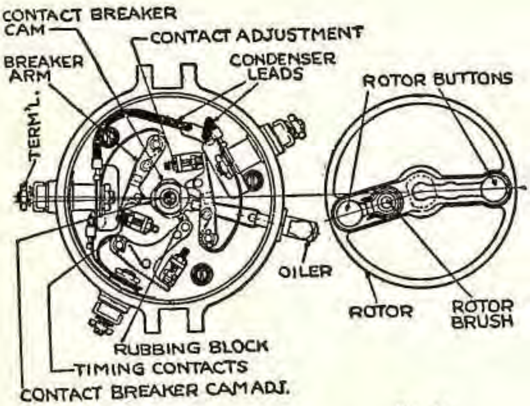



Fig. 14 Fig. 15

Fig. 14. Clearer top view of Lincoln. **On the interrupter,** owing to the fact that the cylinders are 60° apart, they are not placed opposite to each other.

Leads from each of the eight equally spaced terminals around the distributor head should be connected to spark plugs in the cylinders which carry a corresponding number.

**The high-tension lead** from the right-hand ignition coil is connected to the center terminal (the long screw) of the distributor head. Current from this coil takes care of ignition in the right bank of cylinders Nos. 1, 3, 7, and 5, through the rotor brush connected with the center plunger contact in the head.

**The left-hand bank of cylinders** Nos. 6, 8, 4, and 2, receive ignition current from the left-hand ignition coil whose high-tension lead is connected to the terminal (the short screw) near the center of the distributor head. This current passes through the rotor brush connected with the carbon brush.

Care must be taken to see that the leads from both primary and secondary terminals of the ignition coils connect to their correct terminals on the distributor.

The distances between the contact points when opened by the cam are adjustable by means of the contact screws which carry the stationary contact points. They should be adjusted so that they are .020″ apart when the fiber rubbing block of the contact arm rests directly on top of the cam lobes. Due to the slight wear of the fiber block during the first 2,000 miles driving, it may be necessary to make one or two adjustments of the points, after which practically no attention is necessary other than to note occasionally that the adjustment conforms to specifications.

**The thickness of the gauge** on the distributor wrench provided in the tool equipment should be used in adjusting the points.

When a slight readjustment of the contact points will not affect the timing noticeably, it is recommended that the ignition timing be checked, and if necessary corrected after each adjustment of the contact points.

**After assembly of the parts** of a repaired Lincoln distributor it will be necessary correctly to adjust the two sets of timing contacts, so that they separate at intervals of exactly 30° and 60° of distributor-shaft travel.

These values correspond to 60° and 120° on the flywheel, which are the intervals of crank-shaft travel between cylinder firings.

**To obtain the correct setting,** first adjust each of the two sets of contacts to the correct maximum dimension of .020″. Then shift slightly the position of the contact-point mounting plate until a setting has been found which will cause the contacts to open exactly at 30° and 60° intervals. This plate may be shifted within small limits after loosening the three screws securing it to the distributor housing, and allowing the plate to pivot on the screw nearest the oiler.

**In order to measure accurately** the 30° and 60° intervals, the mechanic should connect a small lamp in series with each set of contacts similar to the test set in Fig. 20, page 221, to indicate the instant the points separate. An ordinary protractor, or similar measuring device calibrated in degrees and approximately 4″ in diameter, must be used to measure the number of degrees of interval between the separation of the contacts. Small scratches may then be made on the distributor housing opposite a previously made scratch or mark at any point on the edge of the rotor, indicating the actual intervals between the separation of the two sets of contacts. These angular distances may then be measured with the protractor, and if not correct, the contact mounting plate may again be slightly shifted

If **during the shifting of the plate,** the adjustment of the contacts is appreciably changed, their adjustment should be corrected, after which a re-check should be made with the protractor and lamps of the intervals between the separation of the two sets of contacts. It would be advisable to check up the adjustment of the contacts once or twice during the first 2,000 miles driving, so that any necessary correction might be made.

**Lubrication** of the upper ball bearing is taken care of by placing in the oiler three or four drops of engine oil every 500 miles. The lower ball bearing of the distributor shaft and the advance ring of the manual-spark control mechanism receive their lubrication from the light cup grease carried in the lower part of the distributor housing. This section of the housing should be kept filled with light cup grease to a level just above the advance ring. Lubricant may be placed in the housing by removing the cover plate near the spark-advance lever on the forward side of the housing about every 5,000 miles.

A very small amount of light grease or vaseline should be applied to the surface of the breaker cam each 2,000 miles. The rubber track containing the eight inserts or contacts should receive a very small amount of vaseline applied occasionally during the first 1,500 miles driving. The track will then become glazed, and no further lubrication will be required. It is then only necessary to wipe out the distributor head occasionally with a clean cloth. No lubricant is required on the slip ring in the distributor head, against which the carbon brush rests. The center plunger contact in the distributor should always make contact with the rotor, and the carbon brush in the rotor should always make contact against the slip ring.

**A slight blackening of the surface of the distributor** head inserts has no effect whatever upon the perfect performance of the ignition system.

### Delco-Lafayette Distributor (1921)

Figs. 16 and 16A show the top and side cross-section views of **the interrupter and the distributor** used on the Lafayette model, which is similar to that shown in Fig. 4, page 214. The vertical shaft, turning at one-half engine speed, carries the manual advance mechanism, governor assembly controlling the automatic spark advance, the eight-lobe breaker cam, and the rotor.

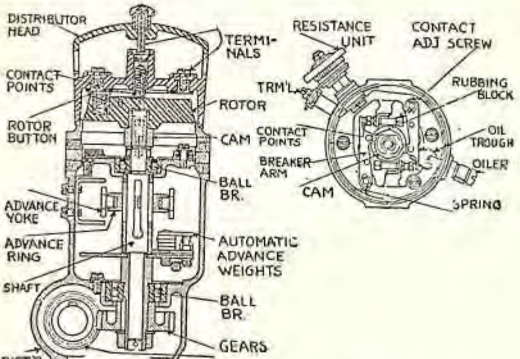



Fig. 16 Fig. 16A

Figs. 16 and 16A. Side and top view of Delco-Lafayette distributor.

**Two sets of timing contacts** are provided, the object being to distribute over two sets of points the current which would otherwise pass through one set. Both sets of points separate, and therefore are arranged to separate at the same instant.

See Index for "Wiring diagram."

### Delco-Packard (Six-Cylinder) Distributor

Fig. 17 shows the general construction of the **interrupter and distributor** used on the six-cylinder **Packard** models.

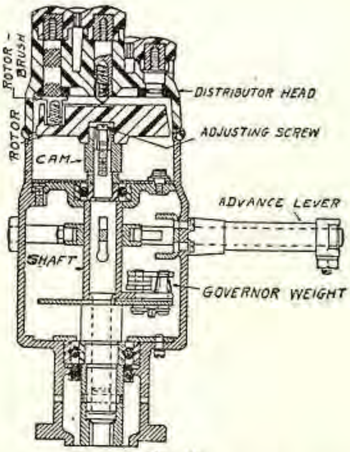



Fig. 17

**Two sets of interrupter contacts** are provided, each set being connected in series with a separate ignition coil. One of these coils provides ignition for the engine cylinders, while the other coil supplies ignition at the fuelizer spark plug. Electrical connections of this system are shown clearly in the circuit diagram. See Index for "Wiring diagram."

### Delco-Buick Distributor

Figs. 18 and 19 show the top and sectional views of the Delco distributor and interrupter used on the 1921 **Buick models.** The design is such that advance and retard of the ignition is accomplished through an **advance ring** (see Fig. 18) within the distributor instead of by an oscillating movement of the distributor head changing the angular position of the timing contacts with the distributor cam. (a later model is shown in Fig. 13, page 307).

**A condenser,** mounted in former models inside the ignition coil, is now contained in a moisture-proof metal case within the distributor housing, next to the interrupter. Delco coil (1921) is Delco No. 2159 (Fig. 2, page 213).

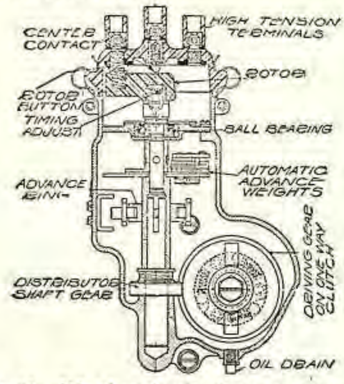



**Fig. 18.** Side view of Delco-Buick distributor.

**The distributor** consists of parts as shown in Fig. 18. The rotor revolves at cam-shaft speed, or one-half the speed of the crank shaft. The distributor shaft is driven from the generator shaft.

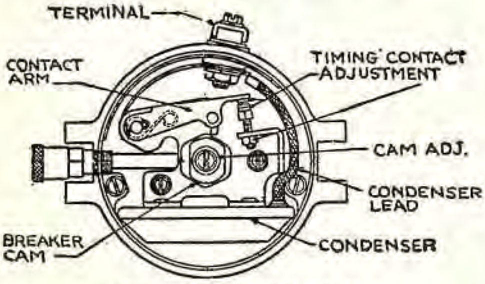



Fig. 19. Top view of Fig. 18.

### Timing the Buick-Six and Four Ignition

1. Adjust the interrupter point gap to .020″ when the contact arm is on top of cam.
2. Place the spark lever on the steering wheel in the fully retarded position (on 1926 models fully advanced).
3. Turn the engine to the seven-degree mark (which is approximately one inch after dead center), with the No. 1 cylinder on the firing stroke (on 1926 models 17 degrees).
4. Loosen the timing-adjustment screw in the center of the distributor shaft and contact-breaker cam.[1] Turn the cam so that the rotor button will be in position under No. 1 high-tension terminal when the distributor head is properly located. Locate the contact-breaker cam carefully in this position so that when the backlash in the distributor gears is rocked forward the contact points will be opened, and when the backlash in the gears is rocked backward the contacts will just close. The distributor shaft turns clockwise when viewed from the top.
5. Tighten the adjustment screw securely and replace the rotor and distributor head. The **cylinders fire** in the following order: 1, 4, 2, 6, 3, 5, and 1, 3, 4, 2.

**The proper spark-plug gap** should be twenty-five thousandths of an inch (.025″).

On account of the wearing to a seat of the fiber rubbing block on the contact arm, one or two adjustments may possibly be necessary during the first 2,000 miles of driving, after which practically no attention is necessary other than to note occasionally that the adjustment of the contacts conforms to specifications.

**A frosted appearance of the contacts** indicates that they are making **good contact** with one another, and should not be disturbed as long as proper operation is maintained. The contact points are made of tungsten. This metal is too hard to file. Should it be necessary to dress them, an oil stone should be used. Care should be taken that they seat properly against each other and are correctly adjusted after being replaced.

It is a good plan after adjusting the timing contacts to check the ignition timing. See instructions under "Timing the Ignition."

## DELCO IGNITION TIMING[2]

### Adjusting Timing Contacts

See also instruction on "Ignition Timing," which explains advance and retard of spark, etc.

**The timing contacts should be adjusted so that when they are separated by the breaker cam they are apart by the following thickness:** All Delco distributors for four and six-cylinder engines should have their contacts adjusted to .020″ to .0275″; all distributors used on eight-cylinder cars, except Cadillac, should be adjusted to .015″ to .0225″; Cadillac should be .015″ to .020″; Packard should be .020″ to .025″ (a 3-lobe cam running at engine speed is used).

On those distributors, except the Packard and Pierce-Arrow, having two sets of timing contacts, the separation of the contacts, where there are two sets, should be as nearly simultaneous as possible. Both are intended to separate at the same time, and the maximum contact separation of each set of contacts should be held to the specifications. Should difficulty be encountered in obtaining the adjustment to synchronize the operation of the points, the contact-breaker plate on which the contacts are mounted may be shifted within certain limits after loosening the three screws holding it in place. These screws should be carefully tightened after the necessary adjustments.

On account of wearing to a seat of the fiber rubbing block on the breaker arms, the points will require one or two adjustments during the first season's driving, after which practically no attention is required.

**Interrupter contact points are made of pure tungsten metal,** which is very hard and of long life. Should the contacts require cleaning or redressing, rub the points lightly over an oil stone—the tungsten metal is too hard to file. The contact arms may be removed by lifting them from the posts on which they are pivoted, after taking out the cotter-pins and loosening any clamping nuts holding the ends of the steel springs.

**Always adjust interrupter contact points before timing the ignition.** See page 307 for reason.

### Timing the Delco Ignition

**The breaker cam** is secured to the distributor shaft with the cam adjustment screw, as in Fig. 4, page 214, in the majority of distributors; in others, by the timing adjustment screws. The adjusting screw permits the cam to be placed in any angular position for timing.

**The manufacturer of the car should be consulted for the exact directions for timing the engine. However, the following directions will give an approximate timing which will prove satisfactory under ordinary conditions:**

1. Place the spark lever on the steering wheel in a position one-third advanced.
2. Turn the engine by hand until the piston in No. 1 cylinder is just on top dead center on the compression stroke.
3. Loosen the timing adjustment screw in the center of the cam, and locate the proper lobe of the cam by turning the rotor until the rotor button comes under the high tension terminal of the distributor head connected to the No. 1 cylinder.
4. Locate this lobe of the cam so that when the back-lash in the distributor gears is rocked forward the timing contacts will be opened and when the back-lash is rocked backward the timing contacts will just close. The distributor shaft usually rotates in a clockwise direction when viewed from the top. Tighten adjusting screw and replace rotor and distributor head.

Note. The Lincoln distributor rotates counter-clockwise.

**In the Stutz double distributor** (similar to the Pierce-Arrow, Fig. 9, page 216), the distributor cam and collar, which carry the two rotors, are keyed in position, and are not adjustable. Timing is accomplished through an adjustable coupling through which the distributor is driven.

[1] On the 1924 to 1926 system a plug is removed and adjustment made at bottom of shaft (see Fig. 13, page 307).

[2] See also page 307.

### Adjusting Spark Plugs for Delco Ignition

The adjustment should be .030". On spark plugs having more than one gap, all but one gap should be made wide, and closest gap adjusted to .030".

**An exceptionally wide adjustment** may be the cause of missing at the higher speeds. **Too close an adjustment** will cause the ignition to be poor at very low speeds when idling.

### Synchronizing Two Sets of Interrupter Contact Points (Delco)

Fig. 20 shows a simple device which is of material assistance in synchronizing the operation of two sets of timing contacts. This handy test set consists of a small block of wood upon which are mounted two small 6-volt lamps provided with the leads (C), (D), and (E). Terminals (A) and (B) are each made of a thin piece of fiber 1½" by 1", one side being covered by a thin piece of brass or copper to serve as a contact.

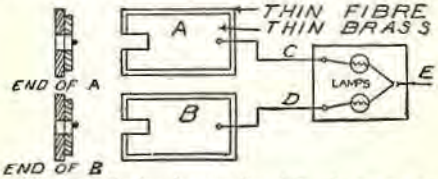



Fig. 20. Device for synchronizing interrupters.

Distributors with which this set is used are divided into two types: type 1 (Fig. 21) has two sets of timing contacts connected in parallel; in type 2 (Fig. 22) the double distributors have two sets of contacts, each of which is connected to a separate primary ignition circuit, as in the Pierce-Arrow and Stutz distributors.

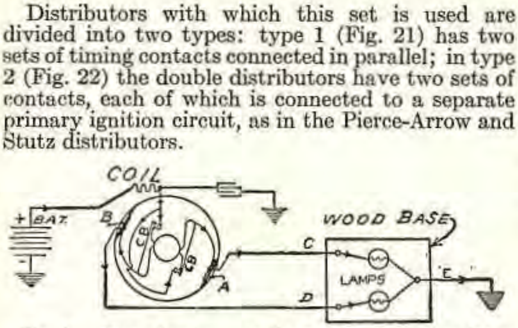



Fig. 21. Type 1 connection for synchronizing two interrupter contact-breakers (CB) connected in parallel.

**When used with distributors in type 1** (Fig. 21), each of the terminals (A) and (B) are slipped between the contact-arm spring, and the distributor housing with the metal side of the terminal in contact with the spring. Connect lead (E) to "ground." Current is obtained from the storage battery on the car by placing the ignition switch lever in "on" position.

During this operation it will be well to place a piece of cardboard beneath one of the generator brushes on those generators not equipped with a cut-out relay, in order to prevent a flow of current through the generator windings.

In this type of distributor which is supplied with two sets of contacts the primary ignition current is divided between the two sets, which reduces the amount of burning and offers an additional factor of safety to the system.

**The separation of each set of timing contacts** will be indicated by the lamp in the circuit, and when both lamps go out at practically the same instant the contacts are properly synchronized.

**When used with type 2 distributor** (Fig. 22), the notches in the ends of the terminals (A) and (B) permit them to be readily connected to the two terminals on the distributor as shown.

In the Pierce-Arrow (page 216) and Stutz double distributors there are two sets of timing contacts. In these cases each set of contacts interrupt a separate primary ignition circuit, giving double ignition. One circuit supplies high-tension current to the plugs over the intake valves, while the other circuit takes care of plugs over exhaust valves.

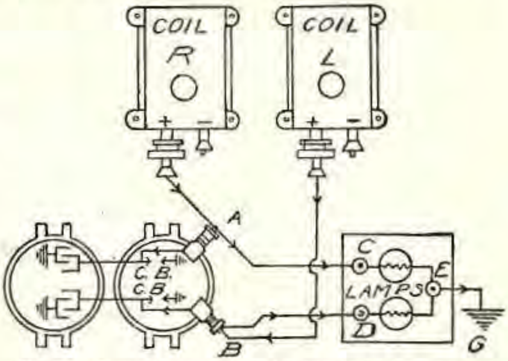



Fig. 22. Type 2 connections for synchronizing two interrupter contact-breakers used on double ignition.

By examining the connections as shown in Fig. 22, it will be noted that as each set of contact-breakers separate, the lamp in its circuit lights. When contact-breakers are closed, a short-circuit will be formed around lamps, causing them to go out.

In setting the Stutz contacts, both lamps should light at the same time; that is the timing contacts should be synchronized.

**Pierce-Arrow interrupter contacts are not synchronized.** By referring to the Pierce-Arrow wiring diagram, page 403, and to Fig. 8, page 216, it will be noted that one contact-point is for the ignition system on the exhaust side of the engine and the other is for the ignition system on the intake side.

The contact points for the exhaust side are set ahead of the intake, as mentioned below, the degrees referred to being flywheel degree movement.

| | |
|---|---|
| Models 31 and 51: | exhaust set to open 3° before inlet. |
| Models 32 and 33: | exhaust set to open 3° to 7° before inlet. |
| Models X-5-W-2: | exhaust set to open 0 to 3° before inlet. |
| Models R-10: | exhaust set to open 0 to 3° before inlet. |

For example, with models 32 and 33, the lamp connected in the circuit (Fig. 22) with the contact-points for the exhaust side should light 3 to 7 flywheel degrees before the one connected in the circuit with the contact-points for the intake side.

### Contact-Point Surfaces and Removal

**The contact-point surfaces often have a frosted appearance.** This is not an indication of trouble, as is often believed, but shows that the contacts are making good contact with one another, and they should not be disturbed as long as proper operation is maintained. The contact points are made of tungsten. This metal is too hard to file. Should it be necessary to dress them an oilstone should be used. Care should be taken that they seat equally against each other after being replaced.

**The contact arms may be removed** by lifting them from the posts on which they are pivoted, after taking out the cotter-pins and loosening any clamping nuts holding the ends of the steel springs.

See Index for "Delco motor-generators and wiring diagrams."

# INSTRUCTION No. 21

# TESTS AND ADJUSTMENTS OF THE VIBRATOR TYPE OF HIGH TENSION COIL: Ford Ignition Coil

This instruction deals only with vibrator-type coil adjustments and tests. The next instruction will deal with the non-vibrator type.

### Adjusting Vibrators of an Ignition Coil

The usual method of adjusting a coil trembler or vibrator is the rather rule-of-thumb method of screwing down the trembler screw till there is a sharp musical "buzz" obtained, and, as near as it is possible to determine, to adjust the screws so as to obtain the same note from each trembler.

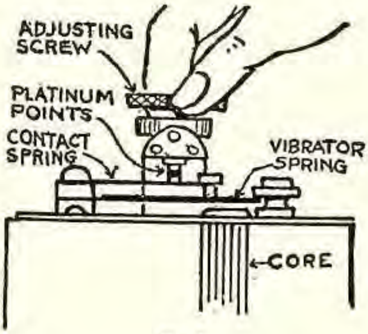


Fig. 1

**Current consumption** of the coil depends largely on how close the vibrator contacts are set. Very often it happens that a good deal of current is wasted in having too close contact, and at the same time the platinum points on both the vibrator and the adjusting screw are soon "pitted" and worn out from the excessive sparking.

There is a further serious disadvantage, inasmuch as the firing point cannot be synchronized for each cylinder, the closely-set trembler firing the charge earlier than the lightly-set one, and thus it happens that an engine rarely gives off the full amount of power. Perfect synchronization is required in obtaining full power. This explains why some engines often give more power on the magneto. The fault lies in bad setting of the coil and sticking vibrators.

### Instructions for Adjusting the Ford Vibrator Coil (K.W. Ignition Co.'s Make)

**There are four vibrator-type coil units** (Fig. 2) contained in the Ford coil box.

**The primary winding** starts at the bottom of the coil unit, which consists of a metal disk which makes contact with a spring inside of coil box and which is connected with electric current, either from the battery, the generator, or the magneto (see Index under "Ford wiring diagram").

The primary current passes through the primary winding, through vibrator blade (VS), through points (P), to the contact spring, to the primary contact to the timer, to the contact on the timer or commutator.

**The secondary winding** is shown in Fig. 2. See also Index, for "Ford wiring diagram."

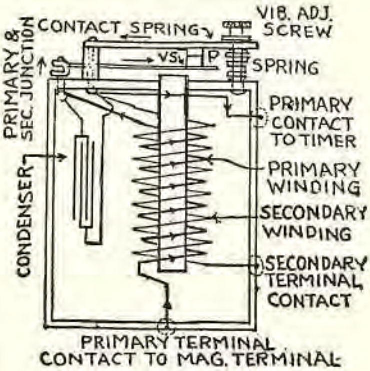


Fig. 2. Ford vibrator coil unit (K.W.)

**Adjustment of vibrator:** The K.W. coil unit shown in the illustration is designed to operate on a current consumption in the primary winding of 1 1/10 to 1 2/10 amperes at a voltage of 6 to 8 volts.

When the vibrator tension on a coil is increased, or more vibrations are produced in a given time by screwing down on the vibrator adjusting screw, the secondary voltage is increased and the primary will draw more current.

Therefore the proper adjustment of this adjusting screw for certain current values is necessary in order to prevent the building up of too high a voltage, which is liable to puncture the insulation of the secondary winding.

A Ford coil unit (K.W., Fig. 2), when tested on a 6-volt circuit with a low-reading ammeter in series with the primary circuit, should register 1 1/10 to 1 2/10 amperes.

When the vibrator spring is pressed down against the iron core, the air-gap clearance between points (P) should be 1/32″ apart. It is very essential that this vibrator spring have the proper tension, inasmuch as on this depends the amount of current that the primary winding consumes, as well as the effectiveness of operation.

**The tension, or number of vibrations, can be** adjusted by the vibrator adjusting screw. First, however, in order to adjust properly, the vibrator spring itself should be tested for proper tension as follows:

Remove the top bridge. If "tungsten" contact points are used, the vibrator spring should stand exactly ¼″ above the iron core. If K.W. "sparkite" springs and contact points are used, the spring tension is less, owing to the low-surface resistance of this metal; therefore the vibrator spring should be 5/32″ above the iron core.

**It is important that the vibrator-spring tension be correct,** as just stated, before attempting to adjust

Applies to Ford Model "T."

the tension of the vibrator spring with the adjustment screw.

**The condenser** is located in each coil unit, and is connected or shunted across the vibrator contact points.

**Hard starting,** due to vibrator adjustment: If there is **too much tension** on the vibrator springs, the weak current generated by the magneto at cranking speeds will not be sufficient to cause the vibrators to buzz, and it will be difficult to start the engine. **Too little tension** will not let the vibrators respond quickly, and the engine will run unevenly.

**A defective coil unit** can be detected by noticing if the vibrator buzzes without producing a spark at the plug. Then the suspected unit can be exchanged with another unit to make sure that the trouble is actually in the coil unit. A defective or punctured condenser is indicated by a heavy spark at the vibrators and a weak spark at the spark plug.

**If the engine has a tendency to miss** when driving over rough roads, this may be due to the coil units not fitting tightly in the coil box. The bouncing of the car makes the coil units touch the metal cover of the box and causes misfiring. Coil units in the Ford coil box depend upon spring tension for contact.

Sometimes, misfiring is due to the wooden lining of the metal coil box being damp and allowing the electric current to leak across from one terminal to another.

**The spark plug:** On the Ford and some magnetos where there is a volume of spark, a spark plug recommended by the manufacturer should be used, as the points usually have metal of slightly high resistance to prevent pitting and burning of points, due to the excess of current supply. **The spark-plug gaps** are 1/32″ apart on Ford plugs.

### Vibrator Coil Cause of Missing

In rare instances one of the coil sections will become short-circuited or the insulation may become punctured on the secondary winding. This is commonly caused by using too many batteries or too high a voltage. In this case the plug would not spark at all, therefore it would be advisable to try changing positions of the coil units in the box. If the plug sparks properly on one of the other coil sections, then you may know that that particular coil unit is defective. Therefore, inspect the platinum points on the vibrators and contact points, as they may be partially burned away or badly pitted. If this coil section still fails to give a spark, then it is evident it is burnt out inside.

In some instances a coil may have its insulation short-circuited for only half its length of winding and would give a spark. If a short circuit was near the beginning of the winding, it would not spark at all.

### Testing the Coil

**If a multiple-cylinder engine,** test each unit separately until it is determined which coil is missing. After assuring yourself the missing is not caused by a spark plug, weak batteries, carburetion, or other causes, then test the coil itself.

### Vibrator Coil Tester

A very serviceable device for testing Ford coil units, single and double contact lamps, as well as spark plugs, is the tester[1] illustrated above.

**To replace or readjust contact points on a Ford coil unit:** The coil to be tested is slipped into place so that the contact springs touch the proper contacts. A 6-volt battery is attached by means of cord and test clips. The ammeter on the Tester has zero (0) center, and it is proper for it to read in either direction. The adjustable spark gap should now be set with one-quarter inch (¼″) gap. This may be measured

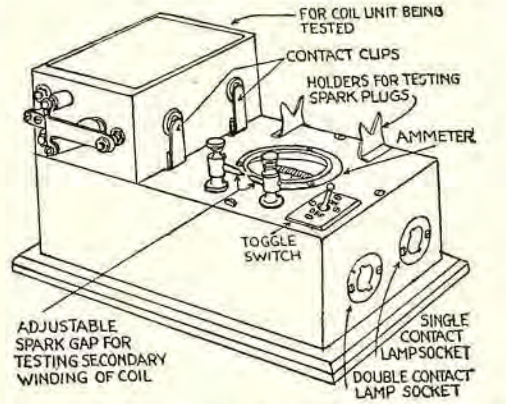



Fig. 3. The "B W" tester. Designed for testing Ford coil units, spark plugs, and lamp bulbs.

by gauging the gap with one-quarter inch (¼″) drill or rod. This gap is much greater than the gap in the spark plug, due to the fact that a spark takes place in the open air, while in the case of the spark plug, the sparking takes place in a highly compressed charge in the cylinder which requires the spark gap to be considerably smaller.

The switch is now closed, and the ammeter should give a fairly steady reading of about 1½ amperes. While this current is flowing, a continuous flow of sparks should follow across the spark gap. If the flow of sparks is not constant, this indicates that the vibrator contacts of the coil have probably become pitted; they should be removed and smoothed with a fine file. The adjusting screws on the coil should be turned one way and another until the stream of sparks appears the hottest.

If at this point of adjustment the current is lower than 1.2 amperes, then the vibrator spring on the coil is weak and should be strengthened as follows: Remove the cross-piece that carries the adjustable contact. Now note the distance that the vibrator spring stands away from the coil head. Increase this distance slightly by bending the vibrator spring away from the coil head; then replace the adjusting cross-head, and the current will have increased as well as the stream of sparks. If the current is higher than 1.8 amperes, then the vibrator spring is too strong and stands away too far from the head of the coil. In this case the vibrator springs should be bent inward.

If the ammeter pointer flies over to the end of the scale, then this indicates that the vibrator contacts are stuck together. If in this case they are worn out and cannot be smoothed with a file, they should be replaced.

If it is impossible to get a reading of 1½ amperes and a continuous hot spark across ¼″ spark gap, after making all the adjustments named above, the coil is no longer serviceable and should be replaced.

**Note:** The coil must give a hot spark with **not more** than 1½ amp., because at low speeds the magneto does not generate more than 1½ amp.

**To test a spark plug with the tester shown above:** Connect the Tester to a source of power, as instructed above. Place a Ford coil into the coil guides in the same manner as in testing the coil. Now open the spark gap to at least ½″, then place the spark plug into the rack provided on the Tester and close the switch. Where it is possible, it is a good idea to open the spark gap of the spark plug to about ¼″, so as to get the same condition in the open as with the small gap in the highly compressed cylinder. Set spark-plug gap to about 1/32″ after testing.

If the spark plug is only foul from carbon deposit on the porcelain, the carbon will be immediately burned off. If there is a cracked procelain, the spark will short-circuit through this crack and no spark will flow at the spark-plug gap, and the plug is no longer serviceable.

**To test lamp bulbs:** Both the single and double-contact sockets provided for testing lamps are directly connected to the transformer, and all that is necessary to test lamps is to connect to source of power as instructed above and push the lamp into the proper socket.

### Causes of Spark Plug Missing

**The usual cause of missing of explosion** is that the spark plug becomes fouled by carbon, or soot is deposited on the porcelain insulation, causing the plug to become short-circuited. It is generally caused by using a poor grade of oil or loose piston

[1] This can be secured of A. L. Dyke, Electrical Department, Granite Bldg., St. Louis, Mo., price \$11.65 for use with a 6-volt battery; for use with alternating current lamp socket, price \$14.35.

rings, which permits the oil to pass too freely into the head of the cylinder.

**Other causes** are sticking vibrator points, a defective commutator, or a weak battery.

**When mis-firing occurs,** particularly when running at high speeds, it would be advisable to inspect the commutator, as the fiber may be worn so that the roller touches only the high spots, or it may be that the roller has worn out of round and consequently forms imperfect contact on all of the points.

**At slow speeds,** mis-firing is apt to be the result of improperly seated valves or air-leak in the carburetor or cylinder-head gaskets.

**A weakness in compression** may be detected by lifting the starting crank slowly the length of its stroke for each cylinder in turn. In rare instances an exhaust valve may become warped by the engine becoming overheated, in which case the valve seat will have to be reground or the valve replaced.

**When starting to test** for the trouble, first determine if the missing occurs when running slow or when running fast, or if at all times. Also be sure the carburetion is right.

### Testing for Miss with Vibrators

We will assume the engine is a four-cylinder engine.

**To ascertain which, if any, of the four plugs are fouled with oil,** short-circuit with carbon, or inoperative from some other cause, open the throttle two or three notches to speed up the engine; now hold your two fingers on two outside vibrators so that they cannot buzz. The evenness of the exhaust will show that the other two are working correctly and that the trouble is not there; or an uneven exhaust will indicate that it is between the two that are free.

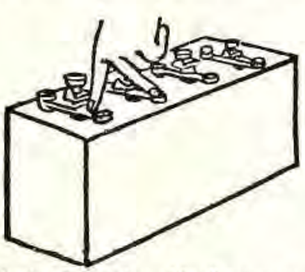


Fig. 4. Testing for missing with vibrators on the coil.

**If the two cylinders fire evenly,** change the fingers to the two inside vibrators and again listen to the exhaust. Having ascertained in which pair the trouble is, hold down three fingers at a time until you find the one which does not fire.

Cylinder No. 1, we will say, is the front cylinder, and they number in rotation 1, 2, 3, 4. No. 1 coil unit would be the one farthest from the steering post (left-side drive), and they number 2, 3, 4 to the left.

**Causes of commutator troubles** (Fig. 5): (1) worn metal segments (C) often cause missing by not making good contact. (2) The commutator may also become loose on the shaft and get out of time. (3) Spring weak. (4) Loose connections at binding posts. (5) Depressions worn on face of fiber on which the roller (R) travels, resulting in the roller jumping (at high speeds) almost over the metal contacts (C). The roller (R) and pin of the revolving part will also probably be found in bad shape. To repair, turn down in a lathe or replace with a new one. (6) Grease will coat the insulated fiber ring (C) from one segment to another, and cause a short circuit. Too much oil will also cause a glazed

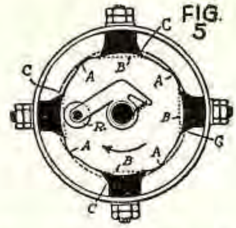


FIG. 5

surface over the segments (B), and good contact cannot be made between roller (R) and these metal segments.

### Platinum Iridium Contact Points

**Platinum-iridium is the best metal for contact points** on vibrator-type coils and also for magnetos, for reasons explained farther on.

It is **best for the contact points on the vibrator-type coil** (as in Fig. 6) because it allows finer adjustment and more rapid operation.

Platinum is usually alloyed with iridium (80 per cent platinum and 20 per cent iridium) in order to attain toughness and hardness of the contact point, which gradually enhances its electric value. Pure platinum would hammer under action of the contact breaker; thus iridium which is harder is used with it. **Platinum-iridium points are always used on magneto contact breakers** (pages 257, 258, 280). **Platinum** has the property of a very high fusing point and does not oxidize (an action similar to rusting, but usually of dark color) under ordinary conditions. It has a very low surface resistance, which remains throughout the life of the point. While it is subject to a certain building up and pitting process, this process extends over the entire surface of the point, with the result that the contact area is not impaired. It has long life and can be used to the last thousandth of an inch with utmost efficiency.

It must, however, be kept clean to insure best operation, which is easy as it can be dressed with a fine file. Platinum is also subject to electrolysis, especially where direct current is used, as explained farther on.

**Sparkite points,** produced by the K.W. Ignition Co., Cleveland, Ohio, is also well adapted for vibrator coil use. Sparkite metal has a very low surface resistance and is excellently adapted to all vibrating coil ignition. It disintegrates somewhat more rapidly than either tungsten or platinum, but has a much lower surface resistance than tungsten and does not readily oxidize.

### Effect of Electrolysis on Platinum

Every time the contact separates, a minute quantity of platinum is transferred from one contact to the other. If the current is reversed by means of a reversing switch, the lost platinum will be transferred back to some extent. This is called depolarizing (see page 203). Therefore, when using "direct" current for vibrator-coil ignition, it is a good idea occasionally to change the connection on the battery. The current flowing in one continuous direction causes the point connected with the (+) side to deposit on the point in the (−) side, thus pitting the points. Where "alternating" current is used, as with a magneto, the points do not pit as much, because the current is constantly changing its direction of flow.

On the Ford, the magneto generates "alternating" current. Therefore the pitting of points is not so bad; but when the car is run continuously at high speed, naturally the magneto generates a higher voltage which reacts through the contact points by arcing; thus pitting the platinum points due to the heat produced.

### Testing Platinum-Iridium Contact Points

**Procure genuine platinum-iridium points** when purchasing new screws or vibrator springs, if possible. **Imitation points will pit and burn together,** and will cause sticking of points and missing. See also mention above of K-W Sparkite points for vibrator coil use. Platinum-iridium must be used for magneto points for reasons explained farther on.

**Test the points** to see if they are genuine platinum by putting nitric acid on them. If it eats into the metal, it is not genuine platinum. A jeweler's stone can also be used for this test. Ask any jeweler.

Fig. 6.

Fig. 7

Fig. 6 (left). Shows pitting, and is the state to which a properly set contact-point finally arrives. Illustrations represent the screw above and vibrator spring below with platinum point contacts as used on vibrator type coils. The same principle applies to platinum points used on magnetos.

Fig. 7 (right). Shows the result of a badly set contact which is worn unevenly. The platinum would have to be filed away right down to the steel, and the spark would then soon eat the rivet hole and cause serious misfiring.

### Dressing Platinum-Iridium Contact Points

**To dress the platinum points,** remember that the main requirements are to remove only as small an amount of the valuable metal as possible and to trim the surface dead level and smooth. This can be done with a small finely cut jeweler's file. If the file is not a very fine-cut file, it will leave roughness on the points. A smooth glassy surface is best. Platinum-iridium points can best be dressed on an oil stone (Fig. 8) which insures a smooth, flat surface. In making the final adjustment of the screw, do not set the points closer than necessary to give a good, steady buzz of the vibrator. In setting magneto contact points, they must not be too close together, or too far apart.

**If the surfaces are merely blackened** with dirt or grease, forming a film over the points, thus offering resistance to the primary circuit building up, this can be removed by inserting a strip of 00 sandpaper between the two points, and by pulling the paper through them a few times under its own spring tension. A better plan to brighten up a platinum point surface is to use coarse paper instead of sandpaper, as sandpaper has a tendency to leave a rough surface on soft platinum. Always **adjust** the opening of the points after cleaning.

### Tungsten Contact Points

**Tungsten points are used almost entirely on coil and battery ignition interrupters of the non-vibrator type** (pages 205, 208, 211, 214), because of its extreme hardness, which withstands the hammer blows caused by the high spring tension which is necessary in high-speed interrupters to prevent chattering and also to obtain good contact at the point surfaces. It is not rapidly consumed or disintegrated by electrolysis, but it is subject to oxidation, and inherently has a high resistance. This oxidation results in a high resistance oxide film coating on the points (similar to rust, but of dark color), reducing the flow of the primary current. Thus a high potential or voltage across the points of the interrupter in the primary circuit is necessary (generally 6 volts supplied by the battery). The current consumption of the primary circuit of a non-vibrator type coil is usually less than of the vibrator-type coil, and is nearly always less than 5 amperes. Where 5 amperes or more are used in the primary circuit platinum-iridium is best.

**The disadvantage of tungsten for magneto contact-breaker use** is oxidation of the points and its high surface resistance, both of which prevent the magneto primary current from building up to its maximum value (page 253), resulting in weak current and difficult starting.

Arcing across the points of tungsten is more common than with platinum-iridium, and it is difficult to determine when a condenser is defective. When platinum iridium contacts are used, extreme arcing is always an indication of a defective condenser. Tungsten points require a greater condenser capacity to overcome arcing than do platinum points

### Dressing Tungsten Contact Points

**Conditions which necessitate dressing tungsten points are as follows** (see also, pages 203, 211, 221):

1. **When dirty,** by being coated with grease, etc. The points can be cleaned with gasoline.
2. **When oxidized by a dark or blackened** oxide film forming on the surfaces. The film will readily yield to the file and leave a clean surface. It will be found, however, owing to its hardness, that the metal itself cannot be removed except by grinding or dressing on an oil stone.
3. **When pitted,** caused by an electrolytic effect and arcing. If this is slight, the point can be dressed on the oil stone (Fig. 8), but if deeply pitted, new points are necessary. In extreme cases of pitting a reversal of the primary current will sometimes rectify this trouble.
4. **When burned,** owing to sparking or arcing across the points which pits the points. Dressing on an oil stone will remedy the trouble. It is best to renew the points if badly burned or pitted.

**Appearance of tungsten points: a silver gray** appearance with pebbled surface at point of contact is O.K. **New points** may show a small spot, usually near the edge, and need not be disturbed. If points are **blackened,** clean, and adjust.

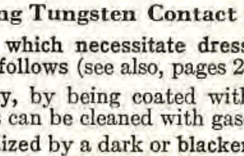



Fig. 8. Method of dressing tungsten points on an oil stone (also applicable to platinum points). The contact point screw (S) is clamped, by means of two nuts, to the center of the metal strip. The strip is moved forward and backward over the oil stone, thus securing a true surface on the tungsten point, which makes it last much longer without grinding. The main point is to have a **smooth flat surface** so that each point will make **full face contact with the other,** and not on one side or edge.

Another plan of dressing the screw point is to put it into a chuck of a drill press and dress it down on an oil stone. The point on the interrupter arm however will have to be dressed by hand.

### Spark-Gap Suggestions

**Do not set spark-plug gaps over 1/32" apart** for vibrator-coil ignition. The usual setting for non-vibrator coil ignition is .025". Too large a gap will likely cause a misfire (see also page 238).

When testing the spark, by removing the wire from the spark plug, **do not separate the terminal wire from the plug or engine** frame more than ⅜" on a vibrator type coil, or ¼" on a non-vibrator type, and about 3/16" on a magneto, as it will strain the coil windings and may break down the insulation. On a magneto, or coil which uses a safety gap the **safety spark gar** is usually set ⅜"; if a test is made with a spark too wide it may jump at the safety gap instead.

# INSTRUCTION No. 22

## TESTING IGNITION COILS OF NON-VIBRATOR TYPE: Condenser Tests; Resistance-Unit Tests

As an example of the procedure for testing an ignition coil of the non-vibrator type, the North East Ignition system as used on the Dodge car will be used.[1]

See Index for "Dodge wiring diagram" for the internal circuit of this system, and study it carefully.

### LOCATING IGNITION TROUBLE: N. E. IGNITION SYSTEM (MODEL "O")

1. Whenever it is determined that trouble has been located in the ignition mechanism or in the coil windings, and that it is not in the spark plug or loose connections, or due to a run-down battery, then turn off the ignition switch and remove the distributor head in order to expose the interior of the breaker box. Crank the engine slowly until it is seen that the breaker cams come together.

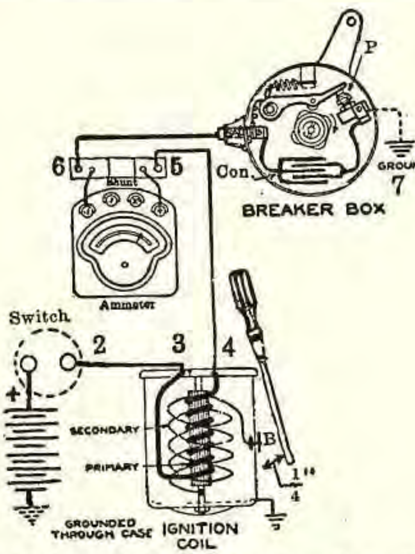



Fig. 1. Testing the North East ignition coil as used on the Dodge.

2. Disconnect the wire at the contact breaker leading from the switch to the contact breaker, and insert a low-reading ammeter in the circuit, as shown in Fig. 1. (The ammeter shown is the model "280" Weston.)

Note. The use of a screwdriver is not resorted to in this test. Fig. 1 is used to illustrate several different tests.

3. Turn on the ignition switch and note the amount of current through the primary circuit. With a battery voltage of 12 volts, the normal amount of current consumed by the coil with the engine idle and breaker contacts (P) closed, is approximately 2.5 amperes. This will determine if the primary circuit of the coil is in proper shape.

Note. It is best to use first the 30-amp. shunt, if a Weston model 280 instrument is used, because, if there is a short circuit it will read far more than 2.5 and burn out the meter. If a low reading is thus obtained, then connect the 3-ampere shunt and use the lower reading scale, which is more accurate for low readings.

#### To Test the Secondary Winding

**a) A ground** in the secondary from the secondary winding to the coil box cannot be tested with an ordinary test lead, because the inner end of the secondary coil is normally grounded to the core. A ground from the coil to the core can usually be indicated by burning of the insulation appearing on the outside of the coil where the spark has punctured it.

**b)** The simplest method of **testing for a short circuit of the secondary winding** is to substitute another coil temporarily for the suspected one, and to compare their behavior under similar operating conditions.

**c) To test for an open circuit in the secondary winding:** Remove the high-tension terminal bushing (B) (Fig. 1) on the side of the coil, and then run the distributor unit at a moderate speed with ignition switch on, while a screwdriver is held against the housing with its tip about ¼" from the high-tension contact button (B) on the ignition coil. If no spark jumps, the winding is probably open-circuited. Before accepting this as final, however, be sure the primary coil winding is in proper shape, because the induced current comes from the primary coil.

If the primary winding test shows abnormal ammeter readings, either more or less when the meter is inserted between switch, coil, and breaker box, as in Fig. 1, or if there is an open circuit, then other portions of the circuit should be tested as follows:

1. **Test the wiring from coil to switch** by placing one lamp test point on 2, and one on 3, then from switch to ammeter (2 to 5), and ammeter to breaker (6 to 7), to see if these are open circuits, grounds, short circuits, or loose connections. Also examine the switch and coil connections. The 110 or 220-volt direct-current test lamp and leads (Fig. 3 can be used for this, but be sure no current is passed through the ammeter and that the ignition switch is open.

2. **Test the battery:** If the battery shows 2.6 volts across each cell, it is fully charged. If it shows 1.8 volts or less per cell, it is discharged. However, voltmeter readings are not accurate, for if a battery is sulphated, unreliable high-voltage readings will result when tested while on charge. Therefore a battery should be tested on discharge also. See Index for "Testing a storage battery on discharge."

3. **Examine switch, ammeter, and also the storage battery connections** for loose or poor connections or grounds. Quite often poor or loose connections on

[1] Applies to Dodge 4-cylinder car. By courtesy United Motors Service, Inc. (Overseas Motor Service Corp. in export territories).

the battery or switch will cause lack of proper current supply, as a loose connection not only causes missing, but offers resistance and cuts down the current supply.

### To Test the Condenser[1]

**The condenser in the N.E. Model "O" interrupter** is in the contact breaker housing, and connects across the points of the contact breaker. One point of the contact breaker in this system, is grounded, and so also is one end of the condenser (see Fig. 2). The purpose of the condenser is

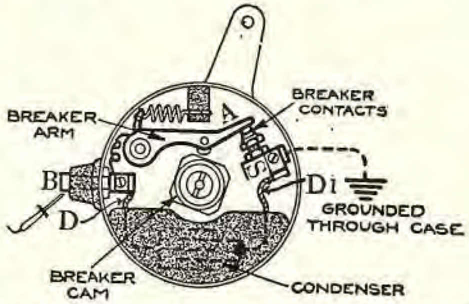



Fig. 2. Testing condenser on N. E. (Dodge) model "O" interrupter or contact-breaker.

explained on page 191. On some ignition systems the condenser is placed on the coil.

**To test condenser for a ground:** Disconnect condenser leads (**D, D1**) from the contact breaker mechanism (Fig. 2). Hold one test lead (110 or 220-volt direct-current lamp and leads) against the condenser case, and touch the two condenser leads (**D, D1**), one at a time with the other lead. The test lamp will light if there is a ground; if the condenser is in proper shape, the lamp will not light.

**To test condenser for a short circuit:** Separate breaker contact points. Place a test lead on each of the condenser terminals (**D, D1**). If the condenser is short-circuited the lamp will light; if nothing is wrong, it will not light.

**To test condenser for an open circuit:** This test should be made with a test lamp from alternating current. Separate the contact breaker points. Hold one test lead on one terminal (**D**) of the condenser and touch the other condenser terminal (**D1**) lightly with the other test point. If the condenser is in proper condition, a slight spark will occur every time the test lead is applied. If the condenser is open-circuited, no spark at all will occur. In either case the test lamp will not light, because even with a normal condenser, the current permitted to flow through the test lamp is so small that no visible effect will be produced.

### To Test Contact Breaker

**To test contact breaker for a ground:** Disconnect the wire to the contact breaker binding post at (**B**), (Fig. 2). Separate the contact points. Touch one test lead to the shell of the contact-breaker box and the other to breaker arm (**A**). The lamp should not light if everything is correct. If the breaker is grounded it will light. The condenser should be tested first, as a short-circuited condenser would cause the lamp to light, since it would be in the circuit.

Note. If the contact breaker has two binding posts and has an insulated return instead of a grounded return, the test should be made with breaker points closed in order to include the stationary contact point (S), as well as the rest of the breaker mechanism.

**To test contact breaker for short circuit:** Disconnect wire at (**B**) (Fig. 2) to contact breaker. Separate points. Place one test lead on the terminal (**B**), and the other on the stationary contact (**S**). If the lamp lights there is a short circuit. Be sure the condenser is in good order, for the reasons given in the test immediately preceding. If the lamp does not light it is without defect.

**To test contact breaker for open circuit:** Make the same test, except that the contact points should be closed instead of being separated. If the test lamp fails to light when the breaker contact points are closed, an open circuit is indicated.

### To Test Primary Winding

**To test primary winding of ignition coil for ground:** Remove the coil-housing cover and disconnect the coil leads from the terminal block on the cover (Fig. 3). Hold one test lead against rod (6) in the center

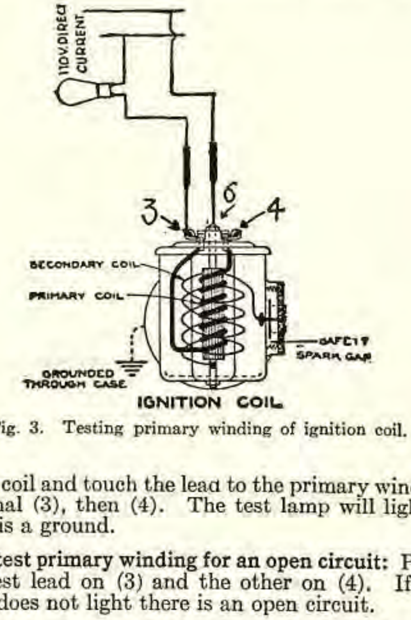



Fig. 3. Testing primary winding of ignition coil.

of the coil and touch the lead to the primary winding terminal (3), then (4). The test lamp will light if there is a ground.

**To test primary winding for an open circuit:** Place one test lead on (3) and the other on (4). If the lamp does not light there is an open circuit.

**To test primary winding for a short circuit:** See paragraphs 2 and 3 under "Locating Ignition Trouble." If the ammeter reads more than 2.5 with switch closed, points together, and engine idle, it indicates a short circuit either in the primary winding or elsewhere in the circuit.

### Operating Test: Bench Running Test of N.E. Ignition System (Model "O")

The N.E. ignition test is made on a special test bench (Fig. 4) with apparatus designed for the purpose.

[1] A method where many coils are tested is to have an interrupter connected with a drive system of some sort. See Fig. 12, page 230.

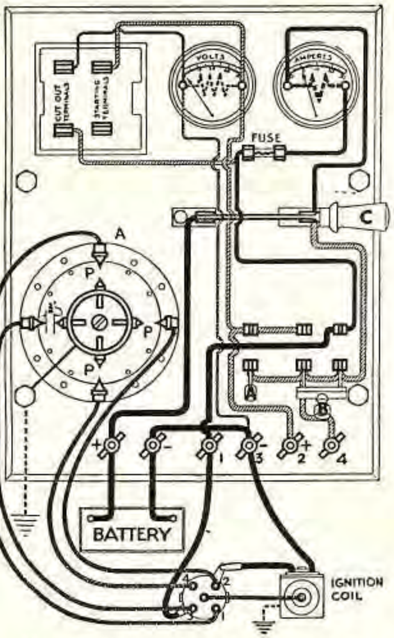



Fig. 4. N. E. ignition test-board for testing the ignition system, generator, and cut-out.

**The ignition unit is placed on the test-bench** and connected to a motor which drives the ignition unit under conditions as nearly like those encountered in service as practical, and is carried out with a range of speeds equal to that of the engine. The test-board shown in Fig. 4 is the N.E. testing outfit for testing the ignition system, generator, cut-out, etc.

**The ignition unit,** consisting of distributor, interrupter, and coil, all in one unit (see Index for "Dodge ignition unit"), is connected with a motor which drives it at various speeds as stated above. The distributor is connected with an adjustable spark device (Fig. 4), with the points (P) adjusted to ¼" gap. The unit is first driven at 1,200 r.p.m., and switch (C) is closed. High-tension sparks are at once produced at points (P). The speed is varied from 1,200 to 2,000 r.p.m. A low-reading ammeter is inserted in the primary circuit as shown.

At 500 r.p.m. with a 12-volt fully charged battery, the consumption should be nearly 1 ampere; at 1,200 r.p.m. approximately 0.8 ampere; and at 2,000 r.p.m., 0.6 ampere.

**The black wires** show the primary circuit of the coil connected with battery, switch, and ammeter. For instance, the primary circuit is from battery to (+) terminal, to switch, to ammeter, to fuse, to terminal of switchboard 1, to contact breaker, through points, to primary coil, from other end of coil primary to (−) terminal (3) on switchboard, to (−) terminal of battery.

**The secondary circuit of the coil** is from the secondary terminal of the coil to the center of the distributor, thence from terminals on distributor to points (P) on spark tester (A), through points to ground, to ground of coil.

**A coil on a test** should jump ¼" in the open air without missing. If it will not jump this gap continuously, then it is certain not to jump the spark-plug gap inside the engine which is under compression and thus shows greater resistance.

For timing the N.E. ignition system on the Dodge, see Index under "Dodge ignition timing."

## REMY NON-VIBRATING COIL AND CONDENSER CONNECTIONS

**The condenser** is always connected or "shunted" across the interrupter points (P) of all high-tension coil primary circuits and magnetos. It can be placed **on the coil,** as shown in Fig. 5, or **on** the **interrupter,** as in Fig. 6.

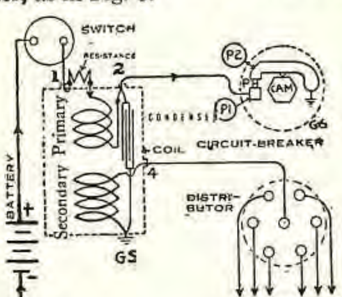



Fig. 5. Remy grounded ignition system using a non-vibrating cylindrical type, two-terminal coil with condenser in coil. Note that the condenser is across the contact-breaker points (P).

When the condenser is in the coil away from the points, a greater condenser capacity is required to prevent sparking and the points are usually set farther apart.

**The primary circuit** (Fig. 5): From (+) of battery, to switch, to coil terminal 1, through resistance unit, through primary winding to coil terminal 2, to interrupter stationary contact (P1), through movable contact (P2), to ground, to (−) ground of battery. Note that the **condenser** in the coil is **connected across interrupter points (P).**

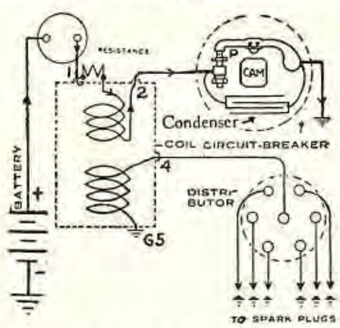



Fig. 6. The same ignition principle as shown in Fig. 5, but with the condenser in the interrupter housing. The condenser is shunted across the contact-breaker points (P), as in Fig. 5. It is best to have the condenser as near the points as possible, as above, as there is less sparking at the points.

**The primary circuit** (Fig. 6): From (+) of battery, to switch, to 1, through resistance unit, through primary winding to 2, through points (P) on interrupter, to ground, to (−) ground of battery.

Note that the condenser in the interrupter housing is connected across the interrupter points (P).

**In order to explain the importance of connecting the proper wires to a coil where a condenser is in the coil,** the diagram (Fig. 7) is used to show how the condenser can be cut out of action to a great extent, thus reducing the efficiency of the coil and causing sparking at the interrupter points.

**Primary circuit** (Fig. 7) (connected wrong): From (+) battery to 2, through primary winding, through resistance unit, through points (P), to ground, to (−) ground of battery.

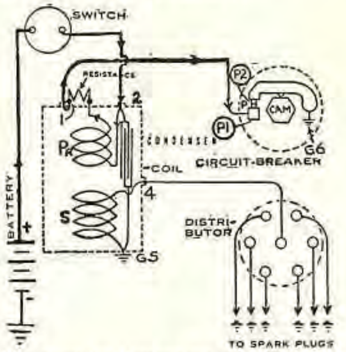



Fig. 7. The same ignition system as in Fig. 5 with leads to and from the ignition coil connected wrong, thus disconnecting the condenser from across the contact-breaker points where it is required.

Note that the condenser is not directly across the interrupter points (P); the primary winding and resistance unit are between one end of condenser (2) and (P1) of interrupter. The proper connection is shown in Fig. 5. Coils are usually marked (B) for battery, and (T) for timer. Thus the terminal from the battery leading to the switch and from the switch, should connect with (B) or (1) on the coil. See page 209, explaining Remy 2 and 3 terminal coils; see also page 213, for Delco coils.

### Remy Condenser Instructions and Tests

**Condenser trouble** will usually be distinguished by severe arcing at breaker contacts.

**Test for shorted condenser:** Disconnect the condenser, or, if condenser is inside of coil, disconnect coil. Connect terminals leading to the condenser, across 110 volts A.C. or D.C. with a lamp in series. If lamp lights, the condenser is short-circuited or broken down between layers. Test points from lamps are indicated as (T) (T1) (Figs. 8, 9).

**On systems using grounded ignition,** that is, grounded primary winding in ignition coils (Fig. 8), connect test point (T) to post (2), to which the lead from the breaker is attached, marked "Timer," and to base of coil with test point (T1), for this test.

Note. If primary winding has become grounded in this type of coil, the lamp in this test will be lighted the same as if the condenser is shorted. However, if the breaker points are badly and are burned, it can be assumed to be condenser trouble.

**On systems using insulated ignition** (primary winding not grounded), (Fig. 9), connect test point (T) to center post (2), marked "timer-switch" and connect (T1) to outside post (3) which has not the resistance unit connected to it.

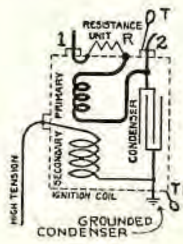



Fig. 8

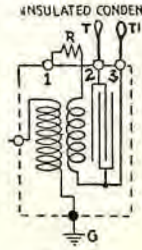



Fig. 9

Fig. 8. Remy ignition coil (two-terminal type) with condenser grounded.

Fig. 9. Remy condenser coil (three-terminal type) with both terminals of condenser insulated.

**Open condenser:** An open condenser may be one which is disconnected inside of the box or coil tube, or one which has opened up between layers so that its capacity is very low. With an open condenser or one which has no capacity from any cause, very severe arcing will occur at contacts as stated above.

**Capacity test:** In case 110 volts D. C. is available, a capacity test can be made by connecting across the condenser with the test lamp in series, then disconnect the test lamp and bring the condenser terminals together. If a good spark is obtained, the condenser is all right. A. C. current is not as dependable for this test as D.C. current, although with proper care fair results can be obtained. In using A.C. current a good spark will not be obtained every time the condenser leads are touched together, but only occasionally.

**Ignition coil test:** In all battery ignition systems a good spark should be obtained at maximum engine speed. For testing a coil in the open through ordinary spark-gap points, which are well cleaned, a good coil will jump a gap of not less than 5/16″ when the coil is connected up in the regular way at 3,600 or less sparks per minute with breaker points opening at a point between .020″ and .025″. Test coil for at least one hour until well heated up, according to the instructions given above, before mounting on the car. A coil which cuts out or misses under these conditions should be taken out of service.

## DELCO INSTRUCTIONS RELATIVE TO TESTS OF RESISTANCE UNIT AND CONDENSER

Delco ignition coils, interrupters, and distributors, as well as adjusting Delco timing contacts are explained on pages 213–221. In the present discussion we deal with the Delco ignition resistance unit and condenser tests.

### Resistance Unit Tests

**Resistance units sometimes break down or burn into,** with the result that there is no spark at all, or a very weak one.

Connect the coil so that the resistance is cut out and note if the spark is improved. See pages **213**, 214, showing resistance on coils.

**A resistance unit, if short-circuited,** will permit excessive current to pass through the contact-points, and this will cause them to be burned or pitted excessively, although the ignition may appear to be very good and without a miss.

**If the resistance unit is connected properly,** it will heat up; if it does not heat up it will indicate that the resistance unit is not in the circuit. See page 198, explaining the purpose of a resistance unit. Also refer to page 231, relative to the resistance unit becoming thin, owing to heat, thus weakening the spark.

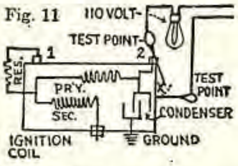
### Condenser

**If the condenser is not in good condition,** the contacts will burn and pit rapidly, owing to the excessive arcing when they are separated, but the ignition will be rather bad if, indeed, it will operate the engine at all, so that the burning of the contacts, due to a bad condenser, can, as a rule, be distinguished from burned contacts due to a high voltage or to a short-circuited resistance unit.

**A good test for the condenser when separate from the coil,** by which to show whether it is in good condition or not, is to connect it up in accordance with the circuit diagram shown in Fig. 10. For this


Fig. 10

Fig. 11




test a 110 or 220-volt direct or alternating current is necessary, a lamp of the same nominal voltage as the circuit, and the wiring shown. The lamp is connected in series with the line and the condenser across the line.

If the terminals (A) and (B) are connected together, a very faint spark, which has a snapping sound similar to the sound made when leads from a storage battery are attached, should occur. If the condenser be disconnected from the circuit, a much different arcing will be observed, somewhat longer and yellower, and without the distinct snapping sound mentioned previously.

If a condenser, known to be good, is tested in this manner once, it will enable the observer to distinguish very readily between the sparks at the points (A) and (B) obtained with a good condenser and a bad condenser, as a bad condenser will give the same quality of spark as if no condenser at all were in the circuit. This test is a mere qualitative test, but this is about the only satisfactory test which can be found which does not require expensive apparatus.

**If a condenser is in coil,** it can be tested in the same manner as shown in Fig. 10, by placing the test points (Fig. 11) so that the same effect can be had. One end of the condenser is usually grounded.

### Condenser and Coil Test Suggestions

**Possibly the most common test is to disconnect the doubtful condenser and substitute one that is known to be correct.** The results obtained when using the good condenser will show up the action of the original condenser, as explained on page 231.

For instance, if an excessive amount of sparking is at the contact points, it is probably due to a defective condenser. Therefore if a good condenser is connected right across and over the condenser to be tested, and if the sparking stops, then you may know the trouble is with the old condenser.

Where there are many coils and condensers to test, it is a good idea to rig up a contact breaker on the bench (Fig. 12), so that it can be driven at various speeds, and then to have a good condenser across its points which can be connected and disconnected by a switch (SW). Then when a coil is tested it can be connected with the contact breaker. If it has a condenser in the coil, disconnect the condenser on the contact breaker; then watch if it sparks at points (P). If it does, cut in the good condenser.

**Also watch the spark at secondary test points (S).** It should spark for at least ¼″ to 5/16″ without missing for, say, 50 or 60 sparks. Be sure the coil is well warmed up when making the test.

**The quality of the spark should be closely observed when testing the condenser.** If the spark

Fig. 12

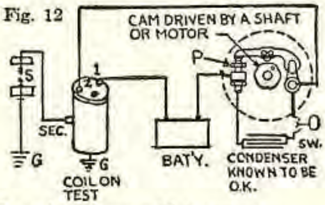



Fig. 12. Test of condenser with interrupter.

at the tester gap (S) is fiery, showing glints of purple or purplish-red flame, the coil is normal.[1] If the spark is thin, thread-like and whitish or very light blue, and there is a snappy spark at the interrupter breaker points, the indication is that the condenser is punctured. This can then be checked by placing an extra condenser, known to be in good condition, as described. **If the coil will deliver a good spark when connected to a known normal condenser and will not give a spark when the condenser is disconnected, the proof is conclusive that the coil condenser is defective.**

**When making condenser tests, the object is to see if there is excessive sparking at the interrupter points, if not,** and if the coil delivers a voluminous, intense spark at gap (S), then the system is in proper condition.

**If contact points arc excessively,** the trouble may be due to the interrupter points being too close, or pitted, or having uneven surfaces. If not, then the fault is likely due to the condenser, or possibly a shorted secondary winding.

**First, however, see if the terminals of the coil are well connected, and if the condenser screws and leads are tight.** If so, and contact points are smooth and properly adjusted, and arcing continues, test the condenser as explained on this page and on page 227. **If the spark is weak at (S)** but no arcing shows at the points, then **test the coil.**

**It is not always true that pitted contacts are due to improper functioning of the condenser.** An excess of oil vapor within the distributor housing, or an excess of oil due to careless or excessive lubrication of distributor shaft bearings getting on the contact point surfaces during their operation, causes arcing and pitting of points. **Too high a voltage will cause points to burn black.**

**(a) A short-circuited condenser will cause complete failure of ignition.** The lamp will light when the condenser is tested with 110-volt test-points and lamp.

**(b) An open-circuited condenser will cause complete failure of ignition.** The trouble is usually due to a broken lead inside the condenser case.

**(c) A weak condenser will cause irregular ignition** and tend to increase burning of tungsten contacts.

**If the condenser of the system being tested is in the contact breaker,** it can be tested without removing, by connecting a good condenser so that it will be across the points of the contact breaker and noting results.

### Home-Made Tester for a High-Tension, Non-Vibrating Coil and Condenser

This device (Fig. 13) consists of a sheet copper plate about 6″ wide, by 8″ long, by ⅛″ thick to serve as a base.

**A magnetic vibrator (V),** similar to a vibrator on a high-tension vibrator coil, is mounted on the plate with fiber blocks (F), as shown.

**The purpose of the device** is to produce a vibrating action on the end of a coil, thus producing the same effect as a vibrator coil. By this method the strength or intensity and the constant steady spark of the secondary can be tested.

[1] See also, page 286.

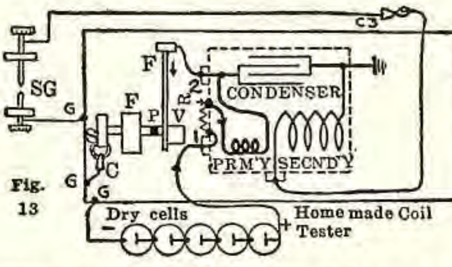



Fig. 13

When testing a coil (Fig. 13), it does not make much difference which end is used; furthermore, the magnetic effect is so great that the vibrator will vibrate directly on the metal shell. It is best, however, to have the vibrator knob (V) vibrate against the end of coil if possible. Either end could be used.

Fig. 13 illustrates a **Remy two-terminal coil with a condenser in the coil.** With coils where the condenser is in the contact breaker, they should be tested separately with a 110-volt test light, as previously explained (see also page 232).

**The primary circuit through the coil** is from (+) of battery to (1), through primary winding to (2), through vibrator blade (V), through points, to vibrator screw, through clamp (C), to ground of plate (G), to ground on plate, to (−) of battery. The condenser on the test outfit is across the points of the vibrator. By adjusting the vibrator screw (S) the vibrator blade (V) will vibrate, causing a spark at secondary spark gap (SG).

**The secondary circuit** is from the secondary winding to a clamp (C3), thence to a spark gap tester (SG), which can be made of two finely pointed brass rods through a fiber support. The gap of the points should be adjusted to ¼″.

### Ignition Coil Test (Fig. 13)

Operate coil and see if it will produce a spark continuously at **secondary** gap (SG) for at least one hundred steady sparks without missing with gap ¼″. If there is a safety gap on the coil being tested, the gap (SG) should be slightly less than the gap of the safety gap on the coil. (See page 232, testing the **primary winding** of a coil.)

**Condenser test** (Fig. 13): Note that the **condenser is in the coil.** The object is to see if there is excessive sparking at the vibrator points (P). If so, it may be due to too high a voltage, or to pitted or improper adjustment of the vibrator. If arcing continues (after determining this), and is thread-like, whitish and snappy (see also under Fig. 12, page 230), it is then probably due to the condenser.

A good plan is to **have another condenser known to be in good condition.** If there is excessive sparking, place the terminals of the good condenser across the vibrator points, by placing one terminal at (2) and one on screw (S). If the sparking then ceases, it is clear that the condenser in the coil is defective.

A Delco No. 13057 (Packard) condenser which has two leads would be a suitable condenser for use in this manner. (See page 481 where to obtain parts.)

In some instances **the condenser ground comes loose** in the coil where it is soldered. This can be remedied by soldering.

### Ignition Resistance Unit Test

In testing a coil with a resistance unit in it, test with the resistance in circuit and with the resistance out of circuit. This can be done by making connection on the opposite side (R) of it from 1 (Fig. 13) thus cutting it out.

**This may be the cause of a weak spark,** because the resistance wire (Fig. 13B) burns out at times, and, if not burned into, may be thin (owing to heat), and thus reduce the quantity of current going through it, consequently weakening the spark. By cutting it in and out of circuit, the intensity of the spark at gap (SG) can be observed.

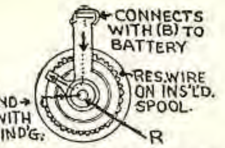




FIG.13A. TOP OF REMY COIL FIG.13B. BOTTOM VIEW RES.UNIT

**If current cannot be passed to coil through the regular terminals,** it may be suspected that the resistance unit is burned out. **This can be determined by touching a test wire to the central nut** (R, Fig. 13A), which holds the unit in position. This has the effect of cutting the unit out completely and sending the current directly to the primary windings. If current does not flow, the indication is that there is a break between the resistance-unit screw (R) and the end of the coil winding inside the coil.

**Ignition resistance units can easily be fitted if burned out,** or **condensers can be replaced when in contact breakers,** but if the coil is defective otherwise, do not attempt to repair it; obtain a new one. See page 481 **where to obtain ignition parts** [1]

### Spark-Plug and Lamp-Bulb Portable Testing Outfit and Test Board

**A portable testing outfit** for carrying from one part of the shop to another for testing on different cars is shown in Fig. 14.

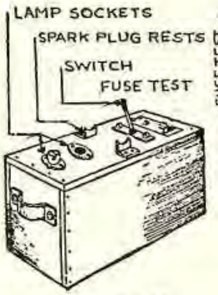



Fig. 14

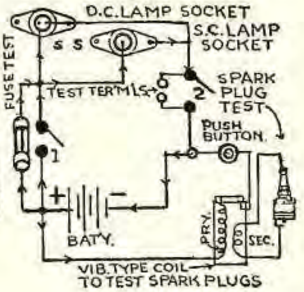



Fig. 15

Dry cells are placed in a box. The switch throws the two types of lamp sockets (single and double contact) into circuit The push button connects the batteries through the vibrator type coil to test spark plugs.

**A test board** (Fig. 15) can be constructed by using a storage battery instead of dry cells, for testing spark plugs, coils, lamp bulbs, fuses, etc. To determine if the cause of a lamp bulb not burning is that it is burned out, or whether the trouble is in the wiring, it can be quickly tested. If it burns, then the trouble is in the wiring. This also applies to the fuse.

**To test lamp bulbs** (Fig. 15), place the bulb in either or both sockets, close switch (2). **To test the fuse,** open switch (1) Place lamp bulbs in both sockets. Place fuse in clips. If lamps light, the fuse is in proper condition. **To test spark plug,** place spark plug in test clips, press push button. **Testing point terminals:** to use, insert test point plugs in terminal and close switch (1), but open switch (2). This will cause lamps in each socket (S) to burn when the circuit is completed between test points.

**Testing electric horns:** See pages 445, 453, 451, 485. **For test lamps and test points,** see Index.

[1] To find the make of ignition system used on different makes of cars, see Index under "Specifications of passenger Cars."

## MODERN IGNITION COILS AND INTERRUPTERS

**Ignition coils in general use are of the closed-circuit, non-vibrator type**; with two primary terminals; ignition resistance unit in or on the coil, or connected at the interrupter; the secondary is grounded to the primary winding, or to the base of the coil; condenser is usually in or on the interrupter.

**The Atwater Kent coil** (see below) has a (+) and (−) primary terminal. See also Figs. 16**D**, 16**E**, page 207, explaining.

**The Connecticut coil** has a condenser with coil: thus the primary terminals (1, 2) must connect properly with (+) and (−) of the battery. **If (−) of the battery is grounded,** use a "positive coil" and connect (1) with (+) of the battery and (2) with the interrupter. **If (+) of the battery is grounded,** use the "negative coil" and connect (2) with (−) of the battery and (1) with the interrupter (see page 229 why necessary).

**Interrupters in general use are of the closed-circuit type. The gap opening of points** is given in illustrations. On some makes the advance lever moves the entire **distributor**; on others, **interrupter plate only.**

**Average timing:** Place piston (No. 1 cyl.) on top d.c. of compression stroke, with spark lever **retarded.** There are **two general methods of setting the cam** to open contact-points at the correct time: (1) by loosening the cam; (2) by loosening the advance arm lever (page 301). A good, clean, smooth surface contact is very necessary. Most points are tungsten (see page 225). Too high a voltage burns points black.

**For timing instructions** see: Atwater Kent, pages 205, 206; Bosch, 208, Connecticut, 200, 303; Delco, 220, 307; N.E., 371; Remy, 208, 212, 302; Westinghouse, 207. See also pages 301, 302, 303.

**Ignition operates under three different voltages: 4**-volt when using starting motor (battery voltage being reduced by starting motor current drawn); **6**-volt with a normally charged battery when engine is running at a speed below that at which the generator starts to charge; **8**-volt when generator is charging a full battery.

### Ignition-Coil Test

**Test primary winding of coil** by connecting ammeter in series with fully charged battery and primary terminals of coil.

Average **initial reading** on dead short-circuit will be **approximately 5 amperes.** This is of short duration, as current falls off rapidly (due to coil **warming up** and to heating of the resistance unit; hence an increase in resistance) and within 30 to 60 **seconds** the reading will drop to **approximately** 3.5 **amperes** (average) and remain constant. (On a 12-volt coil the **initial** would average approximately **3 amperes,** and **warm test, 2.5** average, and **running test,** .5 amperes, because, as the voltage increases, the amperage decreases).

**If on this test, reading is considerably more,** then there is likely a short circuit, or ground in primary winding (due to less resistance, as part of winding may be cut out of the circuit). **If there is no reading at all,** there is an open circuit in wiring, winding, or resistance unit.

**Too high an amperage will cause the contact-points to burn** and may be due to **too high a generator voltage, caused by a loose or corroded battery terminal,** or **a coil with too coarse a winding drawing over 5 amperes.**

**Running test:** Many repair men have an interrupter (driven from motor or shaft, Fig. 17) connected in series with battery, ammeter, and primary winding of coil. This test will not indicate the true value of the current at rapid breaking of interrupter points because the moving parts of an ammeter are such that the needle cannot follow the fluctuations. An oscillograph (page 188) for accurate tests is used in laboratories.

There is no particular value in making this test; as long as the current values given in the foregoing tests compare favorably with the average, the test above mentioned is sufficient. The object is to point out that the current value drops considerably when the coil is connected with an interrupter operating at high speed.

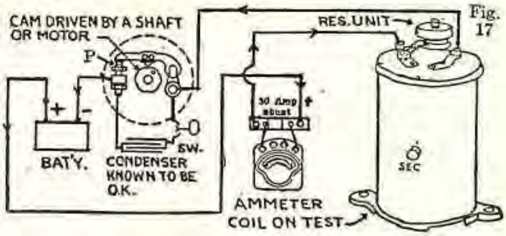



Fig. 17

**For example,** with the Remy 6-volt coil, with interrupter operating at **1100 r.p.m.,** the current value would be approximately **2.5 amperes,** and at **1500 r.p.m.** approximately **1.5 amperes.** This test is an **approximate average** where an ammeter is used. If an oscillograph was used, the reading would probably be less.

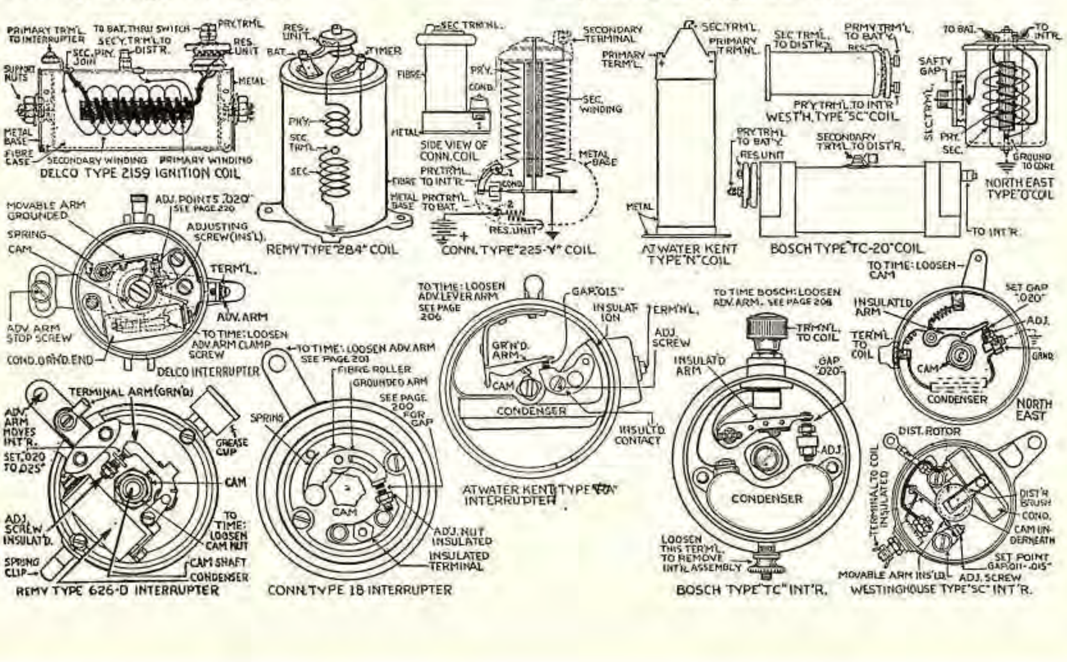
**The current taken by the coil through an interrupter will depend upon:** (1) speed of interrupter; (2) battery voltage; (3) number of cylinders for which interrupter is designed; (4) adjustment of contact points.

**Secondary coil test:** This test is made at the time of making the running test or while on the car and after the coil is warmed up. It should throw a spark for about ¼″ (with secondary wire held away from terminal) for at least a minute test without missing and the spark should be **voluminous** and **intense** (see also page 286).

**If secondary spark is weak,** look to interrupter contact-points (**P**) and see if there is arcing. If so, and the arc is of a whitish color, the condenser is likely at fault. If there is no condenser or contact-point trouble, then the secondary winding is faulty.

**If the secondary spark is too strong,** it will burn the plug points and may be due to an **excessive generator voltage caused by a loose or corroded battery terminal.**

**For address of ignition manufacturers and where to obtain ignition parts, see page 481. For test lamps and test points,** see Index **for testing the electric horn,** see pages 445, 453, 451, 485. See also pages 462B to 462G.



# INSTRUCTION No. 23

## SPARK PLUGS: The Missing Spark; Spark Intensifier

### Spark Plugs[1]

**The purpose of spark plugs** is explained on page 188. There is usually one spark plug for each cylinder.

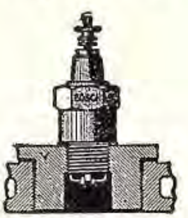
**Location of spark plug in cylinder:** The spark plug can be placed in the cylinder as follows: over the center of the piston, over the exhaust valve, or over the inlet valve. The first position is not the best, as it is found that it too easily becomes fouled. If screwed above the exhaust, it will likely miss fire; this is on account of the dead gases surrounding it. The correct position is **over the inlet valves,** as it will be kept cool by the inrush of fresh gas, and it is in an atmosphere perfectly suited for explosion directly the spark appears, as this is the more perfectly scavenged part of the cylinder, i.e., in the direct path of the fresh gas.[2]

The plug is usually placed over the inlet valve on "T" or "L"-head cylinders. In the overhead valve type, the plug is placed in the top center or in the side of the cylinder. It is exposed to the full heat of the explosion when overhead, directly in the center of the bore; consequently in a high-compression engine, a well-made plug, gas-tight and free of electrical leaks, must be used.

**Double ignition:** On the Stutz series "K" and Pierce-Arrow "48" engines, there are two spark plugs in each cylinder, which is an advantage, in that a very hot spark is produced which ignites all of the gas more quickly, thus saving in gasoline consumption. One spark plug is placed on the exhaust side of the cylinder and the other spark plug on the inlet side. See Index.

As previously stated, where one spark plug per cylinder is used, the usual location is in the neighborhood of the inlet valve, as it should be surrounded by fresh gas that enters during the inlet stroke. If it is located on the exhaust side, dead gas will collect about the plug electrodes and cause missing, and also heat.

It is also desirable to have the plug where the water jacket surrounds it, as in Fig. 4, to avoid overheating, else the plug electrodes are liable to be overheated and become incandescent and to cause pre-ignition.



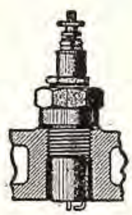


Fig. 1. Valve cap too thick; out of the path of the gas and too long a path to cooling water.

Fig. 2. Recess around the plug shell retains heat.

**A poor location** is shown in Fig. 1. When set in a thick valve cap (V) with short threads, dead gas accumulates in the recess and causes missing at slow speeds. Fig. 2 shows another poor method. The recess accumulates heat, and metal extension is liable to result in a plug becoming red hot and warping electrodes, altering the size of the gap.

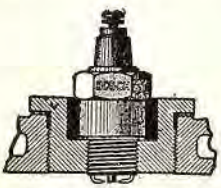


Fig. 3. Correct position of plug in valve cap, but too long a path to cooling water.

Fig. 4. Correct position of plug when set in water jacket. If the plug seat was directly surrounded by the water the cooling of the plug would be more effective.

**A good location** is where spark-plug points or electrodes just reach the combustion chamber, where cool fresh gas will come in contact with them and flame will spread with maximum rapidity.

When the plug extends too far in the combustion chamber, there is danger of the valve head striking it.

### Spark-Plug Construction

**Construction:** There are two types in general use: the "separable" type plug, where the insulation or core can be removed, as shown in Fig. 6, and the "integral," or one-piece plug, shown in Figs. 10 and 11.

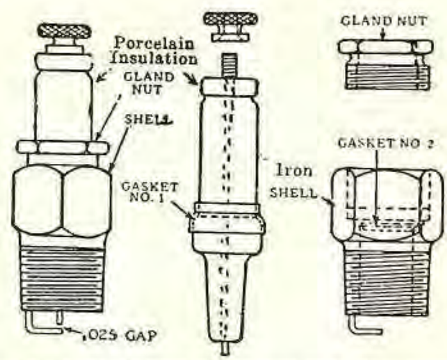



Fig. 6. Parts of a porcelain insulated spark plug—separable type.

**The parts of the plug** are: the iron shell or body which screws into the cylinder (see Fig. 6); the insulation which is held in the shell by the bushing or a gland nut; the center electrode which passes through the insulation and conveys the electric current to the gap. Washers or gaskets are used as a gas-tight packing (Fig. 6).

**The insulation** is sometimes made of mica (Fig. 7), but owing to the construction, which is usually with washers, one placed on top of the other, it has been

[1] See footnote, page 236.

[2] **Spark plug location.** At the time this page was prepared this was the accepted theory. On several engines, the spark plugs are now located close to the exhaust valves. Quoting from Chevrolet literature: "In the Chevrolet head, the exhaust valve is located relatively close to the spark plug, in the area of the first gas burned. The inlet valve is located at the opposite side of the combustion chamber, farthest from the spark plug, in the area of the last gas burned. This serves to control the mixture temperature by allowing the excess heat to pass from the last unburned part of the charge to the cool inlet valve. Thus the entire mixture is conditioned, because the heat absorption is controlled." See footnote, p. 37 for additional information. See also p. 1051 for *spark plug sizes.* A very small 10 mm spark plug is now used on several engines. See p. 690 under "Spark Plugs" for instructive literature. **Valve caps shown in illustrations above are no longer used in automotive gasoline engines with detachable cylinder heads.**

more or less a source of trouble in that the washers absorb oil between the layers, permitting current to pass to the electrode, especially when oily. However, mica plugs are now made which are giving very satisfactory results in aircraft engines and have the advantage of withstanding considerable heat. The insulation in general use is porcelain, or a similar material, and this, unless of the best grade (not porous) will also leak and crack under extreme heat conditions, thereby weakening the spark.

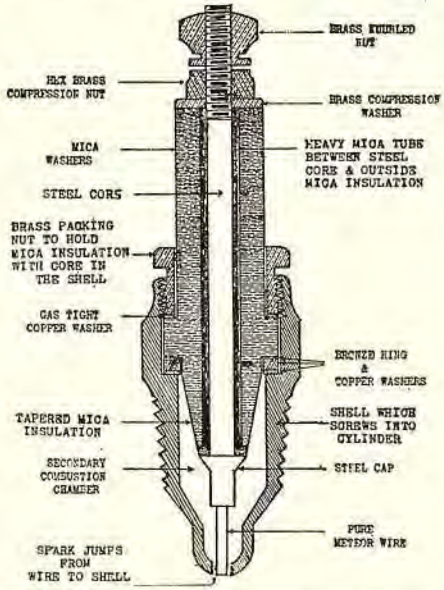



Fig. 7. Parts of a mica insulated spark plug—separable type.

**Spark plugs for aeronautic use:** Mica and porcelain insulators are used on plugs for aeronautic engines. The metric thread is used exclusively.

Fig. 8

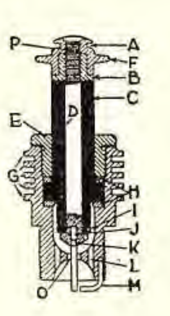



Fig. 9

**The aeronautic type of spark plug** is designed for great heat and high compression. The spark plug shown in Figs. 8 and 9 is made of mica and is very costly to construct. Note the heat radiation flanges on the shell; also the baffle plate (O) which tends to keep oil from the mica; stem (P) made of brass or copper for heat conductivity; electrode (J) is swedged at bottom of stem (K). The core is of mica washer sections (I), with a mica insulation tube at (D). The usual gap opening is .015" to .018". They are subjected to a pressure of 90 to 110 lbs. The life of a plug of this type is 100 hours or less.

**The parts of the Splitdorf** mica aeronautical spark plug (Fig. 8) are as follows: brass terminal, mica washers, lateral wound mica, steel center rod, 98 per cent pure nickel electrode point, carbon steel from brass terminal to electrode, and carbon steel shell.

**The AC Titan,** one-piece porcelain spark plug was used on the Liberty 12-cylinder engine. There are two spark plugs per cylinder to the Liberty 12 engine.

### Separable and Integral Spark Plugs

Separable spark plugs are those in which a gland nut or bushing holds the porcelain or mica in place, as shown in Figs. 6 and 7. The integral plug is of the one-piece construction.

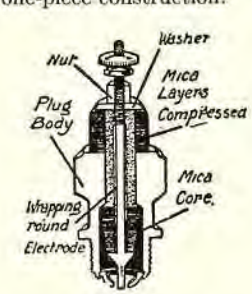



Fig. 10

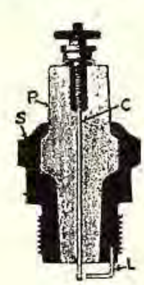



Fig. 11

Fig. 10. Integral type of spark plug with mica insulation. This plug is not separable.

Fig. 11. Integral type of spark plug with porcelain (P) or composition insulation. This plug is not separable.

**The electrode** (C) is made of steel, or manganese nickel alloy, or a special alloy. If not properly made it will expand under intense heat and break the porcelain. Spark plug electrodes, or wires, are approximately .050" or. 060" diameter.

**Cement** is placed around the electrode. As it dries, it becomes porous, and porosity means electrical leaks.

Thus, it will be clear that "leakage of gas" and "leakage of electricity" are the troubles to be overcome in spark-plug construction. Leakage of gas causes "leakage of compression," and leakage of electricity causes a "weak spark."

Poor throttling, poor pick-up, missing on hard pulls and high speeds, are frequently caused by using a poor grade of plug. Of course there are other conditions which will cause this, such as carbonized insulators, or too close or too wide a gap at the plug points, or improper carburetion adjustment, but assuming that these troubles are corrected, the leakage of gas and electricity are two of the fundamental troubles seldom noticed.


Fig. 12. Double spark plug—shell is not grounded. P1 and P2 are separate porcelain insulators.

Therefore, the highest priced plug is often the cheapest. Likewise, a poor grade of ignition coil, when hot, will lose its efficiency.

**A spark-plug porcelain, if porous, will permit an electrical leak** from electrode to shell during high compression, thus weakening the spark. **To tell if porous:** if burned a nut-brown color it is not porous; if burned black (do not confuse with carbon, which can be cleaned off), the porcelain is porous. **To test,** see Fig. 28A, page 239.

### Spark-Plug Sizes and Threads

Different threads and different lengths of spark plugs are used, illustrated in Fig. 13.

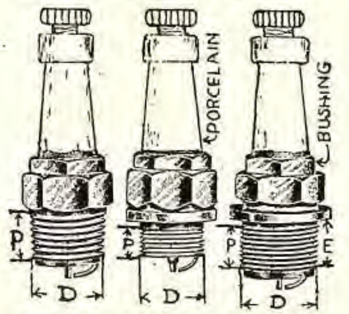



Fig. 13. Regular length of ½″, metric, and ⅞″ spark plugs

Spark plugs are made with three standard threads (see Fig. 13): the ½″ pipe thread; metric; and ⅞″-18 S.A.E.

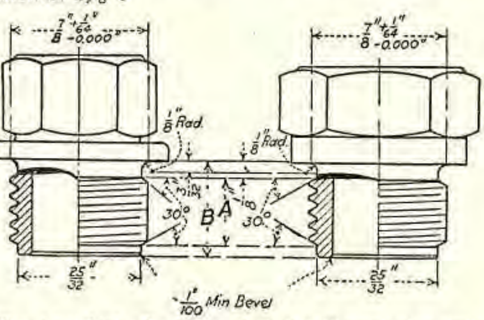
**The half-inch size** is a thread which is a standard ½″ iron pipe size, and has a slight taper.

**The seven-eighths inch 18-size** is the size adopted as a standard by the Society of Automotive Engineers for automobile use. It was formerly known as the A.L.A.M. The thread is ⅞″ in diameter, with 18 threads to the inch. It is used on a majority of the cars today. See Figs. 14, 15.

**The metric size** is smaller than either of the others. Its diameter is 18 millimeters, or approximately 23/32″; pitch: 1½ millimeters. This is the size of thread for spark plugs, adopted by the Society of Automotive Engineers for automobile and aeronautic[2] engines. It is also used on motorcycles. It is used extensively abroad. See Fig. 15A.

### S.A.E. Spark-Plug Shell Sizes

Figs. 14 and 15 show the two S.A.E. spark-plug shells. It will be noticed that the diameter of the hexagon part of shells differs. The "small hex." measures 15/16″ across the flat, and the "large hex." measures 1⅛″.




Figs. 14 and 15. S.A.E. standard ⅞″-18 spark plug shells. The ⅞″-18 means that the outside diameter is ⅞″, and that there are 18 threads to the inch.

The ⅞″ S.A.E. plug requires a special tap cutting of 18 threads, whereas the standard ⅞″ thread tap is 14 threads to the inch.

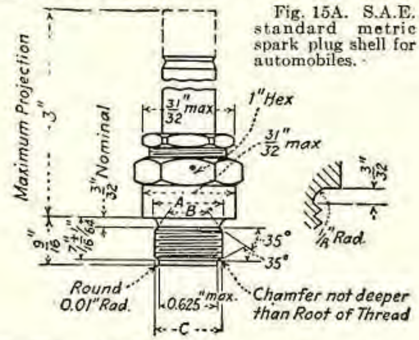



Fig. 15A. S.A.E. standard metric spark plug shell for automobiles.

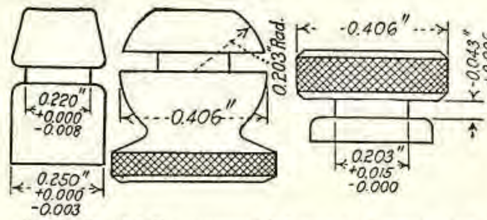



Fig. 15B. S.A.E. recommended standard spark plug terminals (left to right); post type, ball type and slip type.

### Spark-Plug Lengths[1]

**The length of a spark plug** depends upon the engine. If the valve cap is deeply recessed as in Fig. 16, a **long body** plug is required, otherwise the wrench could not reach the hex. If it is not recessed, a **long thread** is required. If, however, the valve-cap plug should not screw well down into the combustion chamber, an extension of the spark plug is required, for it is important that the points of the plug extend to the combustion chamber, but not too far. Spark plugs are therefore made with ½″ and 1″ extension. Figs. 17 to 19 will make this clear.

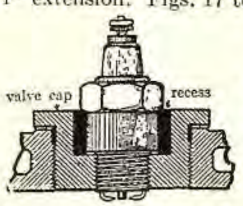



Fig. 16. Note the long body for raising the hexagon part of the plug above the recess in the valve cap so that a wrench can be applied. Different kinds of valve caps require different lengths of plugs.[1]

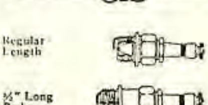



Fig. 17


Fig. 18

Fig. 17. ⅞″-18 (threads per inch) thread spark plugs with different length of body or shell.

Fig. 18. ½″ pipe-thread spark plugs showing the different lengths of body.

[1] Engine manufacturers now design engines so that standard lengths are used, and this great variety of lengths is not now necessary. Very few engines now employ valve caps, as the majority have cylinders cast in-block with detachable cylinderhead.

[2] Specifications are slightly different on the metric aeronautic spark plug.

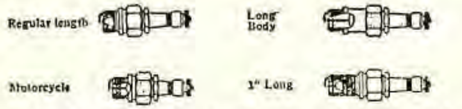



Fig. 19. The metric thread (18 m.m.) spark plug which is also made with different body lengths as shown.

### Spark-Plug Sizes and Lengths Used on Cars[1]

The 7/8" spark plug with 18 threads per inch has been the popular size spark plug but the metric thread spark plug is now more extensively used. The 1/2" thread spark plug is almost obsolete. Extension spark plugs are also seldom used.

### Gaskets for Spark Plugs

**Copper, asbestos-lined gaskets** are used between bushing and shell on all "separable" plugs, to make them leak-proof. They are also used on 7/8" and metric plugs between the shell and where they screw into the cylinder—but not on the 1/2" plug, because it has a taper thread and no shoulder on the shell.


Fig. 20. Spark plug copper gaskets. Measurements of gaskets are as follows: S. A. E.: 7/8" (inside di. 7/8"; outside di. 1 1/8"); Half-inch: (inside di. 27/32"; outside di. 1 3/32"); Metric: (inside di. 23/32"; outside di. 63/64").

### Spark Plug Wrenches

There is a variety of spark-plug wrenches on the market. See automobile supply catalogues.

### Spark-Plug Gap[2]

**The gap** is the distance between the points on the plug shell and electrode. It is important that this distance be exact.

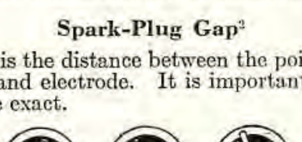



Fig. 21. Different kinds of plug points or gaps.

**A spark plug used with magneto ignition** should not have too wide a gap, because, when the engine is running slow, the current is weaker.

**Relation of spark-plug gap to engine compression:** Assume that we have a four-cylinder magneto, the "safety gap" of which is set at 3/8", corresponding to 8,000 volts, which also corresponds to the voltage required to fire a spark plug having a gap .025" under a pressure of 65 lbs. If this magneto was required to fire an engine where there was a higher compression of 85 to 90 lbs., even if the mixture represented slightly lower resistance, it would probably fail to fire and, instead, would jump across at the safety gap. However, a slight reduction of the distance between the spark-plug points would lower the effective pressure, so that it would operate in the proper manner. On the other hand, if the engine had low compression, the spark-plug points should be opened up, but if too wide, this would immediately place a greater strain on the spark-plug insulation and if the plug carbonized badly it would be likely to flash over.

**Spark-plug gap and compression:**[2] Approximately for high-compression engines (say from 75 to 90 lbs.) set gap .020"; for medium-compression engines (about 65 lbs.) set gap .025"; for low-compression engines (about 55 lbs.) set gap .030"; for racing engines of extremely high compression and high speed, about .015". (See pages 1054A and 116 for compression-ratio.)

It does not always hold true, however, that spark-plug gaps should be set according to compression, because on some engines of high compression the gap is not made less, but the coil is wound for a stronger current to take care of the extra high resistance.

Greater resistance at spark-plug gaps in high-compression engines is due to the fact that air offers less resistance than does gas under pressure. A spark plug in the open air will jump a greater distance than when under pressure. The higher the pressure, the greater the resistance at the gap.

The space between the spark points must be considered an insulator, and it must be remembered that the compressed charge in the cylinder through which the spark is required to jump is a better insulator than uncompressed air.

A spark that will jump the point or gap of a spark plug when the plug is out of the cylinder may not have strength enough to jump when the plug is screwed in the cylinder and under compression. So the spark must be especially strong, and should be able to punch a hole through a visiting card held between the points.

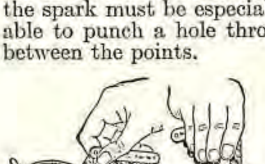


Fig. 22. Method of testing the gap of a spark plug with a thickness gauge (right). Method of testing ignition breaker-contact gap with a thickness gauge when breaker-cam is causing the points to separate (left). The breaker-contact points should be checked for cleanliness and squareness and then set gap as recommended by manufacturer.[2]

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[1] **The development of the present day high-compression engine with a higher operating temperature and a great variety of heat conditions, has necessitated the use of scientifically constructed plugs** having varying heat ranges in order to control the rate of heat-flow from the gap of the plug to the cooling medium, which is either water or air.

High temperature engines demand a plug with a short insulator and less exposed surface which will dissipate the heat at a rate sufficiently rapid to keep it cool enough to avoid overheating of the insulator and not pre-ignite, yet retain sufficient heat to burn carbon, or maintain a "self-cleaning temperature"; this is termed a **cold running plug.**

On the other hand, low speed, low-compression engines, where the temperature is not excessively high, demand a plug with a longer insulator, which will quickly heat up and retain sufficient heat to keep it hot enough to maintain the self-cleaning temperature, to prevent fouling; this is termed a **hot running plug.**

**The metric size of spark plug** with an 18 mm. international standard thread diameter and 1 1/2 mm. pitch has been approved by the S.A.E. Standards Committee and more and more car manufacturers are now using this thread.

**The heat of the spark plug** center wire point does not dissipate through the threaded portion of the shell, but travels through the tip of the insulator and insulator body to gasket seat; thence through the gasket, spark plug shell and outside plug gasket into the cylinder wall and cooling water (or air).

**The reader who is interested in learning more about the development which has been made in spark plugs,** and the importance of using the correct spark plug, is directed to write to the following spark plug manufacturers and ask for their illustrated and interesting pamphlets on spark plugs, which thoroughly explains the principle of the "hot running plug" and the "cold running plug," etc. Address: AC Spark Plug Co. Flint, Mich., The Robert Bosch Magneto Co., Inc., 3601 Queens Blvd., Long Island City, N.Y., and Champion Spark Plug Co., Toledo, Ohio, and Windsor, Ontario, Canada.

[2] **For exact gap follow manufacturers' instructions** as high-compression engines require close and careful adjustment. See also specifications, pages 1055–1062.

It is essential that the battery be kept charged so that it will deliver its proper voltage with a "single-spark" system—as it is quick and must have pressure enough behind the coil to cause a hot spark.

**If points are too close,** it will be impossible to run slowly, for the actual area of the flame will be too small.

**If the gap is too wide,** misfiring (on a high-compression engine) is likely to take place, especially when one tries to accelerate suddenly, after going slow. The effect of opening the throttle and admitting a full charge is to increase compression, and it is a well-known law that resistance increases with pressure.

**The coil** will operate up to 1/32", but bear in mind that the greater this distance, the more strain on the coil and the "leaner" the spark.

**Therefore the gap depends upon:** (1) the kind of ignition system; (2) the amount of compression of the engine.

**Where a vibrator coil is used,** the usual distance is about 1/32". With a "single-spark" system, however, such as the Atwater-Kent, where the spark is very quick, the gap must be very small, about .025". In fact, this is the average distance.

The spark-plug gap varies on different engines. Some manufacturers recommend .027" to .030", others .020" to .022"; and on some magneto ignition systems, .015" or .016" is recommended.

**To experiment,** try setting the plug point on, say, one cylinder until it misses on a hard pull up hill with throttle closed or as much closed as it will pull up the hill comfortably. Then slightly close the gap and try the hill again, and continue experimenting in this way until the missing stops. When the correct distance is found, then set the other plugs accordingly.

**Where spark plugs are used on magneto ignition,** the metal electrode of the plug is carefully figured out as to its resistance capacity, as a very heavy voluminous spark requires an electrode of somewhat higher resistance metal, to prevent burning and pitting. **Therefore always use a spark plug that is recommended by the manufacturer.** See specifications, pages 1055–1062.

### To Clean Spark Plug

When cleaning with kerosene or gasoline, this may get it white, but that is what put carbon there in the first place—thus it leaves a sticky film which adheres to porcelain. Alcohol is better; it evaporates.

If metal polish is used, which contains a large percentage of wood alcohol, pour it into the plug inverted, let stand a few minutes, then use a knife blade and remove the carbon, but do not mar the porcelain by scraping.

Clean all carbon off each plug. **Don't scrape porcelain,** as it will roughen the glazed part and cause it to retain carbon, and will also cause "porosity," which causes electrical leaks. If the oil is burned on the porcelain, muriatic acid will remove it. In placing the porcelain back into the shell, be sure that the copper washer is placed back and that the bushing screwed tight so as to prevent leaking.

## SPARK INTENSIFIER

This device consists of an insulated base and screws for adjusting (Fig. 23).

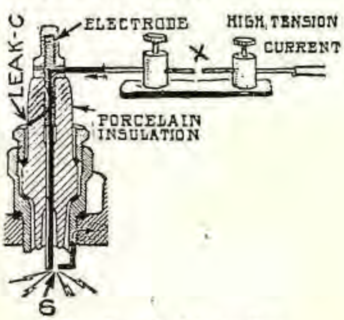


Fig. 23. Spark intensifier.

**The purpose** is to provide a gap (X) in series with the high-tension circuit for the spark to jump before it reaches the plug. It is claimed that this will intensify or raise the voltage of the high-tension circuit to such an extent that it will jump across a carbonized plug in spite of its fouled condition.

**The extra gap throws an additional load on the coil.** Naturally, if it is not well made, the high voltage will be very likely to break down the insulation. Furthermore, a fat voluminous spark is hotter and will ignite the gas quicker than a thin, lean spark. Although the intensified spark will jump across the fouled part of a plug, the spark is thin, and it is best to use good clean plugs. It is a question whether or not the intensifier will add anything to the efficiency or performance of a clean-running engine; if so, the gap at the spark-plug points might be widened. This, of course, would be impractical as the gap under compression offers more resistance to a jump than in the open air; but at that, if the gap in the cylinder was widened in proportion, this cylinder would likely miss fire.

One theory is that the intensifier is beneficial where a plug has a tendency to collect drops of oil on the points, and that by increasing the intensity the spark will jump through the oil. There is one thing certain, and that is that any electric current is going to follow the path of least resistance.*

**The action** is this: In order to cause the spark to jump the gap (S) at the spark plug in the cylinder, 5,000 or more volts are required. Suppose, however, that the spark plug has an accumulation of carbon from the porcelain insulation to the plug shell, or a crack in the porcelain which fills up with carbon, oil, and dirt, as at (C) to the electrode (Fig. 23). Although this path is longer than the spark-plug gap, it is not under compression and thus it offers less resistance than does the gap (S), or, in other words, it requires less voltage to go over the carbonized path. There is then a leak of voltage at the carbonized path which prevents 5,000 volts reaching the plug-gap (S). This explains the reason for its missing.

If the intensifier gap (X) is provided, this temporarily acts as a dam to the flow of current, and, like flowing water, it will pile up against the dam and thus establish a greater force when released. After the breakdown of the dam, the current comes with such a rush that it cannot all pass through the carbon path, and as its voltage is now sufficient, it will also jump the spark-plug gap.

* This is not technically true; the current divides itself in proportion to the resistance of two parallel paths.

## THE MISSING SPARK

**If the engine misses explosion,** the trouble may be due to carburetion being at fault (see "Digest of troubles" and "Carburetion"). If the trouble is not with carburetion[1], then the chances are the spark plug is missing through being fouled. The spark plug causes more trouble in this respect than any other part of the ignition system.

**The cause of spark-plug sooting and pre-ignition:** A poor grade of oil or too much oil will turn to carbon (soot), and will deposit on the end and inside of the spark plug, and "short-circuit" the plug, so that the spark will not occur at the point, consequently causing missing of explosion.

**Poor oil or too much oil** will also leave carbon or soot deposit on the end of the piston and inside of the combustion chamber. This deposit hardens, and sharp points of it will project. This projection will become white hot, causing the gas to ignite before it is time. This is called premature or "pre-ignition."

**Spark-plug troubles** are therefore usually as follows: short circuit from carbon, cracked porcelains, electrodes burned away, spark plugs not pressure tight, moisture condensing on insulator.

**There are several general causes for ignition missing, or for a failure to ignite the gas,** as follows:

1. **Lack of current** from the battery.
2. **Loose connections.**
3. **Burned out or thin resistance unit** occasioned by excessive heating, thus permitting only a small amount of current to pass through.
4. **Improperly set interrupter** points.
5. **Defective condenser,** causing sparking at the interrupter points and weakening the spark.
6. **Defective primary winding.**
7. **Spark-plug crack** on that part of the plug which is not in the cylinder under compression. This crack fills up with oil and dirt, and while the crack is longer than the spark-plug gap, it is not under compression. The result is, usually, missing at low speeds and hard pulls, but hitting on high speeds.

   The reason for this is because at low speeds and on hard pulls the throttle is wide open and the low piston speed greatly increases the degree of compression. Compression offers greater resistance; therefore the spark takes the easiest path, through the carbon.

   At high speeds, the cylinders do not have time to fill up with gas and, the piston speed being greater, the degree of compression is not so great in comparison; thus there is sufficient voltage to jump the gap.
8. **Carbonized spark plugs,** of course, will cause missing at low or high speeds.
9. **Burned points,** due to excessive current. For instance, the Ford spark plug, unless of the proper quality of metal in the electrode, will burn the points badly due to the excess of current. This coil should be adjusted according to instructions on page 222, and only high-grade Ford plugs should be used.
10. **Moisture on the outside of the porcelain at high voltages** will cause the current to leak over the surface of the shell as in Fig. 24 (10).

Fig. 24. Spark-plug troubles.

11. **Points may have come together** as in Fig. 24 (11), when they were screwed into the cylinder.
12. **Wire may be loose** on the terminal (Fig. 24) (12).

**To adjust the gap,** use a thickness gauge or paper (Fig. 24) (13). Adjust to $\frac{1}{32}$" for vibrator coil ignition; to .025" for non-vibrator coil ignition, and to about $\frac{1}{64}$" or .015 to .020" for magneto ignition

### To Find Cause of Missing

**First, check the ignition circuit,** and also find the cylinder which is missing by loosening the spark-plug wire from one plug at the time and holding it about 3/16" away from the spark-plug shell (Fig. 25). With the engine running slow, the sparks

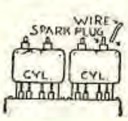


Fig. 25. Testing the ignition system by observing the steadiness and intensity of the spark.

should be counted for at least 50 without missing. It is safe then to assume that the ignition is doing its part.

**If there is missing** and the spark is not hitting regularly, then clean the interrupter points and see if they are properly adjusted; look for loose connections; see if the current from the battery is of proper strength; try another coil, if results are not obtained otherwise.

**Second, check the spark plugs.** It is useless to check these until you first know that your ignition system is in perfect order. If good sparks have been obtained on the first test, then proceed to test each spark plug with the engine running and the ignition switch "on," as follows:

**Place the point of a screwdriver** (Fig. 26) on top of the plug terminal, and hold the metal part of the

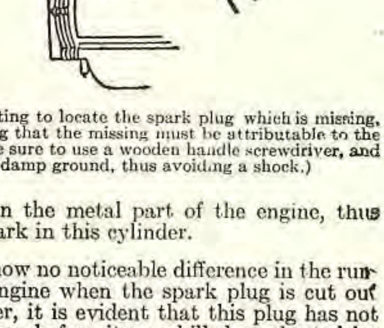

Fig. 26. Testing to locate the spark plug which is missing, after determining that the missing must be attributable to the spark plug. (Be sure to use a wooden handle screwdriver, and do not stand on damp ground, thus avoiding a shock.)

screwdriver on the metal part of the engine, thus killing the spark in this cylinder.

If there is now no noticeable difference in the running of the engine when the spark plug is cut out in this manner, it is evident that this plug has not been firing even before it was killed or shorted by the screwdriver. Thus the missing plug is located.

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[1] Carburetion troubles are dealt with elsewhere. Missing is quite common when first starting the engine with cold, unvaporized gasoline. Therefore be sure that the trouble is not due to carburetion.

It is possible that **a sticking valve** or other engine trouble may cause missing. Remove the spark plug from a cylinder which you know is not missing and exchange it with the plug in a cylinder which is missing. If the missing continues, then you know it is not in the plug.

**On eight-cylinder and twelve-cylinder engines** it is difficult to locate missing. A good plan is to detach all the spark-plug wires from one side, or block, and lay the wires on the engine (in order not to overload the coil). Also open the relief valves, so that one side only will run on power. Thus it is easier for the test as outlined above.

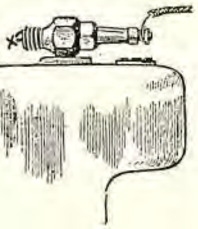



Fig. 27

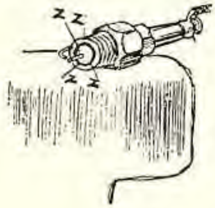



Fig. 28

**To test a spark plug to see if it is carbonized:** Place the spark plug on the cylinder with wire connected and switch on (Fig. 27). Crank the engine slowly. If the spark occurs at the gap (**X**) the plug is in order. If it sparks up inside of the shell, between the porcelain and shell at (Z) (Fig. 28), it is fouled and misses. It must then be taken apart and the carbon must be removed.

Remember the plugs may spark in the open air, but when under compression will fail to spark, because the resistance is greater. Therefore be sure the spark-plug gap is correct.

**To test spark plug for electrical leak,** such as a porous porcelain, or crack: remove plug and place a piece of mica between the points (as in Fig. 28**A**). Connect spark plug with the ignition coil and battery. The spark will jump at the **weakest point**.

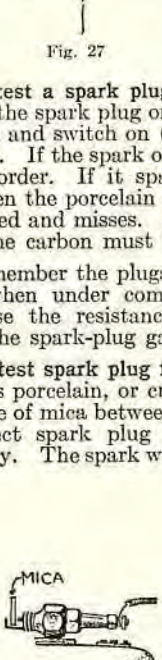



Fig. 28A

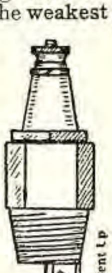



Fig. 29

**Too much oil** in the combustion chamber may have a tendency to cause missing due to the current passing through the oil. A good plan, if the **plug points** are of the type shown in Fig. 29, and plug sets **vertically** in cylinder, is to bend the outside point, as shown, which may cause the oil to collect at the bend instead of the gap; if set **horizontally** or at an **angle,** set as shown at (**B**) (Fig. 22, page 236).

**To test for a spark-plug leak around the porcelain** at the top (**A**) of bushing or below (**B**) where the bushing is screwed into the shell of plug (Fig. 30): squirt gasoline at these points, while the engine is running and note if bubbles appear. If so, there is a leak, and if tightening of the bushing does not remedy the trouble, then put in a new gasket.

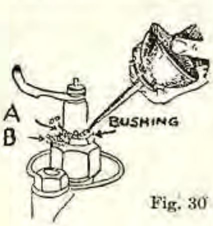



Fig. 30

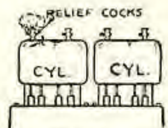



Fig. 31

A method often used **to see if a cylinder is firing** is to open the relief cocks, one at a time (Fig. 31). Watch for the flame shooting out of each opening and listen for the sharp reports of the explosions. The cylinder without flame, out of which issues only hiss, but no sharp report, is the one at fault.

**This test, however, is not reliable,** because, when the relief cock is open, air is drawn into the cylinder which mixes with the carburetion mixture and thus changes the proportions of the mixture.

**Causes of spark plugs fouling:**

1. Poor ignition (weak spark furnished by the ignition system)
2. Leaky cables.
3. Mixture too rich at idling and medium speeds.
4. Engine operated with choke partly open.
5. Poor compression caused either by leaky valves or bad pistons and rings.
6. Engine runs at too low a temperature.

**Causes of pre-ignition and burning of electrodes:**

1. Intake air too hot.
2. Spark too far advanced.
3. Leaky inlet manifold.
4. Cooling system out of order (engine runs too hot).
5. Back pressure in muffler.
6. Spark plugs not properly tightened (leakage at gaskets).
7. Plugs project too far or not far enough into the cylinders.
8. Plug channel improperly located.
9. Unsuitable "doped" fuel used.

### The Airco Ignition Tester

**The tester** consists of an insulating hard rubber shell into which is packed a sensitized glass tube of Neon.

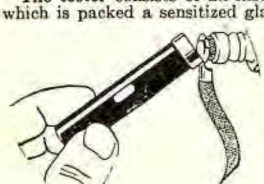


Fig. 32. The Airco tester as applied to the end of a spark plug. Flashes occur in the white gap if there is current. If placed on an insulated wire conducting a high tension, current flashes will occur.

**The active element** in the Airco ignition tester is a gas which the Air Reduction Sales Co. extracts from the air through a process of mechanical and chemical operation. This particular gas which is known as "Neon" has the peculiar property of becoming luminous when brought into contact with electricity. (See Index under "Neon gas.")

Neon, as applied to the Airco ignition tester, is contained in a small glass tube, the ends of which have been plated similar to the manner in which a mirror is silvered. The entire tube is then packed inside of a hard-rubber shell, and a quantity of steel wool is used to make the contact between the metal cap of the hard-rubber tube and the silvered end of the glass tube containing the Neon. By placing this device to the end of the spark-plug terminals, or even on the insulated wire itself, if there is a high-tension current passing in the wire, the gauge becomes luminous or emits flashes.

**The following indications point to trouble:**

**No flashes:** Spark plug completely fouled or shorted, or no current to the plug.

**Flashes continuing for an unusual distance as the gauge is withdrawn from the plug:** Broken plug—probably broken porcelain.

**Very intense flashes:** Spark gap too wide.

**Overlapping flashes (not clean-cut with each piston stroke):** Leaks between feed wires or fouled distributor.

**Dim or irregular flashes:** Plug partly fouled, or feed wire leaking excessively. Examine plug.

# INSTRUCTION No. 24

# WIRE FOR IGNITION SYSTEMS

**There are three kinds of ignition wire** for general use with the ignition system of a car, as follows:

**Primary wire or cable,** also called **low-tension ignition cable,** is made of several strands of fine wire in order to make it flexible and insulated, oil and moisture proof. This wire is usually used between the ignition switch, coil, and timer for all **low-tension work,** and must be of sufficient size to carry the current. Usually No. 14 or No. 16 size is used.

**Secondary cable, also called high-tension ignition cable,** is also made flexible and the insulation on the wire is much heavier. This is used to conduct the **high-tension current** from the coil or magneto to the spark plugs. It should be kept free from all metals, as much as possible. Size is usually 7 m.m. (see page 425).

**Duplex cable** is also flexible, but generally two to four wires are run in one insulation, being separated, of course, from each other by insulations. This wire is generally used for lighting and low-tension work.

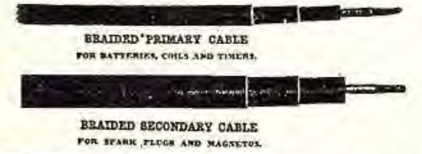



Fig. 1. Ignition wires.

**Metal conduit:** A good plan in wiring a car, where several wires are run together, is to enclose the wires in a metal conduit, or use **armored cable,** as explained on page 428. See also pages 425–427.

The wires running from coil, or magneto distributor to the spark plug, carry the high-tension current and are called "secondary cables." This current escapes more readily than from the wires running from the battery to the timer or coil. The wires running to the plugs are called "high tension" wires because the tension or voltage is high and current will often jump through the insulation and short-circuit (cutting out spark plug) to any metal part it happens to be in contact with. For this reason these wires must be carefully protected and very heavily insulated.

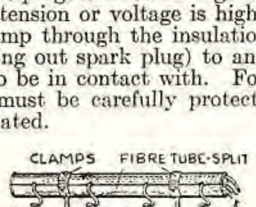



Fig. 2

Fig. 2 shows one method of distributing the secondary or high-tension cables on multi-cylinder engines. A divided fiber tube supported on brackets encloses the cables and permits of easy inspection or renewal if required. Any number of leads or cables can be distributed. The eight plug leads required for dual ignition on a four-cylinder engine can be accommodated in a two-inch fiber tube.

The primary wires running from the battery to the timer or to the interrupter on the magneto are "low tension." They do not need to have as heavy insulation, but the connections should be well made and clean because the pressure is so low that the current will not pass over dirty or loose connections, and a loss of current will result. All connections ought to be soldered and taped.

**Do not use lamp-cord wire** under any circumstances as it will give unsatisfactory results and cause missing if damp. Wire for the electric horn is usually No. 14 armored cable (see Fig. 8, page 426).

### Size of Wire Used for Winding a Coil and Magneto

**Primary winding** is No. 19 to 24 B. & S. gauge copper insulated wire. **Secondary winding** is No. 34 to 38 B. & S. gauge silk-covered insulation.

**There is usually a ratio of about 60 to 1.** For instance, if the primary consisted of 200 turns, the secondary would have 12,000 turns.

The winding of a Bosch DU4 magneto armature usually consists of three layers of No. 20 or No. 22 wire, to form the primary winding, and of 70 to 72 layers of No. 36 silk-covered wire to form the secondary winding. The reader, however, never has occasion to bother with wire on a coil or magneto armature as this is the work of a specialist.

### Making Connections and Ignition Wiring Troubles

**A grounded connection** should be filed or scraped bright before attaching the wire, and the connection when made should be covered with vaseline or paraffine. A copper washer should be placed under the head of the screw, to hold the wire firmly in position, and tightly drawn up.

All connections must be bright and clean, for a dirty connection will add resistance. Binding posts, screws, and the ends of the wire must be scraped clean before the wire is attached. This is very important on low-voltage wiring.

**When joining two wires or attaching terminals** (Figs. 3, 4 and 5), solder and then tape.

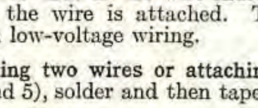



Fig. 3　Fig. 4

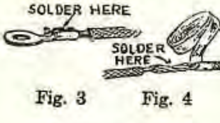



Fig. 5

Figs. 3, 4, and 5 show how to make a connection with wire and terminal; solder and tape all connections.

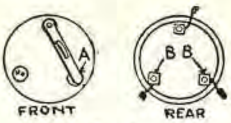



Fig. 6

Fig. 7

Fig. 8

Fig. 6. Loose switch terminals will cause missing as will also loose binding posts (Fig. 7).

Fig. 8. A good method of protecting primary (battery) wires when they run along the frame.

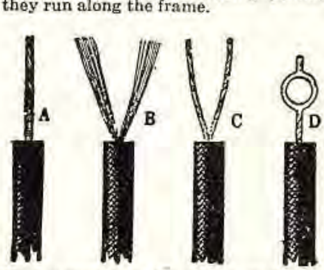



Fig. 9. Four steps in making loop end: (A) insulation removed; (B) separating the strands; (C) twisting wires into two leads; and, (D) the looped end dipped in solder. (*Motor Age.*)

No possible cause for leakage of the current should exist; a single strand of fine wire projecting from a flexible cable will be enough to cause a short circuit if it should touch metal.

**Missing of ignition where dry cells are used** (Fig. 10) may be due to weak batteries. To test, use an amperemeter. Test each cell separately by placing the terminal of the meter on the terminal of the battery. Each battery ought to show 15 to 25 amperes. If less than 8 amperes are shown, replace. If one should test, say, 10 amperes, and another 20, then the good battery will be brought to the level of the poor battery. Remove it and put in a fresh one. See Index for "Testing a storage battery."

**An emergency dry-cell connection** is shown in Fig. 11. Usually two sets of dry cells are provided when ignition is on dry cells alone. Only one set at a time is used, however. If both sets should run down, a multiple connection of the two sets can be made, as shown, which will suffice to enable the car to reach home. Dry cells are now seldom used.

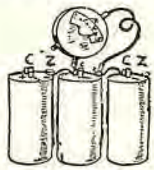



Fig. 10

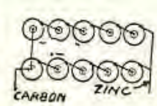



Fig. 11

Fig. 12

Quite often **missing will occur from loose connections** at the battery terminals (Fig. 3). See that they are always tight. On some connections, the wire may be broken or not soldered well to the terminal. A good connector for dry cells, called the "Bull Dog," is shown in Fig. 12. For storage batteries, see Index.

**On many cars one wire is grounded** (Fig. 13). It is therefore essential that the grounded connection be well cleaned and then tightened. A copper terminal should be soldered to the wire, the surface cleaned, and drawn tight with a bolt.


Fig. 13


Fig. 14


Fig. 15

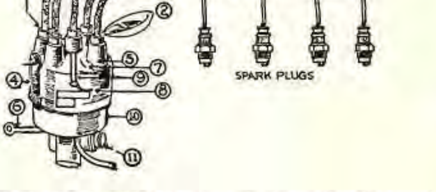

Fig. 16

**When metal battery boxes are used** (Fig. 14), and dry cells are placed in them, dampness will short-circuit the batteries through the paper insulation around them. Therefore keep the box dry inside, and watch the wire where it passes through the metal box.

**When removing the wires** (Figs. 15, 16), mark them by painting the ends with cheap water colors, or tag them, thus saving a lot of time when replacing.

## IGNITION DISTRIBUTOR WIRING TROUBLES

1. **Arcing from one cable to another,** called "static discharge"; due to rubber on cables being old, hardened and porous, or to dampness. Separate cables, or put in new ones.




**Moisture, when washing car gets into distributor.** If there is too much space at plug terminals, open and pour in melted wax.

3. **Loose connections.**

4. **Loose distributor cap spring.**

5. **Loose distributor terminals.**

6. **Loose spark advance lever.**

7. **Crack in distributor cap** permits dust and grease of conductive material to collect, and high-tension current will follow it to ground.

8 **Rotor metal tip burned** (if a brush, may not make good contact).

9. **Poor contact from rotor spring** to center terminal.

10. **Wobbly distributor head or cam,** due to shaft bearing worn **from lack of oil.** See page 462C: "Noisy distributor."

11. **Don't forget to grease or oil** distributor shaft.

**Miscellaneous:** Dirty and gummed distributor head, coated inside and outside.

Loose connections in the primary circuit, as at battery, switch, fuse block, junction block, coil or interrupter will cause missing (not illustrated).

Worn fiber or roller on interrupter points (not illustrated).

Loose interrupter contact arms (not illustrated).

Broken or weak tension of interrupter contact arm spring (not illustrated).

# INSTRUCTION No. 25

## LOW-TENSION MAGNETO: Principle of Magneto Ignition

In the preceding instructions, we dealt with the low-tension coil, using only a primary winding, and the high-tension ignition coil using a primary and secondary winding.

In this instruction we shall deal with the low-tension magneto, a mechanical generator of a low-tension alternating current.

**The difference between a low-tension magneto and a high-tension magneto** is that, on the low-tension magneto armature core there is but **one winding,** called a primary winding, whereas on the high-tension magneto armature there are **two windings,** a primary winding and a secondary winding.

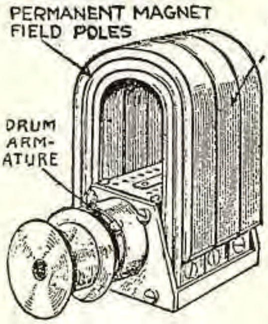



Fig. 1. Magneto.

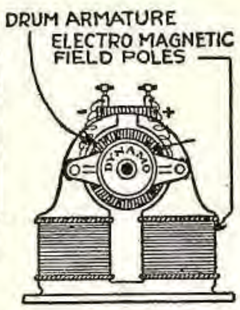



Fig. 2. Dynamo.

Mechanical devices, such as **a magneto and a dynamo** (Figs. 1 and 2), are termed **mechanical generators of electricity.** The armature, which revolves between the pole pieces, is driven by the engine, and alternating current is generated.

**Alternating current is suitable only for ignition,** and all magnetos generate alternating current.

**Where a generator** (dynamo) **is required** to charge a storage battery, it is necessary that **the current should be "direct,"** that is, flowing in one direction continuously, from positive (+), to negative (−).

Therefore, while, as stated above, all generators or dynamos or magnetos generate alternating current, on a generator used for charging a storage battery, the **alternating current is transformed,** or commutated, into a "direct" current by means of a commutator and brushes. Thus while alternating current is generated inside, direct current is delivered outside, or from the brushes. Generators of direct current supply current for coil ignition and lights, and also charge a storage battery. This subject is explained under "Generator principle," farther on.

The magneto generates alternating current inside and delivers alternating current outside, and, as previously stated, is suitable only for ignition. It will not charge a storage battery because the electric current it generates flows first in one direction and then in another direction, and thus "alternates" its flow.

### Construction

**The principle of a low-tension magneto** is similar in many respects to that of a low-tension coil. In a magneto, the armature on which the primary wire is wound is called upon to produce its own electric supply, whereas in a primary or low-tension coil, the electric supply is from another source.

**Field magnets:** Permanent magnets (1a), called the "field magnets," are provided as shown in Fig. **1A.** The **pole pieces** (11a) provide a magnetic field for the shuttle-type armature (Fig. **4A**) to **revolve** in. End plates with ball bearings are attached to screw holes in pole pieces (11a, Fig. 1A). There is very

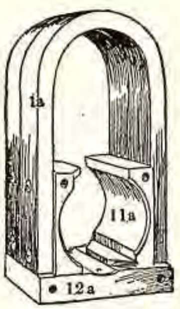



Fig. **1A.** Permanent magnets **(1a)**; pole pieces **(11a)**; base of brass or aluminum (12a).

little clearance between the armature and the poles, and therefore accurate fitting is necessary.

There are usually two, four, or six magnets placed over the pole pieces; all north poles on one side and all south poles on the other side. The base (12a) is usually made of brass or aluminum, as neither will become magnetized.

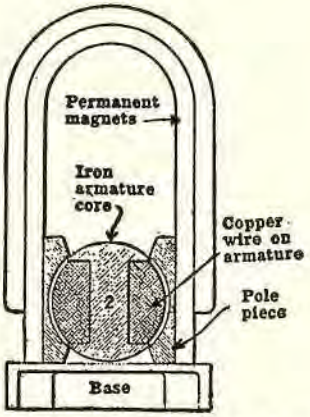



Fig. **1B.** View of a low-tension magneto with the end-plate off and the armature shown in section. (1) permanent magnets (magnetized at all times); (2) the armature, revolved by a gear connected with the engine shaft. Note that a single winding of insulated copper wire is wound on the armature.

Fig. 1C. The low-tension magneto complete. View shows the drive end of the armature, which is driven at a fixed speed from the crank shaft of the engine, by gear or chains. The direction of rotation of all generators is considered at the drive end.

**The armature of a direct-current generator** (Fig. 3) is called a "drum-wound armature." It differs from a magneto armature in that the coils wound over the armature core are connected in such a manner with the commutator segments that the current delivered from brushes resting on the commutator segments is direct.


Fig. 3. Armature of a direct-current generator.

This drum-type armature could be made to revolve between permanent magnets, and current would be generated, but it is not practical, because the voltage must be a steady voltage. And since the voltage increases with speed, the armature of a direct-current generator is made to revolve between poles which are wound with wire, called "electro-magnets." This subject is dealt with under "Direct current generators," farther on.

**Permanent magnets** are of the horseshoe type and are permanently magnetized. They are called the "field" magnets.

**Electro-field-magnets** are wound with copper wire and are electrically magnetized. They remain magnetized only when the armature revolves between the field-magnet poles. This type of dynamo or generator generates a steady "direct" current, usually of 6 or 8 volts, and will light electric lamps and recharge a storage battery and supply current for ignition. It is usually run in connection with a starting and lighting system, and, in smaller models, is used for ignition on stationary and marine engines to a considerable extent.

**The armature of a magneto,** which delivers alternating current, is called a "shuttle-type armature." It revolves between the poles of "permanent field magnets."

**The parts of an armature** are as follows: Bronze heads (**B, B1**) are screwed to the armature core (**C, C1**) (Fig. 4). Shafts (**A, A1**) are driven and riveted to the bronze heads. Wire is wrapped around space (**C, C1**), called the core.

It will be seen that the core is not a solid casting; rather it is a pair of castings between which is clamped a group of soft iron stampings (**D**), having the form shown in the detail sketch. The object of

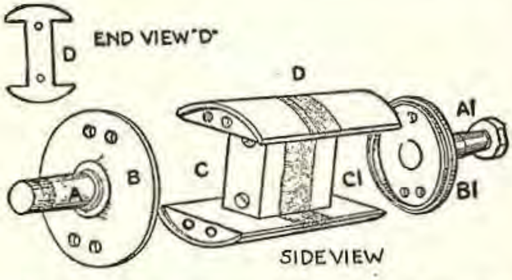



Fig. 4. Magneto armature core and end plates. The winding is placed on the core C and C1.

thus "laminating the core," as it is called, is to retard the circulation of "eddy currents" in the core due to induction. The same forces of induction which are at play in the windings operate also in the iron core itself, and if unchecked, would both consume power and heat the armature unduly. As the voltage of these currents is very low, even the slight obstruction of the laminations is sufficient to retard them.

The laminated section of the armature is shown at (**D**). "Laminated" means that instead of the castings (**C**) being solid, there are several layers of flat sheet iron placed together, between the cores (**C**), as shown at (**D**).

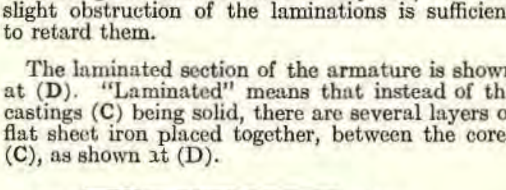



Fig. 4A. Shuttle type of armature with one winding (low-tension).

The completed magneto shuttle-type armature is shown in Fig. **4A**. Note the "collector ring," from which the current is taken by a brush resting on the flat surface of this ring.

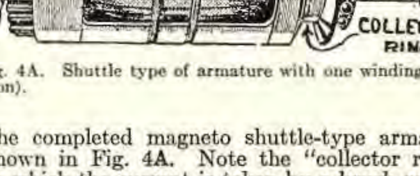



Fig. 4B. Primary winding on armature core. Note that one end is grounded to the core and the other end is insulated.

**The single primary winding** is shown in Figs. 4B and 4C. One end (**A**) conducts the current from the armature to the collector ring and the other end is grounded (**G**).

A sectional view (Fig. **4C**) shows one method of conducting the low-tension current from the armature, where a collector ring is not used. The principle, however, is similar.

One end of the primary winding, which is heavy, coarse wire, is grounded to the armature core at (**G**). The other end (**A**), is insulated and passes through the hollow end of the armature shaft and makes contact with a point (**D**).

As the armature revolves, the spring (**S**), which is mounted on an insulated block (**IB**), conducts the current through a wire connected with it, to the terminal. "Collector rings," are more often used.

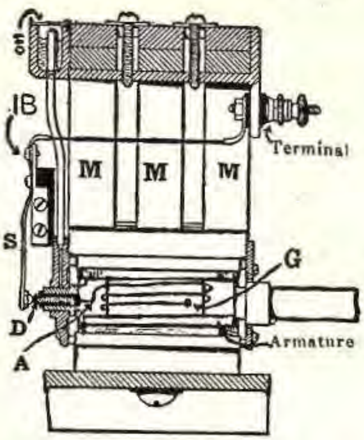



Fig. 4C

From the terminal the current is carried to the "igniter," as in Fig. 5. This is a "make-and-break" low-tension ignition system similar to the system described on page 185.

It will be noted, however, that a separate low-tension coil is not necessary in this instance, as the winding on the armature takes its place.

If the low-tension magneto is used in connection with a separate high-tension coil, then this wire (A) (Fig. 4C) from the armature would go to the primary winding of the coil.

**Two methods of utilizing the low-tension magneto** are therefore used, as follows:

1. In connection with a low-tension "make-and-break" ignition system.
2. In connection with a high-tension coil.

### Low-Tension Magneto Supplying Current for a "Make-and-Break Ignition System

On page 185, this system is explained. The magneto, however, was not explained.

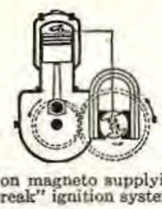


Fig. 5. Low-tension magneto supplying current for a low-tension "make-and-break" ignition system.

It is well to bear in mind that a low-tension magneto used in connection with the low-tension "make-and-break" system, shown in Fig. 12, page 185, **does not require a low-tension coil,** because the action of intensifying the current, is obtained by the snapping of the "igniter" points, by action of a cam, and the winding on the armature of the low-tension magneto takes the place of the low-tension coil. See also explanation, page 186.

### Low-Tension Magneto and High-Tension Coil

The low-tension magneto can be used in connection with a high-tension coil and produce a "jump-spark" or high-tension spark at points of a spark plug in the cylinder, by using the low-tension magneto to produce the current, and a separate high-tension coil (without vibrator) to intensify the low-tension current to a high pressure, so that it will jump the gap of the spark plug.

We should need for this system **a high-tension coil, a distributor** on the magneto to distribute the high-tension current to the spark plugs (if a multiple-cylinder engine, which, in this instance, we will say, is a four-cycle, four-cylinder), and **an interrupter** to break the low-tension current at the proper time.

**The coil:** The double-wound high-tension coil, but without a vibrator, can be used. The interrupter will take the place of the vibrator. Therefore we should have a single spark instead of a succession of sparks. When the contact points separate, as explained under "Interrupter," the low-tension magneto current is intensified, and "induced" current is set up in the secondary winding. This coil can be placed separate from the magneto.

**The distributor:** This "induced" or high-tension current is then distributed to the spark plugs in correct firing order by the distributor rotor and brush, as shown in Figs. 6 and 6A. The distributor is driven at one-half the speed of the armature.

**The interrupter**[1] (see Fig. 6A) is mounted on the front end of the magneto armature shaft. The housing on which the interrupter parts are mounted can be shifted, by means of a rod (SL) (Fig. 6A). This rod connects with the spark lever on the steering wheel.

Therefore the time for the spark to occur can be made early ("advanced"), or late ("retarded"). The usual range of advance on a magneto is from 22° to 35°.

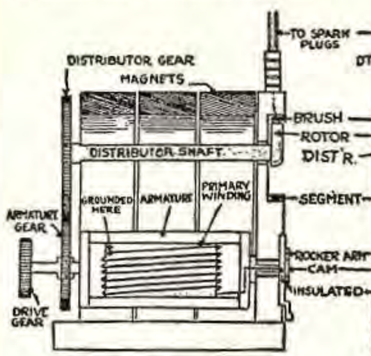
Attached to the housing, and moving with it, is the interrupter arm (A) and the terminal (B).

On the end of the interrupter arm (A) is a platinum point (P). There is also another platinum point (P) on terminal (B).

**Platinum** is used because there is more or less sparking occurring at the points and, platinum being hard, it stands the spark with less pitting than other metals.

**The condenser** is in the coil and takes up excess sparking to a great extent. This condenser can be placed in the coil box or on the magneto.

**The cam (C)** is attached to the front end of the armature and revolves with it.



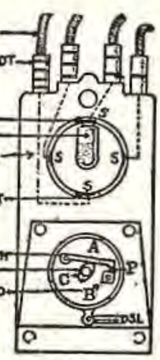




Fig. 6 Fig. 6A

Fig. 6. Note how the distributor shaft is driven by the gear on the armature.

Fig. 6A. Front view of distributor and interrupter.

[1] There are many different constructions of the interrupter This one is shown in order to simplify the explanation.

When the nose of the cam raises the interrupter arm (A), the current is interrupted in the primary winding, causing the high-tension current to be set up in the secondary winding of the coil.

The cam has two lobes. It will therefore raise the interrupter arm twice during one revolution, or four times during two revolutions of the armature. The armature would then run at the same speed as the engine crank shaft. As the cam (C) is attached to the armature, it must revolve with it.

The cam is set on the armature, so that the nose will raise the interrupter just as the armature is in a vertical position.

If the cam raises the interrupter arm (A) when the armature is in a vertical position and the interrupter housing is at full retard position, this will then allow for advancing of the spark full 35° or less, according to the range of the magneto.

**The primary circuit** on the armature of the low-tension magneto consists of a winding of coarse wire. One end is grounded to the armature core (see Fig. ), and the other end is carried to the insulated terminal (B, Fig. 6A).

The armature revolves, therefore the end of the armature primary winding, from which the low-tension current is taken, is carried through the end of the armature shaft (insulated).

The current is then carried through the primary winding of the coil, to the insulated terminal (B), through the interrupter points (P) (which open when the armature is in maximum position), to arm (A) which is grounded, thence to the other end of the magneto primary winding, which is grounded to the armature core (Fig. 6). This completes the primary circuit of the magneto and high-tension coil. See Figs. 38 and 39 for two different methods of connecting a low-tension magneto with a high-tension coil.

**The secondary circuit is clearly shown in Figs.** 38 and 39, page 252.

**The magneto armature** must be driven at a fixed speed because the interrupter and the position of the armature govern the time of the spark. Therefore the magneto is either driven by a chain or by a gear from the cam shaft, but not by a belt. This subject is treated farther on.

Also bear in mind that **the magneto is a closed-circuit system, and interruption of the closed circuit by the interrupter points being separated by** the cam occurs when the spark takes place.

Note the arrangement of the interrupter on page 258. It is a different construction from that shown in Fig. 6A. The interrupter on page 258 is more modern. The one in Fig. 6A is simplified.

### Remarks Relative to Distributor on a Low-Tension Magneto Operating a High-Tension Coil

**The purpose of the "high-tension"** distributor is to distribute the high-tension current to the spark plugs. The distributor brush in the end of the rotor should make contact with one of the spark-plug leads just as the interrupter points (P) are breaking. See the discussion farther on, explaining connections to the distributor.

**The distributor is usually attached to the magneto**—when operated with a magneto, either of the low or high-tension type.

The distributor is usually made of hard rubber insulation material with metal segments (S). The rotor with a brush revolves by means of a gear wheel twice the size of the gear wheel on the armature (Fig. 6).

**The armature** for a four-cylinder magneto would revolve at engine crank-shaft speed and make four sparks during the two revolutions of the crank shaft.

The distributor, however, would revolve once and the rotor brush would make four contacts during two revolutions of the crank shaft, or one revolution of the distributor rotor. Hence the reason for the larger gear on the distributor.

On a six-cylinder engine the armature revolves 1½ times to one revolution of the crank shaft, but the distributor is geared to turn at half the speed of the crank shaft, or one complete revolution to two revolutions of the engine crank shaft.

**There are two kinds of contact arrangements on a distributor:** the "gap-type," and the "brush-type." The gap type does not make a wiping contact, but a slight gap clearance is allowed between the distributor rotor and segment (S). The brush type makes a wiping contact.

It must be remembered that while we are referring to the magneto distributor of the true "high-tension type magneto"—to show the parts of a "high-tension distributor"—the distributor used with the low-tension magneto and separate coil differs only in that on a true high-tension magneto there are two windings on the armature which take the place of the separate coil.

### Dual System; Low-Tension Magneto, Coil, and Battery

**A dual system of ignition** is where a set of batteries are provided to start on. After starting the engine, the magneto is used as a source of electric supply instead of the batteries.

### Types of Magneto Armatures

Magneto armatures may be classified as of two types. Although this instruction deals with low-tension magnetos, it will be necessary to allude to the armature of the high-tension magneto in order to make the explanation clear.


Fig. 7. Primary armature.

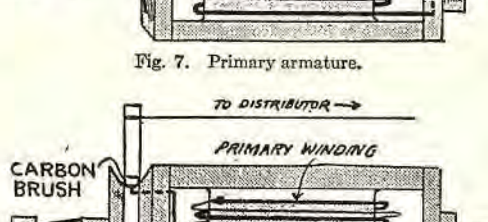



Fig. 8. Compound armature.

**Magneto armatures** are known as of the "shuttle" type because they are shaped like a shuttle. They are further classified as the "armature" type and the "inductor" type.

**The "armature" type** is where wire is wrapped around the armature core and the armature and wire revolve between the permanent magnet field poles. The armature type can be a single primary-wound armature used on a low-tension magneto, as in Fig. 7, termed a "primary-armature type." If there are two windings on the armature, a primary and secondary, as in Fig. 8, which is used on a high-tension magneto, then it is termed a "compound-armature type."

**The "inductor" type of armature** differs from the "armature type," principally in that the wire does not revolve. The inductor type of armature can be a low-tension magneto or a high-tension magneto, and differs from the armature type magneto only as mentioned above

### K. W. Inductor-Type Magneto

The K. W. Ignition Co. makes a low-tension and a high-tension inductor-type magneto. The Remy Electric Co. formerly made a low-tension inductor type of magneto used with a high-tension coil, as explained on page 247.

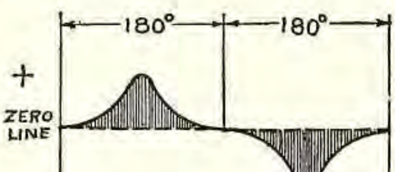



Fig. 9. Note that the shuttle type of armature produces two impulses or waves, of maximum strength per revolution (360°).

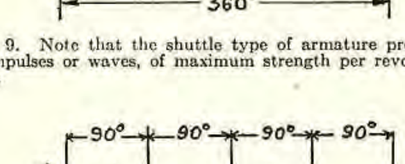



Fig. 10. Note that the K.W. "inductor" type of armature produces four impulses or waves, of maximum strength per revolution. (The line is zero, or no current.) Also note that the direction of the flow of current is changed twice in Fig. 9, and four times in Fig. 10, during a revolution.

**The K. W. inductor type magneto** is a leading magneto of the inductor type. Construction: magnets, permanent type; pole-pieces placed above armature 90° apart; rotors set 90° apart. There are two rotors with four ends as shown in Fig. 11, which illustrates the arrangement of the rotors on the armature shaft. This gives the same effect as if two shuttle armatures were placed cross wise—which would be four impulses per revolution (Fig. 10) instead of two in the shuttle type (Fig. 9). If we continued adding rotors we should soon have the alternations so close together that we could light an electric lamp—in fact, the K. W. low-tension magneto at high speeds will accomplish this.

**The coil winding between the rotors of the K.W. magneto** (Fig. 11) is stationary and the rotors revolve. With a single primary winding on this coil core it is a low-tension magneto. With two windings, it would be a high-tension magneto.

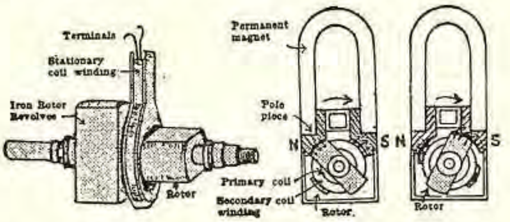



Fig. 11 Fig. 11A Fig. 11B

Fig. 11 shows the "inductor-type armature." Note that the winding is stationary.

Fig. 11A, shows the lines-of-force passing down through the rotor wing from N pole, then centrally through the core over which the coil is placed, up the rotor to S pole.

Fig. 11B shows rotors moved in position where the lines-of-force are now passing in the reverse direction, which causes a complete reversal of polarity through the coil winding. This is maximum position, where contact points (P) should separate.

Interrupter points are used on the K. W. inductor-type magneto when of a high-tension double-wound type. See also page 279 and page 301.

### The K. W. Low-Tension Inductor Type Magneto and Master-Vibrator

The K. W. inductor type of low-tension magneto, used with a master-vibrator, is shown in Fig. 12. Dry cells are used as a source of supply for starting when the switch lever is on the left, or (B) side. The magneto is used when the switch is on the (M) side. Note that the vibrators on the dash coil are short-circuited, as seen in the top left illustration, and are not used on the multiple dash coil to the right, as the one vibrator on the master-vibrator coil does the vibrating for the four coils.

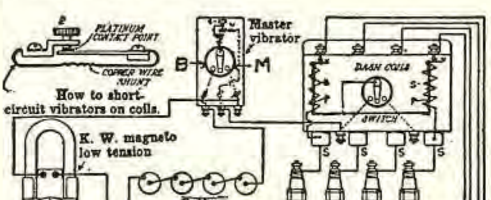



Fig. 12. K. W. low-tension inductor-type magneto connected with a high-tension coil-ignition system using a K.W. master vibrator coil.

With this low-tension inductor-type magneto an interrupter is not used, because the vibrators on the coil take the place of an interrupter on the magneto. This type is not timed. Note that the commutator or timer is timed instead, as on a vibrator-coil system.

### The Remy Low-Tension Inductor Type Magneto (Model R D)

The principle is similar to the K. W. (Fig. 11) except that the Remy rotor is a half-rotor, whereas on the K. W., both ends of the rotor are utilized

The Remy produces two impulses per revolution and the K. W. four impulses per revolution.

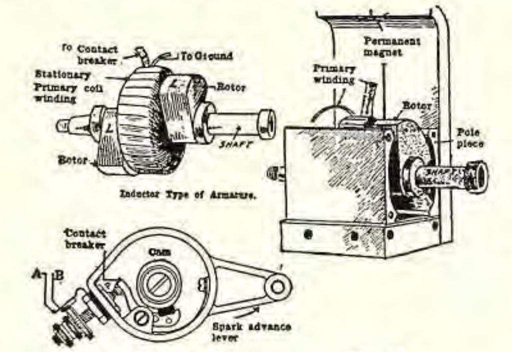



Fig. 13 (upper) Fig. 15 (lower) Fig. 14

Fig. 13. Remy rotors (L) which revolve and the stationary single primary winding.

Fig. 14. Remy inductor or rotor in maximum position.

Fig. 15. Remy contact-breaker or interrupter. The points (P) should have a clean surface. Dirt and grease should not be allowed to accumulate.

**A distributor** is mounted on the low-tension magneto which distributes the high-tension current from the high-tension ignition coil to the spark plugs.

If the engine misses with spark retarded at slow speed, adjust the contact screw (B) (Fig. 15) out a few notches.

If the engine misses with spark advanced at high speed, adjust the contact screw in a few notches.

On this magneto ignition system adjust the spark-plug points .025″.

The contact-breaker is used on this magneto just the same as on a shuttle-type magneto armature, to interrupt the flow of current in the primary winding.

**To set the rotors:** The rotors are placed in just the same position as on the shuttle-type armature when they are originally set, at which time the interrupter points open.

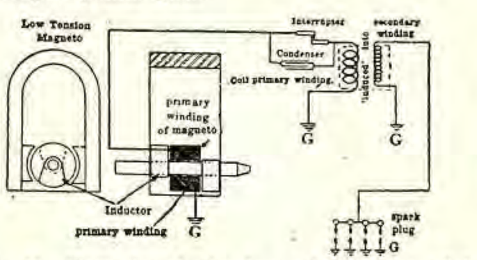



Fig. 16. Illustration showing how a high-tension coil is used in connection with Remy low-tension magneto. (G, ground.)

Note that the condenser is in the coil.

## Examples of Remy Low-Tension Inductor-Type Magneto Systems

**A dual system** (Fig. 17) consists of a Remy model R.D. low-tension "inductor"-type magneto used in connection with a high-tension coil. Note that the condenser is placed in the coil, but is shunted across the interrupter points.

**Dry cells are used** to supply current to start with, by pressing a switch button (S) with switch lever

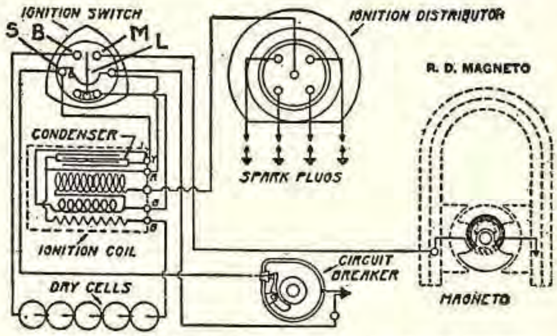



Fig. 17. Dual ignition system using a low-tension magneto of the "inductor" type in connection with a high-tension coil, with condenser in the coil. Note that the dry cells supply current for coil when on (B) side of switch, as when starting.

(L) on battery side (B) of the switch, which closes the circuit between dry cells, primary winding of coil, and interrupter points. Thus when the engine is being cranked, the dry cells supply the current instead of the magneto.

**The distributor and interrupter** are mounted on the inductor-type low-tension magneto. The high-tension ignition coil is separate, as is also the switch.

**After the engine is started,** the switch lever (L) is placed on the magneto (M) side of the switch, the dry cells are cut out, and the magneto supplies current. The magneto interrupter is timed, so that the interruption of sparks occurs at the right time

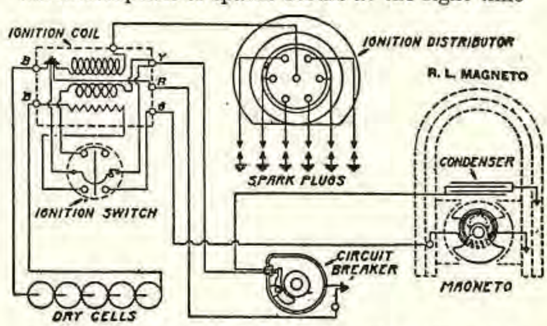



Fig. 18. Similar to Fig. 17 except that the condenser is on the magneto.

**Fig. 18 is similar to Fig. 17,** except that the condenser is mounted on the magneto, being across the interrupter points as usual. The magneto model is R.L., and is an inductor type similar to the model R.D. in Fig. 17.

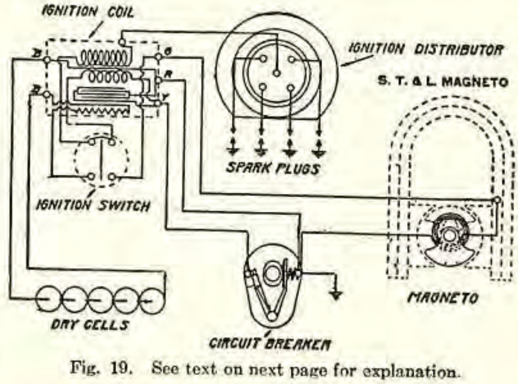



Fig. 19. See text on next page for explanation.

The system shown in Fig. 19 in many respects is similar to model R.D., except that the push button is not used and the interrupter is arranged differently. This type of low-tension inductor magneto is the S.T. & L. Dry cells are used for starting.

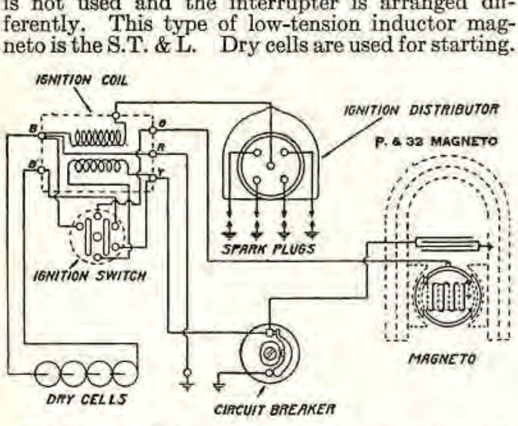



Fig. 20. Dual ignition system using a low-tension magneto of the "primary armature type."

In Fig. 20, this system (Remy P and 32 magneto) differs from that just described, in that the magneto armature is a "primary-armature type" low-tension magneto, instead of an "inductor" type. The push button is not used, and the switch is arranged differently.

All of the foregoing are examples of dual high-tension ignition systems, using a low-tension magneto of the inductor type (except Fig. 20) as a source of electric supply.

Note. The letters **Y, R, B, G,** refer to the color of wire on these systems. To time the Remy RD and RL low-tension magnetos: Place No. 1 piston on top of compression stroke. Press in on timing button (Fig. 17) which is at the top of the distributor and turn the shaft of the magneto (with coupling loose) until the plunger back of the timing button drops into the recess on the distributor gear. Then couple the magneto to its drive member. It is not necessary to set the interrupter in this instance, as the interrupter is in correct position with this operation, and No. 1 distributor segment is in contact with No. 1 distributor terminal, which is marked.

### Ford Inductor-Type Low-Tension Magneto

Another form of low-tension alternating-current magneto of the inductor type is the Ford magneto.

**This magneto might be termed a high-frequency magneto,** meaning that there are 16 impulses per revolution. For instance, on the "shuttle-armature type" magneto there are 2 impulses per revolution. On the K.W. inductor magneto (Fig. 11, page 246), there are 4 impulses per revolution.

**The term "impulse"** refers to the points where the generated current is the strongest and is where the interrupter, as on the shuttle-type armature magneto, interrupts or opens the primary circuit just as the armature is leaving the pole pieces. Thus the spark or "impulse" occurs.

**The term "frequency"** refers to one-half the number of times the current changes its direction of flow in the winding per revolution (see "cycle" and "frequency" explanation, Fig. 7A, page 192). For instance, on an "armature or shuttle-type" magneto the direction of current in the primary winding on the armature changes its direction twice during one revolution (see Fig. 9, page 246). On the K. W. (Figs. 11 and 10, page 246), there are 4 changes during one revolution, because there are 4 ends to the rotors.

**On the Ford magneto** there are 16 changes per revolution, because there are 16 stationary coils attached to a plate or support inside of the flywheel housing. These coils consist of a thin strip of copper wrapped around a small soft iron core (C). The consecutive coils are wound in opposite directions on each coil core and are connected in series.

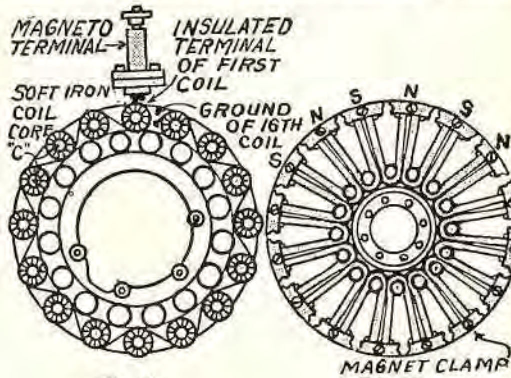



Fig. 21 Fig. 22

Fig. 21. The sixteen stationary coils of the Ford low-tension inductor type of magneto mounted on the coil plate.

Fig. 22. The sixteen permanent magnets which are attached to the flywheel and revolve in front of the core of the coils. Like poles of the magnets are placed together.

The terminal of the first coil connects with the magneto terminal, which conducts current to the four primary windings on the four-unit vibrator-type coil. The end of the sixteenth coil is grounded.

There are 16 permanent magnets, but instead of being placed over the pole pieces and the armature being made to revolve between them, as in the "armature-type" magneto, the magnets are attached to the fly wheel by means of non-magnetic studs and are made to revolve within 1/32" in front of the coil cores (C) (Fig. 23).

Note. Fig. 23 shows magnets separated, as if separate horseshoe magnets, as an explanation as to how they revolve in front of the coil cores. The magnets are placed close together, as shown in Fig. 22.

The N poles of the magnets are placed together; so are likewise the S poles. Thus we have N and S polarity alternately around the magnets, as shown in Fig. 22.

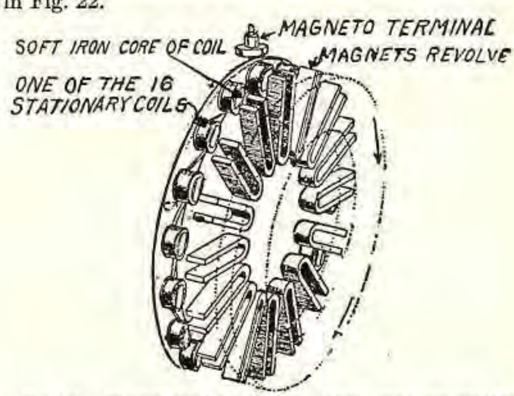



Fig. 23. Illustrating how the permanent magnets revolve in front of the coil cores. The magnets are within 1/32" of the coil core.

When the N pole ends of the magnets are in front of one of the coil cores (C), the magnetic lines-of-force flow from N pole to the magnet, through the coil core (C), through the plate to which it is attached, through the core (C) of the coil next to it, to the pole end of the magnet, thus completing a magnetic circuit from N to S pole end of the magnet, and setting up a generated electromotive force in the coil winding, causing current to flow out of the coil windings into the magneto terminal (Fig. 21).

When the flywheel moves one-sixteenth of a revolution, the flow of current is reversed. Thus there are sixteen alternations or changes of flow of current during one revolution of the sixteen magnets, or sixteen "impulses" per revolution, because there are sixteen coils and sixteen inductors or magnets.

In other words, each revolution of the flywheel, to which the magnets are attached, means one revolution of the crank shaft. There are 16 positions of the magneto when the current output is at its maximum, and each of these positions is called **the peak** of the current wave. There are, also, 16 positions during which no current is flowing at all. Each of these is called **the neutral** position, and each is half-way between two peaks. Therefore, at every sixteenth of a revolution of the magneto a position is reached when no current is being generated. These are termed "dead points."

**Each alternate peak is of an opposite polarity,** that is, there are 8 positions in each revolution when the current flowing from the magneto winding to the spark coil is positive, and between these positions are 8 other positions when the current is negative. In other words, the frequency is 8 cycles per revolution.

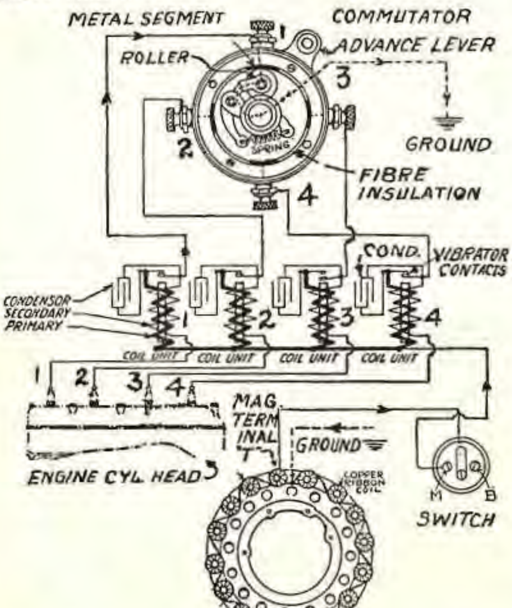



Fig. 24. Illustrating tne circuit from the magneto terminal (T) to the switch, to the primary winding of one of the four high-tension coils, to segment (No. 1 in this example) of the commutator, to ground, to the grounded end of the sixteenth magneto coil. Note. There is a mistake in the drawing. The coil vibrator of No. 1 coil should be shown open instead of No. 3.

**The Ford coil circuit and connections** are shown in Fig. 24. See also Index for "Ford wiring diagram" and "Relation of speed of magneto to voltage generated."

**The Ford inductor-type magneto,** owing to its high frequency, will light lamps and supply current for a vibrator-type coil, but the voltage varies considerably. Thus the lamps will vary in brilliancy

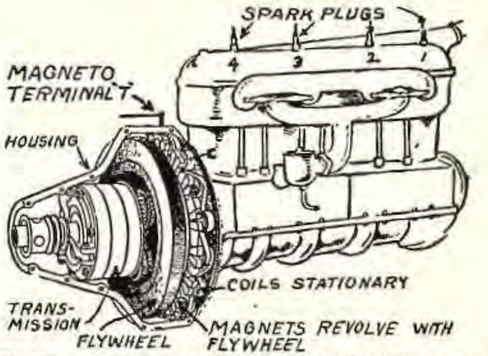



Fig. 25. Illustrating the location of the Ford magneto on the engine.

in relation to the speed of the engine. Owing to these variations of voltage, the ignition coil should be adjusted carefully, as explained on page 222, or else the spark-plug points will burn as well as the points on the vibrator blade of the coil.

### Low-Tension Magneto, "Armature Type"

**The low-tension magneto** like the low-tension coil, does not supply a very high voltage and would not jump a straight open gap like a spark-plug gap, but the voltage is raised sufficiently in the single coarse wire primary winding to produce a flash or spark when its circuit is very quickly opened.

The low-tension magneto can be used with a "make-and-break" igniter (Fig. 13, page 185), or with a "wipe-spark" igniter (Fig. 18, page 187).

The low-tension magneto can also be used in connection with a high-tension coil, but it would not be termed a high-tension magneto, even though the high-tension coil and the distributor were mounted on it; which is often the case. It would, however, be termed a high-tension ignition system.

The low-tension magneto is now seldom used, but is explained, because it is necessary to understand the principle of it before taking up the subject of the high-tension magneto.

**The parts of an "armature type" low-tension magneto** are: (1) magnets to produce the magnetic lines-of-force; (2) pole pieces of soft iron (see Fig. 1A, page 242); (3) a primary winding on a soft iron armature core which revolves, being driven at a fixed speed by the engine; (4) a contact-breaker (also called an interrupter) and a cam.

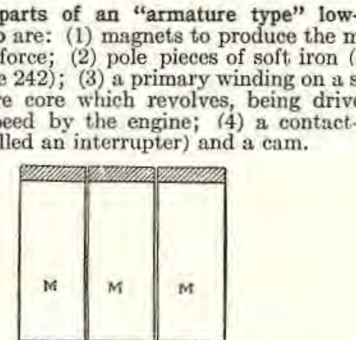



Fig. 26. Sectional view of low-tension magneto. (O) is the primary winding on the shuttle-type armature, of which there are several layers of coarse copper insulated wire (only one layer shown). This wire connects with a contact-breaker (P) and (G).

This contact-breaker would be in the form of an igniter (see page 185) and would be inside of the cylinder, if the "make-and-break" system of ignition is used.

If the system consisted of a low-tension magneto and high-tension coil, then the contact-breaker (G and P) above would be mounted on the end of the armature shaft and the circuit would be opened at the correct time, producing a spark, by a cam on the end of the armature shaft.

**The circuit of a magneto system** is a closed circuit; that is, the primary winding is closed and the circuit is opened by the cam only at the correct time, which is just as the armature passes the vertical position. At this time the greatest energy exists in the circuit, the position being termed the "maximum" position.

In other words, the spark is produced by the change from closed circuit to open circuit when the contact-breaker is opened by the cam. This break is made very quickly, and in order to get the hottest spark at the points of the spark plugs or igniter, the opening should occur when the armature is in "maximum" position. If the opening occurs earlier or later than maximum, then the intensity of the spark is weaker.

**The primary winding** on an "armature-type" magneto, consists of about 200 turns of No. 19 to 24 B. & S. gauge copper insulated wire.

## HOW THE "ARMATURE-TYPE" MAGNETO GENERATES ELECTRIC CURRENT

**A permanent magnet** is made of hard steel and retains its magnetism. Its magnetic influence extends from one pole to the other, which is called the magnetic field, as shown in Fig. 27.[1]

Fig. 27

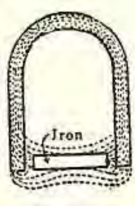


Fig. 28

**The magnetic lines of force** always flow N into S outside of the magnets or between the poles, and from S to N through the magnetic field poles. See Fig. 27.

If a bar of iron be placed between the poles (N and S), or in the magnetic field (Fig. 28), the magnetic lines of force will travel freely through the iron. It offers an easier path, because the air gap between poles offers 280 times the resistance that iron does. The magnetic lines will also be greatly increased, as the iron will collect a lot of stray lines of force and concentrate them.

Therefore a soft iron armature core (shuttle type) (Fig. 4A, page 243), with wire wrapped on it, is placed between pole pieces and made to revolve by being driven, usually by a gear from the cam shaft. The space between armature and pole pieces is very slight. The pole pieces (see Fig. 1A, page 242) are soft iron attached to the hard-steel permanent magnets. The armature is the "shuttle" type.

### How Electromotive Force Is Induced into Wires of Armature

Whenever a loop of wire forming a closed circuit is placed in a magnetic field, an e.m.f. will be induced in the wire whenever the strength of the magnetic field changes.

Or, if a wire is moved up or down quickly in the magnetic field, so that the wire will cut across

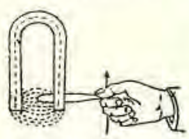


Fig. 29

the magnetic lines-of-force or magnetic flux[1] at right angles (Fig. 29), an e.m.f. will be generated in the wire, and if the wire is in the form of a closed loop, the electromotive force thus generated will force the electricity in the wire to move. Why the electricity is in the wire we do not know, but we do know that the generated e.m.f. will cause it to move, or flow.

**The e.m.f. is induced in the wire** by the lines being stretched by the movement of the wire, like rubber bands, then snapping at the weakest point—the S pole—then wrapping or whirling around the wire, thus generating e.m.f. in the wire. The intensity and number of lines-of-force around the wire will depend upon the strength of the magnetic field and the rate of speed with which the wires cut the lines-of-force. The direction in which the e.m.f. will force the electricity or current to move in the wire will depend upon the direction in which the wire itself is moved.

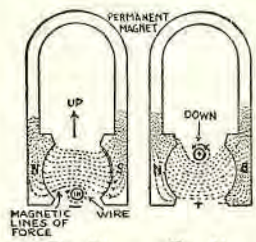


Fig. 30 Fig. 31

**If the wire is moved up** (as in Fig. 30), the magnetic lines-of-force whirl around the wire in a clockwise direction and current will flow **into** the wire.

**If the wire is moved down** (as in Fig. 31), the lines-of-force will whirl counter-clockwise, and current will flow **out of** the wire.

If we have two wires (as in Fig. 32), revolving in the direction of the arrow point, the wire on the left would then cut the lines **up** as it revolved, and current would flow into the wire. The wire on the

[1] A "permanent magnet" will retain its magnetism a long time if a keeper is kept on the ends of the poles. The armature on a magneto, when in a horizontal position, acts as a keeper.

An "electro-magnet" is a magnet consisting of an iron core around which wire is wrapped. When direct current is passed through the wire, the iron core becomes a magnet—if current is flowing in one direction. Soft iron cores are used, as it quickly loses its magnetism when current ceases flowing.

[1] "Magnetic flux" is the total number of lines-of-force flowing through a magnetic circuit.

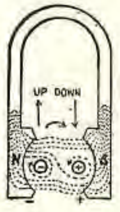



Fig. 32

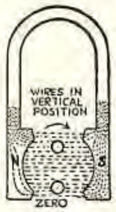



Fig. 33

right would move down and cut the lines down, and consequently the current would flow out. Thus we should have a complete circuit of current flowing, if the wires were in the form of a closed loop.

**When the wires reached a vertical position** (as in Fig. 33), there would be no e.m.f. generated in the wires and the e.m.f. would be zero value, because the wires would not be cutting **across**, or at right angles to the path of the lines-of-force.

This position of wires in Fig. 33 would be represented by the position of the armature of the magneto in Fig. 34. Note that all the lines-of-force would flow through the armature core, and the wires on the armature would not be cutting the lines-of-force at all; thus the e.m.f. is "zero" value.


Fig. 34

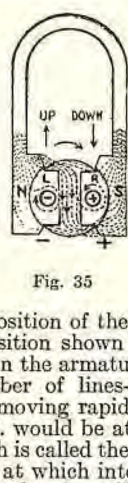



Fig. 35

Fig. 32 represents the position of the wires when the armature is in the position shown in Fig. 35. In this position the wires on the armature would be cutting the greatest number of lines-of-force, if, of course, the wires were moving rapidly with the armature. Thus the e.m.f. would be at its highest value at this position, which is called the "maximum position." It is the point at which interruption of the primary circuit should take place, if it were not for a factor called "armature reaction."

Owing to the fact, however, that the circuit is a closed circuit in which the current is flowing, there is an "armature reaction" which produces a hindering effect (explained farther on), and consequently the maximum position of the armature is reached a few degrees later, or just as the armature cheek breaks from the pole tip.

Before we proceed any farther, however, there are laws governing the generated e.m.f. which must be considered as follows:

**The momentary induced e.m.f.** is greatest when the wire is moved so as to cut the magnetic lines of force at right angles. Applying this principle to the coil of wire on the magneto, the coil would be cutting the greatest number of lines of force when in position shown in Fig. 35—or when it is moving at right angles so as to **cut** the lines of force.

**The electric current in the wire** depends upon the e.m.f. (electromotive force) causing it to flow; therefore e.m.f. is generated in wire when it is made to cut the lines-of-force, and a current flows when its circuit is complete, due to the generated e.m.f. The faster the coils cut the lines-of-force, the greater will be the e.m.f. generated.

**The generated e.m.f.** depends upon the speed of cutting the lines-of-force, that is, the number of lines cut per second. Therefore the greater the number of lines and the greater the number of wires there are, the greater will be the e.m.f. Therefore several layers and many turns of wire are wrapped on the armature core called the primary winding.

Referring now to Figs. 33 and 34, it will be seen that the coil is not cutting any of the lines-of-force—the lines are passing freely through the armature core from N to S; therefore e.m.f. (voltage) strength is at zero.

In the position shown in Figs. 32 and 35 the coils of the wires of the primary winding are cutting the greatest number of lines-of-force at right angles to the flow of lines-of-force. Some few lines are flowing through the ends of the armature core, but most of the lines are being cut by the wires on the armature. Therefore this position would appear to be the logical position at which the spark should occur, since it is the position where the **generated e.m.f.** in the wires is greatest.

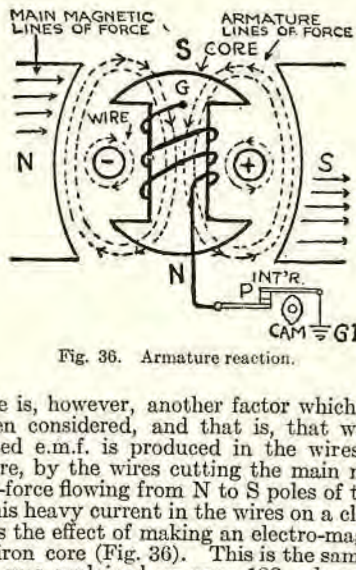



Fig. 36. Armature reaction.

There is, however, another factor which has not yet been considered, and that is, that when this generated e.m.f. is produced in the wires on the armature, by the wires cutting the main magnetic lines-of-force flowing from N to S poles of the magnets, this heavy current in the wires on a closed circuit has the effect of making an electro-magnet out of the iron core (Fig. 36). This is the same condition as was explained on page 182, where current from a battery flowing through a coil of wire around an iron core caused magnetic lines-of-force to whirl around the entire coil and thus form an electro-magnet with an N and S polarity.

Due to the generated e.m.f. in the primary wires on the armature, which is a closed circuit, the same effect is being produced, that is, independent magnetic lines-of-force are set up around the armature core which has made a S pole and N pole of the armature core (Fig. 36), with the result that these independent armature lines-of-force cause the main magnetic lines-of-force to follow their own path. This action is termed **"armature reaction."**

Note. The position of the armature in Fig. 36 is represented in Fig. 35. In the latter, the main magnetic lines-of-force are passing in at the **top** of the armature core and coming out at the **bottom**. This is due to the fact that the "main magnetic lines-of-force" are flowing **"with the armature lines-of-force."** See arrow points of both, in Fig. 36.

We have now built up a very strong magnetic field which extends all around the wire on the armature, and the principle is now similar to the coil action, explained on pages 182, 184. Now, the point is, if we could demagnetize the core of the armature, so that the lines-of-force which have been built up around the armature (Fig. 36) could collapse rapidly (as with the coil on pages 182, 184), then, as the lines-of-force collapsed, they would cut the wires at a very rapid rate of speed, if the core was fully demagnetized, or magnetized in an opposite direction. The result would be another independent induced (or self-induced) e.m.f. in the wires of a higher voltage, causing the current to flow in the wires in the same direction as it did before the circuit was opened.


Fig. 37

**The demagnetization of the core** is accomplished by two different factors. If the circuit is opened at the interrupter points (P) (Fig. 36), just as the armature breaks from the pole piece (e), (Fig. 37), the magnetic lines-of-force which were flowing through the armature core in the direction shown in Figs. 35 and 36, will now flow in the opposite direction, coming in at the bottom instead of the top, as in Fig. 37, thus assisting in the demagnetization of the armature core.

These two actions combined cause the lines-of-force to collapse more rapidly on open circuit. Thus a fairly high induced voltage is built up in the wires, which, being generated on open circuit, will have no other outlet[1] except at the open points of the interrupter. Thus the voltage jumps the interrupter-point gaps in a manner similar to the action of the low-tension coil (Fig. 11, page 184). There being only a limited number of turns of rather coarse wires in the primary winding, however, the voltage will not be very great, but great enough to jump the interrupter point gap.

If the low-tension magneto is used with a "make-and-break" igniter (Fig. 12, page 185), (or a "wipe-spark" igniter), the spark is desirable at the break, because it would be in the cylinder where it is required.[2]

### Low-Tension Magneto and High-Tension Coil in Series

If the low-tension magneto is used in "series" with a high-tension coil (Fig. 38), the spark is desired at the spark-plug point. It will then be necessary to have a condenser to absorb the current passing through the primary winding (PRY) of the coil from the magneto at the time of the break at interrupter or contact-breaker points and also to assist in demagnetizing the core of the high-tension coil, so that the lines-of-force built up around the coil core will collapse quickly and induce a high voltage in the secondary winding (SECY) of the high-tension coil. Thus a very high voltage will be produced at spark-plug points (Fig. 38).

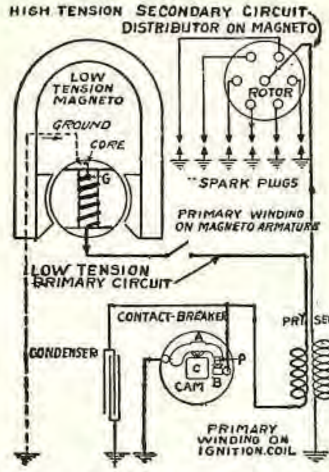



Fig. 38. Low-tension magneto connected in series with the primary winding of a high-tension coil.

### Low-Tension Magneto and High-Tension Coil Shunted

**If the low-tension magneto is connected with a high-tension coil,** so that the interrupter or contact-breaker is "shunted" across the path from magneto to coil, instead of being in "series" with it (as in Fig. 38), the action would be slightly different as shown in Fig. 39.

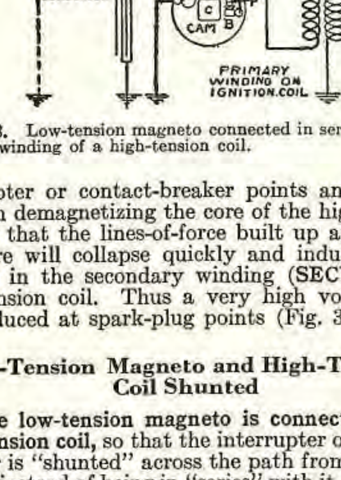



Fig. 39. Low-tension magneto connected with the primary winding of a high-tension coil, but the interrupter or contact-breaker is "shunted" across the circuit.

**The primary current from the magneto** would have two paths: one through the interrupter points (P), and the other through the primary winding (PRY) of the coil. The current takes the easiest path through the interrupter points, and consequently there is no current flow in the primary of the coil and its core is free from magnetism. Thus

[1] Even though the circuit is open at the interrupter, we term it a circuit if there is sufficient self-induced voltage in the wires to cause the electric current to jump the gap.

[2] It would appear that the "make-and-break" system would be the simplest, which it is, but the movable contact points in cylinders exposed to intensity of the heat soon get out of adjustment.

when points (P) are opened by the cam, this sudden break of the current flowing through the armature and interrupter points, or the shunt circuit, causes, with the assistance of the condenser, an induced current to be set up in the armature winding, as explained in connection with Figs. 35 and 36. This rush of self-induced current, having no other outlet, rushes through the coil primary winding (PRY). As the coil core is demagnetized, because of the fact that no current was flowing through it previously, the magnetic lines-of-force build up rapidly around the turns of wires, causing a momentary high voltage in the secondary winding, and thus causing a spark to jump the gap at the spark plug which is in the cylinder.

Note in Fig. 38 that **the lines-of-force in the coil core were made to collapse,** to produce the high-tension spark, whereas in Fig. 39, **the lines-of-force are built up in the coil core** to produce the high-tension spark. This was possible in this instance, because there was no current flowing in the primary winding of the coil, and its core was completely demagnetized. Thus the lines built up rapidly, generating a high induced voltage in the secondary. This system is the one in general use where a low-tension magneto is used with a high-tension coil.

It is well for the reader to grasp the difference between **generated e.m.f.** and **self-induced e.m.f.,** in order that he may clearly understand the foregoing explanations.

**Generated e.m.f.** refers to the e.m.f. generated in a wire when a wire is made to cut the lines-of-force, as when the armature is revolved between the pole pieces. In such a case the wires cut the main magnetic lines-of-force, and lines-of-force are built up around the turns of the wires.

**Self-induced e.m.f.** is where the lines-of-force have been built up around the wires, as described above, and then the circuit is suddenly opened, or the direction of the lines-of-force is changed. This causes a collapse of the lines-of-force, which cut the wires as it collapses into the core, thus causing what is termed a self-induced e.m.f. which causes current to flow.

### Two Sparks or Impulses[1] per Revolution of Armature

**With the shuttle type of magneto armature** there are two positions of the armature during one revolution, called **"maximum position."** These are the points at which the e.m.f. is the highest and are the position in which the armature is when the contact points should open, or slightly later, owing to "armature reaction," as already explained.

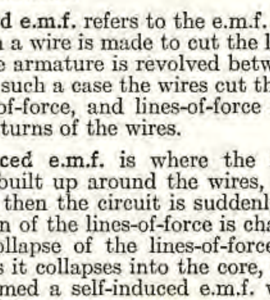



Fig. 40. Voltage wave.

[1] The word "impulse" is also used in connection with the ignition of gas in the cylinder; for instance, when the explosion takes place in the cylinder, the piston receives an "impulse."

In explanation of this, let us refer to Fig. 40, which shows the open-circuit voltage wave. Start with the position of the armature at (A) on the left. Note that the armature is in a horizontal position and the e.m.f. (electromotive force[1]) is at zero, because the lines-of-force are passing freely through the iron armature core, as is also shown in Fig. 34. Thus, at this point the wires on the armature are not cutting any lines-of-force.

**When the armature travels 90°,** or a quarter-revolution in the direction of rotation (clockwise, in this instance), it is in a vertical position (B). Technically this is the position where the highest break of e.m.f. or voltage is reached, because the wires are cutting the greatest number of lines-of-force. Practically, however, the maximum position is just a few degrees farther in the rotation, as shown in Fig. 37, for reasons already explained.

**When the armature travels 90° more,** or half of a revolution, it has again reached the horizontal position (C). The voltage is again at zero value.

**When the armature travels 90° more,** or three-quarters of a revolution, it has again reached another maximum voltage position (D).

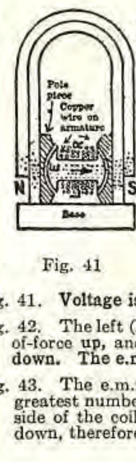



Fig. 41

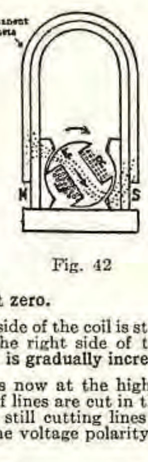



Fig. 42

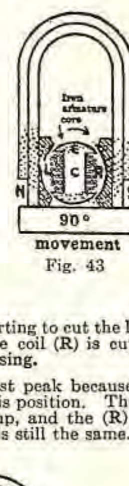



Fig. 43

Fig. 41. **Voltage is at zero.**

Fig. 42. The left (L) side of the coil is starting to cut the lines-of-force up, and the right side of the coil (R) is cutting down. **The e.m.f. is gradually increasing.**

Fig. 43. The e.m.f. is now at the highest peak because the greatest number of lines are cut in this position. The (L) side of the coil is still cutting lines up, and the (R) side down, therefore the voltage polarity is still the same.

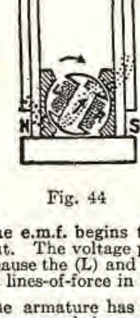



Fig. 44

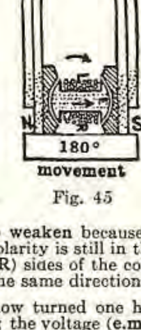



Fig. 45

Fig. 44. **The e.m.f. begins to weaken** because less lines are being cut. The voltage polarity is still in the same direction, because the (L) and (R) sides of the coil are still cutting the lines-of-force in the same direction.

Fig. 45. The armature has now turned one half-revolution. No lines are now being cut; the voltage (**e.m.f.**) strength is **at zero.** Thus we have had the positions as represented in Fig.40; **(A)** to **(C)**, where the e.m.f. was in one direction. During the next half-revolution, the same action of the wires cutting the lines-of-force is repeated, except that the **(R)** side of the coil will now cut **up** and the (L) side will **cut down.** In this case, therefore, the e.m.f. will be in the opposite direction during the next half-revolution, as shown in Fig. 40, (C) to (E).

[1] Refers to voltage.

**When the armature travels 90° more,** or a full revolution of 360°, it has again reached zero voltage position (E).

Thus we have during one revolution[1] of the armature two positions (B and C) when the voltage is at its highest voltage peak, and two positions (C and E) when it is at zero voltage.

**The voltage wave** is in one direction (A) to (C), which we will call positive, and in another direction (C) to (E), which we will call negative, or two directions during one revolution, termed "alternating" current. Thus the voltage wave changes polarity at (A) and (C), as will become clear by the following sequence:

### The Current Wave

**The voltage wave** (Fig. 40) differs slightly from the current wave (Fig. 46). The e.m.f. or voltage generated is necessary to force the current to flow.

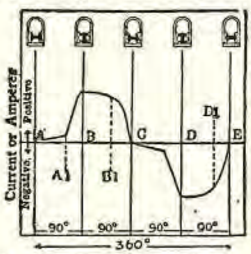



Fig. 46. Current wave diagram

The e.m.f. starts to build up at about 60° from (A) or at (A1), (Fig. 46), and consequently the current in the closed-circuit winding also starts to flow in a positive direction from (A) to (C) and reaches maximum when the contact points are opened at (B), or slightly afterwards.

Position (B) would correspond to the extreme **advance** position of the contact-breaker, and position (B1) to the extreme **retard,** or about a 35° or 40° movement.

Therefore if the contact-breaker housing was advanced so that a spark would occur before (B), or retarded after (B1), the spark would be weak.

There are two points in a revolution from (A) to (E), where a strong spark can be obtained, namely: between (B) and (B1), which represents half a revolution of the armature with the current flowing in a positive direction; and between (D) and (D1), which represents another half-revolution of the armature with the current flowing in a negative direction.

It is clear that **the contact-breaker must be opened at a certain position of the armature** and the armature and cam must be driven at a fixed speed, which is termed "setting" or "timing the ignition."

**The cam:** As the change takes place twice during one revolution of the armature, it is necessary that a two-point cam be used on the contact-breaker in order to break contact twice during one revolution.

**To set the magneto:** As stated, the point at which the armature cheek is just breaking from the pole (Fig. 37) is the correct position in which to set the magneto armature, and at the same time the interrupter points should just separate. Both operations should occur at the same instant.

[1] On some magnetos for eight and twelve-cylinder aero engines the pole pieces are arranged so that four maximum positions are reached per revolution. The K.W. magneto, page 246 produces 4 maximum positions or sparks per revolution.

**Advancing and retarding:** The cams are made of steel and are in a casing, and by having this casing made so that it can be moved through, say, the one-tenth part of a circle, the time of the interruption of current can be advanced or retarded with relation to the movement of the armature. This means the spark will occur early or late, relative to the movement of the pistons.

**The low-tension magneto** described is one which uses a shuttle-type armature, called the "armature" type of magneto. The wires revolve with the armature.

**The inductor-type magneto** is a magneto where the coils or wires are stationary.

### Splitdorf Model "D" Low-Tension Magneto and Coil System: a "Dual Ignition System"

The illustration (Fig. 47) shows a Splitdorf dual system, using a low-tension "armature-type" magneto and high-tension coil with battery to start on and magneto to run on. The contact breaker on the magneto is utilized for either the battery or magneto system. The primary circuit through the armature, however, must be opened to prevent the battery from demagnetizing the magnets when the battery is used.

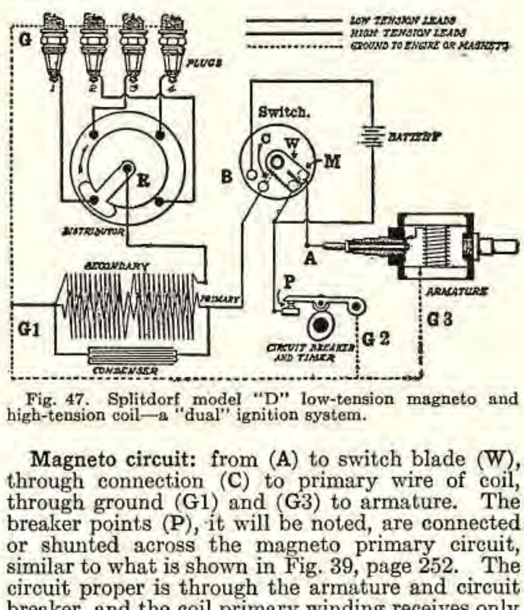



Fig. 47. Splitdorf model "D" low-tension magneto and high-tension coil—a "dual" ignition system.

**Magneto circuit:** from (A) to switch blade (W), through connection (C) to primary wire of coil, through ground (G1) and (G3) to armature. The breaker points (P), it will be noted, are connected or shunted across the magneto primary circuit, similar to what is shown in Fig. 39, page 252. The circuit proper is through the armature and circuit breaker, and the coil primary winding receives only the kick of the armature (extra current) when the contact points open, as explained on page 252. It will be noted that the battery circuit is open at the switch.

**Battery circuit:** the switch blade (W) should now be on (B) side, connecting the two terminals, and the magneto terminals on the (M) side are open. Current travels from top of battery (+) to switch point, to primary winding of coil, to ground (G1) to (G2), thence through interrupter points (P) to a lower connection of battery. Note that the armature is cut out entirely, but not the interrupter.

**High-tension current** is distributed from the secondary winding on the coil to brush (R) on the distributor (the distributor is on the low-tension magneto and is driven from the armature shaft), thence to the spark-plug center electrode, thence through the spark gap to plug-shell ground (G) of the engine and frame, back to the coil where the primary and secondary connect.

**Condenser:** Although this is located in the coil, if the circuit is traced it will be observed that it "bridges" the points of the contact-breaker.

### Splitdorf Model "T" Low-Tension Magneto and Coil System; "Dual Ignition Systems" Using a Dash Coil and a Tube Coil

The diagrams below show the Splitdorf low-tension model "T" magneto used in connection with a dash type of high-tension coil (Fig. 47A) and with a tube type of coil (Fig. 47B). The coils are also termed "transformers." Both systems are typical "dual" ignition systems of the interrupted shunt-current type.

Note that the distributor for distributing the high-tension current to the spark plugs from the coil is mounted on the low-tension magneto.

Also note the connections on the coil for the battery. By switching to one side, the magneto supplies current to the coil, and by switching to the other side, the battery supplies current to the coil.

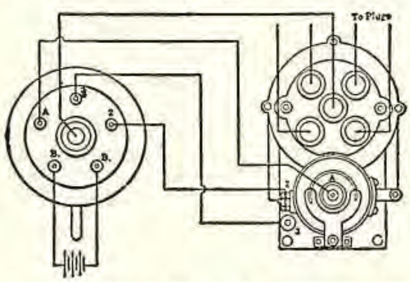



Fig. 47A. Splitdorf model "T" low-tension magneto used in connection with a "dash" or "box type" of high-tension coil.

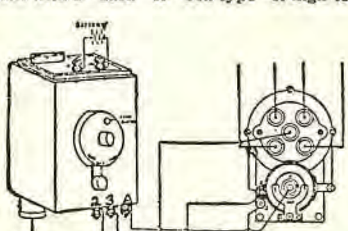


Fig. 47B. Splitdorf model "T" low-tension magneto used in connection with a "tube type" high-tension coil.

### The Oscillating Low-Tension Type Magneto

This type is a regular shuttle or armature type magneto (Figs. 48 and 49), and is the original magneto principle, designed for slow-speed engines. The armature does not revolve, but oscillates back-and-forth from position Fig. 48 to Fig. 49 (30°).

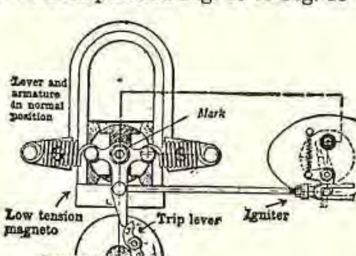



Fig. 48

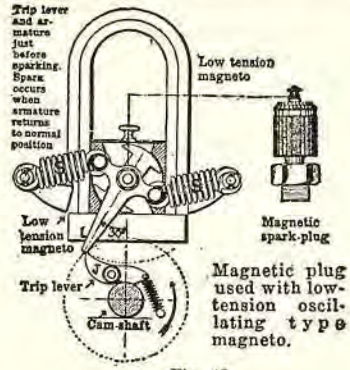



Fig. 49

It can be used with an igniter arrangement (Fig. 48), which is similar to that shown in Fig. 13, page 185, except that the igniter rod is actuated by lever (L) on the magneto, which is tripped by trip (J). It can also be used with a magnetic plug, as shown in Fig. 49, which is screwed into the cylinder.

### The Magnetic Plug

**The principal parts of the magnetic plug** (Fig. 50) are: magnetic coil (5), pole-piece (2), interrupter

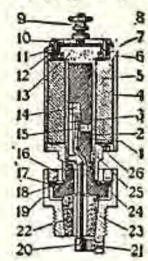


Fig. 50

(20), and contact-piece on plug shell (21). The plug is screwed into the cylinder.

**Principle:** owing to the sudden flow of current through coil (5), the upper portion of hammer bar (1), called the armature, is attracted to pole-pieces (2), which effects a quick separation of contacts (20) and (21), producing a spark at these points.

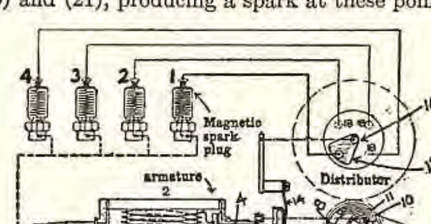



Fig. 51

**The use of the magnetic plug** is shown in Fig. 51, in connection with a low-tension magneto (type "K4" Bosch) with a revolving armature, with a main and auxiliary winding, one being a continuation of the other, and with a distributor for connections to the magneto plugs. This system is termed the Honold system, and is for 2, 3, 4, 6 and 8-cylinder engines.

The systems just described are not used for automobile ignition, but are designed for slow-speed heavy-duty stationary and marine engines.

# INSTRUCTION No. 26

## THE HIGH-TENSION MAGNETO: Principle; Construction; Types

### Preliminary Explanation

**The high-tension magneto** is not only a mechanical generator, or a substitute for the battery, but combines all the elements of a complete ignition system, except the plugs and switch.

**It performs three separate essential functions** as follows: generating current; transforming the current to a high pressure; distributing the high-tension current to the individual cylinders. Besides these main functions, a number of minor functions have to be performed. The high-tension magneto differs from the low-tension magneto in only a few particulars.

The high-tension magneto can be of the "inductor" type or of the "compound-armature" type.

We shall deal here with the armature type and explain the inductor type farther on.

**Armature winding:** The armature (armature type) on the high-tension magneto is wound with an additional winding, called the "secondary winding," whereas the low-tension magneto has but one winding, called the primary winding.

Instead of using a "separate" high-tension coil, as with the low-tension magneto, explained in the preceding instruction, this second winding on the armature of the high-tension magneto takes its place. This secondary winding is carefully insulated from the primary winding, except at one end, where it connects at (N), (Fig. 1), with the primary winding. As the primary winding is grounded at (GP), the secondary winding is thus grounded through the primary winding. (PW) is the primary winding, and (SW) is the secondary winding.

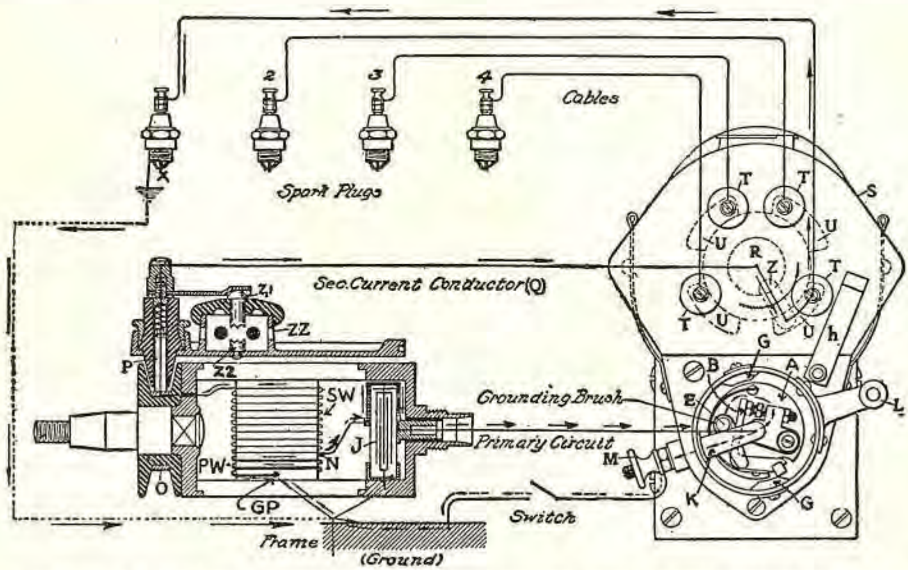



Fig. 1. Diagram of a high-tension "compound-armature-type" magneto, showing internal connections of armature The armature is double wound. It revolves between permanent magnet pole pieces with its wire winding.

One end of (SW) is led, carefully insulated, to a collector ring (O) mounted on the armature shaft, and a carbon pencil or brush (P) rubbing on this collector ring takes off the secondary current and leads it to the distributor brush (Z). The primary winding circuit is explained farther on.

The other respect in which this type differs from the low-tension magneto is that **the condenser** which is employed in connection with the interrupter is usually built into the high-tension magneto (J, Fig. 2), whereas with the low-tension magneto, the condenser is in the separate high-tension coil. The condenser is usually, though not necessarily, located on the armature shaft in order to get it as close to the interrupter as possible, and it is there shown in Fig. 1 (J). In some magnetos, for the sake of greater accessibility and other reasons, the condenser is located outside the armature in a stationary sealed box.

Owing to the fact that the secondary coil of the high-tension magneto is located on the armature itself, it follows that it not only receives an induced current, due to the breakage of the primary current, but itself induces a current like that of the primary coil, but smaller in volume.

It has the same form of armature, field magnets, and principle of interrupter as the low-tension magneto, but of varied construction. The armature coil, however, is different, having a primary winding with a secondary winding over it, as previously explained.

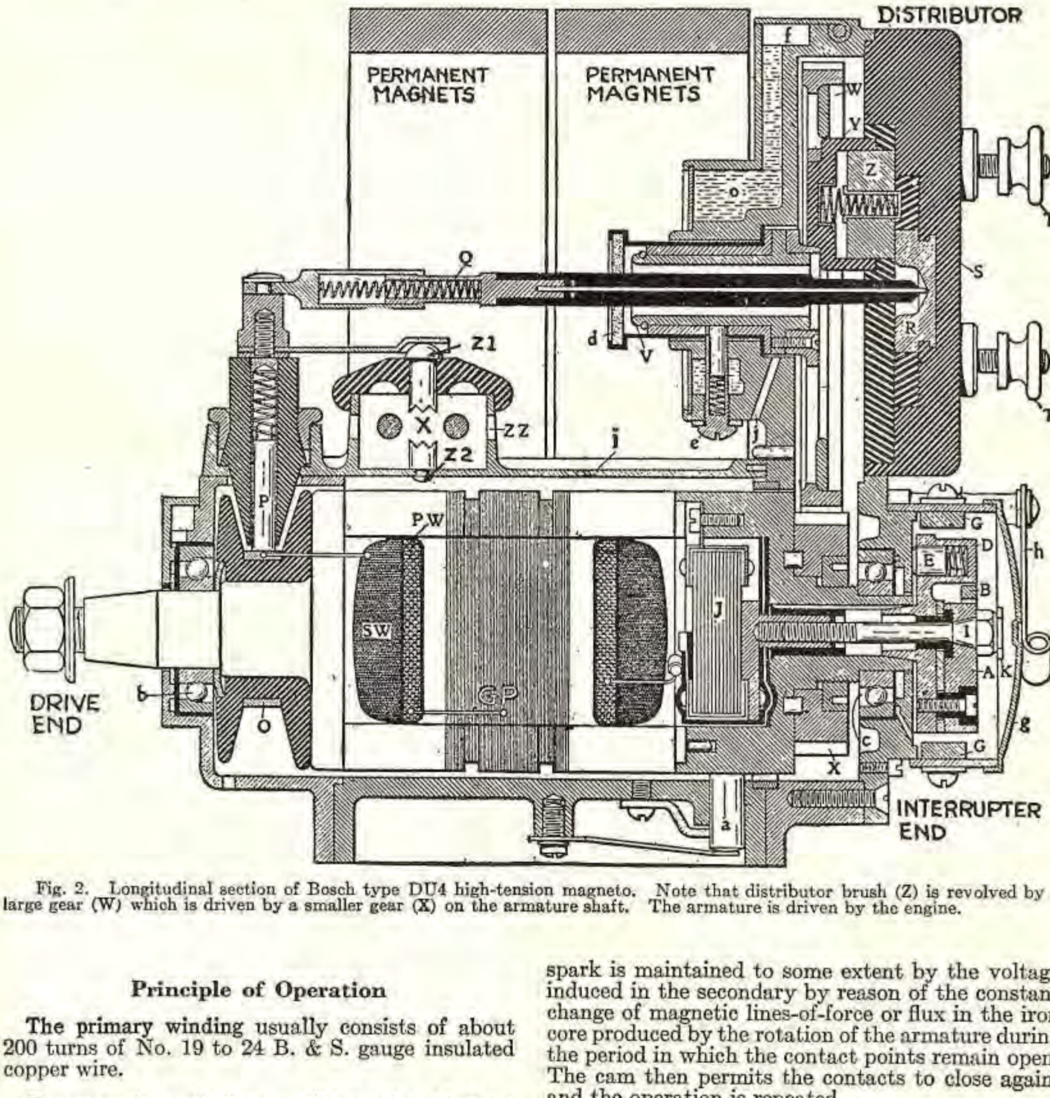



Fig. 2. Longitudinal section of Bosch type DU4 high-tension magneto. Note that distributor brush (Z) is revolved by a large gear (W) which is driven by a smaller gear (X) on the armature shaft. The armature is driven by the engine.

### Principle of Operation

**The primary winding** usually consists of about 200 turns of No. 19 to 24 B. & S. gauge insulated copper wire.

**The secondary winding** usually consists of about 12,000 turns of very fine wire, No. 34 to 38 B. & S. gauge, and is of enameled silk-covered copper wire. The ratio is about 60 to 1.

We have already learned that the electromotive force induced in a winding depends upon the rate of change in the number of lines-of-force and the number of turns of wires the lines-of-force cut. Therefore with this great additional number of turns of secondary wires on the armature, the e.m.f. will be greatly increased.

**The principle** is very much the same as that explained on pages 251, 253. The interrupter breaks the primary circuit when the armature is in maximum position, or just when the armature cheek is leaving the pole tip. Thus the armature core is demagnetized, and the lines-of-force collapse and cut the secondary and primary wires at a very rapid rate. And, since there is such a large number of turns of wires in the secondary winding, the result is, that a very high voltage is induced in the secondary winding, which at normal speeds will cause a spark to jump across a gap of the spark plug. This spark is maintained to some extent by the voltage induced in the secondary by reason of the constant change of magnetic lines-of-force or flux in the iron core produced by the rotation of the armature during the period in which the contact points remain open. The cam then permits the contacts to close again, and the operation is repeated.

### Importance of Condenser and of Quick Opening of Contact Points

**The condenser** is provided in order to absorb the spark at the interrupter points when the primary circuit is interrupted or separated. In other words, if the condenser were not across the points, the lines-of-force collapsing so rapidly would produce a very high voltage in the primary winding and thus cause a heavy spark at the breaker points, before they had time to separate properly, just as it does when used with a low-tension magneto and make-and-break igniter. As explained before, this results in burning the platinum points.

If the contact points could be opened quickly enough, the condenser could be dispensed with. In fact, if this were possible, the magneto would be better without it, because the condenser absorbs the initial current rush from the primary, produced by the collapsing lines-of-force, until the points are fully opened, thus preventing sparking at the points. But this is accompanied by the disadvantage of preventing the voltage from building up to a high value before the contact points have had time to separate properly. At the same time that it retards the development of the primary voltage, it retards the secondary voltage in building up also. Therefore the condenser capacity should not be greater than just enough to suppress the spark at the points. Of greater importance is the **quick opening of the contact points,** and proper adjustment.

An advertisement of a magneto manufacturer reads as follows: "The most perfect interrupter that has ever been placed on a magneto. Its quick opening is largely responsible for the efficiency of the magneto." This is mentioned so that the reader will appreciate the importance of the quick opening and the proper adjustment of the interrupter points.

In the instruction book of the K. W. Ignition Co., the following wording appears relative to the interrupter points:

"A word of warning at this time, as to the proper distance to set the contact points to open, might be of value.

"The volume of spark produced depends to a large extent on the proper break of the points. If they are opened quickly and make a clean break, the maximum spark is produced. When the points are too close, they do not break clean, as the arcing at the point causes the current to linger in the primary. When the points are too far apart, they may not close tight enough to allow current to flow, and in addition the opening of the points occurs too early and causes an unnecessary pounding on the roller. You will, therefore, note that the proper adjustment of the points will safeguard both electrical and mechanical difficulties.

The points should be set to open 1/64" in order to get the best results. (This is on the K.W. high-tension magneto.) As a rule magneto manufacturers supply a gauge to which these points should be accurately set."

There are many different constructions of interrupters, some of which are shown farther on.

## CONSTRUCTION OF A HIGH-TENSION MAGNETO

The following description refers to the **"compound-armature type" magneto.** As an example, the Bosch type "DU4" will be used. See Figs. 1, 2, 3, 4, and 5, and also other exaggerated illustrations in order that the purpose of the parts may be clearly understood.

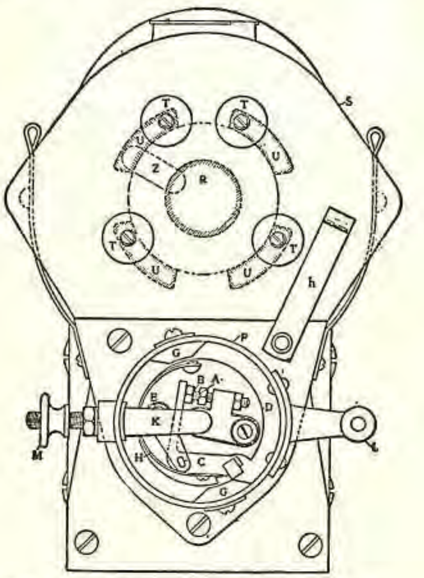



Fig. 3. Front view of Bosch 'DU4" magneto.

### Interrupter Parts

A—Platinum point on insulated contact-breaker block which connects with one end of primary winding.

B—Platinum point on grounded breaker arm (C).

C—Contact-breaker arm; platinum point at one end and lug at other end, which comes in contact with cam (G) as (C) revolves.

D—Brass disk, fastened to armature shaft and rotating with it. (A), (B), and (C) are fastened to this disk and revolve with it, but (A) is insulated from (D) while (B) and (C) are grounded to it.

E—Carbon brush grounds (D) to magneto frame (see Fig. 2, page 257).

F—Cylindrical breaker-box housing which can be shifted by (L), to advance or retard.

G—Cam blocks which cause arm (C) to separate points at (A) and (B).

H—Spring keeps points (A) and (B) closed until separated by (G)

K—Connects with (A) or one end of primary, and connects with terminal (M) (insulated).

M—Connects with switch as shown in Fig. 1. Other side of switch is grounded. When switch is closed magneto is "off".

**h—Spring for holding cover in place.**

### Distributor Parts

T—Terminal to spark plugs.

Z—Distributor brush connecting with (R).

R—Connects with pencil brush (P) on collector ring (O), through contact conductor (Q), as in Fig. 2.

U—Segments or contact pieces connected with terminals (T) on which brush (Z) slides.

### Magnets and Pole Pieces

**Magnets and pole pieces:** In any standard magneto made on this principle the general construction would be as follows: The permanent field magnets consist of two—or three—pairs. One magnet of each pair is superimposed above the others, as in Fig. 6; or 2 magnets are sometimes placed side by side.

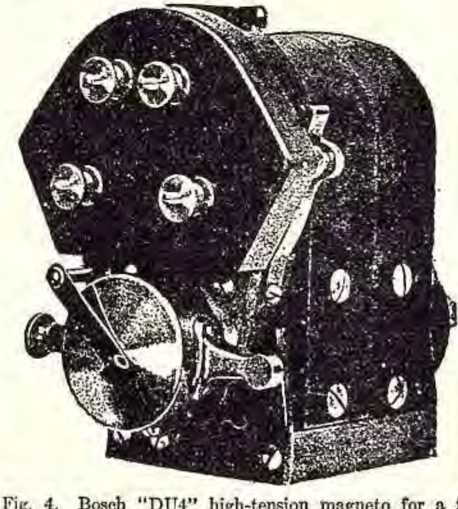


Fig. 4. Bosch "DU4" high-tension magneto for a four-cylinder engine. Note single magnets. Type "DU6" is the same, except that it is for a six-cylinder engine. Type "D4" has three-bar magnets; type "DR4," two-bar magnets.

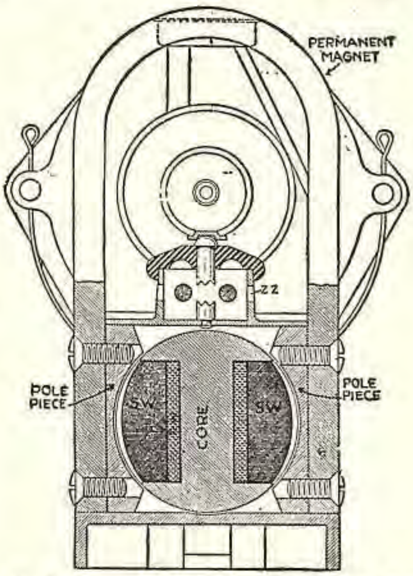



Fig. 5. Rear sectional end view. Note safety spark gap (ZZ); see also, Figs. 1 and 2. Note pole-pieces screwed to end of field magnets. The dark shaded part on the armature represents secondary winding; light shading, primary winding.

In some few cases three magnets are placed one over the other. For instance, on the Bosch "DU4," four-cylinder engine magneto, there are two magnets side by side. On the "D4" there are three magnets, and on "DR4," two magnets, as will be clear by examining Fig. 6. The magnets are set to give correct north and south polarity. All north poles on one side and all south poles on the other side.

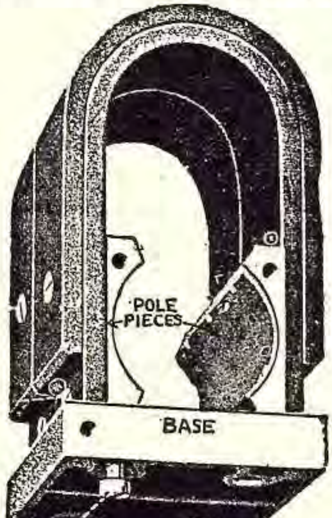



Fig. 6. Showing how the magnets are placed, and also the end pole pieces.

The ends or poles embrace "pole pieces" of soft iron bored out to allow the armature to rotate quite freely, but very closely to the pole faces; in some cases the clearance is only .002 inch. See also, Fig. 5.

### Armature

**The armature:** This consists of a core of soft iron of H-shaped (Fig. 7) cross-section; it is also referred

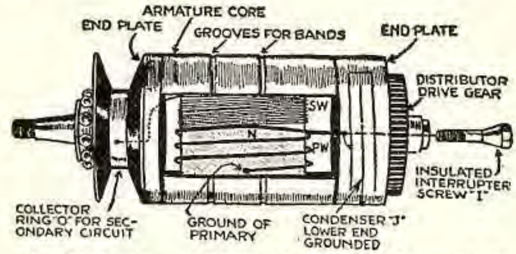



Fig. 7. Armature of the revolving compound type (double wound).

to as a "shuttle" armature. This core of soft iron serves to form a bridge for the magnetic flux between the pole shoes, and also to carry the winding in which the current is induced.

The armature is found in practically every standard type of the well-known "shuttle" type. The best class machines have the armature built up of thin stampings of soft iron, each insulated from the other by a thin film of varnish. This form of construction is known as a "laminated armature core." A laminated armature core is shown in Fig. 4, page 243, and a complete armature wound with double winding is shown in Fig. 7. Laminated cores have the advantage over a solid cast-iron core in that the electrical efficiency is higher through the absence of "eddy" currents in the iron core which represent considerable waste of energy and cause heating.

By laminating or breaking up the core into thin sections, the currents are prevented from circulating through the iron (spoken of as "eddy currents"). In the case of a solid core, the iron would be annealed to render it as "soft" as possible, to obtain the best magnetic effect.

**Armature winding:** The armature core is first insulated with mica or similar material. Then it has several layers of heavy insulated wire wound upon it. The Bosch DU-4 magneto has approximately three layers of No. 21 insulated primary wire and seventy to seventy-two layers of No. 36 silk-covered secondary wire.

To the end of this heavy primary wire is connected the beginning of a very fine secondary wire (see **N**, Fig. 1), insulated with silk, which is wound on the core until the slot is filled almost to the height of the cylindrical portion. After this a wrapping of insulating cloth is applied, and bands are put around the circumference of the armature to prevent the wire and insulating material from flying out and coming in contact with the pole shoes when the armature is rotated at high speed. To the ends of the armature the steel shaft or spindle is fixed by brass end plates (Fig. 7).

It will thus be noted that there are really two windings on the armature, whereas the low-tension magneto has but one winding—an inner winding of relatively few turns of heavy wire, and an outer winding of a large number of turns of fine wire.

**The armature shaft** is mounted in annular ball bearings (Fig. 2, **b** and **c**), which are provided with oil guards so that any lubricant supplied to them will not be easily lost or reach the insulating parts. The armature tunnel is closed on top by an aluminum cover **i**, (Fig. 2), and the front of the circuit-breaker housing is provided with a brass cover (**g**), which is held in place by means of a hinged flat spring (**h**), so that it can be removed and replaced

### Primary Winding and Circuit

**The winding of heavy wire,** or primary winding, serves primarily for generating the current, and in connection with the fine wire or secondary winding, it also serves for multiplying the pressure or voltage to such an extent that it will produce a spark at the gap of the spark plug in the cylinder.

**The primary circuit** (Fig. 1) begins with the primary winding (**PW**) on the armature. It flows through the contact-breaker screw (see I, Fig. 2), to the stationary contact (**A**), thence across to the movable contact (**B**), from which it is led through the contact brush (**E**), into the metallic framework of the magneto, whence it returns to the beginning of the primary winding, which is also connected or grounded to the frame (**GP**).

### Interrupter or Contact-Breaker

**The interrupter,** also called a "contact-breaker." To accomplish this breaking of the primary circuit at the proper moment and then to close it again, a device known as a "circuit-breaker" or "interrupter" is used. This is carried on the armature shaft opposite the driving end.

In order clearly to explain the construction of an interrupter, exaggerated illustrations will be used as, for instance, in Figs. 8 and 8A.

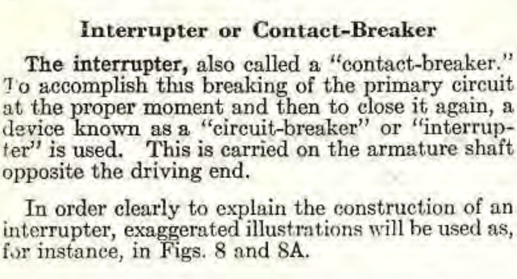



Fig. 8 Fig. 8A

It consists essentially of a stationary insulated contact point (**A**), (Fig. 8), and a movable contact point (**B**) on one arm of the bell crank (**C**). Both of these parts are mounted on a brass disk (**D**), which is securely fastened to the armature shaft and rotates with it.

The stationary contact (**A**) is insulated from the supporting disk (**D**), while the movable contact (**B**) is in metallic connection with it, and the disk (**D**) is grounded to the frame of the magneto by a carbon brush (**E**). (See also Fig. 2.)

**The circuit-breaker** is surrounded by a cylindrical housing (**F**), to the interior surface of which, at diametrically opposite points, are secured steel cam blocks (**G** and **G1**).

Ordinarily the two contact-points (**A** and **B**) are kept in contact by a spring (**H**). As the disk (**D**) rotates, the outer arm of the bell crank (**C**) comes in contact with the cam blocks (**G**), whereby the contact-points (**A** and **B**) are separated momentarily, as in Fig. 8A.

As soon as the end of the bell crank (**C**) passes the cam block (**G**), the spring (**H**) brings the two contact-points (**A** and **B**) together again, as in Fig. 8.

The stationary contact-block (**A**) is connected with one end of the primary winding of the armature, through a screw (**I**, Fig. 2), which is screwed into the center of the armature shaft.

The other end of the primary winding has metallic connection with the armature core; in other words, it is grounded, as at (**GP**), (Figs. 1 and 2).

### Secondary Winding and Circuit

The beginning of the secondary winding (**SW**, Figs. 1 and 2), is connected to the end of the primary winding at (**N**) (Fig. 1), and since one end of the primary winding is grounded at (**GP**), the secondary is also grounded through the primary. The end of the secondary winding leads to an insulated contact ring (**O**) (Fig. 2), at the driving end of the magneto.

From this ring the current is taken off by a carbon contact-brush (**P**). From the brush holder the current is carried through a spring contact-conductor (**Q**) to the central distributor contact (**R**).

**The collector ring** is made of hard rubber with a brass ferrule (**O**) surrounding it, against which ferrule a heavily insulated stationary carbon pencil (**P**) bears. The hard rubber spool has wide flanges for the purpose of preventing the high-tension current from escaping.

### Secondary Distributor

**The distributor** consists of a disk of insulating material (**S**), in which are imbedded on the inner side one central cylindrical contact-piece (**R**) and four annular sector-shaped contact-pieces (**U, U, U, U**, Fig. 1).

The distributor also comprises a shaft (**V**, Fig. 2), which carries a gear wheel (**W**) meshing with a pinion (**X**) on the armature shaft. The gear wheel (**W**) has twice the number of teeth as the pinion, and the distributor shaft (**V**) therefore makes one turn while the armature makes two.

**Distributor speed:** The reason for driving the distributor at one-half the armature speed is as follows: The armature, as already stated, turns at the speed of the engine crank shaft. The magneto here described is for a four-cylinder, four-cycle engine. In such an engine, each cylinder requires a spark once in two revolutions of the crank shaft.

The distributor is therefore geared so that it makes one revolution to two revolutions of the crank shaft and establishes connection between the high-tension or secondary winding of the armature and the spark plug to each cylinder once in every two revolutions of the crank shaft.

Regardless of the number of cylinders an engine may have, the distributor rotor always turns at engine cam-shaft speed.

The gear wheel (**W**) carries a brush holder (**Y**) containing a carbon brush (**Z**), which is adapted to make contact simultaneously with the central distributor contact (**R**), and with one of the annular distributor contacts (**U**).

This type of distributor is the "brush" type, as it makes a wiping contact. The "gap type" is shown in the Berling, explained farther on.

**The distributor sectors** (**U**, Fig. 1), are surrounded at the inside and outside by annular rings of a highly insulated material, since they carry the high-tension current.

Each of the four annular contact segments (**U**) has secured to it a binding post (**T**) on the face of the distributor disk, and each of these binding posts is connected by a high-tension (highly insulated) cable to one of the spark plugs.

**The connections** from distributor terminals (T) to the spark plugs are connected according to the firing order of the engine.

If distributor rotor (Z, Fig. 1) revolved as shown by the arrow point and the firing order of the engine was, say, 1, 3, 4, 2, the terminals (T) would be connected with the spark plugs accordingly.

**The secondary circuit** to the spark plugs is from (P) (Figs. 1 and 2), to (R), to (Z), to (U), to (T), to spark-plug center electrode, through spark-plug gap (X), through engine to ground (GP) on the magnets to (N) (Fig. 1), where the secondary is connected with the primary winding.

There are numerous methods of **taking the current from the secondary winding on the armature,** but in the Bosch a carbon brush pressing on an insulated ring is adopted, thus allowing the armature to rotate freely, and also enabling the induced current to be drawn off.

The distributor is, in effect, a rotary switch, especially insulated and provided with a number of contacts equivalent to the number of cylinders on the engine.

**The distributor shaft** is mounted in a plain bronze bushed bearing (V, Fig. 2), which is lubricated by means of a wick oiler (e). A felt washer (d) encloses the inner end of the bearing, while at the distributor end is provided a channel (j) for the escape of any oil working out of the bearing so that it will not reach the distributor. A large-sized oil well (o) is provided for the wick oiler and is closed by a hinged cover (f) on top.

### Ground Brush

Some of the mechanical details of the magneto may be seen in Figs. 1 and 2, which are views of the Bosch model "DU4." It will be observed that a spring-pressed contact brush (a, Fig. 2) is placed in the base of the magneto bearing against the circumference of one armature end-plate. The object of this contact brush is to make absolutely sure that the revolving grounded metallic parts of the magneto are at all times in good metallic connection with the stationary part and the frame of the car; in this construction, therefore, the armature bearings carry no ground current.

### Magneto Condenser

**Condenser principle:** When the two contact points (A) and (B) of the interrupter (Figs. 1, 2, and 3) are suddenly separated, there is a tendency for the current to continue to flow across the gap, since it possesses a property similar to the inertia of matter. This would result in a hot spark being formed between the contact points, which not only would burn the points away rapidly, but also would prevent a rapid cessation of the current, which, as already explained, is necessary in order to effect a rapid change in the lines of magnetic force through the armature and a high inductive effect in the secondary winding. To obviate this effect a condenser (J, Figs. 1 and 2) is employed, which, in the Bosch magneto, is placed in a hollow of the armature end-cover at the circuit-breaker end.

**Condenser construction:** This condenser consists of two sets of tinfoil sheets, sheets of opposite sets alternating with one another, and being separated by sheets of insulating material. All the sheets of each set are metallically connected, and one set is connected to the conductor leading from the primary winding to the stationary contact point (A), while the other set is grounded. In other words, the condenser is shunted across the interrupter.

Such a condenser is capable of absorbing an electrical charge, and its capacity is so proportioned that it will take up the entire charge of the extra, or self-induced current produced when the contact points (A) and (B) separate; that is, the extra current, instead of appearing in the form of a spark across the gap between (A) and (B) passes into the condenser (J). In this way the objectionable arcing or burning at the contact points is avoided, and the current flow in the primary circuit is more quickly stopped. See Index under "Condenser principle."

### Magneto Safety Spark Gap

**Purpose:** This is practically a safety valve for the high-tension current. If, for example, a wire became detached from the sparking plug or from the distributor so that the ordinary path of high-tension current was barred, there would be considerable danger of the current forcing a circuit through the insulation of the armature, and thus doing very considerable damage, were it not given some easier escape.

In order to protect the insulation of the armature and all other parts from injury due to excessive voltage, a **safety-spark gap** (Z1, Z2, Fig. 2) is provided to permit the passage of the current to ground without injury. The current will pass across the safety-spark gap (X, Fig. 2) in case a high-tension cable is disconnected, if the spark-plug gap is too great, or if for any other reason the spark-plug or distributor circuit is open.

Discharge should not be permitted to pass through the safety spark gap for any great length of time, however. This should be particularly guarded against if the engine is operated on a second or auxiliary ignition system. When the engine is operated on such a system, the magneto should be grounded (by closing the primary circuit) in order to prevent the production of high-voltage current. See also Index under "Safety spark gap."

A magneto must be so designed that it will give a sufficiently hot spark at a comparatively low engine speed, and the ability to do this implies the ability of generating very large and hot sparks and enormously high tension at high engine speed.

The actual electromotive force or tension produced in the secondary winding is, however, limited by the size of the spark gap in the spark plug, for as soon as the tension reaches a point sufficient to jump this gap the discharge occurs, and there is no further increase in the electromotive force.

Suppose, however, that the terminals of the spark plug are by chance bent unduly far apart, or that one of the high-tension connections to the spark plug accidentally comes loose, then there would be no chance for the spark to pass in the ordinary way and the electromotive force in the secondary winding might build up to such an extent as to puncture the insulation of the winding, which would ruin the armature. To avoid this the safety spark gap is provided.

**Safety spark gap construction:** It consists of a little chamber (Fig. 2) formed on top of the armature cover plate with a top of insulating material (ZC). Into the top and bottom of this chamber, spark terminals (Z1, Z2) are set.

The spark terminal in the bottom is, of course, grounded, and that in the insulated top is connected with a high-tension contact brush (P) by a strip connector. Or, in other words, the safety gap is shunted across the secondary circuit.

The gap (**X**) between the two terminals (Z1, Z2) is longer than the gap between the spark plugs, and ordinarily no spark will pass between these terminals. But if, owing to the conditions already mentioned, no spark can pass at the regular spark plug and the electromotive force in the secondary winding attains an abnormal value, a discharge will occur at the safety spark gap, thereby preventing the secondary electromotive force from rising still higher.

**The width of gap** should be 5/16″ to ⅜″, and, of course, is always more than the width of the spark-plug gap, otherwise the spark would occur at the safety gap.

For high-compression engines it should be set at ⅜″. Under high compression, the sparks may fire across the safety gap instead of firing in the engine. Missing under such conditions can easily be remedied by opening the safety gap so that it will offer a greater resistance to the secondary current than the spark-plug gap, under compression.

A number of other illustrations are also shown of the Bosch DU4 magneto, in Figs. 3, 4, and 5, which may aid those not familiar with mechanical drawings to grasp the arrangement of the parts.

So far as the above description of the individual parts and their functions is concerned, it applies to any true high-tension magneto, that is, a magneto having both a low-tension and a high-tension winding on the armature.

Each of the elements here described is always present, and serves the purpose indicated, though the relative location of the parts varies somewhat.

### To Cut Off the Magneto Ignition; the Switch

It is necessary to be able to stop the magneto from producing sparks when it is desired to stop the engine. (See Fig. 2.) To this end a sheet-metal strip (**K**) is provided which makes contacts with the stationary contact point (**A**) of the circuit-breaker and leads to a binding post (**M**) on the circuit-breaker housing. From this binding post a wire is carried to a switch on the dashboard. One side of this switch is grounded.

**When the switch is closed** (Fig. 1), the current generated in the primary winding of the armature flows to contact-point (**A**), thence through strip (**K**), binding post (**M**), and connecting wire to the switch, whence it passes through a wire into the framework of the car and returns to the grounded primary (**GP**). The effect of this is that the primary winding is "short-circuited" all the time, and the opening and closing of the contact-points (**A**) and (**B**) has no effect. In other words, the circuit-breaker is "cut out."

**When the switch is open,** the circuit is then from primary circuit to (**A**), through points to (**B**), through ground (**GP**) to the other end of the primary. Thus when the circuit-breaker opens, it is in series with the primary circuit, and performs its regular duty.

**The flow of the primary current** can easily be followed in the diagram of connections (Fig. 1), where its direction when the magneto is working regularly is indicated by full arrows, and its return path when the magneto is running but not producing sparks, is indicated by dotted arrows.

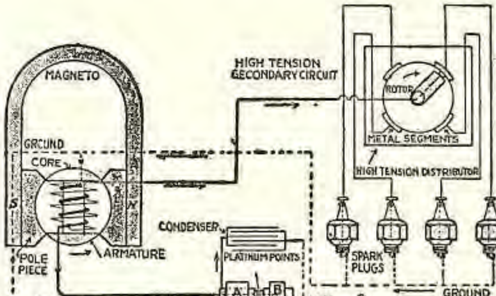



Fig. 9. Another simplified illustration of a high-tension magneto ignition system, showing circuit of primary wire winding on armature and its connection with interrupter. Note the condenser is "shunted" across the interrupter. Another view shows the distributor and spark plugs and connections. Dotted lines represent the earth or ground connection to frame.

## HIGH-TENSION MAGNETO IGNITION SYSTEMS

### High-Tension Magneto Alone

In Fig. 1, page 256, and in Fig. 1, below, note the high-tension magneto supplies current to the four spark splugs on a four-cylinder engine.

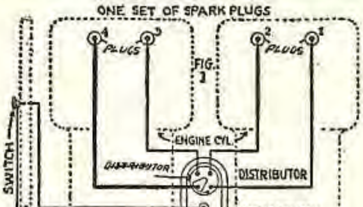



Fig. 1. A "single" high-tension magneto; engine is started direct from magneto current. Current is distributed to the one set of spark plugs. The switch connects to interrupter on magneto on one end, and to "ground" on the other. To stop magneto, the switch is closed, not opened.

The armature is double wound; therefore a separate coil is not necessary. The distributor on the magneto distributes the high-tension current to the spark plugs.

**The advantage of using a high-tension magneto** is that a well-designed magneto gives a very hot, fat spark and this spark exists for a definite period, thus firing all of the gas in each cylinder of the engine. The volume of the spark and the heat of the spark are important factors. Both are necessary to ignite the gas quickly, so that it will all be ignited before any part of the unburned gases can pass out of the exhaust. Thus it is clear that a heavy magneto spark has a very high degree of heat, whereas a lean spark takes longer to ignite the gas. Consequently, in the latter case, part of the gases have a chance to pass out the exhaust in an unburned state.

**The disadvantage** of this system is in starting. The armature on the magneto must be revolved fast enough to generate current before the spark will occur at the plugs. Therefore it is necessary to "spin" the crank. This is not very satisfactory unless an "impulse starter" or electric starter is provided to crank the engine. Hence this is one reason why "dual ignition systems" are adopted where a magneto is used. The starting of the engine is accomplished with a coil and battery system, and after the engine is started, the magneto is switched on.

**The magneto, using an impulse starter** (see Index) is used quite extensively on trucks and tractor engines, but is not used on passenger car automobile engines.

### Dual Ignition

**Dual system of ignition:** Where a car has two ignition systems, for instance, a "coil and battery" and independent "magneto," but both systems using one set of spark plugs, this system is called a "dual" ignition system.

Dual ignition is quite common where magnetos are used, that is, before the advent of the "impulse starter"; the idea being to have an auxiliary battery and coil system to start on, and the magneto to run on.

**There are two general principles** of dual systems, which were formerly used to a great extent: the "low-tension magneto" and a separate "high-tension coil" and battery—as explained in pages 247, 254. The coil and battery were used for starting the engine; after starting, the magneto supplied the current to the coil.

The other method is the use of a "high-tension magneto" and a separate and distinct "high-tension coil" and battery ignition system. The engine is started on the battery and coil system, then switched over to the high-tension magneto which is independent of the coil and battery.

An example of a dual system using a high-tension magneto and separate high-tension coil and battery is shown in Fig. 2.

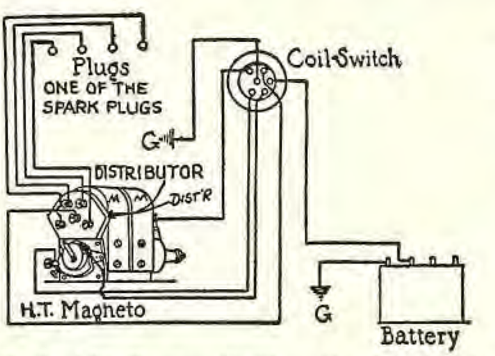



Fig. 2. A "dual" system of ignition; either the high-tension single coil with battery (using the distributor on the magneto) may be used or the high-tension magneto alone, may be used. Only one set of spark plugs.

### Double Ignition

**Double system of ignition:** Where two sets of spark plugs are used with two independent ignition systems, this is called a "double" system. An example of a "double" ignition system using a battery, high-tension coil, timer, and distributor for one system, and a high-tension magneto for the other with two spark plugs in each cylinder, is shown in Fig. 3. Either of the two independent ignition systems can be used separately, or both can be made to operate at one time.

**The positive (+) terminal** of the battery is grounded and the negative (−) terminal led to terminal (5) of the stationary switch plate at the rear end of the coil. Switch terminal (1) is then connected with the binding post located on the under side of the timer-distributor. The second binding post on the timer-distributor, which is

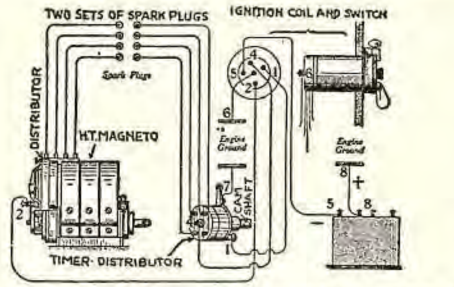



Fig. 3. Bosch "double" system of ignition—two sets of spark plugs and two independent ignition systems.

located on the under side of the timing control arm (7) is grounded. Switch terminal (2) is connected to the grounding terminal of the magneto.

**The distributor contacts** on the magneto and timer-distributor are connected in accordance with the firing order of the engine.

**When the switch lever is in the off position,** the battery circuit is broken and the magneto is grounded, in consequence of which no sparks will be produced when the motor is cranked.

**With the switch lever thrown to the battery side (B),** the magneto will continue grounded, but the battery circuit will be completed, and, in consequence, the breaking of the circuit by the timer-distributor will result in the production of a spark that will be transmitted to the proper cylinder by its distributor.

The same condition will exist **with the switch lever thrown to position (MB)** (where both the magneto and the coil and battery are in operation), except that then the magneto ground circuit will be broken and magneto sparks will be produced in addition to the battery sparks.

**With the switch lever thrown to position (M),** or the magneto alone, the magneto will operate in the normal manner, and the battery circuit will be broken.

### Two-Spark Ignition System[1]

Here we have two distributors on the one magneto, and two spark plugs are provided for each cylinder. The principle is similar to the "double" system, except that the one high-tension magneto has two distributors.

**The purpose** of the two-spark magneto (Figs. 4 and 5) is to produce ignition at two plug points in

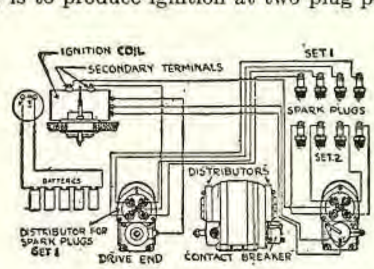



Fig. 4. Remy two-spark magneto ignition system; one magneto with two distributors connecting with two sets of spark plugs.

[1] The "two-spark" system was formerly used on the Stutz and Mercer. It has also been used on some Fiat, Locomobile, and Marmon cars. Some of these cars are now using a two-spark coil and battery ignition system.

each cylinder, in order to reduce the time interval between ignition and complete combustion; and, where it is possible, to locate two spark plugs in each cylinder (usually in T-head engines, one set of spark plugs being placed on the inlet side of the engine and one set on the exhaust side). The result is to reduce the ignition advance necessary, and thus to secure an increase in the efficiency and output of the engine.

**The advantage of having two spark plugs fire at one time in each cylinder is the resulting increase of power and speed, explained as follows:** By referring to the subject of "ignition timing," we learn that there is a difference between the time when the spark occurs and the actual time of combustion. Therefore with a weak spark, the time of the spark is made to occur earlier, that is, "advanced," before the piston reaches the top of the compression stroke, in order that it may have time to ignite the gas, combust, and expand before the piston gets too far down on the power stroke. With a "double" system or "two-spark" system, or a good hot spark, this advance of ignition is less, as the combustion is almost instantaneous. Consequently, with less advancement of spark, there is less liability of firing back on the piston before it reaches the top of the compression stroke. Furthermore there is a saving of gasoline, because with a good hot spark, all of the gasoline is ignited and used for power instead of part of it passing out of the exhaust, not fully ignited. In other words, a weak spark produces slow combustion, and a hot spark quick combustion.

The Remy two-spark magneto is shown in Fig. 4 and the Bosch two-spark magneto is shown in Fig. 5.

### Bosch Two-Spark Magneto

The types "ZR4" and "ZR6" Bosch magnetos are produced with the two-spark, independent or dual form. The noticeable difference in the two-spark magneto from the single-spark magneto is in the double distributor (**DD**) (Fig. 5) and arrangement of the safety spark gap under the arch of the magnets.

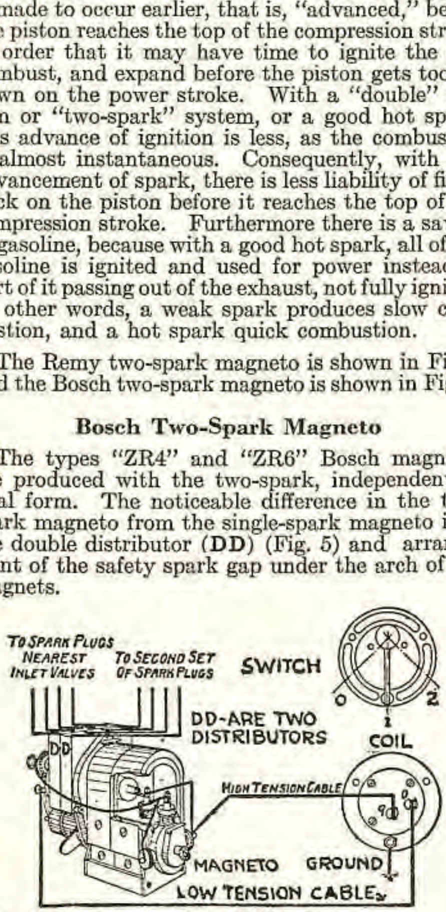



Fig. 5. Bosch two-spark magneto ignition system.

Fig. 5A (upper). Switch: 0, off; 1, one set of plugs operating; 2, both sets operating.

In the single-spark magneto, the beginning of the armature secondary circuit is grounded on the armature core through the armature primary circuit, whereas in the two-spark magneto, the two ends of the armature secondary circuit are connected to two sectional metal segments diametrically opposite on a single slipring.

Two slipring brushes are provided, which are horizontally mounted in brush holders on opposite sides of the shaft and plate. During the portions of the armature rotation when high-tension current is being delivered, each of the two slipring segments will be in contact with one of the brushes. One brush is connected to the inner distributor by means of a conducting bar similar to that used on single-spark magnetos. The second slipring brush is connected to the outer distributor by means of a short length of cable passing around the magnets. The rotating distributor piece is of double length and carries two brushes insulated from each other.

**The four and six-cylinder types** are fitted with eight and twelve distributor outlets respectively, each pair of outlets being connected to the spark plugs of the proper cylinder by the usual cables.

**Advance and retard:** The use of two-spark ignition permits the ignition lead to be cut down anywhere from 30 to 50 per cent. It will be understood that if the timing is correct for two-spark ignition, and one of the series of spark plugs is cut out of action, the remaining series will operate considerably in retard of what it would if the engine were timed for single-spark ignition. Therefore, if the two-spark ignition provides the full advance, the effect of retarding the spark is obtained by cutting out one series of plugs.

**The switch** (Fig. 5A) provided for the two-spark independent magnetos is so arranged that ignition may be secured, either with both sets of spark plugs, or with but one set. The purpose of this is to give the effect of retarding the spark, without altering the relation between the interrupter opening and the armature, as is done under normal conditions. The connections should be so made that the system of plugs that is operative when the switch is thrown to the single position is located near the inlet valve.

**In starting,** throw the switch lever to "single plug" position. This gives the effect of a retarded spark.

**For ordinary running,** operation should be on both series of plugs; **for slow work** through traffic, or when the engine is running idle, use the single plugs, or only one set.

**Timing:** "Time" in this connection refers to timing a single-spark magneto (interrupter retarded and piston on top of compression stroke). It will be found however that this timing will likely give two great a spark advance when the interrupter is fully advanced, as the two-spark magneto should have from one-third to one-half the advance of that of a single-spark magneto. Therefore retime, so that the interrupter points will open slightly later. A good method to follow is as given below.

**To replace a single-spark magneto with a two-spark instrument,** the maximum advance for the single-spark magneto is to be marked—preferably on the flywheel—and the two-spark magneto timed in the advanced position, so that the interrupter opens the circuit at a point midway between the mark on the flywheel indicating the single-spark advance, and that indicating top dead center retarded. A more exact timing may then be secured by experiment.

### Berling Type "D" Two-Spark Magneto

This magneto is designed for four, six, and eight-cylinder engines where the charge in each cylinder is ignited simultaneously at two separate spark plugs.

**The eight-cylinder type,** shown in Figs. 6 and 6A, is designed to operate at twice the crank-shaft speed, and the six-cylinder magneto at one and one-half crank-shaft speed. The four-cylinder is designed to operate at crank-shaft speed. This type of magneto is designed for heavy duty, marine, and aeronautical engines.

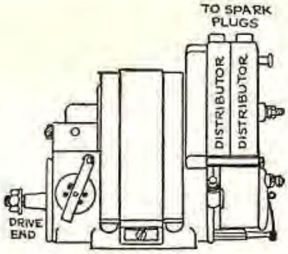



Fig. 6

In the type "D" two-spark Berling magneto, neither end of the secondary winding is grounded, but each is connected to one of the two separate segments on the collector ring.

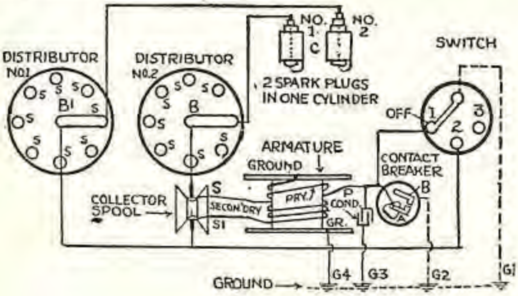



Fig. 6A

**The distributing mechanism** consists of two separate distributor blocks (Fig. 6) and one distributor finger carrying two separate distributor brushes (B), each brush connecting with the segments (S) of its respective distributor block. Thus, any two cable terminals directly opposite each other on the distributor blocks will practically possess an equal electrical potential relative to any part of the body of the engine.

When any two opposite cable terminals are connected each to one of two plugs in the same cylinder, the electrical circuit of the secondary or high-tension current will be closed the moment the spark gaps are bridged and that portion of the cylinder (C) between the two plugs forms part of the electrical circuit. The two sparks are the result of one break in the primary circuit by the interrupter, and are therefore absolutely simultaneous.

**When the switch is in position 1** (Fig. 6A), the primary winding of the magneto is short-circuited and the magneto is "off." Note that the circuit is from (P) to (1), to ground (G1), to ground (G4), to the other end of the primary winding at "ground."

**When the switch is on 2,** note that the primary circuit is open at 1. Therefore the interrupter points on (A) and (B) perform their regular duty of opening the closed circuit at the proper time. The path is from (P) through (A) and (B) to (G2), to (G4), to "ground," or the other end of the primary.

**The secondary circuit** is then from (S) to (B), to No. 1 spark plug, through ground of engine, to ground (G1), to (2), to (S1), or to the other end of the secondary. Thus the magneto acts as a single-spark magneto and the entire voltage generated in the magneto is concentrated on the one spark plug for starting, instead of being divided in half.

**When the switch is in position 3,** the primary circuit is the same as when on 2 (in action), but the secondary is not grounded. Therefore, the secondary circuit would be from (S), to one of the two separate segments on the collector ring, to No. 1 spark plug, through cylinder (C) to the shell of the other spark plug (No. 2), across the spark-plug gap, to the distributor brush (B1), to the other segment on the collector ring, to (S1), thus completing the secondary circuit through both distributors with the result that the two spark plugs, which are thus in series with the secondary circuit, both fire at one time in the same cylinder.

### Bosch Two-Spark Dual Ignition System

**When the switch** (Fig. 7A) **is thrown on the magneto side,** without the two-point switch (Fig. 7B) in the circuit, the path of the current is as follows: The low-tension current generated in the primary winding of the magneto passes through the breaker-points to ground. At the break of the points a high-tension current is set up in the secondary winding, this current leaving the magneto at 3 and passes to the point 3 on the coil, as indicated by the arrows. Then from point 3 to point 4 and thence to the distributor wire, along this wire to point 4 on the magneto. The distributor arm next receives the current which in turn is sent to the different plugs as indicated by the arrows. The current is sent to the ground after leaving the spark plugs, and the high-tension or secondary winding being grounded at one end, the secondary circuit is complete.

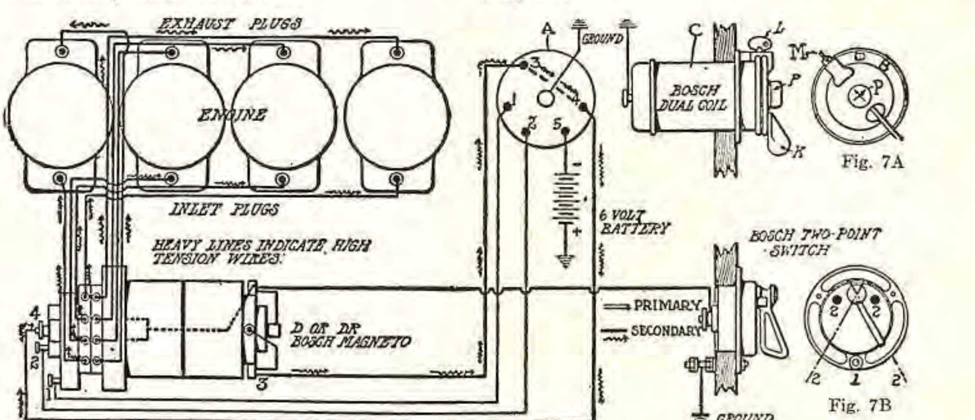



Fig. 7. Bosch two-spark dual ignition system. The coil parts (Fig. 7A) are: (L) key lock; (K) kick lever; (P) push button; (M) magneto operating both sets or one set according to position of two-point switch; (B) battery operating inlet plugs.

**When the two-point switch** (Fig. 7B) **is thrown so that both sets of plugs are to come into play,** both distributors of the magneto become operative. The path of the primary and secondary current to the magneto in this case is the same as before, but when delivered to the magneto, the current is passed to two distinct distributors instead of one. In this way two distinct electrical currents are distributed to two different sets of spark plugs.

**The coil and battery ignition** is used independently of the magneto by switching to the (B) side of the switch (Fig. 7A) and one or both sets of plugs are connected with the two-point switch (Fig. 7B) (*Motor Age*).

### Two-Point Ignition System

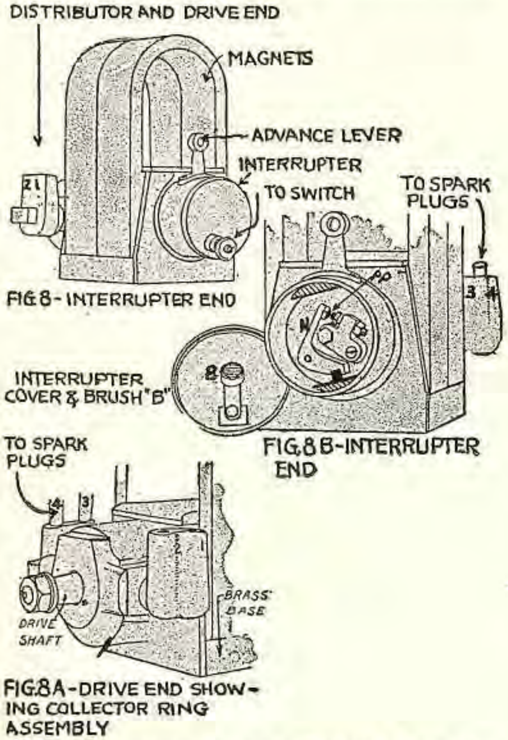
**The "two-point"** system is where two sparks occur at the same time but in different cylinders.

**On a four-cylinder engine,** the spark would occur at two spark plugs at once, but inasmuch as one of the pistons would be on exhaust stroke, this would make no difference.

The Bosch type "NU4" high-tension magneto is an example of a "two-point" system where two sparks occur at the same time, but in different cylinders.

### Bosch Two-Point Magneto Ignition

The type "NU4" Bosch magneto differs from the usual type of magneto in that the distinct gear-driven distributor, common to other types, has been eliminated, and in its stead is a double slipring combining the functions of current collector and distributor. Otherwise it is about the same as any other form of magneto.




**The spark occurs in two cylinders at one time** with this system, but one of the cylinders in which the spark occurs has not completed its exhaust stroke; therefore the spark does no harm.

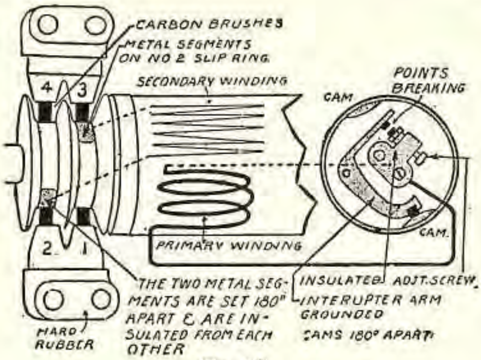



Fig. 8C

**The interrupter contacts** in the full retard position should open not later than top dead center of the compression stroke; therefore **the effective spark** is produced in the cylinder always toward the end of the compression stroke and **the surplus spark** will always occur near the end of the exhaust stroke and never during the inlet stroke. In any four-cylinder, four-cycle engine, regardless of firing order, when cylinder No. 1 is nearing the end of the compression stroke, cylinder No. 4 is nearing the end of the exhaust stroke, and vice versa; similar conditions apply also to cylinders Nos. 2 and 3.

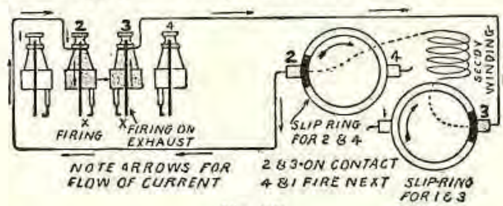



Fig. 8D

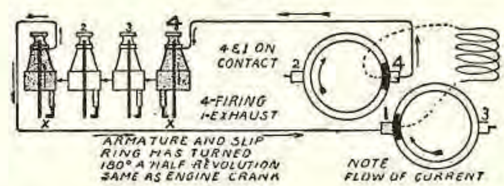



Fig. 8E

**The brushes,** when making contact with the metal strip in the collector rings, collect the high-tension current and carry it to the spark plugs. Note the connections from ring to plugs. When brushes 2 and 3 are making contact, follow the circuit in Fig. 8D, and note the arrow points. Now if the piston makes another stroke, or 180° travel, the armature will turn 180° or half a revolution also, as it runs at engine speed in the four-cylinder, four-cycle engine. Therefore the contact on the ring will turn 180° or a half-revolution and cylinders 4 and 1 will fire as in Fig. 8E. This type of magneto was used on the model 80 Overland.

**Timing the "NU4" magneto:** With the average engine, this result is obtained by connecting the magneto so that its interrupter housing is in full retard position, and the platinum interrupter screws just about to separate, when the piston of No. 1 cylinder is on top dead center of the compression stroke.

At the same time the metal segments of the slipring should be in contact with the brush marked "1" in each brush holder, and this can be observed by removing one of the holders.

The installation is completed by connecting the brush marked "1" with cylinder No. 1, and the other with cylinder No. 4, and the two remaining brushes, marked "2" and "3," with cylinders Nos. 2 and 3.

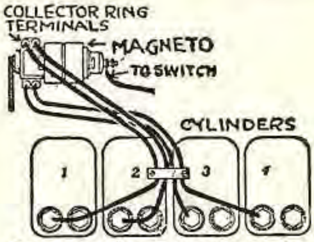



Fig. 8F. Note connections from collector ring terminals to spark plugs.

It is important to note that the type "NU4," driven, as it should be, at engine speed, produces a surplus spark in each cylinder exactly 360° behind the effective or power spark and, in coupling the magneto to the engine, it must be timed so that the surplus spark occurs during the exhaust stroke and not after the inlet valve has commenced to open.

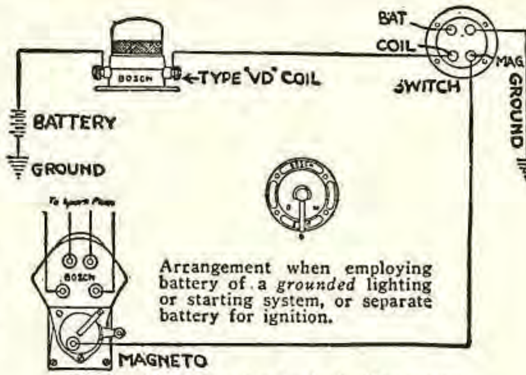



Fig. 9. Bosch vibrating duplex ignition system.

### Bosch Vibrating Duplex System

The Bosch vibrating duplex system is designed to permit easy starting on cars that are cranked by a starting motor at such a low speed that the ignition current from the ordinary magneto is insufficient to give certain ignition.

Do not confuse this system with an electric system of starting by movement of the crank shaft. The principle of this system is to supply a separate battery and vibrating coil to start the engine on, doing away with a dual system.

**How it operates:** The arrangement is such that, while the magneto circuit is absolutely independent and complete in itself, the battery circuit includes both the coil and the magneto.

**With the switch in the battery position,** the battery and coil are in series with the primary winding of the magneto armature, and the current from the battery supplements that generated by the magneto. Thus there is induced in the secondary winding of the magneto armature a very powerful sparking current, which, on account of the vibrator action of the coil, appears not as a single spark, but as a series of intense sparks that will act with certainty on any explosive mixture. The sparking current so produced is distributed in the usual way by the magneto distributor.

**After the engine is started,** the switch is turned to (M) side, and the coil and battery are disconnected.

## THE BOSCH DUAL-IGNITION SYSTEM

The parts of this system are shown in Fig. 10. This system provides a coil and battery system and a high-tension magneto system, both independent. One set of spark plugs and one distributor on the magneto is used for both systems.

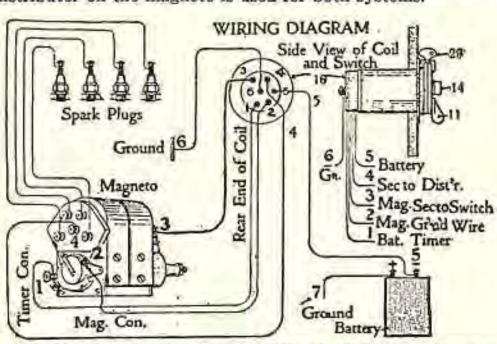



Fig. 10. Wiring diagram of the Bosch "DU4" dual-ignition system. The "DU4" type magneto is fitted with two interrupters as in Fig. 11, instead of one as generally used.[1]

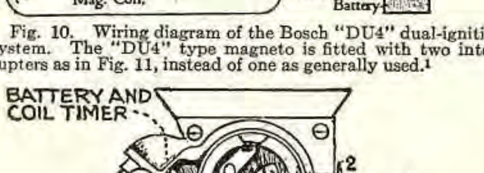



Fig. 11. The magneto is the regular "DU4" high-tension magneto fitted with an independent timer or interrupter for the coil and battery system. This contact-breaker has no electrical connection with the magneto. The second alteration from that of the regular single "DU4" high-tension magneto consists of the removal of the connection (see Fig. 2, page 257), which on the ordinary magneto connects the high-tension collector-ring to the distributor; when the distributor does duty for two ignition systems, the current must be carried to it through the switch, via wire 4 when the battery and coil system are switched on (see Fig. 10), or via wire 3 when the magneto is switched on.

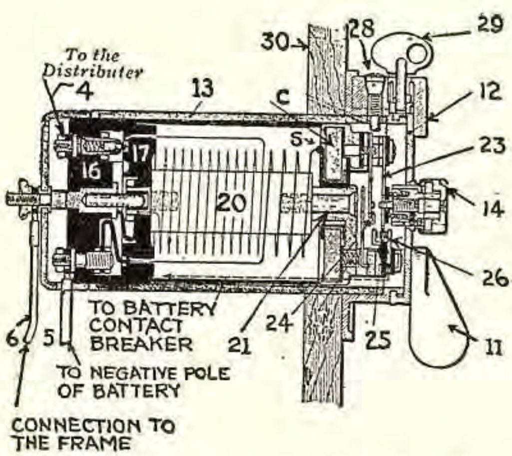



Fig. 12. The coil and switch (mounted on dash) are shown: The coil is a double-wound high-tension coil. The switch controls both ignition systems. Note that when switch (11) is turned, the coil with its core (20) and winding, and end of coil (17) turn also. Switch plate (16) is stationary.

Parts of the switch and coil are as follows: 11, switch handle (also called, kick-switch); 12, movable switch cover; 13, coil case; 14, starting press button; 16, fixed or stationary switch plate (see also, Figs. 17 and 18); 17, movable switch plate on rear end of coil (see Fig. 16); 20, iron core of coil over which primary and secondary are wound; 21, plate carrying starting arrangement and condenser; (C) condenser. Primary winding connects to it at (S); 23, contact spring; 24, trembler blade also called vibrator blade; 25, auxiliary contact-breaker; 28, screw holding switch plate to coil; 29, locking key; 30, dashboard or cowl.

[1] In practice, connections from distributor to spark plugs are not as shown; if so, it would fire 1, 2, 3, 4, whereas it should connect to fire 1, 2, 4, 3, or 1, 3, 4, 2. The main purpose of diagrams is to show the switch circuits


Fig. 13

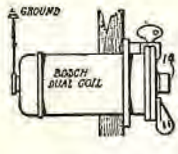



Fig. 14

Fig. 13. Front view of switch (M), magneto side; (B), battery side.

Fig. 14. Side view of switch and coil case.

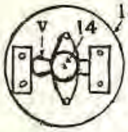



Fig. 15

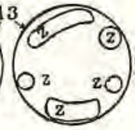



Fig. 16


Fig. 17


Fig. 18

Fig. 15. Front view of coil to which the switch is attached; (V) is the trembler or vibrator blade (26, Fig. 12); 14, the press-button contact.

Fig. 16. Rear movable switch-plate with busbars and connections (Z) on end of coil. (It is the part as shown at 17, Fig. 12.)

Fig. 17. Inner side of stationary switch-plate (as shown at 16, Fig. 12) showing connections 1, 2, 3, 4, 5, and 6, which make contact with connections (Z, Fig. 16) when switch is turned to (B) or (M) side.

Fig. 18. Rear-end view of switch-plate (16, Fig. 12) showing terminals to which wires are connected as shown in Fig. 10.

## Starting Engine

The engine is usually started by the switch being placed on the (B) or battery side; the interrupter (1) on magneto being used for the primary winding on coil and the distributor on magneto being used to distribute the high-tension current to the spark plugs. Otherwise the magneto has no connection with the battery and coil-ignition system when the switch is on the (B) side.

**In order to start the engine with the starting handle** (or electric starter, if one is provided), the press-button (14, Figs. 10 and 12) is pressed down and then turned at right angles, a process which locks it in position for the trembler spark.

**The engine can also be started on the switch** or "ignition," as it is often termed. The switch is turned to (B) side and then the brass press-button (14) is pressed down. Often this will start the engine, if the cylinder has a charge of gas in it. If not, then it will be necessary to crank the engine after locking the press-button as explained above.

**To understand this ignition starting feature,** see Fig. 19. The six-volt storage battery (or 10 dry cells) is supposed to be switched on (B) side.

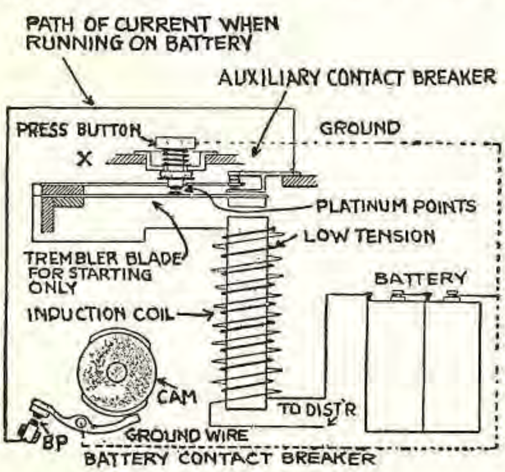



Fig. 19

Starting from the left-hand storage battery terminal (to make it easier to understand), the current passes through the primary winding and arrives at the end of the trembler blade and the blade above, called the auxiliary contact-breaker. The current cannot travel beyond the trembler blade because, as will be seen, the platinum points are separated. Neither can it complete the circuit along the auxiliary contact-breaker blade because the main contact-breaker (left-hand lower corner) also stands open, being the position in which the contact-breaker always comes to rest when the engine stops, save for the few occasions when the engine stops with the piston about dead center.

**To start the engine, therefore,** we have only to press the button so that the upper platinum point comes into contact with the lower one, and immediately the circuit will be completed, the trembler will start buzzing, and a shower of sparks will be sent through the plug of the cylinder which is next to fire. Now the work of the trembler blade is done, the engine has started, and the main contact-breaker is set in motion. The current troubles no longer about the trembler blade, but follows the upper path along the auxiliary contact-breaker and through the main contact-breaker, the making-and-breaking of which does the work of the trembler and creates the high-tension current. The engine may be kept running in this manner at the pleasure of the driver.

**The auxiliary contact-breaker** (Fig. 19): Now let us take the exceptional case of the engine stopping with the pistons about dead center and the main contact-breaker points (BP) closed. The current this time finds an easy circuit through the closed points, the iron core becomes magnetized, the trembler blade is held down on the core, and pressing the button as before has no effect. No spark is made because there is no break in the circuit. But if the reader will examine the diagram closely, he will observe that the act of pressing the button presses the auxiliary contact-breaker blade away from its upper platinum point and on to its lower one, the momentary break thus caused in the circuit being sufficient, under the circumstances we are supposing, to create the necessary high-tension current for the spark in the cylinder and so to start the engine.

**When the engine stops in the more usual way with the storage battery contact-breaker open,** the opening and closing again of the auxiliary contact blade has no effect. The diagram (Fig. 12) shows the coil as it actually exists.

## Battery and Coil Position

The illustration (Fig. 20) is supposed to represent the rear of coil and switch. Points 3 and 4 are not connected, consequently the magneto secondary circuit is open. Note that the magneto primary wire is grounded at 2; therefore it is out of service.

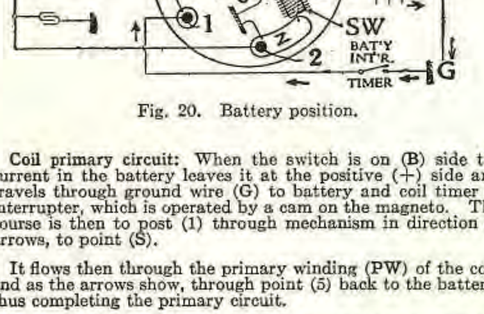



Fig. 20. Battery position.

**Coil primary circuit:** When the switch is on (B) side the current in the battery leaves it at the positive (+) side and travels through ground wire (G) to battery and coil timer or interrupter, which is operated by a cam on the magneto. The course is then to post (1) through mechanism in direction of arrows, to point (S).

It flows then through the primary winding (PW) of the coil, and as the arrows show, through point (5) back to the battery, thus completing the primary circuit.

**Coil secondary circuit:** In passing through the primary winding, a high-tension current is set up in the secondary winding (SW), when breaker-points separate.

This high-tension current flows to the distributor wire at (4), thence to magneto distributor (D). Here it is passed to the different spark plugs in order. It goes through the spark-plug center terminal across gap to shell of plug to cylinder, thence to ground back to other end of secondary winding (note lower end of secondary is grounded to bus-bar (Z) which is grounded with 6). The coil condenser is shown at (C).

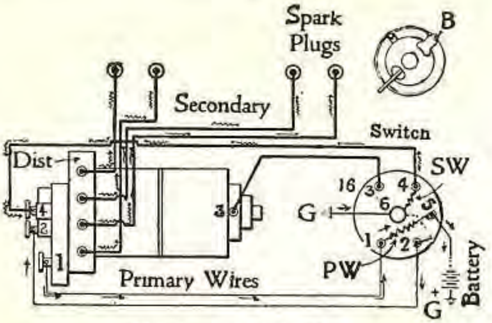



Fig. 21. Battery position.

The outside wiring of the battery and coil system is shown in Fig. 21, when the switch is on (B) side. (Note that points 3 and 4 are not connected, thus opening the magneto circuit.) The primary current leaves the battery and travels to ground (G). As (6) is grounded, current goes to (6), thence to (2) and along (2) to the magneto; then tc (1) on magneto along wire as indicated by arrows to the point (1) on switch plate (16). Here it travels through primary winding (PW) of coil then to (5) and back to battery, thus completing the primary circuit. The secondary circuit is from (4) to distributor, thence to spark plugs.

Note: When the switch is turned, the rear end of coil (Fig. 16), with the bus-bars (Z) moves and connects with the inner side of switch plate (17). Therefore, when the switch is thrown on (B) side the point (1) on switch-plate (17) lines up with point (1) (one of the bus-bars Z) on rear end of coil (Fig. 16); likewise (2) and (5) line up with bus-bars on the end of coil. A study of Fig. 20 will help make this explanation clear.

### Magneto Position

Note in Fig. 22 that the switch is now on (M) magneto side and there is but one closed circuit; it was made by connecting (3) and (4) on switch plate (16) with bus-bar (Z) on rear of coil. Note all other points of contact are open, including the magneto short-circuiting or grounding wire connected with (2).

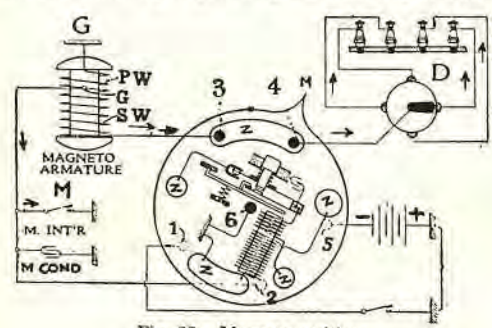



Fig. 22. Magneto position.

The magneto primary circuit is then from primary winding (PW) of magneto armature, to magneto interrupter (M), thence to ground. The other end of the primary winding (PW) is grounded, thus completing the primary circuit.

**The magneto secondary circuit:** One end of the secondary winding (SW) goes to (3) and (4) which are now connected with bus-bar (Z). From (4) it flows to distributor (D), thence to and through spark plugs. Here the current is grounded. The other end of the secondary winding (SW) is grounded, also by connection with primary wire, thus completing the high-tension circuit. Note the magneto condenser below the magneto interrupter.

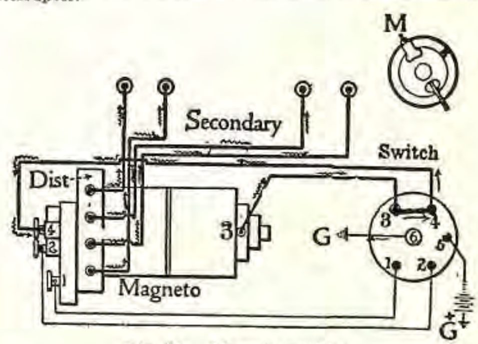



Fig. 23. Magneto position.

The outside wiring of the magneto position is shown in Fig. 23. Note points 1, 2, and 5 are not connected.

The high-tension (secondary) current generated in the magneto armature leaves the magneto at (3), travels to (3) on switch-plate (16), thence to distributor wire (4), then to the distributor, where it is then distributed to spark plugs.

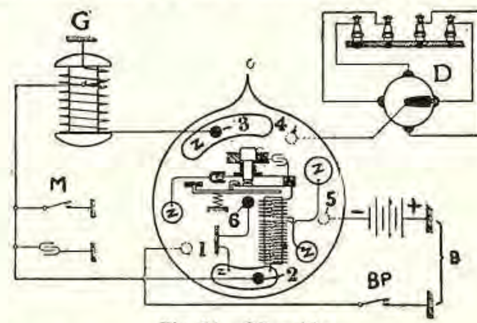
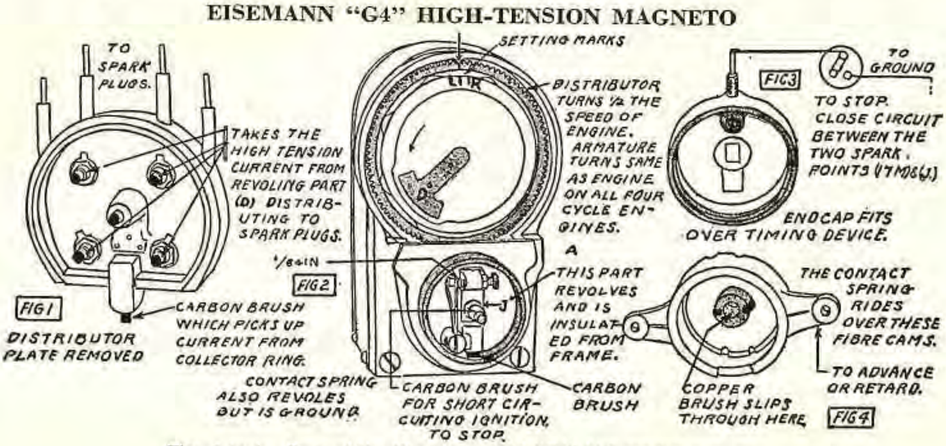



Fig. 24. Off position.

The off-position of the switch is shown in Fig. 24. Note in this position there is no complete circuit, as points 1, 5, and 4 of switch-plate do not coincide with points 1, 5, and 4 of coil switch-plate. Note, too, that the primary circuit of the magneto is short-circuited, or grounded at (2) on switch-plate; thus it is out of service. The magneto secondary circuit is open from 3 to 4.

## EISEMANN "G4" HIGH-TENSION MAGNETO




Figs. 1 to 4. Parts of the Eisemann model "G4" high-tension magneto.

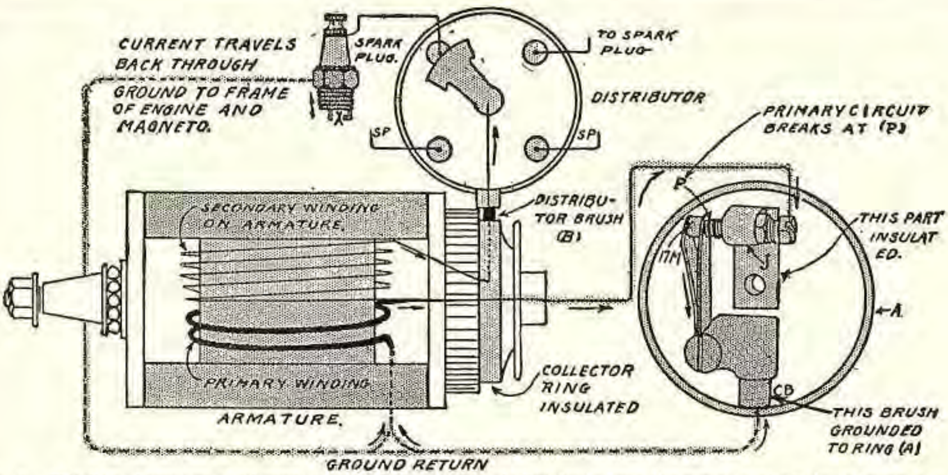



Fig. 5. Winding of armature and connections. **The primary winding** leads from the upper part of the primary winding to (J), to points (P), to (17M), to (CB), to ground, to the lower end of the grounded primary winding.

**The secondary winding** leads from the upper part of the secondary winding, to the distributor brush, to the spark plug, to ground, through the grounded primary winding, to the lower part of the secondary winding, where it is connected with the primary winding.

**The Eisemann "G4" type of high-tension armature-type magneto** differs from other Eisemann types in that the make-and-break or interrupter mechanism is constructed on different lines. The platinum contact springs (17M) (Fig. 5) connect with a carbon brush (CB), which revolves in a brass ring (A). Ring (A) is stationary, whereas the spring (17M) revolves with the other contact plate (J). Contact plate (J) is insulated from (17M). One end connects with primary winding on armature, and when contact is interrupted by (17M) and the point on the screw in plate (J), the spark is given as usual. Rings (A) and (17M) are grounded.

The points of (17M) and the screw on plate (J) are separated by the timing device (Fig. 4) which goes over the ring (A). The contact spring rides over the fiber cams.

The novel features of this system, besides the breaker, are: its accessible and efficient grouping of the working elements all at one end, and its waterproof qualities.

**To set the time of spark:** Place piston of No. 1 cylinder on top of compression stroke. Set interrupter points to break in full retarded position.

With these systems it is merely necessary to bring No. 1 piston to top dead center, rotate the magneto until the setting mark on the distributor is opposite the pointed screw at the top and couple up the drive. Use marks (R) or (L) (Fig. 2) for right or left-hand rotation, respectively, as needed—rotation being judged from the driving end.

**Adjustments:** The breaker gaps should be set .012" and spark-plug gaps 1/64" to 1/32".

**To stop or cut off ignition:** On all magnetos the magneto is stopped generating by closing or short-circuiting the primary circuit—not by opening the circuit, as in a coil system.

## EISEMANN AUTOMATIC SPARK-CONTROL MAGNETO

Construction of the Eisemann high-tension armature-type automatic spark-control magneto is the same as that of the standard high-tension magneto with the addition of the automatic mechanism.

As for the details of the method by which the **automatic timing is obtained,** a cage is mounted on an extension of the armature shaft, and a rectangular block slides in this cage. This block is drilled and threaded for the reception of a helically-cut shaft (T). This shaft is the driving shaft which is attached to the gearing. It has a thick, double thread which is square cut and the block slides back and forth on this threaded shaft.

Centrifugal governor weights are attached to the blocks by means of links. The weights fly outward when the shaft is revolved, and the action of the links causes the block to slide in the cage. In so sliding it travels along the threaded shaft, and as a result the block is slightly rotated.

**The drive of the magneto** is applied through the shaft which therefore is unyielding, and as the block rotates it carries with it the cage in which it works and the armature shaft to which the cage is fixed. The armature is thus advanced, and the contact-breaker, attached to the other end of the armature shaft.

When the speed drops, the reverse motion takes place, assisted by action of a spring against which the governor works at all times. With this device automatic advance may be obtained from 18° to 57°.

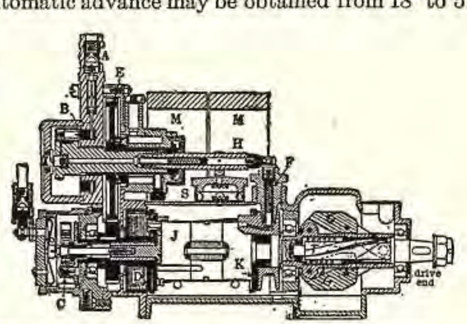



Fig. 6. Sectional view of Eisemann automatic spark-control magneto.

A—terminal to spark plug from distributor; B—distributor brush; C—contact-breaker; D—condenser; E—distributor gear on distributor to lower gear on armature; F—collector brush; G—governor weights; H—high-tension current conductor; J—armature; K—collector spool at end of armature; M—magnets; S—safety spark gap; T—spiral thread for spark advancing by centrifugal force action.

## MEA MAGNETO

In the "Mea" high-tension armature-type magneto the design is such that the **magneto field can be moved round simultaneously with the contact-breaker,** so that the armature is always in the same position relative to the field when the break occurs. This is effected by having a bell-shaped magnet mounted horizontally, the axis of the armature and the magnet coinciding. As the contact-breaker is moved, so also is the magnet to a similar distance, and the result is that the spark is of ample strength at the retarded position, even allowing for the slow speed of rotation. This bell-shaped magnet (Fig. 1C), it is claimed, has some other advantages over the ordinary U-shaped magnet, inasmuch as it can hold a greater amount of magnetism and retain it at full strength for a longer period. The range of advance and retardation on this magneto is 40°. The armature and distributor are made practically on the lines of the standard magneto with fixed magnets.

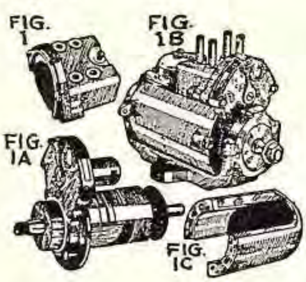



FIG. 1D. Advanced.

FIG. 1E. Retarded.

Fig. 1. Parts of Mea magneto: Cover: **1A**, armature and distributor units; **1B**, complete machine; **1C**, movable bell-shaped field magnets. The relative positions of the pole pieces and armature are shown in Figs. 1D and 1E. Note that 1D shows the armature advanced, and 1E in retarded position, showing that the "maximum position" where the armature breaks from the pole piece is not altered.

**Timing the "Mea" magneto:** Unless the timing of the magneto can easily be changed by advancing or retarding the gear driving the magneto, the coupling should not be keyed to the tapered shaft before the magneto is first placed on the engine, but it should be clamped on so that the timing may still be somewhat modified if found desirable.

Place the magneto in the position of its maximum retard (Fig. 1E), by turning the magneto housing or timing lever in the direction of the armature rotation. Remove the cover from the breaker box and turn the armature shaft in direction of rotation until No. 1 appears on the indicator (Fig. 1B) in the front plate of the magneto, and until the contact-breaker begins to open.

With the dual-type magneto, remove the cover over the battery breaker (driven end of magneto), and the number of the cylinder firing can be seen opposite the red line on the magneto housing. Turn the armature of the magneto until No. 1 on the distributor gear is opposite the red line on the housing and until the magneto-breaker (not battery-breaker) just begins to open. Then turn the engine to dead center of cylinder No. 1, and if of the four-cylinder type, about 1½" beyond, measuring on the circumference of the fly wheel, or from 1/16" to 3/32" downward on the explosion stroke. With six-cylinder engines, it is preferable to time full retard only slightly beyond dead center.

After the magneto and engine have thus been set, effect a positive connection between the two. Of course contact hole No. 1 of the distributor is connected with cylinder No. 1 by means of cables, and so on until all the cylinders are properly connected.

With the "Mea," the engine should be started with the spark fully retarded, and by increasing the speed gradually it can readily be determined if the engine will stand all the advance which the magneto can furnish with the original setting, or whether the whole timing can be further advanced. After it has become assured that the best timing is obtained, the coupling should be keyed to the magneto shaft.

## DIXIE MAGNETO[1]

The large number of magnetos commercially in use prior to the advent of the "Dixie" were of the "armature type." It is therefore necessary to make a comparison in order thoroughly to explain the "Dixie."

### Armature-Type Magneto

An "armature"-type magneto is shown in Figs. 1, 2, and 3. Referring to Fig. 1, note that the magnetic lines-of-force, hereinafter referred to as "flux lines," flow from the N to the S pole of the U-shaped magnet through the revolving armature in the direction indicated by the arrow. The shaded end (E) of the armature is shown in the figure as being under the influence of the N pole of the magnet.

In Fig. 2, the armature has revolved to the right sufficiently for the end (E) to come under the influence of the S pole of the magnet. Immediately the direction of the flux lines is reversed through the armature as shown by the arrow, and at the instant that current is generated in the winding about the armature, the spark occurs. In practice, more than

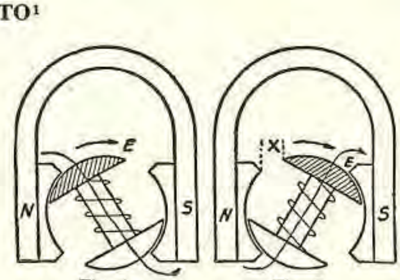



Fig. 1 Fig. 2

one winding is employed, also an interrupter and a condenser are used. But the function of these parts need not be referred to here, it being the purpose now to show only the differences in the operation of the **magnetic circuit** of the two types.

Now it is obvious that the mass of iron in the armature must reverse its magnetic polarity. In Fig. 1, it is saturated with magnetism flowing in one direction. In Fig. 2, the direction is reversed. This reversal must take place in each rotation, so at high speeds the quicker the iron reverses the better the spark. As a laminated armature, or one built up of a number of pieces of iron, reverses quicker

[1] Most of the text has been taken from the printed circular of the Dixie magneto.

than a solid one, all good armatures are laminated. But it is also evident that to secure the desired amount of current the armature must be of a certain size to contain the necessary wire, and therefore contains a certain amount of iron in some form. Now, the more iron beyond a certain limit, the slower the reversal; also the reversal is not as abrupt.

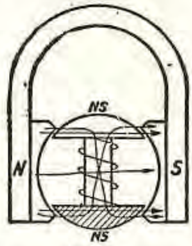



Fig. 3

Fig. 3 shows the "neutral" position of the armature wherein it is subject to flux-flowing across through its ends as shown. This position does not permit of an abrupt change of flux-flow as hereafter described, and such as occurs in the Dixie. The armature is never completely out of the flux, but simply turns around in the flux-stream, twisting the lines about, but not actually abruptly breaking them.

**Dixie Principle**

The "Mason" principle, on which the Dixie operates is shown in Fig. 4. The magnet has two rotating polar extremities (N) (S), which are always of the same polarity, never reversing. These poles are in practical contact with the inner cheeks of the permanent magnet (M), all air gaps being eliminated. Together with the U-shaped magnet, they form a magnet with rotating ends.

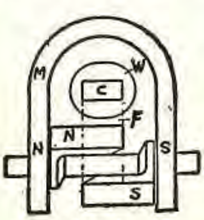



Fig. 4

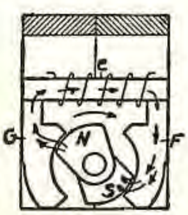



Fig. 5

The magnet is positioned at right angles to the rotating poles or ends of a field structure consisting of laminated pole-pieces (F) and (G) (Fig. 5), carrying across their top the laminated core (C) carrying the windings (W). When (N) is opposite (G) the flux flows from one pole (N) of the magnet to (G) and through the core (C) to (F), this action corresponding to what happens in the armature type with the armature in the position shown in Fig. 1.

In Fig. 6, the pole (N) has moved over to (F) and the direction of the flow of flux is reversed, it now flowing from (F) through (C) to (G).

Fig. 7 represents the rotating poles occupying a position midway between that shown in Figs. 5 and 6. Here the field pieces (F) and (G) are magnetically short-circuited, as it were, thereby completely scavenging stray lines of flux out of the core (C). Compare this with the uncertain corresponding action that takes place in the armature type, when the armature is in the same position (Fig. 3).

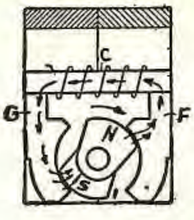



Fig. 6

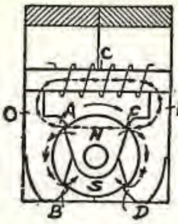



Fig. 7

Now the first great difference between the Dixie and the "armature" type is in the fact that the rotating poles in the Dixie do not reverse their polarity at any time, consequently the lag due to the magnetic reluctance in this part is eliminated. This partly accounts for the high efficiency of the Dixie at low speeds, for motorcycles and for high-speed engines. In the Dixie, the windings are never actually in the field. The flux is shot through them, as described, producing a hot, "snappy" spark of peculiar and highly efficient igniting power, owing to the quick break and absolute reversal of the flux at each revolution.

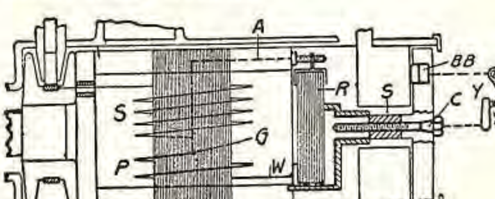



Fig. 8. Armature-type magneto armature.

**With the armature-type machine,** it is the central core or part actually enclosed by the winding that is laminated, as the ends adjacent the windings must be solid. In the Dixie type, not only the core (C), around which the wire is wound, is laminated, but also the pole shoes (G) and (F), consequently all parts of the magneto subject to reversal of flux are "laminated."

**The armature-type magneto** (Fig. 8) has a rotating element carrying windings, a laminated core, a condenser, a collector ring, etc.

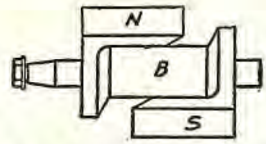



**Fig. 9.** Rotating element in Dixie.

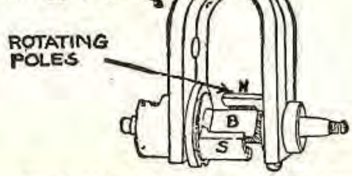



Fig. 10. Showing how the rotating poles (Fig. 9) are placed between magnets of Dixie magneto.

**The Dixie rotating element,** or armature construction, consists of two pieces of cast iron (N and S) (Fig. 9), and a brass block (B) placed between them. There are no rotating wires. Figs. 10 and 4 show more clearly how they are positioned between the poles of the magnets. On the four and six-cylinder magneto, there are two N and S poles and on the eight and twelve-cylinder magneto there are four.

**The generating winding** (W) (Fig. 4) in the Dixie is carried on a small coil placed across the upwardly projecting ends of the two pole-pieces (C) (Fig. 4).

### Comparison of Primary Circuits

Fig. 8 shows **the usual primary circuit** in the armature-type machine, and Fig. 11 the same circuit in the Dixie. (A) (Fig. 8) denotes the revolving armature on which is wound the primary winding (P) and the secondary (S). Grounding brushes (B) and (BB) are necessary to insure a good contact between the grounded end (G) of the primary and the breaker point (X), the latter being positioned in the breaker mechanism which is movable for timing purposes. It will be seen that the free end (W) of the primary connects to the condenser (R), and attention is called to the fact that this condenser is built into the armature and revolves with it, and the armature must be disassembled to get it out. The shaft (S) is made hollow, and a bolt (C) is carefully insulated where it passes through. This bolt connects the free end of the primary and the condenser to the insulated point (Y) of the breaker which revolves as a unit with the armature.

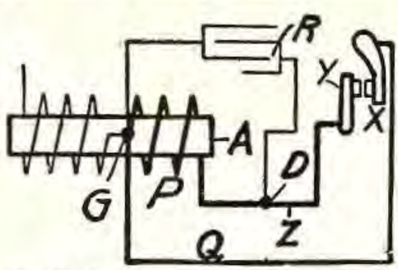



Fig. 11. Simple primary circuit of Dixie. No brushes or contacts except breaker points.

In the Dixie, the core of the coil (A) (Fig. 11) is stationary, and the inner end (G) of the primary winding (P) is grounded on the core. (Q) indicates the metal frame of the machine, which is put together with screws, so that there are no brushes or sliding contacts. Therefore brushes (B) (BB) (Fig. 8) are eliminated.

The brush (B) is necessary in the armature type to insure a good circuit from the revolving armature to the frame of the magneto and thence to the engine.

The condenser (R) in the Dixie is positioned immediately above the coil and is readily removable, it being only necessary to take out two screws. This condenser does not revolve as in the armature type. The terminal (D) is a screw on the head of the coil, and the wire (Z) connects to the contact (Y) of the breaker.

### High-Tension Circuit

Fig. 12 shows **the high-tension circuit in the armature-type machine.** In the metal armature head (A) is the insulating bushing (B), through which the free end (C) of the high-tension winding passes. This connects to a metal ring (D) carried on the rubber spool (E). A brush (F) engages

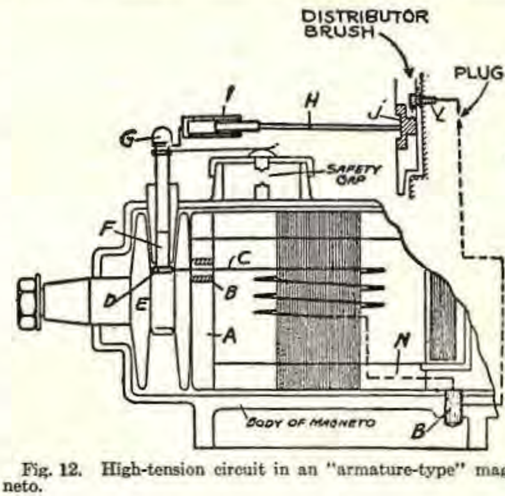



Fig. 12. High-tension circuit in an "armature-type" magneto.

the ring and carries current to the terminal (G), which in turn supports one end of connector (H), which has a sliding portion (I), so that it can be removed. The outer end of (H) connects at (J) to the traveling contact of the distributor, which in turn contacts on the segment (L), to which is connected the spark-plug cable. It will be understood that the high-tension circuit is completed from the frame of the armature (N) through brush (B) to the frame of the magneto and to the engine and spark plug.

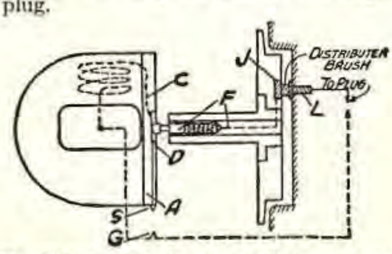



Fig. 13. High-tension circuit of Dixie magneto. Note direct path from spool to distributor; no revolving contacts except at distributor.

Fig. 13 shows the **Dixie high-tension circuit.** Here the end (C) of the high-tension winding goes to a metal plate (D) carried on the rubber side (A) of the coil. Against (D) bears a connection (F), which is practically one piece with the traveling contact (J), which connects to the spark-plug segment (L), the circuit being completed through the spark plug, engine frame, and frame of magneto in the usual manner without brush (G). The first difference to be noted in the Dixie construction is that the secondary winding being stationary, the spool (E), the revolving ring (D) and the brush (F) bearing thereon are entirely eliminated, as are also all their troubles, such as punctured insulation in the spool (E), wear of the brush (F), collection of oil on (D), etc. And the sliding connection (I) and member (H) are eliminated, their equivalent being a steel point (F) turning in contact with the plate (D).

### Safety Gap

**An efficient safety-gap arrangement** is provided by the point (S) arranged in proximity to the framework indicated at (G), (Fig. 13). The width of gap should be 5/16″ to ⅜″. **For high-compression engines** set ⅜″. Under high compression, the sparks may fire across the safety gap instead of firing in the engine. Missing under such conditions can easily be remedied by opening the safety gap so that it will offer a greater resistance to the secondary current than the spark-plug gap, under compression. Sparks should not be permitted to discharge across the safety gap for any length of time.

### Dixie Contact-Breaker or Interrupter

**Contacts are stationary** and do not revolve as in the "armature" type. See Fig. 14 and compare it with the armature type (Figs. 1 and 2, pages 256, 257).

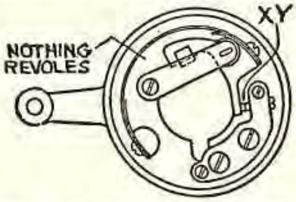



Fig. 14. Breaker (or interrupter) of Dixie magneto. A cam (Fig. 15) opens the points by raising the end of the arm. The cam is the only part of the breaker mechanism which revolves. Cam is not shown.

**To adjust Dixie interrupter points (XY):** This can be done while the magneto is running and the intensity of the spark can be seen while adjusting.

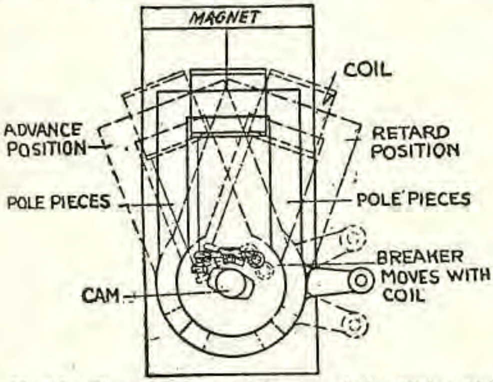



Fig. 15. Shows breaker and housing of the Dixie which, when retarded or advanced, moves the coil structure with which it is attached, giving the same intensity of spark at full advance or retard.

### "Armature"-Type of Magneto Timing

**The advance and retard of a magneto** is necessary to make up for the "lag" in engine operation as well as variation of speed, fuel, etc.

**Setting an "armature"-type magneto armature to the time of break of interrupter points** is usually accomplished by measuring the distance (X) (Fig. 2, page 271) between one of the pole pieces and the adjacent edge of the armature. The breaker is then adjusted so that the points are just separating. This is taken as the advanced position of the magneto, and with this setting the maximum spark is obtained.

**Timing an "armature"-type armature with engine:** The usual practice is to place the piston on top dead center of compression stroke with the breaker box fully retarded and with points just opening. This of course increases the width of opening of (X) (Fig. 2) with a corresponding weakening of the spark. To advance the spark, the breaker box is moved so that the points open sooner in relation to the piston, thereby obtaining the best spark when running.

It is clear that the spark will be weak at retard position, because gap (X) is wide. Consequently the sudden surge of the flux line through the armature has already passed its maximum.

It has therefore been customary with some armature-type magneto manufacturers to use a compromise setting for the breaker in which the maximum efficiency of the machine is not utilized at full advance setting on the engine. This compromise setting permits a mechanical advance in such magnetos of approximately 30°, but it is doubtful if in many of these machines the effective range exceeds 12° or 15°, as the maximum spark of the magneto is never utilized.

### Dixie Timing

**The advance and retard of the Dixie magneto** is obtained by shifting the breaker box. But note in Fig. 15 that it is attached to the "coil structure" (C-F-G, Figs. 4 to 7). Therefore the breaker housing and coil structure are all advanced or retarded at the same time. An absolute advance of 30° or more is obtained by simply rotating the coil-carrying structure to which the breaker box is attached, around the axis of the rotating poles N, S (Figs. 4 to 7 and 15).

**Setting Dixie armature or "rotor" to breaker points:** The distance (X) (Fig. 2, page 271) (armature-type illustration used to explain Dixie) is usually .020″, just as points are breaking. The maximum rate of change of flux occurs in this position of rotor (X, Fig. 2), where the rotor wings have just reversed the direction of the flux through the core.

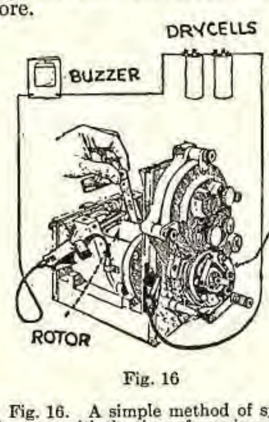



Fig. 16


Fig. 17

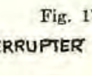



Fig. 18

Fig. 16. A simple method of synchronizing the position of the rotor with the time of opening of breaker points, is explained below, and as shown in Fig. 16. Contact points should separate .020″ when opened by cam.

If a buzzer is connected as shown, it will be in circuit with the contact-breaker points. While the contact points are closed, the buzzer will operate. Turn the armature slowly (direction of rotation) until the instant when the buzzer ceases. Just at this time the distance between the "rotor" and the "pole piece" should be .020″. The spark-plug gap is set at .025″.

Fig. 17. The breaker housing is adjustable. Being screwed to coil-carrying structure, it can be moved in the same direction as the cam operates—if rotor gap is too small. If too large, rotate in the opposite direction (to adjust for wear of fiber bumper also).

Fig. 18. Correct position of distributor brush in contact with segment (A) when breaker is fully advanced. Correct position prevents back-firing and tail-burning of distributor segment.

To facilitate this setting of the relation between the rotor and separation of contact points, a buzzer can be used, as shown in Fig. 16. The most effective distance for (X) is never varied on the Dixie.

**To position breaker or interrupter box** so that points open at desired point: Note that the breaker housing (Fig. 17) can be moved by means of set screws around the cam, so that the break can be made to occur without interfering with the adjustment of the points.

**To time the Dixie magneto to the engine:** (1) place piston on top of compression stroke; (2) uncouple magneto; (3) place breaker in retarded position; (4) rotate driving shaft of magneto in direction it is driven until platinum points are about to separate; (5) couple magneto; (6) connect distributor terminals as explained on page 294.

This timing is for the four and eight-cylinder magnetos, and also one and two twin-cylinder motorcycle type (M1 and M2); also Dixie models 11 and 21.

**On the eight-cylinder, the distributor brush** (A2, Fig. 20) should be in contact with No. 1 terminal of distributor block (see Figs. 22 and 23).

**To time six-cylinder, model "60" magneto,** place piston 1/16" ahead of the end of the compression stroke with timing lever in full retarded position and breaker points just separating. The distributor terminal is connected with No. 1 plug terminal.

**To time twelve-cylinder, model "120" magneto,** place the piston 3/16" ahead of the end of the compression stroke. With the breaker or timing lever retarded, turn the magneto drive shaft in the direction of rotation until carbon brush is in contact with the segment connected with terminal No. 1 of distributor block (Figs. 21, 24, and 25). When the points are about to separate, couple the magneto. See under Figs. 24 and 25 for distributor connections.

**Cams** on four and six-cylinder interrupters have 2 lobes; on eight and twelve-cylinder interrupters, 4 lobes.

### Dixie Eight-Cylinder Distributor

**Four sparks are produced during each revolution** of the drive shaft, at the instant of the "break" from the edge of the field structure. There are four rotating poles to the eight and twelve-cylinder magneto. On the four and six-cylinder magneto there are two.

**The magneto is driven at crank-shaft speed,** because an eight-cylinder magneto four-cycle engine fires four cylinders per revolution. This eight-cylinder magneto generates four sparks per revolution. As the firing of the cylinders takes place at cam-shaft speed, the distributor is geared down two to one of the armature shaft.

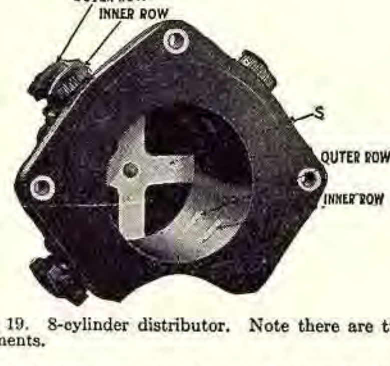



Fig. 19. 8-cylinder distributor. Note there are two rows of segments.

**Distributor:** On the four and six-cylinder magneto the segments are placed in one row, the proper distance apart. On the eight-cylinder magneto there are two four-cylinder distributors (Fig. 19), placed side by side, but moulded together, and having a double "finger" or rotor (Fig. 20). Contacts are so arranged that one segment in each row is alternately in contact. The rotor is hard rubber.

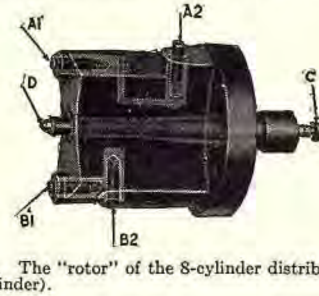



Fig. 20. The "rotor" of the 8-cylinder distributor (also for the 12-cylinder).

**The high-tension current** is collected by brush (C) (Fig. 20), which is in contact with the high-tension winding (see Fig. 13, page 273), and conducted through the center of the "finger" or rotor, to brush (D), thence by means of a metal sector (S) (Fig. 19), moulded in the hard rubber block. The current is conducted to either of two sets of brushes (**A1, A2, B1, B2**, Fig. 20) in the wings of the distributor rotor.

These brushes, arranged in sets, become alive alternately at the moment when they are actually in contact with a segment in either of the two rows of four segments in the block, making it impossible for the spark to jump to the wrong segment, as in this manner a spark received at any post in the inner row of the block will be followed by a spark from a post in the outer row, but 180° away.

### Dixie Twelve-Cylinder Distributor

Four sparks are produced with each revolution of the drive shaft of the magneto. There are four rotating poles, the same as on the eight-cylinder.

Six cylinders must be fired with each revolution of the crank shaft. Therefore the magneto will turn 1½ revolutions to 1 of the crank shaft. The distributor is geared 3 to 1 of the armature shaft.

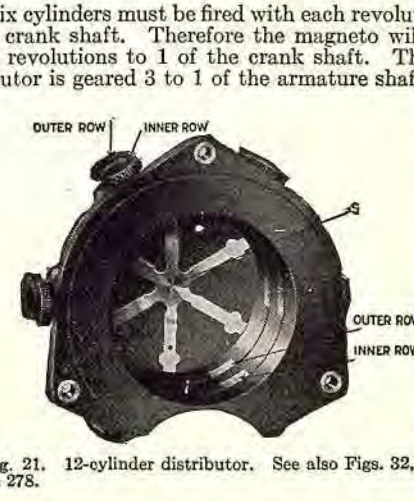



Fig. 21. 12-cylinder distributor. See also Figs. 32, 33, 34, page 278.

**The distributor** consists of two six-cylinder distributors moulded together as in Fig. 21. Note sector (S) in Fig. 21, how it differs from the eight-cylinder sector (S), (Fig. 19).

**The "rotor"** of the twelve is similar in construction, as in Fig. 20.

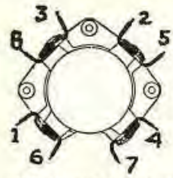



Fig. 22. Right-hand rotation.

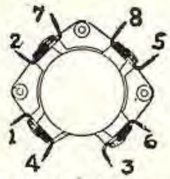



Fig. 23. Left-hand rotation.

Figs. 22 and 23 show order of sparks delivered by eight-cylinder distributor.

Figs. 24 and 25 show order of sparks of twelve-cylinder distributor.

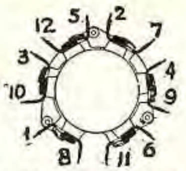



Fig. 24. Right-hand rotation.

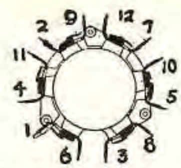



Fig. 25. Left-hand rotation.

Terminals on 24 and 25 are marked 1R–12R for right-hand rotation and 1L–12L for magnetos left-hand rotation.

Therefore, the right-hand rotation connects the cable from terminal 1R to spark plug No. 1 cylinder; cable from 2R to spark plug next in sequence of firing, and so on.

### Parts of the Dixie Magneto

**To replace parts** on the Dixie: First remove the distributor plate carrying contacts. Then pull out the travelling contact and all its insulation. This leaves the coil and metal plate—and, if the spark does not jump the safety gap, a new coil may be put in in a few minutes.

For timing the Dixie magneto, see page 274.

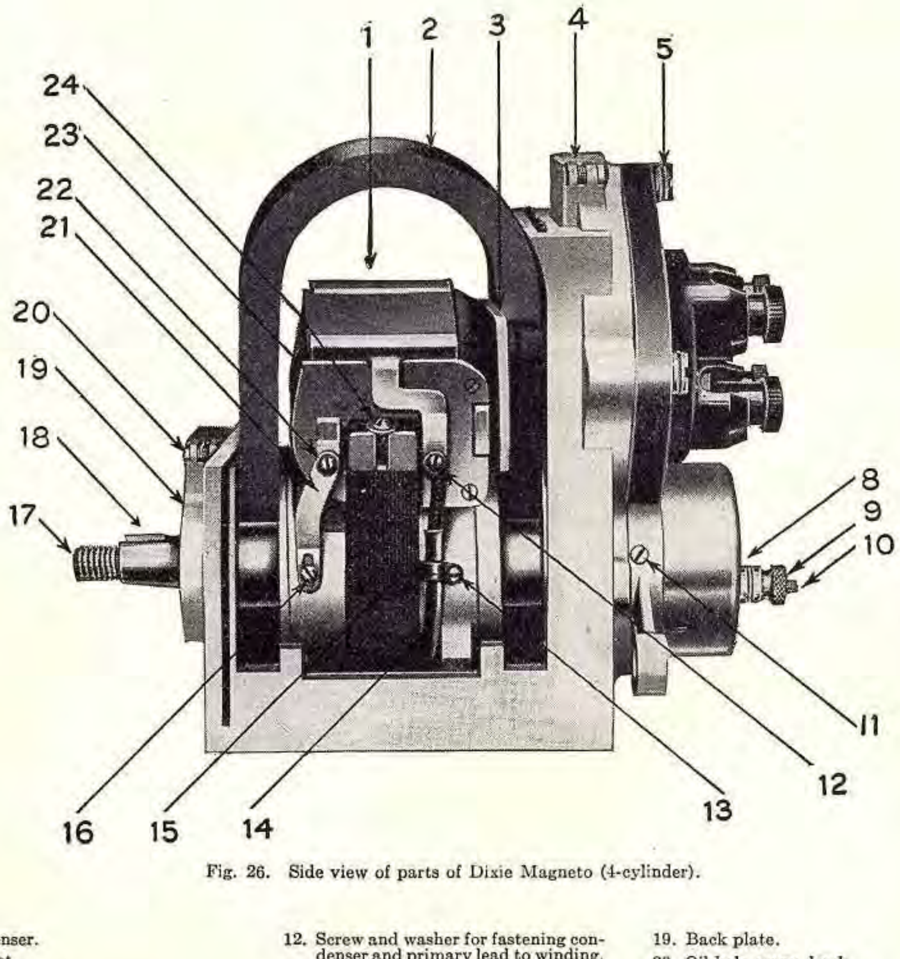



Fig. 26. Side view of parts of Dixie Magneto (4-cylinder).

1. Condenser.
2. Magnet.
3. Gap protector.
4. Oil hole cover, front.
5. Screw for distributor block.
8. Hexagonal nut for grounding stud.
9. Thumb nut for grounding stud.
10. Grounding stud.
11. Screw and washer for fastening breaker.
12. Screw and washer for fastening condenser and primary lead to winding.
13. Screw and washer for fastening primary-lead tube clamp.
14. Primary-lead tube.
15. Primary-lead tube clamp.
16. Screw and washer for fastening grounding clip to pole structure.
17. Rotor or armature shaft.
18. Woodruff key.
19. Back plate.
20. Oil-hole cover, back.
21. Grounding clip.
22. Screw and washer for fastening grounding clip to winding.
23. Winding.
24. Screw and washer for fastening winding to pole structure (Fig. 31).

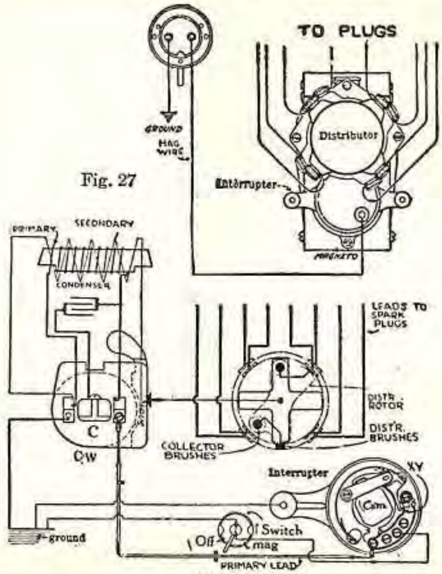



Fig 27. External wiring for an eight-cylinder engine.

Fig. 28. Internal wiring for an eight-cylinder engine. See Figs. 11 and 13, which will assist in making this diagram clear. Note that (CW) in Fig. 28 is the coil winding and connections. Above it is the internal wiring as an explanation.

### To Oil Dixie Magneto

After 200 hours of operation put oil at the point marked "OIL."

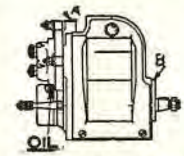



Fig. 29. Places to oil on Dixie magneto.

After every 20 hours of operation put two drops at (**A**).

After every 20 hours of operation put four drops at (**B**).

Fig. 30

Fig. 30. Pole structure in which rotating poles revolve and to which the condenser and coil winding attach to its upper part. See (24) and (16) in Fig. 26, showing how connections are made to it.

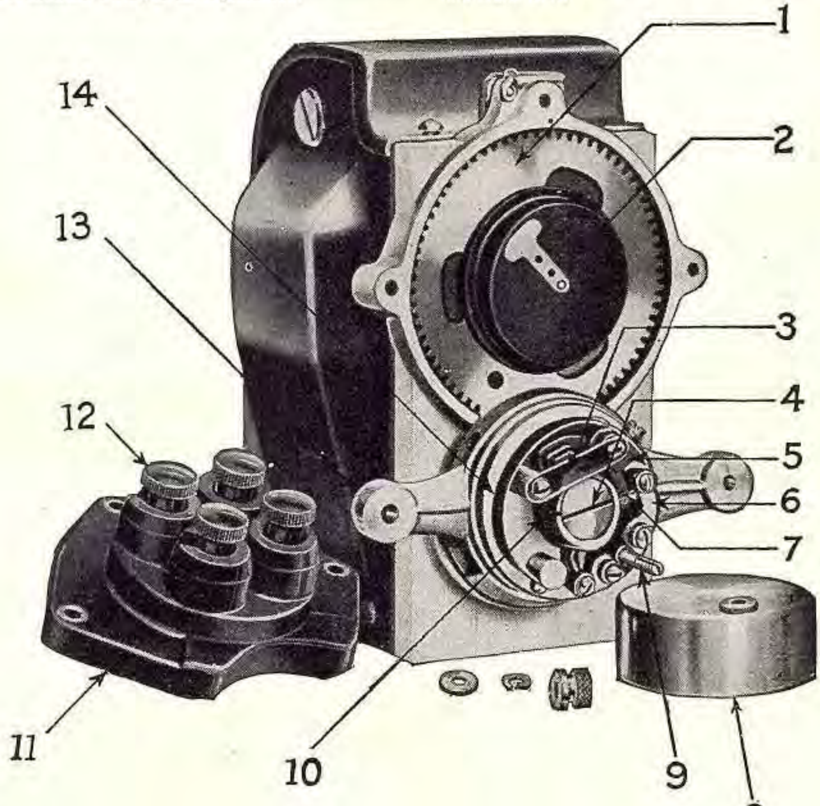



Fig. 31. Front view of parts of Dixie Magneto (4 cylinder).

1. Distributor gear.
2. Distributor disk.
3. Finger spring for breaker bar.
4. Cam screw.
5. **Breaker** bar with platinum point.
6. Contact screw bracket with insulation bushings.
7. Platinum contact screw.
8. Breaker-box cover.
9. Grounding stud or terminal post.
10. Cam.
11. Distributor block.
12. Thumb nut for distributor block.
13. Breaker advance and retard lever
14. Breaker bar spring.

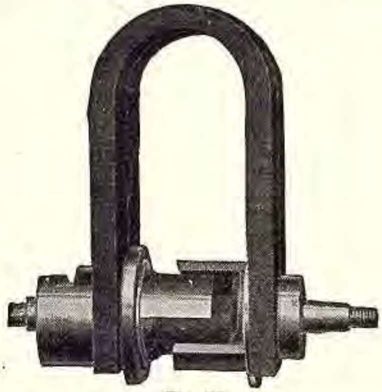


Fig. 32

Fig. 32. Rotating poles on the Dixie model "120" for 8 and 12-cylinder engines. Note that there are four rotating poles. On the 4 and 6-cylinder there are two.

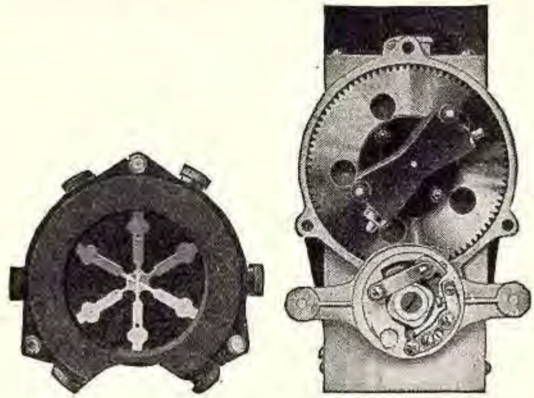


Fig. 34. Front view of Dixie model "120" 12-cylinder magneto. Note the distributor to the left and the distributor rotor and gear which is placed behind it and which drives the distributor rotor and which is driven from a gear on a rotating pole shaft. Note that the distributor rotor is arranged differently from (2) in Fig. 31, a 4-cylinder rotor.

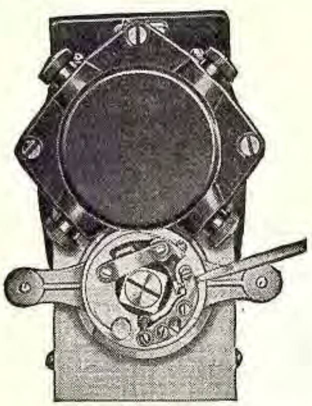


Fig. 33

Fig. 33. Showing method of raising or lowering the platinum point screw in (7) Fig. 31. The usual distance to set these points is .020" or 1/50". This adjustment can be made with a screwdriver. The spark-plug gap is set .025".

Note. The contact breaker box is permanently attached to the pole structure or part (Fig. 30), which carries the coil and condenser. When moving the breaker to retard or advance, all the parts (Fig. 26) 1, 3, 24, 22, 21, 16, 15, 14, 13, 12 move with it (also shown in Fig. 15, page 274).

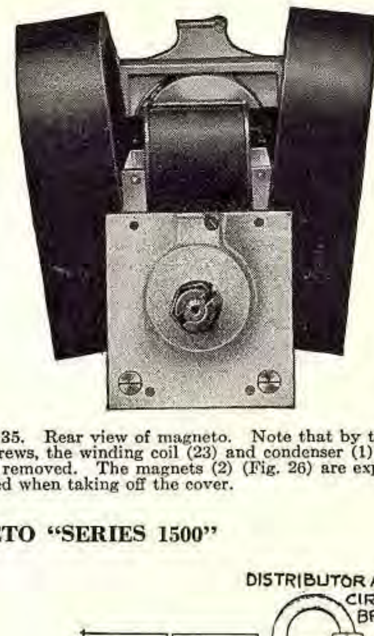


Fig. 35. Rear view of magneto. Note that by taking out four screws, the winding coil (23) and condenser (1) (Fig. 26) can be removed. The magnets (2) (Fig. 26) are exposed and removed when taking off the cover.

## REMY HIGH-TENSION MAGNETO "SERIES 1500"

**This magneto is a double-wound high-tension "armature-type" of magneto.** The design of this magneto has been towards accessibility.

The circuit breaker, cam, and distributor rotor are mounted on a vertical shaft driven by hardened spiral gears which run in grease.

**The circuit breaker and distributor parts** form a complete and independent assembly which may be removed from the magneto by simply loosening one screw.

**The circuit diagram** (Fig. 2) shows clearly how short and direct both primary and secondary circuits are, and how accessible are all parts of these circuits.

**The inner end of the primary winding** is grounded to the core (G2) and from this point the current flows through the primary wire to a collector ring which is of copper and insulated from the armature head. Here it is picked up by a brush (B) carried by means of a copper pig-tail to the primary brush-holder

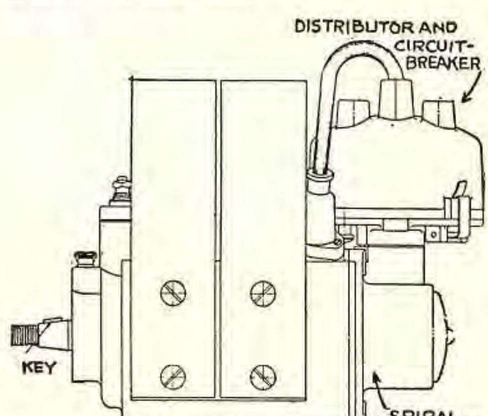



Fig. 1. Side view of the Remy "Series 1500" high-tension magneto.

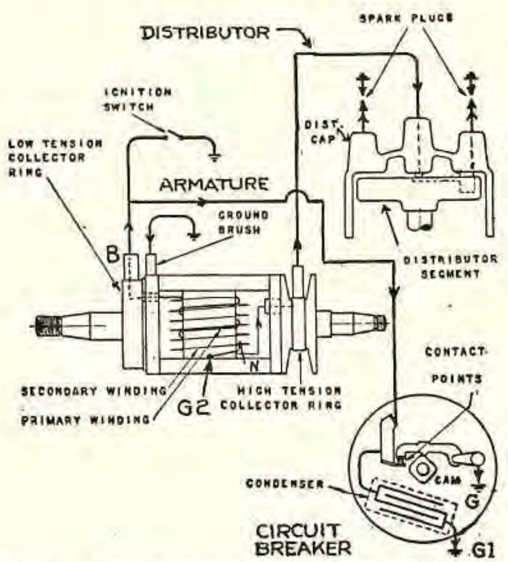



Fig. 2. Wiring diagram of the Remy "series 1500" high-tension magneto.

terminal, from which it passes through an insulated cable to the circuit breaker, condenser, and ground (G) and (G1) to ground (G2) on the magneto armature core.

**Ground brush:** Immediately under the primary brush holder is a brass plate grounded to the magneto frame, to which is connected a collector or "ground brush" which makes contact with the bronze head of the armature and by means of which the ground circuit is more fully completed, as, for instance, oily or gummed bearings would prevent good contact, hence the reason for using a ground brush.

**The secondary or high-tension circuit** is from grounded end (N), through the secondary winding, which consists of a great many turns of very fine copper wire, to the high-tension collector ring. This collector ring is bronze moulded between two flanges of hard rubber and the current is picked up from this ring by a carbon brush in the high-tension brush holder.

From the brush holder the current goes direct through a heavily insulated cable to the center terminal on the distributor cap. From here it is distributed by the rotor under the cap by means of a wipe contact to the segments. The distributor cap is of molded material with a hard-rubber track over which the distributor brush travels. From the distributor, the secondary current goes to the spark plug, to ground, to ground (G2) on the armature, to (N) where the secondary connects with the primary, thus completing the circuit.

**The drive gear** is fitted to a taper on the armature shaft.

**Interrupter-gap clearance:** Contact points on the interrupter should have a maximum opening of .020" to .025".

**Spark-plug gap:** The spark-plug gap clearance should be .030".

**Safety gap:** The safety-gap clearance should be slightly more than the spark-plug gap clearance.

The safety gap on this magneto is formed between the end of the pointed screw which projects from the magneto housing and the high-tension collector ring. When this screw is in place and properly tightened, the safety gap will automatically be adjusted to the proper distance which is 7 m.m. or .275."

## THE K-W MAGNETOS[1]

**The K. W. magneto** is of an "inductor" type, the principle of which is explained on page 246, and below. Unlike other magnetos, it generates four impulses per revolution instead of two, as explained on page 246. The K. W. magneto is used extensively on truck, tractor, marine, and stationary engines. The K. W. magnetos are made with two windings for high-tension work (A), and with a single winding for low-tension work (J). They both generate and deliver alternating current.

### K.W. High-Tension Magneto

The K. W. magneto differs from other magnetos in many ways, and possibly the clearest information that can be given, is to assist in a careful study of the diagrams and accompanying explanation.

Diagram "A" shows a longitudinal sectional elevation of the model "HK" high-tension magneto. By referring to the numbers in the following description, a clear idea may be obtained of the function of the various parts.

Diagram "B" shows the rotor (which is the only revolving part in the K. W. magneto) and the complete assembled winding. The rotor is made up of soft Norway sheet-iron stampings, which are riveted together and very accurately machined, as these rotor blocks, which run on high-grade annular ball bearings, have only .003" space between their face and the face of the pole-pieces. The rotor blocks are made in two halves and are held on the shaft by a taper pin, and are mounted at right angles to each other.

**In mounting the winding** between these rotor blocks, the pin is taken out of one half, and the rotor block is withdrawn from the shaft to allow the winding to be placed in the center.

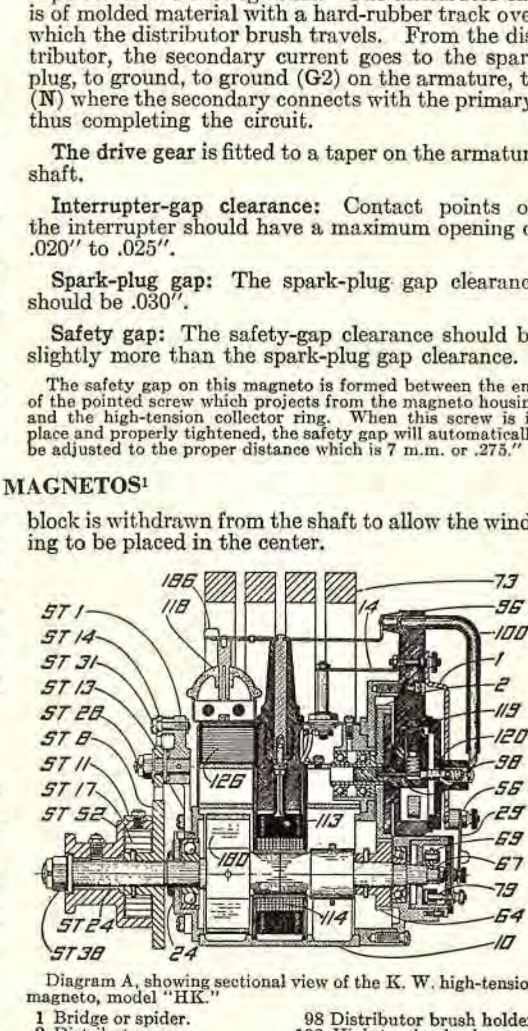



Diagram A, showing sectional view of the K. W. high-tension magneto, model "HK."

| | |
|---|---|
| 1 Bridge or spider. | 98 Distributor brush holder. |
| 2 Distributor gear. | 100 High-tension lead. |
| 10 Base. | 113 Secondary winding. |
| 14 Low-tension bus bar. | 114 Primary winding. |
| 24 Dust cap or cover. | 118 Safety spark gap. |
| 29 Retainer spring. | 119 Secondary distributor brush. |
| 56 Switch binding post. | 120 Secondary contact plunger. |
| 64 Driving pinion. | 126 Condenser. |
| 67 Cam. | 180 Rotor. |
| 69 Rocker-arm roller shaft. | 186 High-tension bus bar. |
| 73 Magnets. | |
| 79 Plunger for primary circuit. | |
| 96 Distributor block. | |

[1] See page 300 for wiring diagram of K.W. high-tension magneto circuit.

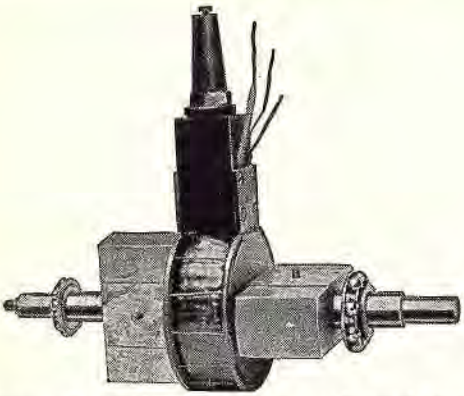


Diagram B, showing the stationary secondary and primary winding (113 and 114) (as in Diagram A) mounted between the rotors (180) which revolve.

**The winding:** Complete assembled winding (diagram C) consists of a primary winding of heavy copper wire and a secondary winding (see also diagram A) ,which is made up of a great number of turns of very fine wire, these coils being wound circular in shape, assuring the largest number of turns with the least length of wire, which makes the most efficient type of coil.

Diagram C, showing the windings (113 and 114) (as in Diagram A) and also shown in (B).

These windings are given an impregnation of high-grade insulating compound by the vacuum process, and the secondary winding is given 27 separate coats of varnish, each one being baked twenty-four hours, which thoroughly insulates it from the primary winding and also assures it being as near water and oil proof as it is possible to make any high-tension coil. These windings are assembled with the secondary outside of the primary, and then enclosed in a brass housing with a hard rubber plug, through which the high-voltage secondary is carried through parts 186 and 100 to the distributor brush of the magneto.

**The condenser,** No. 126, in diagram **A,** is made up of a number of alternating sheets of tinfoil and mica, every other sheet of tinfoil being connected together, which makes two series of tinfoil layers separated from each other by sheet mica. Each sheet of mica is tested separately, before being used, with 5,000 volts for breakdown and after it is assembled, it is given a test of five to six times the normal working voltage to which it is subjected, assuring reliability under adverse conditions.

**The safety gap,** No. 118, diagram **A,** is a necessary part of any high-tension magneto, its object being to form a path for the high-tension current to jump across in case a secondary cable, that leads to the spark plugs, should be off when the engine is running. This safety gap, as its name implies, prevents the winding from burning out, for as long as there is a path for the high-tension current to pass through, it will never puncture the insulation of the secondary winding.

**The magnetic field of the magneto** is composed of four horseshoe magnets, No. 73, shown in diagram **A,** which are mounted on two cast-iron pole-pieces, spaced 90° apart. The rotor, No. 180, revolves within this magnetic field, and as the rotor blocks are spaced 90° apart, they create four current waves for each revolution of the magneto shaft.

**When the rotor is revolved** within this magnetic field, the magnetic lines-of-force are caused to alternate through the center of the rotor, producing an electric current in the primary winding, which is carried up through part No. 14 to bridge No. 1, then through spring No. 29 to the circuit-breaker cap, and through the contact points in the circuit breaker back to the other side of the winding, completing the circuit.

**When the current has reached its highest point,** the circuit-breaker points are open, and the change of the magnetic flux causes a high voltage to be set up in the fine wire secondary winding. This induction is assisted by the condenser, which is connected across the circuit-breaker points, absorbing the spark which would occur if the condenser were not in circuit, and also assisting by the discharge which takes place immediately after it is loaded.

**The high-tension current** is carried up through the hard rubber plug to the bus bar, No. 186, then through lead No. 100 to the distributing brush, which distributes it to the different segments on the distributor block, these segments being connected by high-tension cables to the different spark plugs on the engine.

**The distributor block** is made of hard rubber into which are molded brass segments, one for each cylinder. The distributor brush holder which turns with the gear of the magneto is also molded of hard rubber and carries a carbon brush, which bears lightly on these segments as it passes, and the magneto is timed so that the circuit-breaker points open and the high-tension current is generated just at the instant this brush goes to the segment.

### The K.W. Circuit Breaker

**The entire circuit breaker** is removable. Release spring No. 29 by pushing it aside. Pull out complete breaker box and remove cover nut No. 79. This allows removal of the circuit-breaker cap and gives access to the breaker parts. The same type of circuit breaker is used on all K. W. high-tension magnetos, and is shown by diagram **D.** It is arranged to have 30° of advance or retard for regular work.

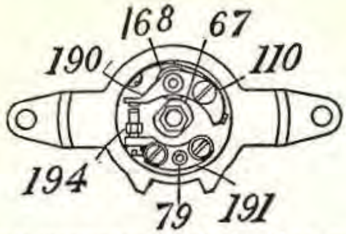



Diagram D, showing the circuit-breaker (also termed contact-breaker).

**When the points fail to separate,** or when the distance is too far apart, adjust part 194 with a small screwdriver inserted through the hole for that purpose in the housing. The proper distance apart is 1/64″. A gauge is sent with every magneto. Spark plug 1/64″.

**The firing point of the magneto** is just when the points are beginning to open or break the circuit, not when they touch.

### To Open Distributor

**Remove the high-tension lead No. 100,** by turning it to the right, which releases it at the bottom. Unscrew nut at top of spider, and remove the bridge or spider No. 1, thus releasing the cap on the distributor block and giving a view of the distributor and brush No. 119.

### Impulse Starter

Diagram **E** shows the impulse starter as applied to the model "HK" magneto, and diagram **F** shows a sectional view of the impulse starter only.

The impulse starter consists of two separate members, one of which is called the ratchet, and one the starter case. The ratchet is fastened directly to the rotor shaft of the magneto, and the case connects

Diagram E, showing impulse starter mounted on the K. W. high-tension magneto.

to the coupling, which is fastened to the shaft that drives the magneto. Interposed between these two members is a clock spring which performs the function of driving the rotor when the starting mechanism is used.

**When the engine is to be started,** the ratchet catch lock (ST–14) is pressed down, which allows the ratchet catch (ST–13) to engage with a notch on ratchet (ST–6). Thus while the starter case (ST–2) is turned by the drive shaft, the ratchet (ST–6) remains stationary and the spring inside of the case is wound up. After the case (ST–2) has turned 80°, trip cam (ST–11) comes up into such a position as to disengage ratchet catch (ST–13).

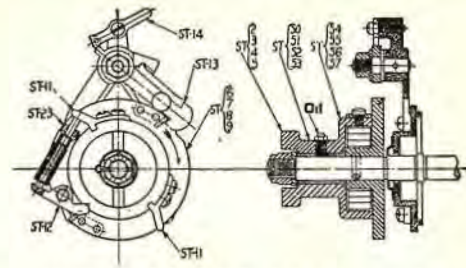


Diagram F, showing parts of the impulse starter.

**As soon as the ratchet is released,** it is thrown forward to its original position relative to the starter case (ST–2). In doing this, it carries the rotor of the magneto with it, and as the circuit-breaker points open during this period, an intensely hot spark is produced at the proper moment, regardless of how slowly the engine is turned over.

The starter continues to operate until a predetermined speed has been reached, when the ratchet catch is thrown up and latched, and the magneto is driven direct. The speed at which the starter throws out of engagement is determined by the tension of the cushion spring on the hook dog.

### To Time Magneto to the Engine

First, Turn over crank shaft of engine, placing No. 1 cylinder from 3° to 5° past top dead center on firing stroke.

Second, Mount the magneto and turn the impulse starter case until it is just ready to disengage the ratchet catch. In this position couple it securely to the drive shaft of the engine.

Diagram G, showing K. W. high-tension magneto, model "TK."

Diagram **G** shows K. W. high-tension magneto, known as model "TK," while diagram **H** shows a cross-sectional view of this magneto. It will be noted that the principle of the model "HK" and "TK" magnetos is exactly the same, the only difference being in the size of the magnetos and their appearance. The same principles of design and construction, are employed in both. Model "TK," however, has flat magnets.

Both magnetos are of the inductor-type construction, having a stationary winding and revolving rotor. This does away with all moving wires, collector rings, special contacts, etc., and is considered by the manufacturers the simplest form of construction.

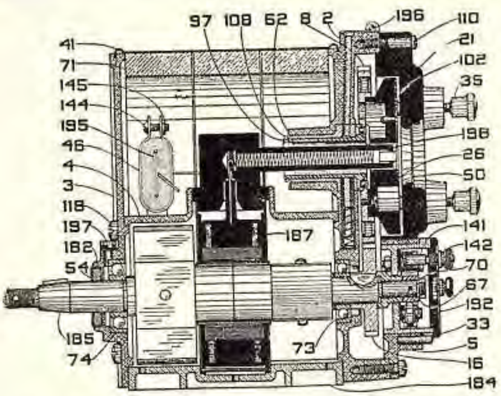



Diagram H, showing sectional view of model "TK" high-tension magneto.

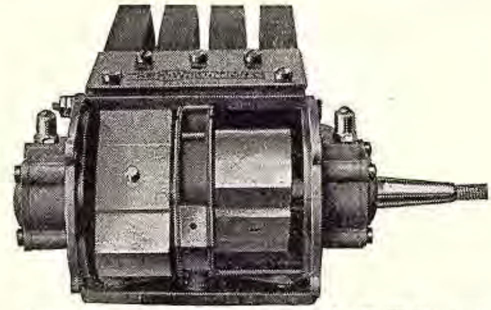


Diagram I, showing bottom view of the K. W. low-tension magneto and also showing rotor and primary winding.

### K.W. Low-Tension Magneto

**These generators are made for ignition,** using a vibrating spark coil and low-tension timer, and are made in several models, for either friction or belt drive.

They are also made for tractor and motor-boat electric-lighting systems, feeding the current direct to the lamps. These generators will not charge a storage battery, as they produce alternating current.

### Internal Construction

Diagram **I** shows the internal construction and extreme simplicity of the K.W. low-tension magneto, designed somewhat similar to the K. W. high-tension magneto, except that there is but one winding: the primary. This magneto is also termed an inductor type, designed on entirely different principles from other makes of magnetos, and patented by the makers. Instead of having wires wound longitudinally around a revolving armature, it has a stationary spiral winding of copper ribbon, as is shown in the center of diagram **J** and also in diagram **I,** which is a view of the inside of a low-tension magneto. The rotor changes the direction of magnetic flux through the winding, four times per revolution, and thus produces the electric current. This rotor revolves in two sets of high-grade ball bearings, and does not rub against or touch any other part on the entire magneto, as all other parts stand still.

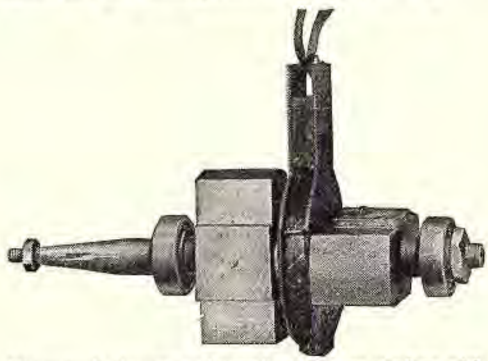


Diagram J, showing rotor and stationary winding with a single primary winding of the K. W. low-tension magneto.

**The terminals of the winding** extend through the top of the pole pieces in which the rotor revolves, and are securely connected to the winding posts, which are located at the end of the magneto.

**The electrical part** is housed in a case, making the magneto practically waterproof. It will stand any amount of spray or rain.

**All models of K. W. lighting magnetos or generators,** in addition to having a special winding suitable for lights, are so constructed and designed that the voltage can never exceed that actually required, regardless of speed. This takes care of various engine speeds, and entirely eliminates the use of automatic cutouts or other regulating devices.

The manufacturers of K.W. magnetos are the K. W. Ignition Co., Cleveland, Ohio.

## REMARKS RELATIVE TO THE DIFFERENT MAGNETOS

If the reader will master **the purpose and principle of the following,** it will then be easy to analyze any system of ignition he may come across. For instance, learn the difference between: low-tension coils; high-tension coils; low-tension magnetos; high-tension magnetos.

Other details to classify would be: the difference between the ignition commutator, timer and interrupter, and sources of electric supply, as direct-current chemical generators (dry cells and storage batteries); direct-current, mechanical generators (dyna os); alternating-current, mechanical generators (magnetos); methods for distributing the secondary current to the spark plugs, by a distributor as used on a magneto, or by an ignition commutator in connection with a vibrator coil.

In other words, very nearly all of the systems comprise one or more of the parts of the four principles of ignition.

### Difference in Makes of Magnetos

An inspection of the illustrations of **the different leading makes of magnetos** will give the reader an idea of the variance in construction. In these pages we illustrate magnetos of low-tension type and magnetos of high-tension type.

As previously explained, the low-tension type of magneto employs an armature wound with only one winding of wire, which is called the primary winding. We learned in a previous instruction that when a magneto employs a single primary wound armature, then a transformer (high-tension coil), separate and distinct from the magneto, is necessary in order to step up or transform the low-tension voltage (pressure) up to a high pressure.

By referring to pages 247, 254, we find that the Remy and Splitdorf (in the models shown) have primary wound armatures and need separate coils or transformers. But going a little further into detail, we find that the Splitdorf, Eisemann, Bosch, Mea, and the pivoting magnetos all have armatures which **revolve with the winding wound on the revolving part.**

In the Remy model "RL," page 247, and K.W., as well as the Dixie and Ford inductor-type magnetos, we find that **the winding does not revolve,** but is stationary.

### "Armature" and "Inductor" Type; "Primary" and "Compound" Wound Magnetos

**The revolving type of armature,** with the wire wound thereon, is called the "armature" type, and the type where the wire is stationary is called the "inductor" type.

**If there is only one winding** it is called a "primary" wound armature. **If there are two windings,** then it is called the "compound" type.

**The primary wound armatures** are low-tension, and require separate coils.

**The compound wound armatures** are high-tension, and do not require separate coils—except as a matter of convenience for easy starting or dual systems of ignition.

By referring to the K. W. magneto, in Fig. 6, page 284, we find that the winding on this type is also stationary, but instead of being a single primary winding, as on the Remy, it is a double or compound wound armature like the Bosch, Eisemann, and Mea—but differs from the last-mentioned in that the winding does not revolve.

In the Bosch, Mea, and Eisemann the armature is compound wound, and of the "armature" or revolving type. The principles of the magnetos are about the same, with some few minor differences in construction.

### "Pivoting" or "Rocking" Type of Magneto

**The Mea magneto** (Fig. 2, this page) differs in that the magnets can be turned from side to side (called pivoting type); they are bell-shaped, and placed horizontally; therefore, unlike the customary horseshoe type, are mounted vertically. In this construction the magnets and breaker are moved simultaneously instead of the advance and retard of the contact-breaker alone.

This style of magneto, owing to the fact that it is rocked from side to side, gives an unlimited range of advance, and thus adds wonderfully to the flexibility of the car on which it is mounted. This great range of advance makes this instrument especially suitable for two-cycle engines, which require a much greater degree of advance and retard than the four-cycle type.

### Magneto; Automatic Advance

**The Eisemann automatic advance of spark** (page 270): With all magnetos treated up to the present time, the advance and retarding of the time of spark is accomplished by hand, called "manual" advance by means of a spark lever on the steering wheel. With the Eisemann automatic advance, the same thing is accomplished by a governor arrangement automatically. This type of magneto is extensively used on commercial cars.

### Illustrations of Some of the Different High and Low-Tension Magnetos

Note that while the magnetos may vary in construction, the principle is very much the same.

**Note:** The magnetos shown here are **not intended to represent the latest models** of manufacturers mentioned, but are intended to show the different constructions.

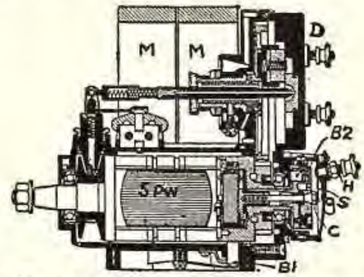



Fig. 1. The Bosch high-tension magneto. Armature revolves. The Simms, Eisemann, and other types are similar.

(M), magnets; (D), distributor; (PW), primary winding; over this winding is (S) the secondary winding; (H), is the terminal which connects with the switch.

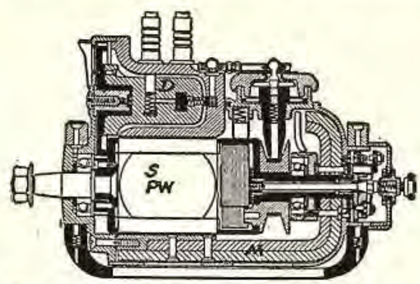



Fig. 2. The Mea high-tension magneto. Pivoting type. Revolving armature. Note that the armature is of the double-wound, shuttle-revolving type. Instead of shifting the interrupter housing, in order to advance or retard, the field magnets with the interrupter are shifted.

Fig. 3. The Eisemann high-tension magneto, pivoting or rocking advance magneto. The advance and retard are obtained by rocking the magneto bodily on its cradle. Otherwise the magneto is the same as other magnetos. The armature revolves. (Not now manufactured. It is shown in order to exemplify the meaning of a "pivoting or rocking" method of advance and retard.)

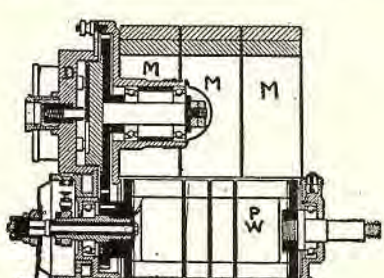



Fig. 4. The Splitdorf low-tension magneto. Armature is primary wound. Armature revolves and is of the "armature" type. A separate high-tension coil, called a transformer, must be used with this magneto. The Splitdorf Co. also manufactures a high-tension type magneto.

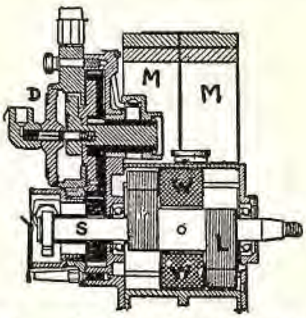



Fig. 5. The low-tension magneto armature is primary wound—only one winding. The magneto is of the "inductor" type. Armature does not revolve. The winding (W) is stationary, and rotating magnets (L) revolve. Separate high-tension coil (called a transformer) must be used with this magneto. The breaker gaps are set .025" apart.

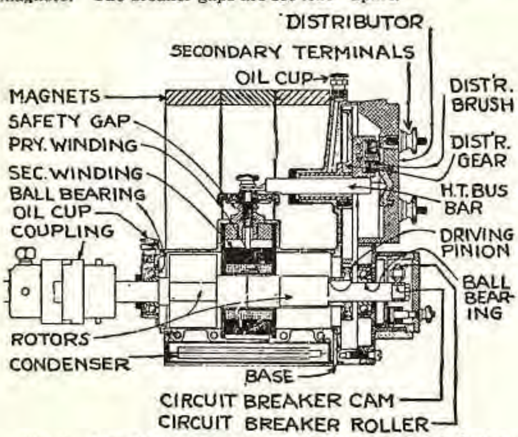



Fig. 6. The K.W. high-tension magneto with an inductor-type rotor. There are two windings on this type: a primary and a secondary. The windings are stationary, however, and the inductor rotors revolve. The principle of inductor-type magnetos was explained on page 246. The same principle applies here, with the exception that the two windings obviate the necessity of a separate high-tension coil, as it is here provided for in the secondary winding of the stationary coil winding. By referring to the Index under "Impulse and waves of current," and also on page 246, you will note that the K.W. gives four waves or impulses per revolution. However, either one, two, or four sparks per revolution can be obtained by using a single or a double cam.

On the K.W. there are four sparks per revolution, with a two-point cam, therefore the magneto would be driven at crankshaft speed for an eight-cylinder engine, and at 1½ times crankshaft speed for a twelve-cylinder.

**The setting of the inductor-type armature** is similar to the setting of any other type. The fact of its having two inductors, placed crosswise, is a bit confusing, but in the setting, only one is taken into consideration, and is therefore as simple to set as the ordinary type. The breaker and plug gap are set to 1/64"

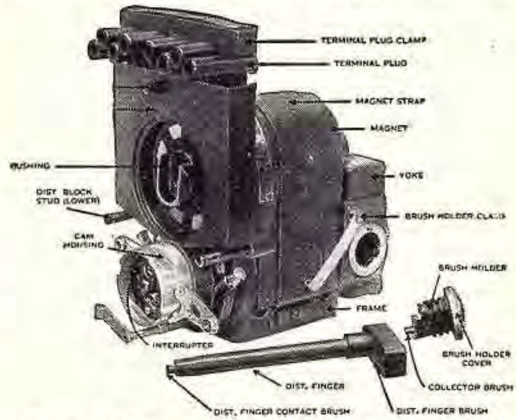



Fig. 7. Berling type D-81x-2, high-tension 8-cylinder single-spark, high-tension, revolving type of armature magneto, as used on the Curtiss training planes.

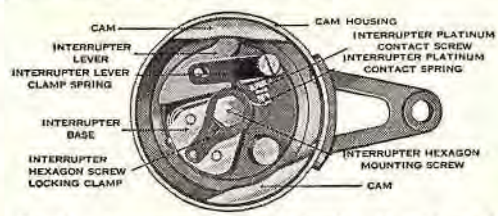



Fig. 7A. Interrupter or contact-breaker as used on the Berling magneto shown above.

**Adjusting interrupter:** With the fiber lever in the center of one of the embossed cams, the opening between the platinum contacts should be not less than .016" and not more than .020". The gauge riveted to the adjusting wrench should barely be able to pass between the contacts when fully open. The platinum contacts must be smooth, and if pitting of the contacts is in evidence, they should be smoothed off with a very fine file. When in closed position, the platinum contacts should make contact with each other over their entire surfaces.

## Addresses of Magneto Manufacturers

K. W. Ignition Co., Cleveland, Ohio.

American Bosch Magneto Corporation, Springfield, Mass., "Bosch" Magneto.
Ericsson Mfg. Co., Buffalo, N.Y., "Berling" Magneto.
The Eisemann Magneto Co., Brooklyn, N.Y., "Eisemann" Magneto.

Splitdorf Electrical Co., Newark, N.J., "Aero" and "Dixie" Magnetos.

## "COMBINING" THE HIGH-TENSION MAGNETO AND COIL AND BATTERY SYSTEM INTO "DUAL" AND "DOUBLE" SYSTEMS

We have now explained the different leading low and high-tension ignition systems for firing the charge of gas in the gasoline engine. In order to explain more clearly the four systems of high-tension ignition, we will now place the four ignition systems (high-tension) on one four-cylinder engine.

Some of these systems (see Fig. 8) are out of date, but are shown in order that the reader will understand the different principles. The modern battery and coil-ignition system, using a closed-circuit interrupter, as explained on page 197, is not shown.

The system of using four ignition systems on one four-cylinder engine is not in actual use, but is intended to make the combination of "dual" and "double" systems clear to the reader, by showing how they can be combined.

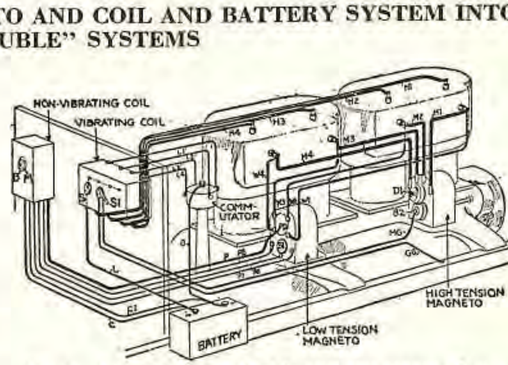



Fig. 8. Four high-tension ignition systems connected to one four-cylinder engine. Only two systems are usually placed on an engine. The idea is merely to show how the various systems can be combined into "dual" or "double" ignition systems

The vibrating coil is seldom used. The low-tension magneto is seldom used. A modern "dual" and "double" system is shown on page 263. A modern "battery and coil" system is shown on pages 197, 211.

We shall first explain each system separately, showing how each would be connected.

First, **The "single" high-tension magneto system:** By referring to Fig. 8, we will put our pencil on the switch on the dash coil box (S1). If this lever is thrown to the left with all other switches "off," this high-tension magneto system will supply current for sparking the lower set of spark plugs (M1, M2, M3, M4). Note that these wires run from the distributor on the magneto.

Second, **The high-tension coil, battery and commutator system:** If switch (S) is thrown to the left, the four high-tension vibrating coils will spark the plugs (H1 to H4). The battery of either storage or dry cells (usually storage) will supply the electric current in this instance. The commutator, operated from one of the cam shafts through a system of bevel gears, will control the time of spark in each cylinder.

Third, **A non-vibrating single high-tension coil with battery,** using the circuit-breaker on the low-tension magneto as the timer, and the distributor on the magneto to distribute the current to the spark plugs: If the switch on the non-vibrating coil is on (B), the battery will supply the electric current, passing through the primary winding of the non-vibrating coil. The circuit-breaker (B1) on the low-tension magneto will take the place of the timer and vibrator. The secondary current from the coil will be distributed to the spark plugs (W1 to W4), through the distributor (D) on the low-tension magneto.

Fourth, **Low-tension magneto and separate high-tension coil:** If the switch is on (M) on the non-vibrating coil, the low-tension magneto will pass its current through this non-vibrating coil, increase it to high pressure, and then distribute the high-tension current through the distributor (D) to the spark plugs (W1 to W4), the circuit-breaker opening and closing the primary circuit of the magneto.

### Combining into Dual Systems

If we were to combine the two last-mentioned systems, we should have **two systems of ignition using one set of spark plugs**—but only one system sparking the plugs at the time.

The single non-vibrating coil and battery would be used to start on, by throwing the switch to (B), and after the engine was started; then, by throwing the switch to (M), the low-tension magneto would take the place of the battery.

**Another dual system:** A vibrating coil with switch (S1), storage battery and commutator (timer), with secondary wires (H1 to H4), connected to the spark plugs (M1 to M4), in connection with high-tension magneto, connected to same spark plugs, would give another form of dual system.

### Combining into Double Systems

The vibrating coil, timer, and battery with spark plugs (H1 to H4) would constitute one independent system. The high-tension magneto with its spark plugs (M1 to M4) would constitute the other. This would be called a double system.

**Another double system** could be formed by using the low-tension magneto and separate non-vibrating coil and spark plugs (M1 to M4). The vibrating coil, timer, and battery with spark plugs (H1 to H4) would constitute the other system.

There are many methods employed to combine the different ignition systems into "dual" and "double" systems.

## A BRIEF REVIEW OF THE VARIOUS IGNITION SYSTEMS: ADVANTAGES AND DISADVANTAGES

**We have now mastered the various methods of producing an electric spark for igniting the gas;** with a "primary" or low-tension coil, and a "secondary" or high-tension coil, and a low-tension magneto; a low-tension magneto and a high-tension coil, and a high-tension magneto alone, or a high-tension magneto and a coil-and-battery ignition, as a "dual" system, also the "double" ignition system.

We shall now review the different systems as to their relative advantages and disadvantages.

**Low-tension coil systems:** The disadvantage of the "make-and-break" is its lack of "flexibility" and slow spark. It would be considered fairly good for a slow-running constant-speed stationary or marine engine.

**Coil with vibrator:** The disadvantage of a vibrator coil is its tendency to miss; if the battery is weak, the vibrator will not operate. If too strong, the points on the vibrator will weld together and stick, causing missing. The spark is not fast enough. The consumption of current is rather heavy.

**Master vibrator coil:** Where a system is already equipped with a multiple of vibrator coils, this would be an excellent method to improve it. Its disadvantage is a sticking vibrator, with all work on one vibrator and a succession of sparks.

**Dry battery as a source of electric supply:** Its disadvantage is unreliability. A battery of 5 or 6 dry cells will do fairly good work when fresh for short periods of time—provided two sets are used and the use alternates from one to the other. It gets weaker as used, however, and is unreliable. Intended for "intermittent" work—as ringing door bells, etc., where used only for a few seconds at a time.

**Storage batteries** are better, as they maintain their pressure until exhausted. They contain a greater quantity of current and are far more satisfactory. Their disadvantage lies in the fact that they must be recharged when exhausted, and the operator must watch it for fear of running down.

**Battery, coil, and magneto:** The battery and coil ignition, using dry cells or a storage battery, could be used for starting the engine and the magneto can be used for ignition after starting. The disadvantage would be that dry cells would soon get weak and the storage battery would require charging in time. If a generator or dynamo (direct current) was connected to the engine to charge the battery, this would be an improvement, but would add another piece of machinery. The magneto generates "alternating" current; therefore it is not suitable for charging a battery and can be used only independently for ignition.

**High-tension magneto alone:** The magneto generates a very hot and voluminous spark which is desirable as the time between ignition and actual combustion is less, with the result that more power is obtained (for the same reason that "double" and 'two-spark" ignition is an advantage). The disadvantage is that the magneto must be turned fast enough to generate current when starting, and this cannot always be relied upon when cranking by hand. Therefore some form of starter must be employed. The popular type of magneto starter is the "impulse starter," as explained on page 281. It is used extensively on truck and tractor engines. This overcomes the starting disadvantage, but is not altogether desirable for pleasure cars.

**The low-tension magneto and separate high-tension coil** are now seldom used, because the high-tension magneto is simpler, and thus the separate coil and wiring are dispensed with.

**The high-tension magneto** is a very desirable system of ignition. The spark is hotter, fatter, and exists across the spark-plug gap for a longer period of time than in other systems. Thus it fires all of the gas in each cylinder. The high-tension magneto is several times hotter than any other spark, and thus the gas is ignited more quickly. For reasons stated below, however, the magneto is not used on pleasure cars to as great an extent as formerly, and now that great improvements have been made with coil-and-battery ignition, this latter system is in general use.

**The double system of ignition** is an advantage. See pages 263, 264, explaining why.

### The Electric System in General Use

**Battery, coil, generator and electric starting motor:** A very satisfactory system and one which is now generally used for pleasure cars is an ignition system using a high-tension coil without a vibrator, and a "closed circuit," "single spark" interrupter. The source of the electric supply for ignition and starting the motor is taken from the storage battery when starting the engine, and after the engine is up, speeding the "direct current" generator charges the battery and supplies current for ignition and lights. The advantages of this system would be a constant source of electric supply, a hot spark regardless of the speed of the engine, ease of starting the engine, and a constant source of electric current for lights when the car was idle or running.

The question then arises, Why use only a magneto on a truck, and this system on a pleasure car? The answer is, to avoid complication. The driver of a truck seldom runs the truck after dark, and seldom at a high rate of speed. A truck must be operated on an efficient basis, and for this reason the added complication of battery and starter is eliminated.

On the other hand, the pleasure car is driven considerably at night, and quite often at a high rate of speed. Therefore strong lights are essential. The pleasure-car driver also demands an easy method of starting. Inasmuch as a starting motor and strong lights consume a great deal of current, it is necessary that a generator be supplied that will continually charge the battery while running. Therefore, if a battery is required, and a generator to charge the battery, then by adding a timer, distributor, and non-vibrating high-tension coil, we have added an ideal ignition system, combining all the desirable features and eliminating entirely the magneto.

**The disadvantage of the battery, coil, generator, and electric starting motor system** would appear to be: (1) the probabilities of the dynamo at high speed burning out the ignition coil, as the voltage increases with the speed of the dynamo, or, (2) when running slow, the connection being between the storage battery and field coils, the current would flow from the battery into the generator. This, however, is all taken care of: (1) by "regulation" of the dynamo field windings, so that the output remains constant at low or high speeds; (2) by a "cut out" arrangement, which is explained farther on.

**The greatest source of trouble** with this system is the storage battery, as it requires careful watching. But by having the battery tested about every two weeks and seeing that the generator is charging the battery while running, which is a simple operation, battery troubles can be eliminated.

### The Modern Battery and Coil Ignition System

The ignition system in general use today is the closed-circuit coil and battery system, illustrated on page 197.

The current is taken from a storage battery or the generator, then passed through the primary winding of a high-tension non-vibrating coil, using an interrupter and a distributor to make and break the primary current and distribute the secondary current to the spark plugs.

## WHAT IS A GOOD SPARK?

**A good ignition spark** is a hot, intense spark which will quickly ignite the mixture and penetrate a compressed mixture.

**What is the color of a good ignition spark?** This question is often asked. The color of the ignition spark will not always verify its value because the color depends more on what the electrodes are made of, than the actual amperage and voltage it represents.

For example, assume that the spark is to jump between two carbon electrodes. In this case it will make three times as much light and appear to have a great deal more volume and heat than if the same spark were to jump the same gap made of steel electrodes.

A spark existing between two steel ball electrodes would have an intense white appearance and a purplish corona which would represent intense heat.

**A fat, voluminous spark** usually indicates high current value (amperage).

**A thin intense spark** usually indicates high potential (voltage).

A spark of **high current value is hotter** than a spark of high potential. A spark of **high potential is more penetrating. A combination of the two factors** is the spark desired, that is, **a hot intense spark.**

An ignition spark, if examined closely, will be found to have **a** snappy center (N, Fig. 10), called the **nucleus,** which indicates


Fig. 10

**intensity,** and a **corona** (C) surrounding the nucleus which indicates **volume** or **heat-radiating** qualities. Ordinarily, if the nucleus is snappy and the corona is a voluminous blue or purplish-red, it is considered intense and hot.

**Therefore, the heat from an ignition spark is dependent upon the current value** (amperes), and **the intensity is dependent upon** the potential value (voltage). This combination effect depends upon the voltage of the battery, the winding of the coil, absence of any form of resistance in the primary circuit which is not intended, such as loose connections, insufficient tension at interrupter points, oxidized interrupter points, uneven surfaces, pitted points, etc., and also the time the interruption takes place, and quick opening of the interrupter points, and the length of time the contact points are closed so that the coil magnetism can build up to its proper value.

**For example, if the contact points of the interrupter are** separated so that they open too wide, the points would be late in closing and thus would not give sufficient time for the building up of the coil magnetism, thus causing missing at higher speeds. The best practice is to set the points as close as possible without arcing: about .015" to .025" is the average. See pages 290 and 304 for the subject of "Flame Propagation."

# INSTRUCTION No. 27

## MAGNETO INSTALLATION: Driving the Magneto; Magneto Speeds

### Fitting the Magneto

One method of **fitting a magneto to the engine frame** is by means of pins, and is held down on its base by a strap of metal passing over the magneto, as in Fig. 1. The band is usually in two sections, as illustrated in Fig. 1, thus bringing the nut (A), which tightens or loosens the band at a point which is easily gotten at. In other instances, however, the magneto is bolted direct to its base, and since the nuts are below, it is almost impossible to remove the magneto after the engine has been placed in the chassis. It might also be worth mentioning, at this point, that some magnetos are strapped down on iron or steel brackets and no precaution taken to see that brass or non-magnetic fittings are used at the point where the tightening bolts join the straps. A little thought will show that, as illustrated, a portion of the lines-of-force will return by way of the bolts and base instead of through the armature. Although the effect of this may not be noticed at ordinary speeds, it will have much to do with determining the lowest speed at which a good spark is produced. Magnetos therefore must have a brass or aluminum base.

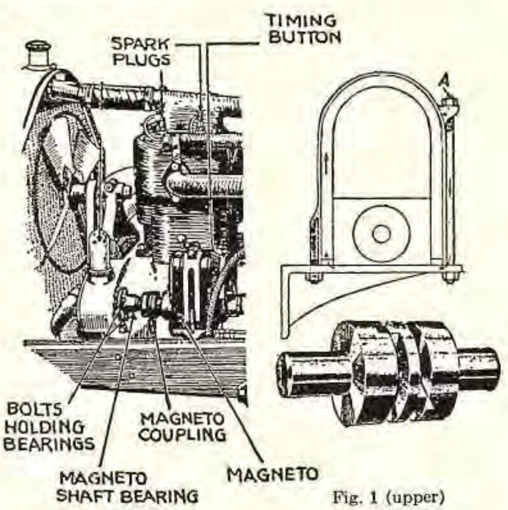



Fig. 2 Fig. 1 (upper) Fig. 3 (lower)

Figs. 1 to 3 apply to the types of high-tension magnetos with double-wound armatures.

### Magneto Location

**The magneto is usually placed alongside of the engine** (see Fig. 2), mounted on a separate base provided for it. The base of the magneto is usually made of brass, as brass will not become magnetized; therefore the magnetism is confined to the magnets, otherwise they would soon lose their magnetism.

### Magneto Drive

**The magneto armature shaft** can be driven by gears (Fig. 4), or a silent chain (Fig. 5). The usual practice is to drive with gears (see Figs. 5A and 5B).

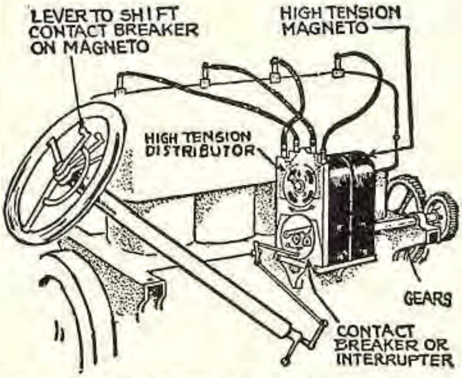



Fig. 4. Simplified illustration showing how the magneto is usually driven and how the interrupter, or contact-breaker is connected with the spark lever.

The magneto which is timed to give a spark at a fixed time cannot be driven by a belt or friction, because the armature must be in a certain position in relation to the time of spark. A belt would slip

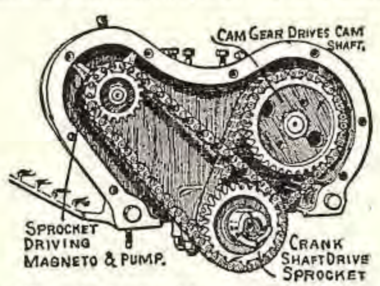



Fig. 5. The silent-chain drive method on a six-cylinder engine. Note that the sprocket driving the magneto gear is slightly smaller; therefore the magneto gear will turn 1½ revolutions to the crank shaft gear's 1 revolution. (The magneto is usually driven by gears.)

**A coupling** is usually provided between the drive shaft and armature shaft, as shown in Fig. 2. One type of coupling is the Oldham, shown in Fig. 3; another type is a flexible leather or fiber disk bolted between two flanges. By the use of a coupling, the magneto can be uncoupled from its drive member and properly timed without removing the gear-case cover.

The coupling and shaft are usually driven by a gear. This permits undue strain on the armature, if it is not exactly in line, and also reduces vibration to the armature shaft. The chain drive is the least desirable for magneto drive, but is a popular drive method for the interrupter of a coil and battery system of ignition.

**If a gear is used to drive the magneto direct to a gear on the armature shaft,** sufficient clearance must be allowed between the gear on the magneto and the driving gear, in order to reduce strain on the armature shaft.

**The magneto must be driven at a fixed speed,** because the armature must be in approximately a vertical position and with the interrupter point just breaking when the piston is in the correct position to receive the spark. The correct position for the piston to receive the spark is just an instant before it is at the end of its compression stroke.

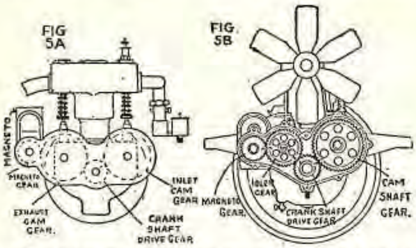



Fig. 5A. Magneto driven by gears on a "T"-head engine.

Fig. 5B. Magneto driven by gears on an "L"-head engine.

**The armature is therefore set** by meshing its drive gear in relation to the gear on the crank shaft, so that it will be in this position at this time.

**The magneto drive shaft** is usually tapered, therefore the coupling should be tapered to correspond. If driven by a gear, and teeth are meshed too tight, undue strain will result on the bearings.

### Magneto Connection with Spark Lever

**The method for advancing and retarding the time of spark** is usually by means of a rod connected at one end with the spark lever on the steering wheel; the other end connects with the bell crank, thence by a rod to the interrupter or breaker-box housing (Fig. 4).

By shifting this housing in the opposite direction of the rotation of the cam, the cam would raise the interrupter arm and interrupt the flow of current earlier, or in "advance."

By shifting this housing with the direction of rotation of the cam, the interruption would occur later, or "retarded."

On some types of magnetos, such as the Mea, page 271, the field magnets are "advanced" and "retarded" by rocking the magnets bodily around the armature (called "pivoting advance").

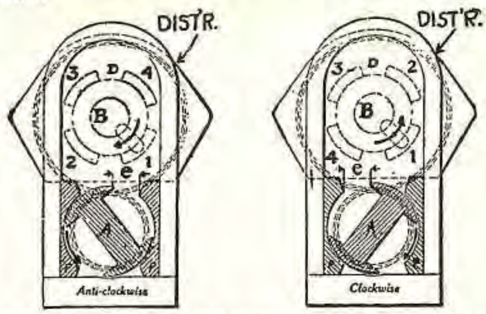
The advance which can be obtained on a magneto is usually 22° to 35°.

### Clockwise and Counter-Clockwise Drive

**The drive-end of a magneto** is the end where the drive gear or coupling connects with it. The direction of rotation of armature is always considered from the drive-end.

**Clockwise rotation of the armature** would therefore be as in Figs. 6A and 7A. Note that the direction of rotation of the armature is right hand, or as the hands of a clock move.

**Counter-clockwise rotation** would be as in Figs. 6 and 7. Note that the direction is a left-hand direction, or opposite to that of the movement of clock hands.




Figs. 7 and 7A. Drive end of magneto which is opposite to the interrupter and distributor end.

Note in Figs. 7 and 7A that the distributor would revolve in the opposite direction to the armature.

Note also in Figs. 7 and 7A the position where armature (A) should be placed when the contact-points should open, with the contact-breaker fully retarded. The illustration on the right shows a clockwise rotation, and the left-hand illustration shows it as counter-clockwise, both armature positions being retarded. By this is meant that the contact-breaker points are retarded from separating until the armature has reached a position as shown at (e).

Figs. 6 and 6A show the drive-end of a magneto with the contact-breaker lever (L) retarded when running clockwise and counter-clockwise, as in Figs. 7 and 7A.

### Meaning of "Advance" and "Retard" of Spark

Since in regular operation of the engine the charge is ignited just an instant before the top of the compression stroke, the magneto armature is so set, relative to the engine crank shaft, that the maximum induction effect occurs at this moment.

It is, however, necessary to be able to vary the point in the cycle at which the ignition occurs, since, **when the engine is cranked by hand,** the spark must occur after the end of the compression stroke, or else the engine may kick back.

**If started by some form of self-starter,** it is then possible to start with slightly more advance than when starting by hand, because the self-starter turns the engine crank somewhat faster; however, even with a starter, if advanced too far it will cause a back-kick and may result in damage to the starter.

The meaning of "advance" of spark is to cause the spark to occur earlier, before the piston is on top of compression stroke.

The meaning of "retard" of spark is to cause the spark to occur later. On engines that are cranked by hand, the spark is usually set "retarded" after top, so that there will be no danger of a kick back.

**The exact position to "advance" or "retard"** is determined by running as far "advanced" as possible at all times until a knock is detected, and then "retard" until the knock disappears. The driver will then soon learn the exact position where the engine gives the greatest power. Remember also, that a retarded spark heats up the engine.

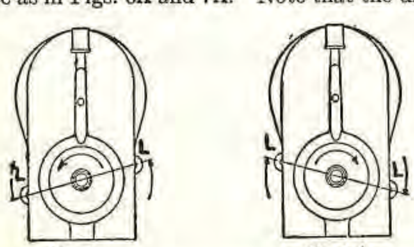



Fig. 6 Fig. 6A

Fig. 6. Positions of full retard of the cam plate when looking at the driving end of the Simplex magneto. Fig. 6 is a view of the counter-clockwise setting and Fig. 6A. the clockwise setting.

### Control of Spark

**Principle:** As the spark occurs only when the primary circuit is broken by the opening of the platinum contacts, the timing of the spark can be controlled by having these platinum contacts open sooner or later. This latter is accomplished by the angular movement of the timing lever (L) (Figs. 8 and 8A). This movement gives a timing range of about 34°. The spark is fully retarded when the timing lever is pushed as far as possible in the direction of rotation of the armature, and is advanced when pushed in the opposite direction.

**Magneto spark control:** In order to make it possible to vary the time of the spark on a magneto, the circuit-breaker housing is so arranged that it can be rocked around its axis, being provided with a lever arm (L) (Fig. 8) for the purpose, from which connection can be made to a spark lever on the steering post, as in Fig 4.

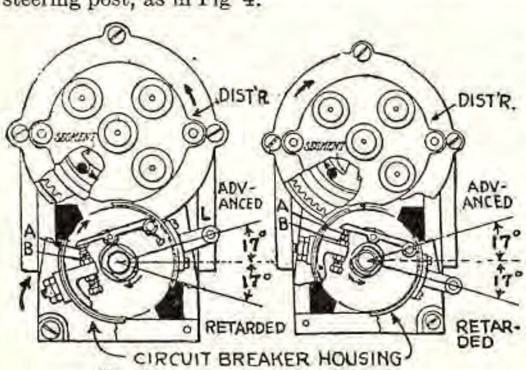



Fig. 8 Fig. 8A

Fig. 8. Illustration showing circuit-breaker in "advanced" position when magneto armature is running "counter-clockwise" (view from front of magneto).

Fig. 8A. Illustration showing circuit-breaker in "advanced position" when magneto armature is running "clockwise" (view from front of magneto).

It will readily be understood that if the armature shaft turns right-handedly (Fig. 8A) (view is from the distributor end, not the drive end), and if then the circuit-breaker housing is moved through a certain angle in a right-hand direction, the contact points (A) and (B) will separate later, or "retarded," with relation to the position of the engine crank shaft; while, on the other hand, if the housing is moved in a left-hand direction, the circuit-breaker point will open earlier, or "advanced," the position in which it is now in Fig. 8A. In this way the point at which the spark occurs can be shifted through an angle of about 34°.

**Coil and battery system control:** On the Delco and Atwater-Kent or similar systems, the advance and retard is obtained by shifting the housing surrounding the timer and distributor and also by governor action (see pages 202, 214).

### Spark-Control Methods

**There are three general principles used for control of spark:** (1) by hand, to vary the spark position, which would be termed "variable spark"; (2) by a governor, which would also vary the spark according to speed; (3) by a fixed spark.

(1) **By hand** means that the spark lever on the steering post shifts the commutator or interrupter (see Fig. 4, page 287).

**Where magneto ignition is used,** the housing on which the interrupter arm is placed is shifted in the opposite direction of rotation to the armature to "advance," or cause the spark to occur earlier, or, in the direction of rotation to cause the spark to occur later.

When the spark is advanced or retarded by hand, it is left to the good judgment of the driver to manipulate the spark lever, except where the system is equipped with an "automatic" advance. The automatic advance is seldom used with magneto ignition.

(2) **The automatic advance** is probably the most satisfactory with a battery and coil system of ignition, because the spark occurs just at the right time automatically, and there is no guessing as to just how far to advance or retard at various speeds. See Index.

(3) **The fixed spark** is sometimes used with a high-tension magneto, which means that the time of spark is fixed at one position, usually advanced, and the contact-breaker breaks at one position, regardless of speed. This system has not proved very satisfactory on engines where speed varies, but would be satisfactory if the speed of the engine was constant and did not vary. The objection, however, would be in starting—liability of a kick—for the spark would necessarily be placed advanced for proper running.

**The disadvantage** in one instance: Suppose the car was running up hill, the charge of gas would be heavy and the throttle would be open, consequently there would be a high compression. If the spark was advanced, which it usually is with a fixed spark, the spark would occur at such a time that the combustion would take place before the piston reached the top, because the piston would be moving slow at, say, ten miles an hour; the result would be that the force would be exerted on the head of the piston causing the momentum of the piston to buck against the force of the combustion, which would invariably cause a knock and loss of power.

The fixed spark, however, is not at all advisable on variable speed engines.

### Relation between Position of Armature to Contact-Breaker when Advanced or Retarded

**Advanced position:** Referring to (M), the armature cheek is just breaking from the pole tip (e), in the direction of rotation. This is the maximum position, or when current strength is strongest. At this time the contact-points (P) (Fig. 9) should separate.

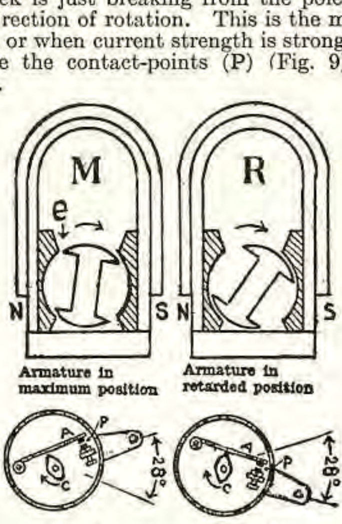



Fig. 9 Fig. 10

Fig. 9. Contact-breaker advanced.
Fig. 10. Contact-breaker retarded.

The magneto is set at the factory with armature in maximum position (M), and the contact-breaker housing (Fig. 9) is placed in an advanced position. That is, it is moved opposite to the direction of rotation of cam (c). The cam (c) is set so that it causes points (P) to separate when the contact-breaker housing is in the advanced position.

**Retarded position:** Suppose the contact-breaker housing is retarded, or moved with the direction of the cam rotation as far as it will go (Fig. 10) (28° is average range),[1] then points (P) of the contact-breaker would not separate until the armature had traveled farther[2] in the direction of rotation, approximately the position shown in (R). At this point the armature has passed the maximum position and is where the current strength is weaker. By referring to pages 253, 254, we learn that the current strength begins to weaken the nearer the armature travels to zero position after maximum position.

From this we learn that the spark is strongest at maximum position of the armature (M), with the contact-breaker in advanced position (Fig. 9), and that the spark is weaker when the contact-breaker is in retarded position (Fig. 10), because the armature has passed the maximum position.

Let us see what happens when we follow out the magneto-setting given on page 297, which says: Place piston on top of compression stroke, place contact-breaker in retarded position, then turn armature in direction of rotation until contact-points just start to separate.

This would place the armature in position (R), and the contact-breaker in position shown in Fig. 10; both retarded. In this position the spark would occur when the piston was on top of the stroke—but we must remember that the combustion is not instantaneous; therefore allowing for this lag, the spark would occur when the piston had moved slightly down after top—which at slow speed is desirable, but which is a weaker position of the armature for starting the engine on.

This is why spark-plug points ought to set close together, and why magnetos do not permit the engine to throttle down as slow as a constant source of electric supply, such as a battery. The contact-breaker is usually retarded when the engine is running slow and the magneto armature is turning over slowly. Therefore both actions tend to weaken the spark. Always run as far advanced on magneto ignition as possible.

**As the speed of the engine increases,** if the contact-breaker was retarded and combustion was not instantaneous, as explained above, then the piston, traveling fast, would move farther down after top before the spark occurred. Therefore as we have a range of 28° in which we can move the contact-breaker housing so that the spark will occur earlier, we then advance the contact-breaker more and more as the speed of the engine increases, so that the spark will occur before top of compression, thereby giving the combustion time to take place, when the piston is on top, or just starting down. The more we advance the breaker, the nearer we reach maximum or the strongest position of the armature. Therefore the current strength is greatest at high speeds.

**When setting a magneto,** the only point to consider is whether the breaker housing is to be retarded or advanced when interruption takes place, and the position of the piston.

## FLAME PROPAGATION

**In a gasoline engine the piston is caused to move by the expansion of the combusted gases.** The greater the **heat** produced by the combusted gases, the greater the **expansion,** and thus the greater the **power** delivered.

**The combusted gases will produce greater heat if flame propagation (travel) is rapid, which is produced by having a combustible mixture and a hot, intense spark** (see also pages 286 and 304).

**To be combustible, the gasoline must be heated just enough so that it vaporizes,** and this vapor is mixed with air in the proper proportion, that is from 14 to 17 parts of air to 1 of gasoline vapor (by weight). There should be just enough air to completely burn or oxidize the gasoline vapor.

Take for example, gunpowder. If this is ignited when damp, flame propagation is slow. If ignited when dry, flame propagation would be more rapid; in fact, an explosion results, if under compression.

Likewise, if the gas mixture is cold and mostly gasoline is taken into the cylinder, as in a cold engine, it gives off very little vapor, the balance either passing out the exhaust to be wasted, or condensing on the cylinder walls, diluting the lubricating oil. Thus flame propagation would be much slower than if the gasoline were heated enough to give off vapor and were properly mixed with air.

**A very hot spark is necessary to ignite a cold, unvaporized mixture,** and also for a dense mixture, when running slowly with hard pulling and the throttle well opened.

**When speeding, the throttle is opened wider, admitting more gas which increases compression. Thus an intense, hot spark and combustible mixture are necessary for the following reasons:** (1) because the greater the compression the greater the resistance offered to the spark; (2) at high speeds flame propagation must be rapid, otherwise the exhaust valve would open before the gases were completely combusted, and thus power and gasoline would be lost by part of the unburned gases passing out the exhaust valve port.

**The average engine requires approximately 1/25th part of a second at a car speed of 30 m.p.h. to vaporize, compress, ignite, combust, and expand one charge.** Thus the necessity of quick vaporization, hot spark, quick opening of interrupter points, and quick combustion (flame propagation).

**The time at which the spark should occur** would be far more advanced if flame propagation was slow, than if flame propagation was rapid. The hotter the spark and more combustible the mixture, the less the advance at a given speed (see also "Range of Spark advance and Retard," page 305, and "Spark Control and Overheating," page 304).

**With double ignition, less spark advance is necessary,** because flame propagation is more rapid (if the mixture is of the proper combustible nature). We might make a comparison of a double spark with that of starting a fire. If a bundle of kindling wood is ignited with two matches, its flame propagation would be more rapid than if ignited with one. Where double ignition is used, this permits more rapid combustion, or flame propagation, and thus a wider speed range on high and less detonation (sudden pressure), and consequently more silent operation.

**Advantage of double ignition:** (1) gas burns much quicker, thus causing more **rapid flame propagation;** (2) less advance of spark lever, permitting the gas to combust at the highest point of compression and not after it has started expanding; (3) burning of all the mixture, thus more power and saving of gasoline; (4) tendency to prevent sooty spark plugs, accumulation of carbon on pistons, pitted valves, etc., because the gas is completely burned and not aflame when valves open, which is often the case with slow flame propagation.

The **magneto** gives a very intense, hot spark, especially at high speeds, but at low speeds the spark is weaker; thus it is sometimes difficult to start the engine, especially if the engine is cold and the gasoline not vaporized.

[1] The average advance range of the armature is 22° to 34°—many magnetos actually having but 22° or 28° in which the breaker moves from full advance to full retard. The Bosch Co. states that the Bosch four-cylinder standard average speed (less than 2,000 r.p.m.) has a timing range of 35° figured on the magneto axis. On a timer or commutator, it is possible to get as high as 48°; for instance on the Atwater-Kent timer, the timer shaft will advance automatically about 15° at high speed, and the housing itself can be advanced about 33°.

[2] About 1/16" break from cheek of armature to pole-piece (e) when advanced, is the average break. The distance at full retard would be about 23/32".

A four-cylinder engine, with a speed of 2,000 or less, is termed an average-speed engine, and the gap between pole-piece and armature cheek is 1/16". An engine with speed of 2,000 to 3,500 r.p.m. would be termed a high-speed engine, and in this case the gap opening is increased to 5/32" or 3/16".

is connected across the interrupter points (P, Fig. 3), we can absorb or suppress the spark across the interrupter points (P) of the primary circuit and stop the flow of self-induced current which is still trying to build up lines-of-force in the core, and thus aid the primary current to fall to zero value more quickly. Hence the reason for placing the condenser (Fig. 3) across interrupter points (P) of the primary circuit.

### Purpose of the Condenser

1. To **absorb** the self-induced current of the primary, thereby allowing the magnetic field to collapse with the greatest possible speed, and also eliminating the spark at the contact points.

2. To **discharge** in an oscillating (alternating) manner back and forth into the primary circuit, thus completely neutralizing or demagnetizing the iron core and thereby preparing it for repeated action.

### Condenser Construction

**The condenser** consists of a series of sheets of tinfoil separated from each other by a good insulator, such as mica, or several sheets of wax paper.[1] These


Fig. 4


Fig. 4A

are built up in a pile, somewhat as shown in Fig. 4. The even-numbered sheets of tinfoil, 2-4-6, etc., are connected, making one terminal (T) of the condenser. The odd-numbered sheets, 1-3-5, etc., are likewise connected, making the second terminal (T1) of the condenser. There is no connection between the two series of sheets. These connections are then made across the primary circuit at the contact points, as shown in Fig. 7.

### Condenser Action

**With contact points (P) closed** (Fig. 5), the current flows as shown by arrows through the primary winding. The condenser and secondary winding are not considered, as they are inactive. A current of low value is induced in the secondary in a direction opposite to that of the primary-current flow.

**With contact points (P) open** (Fig. 6), the condenser is charging. The spark of highest value is now at the secondary terminals. Note that when points (P) open, the magnetic field of lines-of-force collapse, and the induced current in the secondary is then flowing in the same direction as that in the primary. This spark is greatest just as the points open, because the condenser absorbs the self-induced current of the primary and thereby stops its flow, thus preventing it building up lines-of-force in the core. On the other hand, it neutralizes the core, and also eliminates any flow of current or of sparking at the contact points.

[1] **Never attempt to open a condenser,** as this will destroy it. In the manufacturing process the tinfoil and insulating sheets, with the aid of an insulating compound, are pressed closely together under heat, with high pressure (Fig. 4A). Obtain a new one when necessary.

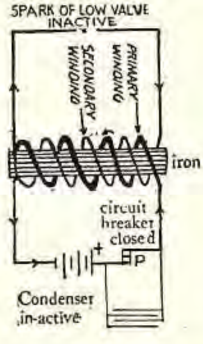



Fig. 5

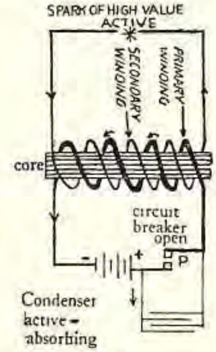



Fig. 6

On account of this action the lines-of-force or magnetic field can collapse with greater rapidity and cut the turns of wires faster, thus inducing a current in the secondary winding of a much higher voltage.

The current flows into the condenser in one direction when charging, which action takes place immediately the points are opened.

When the condenser is charged with the (+) positive current flowing into the (+) side, it will establish a (−) negative charge on the other side.

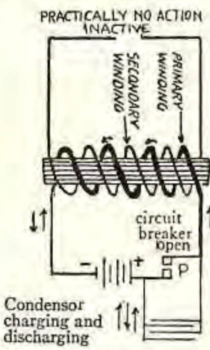



Fig. 7

**The condenser, after being charged, makes an oscillating discharge** of high voltage and frequency through the primary winding and battery (Fig. 7). That is, the discharge is first in one direction and then in the other, the strength of this current gradually decreasing (owing to the resistance of the circuit) until it dies down to zero. This alternation or reversal of the current flow is very rapid, sometimes reversing from one direction to the other as many as two hundred thousand times every second, and its discharge can therefore be considered almost instantaneous.

The main purpose of the alternate discharges shown in Fig. 7 is to completely demagnetize or neutralize the iron core, thereby preparing the core for a repeated action of building-up again as shown in Fig. 5, and collapsing, as shown in Fig. 6.

As this is written out, or as it is read, it seems a rather long action. The process, however, does not require one-thousandth of a second, inasmuch as the current alternates at an extremely high frequency, sometimes having as many as 100,000 cycles per second.

### Meaning of Cycle and Frequency

**A cycle** means a series of events which continually reoccur. In the case of a condenser, for example, the current discharge at one instant is a maximum (+), as shown at (C) (Fig. 7A). It gradually declines to 0 at (A), then builds up to a maximum (−) as shown at (D), again declining to 0 at (B), reversing in direction and building up to a maximum (+) at (E), which is the same condition as at (C), thus reversing the direction twice at (A) and (B) and completing the cycle evolution, which is repeated over and over again until the discharge dies down to 0 (zero).

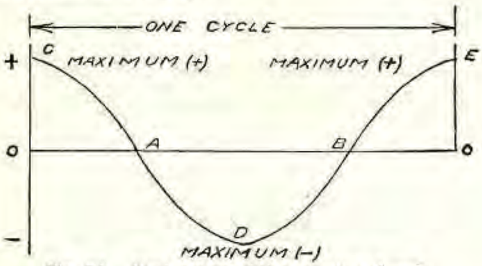



Fig. 7A. Explanation of the meaning of cycle.

**Frequency** means the number of cycles completed per second. As mentioned above, it is 100,000.

### The Ignition Commutator

Because **the secondary current is only needed when it is time for the spark to pass and ignite the mixture,** the primary current is switched into the primary winding only once during two revolutions on a single-cylinder engine. The switching is done by a commutator, which might be termed a revolving switch.

**Where there are four cylinders to an engine,** then it would be necessary to have four segments (S) on the commutator, because four sparks are required during two revolutions of the crank shaft.

**A four-cylinder ignition commutator** is shown in Fig. 8. An ignition commutator is used only with a vibrator-type coil, as on the Ford. The vibrator-type coil and commutator are seldom used on any other make of car.

**The spark timing device** (commutator) is so named because it "times" the spark at the right time. In other words, the roller makes contact with one of the segments (1, 2, 3, or 4 on a four-cylinder engine). Each segment controls one of the spark plugs (through a coil) in one of the four cylinders. When the right cylinder is ready to fire, the timer makes contact and starts the vibrator on the coil, which causes a spark at the points of the spark plug. This device is called a "commutator," and is used only with a high-tension coil using a vibrator.

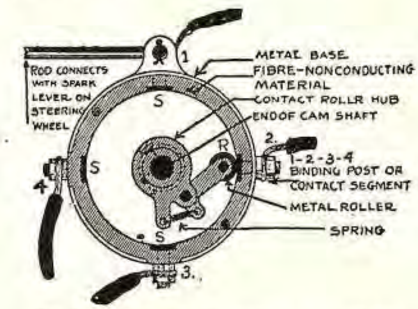



Fig. 8. A four-cylinder ignition commutator.

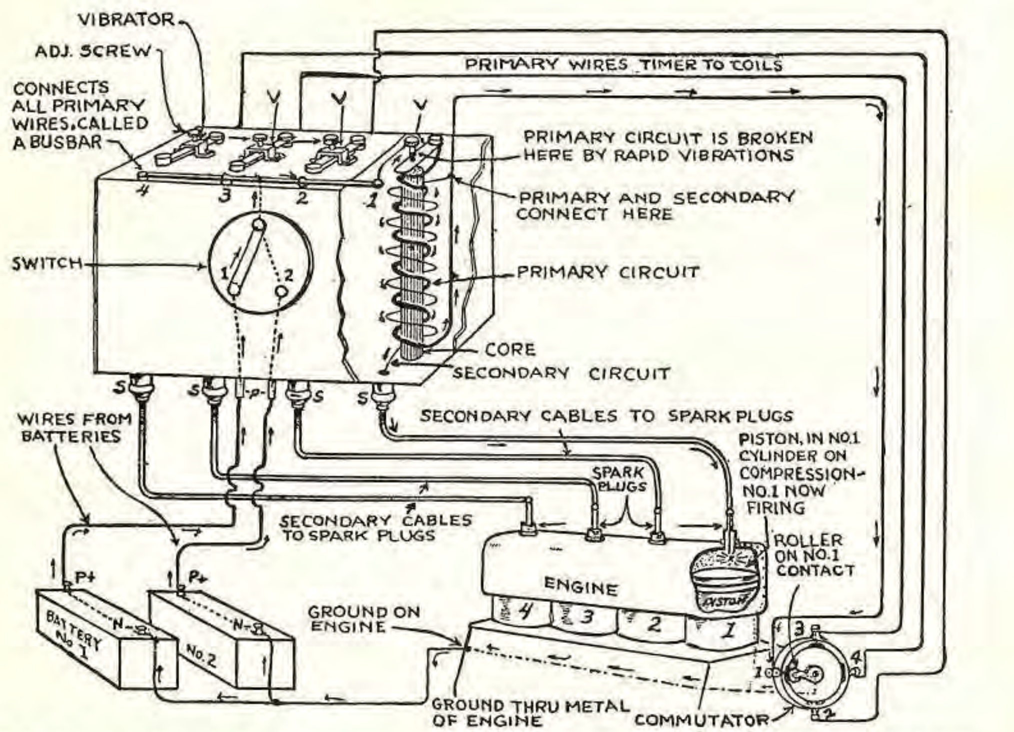



Fig. 9. Circuit of a four-cylinder vibrator coil ignition system using a commutator (exaggerated) and two sets of batteries.

**Commutator construction:** There are many different constructions. One which will explain the principle of a commutator is shown in Fig. 8.

**The metal roller hub** is connected to the cam shaft of the engine. A roller (R) revolves in a housing lined with an insulated, non-conducting material, usually fiber. Metal segments (S) are placed 90° apart for a four-cylinder engine. These segments are connected with one terminal of the primary winding of the coil. There are as many segments on the commutator and as many coils as there are cylinders. Since the cam shaft makes one revolution while the crank shaft makes two revolutions, then the roller (R) would revolve the same number of times as the cam shaft, because it is connected with it. Thus roller (R) would make contact with each of the four segments during one revolution, and so would produce four sparks in the engine cylinders, or one spark for each cylinder during one revolution of the roller (R), or two revolutions of the crank shaft of the engine

### Electric Circuit of a Four-Cylinder Vibrator Coil Ignition System

The illustration (Fig. 9) explains how a commutator is driven from the cam shaft of a four-cylinder engine and how it is connected with the primary windings of four-vibrator type coils contained in one coil box.

The illustration also shows the primary wiring connection from the battery, through one of the coils and connections to the other three coils and to the commutator, back to the battery; also the secondary circuit from coil to spark plugs, back to the coil.

**Primary circuit:** Place your pencil on the drawing at the positive pole (P+) of No. 1 battery, and follow out the circuit.

We will begin with the positive pole connection of No. 1 battery; there are two sets of batteries, but only one set is used at the time. If one runs down, the other one is thrown into service by a switch on the coil.

The switch is now on No. 1 contact, and the circuit is from No. 1 battery to the switch, through the switch lever to the bus-bar on the front of the coil, which connects to the contact screw (V) of the coil, thence through the platinum points, through the magnetic vibrator spring, to the primary winding which is wrapped around a core or bundle of soft iron wires.

The other end of this primary wire of coil connects with the segment on the commutator; the current is closed here at the proper time. The commutator roller-contact revolves as explained previously. When this contact is completed, the primary circuit is closed on one of the four coils (it is now closed on No. 1 coil). When this circuit is closed, the bundle of iron wires (core) becomes magnetized and draws the vibrator down, but the moment the vibrator is drawn away from the contact with the vibrator screw, the circuit is broken and the vibrator springs back and makes contact again, but is immediately drawn down again; this, of course, is quick and rapid. This vibration is kept up as long as the contact is made on the timer, which, of course, is only for a moment, but during that time the vibrator makes several vibrations or "buzzes" as explained previously.

**Secondary circuit:** When these vibrations, or interruption of current, occur, a current is "induced" into the secondary winding of fine insulated wire wrapped around the primary winding of the coil, called a "secondary winding." (How and why this current is induced into the secondary winding without any metallic connection was explained.

This secondary winding, of course, has two terminals; one end goes to a spark plug, and the other end connects to one side of the primary wire, which grounds it through the commutator roller to the engine, when the roller makes contact; thence the circuit is to the metal shell of the spark plug in the engine, across the spark-plug gap, to the insulated part of the spark plug, back to the coil. A separate coil unit is provided for each cylinder.

**The duty of the commutator,** therefore, is to make contact at a certain time in order that the right coil will operate and supply an electric spark to the right cylinder at the right time.

Note. When one wire (on any wiring diagram) passes over another wire without making contact, a half-circle is made, as shown above.

### How the Commutator Helps Control the Speed

The commutator is connected to the spark lever on the steering wheel (Fig. 10). When the spark-lever is pushed forward, the commutator is shifted forward so that the metal roller makes contact earlier with the contact segment. This is called "advancing" the spark.

If the commutator is shifted back instead of forward, the contact is made later. This is called "retarding" the spark.

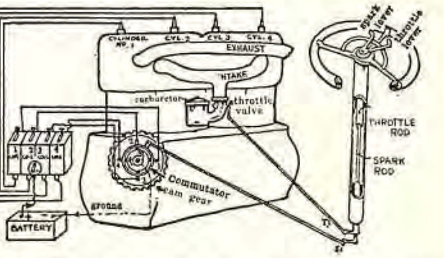



Fig. 10. Note the manual (hand) method of "advancing" and "retarding" the commutator. (Four-cylinder engine as example.) If the roller is revolving to the left, by shifting the commutator housing to the right, contact would be made earlier. This would be called "advancing" the spark. If the commutator is shifted to the left, contact would be made later—called "retarding."

When using a vibrator coil (which is the case here), the time of the spark is set earlier than when using the single-spark system, because plenty of time must be given the spark to ignite the gas so that it will ignite and combust when the piston is at the top of its stroke instead of after the top. (Note the connections to the commutator for firing order of 1, 2, 4, 3.)

**The setting for the time of spark to occur** is done by placing the contact roller at a certain position, as will be explained under "Ignition timing."

**The gas-throttle lever** is the lever used to run on, and is used to increase or decrease the speed of an engine. This is done by opening and closing the throttle, as explained under the subject of Carburetors.

**It is well to run with the spark lever as well forward, or advanced, as possible,** as it will tend to keep the speed of the engine up and consume less gasoline and create less heat. If the spark lever is too far advanced, then the engine will pound or knock, because the ignition will take place before the piston is over the center. A retarded spark produces heat.

The amount of advancing and retarding of the spark by hand must be learned by actual practice, in order to get the best results.

### High-Tension Vibrator Coil Using a Commutator as Used on One, Two, and Four-Cylinder Engines

As previously stated, the vibrator-type coil is now seldom used on automobile engines. It will often be found on small marine and stationary engines. A few examples of connections are shown below.

There are as many coil units and as many commutator segments as there are cylinders.

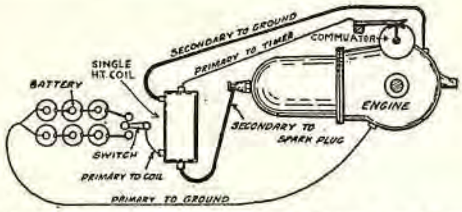



Fig. 11. One-cylinder engine with a vibrator type of jump-spark coil and two sets of dry batteries for ignition. Only one set of batteries is in use at the time. The commutator revolves at one-half the speed of the crank shaft. Note that there is one commutator segment.

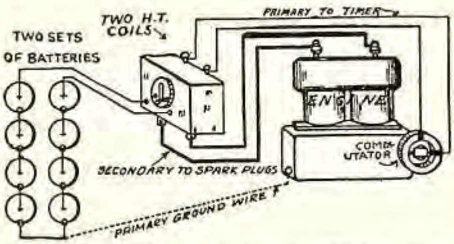



Fig. 12. Two-cylinder vertical engine (180° crank shaft) with a vibrator-type of jump spark coil and two sets of dry cells for ignition. Note the position of the segments on the commutator. The commutator revolves at one-half the speed of the crank shaft. (This type of engine is seldom used.)

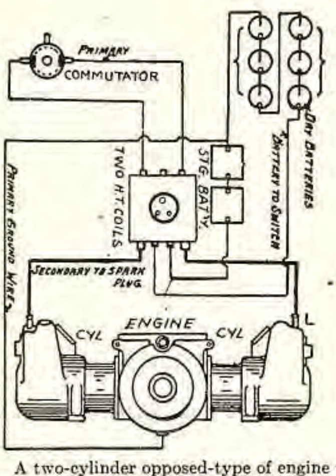



Fig. 13. A two-cylinder opposed-type of engine with a two-cylinder jump-spark coil and a set of dry cells and a storage battery, either of which may be used. The two contacts on the commutator are placed opposite. This revolves at one-half the speed of the crank shaft.

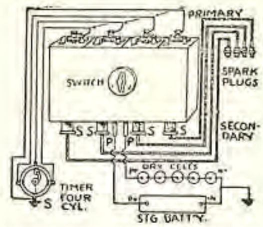



Fig. 14. A four-cylinder vibrator-type coil, using a commutator with four segments and a set of dry cells and a storage battery, either of which may be used. (S) are secondary terminal connections to the spark plugs.

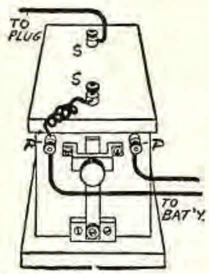



Fig. 15. A single-cylinder vibrator-type of jump-spark coil. This type is usually called a "box coil," and is only used on small marine or stationary engines. Quite frequently a single-cylinder box coil has but one secondary connection on top. In this case the secondary connection shown at the front of the coil is connected inside of the coil to the primary wire which connects to binding post (P).

### The Master Vibrator Coil

With the "high-tension" vibrator coil system, just described, as many coil units, each with vibrators, would be provided as the engine had cylinders. If a four-cylinder engine, four vibrator coil units would be necessary. If a six-cylinder engine, six vibrator coil units would be necessary.

It will be noted that with this number of vibrators, one or more would be constantly sticking, unless a great deal of attention was given to them.

Therefore, by using a **master vibrator,** only one vibrator coil is used, which is connected with the other coils as shown in Fig. 16 (page 195).

The master vibrator coil has but a **single primary winding,** and is connected in series, so the primary current must travel through it before reaching any of the coils. The usual commutator is employed.

**The master-vibrator coil** can be connected with a "multiple" of coils, by screwing down the vibrators on all coils and short-circuiting them, by connecting as shown in Fig. 16A. Note that the coils are the regular double-wound, high-tension coils.

The advantage of such a system is that there is but **one vibrator** to keep in adjustment, since this vibrator serves for all the cylinders; whereas, with several vibrator-coil units the difficulty of keeping several adjustments is a considerable factor.

The disadvantage is the great amount of wiring necessary with the multiple-coil system. Although the master vibrator is easily connected and requires very little wiring, the "distributor" system, which will be explained next, requires considerably less wiring. The master vibrator is an excellent addition to be applied to a multiple system of ignition, already installed, which uses vibrator-type coils.

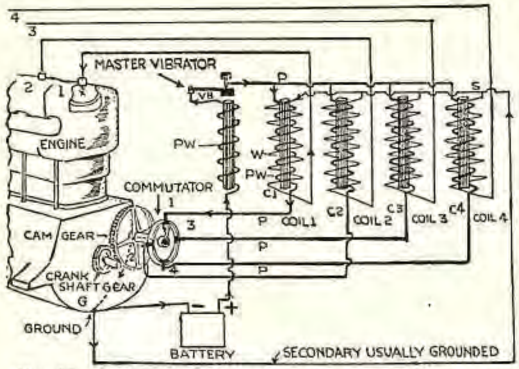



Fig. 16. A simplified illustration of a **master vibrator coil** on a four-cylinder engine, as an example. (W) secondary winding; (PW) primary winding; (P) primary wire; (VB) vibrator; (C) coils; (G) secondary ground wire; Fig. 16A, shows how the vibrator on the coils **C1, C2, C3,** and **C4** are short-circuited.

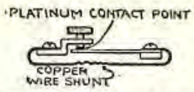



Fig. 16A. How to short-circuit vibrators on coils.

The firing order is 1, 2, 4, 3. No. 1 segment of the commutator is now connected; therefore coil (C1) is firing No. 1 cylinder. Note that the master vibrator is in series with this coil. The primary circuit in this instance is from (+) battery, through the winding of the master vibrator, through the vibrator points, through the primary winding of coil (C1), to the commutator segment, through the metal roller, through the ground of the engine, to the other terminal of the battery.

The secondary circuit is from wire (S) to the spark plug, through the engine, back to the other end of the secondary winding on the coil.

The next cylinder to fire will be No. 2, and coil (C2) will be the next one connected by the roller on the commutator. The next to fire will be cylinder No. 4 through coil (C4), then cylinder No. 3. through coil (C3).

### The "Distributor" or Synchronous System of Ignition

In the foregoing examples it will have been noted that the amount of wiring required for engines having more than one cylinder becomes increasingly complicated. A system now generally used, known as the "distributor system," very considerably simplifies the wiring, and at the same time a more accurate timing of firing of the respective cylinder is obtained. (See Fig. 17).

**One vibrator coil only is necessary,** this having the high-tension terminal joined up to the "distributor," which is a special form of rotating switch highly insulated, which directs the high-tension current to the cylinders in the required order.

**The secondary distributor brush** (B) rotates at the same speed as the commutator roller contact-maker, and in perfect unison with it; that is to say, when the low-tension circuit is completed, the high-tension circuit is completed likewise. The diagram should make the system clear, it being borne in mind that the distributor is rotating as well as the contact maker, and in perfect "synchronism" with it.

The secondary distributor is made in combination with a commutator, each with as many contacts as the engine has cylinders, and with the moving parts of each attached to the same shaft and revolving. (See Fig. 18).

**The battery** is connected to the single coil in the usual manner, and a wire is run from the primary terminal of the coil to the commutator, where it is connected to the four segments of the commutator. Thus when the commutator revolves, the current is passed through the one coil every time that contact is made.

If with this arrangement a wire was run from the secondary terminal of the coil to the four spark plugs, sparks would pass in all four cylinders whenever the timer made contact. Instead of this, one secondary wire is run from the secondary terminal to the moving part of the distributor, termed the "distributor brush," or "rotor," and from each contact point, or distributor segment of the distributor to the proper spark plug.

**When the commutator makes contact, and the secondary current is formed,** it flows to the secondary distributor, which at that instant has made contact with one of its segments, so that that secondary current flows across the contact and to the spark plug that is connected.

The advantage of this system is that there is only one vibrator to keep in adjustment, and only one coil, thus fewer parts. The disadvantage is that the constant action of the vibrator is liable to burn the vibrator points, and destroy them. Electrical lag is also a factor to be considered, as is also a greater consumption of current.

The more modern ignition system uses a distributor for distributing the secondary current to the spark plugs in a similar manner, but instead of using a coil with a magnetic type of vibrator, or interrupter, a coil without a vibrator, termed a "non-vibrating" high-tension double-wound coil, is used, and instead of using a commutator, a timer or "interrupter," which is mechanically operated from the engine, is used. This system will be treated in the next instruction.

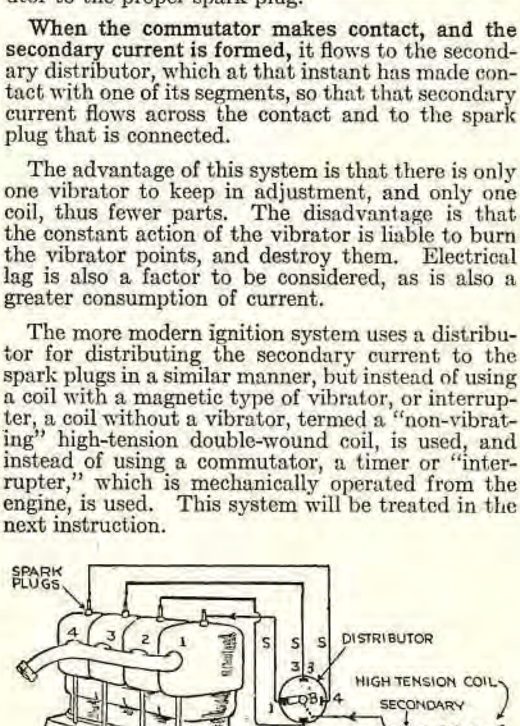



Fig. 17. A simplified illustration showing the principle of a high-tension **distributor** or **synchronous system** of ignition using a vibrator type of coil. Not in general use. (P) primary winding; (S) secondary. Note that one end grounds to the engine (usually grounded on the coil). (VS) vibrator screw.

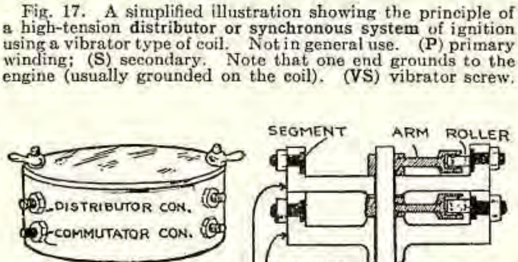



Fig. 18. Simplified illustrations to explain the principle of a **distributor and commutator** in one housing and operated by one drive shaft, used in connection with a vibrator type of coil. This method is obsolete, but a similar principle, of different construction, is the modern method, as will be explained farther on. Note that the distributor and commutator are together. The wiring diagram (Fig. 17) shows the two separated merely to explain the action.