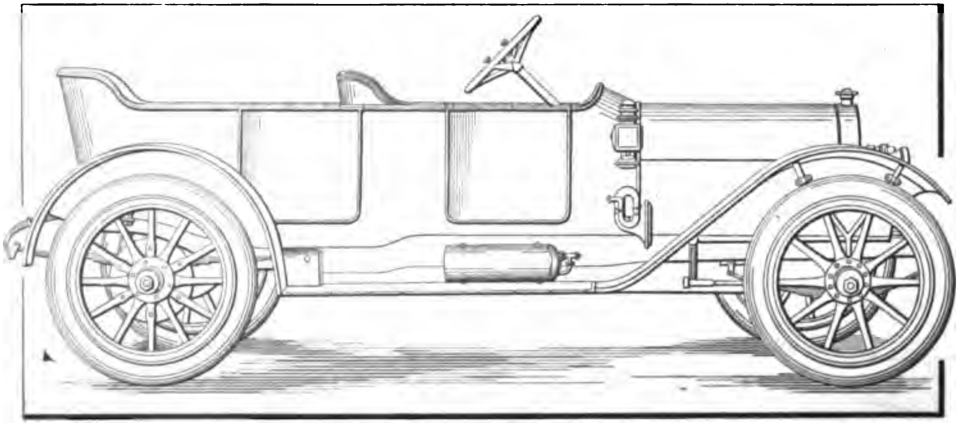
AUTOMOBILE CATECHISM



TYPICAL AMERICAN FOUR-CYLINDER TORPEDO TYPE OF AUTOMOBILE

AUTOMOBILE CATECHISM

FOR THE USE OF OWNERS AND DRIVERS OF CARS FITTED WITH INTERNAL COMBUSTION MOTORS

BY

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THIRD EDITION

NEW YORK:
THE CLASS JOURNAL COMPANY
231-241 West 39th Street
PUBLISHERS OF "THE AUTOMOBILE"
1910

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Preface to Last Edition

Ignition is given special attention in this revision. The scope of the work has been broadened, and the size of the book is more than doubled. It contains practically new matter.

FORREST R. JONES.

Detroit, Mich., Oct. 28, 1910.

AUTOMOBILE CATECHISM

Motor Parts and Function

1. Q.—Describe each of the following parts of an internal combustion engine and explain its use. (See Figs. 1 and 2.)

A.—Cylinder: The principal stationary part of the engine, cylindrical in form, closed at one end, except small openings for the admission and exhaust of gases, and an opening for the igniting device (spark plug, make-and-break igniter, contact igniter).

Piston: A cylindrical cup-shaped piece which fits accurately and has a reciprocating motion in the bore of the cylinder. It has three or more circumferential grooves into which expansion rings fit to make an air-tight joint.

Piston ring: A thin, narrow, elastic ring which fits into a circumferential groove in the piston. The ring is cut through on one side to allow it to expand and press against the cylinder wall.

Combustion chamber or compression space: The closed extension at the head of the cylinder into which the piston does not extend in its reciprocating motion.

Crankshaft or main shaft: The principal shaft, either bent to form cranks, or built up of parts to give the same form, and which rotates when the engine is in motion (turning over). The flywheel when used is placed on the extension of the crankshaft.

Connecting rod: The connecting member between the piston and crankshaft. It usually has a cylindrical hole at each end. The axes of the holes are parallel.

Connecting rod cap: The semi-circular piece attached to the crank end of the connecting rod.

Wrist pin: The pin which forms the pivotal connection between the piston and connecting rod, being central in the piston.

Crank pin: The part of the crankshaft on which the connecting rod turns.

Main-shaft bearings: The parts of the engine frame which support the crankshaft and allow it to turn in them.

Crank-case: The metal case to which the open end of the cylinder (or cylinders) is attached, and which encloses the cranked portion of the main shaft and one end of the connecting rod.

Inlet (admission, intake) port: The opening into the combustion chamber through which the charge enters into the cylinder.

Inlet valve (also called admission, intake or mixture valve): A piece of metal, generally shaped like a toadstool or mushroom, which closes the opening (port) through which the combustible mixture enters the engine.

Exhaust (discharge, release) port: The opening into the combustion chamber through which the inert exhaust gases escape from the cylinder.

Exhaust (release) valve: The valve, generally shaped like a mushroom or toadstool, which closes the port through which the gases are discharged from the combustion chamber when the valve is lifted from its seat.

Cam: An irregular-shaped machine part, which when rotating about its axis (in the rotative type) gives a required motion to another part. (Cams are of numerous types, as rotative, rectilinear motion, inverse cam, etc.) The rotative type is generally used in automobile engine practice, but other types are found infrequently.

Camshaft: A shaft which supports and rotates a cam or cams. A shaft and its cams are often made of a single piece of metal (solid steel shaft and cams, integral cam and shaft).

Inlet cam: A piece of metal irregular in outline which rotates about a shaft so as to lift the inlet valve from its seat at the proper time.

Exhaust cam: Same as inlet cam, except that its function is to lift the exhaust valve.

Igniter cam: An irregular-shaped piece of metal whose function is to separate the contact points when the low pressure direct current is used for make-and-break contact ignition.

Cam follower: A piece of metal which rests or presses against a cam and follows its outline as the latter rotates.

Petcock: A small valve, generally with a thumb grip, for releasing compression in the cylinder, or draining radiators, water jackets, etc.

Piston pin: See "wrist pin."

2. Q.—What is a valve spring?

A.—A spring (usually coiled) which holds the valve against its seat so as to close the port except when it should be open.

3. Q.—What is an automatic valve?

A.—One which opens by suction. (By pressure of the atmosphere from without when the intake stroke of the piston reduces the pressure inside the cylinder.) Such a valve is shown in Fig. 1 at H.

4. Q.—What is a mechanical valve (mechanically operated)?

A.—One which is opened by a positive force.

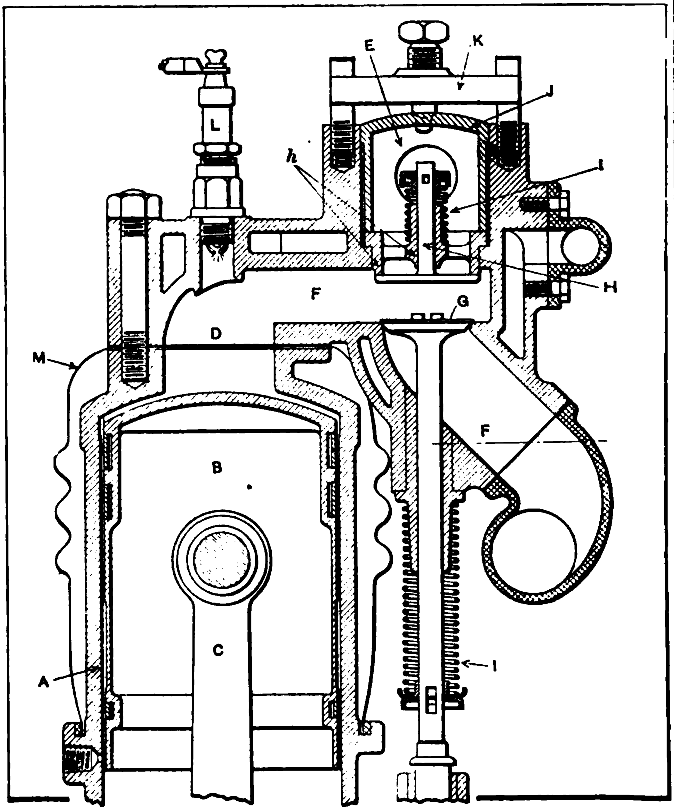


Fig. 1—SECTION OF CYLINDER OF FOUR-CYCLE MOTOR WITH AUTOMATIC INLET VALVE

A, cylinder. B, piston. C, connecting rod. D, combustion chamber. E, inlet port. FF, exhaust port. G, exhaust valve. H, inlet valve and stem. II, valve springs. J, inlet valve chamber. K, yoke for retaining inlet valve chamber. L, spark plug. M, separate shell for water jacket.

NOTE: This illustration is applicable to the type of motor that is provided with automatic, rather than positive, inlet valve mechanisms.

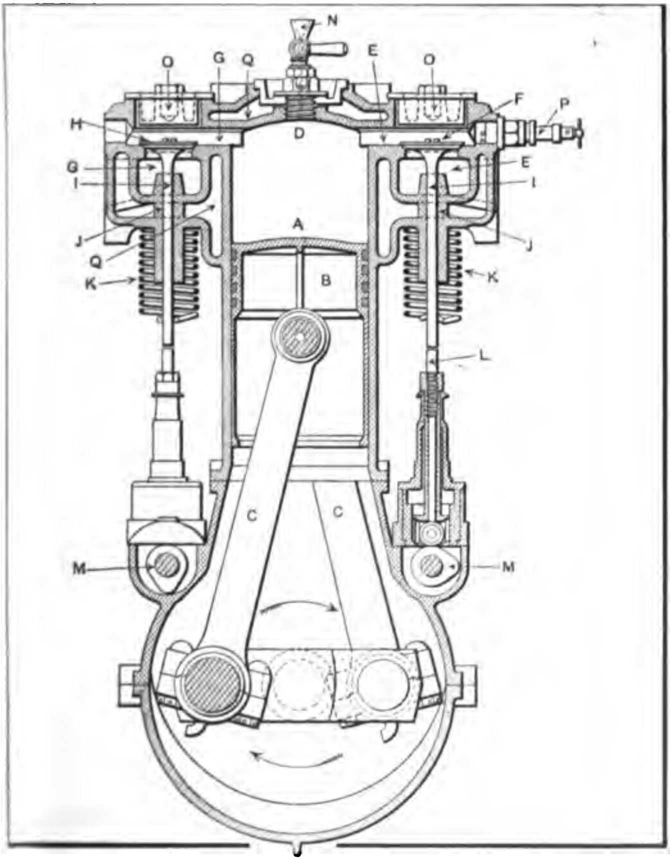


Fig. 2—SECTION OF FOUR-CYCLE MOTOR WITH MECHANICALLY OPERATED VALVES

A, cylinder. B, piston. CC, connecting rods. D, combustion chamber. EE, inlet port; leads from inlet pipe to combustion chamber. F, inlet valve. GG, exhaust port; leads from combustion chamber to exhaust pipe. H, exhaust valve. II, valve stems. JJ, valve stem guides. KK, valve springs. L, valve lifter, push rod or cam follower, with adjustable screw cap and roller that rests on cam. MM, cams. N, petcock with funnel top. OO, plugs, removable for taking out valves. P, spark plug. Q, water jacket space.

5.—Q.—Are inlet valves automatic or mechanical?
A.—Both forms are used.

6. Q.—Is an exhaust valve ever automatic?
A.—No. It is always opened against a pressure in the cylinder which acts to hold it closed, and must be opened by a positive force (a cam and its follower or other mechanism positive in its action) when the engine is working properly.

7. Q.—In an engine with an automatic inlet valve, which must have the stronger spring, the inlet or exhaust valve?
A.—The exhaust valve. Only the inlet valve should open during the suction (charging) stroke. If both springs were of the same strength, the exhaust valve would be more apt to open on account of the pressure in the exhaust pipes being higher.

8. Q.—When the inlet and exhaust valves are both mechanically operated should there be any difference in the strength of the valve spring?
A.—Not necessarily. But on account of the exhaust valve being more likely to stick or bind in the hole which guides it, a stronger spring is sometimes used.

9. Q.—What is a stroke of the piston?
A.—The movement of the piston from its extreme position at one end of the cylinder to its extreme position at the opposite end. The distance of travel between the two dead centers of the piston.

10. Q.—How many strokes does a piston make during one revolution of the crankshaft?
A.—Two in the ordinary form of motor—the instroke and the out-stroke.

11. Q.—What is a cycle with reference to an internal combustion engine?

A.—A series of events in regular order through which the engine and its auxiliary apparatus pass.

For a better understanding of the four cycles, study Fig. 3, which represents the cylinder of a motor shown in section with the piston in four successive positions, i.e. suction, compression, power and exhaust strokes. In the suction stroke, as shown at (A), the piston is in the position of having just completed the downward sweep; the compression stroke is just be-

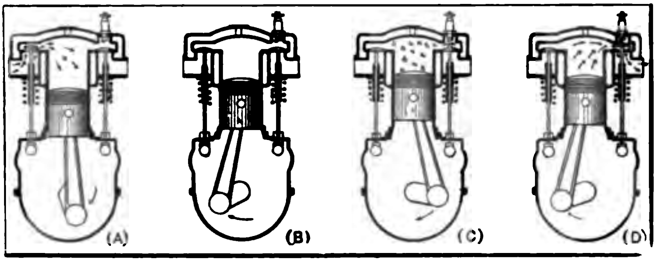


FIG. 3—SHOWING THE FOUR POSITIONS OF THE PISTON OF A MOTOR DURING THE FOUR-CYCLIC FUNCTIONS

ginning at (B); the power stroke is about half finished at (C), and the (upward) exhaust stroke is under way at (D). The arrows show the direction of rotation of the crankshaft. On the suction stroke at (A), the inlet valve is on the open position; during the compression stroke at (B), both inlet and exhaust valves are closed; this condition also continues through the power stroke at (C), and during the exhaust stroke the inlet valve is closed, but the exhaust valve is open.

12. Q.—What is a four-stroke cycle (usually called four-cycle) engine?

A.—An internal combustion engine in which the complete cycle (series of events) occurs during four successive strokes of the piston.

13. Q.—Give the events that occur in a four-cycle gasoline engine in the order of their occurrence.

A.—Any part of the cycle may be taken as the starting point. It is convenient to begin with the stroke that draws in the combustible mixture.

First stroke: Intake or admission stroke. The piston starts from its extreme position next the combustion chamber (from the highest position in a vertical cylinder engine) and the inlet valve is opened either by suction (automatic valve) or by the inlet cam (mechanical valve) at about the same time so as to allow the combustible mixture (charge) to be drawn in by suction until the end or about the end of the stroke. The inlet valve closes at (or about) the end of the intake stroke.

Second stroke: Compression stroke. Both valves are closed. The piston moving toward the closed end of the cylinder (combustion chamber) compresses the charge to a pressure of about 65 pounds per sq. in., as shown by gauge reading if a gauge is attached to the combustion chamber for obtaining the pressure.

Third stroke: Impulse, working, expansion or driving stroke. Includes ignition, inflammation, combustion and expansion of charge. The electric spark or other ignition device ignites the charge about the time the piston has completed compression, and combustion (following inflammation) takes place more or less rapidly. The gas pressure is increased by the heat of combustion (to about 350 pounds per square inch or less) and drives the piston out from the closed end of the cylinder. The expansion and cooling of the products of combustion lower the pressure as the piston moves out. Shortly before the end of the impulse stroke the exhaust valve is opened by the exhaust cam (the exhaust valve is always opened by a cam or other device positive in its action) and the gases escape rapidly with a characteristic puff until the pressure falls to about that of the atmosphere (to nearly zero by gauge).

Fourth stroke: Exhaust stroke. The piston, moving toward the closed end of the cylinder, expels more of the remaining gases through the open exhaust port. The exhaust valve is held off its seat until (or after) the end of the stroke. This completes the cycle. It is begun again with the next stroke.

14. Q.—What speed of rotation must the camshaft have?

A.—Half as fast as the main shaft of the engine if each cam has only one lobe (lug, protuberance) or depression. The camshaft must be positively driven, as by tooth gears, by the main shaft. The gear on the camshaft has twice as many teeth as the one on the crankshaft. This applies to the four-stroke cycle motor. In a two-stroke cycle motor the camshaft rotates at the same speed as the crankshaft when the cam has only one lug, provided there is a camshaft, which is not usually so for a two-cycle motor.

15. Q.—What are two-to-one gears?

A.—The gears used to drive the camshaft of a four-cycle motor. The driving gear is on the crankshaft. The driven gear on the camshaft has twice as many teeth as the driving gear.

16. Q.—What is a muffler and why used?

A.—It is an enlargement (or enlargements) of the exhaust pipe, or a corresponding device to deaden the noise of the exhaust.

A muffler is shown in Fig. 4, and the dotted lines are so placed as to indicate the internal construction. Fig. 5 depicts the muffler pipe passing under the gasoline tank at the rear of the automobile, and it is the purpose here to indicate that if the pipe is not properly secured it will vibrate and, perhaps, chafe a hole in the tank. At all events, it is proper to secure the pipe so that it will not make noise. Fig 6 is another view of the muffler pipe as it extends out beyond the line of the gasoline tank; it should not be pointed at the ground; dust will be raised by the exhaust gas if it sweeps against the top dressing of the road.

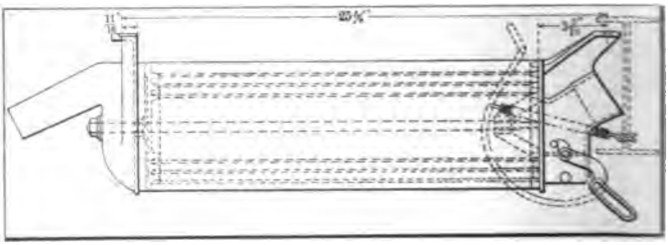


FIG. 4—OUTLINE OF A CONVENTIONAL TYPE OF MUFFLER AS USED IN AUTOMOBILE MOTOR WORK

17. Q.—Does the muffler reduce the effective power of the engine?

A.—Yes, but only to a slight extent when properly designed and installed. A cut-out valve is often applied to allow the exhaust to escape without passing through the muffler.

18. Q.—Why are piston rings used?

A.—In order to make an air-tight fit of the piston and rings combined in the bore of the cylinder. It is found impossible to make the solid piston fit tightly enough in engine practice. The rings, on account of their thinness and being cut open on one side, expand by their elasticity against the bore of the cylinder so as to make a tight-fitting joint and adjust themselves to variation in bore caused by heat and wear.

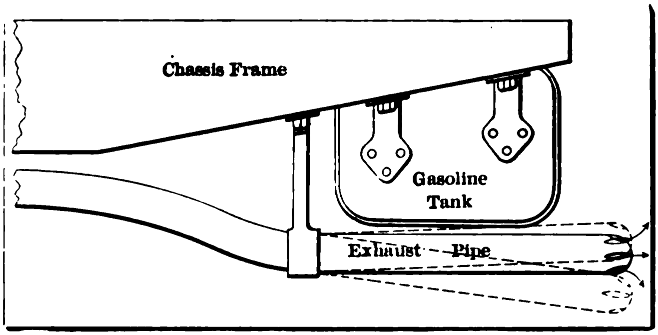


Fig. 5—SHOWING HOW THE MUFFLER PIPE PASSES UNDER THE GASOLINE TANK AT THE REAR OF THE CHASSIS

19. Q.—What is a "dead center"?

A.—In reference to an engine, it means the position of the crankshaft which brings the connecting rod and crank in line so that a force exerted upon the piston to move it along the bore of the cylinder has no ro-

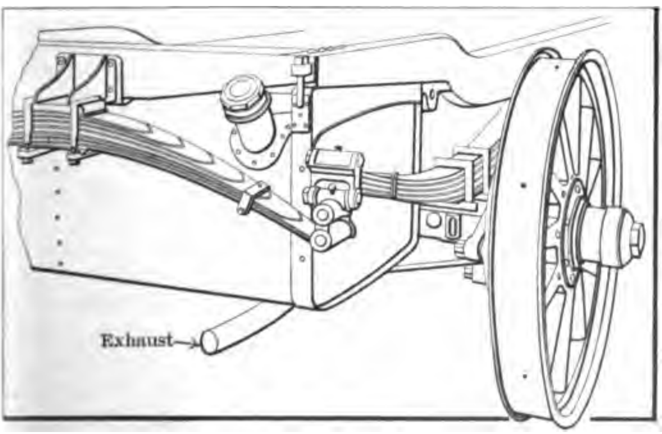


Fig. 6—LOOKING AT THE REAR END OF THE CHASSIS DEPICTING THE MUFFLER PIPE TURNED SO THAT THE EXHAUST WILL NOT RAISE DUST

tative effect on the crank, and the engine remains dead. In the ordinary types of engine each crank has two dead centers, one-half revolution of the crank apart, one for each position of the piston at the end of a stroke. The dead centers are not one-half revolution apart in an engine whose cylinder is offset so as to be somewhat to one side of the crankshaft. This practice is adopted to reduce piston pressure.

20. Q.—Give the events that occur in a two-stroke cycle (usually called two-cycle) engine in the order of their occurrence.

A.—As a convenient method for a beginning, it will be assumed that there is a compressed charge in the combustion chamber, and the piston in its position nearest the combustion chamber. When a charge is fired, the piston is driven out on the impulse stroke by the pressure caused by the combustion until the stroke has been nearly completed. A number of small port holes arranged circumferentially around the cylinder walls and previously covered by the piston are then uncovered by its motion. The gases in the cylinder still being under considerable pressure rush out through these openings which form the exhaust port. Still further motion of the piston on the impulse stroke uncovers another row of port holes circumferentially arranged, which connect with the crank chamber. When the piston starts on the impulse stroke the crank chamber is filled with a combustible mixture at about atmospheric pressure. The impulse stroke compresses this mixture, so that when the inlet ports—just referred to as being uncovered by the piston—are open, a charge passes from the crank chamber to the cylinder and combustion chamber. The next stroke (up-stroke in a vertical engine, in-stroke in a horizontal engine) of the piston closes first the inlet port then the exhaust port, and finally compresses the charge in the cylinder. On the compression stroke, mixture is drawn into the crank chamber. This completes all the operations related to the cycle. As the name indicates, the complete cycle occurs in the two strokes of piston corresponding to one revolution of the crankshaft. (See Fig. 8.)

21. Q.—Does the gasoline engine main shaft reverse its direction of rotation when the car changes from forward to backward motion?

A.—No. The change-speed and reverse gears provide for this.

22. Q.—Will a four-stroke cycle engine run its main shaft in either direction?

A.—No. Except in very unusual designs.

23. Q.—Can a two-stroke cycle engine be run in either direction?

A.—Yes. By moving the timer to ignite properly, it will run equally well in either direction of rotation —clockwise or counter clockwise. This applies especially to one which has no mechanically operated valve, such as the valve in the crankcase.

24. Q.—How are the cylinders placed in a two-cylinder opposed engine?

A.—On opposite sides of the crankshaft.

25. Q.—How do the pistons move in a two-cylinder opposed (horizontal) engine?

A.—They move toward each other during one-half revolution of the crank, and both recede during the remaining half-revolution.

26. Q.—How is compression produced in the crank chamber of a two-cylinder opposed engine?

A.—By the motion of the pistons toward each other.

27. Q.—How do the pistons move in relation to each other in a four-cylinder vertical engine of the four-stroke cycle type?

A.—The front and rear pistons move upward to-

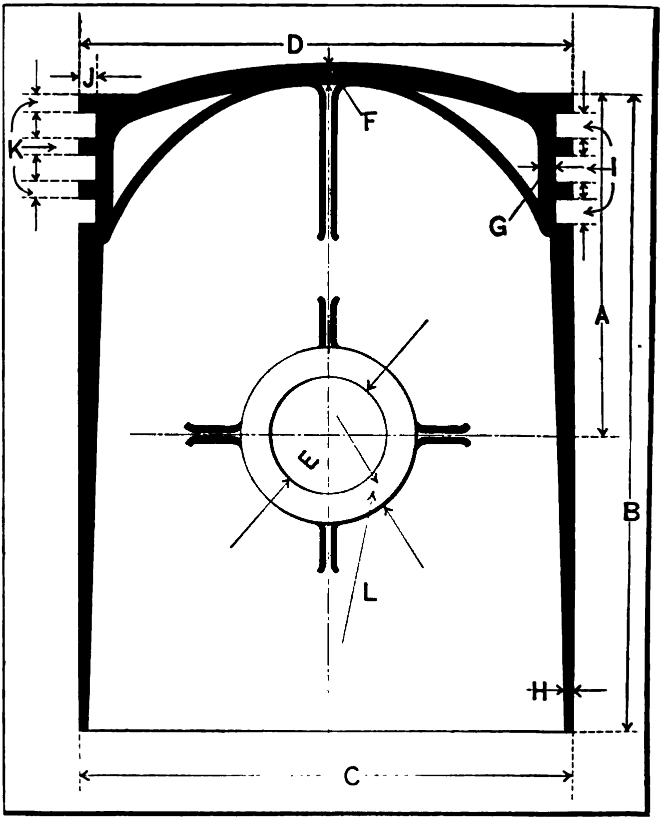


FIG. 7—SECTION OF A PISTON OF A MOTOR, SHOWING THE SPACES FOR THE RINGS, WHICH HAVE TO BE A NEAT FIT

gether at the same time that the intermediate ones move down together. This is the usual construction.

28. Q.—In what order are the successive charges exploded in a four-cylinder four-stroke vertical engine whose pistons move as just described?

A.—Starting with the front cylinder they come in the following order: (1) Front cylinder; (2) one of the intermediate cylinders; (3) rear cylinder; (4) remaining intermediate cylinder.

[NOTE.—Referring to the piston, Fig. 7, A is the distance from the center of the piston pin to the top of the same; B is the distance over all; C is the diameter at the bottom; D is the diameter at the top; E is the diameter of the piston pin; F is the thickness of the wall of the head; G is the thickness of the wall back of the rings; H is the thickness of the wall at the lower extremity; I is the width of the piston rings; J is the depth of the groove; K is the thickness of the dividing wall between rings, and L is the thickness of the boss. These distances are fixed with great exactness in well-made motors, and it is important to hold to them in case the pistons are replaced for purposes of repair. The clearance of the piston in the cylinder is rarely ever more than from .006 to .010 of an inch.]

Carbureters and Fuel Control

29. Q.—What is a carbureter?

A.—An apparatus for enriching air with fuel hydrocarbon such as gasoline, naphtha, kerosene, alcohol, etc.

30. Q.—What types of carbureters are most commonly used?

A.—Float feed, disk feed and diaphragm feed.

31. Q.—Describe a float-feed carbureter.

A.—It has a small reservoir into which the liquid fuel flows through pipe connection from a tank. When the fuel reaches a certain height, a cork or hollow metal float closes a valve which stops the flow. From the reservoir a small opening leads through a pipe (or hole in the casting) to a large tube or opening through which air passes. The upper end of the pipe is slightly higher (1-16 to 1-8 inch) than the level of the liquid maintained by the float. At the end of the pipe is a minute opening (nozzle) for the escape of the liquid. When a current of air is drawn through the air passage the suction draws the liquid fuel (gasoline) out of the nozzle.

When gasoline is thus drawn out it quickly vaporizes and the vapor mixes with the air and forms a combustible mixture when the proportions of air and gasoline are correct. As the gasoline is drawn out, the float descends with the lowered supply in the carbureter. reservoir and more gasoline flows in from the tank till the float valve again shuts it off. A small valve with a conical point and threaded stem, called a needle valve, is adjustable in the opening from the carbureter reservoir to the air passage to regulate the quantity of gasoline drawn out by the air.

One or more throttle valves are placed in the air passage to control the amount of air passing through when the carbureter is used in connection with an internal combustion engine. Some carbureters have more than one gasoline outlet; a small one which operates when the air throttle is nearly closed and only a small amount of air is passing through, and a large nozzle which alone supplies gasoline when the air throttle is opened to a considerable extent. Each opening has its own needle valve.

A spring valve is often used to nearly or completely close the air inlet to the carbureter when resting on the valve seat, but a small bypass or auxiliary air inlet is always left open. This air-valve remains on its seat when the throttle is nearly closed, and all the air comes in through the bypass. But when the throttle is opened, the suction lifts the air-valve from its seat, thus securing a sufficiently large passage. The tension of the air-valve spring is adjustable to regulate the extent of the partial vacuum caused by suction, and thus the amount of gasoline drawn out to enrich the air.

In some carbureters several metal balls are used to close a corresponding number of ports. When the demand for air through the carbureter becomes great enough, the suction lifts the balls from their seats so as to open the ports and allow air to pass in freely. The balls rest on the ports by their own weight only, no spring being used.

The air current in some designs passes by the nozzle in the direction of its opening, in others in the reverse direction, and in some at right angles to the nozzle.

A typical arrangement of float-feed carbureter is shown in Fig. 9.

32. Q.—Describe a disk-feed carbureter.

A.—In the disk-feed carbureter the air is drawn through a large passageway in which is a minute opening that terminates the gasoline feed pipe that leads from the tank. This opening is closed by a needle valve which has a disk of very thin sheet metal attached to the stem. When no air is passing through the carbureter the needle valve closes the gasoline nozzle. As soon as air is drawn through, the current striking against the disk lifts it from its seat. Gravity and suction then both bring gasoline out of the nozzle to mix with the air. The lift of the valve and its disk is controlled by an adjustable screw which regulates the extent of the movement. Sometimes a spring is used to hold the disk down and the valve to its seat; also to regulate the amount of opening due to suction.

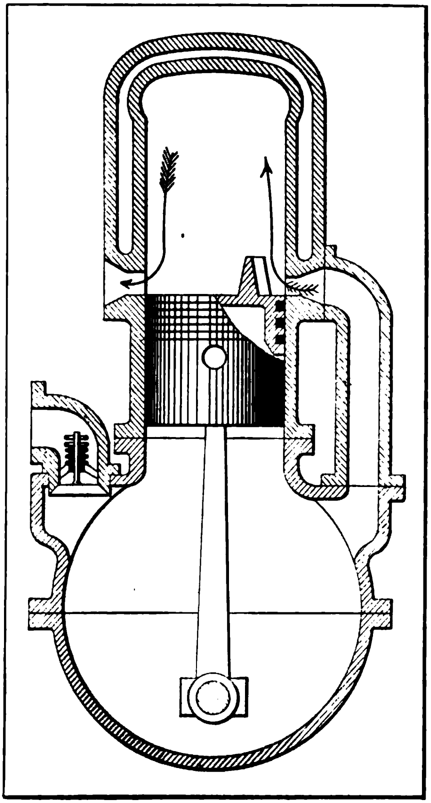


FIG. 8—SECTION OF A 2-PORT 2-CYCLE MOTOR, SHOWING THE INTAKE VALVE IN THE CRANKCASE AND THE LOCATION OF THE TRANSPORTS

33. Q.—Describe a diaphragm-feed carbureter.

A.—In this type the air is drawn through a large passageway as in the types just described. The reduction of air pressure causes action on a diaphragm supported at its circumference and free to move at the center. The needle valve for controlling the outlet of gasoline is held to its seat when no air is passing. As soon as air is drawn through, the pressure is reduced on one side of the diaphragm, which causes its center to move. The needle valve is attached to its center and the motion of the diaphragm lifts the valve from its seat to allow gasoline to flow either by gravity or suction, or both.

34. Q.—Where is the carbureter attached to the engine?

A.—To the inlet ports by means of one or more pipes or by a suitably formed part with passageways. The latter is usually called the "manifold." It is important that the connections be air-tight; if any air passes through the joints it will have the effect of unbalancing the mixture.

35. Q.—What effect on the temperature of the mixture has the vaporization of gasoline in the carbureter?

A.—It cools the mixture. It is not unusual to find frost both outside and inside of the carbureter, just beyond the gasoline nozzle, even in hot, dry weather.

36. Q.—What is the hot-water jacket as applied to the carbureter and why used?

A.—A thin layer of water surrounding the inner part of the carbureter. It is used to make the gasoline vaporize more readily and to prevent the collection of frost on the carbureter.

37. Q.—Why is the air sometimes warmed on its way to the carbureter, and how?

A.—It is warmed to facilitate the vaporization of the gasoline. It permits the use of a heavier (less volatile) liquid fuel than can be used without warming the air. The method of obtaining preheated air is to take it from around the exhaust pipe or unjacketed portion of the engine cylinder.

38. Q.—Will one carbureter supply more than one cylinder?

A.—Yes. It is common practice to use one carbureter for two, four, and even six-cylinder engines.

39. Q.—What is the throttle control lever?

A.—The device for regulating the amount of fuel (combustible mixture) supplied to the engine. A connection from the carbureter throttle is brought to a position to be operated conveniently either by hand or foot, or both. The hand control is generally placed on the steering wheel or column, and the foot control consists of a pedal within easy reach of the driver's foot.

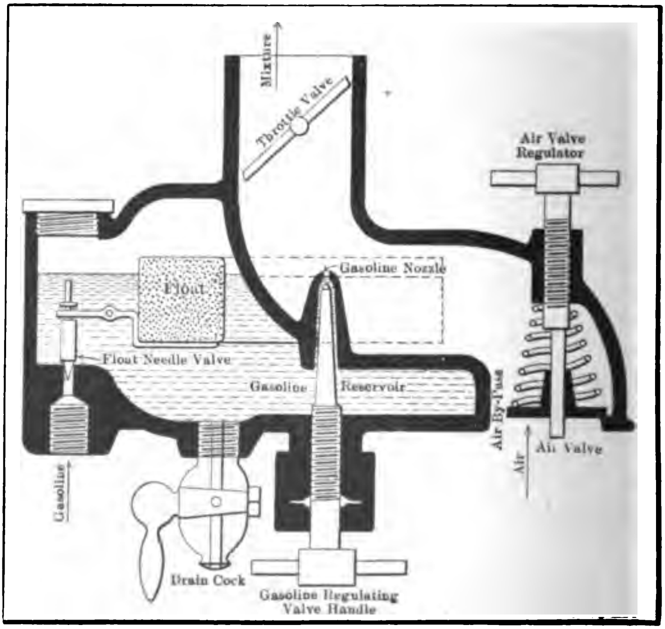


Fig. 9—DIAGRAMMATIC SECTION OF A FLOAT-FEED CARBURETER OF THE CENTER-FEED TYPE USING A HORSESHOE SHAPE OF FLOAT

40. Q.—How is the throttle actuated?
A.—By hand, or by a governor.

41. Q.—What is a governor?
A.—In automobile practice it is a mechanism used to limit the speed of the engine.

42. Q.—What forms of governors are usually employed?
A.—Centrifugal and hydrostatic.

43. Q.—What is a centrifugal governor?
A.—One which rotates about a shaft and has one or more weights held in near the shaft by springs when the governor is at rest or rotating below the critical speed, but when the limiting speed is reached, the centrifugal force acting on the rotating weights overcomes the tension of the springs and the weights move.

43. Q.—What is the hydrostatic type of governor?
A.—One in which the pressure of a liquid, generally the circulating (cooling) water, moves a diaphragm or plunger. In most automobiles with forced circulation by pump the pressure of the water near the outlet of the pump is more or less nearly proportional to the speed of the engine. By connecting the hydrostatic governor to the circulating system at or near this point, it will be acted upon by the varying pressure of the liquid to give motion to the proper part.

44. Q.—What does the governor act upon?
A.—Usually on the throttle valve of the carbureter, which it closes more or less completely at the limit of speed for which the governor is set.

45. Q.—What is an accelerator?
A.—A lever or other device for throwing the governor out of action so that the speed of the engine may

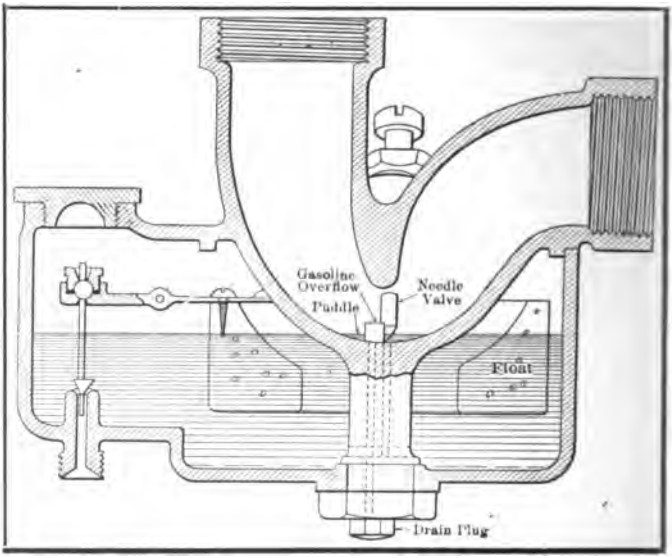


FIg. 10—SECTION OF A SCHEBLER CARBURETER, SHOWING THE LOCATION OF THE CONCENTRIC FLOAT, WORKING OF THE STOP-VALVE, AND THE MECHANISM FOR THE NEEDLE-VALVE IN THE GASOLINE NOZZLE

be increased. It is generally operated by the driver's foot.

46. Q.—Where is the gasoline tank placed in relation to the carbureter?

A.—Either high enough above it for the gasoline to flow by gravity into the carbureter, or it is placed below the level of the carbureter. If the gasoline is under the control of gravity it is important to have the "head" or pressure sufficient to assure all the pressure that is required.

47. Q.—What precaution should be taken for allowing free flow of gasoline from the tank in the gravity system?

A.—There should be a small opening (vent) in the top of the tank. It is usually in the plug; 1-32 inch diameter is sufficient. It is advisable to have the metal raised in a hump or knob where the vent hole is made. This will prevent stoppage by collected dirt.

48. Q.—When the gasoline tank is below the carbureter how is gasoline made to flow to the carbureter?

A.—By pressure of air or gas inside the tank and above the gasoline (compression fuel supply).

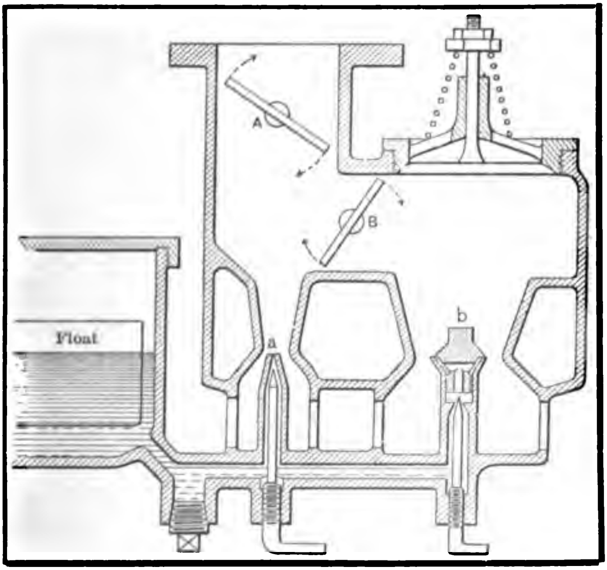


FIG. 11—SECTION OF A CARBURETER OF THE DOUBLE-NOZZLE TYPE WITH THE FLOAT LOCATED IN A BOWL TO ONE SIDE. THIS CARBURETER ALSO HAS AN AUXILIARY AIR-INLET VALVE WHICH IS UNDER SPRING CONTROL. FOR STARTING THE BUTTERFLY VALVE B IS CLOSED; ALL THE AIR THEN PASSES IN AROUND THE NOZZLE a. UNDER RUNNING CONDITIONS THE VALVES A AND B ARE MANIPULATED

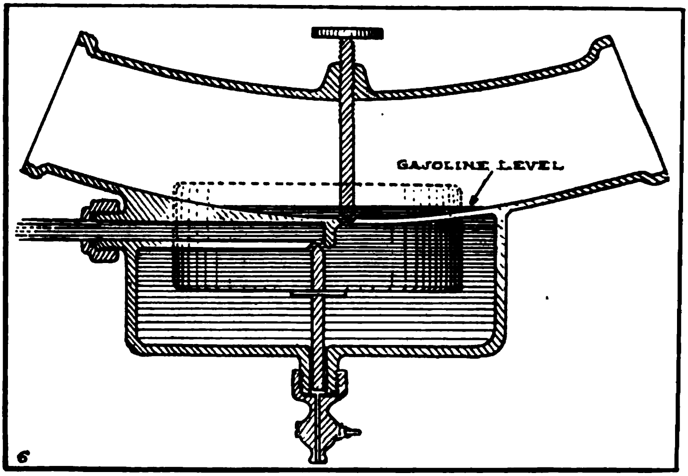


FIG. 12—SECTION OF THE DURYEA TYPE OF CARBURETER. SHOWING HOW THE GASOLINE IS MAINTAINED AT A CONSTANT LEVEL WITH BUT A SLIGHT HEAD

49. Q.—How is the pressure produced and maintained in a compression gasoline tank?

A.—In some systems a small hand air-pump is used to pump air into the gasoline tank until sufficient pressure is secured to start the motor. The exhaust of one cylinder of the motor is then used to maintain the pressure by means of a small tube leading from the pipe at a point near the engine cylinder to the top of the gasoline tank. A check-valve in the tube allows the flow of a portion of the exhaust gas into the tank at the instant the particular cylinder to whose exhaust pipe it is connected is exhausting, but prevents the return of the exhaust gas from the gasoline tank.

The following modification of the above compression system eliminates the necessity of the hand air-pump. A small tank through which the gasoline passes on its way to the carbureter from the compression tank

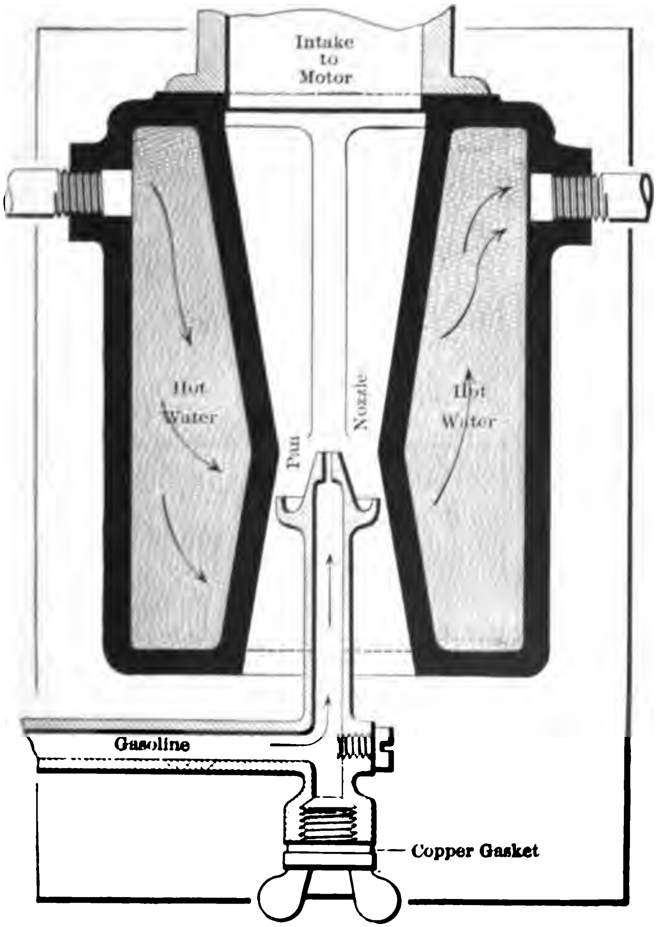


FIG. 13—DEPICTING A PLAN OF WATER-JACKETING AROUND THE NOZZLE OF A CARBURETER IN ORDER TO IMPART ENOUGH HEAT TO THE SPRAY TO VAPORIZE IT BEFORE IT ENTERS THE COMBUSTION CHAMBER OF THE CYLINDER OF THE MOTOR

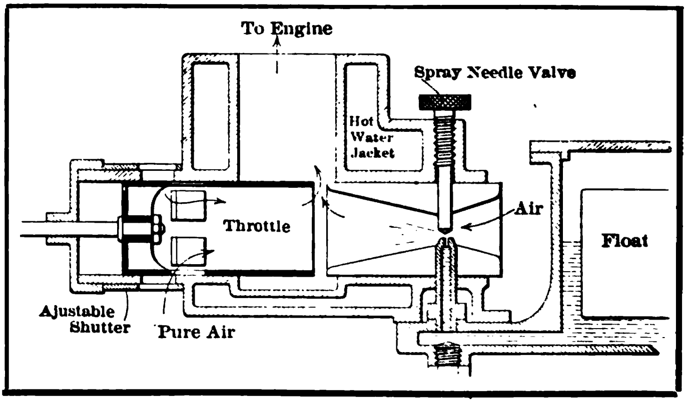


FIG. 14—DEPICTING A TYPE OF CARBURETER USING A SLEEVE-VALVE IN THE AUXILIARY AIR-PASSAGEWAY, SHOWING THE GASOLINE NOZZLE TO THE SIDE OF THE FLOAT-BOWL JUST AT THE JUNCTION OF THE TRANSFER PORT THROUGH WHICH THE MIXTURE GOES TO THE COMBUSTION CHAMBER OF THE MOTOR

is placed above the level of carbureter, and a little of the gasoline always remains in the small tank. When starting the motor it will supply the carbureter long enough for the pressure in the larger gasoline tank to be brought sufficiently high by the exhaust to force the gasoline to the carbureter.

When the main gasoline tank becomes empty, it is indicated in the small tank by the lowering of the gasoline level. The small tank is usually placed where visible, as on the dashboard; it often has a capacity sufficient to run the car a few miles.

50. Q.—Should the compression tube between the exhaust pipe and gasoline tank have a small inner diameter for any reason other than for lightness of weight and cost?

A.—Yes. If a tube with a large opening is used there is possible danger of its becoming filled with a combustible mixture if the cylinder to whose exhaust pipe it is connected misses explosions several times in succession. The combustible mixture in the tube may then become ignited by the hot exhaust gases. In a large tube, the flame might pass through to the tank and, if considerable air had just been pumped into the latter, an explosion might result. When the tube is of small diameter the cooling effect of its walls will prevent the flame from passing through it to the tank.

51. Q.—What means to prevent emptying of a gravity fuel tank are sometimes used?

A.—A small compartment in the tank will not allow the fuel to flow from it till a valve is opened by hand. When the fuel from the main body of the tank is all

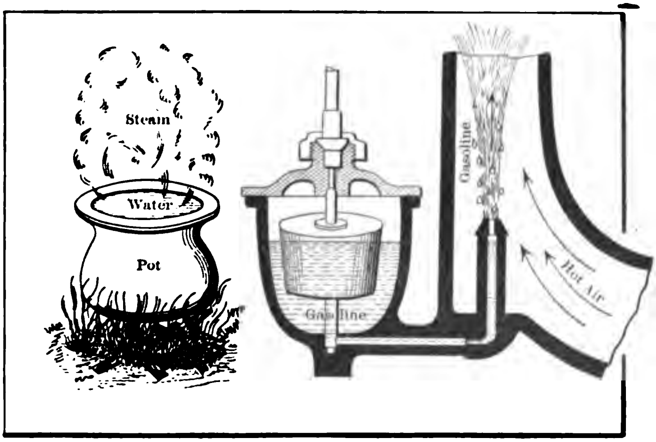


Fig. 15—DEPICTING THE PRINCIPLE OF EVAPORATION IN A CARBURETER; THE GASOLINE IS BOILED AT THE ATMOSPHERIC PRESSURE BY HEAT FROM THE SURROUNDING ATMOSPHERE; THE IDEA IS THE SAME AS WHEN WATER IS BOILED IN A POT BY BUILDING A FIRE UNDER IT; THE ONLY DIFFERENCE IS THAT GASOLINE BOILS MORE READILY THAN DOES WATER

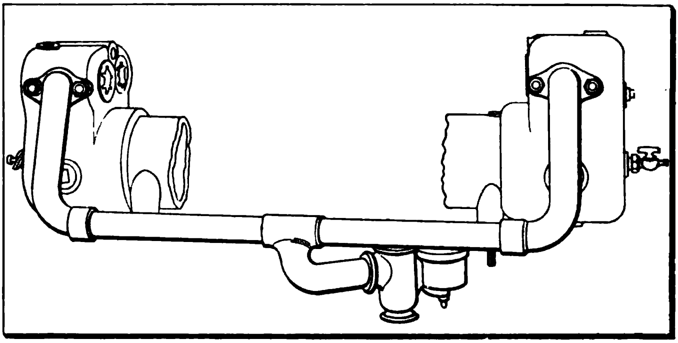


Fig. 16—SCHEME OF LOCATING THE CARBURETER MIDWAY BETWEEN TWO CYLINDERS OF A DOUBLE-OPPOSED MOTOR

drawn out, the motor of course stops. Then by opening the valve to the small reserve compartment, the fuel retained in it becomes available.

The efficacy of the intake manifold of a motor is a matter that must be given good consideration. If the manifold is properly designed, which may not be true, it still remains to keep the same tightly in place if it is desired to maintain the even balance of the mixture. If, for any reason, it is considered that the mixture is not all that it should be, while it will be desirable to examine the carbureter and see if it is acting properly, it still remains to be sure that the manifold is tight. If it is not so tight as to properly serve its function, there are two courses to pursue—get a new manifold, or fix the old one. That the old manifold can be repaired is probably true, at least, in most instances. One plan has for its foundation the ability of shellac to adhere to the metallic surfaces and further, to its ability to stop up all the little leaks that may stand in the way of success. The way to do the work is to warm up the manifold; spill a quantity of the shellac in at one end, and by deft manipulation, cause it to run all over the surfaces. It will spread out quite thin, and when it hardens it will form a film over the surfaces, filling up all the little holes. If the holes are large, all that can be done is to plug them up.

Should the manifold be too large, or improperly shaped, it is scarcely possible to do anything with it; a new member will then be necessary. If the manifold is too large, that is to say, if the area is excessive, popping back will be difficult to prevent. This is due to the slow rate at which the mixture will travel, as compared with the speed of the flame in the mixture. To some extent this difficulty will depend upon the richness of the mixture. If the mixture is too rich or too lean, it will be slow-burning and aggravate the ills of a poorly shaped manifold.

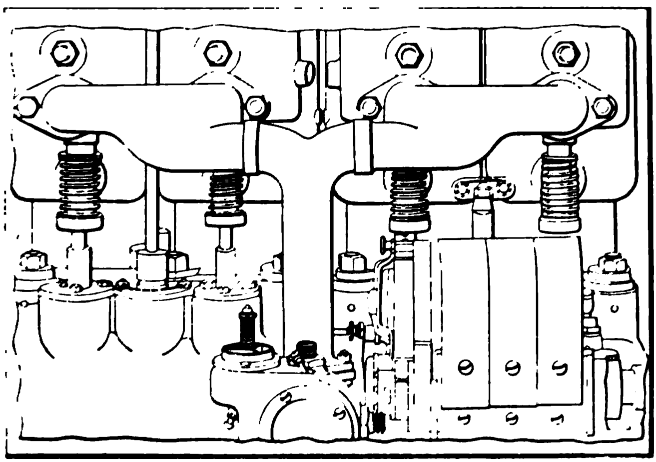


FIG. 17—DEPICTING THE CARBURETER NEAR THE MAGNETO AT THE SIDE OF A MOTOR; IT IS NECESSARY TO AVOID LEAKS OF GASOLINE IN ORDER NOT TO HAVE A FIRE HAZARD, DUE TO THE CLOSE PROXIMITY OF THE SPARKING EQUIPMENT

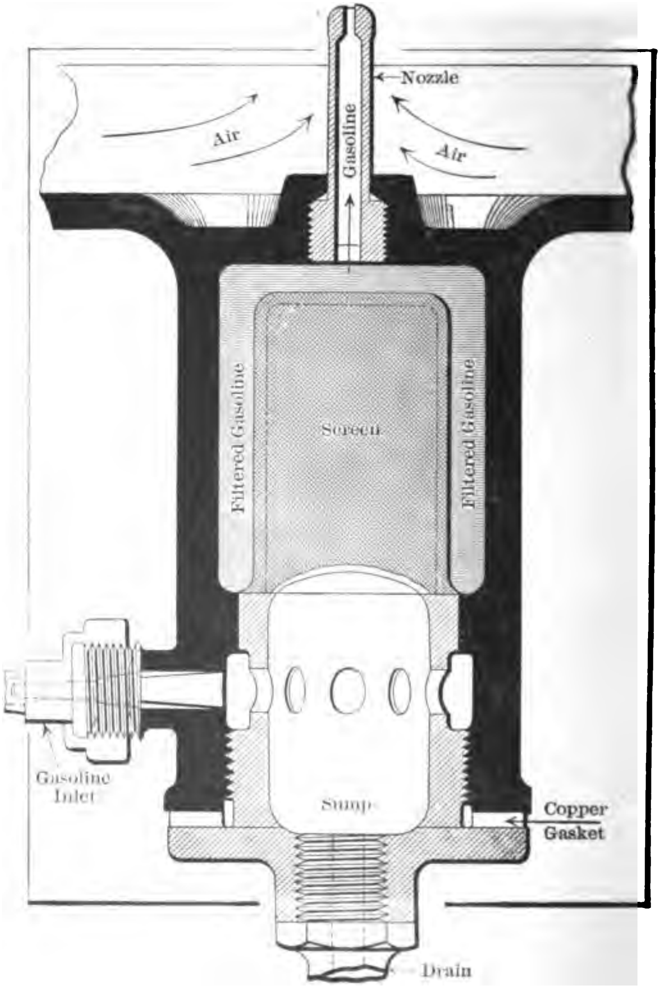


Fig. 18—SECTION OF A STRAINER FOR USE IN CONNECTION WITH A CARBURETER FOR THE PURPOSE OF PREVENTING SCUM FROM STOPPING UP THE GASOLINE NOZZLE

Cooling the Motor

52. Q.—What heats the combustion chamber and cylinder walls when the engine is working properly?

A.—The heat of combustion, of compression, and that produced by the friction of the piston and its rings against the cylinder walls. The heating is chiefly due to combustion. Friction causes but little heat under correct conditions (proper fitting of parts and lubrication).

53. Q.—How is the engine kept cool enough for working conditions?

A.—Generally by a jacket of circulating water, or by air cooling. Oil is used for cooling sometimes.

54. Q.—What is a water jacket?

A.—A comparatively thin layer of water surrounding the combustion chamber, ports and part of the cylinder. It is retained by an outer casing of metal, either cast integral with the cylinder or attached, as in the case of a copper outer casing.

55. Q.—How much of the cylinder is surrounded by the water jacket?

A.—From one-third to two-thirds of the part of the bore (measured lengthwise of the cylinder) which is next the combustion chamber.

56. Q.—In an air-cooled cylinder what provision is made for sufficient cooling?

A.—Metal projections in the form of thin rings, lugs, rods, wires or teeth of a comb are provided to present a maximum amount of radiating surface to the air which (in the motor-in-front type) enters the engine space under the bonnet through a grating in front that occupies the place of the radiator used in water-cooled cars. The flow of air is usually assisted by fans driven by the engine. The projections are sometimes surrounded by a sheet-metal casing and air is forced, or drawn, through the enclosed space by a fan.

57. Q.—How is the jacket (circulating) water kept sufficiently cool?

A.—By causing it to flow through a cooling pipe, coil or radiator which is connected by tubing or piping with the water jacket space.

58. Q.—Describe a radiator.

A.—In the simplest type a pipe is bent to form a fairly compact group of convolutions. Thin copper or brass pipe is used. Numerous fins or collars of the same material are placed at a small distance apart along the pipe in order to increase the heat-radiating surface. The hot water coming from the jacket passes through the entire length of the coil, which is cooled by air blowing against it.

Numerous types of radiators are used. Many have flattened pipes (cellular radiators) which contain only a thin layer of water and present a large radiating surface to the air. Copper, or its alloy, brass, is used on account of its great capacity for conducting heat; it also has mechanical advantages such as ease of forming and soldering. The weight can be kept low by using copper and brass.

59. Q.—What is a radiator fan?

A.—A fan of the propeller type used to insure the passing of sufficient air over the outer surface of the coil. It is usually hung in a frame back of the radiator and driven by a belt from a small pulley on the engine shaft. Thus a current of air is passed through the engine space even when the car is at rest, if the motor is running; otherwise the air current would be practically nil and the engine would quickly overheat.

In some cars the fan blades are incorporated in the flywheel, and the bonnet is made "tight"—the air being drawn through the apertures in the radiator and discharged under the car, back of the flywheel.

60. Q.—What causes the cooling water to circulate through the piping, radiator, and the jackets of the motor's cylinders?

A.—Either a pump (forced circulation) or the heat imparted to it by the cylinder and combustion-chamber walls (thermal circulation).

61. Q.—How should the piping be connected for thermal circulation.

A.—A pipe for carrying the hot water from the jacket to the radiator should run from the highest part of the jacket space to the upper portion of the radiator. The top of the radiator must be higher than the highest part of the water jacket space of the engine. Another pipe should connect the bottom of the radiator to the jacket space at or near its lowest

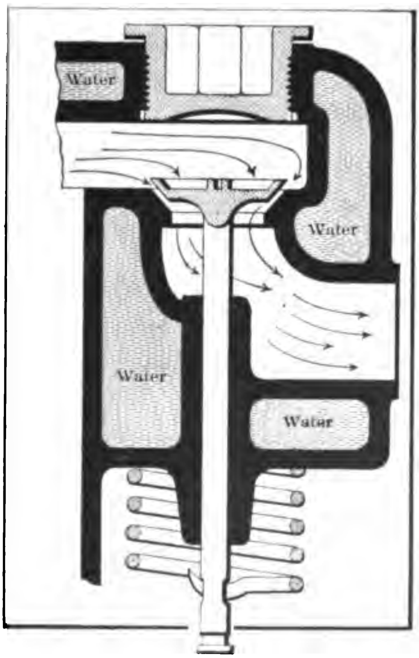


FIG. 19—SECTION OF A CYLINDER, SHOWING HOW THE WATER IS CARRIED ALL AROUND THE VALVE-STEM WALL

point. With this arrangement the heat imparted to the water in the jacket space causes the water to rise and flow out through the pipe connected at the highest point, thus inducing circulation. The hot water which enters the upper portion of the radiator and then becomes cooled has a tendency to fall to the bottom as it cools. This also induces circulation. For the best results, the bottom of the radiator should be at least as high as the point where the water enters the cylinder jacket, and the pipes should be short and without downward U-shaped bends.

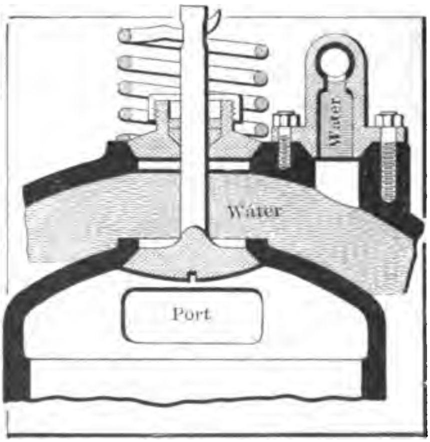


FIG. 20—SECTION OF A CYLINDER PRESENTING A METHOD OF KEEPING WATER OUT OF THE COMBUSTION CHAMBER, USING A GROUND-IN MUSHROOM ON A STEM, HELD TIGHT BY A SPRING

If a tank is used in addition to the parts described, it should be placed as high or higher than the radiator. The connections may then lead the hot water from the top of the jacket space to the tank, thence to the top of the radiator and from the bottom of the radiator to the lower part of the jacket.

The opening through which the hot water enters the radiator should be low enough to be always covered with water, even when the radiator is not completely filled. Circulation due to heat ceases when the water level falls below the hot-water inlet of the radiator.

62. Q.—How is a pump used to circulate the water?

A. — By introducing it into the circulating system so that all the water must pass through it.

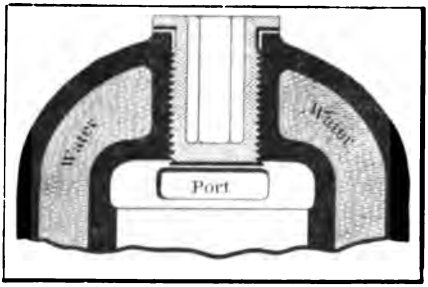


FIG. 21—SECTION OF A CYLINDER, SHOWING A LARGE AMOUNT OF WATER OVER THE DOME OF THE COMBUSTION CHAMBER

63. Q.—Where should the pump be placed?

A.—Preferably at the lowest part of the system, so that water will flow to it as long as any remains. This is not absolutely necessary, however. It should receive water by gravity from the tank when one is used, or from the bottom of the radiator.

64. Q.—What class of pumps are used for circulating the water?

A.—The rotary class in the automobile. That is, those in which the water is impelled through the system by a rotatin' part inclosed in : casing. See Fig. 22.

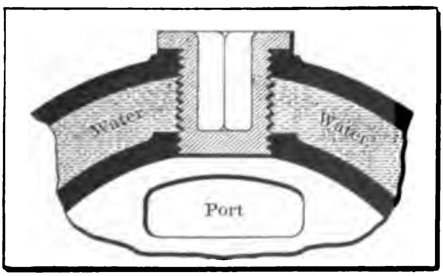


FIG. 22—SECTION OF A CYLINDER, SHOWING THE PLUG IN THE HEAD SO PLACED THAT IT IS LIKELY TO CAUSE A LEAK OF WATER INTO THE COMBUSTION CHAMBER

65. Q.—Wha types of rotar pumps are used

A.—The centrifugal and the fixed-volume-per-revolution (positive) types.

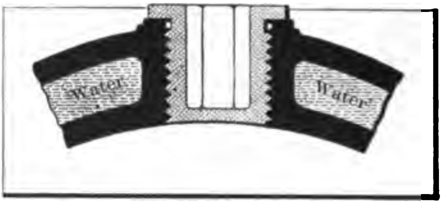


Fig. 23—SECTION OF A CYLINDER WITH A CURVED DOME AND A PLUG THAT IS NOT LIKELY TO CAUSE LEAKAGE OF WATER INTO THE COMBUSTION CHAMBER

66. Q.—How does a centrifugal pump operate?

A.—A rotary part (rotor or runner) with radial (or curved) vanes revolves inside a casing which incloses it. Water flows in at the axis (center) of the rotor and is thrown out by centrifugal action to periphery.

67. Q.—Upon what does the volume of water delivered by a centrifugal pump depend?

A.—On the speed of rotation and resistance.

68. Q.—If the water circuit becomes closed what is the result with a centrifugal pump?

A.—The pressure will be increased and less power will be required to drive the pump. The water in the pump will be whirled around by the rotor, but none will pass out

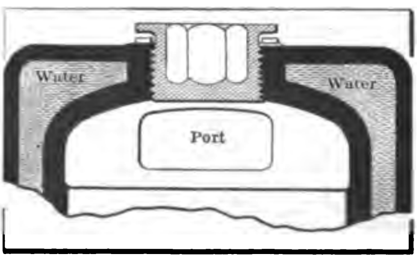


Fig. 24—SECTION OF A GASOLINE ENGINE CYLINDER SO CONTRIVED THAT THE INTERNAL WALL IS CURVED AND THE EXTERIOR PRESENTS A FLATTENED APPEARANCE

69. Q.—How does a fixed volume (positive) rotary pump operate?

A.—The volume of liquid passing through the pump in the same way per revolution whatever the speed of the pump or the resistance to flow in the circuit. There are two characteristic types. One has an ordinary pair of intermeshing spur gears inclosed in a tight-fitting case, which extends around something more than half the periphery of each gear. Water is drawn in at one side or edge of the case between the gears and forced out the opposite side.

In another type a cylindrical rotor is placed eccentrically in a tight cylindrical case. The rotor is provided with radial wings or vanes which are held out against the cylindrical wall of the case so that each rotation takes in a fixed amount of water at one side of the rotor and forces it out on the opposite side Other forms are used.

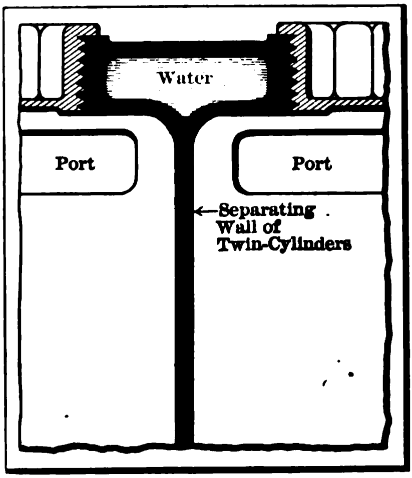


FIG. 25—SECTION OF THE PARTING WALL BETWEEN A PAIR OF CYLINDERS SHOWING WATER IN THE INTERVENING SPACE

70. Q.—What effect has the stoppage of a pipe on a fixed-volume (positive) pump?

A.—The pump continues to force water through its discharge opening and increases the pressure till the pump stops or something gives way. As a matter of fact, fixed-volume pumps usually have so much leakage between the rotor and casing that they cannot increase the pressure to a dangerous point and this leakage tends to increase with the life of the pump.

Ignition—Descriptive

71. Q.—What is jump-spark, or high-tension, ignition?

A.—Ignition of the combustible charge in the motor cylinder by means of a spark of electricity which jumps across the space (spark-gap) between two pieces of metal which remain at a fixed distance apart while in use.

Sparks jump across the spark-gap in a series in some types of high-tension ignition systems; in others, only a single spark passes during ignition. The single spark, as distinguished by a single snapping sound, is in reality made up of several sparks, or oscillations, following each other in extremely rapid succession.

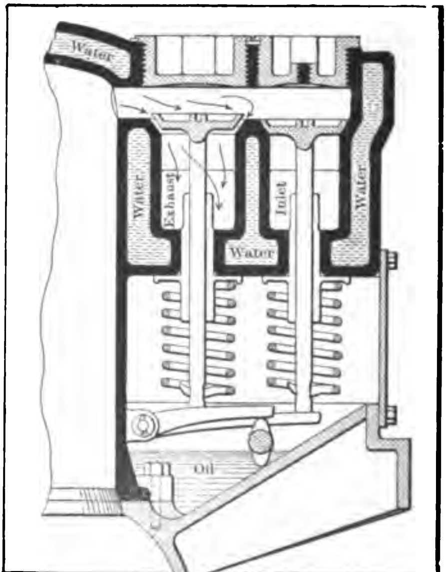


FIG. 26—SECTION OF A CYLINDER OF THE TYPE THAT BRINGS BOTH INLET AND EXHAUST VALVES IN THE SAME LATERAL PLANE, INDICATING HOW WATER IS CIRCULATED TO KEEP ALL THE SURFACES COOL

72. Q.—What is make-and-break ignition, also called low-tension ignition and contact ignition?

A. — Ignition of the charge in the motor cylinder (taking advantage of an increased energy, with added heat) by means of an electric arc (also called a spark) which is drawn between two metallic points as they are separated from contact with each other.

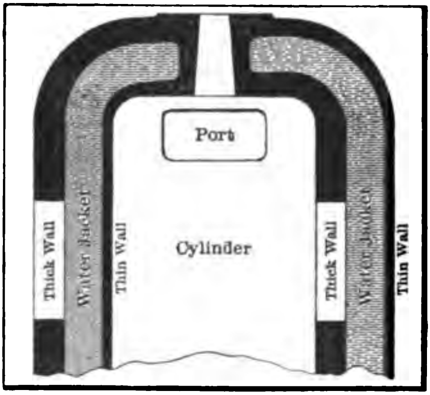


FIG. 27—SECTION OF A CYLINDER WITH A CORED HOLE IN THE DOME; THIS CORE MIGHT BE MISPLACED IN THE CASTING PROCESS AND A LEAK WOULD BE THE RESULT IN SERVICE

73. Q. — How can high-tension electricity, as used for motor ignition, be distinguished from low-tension electricity?

A.—If the end of an insulated wire charged with high-tension electricity is held within a quarter of an inch or so from the metal of the motor, a spark will jump across the space between the end of the wire and the motor. If one's hand touches the metal of a charged high-tension wire, a startling shock will be received. The shock is not dangerous, however, unless continued for a considerable time.

Low-tension electricity will not jump across an air space. It will not give a shock except at the instant the contact points are separated to form an arc. The shock from the low-tension electricity even then is not nearly as strong as that from high-tension.

74. Q.—Describe one form of mechanically-operated mechanism for low-tension (contact-arc, make-and-break) ignition.

A.—A stationary metallic rod or bar extends through the wall of the combustion chamber into the combustion space of the motor, and is electrically insulated from the metal of the cylinder by mica, porcelain or steatite (soapstone). Another metallic part also extends into the cylinder, but is not electrically insulated from it. It has a running fit in the hole it fills, so that an arm attached to it inside the combustion chamber can be oscillated as a rocker arm both to bring it into contact with the insulated rod and to open the contact by the use of proper mechanism.

A spring is used outside the combustion chamber to hold the contact points together inside. When in operation the points are either kept closed most of the time or are brought together just before the time for ignition and an electric current from some source. An igniter cam or other device is attached to some rotating part of the engine so as to rapidly separate the contact points at the instant a charge is to be fired in the cylinder. The separation of the points draws an electric arc which ignites the charge

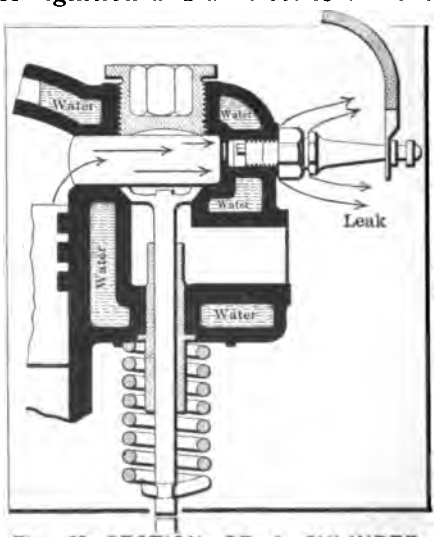


Fig. 28—SECTION OF A CYLINDER, SHOWING HOW WATER IS CIRCULATED AROUND THE SPARK PLUG BOSS; THIS KEEPS THE SPARK PLUG FROM BURNING

75. Q. — Describe a jump-spark igniter. (High - tension spark-plug.)

A.—The essential elements of the ordinary types are: An outer sleeve or shell of metal; a tubular part of insulating material such as porcelain, mica or steatite (soapstone). which fits into the outer sleeve; and a central metal rod or wire which fits in the hole through the insulating part.

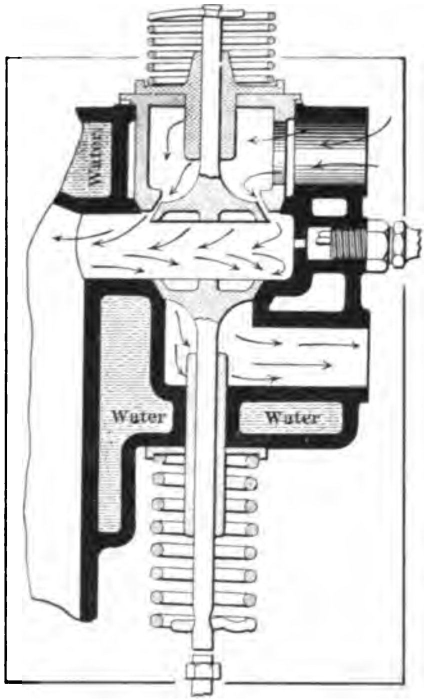


FIG. 29—SECTION OF A CYLINDER, SHOWING AN AUTOMATIC INLET VALVE IN A CAGE AND THE WATER CIRCULATING AROUND IT

The outer sleeve is threaded to screw into the cylinder casting of the motor in the common form of jump-spark plug.

The insulated central rod or wire terminates either near the outer metallic shell or near a piece of metal attached to the shell, so as to leave a short spark-gap or air-gap at the plug-end which is inside the combustion space.

76. Q.—What supplies electricity for automobile ignition?

A.—Either a primary electric battery, a storage battery or a mechanically-driven electric generator.

77. Q.—What is a magneto?

A.—A power-driven electric generator which has permanent magnets as an important part of its construction.

78. Q.—What is a dynamo (dynamo-electric machine)?

A.—In the more general usage it is a power-driven electric generator whose magnets require an electric current to keep them magnetized.

79. Q.—What is an electro-magnet?

A.—A magnetized piece of iron or soft (mild) steel whose magnetism depends on electric current flowing, either around it or in other proper relation to it.

80. Q.—What is a direct electric current?

A.—One which flows in only one direction. It may flow either continuously or intermittently.

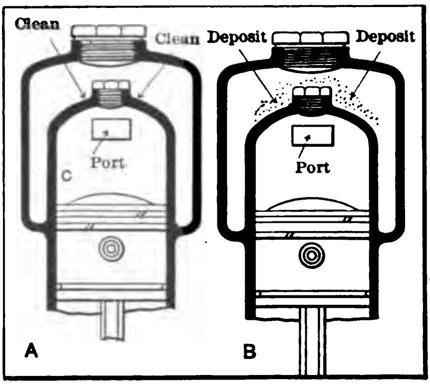


Fig. 30—SECTION OF A PAIR OF CYLINDERS, SHOWING, AT A, HOW THE SURFACES SHOULD BE WHEN THE MOTOR IS NEW AND THERE IS NO ACCUMULATION OF SCALE OVER THE SURFACES; B INDICATES THE PRESENCE OF SCALE WHICH SHOULD BE SCRAPED OFF

81. Q.—What is an alternating electric current?

A.—One which flows first in one direction, then reverses and flows in the opposite direction and so on.

In ignition systems using alternating current, there are generally as many, or more, reversals of current per second as revolutions of the motor crankshaft during the same time.

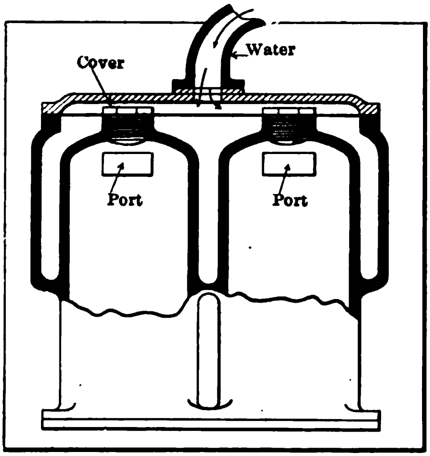


FIG. 31—PRESENTING A PAIR OF CYLINDERS SO DESIGNED THAT THE COVER MAY BE REMOVED IN ORDER TO GET AT AND SCRAPE SURFACES FREE OF DEPOSIT

Batteries

82. Q.—What is an electric battery?

A. — Two or more electric cells assembled and connected together so as to deliver an electric current. It is not unusual to call a single cell a battery.

83. Q.—What is a primary battery?

A.—One which is in condition to deliver current as soon as its elements are assembled properly. In other words, a battery that eats away its elements by electrochemical action.

84. Q.—Describe a primary electric battery such as is used for ignition on a gasoline automobile.

A.—Dry cells (semi-dry) are almost exclusively used in primary batteries intended for automobile ignition. These cells are actually moist, or wet, inside, but are sealed water-tight.

Carbon and zinc are the substances which are ordinarily used as the electrically active solid elements of a dry battery cell. These elements are moistened with a liquid electrolyte, which is usually water with sal-ammoniac dissolved in it.

The ordinary dry cell consists of a zinc cup or can lined with absorbent paper (blotting paper); a bar or rod of compressed carbon (coke) occupies the middle of the cup, and the space between the carbon rod and paper lining is filled with a mixture of coke and oxide of manganese, both in a granular form, generally a rather fine-grained powder. The contents of the cup are moistened with the solution of salammoniac. The blotting paper is folded over the top of the powder, and the cell is closed with some sealing substance, such as pitch or some mixture of a similar nature. The seal is to prevent leakage and drying out by evaporation. The oxide of manganese is necessary to keep the cell in proper condition when in use.

Each cell of the individual-cell type is either wrapped in pasteboard or placed in a box of the same material to protect the zinc of different cells from coming into contact with each other when the cells are ground together to form a battery. A binding post for holding the wire connections is attached to the zinc, and another to the carbon. Carbon is the positive element and zinc the negative.

In any cell or battery:

P or + (plus sign) indicates the positive terminal (binding post and nut or other fastening).

N or — (minus sign) indicates the negative terminal (binding post and nut or other fastening).

The carbon (+) terminal is at the center of the top of the cell, and the negative (—) terminal is soldered to the edge of the cup.

When the terminals of a battery or cell are connected together by a metallic wire a current of electricity flows through the wire from the positive (+) terminal to the negative (—) one. If a short wire is used to make the connection, more current will flow than if a long wire is used, both wires being of the same thickness and material; also, if a thick wire is used, more current will flow than if the wire were thin, both being of the same length and material. This is analogous to the flow of water through pipes of different diameters and lengths.

85. Q.—Does a primary battery deliver a direct current, or an alternating current?

A.—A direct current.

86. Q.—What is a series battery connection of carbon-zinc cells?

A.—One in which each carbon is electrically connected to the zinc of another cell, except the carbon of one end cell and the zinc of the other end cell. The two binding posts left free are the battery terminals. Fig. 34 shows a battery of series-connected cells.

87. Q.—What is a multiple, or parallel, connection of carbon-zinc cells in a battery?

A.—One in which all the carbons are electrically connected together, and all the zincs connected in the same manner. Fig. 33 shows a battery of multiple-connected cells.

88. Q.—What is a volt?

A.—The unit of electromotive-force (electrical pressure, potential). The volt is analogous to pounds per square inch of liquid or gas pressure.

89. Q.—What is an ampere?

A.—The unit of current volume; a certain rate of flow of electricity (electric current). It corresponds to gallons per minute, etc., for the flow of a liquid.

90. Q.—What is an ohm?

A.—The unit of resistance to the flow of electric current. All substances offer more or less resistance to the flow of current through them. This is analogous to the resistance of a pipe to the flow of a liquid or gas through it.

A copper wire 160 feet long and of No. 18 A. W. G. (American Wire Gauge, corresponding to .0403 of an inch diameter, or about 1-25 of an inch diameter) has a resistance of about one ohm at ordinary temperature. A No. 24 A. W. G. (.0201 inch diameter) copper wire of the same length has about four times as many ohms resistance. The ohmic resistance is inversely proportional to the sectional area of the wire, that is, inversely proportional to the square of the diameter. The ohmic resistance is also directly proportional to the length of the wire.

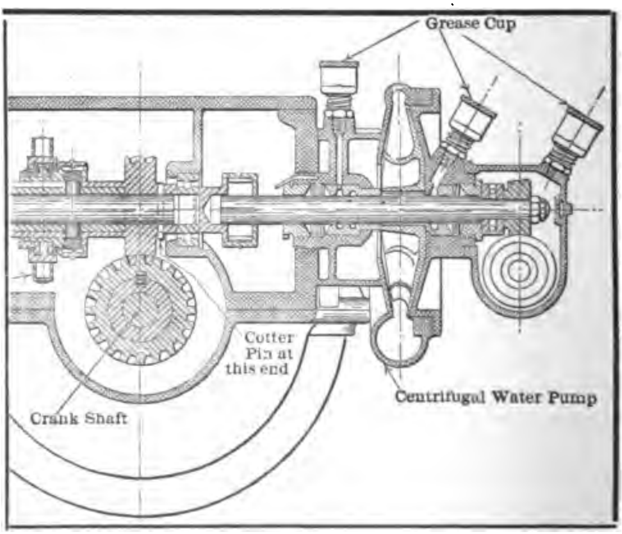


FIG. 32—SECTION THROUGH A MOTOR PRESENTING TO CENTRIFUGAL WATER PUMP AND THE METHOD OF DRIVING THE SAME; THIS IS BUT ONE OF A NUMBER OF SCHEMES OF DRIVING

91. Q.—What is a voltmeter?

A.—An instrument for measuring electric pressure, or tension (voltage). It is analogous to a steam gauge for measuring steam pressure.

The simplest form of voltmeter has two terminals which are connected to the two points between which pressure is to be measured, thus, for measuring the pressure of a battery, one terminal of the voltmeter is connected to one terminal of the battery, and the other voltmeter terminal is connected to the other terminal of the battery. In a similar manner, the terminals of the voltmeter are connected to any two points in a circuit between which points the pressure is to be measured.

The needle (pointer) of the voltmeter moves to a position which indicates the voltage on a graduated scale.

Small pocket voltmeters resemble a watch in some designs. The metal casing, or a metal part attached to the casing, sometimes serves as one voltmeter terminal; the other terminal may be at the end of an insulated wire which forms part of the instrument.

92. Q.—Is it necessary to open a circuit when measuring voltage?

A.—No. The voltmeter can be connected to any two points of the circuit, between which points pressure is to be measured, without previously opening or otherwise modifying the circuit.

93. Q.—What is an ammeter?

A.—An instrument for measuring electric current. It is analogous to a water meter for measuring the amount of water flowing through a pipe.

An ammeter has two terminals for making connection when current is to be measured. One of the ter-

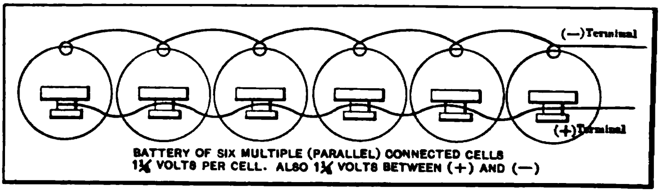


FIG. 33—DIAGRAM OF A SET OF DRY CELLS CONNECTED UP IN MULTIPLE

minals may be the casing of the instrument, or a projecting metal piece attached to the casing.

94. Q.—How is an ammeter applied for measuring current?

A.—For a battery which is not connected to any circuit, one terminal of the ammeter is connected to one terminal of the battery, and the other terminal of the ammeter is connected to the other battery terminal. The needle (pointer) then moves to a position which indicates the amount of current on a graduated dial scale. (See Q. 203.)

For any complete circuit: The circuit can first be broken (opened) and the ammeter inserted in the circuit so as to close the circuit through the ammeter. If the circuit is broken by disconnecting a wire from a binding screw, then one terminal of the ammeter can be connected to the binding screw, and the other

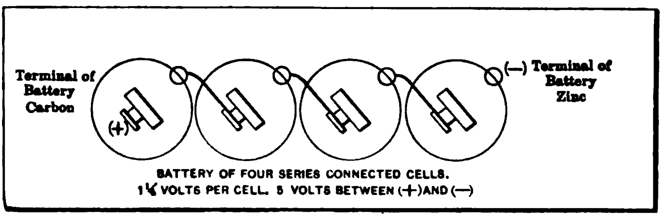


FIG. 34—DIAGRAM OF A SET OF DRY CELLS CONNECTED UP IN SERIES

ammeter terminal to the wire end that has been disconnected from the binding screw.

Ammeters resemble voltmeters in general appearance.

95. Q.—Is it always necessary to open the electric circuit and to insert the ammeter at the opening in order to measure the current?

A.—Yes. Otherwise only a portion of the current would flow through the ammeter, and the reading would consequently not be correct. The ammeter must

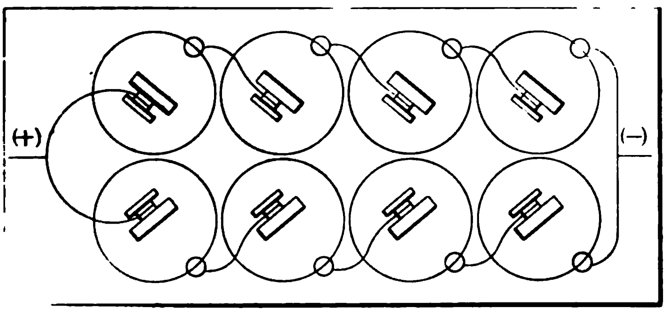


FIG. 35—DIAGRAM OF A SET OF DRY CELLS CONNECTED UP IN SERIES MULTIPLE

be inserted in the circuit so that all of the current will flow through the instrument.

96. Q.—What is a milli-voltmeter?

A.—An instrument for measuring very small (low) electric pressure, such as a small fraction of a volt.

97. Q.—What is a milli-ammeter?

A.—An instrument for measuring very small electric current, such as a small part of an ampere.

98. Q.—What is a volt-ammeter?

A.—A volt meter and an ammeter combined in one

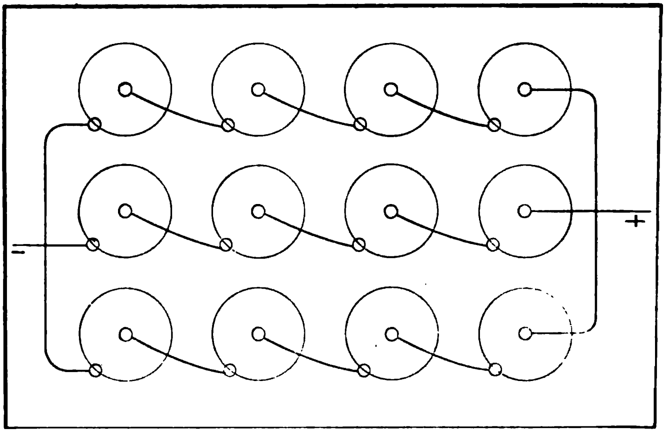


Fig. 36—DIAGRAM OF THREE SETS OF DRY CELLS CONNECTED IN SERIES-PARALLEL

instrument. In the small watchlike forms of volt-ammeters there are generally three terminals, one for measuring pressure, one for current, and a third to be used for both pressure and current. There are two corresponding scales usually, one reading in volts and the other in amperes.

[NOTE.—Dry batteries are much in vogue as the auxiliary source of electrical energy when a magneto is relied upon under working conditions for ignition purposes. The improvements that have been made in dry cells in view of the promise of a large return since the coming of the automobile were very marked indeed. It is within the memory of the average automobilist when dry cells were absolutely limited to unimportant open circuit work, as for bell-ringing in private dwelling houses, and even then confined to the minor responsibilities.

The unknown quantity in a dry battery is the internal resistance. Let the voltage be what it may on open circuit, the fact remains that if the cell is poorly made, or "dried out," instantly the circuit is closed, and the current begins to flow, the voltage will drop responding to the conditions of Ohm's Law, which may be stated as follows:

"The electro-motive force in volts is equal to current in amperes divided by the resistance in ohms."

The understanding of this law will compel the conclusion that measuring the voltage of the cell affords no information other than that given by the measurement. The energy output of a battery may be known as follows:

"The instantaneous value of the energy in watts is equal to the electro-motive force (unclosed circuit) multiplied by the current in amperes."

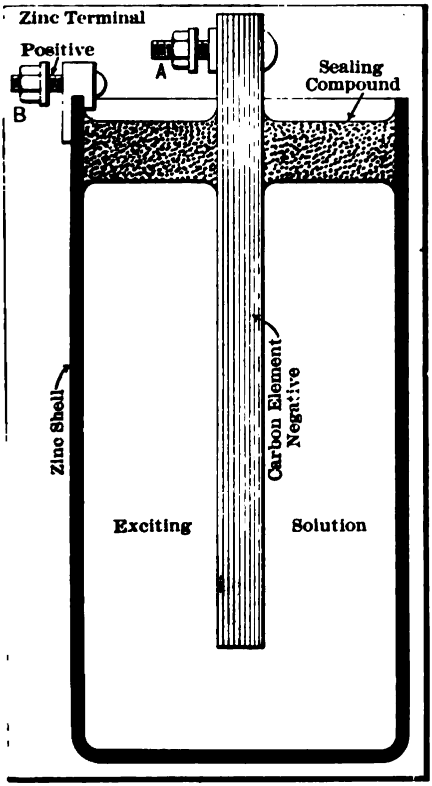


FIG. 37—SECTION OF A DRY BATTERY, SHOWING THE CARBON ELECTRODE IN THE CENTER AND THE ZINC CAN, WHICH ALSO SERVES AS THE OTHER (NEGATIVE) ELECTRODE

An examination of this statement will suffice to indicate that if the internal resistance of the cell is high, since it is the constant in the formula, the voltage will drop as the current increases and the output in watts will be low and in a poor battery too low to properly serve the intended purpose.]

99. Q.—How much is the voltage of a carbon-zinc dry cell?

A.—About $1\frac{1}{4}$ volts per cell when operating for ignition purposes. It is slightly higher than this in a good cell that is not in use. The voltage continues to drop as the cell is used.

100. Q.—If four cells are connected in series (Fig. 33) and the electromotive force of one is $1\frac{1}{4}$ volts, what is the total voltage?

A.—$4 \times 1\frac{1}{4} = 5$ volts.

101. Q.—If a battery of series-connected cells of $1\frac{1}{4}$ volts each is in parallel with another battery just like it, thus making a battery consisting of two series-connected rows of cells, four cells in a row, as in Fig. 35, how will the voltage and current thus obtained compare with that of one set of four cells alone?

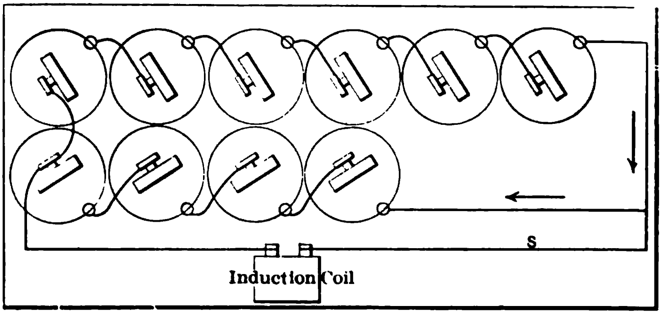


FIG. 38—DIAGRAM OF A SET OF DRY CELLS WRONGLY CONNECTED UP

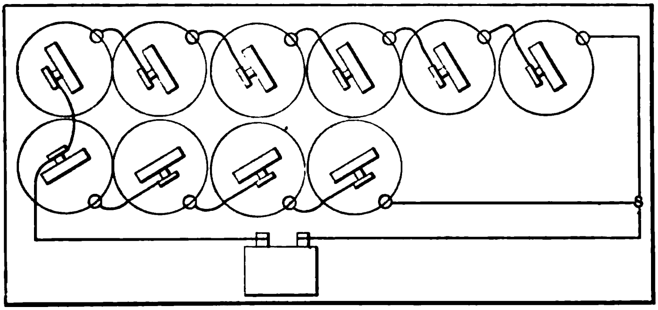


FIG. 39—DIAGRAM OF A SYSTEM OF DRY CELLS PROPERLY CONNECTED UP

A.—The voltage will be $4 \times 1\frac{1}{4} = 5$ volts. This is the same as for four series-connected cells. The current will be increased. The amount of increase will depend upon the resistance of the circuit through which the current flows outside of the battery. With the resistance ordinarily used in ignition apparatus, the current will be considerably larger than for the single set of series cells. With a circuit of greater resistance the flow of current would be but slightly increased.

102. Q.—If three sets of series-connected cells, four cells in each series set, are connected in parallel with each other, as in Fig. 36, so as to make a parallel-series battery, how will the voltage and the current that the battery will deliver compare with those of a battery having only four cells in series?

A.—The voltage will be the same for both batteries. The current will be greater for the parallel-series battery of twelve cells than for the four-cell series battery. The internal resistance of the cells arranged in parallel will be very much lower, which is the reason for the better current producing ability of that type of battery.

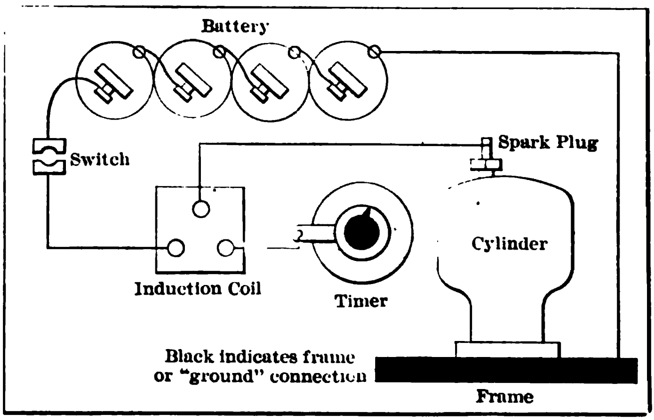


FIG. 40—WIRING SYSTEM FOR A SINGLE-CYLINDER MOTOR WITH THE CELLS OF BATTERY CONNECTED UP IN SERIES

103. Q.—How much is the resistance of a carbon-zinc dry cell?

A.—A dry cell of the standard size (about 2½ inches diameter and 6 inches high) has a resistance of only a small fraction of an ohm; generally not more than one-tenth of an ohm, depending upon the condition of the battery.

104. Q.—Do two like cells give the greater amount of current when connected in series or in parallel?

A.—It depends on the resistance of the external circuit; that is, on the resistance of the apparatus and connecting wires through which the current is sent by the battery.

If the resistance of the external circuit is greater than that of either of the cells, the series connection will give the greater current; but if the resistance of the external circuit is less than that of one of the cells, then the parallel connection will give the greater current.

When the resistance of the external circuit is just equal to that of one of the battery cells, the same amount of current will be obtained by the parallel as by the series connection of the two cells.

105. Q.—Which of the following two methods of connecting eight like cells to form a battery will give the greater amount of current? In two parallel series with four cells in each series, as in Fig. 35, or by connecting all eight of the cells in series with each other?

A.—If the resistance of the external circuit is greater than that of four cells in series, connecting all eight

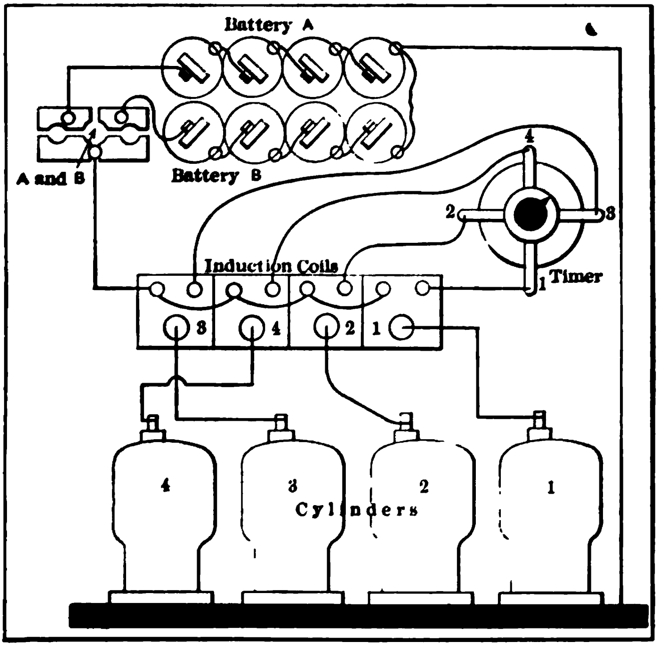


FIG. 41—WIRING DIAGRAM OF A 4-CYLINDER MOTOR USING A SERIES-MULTIPLE ARRANGEMENT OF THE BATTERY

cells in series will give the greater current; but if the external resistance is less than that of four cells in series, then the parallel-series connection will give the greater current. When the resistance of the external circuit is exactly equal to that of the four cells in series, then both methods of connection will give the same amount of current.

106. Q.—Suppose two batteries of the same kind of electric cells, one battery having six cells in series and the other four in series, are connected in parallel, would there be any action in the cells when the circuit is open?

A.—If the circuit is open, as at S in Fig. 38, the six cells on account of having more electromotive force than the four cells, will overpower the four and cause a current to flow as indicated by the arrows on the connection. This current flows through the four cells in the direction opposite that in which they deliver current when operating properly. The current continues until the pressure of the six cells has dropped to that of the four on the other side of the battery. This will use up the energy of the six cells, but will not weaken the four. When the circuit is open, as at S in Fig. 39, there will be no action in the cells and no damage will be done when the battery is not in use.

107. Q.—What is an electric storage battery (accumulator, or secondary battery)?

A.—One which requires electric energy to be supplied to it before it will act to deliver current. It consists of two electric elements immersed in a liquid electrolyte. The more common form has perforated lead plates or grids whose pockets are filled with compounds of lead. The plates are immersed in dilute sulphuric acid. When electric current is forced through the cell, it changes the chemical composition of the lead compounds which are thus brought to a conditi n to give out electric energy to an amount somewhat less than that received by the cell.

The ordinary form of storage battery for ignition is made up of three cells, connected in series. The three cells are all inclosed in one case. The positive (+) terminal of one end cell, and the negative (—) terminal of the other end cell together form the terminals of the battery.

108. Q.—Is it generally advisable to connect different kinds of cells together to form a battery, especially in multiple?

A.—No. In multiple connection the voltage of the different cells will not remain the same even if equal at the beginning. Action will take place between them in multiple connection even when the external circuit is open. Different kinds of cells in series connection do not generally work satisfactorily on account of different internal resistance and capacity to give out electric energy.

109. Q.—What is a ground connection?

A.—As used in automobile practice the term means any electrical connection between a wire or part of the electrical apparatus and the metal of the machine frame of the motor or other parts connected electrically (metallically) to the frame. A "ground" may be made either purposely or accidentally.

110. Q.—What is a short circuit in an electrical wiring system?

A.—It is an undesirable path for the electric current which allows it to flow without passing through all the apparatus which should be included in the circuit. A short circuit generally has less electrical resistance than the proper circuit, although this is not necessarily true.

111. Q.—Why are the wires of the ignition system covered with insulating material?

A—To prevent undesirable short circuits and ground connections.

112. Q.—Why is the insulation on wires carrying high-tension electricity heavier, or thicker, than on low-tension wires?

A.—Because greater resisting capacity is necessary to prevent short circuits, grounds, and leakage of high-tension electricity than low-tension.

Spark-Coils

113. Q.—What is a spark-coil?

A.—An electrical apparatus which so acts upon the current supplied to it as to produce a sufficiently intense spark or arc at the igniter in the motor.

114. Q.—Is a spark-coil for low-tension ignition suitable for high-tension ignition, or vice versa?

A.—No. Neither will answer the purpose of the other.

115. Q.—What is a kick-coil or reactance coil?

A.—The kind of spark-coil used for low-tension (make-and-break) ignition when electric current is supplied by a battery.

116. Q.—Describe a kick-coil with regard to constructive form.

A.—An insulated copper wire is wound around a soft (mild) steel or iron core. This core is composed of wires gathered together in a bundle or sheaf. The insulated copper wire is kept from contact with the iron core by substantial insulating material, such as treated wood, fibre, hard rubber, etc., which form the neck, or body, of a spool on which the copper wire is wound.

The ends of the copper wire, or the fastening devices to which they are connected, form the terminals of the spark coil.

117. Q.—How does a kick-coil (reactance-coil) affect a current passing through its winding?

A.—It prevents sudden variation in the volume of the current as compared with the rapid variation which may occur if there is no kick-coil in the circuit, especially if the current is furnished by a battery.

118. Q.—How does the action of the kick-coil affect the ignition arc?

A.—It gives the arc greater length and volume, and consequently more heat.

119. Q.—What is the specific manner in which the kick-coil intensifies the heat of the arc when current is supplied by a battery?

A.—By causing the current to flow for a longer time across the space formed by the separation of the contact points (spark points) of the igniter. If no kick-coil is in the battery circuit, only a faint, or weak, spark is formed at the contact points when the current is of ordinary volume and pressure. But when the kick-coil is interposed in the circuit, it prevents sudden cessation of current and forces the current to flow across the space between the contact points for a longer period after the points begin to separate, thus making the hotter arc.

120. Q.—Why is a core of soft steel or iron used in the kick-coil?

A.—To increase the inductive capacity of the spark-coil, and thus produce a stronger arc at the ignition points. The current passing through the winding of the coil magnetizes the core. When the current is interrupted the magnetism disappears almost completely. The magnetism, while decreasing, tends to prevent the current in the winding from ceasing instantly.

121. Q.—What is a hammer-break low-tension igniter, and why is the hammer break used?

A.—One in which the contact points of the igniter are separated suddenly by a hammer-like blow of a moving part striking against the rocker-arm of the movable contact point; generally a spring is provided at or near the rocker-arm just mentioned. The operating mechanism (push-rod, cam) first forces the movable contact point against the stationary point, then continues moving still further, this additional movement being allowed by the spring.

At the instant for ignition the part which acts as a hammer is rapidly forced back by the elastic recoil of the spring without moving the contact point at first. The hammer then strikes the rocker-arm sharply and causes rapid separation of the contact points.

Excessive fusing and burning of the contact points is obviated by their rapid separation, and a good arc (or spark) is obtained.

122. Q.—How many windings has a high-tension spark-coil (transformer)?

A.—Two generally. There must always be at least two.

123. Q.—What is the primary or low-tension winding of a spark-coil?

A.—It is a comparatively coarse copper wire insulated and coiled around a spool next to the iron core of the coil. It generally has only a few hundred turns.

When a battery is used with a high-tension spark-coil, the current from the battery passes through the primary coil. This coil is therefore also called the battery coil.

124. Q.—What is the secondary or high-tension winding of a spark-coil?

A.—It is a very thin insulated copper wire of great length wound in many hundred turns around the outside of the primary winding and on the same spool.

125. Q.—What is the purpose of a high-tension spark-coil?

A.—To transform the low-tension current from a battery or other source into a current of enormously higher pressure (tension, voltage) and a correspondingly smaller volume (amperage).

126. Q.—How does the high-tension spark-coil operate?

A.—When a low-tension current is caused to flow through the primary winding and then suddenly interrupted, a high-tension current is induced in the secondary winding. This high-tension current is used to produce the electric jump-spark in the combustion chamber of a gasoline (alcohol, gas) engine.

127. Q.—Does the high-tension spark-coil produce a spark for ignition when the low-tension circuit begins to flow through the primary circuit?

A.—No. Except in unusual cases. The coil is intended to give a spark only at the instant of breaking the primary circuit.

128. Q.—By what means is the primary (low-tension) current of a transformer (high-tension) spark-coil interrupted for producing an ignition jump-spark?

A.—By either an electrically-operated trembler or by a mechanically-operated interrupter.

129. Q.—What is the form of the trembler of a spark-coil?

A.—It is generally a flat strip of thin spring steel held firmly at one end and free to vibrate at the other. In some designs a disk of soft steel or iron is attached near the free end. The free end of the spring (or the attached disk) is located just over, or opposite, but not touching the end of the magnetic (iron or steel) core of the coil to which it is connected.

A contact piece is attached either directly to the vibrating portion of the spring, or to an additional part which is moved by the vibration of the trembler.

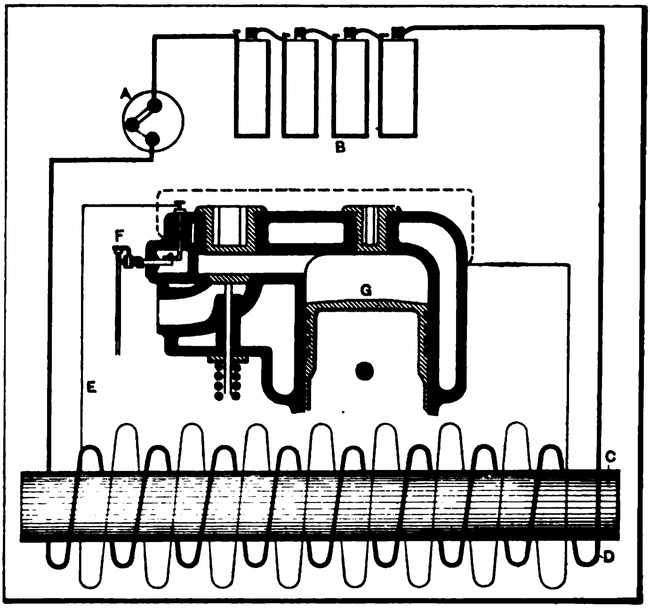


FIG. 42—DIAGRAMMATIC ILLUSTRATION OF THE LOW-TENSION SYSTEM OF IGNITION

A is the switch; B is the battery; C is the core of the magnet chamber of the sparkcoil; D is the battery (low-tension) wire and coil; E is the high-tension wire and winding; F is the hammer and anvil; and G is the combustion chamber in the cylinder of the motor

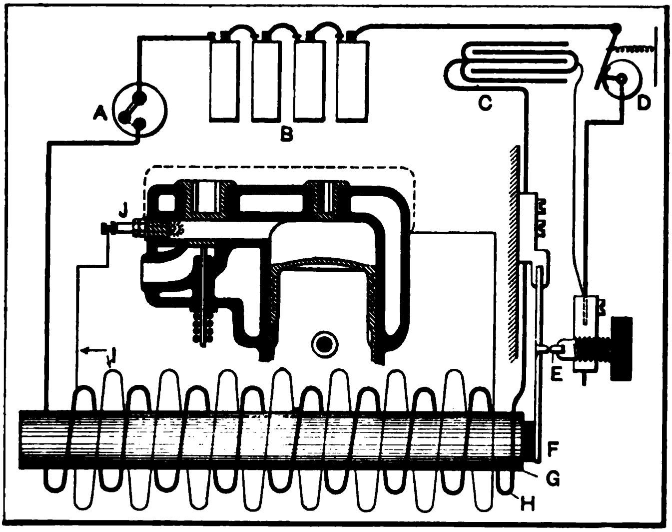


FIG. 43—DIAGRAMMATIC ILLUSTRATION OF THE HIGH-TENSION SYSTEM OF IGNITION BY BATTERY AND INDUCTION COIL

A is the switch; B is the battery; C is the condenser; D is the timer; E is the contact at the trembler; F is the trembler; G is the core of the coil; H is the battery wire and low-tension winding; I is the high-tension winding, and J is the sparkplug

130. Q.—How does the trembler operate?

A.—When an electric current is sent through the primary winding by a battery, the trembler vibrates rapidly so as to alternately separate the contact points and allow them to come together again.

The battery current, when first started through the primary winding, magnetizes the steel or iron core of the coil, thus making the core an electro-magnet.

The magnetism of the core weakens as soon as the current is interrupted, and the elasticity of the trembler brings the contact points back into contact with each other again. As soon as this occurs the current begins to flow through the primary winding again, the core is again magnetized and the whole operation repeated; and so on as long as the battery circuit is kept closed except the breaking at the contact points of the trembler.

Each time the trembler breaks the circuit a high-tension current is induced in the secondary winding.

131. Q.—What is a hammer-break trembler?

A.—One which has the movable contact point mounted on an electric part that is moved by a striking piece attached to the trembler.

The parts are so constructed and adjusted that when the trembler is attracted by the magnet the trembler moves through a considerable portion of its oscillation and gains speed before its striking piece comes into contact with the elastic part on which the movable contact point is mounted. The striker hits the elastic mount a sharp blow and causes rapid separation of the contact points.

132. Q.—Why is a hammer-break trembler used?

A.—Chiefly to reduce as far as possible the burning or fusing of the contact points. The current always continues a very short time after the contacts are first separated. This time is shortened by increasing the rapidity of separation of the contacts.

133. Q.—What is the condenser of a spark-coil with a trembler?

A.—A considerable number of sheets of tin-foil laid together with thick sheets of insulating material between them. The alternate sheets of foil are all connected together electrically or by pressing their ends together. Two groups of interlying sheets are thus formed.

The insulation between the foil sheets may be of paper, waxed, varnished, paraffined, or otherwise treated to obtain good insulating properties. Other materials, such as sheet mica or properly treated silk fab ric, are also sometimes used for the insulation of the condenser.

134. Q.—What is the function of the condenser?

A.—Chiefly to prevent the drawing of a long, hot arc at the contact points of the trembler, and the consequent rapid destruction of these points by burning or fusing. Without the condenser a large arc would be drawn, as has already been stated, relative to kick-coil in a low-tension ignition circuit.

135. Q.—How does the condenser prevent the burning of the contact points of the trembler?

A.—Electricity flows into the condenser and becomes temporarily stored there when the circuit is broken. An electric current tends to keep flowing after the breaking of the circuit. The flow is diverted from the course through the contact points into the condenser and charges it electrically. The condenser probably discharges immediately; that is, before the vibrator contacts come together again.

136. Q.—Where are the two sides of a condenser connected to the other parts of a transformer spark-coil that has a trembler?

A.—On opposite sides of the contact pieces of the trembler. Ordinarily one side of the condenser is connected to the part which carries the trembler and the other side to the part to which the stationary contact point is fastened. These connections are generally made inside the box containing the sealing compound when such a compound is used. The condenser is connected in parallel with the trembler.

137. Q.—What is the safety spark-gap of the high-tension coil?

A.—A gap from one-quarter to one-half inch wide, or more, between two parts which are connected to the high-tension terminals of the winding. If no external circuit is connected to the high-tension terminals, and a primary current is sent through the coil in the usual manner, sparks will pass between the points of the safety gap, thus protecting the insulation of the coil from being broken down by the high electric pressure which would be induced if there were not some outlet provided for it. The safety spark-gap is sometimes found on the outside of the coil-box, but in other coils it is inside of the box.

Timers

138. Q.—What is a timer for jump-spark ignition?

A.—A mechanically-operated device for closing the primary circuit (battery circuit) of a trembler spark-coil so that a jump-spark is produced in the combustion chamber of the motor at the proper instant.

The most general use of a timer is as a part of a jump-spark ignition system in which current is supplied by a battery.

139. Q.—What is the general form of a timer?

A.—In the more usual designs it consists of an outer casing of insulating material (hard rubber or wood fibre) with a hollow cylindrical surface into which metallic contact pieces are set.

A central rotating part (the rotor) driven by the engine brings a metal arm or other suitable form of metal part into contact with the stationary contacts in the casing, thus completing the primary circuit through the timer. While many greatly different forms of timers are used, their function is always the same.

140. Q.—Is the timer intended to produce an ignition spark in the motor at the instant the primary circuit is broken by the separation of the timer contacts?

A.—Only in case the trembler of the spark-coil fails to operate, as when its contacts stick together on account of fusing or burning. A spark may be formed at the igniter when the timer contacts separate at the instant the trembler contacts are touching each other during the proper operation of the trembler.

141. Q.—How often should the timer close the primary circuit for each cylinder of a four-stroke cycle engine?

A.—Once every two revolutions of the main-shaft (crankshaft) for each cylinder (every four strokes of each piston).

142. Q.—At what speed should a timer with a

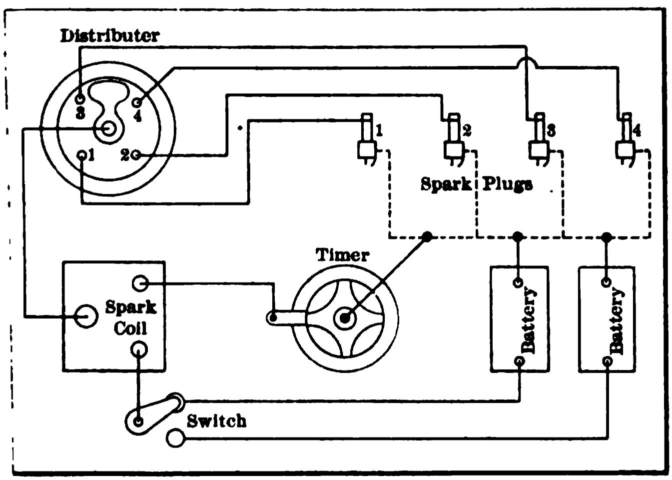


FIG. 44—HIGH-TENSION IGNITION SYSTEM, SHOWING HOW THE DISTRIBUTOR AND BATTERY ARE CONNECTED UP

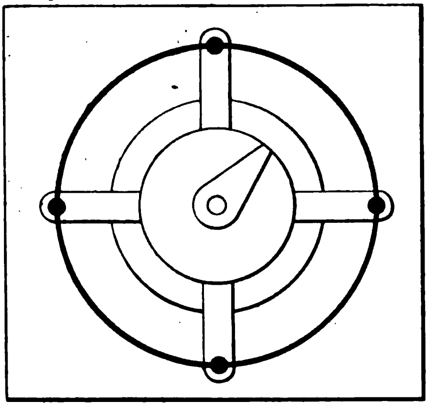


Fig. 45—ORDINARY TIMER FOR FOUR-CYLINDER, INDIVIDUAL COIL SYSTEM, MODIFIED FOR HIGH-TENSION DISTRIBUTER SYSTEM. THE WIRE CONNECTS ALL THE STATIONARY CONTACT PIECES TOGETHER

single rotating contact-arm or contact-point rotate in a four-stroke cycle engine?

A.—Half as fast as the main-shaft (crankshaft). This is the same speed as that of the camshaft.

143. Q.—Where is the timer attached to the four-cycle engine?

A. — Very frequently to the camshaft (half-speed shaft, half-time shaft). A shaft or chain drive especially for the timer is also frequently used in order to bring it in an accessible position, or where dirt and grit are not apt to accumulate on it, as well as for other reasons.

144. Q.—Should the timer always close the primary circuit when the piston is passing through the same position in its travel, whether the engine is rotating rapidly or slowly?

A.—No. The primary circuit should be closed earlier in the cycle when the engine is turning over rapidly than when it is running slowly.

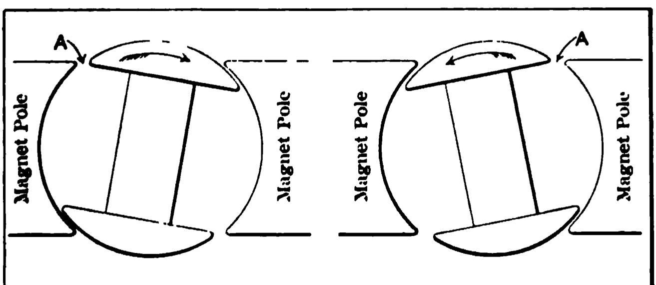
145. Q.—Why should the timer be closed earlier at high rotative speed of the engine than at slow?

A.—For two reasons:

First.—There is an appreciable time between the instant at which the timer closes the primary circuit and the instant of the occurrence of the spark between the ignition points in the combustion chamber. This time interval is constant whatever the speed of the engine. It may be called the lag of the spark. In order, therefore, to have the spark occur at a given position of the piston, the timer must close the primary circuit earlier in the cycle when the engine is running rapidly than when it is turning over slowly.

Second.—An appreciable time is also required for the inflammation of the charge in the combustion chamber, and the rapidity of inflammation after ignition by the jump-spark varies with the intensity of compression in the charge. When the charge is small and the compression low, more time is required for inflammation than with a full charge and correspondingly high compression. There are other possibilities when the compression is low that might not be noticed under conditions of higher compression.

For these reasons the timer should close the primary circuit earlier in the cycle when the engine is running rapidly than when it is turning over slowly; and also when the charge is small (by throttling) as compared



Figs. 46 and 47—IN EXPLANATION OF QUESTION NUMBER 395 with the full charge allowed to enter by an open throttle.

146. Q.—What provision is made for adjusting the timer with regard to the instant of closing the primary circuit of the spark-coil?

A.—The part which carries the stationary contacts is adjustable by rocking around the shaft on which the rotor is mounted. Sometimes the outer casing is rocked, and in other designs an additional rocker which carries the stationary contact pieces is provided. Sometimes the rocker can be moved as much as 90 degrees around the rotor shaft.

The rocker is connected to the spark control in reach of the driver by means of rods, wires, gears, etc. An arm (rocker-arm) is generally provided for this connection.

147. Q.—How much will a rotation of 90 degrees of the timer rocker change the time of closing the primary circuit of the spark-coil relative to the rotation of the crankshaft of a four-stroke cycle motor?

A.—One stroke of the piston for a timer which has only one contact point on its rotor. This corresponds to one-half revolution of the crankshaft in the ordinary type of engine.

148. Q.—What is a late spark (late ignition)?

A.—One that comes late in the cycle of the engine. The spark coming after the piston has gone some distance on the impulse stroke is a late spark. A late spark may come much earlier than this, however, when the engine rotates rapidly, since the speed of the engine enters as a factor in determining what is a late spark.

149. Q.—What is an early spark (early ignition)?

A.—One that occurs earlier in the cycle than the late spark. When the engine is running at considerable speed an early spark comes before the completion of the compression stroke. The timer may be adjusted so that the primary circuit is closed when the piston has completed less than half its compression stroke, but under this condition a spark will not pass when the speed is very high until the compression stroke has been nearly completed. This refers to a system having a timer and a trembler spark-coil.

150. Q.—What is meant by advancing the spark?

A.—Moving the spark-control so that the primary circuit is closed earlier. This is the general acceptance of the term, but, as may be seen from the foregoing, does not always mean that the spark occurs earlier in the cycle.

151. Q.—How wide should the spark-gap be in an igniter?

A.—It depends on the source of electric current and, to a less extent, upon the kind of spark-coil used.

For battery current the spark-gap should ordinarily be about 1-32 of an inch wide, or long.

When current is supplied by some types of magnetos, the igniter spark-gap should be 1-50 to 1-60 of an inch wide.

Width here means the distance between the inner rod or wire and the outer shell where they are nearest to each other with no insulating material between them.

152. Q.—Does the spark-gap in the spark-plug offer the same resistance to the passage of a spark in the open air as in the combustion chamber when the charge is compressed?

A.—No. The resistance to the jump-spark is greater in the compressed mixture than in open air.

153. Q.—If the electrical pressure of the secondary coil is only high enough to force a spark across the gap of the spark-plug at atmospheric pressure (in open air), will any spark be produced when the plug is in the combustion chamber and the charge compressed?

A.—No. It is necessary to have enough pressure to produce a spark about ¼ inch long in the open air in order to be certain of securing one inside the combustion chamber at the proper time.

154. Q.—How is the automobile ordinarily wired in the jump-spark ignition system for a single-cylinder engine using a battery for the source of electrical energy?

A.—One terminal of the battery (Fig. 40) is connected by a wire to the frame of the automobile (a bare wire will answer). The other battery terminal is connected to one end of the primary winding of the spark-coil. The other end of the primary winding of the spark-coil is connected to the insulated stationary metal portion of the timer. The rotor of the timer is electrically connected to the frame of the machine either by its metallic contact with the shaft which carries it, or by a wire or brush when the rotor is made of insulating material and does not connect electrically with its shaft.

A brush in this usage is a piece of electric conducting material which bears and rubs against a metallic part that moves relative to the brush.

The path of the electric current is then from the battery to the primary winding of the spark-coil through which it passes; then to the timer and through it during the time contact is made between the timer contact points; then to the frame of the machine and through it to the wire which connects to the "grounded" terminal of the battery.

A switch for opening the circuit is placed somewhere in the primary circuit, sometimes by cutting into the wire between the battery and the spark-coil. In other cases the switch is placed on the induction coil box, so that there is no break in the wiring at any place outside of the apparatus.

A wire leads out from the secondary or high-tension winding of the spark-coil to the spark-plug. This completes the wiring.

The high-tension current passes along the wire from the spark-coil to the insulated central wire of the spark-plug, jumps across the spark-gap to the outer shell or bushing, which connects to the metal of the engine.

From the motor the high-tension current may pass back to the spark coil either through the timer to its stationary contact and thence through the wire between the timer and spark-coil, already mentioned, which wire also carries the primary current, or it may flow back from the metal of the motor through the ground connection of the battery, through the battery and the battery connection to the spark-coil. In most coils one end of the primary wire and one end of the secondary wire are both connected to the binding post of the induction coil to which the wire leading to the timer is connected. When this is not the case, an additional wire must be used to connect the body of the engine to a binding post at the remaining end of the secondary winding.

155. Q.—Is the electrical insulation which is high enough for the battery or low-tension electric wiring, sufficient for the secondary or high-tension wire?

A.—No. The secondary wire requires a much higher electric insulation resistance. Rubber is generally used with a protective covering of braided cotton or silk cord.

156. Q.—How many spark coils, each with its own trembler, are used for a two-cylinder engine?

A.—Two, generally. A coil is provided for each cylinder, and a wire connects its high-tension terminal to the spark-plug in the cylinder.

In more unusual cases, however, only one spark-coil is used, in which case it must have two binding posts for the terminals of its secondary winding. One spark-plug is connected to one of the secondary binding posts of the coil and the other spark-plug to the other high-tension terminal of the coil. The path of the high-tension current is then from one terminal of the high-tension coil to its spark-plug, thence across the spark-gap to the metal of the cylinder, through which it travels and jumps to the insulated central wire of the other spark-plug, and then goes back to the remaining terminal of the secondary coil. By this method of wiring a spark is produced twice as often in each cylinder as is necessary.

157. Q.—When four spark-coils, each with its own trembler, are used for a four-cylinder engine, how are the electrical connections made between the different pieces of the apparatus?

A.—The four coils (Fig. 41) are usually placed in a box side by side. A wire leads from one terminal of the battery to the spark-coil box, and connects to the terminals at one end of the primary winding of each induction coil. The remaining terminal of each primary winding is connected to its own contact piece on the timer, so that there are four wires between the timer and spark-coil. The rotor of the timer closes the electric circuit through the four primary windings of the spark-coils in succession, thus causing only one spark-plug to operate at a time and at the proper instant.

158. Q.—How is a master trembler coil used in connection with individual transformer spark-coils for high-tension ignition with current supply from a battery?

A.—There is one transformer spark-coil, without a trembler, for each cylinder of the motor. A master coil with a trembler and only a low-tension winding is connected to all of the transformer coils so that all low-tension current passing through the transformers must flow through the master trembler-coil. Each transformer is connected to its own stationary contact on the timer.

The system is the same as can be obtained by inserting, in Fig. 41, a master trembler-coil between the switch and spark-coils, and permanently closing the circuit at the trembler contacts of the transformer spark-coils. The trembler contacts on the transformers can be permanently closed by setting the adjusting screw so that the contact points are pressed firmly together. An additional precaution is to short-circuit each trembler by a wire fastened to the metallic supporting parts at each side (or end) of the trembler, so as to bridge the trembler.

159. Q.—What is one object in using an auxiliary trembler coil?

A.—To secure synchronous ignition.

160. Q.—What is synchronous ignition?

A.—Ignition which occurs successively in the different cylinders when the piston in the cylinder where ignition occurs is passing through a position which is the same relative to its own cylinder as the position of the piston in each of the other cylinders at the instant of ignition in the corresponding cylinder. Thus, if ignition occurs in one cylinder at the instant when its piston lacks just one-eighth inch of completing its compression stroke, then, for synchronous ignition, the ignition must occur in each of the other cylinders at the instant when the corresponding piston lacks just one-eighth inch of completing its compression stroke.

In the more common forms of multiple-cylinder motors the time intervals between successive ignitions are all equal to each other when the motor crankshaft is rotating at a constant number of revolutions per minute.

161. Q.—How does the auxiliary trembler-coil aid in securing synchronous ignition?

A.—By eliminating unequal periods of lag such as are apt to occur when each individual spark-coil has its own trembler. Each trembler is apt to have a time lag whose duration is greater or less than that of the other tremblers. It is difficult to adjust all of the tremblers exactly the same.

162. Q.—What is the high-tension distributor system of jump-spark ignition with battery current supply?

A.—A system in which only one transformer spark-coil is used for all the cylinders of a motor with several cylinders. The timer closes the primary circuit always through this one spark-coil. The high-tension current from the spark-coil passes through a distributor which distributes it in proper order of succession to jump-spark plugs in the different cylinders.

The timer rotor and the distributor arm are both rigidly attached to and rotated by the same shaft in some designs. This shaft rotates at half the speed of the crankshaft for a four-cylinder motor. The timer may have either four contact points on its rotator and one stationary (rocker) contact connected to the spark-coil, or it may be of the form used when each cylinder has its own individual spark-coil. In the latter case the stationary contacts are all electrically connected together, and only one connection is made between the timer and spark-coil. This one connection joins all of the stationary contacts of the timer to the spark-coil.

The trembler of the spark-coil has, in a distributor system for a four-cylinder motor, four times as much work to do as the trembler of each spark-coil when each motor has its individual spark-coil. This brings four times as much heating and burning effect on the contact points of the spark-coil in the high-tension distributor system as in the individual spark-coil system.

163. Q.—Is it necessary for the timer to rotate at the same speed as the high-tension distributor arm?

A.—No. It is common practice to rotate the timer twice as fast at the distributor arm for ignition in four-cylinder motors. The timer then closes the primary circuit twice during one revolution. The rotative speed of the timer in such a case is the same as that of the crankshaft of the motor.

In some cases, for six-cylinder ignition, the timer rotates three times as fast as the distributor, and closes the primary circuit twice during one revolution. In this case the timer rotates one and a half times as fast as the motor crankshaft.

164. Q.—Does a high-tension distributor ignition system have any advantage over an individual trembler-coil system relative to synchronism?

A.—Yes. The high-tension distributor system eliminates the possibility of variable lag such as may occur in a system having individual trembler-coils.

165. Q.—What is a mechanically operated interrupter for an ignition system?

A.—A device operated by mechanical means for first closing the primary circuit and then breaking it at the instant a spark is required for ignition in a high-tension system.

An interrupter of this nature usually performs the functions of both a timer and an electromagnetically-operated trembler operating in unison as used in some systems. It may be remembered that the timer closes the circuit and the trembler immediately afterward breaks the circuit at the instant a spark is desired. (The effect of lag is neglected in this statement.)

Mechanically operated interrupters are used in both individual transformer spark-coil (without trembler) ignition systems and in high-tension distributor systems.

166. Q.—Does the mechanically operated interrupter produce only one or more than one spark for one ignition?

A.—The usual form of mechanical interrupter breaks the primary circuit only once for each ignition, thus producing but one spark.

167. Q.—Is the primary circuit kept closed during the same length of time (by the clock) whether the motor is rotating fast or slow, referring to battery ignition?

A.—In many designs the length of the time of contact, during which time the primary circuit is kept closed, is the same whether the rotative speed of the motor is high or low.

168. Q.—What advantage is there in having an interrupter which closes the primary circuit only once for each ignition, and during a time period which does not vary with the rotative speed of the motor?

A.—Saving of wear (burning, fusion) at the contact points and of electricity used.

If the current is supplied by battery the keeping down of the amount of electricity used is an important feature, since the useful life of the battery will be longer the smaller the current it is called upon to supply.

By closing the primary circuit only once and making the time during which the circuit is kept closed as short as possible for proper operation of the spark-coil the current consumption is kept small.

When the low-tension current is supplied by an electric generator the preservation of the contact points of the interrupter requires more consideration than the saving of electricity. The single closure of the primary circuit per ignition and a short time closure are favorable to long life of the contact points.

169. Q.—Describe one method of operating a mechanical interrupter so as to keep the primary circuit closed during the same length of time for each ignition regardless of variation in the rotative speed of the motor.

A.—The movable contact point is attached to a lightweight part which is moved against spring resistance by the power-driven operating mechanism. The operating mechanism then disengages from the part carrying the movable contact and the latter are snapped back by the spring. The contact points come together and separate again during the snapping-back movement, the period of contact being short and of uniform time duration whatever the speed of rotation of the driving mechanism. The latter has a speed proportional to the rotative speed of the motor.

170. Q.—How does the consumption of electricity in an ignition system having an ordinary timer differ from that in a system having an interrupter, which closes the circuit the same length of time for each

ignition, whether the motor is rotating at high or low speed?

A.—The ordinary timer keeps the primary circuit closed the same proportion of the time (by the clock) that the motor is running whether the speed is slow or fast. Thus, if the circuit is closed one-tenth of the time during one revolution of the timer rotor, it will be closed one-tenth of the time by the clock whether the rotative speed is high or low, the timer must keep the circuit closed long enough for the trembler to act and for an ignition spark to be produced at the highest speed of rotation. It therefore keeps the circuit closed longer than necessary when the rotation is slow, and is therefore wasteful of current at slow speed.

An interrupter which keeps the circuit closed only long enough for the spark to be produced whatever the rotative speed of the motor is not wasteful of current at any speed of the motor, provided the system is properly proportioned.

In Hardening Permanent Magnets

Retentivity will be great as the carbon content is increased, being a maximum at 90 points carbon, with the metal in the hardened state, as when it is heated at a high temperature and quenched in brine. If tungsten is added to the metal the carbon may then be reduced from 90 points to a lower level with a gain in the good working of the magnets. If the tungsten is 6.5 per cent. or nearly so, the carbon may then be held at about 60 points and for magneto work this metal will hold to a high state of magnetic saturation for a long time.

There are two reasons for desiring to reduce carbon and add tungsten. It is unfortunate, perhaps, that as carbon is increased the flux density decreases. This difficulty is overcome to some extent by reducing carbon and adding tungsten. It has also been found that the magnets will weaken faster if carbon is high without tungsten than with lower carbon and when tungsten is present.

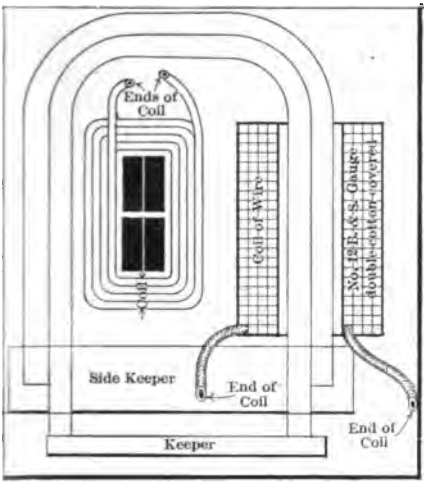


FIG. 48—SHOWING HOW THE MAGNETIZING COIL IS WOUND AROUND THE MAGNETS TO BE REJUVENATED

Substituting high carbon tungsten steel for the soft iron core of electromagnets will result in permanently magnetizing the cores and thereafter the occasion for using a field winding is done away with. True, a soft core will build up a stronger field, and if this is necessary the soft core must be used; in lighting and power dynamos such is the necessity. For magnetos as used in ignition work permanent magnets provide a field that is amply strong and it is an advantage therefore to do away with the winding.

In the course of time the permanent magnets lose some of the magnetic flux and the voltage generated in the windings of the rotor is then reduced considering a given speed. Under such conditions it is either necessary to run the rotor at a higher speed, or have the permanent magnets remagnetized. It is not a large undertaking to do so. A very simple way is to purchase a length of No. 12 Brown & Sharp's gauge, double-cotton-insulated copper wire, sufficient to measure 0.3 ohm. Wind this wire into a coil with an opening in it so shaped as to permit the permanent magnets to enter it as shown in the illustration. When the wire is in place put the keeper in place and then connect the two terminals of the coil of wire to a 3-cell storage battery such as is used for ignition work. The flow of electrical current from the battery will be:

Let I = current in amperes; E = electromotive force in volts, and R = resistance of the coil of wire in ohms.

When,

$$I = \frac{E}{R} = \frac{6}{.3} = 20 \text{ amperes of current.}$$

This is on the assumption that the storage battery of three cells in series will deliver 20 amperes of current at 6 volts. The resistance is given as .3 ohm; it is measured cold, remembering that the current will not be passed through the coil long enough to raise the temperature so high as to interfere with the process.

Several applications of current are better than one, but the time required for each application will scarcely have to be more than a few moments. In parting the circuit when it is desired to interrupt the flow of current, it is right to pull the wire away slowly in order not to reverse the polarity of the permanent magnets. Drawing the arc is but a matter of parting the wires at a slow rate and this process has the same effect as putting a resistance in the circuit and increasing the same until the current recedes to zero.

The storage battery will not be damaged even if this work does require a discharge greater than the normal rating of the same.

171. Q.—What is a low-tension magneto?

A.—One which delivers low-tension current of a pressure suitable for make-and-break ignition, or for the primary winding of a transformer spark-coil for high-tension (jump-spark) ignition.

172. Q.—What is a high-tension magneto?

A.—One which delivers high-tension current suitable for jump-spark ignition without the aid of a transformer spark-coil exterior to the magneto.

173. Q.—What is the general nature of the more usual type of low-tension magneto for automobile ignition?

A.—It consists usually of a group of U-shaped permanent magnets grouped together and provided with a pair of iron or soft-steel pole-pieces fastened, or fitted, to the ends of the magnets, and of a rotary part (the rotor) which revolves between the pole-pieces. The pole-pieces are bored out cylindrically to fit close to the rotor without touching it. The magnets are of hard steel. Only one magnet is used in some magnetos.

A coil of insulated copper wire is wound on some part of the apparatus. In some designs the wire is wound on the rotor and revolves with it; in others the winding is on a spool which remains stationary. The stationary spool winding encircles a portion of the rotor in some cases, but in others it is at a considerable distance from the rotor.

174. Q.—What is the armature of a magneto?

A.—Broadly speaking, it is the wire winding together with the iron or soft steel part on which the wire is wound. It is hardly possible to define it more closely in view of the numerous forms of magnetos.

The armature either rotates or oscillates in many designs of magnetos, but in numerous other designs it remains stationary.

175. Q.—What is the core of an armature?

A.—The iron or soft steel part upon or around which the armature wire is wound is called the armature core. The core, or at least a portion of it, is generally made up of thin sheets of armature steel cut to proper form and held together side by side. This forms a laminated core.

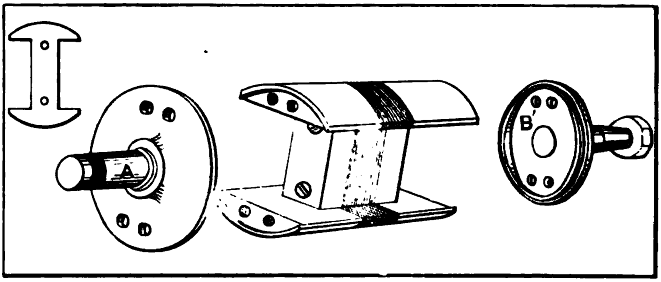


FIG. 49—BOBBIN ARMATURE FOR A CONVENTIONAL TYPE OF HIGH-TENSION MAGNETO

176. Q.—What is the magnetic field of a magneto?

A.—In a limited sense it is the space between the pole-pieces of the magnets. This is where the magnetism is strongest exterior to the magnets and pole-pieces.

The armature, or the inductor, of a magneto is always located in this magnetic field.

177. Q.—What is a bi-polar magneto?

A.—One which has two magnetic poles (pole-pieces). A magneto always has at least two poles. Probably all automobile ignition magnetos with shuttle-wound armatures are bi-polar.

178. Q.—What is a multi-polar magneto or other form of dynamo-electric generator?

A.—One having several magnetic poles; sometimes as many as twelve or fourteen magnetic poles are used in a magneto applied to ignition purposes.

179. Q.—What is the inductor of a magneto?

A.—It is a rotor of iron or soft steel which revolves between the pole-pieces of the magnets. It has lugs, or arms, which pass close to the pole-pieces during its rotation. The inductor has no winding on it in a magneto.

180. Q.—Does a magneto deliver a direct, or an alternating, electric current?

A.—It depends upon how the armature is wound. Nearly all magnetos for automobile ignition deliver alternating current.

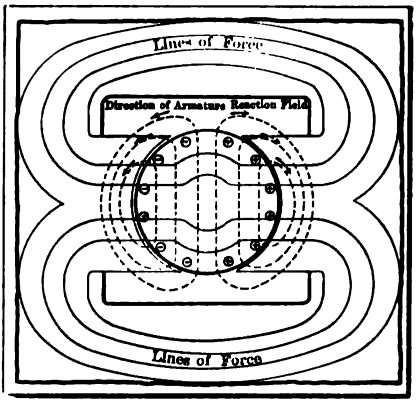


FIG. 50—CONSEQUENT POLE MAGNET, SHOWING LINES OF MAGNETIC FORCE AND ARMATURE REACTION

181. Q. — In what feature does a direct-current magneto differ chiefly from an alternating-current magneto?

A.—In the winding of the armature, and in having a commutator. The armature of a direct-current magneto has a rather complicated winding as compared with that of an alternating-current magneto. It is probable that all direct-current magnetos used for automobile ignition have rotary armatures.

182. Q.—What is the commutator of a direct-current magneto?

A.—It is a cylindrical group of copper segments such as may be obtained by slitting a short piece of tubing lengthwise, then placing the segments in the same positions as they occupied in the tubing and separating each segment from the two adjacent ones by sheet mica.

These retaining parts are insulated from the segments. Each segment of the commutator is electrically connected to a corresponding part of the armature winding. There are seldom less than twelve segments in the commutator of a direct-current magneto used for ignition.

A commutator and a timer are not of the same nature and do not perform the same kinds of service.

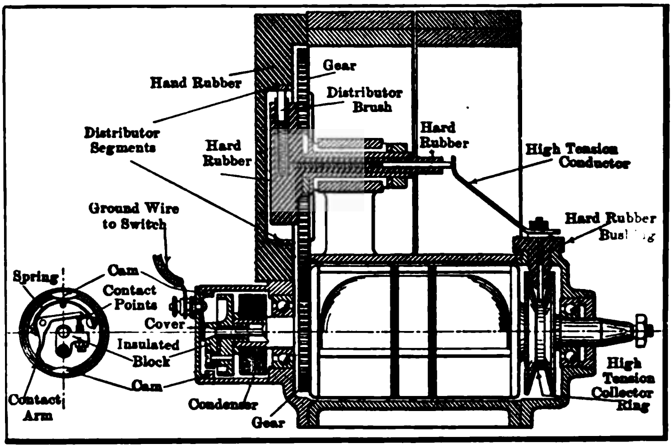


Fig. 51—SECTIONAL VIEW OF HIGH-TENSION, MAGNETO SHOWING RELATIONS OF THE COMPONENT PARTS

It is not unusual for a timer to be incorrectly called a commutator.

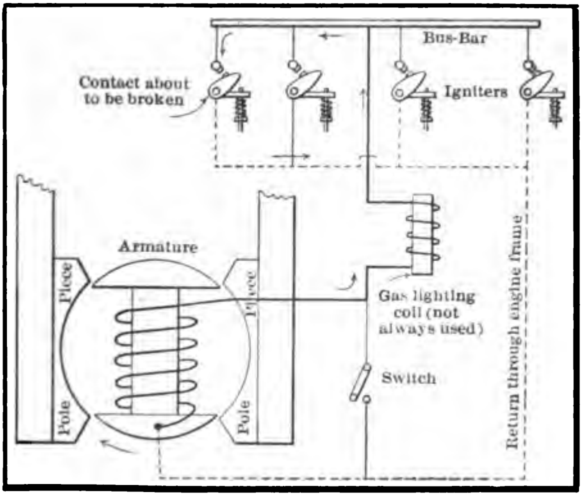


FIG. 52—DIAGRAM SHOWING PATH OF CURRENT IN A LOW-TENSION MAGNETO SYSTEM

183. Q.—What is a "brush" in a magneto or other form of dynamo-electric generator?

A.—A part, generally stationary, which has sliding contact with a moving (rotary) part for the purpose of making electrical connection between the moving and stationary parts of the electric circuit.

The "brushes" used in ignition apparatus are generally made of compressed pulverized carbon, or copper wire gauze and carbon compressed together. These brushes ordinarily have the form of a round, square, or rectangular pencil. Ordinarily a spring presses one end of the brush against the moving part with which the brush makes electrical contact.

184. Q.—How is electricity generated in an alternating-current magneto?

A.—By the variation which occurs in the number of lines of magnetic force which pass through the armature winding during the rotation (or oscillation) of the armature, or inductor, as the case may be.

When the armature, or inductor, during its rotation, is in a position which brings its ends, or sides, nearest the pole-pieces of the magneto, then the greatest num-

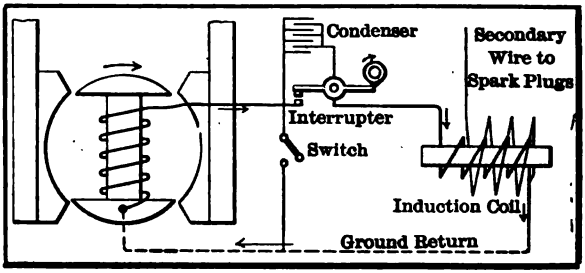


FIG. 53—DIAGRAM SHOWING THE PATH OF CURRENT IN A HIGH-TENSION MAGNETO SYSTEM WITH A SEPARATE INDUCTION COIL

ber of magnetic lines of force pass through the core and the winding. As the armature of the inductor rotates from this position, the number of lines of force through the core and the winding decrease in number. This variation in the intensity of magnetic flux through the winding induces an electromotive force in the winding and causes an electric current to flow when the electric circuit is complete, or closed.

As the armature, or inductor, continues its rotation, the lines of magnetic force through it and the winding increase in number as its ends, or sides, again come near the pole-pieces. This increase of magnetic flux through the winding again induces an electromotive force in the winding and current again flows if the circuit is closed.

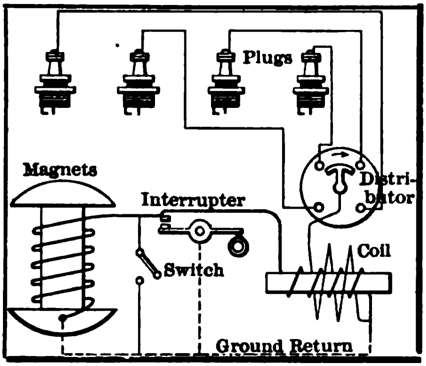


FIG. 54—HIGH-TENSION MAGNETO, UTILIZING SEPARATE HIGH-TENSION DISTRIBUTOR TO TRANSMIT THE CURRENT TO THE SPARK PLUGS

In the ordinary form of alternating-current magneto with rotary armature the magnetic flux through the core and winding is first in one direction and then in the opposite direction, and the maximum electromotive force is induced at or about the instant that the direction of magnetic flux reverses. The maximum current can be obtained at about the same instant. This also applies to most forms of alternating-current magnetos with stationary winding and rotary inductor.

185. Q.—What is an interrupter as used on some alternating - current magnetos?

A.—A device for breaking the low-tension circuit at the instant an ignition is to occur. It has a pair of contact points of the same general nature as those used on a trembler spark-coil. One of the contact points is mounted on a lever (interrupter lever) which is mechanically operated by the lobe, or lobes,

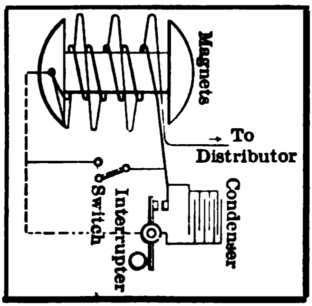


FIG. 55—SHOWING THE RELATION OF THE CONDENSER TO THE INTERRUPTER; THE CONDENSER BEING IN PARALLEL ACROSS THE GAP

of a cam as the armature, or the inductor, of the magneto rotates. In some designs the interrupter lever and the parts which support it are carried on the shaft of the rotor (armature or inductor, as the case may be) of the magneto and revolve with the rotor; the cam is then stationary except that a rocking motion can be given it to vary the time of ignition (to advance or retard the spark).

In other designs the cam is attached to the rotor of the magneto, and the interrupter arm is carried on a pivot which is stationary except that it can be rocked to advance or retard the spark.

A spring acts on the interrupter lever so as to keep its contact point pressed against its mating point and thus keep the circuit closed, except when the lever is pressed back by the cam. Keeping the primary circuit closed the greater portion of the time is necessary to allow the current to flow and arrive at or near the maximum value that can be obtained. The question of waste of electricity does not need consideration in this connection.

186. Q.—Describe a shuttle-wound rotary armature of a low-tension magneto.

A.—The armature core when of the usual laminated type is built of numerous thin I-shaped, or (—)-shaped, pieces of soft steel cut, or stamped, from a sheet of metal. These laminæ are placed side by side so as to form a core of considerable length with a large groove on each side. This laminated core is fastened to end pieces or plates, as by the rivets or rods. The end pieces are mounted on spindles, or shafts, which rotate in the bearings that support the armature.

A coil of insulated copper wire is wound around the laminated portion in the grooves of the core after the manner of winding thread or cord on the shuttle of a weaving loom. This coil is the "armature winding."

187. Q.—To what are the ends of the armature winding usually connected in a low-tension alternating-current magneto with mechanical interrupter?

A.—In the majority of designs one end of the insulated armature wire is electrically connected (as by a screw or solder) to the metal of the armature core; the other end is connected to some insulated portion of the rotor against which portion a brush (carbon pencil) is pressed by a spring. Connections lead from this brush to one of the contact points of the interrupter of the magneto. The stationary contact point is generally the one that is insulated.

The armature core is electrically connected (grounded) to the body or frame of the magneto, sometimes only by the metallic contact of the armature shaft against the bearings in which it rotates, but in the better class of magnetos there is also generally a brush (carbon pencil) which makes electric connection between the armature core and the body of the machine in addition to the contacts at the bearings. This brush is used to secure perfect grounding of the armature core, without which the operation of the magneto would not generally be satisfactory.

188. Q.—What apparatus, in connection with a low-tension magneto having an interrupter, is used in an ignition system for a multiple-cylinder motor?

A.—Usually a transformer spark-coil without a trembler, spark-plugs and a high-tension distributer. This makes a complete system when the ignition control (spark lever) is connected to it.

The high-tension distributer is usually a part of the magneto, but not necessarily. When a part of the magneto it is usually mounted on a shaft which is parallel to the rotor shaft. The distributer arm and its shaft are driven by a pinion (small tooth gear) on the rotor shaft. This pinion meshes (engages its teeth) with a gear on the shaft which carries the distributer arm. The distributer gear of a magneto for a four-cylinder motor generally has twice as many teeth as the driving pinion so that the distributer arm rotates half as fast as the armature.

189. Q.—What is the nature of the current in a shuttle-wound armature if the circuit is kept continuously closed while the armature is rotating?

A.—The current increases from zero to its maximum value during about one-quarter of a revolution then falls again during the second quarter revolution, reaching zero value again at half a revolution from the first zero position. The current then increases again during the third quarter revolution, reaching a maximum again at the end of the third quarter, from which it drops to zero at the completion of the full revolution. The current during the second half revolution flows in the opposite direction from that during the first half and is therefore an alternating current.

190. Q.—At what position of the shuttle-wound armature during its rotation is the current at its maximum value?

A.—At about the two positions in which the crowned ends of the armature core bridge the two spaces between the edges of the pole-pieces of the magneto.

The maximum value of the current occurs somewhat later in the rotation of the armature than the positions just mentioned. This is on account of both magnetic lag and current lag in the armature.

191. Q.—How many times does the pressure and

current in a shuttle-wound magneto reach a maximum value during one revolution of the armature?

A.—Twice per revolution of the armature. One each half revolution.

192. Q.—At what speed does a shuttle-wound armature rotate for a four-cycle motor?

A.—At the same speed as the crankshaft for a four-cylinder, four-cycle motor. At one and one-half times the speed of the crankshaft of a six-cylinder four-cycle motor. For a two-cylinder motor in which the ignitions occur at equal intervals the shuttle-wound armature may rotate at either the same speed as the crankshaft or at half the crankshaft speed.

Every electric impulse of the magneto is utilized to produce ignition under the conditions just mentioned for the four-cylinder and six-cylinder motors; also when the armature rotates at the same speed as the crankshaft of a two-cylinder, four-cycle motor. But if the armature rotates at the same speed as the crankshaft of a two-cylinder, four-cycle motor only half of the electric impulses are utilized for ignition.

The armature may rotate faster than the speed given above, but not slower, and must always be in synchronism with the motor when it has a mechanical interrupter.

193. Q.—What precaution should be observed if some of the electric impulses of a magneto are not utilized for ignition as when the armature rotates so as to generate more impulses than are required?

A.—Each idle high-tension terminal should be short-circuited or at least provided with a spark-gap narrow enough to prevent sparking at the safety spark-gap of the magneto. A spark-gap of the same width as that of the spark-plugs is suitable for the idle terminal if it is not short-circuited.

194. Q.—For a two-cycle motor what is the speed of a shuttle-wound armature of a magneto?

A.—Twice as fast as the crankshaft for a four-cylinder, two-cycle motor.

The same speed as the crankshaft for a two-cylinder, two-cycle motor ignited at equal time intervals.

Two and a half times as fast as the crankshaft for a six-cylinder, two-cycle motor.

195. Q.—How is the low-tension alternating current from a magneto with interrupter utilized to induce a high-tension current for jump-spark ignition?

A.—By sending the low-tension current, or a portion of it, through a transformer spark-coil without a trembler and then causing a sudden decrease of current in the primary of the transformer.

The three usual methods of doing this are:

(1) By breaking the low-tension circuit at the interrupter. The interrupter is kept closed so that the current flows through the primary of the transformer spark-coil until it reaches its maximum value, then breaks the circuit by the separation of the interrupter contacts. The resulting sudden cessation of low-tension current in the primary winding of the spark-coil induces a high-tension current suitable for jump-spark ignition.

(2) By short-circuiting the low-tension current at or about the time it reaches its maximum value. In this system the circuit comprising the magneto armature and the primary winding of the spark-coil is never broken, but a short circuit through the interrupter is made at the instant of ignition.

The low-tension magneto current all flows through the primary of the spark-coil until the current reaches its maximum value. The interrupter then closes the short circuit and thus shunts the primary current away from the spark-coil. The consequent sudden decrease of current in the primary of the spark-coil induces a high-tension current in the secondary suitable for a jump-spark.

(3) By first electrically charging a condenser and then discharging it through the low-tension winding of the spark-coil. The magneto has two interrupters and two pairs of contact points in this system. One interrupter is in a circuit comprising the magneto armature and the condenser; the other interrupter is in a circuit comprising the same condenser and the transformer spark-coil.

Both of these circuits are open circuits, since electricity does not flow through a condenser, but it is convenient to say that the circuits are closed in the following explanation of the operation.

The magneto condenser circuit is kept closed while the pressure and current are increasing, thus charging the condenser. The interrupter in this circuit then opens and breaks the circuit, leaving the condenser charged on open circuit. The transformer condenser circuit is then closed by the other interrupter and the condenser immediately discharges its electricity through the primary winding of the spark-coil. The result is a high-tension current in the secondary of the spark-coil suitable for a jump-spark.

196. Q.—How are the electrical connections made from a low-tension magneto having a high-tension distributer to the other apparatus of a multiple-cylinder ignition system in which the circuit between the magneto and spark-coil is broken to interrupt the primary current through the spark-coil?

A.—The insulated low-tension terminal of the magneto is connected to one of the primary terminals of the spark-coil.

The high-tension terminal of the spark-coil is connected to the magneto at the terminal whose interior connections lead to the high-tension distributer arm. The distributer arm terminal is generally located by itself at some distance from the other terminals.

The group of high-tension terminals of the magneto (as many as there are motor cylinders) are connected to the spark-plugs, one terminal to each spark-plug.

The remaining primary terminal of the spark-coil must have electrical connection with the magneto. This connection is made in various ways, some of which are:

(a) A ground wire is connected from the remaining primary terminal of the spark-coil to the metal of the automobile frame or of the motor; the body of the magneto either makes direct metallic (electric) contact with the automobile frame or with the metal of the motor, or a wire is used to connect the body of the magneto to the frame of the automobile. In the latter case the magneto is provided with a ground terminal that has internal connection with the grounded end of the armature winding.

(b) The remaining primary terminal of the spark-coil is connected by a wire to a terminal on the magneto. This magneto terminal is usually fastened directly to the body of the magneto or to some part in immediate contact with the body. The terminal of the spark-coil is thus connected to the grounded end of the armature winding.

197. Q.—What simplification of construction is obtained in a low-tension magneto having a stationary winding, a rotary inductor with no winding, and an interrupter, as compared with a magneto having a shuttle-wound rotary armature?

A.—Sliding electric contacts are eliminated if the interrupter lever is mounted on a stationary pivot, which is the usual form of construction in this type of magneto.

198. Q.—How many electric impulses per revolution are produced in a bi-polar magneto having a stationary winding, a rotary inductor with no winding, and an interrupter?

A.—Ordinarily two impulses per revolution of the inductor. This is the same number as for a shuttle-wound rotary armature.

In some cases the rotary inductor is constructed to give three electric impulses per revolution in a bi-polar magneto, but it is not good to use a mechanically operated interrupter as part of such a magneto.

199. Q.—What is a high-frequency magneto?

A.—One which produces electric impulses at a much more rapid rate than ignition occurs in the motor. This refers especially to automobile practice.

200. Q.—How is high-frequency low-tension electric current utilized for high-tension ignition?

A.—Ordinarily in the same manner as battery current. The ignition system is of the same form as for a battery, with the exception that the high-frequency magneto is substituted for the battery.

A transformer spark-coil with a trembler is used in connection with a timer as for high-tension battery ignition. Or the battery system with auxiliary trembler-coil can be used on high-frequency current.

201. Q.—Will all trembler spark-coils operate satisfactorily on high-frequency alternating current?

A.—No. Only those whose trembler is light enough and so constructed as to vibrate at a very rapid rate. Some trembler spark-coils, especially those of earlier design for battery current, have tremblers which do not vibrate rapidly enough for high-frequency current.

202. Q.—Is a constant speed-ratio necessary between the crankshaft of a motor and the rotary inductor of a high-frequency magneto which has no interrupter?

A.—It is desirable, but not necessary, to have the rotor and magneto operate in synchronism. It is more desirable the lower the frequency of the generator. A very high-frequency magneto may be belt-driven and give fairly satisfactory ignition.

203. Q.—How fast does the inductor of a high-frequency bi-polar magneto rotate?

A.—Generally at least twice as fast as the crankshaft of the motor; considerably faster in most cases.

204. Q.—Describe the general form of one type of multipolar magneto for high-frequency current.

A.—In one type several wire-wound spools are arranged in a circle with one end of the core of each spool fastened to one side of an iron ring. The arrangement is such as would be obtained by fastening the spools to one side of the rim of a wheel with the spool-ends against the side of the rim.

Each spool is wound with a single coil of insulated wire. Each coil is electrically connected to the coils of the two spools which are adjacent on opposite sides. The windings are connected together, end to end, except one pair of ends which are left free for connecting to the other apparatus.

Several permanent magnets of a V-shaped form are fastened to the side of a rotor so that the bend, or crown, of each magnet is near the shaft of the rotor, and the pole ends point out radially. The sides of the magnet poles pass close to the free ends of the cores of the coils as the rotor revolves. There are as many V-shaped magnets as there are spool-wound coils.

Electric impulses are generated in the winding as the rotor carries the magnet poles successively past the ends of the coil cores. As many electric impulses are generated per revolution as there are spool-wound coils in the magneto.

High-Tension Magnetos

205. Q.—What is a high-tension magneto for jump-spark ignition?

A.—One that generates an electric pressure high enough to force a jump-spark across the spark-gap of a high-tension spark-plug without the aid of any auxiliary apparatus such as a spark-coil. High-tension magnetos ordinarily have an interrupter which operates to produce a spark at the proper instant.

The high-tension magneto is an embodiment in one piece of apparatus of all the parts which make up a high-tension system composed of separate pieces connected together by electric conductors such as wires.

206. Q.—Describe some of the principal types of high-tension magnetos?

A.—In one type the armature is of the ordinary shuttle-form with a single coil wound on it. A transformer coil lies in the space between the armature and the crown of the magnets. The high-tension terminal of the transformer is connected to the arm of a high-tension distributer from whose contact points wires lead out to the jump-spark plugs. The low-tension circuit includes an interrupter which breaks the circuit so as to interrupt the armature current when ignition is to occur. A condenser is also included in the magneto. It is generally located alongside the transformer in the space between the armature and the crown of the magnets. The distributer arm is driven by a pair of spur-gears, one on the armature spindle and the other fastened to the distributer arm or the parts which carry it. The method of operation is the same as that of a low-tension magneto with an interrupter and a separate transformer.

In another type the armature has two windings, a low-tension winding next the core, and a high-tension winding on top of the low-tension one. The condenser is generally also placed in the armature at one end. The low-tension electricity generated in the primary winding of the armature is transformed to high-tension in the secondary. The armature therefore acts as the transformer as well as the generator. An interrupter breaks the low-tension circuit at the instant for ignition. The high-tension terminal of the armature is connected to the arm of a high-tension distributer from whose contact points wires lead to the spark-plugs. The distributer arm is driven in the usual manner by a pair of spur gears. In a later form of double-wound magneto the length (axis) of the armature is parallel to the legs of the magnet, and the armature shaft pierces the crown of the magnet.

A third type operates on the condenser charge and discharge principle. It differs from the above two types chiefly in having two interrupters instead of one. More properly one is an interrupter and the other a circuit-closer. The armature is of the shuttle type with only one winding. A transformer and a condenser are provided and usually located between the armature and crown of the magnets. The condenser is first charged by current from the primary winding of the armature and the primary circuit then broken by the interrupter, thus leaving the condenser charged. The circuit-closer then closes a circuit which includes the primary of the transformer, so that the condenser discharges through the low-tension winding of the transformer, thus inducing high-tension in the secondary of the transformer. The high-tension terminal of the secondary winding is connected to a distributer which directs the current to the different spark-plugs as desired.

207. Q.—What is one general form of high-tension

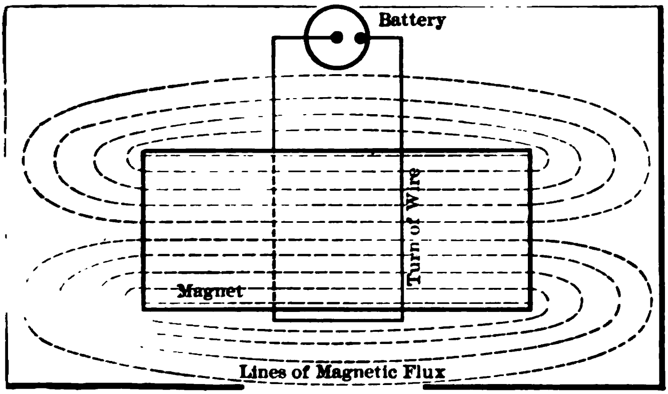


FIG. 56—MAGNETIC DIAGRAM OF A SPARK COIL, SHOWING HOW THE LINES OF FORCE THREAD THE WIRE OF THE CORE

magneto for operating two sets of spark plugs (duplicate spark-plugs) simultaneously?

A.—The armature has essentially three windings—one low-tension (primary) winding and two high-tension windings. Each of the latter is connected to its own set of spark-plugs. Thus one high-tension winding supplies current successively to one set of spark plugs, one plug in each motor cylinder, and the other high-tension winding similarly supplies current to another set of spark-plugs. A suitable form of high-tension distributer is of course required.

208. Q.—What is the safety spark-gap of a high-tension magneto?

A.—A gap an eighth of an inch or so wide whose sides are connected to the terminals of the high-tension winding. It is wide enough to prevent the high-tension current from passing across it when the spark plugs are operating properly. If the connection to two or more of the spark plugs is removed, however, a spark will jump across this safety gap, thus preventing an excessive electric pressure being brought upon the insulation of the high-tension winding. Otherwise the pressure might become so high as to break down the insulation.

209. Q.—How can ignition be cut off while a high-tension magneto is still running?

A.—By short-circuiting the armature winding. Means are ordinarily provided for doing this. A common method is to have an electric switch connected to the magneto and to the frame of the car. Closing the switch shuts off ignition as stated above.

A suitable terminal is usually found on a magneto for attaching the switch wire.

Magnetic Spark-Plugs

210. Q.—What is a magnetic spark-plug?

A.—One which has an electro-magnet embodied in it.

211. Q.—Describe one form of low-tension (contact-arc) magnetic spark-plug.

A.—The plug has a coil of insulated wire wound on a spool which is outside of the motor cylinder when the plug is in place. A magnetic core of iron or soft steel extends into the coil-spool, partly filling the bore of the spool. One end of a small rocker-arm also extends into the spool alongside the magnetic core. This arm carries a contact point at the end which extends into the motor cylinder. The rocking point (fulcrum) of the arm is in the neighborhood of the middle of its length. A spring bears against the rocker arm so as to keep its contact point pressed against the stationary contact point of the plug when no current is passing through the plug.

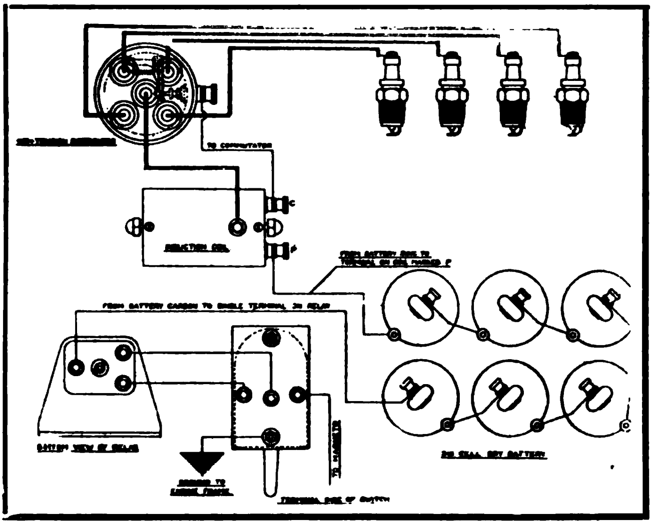


FIG. 57—WIRING DIAGRAM OF A FOUR-CYLINDER MOTOR FITTED WITH A UNISPARKER

As soon as the external electric circuit is closed, as by a timer, current begins to flow through the plug. The circuit in the plug includes the contact points and the coil in series. When the current reaches the amount at which the plug operates the magnetic core attracts the rocker arm end that is inside the coil, causing the arm to rock so as to draw the movable contact point away from its mate, thus breaking the circuit at the contact ignition points. An electric arc suitable for ignition is drawn at the contact points as they separate. The contact points are forced together again as soon as the current ceases. This is done by the spring which bears against the rocker-arm. By the time this occurs the external circuit has been broken at the timer under ordinary conditions, and the plug does not operate again until the external circuit is again closed by the timer.

Magnetic plugs of this type are generally screwed into the motor cylinder in the same manner as ordinary high-tension (jump-spark) plugs.

Dual and Combined Ignition Systems

212. Q.—What is meant by "dual ignition"?

A.—In general, ignition by two separate means. The meaning is not specified and well defined as ordinarily used, however.

A true case of dual ignition exists when two complete and separate systems operating entirely independent of each other are used on a motor. Thus, a motor may have both a high-tension ignition system and a low-tension system, either of which will operate when the other is entirely removed, or out of commission, including the source of electricity. In such a case both systems can be operated at the same time.

On the other hand any ignition system which has two sets of igniters is commonly called a dual system, although the same apparatus in all or part of the remainder of the system is used for both sets of igniters, and both sets of igniters cannot be used simultaneously. Thus the same source, or sources, of electricity and the same timer or interrupter may be used for both sets of igniters.

Again, it is not unusual to call a system dual when there is only one set of igniters, but electricity is supplied by two sources, as a battery and a magneto, only one section operating at a time.

The combinations which are called dual ignition system are numerous.

213. Q.—Describe the "battery floated on the line" system of electric supply.

A.—A direct-current electric generator and a storage battery are connected together in parallel. (Positive brush of generator to positive terminal of storage battery, and negative brush to negative terminal.)

The generator keeps the storage battery charged during the operation of the ignition system. If the generator stops rotating, or runs too slowly to give sufficient pressure, it is automatically cut out of circuit so that the battery cannot send current through the generator, since this would be a waste of electricity and generally harmful to the generator. When the generator is again run fast enough to give sufficient pressure, it is automatically put into the circuit as before. The storage battery alone furnishes current during the time the generator is cut out of circuit. It is not necessary to charge the battery from any source other than that of the generator which forms part of the system, unless excessive demands are made upon the battery while the generator is not operating.

The system is in a measure analogous to a water supply system of a city in which a pump, corresponding to the electric generator, forces water into the pipes and a reservoir. Part of the time the pump delivers water faster than it is used by the consumers. The excess then goes into the reservoir. If the pump stops, the reservoir then supplies the water to the consumer.

214. Q.—Is the "battery floated on the line" sys-

tem suitable for both high-tension and low-tension ignition?

A.—Yes. Even if the low-tension system is such as to require a large amount of electricity the generator is capable of supplying it.

215. Q.—Is a battery alone suitable for a contact-arc (make-and-break) ignition system?

A.—Only in case the current flows through the contact points of the igniter during but a very short time for each ignition. Otherwise the amount of electricity used will be so great as to rapidly exhaust the battery.

Clutches and Transmissions

216. Q.—What is a friction clutch and how used?

A.—A device for transmitting power in which the frictional resistance to the sliding of one smooth surface over another is utilized as the means of driving one part by another.

One part of the clutch is generally attached to the crankshaft or flywheel of the engine, and the mating part of the clutch to a shaft which transmits power to the remainder of the transmission that connects to the driven wheels.

217. Q.—Why is a friction clutch adopted for this purpose?

A.—Because it is necessary to give a gasoline engine considerable speed of rotation before attempting to move the car by its power.

218. Q.—What is a cone friction clutch?

A.—One in which the contact surfaces (male and female) that transmit power by their frictional resistance to sliding are conical in shape (cone frusta). The parts are pressed together, generally by a spring.

219. Q.—What is a multiple-disk friction clutch?

A.—One in which a number of disks, really thin rings resembling the washers commonly used under the heads and nuts of bolts, placed on concentric axes transmit power by the frictional resistance to sliding between their surfaces when pressed together. The ordinary type consists of two sets of flat metal rings,

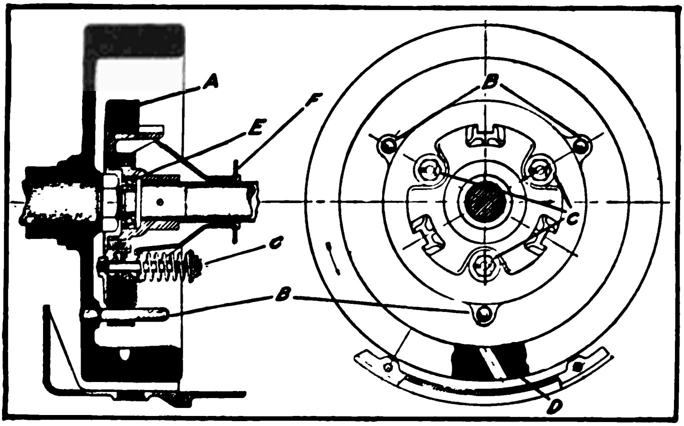


FIG. 58—ALTERNATE DISCS OF HARD COPPER AND STEEL SHOWN AT "A." COPPER DISCS DRIVEN FROM FLYWHEEL BY PINS "B." CLUTCH ACTUATION BY MEANS OF SPRINGS "C." CLUTCH CAN THROW NO END THRUST UPON CRANKSHAFT AS SAME IS TAKEN BY FRONT TRANSMISSION BEARING. CLUTCH HUB FLOATS UPON ANNULAR BEARING "E." FLANGE FOR BEARING OF CLUTCH THROW-OUT COLLAR AT "F."

each set composed of alternate rings. Each ring lies between a pair of the other set. One set is attached to a shaft passing through their centers, and the other set to a sleeve or casing surrounding them. The rings are keyed so they must rotate with the part to which they are attached, but are free to slide in the direction of the length of the shaft or thimble. The clutch is put into action by pressing the rings together.

220. Q.—What advantage has a multiple-disk clutch over one with only one pair of flat surfaces rubbing together?

A.—If only one pair of friction surfaces were used to transmit a given amount of power at a given speed of rotation the pressure between the rubbing surfaces would have to be much greater than when a number of rings of the same diameter and material are used. Thus if the number of pairs of rubbing surfaces is thirty, the pressure required to hold the rings together for transmitting the power would be about 1-30 of that necessary for only one pair of rubbing surfaces of the same form and size. By the use of several pairs of rubbing surfaces the diameter of the clutch can be kept small.

221. Q.—What is a plate clutch?

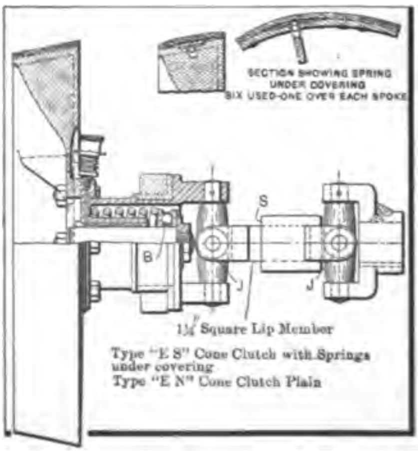


Fig. 59—SECTION OF LEATHER-FACED TYPE OF CLUTCH WITH ENCASED SPRING AND TWO UNIVERSAL JOINTS TO COMPENSATE FOR INCORRECT ALIGNMENT

A.—It is of the same nature as a multiple-disk clutch, but has only a few friction rings. Only three rings are ordinarily used, giving two pairs of friction surfaces. The friction rings are of large diameter on account of being few in number.

222. Q.—What modification of a multiple-disk clutch is used?

A.—A form in which the friction rings resemble a washer with a V-shaped groove running circumferentially around it on one side. The metal projects on the other side of the ring in a correspondingly shaped ridge. In the assembled clutch each ridge fits into a corresponding groove in the next ring. Wedging action in conjunction with several pairs of friction surfaces is thus obtained, and the force pressing the rings against each other is not so great as when flat rings are used.

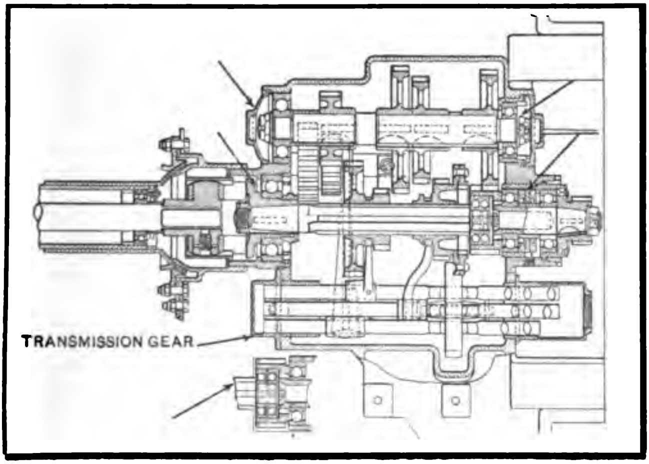


FIG. 60—SELECTIVE TYPE OF TRANSMISSION, SHOWING THE SELECTING ARMS AND UNIVERSAL JOINT AT REAR OF GEAR BOX

223. Q.—What is a contracting-band friction clutch?

A.—One in which a band or outer friction member grips the outside of the other friction member of the clutch when the parts are engaged with each other. The friction surfaces are generally cylindrical, but not necessarily so.

224. Q.—Describe an expansion clutch.

A.—It has an internal friction member which when forced outward (as by a spring) presses against the inner surface of the mating friction member. The friction surface of the latter is generally cylindrical.

225. Q.—What is a coil-spring friction clutch?

A.—One in which one of the friction members is a coiled spring. The other friction member may be either cylindrical or conical. In one type the driving effort of the motor draws the coil-spring friction member tightly against the other friction member. In another type the driving effort causes a reduction of pressure between the friction members. The rubbing surfaces are metal against metal.

226. Q.—What advantageous feature has a coil-spring clutch in which the driving effort causes a reduction of pressure between the friction surfaces?

A.—It is impossible for the clutch to seize and jerk. A car can therefore be started gently under any condition.

227. Q.—What materials are commonly used for the friction surfaces of ordinary cone clutches?

A.—The inner member is generally faced with soft leather which rubs against the smooth inner surface of the outer member. The latter may be of any metal, but cast iron and steel casting are most common.

Cork inserts are sometimes set through the leather into a recess in the metal cone under the leather. These are used to obtain a more uniform frictional grip between the rubbing surfaces and to obviate sudden seizure and jerking. The cork inserts have the general form of an ordinary bottle stopper of the same material.

228. Q.—Of what material are the rubbing parts of multiple-disk and plate clutches made?

A.—In numerous cases steel against steel, or steel against bronze, rubbing parts are used. Cork inserts are frequently used in one of the metal to metal rubbing members.

In other numerous cases one of the rubbing materials is some soft material such as leather, woven asbestos, etc. The soft material is fastened to the metal of one of the friction members (or to one set of friction members) and rubs against the metal of the other member (or set of members). The metallic rubbing surface is generally of steel in such a clutch.

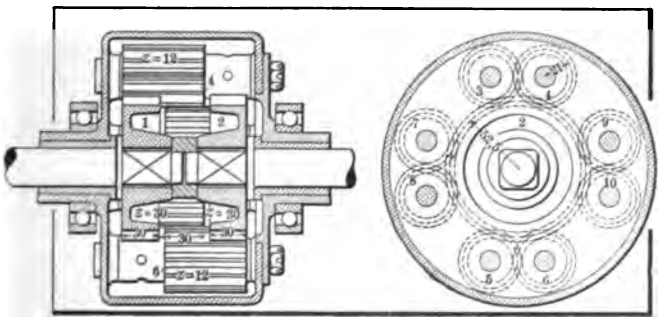


FIG. 61—TYPE OF DIFFERENTIAL GEAR USING SQUARE-CUT TEETH IN EACH PINION

229. Q.—What is a positive clutch?

A.—One in which projection or jaws on one member fit into corresponding recesses of the other so that, when the jaws are brought into engagement, they must turn together without slip.

230. Q.—What is a change-speed transmission gear?

A.—A number of gear wheels with teeth, generally inclosed in a case, which are used to give different speeds of travel to the car for a given speed of rotation of the engine. This is done by bringing different groups of gears into action for each speed of travel.

231. Q.—What is a sliding-gear change-speed transmission?

A.—One in which the different groups of gears of unequal diameters are brought into mesh by sliding one or more of the set along the shaft which supports it. The teeth of the gears are thus slipped between each other.

232. Q.—Where are the sliding change-speed gears located?

A.—Between the friction clutch and the driving mechanism which connects to the rear axle or the rear road wheels. The gears generally occupy one of the three following locations:

(1) Just in the rear of the motor and friction clutch in a case fastened to the frame of the chassis.

(2) Immediately in front of the rear (driving) axle.

(3) At the forward end of a tube which extends from the rear axle toward the clutch and motor.

233. Q.—What is a planetary change-speed transmission?

A.—One in which some of the gears are supported on pins or short shafts which revolve around the main axis of the group. The same gears always remain in mesh with each other. Different sets are brought into action by stopping the rotation of one or the other of the parts which support the gears whose axes revolve around the main shaft. To stop the rotation of any part it may be gripped by a strap or band similar to a band brake.

234. Q.—What is an individual-clutch change-speed transmission?

A.—One in which the same gears are always in mesh, and different pairs or sets are brought into action by the use of a clutch which operates for that set of gears only. One clutch is provided for each set.

235. Q.—What is meant by direct drive?

A.—When the shaft connected to the rear member of the friction clutch is brought into direct engagement with the shaft which carries power to the road wheels so that none of the change-speed gears are used for transmitting power. In many designs the change-speed gears revolve idly, however, when the direct drive is on.

236. Q.—What is the propeller shaft?

A.—The shaft extending forward from the rear axle and by means of which power is transmitted to the rear axle.

237. Q.—What is a differential?

A.—A device for allowing the driven road-wheels to rotate at different speeds and still receive the same amount of force to rotate (drive) them. (Same torque.)

238. Q.—Describe a differential.

A. — When the propeller shaft drive is used the part of the rear axle which turns the road wheels is in two parts, each

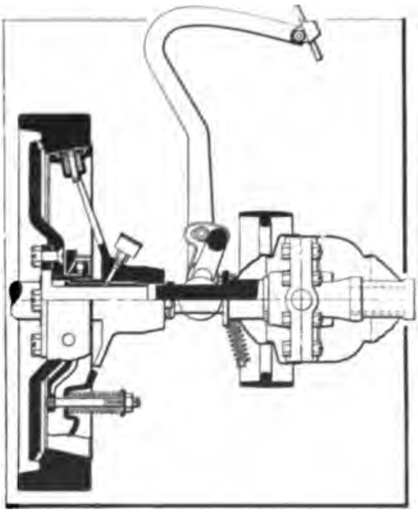


FIG. 62—SECTIONAL VIEW OF A LEATHER-FACED CLUTCH, SHOWING SPRINGS BELOW THE LEATHER SURFACE TO INCREASE THE ADHESION AND RELIEVE THE SHOCK OF TOO SUDDEN ENGAGEMENT

of which is connected to its own road-wheel. The division is generally near the middle of the axle. Each half of the live axle has a gear attached rigidly to its inner end. Both gears are usually of the same form and size. Either bevel gears or spur gears are used. When bevel gears are used, two or more smaller bevel gears are interposed between those on the half axles. The axles of the interposed gears are perpendicular to the rear axle. The casing or part which supports the interposed gears is driven by the propeller shaft, and the torque it receives is transmitted in equal portions to the two road-wheels, whether the latter are rotating at the same speed when the car is traveling in a straight path, or at different speeds when rounding a curve. If the road-wheels are lifted so as to turn freely and one is turned forward the other will turn backward at the same rate when the propeller shaft is at rest.

In a spur differential the action is exactly the same. Each intermediate gear of the bevel gear differential is replaced by two spur gears, one of which engages with the spur gear on the inner end of the right-hand half axle, and also with a gear of its own size and form which in turn engages with the spur gear on the inner end of the left-hand half axle. Two or more pairs of these small intermediate gears are used.

239. Q.—What is the arrangement of the differential for a single chain drive?

A.—The differential is placed on the rear axle, as for the propeller shaft drive, and its action is the same as for the latter.

240. Q.—What is the arrangement of the side chain drive with a chain for each rear wheel?

A.—The rear axle is made solid and the differential is placed on an additional shaft extending across the length of the car in the rear of the change-speed transmission gears. Chains lead from sprocket wheels at the outer ends of the divided countershaft to sprockets on the rear wheels. The road-wheels can thus rotate at different speeds and each always receives half of the torque transmitted to both.

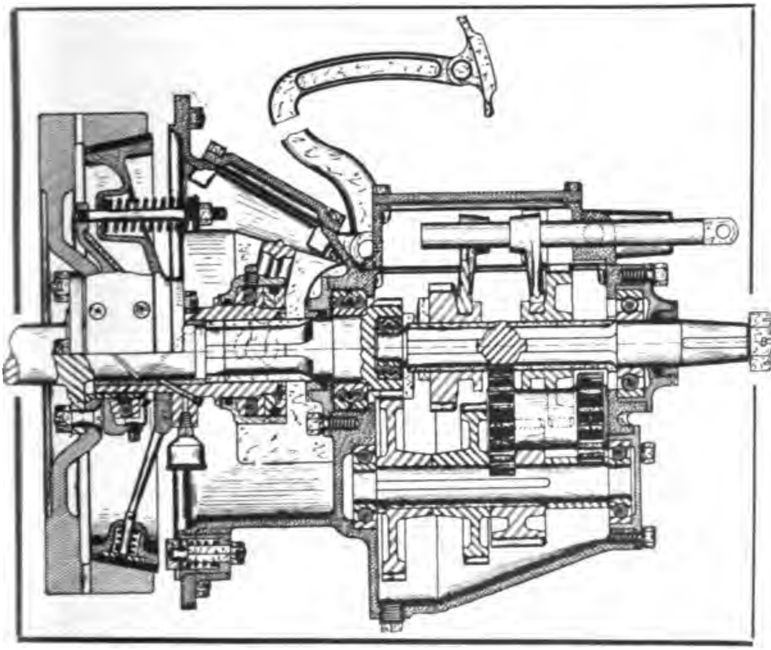


Fig. 63—LEATHER-FACED CLUTCH, WITH EXTERIOR SPRINGS ATTACHED TO A ROCKING SPIDER AND TRANSMISSION GEARS WITH MILLED KEYWAY SHAFTS

241. Q.—What is a floating axle?

A.—A shaft inside the hollow non-rotating rear axle, but not supported by rotative bearings. The only function of the floating axle is to transmit power to the road-wheels so as to drive them. It is divided into two parts, one for each road-wheel. Each half of the floating axle is supported at one end by its engagement with the hub of its road-wheel, and at the opposite by its engagement with one of the driven differential gears.

The road-wheels are carried entirely on the dead (non-rotating) axle when a floating axle is used to drive them. The differential gears are carried by bearings on their hubs or on hub-like extensions of the hubs.

242. Q.—What is a semi-floating axle?

A.—A divided live shaft for driving the road-wheels, each half of which has a running bearing at one end and is supported at the other end by its engagement with the part that rotates with it. Ordinarily the rotative bearing is at or near the end which engages with the driven differential gear and the opposite end is supported by the wheel. The latter runs on the dead axle.

The semi-floating axle differs essentially from the full floating axle only in having one end of each half carried on a rotative bearing.

243. Q.—What are friction gears?

A.—Power-transmitting gears which engage with each other by means of smooth, frictional surfaces. They have no teeth such as are on spur gears (cog-wheels).

244. Q.—What is one form of friction gears that are used as part of the transmission system on automobiles?

A.—One form consists of a metal disk against whose flat side the edge (periphery) of a friction wheel is pressed. The axes of the shafts, one carrying the disk and the other the friction wheel, are at right angles (perpendicular) to each other. The edge of the wheel is made of some non-metallic material, such as rawhide or paper fibre. The friction disk is carried on an extension of the motor crankshaft, and the shaft of the friction wheel lies across the length of the car in the ordinary construction.

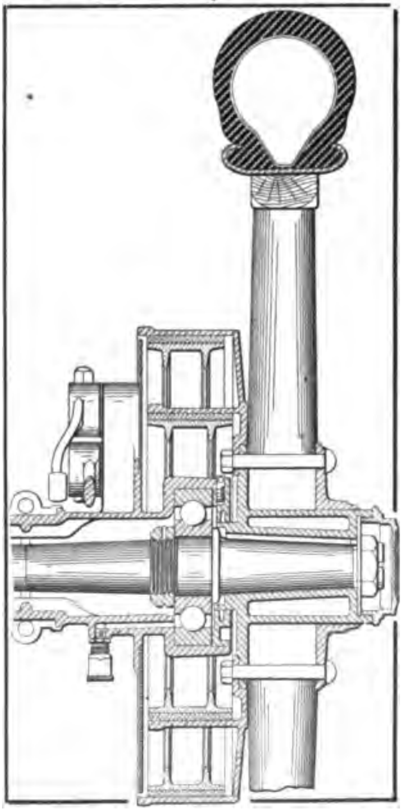


FIG. 64—SEMI-FLOATING TYPE OF REAR AXLE IN WHICH THE WEIGHT OF THE CAR IS PARTIALLY CARRIED BY THE LIVE AXLE

245. Q.—How is a variable driving speed obtained by friction gears?

A.—By shifting the friction wheel across the face of the driving disk.

When the friction wheel is brought near the center of the disk the road-wheels are driven slowly. By shifting the friction wheel farther away from the center of the disk the speed of car travel is increased.

246. Q.—How is reverse of direction of car travel obtained with friction gears?

A.—When only one friction wheel is used it can be shifted across the center of the disk and will then be driven in the opposite direction, thus reversing the direction of car travel.

Another method of reversing is to use two friction wheels, one acting against the rear face of the disk and the other against the forward face. Only one friction wheel is pressed against the disk at a time.

Various other forms of friction drives having one friction disk and two or four-friction wheels are used.

247. Q.—What is another form of friction gears?

A.—That in which the friction gears resemble bevel spur gears with the teeth removed. The member corresponding to the disk of the drive mentioned above has two or more conical grooves at different distances from the shaft which carries it. The driven friction gear can be shifted to engage with any of these grooves.

Brakes, Bearings and Steering Gears

248. Q.—What is a contracting band brake?

A.—A band (shoe) surrounding a smooth surface, generally cylindrical, and brought into action by tightening it to grip the part whose motion is to be resisted. The inner part is the brake drum.

249. Q.—What is an expansion brake?

A.—One in which an inner part (the shoe) is expanded to press against the inner surface, generally cylindrical, of the part whose motion is to be resisted.

250. Q.—How may brakes placed on the hubs of the rear wheels differ in their action from a brake placed between the differential and the engine?

A.—If the hub brakes are not properly adjusted, or if one is oily and the other dry, they will not offer equal resistance to the rotation of the rear wheels, and consequently the car will swing to one side when they are applied. This is liable to cause skidding and turn the car across the direction of its travel on a slippery road. With the brakes applied in front of the differential, however, equal resistance is offered to the rotation of both wheels.

251. Q.—What is an equalizer as applied to brakes?

A.—Some devices, such as a bar, to which force is applied at the center for putting on the brakes. The brake-shoe rods are fastened at each end of the bar. By this device each hub brake is equally tightened.

252. Q.—Will an equalizer bar apply hub brakes so as to offer equal resistance to the turning of the road-wheels?

A.—Only when the rubbing surfaces of the brake and brake drum are in the same condition. If one is dry and the other oily the dry one will offer far greater resistance to turning.

253. Q.—What is a plain journal bearing?

A.—A cylindrical part rotating in a cylindrical hole. A rotating shaft turning in a hole bored in a piece of metal is an example.

254. Q.—What is a journal box?

A.—The removable lining that is generally interposed between the journal and body of a machine. It is attached to the concave member.

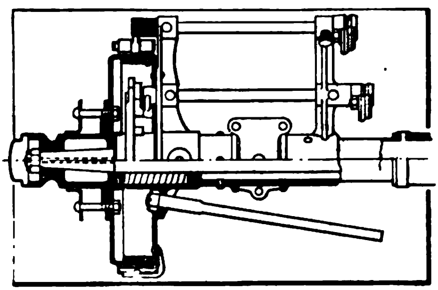


FIG. 65—SHOWING DISPOSITION OF INTERNAL AND EXTERNAL EXPANSION BRAKES ON THE REAR WHEEL HUB

255. Q.—What is a ball bearing?

A.—One in which balls are interposed between the rotating part and the other member of the bearing.

256. Q.—What forms of grooves are used in ball bearings?

A.—Generally those whose cross section is an arc of a circle slightly larger in radius than that of the ball. From 4 per cent. to 10 per cent. larger.

257. Q.—Will a ball bearing withstand end thrust?

A.—Yes.

258. Q.—What is a cylindrical roller bearing?

A.—One having cylindrical rollers interposed between the rotating and stationary parts of the bearing, both of whose surfaces are also cylindrical. The rollers are either solid or made up of a ribbon of metal wound spirally to form a roller which is elastic.

259. Q.—What is a cone roller bearing?

A.—One in which conical rollers are interposed between the surfaces of the rotating and stationary parts, which are also both conical (tapered cone-frusta).

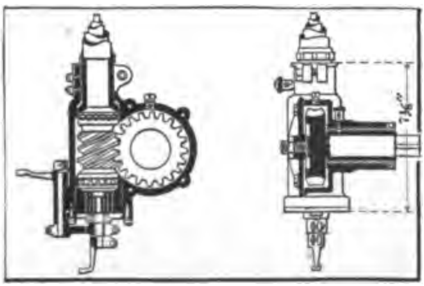


FIG. 66—SECTION VIEWS OF THE PINION AND WORM TYPE OF STEERING GEAR, TOGETHER WITH THE CONTROL RODS PASSING THROUGH SAME

260. Q.—Will a conical roller bearing resist end thrust?

A.—Yes, in one direction. A pair of such bearings is generally used with the small ends toward each other so as to resist thrust in either direction.

261. Q.—What is a ring-oiled bearing?

A.—One in which a thin, narrow ring hangs over the journal and dips into a small reservoir of oil below the bearing sleeve. The rotation of the journal causes the ring to rotate by friction against it when it rests on the journal.

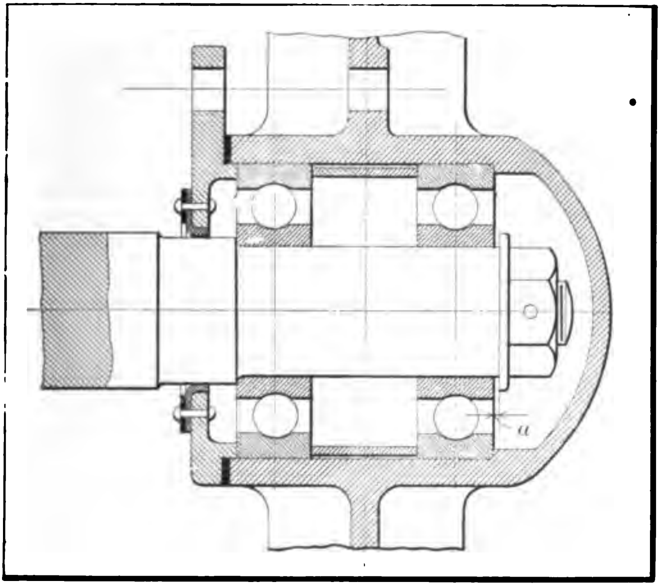


FIG. 67—SECTIONAL VIEW OF A SHAFT, SHOWING THE BALL BEARING IN PLACE AND THE METHOD OF DISTANCING SAME

262. Q.—What is a universal coupling such as is used on the propeller shaft?

A.—A jointed coupling which acts as a hinge to allow the connected shafts to swing out of line in any direction relatively to each other.

263. Q.—Why are universal couplings used on the propeller shaft?

A.—To allow the rear axle and the parts rigidly attached to it to move freely relative to the parts to which the shaft is connected and which are rigidly fastened to the frame of the chassis. The action of the springs on the car causes considerable vertical and side motion between the change-speed gear shaft and the rear axle.

264. Q.—What is the arrangement of the steering gear?

A.—Each front wheel is supported by a knuckle joint which is pivotally connected to the front axle at a point near the hub of the wheel. Sometimes the pivot is at the center of the hub. The knuckles have arms of equal length which project either forward or backward. The ends of the arms are connected by a distance-rod which holds the wheels so that they head straight forward when in position for traveling a straight road and causes them to swivel through proper angles for turning a curve. A second arm on one of the knuckles has a reach-rod connected to it that is also attached to the mechanism at the lower end of the steering post. The latter is operated by the steering wheel. When the steering wheel is rotated by hand the road-wheels are turned either to the right or the left as desired.

265. Q.—What is the difference between a reversible and an irreversible steering gear?

A.—The reversible steering gear is one which allows the front road-wheels to be swung about their swivels by a force applied to the wheels. In the irreversible gear this is not possible.

Steering gears on small cars are generally reversible.

In large cars they approach quite near to non-reversibility.

266. Q.—Are the angles through which the front wheels swivel from the position for straight ahead equal when they are put into position for rounding a curve?

A.—No. The wheel on the inside of the curve (curve of smaller radius) swivels through a greater angle than the outer one. This is necessary to bring the wheels in position to travel around the curve without a tendency to go in different directions. The wheels must swivel so that if the axes of the front wheels were extended toward the center of the curve they would intersect at a point on an extension of the rear axle which lies at or near the center of the curve.

Lubrication

267. Q.—What methods of lubricating the motor are in common use?

A.—Two methods as regards the manner of using the oil are in general use. They may be designated as the gradual-feed system and the circulating system. In both systems oil is allowed to collect in the crank-case to a level high enough for the lower end of the connecting rod, or a splash-piece fastened to it, to strike the oil and splash it into the cylinder and onto the wristpin of the piston.

In the gradual-feed system the oil is gradually fed from the oil reservoir of the lubricator onto the rubbing parts to be lubricated. It is not used again. Part is burned, or vaporized, and passes out with the exhaust gases, except such residue as is deposited inside the cylinder. The remainder drips away and is lost. The rate of oil fed is, or should be, regulated so as to allow enough oil to flow to lubricate the parts sufficiently.

This regulation is generally attained by means of a needle valve in conjunction with a sight-feed where the rate of oil flow can be observed. Tubing or pipes ordinarily lead from the lubricator to the parts to be oiled.

In the circulating system of lubricating a motor the oil is circulated by a pump so as to be repeatedly applied to the parts to be lubricated. It is especially adapted to vertical motors. The oil is applied much more copiously, except to the cylinder, than by the gradual-feed system. Additional oil space (oil pocket) is generally provided at a lower level than that at which the oil is to be maintained in the crankcase. This pocket is kept more or less completely filled with oil. A pump draws the oil from the pocket and forces it through pipes leading to the rubbing surfaces to be lubricated. The oil flows from the latter down into the crankcase, which is provided with overflow openings at such a height as to keep the oil at a level just high enough for the connecting rod ends to strike and splash it up into the bore of the cylinder. The overflow oil from the crankcase returns to the oil pocket and is again pumped to the bearings, and so on repeatedly.

268. Q.—How is the cylinder of a horizontal motor lubricated?

A.—Generally through an oil-hole in the top of the cylinder with oil from an oil-cup or, more generally, from one of the pipes connected to a lubricator. In some horizontal motors the splash system is also used, enough oil being allowed to collect in the bottom of the crankcase for the connecting rod to strike and splash it.

The piston pin is usually lubricated by oil thrown from the crankshaft and the crank-end of the connecting rods, even when the splash method is not used.

Special devices must be used to prevent one cylinder from receiving more oil than the other when the splash method is used on a horizontal motor with opposed cylinders. The tendency is to throw more oil into the cylinder toward which the crank-end of the connecting rod moves while in its lowest position than into the other cylinder.

269. Q.—What is forced lubrication?

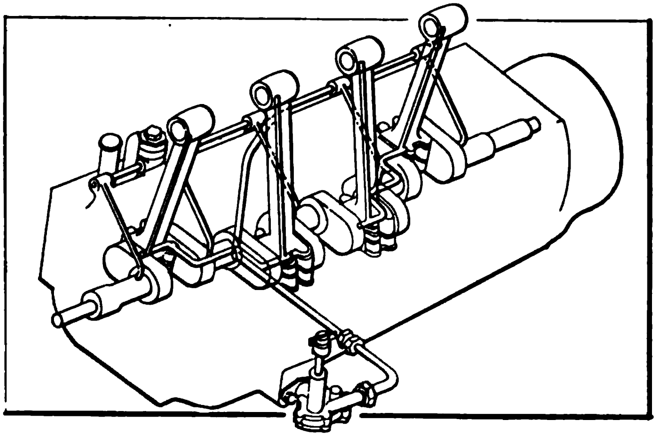


FIG. 68—FORCED FEED LUBRICATION DIAGRAM, SHOWING THE PUMP AND THE PIPING. THE OIL IS DRAWN FROM THE BASE AND IS FORCED BY THE PUMP THROUGH THE PIPES TO ALL THE BEARINGS

A.—That in which pressure is used to force the oil between the rubbing surfaces to be lubricated. A pump is used to force the oil into and through the bearings. The rubbing surfaces are so constructed and the capacity of the oil pump is such that a considerable oil pressure is maintained at the bearing and a large amount of oil is forced through between the rubbing surfaces

270. Q.—What types of pumps are used for circulating the oil in a circulating system?

A.—The reciprocating-plunger type, the centrifugal type, and the fixed-volume-per-revolution type are all used. For forced lubrication the centrifugal type is not much used on account of the high speed of rotation necessary to maintain a few pounds pressure per square inch at the bearings.

A simple form of positive acting rotary pump is composed of two ordinary spur gears enclosed in a case so that the gear teeth intermesh in the usual manner. When the gears rotate, oil is drawn into the case through the inlet opening of the pump, carried around in the pockets between the gear teeth and casing and delivered through the outlet.

271. Q.—What kind of lubricators are used for the motor?

A.—Gravity feed, compression (force) feed, and mechanical (positive force) feed. (Do not confuse the last two with forced lubrication.) In all of these the oil contained in a reservoir is fed out as required.

272. Q.—How is the rate of flow of oil adjusted in the gravity-feed lubricator?

A.—By a needle valve or corresponding device for each pipe leading out to the different parts of the engine. By adjusting the needle to regulate the size of the orifice, the desired rate of flow is secured and maintained with fair accuracy as long as the temperature of the oil remains constant.

273. Q.—How does the compression (force-feed) lubricator operate?

A.—The oil is contained in a reservoir to whose top is connected a pipe from the crankcase of the engine or from one of the exhaust pipes.

In engines of the two-cylinder opposed type the pistons approach and recede from each other when in motion (they both move toward the crankshaft at the same time). This movement of the pistons compresses the air in the crankcase every revolution and some is forced up through the tube to make air pressure above the oil. A check-valve in the lubricator or tube prevents the return of the air to the crankcase when the pistons recede from each other. The pressure is thus constantly kept in the oil tank. The oil is fed through a passage, or duct, starting at the bottom of the tank

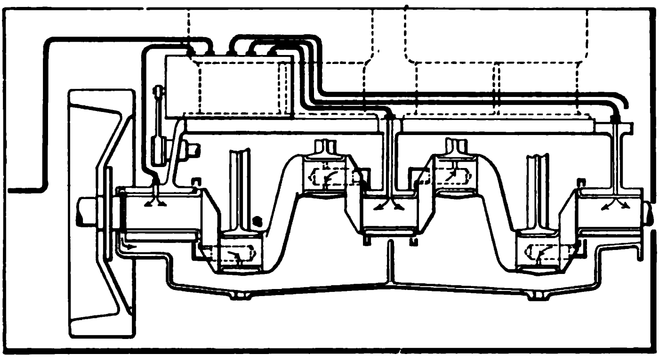


FIG. 69—DIAGRAM OF THE OIL LEADS OF A MECHANICAL OILER. THE OILER IS DRIVEN BY AN ECCENTRIC OFF THE REAR END OF THE CAMSHAFT AND THE OIL IS FED TO THE MAIN BEARINGS

and leading to the various needle-valve regulators for the pipes leading to the different parts of the engine. When the engine is not in use no oil flows, but as soon as it is started the compression produced causes it to feed and continue as long as the engine is running. It will also continue some time after the engine is stopped if some means are not provided for relieving the pressure in the oil tank. An escape valve which can be pressed open by one's finger is usually provided for relieving the pressure when the motor stops. The regulation of flow is as for the gravity system.

274. Q.—Describe a mechanical-feed lubricator.

A.—In one, which is typical of several, an oil reservoir contains several plunger pumps which are all driven by the same shaft that receive power from some moving part of the automobile. There are as many pumps as localities to be lubricated by oil directly from the lubricator. A tube leads from each pump to the place to be lubricated. The feed can be regulated so that the desired quantity of oil passes out through each tube for each stroke of the individual pump connected to it.

The speed of the pump is proportional to the rotative speed of the motor, therefore the amount of oil fed out is also proportional to the speed of the motor; that is, a certain amount of oil per revolution, or hundred revolutions, of the motor. The quantity of oil thus fed is not appreciably affected by its being thick or thin, as when cold or warm, in a properly designed lubricator.

275. Q.—What desirable features does a mechanical-feed lubricator have that are absent in both a gravity lubricator and a compression lubricator?

A.—The delivery of oil at a rate proportional to the speed of rotation of the motor, which rate is not appreciably changed by the oil being thick or thin, cold or warm.

The gravity lubricator delivers oil at the same rate whether the motor runs fast or slow. It delivers much more slowly when the oil is cold than when it is warm.

The compression lubricator does not deliver oil at a rate proportional to the speed of the motor, and delivers slower when the oil is cold than when warm.

The lubricator does not receive a constant pressure from the motor exhaust or from the crankcase if the latter is leaky, which is not unusual. The exhaust pressure is higher when the motor is pulling hard than when it is throttled down. This latter condition is a favorable one, however, since the motor requires more oil when pulling hard than when throttled, and the higher exhaust pressure causes more oil to flow from the lubricator.

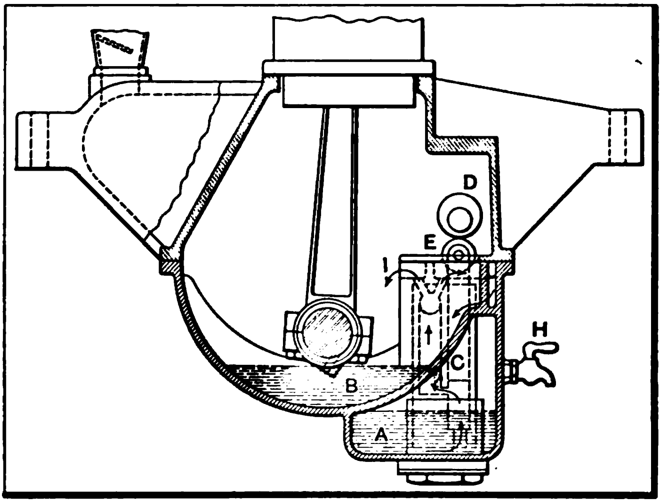


FIG. 70—PLUNGER TYPE OF LUBRICATOR PUMP DRIVEN BY A CAM ON THE CAMSHAFT. THE SCOOPS ON THE END OF THE CONNECTING RODS SPLASH THE OIL UP TO THE CYLINDERS AND WRIST PINS

276. Q.—How is the rate of oil feed regulated in a mechanical lubricator?

A.—In some by adjusting the pump plunger to a greater or less length of stroke until the desired rate of feed is attained; in others by changing the amount of opening of a by-pass valve so as to allow more or less of the oil pumped each stroke to flow back into the oil reservoir, the balance passing out to the part to be lubricated.

An extra tube with a hand valve is run from the lubricator to the crankcase. When the valve is opened oil flows freely into the crankcase.

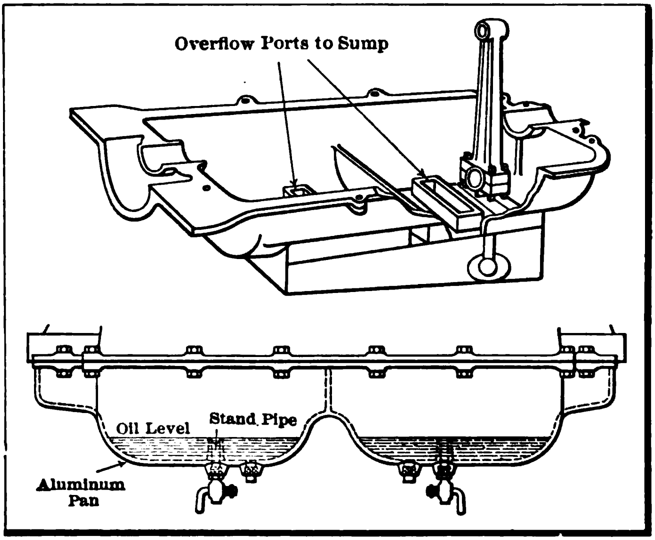


FIG. 71—THE TOP ILLUSTRATION SHOWS TROUGHS UNDER THE CONNECTING RODS, AND THE LOWER A CROSS SECTION OF BASE CHAMBER, SHOWING OIL LEVEL AND DRAIN COCKS TO ASCERTAIN THE CORRECT LEVEL

277. Q.—How is enough oil for a long run carried although the lubricator is comparatively small?

A.—In a supply tank which is usually connected to the lubricator by a pipe. A hand pump is also provided, by means of which oil can be pumped from the supply tank into the lubricator. In some systems the lubricator can be filled in this manner while the car is running.

Lighting

278. Q.—From what sources is acetylene gas obtained for headlights?

A.—Either from a gas generator or from a tank containing compressed gas.

279. Q.—How is acetylene gas generated on the car?

A.—By allowing water to come gradually into contact with calcium carbide in a tightly closed vessel called the generator. The water and carbide combine chemically so that acetylene gas is formed. A grayish white ash is also produced.

The generation of gas produces a pressure in the tank sufficient to force the gas through tubing or pipes to the lamp burners (tips) and out through small openings in them.

The gas carries small particles of solid matter with it as it leaves the generator and must be passed through a filter for cleaning, since the particles would otherwise clog the burners. A piece of fine sponge answers well as a filter.

280. Q.—In what form is calcium carbide used in a gas generator?

A.—Generally in the form of lumps, the largest of which will pass through a hole somewhat larger than one-half inch in diameter. Sticks or bars molded from pulverized calcium carbide and a matrix for cementing the powdered carbide together.

281. Q.—How is the rate of gas generation regulated to the proper quantity for the lamps?

A.—By regulating the rate at which water is allowed to come into contact with the carbide. Some generators are made so that the pressure of the gas automatically regulates the flow of water. When the gas pressure increases it reduces the flow of water and as the gas pressure falls in consequence, the rate of water flow again increases, and so on.

282. Q.—Describe a typical form of acetylene gas generator for using lump carbide.

A.—It consists of a gas-tight vessel, inside and near the bottom of which is a wire basket for containing the carbide. A water reservoir occupies the upper part of the generator. The reservoir has an opening at the bottom, through which water can flow so as to drip on the carbide. This opening has a valve for regulating the water flow. The water passage may include an automatic device for regulating the flow of water. The gas outlet is at or near the top of the lower half of the generator. A filter may be included in the generator or it may be inserted in the pipe line.

Invertible generators of the above type are swung on trunnions (like a cannon). By inverting them the water reservoir is brought to the bottom, and the water flow is of course stopped and the generation of gas ceases. When brought to the upright (obverted) position again, the water begins to flow and gas generation begins. It is not necessary to disturb the regulating valve when stopping gas generation.

283. Q.—Why is a water pocket sometimes placed in the pipe line of the generator?

A.—To catch water which may be carried out of the generator with the gas. Otherwise water may collect in the lowest part of the pipe line and cause an irregular or pulsating flow of gas. The water pocket, or drip space, is included as part of the generator sometimes. It should have a convenient means for draining it.

284. Q.—How is compressed acetylene gas provided for headlights?

A.—In tanks containing a substance which absorbs a large quantity of the gas under pressure. A small valve can be opened wide enough to allow the proper amount of gas to flow to the lamps. As the pressure drops the valve must of course be opened wider. A pressure gauge on the tank indicates the pressure of the gas in the tank, thus also giving information as to the amount of gas on hand. When the supply is exhausted the tank must be returned to the gas-maker for refilling.

Packing, Gaskets and Accessories

285. Q.—What is a speedometer (tachometer)?

A.—An instrument for indicating the speed at which an automobile is traveling. It is connected with one of the road wheels, usually by a flexible shaft.

286. Q.—What is a distometer (odometer)?

A.—An apparatus for indicating the distance the car has traveled. Most types can be set to show the distance for the entire season and also the distance traveled on any particular run. It is connected to one of the road-wheels. The speedometer and distometer are frequently embodied in a single instrument.

287. Q.—What is a gradometer?

A.—An instrument for indicating the percentage of grade of the road over which the car is traveling.

288. Q.—What is a gasket?

A.—A piece of comparatively soft material placed between two harder surfaces, generally metallic, for making a tight joint. The gasket is used in pipe couplings on engine cylinder heads when they are separate from the cylinder, etc.

289. Q.—What material would you use for a gasket on an exhaust pipe?

A.—Something that is not affected by high temperature. Woven asbestos with copper net is commonly used. Soft sheet copper, or copper asbestos gaskets made by placing asbestos between the copper parts.

290. Q.—How can a gasket be treated so as to remain in place well and yet allow an easy separation of a joint?

A.—In places where there is not much oil, gasoline, etc., the gasket can be made to adhere on one side by coating that side with varnish or paint of a sticky nature, before putting in place. Coating the other side of the gasket with graphite will cause easy separation when the joint is opened.

The adhesion of the gasket to one side of the joint prevents its loss, especially if it is small, and makes convenient the putting of the joint together again?

291. Q.—What kind of material is suitable for an inlet pipe gasket?

A.—Something not affected by gasoline. Wood fiber, leather, paper, soft copper, lead. Do not use rubber except temporarily.

292. Q.—For a water circulating pipe gasket?

A.—Any good steam packing will answer, also leather and wood fiber. If oil is used to make a non-freezing solution, anything containing rubber would hardly be suitable.

293. Q.—For a gasoline pipe gasket?

A.—The gasoline pipe is generally small and the nature of the material that may be used depends upon the form of the joint. In some cases wood fiber, leather, thick paper or a thin piece of sheet lead or soft sheet copper can be used. Regrinding the joint can be resorted to if the packing cannot be put on, or a small amount of cake soap rubbed on the joint, or, as emergency calls for it, some of the rubber solution cement for tires will answer temporarily.

294. Q.—What packing is suitable for a circulating pump?

A.—Any valve-steam packing for where the shaft comes out of the casing. Candle wicking covered with a mixture of oil (or grease) and flake graphite does well. Flax fiber, such as used for weaving linen fabric, makes an excellent packing for the shaft or plunger of a water pump. A low grade of flax (tow) is suitable.

Between the parts of the pump-case, rubber cement is good for a very thin film of packing. Ordinary gasket material answers for thick packing. Thick paper may answer.

Operation

295. Q.—What preparation should be made before starting out with a car that is in good condition?

A.—Make certain of having:

Gasoline in the fuel tank;

Vent in fuel tank of gravity system not clogged or closed by anything lying over the vent;

Oil in the lubricator and oil cup screwed on tight if pressure (compression) oil feed is used;

Oil in the crankcase, especially if the circulating system of lubrication is used;

Grease in the grease cups;

Grease in the timer, or current interrupter housing, if they are of the type intended to be lubricated with grease;

Water in the cooling system;

Carbide and water in the gas generator, or sufficient pressure in the compressed-gas tank;

Oil in the oil lamps;
Tires properly inflated.

296. Q.—When starting an automobile motor by cranking. What operation should be carried out?

A.—Such of the following operations as apply to the car:

Turn on the gasoline. There is generally a valve just under the fuel tank in a gravity system. (See "Air Lock," Q. 437.)

Pump up the pressure in a compression fuel system if necessary.

Turn on the lubricating oil if a gravity lubricator is used.

Set one (pair of) brake. Select the one whose setting also releases the friction clutch.

Set the change-speed control lever in neutral position, so that the transmission gears are disengaged.

Open the throttle part way. Ordinarily less than half way.

Close the switch of the primary electric circuit.

Set the spark-control lever in position for a late (retarded) spark.

Prime the carbureter if thought necessary. This can be done by pressing down the float, or by lifting the needle valve if there is no float. The stem of the needle valve projects from the body of the carbureter in most designs without a float.

See Q. 297.

Put the hand-crank in place, engaging it with the crankshaft so as to pull up on the handle when cranking. It may be necessary to turn the crank several times to draw the mixture into the cylinder and ignite it. In some motors with magneto ignition it is necessary to give the crank one or more rapid complete turns to get an ignition spark. It is unsafe to push down on the crank when battery ignition is used, since there is always a chance that ignition may come early enough to cause the motor to start backward. This backard starting is called "kicking," or back firing.

Fasten the hand crank up so that it will not strike obstructions on the road.

Close the throttle as far as is possible without causing the motor to stop, and set the spark control in position to give slow speed of rotation.

297. Q.—How is compression relieved when cranking to start the engine?

A.—In some engines the exhaust camshaft has two sets of cams. When the crank is pushed in to engage with the crankshaft, the exhaust camshaft is moved endwise so as to bring the auxiliary cams into action. The latter hold the exhaust valves open during part of the compression stroke. Another method is to open the petcocks leading into the combustion chamber.

298. Q.—What is the object in relieving compression when cranking the motor?

A—To make cranking easier. It is not generally necessary for small motors.

299. Q.—How is the car started after the motor is running?

A.—Release the clutch if it is not already held disengaged.

Set the speed-control lever for slow speed. For one just learning it is best to start on slow speed.

Retard the ignition and open the throttle so as to give the motor considerable speed.

Release the brake.

Engage the friction clutch very gradually if it is not of the type that automatically prevents seizing and jerking. Open the throttle still farther as the clutch goes into engagement; otherwise the motor may stop.

Advance the spark as the rotative speed of the motor increases.

Shift the speed-control lever to bring the change-speed gears into position for faster travel of the car. To do this, first retard the spark and close the throttle somewhat, then release the clutch fully and shift the speed-control quickly and firmly immediately after the clutch is released. Let the clutch into engagement gradually unless it is of the type that automatically prevents jerking. When ascending a grade it may be necessary to let the clutch into engagement quickly after shifting the change-speed gears, thus taking the chances of its jerking. After becoming skillful in shifting the change-speed gears it may not be necessary to close the throttle any while doing it, since the change can be made so quickly as not to allow the motor time to race. It is nearly always advisable to retard the spark before shifting the gears to a position to increase the rate of travel of the car.

As skill is acquired, modifications of the above method of shifting the change-speed gears will generally be found by the driver; the nature of these modifications will usually depend on the construction of the car. Thus, in some cars it is possible to shift the gears without disengaging the clutch when the latter is in good order. This is not a very safe operation, however, since there is always danger of the clutch having so firm a grip as to strain or break the gear-teeth as they are thrown into mesh.

300. Q.—What causes a grating noise while shifting of the change-speed gears if it is not properly done?

A.—The striking of the ends of the gear-teeth of one gear against those of the gear with which it is to be engaged.. This is extremley destructive to the gears and should not be allowed to occur. It is either an evidence of a faulty car or lack of skill in the operator.

301. Q.—If the motor is cold and will not start, what may be done?

A.—Prime the cylinders by putting about a thimbleful of gasoline into each one. A cup-shaped priming valve for this purpose is found on the cylinders of several makes of cars.

Place a stop over the (main) air intake of the carbureter so as to nearly close it. One's hand will serve. Some carbureters have a valve for this purpose.

Warm the cylinders by pouring hot water into the water jacket space, or over the outside. Care should be taken not to wet the magneto or spark-coil.

Warm the cylinders with a torch. The flame of the torch should be moved rapidly over the cylinder surface, since directing it against one spot for some time is apt to crack or otherwise injure the cylinder. The flame should not be allowed to come near the insulated electric wires. The insulation is almost always made partly of rubber or other combustible substance which is readily injured by fire. Neither should the flame be allowed to strike the ignition plug long, especially if it has porcelain insulation. The temper of springs may be drawn if struck by the flame. A piece of cotton waste on the end of the wire can be used as a torch when saturated with gasoline or kerosene.

The use of fire about the motor in the above manner should always be preceded with the precaution of removing gasoline and oil which have accumulated in the drip-pan or apron and about other parts of the car.

See Q. 450.

302. Q.—Why should the timer be set for late spark when cranking?

A.—If set for early spark the charge may be ignited before the piston has completed the compression stroke. This will drive the piston back and turn the shaft in the wrong direction. The "resulting" kick is dangerous, or at least painful, since it is generally powerful enough to snap the crank out of one's hand.

303. Q.—What may cause a "kick" when cranking just after the engine has been running, although the timer is set for late spark?

A.—An overheated cylinder, on account of some of the carbon which is almost invariably found on the walls being high enough in temperature to ignite the charge before compression is completed.

304. Q.—How can a four-cylinder motor be started without cranking (starting on spark)?

A.—If, just before the engine stops, the ignition is cut off and the throttle opened, one cylinder will generally receive a charge and its piston stop in a position to start when the charge is ignited. By closing the ignition circuit and moving the timer so as to produce a spark, the engine will generally start.

305. Q.—How can you start the motor if the crank is broken or lost and the engine will not start on spark?

A.—When the fly-wheel is accessible it may be used to turn over the engine, but care should be exercised to push rather than pull it; grasp it by the smooth rim, so that no harm will be done the hands when explosion occurs. Pouring a small quantity of gasoline into the cylinder through the small petcocks at the top may help.

The automobile may be pushed forward or allowed to run down hill with the driver in his seat, holding the clutch disengaged. The car may be run either forward or backward down hill, the gears being set accordingly. After some speed has been attained the clutch may be thrown in, and the momentum of the car will start the engine to turning over. As soon as an explosion occurs, the clutch should be released to allow the engine to gain speed of rotation. The car can be pushed most easily when the gears are set for high-speed forward and the car runs forward.

Another way of starting the motor is to jack up one rear wheel; throw in the high-speed gear and rotate the road wheel in forward direction, taking care to keep free of the wheel when the motor starts.

306. Q.—Why should the timer be advanced as the engine increases in speed when driving the car?

A.—If the timer is left for a late spark the charge will not be all burned before the exhaust valve opens and will continue burning as it passes out through the exhaust port and pipe. This results in a loss of power and also causes excessive heating of the engine, especially at the exhaust valve and around the exhaust port. The combustion should begin early enough to be complete in the early part of the impulse stroke, in order to utilize the heat of combustion to drive the piston and to allow the gases to cool somewhat by expansion and contact with the cylinder walls before passing out.

No provision is made for varying the time at which the contact points in the cylinder are separated in at least one automobile with make-and-break low-tension ignition. The magneto used for furnishing the ignition current increases in speed as the engine turns over faster and gives a stronger and hotter ignition arc with the increased speed. The larger volume of mixture ignited by the hotter arc and the more rapid inflammation resulting compensate in a measure for the greater speed of rotation.

307. Q.—What indication, observable while driving the car, may show that ignition is too late?

A.—The circulating water may become so hot as to be converted into steam, which if there is any visible opening to the radiator can be seen escaping. The exhaust pipe may become red hot near the engine.

308. Q.—What permanent injury may be caused by running with too late ignition for a considerable length of time?

A.—The exhaust valve is apt to become pitted and warped so as to leak. The exhaust pipes may warp and leak where they connect to the engine casting.

309. Q.—How should the spark and throttle control be set when running a car at a uniform speed along a good, level road?

A.—The throttle should be closed as much as possible in order to economize fuel and prevent undue heating of the engine, and the spark should be advanced as far as possible for satisfactory running of the engine.

310. Q.—If the spark is advanced too far when running, what bad result follows?

A.—The combustion pressure will become too high in the cylinder before the piston has completed its compression stroke and offer so much resistance to it during the completion of the stroke as to produce heavy stresses in the crankshaft, which may be sufficient to break it.

311. Q.—What is an indication that the spark comes too early when running?

A.—There will be a pounding sound (knocking) in the engine generally, and in a one-cylinder or two-cylinder engine an additional tremor may be given the car. In an engine with four or more cylinders that is new, with all parts snugly fitted, there may be no knock or other indication that is discernible, unless the spark is excessively advanced. Loss of power will always come with excess of advance, but not necessarily with the amount of advance that produces knocking in a somewhat worn engine, or even in a new engine of the single-cylinder or two-cylinder type.

312. Q.—If the spark and throttle are properly set when running at the legal rate on a level road, how would you manipulate them to climb a grade without losing speed?

A.—Retard the spark slightly and open the throttle gradually, then advance the spark carefully up to the safe limit.

313. Q.—When the car slackens speed on an increasing grade, how do you throw the sliding gears from high speed to a slower speed?

A.—Disengage the clutch, bring the gears to neutral position between high-speed and next to high-speed, increase the speed of the engine, throw in the clutch momentarily, disengage again, and bring the sliding-gears quickly into the next to high-speed.

314. Q.—How would you adjust a carbureter which has a valve in the air inlet that is lifted against a spring (automatic air-valve) by the air when the throttle is open wide?

A.—First make the preparation for starting the motor (Q. 295).

Set the gasoline (needle) valve of the carbureter to what is judged as about the proper opening. A quarter-turn of the valve, or less, will generally answer for the first trial.

Set the automatic air-inlet valve about midway between its extreme adjustments.

Open the throttle one-quarter way, or less.

Prime the carbureter if there is any provision for so doing.

Set the spark control for late ignition.

Crank the motor several times. If it does not start, and there is provision for priming the carbureter, partly close the air inlet of the carbureter while cranking. The air inlet can be thus partly closed by one's hand or a piece of flat metal. The air inlet should be left free as soon as the motor starts. Several trials at starting, with different settings of the throttle lever, should be made.

If the motor starts, but runs only a few revolutions, and no black smoke (not blue, or blue-white) appears at the exhaust just before the motor stops, then open the regulating valve of the carbureter wider to let more gasoline into the air passage (to make a richer mixture). Crank the motor again, as before.

If black smoke appears at the exhaust just before the motor stops, then slightly close the regulating valve of the carbureter. Crank as before. After the motor is started, adjust the regulating valve of the carbureter to obtain the maximum speed of motor for a given setting of the throttle, the latter being kept well closed in order to prevent excessive speed. It will generally also be advisable to give the ignition different settings to obtain the best results. If the exhaust shows black smoke, the carbureter is feeding too much gasoline. This is apt to be accompanied by misfiring and explosions in the exhaust pipe and muffler. If there is back-firing (popping) in the intake pipe and carbureter, too little gasoline is going in, unless this is due to a faulty valve, valve-spring, or some unusual cause.

Set the spark and throttle so that the motor runs compartively slow. Then open and close the throttle quickly. The motor should speed up rapidly without misfiring or backfiring while speeding up. It is not unusual for backfiring to occur when the throttle is quickly closed, although the motor operates satisfactorily otherwise.

If backfiring occurs when speeding up rapidly, open the regulating (needle) valve to feed more gasoline. If black smoke and misfiring occur, close the regulating valve slightly. The air-valve spring will need adjustment after changing the setting of the gasoline valve. It is a matter of trial for each type of carbureter to determine which way to make this adjustment. Tightening the air-valve spring makes a richer mixture, and relieving it produces a leaner one.

After the above adjustments have been made, the car can be tried out on the road. Hills of steep grade naturally give the best means of trying out. In the absence of steep grades, the rapid speeding up of the car is a good way of determining the action of the carbureter.

The adjustments of the carbureter to be made on the road are of the same nature as those already given above. The maximum pull and speed of the motor are, of course, what are sought.

Several of the manufactures of carbureters give specific instrucions for their carbureters. It is advisable to follow these instructions when they are available.

315. Q.—How do you adjust a gravity lubricator?

A.—Set the screw needle valve for each pipe until the required number of drops of oil per minute pass through the sight feed.

316. Q.—How do you adjust a compression lubricator?

A.—Start the engine and adjust as for the gravity lubricator. The speed of the engine when adjusting may be about the average at which it is used.

317. Q.—How is a mechanical lubricator adjusted?

A.—There is usually some means of adjusting the length of stroke of each plunger which forces oil out to its own particular part to be oiled or of allowing a portion of the oil to flow back into the oil reservoir of the lubricator. Some have a sight feed, others visible outlets to be used only temporarily during adjustment and wasting the oil, so that they can be set for the required amount of oil for each movement of the pump plunger, or other device for forcing the oil out. Start the engine and adjust for the required amount of oil. The feed device for each pipe should continue delivering the same amount of oil per stroke of its plunger or other device, whether the oil is thick or thin, hot or cold.

318. Q.—What kind of lubricating oil should be used for the cylinders and crank case?

A.—One that will stand a high heat test and leave no deposit in the combustion chamber and on cylinder walls when burned.

319. Q.—When smoke is discharged from the exhaust, what does it indicate?

A.—Excess of lubricating oil gives blue smoke. Too much gasoline causes black smoke and soot.

320. Q.—Can excess of gasoline be distinguished from excess of lubricant?

A.—Yes. Excess of gasoline produces a strong, disagreeable odor, and if the engine is exhausting in a closed room the eyes will suffer.

321. Q.—What are the indications of poor lubrication in the cylinder?

A.—In a single-cylinder or two-cylinder engine there will be loss of power, and the engine will slow down and even stop. With four or more cylinders there will be loss of power and some slowing down of the engine, which, however, may not be noticeable if lubrication is poor in only one cylinder. In such a case the remaining cylinders would keep the engine running, and abrasion or cutting will follow, which is not infrequently accompanied by a groaning or creaking noise in the cylinder.

322. Q.—If the water circulation fails or the water supply is insufficient in a water-cooled engine, how will it manifest itself?

A.—In practically the same manner in a single-cylinder or two-cylinder engine as poor lubrication; in the case of four or more cylinders the behavior is the same except that the motor will lose power and probably stop, since lack of cooling will destroy the lubricant in all the cylinders and cause excessive frictional resistance to the motion of the pistons.

323. Q.—Is the same kind of lubricant suitable for both water-cooled and air-cooled cylinders?

A.—No. The air-cooled cylinder requires a lubricant with a higher fire test than that for the water-cooled cylinder.

324. Q.—Is flake graphite a suitable lubricant for a motor cylinder, the graphite being mixed with oil?

A.—The results which have been obtained differ radically as to its being satisfactory. In some trials the use of a small amount of graphite together with the oil seems to have given extremely satisfactory operation; in other trials the addition of graphite to the oil caused the cylinders to heat excessively. It is, of course, possible that in the latter case too much graphite was used. The question as to whether graphite clogs the piston rings does not seem to be settled.

325. Q.—What kind of lubricant is suitable for sliding transmission gears?

A.—Practice shows great diversity. It is safe to say, however, that any lubricant of reasonable body that the gear-case will retain gives good service. The construction of some gear-cases is such that good machine oil is retained and answers with entire satisfaction, while in other types a grease must be used, since the oil leaks out rapidly. A combination of oil and grease is not infrequently put in gear-cases and found satisfactory. Graphite grease especially is much used, or mica grease, which is of much the same nature. These greases have either graphite or mica in small flakes mixed in with the true grease. Yellow grease used for axles has also proved good. Graphite or mica grease should be used with care when there is any possibility of its working into the crankcase and from there to the cylinders. The solid matter may cause the pistons to bind and heat the cylinder.

326. Q.—What kind of lubricant is suitable for ball bearings?

A.—Oil or grease that is not too heavy or solid. Generally the most fluid lubricant, not thinner than the heavier machine oil, that can be satisfactorily retained, is the one to select. A grease containing solid matter in considerable quantity should not be used, especially if the bearing runs at high speed.

327. Q.—What kind of lubricant is suitable for roller bearings?

A.—The same as for ball bearings, except the thicker grease. A very thick grease will prevent the free rotation of the rollers and may have a tendency to throw them out of alignment with the journal.

328. Q.—What kind of lubricant is suitable for a disk clutch with metal-to-metal friction members?

A.—It depends on the form of the clutch. Several types operate best with a mixture of machinery oil and kerosene as a lubricant. The proportions vary from equal amounts of oil and kerosene to a comparatively small amount of kerosene. Some such clutches operate best with oil only, such as machinery oil or motor cylinder oil. A few clutches use heavier oil.

329. Q.—How can you test gasoline for its suitability to use in the engine?

A.—By use of the hydrometer to find the specific gravity.

330. Q.—What is the hydrometer?

A.—The ordinary type is a short tube of glass, with a stem similar to that of a thermometer, and has a small receptacle at the bottom, in which lead shot is placed to cause the instrument to stand vertical and sink into the liquid until well covered. The stem, part of which remains above the liquid, is graduated, and the graduations marked.

331. Q.—How far should the Baumé hydrometer sink into gasoline suitable for the internal combustion engine?

A.—To the 76 or 74 degree graduation on the stem for the best grades of gasoline. The temperature of the gasoline affects the reading. The hydrometer sinks further in warm gasoline than in cold. The reading is higher in numerical value when the gasoline is warm. In the inferior fuel, cold gasoline, the hydrometer does not sink near so far as just stated. The reading is not infrequently less than just stated by as much as 10 degrees or more.

Bearings and Brakes

332. Q.—How should cup-and-cone ball bearings be adjusted when replacing a wheel?

A.—So that the wheel will turn perfectly free. A little looseness is not objectionable. A tight bearing is apt to crush the balls or damage the ball race (cup or cone).

333. Q.—What are the indications of wear in a ball bearing?

A.—The balls become rough by flaking off of the skin of the metal, and the same effect may be noticeable on the ball races. If the races are too soft they may groove without flaking.

334. Q.—When assembling a ball bearing that has no cage for retaining the balls in place, how can the balls be kept from falling out?

A.—By using a liberal supply of grease as a cement for holding them.

335. Q.—What is the remedy for a cut or seized plain journal bearing?

A.—If it is a split bearing, open it by removing the cap. Smooth the convex surface with a fine-cut file, or fine emery paper folded over a stick or file. Scrape the concave surface with a hard metal scraper or smooth it with emery paper. Large, hard lumps may be chipped off first with a cold chisel. Lubricate with a thin oil.

A solid bearing, or one difficult to open, can generally be worked free by oiling and turning, first slightly backward, then forward, and so on.

336. Q.—If a journal bearing does not take lubricant well, what may be the cause?

A.—The oil grooves in it may be filled with dirt, or the grooves may not be large enough or in the right place. Clean the grooves or give them the proper form and size.

337. Q.—How can the brakes be tested?

A.—By running the car and applying them. They should cause the wheels to slip on the road when fully applied.

Another method is to lift the rear wheels free from the road or floor and run the motor with the gears set for low speed, then apply the brakes. This should stop the road wheels from rotating. It may or may not stop the motor, according to how tightly the friction clutch holds.

338. Q.—If a band- or strap-brake wears so that it will not grip the brake drum, how can it be adjusted?

A—There is usually an adjusting screw or rod connected to the band, so that it can be tightened as wear occurs until the band or lining is worn out. Then a new lining must be fastened in. Rivets are very commonly used for attaching the lining to the shoe. Copper harness rivets answer well.

339. Q.—How do you adjust an expansion brake for wear?

A.—An adjusting screw or bolt similar to that used for the band brake is generally provided for this purpose and used in a manner similar to that for band brake.

340. Q.—How would you adjust a pair of hub brakes which have no equalizing bar or other equalizing device?

A.—Lift the wheels clear of the floor and adjust as judgment dictates by tightening the band or shoe of an external brake and expanding the shoe of an internal brake. Then start the engine and apply the hub brakes. If one brake is tighter than the other it will stop the rotation of its wheel, while the other continues to move. By trial the shoes can be set so that they will hold both wheels equally well unless the brake mechanism is of a type which has the rod running back to one brake attached to or near the brake lever at one side of the car, while the other brake rod is operated by a shaft extending across the car and having a bell crank at the end. In such a case it is not possible to adjust the brakes so that they will hold both wheels with equal grips when the brake is applied with different degrees of force. In general, the best setting is that which grips the wheel farthest from the brake lever and allows the other to rotate when the brake is lightly applied, but holds the one next the lever with the hardest grip as the brake is put on more forcibly. When there is an equalizing bar or similar device it is only necessary to adjust until the shoe or band fully grips the drum or cylinder, with some allowance for wear, and frees itself when the brake is released.

341. Q.—How are brakes kept from overheating on long, heavy grades?

A.—By cooling with water dropped on the drum, or shoe, or both. The water is usually carried in a small tank for this purpose and turned on as needed. A small pipe carries it from the tank to the brake drum.

Clutch Troubles

342. Q.—If a leather-faced cone friction clutch suddenly seizes or bites when closed gradually, what would you do toward remedying it?

A.—If the leather is dry, put on an ounce or two of castor oil, or neat's-foot oil, distributing it carefully over the leather by allowing one part of the clutch to slip over the other; then fasten the clutch open and let it stand for ten or twelve hours.

If the leather is very oily, use some powder such as fuller's earth or chalk with all grit removed. Put it in the clutch to absorb the oil. It is sometimes advisable to clean the leather with gasoline before applying the powder. This can be done fairly well in some cases while the clutch is in place.

Never use resin. It will bite viciously after the car has been standing and will let the clutch slip when warmed up.

Get a new clutch leather.

343. Q.—If the clutch slips too much when the leather is in good condition, what is the remedy?

A.—Tighten the spring which holds it closed.

344. Q.—If a leather-faced clutch is allowed to slip excessively, what injury results to it?

A.—The leather becomes burned and charred by the frictional heat. The surface of the leather is thus made hard and glazed so that the clutch cannot be made to operate satisfactorily.

345. Q.—If a disk clutch, using metal-to-metal friction members intended to run in oil, slips excessively, what may be the cause?

A.—The lubricant may not be suitable or may have become thickened on account of the frictional heat.

The friction members may have become so much worn that those mounted in (or on) the same member of the clutch press against each other. This is the ordinary case of disks worn thin. The disks which engage frictionally are thus prevented from being pressed together sufficiently hard, although the clutch spring may be amply strong.

346. Q.—If a disk clutch, designed to run in oil, seizes and jerks hard when brought into engagement, what may be the cause?

A.—The spring may be too strong. There may not be enough lubricant in the clutch. The lubricant may be too thin, or made thin by frictional heat.

347. Q.—What remedy may improve the action of a disk clutch with metal friction surfaces if the clutch slips excessively and then seizes hard?

Clutch does not grip	How to cure it
(a) Leather face oily.	Wash with kerosene or gasoline and sprinkle fuller's earth when dry.
(b) Leather face charred.	Caused by overheating or slipping. Fit new leather.
(c) Leather face hard and does not press uniformly.	Take out clutch, turn level in lathe and apply castor oil.
(d) Clutch spring weak.	If tightening is no good, fit new spring.
(e) Clutch out of alignment.	Realign till shaft runs true.
(f) Sliding bearings are dry.	Wash with kerosene and apply oil.
(g) Leather worn and will not advance to a bearing.	Fit new leather.
(h) Clutch band broken.	If possible, re-rivet; if not, fit new band.
(i) Clutch lever bent.	Straighten same.
(j) Dog bent or worn.	Straighten, true-up or re-bush.
(k) Toggle with excessive lost motion.	Re-bush.
(l) Foot lever strikes deck.	Cut part of deck away.
(m) Take-up all in.	Take out and cut more thread on rod.
(n) Disc facings worn out.	Fit new discs.
(o) Discs adrift from keys.	Take clutch apart; refit discs; if keys are worn fit new ones.
(p) Cork inserts worn below surfaces.	Fit new cork inserts.
(q) Clutch cone worn.	Take out and true up in lathe.
(r) Wedge cut away.	Fit new wedge.
(s) Screw worn.	If adjustment is all in, fit new screw.
(t) Excessive oil.	Leather, wash with kerosene; metal, drain some oil or add kerosene.
(u) Dirt impediment.	Wash out with kerosene.
(v) Take-up backs off.	Improvise locking device.
(w) Engine or transmission out of alignment.	Re-align till shaft runs true.
(x) Spiral band too long.	Shorten and re-rivet holder.
(y) Affected by centrifugal force.	Mechanical fault; angle of cone insufficient or weak spring.
(z) Brakes either on or too tightly adjusted.	Loosen brakes.

A.—Clean out the clutch thoroughly with kerosene so as to cut baked and burned oil from the friction surfaces, then put in the proper kind of lubricant.

It may be necessary to take the clutch apart in order to clean the disks properly.

Valve Timing

348. Q.—How do you determine whether the valves are properly timed as to their opening and closing?

A.—In many engines the face of the flywheel has

Clutch sticks	How to cure it
(a) "Frozen" shaft.	Keep running and apply castor oil or graphite.
(b) Lack of lubrication.	If scored, take out and clean up.
(c) Congealed oil (cold weather).	Apply hot rags, run engine and let clutch slip.
(d) Sag in chassis frame.	Have it straightened and fit strengthening plate.
(e) Shaft twisted.	Straighten, if possible, or fit new one.
(f) Spring broken.	Requires new and stronger one.
(g) Disc deformed.	Straighten steel discs, but renew bronze.
(h) Broken motor or gearcase arm.	Have it welded, if possible.
(i) Deformed driving arm.	Straighten.
(j) Thickened leather or other facings of disc clutches.	Turn down leather face; true-up metal faces.
(k) Damage due to thrust.	Fit new thrust races; if possible, larger.
(l) Bent crankshaft.	Straighten shaft.
(m) Bent planetary shaft.	If caused by weakness, fit shaft of stronger metal.
(n) Deformed linkages.	If weak, fit stronger ones.
(o) Stuck dogs.	Soak in kerosene, dismantle and readjust; fit oiler.
(p) Worn screw.	Fit new one.
(q) Tight spiral band.	Slack off slightly.
(r) Dent in housing.	Hammer out carefully.
(s) Shifted motor.	Tighten up bolts and fit lock nuts or washers.
(t) Shifted transmissions.	Tighten up bolts and fit lock nuts or washers.
(u) Dirt (foreign substances).	Wash out with kerosene.
(v) Bent pedal.	Straighten, and if weak, reinforce.
(w) Insecure locking devices.	Fit one of better design that does lock.
(x) Centrifugal force trouble.	Faulty design up to makers under guarantee.
(y) Torn leather facings of leather clutch.	Fit new leather.
(z) Worn facings, changing the distance of travel.	Fit new facings.

slight grooves cut partly across it for this purpose. When one of them comes to a certain position, as opposite a stationary reference mark or finger (or to the top of the wheel when there is no other reference mark), the valve to which the groove refers should begin either to rise from its seat, or just complete closing down on it.

In a single-cylinder engine with automatic inlet:

Insert a piece of tissue paper or other very thin material between the end of the valve-stem and the part that lifts it (thick paper will not answer). Rotate the crankshaft slowly until the piston has gone about three-quarters of the impulse stroke. Notice the groove nearest the reference mark (or top of flywheel) and continue turning very slowly, at the same time moving the paper under the valve stem. Stop turning as soon as the paper is held tight so as to indicate that the cam is just beginning to lift the exhaust valve. The flywheel grove should register with the reference mark just as the paper becomes tight. If the groove has not reached the reference mark when the paper tightens, then the valve opens too early; if it has passed it, the valve opens too late.

The shaft can be turned very slowly by pulling lightly on the crank with one hand and tapping it with the other at the same time. Now turn the flywheel about half a revolution in the direction that the engine rotates when running, until the other groove is near the reference mark. Then turn slowly as before, and pull lightly on the paper. Stop turning as soon as it becomes loose. The second groove should now coincide with the reference mark. If the paper loosens before the groove registers, the valve closes too early; if it does not loosen till after the reference mark, it closes too late.

If the flywheel is not marked to indicate the positions of opening and closing of the valves, then the dead centers of the engine must be found.

To find the dead centers it is necessary to locate the piston in its positions during two strokes. If there

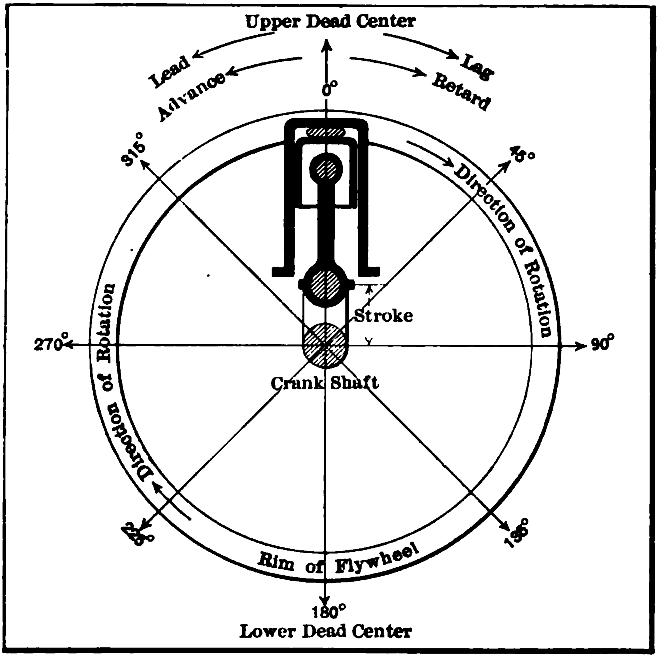


FIG. 72—DIAGRAMMATIC SCHEME, SHOWING THE RELATIONS OF THE MARKINGS ON THE FLYWHEEL OF A MOTOR WITH RESPECT TO THE POSITION OF THE PISTON

The timing may be stated as follows: Exhaust valve closes say 5 degrees (lag) past center; the exhaust valve opens say 40 degrees (lead) before center; the inlet valve opens 10 degrees (lag) past center; the inlet valve closes 30 degrees (lag) past center, and the spark is made approximately 35 degrees (lead) before center. The above timing is standard with some of the makers of motors, and while it may be varied quite a little, this is equal to saying that it is a safe timing to employ.

is a petcock or other opening through the combustion chamber over the piston, this can be done by the aid of a wire inserted through the open petcock and resting against the piston, provided the latter has a flat top. If it is not possible to place anything against the end of the piston to determine its position, it may be necessary to remove the crank-case covering and to bring the piston into the positions necessary by measuring its distance from the end of the cylinder bore. A stick, as a rule, or a stiff wire notched or cut to length may be used for this purpose, according to the conditions.

When there is such an opening, put the wire in place, with its end against the piston, and turn the engine over once to note roughly the positions of the wire at the two ends of the stroke. Then place a mark on the wire which will be even with the top of the petcock when the piston is about one-third of the way from the head of the cylinder (the cylinder head is at the combustion chamber end). It is not necessary to determine this position of the piston with any degree of accuracy, but only by judgment. Then turn the crankshaft until the mark on the wire registers as the piston is moving toward the cylinder head. Place a mark across the face of the flywheel with a scratch awl opposite some stationary part on which a reference mark is made. Then turn the shaft to move the piston up to the end of the stroke and down again until the mark on the wire registers with the top of the petcock. Now make another mark across the face of the flywheel to coincide with the reference mark. Divide the distance between the two marks on the face of the flywheel into halves. This can be done by measuring along the face of the flywheel with a tape or string and halving the distance thus obtained.

A third mark drawn across the face of the flywheel midway between the other two will, when brought to register with the reference mark, place the engine on its dead center next to the head of the cylinder.

The dead center for the crank end of the stroke can be found in a similar manner by placing another mark on the wire so that when it is at the top of the petcock the piston will be roughly one-third of a stroke from the crank end of the cylinder. The two dead-center marks thus obtained should be diametrically opposite. This can be checked by measuring the distance between them around the periphery of the flywheel on both sides of the marks. These distances should agree, otherwise one or both marks are incorrectly located.

The location of the marks on the flywheel to indicate the opening and closing of the valves can now be determined in accordance with the judgment as to when the valves should open and close. This differs considerably in different makes of engines. In some makes the exhaust valve opens just before the crank reaches dead center, and in others as much as 40 degrees (1-9th of a revolution) before the piston reaches dead center. In some it closes exactly at the head dead center, while in others it remains open until 15 degrees or more after the crank passes the head dead center. (There are 360 degrees in a complete circle.)

The inlet valve, when mechanically operated, opens at or somewhere near the time the exhaust closes. In some motors the inlet opens 10 degrees or more before the exhaust valve closes, in others the inlet opens after the exhaust closes. The inlet closes, in some cases, on the crank dead center, in others as much as 15 degrees later (1-24th of a revolution).

The area of the ports, the speed at which the motor is intended to run, and the form of cam used all enter into the selection of time that the valves shall open and close, as determined by the designer.

If the exhaust valve is to open 30 degrees of rotation of the crank before dead center, then measure from the crank dead-center mark on the flywheel 1-12th of the circumference of the wheel in the direction that the wheel rotates, and mark across the face of the flywheel for the opening of the exhaust. If it is to close five degrees after dead center, then measure, in a direction opposite the rotation of the flywheel, 5-360 = 1-72d of the circumference of the flywheel from the head dead-center mark. Then, if the inlet is to open five degrees after the exhaust closes, measure another 1-72d of the circumference further in the same direction, and mark across the face of the flywheel for the opening of the inlet valve. If the inlet is to close five degrees after crank center, measure 1-72d of the circumference from the crank dead-center mark in a direction opposite the rotation of the flywheel. It is well to designate each of these marks in some manner at the time of locating them in order to avoid confusion.

The following notation is convenient:

H.C. = head center.
C.C. = crank center.
Ex. op. = exhaust opens.
Ex. cl. = exhaust closes.
In. op. = inlet opens.
In. cl. = inlet closes.

The valves can now be tested for the actual time of opening and closing, as already given. If one does not begin and complete closing at the proper time, it may be due to a cam or its follower being worn, or wear on the end of the valve stem or its lifter, or possibly the valve stem extending too far toward the lifter after the valve has been ground in. The remedy for too long a valve stem is to cut or grind it off; too short a stem may be lengthened by placing a thimble-shaped piece of metal over the end, or by cutting it off, boring a hole in the end and having a cap made with a pin to fit tightly into the hole. Many engines have screw adjustments on the lifter. If the cams are worn, new ones will be necessary, or they may be built up by brazing a piece of steel on them.

When the cam is pinned on its shaft, it may become loose so as to make a slight rotation about the latter. This will affect the time of opening and closing of the valve. The duration of opening will be lessened.

In a two-cylinder opposed engine the marks indicating the opening and closing of the valves will be identical for both cylinders, and therefore need to be located for only one cylinder.

In a four-cylinder engine each set of marks will answer for the two cylinders whose pistons move in unison when all the cylinders are on the same side of the shaft, as in a vertical engine. There will be another set of marks located at the same distances from the dead-center marks, but on the opposite sides of the flywheel for the other two cylinders.

The following marking is frequently found on the flywheels of four-cylinder motors of the four-cycle type. The consecutive order is not as here given, however:

Ex. op. 1 & 4.	In. op. 1 & 4.
Ex. op. 2 & 3.	In. op. 2 & 3.
Ex. cl. 1 & 4.	In. cl. 1 & 4.
Ex. cl. 2 & 3.	In. cl. 2 & 3.

349. Q.—Why is it better, in most cases, to time the valves while the motor is hot from running?

A.—The expansion of the metal of the motor by the heat, especially the exhaust valve stem, generally affects the timing to some extent. It is therefore better to time while the motor is hot.

In some motors the expansion of the exhaust valve stem is great enough to prevent the valve from completely closing if the stem is of such a length that there is only a very slight space between it and the valve lifter when the motor is cold and the valve closed. In other motors this effect is so slight as not to be noticeable.

Grinding in a valve brings the stem nearer to the valve-lifter. They should be examined to see if there is still sufficient space between them after the valve is ground in.

350. Q.—Before removing the camshaft when dismantling an engine, what precautions should be taken to facilitate replacing it properly?

A.—A tooth on the camshaft gear and the corresponding tooth space in its mate should be marked so that they can be placed together again. Such marking is placed on the gears by many manufacturers. A center-punch mark or a notch made by a file is often used.

351. Q.—How would you replace a camshaft that has no marking to indicate its position?

A.—Turn the crankshaft to the position for the opening (or closing) of one of the valves. This can be done by the aid of the marks on the flywheel (Q. 348). Then put the camshaft in place, with the cam in position for beginning to open the valve (or for just completing its closing). It is not always possible to do this at the first trial. In such a case shift the camshaft gear one tooth in the direction that will correct the error. Test the timing in the regular manner.

The setting for one cylinder answers for all in a multi-cylinder engine when all the cams are in their proper position on the camshaft.

352. Q.—What effect has wear on the end of the valve stem, the valve-lifter, or on the cam upon the time of opening and closing of the valve?

A.—It causes it to open too late and close too early. The duration of the opening is decreased. This reduces the power of the engine.

353. Q.—What effect has a loose cam on the time of opening and closing of the valves?

A.—The same as in the previous question.

Ignition Tests, Adjustments and Troubles

354. Q.—What voltage will answer for the primary of a spark-coil?

A.—Two classes of coils are found on the market, one making about four volts, and the other six or seven. It is well to find from the maker what voltage should be used. It should be marked on the box.

355. Q.—How do you test a dry-cell battery to determine whether it will give enough current to make a strong ignition spark?

A.—Measure both voltage and current (amperes) with a voltmeter and ammeter. The two instruments are frequently combined in one. To measure the voltage, place the terminals of the voltmeter on the battery terminals. The voltage will then be shown by the reading on the graduated scale of the voltmeter, provided care has been taken to bring the terminals of the battery and the instrument into good metallic contact. The battery will not be damaged by keeping the voltmeter on it. The terminals should be clean and held firmly together so as to make good metallic contact. Otherwise the voltmeter will not indicate the full voltage.

To measure the amperes, hold one terminal of the ammeter against one terminal of the battery (or fasten the terminals together) and press the other ammeter terminal against the other battery terminal, keeping them together only long enough to get the reading of the ammeter. A second or two should be long enough to get the ampere reading with a suitable ammeter. The ammeter should never be left connected to the battery longer than is necessary for the needle to come to rest, or nearly to rest; leaving the ammeter connected to the battery for a considerable time causes rapid exhaustion of the battery.

356. Q.—What amperage should a good dry battery cell show when tested with an ammeter?

A.—Several good dry cells of standard automobile ignition size give from twelve to fifteen amperes, or even more, when tested with a low-resistance ammeter such as is ordinarily used for this purpose.

357. Q.—Is the voltage test of a dry battery cell a completely satisfactory one?

A.—No. A dry battery may show the voltage of a good one and yet be practically exhausted. The test has some use, since if the voltage is not up to the standard, the cell is not good.

358. Q.—If the amperage test of a dry battery cell shows it nearly or quite up to the standard, is it a sure indication that the battery is good?

A.—No. A cell, especially one that has been standing idle for several hours, may show nearly or quite the full amperage and yet be nearly exhausted. Such a cell when put into service will operate the ignition satisfactorily for a short time, then fail to deliver enough current for satisfactory operation.

359. Q.—How can the voltage of a battery be measured while the battery is in operation?

A.—In the same manner as when it is not connected to any electric circuit. It is not necessary to open the circuit to measure the voltage.

The voltage between any two points of the battery circuit can be measured in the same way while the ignition system is operating.

360. Q.—How can the amperage of a battery in operation be measured?

A.—By opening the battery circuit before operation begins and inserting the ammeter in the opening so that the current will flow through the ammeter when operation begins. Or the ammeter can be attached to any two points of the circuit, between which points there is

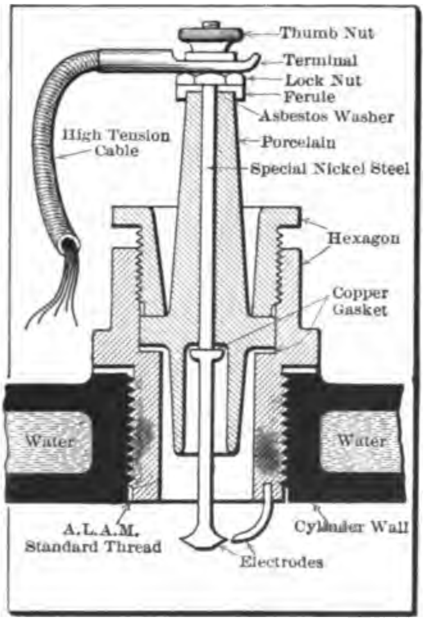


FIG. 73—SECTION OF A SPARK PLUG, SHOWING THE RELATIONS OF THE COMPONENTS

no apparatus, while the system is operating, and then the circuit opened between the two points of attachment. The current will then flow through the ammeter, so that its strength can be read. (See Q. 95.)

It is ordinarily necessary to use a milli-ammeter for measuring the battery current of an automobile ignition system, since the amount of current is too small to be read on an instrument that will not measure small fractions of an ampere.

361. Q.—What effect has a reversed cell in a battery?

A.—Practically the same as removing two cells from the battery. The reversed cell opposes and counteracts the action of one of the other cells. The battery with the reversed cell will not give out quite as large a current as it would if two of its cells were removed instead of one being reversed. This is because the battery with the reversed cell has more internal resistance than it would have with the two cells removed.

362. Q.—How much battery current flows through an ignition system?

A.—The amount varies in different systems, from less than half an ampere up to two amperes or more, as indicated by the ammeter. The instrument gives the reading of the average amount of current, not of the maximum current.

A four-cylinder motor takes four times as much current for its four cylinders as one cylinder takes, as shown by the ammeter. In the same manner, a single-cylinder takes only one-fourth as much current as a four-cylinder one, other conditions being equal.

In some of the best ignition systems a four-cylinder motor operates on but slightly more than half an ampere (as shown by the ammeter).

The variation of the amount of current used in different ignition systems is chiefly due to the kinds of timers and induction coils used. A timer that keeps the circuit closed only long enough at all motor speeds to produce the spark is, of course, more economical of electricity than one which keeps the circuit closed just long enough at the highest motor speed, but much longer than necessary at slow speed.

363. Q.—When two dry-cell batteries are carried for one motor, what is the most economical way of using them?

A.—If the battery supplies current several hours daily, as an average, it is more economical to use the two batteries in parallel—both batteries operating at the same time. Tests show that two batteries will render a greater amount of service if used in parallel when the demand for current extends over several hours daily than when only one battery is used at a time.

There is a certain advantage, however, in using only one of the batteries at a time.

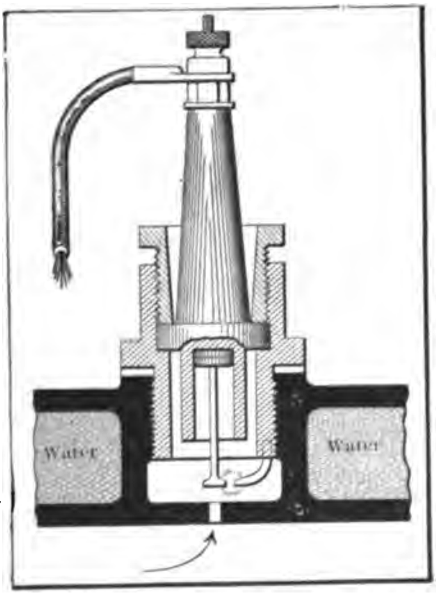


FIG. 74—SECTION OF A DEFECTIVE SPARK PLUG INDICATING ABSENCE OF PACKING UNDER THE GLAND—PLUG WILL LEAK COMPRESSION

By using them in this manner, one of the batteries can be used most of the time until it becomes exhausted. The other battery can then be put into service by switching it into the circuit while the motor is running, the exhausted one being put out of circuit at the same time. The exhausted battery can be replaced by a new one when convenient, and the new one held in reserve till its mate becomes exhausted.

Keeping one of the batteries in reserve affords a means of making a partial test of the ignition system when the ignition is faulty. By switching in the reserve battery it can easily be determined whether the battery is the cause of unsatisfactory ignition. A search for ignition troubles can thus be obviated sometimes.

364. Q.—If both batteries are run down too far to give ignition, how can they be arranged to work a while longer?

A.—Connect them (the batteries, not the cells) in parallel first (see Q. 101). If they fail again, then connect all the cells in series (see Q. 86).

365. Q.—How can an exhausted dry cell be temporarily revived?

A.—By putting water into the cell. Water with sal ammoniac dissolved in it is better for this purpose than plain water.

The water can be put in through a hole made in the sealing compound at the top of the cell. Another way is to jab holes through the zinc can (and the paper covering), then place the cell in water or sal ammoniac solution, so that it will absorb the liquid (see Q. 367).

A cell revived in the above manner has but very little life. The process is hardly worth while except in case of necessity.

366. Q.—Do dry batteries deteriorate and run down when not in use?

A.—Yes. Sometimes very rapidly in the usual type that is moist inside when sent out by the manufacturer. Poor grades of cells sometimes become nearly exhausted within a month, although not used. A high grade of cell will sometimes still be in good condition after a year or more of idleness.

The type of dry cell that is sent out actually dry by the manufacturer, and must be moistened by pouring water into it (through an opening in the top of the carbon which is kept corked at other times) before it will deliver current, will apparently keep in good condition for a long time before it is moistened.

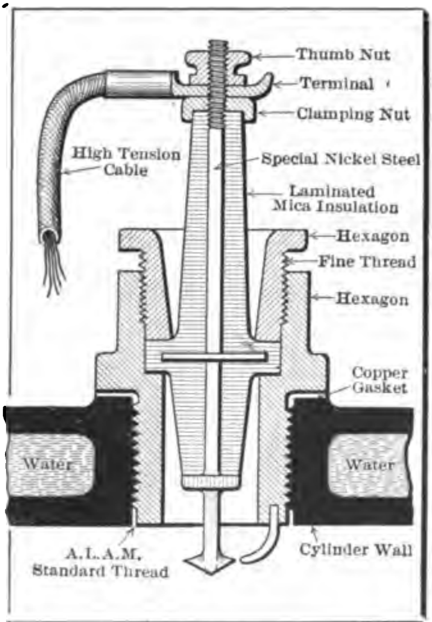


FIG. 75—SECTION OF A SPARK PLUG, SHOWING ONE OF SEVERAL WAYS FOR UTILIZING MICA INSULATION SO THAT IT WILL STAND UNDER COMPRESSION

367. Q.—In placing cells in a position for a battery, what care should be taken?

A.—The binding post or zinc of one cell should not touch the metal of another cell. The paper cover prevents the zincs from touching. If the cells are likely to become wet, place pieces of rubber or window glass between them. The cells should be firmly held in place in the battery box to prevent shaking and loosening of wire connections.

368. Q.—What are some of the means by which a properly installed battery in service may become rapidly exhausted?

A.—By leaving the battery circuit switch closed after the car is stopped in some types of ignition systems. The motor may sometimes stop in such a position as to leave the timer or interrupter contacts together, thus keeping the circuit closed if the switch is not open. When there is no trembler on the induction coil, there is nothing to indicate that the circuit is closed.

A metallic tool or a piece of bare wire lying on or against the exposed ends of the cells is apt to short-circuit some of them, which, of course, exhausts them rapidly.

Care should be observed to keep the exposed parts of the cells free from all tools, wires, oil cans and other conductors of electricity.

369. Q.—What is the voltage of a storage battery such as is used for ignition?

A.—The "lead accumulator," or storage battery with lead and oxide of lead elements, with three series-connected cells, has a pressure of about 6.5 volts on open circuit—that is, when not delivering current. Each of the cells has about 2.2 volts.

The voltage drops as soon as the battery begins to deliver current and continues to decrease slowly as the battery becomes discharged. When the voltage has dropped as low as 1.9 volts the battery should not be used much longer before recharging. The voltage drop during discharge is greater the more rapid the rate of discharge—that is, the voltage is lower when discharging rapidly than when discharging slowly.

The instructions of the manufacturer should be followed in preference to the above general statements.

370. Q.—How is the capacity of a storage battery stated?

A.—In ampere-hours. A 60-ampere-hour battery will deliver current at the rate of 1 ampere for 60 hours, or two amperes for $60 \div 2 = 30$ hours, or four amperes for $60 \div 4 = 15$ hours.

371. Q.—How can a storage battery be charged?

A.—By connecting it to a suitable source of direct (not alternating) current supply, first removing the rubber stoppers from the top of the battery in order to allow gas to escape while charging.

The positive (+) side of the battery must be connected to the positive (+) side of the charging circuit, and the negative (—) side

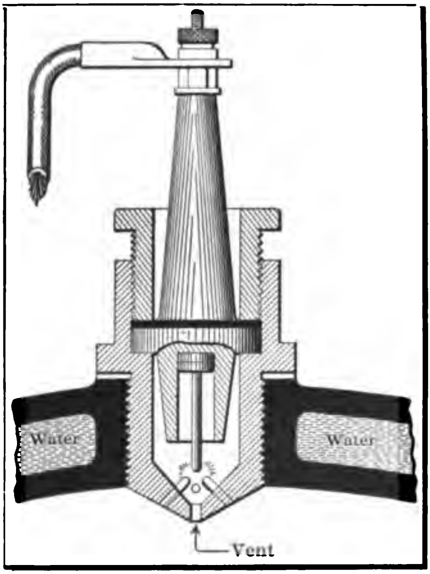


FIG. 76—SECTION OF A SPARK PLUG, SHOWING THE PACKING UNDER THE GLAND, BUT NO PACKING UNDER THE ENLARGEMENT OF THE PORCELAIN—THIS IS LIKELY TO RESULT IN A CRACKED PORCELAIN

of the battery to the negative (—) side of the charging circuit (see Q. 372). The charging current must be regulated by suitable means, as by resistance in the charging circuit.

A direct-current electric lighting system can be utilized for charging a storage battery. The current can be regulated by inserting incandescent lamps in series with the storage battery. The lamps should be in parallel (multiple) with each other, and as many used as will give the requisite amount of current. Thus, if the charging current is to be 6 amperes and each lamp takes 6-10 of an ampere, ten lamps in parallel with each other will be required. Seven lamps will give 4.2 amperes. If the battery were connected to the lighting circuit without any lamps to regulate the current, the comparatively high voltage of the lighting circuit would send so much current through the battery as to injure it seriously, perhaps irreparably.

The pressure of the charging circuit must always be somewhat higher than that of the battery on open circuit, in order to be able to send current through the battery. At least two volts more than that of the battery is required for the ordinary storage battery.

Alternating current can be rectified into pulsating direct current, which is suitable for charging a storage battery. The mercury arc rectifier is generally used for this purpose when charging storage batteries for ignition uses. These rectifiers are usually in the form of a comparatively small panel, on which are mounted the mercury tube and the instruments required for measuring and regulating the current.

372. Q.—By what means can the positive and negative sides of a direct-current circuit be determined?

A.—By connecting wires to the two sides of the circuit and immersing their ends in slightly acidulated water. Bubbles will be given off at the end of the negative (—) wire. A small quantity of sulphuric acid (the dilute acid) put into a glass of water is suitable. It is safer to put the water in a non-conductive vessel than one of metal, on account of the possibility of short-circuiting if a metal vessel is used. The immersed ends of the wires should be kept well apart at first, and then brought nearer together gradually till the bubbles are given off rapidly. The bare ends of the wires should not be allowed to touch each other, since this would short-circuit them.

Small glass tubes containing a liquid, suitably mounted and provided with terminals, can be obtained for testing the circuit. The passage of current through the instruments gives color to the liquid at one of the inside terminals. Suitable resistance should be provided when testing a service circuit. By connecting the instrument first to a storage battery and then to the service circuit, the positive and nega-

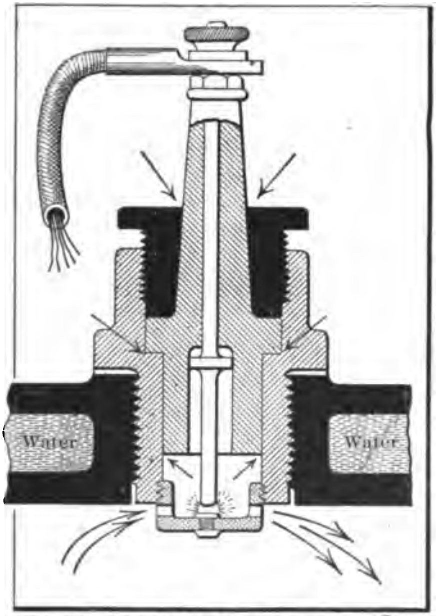


FIG. 77—SECTION OF A SPARK PLUG, SHOWING THE PORCELAIN IN CONTACT WITH THE METAL WALL—THIS WILL CAUSE THE PLUG TO FAIL ELECTRICALLY; INSULATION TOO LOW

tive sides of the latter can be determined. The side of the service circuit which colors the liquid should be connected to the side of the battery which acts in the same manner.

Some voltmeters have their terminals marked for positive and negative, and indicate voltage only when connected into a circuit accordingly. They can be used for determining the positive and negative sides of the circuit.

373. Q.—How large a current may be used to charge a storage battery?

A.—It depends upon the ampere-hour capacity of the battery, and also upon how large a current the battery can deliver without injury to itself.

A 60-ampere-hour ignition battery of three cells ordinarily should not be charged at a greater rate than 12 amperes. This rate should be decreased as soon as the battery begins to give off gas rapidly, then it is

Troubles of Battery Ignition Systems

(a) Run down battery.
(b) Broken plug.
(c) Dirty plug.
(d) Points of plug too far apart.
(e) Points too close.
(f) Bad earth wire.
(g) Short-circuited wire.
(h) Short circuit in coil.
(i) Burnt condenser.
(j) Short circuit in timer.
(k) Bitted contacts of platinum trembler blades.
(l) Time roller jumping contacts.
(m) Weak spring on timer.
(n) Loose connections.
(o) Chafed wire.
(p) Sulphated terminal of battery.
(q) Battery will not hold charge.
(r) Short circuit between coil and plug.
(s) Water or damp in coil.
(t) Faulty windings.
(u) Trembler contacts give off metal one to the other.
(v) Faulty switch.
(w) Loose platinum points.
(x) Unusual buzz inside coil.
(y) Wrong adjustment of platinum contact points.
(z) Broken terminal on coil.

advisable to cut the current down to 5 amperes or somewhat less, regulating it so as to avoid excessive bubbling. If the battery is completely discharged before charging begins then the total input must be somewhat greater (ten per cent. or so) than the ampere-hour capacity of the battery when discharging.

General instruction such as the above can not be safely applied to all makes of lead plate storage batteries, or to all designs of those made by one manufacturer who sends out batteries for different uses. It is advisable to follow the manufacturer's instructions when possible.

Otherwise be very careful not to start too large a current through the battery at first. It is always safe to err on the other side to any extent, provided the current is started in the right direction.

How to Fix Battery Ignition Troubles

(a) Charge four-volt batteries to 4.3 minimum.
(b) Fit new plug or if porcelain broken fit new one.
(c) Clean with gasoline and tooth brush.
(d) Set to between 1-32 inch and 1-16 inch.
(e) Open slightly with blade of penknife.
(f) Clean around both and scrape wires.
(g) Replace wire by new piece at once.
(h) Send coil to makers.
(i) Caused by batteries of too high voltage. Return to maker.
(j) Clean out pitted oil and refill with fresh.
(k) Clean with fine file, perfectly level.
(l) Due to worn fiber; take off timer and have it turned true.
(m) Fit new and stronger spring or shorten.
(n) Go over all connections once a month and fit lock nuts.
(o) Fit new wire and secure same with staple.
(p) Clean; finish with fine emery paper; when the battery is not in use cover terminals with vaseline.
(q) Plates buckled or loose paste causing short circuit; test specific gravity.
(r) Poor insulation or broken wire inside; fit new wire.
(s) Put coil wrapped in flannel in slow oven; more a job for coil expert.
(t) Beyond owner's control; return to makers.
(u) Voltage too high for coil; change poles of battery.
(v) See if it insulates properly; look for crack in vulcanite.
(w) Have them resoldered with silver.
(x) Probably due to faulty insulation of the windings.
(y) Adjust with least clearance to give a high-pitched tone.
(z) Buy a new coil.

374. Q.—In what manner does the voltage of a storage battery vary while it is being charged?

A.—The voltage rises above that on open circuit as soon as the charging current starts, and continues rising gradually until charging is completed. It drops immediately to that of the battery on open circuit as soon as the charging circuit is opened.

375. Q.—How can it be determined that the charging of a storage battery is completed?

A.—By measuring the voltage. The voltage of each cell is about 2.6 volts when charging is complete and the charging current is still flowing through the battery, that is about 7.8 volts for a 3-cell battery. This refers to a lead storage battery of the usual type while using a maximum safe current rate of charging during the latter part of the operation, the voltage being measured while the charging current is flowing.

376. Q.—Are voltage measurements of a storage battery while it is idle reliable as indicating the condition of the battery?

A.—No. Except to show whether the battery is in very bad condition.

377. Q.—Is it safe to connect an ammeter across the terminals of a storage battery?

A.—No. The resistance of the ammeter is so small as to practically short-circuit the battery and thus injure it. The ammeter is also apt to be injured by burning out.

378. Q.—How much liquid electrolyte should each cell of a storage battery have in it?

A.—Enough to fully cover the tops of the electrodes (plates). If some of the electrolyte is spilled during charging, it should be replaced before the battery is put into use.

379. Q.—How can you determine whether the electrolyte in the battery has the proper acidity?

A.—By measuring the density (specific gravity) with a hydrometer. Some of the electrolyte can be removed from the battery for this purpose. A hydrometer syringe with a glass body in which a small hydrometer is enclosed is convenient for this purpose.

380. Q.—What should be the density of the electrolyte in a storage battery?

A.—At the temperature of an ordinary living room its density should be from 1.27 to 1.28 when the battery is fully charged. The density of the electrolyte gradually decreases as the battery is discharged until it reaches a value of 1.2 when the battery is fully discharged. If the electrolyte has become warm during the charging or discharging of the battery, its specific gravity will be somewhat lower than the values just given. The decrease of specific gravity is so slight, however, for the heat increase

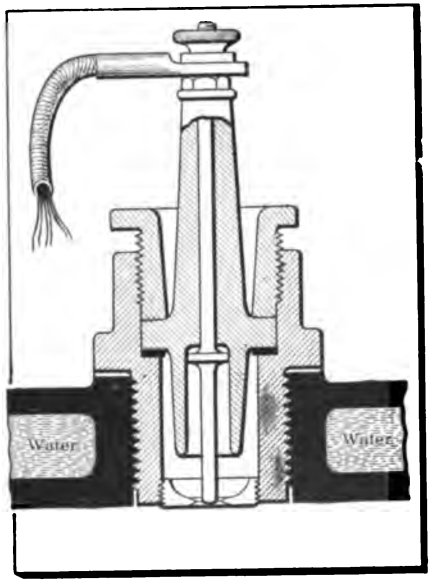


FIG. 78—SECTION OF A SPARK PLUG, SHOWING THE PROPER PLACING OF THE PACKING UNDER THE PORCELAIN AND CLEARANCE BETWEEN IT AND THE METAL PARTS

that ordinarily occurs in an ignition battery as to be hardly noticeable on a hydrometer such as is commonly used for battery test.

A density of 1.2 corresponds to 25.3 on the Baume Hydrometer. The 33 degree mark on the hydrometer represents a density between 1.27 and 1.28.

381. Q.—New electroylte for a storage battery should have what density?

A.—If it is to be put into a battery while the latter is fully discharged it should have density of 1.2; electrolyte for putting into a fully charged battery should have a specific gravity from 1.27 to 1.28.

382. Q.—If the electrolyte in a storage battery has become too dense, how can it be remedied?

A.—By putting in pure water. Distilled water is best. Pure rain water will answer fairly well in case of necessity.

383. Q.—How can electrolyte of the proper density be made?

A.—By mixing together pure sulphuric acid (1.84 specific gravity) and distilled water, in the proportion of one part acid to three parts water for 1,275 specific gravity. The acid should be poured very slowly into the water, stirring with a piece of wood. Under no conditions should the water be poured into the acid. Do not use a metal vessel for mixing.

384. Q.—What precaution should be taken to obviate accidental short-circuiting of a storage battery?

A.—Never allow bare wire, metal tools, oil cans, etc., to remain near it, especially if the battery has bare metal terminals.

385. Q.—What are some of the troubles that occur in jump-spark igniters (spark-plugs)?

A.—Carbon and grease collect on the insulation and, in mica plugs, between the disks of mica, thus causing a short circuit, which prevents sparking between the points inside the cylinder. The porcelain cracks. The spark points may come too close together or be too far apart. The spark points may fuse and burn with magneto ignition. The spark-gap should be about 1-32d of an inch wide for battery ignition and about 1-64th to 1-50th of an inch for magneto ignition.

The remedy for a dirty spark plug is to clean it with gasoline and a stiff bristle brush. A piece of cloth will sometimes answer. Do not scrape with a knife. There is no remedy for a broken porcelain, or loose disks in a mica plug. They must be replaced by new parts or a new plug. Extra plugs should always be carried to meet such troubles.

The metal beads which sometimes form at the spark points in a magneto ignition system can be filed off or broken off with some hard-pointed instrument. The metal (points) should be filed smooth after the points are broken off.

386. Q.—How is the "auxiliary spark-gap" used to help out a defective spark-plug?

A.—A simple method of doing this is to use a fiber false terminal at the spark-plug and connect the wire to it so that the shortest distance between the end of the wire and the binding screw of the spark-plug is about 1-16th of an inch. The spark will then have to jump from the wire across this auxiliary-gap in order to pass between the spark points inside the cylinder.

387. Q.—What may cause an intermittent, or swinging, short circuit?

A.—A wire from which the insulation has become worn off, and which is free to swing so as to make "ground" connection with some metal part of the car, or electric connection with some other part of the circuits.

388. Q.—What is the proper adjustment of the trembler of a spark-coil?

A.—That which requires the least amount of current for satisfactory operation of the ignition system.

389. Q.—How can the trembler of a spark-coil be adjusted?

A.—By means of a screw for that purpose, which. when moved to make adjustment, varies the distance that the trembler can move away from the magnetic core of the coil. The rate of vibration of the trembler is changed by moving the adjusting screw. Some trembler coils are provided with another adjusting screw which can be moved to change the tension of the trembler spring, and consequently the rate of vibration of the trembler.

The only really satisfactory way of determining when the trembler (or the tremblers of a set of spark-coils) is properly adjusted is to put an ammeter (milli-ammeter) in the primary circuit and make the adjustments, while the motor is running, until the current reading of the ammeter is as small as possible to get it with satisfactory ignition. When all of the spark-coils of a multi-cylinder motor have the same kind and size of tremblers, as is usually the case, the tremblers should be adjusted so that all will give the same sound, indicating the rate of vibration.

390. Q.—What troubles may occur to a spark-coil? How may they be remedied?

A.—Dirt may get between the contact points at the trembler and prevent their coming together so as to close the circuit. It can be removed with a piece of paper, or fine emery cloth, inserted between the points and then drawn out while the points are pressed toward each other; or it can be scraped off with a knife. Clean the coil carefully to remove all dirt from the neighborhood of the trembler.

The contact points may become fused so as to stick together, or burned so as not to make metallic contact. The points should be smoothed down with a very smooth (fine cut) file. It is generally necessary to remove the trembler in order to do this. In the absence of a file, a piece of emery cloth answers fairly well if wrapped around a flat stick.

The trembler spring may become bent by accident so that the trembler will not operate correctly, or at all. Straighten the spring or readjust the adjusting screws.

The contact points may become loose in their fastenings. The vibrator may rub against some part of the mechanism. Water may get between the contact points and prevent the breaking of the circuit.

Loose connection of the wires at the binding posts on the outside of the box may cause trouble and should be tightened. Other troubles are generally not easily repaired, although a loose connection or broken wire inside the outer box may be soldered.

Other troubles, which seldom occur, may be failure of the insulation inside the coil, or a broken wire. Such faults can be repaired satisfactorily only by the manufacturer of such apparatus.

391. Q.—If large sparks show at the trembler contacts, and it is impossible to prevent them by adjusting the trembler, what is the probable cause?

A.—The battery may be too powerful. Try one of lower voltage, unless it is known that the coil has operated right with one of the same voltage as that in use.

The condenser in the coil box may be defective. A condenser whose insulation is defective (broken down) to any great extent will always cause excessive sparking at the contact points.

The insulation of the primary winding may be defective.

The coil should be replaced by a new one or sent to the manufacturer for examination and the necessary repairs.

392. Q.—What troubles may sometimes develop in a timer?

A.—The springs for bringing the parts in contact may become weak or broken; the parts may wear away so as not to close the circuit; dirt may get between the contact parts; wear may allow metal parts to come into contact that should not, and thus close the circuit at the wrong time; the rotor may get loose on the shaft and slip around so as to alter the time of closing the circuit.

393. Q.—In putting a new timer in place, or replacing an old one that has become loose, how would you set it in the correct position?

A.—Remove the spark-plugs or disconnect the igniter wires, open the petcocks if the spark-plugs are not removed, turn the crankshaft till the dead-center position is reached. Select the cylinder whose piston is ready to start on its impulse stroke, and set the timer as follows according to that piston:

Set the spark-control lever slightly in advance of its position for latest spark. If the rotor of the timer is loose, or can be loosened, on its shaft, then turn the rotor on its shaft, in the direction that it rotates when the motor is running, until it just closes the circuit for the cylinder with regard to which the crankshaft was set; secure the rotor in position. If the timer rotor cannot be turned on its shaft, then, in order to set it in position to just close the circuit, it can be turned to the desired position by bringing the driving gears into mesh to suit, or by such other means as the design permits.

Move the spark-control lever to the position for late ignition, fasten the spark-plug in place, connecting the wiring and start the motor.

If the motor speed is too high when running idle (when the car is standing still), with the throttle closed as far as possible to still keep the motor going, and the ignition set as late as possible, then reset the rotor of the timer for later spark by turning it slightly in the direction opposite its rotation; or the lever and rods of the spark-control may be adjusted to set the rocker of the timer further around in the direction of rotation of the timer.

For make-and-break ignition:

The method is practically as given above for setting the rotor. The igniter camshaft is the part to be adjusted, or, if the igniter cams are on the same shaft that also carries the valve cams, the igniter cams must be rotated to the proper position on the shaft, as above.

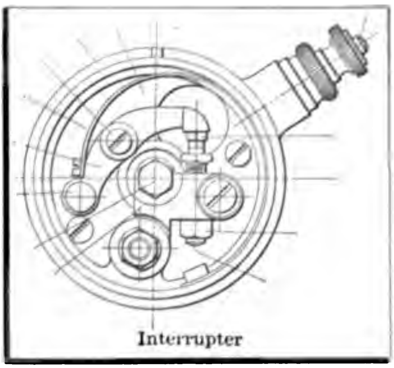


FIG. 79—LOOKING AT AN INTERRUPTER WITH THE COVER OFF, SHOWING THE ROLLER CONTACT MEMBER ON THE END OF THE SPRING-CONTROLLED FINGER

394. Q.—Is the direction of rotation of a magneto with an interrupter (primary circuit-breaker) material?

A.—Most magnetos of this kind are intended to run in one direction only, especially one that also has a high-tension distributer. Probably all of them will rotate in the opposite direction without injury, but will not operate satisfactorily to give a spark when rotating backward. It is necessary, as a matter of safety, to have the magneto so made as to rotate in both directions, since the motor sometimes is turned in the reverse direction a revolution or two, as when it kicks backward.

395. Q.—In what position should a shuttle-wound armature be when the interrupter points begin to separate?

A.—When the rotation of the armature is clockwise, the interrupter points should begin to separate just as the armature core is passing through the position shown in Fig. 15. If the rotation of the armature is counter-clockwise, then the position of the armature should be as shown in Fig. 16. The direction of rotation is indicated by the arrow on the armature core in each figure.

In a magneto whose magnets, pole-pieces and interrupter housing (casing) all rock together when advancing or retarding the spark (ignition), the space **A** between the edge of the armature core and the lip (edge) of the pole, should be about 1-16th of an inch. This space is not the same for all magnetos, however. In the more usual forms of magnetos in which the ignition is advanced or retarded by moving a rocker arm which is connected to the interrupter casing only, but in which the magnets and poles are not rocked, the space **A** should generally be somewhat more than 1-16th of an inch at the instant the interrupter contacts begin to separate when the rocker for advancing and retarding ignition is at or near the middle of the arc through which it rocks—that is, when it is set for ignition midway between the most advanced and most retarded.

396. Q.—What should be the position of the high-tension distributer rotor at the instant the circuit is opened at the interrupter?

A.—The distributer brush (carbon pencil) should be in contact with one of the stationary terminals of the distributer at the instant the contact points separate from each other, or if the distributer is so made that the high-tension brush never touches the stationary terminals, but only passes very near them, then the brush should be in its nearest position to one of the terminals at the instant the contact points begin to separate.

The above also applies to magnetos which have the interrupter mounted on a rocking piece for advancing and retarding ignition, whether the rocker is set for latest or earliest spark, or in any intermediate position.

The teeth of the gears which drive the distributer rotor are generally marked to show how they are to be put together. It is common practice to mark the tooth of one gear and space between two teeth on the other gear. The marked tooth should go into the marked space. One of the gears is on the armature shaft, and the other (the larger) one on the distributer shaft. For four-cylinder motors the distributer gear has twice as many teeth as the one on the armature shaft.

The gears just mentioned do not mesh (engage) with the one by which the armature receives driving power.

397. Q.—When putting a magneto on a motor, how would you set the armature shaft gear by which the

armature is driven in a magneto which has a rocker for advancing and retarding the spark?

A.—Of the following two methods, the first has the most general application, especially when the driving gear can be loosened so as to rotate on the armature shaft, and then locked in any desired position by tightening a nut so as to force the gear hard against a tapered portion of the armature shaft:

1st Method.—While the armature gear is still tight on the armature shaft, move the armature of the magneto to a position between those shown in Figs. 15 and 16. If the edges of the armature core cannot be seen, it can be determined whether the armature is in this position by the resistance it offers to rotating it in either direction. If rotated through an angle of a few degrees in either direction, it will return to its original position as if actuated by a spring. The magnetic pull draws it back. The magnetic resistance to rotate can be distinguished from the frictional resistance of a tight bearing, or of some rubbing part, because such frictional resistance has no tendency to return the armature to any position.

Loosen the armature driving gear that is on the armature shaft. Turn the motor crankshaft to somewhere from 45 to 30 degrees (1-8th to 1-12th of a revolution) before dead center. Tighten the gear on the armature shaft (by means of the nut) so that the gear cannot slip around on the shaft. It may be necessary to prevent the armature from rotating while tightening the nut, as by placing one's hand on the interrupter mounting or the high-tension distributer.

Now set the spark-control lever to the position for latest ignition. Turn the crankshaft over very slowly and note when the contact points just begin to separate. The instant at which separation begins can be determined with sufficient accuracy by placing a piece of very thin tissue paper between the points when they are separated, allowing them to close down on the paper, and then pulling on it gently as the crankshaft is rotated, stopping the rotation as soon as the paper begins to become loose. The crankshaft should have rotated at least as far as dead center when the contact points of the interrupter begin to separate. This in order to insure that an ignition spark will not occur before dead center when cranking the motor to start it. Even if the interrupter points begin to separate just at dead center of the crankshaft, the ignition spark will not occur till slightly later, since the points must open far enough to break down the current before an ignition spark can occur. Connect the high-tension magneto terminals to the corresponding spark plugs and start the motor.

It may be found necessary to adjust the driving gear slightly in one direction or the other to get the best results, as determined by running. Do not adjust it so that the spark will come so early as to cause a back-kick when cranking at the slowest speed at which ignition will occur.

2d Method.—Set the crankshaft of the motor on dead center. Put the spark control to latest ignition position. Loosen the armature gear and rotate the armature till the contact points begin to separate. Tighten the driving gear without allowing it to turn any more on the armature shaft.

There may be difficulty in rotating the armature against the magnetic pull when bringing it around to the position for the beginning of separation of the contacts. It can be overcome usually by grasping the distributer rotor and twisting on it to turn the armature. The apparatus should be handled carefully to avoid breakage. Connect the high-tension terminals of the magneto to the spark-plugs, and try out by a running test. Adjust the gear on the armature shaft to obtain best results, taking care never to set it so that a back-kick will occur when cranking with the spark-control lever in latest spark position.

The only really satisfactory way of setting a magneto is by the manufacturer's marks and instructions. These should be followed when available.

In some magnetos the high-tension distributer has numerical figures on the side of the gear or other suitable part of the rotor. These figures become visible consecutively at a small opening (or window) as the distributer rotates, in the same manner that the numbers back of a photographic film appear at the back in some types of cameras. The interrupter breaks the circuit at the instant one of the numbers registers at the window. The numbers appear in the order in which the cylinders should be fired in the ordinary motor. The number visible at the window indicates the cylinder that is fired at that instant, if the connections between the magneto and spark-plugs are properly made.

398. Q.—What are some of the troubles which occur in a magneto?

A.—Carbon dust and metal particles may collect around the high-tension distributer so as to cause a short-circuit.

Dirt may collect around the interrupter so as to interfere with its movement.

The contact points of the interrupter may become fused or burned so as not to make good contact for closing the circuit.

The contact points may not separate far enough on account of binding or wear in some of the parts (such as the cam or tappet) which actuate the movable one.

A contact point may become loose in its setting.

The brush (carbon pencil) may become worn. Put in a new one. The brush spring may become weak. Put in a new one or stretch the old one.

The brush may bind in its holder.

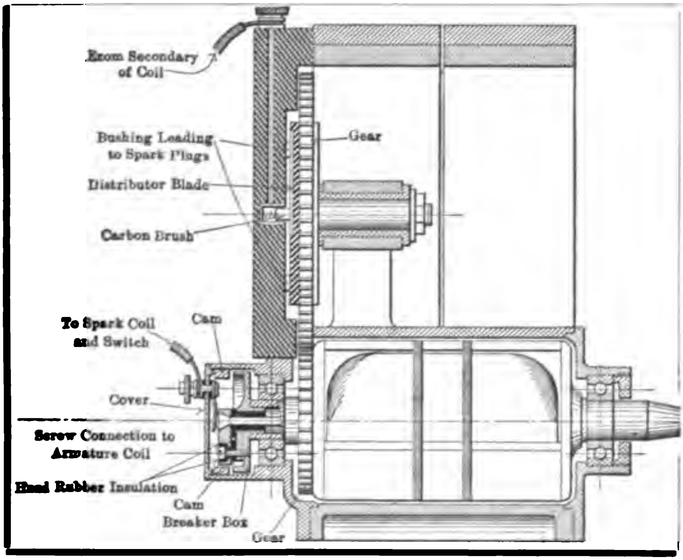


Fig. 80—SECTION OF A HIGH-TENSION MAGNETO, DEPICTING THE PROPER RELATIONS OF THE COMPONENTS, INDICATING COMPACTNESS; THE USE OF BALL BEARINGS, AND HOW THE PARTS ARE ASSEMBLED

The safety spark-gap may have its point burned off so as to be too wide.

The armature insulation may become defective.

The armature connection may become loose.

Magnets may weaken by losing magnetism so that sufficient electric pressure cannot be generated.

Water may cause trouble. On the armature it is apt to injure the insulation; at the interrupter points it prevents breaking the circuit; on the distributer it may cause short circuits. Never allow water to remain on any part of the magnets. It can be dried off by opening up the parts and warming them very gently for several hours.

399. Q.—How can the high-tension distributer be cleaned?

A.—By wiping it off with a soft cloth moistened with a little gasoline or kerosene. A moderately stiff brush may help. The rubbing surfaces should be moistened with kerosene or oil after gasoline is used.

400. Q.—How can the interrupter be cleaned?

A.—By washing it out with kerosene and a brush. Gasoline is hardly suitable. The interrupter should be

Some Causes of Magneto Trouble

(a) Lack of protection.
(b) Second-thought installation.
(c) Poor wiring.
(d) Inferior spark plugs.
(e) Improper timing.
(f) Lost motion in control system.
(g) Weak magnets.
(h) Defective insulation.
(i) Loose electrical connections.
(j) Open circuit.
(k) Excess of lubricating oil.
(l) Bad alignment.
(m) Defective bearings.
(n) Worn-out brushes.
(o) Pitted collector rings.
(p) Poor ground connections.
(q) Static discharge.
(r) Induction interference.
(s) Defective design.
(t) Mechanical interferences.
(u) Unequal polar gaps.
(v) Magnetic leakage.
(w) Loose driving gear.
(x) Loose spindles.
(y) Loose magnets.
(z) Faulty switch.

well oiled after cleaning, or the casing packed with a soft grease.

401. Q.—How can a fused and pitted interrupter contact point be repaired?

A.—By removing it, together with its mountings if more convenient, and filing the end smooth and true so that it will make flat contact on its mate when both are in place. A very fine-cut (smooth) file should be used.

402. Q.—By what means can the distance of separation of the contact points of a magneto interrupter be adjusted?

Remedies for Magneto Troubles

(a) Fit leather of vulcanite cover.
(b) Take down and reinstall properly.
(c) Poor wiring always spells trouble; fit new.
(d) Inferior plugs are worse than bad wire; the best for magneto is not too good.
(e) Retime; if you are not sure ask some one who is.
(f) Take up slack, and keep connection oiled to obviate wear.
(g) Have them remagnetized.
(h) This is sometimes difficult to locate; after you are sure it does not lay in the wiring or bedplate, send the magneto to the makers if mechanic does not thoroughly understand it.
(i) These should be looked to often, and where possible fit lock nuts.
(j) Go over switch to find the fault.
(k) If it has not got in the armature clean all parts and use less oil often and little rather than a lot now and then.
(l) Causes wear quickly if sideways; make holes for holding bolts larger; if too low pack up with thin fiber.
(m) Have them rebushed.
(n) Fit new ones.
(o) Clean with gasoline, or if badly worn use very fine emery paper.
(p) Undo same, wash with gasoline and clean with emery paper; if the spot is likely to be covered with oil make new connection elsewhere.
(q) Close safety gap slightly.
(r) Caused by flaw or improper windings; have same repaired.
(s) Outside owner's power.
(t) Readjust the parts so that they clear.
(u) Take out all plugs and adjust them all to one gauge of between 1-32 and 1-64 inch.
(v) Avoid a magnetic short-circuit by keeping the magnets clear of iron brackets, etc.
(w) If key is worn, have new key cut and keyways cleaned; if pinned to shaft, ream holes and fit larger pins.
(x) Have shaft turned true and rebushed to accommodate same.
(y) Tighten up holding screws.
(z) Repair same, but if cracked it is better to fit a new one.

A.—One of the contact pieces is usually threaded in place and fastened by means of a lock-nut. To adjust, loosen the lock-nut, turn the screw to bring the points to the correct distance apart, then tighten the lock-nut. It may be more convenient to remove the contact piece together with its mounting when adjusting.

403. Q.—How far apart should the interrupter contact points open?

A.—About one-fiftieth (1-50th) of an inch. A slightly less opening is used on several magnetos, but apparently none less than one-sixty-fourth (1-64th) of an inch. The amount of separation of the points is given in metric measure as .4 to .5 of a millimeter.

It may be remembered that if 50 cards stacked solid measure one inch high, then each card is 1-50th of an inch thick, if all are of the same thickness.

404. Q.—How can a high-tension magneto be tested while the motor is running to determine whether misfiring in the motor is due to the magneto?

A—It is generally more convenient to carry out the following test while the motor is running; but if it will not run, a muscular person may be able to crank it rapidly enough, at intervals, for the test.

Disconnect one of the high-tension wires from the magneto. Look for sparks at the safety spark-gap of the magneto. If sparks pass regularly at the safety gap, it indicates that the magneto is working properly for the disconnected wire. If the sparks pass irregularly, or not at all, then the magneto is not operating properly for the disconnected wire. Connect the wire again to the proper distributer terminal of the magneto. Test each wire similarly. Do not allow sparks to pass at the safety-gap during any longer time than necessary, since this action brings a considerable electric strain on the magneto.

Failure to spark regularly at the safety spark-gap, when one of the high-tension wires is removed, may be due to carbon dust in the distributer, trouble at the interrupter, or to some of the other troubles given in Q. 398.

If the construction of the magneto is such that it is not possible to see sparks which occur at the safety spark-gap, then disconnect one of the high-tension wires from its spark-plug and hold the metal end of the wire within about one-eighth of an inch from the metal of the motor. If sparks pass regularly between the motor and the wire-end, it indicates that both the magneto and the high-tension wire are in good order. If the sparking is irregular, or there is none at all, then either the magneto or the connecting wire is at fault. The wire may be broken inside its insulation or the insulation may be defective.

Connect the wire to its spark-plug again, and try each of the others in the same manner. Otherwise proceed as in the earlier part of this answer.

405. Q.—If the contact points of the current interrupter of a magneto burn away rapidly, what may be the cause?

A.—The spring which presses the contact points together may be too weak.

One of the contact points may be loose in its mounting.

The contact points may not open far enough.

The condenser may be defective. This fault is almost sure to cause burning of the contact points of the interrupter.

406. Q.—How can magnets which have partly, or wholly, lost their magnetism, be remagnetized?

A.—By winding a coil of insulated wire around the bar of each individual magnet alone, then sending a large direct current of electricity through the wire for a few seconds. The current should be stopped gradually, not suddenly as by opening a switch. The current can be decreased gradually by means of a rheostat. A water rheostat is suitable. It can be made by immersing the ends of two copper wires to a considerable depth in acidulated water. The wires should be bare as far as they are immersed. The circuit thus includes the water. By slowly withdrawing one or both wires the current is gradually decreased, and finally stopped when one wire is completely withdrawn. The wires should be kept well apart while withdrawing them. A piece of wedge-shaped sheet metal fastened to the end of a wire makes a good terminal for a water rheostat. The point of the wedge should be down.

Each magnet is usually stamped with an "N" to indicate its north pole. The current should be sent around each magnet in the same direction relative to the "N" pole.

Each magnet should be tested for its polarity after it has been magnetized. This test can be made with an ordinary pocket compass. The south pole of the compass will point toward the north pole of the magnet when brought near it.

When putting the magnets together in a group again, they should be arranged so that their "N" poles will all be on the same side of the armature.

Striking the magnet sharp blows with a very light hammer while current is flowing around it will aid magnetization. It should be remembered that at least some magnets are very hard and brittle. They may be broken by hard blows.

407. Q.—If a motor misfires, what test of the ignition system can be made to locate the fault in a jump-

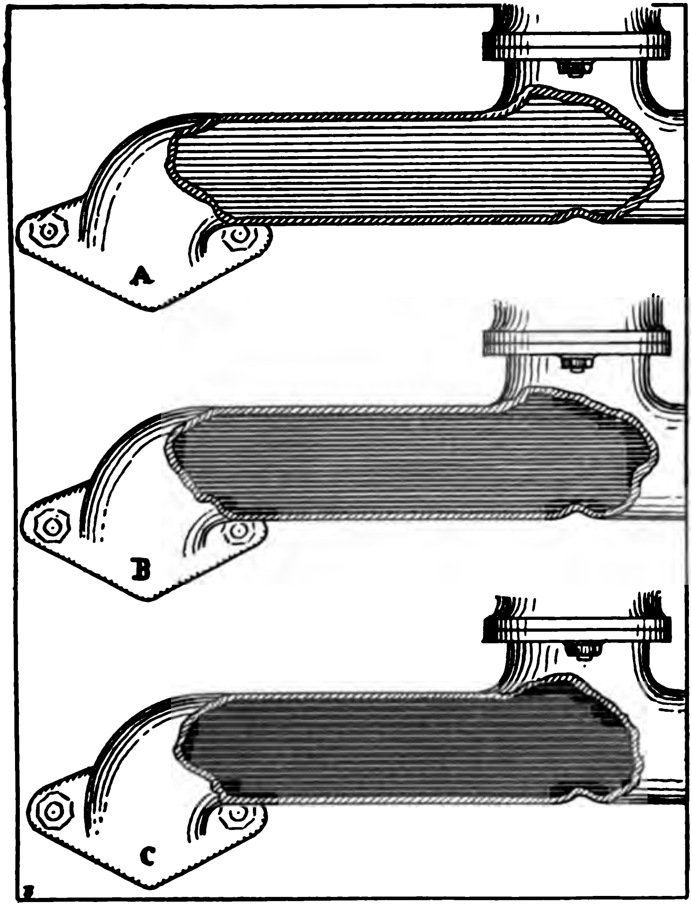


Fig. 81—IGNITION TROUBLE MAY BE DUE TO (A) LEAN MIXTURE, ESPECIALLY IF THE MANIFOLD IS TOO LARGE, (B) PROPERLY PROPORTIONED MIXTURE IF THE SPARK IS NOT EFFICACIOUS, OR PROPERLY TIMED, AND (C) RICH MIXTURE, PARTICULARLY IN A MANIFOLD THAT IS TOO LARGE

spark system with battery current and a trembler spark-coil for each cylinder (individual spark-coil system) ?

A.—Tests in the following order can be made until the trouble is found:

Switch on the reserve battery while still running.

Hold down the tremblers on the induction coils one at a time, or in pairs, to determine which cylinder misfires.

Stop the engine and crank slowly, noting whether each trembler vibrates strongly. If all vibrate weakly, look for loose connections in the battery, the ground wires and the wire connecting the battery to the induction coil. Also examine for a broken wire inside the insulation of the same wires. Look for bare places on the wire between the battery and coils. See that the covering of the battery cells is not wet or worn off so that the zincs touch each other. Put in new low-tension wires.

If only one vibrator has weak action, clean the contact points, readjust its tension and examine the wire and connections between it and the timer. Examine the timer, noting whether the contacts and spring for the weak trembler are in order.

If all tremblers vibrate strongly:

Remove the wire from the spark-plug, hold its end about ¼ inch from the engine casting, and close the circuit for that plug at the timer by turning the engine crank or placing a piece of metal so as to connect the timer terminal for that plug to the frame of the engine. The spark should jump the ¼-inch gap. If not, look for poor insulation on the secondary wire.

If the spark-coil has a visible safety spark-gap, sparking at this point, when the wire is disconnected from the corresponding plug and held well away from the metal of the car, will indicate that the spark-coil is in good condition. The primary circuit must, of course, be closed.

Remove the spark-plug, connect its wire to it, lay the bushing of the plug against the engine and close the primary circuit corresponding to the plug under test. Notice whether the spark is strong between the plug points. If not, clean the plug or replace it with another. Even though the spark is strong when the plug is removed from the cylinder, the current may pass through mica insulation or dirt and grease on the insulating material when the plug is in the engine, owing to the higher resistance of the spark-gap in the compressed mixture.

Put in a new spark-plug.

Interchange the high-tension wires. The misfiring will occur at the plug to which the defective wire is connected.

See also compression test, sticky valve stem, carbureter troubles, timer troubles, defective spark-coil, etc.

408. Q.—In case of misfiring, how would you test an ignition system having a master trembler coil and individual transformer coils (one for each cylinder) without tremblers, the current being supplied by a battery or a low-tension electric generator?

A.—Adjust the trembler.

Ground the spark plugs one at a time, or in pairs, to find where the misfiring occurs.

While the motor is still running, disconnect the wire from the plug of the cylinder which misfires, and hold the end of the wire about a quarter of an inch from the metal of the motor. Sparks should appear at the quarter-inch gap. If they do, the trouble is in the spark-plug. Clean the plug or put in a new one.

If no sparks appear at the end of the high-tension wire when it is held near the motor, and if the safety spark-gap of the transformer coil is visible, disconnect the wire from its transformer. If sparks then appear at the safety gap it indicates that the transformer is in order and that the trouble is possibly due to the insulation of the wire being defective.

If there is no sparking at the safety gap when the wire is disconnected from the transformer, it indicates that the transformer, the timer or some part of the battery (primary) circuit is at fault.

Interchange the high-tension wires to find whether one of them is defective.

Examine the battery circuit for loose connections and insulation worn so as to expose the copper wire.

A test while the motor is stopped can be made by cranking the motor slowly and following out practically the same process as just given.

409. Q.—If misfiring occurs with a high-tension magneto, how can the ignition system be tested?

A.—Ground the spark-plugs, one at a time, or in pairs, to determine which cylinder misfires, the motor still running, of course. A spark-plug can be grounded by placing a piece of metal, such as the blade of a screwdriver, against both the outer terminal of the plug and the metal of the motor. The metal used for grounding should have a handle of insulating material, such as the wooden handle of some screwdrivers. One's hand should not be allowed to touch the metal on account of the shock that will be received.

Disconnect the wire from the plug where misfiring occurred, and hold the end of the wire within an eighth of an inch or less from the metal of the motor. If sparks appear at the end of the wire, then the trouble is probably in the spark-plug. (See spark-plug.) If sparks do not appear at the end of the wire, then keep the end of the wire at least an eighth of an inch away from the metal of the car and look for sparks at the safety spark-gap of the magneto. If none appear there, disconnect the wire from the magneto. The appearance of sparks now at the safety spark-gap will indicate that the insulation of the wire is defective. The absence of sparks means that the trouble is in the magneto. (See magneto.)

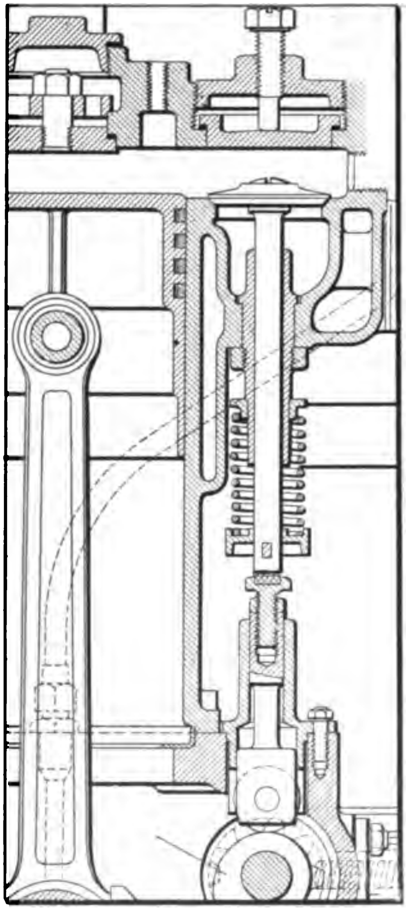


FIG. 82—SECTION OF A MOTOR, SHOWING VALVE MECHANISM AND ADJUSTABLE PUSH RODS

The very unusual case of a high-tension wire broken inside the insulation and the ends of the wire pulled wide apart is indicated by the appearance of sparks at the safety spark-gap of the magneto when the wire is in place, or one end connected to the magneto and the other touching the motor.

If the safety spark-gap of the magneto is hidden so that sparks at it are not visible, the spark-plug wires can be interchanged to determine whether any of them has defective insulation. The misfiring will, of course, occur at the plug to which the defective wire is connected.

410. Q.—When there is misfiring with an ignition system having a low-tension magneto with an interrupter and a high-tension distributer, how can the ignition system be tested?

A.—In the same manner as for a high-tension magneto, with the addition of inspecting the primary wires between the magneto and the transformer spark-coil.

Motor Troubles, Adjustments and Tests

411. Q.—What causes explosions in the exhaust pipe and muffler?

A.—The passage of unburned mixture into the exhaust pipe, due to misfiring in one or more cylinders. The unburned mixture, after passing into the exhaust pipe, is ignited by the hot gases of the following explosion, or by incandescent particles on the walls of the exhaust pipe.

412. Q.—Are muffler explosions dangerous?

A.—Not so far as bursting the exhaust pipe and muffler is concerned, when the latter is properly constructed. Explosions which have partly wrecked a car are not unknown, however. Heaters using exhaust gas may explode or set fire to the body of the car. The only other ordinary danger is starting a fire in a garage where gasoline is vaporized.

413. Q.—What causes back-firing in the intake pipe, also called popping at the carbureter?

A.—Too lean a mixture (air not sufficiently carbureted; a lean mixture may be caused by air drawn through a leak in a joint of the pipe between the carbureter and engine); an overheated cylinder; incandescent carbon on the walls of the combustion chamber; a weak inlet-valve spring which does not close the port before ignition occurs; a dirty or bent inlet-valve stem.

414. Q.—What causes carbon deposit in the cylinder?

A.—Too rich a mixture (too much gasoline), too much lubricating oil or a poor quality of oil.

415. Q.—How and where does the carbon collect in the cylinder?

A.—On at least part of the exposed surface of the piston it generally collects as a hard gray substance resembling coke. It sometimes collects on and near the exhaust valve in the same form. In the other (cooler) parts of the cylinder, it is more apt to be found mixed with the gummy residue of lubricating oil.

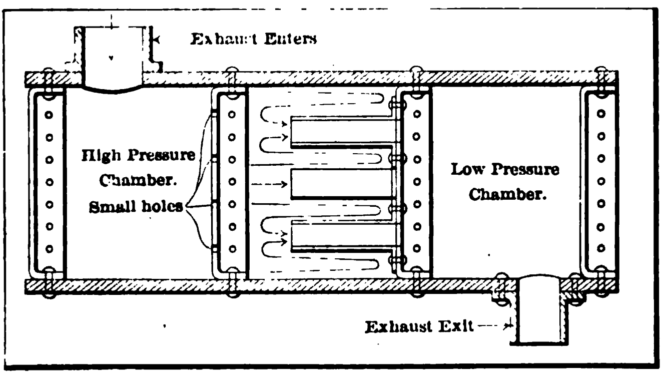


FIG. 83—SECTIONAL VIEW OF A MUFFLER (EXHAUST BOX), SHOWING THE TRAVEL OF THE GASES

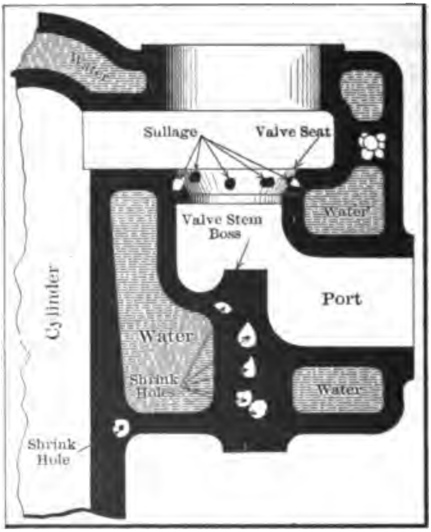


FIG. 84—LEAK AT THE VALVE DUE TO SULLAGED SEAT. THIS CANNOT BE REPAIRED AND NECESSITATES A NEW CYLINDER

It collects in the latter form around and under the piston rings.

416. Q.—What troubles may be caused by excess of carbon deposit in the combustion chamber or on the piston?

A. — Pre-ignition; kicking when cranking, back-firing into the carbureter, scoring the cylinder by a loose flake; sudden loss of compression by a flake getting under the exhaust valve. Carbon under the piston rings prevents their elastic action.

The carbon deposit is apt to be in the form of projections, which become incandescent and ignite the incoming charge while the inlet valve is still open, thus causing back-firing into the carbureter, or, if not ignited while entering, a charge may be fired just before compression is completed. This premature ignition has the same effect as advancing the spark too far, and the corresponding stresses are produced in the parts of the engine.

An engine with considerable carbon deposit frequently continues running some time after the ignition circuit has been broken, thus making it impossible to stop the engine when the carbureter throttle does not completely close the mixture inlet.

417. Q.—How can carbon deposit be removed from a cylinder?

A.—Kerosene, or, better still, some of the carbon removing compounds, put into the cylinder will remove at least the gummy carbon residue. Some of the compounds cut away the hard carbon also, thus cleaning the cylinder quite well. Kerosene does not generally loosen the hard carbon. The liquid cleaner can be poured into the cylinder and the motor and then cranked by hand. This brings the cleaner into contact with all of the inner surface and gives it an opportunity to reach the piston rings and cut the carbon from around them. In a horizontal motor there is generally a petcock at the lower part

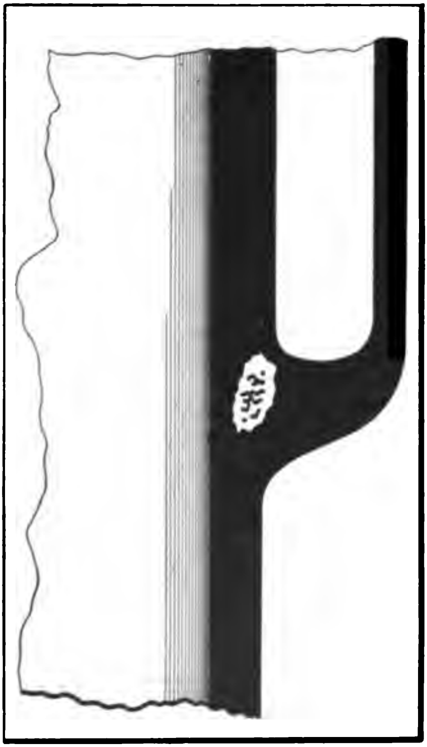


FIG. 85—SPONGE SPOT DUE TO UNEQUAL COOLING AT THE PART WHERE THE METAL IS BUNCHED

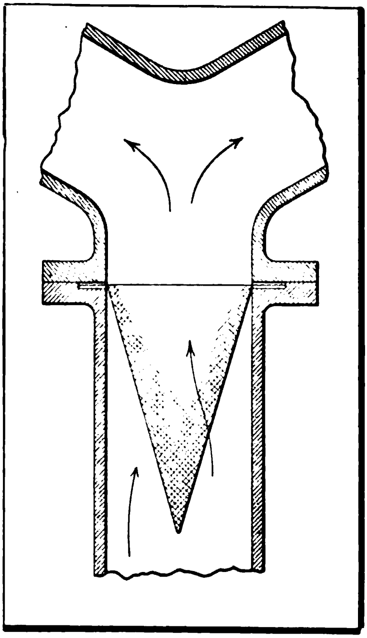


FIG. 86—CONE GAUZE SOMETIMES FITTED IN THE INTAKE MANIFOLD. THE FIRST BACKFIRE WILL PROBABLY SHATTER IT AND IT ALSO CAUSES CONDENSATION

of the combustion chamber. By opening the petcock the cleaner and carbon in it will drain out. It may be necessary to run a wire in through the petcock to keep it open. In a vertical motor it is generally necessary to start the motor so as to blow the liquid out through the exhaust. Care should be observed to see that there is not so much liquid in the cylinder as to fill it full when the piston is in the in position. Too much liquid in the cylinder may cause a broken motor.

Kerosene can be safely left in the cylinder over night, thus becoming more effective in its action. This is also true of some of the cleaning compounds. Some cleaners injure the parts if left in too long.

The best way to remove carbon from the cylinder is to open the cylinder so as to scrape and wipe it off.

418. Q.—How can the inside of the motor cylinder be reached for cleaning it?

A.—By removing the valves of some motors, the inside of the cylinder can be reached with suitable tools (scrapers).

In motors with separate and removable cylinder heads, the latter can be removed for cleaning.

The more usual types of motors have the cylinder barrel and head cast in one piece. By removing the cylinder from the crankcase its interior can be reached for cleaning.

419. Q.—How can a piston ring be removed and replaced?

A.—Very suitable tools are a piece of stiff copper wire flattened at one end like a screw driver, and several strips of thin metal, such as sheet copper or brass,

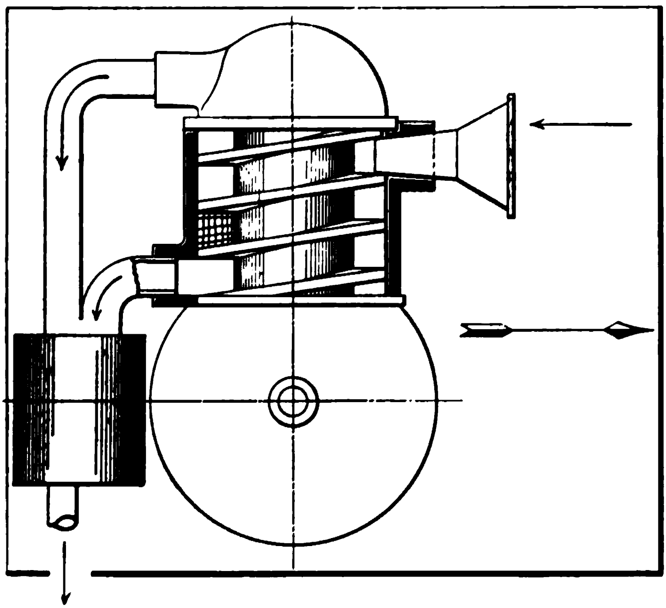


FIG. 87—METHOD OF PASSING THE AIR AROUND THE CYLINDERS TO OBTAIN EQUAL HEATING

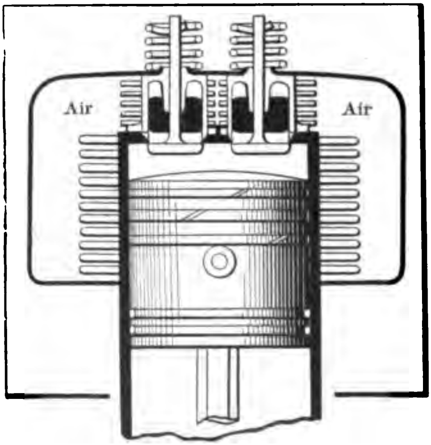


FIG. 88—DESIGN OF AIR-COOLED MOTOR. IT WILL BE NOTICED THAT THE VALVES ARE PLACED IN THE DOME OF THE CYLINDER. THE STEMS ARE VERY NARROW AND THE MUSHROOMS LARGE, WHICH IS APT TO MAKE THEM OVERHEAT

about half an inch wide by three inches long. Hard metal should not be used; it is apt to injure the edge of the ring or of the groove.

Put the flattened end of the wire under the piston ring at the cut, and lift the ring just high enough to slip the end of the strip of metal under it so that the strip extends across the groove in the piston.

Insert two or three more strips under the ring in the same manner, slipping them around under the ring so as to space them uniformly. The ring can now be slipped endwise from the piston.

Do not lift or bend the ring any more than is necessary. Piston rings are generally made of cast iron and are so brittle as to be easily broken.

Replacing a piston ring is done in the reverse manner of removing it.

420. Q.—When replacing a piston ring, what care should be observed to get it in proper position?

A.—Some rings are prevented from rotating by small pins, or stops, to fit the stop. The ring is sometimes notched to fit the stop. It should be turned in the groove to bring it to proper position.

When properly in place, the ring should move easily in the groove so that it can be pressed below the surface of the piston at any point. The ring stands out above the piston surface naturally.

421. Q.—If a piston ring is too wide for its groove, so that it binds in it, how can it be remedied?

A.—Lay the ring flat on a piece of fine-grade emery cloth or paper which rests on a plane (flat) surface. Rub the ring on the emery, keeping the pressure uniform around the entire edge, so as to remove the metal evenly, thus keeping the width of the ring the same at all parts. Try the ring frequently, by rolling it around in the groove. It should go in freely without shaking.

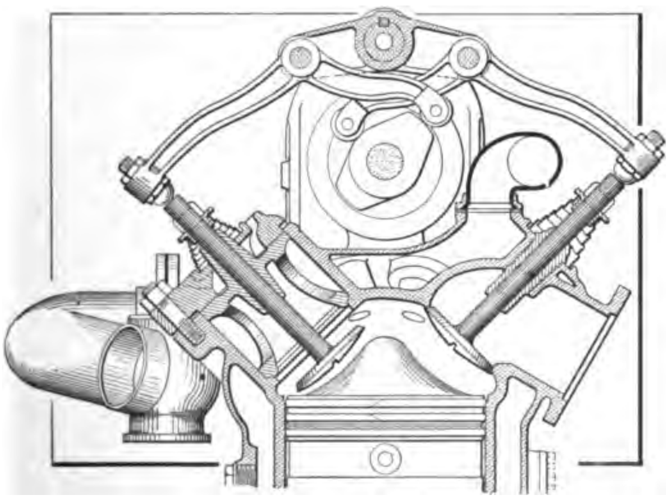


FIG. 89—CORRECT DESIGN OF OVERHEAD VALVE WITH WIDE STEMS AND CLEAN-CUT HEADS. THIS STYLE IS GREATLY IN VOGUE IN RACING ENGINES TO OBTAIN MAXIMUM AMOUNT OF CLEARANCE

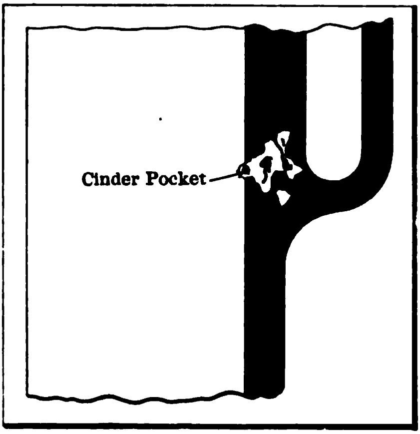


FIG. 90—CINDER POCKET DISCOVERED WHILE REBORING THE CYLINDER TO FIT NEW PISTONS. SUCH CYLINDERS MAY GIVE WAY AT ANY TIME AND THE WATER LEAK INTO THE MOTOR

Do not use coarse emery paper, or cloth. It will leave scratches in the ring.

422. Q.—If the grooves in a piston become worn so as to have a shoulder near the bottom, what should be done?

A.—Have the grooves turned true in a lathe and use rings wider than the original ones. It may sometimes prove to be more economical to get a new piston.

423. Q.—If the cylinder is cracked or has an opening around a plug leading to the water jacket space, what are the indications when the engine is running?

A.—Loss of power and excessive heating of jacket water. If water-cooled, there may also be misfiring after running an hour or so.

424. Q.—To what is a cracked cylinder sometimes due?

A.—Lack of circulating water or initial stresses in the casting.

425. Q.—How is compression tested by hand?

A.—Cut out the ignition and open the petcocks of the cylinder. Crank the motor and note whether it turns freely as it should. If not, put oil in the cylinder till the movement becomes free; or clean the cylinder if the oil is not effective.

Crank the engine slowly by hand. There should be considerable resistance to turning during the compression periods, and when the pull on the hand crank is lessened, during compression, the engine should turn backward a small part of a revolution. If the cylinder petcocks are open there can be no compression. To test one cylinder of a multi-cylinder engine, open the cylinder petcocks of the others; or, if there are no cylinder petcocks, lift the inlet or exhaust valves from their seats by inserting a coin, a piece of sheet metal, paper or cardboard between the end of the valve stem and the part that presses against it.

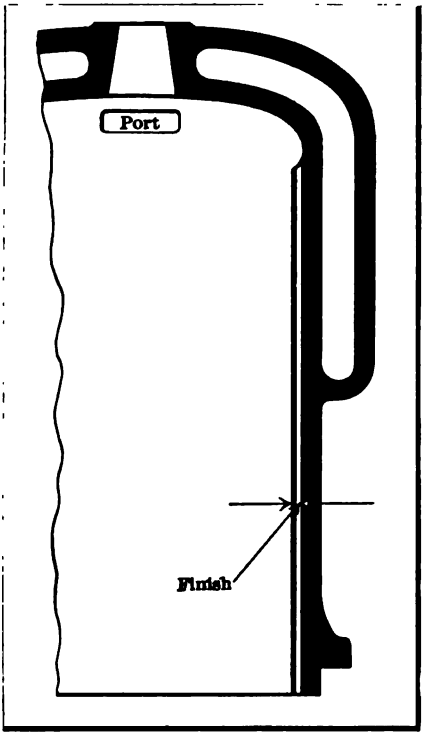


FIG. 91—COMBUSTION CHAMBER DESIGNED TO ALLOW THE PISTON RINGS TO OVERLAP

426. Q.—Loss of compression may be due to what causes?

A.—Leaky valve. Clean or grind in (See Q. 432).

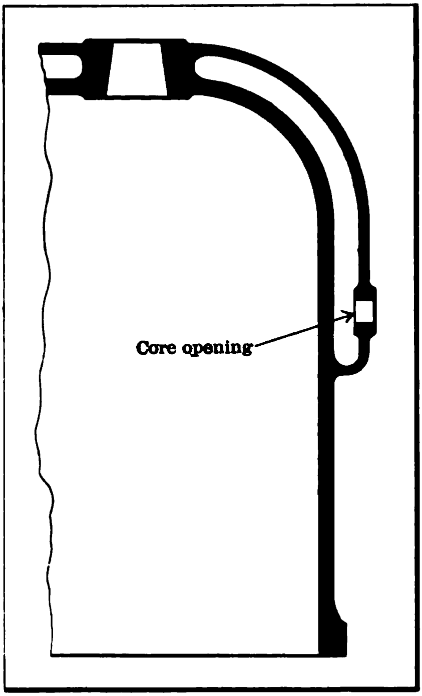


FIG. 92—SHOWING THE POSITION OF THE CORES IN CYLINDER CASTING. IF THESE ARE MISPLACED A THINNESS OF METAL WILL RESULT AND MAY CAUSE LEAKING

A weak spring on the automatic inlet valve. Get a new spring or stretch old one.

A leaky piston. Get new rings or rebore cylinder.

Dirt under the valve. Rotate the valve on its seat. This can often be done by gripping the stem and twisting it. The pressure on the seat may be partly relieved for this purpose by inserting a wedge at the end of the stem, or turning the engine till the cam acts slightly.

Loose or leaky ignition plugs or parts stopping openings into the cylinder. Put lubricating oil around parts and look for bubbles when compressing the charge.

A leaky cylinder plug (see Q. 434 and 435).

A cracked cylinder (see Q. 434 and 435).

A leaky petcock. Regrind the plug with fine emery and oil. Any other suitable abrasive can be used.

427. Q.—What causes inlet and exhaust valve leaks?

A.—Fouling of the valve or its seat; warping of the valve by heat; a particle of carbon scale from the combustion chamber getting between the valve and its seat; and, in the exhaust valve, pitting, or even a foul stem that has collected enough carbon to make it bind in the guide (hole through which the stem passes); a bent valve stem; a weak valve spring.

428. Q.—What is valve "pitting"? How caused?

A.—Small pits formed in the part of the exhaust valve that rests on the valve-seat. They are caused by hot combustion products escaping through the port.

429. Q.—What causes an exhaust valve stem to stick or bind in its guide, and what are the remedies?

A.—Oil and carbon (soot) from the combustion chamber sometimes collect around the valve stem when exhausting and then dry, leaving a hard coating of carbon on the stem and guide which causes it to fit tight and bind in the hole; or carbon alone in the form of soot is deposited on the stem with the same result. The stem may be warped or bent. Kerosene put on

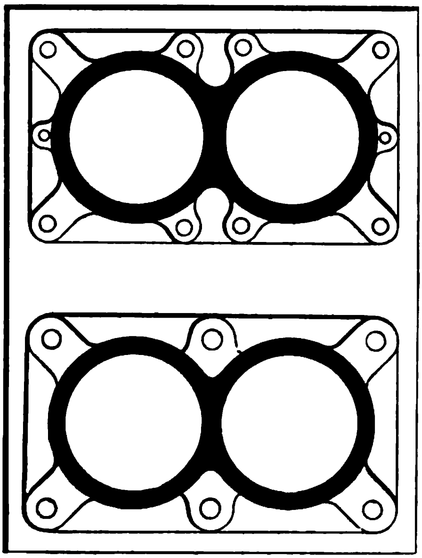


FIG. 93—TWO METHODS OF SECURING CYLINDERS TO BASE CHAMBER

the hot stem while in place cleans it fairly well. This can be done on the road. Gasoline cuts the oil and carbon loose better than kerosene when the parts are cool. Some of the liquid compounds used for cleaning the inside of cylinders may be used. A thorough cleaning requires the removal of the valve, and scraping is sometimes necessary. A bent or warped stem should be immediately straightened.

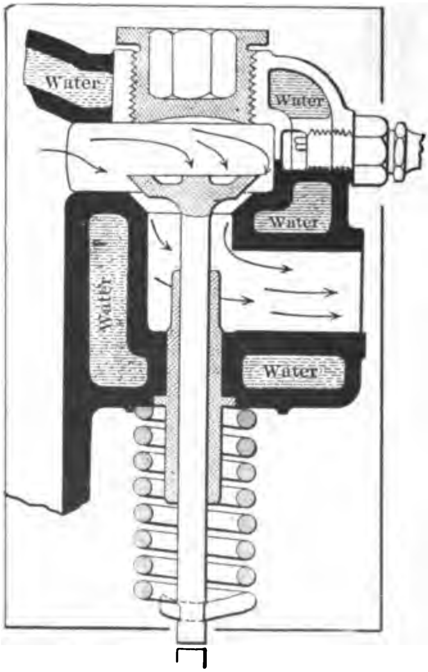


Fig. 94—TYPE OF EXHAUST VALVE THAT IS LIABLE TO OVERHEAT OWING TO THE THINNESS OF THE GUIDES WHICH ATTRACT THE HEAT OF THE OUTGOING GASES

430. Q. — How can a broken valve spring of the coiled type be temporarily kept in use?

A.—By placing a metal or wood fiber washer between the broken parts. The washer should fit loosely on the valve stem. Two thin cupped washers (with a bent-up flange at the edge) placed on the stem with their flat sides together answer well. The flanges prevent the broken spring-ends from getting out of position.

431. Q. — How do you test for a leaky valve?

A.—The test by compression is only partly satisfactory, since leakage may occur at the piston or other places as well as at the valve.

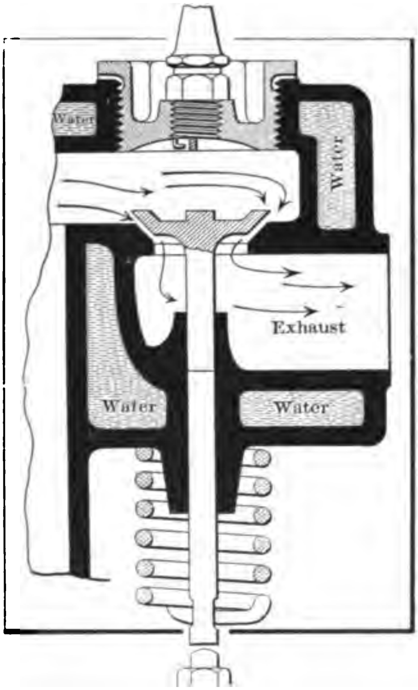


FIG. 95—LEAK CAUSED BY THE BENDING OF THE EXHAUST VALVE STEM PREVENTING THE VALVE SEATING PROPERLY

Leaks at the piston can often be stopped, during a compression test of a vertical motor, by putting enough cylinder oil into the top of the cylinder to cover the joint between the piston and cylinder wall. Care should be taken not to let the oil reach the valve, since it may stop a leak there. Oil put around spark-plug, petcock and other openings into the cylinder will show leaks there during compression.

If the compression is poor, remove the valve and examine for pitting. If pits do not appear to any great extent, put it back in place and rotate with a screwdriver or pin wrench while pressing it down on its seat (the valve has a slot for a screwdriver or holes for a pin wrench), then remove and examine the bearing surface. If the valve fits well, both it and the seat should be bright all the way around. If it is impossible to tell whether the surfaces have been rubbed over all the way around, put a very little of a thin mixture of red lead and oil of white lead and oil over the bearing surfaces, or rub a piece of chalk over them, and rotate as before. If the bearing surfaces do not have a clean ring rubbed by rotating the valve on its seat, it is a sure indication of a leaky valve. If the surfaces are rubbed clean, however, the valve will generally be tight. It may happen that it was not ground properly before, and that the surfaces were warped. This will allow them to rub together so as to become bright throughout the entire circle, and the valve will fit on its seat properly in one position, while in another it would allow leakage.

When the inlet and exhaust pipes can be readily disconnected from the port openings, a piece of thin paper, or sheet rubber, held over the opening will indicate if air is forced under the valve during compression. A candle can be used for the same purpose if there is no gasoline in or about the

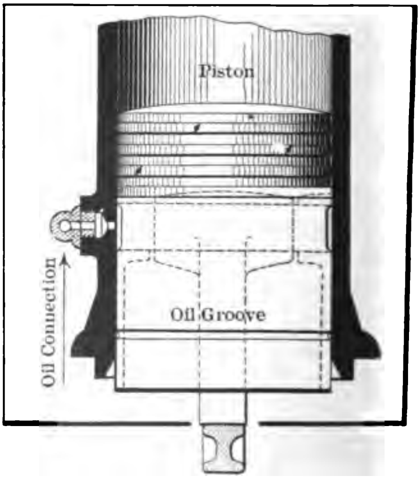


FIG. 96—TYPE OF OIL CONNECTION TO CYLINDERS WITH BALL CHECK NON-RETURN VALVE TO PREVENT BACK PRESSURE

car. The candle will hardly indicate a very small leak, however.

432. Q.—How is a leaky valve ground to fit its seat?

A.—Mix oil or vaseline with fine emery, ground glass or some other abrasive substance, and place on the bearing surface of the valve. Then put the latter in place and rotate it a short distance back and forth (something less than a quarter turn) a few times, then lift slightly from the seat and give it about a quarter turn, then rotate back and forth as before, and lift slightly from the seat to move it to a new position, and so on. A light coiled spring placed under the valve will lift it when the pressure of screwdriver or other device used to rotate it is reduced. The valve should not be turned through a complete rotation without lifting slightly, except at the beginning of regrinding a valve that is in very bad condition, since a complete rotation is apt to cause scratches running around the entire circumference. The valve should be removed and examined at intervals to determine how the work is progressing. The port should be stopped with a piece of cloth or waste to prevent any of the abrasive from dropping in. Clean the parts scrupulously after grinding. Abrasive carried into the cylinder will cut and score it, causing rapid wear and piston leaks.

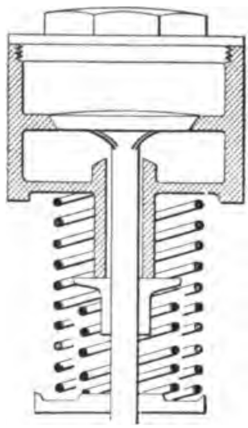


FIG. 97—CAUSE OF A LEAK IN VALVE DUE TO WEAR IN THE GUIDES. THE INSERTED CAP AND EXTRA SPRING CAN BE USED FOR A TEMPORARY REPAIR

Emery two or three grades coarser than flour emery is suitable at the beginning, and a finer emery or powdered pumice stone may be used for finishing.

433. Q.—How can you test for a leaky piston?

A.—In some types of motors, generally those with horizontal cylinders, the open ends of the cylinders can be exposed to view by removing the crankcase cover.

If the leak is a bad one, smoke will be blown out between the piston and cylinder walls while the motor is running.

The following procedure can be applied:

Place heavy oil or thin grease around the valves where they rest on their seats, also place cylinder oil around the spark plugs, petcocks, etc. If any leaks appear at the latter places, when compression by hand cranking is applied, they should be eliminated. Leaks at these places will be indicated by bubbles in the oil.

After eliminating the above leaks and making quite certain that the valves are properly taken care of, the only remaining leak will be at the piston, either between it and the cylinder or through a crack or pore in the piston head, unless the cylinder is cracked or porous, or has a loose plug in its wall between the bore of the cylinder and the water jacket.

434. Q.—How do you test by cranking for a cracked or porous cylinder or a leaky plug in the wall between the combustion chamber and water jacket?

A.—Try compression by cranking. If it is poor, then remove the water pipe from the top of the cylinder, disconnect the circulating pump, fill the water jacket to the top of the opening where the pipe was connected and crank the engine with the petcock closed. Bubbles will rise to the top of the water if the cylinder is cracked or the plug between the combustion chamber and the water jacket is very loose. If no air bubbles appear, then make the running test (Q. 435) or the hydrostatic test (Q. 436).

435. Q.—How can a running test be made for a cracked cylinder or a leaky plug in the wall between the combustion chamber and water jacket space?

A.—Jack up the rear wheels so they are free, start the engine, throw in the clutch, put on the brakes, open the throttle and advance the timer. If gas bubbles do not appear after running the engine for some time, then the engine is tight. A leak of the above nature sometimes does not show till the motor gets well heated under a heavy load. Do not mistake the air bubbles which form on the cylinder walls for gas bubbles. Steam bubbles will also rise after considerable running of the engine.

436. Q.—How is the hydrostatic test applied for cylinder leaks of all kinds?

A.—In a four-stroke-cycle engine, place the engine on its dead center with the piston at the crank end of the cylinder. Fill the cylinder with kerosene or water by pouring in through the petcock, spark-plug opening, or other convenient place. Water will answer to show a leak that is very large, but kerosene will penetrate more readily. Gasoline may be used, but with care; it is not generally advisable to use it. Close the opening (petcock) and turn the engine as for cranking. Note whether any of the liquid passes by the piston. This test generally necessitates removing part of the crankcase. Observations may at the same time be taken for valve leaks; for cracks in the cylinder; for leaky plugs; or at any place where leakage may be liable to occur.

437. Q.—What troubles may come in the carbureter?

A.—The float may stick so that it cannot rise to close the needle valve, and gasoline will overflow (flooding). Tap the carbureter, striking it lightly. Remove the top of the carbureter and lift up the float.

A cork float may become "waterlogged." Remove, dry out by warming and varnish with shellac.

A hollow metal float may leak and become filled with gasoline. Remove from carbureter, put in hot water and locate the leak by bubbles from the hole.

If the hole is small and can be easily soldered, allow the float to cool completely and solder with a

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Carbureter Troubles as Met with Every Day

(a) Nozzle too large.
(b) Nozzle too restricted.
(c) Needle in nozzle not properly set.
(d) Depression too low.
(e) Depression too high.
(f) Too little initial air.
(g) Too much initial air.
(h) Too much auxiliary air.
(i) Too little auxiliary air.
(j) Float too high.
(k) Float too low.
(l) Passageways stopped up.
(m) Air locked.
(n) Pocket of water.
(o) Float punctured.
(p) Mechanical interferences.
(q) Leak around manifold flanging.
(r) Adjustment awry.
(s) Filter stopped up.
(t) Low pressure.
(u) Control system awry.
(v) Carbureter too small.
(w) Carbureter too large.
(x) Manifold not right.
(y) Poor gasoline.
(z) Gasoline not turned on.

soldering iron (copper) taking care not to heat the float much. But if the hole is difficult to solder, and the float becomes considerably heated, then it is better to punch a minute hole in the float with a sharp point, solder the leak and test by blowing into the hole. Then allow the float to cool completely and solder the punched hole quickly.

The inlet needle valve may leak. Press down hard on seat. Press down lightly and rotate. Grind in with fine emery or powdered pumice stone mixed with oil or vaseline. Press down lightly and rotate when

Remedies for Daily Carbureter Troubles

(a) Fit smaller jet or solder up orifice and redrill.
(b) Use taper reamer.
(c) Adjust till correct position is found.
(d) Fit lead washer beneath jet base.
(e) File top of jet or better reset needle valve.
(f) Drill a few additional holes at convenient places.
(g) Fit shutter, locked by a set screw.
(h) Increase tension on spring or block up ports
(i) Decrease tension of spring, enlarge slot and ports.
(j) Unsolder balance weight holder ring, lower same on needle and solder or weight down float equally with a little solder.
(k) Unsolder balance weight holder ring and raise same.
(l) Unscrew same and clean them, using air pressure (tire pump); don't use pins in the jet.
(m) Unscrew gasoline pipe from carbureter and allow gas to flow through, look to stoppage in hole of filler cap in gravity-fed cars.
(n) Same as (l).
(o) Drill another small hole, blow or boil gasoline out and solder.
(p) Disconnect carbureter entirely, thoroughly clean out, verify everything, and if it does not then work have some one put it in order that understands how to.
(q) Replace old joint by a new one; if you haven't a new one make one from stout brown paper and boiled oil or white lead.
(r) Readjust but leave jet alone; if it ran all right once it will do so again unless the motor is worn badly.
(s) Disconnect and clean out; should be cleaned once a month.
(t) Clean pressure valve and go over all connections; copper pipes sometimes split at the seam.
(u) Readjust and tighten up, or if worn take up play.
(v) Fit larger carbureter.
(w) Try adjusting jet and closing ordinary air intake; if it will not work, fit smaller carbureter.
(x) Consult makers of car or engine and have a new one made; patched induction pipes do not work well.
(y) Empty out every drain of old gasoline and pay more money and get better quality, or if the dealer has only one quality go to another dealer, or, better still, buy direct and store it yourself if you have the convenience.
(z) Turn it on.

grinding. Carefully remove all abrasive material when finished.

Dirt may clog the inlet valve or nozzle. Close and open the inlet valve. Wash out with gasoline. Run a fine wire through the nozzle.

The regulating needle valve may be removed by something striking it or by vibration. Readjust. Tighten the packing gland.

Frost may collect so as to obstruct air (mixture) passage. May occur in hot, dry weather, but is more apt to come in damp weather. It will generally thaw by heat from the engine after the latter is stopped. If not, hold one or more inlet valves open and crank the engine or run it with the cylinders whose valves are allowed to work in the usual manner. Pour on hot water from the cooling system.

Water may splash in and freeze. If in one pipe to one of the cylinders only, hold the mixture inlet valve of that cylinder open and run the engine. If there is any passage for the mixture some will be drawn into the cylinder, heated and forced back through the pipe. Crank the engine by hand with inlet held open if it will not run by its own power.

The throttle valve may stick while running. If caused by frost, remedy as in previous paragraph.

Water in gasoline will stop the engine. Open the valve or remove the plug at the bottom of the gasoline reservoir of the carbureter. If there is no opening at the bottom, close the air inlet and crank the motor. The suction may draw the water out. Siphon out with a piece of rubber tubing, a bent pipe, or remove the carbureter and pour out the contents.

Stoppage in the pipe connections. If a gasket or other packing is used in the gasoline pipe, the passage may be stopped by packing becoming squeezed into it.

Gasoline may not flow in after the supply has been completely exhausted and gravity tank refilled (air lock). Blow into gasoline tank so as to cause air pressure above the gasoline.

438. Q.—What will cause stoppage of the circulating (cooling) water?

A.—Steam from a hot cylinder may force itself back into the pump and prevent the pump from forcing the water through the pipes. A check valve at the pump discharge outlet prevents this trouble. The pump may not run on account of a loose or broken part.

When the system has been drained and refilled, air

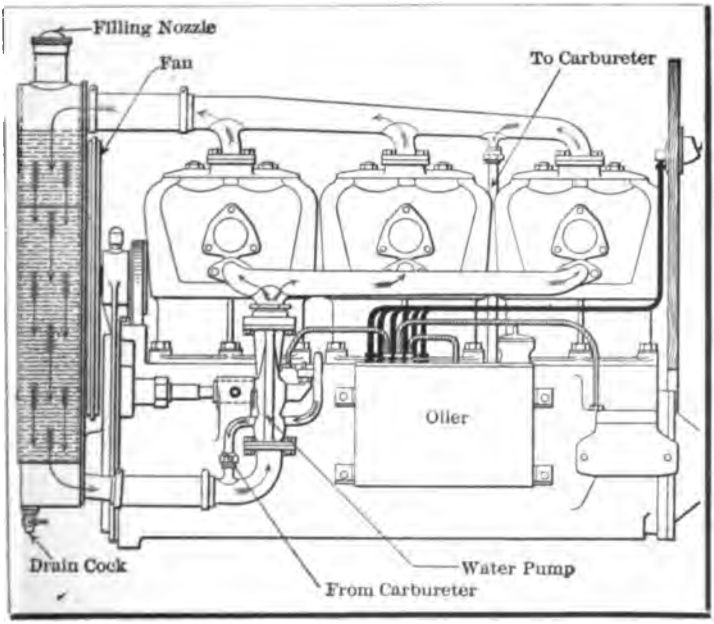

FIG. 98—SECTION OF THE WATER COOLING SYSTEM, SHOWING THE FLOW OF WATER WHERE A PUMP IS EMPLOYED

in the pump may prevent proper circulation (air lock).

Waste or dirt may stop the pipes.

A gasket or packing may be squeezed into the pipe so as to close it.

A flattened or dented pipe.

A short kink in a rubber hose.

A piece of the hose lining may get loose and hang so as to act as a checkvalve to stop the flow. The lining is especially apt to get loose near couplings.

439. Q.—An air lock in the cooling system may occur at what time?

A.—When fresh water is put in after the system has been completely drained. Air interruption in some part of the system prevents circulation of the water. This is not apt to occur except when there is a considerable amount of tubing and pipes.

After putting in fresh water it is advisable to run the engine idle for some time in order to get the air removed and circulation properly started. If the system has a petcock or other means of opening into the pipes at the high points, the air can generally be allowed to escape by opening the pipes at the high points.

440. Q.—When may an air lock occur in the fuel system?

A.—After the fuel has all been used and a fresh supply is then put in, an air lock in the pipe between the fuel tank and the carbureter sometimes prevents free flow of the fuel to the carbureter. The motor gradually stops after it is started. When this condition exists, the behavior of the motor is similar to that when the valve in the fuel pipe is only slightly open.

441. Q.—How may an air lock be removed from the fuel system?

A.—Probably the simplest way to remove an air lock is to blow into the top of the fuel tank while holding the carbureter primer in the position for priming. If this does not answer, the pipe may be loosened at the carbureter so as to allow gasoline to flow out freely. Blow into the tank while the pipe is loosened.

442. Q.—What effect has water in gasoline?

A.—If a considerable quantity of water gets into the carbureter it stops the motor sometimes quite abruptly. It is generally not possible to start the motor when there is any considerable amount of water in the carbureter. A small quantity going into the carbureter while the motor is running may only check the speed of the motor during the time it takes to draw the water out of the carbureter. The motor will then pick up speed and run as before.

Water can be removed from the carbureter by opening a valve at the bottom of the gasoline reservoir, if the carbureter has such a valve at the lower part. It can be drawn out by cranking the motor, while holding the hand tightly over the air inlet of the carbureter, except in a few carbureters of unusual design. In the latter types it may be necessary to remove the carbureter and pour out the water. It is advisable to wipe it dry after doing this.

Water sometimes collects in the bottom of a fuel tank, whose outlet to the carbureter is slightly above the level of the bottom of the tank. When the car runs along the sloping side of a road or turns a curve rapidly, some of the water will run down to the carbureter. This sometimes makes a peculiar operation of the motor. It will suddenly drop off in power and speed, then pick up and run again as it should. This may occur several times in succession if the car turns several curves or runs repeatedly over a sloping road.

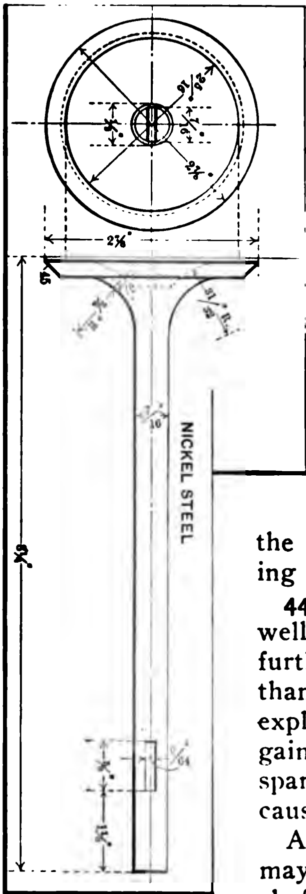

FIG. 99—SECTION OF A WELL-DESIGNED VALVE. NOTE THE RECESSED HEAD FOR LIGHTNESS

443. Q.—If the motor shows good compression when cool, and runs well on light load, but loses power soon after being put on heavy load, as when climbing a hill, and shows no compression in one cylinder if tested immediately after stopping under heavy load, what may be the trouble?

A.—The stem of the exhaust valve is too long. It may be just long enough to touch the valve-lifter when the motor is cool or only slightly warm and the valve closed. The expansion of the valve stem prevents its closing when it becomes very hot.

444. Q.—If the engine runs well for a time, then requires further advancing of the spark than usual, loses power while exploding regularly and possibly gains power again, even with the spark retarded, what may be the cause of the trouble?

A.—The rotor of the timer may be somewhat loose on its shaft and slip backward gradually. When it has lost nearly a quarter of a revolution in a four-cylinder, four-stroke cycle engine, it is in a position to run well if the spark control lever is placed farther in the advance position than usual.

If the rotor gets so loose as to slip back rapidly, the behavior of the engine is apt to be extremely erratic.

The timer rotor should be keyed or pinned to its shaft to prevent its rotation on the latter.

445. Q.—What may be the cause of a sharp click in the engine other than that of the valves and valve mechanism?

A.—Loose piston rings with insufficient lubrication. The looseness is sidewise in the grooves.

The clicking sometimes occurs when the spark is advanced too far with the throttle well open, although the engine is apparently in good order.

General Troubles and Expedients

446. Q.—What may be the cause of a dull heavy knocking or pounding in the car when it runs satisfactorily otherwise?

A.—A loose bearing in the connecting rod of the motor—it generally occurs at the crank end. Loose bearings on main shaft (crankshaft). Flywheel loose on shaft, or a flywheel cracked in its web completely around the shaft so that the two parts of the wheel are loose on each other.

Piston loose in the bore of the cylinder. This does not generally cause pounding except under heavy load with the spark well advanced.

A loose bolt between the motor and frame of the chassis.

Loose couplings in the transmission.

447. Q.—If the motor will not start, although not extremely cold, what course may be followed?

A.—See that there is fuel, and that the valve in the fuel pipe is open.

Prime the carbureter.

Hold the hand over the air intake of the carbureter while cranking the motor. There may be water in the fuel.

Prime the motor by putting a small quantity of gasoline into each cylinder.

Test the ignition system.

Adjust the carbureter.

Look for air leak in the pipes between the carbureter and motor; there may be a loose joint.

448. Q.—If the engine loses power uniformly but quickly, explosions occur regularly, but decrease in force (in a few seconds) and the engine stops, what may be the cause?

A.—No gasoline; water in gasoline; dirt in carbureter (see carbureter troubles).

449. Q.—If the explosions gradually grow weaker and the engine stops after some time, what may be the trouble if the engine cranks by hand with the usual frictional and compression resistance.

A.—The gasoline tank may be air-tight and prevent the free flow of gasoline to the carbureter in a gravity system. Open the vent.

Valve in the fuel pipe may jar shut very gradually.

Air leak develops at intake pipe as by the opening up of joint.

Not enough compression in the compression fuel system. Check-valve in compression pipe may leak or stick. Fuel tank may not be tightly closed.

450. Q.—What are some of the causes of irregular explosions (misfiring) when full impulse is developed at each explosion that occurs?

A.—Dirty or defective spark-plug.

Make - and - break contacts corroded or oxidized.

Battery run down.

Battery too powerful.

Magneto brushes worn away.

Commutator worn out of round.

Trembler out of adjustment.

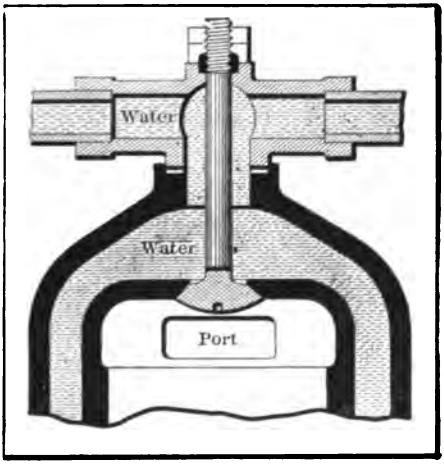

FIG. 100—THE HOLDING DOWN BOLT MAY JAR LOOSE AND CAUSE A LEAK AT THE CONICAL JOINT

Weak spring in magneto interrupter.

Loose contact on trembler.

Contacts of spark-coil corroded or oxidized.

Dirt in timer, weak spring in timer.

Timer worn so that contacts do not come together to close circuit; or so that parts which should not touch come together and close circuit at wrong time.

Timer shaft does not connect metallically (electrically) with body of engine on account of a film of oil surrounding the timer shaft journals.

Timer rotor loose on shaft.

Wiring defective.

Loose connection in wiring. (Battery wire; ground wires; timer wires.)

Wire broken inside of insulation.

Insulation worn off so that the movement of the wire caused by the motion of the car brings it into contact at intervals with the frame of the machine or some other part so as to cause a short circuit.

Poor insulation on high-tension (spark-plug wire).

Weak inlet valve spring or a broken valve-spring.

Sticking or binding of valve stem in guide. Due to dirt or crooked stem.

Water in a leaky cylinder.

451. Q.—If the engine does not give full power, the circulating water heats more than usual, misfires begin and increase in number, what may be the cause?

A.—A cracked cylinder.

A leaky plug between the water jacket and the combustion chamber.

452. Q.—If the engine gives somewhat less than full power but runs steadily without misfiring, what may cause the trouble?

A.—A slight leak. It may be at a valve, the piston, the ignition plug or other parts attached to the cylinder. The leak would affect the compression but slightly as shown by hand cranking. Put lubricating oil around spark-plug and other stopped openings into cylinder and watch for bubbles when testing compression.

Back pressure on account of a clogged muffler. This can readily be determined by opening the muffler release valve or disconnecting the muffler.

Overheated cylinder on account of too late ignition. Overheating is increased by an over-rich mixture.

Fan does not run fast enough.

Improper mixture caused by the carbureter being out of adjustment or by a leak in the pipes between the carbureter and the cylinder casting.

453. Q.—If the engine runs but will not drive the car, what may be the trouble?

A.—Teeth stripped from gears.
Key or pin sheared off.
Clutch spring broken. Clutch slips.
Change speed gears out of mesh (engagement).

454. Q.—If more power than usual is required to drive the car, to what may it be due?

A.—Poor cylinder lubrication.
Lack of lubrication in the bearings.
Hot and cutting bearings.
A dragging brake. (One that does not fully release.)

455. Q.—If an inlet valve or its stem breaks on the road in a four-cylinder engine with one carbureter, how can the engine be arranged to run in this disabled condition?

A.—By closing the inlet port whose valve is broken. It is also advisable to close the exhaust port to prevent scale and dirt from being drawn in through the exhaust pipe. The ports may be closed with a piece of thin sheet metal placed between the pipe and motor, or in some cases the valve lifter can be removed and the valve blocked down by removing the cap over it and placing something between the cap and the valve, putting the cap in place again to hold the valve down. It is generally better to have an opening into the cylinder after the ports have been closed, such as may be made by the removal of the spark-plug. After fixing this, the engine will run on the remaining cylinder.

456. Q.—If the brakes fail when descending a steep grade what would you do?

A.—Throw the gears into slow speed, or next to slow speed if there are four speeds forward, bring the clutch into engagement, thus using the engine as a brake. Open the petcocks if there is connection to them, such as is used for the "mountain brake." This refers especially to sliding gear change-speed transmissions.

457. Q.—If the engine stops and the brakes fail when going up a steep grade, what can be done for safety?

A.—If the engine is on first (slow) speed, leave it there and let it act as a brake. Open the cylinder petcocks if possible.

Throw the change-speed gears either to slow-speed or reverse if not already on slow-speed.

This necessitates steering the car backward and brings out the desirability of some training to acquire the knack.

458. Q.—If one chain breaks beyond repair on a car with side chain drive how can you arrange the car to run by its own power?

A.—Fasten the sprocket at the end of the countershaft from which the chain is gone so that the sprocket cannot revolve. The car can then be driven by the other chain.

The speed of the car will be twice as fast in relation to that of the motor as when both rear wheels are used for driving in the usual manner. The strain on the differential will be twice as great as the ordinary, and the differential gears will run rapidly over each other. The differential should be kept copiously lubricated.

This expedient is hardly applicable to hilly or very bad roads.

459. Q.—If one rear wheel is broken so that it will not carry the weight of the car, but still has some spokes remaining, how can you patch up the car to run by its own power over good level roads?

A.—Place a skid under the axle, and fasten the spokes of the broken wheel to the skid so that the wheel cannot revolve. The car can then be driven by the good wheel. It is not advisable to resort to this expedient except under extreme necessity.

General Adjustments and Repairs

460. Q.—How do you test the front wheels to see that they will take the proper position for running straight ahead?

A.—Place the wheels in position for running straight ahead. Push the car far enough forward to see that it runs in a straight line. Measure between their tires (or rims) at the back part of the wheel at the same distance from the floor as the center of the hub of the wheel. Use a stick cut to the right length and mark the spots on the wheels between which the measurement is taken. Then push the car forward until the front wheels make half a revolution and measure again between the spots previously marked. These spots will be at the front of the wheel after pushing the car forward. The distance should be the same as before.

Do not push the car backward just before measuring between the wheels, since that will give them a position different from that of running forward if there is any lost motion in the parts.

461. Q.—What effect has wear in the distance (transverse) rod upon the position of the front wheels?

A.—It allows the wheels to spread apart in front so that each has a tendency to run forward toward its own side of the road, causing side slipping of the tires and wearing them out rapidly. The distance rod connects the knuckles which support the front wheels.

462. Q.—How do you clean a transmission chain and put it in running order?

A.—One link is removable. It has pins fitted with screws or cotter pins which can be easily withdrawn.

Remove from the sprockets and place in gasoline or kerosene a few hours until the grease is cut free. then take it by the ends and run it back and forth through the gasoline to work out the dirt. Hang it up to dry and then submerge in a good machine oil, moving it about to allow the oil to work in around the pins, then apply a grease, such as axle grease, to retain the oil and prevent as much as possible the entrance of dirt and grit.

463. Q.—How can a broken chain be repaired?

A.—Extra links and pins should always be carried for this purpose. If none are at hand, a short piece of large wire or a wire nail may be used temporarily for a pin. When using such a makeshift for a pin, care must be taken not to rivet it down so as to grip and bind the links together. This repair on the road is not easy in the absence of the proper links.

Wire may be used to replace a link by winding it over the pins to be connected. The pins must be kept at the proper distance apart to correspond with the pitch of the chain, else it will not run on the sprockets. The use of wire in this manner is difficult and only worth while under great necessity.

464. Q.—How should a double chain drive be adjusted?

A.—So that the distance between the driving and driven sprockets (between centers) is the same for both road wheels (on both sides of the car).

The distance between the two sprockets over which one chain runs can be measured by a stick cut to suitable length. This distance can be adjusted by means of the threads and nuts on the radius rods which run forward from the rear axle, one radius rod from near each road wheel.

One of the chains may be tightened more than the other where the distance between sprockets is the same, as above, but this is preferable to an adjustment to make both chains equally tight if they are of different lengths. The latter adjustment tends to make the chain climb on the teeth of the sprocket wheel.

465. Q.—How can a band brake be relined?

A.—Remove the old lining, which is generally fastened in place with rivets, and replace by another with new rivets. See that the band has an even curvature, either the same in diameter or slightly larger than that of the drum.

Copper nuts are more suitable than those of harder material, such as steel or iron. The lining should be countersunk for the rivet heads so that they will not rub against the brakedrum. The drum is apt to be cut by a rivet which rubs against it, especially if the rivet is of hard material.

466. Q.—What materials are suitable for brake linings?

A.—Woven cotton belting (cotton web), woven asbestos with a wire gauze woven in the asbestos, leather, wood fiber, etc. Copper and brass are satisfactory under some conditions, more especially when the brake is lubricated.

467. Q.—How would you put a new leather on the cone of a friction clutch?

A.—Remove the old leather carefully and use it as a pattern for cutting out the new one. Trim the new leather to uniform thickness. A harness-maker can do this readily in a suitable machine.

Fasten one end of the new leather in place on the cone with rivets. Wrap the leather around the cone and cut it a quarter of an inch or so short while holding it in place by hand. Rivet the other end in place. The remaining rivets can now be put in. The leather should fit snugly when pressed into place as the rivets are put in. Copper rivets in deeply counter-sunk holes are suitable.

If the leather is found to be too thick after put in place, it can be turned down in an ordinary engine lathe (machinist's lathe).

It is not actually necessary for the clutch leather to be all one piece. Two pieces can be used with entire satisfaction. More rivets are required, however.

468. Q.—How do you adjust a loose bearing of the plain journal type?

A.—Remove one of the shims, if any are used, and tighten the box till it just moves freely on the journals when there is no oil on it. (Shims are thin pieces of metal placed between the cap and body of the box.) It is far better to adjust with a little looseness rather than a snug fit.

469. Q.—How can a cracked casting such as the metal shell around the water jacket space or some housing or casting of the car be repaired?

A.—There are various processes which can be applied according to the conditions of the case. Some of these are brazing, welding with oxy-hydrogen flame, oxy-acetylene flame, etc. Repair can also be made in the foundry in some cases by pouring molten metal against the broken part so as to melt part of it away and fuse the liquid metal into the remainder so as to form a complete piece. Another method is to put salammoniac solution in the crack when the metal is iron or steel. This causes rust which closes the crack more or less effectively. It may be remembered that sal-ammoniac is used in ordinary dry batteries.

It is advisable to consult those who make such repairs as a business.

A cracked water jacket can sometimes be successfully repaired temporarily by rubbing into or over the crack some one of the plastic compounds (paste) such as plumbers use for a similar purpose.

470. Q.—How can you make an emergency repair of a broken leaf-spring—one of those which carry the body of the car?

A.—Place a bar of steel along the spring and fasten the bar and spring together with U-shaped clips, somewhat like those commonly used for fastening the spring to the axle. Two or more clips must be used. The elastic action of the spring is of course lost to a considerable extent, or even wholly.

A rubber bumper or a block of wood will hold the body up if the spring will still keep the axle in position otherwise.

471. Q.—What is a convenient way of removing a valve spring of the coiled form?

A.—A bar of steel, thin and forked at one end to straddle the valve stem and press against the washer at the end of the spring, is a suitable tool. Put it under the spring, or washer, and compress the spring by lifting on the bar. The key can then generally be readily removed from the valve stem so as to leave the valve free to be lifted out and the spring removed.

If the forked bar can be used as a lever resting on a fulcrum the operation is more easily performed. Some such bars are provided with a chain having a hook to catch on the head of the motor cylinder.

Some of the earlier forms of springs have the end stuck through a hole in the valve stem. No key is used with them. The forked bar can be caught in the spring just above the end of the latter and lifted to relieve the pressure of the spring against the hole in the valve stem. The end of the spring can then be forced out of the hole with more or less difficulty.

472. Q.—When putting a gasket or packing in a pipe-connection, what precautions must be taken?

A.—That the packing does not squeeze into the pipe so as to stop the passage. This is most apt to occur when candlewick packing is used.

Sheet packing between metal parts should be as thin as will allow it to adjust itself to the irregularities of the surfaces.

If the joint is to be opened frequently, coat one side of an asbestos, paper or canvas gasket with graphite and the other side with oil or varnish. This facilitates removals and holds the gasket in place.

473. Q.—How can a cracked or broken gasoline pipe be temporarily repaired?

A.—Slip a piece of rubber tubing over the pipe, or wrap a piece of sheet rubber around it and bind with

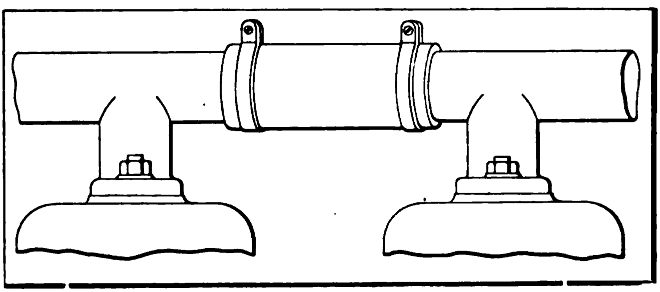

FIG. 101—A BROKEN GASOLINE PIPE CAN TEMPORARILY BE REPAIRED IN A SIMILAR MANNER TO THAT USED IN JOINING WATER PIPING

tape and string. Adhesive tape will not hold long on account of the gasoline dissolving the rubber in it.

Or put rather soft bar soap on the pipe and wrap with tape such as is used on clothing. Bind with cord. In the absence of tape a piece of strong paper may answer. Rubber cement, instead of soap, may serve for a very short time.

474. Q.—How can a leaky radiator be repaired?

A.—Sometimes it is possible for the novice to repair it by soldering. It is generally a decidedly difficult operation, however, and there is danger of doing more harm than good by opening up some of the other soldered joints. In such a case the only satisfactory solution is the skilled repair man.

A honeycomb radiator can be temporarily repaired sometimes by putting a small bolt with a soft washer at each end through the tube around which the leak occurs; tightening the nut on the bolt will draw the washers against the ends of the tube so as to stop the leak. A rubber washer or one of steam packing in the sheet form will answer. The soft washers should be backed by stiff metal ones.

475. Q.—How can a loose nut be prevented from jarring off?

A.—A temporary expedient is to wrap a piece of string under the nut so that when the latter is drawn tight it will pinch the string between it and the part against which the nut would otherwise bear directly. In case the nut is in a place that becomes very hot, some such material as asbestos cord with a wire core is suitable. A thin copper wire may answer in any case.

A split lock-washer under the nut will, of course, always hold it in place. It is sometimes objectionable, however, because of its cutting and gouging the metal when the nut is removed.

Tire Repairs

476. Q.—How can the inner tube of a double tire be removed and replaced by another?

A.—First lift the wheel free from the ground with a jack and deflate the tire. If of the clincher type, with tire lugs (clamps), first loosen the nuts on the radial bolts that hold the heads of the lugs down against the inner surface of the outer shoe; also remove the nut, or nuts, from the valve stem. Remove one side of the outer shoe from the clincher groove. A pair of blunt iron (prodders) about 3-4 inch to 1 inch wide and 1-8 inch or less thick at the end are most commonly used for prying the tire off on one side. Care must be taken not to pinch and tear the inner tube. Remove the inner tube by pulling it out by hand, beginning at the part farthest from its valve, and then by the use of an iron suitable in shape for raising the outer shoe somewhat, take out the valve from the rim of the wheel. A double-prong iron can be used by placing a prong under the shoe on each side of the valve.

If the tube has been punctured, feel inside of the shoe to find whether anything is still projecting through the tire that will injure the inner tube when replaced. Also see that there are no sharp points or edges on the tire lugs.

Rub a liberal supply of powdered talcum (soapstone) on the inner tube, also place a liberal supply inside the shoe and rotate the wheel slowly, at the same time kicking or striking the shoe so that the powder will be well distributed over its inner surface. Place the tube in the shoe. Inflate it slightly to straighten it out, which may need some assistance by hand. Pass the hand carefully around the tube to make sure there are no twists or folds. Then by the use of tire irons force the shoe back into place, remembering that each clamp must be lifted as the part of the shoe next to it is sprung into position.

Push the clamps in to see whether the inner tube lifts freely. If not, it may be pinched under the clamp and should be released. There should be a leather or rubber washer under the clamp nut to prevent the entrance of water and grit to the tire. Tighten the clamp by hand and inflate the tire so that it will bulge only slightly at the sides where it rests on the ground. (Pressure gauges to use with a tire pump can be purchased.) Try the clamps again to see that they are tight. Thumb nuts on the clamps can be made tight enough by hand.

When the outer shoe is to be completely removed from the rim, the clamps or lugs must be taken entirely out after removing the inner tube. A tire iron suitable for lifting the shoe at that point facilitates this operation. Numerous forms of tire irons are in use. None seems to have any great advantage over the others.

A stubborn tire shoe can sometimes be quickly put in place by sitting down and pushing against its side with both feet, at the same time striking the flat part of the bead with a well-rounded hammer.

Various convenient tools for forcing a tire-shoe back into place on the wheel can be found on the market.

477. Q.—How can a tire be tested for a leak at the valve after inflation?

A.—Turn the wheel so that the valve is at the upper part and hold a glass of water around the valve. Bubbles will pass out through the water if the valve leaks. Or saliva can be put around the valve stem cap and note taken of the appearance of bubbles.

The valve itself may be leaky, but the cap on the stem tight. To determine this, move the cap and test as above.

The best remedy for a leaky valve is a new one. They are inexpensive. The valve can be screwed out with the slotted end of the cap. A leaky valve can sometimes be made tight temporarily by putting a drop of oil on it. Use only a drop. More may injure the inner tube by softening it.

478. Q.—How can an inner tube be examined for punctures or slight leaks?

A.—If the tube has been punctured by a nail or a wire look for two holes; one next the tread and the other on the side next the rim. The punctures may be invisible with the tube deflated. Then pump up the inner tube to a light pressure and examine by stretching the rubber while holding it near the face or ear. Too much pressure will cause it to suddenly bulge at one point and possibly rupture. If the leak cannot be found in this manner, immerse the tube in water and look for bubbles while stretching the rubber. The valve should also be immersed.

479. Q.—How can a temporary patch be put on the outside of an inner tube?

A.—Manufactured patches can be secured for this purpose, or a patch can be cut from a sheet of rubber or an old inner tube, whose material has not deteriorated appreciably. Only rubber patches should be used on the inner tube. Canvas, etc., will not do, because it does not stretch like rubber.

Rub the tube around the puncture with a piece of sandpaper, emery paper, or a clean fine file over an area somewhat larger than the patch to be used. The space to be covered by the patch must be clean and free from partly torn out pieces of the rubber. The clean space should be somewhat larger than the patch.

Liquid rubber cement is used for fastening a temporary patch in place. There are almost numberless makes of it. Some dry, or set, much more rapidly than others. The directions for using generally accompany the better grades.

See that the tube is perfectly dry, especially that there is no water on it when beginning to cement on the patch. The patch should also be dry.

In the absence of directions on the cement tube or box the patch may be put on as follows:

Apply the cement with a brush to the rubber tube and one side of the patch. Wait till the cement dries enough to become sticky. Then place the patch on the tube, taking care to put it on with a rolling motion so as to exclude all air from beneath it. Press the patch on firmly, first pressing at the center and gradually working out toward the edges. A small, narrow roller in the end of the bar is a suitable tool for pressing the patch on. It is used by rolling it back and forth across the patch, gradually working sidewise at the same time. The tube should be laid on a smooth surface under the place where the patch is being applied. Lay a smooth piece of board on the top of the patch and weight it. Leave until the cement sets.

If it is not known how long it will take the cement to set, a couple of test pieces of rubber may be stuck together with some of it after the patch is put on. The test pieces can be pulled apart, a little at a time, to note the condition of the cement.

Coat the patch with talcum or other powder to prevent its sticking to the shoe.

A patch put on in the above manner without vulcanizing will last for some time if the tire does not become hot, by rapid running of the car. Heat softens the cement and the patch becomes loose.

The patch is sometimes put inside the tube by the repairman.

480. Q.—How is vulcanizing done when repairing a tire?

A.—After the patch is put on, it is heated to a temperature of about 250 degrees Fahrenheit, or slightly hotter, for a length of time which depends on the amount of rubber that has to be heated. More volume of rubber must be heated when vulcanizing the patch on a tire-shoe than on the inner tube. It is not generally necessary to apply full temperature more than fifteen minutes.

Specially prepared sheet rubber and rubber cement in paste form are generally used for vulcanized tire repairs. A patch is put on in practically the same manner as in the preceding question, and then vulcanized.

Numerous forms of vulcanizers for repair purposes are on the market. The means of heating them is generally electricity, steam, gas or gasoline. A thermometer or a steam gauge often forms part of the vulcanizer. The steam pressure in the vulcanizer corresponds to a known temperature; thus, a steam pressure of fifteen pounds per square inch by gauge corresponds to 250° Fahrenheit of temperature, and thirty pounds per square inch by gauge corresponds to about 275° Fahrenheit. The latter temperature is used on heavy tire-shoes.

The rubber is easily injured by over-heating. Care must be exercised to prevent the vulcanizer from becoming too hot. Some electric vulcanizers are provided with automatic cut-outs, which turn off the current at the temperature to which they are adjusted.

It is advisable to experiment on some rubber which is not valuable before attempting to repair a tire.

481. Q.—How can a small cut or tear in a tire shoe be repaired?

A.—Scrape the rubber clean in the cut or tear and fill it with prepared plastic rubber. Then vulcanize it at the repaired place.

482. Q.—Before putting a tire shoe on a rim, what should be done?

A.—Clean the rim thoroughly where the tire touches it. Scrape and file off all rust and dirt. The edges of the clinch should be carefully smoothed with a file to remove roughness. The file should be fine cut so as not to leave ridges and points; clean well under the clinch.

483. Q.—What injury is almost certain to result by running with a tire too soft (insufficiently inflated)?

A.—Rimcutting of the tire where the clinch of the rim bears against it. The rimcutting occurs in the groove between the bead and body of the tire.

484. Q.—If a tire is run completely deflated, what injury is apt to occur?

A.—If there are tire lugs they are liable to tear the shoe and cut the tube.

When there are no tire lugs the shoe may creep around and cause the tube to pull so hard on its valve as to tear the tube at the valve.

Rimcutting is almost certain to occur in either case.

485. Q.—A tire that is badly worn on the tread can be repaired in what manner?

A.—By retreading. The tire should be carefully examined, especially for rimcutting, to determine whether it is worth retreading.

486. Q.—How can a tire shoe that has a rather large hole through it be run?

A.—By putting a protective lining canvas paster inside of it and a protector outside. The latter is generally laced on; it is usually made of rubber-covered fabric or of leather, as found on the market. The patch, or lining, for the inside of the shoe is usually made of rubber-covered fabric. It is covered with adhesive rubber on the side intended to go against the inside of the shoe. Some internal patches are made to extend under the clinch of the rim.

When putting a protector over a tire shoe, the tire should be first partly inflated, say to almost fifteen pounds per square inch, and the protector then laced on. Then when the tire is fully inflated the protector will be tight in place.

487. Q.—In case of a large hole, such as a blow-out, in a tire shoe, how can it be repaired?

A.—By separating the layers of the fabric and inserting other fabric between them. The tire must be afterward covered with plastic rubber compound at the patch and vulcanized. It is work for an expert.

488. Q.—How is the necessity of removing a tire-shoe from its rim obviated on the road?

A.—By the use of detachable rim, spare wheel, etc.

489. Q.—How can a tire be inflated on the road without the labor of pumping air into it by hand?

A.—By carrying a tube of compressed air. They can be obtained in various sizes, ranging from that which will inflate a large tire once to that which will give several inflations.

Air pumps that can be driven by the motor are also obtainable.

490. Q.—What are suitable air pressures for different sizes of tires?

A.—There is great variation in the pressures recommended by the different tire manufacturers. The following is probably a fair average for ordinary loads on the wheels:

Diameter of tire Inches.	Air pressure in tire, Pounds per sq. in.
2½	45
3	55
3½	65
4	75
4½	85
5	90
5½	95

Lower pressures are used by some, especially for light loads. The pressures run considerably higher in several cases for heavy loads.

Care of Gasoline

491. Q.—How can a liquid (gasoline, oil, etc.) be best poured from a can without a spout?

A.—Tip the can quickly so that the top passes beyond a vertical position with the opening at the highest part. The liquid will then flow clear of the can without dribbling. This method also gives the most free access of air and the smoothest flow.

492. Q.—What precaution should be taken when pouring gasoline into the automobile tank?

A.—Stop the engine and extinguish all lights that burn with a flame. This should be especially observed in a closed room.

493. Q.—Where should the gasoline tank, pipes and carbureter be placed on an automobile?

A.—In positions such that it is not possible for gasoline to drop on the exhaust pipe or muffler in case of leakage. The tank should not be close to the exhaust outlet or any part that will warm it much.

494. Q.—How can water be separated from gasoline when filling the tank of the automobile?

A.—By straining it through a closely woven cloth, felt or chamois skin, taking care that the strainer is

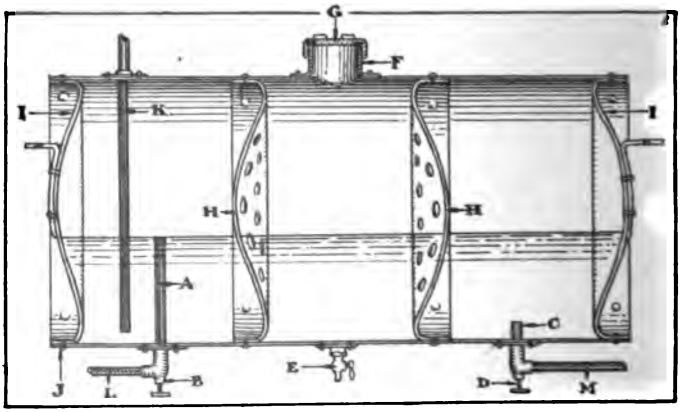

Fig. 102—SECTION OF A GASOLINE TANK THAT CAN BE USED EITHER FOR PRESSURE OR GRAVITY FEED. THE TRANSVERSE SECTIONAL PLATES ARE TO PREVENT SWAYING OF THE LIQUID

wet with gasoline before the water touches it. The gasoline will then pass through freely while the water will be retained. "Linty" cloth should not be used.

Water in gasoline always settles to the bottom, so that by pouring the gasoline out carefully no water will be carried with it, except the minute quantity which is held in suspension.

495. Q.—If gasoline vaporizes in a closed room, where does the vapor gather?

A.—At the floor. Gasoline vapor is heavier than air.

496. Q.—Where should openings be made in a room to allow gasoline vapor to escape?

A.—In or near the floor.

497. Q.—Will ventilator shafts leading upward from openings at the floor of the room remove gasoline vapor in all kinds of weather?

A.—No. In clear weather the circulation of air will ordinarily be enough to carry the gasoline vapor with it, but in very damp, foggy weather, there will generally be no circulation in the ventilators and the vapor of gasoline will remain at the floor.

498. Q.—What is the only sure method of preventing the collection of gasoline vapor in a garage?

A.—To ventilate it thoroughly with a forced draft, drawn out through openings in or near the floor. The ventilation may be forced either by a fan or steam coil.

499. Q.—When gasoline vapor is present in a closed room, in moderate quantities, where is the greatest danger of fire?

A.—At or near the floor.

500. Q.—What are some of the possible sources of ignition of gasoline vapor in a garage?

A.—The spark at the trembler of an induction coil; a "flash" at the timer; a flash at the brushes of a magneto or electric generator on the automobile; the exhaust when there are any cracks or openings in the pipe connections near the engine; sparks blown from the exhaust openings; the exhaust when muffler explosions occur; skidding of iron shod wheels on a cement floor, or even on a wooden floor with nails in the boards or with sand covering them; the spark from a nail in the heel of a shoe striking a cement floor, or from a metal tool dropped on the floor.

501. Q.—From what source is gasoline vapor apt to come in a garage?

A.—From a leaky carbureter, gasoline tank or a pipe connection. The carbureter frequently starts flooding when the car is standing in the garage, and corrosion of the tank, eating away of the solder, etc., sometimes open the tank so as to allow considerable of the contents to run out.

502. Q.—What are some of the precautions that should be taken to prevent fire in a garage?

A.—Above all it should be well ventilated. Gasoline should be turned off at the automobile tank valve, only incandescent lights with keyless sockets should be used for examining the car; all electric switches, key sockets, etc., placed high in the room.

Never strike a match or use a candle or lamp to examine an automobile containing gasoline in a garage.

503. Q.—When a small fire is burning over liquid gasoline on the floor, how can it possibly be extinguished?

A.—By putting sand or earth on it with a side throw across the floor. By smothering it with a wet blanket thrown over it.

504. Q.—What danger to life may arise from running an internal combustion engine in a closed room?

A.—Asphyxiation by the exhaust gases, especially in heavy, damp weather. Much care should be taken to avoid this, since there is no warning odor, and fainting may occur before one realizes the danger.

If only a comparatively small quantity of the exhaust gases collect, headache will result.

505. Q.—What precautions should be used in charging the acetylene gas generator?

A.—It should not be filled more than two-thirds full. When lump carbide is used, it expands as the chemical change produced by dropping water on it takes place.

506. Q.—How can the burner tips of an acetylene gas burner be cleaned sometimes?

A.—By picking the carbon deposit out of the orifices with a small pointed instrument, such as a sewing needle. If the deposit is too hard to be picked out in this manner a small drill can be used. The tips should not be treated roughly since they are brittle and weak.

DON'TS

Don't spill gasoline.

Don't clean your engine with gasoline in a small closed room.

Don't throw burning matches on the floor.

Don't look for gasoline leaks with a candle or match.

Don't use a match for seeing how much gasoline is in a tank.

Don't put a dirty stick in the gasoline tank to measure how much you have. Use a clean one.

Don't use too many full strength cells to operate your induction coil.

Don't start your car with a jerk and skidding of the wheels. It racks the machinery and destroys the tires.

Don't turn short curves at high speed. It damages the tires and may break a wheel or bend an axle.

Don't apply the brakes so hard as to skid the wheels.

Don't let the engine race when the clutch is free. It racks the machinery.

Don't run on a flat tire without removing the inner tube. Bare rims stand hard usage and are less expensive than tires.

Don't let your tires stand in oil.

Don't let a ball bearing run tight.

Don't neglect oiling all rubbing parts.

Don't push down on the crank when starting the engine.

TO BE REMEMBERED

See that your brakes operate properly before starting out.

Put in split pins as soon as you have put a bolt or nut in place. Don't leave it to be done after everything is together.

Drain the water cooling system in cold weather and cold storage unless you have a non-freezing solution or mixture.

Carry a pair of anti-skid tire chains on a long run if your tires are not steel shod.

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[NOTE.—Figures refer to question numbers, not to pages.]