# Practical Automobile Instruction

A Complete Cyclopedia of Practical Information for Garage Men, Chauffeurs, Repair Men and Automobile Designers and Engineers

with

Special Reference to Carburetion, Ignition, Starting and Lighting, Motor Troubles and Repairs, Machine Shop Practice, Oxy - Acetylene Welding and Cutting and Carbon Removal by the Oxygen Process

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# The Automobile Handbook.

**Acetylene Gas.** The gas used in gas lamps is generated by water, in minute quantities, dropping on acetylene (carbide of calcium); the gas thus formed passes from the generating chamber into the body of the lamp and is consumed at the lava tips, which are placed in front of a highly polished mirror. The generators in some cases are separated from the lamp itself and placed on the dashboard, or under the hood, a rubber hose conveying the gas to the lamp.

The interior of the carbide chamber or basket being more or less in contact with the water distribution apparatus, the parts of both apparatus are liable to clogging by the formation of lime residue in the generation of gas. If this residue is allowed to collect, it will have to be removed with a chisel, which is a ticklish operation in a light construction like that of a generator, especially around the water valve or its outlet. Acids are sometimes used to remove the deposit, but as they eat the metal, their use should be prohibited. The basket and pot should be thoroughly washed out after each run with water, the water outlets being cleaned with special brushes, when these are obtainable, or by wires, removing all traces of lime. The water valve should be scraped and tested to see whether it seats properly, care being taken not to damage the valve or its seat in so doing. While the valve is dismounted for cleaning it would be well to see that its stem is straight, and that it works with some ease in the threaded portion attached to the water chamber. The gas valves should be cleaned and should seat snugly, so that there will be no leakage past them. This applies also to the gas valves on the lamps.

The best position for the generator is on the running-board just back of the change-gear quadrant, and sufficiently far out from the frame to allow a free circulation of air all around it. The generator will keep cool in this position and will perform its work to the best advantage when properly cooled.

The system of acetylene gas lighting that is generally used on cars having this source of illumination is that making use of tanks in which the gas is stored under compression. These tanks are designed to hold 40, 60 or 100 cubic feet of gas and from them the illuminant is carried to the various lamps through tubing. Attachments are furnished by means of which the lamps may be lighted, dimmed or extinguished from valves and buttons located on the dash or cowl of the car.

**Acetylene Lamp System—Care of.** As there is little night running during the winter months, the acetylene lighting system is more or less neglected, the generator being left with stale or partially used carbide in the chamber, and the residue being allowed to clog up the water port and the waste ports. The rubber lamp connections and gas-bag suffer also by deterioration as well as the burners and gas valves. For the proper maintenance of the system, strict cleanliness should be maintained at all times, and the various parts should be examined and replaced from time to time as necessary. The results of neglect are seen every spring in lime deposits which have to be removed by means of a cold chisel, in porous connections and in clogged burners which resist the cleaning wire and necessitate the scraping of the burners. By following the accompanying directions, the automobilist can depend on having his lighting system in good shape whenever he desires to use it.

**Acid Solutions.** The electrolyte, or solution used in storage battery cells, is made by pouring sulphuric acid into distilled water until the specific gravity becomes 1.25. The solution becomes extremely warm and should not be used until its temperature is about 60 degrees.

**Active Coil, or Conductor.** A coil, or conductor, conveying a current of electricity.

**Adams Revolving Cylinder Motor.** The Adams motor rated at 50 horse power has a five cylinder engine with a bore and stroke of $5\frac{1}{2}$ and 5 inches. In this motor the crankshaft is mounted vertically and has but one throw, the same as ordinarily used for a single-cylinder engine. This crankshaft is stationary—it never revolves, but the five cylinders revolve around it, as does the front wheel of a motor car on the steering spindle. The car is without a radiator, being an air-cooled machine; as the motor cylinders revolve, a cooling fan is not needed. It is without a muffler, each cylinder exhausting directly into a box which incloses the motor. The motor is directly above the transmission set, and as the motor is without a flywheel of any sort, it has been necessary for the designer to carry the double cone clutch within the selective gear set. The drive from the revolving cylinders to the gear-set is through a bevel gear attached to the base of the revolving crank case, and which meshes with a bevel gear on one of the transverse shafts of the transmission. From the transmission to the rear axle, a chain drive is employed. This car is without a float feed carbureter, but uses instead, a pump to maintain a gasoline level in a chamber in which a spraying nozzle and an air valve complete the carbureter. Instead of controlling the motor speed by advancing or retarding the spark, and opening and closing the throttle, it is done by controlling the length of time each intake valve is held open. This motor has but one cam to open all of the ten valves. This cam being in two parts, it is possible to shift one, thereby varying the length of opening given a valve, and allowing a part of the mixture drawn into a cylinder to escape during a compression stroke, so that the explosive pressure can be varied from 90 lbs. to 0, and the power of the motor, and its speed

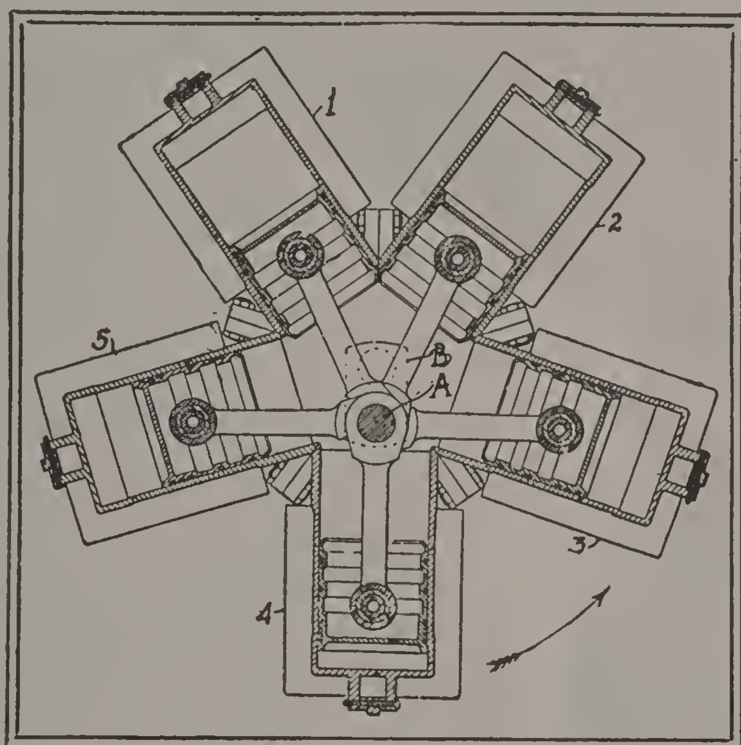



Fig. 1
Sectional View of Adams Motor

correspondingly varied. There is no branching manifold to convey the mixture to the cylinders, neither is there an exhaust manifold.

In Fig. 1 is a sectional view of the motor with its five cylinders designated respectively 1, 2, 3, 4 and 5, with five pistons shown in relative position. The crankshaft A has its one offset B. As each cylinder makes, in unison with the other four, two complete revolutions, it passes through the four cycles of operation common to any four-cycle engine—inspiration, compression, explosion, exhaust. No. 4 cylinder is shown at the end of the out stroke, and the other four at different parts of the stroke; and as each in succession occupies the position of

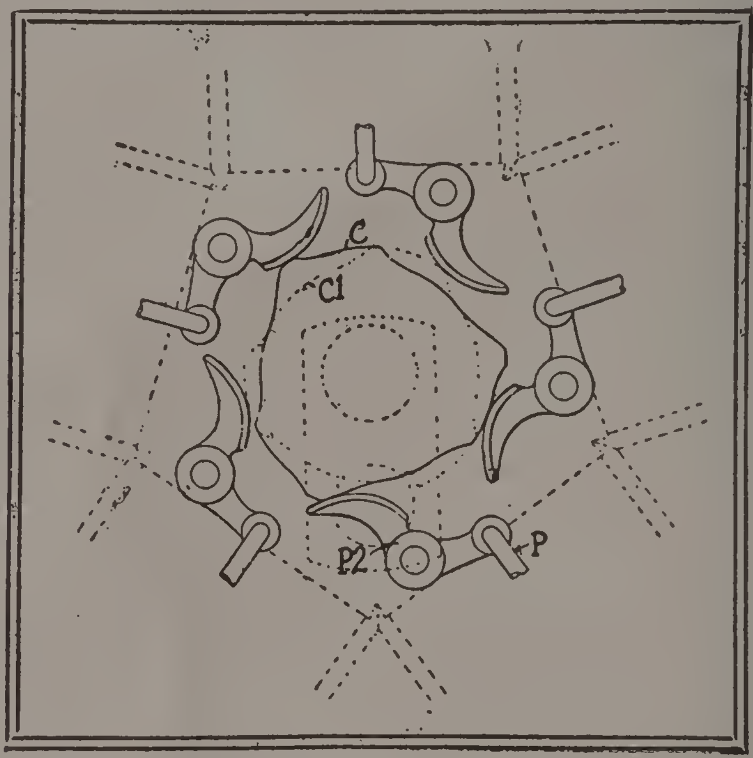



Fig. 2
Cam Diagram—Adams Revolving Cylinder Motor

No. 4, its piston will be at the end of the out stroke. When diametrically opposite to No. 4 they will be at the inner end of the stroke. Thus, as the five cylinders bolted firmly together to a hublike crankcase revolve, the pistons reciprocate in the cylinders, thus performing in perfect sequence, the four functions of cycling. The valves are located in the cylinder heads and opened by rocker arms with push rods paralleling the cylinders on their lower sides. One diagram illustrates the single cam construction and valve operation. On the lower end of the crankshaft is the two-part cam C, CI—Fig. 2. The latter, shown in dotted line, is the movable half for controlling the intake valve period of opening. Both parts of the cam are stationary. On each of the five cylinders is a push rod P, the inner end of which has a peculiar foot P2 pivoted on the crankcase with the curve portion bearing upon the cam, and the short straight arm connected with the push rod P. As the cylinder revolves, the rounded foot follows the contour of the cam, which has been designed so that the four cycles follow one another in order as they do in a four-cycle vertical engine.

The principles of construction and operation of the motor just described are similar to those found in aeronautical work, such as the Gnome and other types of revolving motors. In all of these types the crankshaft is stationary and the cylinder unit revolves. The power for driving is secured by connections on the cylinders. As a general rule, these revolving motors are started from rest by revolving the propeller blades by hand until the first firing stroke is secured. The valve mechanism will differ according to the make of motor. In many cases the fuel mixture is introduced through hollow shafts and castings leading to the cylinders.

**Air.** Air consists, by weight, of oxygen 77 parts and nitrogen 23 parts; by volume, of 21 parts oxygen and 79 parts nitrogen. One pound of air at atmospheric pressure, and 70 degrees, Fahr., occupies 13.34 cubic feet of space. One cubic foot of air weighs 1 1-7 ounces.

TABLE 1.

PROPERTIES OF COMPRESSED AIR

| Comp. in Atmospheres. | *Mean Pressure. | Temp. in Degrees Fah. | *Gauge Pressure. | *Absolute Pressure. | *Isothermal Pressure. |
|---|---|---|---|---|---|
| 1 | 0 | 60 | 0 | 14.7 | |
| 1.63 | 7.62 | 145 | 10 | 24.7 | 30.39 |
| 2.02 | 10.33 | 178 | 15 | 29.7 | 39.34 |
| 2.36 | 12.62 | 207 | 20 | 34.7 | 48.91 |
| 2.70 | 14.59 | 234 | 25 | 39.7 | 59.05 |
| 3.04 | 16.34 | 252 | 30 | 44.7 | 69.72 |
| 3.38 | 17.92 | 281 | 35 | 49.7 | 80.87 |
| 3.72 | 19.32 | 302 | 40 | 54.7 | 92.49 |
| 4.06 | 20.57 | 324 | 45 | 59.7 | 104.53 |
| 4.40 | 21.69 | 339 | 50 | 64.7 | 116.99 |
| 4.74 | 22.76 | 357 | 55 | 69.7 | 129.84 |
| 5.08 | 23.78 | 375 | 60 | 74.7 | 143.05 |
| 5.42 | 24.75 | 389 | 65 | 79.7 | 156.64 |
| 5.76 | 25.67 | 405 | 70 | 84.7 | 170.58 |
| 6.10 | 26.55 | 420 | 75 | 89.7 | 184.83 |

*In pounds per square inch.

**Air Properties of Compressed.** Table 1 gives the Mean pressure, Temperature in degrees Fahr., Gauge pressure, Absolute pressure and the Isothermal or heat pressure of air under compression of from 1 to 6.10 atmospheres.

As energy in the form of power must be used to compress air to any desired pressure, so is energy in the form of latent or stored heat given up by the air during the operation of compression. This heat consequently increases the pressure resulting from the compression, but not directly in proportion to the degree of compression in atmospheres.

This increase of pressure above the Adiabatic or calculated pressure is known as the Isothermal or heat-pressure. As the values of this pressure cannot be calculated by the use of ordinary mathematics, but involve the use of logarithms, Table **1** gives these values for each degree of compression given.

Many persons who are not familiar with the properties of gases, estimate the pressure resulting from the compression to a given number of atmospheres, as the number of atmospheres multiplied by the atmospheric pressure, which at sea level is taken as 14.7 pounds per square inch.

This assumption is erroneous and will often lead to grievous mistakes in motor design, generally giving too much compression, which results in premature ignition, commonly known as backfiring. Such methods of calculation would be true if the air, after compression, was stored in a reservoir and allowed to cool, but under no other conditions.

**Air, Relation of to Gasoline.** Owing to the fact that automobile gasoline is composed of various percentages of the several available fractions of hydrocarbon distillates, it is not possible to fix an exact basis for the relative proportions of air to fuel. However, the average carbureter is capable of altering the ratio of air to fuel over broad ranges, and it is not necessary to know the exact ratio in order to attain the best results. But it is necessary to approximate an average ratio as nearly as possible in designing and adjusting carbureters in order to allow for these variations up and down.

The mixture becomes explosive when 10,000 volumes of air dilute one volume of gasoline, but the best results follow when the ratio is one volume of liquid gasoline to 8,000 volumes of air. With one of gasoline to 3,500 of air the mixture is non-explosive.

The proper proportions, from a theoretical standpoint, are not always best for practical use because a mixture slightly weaker than the one found by calculation is more economical in the use of gasoline. Such a mixture, of course, reduces the power slightly, but the proportion of power lost is much less than the proportion of gasoline saved. Because of the differences in speed of the mixture and the differences in the volume being admitted to the engine, it is almost impossible to secure a proportion that will be uniformly satisfactory over a range of all engine speeds. A larger volume of mixture, at a slow speed, may be required in ascending a hill at ten miles per hour than in traveling on a level road at three times this speed. In the latter case, the velocity of the mixture will, however, be much greater. It is best to secure a mixture that will give satisfactory results from the standpoint of power at low and medium speeds rather than at high.

**Air, Relation of in Gasoline Mixture.** Gasoline is a somewhat uncertain mechanical mixture of several hydrocarbon (fractional) distillates, in which the compound "hexane" is supposed to be the major portion. This compound answers to the formula $C_6 H_{14}$, the products of combustion of which will be $CO_2 + CO + H_2O$, in which $CO$ will not be found if the combustion is complete. A final expression of complete combustion will be as follows:

$$2 C_6 H_{14} \times 19 O_2 = 12 CO_2 + 14 H_2 O.$$

Taking into account the atomic weight of the elements, the volume of air required in the complete combustion of 1 pound of hexane may be set down as follows—atomic weight of the elements involved:

| | |
|---|---|
| Carbon (C) | 12 |
| Hydrogen (H) | 1 |
| Oxygen (O) | 16 |

The molecular weight of $C_6 H_{14} = 6 \times 12 + 14 \times 1 = 86$; the required oxygen will weigh (molecular) $19 \times 16 = 304$; the ratio of the compound hexane, then, to the combining oxygen will be

$$\text{Ratio} = \frac{304}{86} = 3.54, \text{ nearly.}$$

Considering 1 pound of hexane, the weight of oxygen required for its complete combustion will be equal to the ratio as above given, i.e., 3.54 pounds, nearly.

Since the oxygen is taken from the air, it is necessary to consider dry air in the attempt to determine as to the weight of the same. This air, under a pressure of 1 atmosphere, and at a temperature of 60 degrees Fahrenheit contains 0.23 pounds of oxygen, hence the required air=

$$\frac{3.54}{.23} = 15.39, \text{ in pounds.}$$

**Air Resistance, Horsepower Required to Overcome.** The power required to move a plane surface, such as the vertical projection of an automobile, against the air, does not become of much importance until the car attains a speed of 10 to 12 miles per hour, when it becomes an important factor.

The horsepower required to propel an automobile against the resistance of the air may be approximately calculated by the following formula. Let V be the velocity of the car in feet per second, and A the projected area of the front of the car in square feet—this may be assumed as the height from the frame to the top of the body multiplied by the width of the seat at the floor line of the car—let H.P. be the horsepower required to overcome the air resistance, then

$$\text{H.P.} = \frac{V^3 \times A}{240{,}000}$$

To simplify the use of the above formula, Table 2 gives speeds in miles per hour corresponding to their respective velocities in feet per second and also cubes of velocities in feet per second.

TABLE 2.
CUBES OF VELOCITIES IN FEET PER SECOND.

| Miles per Hour of Car. | Feet per Second. | Cube of Velocity in Ft. per Second. | Miles per Hour of Car. | Feet per Second, | Cube of Velocity in Ft. per Second, |
|---|---|---|---|---|---|
| 10.2 | 15 | 3,375 | 34.0 | 50 | 125,000 |
| 13.6 | 20 | 8,000 | 40.9 | 60 | 216,000 |
| 17.2 | 25 | 15,625 | 47.7 | 70 | 343,000 |
| 20.4 | 30 | 27,000 | 54.4 | 80 | 512,000 |
| 27.2 | 40 | 64,000 | 61.3 | 90 | 729,000 |

To ascertain approximately the horsepower that will be necessary to drive a car against a wind of known velocity, the speed of the car must be added to that of the wind, and the required horsepower may be found either by use of the formula given or by reference to Table 3, which gives the horsepower per square foot of projected surface required to propel a car against the resistance of the air, with varying speeds in miles per hour or velocities in feet per minute.

TABLE 3.
HORSEPOWER REQUIRED PER SQUARE FOOT OF SURFACE, TO MOVE A CAR AGAINST AIR RESISTANCE.

| Miles per Hour of Car. | Feet per Second. | Horse-power per Square Foot of Surface. | Miles per Hour of Car. | Feet per Second. | Horse-power per Square Foot of Surface. |
|---|---|---|---|---|---|
| 10 | 14.7 | 0.013 | 40 | 58.7 | 0.84 |
| 15 | 22.0 | 0.44 | 50 | 73.3 | 1.64 |
| 20 | 24.6 | 0.105 | 60 | 87.9 | 2.83 |
| 25 | 36.7 | 0.205 | 80 | 117.3 | 6.72 |
| 30 | 44.0 | 0.354 | 100 | 146.6 | 13.12 |

The horsepower given by the formula and Table 3 simply refers to the additional power necessary to overcome air resistance and not to the actual power required to propel a car at a given speed; this is entirely another matter.

**Alcohol.** There are two kinds of alcohol; methyl, or wood, alcohol, $CH_4O$, and ethyl, or grain, alcohol, $C_2H_6O$. The former has been found objectionable for use in internal-combustion engines, because it apparently liberates acetic acid, which corrodes the cylinders and valves.

As alcohol is a fixed product, and the same the world over, it has a great advantage as a motive power over gasoline and other petroleum products. Denatured alcohol contains 4,172 heat units per pound as compared to 18,000 for gasoline, and, as its cost is higher, this fuel would not seem practicable from an economic standpoint. By mixing the alcohol, however, with a high grade of gasoline, its price is lowered, and the number of heat units per pound greatly increased. Mixtures containing 50 per cent alcohol have a calorific power of 11,086 heat units per pound, and as it has been found by numerous tests in France that it requires no more of this mixture than of gasoline to develop a certain power, its efficiency is considerably greater, reaching a value of 24 per cent as compared to 16 for the gasoline motor. In some recent experiments in France with a motor specially constructed for the use of alcohol, the consumption was lowered to 0.124 pound per horse power, using 50 per cent carburetted alcohol.

Grain, or ethyl, alcohol has a specific gravity of .795, and may be obtained by distillation from corn, wheat, and other grains, potatoes, molasses, or anything containing sugar or starch. When pure, it absorbs water rapidly from the air, more rapidly in fact than it loses its own substance by evaporation; but when diluted to the proportion of about 85 per cent. alcohol and 15 per cent. water, it evaporates practically as if it were a single liquid and not a mixture. In France, it is denatured for motor purposes by the addition of 10 liters of 90° wood alcohol, and 500 grams of heavy benzine, to 100 liters of 90° ethyl alcohol. In Germany, benzol is added to the extent of 15 per cent. for denaturing, no wood alcohol being used. In the United States the so-called "denatured" alcohol, which is that used in the arts and industries, is composed of ethyl or grain alcohol, to which have been added certain diluents calculated to make it unfit for drinking. The Internal Revenue regulations specify that to 100 volumes of ethyl alcohol there must be added 10 volumes of methyl (wood) alcohol and one-half of one volume of benzine, or to the same quantity of ethyl alcohol must be added 2 volumes of wood alcohol and one-half of one volume of pyridine bases.

As compared with gasoline as a fuel for internal-combustion motors, alcohol exhibits several striking peculiarities.

First, the combustion is much more likely to be complete. A mixture of 90° alcohol vapor and air will burn completely when the proportion varies from 1 of the vapor with 10 of air to 1 of the vapor with 25 of air, thus exhibiting a much wider range of proportions for combustibility than is the case with gasoline. As the combustion is complete, the exhaust is practically odorless, consisting only of water vapor and carbon dioxide.

Second, the inflammability of an alcohol mixture is much lower. This is due partly, no doubt, to the presence of water in the alcohol, which is vaporized with the alcohol in the engine and must be converted into steam at the expense of the combustion.

For these reasons, the compression of an alcohol mixture is carried far above that permissible with a gasoline mixture, without danger of spontaneous ignition. The rapidity of combustion of alcohol in an engine is considerably less than that of a gasoline mixture, and for this reason the speed of alcohol engines must be somewhat slow.

The facts that alcohol of sufficient purity for use in engines can be produced from the waste products of many of the country's industries, and at a nominal cost, and that many thousands of acres of land, unfit for the cultivation of first-class grain, etc., may be utilized for the production of vegetable matter rich in the elements which form alcohol upon fermentation, lead to the supposition that within a few years, or as soon as there is a sufficient demand for alcohol to warrant the erection of special distilleries, it may be purchased at such a low price that it will not only be commercially possible, but will in a measure force gasoline and other petroleum distillates from the field.

A carbureter designed to operate with alcohol can always be used with gasoline, but the reverse conditions are not true, that is, a gasoline carbureter will not operate successfully with alcohol, except in some rare instances. Alcohol evaporates slower than gasoline and its time of combustion is much slower, but it maintains its mean effective explosion pressure far better than gasoline.

Explosive motors fitted with alcohol carbureters make far less noise than when using gasoline as a fuel, due to the slower burning of the explosive charge, they also make less smoke and smell.

The jet or spray of a float-feed carbureter will have to pass nearly 40 per cent. more liquid fuel than when using gasoline, consequently the opening in the nozzle must be proportionally larger.

A carbureter using alcohol must be fitted with some form of device to heat the alcohol to ensure rapid evaporation—this is usually done by surrounding the mixing-chamber with an exhaust-heated jacket.

The same quantity of alcohol will only take a car two-thirds of the distance that gasoline will, hence greater storage capacity would be needed on a car using alcohol as a fuel.

An explosive motor designed to use alcohol requires a greater degree of compression than a motor of the same bore and stroke designed to use gasoline, in order to develop the same power.

**Alternating Current, Use of.** It is not only useless but absolutely injurious to attempt to charge a storage battery directly from an alternating current circuit. This can only be done by means of a rotary converter, which is in reality a motor-generator, receiving its power from the alternating current and transforming it into a direct current which can be used to charge the batteries.

**Aluminum.** A soft ductile malleable metal, of a white color, approaching silver, but with a bluish cast. Very non-corrosive. Tenacity about one-third that of wrought iron. Specific gravity 2.6. Atomic weight 27.1. It is the lightest of all the useful metals, with the exception of magnesium.

**Aluminoid, Composition and Use of.** Aluminoid is composed by weight of 60 parts aluminum, 30 parts tin and 10 parts zinc. It has a tensile strength of about 18,000 pounds and is a very suitable material for crank chambers, gear cases and small brackets, being light, extremely ductile and readily machined.

**Aluminum Solder.** The following formula is for a solder which will work equally well with aluminum or aluminoid: Tin, 10 parts—cadmium, 10 parts—zinc, 10 parts—lead, 1 part. The pieces to be soldered must be thoroughly cleansed and then put in a bath of a strong solution of hyposulphate of soda for about two hours before soldering.

**Alloys, Composition of.** The proper composition of alloys of metals for the bearings and other parts of an automobile is a very important consideration from a constructive standpoint. Table 4 gives the composition of various alloys of metals and also solders for different uses.

TABLE 4.
COMPOSITION OF ALLOYS.

| | Tin. | Copper. | Zinc. | Antimony. | Lead. | Bismuth. |
|---|---|---|---|---|---|---|
| Bronze, for Motor bearings....... | 13 | 110 | 1 | ... | ... | ... |
| Bronze, for Axle bearings........ | 25 | 160 | 5 | ... | ... | ... |
| Brass, for light work, other than bearings .................... | ... | 2 | 1 | ... | ... | ... |
| Bronze flanges, to stand brazing... | ... | 32 | 1 | ... | 1 | ... |
| Genuine Babbitt metal........... | 10 | 1 | ... | 1 | ... | ... |
| Bronze, for bushings ............ | 16 | 130 | 1 | ... | ... | ... |
| Metal to expand in cooling, for patterns .................... | ... | ... | ... | 2 | 9 | 1 |
| Genuine bronze ................ | 2 | 90 | 5 | ... | 2 | ... |
| Solder, for tin .... ............ | 1 | ... | ... | ... | 2 | ... |
| Spelter, hard .................. | ... | 1 | 1 | ... | ... | ... |
| Spelter, soft ................... | 1 | 4 | 3 | ... | ... | ... |

It should be understood that no definite rule can be given for the proportioning of any one alloy for the reason that a slight change in the amount of one or more of the elements may suit the metal exactly for some proposed use, while a porportion only slightly different might give unsatisfactory results.

**Ammeter, Construction of.** Ammeters for automobile use are constructed on the principle

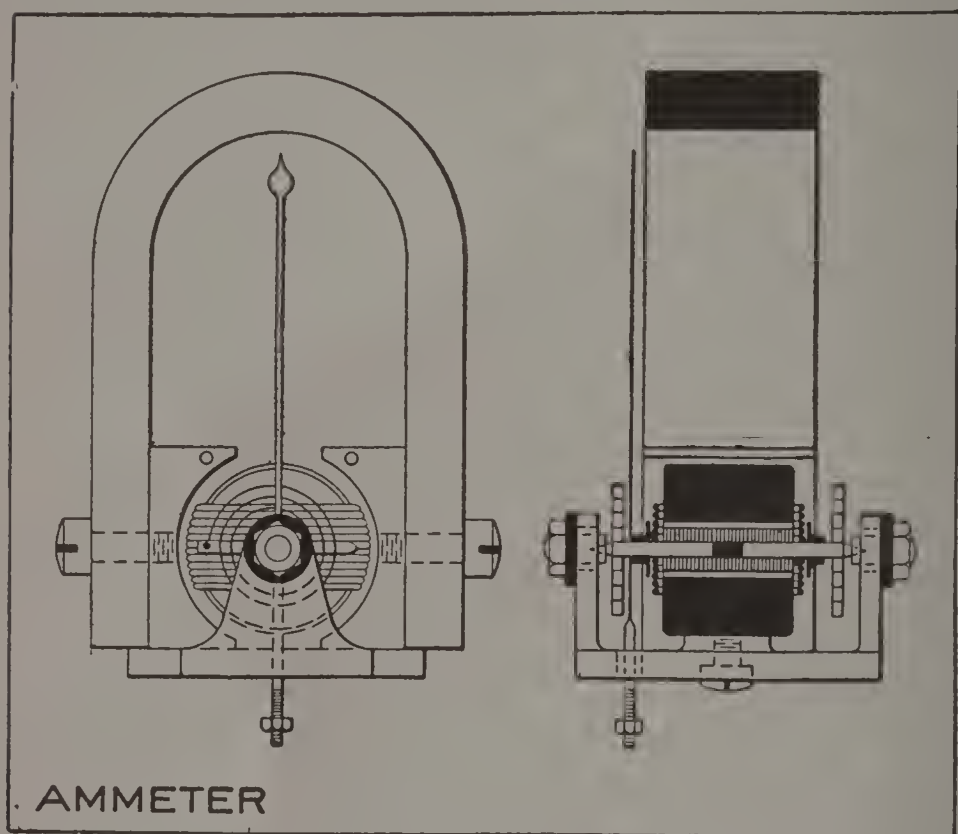



Fig. 3

of the D'Arsonval galvanometer with a permanent magnetic field. The special feature is a small oscillating coil mounted on cone-point bearings surrounding a stationary armature which is centrally located between the pole-pieces of a permanent magnet, with a pointer or index-finger which indicates the electrical variations on a graduated scale.

The construction of an ammeter is fully show in the two views in Figure 3. The permanent magnets used in its construction are of a special quality of hardened steel, made only for this purpose and possessed of great magnetic permeability. The pole-pieces, which are of soft steel and well annealed, are attached to the inside of the lower part of the magnet legs, the joints between the pole pieces and the mag-

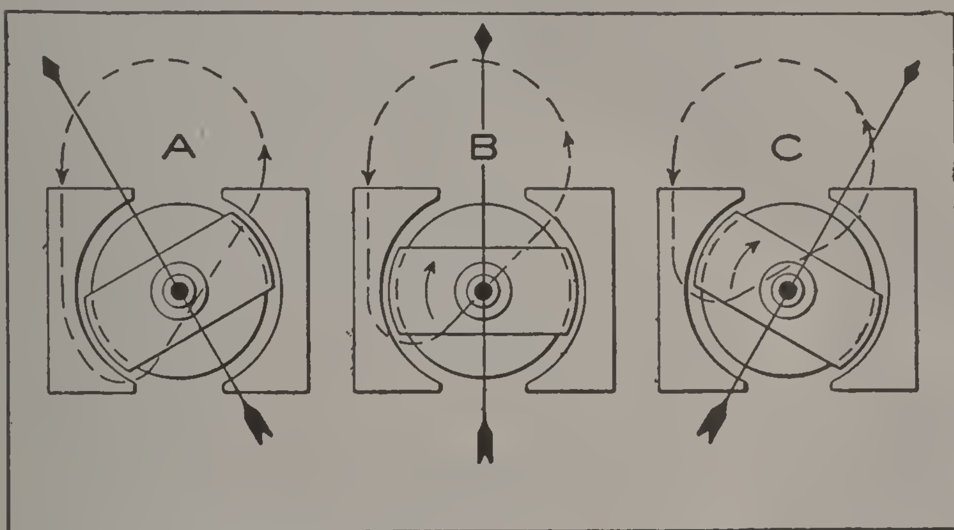



Fig. 4

net legs are usually ground to insure the full efficiency of the magnetic circuit. The soft iron core of the coil is for the purpose of rendering uniform the magnetic field in which the coil must oscillate. A coil of insulated wire is wound upon the stationary armature at right angles to its axis, in the same manner that thread is wound upon a spool, and is short-circuited on itself, that is to say, the ends of the wire forming the coil are connected together. This coil of wire is for the purpose of choking the magnetism induced in the stationary armature by the oscillating coil, as it generates what are known as eddy currents within itself, thus making the instrument periodic, or dead-beat, in its indications. Around the armature core and outside the short-circuited coil of wire is wound the active or oscillating coil and at right angles to the direction of the winding of the first coil. The oscillating coil consists of a number of turns of fine insulated copper wire, to which the current is conveyed through the medium of the controlling springs at each end of the spindle, which is in two parts and connected together by a suitable sleeve of insulating material, as shown.

The pointer or index-finger is made with a boss or hub to go over the end of the spindle of the active coil and also has an extension with a small counterweight or balance, so that the pointer may be accurately adjusted.

The only difference in the construction of a voltmeter and an ammeter is that in the former the active or oscillating coil is in series with a high resistance, while in the latter it is connected across the terminals of a shunt-block. The voltmeter is in reality an ammeter, the resistance serving to keep the amperage in step with the voltage.

Reference to the three views, marked respectively A, B and C in Figure 4, will show clearly the principle of the operation of an ammeter or voltmeter, and the reason that they record the current strength or pressure of an electric current accurately.

Ammeters are of two kinds, the double-beat type, as shown in Figure 3, which indicates the current strength or number of amperes flowing in the electric circuit, without any regard to the polarity of the terminals of the circuit, by the pointer or index-finger moving either to the right or to the left of the zero position. The

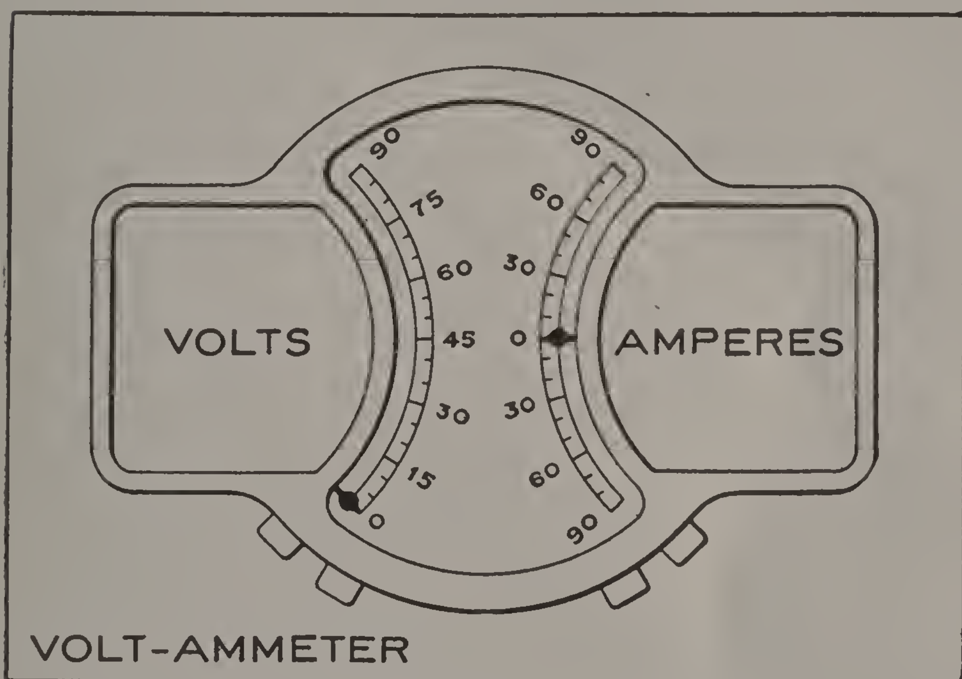



Fig. 5

single-beat type of ammeter only records in one direction, by the pointer moving from the left to the right of the graduated scale of the instrument, consequently the polarity of the terminals of this type of ammeter are marked on its outer casing and the polarity of the terminals of the electric circuit must consequently be determined before connecting them with the ammeter.

**Ampere.** The unit of electric current flow. An ampere is that volume of current which would pass through a circuit that offered a resistance of one ohm, under an electromotive force of one volt.

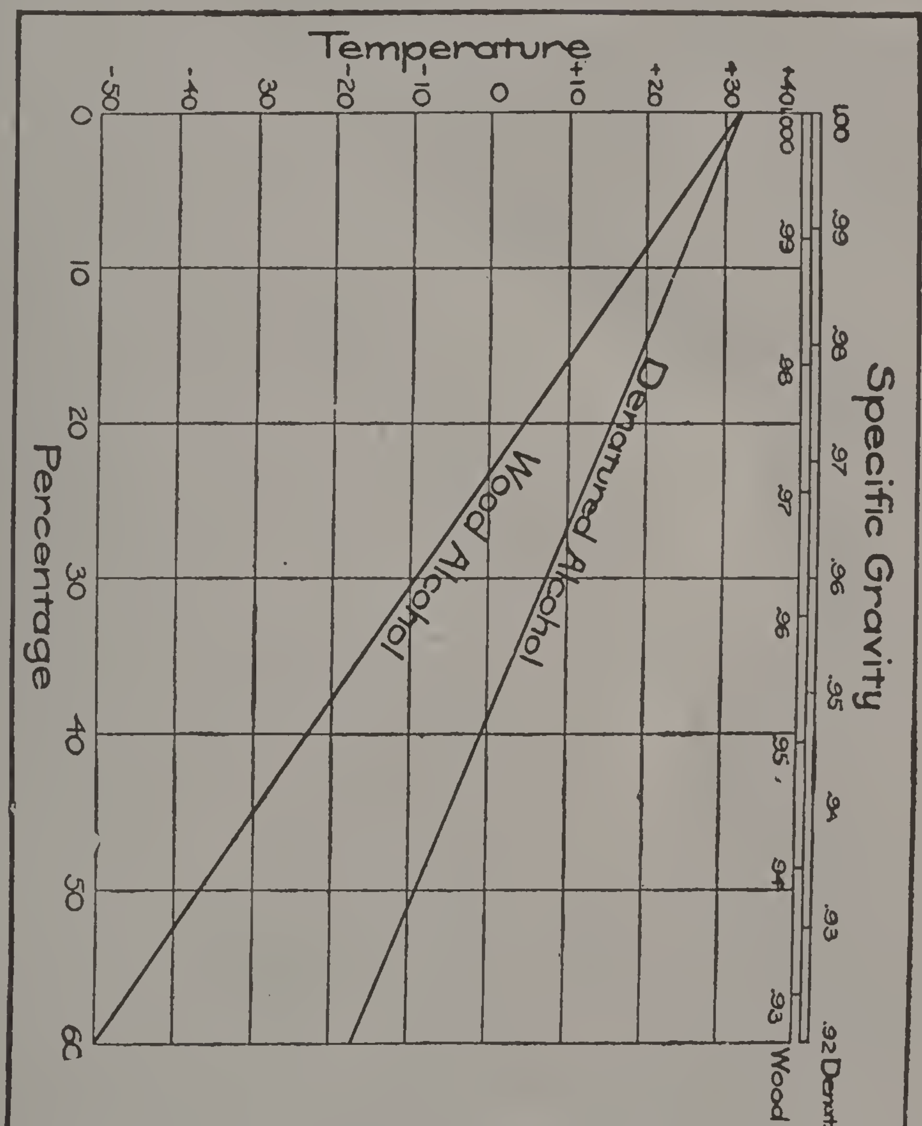
**Ampere-hour, Definition of.** The term ampere-hour is used to denote the capacity of a storage or a closed-circuit primary battery for current. A storage battery that will keep a 2 ampere lamp burning for 8 hours is said to have a 16 ampere-hour capacity. In a similar manner an 80 ampere-hour battery would operate the same lamp 40 hours. The voltage of a battery does not enter into the calculation of its ampere-hour capacity.

**Anti-Freezing Mixtures.** If a solution of alcohol and water is used, the best results will be obtained by having it just strong enough to stand the lowest temperature to which it is likely to be subjected in the climate where it is to be used.

The reason for this is that the alcohol evaporates out from the solution, and the stronger the solution, the more there is to evaporate, the easier it evaporates, and the greater the influence of this evaporation upon the solution left.

The diagram shown on page 33 indicates the freezing points of various solutions of denatured alcohol, also of wood alcohol. From this diagram a solution may be selected which will stand any temperature from 50° below zero to 40° above.

Other solutions may be made with calcium chloride (common salt), also the salts known as potassium carbonate. These with water form a solution that will stand zero temperatures, but are not available where lower temperatures are common.




Non-Freezing Mixtures for Radiators. In cold weather, the circulating water, the oil, and the carbureter require special attention. If the car is to be run regularly during the winter, it is advisable to use a non-freezing mixture in the water-jacket. If the car is not to be used regularly, it may not be necessary to employ such a mixture, but in that case great care is necessary to prevent the water from freezing unexpectedly. If the car is kept in a barn, the water should be drawn off completely after the car has been used, and the drainage cock should be so located and the piping so arranged that there are no water pockets in which the water may freeze and obstruct the circulation. If the water freezes in the pump, the latter is likely to be broken when the car is started the next morning. If water freezes in the water-jackets, it will burst the jackets unless they are made of copper. When the car is left standing for an hour or so, cloths

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PROPORTIONS OF GLYCERINE, ALCOHOL AND WATER.

| Freezing Point | Glycerine and Alcohol (equal parts) | Water |
|---|---|---|
| 28° above | 15% | 85% |
| 15° above | 20% | 80% |
| 10° above | 24% | 76% |
| 5° above | 28% | 72% |
| Zero | 30% | 70% |
| 5° below | 33% | 67% |
| 10° below | 36% | 64% |

or lap robes may be thrown over the radiator to check the cooling; this is cheaper and safer than leaving the motor running.

The two substances most used to prevent freezing are glycerine and calcium chloride. A 30-per-cent solution of glycerine in water freezes at 21° F.; and a solution of one part of glycerine to two parts of water is safe from freezing at 10° or 15° F.; 40-per-cent solution freezes at zero. A small amount of slaked lime should be added to neutralize any acidity in the solution. Glycerine has the objection that it destroys rubber, and the solution fouls rather quickly.

A cheaper mixture, and one preferable where the temperatures encountered are likely to be below 15° or 20° F., is a solution of calcium chloride. This must be carefully distinguished from chloride of lime (bleaching powder), which is injurious to metal surfaces. Calcium chloride costs about 8 cents a pound in bulk, and does not materially affect metals except zinc. A saturated solution is first made by adding about 15 pounds of the chloride to 1 gallon of water, making a total of about 2 gallons. Some undissolved crystals should remain at the bottom as evidence that the solution is saturated. To this solution is added from 2 to 3 gallons of water, the former making what is called a 50-per-cent. solution. A little lime is added to neutralize acidity. A 50-per-cent solution freezes at —15° F.

Whether glycerine or calcium chloride is used, loss by evaporation should be made up by adding pure water, and loss through leakage by adding fresh solution. In using the chloride, it is important to prevent the solution from approaching the point of saturation, as the chloride will then crystallize out and clog the radiator, besides boiling, and failing to cool the motor. A 50-per-cent. solution has a specific gravity of 1.21, and should be tested occasionally by means of a storage-battery hydrometer. Equally important is it to prevent the water from approaching the boiling point, whatever the density, as boiling liberates free hydrochloric acid, which at once attacks the metal of the radiator and cylinders.

A solution of two parts of glycerine, one part of water, and one part of wood alcohol has been recommended, which is said to withstand about zero temperature.

Certain mineral oils used for the lubrication of refrigerating machinery are recommended for cooling, because they remain liquid at very low temperatures. They are not particularly good heat conductors, however, and will not keep the motor as cool as the water solution. If the oil is used, it must be cleaned from the radiator by the use of kerosene and oil soap, before water can again be used effectively.

As regards lubrication, the principal danger is that the oil will thicken from the cold so that it will refuse to feed. This is avoided by using cold test oil, which remains liquid at lower temperatures than ordinary oil, or by adding to the ordinary oil some kerosene or gasoline, and increasing the feed. If the oil tank is located close to the engine, it will remain liquid, even in quite cold weather. But unless the car has been kept in a warm place over night, the bearings are liable to run dry before the car has warmed up.

Cooling Solutions—For Winter. Radiators are costly, delicate and composite in construction, the latter due to the plurality of metals in their make-up, hence electrolytic action takes place, due to the difference of potential natural to the different metals immersed in a saline bath. Therefore great care should be exercised in the preparation of anti-freezing solutions made up of calcium chloride (common salt and water). Any approach to the saturation limit is attended with danger of precipitation. The saturated solution is ascertained at 60 degrees F., and increasing the temperature increases the capacity of the water to hold the salts in suspension.

On the other hand, the Ohmic resistance of a solution is lowest at about half saturation. To sum up, it is experience that counts, and it is still a question as to the extent to which saline solutions can be used with safety. Of course there is no solution as good as water alone, but unfortunately water will expand when it freezes, and it will freeze on small provocation in a radiator. Oil as a cooling medium has points in its favor which some authorities claim render it more efficient than water, as for instance it has a higher boiling point, about double that of water, and as a result the oil will not waste away except by leakage. The heat exchange occurs at a higher temperature, thereby increasing the efficiency of the motor. Then also the area of radiating surface may be smaller, with a conesquent decrease in weight, while the work of the fan is rendered of less importance. A light, thin, pure mineral oil is the most reliable. Animal, and vegetable oils are more apt to become rancid, the acid in them also attacks the metal of the radiator.

**Armatures, Dynamo.** The armature, or revolving member of lighting dynamos, is composed of a core made from wrought iron or mild steel. It is customary to make this core by assembling a sufficient number of thin plates made in the form of the cross section of the core, these plates being covered with an insulating composition and then fastened together on the shaft. This construction prevents the formation of harmful "eddy currents" within the metal.

The assembled core has a number of slots running lengthwise of its body and in these slots are placed the armature coils or winding of insulated wire. The coils are then connected to a commutator mounted on one end of the shaft in such a way that the current generated may be collected by the brushes.

**Armatures, Slotted and Shuttle Types of.** An armature is the rotating part of a dynamo or electric motor which generates electricity or develops power.

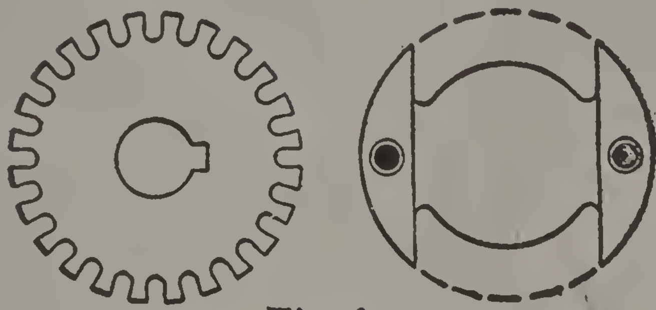


**Fig. 6**

The armature shown at right of Fig. 6 is known as the Siemen's H or shuttle type and is the simplest form of wire-wound armature known. The current given by this form of armature is of the alternating type and is converted into a direct-current, when desired, by means of a two-part commutator on the armature shaft.

The slotted type of armature shown at the left of Fig. 6 has a more intricate system of winding than the shuttle type just described. It has, however, a far greater electrical efficiency and gives off a steadier current than the shuttle type. It is the form most generally used for automobile and street railway motors. Like the shuttle type of armature, the current generated by the slotted type of armature is alternating, and is converted into a direct current by means of a commutator of very complicated form.

**Assembling a Car.** In assembling the car the engine had best be put together first. When putting the pistons in their respective cylinders see that the splits or joints in the piston rings are not in line, but are spaced evenly around the piston. See that all parts are thoroughly clean and that no grit, or stray strands of waste happen to be caught on any projection. All nuts and bolts should be screwed tight and the jaws of the wrench should be properly adjusted to them, that the corners of the nuts and cap screws may not be rounded off. Insert the cotter pin after each nut has been screwed home. In joints where packing is required the old packing may be used if it is in good shape. Joint faces should, of course, be perfectly clean. A stout grade of manila wrapping paper soaked in linseed oil will make an excellent packing for crankcase and other joints having a good contact surface.

While the engine is being reassembled it will be found advantageous to check up the valve timing. To do this, turn the fly-wheel until the inlet valve plunger of No. 1 cylinder just touches the lower end of its valve stem. At this point the line on the fly-wheel indicating "Inlet No. 1 Open" should coincide with the pointer on the engine base. If the contact between the valve stem and the plunger is made before the mark on the fly-wheel lines up with the pointer, the valve opens too early. In most cars the adjustments may be made by the screw cap and lock-nut on the plunger. As the valve stems are lowered by repeated grindings of the valves, the plungers require adjustment occasionally to compensate for this movement. Insert a piece of paper between plunger and valve stem, and by lightly pulling on the paper the time of contact and the moment of release may be determined to a nicety. When the paper is held tightly, a good contact is assured, and the moment the paper becomes loose and can be moved about, the contact is broken. In many cars the reference or index mark on the engine bed is omitted; in this case the markings on the fly-wheel must be brought directly to the top. The other inlets and the exhaust valves should then be similarly checked up and adjusted.

Most cars base the valve setting on a 1-32 inch clearance space between valve stem and plunger rod when the valve is closed. This may be taken as the minimum amount, and should not be increased. A larger amount of clearance will cause the exhaust valve to open too late, and, the exploded gases not being entirely expelled, the power of the motor will be impaired. This clearance is necessary to allow for the expansion of the valve stem when it becomes heated.

Too much stress cannot be laid on the necessity of going about the work in an orderly and methodical manner. A mechanic who leaves parts lying about carelessly will rarely be found a good one, and certainly he is not a proper model for the amateur to copy. With the proper circumspection, then, and with a little "horse sense" in applying the directions to his particular make of car, the amateur owner should have no difficulty in making a good job of overhauling, thus bettering the condition of his machine and at the same time acquiring a valuable stock of knowledge for the future.

**Automobile Driving.** When on the open road, away from cities or towns, the following rules should be borne in mind. (1) Drive with moderate speed on the level, slow speed down hill, and wide open throttle for hill climbing, or getting up speed only. (2) The condition of the road should be noticed, the presence of mud or dust thereon furnishing sufficient reason for slowing down somewhat for the sake of other road users. (3) The ordinary rules of the road regarding the negotiation of turns, and crossings, also the overtaking or passing of other vehicles should be adhered to, even though a lower rate of speed is involved thereby. (4) A sharp lookout should always be kept for traffic of all kinds, as well as on approaching schools, churches, or public buildings, and also for road signs indicating danger, caution, etc. (5) When on the road the autoist should show courtesy to other road users. Courtesy in autoists is much appreciated, and goes a long way toward removing the prejudice which exists in many places against automobiles.

Gear—Changing. In changing gears the autoist should endeavor to have the motor and car moving at nearly corresponding rates of speed before the clutch is engaged. With the planetary type of gear, changing is simple, and drivers usually guess at the proper period at which to make the change, any mistake in estimating the rates of the car and motor being of little consequence, as the bands will slip instead of transmitting the shock to the gear. A similar action occurs in the case of individual clutch or friction gears, but with the sliding type severe strains and shocks have to be taken up by the clutch, and are usually transmitted in part to the gear if the clutch is not slipped. What applies to the sliding type in general applies to the other types as well.

In changing from a lower to a higher gear it will be necessary to speed up the motor by means of the throttle or accelerator in order to store enough energy in the flywheel to furnish the work needed to accelerate the car to its new speed. As the speed of the car increases the higher gear should be engaged, the autoist not being in too great a hurry to make the change. The movement of the change gear lever should be made quickly in order that the car does not lose way. When changing from a higher to a lower gear the change should be made as quickly as possible before the car has time to slow down. When climbing a steep hill it should be ascended as far as possible on the high gear by proper use of the throttle and spark, and the change down to the lower gear made as soon as the motor begins to labor or is in danger of stopping. The presence of an unusual number of passengers in the car will affect its ability to negotiate grades which ordinarily are taken on the high gear, and the autoist should remember this and not attempt to force the car to travel on that gear with the increased load, but resort to a lower gear.

Reversing—Backing Up. Among other things connected with driving which is apt to be neglected, is reversing, or driving a car backward. Usually a car is never reversed for more than a few yards at a time and the maneuvering involved requires no great skill. Steering a car when running backwards is diametrically opposite to that when running forward. A turn of the wheel to the left steers the car in the opposite direction to the right, and vice versa. The usual mistake made in reversing is in turning the steering wheel too far, and describing zigzags in the road as a result. The autoist should remember that the reverse gear of a sliding change gear should never be engaged until the car has been brought to a full stop.

Brakes, Proper Use of. Next to the motive power in importance come the brakes. There are a number of points regarding brakes that every autoist should know and remember. First and most important is the fact that brakes vary in their effectiveness, and that freedom from disaster depends upon the brakes being kept in good condition and properly adjusted. Second, while a brake may be perfectly satisfactory for slowing down, it by no means follows that it will bring a car to a stop as it should, nor hold the car from going backward. Third, brakes should be tested frequently with the car in motion, the pedal or hand lever being applied until the car slows down, or stops. The distance covered in making this test should be noted, and a greater distance allowed in making stops on the road.

In applying brakes, the application should be gradual, reducing the speed of the car as quickly as possible without locking the wheels. As long as the tires retain their grip on the road, the powerful retarding action of the brake continues, but when the wheels are locked the brakes have little or no effect, and the car will either slide along, or skid, in either case being beyond the control of the driver. Should the wheels become locked while descending a hill, the brakes should be released until the wheels are again revolving, and then reapplied gradually, until they act satisfactorily.

Brakes should be examined at regular intervals in order to ascertain if the lining is in good condition. If worn, the old lining should be replaced with new. If the brakes are of the internal-expanding type, the shoes may have become worn, in which case they should be renewed. Toggle joints and adjusting nuts should be inspected, and any looseness taken up. Brakes should be adjusted on the road, as any improper adjustment of the equalizer bar will have a strong tendency to make the car skid. Both brakes should be adjusted alike, that the braking force applied by the equalizer may be transmitted to the wheels equally.

Side Slip, or Skidding. If the rate of rotation of a wheel is greater than the rate of advance over the road, the wheel loses adhesion and thereafter it is just as easy for it to move in one direction as in another.

The wheel can now slip sideways as easily as it can slip forwards, particularly when it has the rounded section slightly flattened, which is the case with pneumatic tires. When traveling straight ahead, and with the motor out of gear, skidding does not usually occur. A slight turn given to the steering wheel checks the speed and introduces a side pressure on both front and rear wheels, due to the machine tending to continue its path in a straight line. Generally this side pressure will not cause skidding. If, however, the motor be suddenly thrown in gear, or the brakes suddenly applied, or, what amounts to the same, a large turn is given the steering wheel, the wheels find themselves either rotating more than in proportion to their advance, or advancing more than in proportion to their rotation. This immediately causes a loss of adhesion, which, once established, causes the car to skid or side-slip.

Spark—Regulation of. Upon the proper use of the sparking device depends the economy of the motor, and in many cases the safety of the driver. On some cars the sparking point on the magneto is fixed, and the autoist controls the car by the throttle only. There are a number of cars in use which employ the battery in connection with separate coils or a single spark system, or a magneto on which the spark can be regulated by the driver. When starting, the spark should be retarded in the case of battery ignition, to prevent backfiring, and slightly advanced to a certain point, depending on the motor and magneto, in the case of magneto ignition. When it is desired to slow the motor down below the point obtained by throttling only, the spark is likewise retarded. In ordinary running, a position of the spark lever can be found which will give fair average results through a considerable range of speed without changing its position, and this position varies with each motor, and can be found by experience. When a higher rate of speed is desired, the throttle is opened and the spark advanced gradually. If a grade is to be negotiated it should be "rushed" if possible, the throttle being opened full and the spark well advanced until the motor begins to slow down and "knock," when the spark should be retarded to correct this. The autoist should always keep the spark as far advanced as possible, without causing the motor to knock.

When to Retard the Ignition. Always re-retard the ignition before starting the motor, and take great care that the ignition is retarded and not by mistake advanced. Some cars are fitted with a device which prevents the starting crank being turned unless the spark is retarded. If it is not clear as to which way to move the ignition lever to retard the ignition, move the commutator in the same direction as the camshaft rotates.

As soon as the motor slows a little when going uphill, retarding the spark enables more power to be obtained from the motor at the slow speed, that is to say, if the spark is not retarded the motor will go slower than if it is retarded. Do not retard the lever to the utmost under these conditions; on the contrary, retard the lever to such a point that the knocking (due to the wrong position) ceases.

Retarding the spark causes the maximum pressure of the explosion to occur at the best part of the stroke, or, rather, the mean pressure of the explosion stroke will be lower if the best point of ignition by retarding is not found. This is a matter of some skill and practice.

To slow the motor, cut off as much mixture as the throttle allows, then slow the motor still further by retarding the spark, but on no account retard the spark when the throttle is full open (for the purpose of slowing the motor), as the motor will merely discharge a quantity of flame at a white heat over the stem of the exhaust valve, burning it, softening it, and making it scale.

WHEN TO ADVANCE THE IGNITION. With too early ignition the pressure upon the piston becomes excessive and without any adequate return of useful work or energy. If the ignition be retarded too much, the maximum explosive pressure occurs too late during the working or power stroke of the piston, and the combustion of the gases is not complete when the exhaust-valve opens. Greater motor speed requires an early ignition of the charge, but greater power calls for late or retarded ignition.

The reason for advancing the spark when fast running is required, is that the explosion or ignition of the charge is not instantaneous as may be supposed, but requires a brief interval of time for its completion.

It may be well to explain without entering into theoretical details, that when a motor is running at normal speed, the ignition-device is so set that ignition takes place before the piston reaches the end of its stroke. The later the ignition takes place the slower the speed of the motor and consequently the less power it will develop. If, however, in starting the motor the ignition-device were set to operate before the piston reached the end of its stroke, backfiring would occur, resulting in a reversal of the operation of the motor and possibly in injury to the operator.

Car Inspection. Most autoists are content to make all their inspection of the car and its mechanism from above, and rarely give more than a casual glance below the frame except when trouble occurs. On cars fitted with pressure-feed on the gasoline, the piping should be frequently inspected, on account of the danger from fuel leakage. Such inspections should be made when the motor is stopped, and the pressure still turned on. The tank should be gone over for leaks arising through the opening of its seams from vibration, or the loosening of the union connecting the fuel lead with the tank. The lead and its connection to the carbureter should also be examined for leaks and abrasions due to rubbing against other parts of the mechanism. If any such are found they should be immedidiately repaired. Twine, tire tape, or rubber bands will act satisfactorily as fenders to prevent further mischief. Unions which cannot be made tight by screwing up should be taken apart and the male connections coated with soap or red lead, which will render them tight for a considerable time.

After going over the fuel system, the brake rods and steering connections should be examined for loose joints and broken oil and grease cups. Grease boots on the drive-shaft joints should be seen to be sound, and filled with grease. A cleaning out of the dirt from the interior of the mud-pan will often reveal lost cotter pins or nuts, and tend to a more agreeable handling of the draincocks, carbureter and filter. This time will be well spent when the chances of fire or accidents arising from faulty steering or brake connections are taken into account.

DONT'S. In the first place don't forget to ascertain the fact that the ignition mechanism is retarded before cranking the motor. Many a sprained wrist and a few cases of broken heads or arms have been caused by the neglect of this simple precaution. It is a good plan to have the ignition-control spring so actuated that in its normal position it is always retarded.

Don't use the electric starting motor to propel the car. It ruins the battery.

Don't use a match or a small torch to inspect the carburetor. It sometimes leads to unexpected results.

Don't forget to fill the gasoline tank before starting.

Don't smoke while filling the gasoline tank.

Don't take out all the spark plugs when there is nothing the matter, except that there is no gasoline in the tank.

Don't forget to always have an extra spark plug on the car.

Don't allow the motor to race or run fast when out of gear. If the car is to be stopped for a few minutes, without stopping the motor, retard the ignition and also throttle the charge, so that the motor will run as slowly as possible.

Don't fill the gasoline tank too full, leave an air space at the top or the gasoline will not flow readily.

Don't have any open hole in the gasoline tank. When the car is washed water may run in this hole, mix with the gasoline and cause trouble.

Don't put grease in the crank case of the motor, it will clog up the oil holes and prevent the oil from circulating.

Don't fill the gasoline tank by lamp or candle light, something unexpected may happen.

Don't keep on running when an unusual noise is heard about the car, stop and find out what it is.

Don't start or stop too suddenly, something may break.

Don't pour gasoline over the hands and then rub them together. That rubs the dirt into the skin. The proper way to do is to saturate a towel with gasoline and then wipe the dirt off.

Don't forget to examine the steering gear frequently.

Don't fail to examine the pipe between the carbureter and the admission-valve occasionally. The pipe connections sometimes get loose and allow air to enter and weaken the mixture.

Don't forget to see that there is plenty of water and gasoline in the tanks.

Don't fail to clean the motor and all the wearing parts of the car occasionally.

Don't forget to oil every part of the motor where there is any friction, except the valve stems.

Don't forget to put distilled water in the battery every ten to fifteen days.

**Automobile Tools.** In Fig. 7 three types of valve lifters are shown. B and C are of the same principle, and quite efficient in almost any case; but A, when properly operated, and on its respective motor, is more quickly applied,

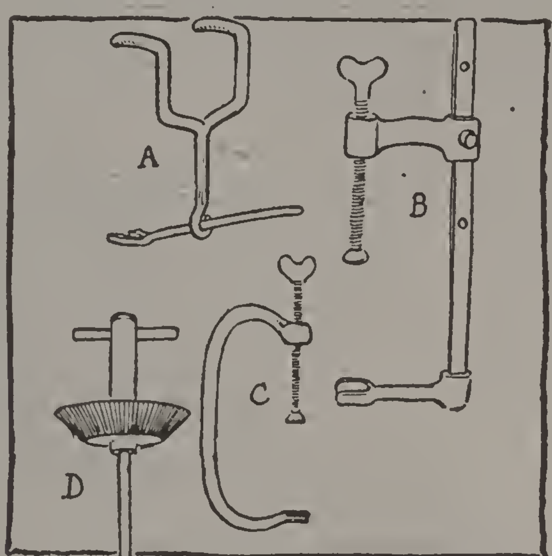



Fig. 7

and consequently a time saver. D is a valve-seating tool, supplied as special equipment by one of the large motor car manufacturers.

In Fig. 8 are shown a couple of spanner wrenches and one or two other tools that are quite uncommon but quite necessary in the work to which they are adapted. A is made from a piece of steel tubing and used on packing glands—the tube to slip over the shaft—and the small lugs at the end engage corresponding recesses in a packing nut. B is representative of a valve-grinder, designed especially for the valves in certain motors. The spanner C is required to conveniently remove certain types of cylinder plugs; while D, which approaches the conventional, is used in adjusting bearings of a particular type.

There is probably a greater variety of wheel and gear pullers now in service than of any

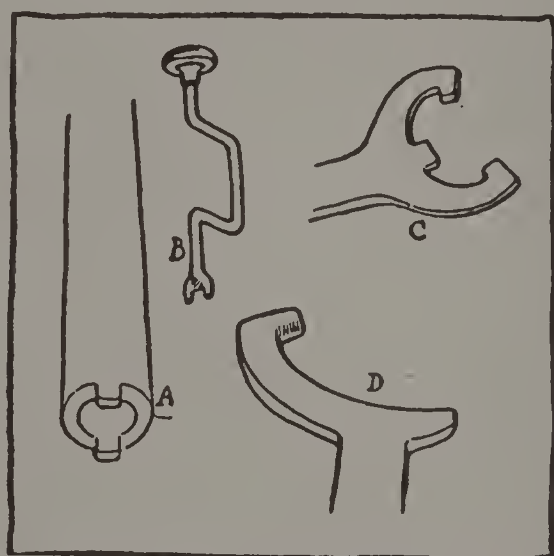



Fig. 8

other special tool. In Fig. 9, A looks very much like the standard adjustable wheel and gear puller for sale in all supply houses; and it practically is the same except that the hooks are larger and twisted in opposite directions and at right angles to the beam. It is found useful in removing road and flywheels and the like. B is a non-adjustable tool made especially for removing flywheels. C and P are road wheel pullers, and are included in the regular equipment of tools supplied with the cars of two prominent manufacturers. C is part of the Rambler tool equipment and is used in connection with their spare wheel; and P represents the type of wheel puller supplied by the Pierce-Arrow. E is a gear-puller designed to remove the half-time-gears of an Oldsmobile, the two

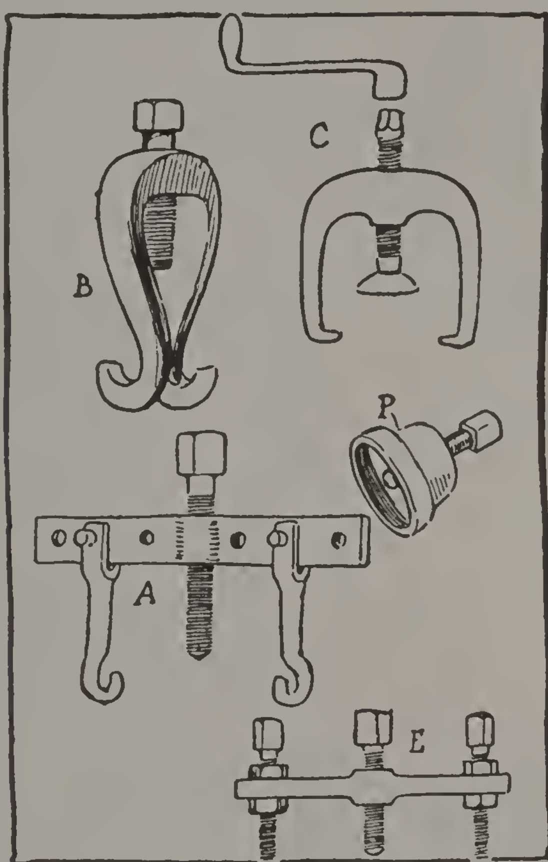



Fig. 9

side-screws being intended to fit into threaded holes in the web of the gears.

When the Jack is Missing. Should the jack be missing or broken, an efficient substitute can be rigged from a large stone or a number of bricks piled one on another until the height is sufficient to lift the wheel from the ground.

Having gotten the stone or piled the bricks one of the floor-boards can be utilized as an inclined plane and the car backed up until the axle rests on the top of the pile. When the work has been performed, the axle will have to be pushed off the pile, but as the drop is inconsiderable no harm can come to the tire. Where stake-and-

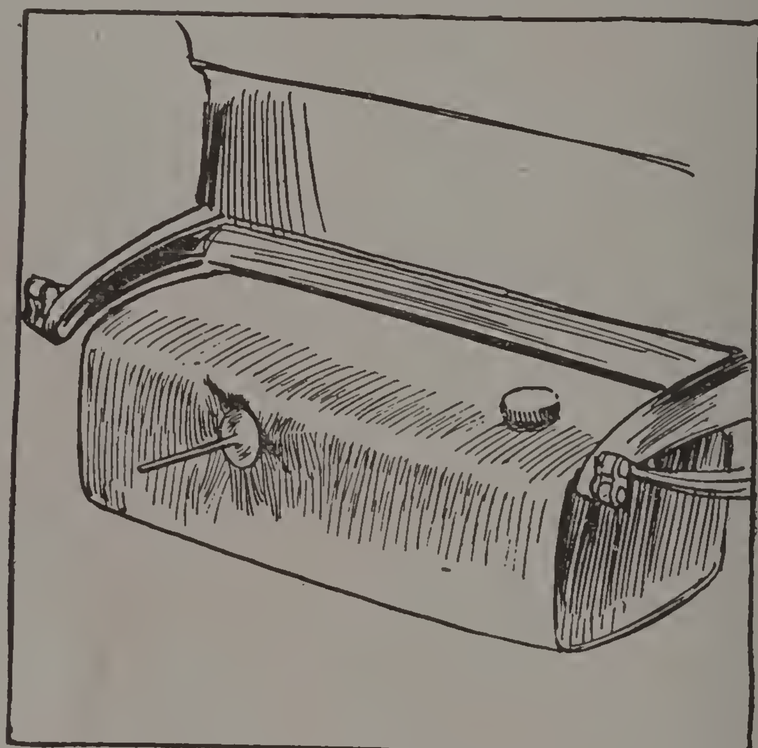


Fig. 10 .
Removing Dent in Gasoline Tank

rider fences abound, one of the rider timbers can be utilized as a lever, with a stone as a fulcrum to raise the axle, supporting the latter with another stone during the repair, and gently easing down the axle when ready to proceed.

Removing Dents. An easy method of removing dents consists of soldering a piece of wire to the bottom of the dent, then pulling the depressed portion out to its proper position. When the dent happens to be in an oil, or gasoline tank, or a radiator, an old valve can be most effectively used in place of the wire, as shown in Fig. 10 The top surface of the valve is filed smooth and bright, then cleaned with soldering acid and tinned with solder. A flat surface of the same area, and as near the bottom of the dent as possible, is treated in the same manner, and the valve sweated on. This sweating on is done by placing the prepared portion of the valve against the tinned surface of the dent, and then applying heat with a torch till a fusion of the solder takes place. The heat should then be removed and the solder allowed to set. When cool, it will be found that with the valve stem as a handle and lever, and probably a few light taps with a hammer around the edge of the dent, the deformed part can be most easily straightened out.

Tools Necessary. The following tools should be in the car when on the road:

Monkey wrench, 9 inch.
Machinist's screwdriver.
Ball pene hammer, one pound.
Combination pliers, 8 inch.
Set of double end, or "S" wrenches.
Flat file, mill cut.
Three cornered file.
Round file, six inch.
Center punch.
Prick punch.

Drift punch, flat ended.
Offset, or "bent-end" screwdriver.
Cold chisel, three-quarter inch.
Spark plug wrench.
Small wire cutting pliers.
Emery cloth.
Cotter pin puller.
Wire brush for spark plugs.

## Break Downs, and Their Remedies.

CHAIN BROKEN. In case a chain should break, and there are no spare links available, the car may be driven by the other chain, provided the idle sprocket is secured so that it cannot revolve. An easy way to do this is as follows: Pass one end of the chain around the sprocket, secure the end link to the chain with wire, and attach the other end of the chain to some part of the car, as a running board bracket.

On shaft driven cars the universal joint pins sometimes work loose, and drop out. In such cases a temporary pin can be made from a bunch of wire, or by a small chisel held in place by wires, or twine.

CIRCULATING PUMP LEAKAGE. Leakage of the water circulating pump occurs usually where the cover joins the pump body by means of a ground joint. A gasket of stiff paper dipped in lubricating oil inserted between the cover and the body will remedy this, the gasket being easily formed with the pocket knife. Asbestos cord is better than paper when treated with vaseline and graphite, but few autoists carry it. For leakage around the pump spindle the cord can be used, pushing it in with a piece of strip brass or other soft metal so as to avoid scratching the shaft. If no asbestos cord is at hand one of the strands of a piece of hemp rope treated with tallow will also answer.

Cranking with Safety. The principle involved in safely cranking an engine is, to get the explosion at the moment the crank is pulling on the fingers, so that if the kick comes the force will simply pull the handle out of the grasp, instead of being expended against the body weight and applied force. Do not attempt to turn the crank all the way around; adjust it to start against the compression, then give a quick pull upward.

Differential Casing. In cases of emergency where oil or grease cannot be obtained for filling the differential casing, beeswax may be used as a substitute.

Dry Cells for Ignition. Dry cells will give very satisfactory ignition for a four cylinder motor by using four sets of four cells each, connected in series multiple so as to get a voltage of only six volts. By having the vibration respond quickly to the pull of the magnet in the coil, battery consumption will be greatly lessened. The slightest current should separate the contact points.

Gasoline Pipe Broken. When the gasoline pipe breaks, a short piece of rubber tubing forced over the broken ends will do for a short time, but as gasoline attacks the rubber, too much dependence should not be put on it, and the pipe should be brazed at the nearest shop. If the hole is only a small one a piece of soap squeezed in and held in place by a soaped rag and string will serve if gravity feed is used. For pressure tanks a piece of rubber tubing split lengthwise and well soaped will tempora-

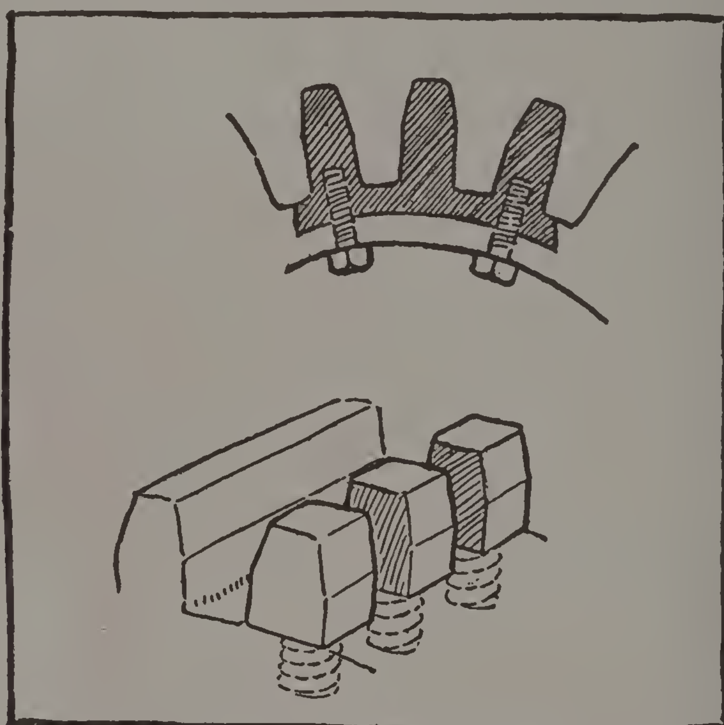


Fig. 11
False Teeth, Permanent Repair

rily stop the hole, if wired tightly around the pipe, but the pressure must be kept low, otherwise the rubber tubing will be loosened and the leaking commence again.

A leak is sometimes hard to locate, but if the pipe is rubbed with soap suds, and then blown through, the leak will be located by the bubbles.

Gear Teeth Broken. If several teeth are

wholly, or partly broken they may be repaired in the following manner; referring to Fig. 11: Shape out a dovetail recess across the face of the wheel, cast or shape up a brass, bronze, or steel segment and dovetail it in, driving it tight from one side, and securing it with screws. Then file the teeth to a template made from the standing teeth of the wheel. For a single tooth proceed in the same way, no screws being necessary if properly fitted and the ends peened over with a hammer; or, file down the broken tooth flush with the bottom, drill and tap two or three holes, according to the width of the wheel, screw in capscrews and trim with a file. It might be well to add, when removing a timing gear for repairs, or any other purpose, care should be taken to see that it, and the gears with which it meshes, are plainly marked.

Miss Fire Cylinder. Should one of the cylinders miss some of its regular explosions at intervals when under a load, it may be located by stopping the engine, and touching each cylinder with the business end of an unlighted match. The cylinders that have been doing their regular work will be hot enough to ignite the match, while the missing cylinder will not.

Nuts and Screws—How to Loosen. Refractory nuts may be loosened by heating, by means of a red-hot piece of iron held on or near them for a few minutes. This will expand the nuts and they will then come off readily. When a screw cannot be readily loosened with a screwdriver, the latter should be pressed hard into the slot, while a helper applies a monkey wrench to the flat part of the blade. A tight radiator cap can be moved by winding a quantity of twine, or cloth tightly around it.

PRIMING. If a motor does not start readily, due to not getting a rich enough mixture at slow speed of cranking, tie a small bunch of waste with a wire close to the air intake of the

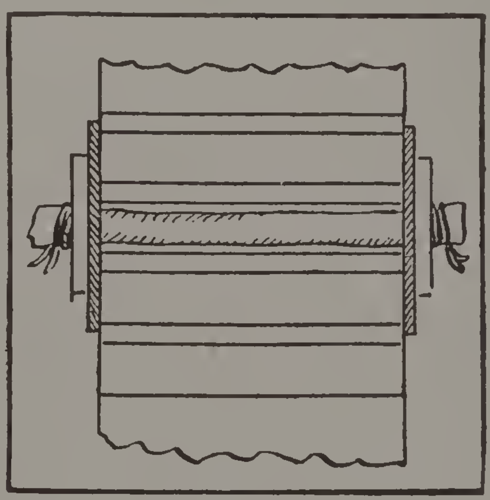


Fig. 12
Section of Radiator Showing Washers Held by Wires on Stick, To Stop Leak

carbureter, then prime by saturating the waste with gasoline. The added vapor will make starting easy.

RADIATOR LEAKING. In case a "honeycomb" radiator starts leaking at the end of a cell, and there is no radiator plug at hand, a substitute may be made by passing a long bolt of small diameter through the defective cell and fitting each end of the bolt with washers made of leather, or rubber backed with iron washers or metal strips, and then screwing down the nut until the leak is stopped. If a bolt cannot be obtained a small piece of wood may be whittled down to take its place, and the washers secured by means of copper wire as shown in Fig. 12.

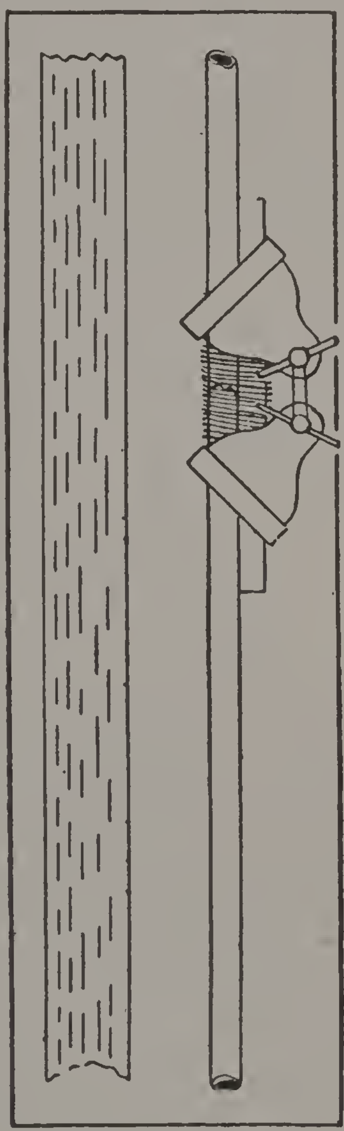


Fig. 13
Repaired Drag-Link, Showing Hand Vises in Place

If a leak occurs inside one of the cells, a square peg cut from soft wood, and covered with a piece of thin cloth smeared with white lead can be used as a plug. Only a moderate force should be used in these methods, as the tubes are easily buckled. Leaks in gilled radiators may be stopped by applying a rubber patch held in place by tire-tape and wire.

Rods or Links Broken. The repair of a broken link in the steering gear can be effected by placing the broken ends together and fasten-

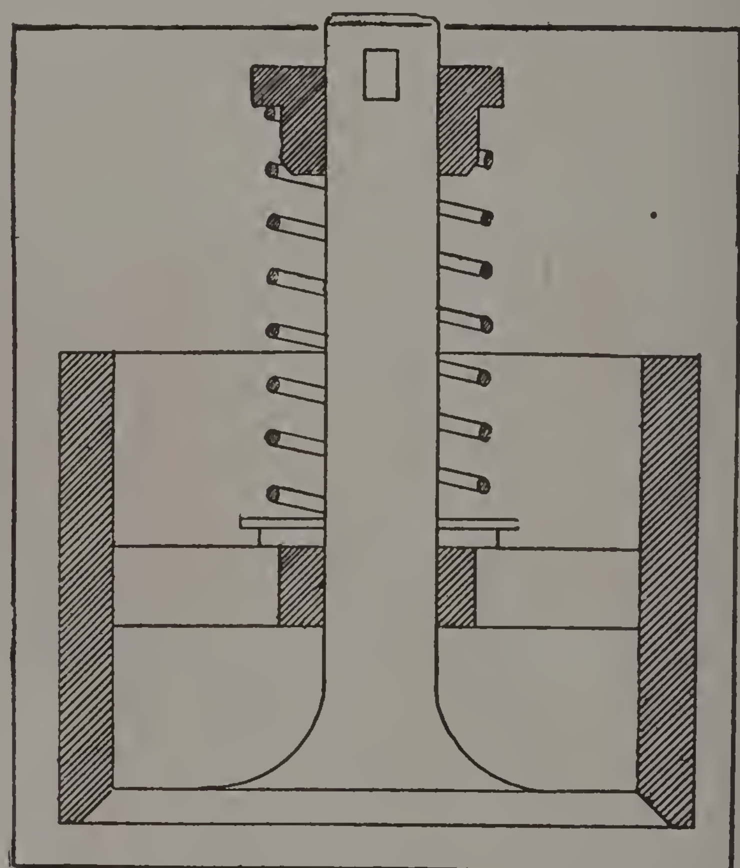


Fig. 14
Valve Spring Strengthened by Inserting Metal Strips

ing a rod or a piece of gaspipe against the link, winding the wire the entire length of the rod. If two hand vises can be obtained they can be attached as shown in Fig. 13. The rod is tied to the joined ends of the link with wire, and the hand vises screwed down on both link and rod. Anything but slow running with either of these repairs is out of the question. Any other rod can be similarly repaired provided there is room for the pipe or the vises alongside of it. Wire cable can be substituted for brake rods, but the brake must be kept clear of the drum by some means when not in use.

SQUEAKING SPRINGS. A frequent source of annoyance is the squeaking caused by the leaves of the springs having become dry from want of lubrication. When such is the case, jack up the

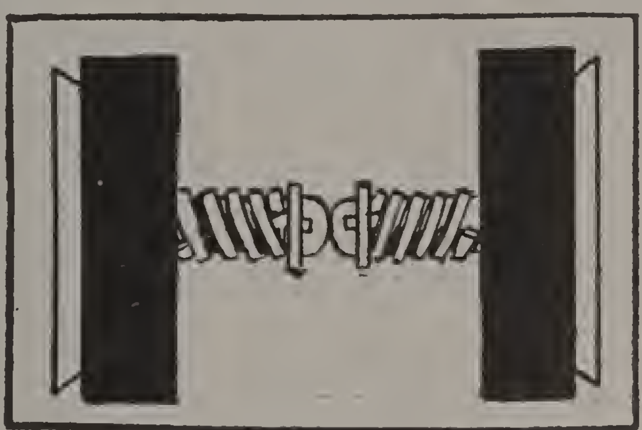


**Fig. 15**
**Method of Testing Valve Springs**

car until the wheels are clear of the ground, and the springs quite free. Then with a thin cold chisel, or a large screwdriver, gently force the leaves apart, one by one, and spread a mixture of vaseline, oil and graphite between them, using an old table knife or thin wooden paddle for the purpose. Where parts cannot be reached in this way, oil should be squirted in, and if necessary the leaf clips may be removed to allow of this being done.

TREMBLER BLADES BROKEN. Corset steels may be used as blades for trembler coils, by cutting them to the proper length, and riveting the platinum button from the broken blade through the hole which is punched near the end. After making the holes for the retaining screw, the blade is complete. A piece of the main spring of a clock will also make a good blade.

TWINE IS USEFUL IN BREAKDOWNS. Autoists should always carry 15 or 20 yards of strong

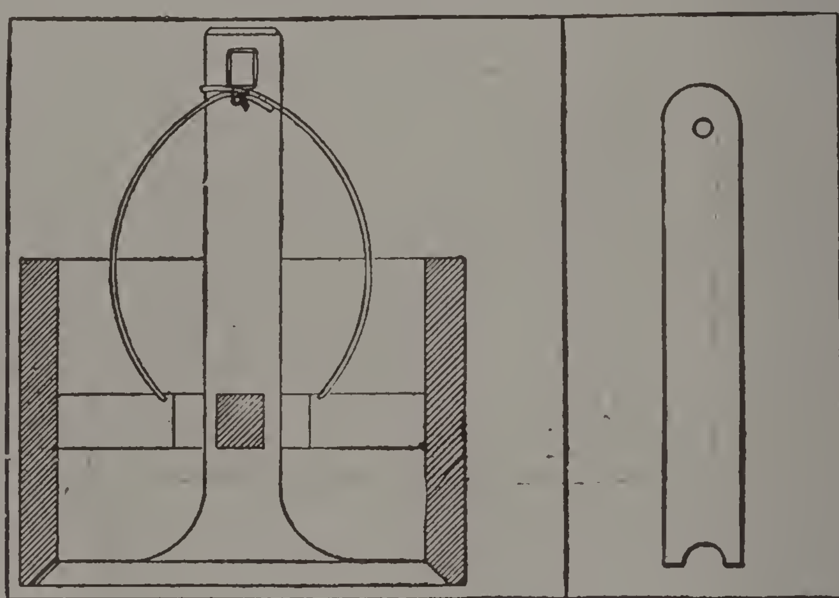


Fig. 16
Corset Steels Used As Impromptu Valve Springs

twine in their kit, as it may be put to various uses about the car, such as reinforcing weak spots in tires, protecting chafed wires, and binding together split sections of the steering wheel. Twine may also be used as a substitute in the absence of a lock washer, by forming a loop slightly larger than the diameter of the nut, and then wrapping twine around this loop, forming a "grommet," as sailors call it. When the nut is screwed down upon the grommet it will be held as firmly as if fitted with a nut-lock, and will stay tight until the twine rots.

**Axles, Definitions of.** The following definitions apply to the forms of rear axles that are now and have been in use on shaft-drive cars.

A "live axle" (no longer used) is one in which the driving member is carried by a bearing at each end, the outer end carries the wheel and the inner end the differential.

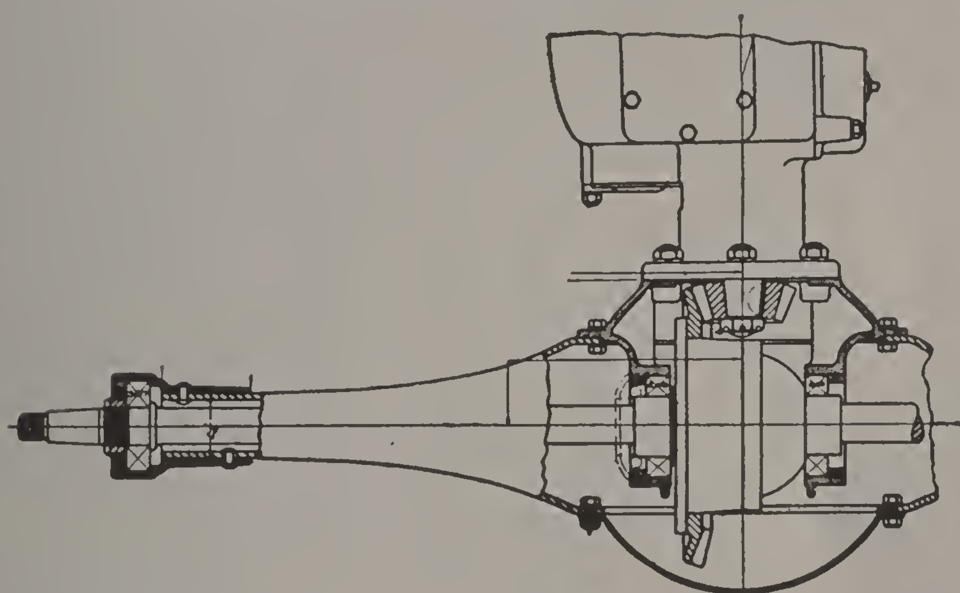


Fig. 17
Semi-Floating Rear Axle

A "semi-floating axle," Fig. 17, is one in which the driving member is carried on one bearing at its outer end and with the inner end supported by the differential. The outer end carries the wheel.

A "three-quarter floating axle," Fig. 18, is one in which the driving member is carried by the differential at its inner end and at the outer end is carried by the hub flange, the flange itself being bolted to the wheel. The wheel is then carried by a bearing that runs on the outside of the end of the axle housing tube.

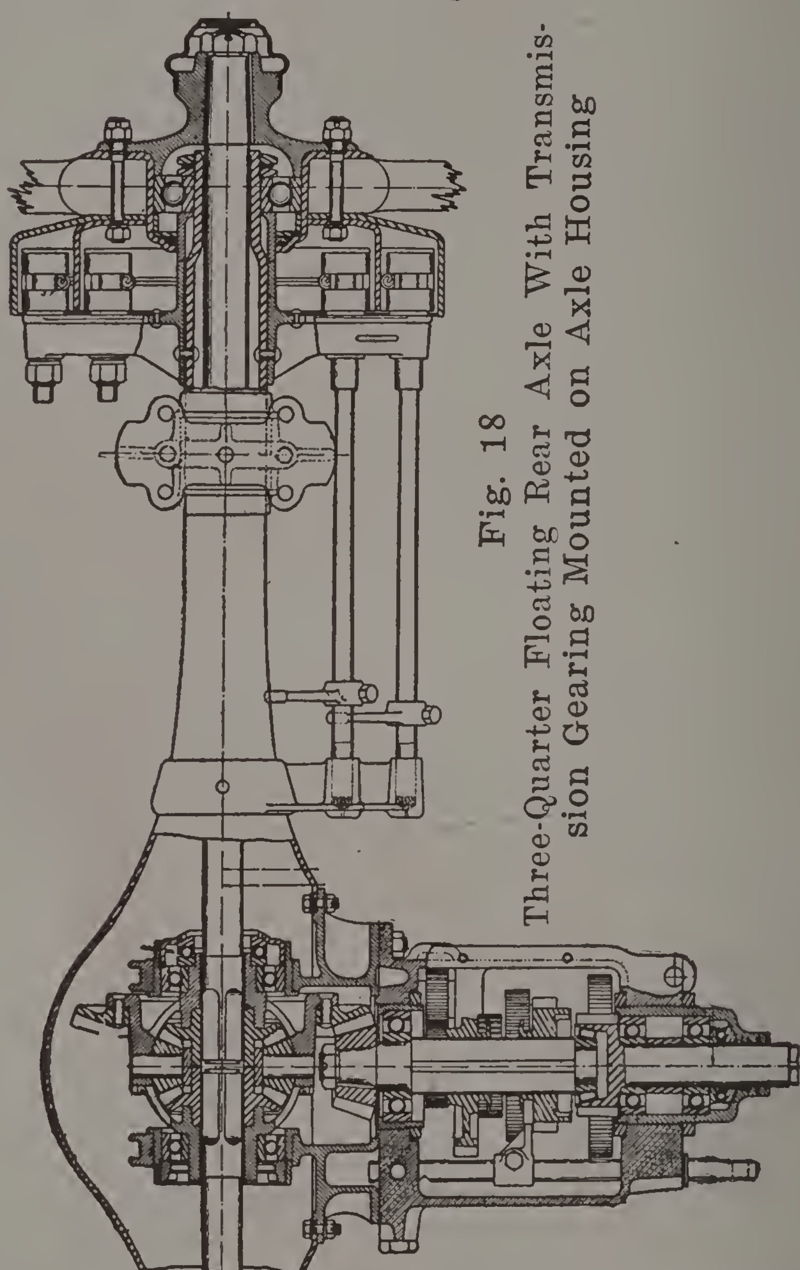


Fig. 18
Three-Quarter Floating Rear Axle With Transmission Gearing Mounted on Axle Housing

A "full floating axle," Fig. 19, is one in which the driving member is carried by the differential at its inner end and at the outer end is carried by a jaw clutch, the clutch itself being engaged with and meshing with the wheel hub. The wheel is then carried on two bearings that run on the outside of the axle housing tube. With

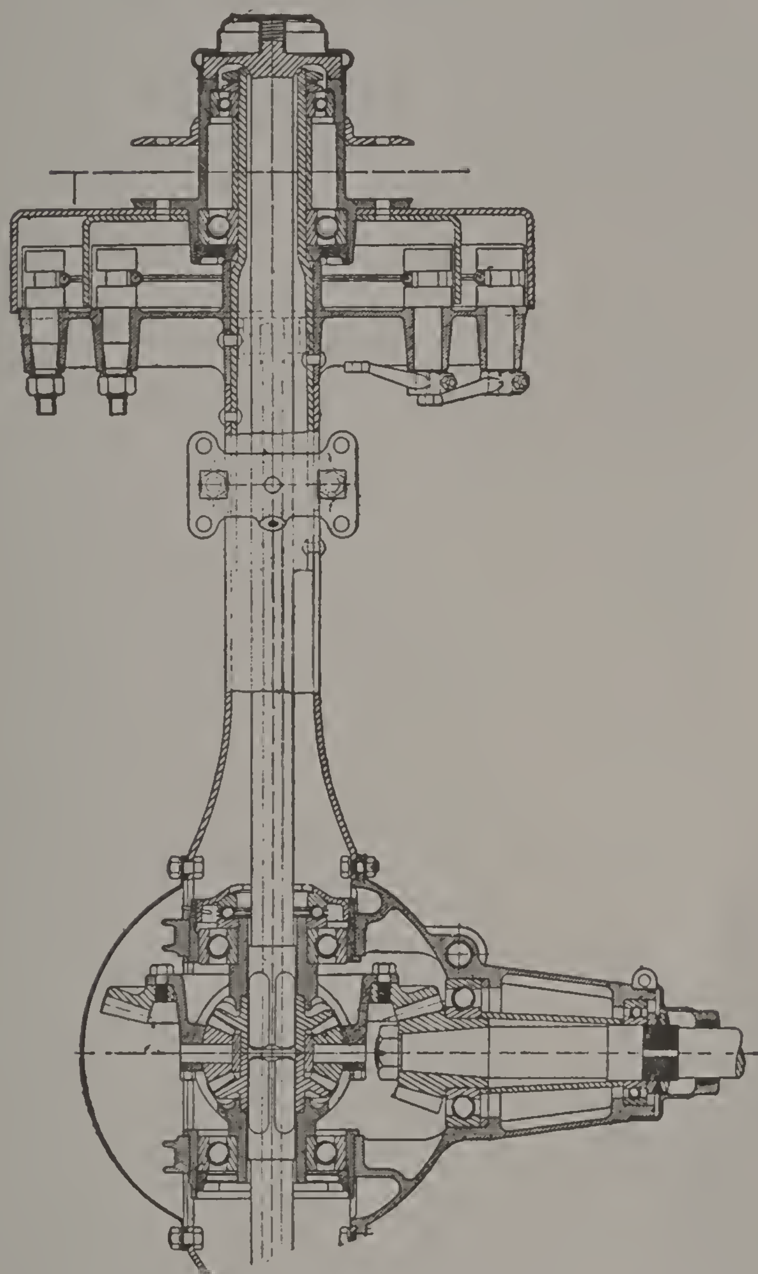


Fig. 19
Full-Floating Rear Axle With Annular Ball Bearings

this construction, the drive shaft may be entirely withdrawn from the car without disturbing the wheel or other axle parts.

**Axle, Front.** So far it has not been found practical to combine the tractive and steering functions of an Automobile in one set of wheels and axle. Therefore it is necessary to use a rigid front axle with knuckle jointed spindles, for steering purposes, and utilize the tractive power of the rear wheels only to propel the car. Some of the earlier forms of steering axles had the wheel pivots inclined so as to bring the projection of the pivot axis in line with the point of contact of the wheel with the ground, but as such constructions have not proved satisfactory they have in most cases been abandoned.

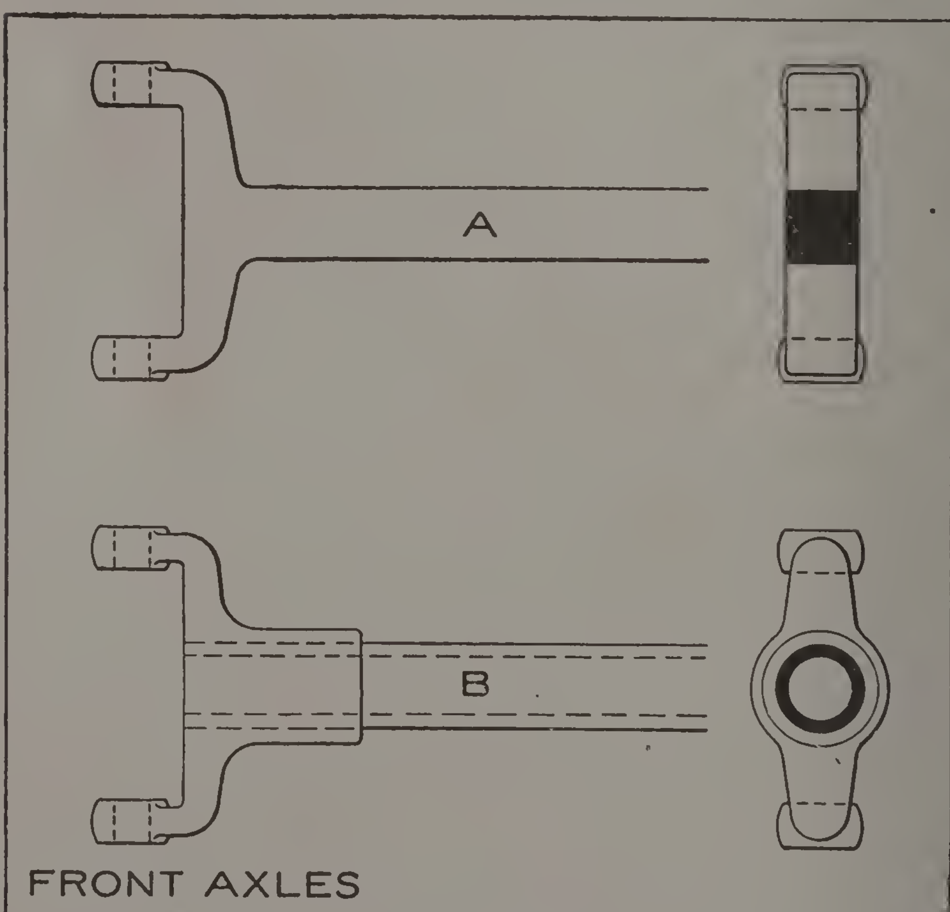



Fig. 20

Front Axles. Figures 20 and 21 show four styles of front axles with steering-pivot ends: A shows a solid axle of square section, with the steering-pivot jaws and axle proper, of a single forging—B represents an axle of tubular cross-section with the steering-pivot jaws bored

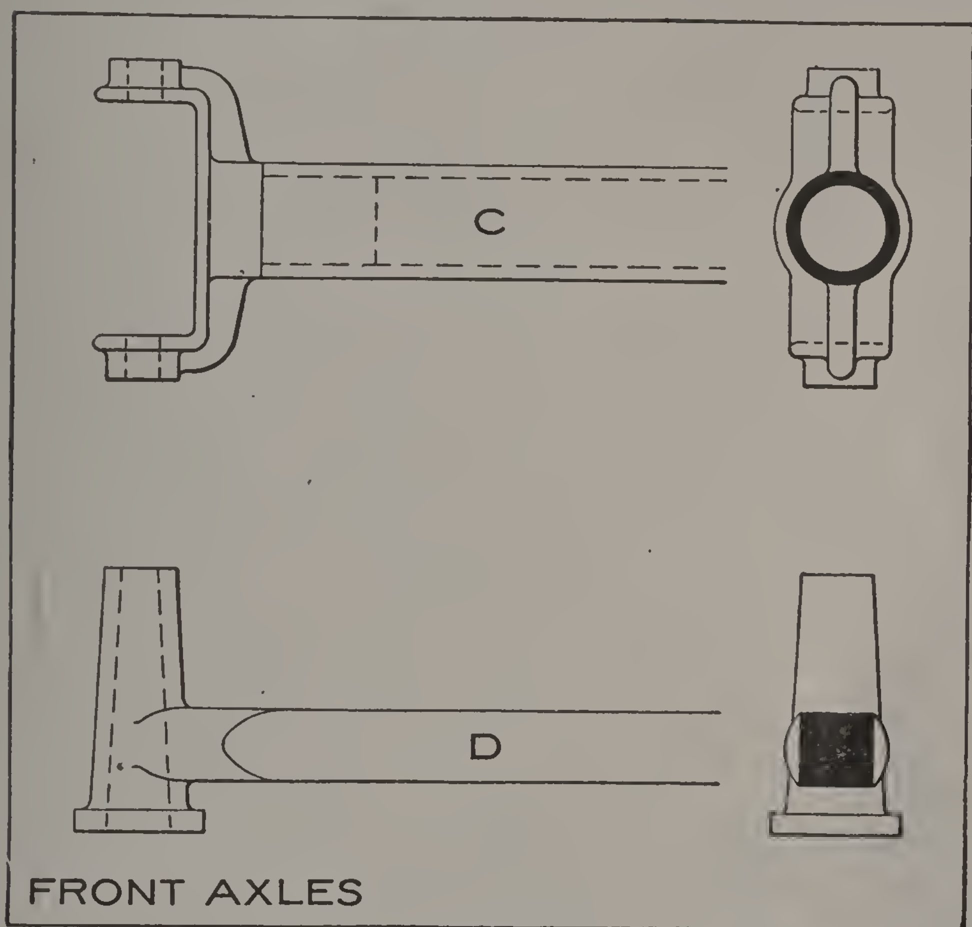
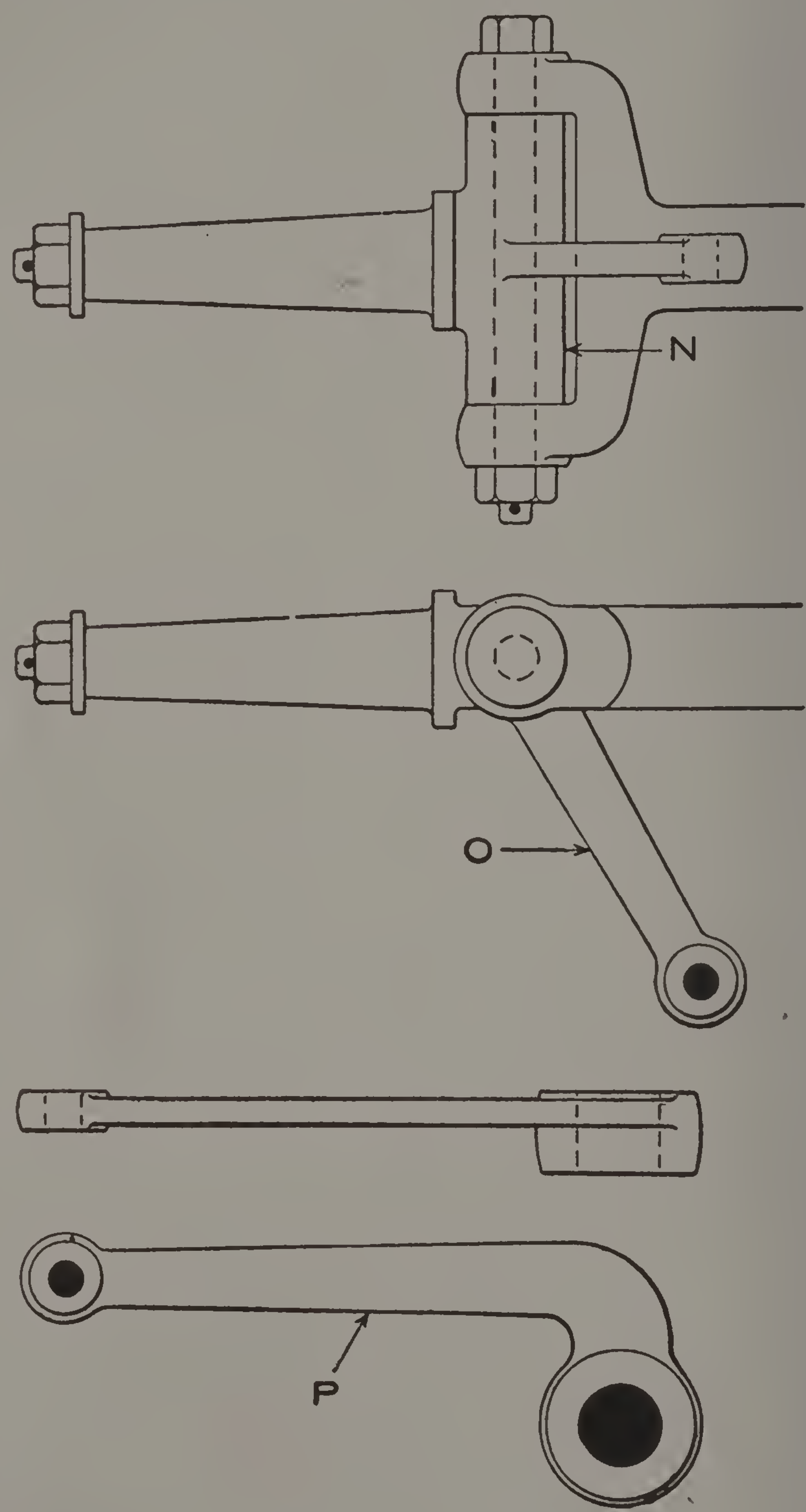



Fig. 21

out to receive the tubular axle which is firmly brazed therein—C shows another style of tubular axle, in which the steering-pivot jaw ends are turned down to fit the inside diameter of the tube and are also brazed in position, while D illustrates a one-piece axle with vertical hubs




STEERING KNUCKLE

Fig. 22

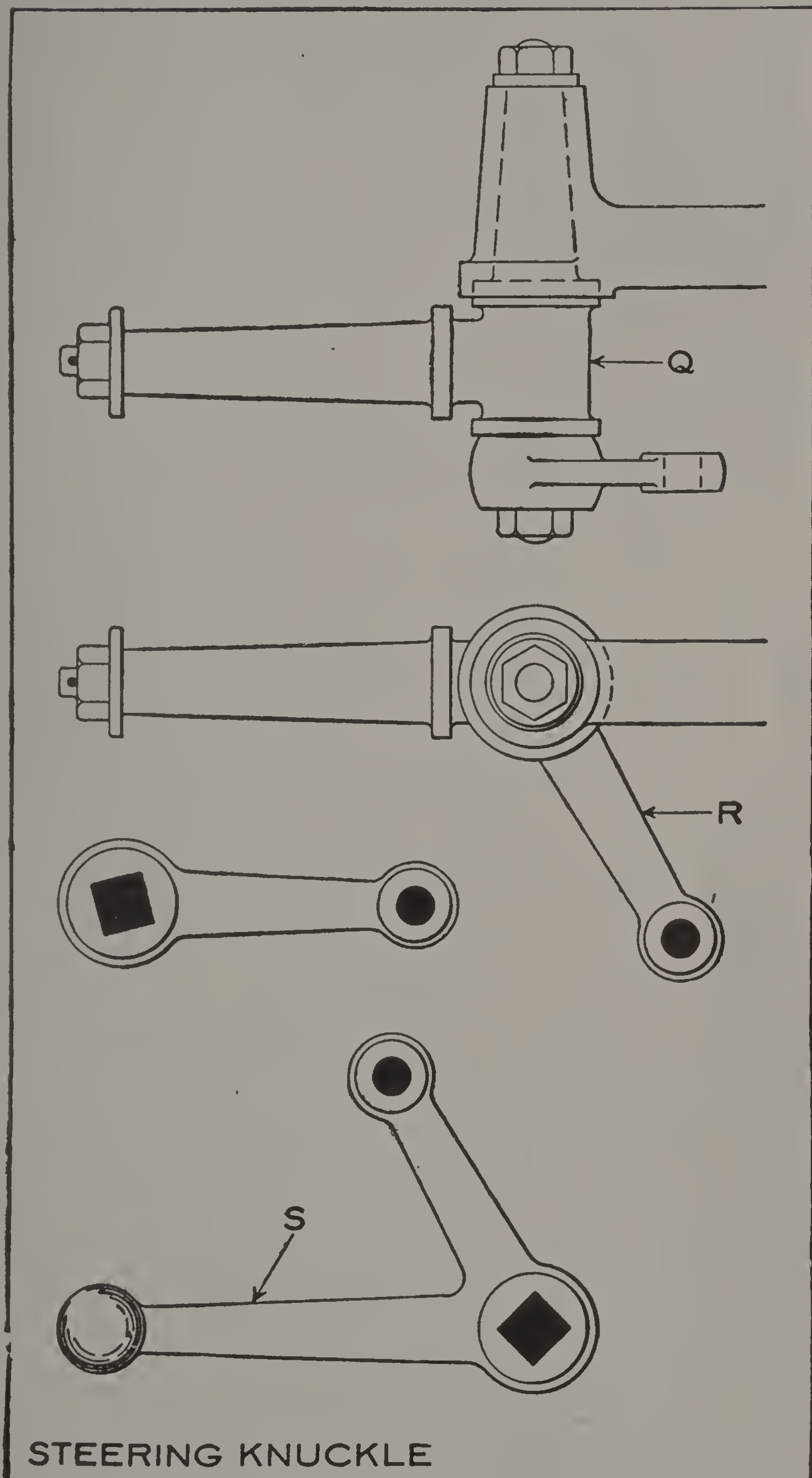



Fig. 23

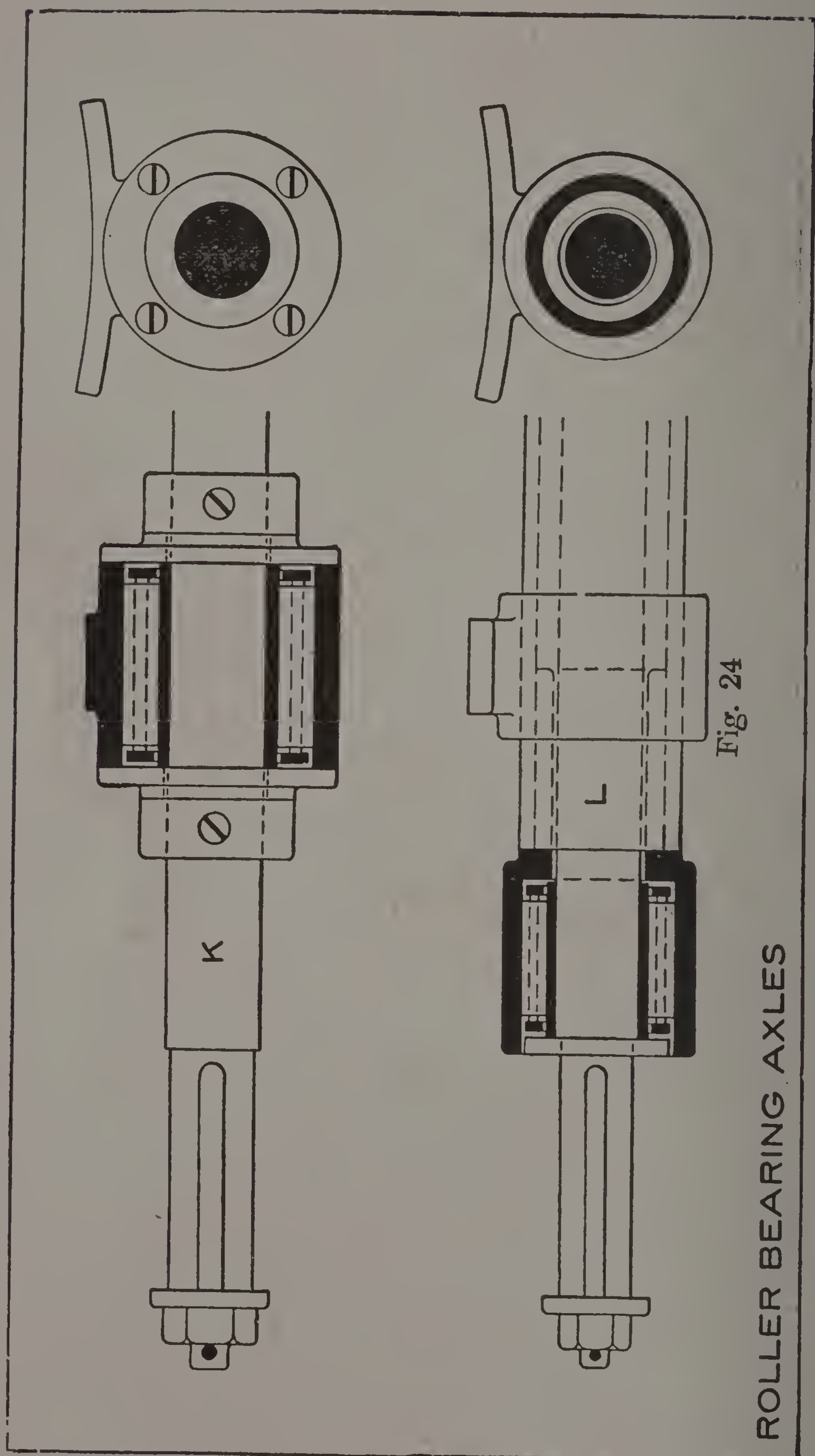



Fig. 24

ROLLER BEARING AXLES

instead of jaws, which carry L-shaped steering-pivots, instead of the usual form of knuckles.

STEERING KNUCKLES. In order to obtain ease of operation and secure the shortest turning radius with the least movement of the steering wheel or lever, the knuckle of the steering pivot should be as close to the center of the wheel as is possible. It is also of great importance that the steering knuckles should be as heavy as is practically consistent with the size and weight of the car for which they are intended. If this imporant point be neglected, rapid wear and probable fracture of the knuckles may be looked for.

A steering knuckle with a spindle and pivot of T shape is shown in Figure 22. The spindle and pivot N and the steering arms O are usually a one-piece forging. The steering arms O are connected by means of a suitable distance rod and the steering lever P is attached to one of the pivots N by turning a shoulder upon it and pinning and brazing the steering lever and pivot hub together.

Figure 23 shows a steering knuckle with spindle and pivot of L shape. The steering arm R goes on the lower end of one pivot Q only, the other pivot having the combined steering arm and ever S on its lower end. The steering arms being detachable, the device may be operated from the right or left hand side by simply exchanging the levers R and S. The steering lever S has a ball upon its outer end to fit in the

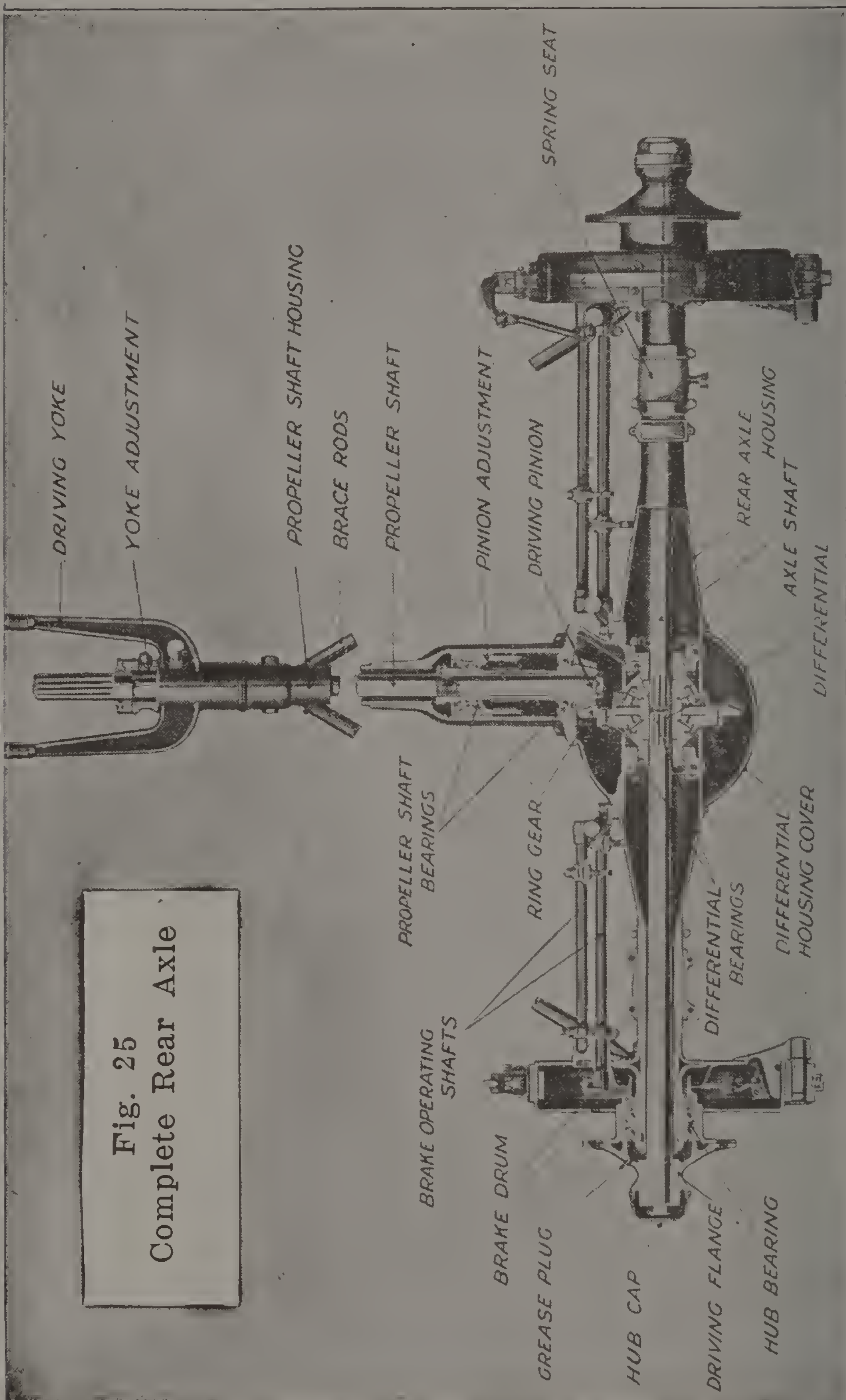



Fig. 25
Complete Rear Axle

socket on the connecting rod of the steering mechanism.

**Axle, Rear.** A live axle is any axle containing parts which turn the wheels in addition to carrying weight.

Dead Axle. A dead axle is an axle which carries weight only.

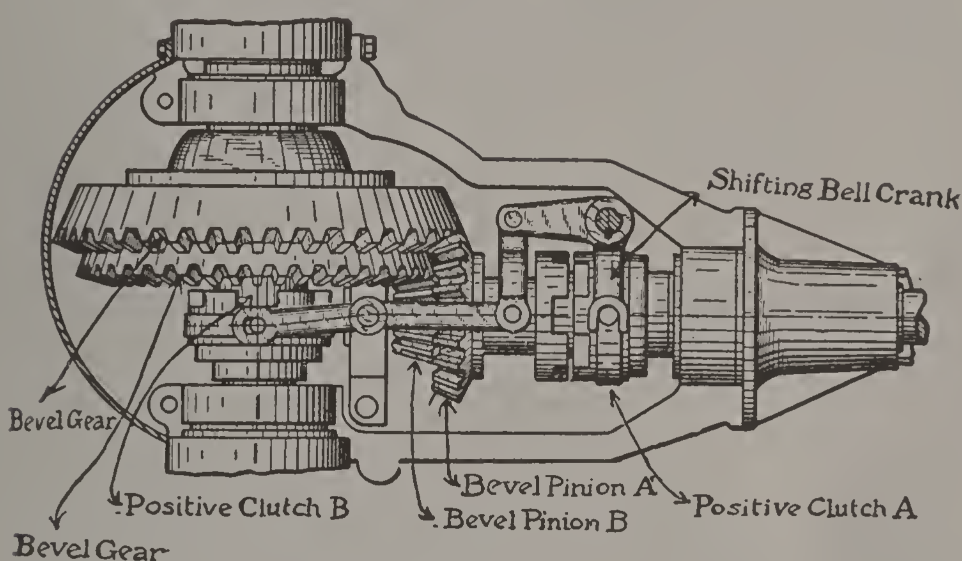



Fig. 26
Two-Speed Rear Axle With Two Bevel Gears and Two Pinions

Floating Axle. A special type of live axle in which the shaft that turns the wheels is independent of the axle proper, and may be removed without affecting the axle's weight carrying capacity.

In Fig. 24, K and L show respectively a live solid rear axle and a rigid tubular axle, equipped with roller-bearings. The spring lugs form part of the roller-bearing boxes of the live axle, while they are usually brazed to the tubular axle near its outer ends.

A rigid tubular axle with ball-bearing live driving shaft is illustrated in Figure 27, the ball-cup or race is adjustable by means of a hexagon upon its outer extension in the rear of the hub of the wheel and is held securely in position

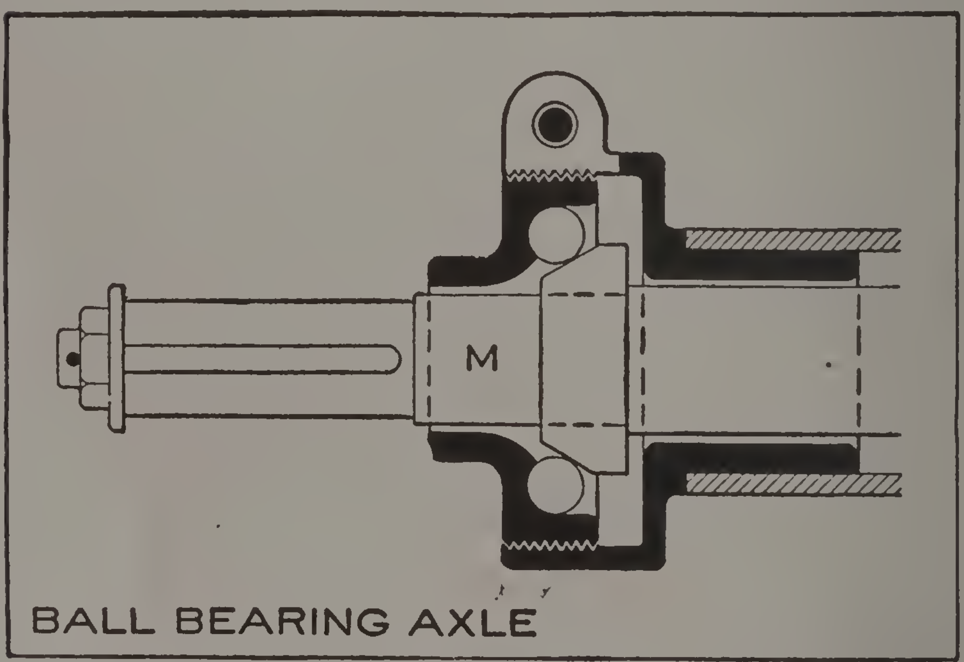



Fig. 27

and prevented from turning by means of the clamping device shown on the upper portion of the bearing. No separate adjustments for the inner two sets of ball-bearings are necessary, as the teeth of the spur gears of the differential which are keyed to the inner ends of the divided driving shaft, being free to slide upon themselves, allow the shafts M to have a slight longitudinal movement within the axle tube, thus taking up the wear of each pair of ball-bearings with a single adjusting mechanism.

In any style of full-floating axle the entire weight of the rear end of the car is carried on the axle housing, or casing, leaving the drive-shafts in the axle with no other work than that of revolving the wheels. In this axle, by the removal of the hub caps, the drive-shaft in each half of the axle can be pulled out, owing to its being free in the housing, and having generally a squared end which fits into the bevel gears of the differential. In a semi-floating rear axle the complete car weight at the rear is carried on the axle housing, identically as in the floating axle, but the drive-shafts of the axle are not removable by pulling endwise through the hub. This is because these shafts are tightly keyed at their inner ends with differentials, bevels or, as is the case in one or two cars, the bevel gear is formed integrally with the shaft.

The newest type of floating axle is that known as "three-quarter floating." As will be seen from the definition on a preceding page, this form combines several of the advantages of both of the other types, while, of course, having certain disadvantages of its own.

The construction used in Fig. 28 shows a full-floating type of live rear axle in which the bearings are of the annular type, and the driving jaws at the ends of the shafts engage with the hub in a proper manner to abort failure from lost motion.

In this case the tube is reduced in diameter to take the bearings, and the shoulder so formed is taken advantage of in the process of providing for thrust. The shaft has no work to do excepting to take torsional moments, and

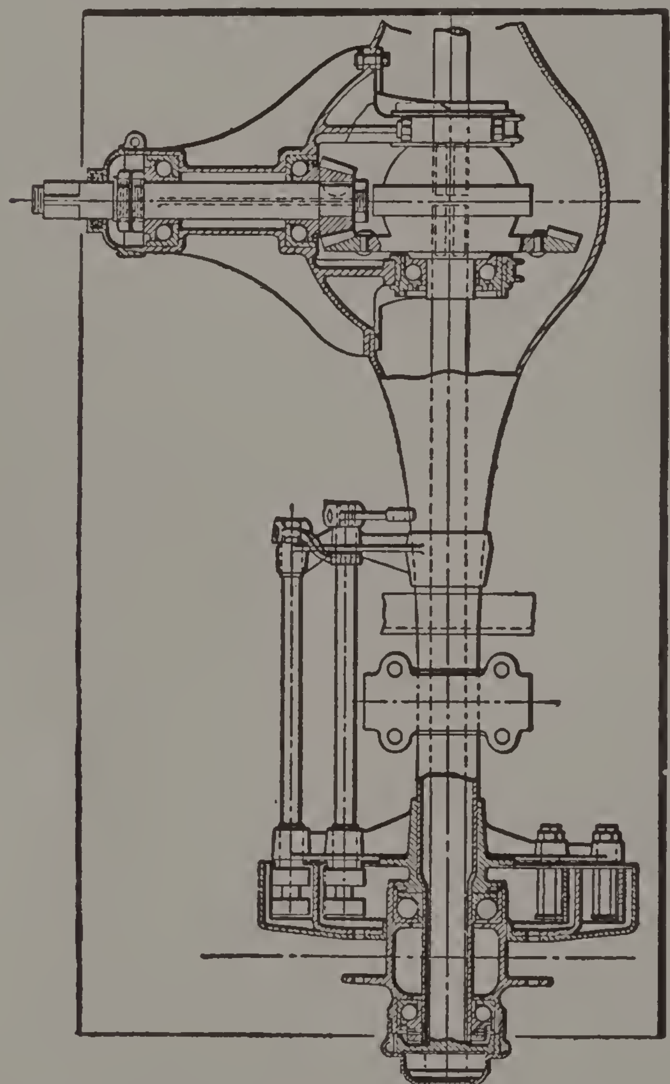


Fig. 28
McCord Full Floating Live Rear Axle With Annular Type Ball Bearings and Parts of Drop Forged Steel

the design throughout includes drop forgings of steel and drawn-steel parts. The inner race of the ball bearings is a sufficiently heavy tube, but it is not shaped in such a way as to act as a "preventer bearing," hence complete dependence is placed on the ball bearings and they are made large enough to take the responsibility.

Axle, Rear, Three-Quarters Floating. In this design, Fig. 18, the axle housing is extended outward to a point in line with the outside surface of the wheel, and the outer end is made of a diameter just large enough to allow the axle shaft to pass through it. Mounted on the outer end of the axle and directly in the center of the wheel is a single bearing, usually of the annular ball type. The wheel spokes are mounted in the hub flange in the usual manner and the flange is carried upon the outer surface of the bearing mentioned above. A large hub forging is bolted to the wheel flange and the bolts pass through the spokes which hold the brake drum on the inside. The outer end of the driving shaft is fastened into this hub forging by a key way and taper; the inner end of the driving shaft is carried by the differential in the same manner as with a full floating type. It will therefore be seen that the radial load of the wheel is carried on the single bearing at the end of the housing, and this bearing is also required to carry the end thrust. The binding strains that are imposed upon the wheel when turning corners, for instance, are provided for through the rigidity of the driving shaft, which is fastened solidly into the wheel hub at its outer end and which is carried by the differential at its inner end. This gives a leverage equal in length to the distance between the outer bearing and point of support in the differential.

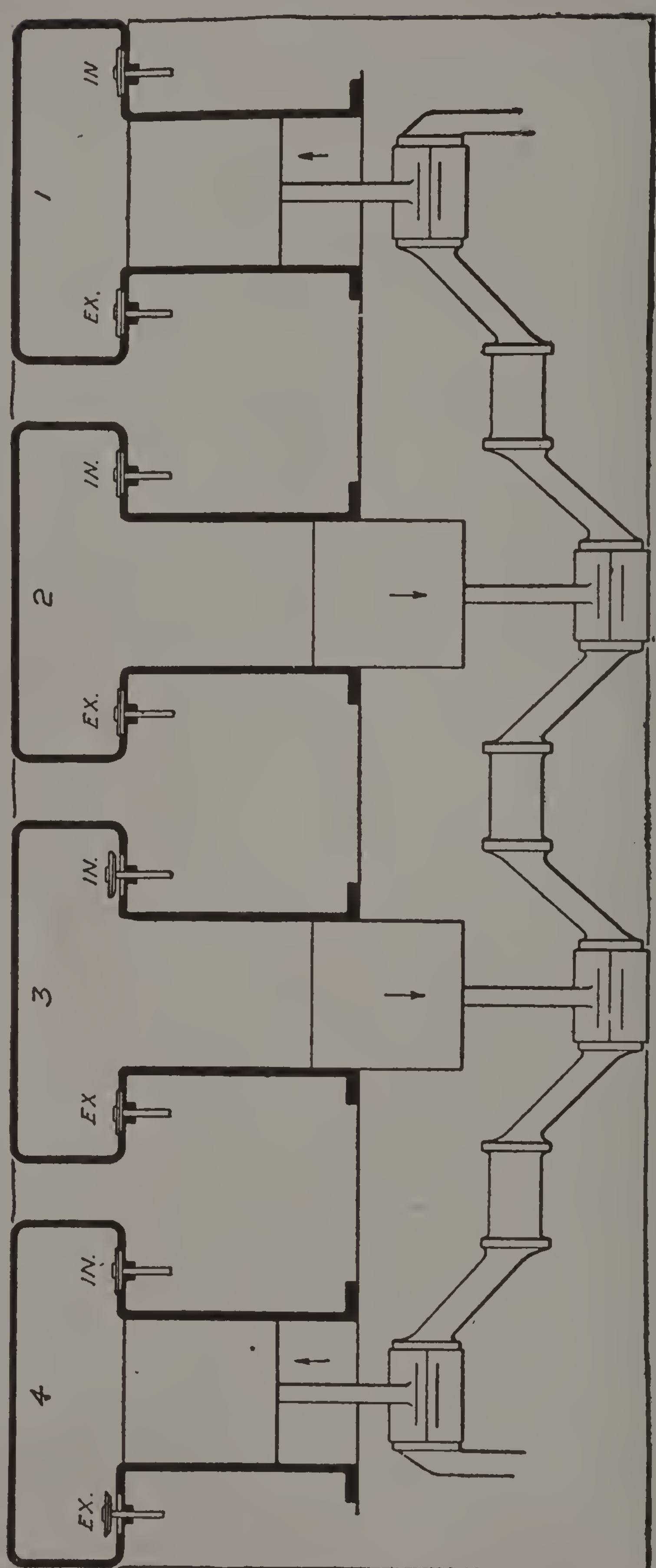



Fig. 29
Diagram Illustrating Theory of Back Firing

**Backfiring, Causes of.** This is a term applied to an explosion or impulse which forces the flywheel of a motor suddenly backwards, that is, in the opposite direction to its proper rotation. The term is sometimes used in connection with explosions which occur in the muffler from the ignition of an accumulation of unburned gases.

When a back kick occurs and the crank-shaft rotates in the reverse direction, that rotation must first be stopped and a rotation started in the correct direction. To stop the back kick or reverse rotation requires power, and to again start the correct rotation calls for power. The forces that stop the back kick are, the arm of the person cranking the weight of the rotating flywheel, and forcing one of the other pistons to compress the mixture. The force that starts the flywheel in the correct direction is the exploding charge of gas in cylinder No. 2 as illustrated in Fig. 29, in which the piston in No. 1 cylinder has not reached the top dead center on the compression stroke when the spark occurs and the reverse movement of the crankshaft starts. In tracing out what happens the valve locations must be considered. Both valves—intake and exhaust—in No. 1 cylinder are closed on the compression stroke and they will remain closed on the back kick stroke. Had the motor been running, No. 2 cylinder would have been going down on the explosion stroke of the piston, but as there was no previous explosion, the motor having been idle, the cylinder would be filled with mixture, with both valves closed, as they always are on the explosion stroke. The piston in this cylinder was normally going down; but, as soon as the back-fire occurred, the piston would start up and the valves remaining closed, the mixture would be compressed. This pressure would help to stop the back kick, and as soon as the power of back-kick was over the compression would start the piston down on the proper explosion stroke, which would prove of sufficient power to carry the motor past the firing point in the other cylinders. Cylinders 3 and 4 would not be factors at all, in that the piston in No. 3 would, when the back-kick occurred, be near the bottom or end of the suction stroke with the intake valve open, and when the reverse action of the piston set in it would start rising, simply driving the mixture out through the open intake valve and through the carbureter. Cylinder No. 4 was near the completion of the exhaust stroke when the back-fire started, and the exhaust valve was open. During the reverse motion caused by the back fire, the piston would start descending, the exhaust valve remaining open, exhaust gases would be drawn into the cylinder from the exhaust pipe.

Other causes of back firing are,

(1) A WEAK MIXTURE. Bearing in mind that the mixture is the fuel of the engine, and that

as in a stove, the character of the fuel influences its manner of burning, it will be evident that like poor wood, slaty coal, or other imperfect fuel, a weak mixture is a slow burner. This is point number one. Proportionate to the speed at which it is running, the motor has a certain sharply defined period of time in which it must complete each part of its cycle, if it is to operate satisfactorily. Should the parts of the cycle lap, or run over into one another, there is bound to be a hitch of some kind. The use of a very weak mixture causes just such a hitch by reason of the fact that it continues burning for some time after the completion of the part of the cycle during which it is supposed to function, i. e., the power stroke. In fact, it is still burning when the inlet valve opens to take in a fresh charge, and as its burning in the cylinder maintains considerable pressure therein, the latter, on the lift of the inlet valve, escapes through it and the carbureter with a pop, exactly similar to that of an unmuffled exhaust except that it is weaker. The remedy is more gas or less air, or sometimes both, and to find out just how much of each is required, start the motor and very gradually cut down its gasoline supply at the needle valve of the carbureter until the motor begins to miss. Then as slowly increase the supply until the motor will run steadily and without missing on the minimum opening of the needle valve. Lock the latter in place. Then speed the motor up by opening the throttle and adjust the spring of the auxiliary intake on the carbureter until the motor is receiving sufficient air to enable it to run and develop plenty of power at all speeds.

(2) An overheated combustion chamber, due to a poor circulation of the cooling water—causing self-ignition of the charge before the proper time.

(3) Advancing the ignition point too far ahead when the motor is running slowly under a heavy load—flywheel has not sufficient momentum to force the piston over the dead center, against the pressure of the already ignited and expanding gases.

(4) The presence of a deposit of carbon (soot) or a small projecting surface in the combustion chamber which may become incandescent and cause premature ignition.

**Batteries.** But two forms of batteries are used in automobile work, the dry cell and the storage battery. Both are described in the following pages. A distinction should be noted between battery and cell. A single unit, complete in itself and capable of giving a flow of current, whether of the dry or storage type, is a cell. The ordinary dry cell gives a voltage of 1½ while a storage cell gives approximately 2 volts. When it is desired to secure higher voltages, two or more cells are used in conjunction with each other and the set then becomes a battery. A single cell is not a battery.

**Batteries—Dry.** A dry battery of the usual type consists of a zinc cell which forms the negative element of the battery.

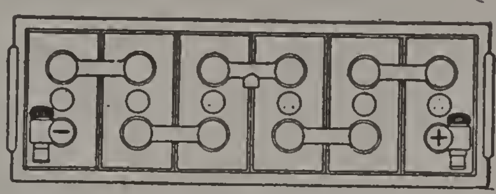


Fig. 30
Six Cells Boxed to Make a Battery

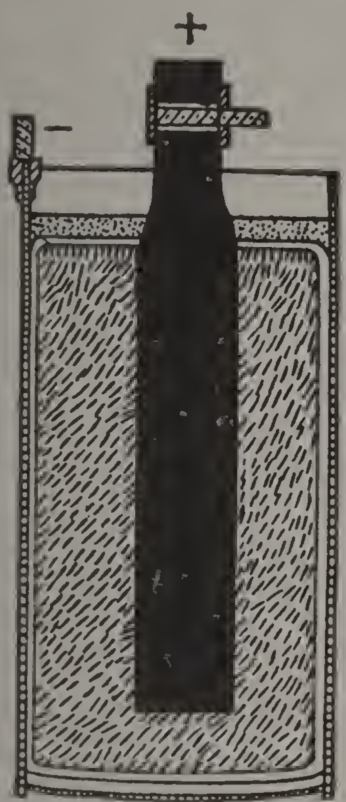



Fig. 31
Section Through Dry Cell

Dry Batteries are very generally used on moderate speed and low-priced cars. They are simple in construction, comparatively simple in operation, and their action is easy to understand. Each cell is composed of three elements: The carbon, the zinc, and the electrolyte. The carbon usually takes the form of a round stick placed in the center of a cylindrical vessel made of zinc in sheet form. The space between the carbon and the zinc is filled with the electrolyte, generally a solution of sal-ammoniac, which is poured in on crushed coke. The top is closed, or rather sealed, with pitch to prevent the loss or evaporation of the liquid. Through this, project the ends of the carbon and the zinc, these being formed into binding posts for holding the wires. As this holding of the wires must be an intimate relation, the usual form is a threaded shank upon which a pair of nuts are mounted. Between these the wire to be connected is crushed or compressed by the moving together of the nuts.

The two poles or binding posts are called the positive and the negative, and are indicated by the + sign for the former and the — sign for the latter. Carbon being the positive element, the + sign attaches to it. Now, the act of connecting these terminals together so as to allow a flow of current allows of two different methods of procedure, a right and a wrong way, it is true, but that was not what was meant.

In one respect dry batteries have a decided advantage over storage batteries for ignition purposes, from the fact that on account of their high internal resistance they cannot be so quickly deteriorated by short circuiting.

On account of this high internal resistance, dry batteries will not give so large a volume of current as storage batteries, but a set of dry batteries may be short circuited for five minutes without apparent injury and will recuperate in from twenty to thirty minutes, while a storage battery would in all probability be ruined under the same conditions.

It is often desired to secure a greater voltage than one cell will give, or else to secure a source of current that will give a greater time of service than can be secured from the single cell. In either case, it is customary to combine two or more cells in certain definite combinations and connect them with each other in such a way that the desired voltage or length of life is realized. It is possible to make such combinations by using either dry or storage cells, although storage cells are usually boxed after forming.

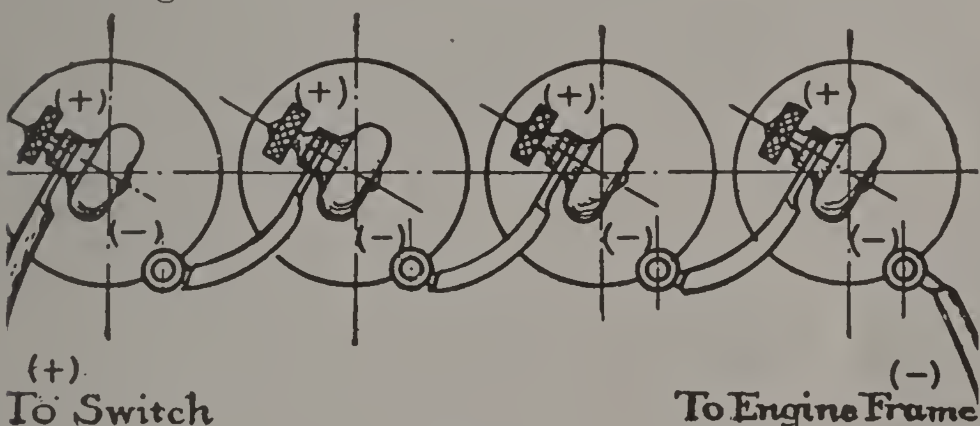



Fig. 32
The Ordinary Battery Connection, in Series

Two methods are usually employed, viz.: series, and multiple, or parallel. To connect dry batteries in series, the terminals are joined alternately, that is, the zinc of the first is connected to the carbon of the second, the zinc of the second to the carbon of the third, etc.

When so joined, the positive element is left free at one end, and forms the positive terminal of the group, which is then considered as a unit. The other free end (the negative) forms the negative terminal of the unit, see Fig. 32, which shows four cells connected in series.

Figure 33 shows four cells connected in parallel which means that all of the positive terminals are connected to one common wire, and all negatives are connected to another wire.

This mode of wiring up the cells gives a smaller output for the group. Thus if the individual batteries have an internal resistance

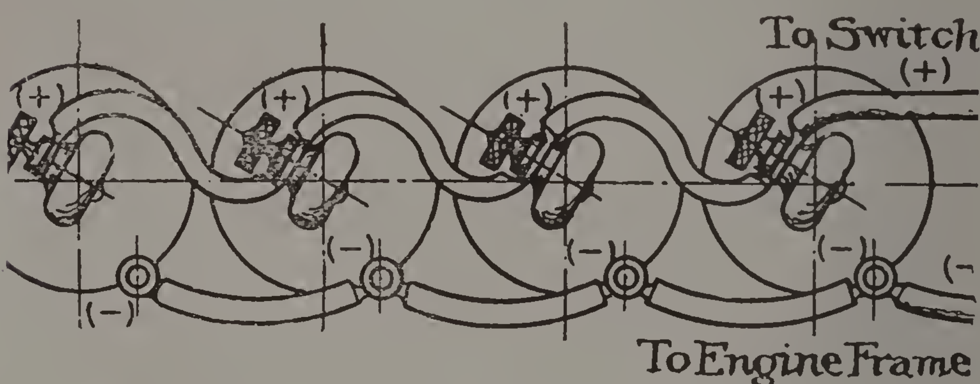



Fig. 33
Parallel Connections are Not as Frequently Used

which is low in comparison with the external resistance, the total output will be but slightly more than that of a single cell. If, on the other hand, the internal resistance is high relative to the external, the current will be roughly proportional to the number of cells.

Where the cells are divided into sets or groups of a small number (four is usual), and more than one of these sets are used at a time, there are again two methods of joining them. These two are the same as before, viz., series and multiple.

The former is very seldom used, if ever, but the other is rather common. When two or more sets of batteries, themselves connected in series are, as sets, joined in multiple the whole is spoken of as connected in series-multiple.

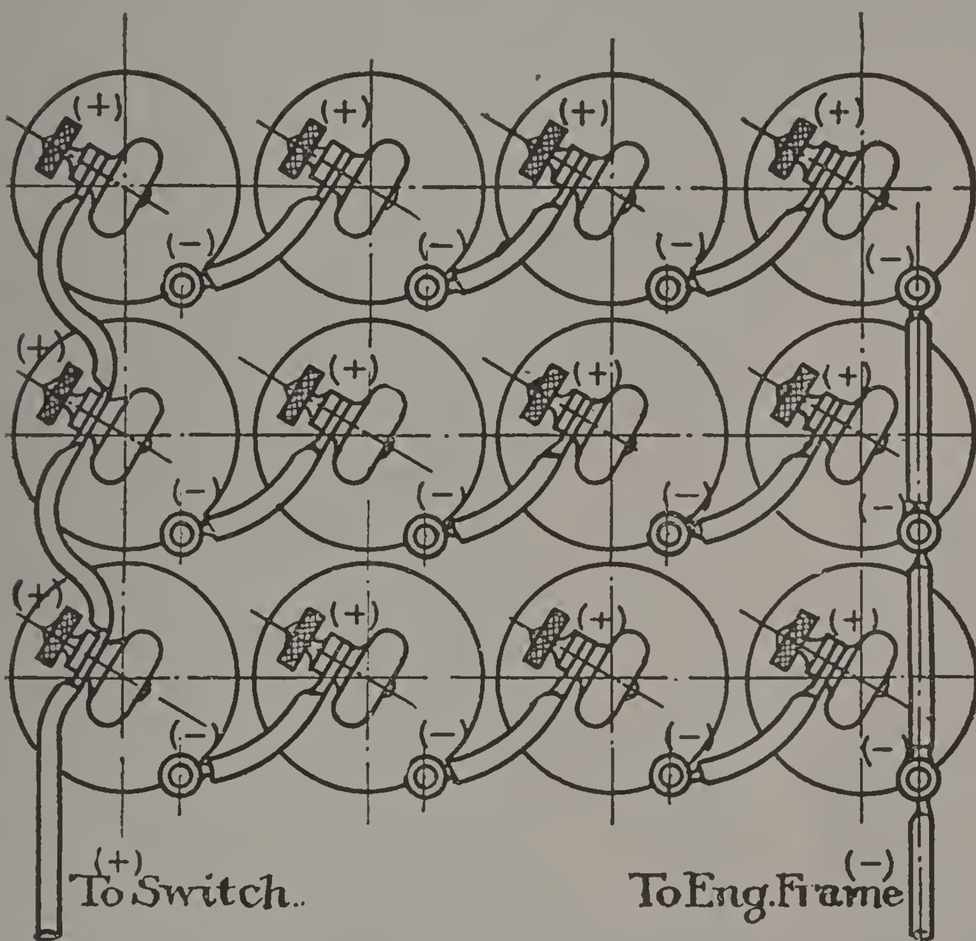



Fig. 34

**Batteries—Storage.** A storage battery as used in ignition service, is usually of the lead-acid type, in which the electrolyte is sulphuric acid and water of a density about 1.2— specific gravity. The plates are of two classes—positives and negatives—there being one more negative than positive in each nesting in a cell. The elements of a cell of storage battery are given in Fig. 35, and consist of the following: Positive plates A, of which there is one fewer than of negatives; negative plates B, of which there is always one more than positives; sepa-

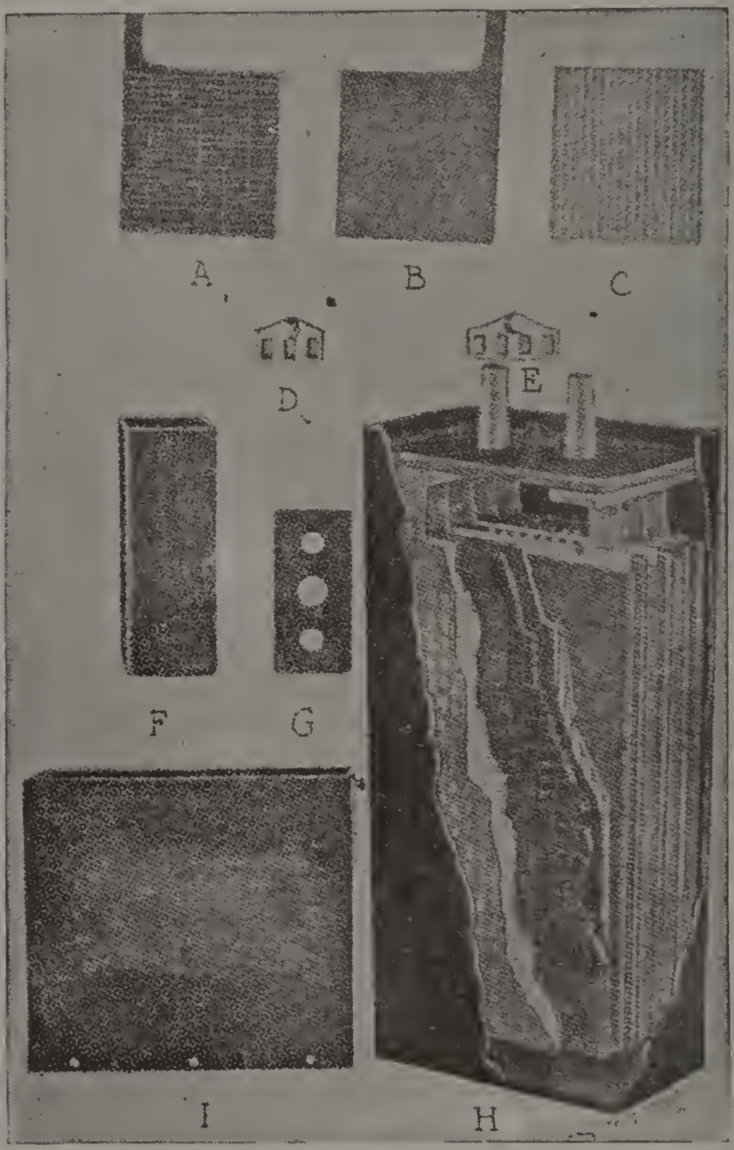



Fig. 35
Elements of Assembled Battery

rators C, which may be of wood, rubber, or other suitable material, and if of wood must be treated; positive strap D, the function of which is to connect all the positive plates, across the top, into electrical relation; negative strap E, the function of which is to connect all the negative plates, at the top, in electrical relation; battery jar F, made of rubber composition, light, strong and acid proof; cover for the jar G, with holes for the terminals of the elements, and a vent; assembled cell of battery H, showing the elements in place, separated, with cover on; ready for connections; and a battery box I, of oak, usually contrived to hold three cells of battery, sometimes two.

The positive and negative plates, called elements, consist essentially of a grid in each case, made of lead-alloy, in which antimony is used to engender stiffness. The grids are in divers forms, depending upon the views of several makers, the idea being to afford space for the active material, and to lock the same in, so that it will not drift out, as it is prone to do, under the action of the charging, and discharging current. Surface is the great requisite, and it is the aim to afford the maximum area of the finished plates, per pound of active material used; limiting the weight of the supporting grid, in so far as it is possible to do so.

The voltage of a battery of this type is usually 2.2 volts when the circuit is closed, but it drops to 2 volts within the first hour of using, which pressure it usually maintains during the next 5 hours, after which the voltage declines at a rapid rate.

Adding Water to Cells. In service water

will have to be added to the cells to compensate for evaporation, and for the loss that takes place during charge, brought about by the entraining of water with the bubbles of gas that shoot off and out of the jars, if they are open, that is to say, if the covers are removed before and left off during charging, which is not usually the case. The result in any event is in favor of increasing strength of the electrolyte, and water will have to be added from time to time in order that the plates may not be exposed to the atmosphere above the line of active material; which is a point that must be cared for if the battery is to last for a long time. The water so added should be pure—distilled—and the right quantity to add, will be determined by means of a hydrometer placed in each cell between the separators if there is sufficient room, or the electrolyte may be withdrawn through the utility of a gun made of hard rubber with a long slender neck. The test should be made when the battery is charged and every cell should be examined rather than to test one cell and conclude that all are in an average condition.

Storage Batteries—Care of. Among the troubles that ultimately attend batteries in service the following are the most conspicuous:

Hardening of negative elements; local action; buckling of plates; shedding of active material; sulphation; reversal of negative elements; disintegration of grids; protruding active material; deformation of separators; broken jars; incipient short circuits; defective electrical contact: loss of capacity; loss of voltage; corrosion of plates, and needle formations.

Hardening of the negative elements will follow if they are exposed to air, as when the electrolyte is allowed to fall below the level of the plates, from any process that will produce over-oxidization if the temperature is allowed to increase much above 90 degrees Fahrenheit. When the negative elements are hard, to reduce them back to the normal condition, assuming the process is not too far gone: Remove the elements from the jar, place the negatives in a cell, with dummy positives, and charge until the negatives are corrected, taking care not to charge at a too high rate. High temperature and excess boiling should be avoided. If the negatives are charged in their own cell with the regular positives the positives will be damaged by the excess charging that will be necessary to reduce the negatives. When the negatives are sufficiently charged to correct the evil they may be returned to their own cell, and when connected up with the positives the cell will be ready to go into service again, if in the meantime the positives are given such attention as their condition would seem to indicate. Local action, following impurities in the electrolyte, will only be prevented as much as it is possible to do so when the electrolyte is removed and pure electrolyte substituted in its stead. This should be done when the cells are fully charged, The electrolyte will hold most of the impurities when the battery is in the fully charged state.

Buckling of plates, when batteries are defective in design, rather than in cells of normal characteristics, is a trouble that will follow in any cell if the discharge is allowed to extend below 1.8 volt as indicated by the cadmium test, rather than by the usual potential difference reading across the two sets of elements in the cell. If the rate of discharge is excessive, a condition that is not likely in ignition work, buckling will follow also. Short-circuiting the elements to see if the battery is alive will tend to buckle the plates, due to the heavy discharge, and the uneven rate of discharge over the surfaces of the elements. In defective construction, if the active material is not of the same porosity, thickness, and in the same condition all over the surfaces of the plates, buckling will follow.

Shedding of the active material, to a slight extent, is a normal condition of batteries; and to prevent trouble due to incipient short circuits, such shedding is cared for by having a space in the bottom of cells to hold such shedded material. When elements are of inferior design and improperly constructed the active material will shed at a rapid rate, and the user of the battery can do nothing more than demand a new battery to replace the defective one. If charging is done at a too rapid rate the active material will be loosened by the rapidly escaping gas, and even on discharge, if the rate is high, the shedding of active material is likely to follow.

Sulphation, which is a normal expectation during discharge of a battery, introduces serious complications under certain conditions as when the active material is not in intimate contact with the grids thus allowing the electrolyte to get between the grids and the active material, with the result that sulphate, which is a high resistance material, isolates the grids and reduces the efficiency of the cell in two ways; first, by increasing the ohmic losses, and, second, by lowering the chemical activity. Excess sulphate is prone to form when the electrolyte is out of balance, and one of the best ways to abort this action is to keep the electrolyte within the prescribed limits of strength. If sulphate is allowed to form until white crystals show over the surfaces of the plates, it is highly improbable that the cells will ever be of sufficient service to warrant continuing them in service. The only way to afford relief lies in reducing the growth of sulphate by continuous charging the sick elements in a cell with dummies until the sulphate is reduced. A slow rate for a long time may bring about a reform.

Negative elements to be reversed must be below capacity, or the cells must be discharged to zero and then reversed. In charging it is always necessary to make sure that the connections are made in such a way that current will flow into the battery, rather than out of it. Voltmeters in which permanent magnets are used will serve as polarity indicators, and with them it is possible to proceed with safety. If a battery is connected up in reverse when it is put on charge, instead of being charged it will be discharged, and then charge in reverse. While it is discharging it will deliver current to the line.

Disintegration of grids will follow if the impurities are allowed to enter the electrolyte, as iron, etc. Continued charging will also have the effect of reducing the grids to form salts of lead.

Protruding active material, due to expansion and displacement of the same, indicates a lack of binding relation between the grids and the active materials. There is no remedy. Deformation of separators, when they are made of rubber compound, follows when the cells are allowed to heat beyond a certain point. This trouble will be aborted if the cells are charged at a normal rate, and if the temperature is not allowed to increase beyond about 90 degrees Fahrenheit. When wood separators are used they will slowly rot and in time it will be necessary to replace them.

Broken jars will allow the electrolyte to leak out, and frequently the fracture is but a minute crack, so that it is well to be on the lookout for just this kind of trouble. If the jars are properly nested and motion between them is prevented they will as a rule serve without breaking.

Incipient short circuits are likely to go unnoticed. They are generally due to detached particles of active material that lodge between the plates, especially in vehicle and ignition types, owing to the short distance separating the plates, and the use of separators, such as perforated rubber in the absence of wood, which have the virtue of being porous but too close to allow the active material to bridge across the space between the plates.

Defective electrical contact is due to corroding of joints that are not made by burning.

Loss of capacity may be traced to such causes as: If the electrolyte is out of balance or below the level of the top of the plate; loss of active material from the grids; sulphate formed on the surfaces of the grids, isolating the active material; lack of porosity of the active material; impurities and sulphate clogging up the pores of the active material; low temperature; high temperature; persistent sulphation, and intercell leakage due to electrolyte spilled over the surfaces, especially if jars are in actual contact with each other.

Loss of voltage, as distinguished from loss of capacity, follows in a battery when one or more of the cells are dead or below voltage. If one or more of the cells are reversed they will set up a counter-electro-motive force, and the over-all reading of the battery will be reduced accordingly. The remedy is obvious. All the cells should read the same way, and all should have the same difference of potential, respectively.

In view of the sulphated condition that attends all batteries that are discharged at a low rate for a long time, as is the case in ignition work, it is necessary to charge at a low rate for a long time in order to reduce the sulphate, which is in persistent form and very difficult to reduce. It will not be enough to correct the strength of the electrolyte once during the charging process for the reason that it will be difficult, if not impossible, to ascertain the condition of the same with any degree of accuracy, and the necessity for noting strength two or three times in the act of charging is apparent. When the battery is fully charged, which may take even sixty hours of continuous charging at a low rate, the electrolyte in every cell should stand at full strength, considering a state of full charge, and the color as well as other indications of a full charge should be fully noted. Boiling at a slow rate should be tolerated for several hours, but the temperature should be held at about 90 degrees Fahrenheit during the entire time. If a battery is charged at frequent intervals it will last longer in service, give less trouble in charging and will be more reliable in service. It is well to begin charging directly a battery is taken out of service as any delay after that time will result in a marked deterioration of the cells.

When a car is put out of commission, even for a few weeks, the battery should be given a light discharge, and a subsequent charge as often as once a week, until it is again brought back into use.

STORAGE BATTERIES — CHARGING. Positive plates in the charged state are of a velvety brown or chocolate color; negative plates have the color of sponge lead, which is very nearly light gray. When a battery is approaching a condition of full charge the color tones up quite noticeably, and it is possible to mistake a condition of full charge, if color alone is taken as the evidence; the exterior will have the appearance of full charge, since the active material, on the exterior surface, will reach its charged form first; if the thickness of active material on the grids is very thick, as it is likely to be in low discharge rate work, charging by color, as evidence of a state of full charge, will be to limited advantage. Details regarding the proper care and upkeep of storage batteries are given in the following pages.

STORAGE BATTERIES—TESTING. Tests for impurities in the electrolyte may be made as follows. For iron;

Neutralize a quantity of the electrolyte to be investigated, after diluting the same, by the addition of an equal amount of pure distilled water, using strong ammonia water for the purpose. To the solution, so neutralized, add one-thirtieth of the amount of the same of hydrogen peroxide, thus reducing any iron present to the ferric state. If a sample of this solution is rendered alkaline by the addition of a sufficient quantity of ammonia water, then, if iron is present, enough to amount to anything of great moment, from the battery point of view, a brownish red precipitate will form. A test for chlorine is as follows:

Make a solution of nitrate of silver in the proportion of 20 grams of the same, in 1,000 cubic centimeters of pure distilled water, and add a few drops of this solution to a small quantity of the electrolyte to be investigated; if chlorine is present the solution will turn white, owing to the formation of chloride of silver, which will precipitate out.

A test for nitrates is as follows: In a test tube, holding 25 cubic centimeters of electrolyte to be tested, add 10 grams of ferrous sulphate; to this carefully add 10 cubic centimeters of chemically-pure sulphuric acid by pouring the same slowly down the side of the tube; in the presence of nitric acid, a brown solution will form between the electrolyte to be tested, and the concentrated solution of sulphuric acid.

The presence of copper may be detected from the fact that when ammonia solution is added to electrolyte, a bluish-white precipitate will form. In testing for mercury, lime water, if it is added to electrolyte in which mercury is present will evolve a black precipitate. Testing for acetic acid is as follows: To a small quantity of the electrolyte to be tested, add enough ammonia water to render the same neutral; ferric chloride added to this solution will cause the same to turn red in the presence of acetic acid and the solution will then bleach, provided hydrochloric acid is added, thus affording conclusive proof of the presence of the undesired acetic acid.

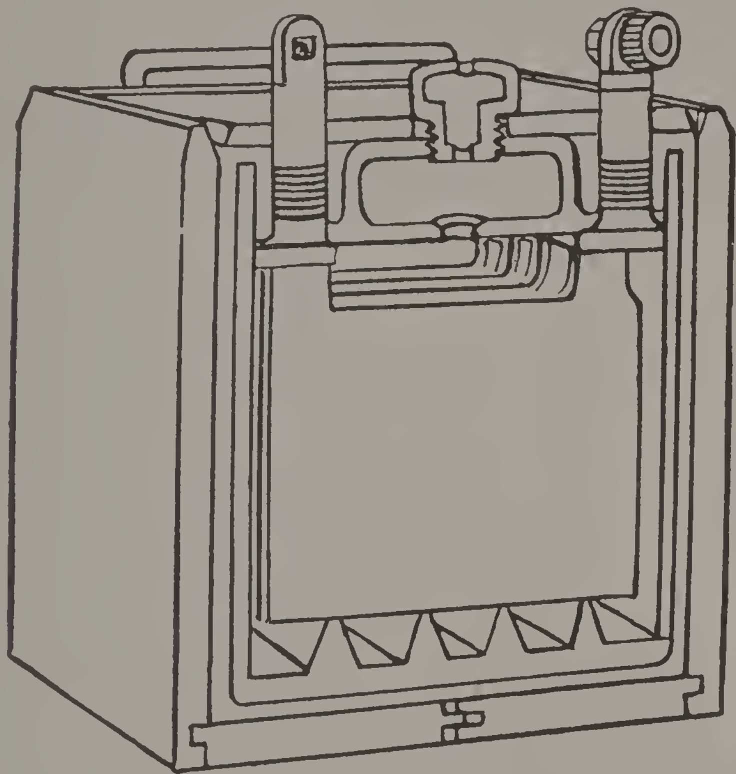


Fig. 36
Section Through Storage Battery Used For Lighting and Engine Starting

**Battery, Storage, Starting and Lighting Types.** The foregoing description and instructions relating to storage batteries apply equally well to ignition, starting and lighting types. The following rules include the standard battery instructions adopted by the Society of Automobile Engineers for the installation and care of batteries used in connection with electric lighting and starting systems.

Batteries must be properly installed. Keep battery securely fastened in place. Battery must be accessible to facilitate regular adding of water to, and occasional testing of, solution. Battery compartment must be ventilated and drained, must keep out water, oil and dirt and must not afford opportunity for anything to be laid on top of battery. Battery should have free air space on all sides, should rest on cleats rather than on a solid bottom, and holding devices should grip case or case handles. A cover, cleat or bar pressing down on the cells or terminals must not be used.

Keep battery and interior of battery compartment wiped clean and dry. Do not permit an open flame near the battery. Keep all small articles, especially of metal, out of and away from the battery. Keep terminals and connections coated with vaseline or grease. If solution has slopped or spilled, wipe off with waste wet with ammonia.

Pure water must be added to all cells regularly and at sufficiently frequent intervals to keep the solution at proper height. Add water until solution is level with inside cover. Never let solution get below top of plates. Plugs must be removed to add water, then replaced and screwed on after filling. The battery should preferably be inspected and filled with water once every week in warm weather and once every two weeks in cold weather. Do not use acid or electrolyte, only pure water. Do not use any water known to contain even small quantities of salts of any kind. Distilled water, melted artificial ice or fresh rain water are recommended. Use only a clean metallic vessel for handling or storing water. Add water regularly, although the battery may seem to work all right without it.

The best way to ascertain the condition of the battery is to test the specific gravity (density) of the solution in each cell with a hydrometer. This should be done regularly. A convenient time is when adding water, but the reading should be taken before, rather than after, adding water. A reliable specific gravity test cannot be made after adding water and before it has been mixed by charging the battery or running the car.

To take a reading insert the end of the rubber tube in the cell. Squeeze and then slowly release the rubber bulb, drawing up electrolyte from the cell until the hydrometer floats. The reading on the graduated stem of the hydrometer at the point where it emerges from the solution is the specific gravity of the electrolyte. After testing, the electrolyte must always be returned to the cell from which it was drawn. The gravity reading is expressed in "points," thus the difference between 1.250 and 1.275 is 25 points.

When all cells are in good order, the gravity will test about the same (within 25 points) in all. Gravity above 1.200 indicates battery more than half charged. Gravity below 1.200, but above 1.150, indicates battery less than half charged. When the battery is found to be half discharged, use the lamps sparingly until the gravity is restored to at least 1.250. If by using the lamps sparingly, the battery does not come back to condition, there is trouble in the wiring or generator system which should be investigated and remedied immediately. Gravity below 1.150 indicates battery completely discharged or "run down." A run down battery is always the result of lack of charge or waste of current. If, after having been fully charged, the battery soon runs down again, there is trouble somewhere in the system which should be located and corrected. Putting acid or electrolyte into the cells to bring up specific gravity can do no good and may do great harm. Acid or electrolyte should never be put into the battery except by an experienced battery man.

Gravity in one cell markedly lower than in the other, especially if successive readings show the difference to be increasing, indicates that the cell is not in good order. If the cell regularly requires more water than the others, thus lowering the gravity, a leaky jar is indicated. Even a slow leak will rob a cell of all of its electrolyte in time and the leaky jar should immediately be replaced with a good one. If there is no leak and the gravity is, or becomes, 50 to 75 points below that in the other cells, a partial short circuit or other trouble within the cell is indicated. A partial short circuit, if neglected, may seriously injure the battery and should receive the prompt attention of a good battery repair man.

A battery charge is complete when, with charging current flowing at the finish rate given on the battery plate, all cells are gassing (bubbling) freely and evenly and the gravity of all cells has known no further rise during one hour. The gravity of the solution in cells fully charged as above is between 1.275 and 1.300.

If for any reason an extra charge is needed it may be accomplished by running the engine idle, or by using direct current from an outside source. In charging from an outside source use direct current only. Limit the current to the proper rate in amperes by connecting a suitable resistance in series with the battery. Incandescent lamps are convenient for this purpose. Connect the positive battery terminal (with red post, or marked P or +) to the positive charging wire and negative to negative. If reversed, serious injury may result. Test charging wires for positive and negative with a voltmeter or by dipping the ends in a glass of water containing a few drops of electrolyte, when bubbles will form on the negative wire. When charging, start at the starting rate and continue the charge at this rate until the cells gas freely. Then continue the charge for six hours at the finish rate. The specific gravity at the end of the charge should read between 1.275 and 1.300. If the specific gravity does not reach this point, continue the charge at the finish rate until the specific gravity stops rising, which is an indication that the battery is fully charged.

A battery which is to stand idle should first be fully charged. A battery not in active service may be kept in condition for use by giving it a freshening charge at least once a month, but should preferably also be given a thorough charge after an idle period before it is replaced in service. Disconnect the leads from a battery that is not in service, so that it may not lose charge through any slight leak in car wiring.

**Bearings, Ball.** Ball bearings may be broadly divided into three classes—thrust, cone and annular. Thrust bearings are those intended to sustain end thrust, and in them care must be exercised to see that the points of contact of the balls are exactly opposite, and that the grooves in which the balls run are formed to a sectional radius a little larger than that of the balls, thereby securing safe and easy movement of the balls. These grooves must be designed not only to give smooth rolling contact, but so that a measurable area of the ball's surface contacts with the race. It is also possible for a thrust bearing to act at the same time as a radial bearing, in which case, however, the four-point system must be used. In thrust bearings the balls are constantly under pressure and table 5 gives suitable loads for equal shaft diameters and revolutions for different sizes and numbers of balls:

TABLE 5.

| Shaft Diameter, in inches. | Allowable Load lbs. | R.P.M. | Number of Balls | Ball Diameter in Inches |
|---|---|---|---|---|
| 2.55 | 550 | 500 | 22 | ⅜ |
| 2.55 | 1,000 | 500 | 15 | ⅝ |
| 2.55 | 1,200 | 500 | 14 | 11/16 |
| 2.55 | 1,300 | 500 | 13 | ¾ |
| 2.55 | 1,600 | 500 | 12 | ⅞ |
| 2.55 | 1,800 | 500 | 10 | 1 |

The adjustable cone bearing, Fig. 39, has been used in millions of bicycles with excellent results, but under large loads has been found inadequate. A ball can roll freely only with opposite points in contact, and every third or fourth point of contact involves more or less spinning, or sliding movement of the ball, which shortens its life, and the bearing must operate to the detriment of the contact surfaces.

The third and great type of ball bearing is the so-called annular one intended for radial loads. It consists of three elements—two races and the balls. The new annular bearings require no adjustment or fitting, and the rolling action of the balls takes place without interference of friction. A wonderful advantage of this bearing is that as high as 96 per cent of the space between the races can be filled with balls, the balls being introduced through filling lots whose size is a little less than the diameter of the balls to be introduced, so that the balls are forced between the two races under pressure and by virtue of the elasticity of the material. In the annular bearing but 30 per cent of the balls are under load at one time, and it is possible for equal axle sizes and speeds to use different dimensions and loading according to the size of the balls. Table 6 gives suitable loads for equal shaft diameter, and revolutions for various sizes, and numbers of balls.

TABLE 6.

| Shaft Diam. inches | Allowable load on Bearing, lbs. | R. P. M. | No. of Balls | Diam. of Balls, Inches |
|---|---|---|---|---|
| 3.14 | 1,000 | 500 | 20 | ½ |
| 3.14 | 1,300 | 500 | 21 | $\frac{9}{16}$ |
| 3.14 | 2,500 | 500 | 12 | 1 |
| 3.14 | 3,000 | 500 | 14 | 1 ⅛ |
| 3.14 | 4,500 | 500 | 11 | 1 ⅞ |

Annular ball bearings are also made with two rows of balls, and in the majority of them each ball is in a separate cage. Experiments have proven that, where the balls contact with one another, after a few years the friction results in grooves being worn in them. In Fig. 37 is shown the form of separator used in the F. & S. bearings. If in the application of this bearing it is

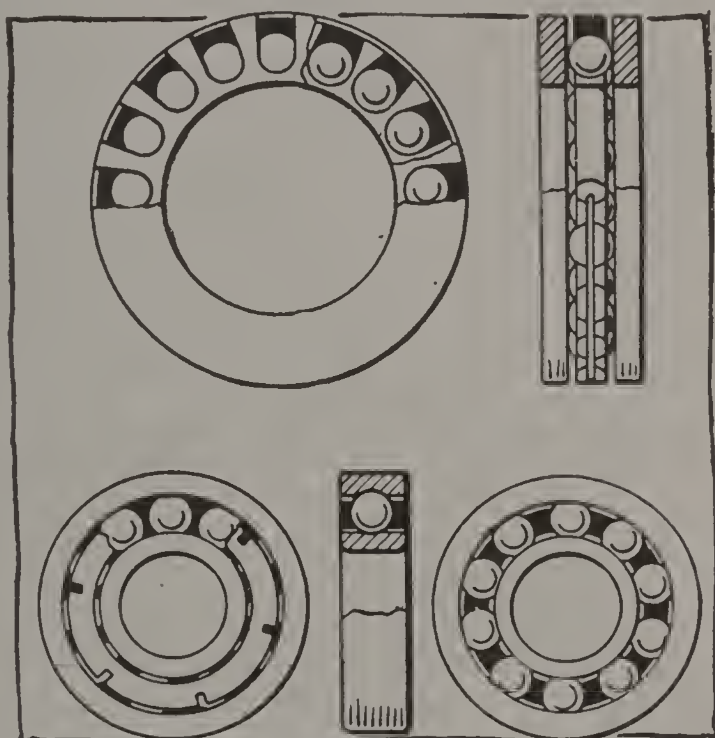


Fig. 37
F & S Bearing Separator

necessary to sustain heavy axle loads, it is absolutely necessary to add an independent thrust bearing, or to employ a combination bearing which takes the place of bolt thrust and radial loads.

Ball Bearings—Two in One. Figs. 38, 39, and 40 illustrate a ball bearing manufactured at Bristol, Conn., which owing to its dual ability as as expressed by its name ("two in one") is especially adapted to automobile service. Its makers claim that it is able to withstand radial or thrust loads, or any combination of the two, with the use of but a single bearing with its attendant simplicity of mounting. In order to bring about this result, two rows of balls are employed in staggered relation to one another, and the ball races are so arranged that the line

Fig. 38
Assembled Bearing Complete

of pressure is either at an angle of 45 degrees or 60 degrees with the horizontal, when the axis of rotation of the bearing is in a horizontal plane.

Figure 38 shows the permanent assembly of the bearing, sufficient metal being provided in the shell to permit of drawing the latter tightly over the cups.

Figure 39 shows the various parts of this bearing, and Fig. 40 is a semi-sectional view showing the order of their assembly, from the shaft outward, as follows; the cone, the separator, the two cups and the shell. It will be noticed that the line of pressure of the cone, cups,

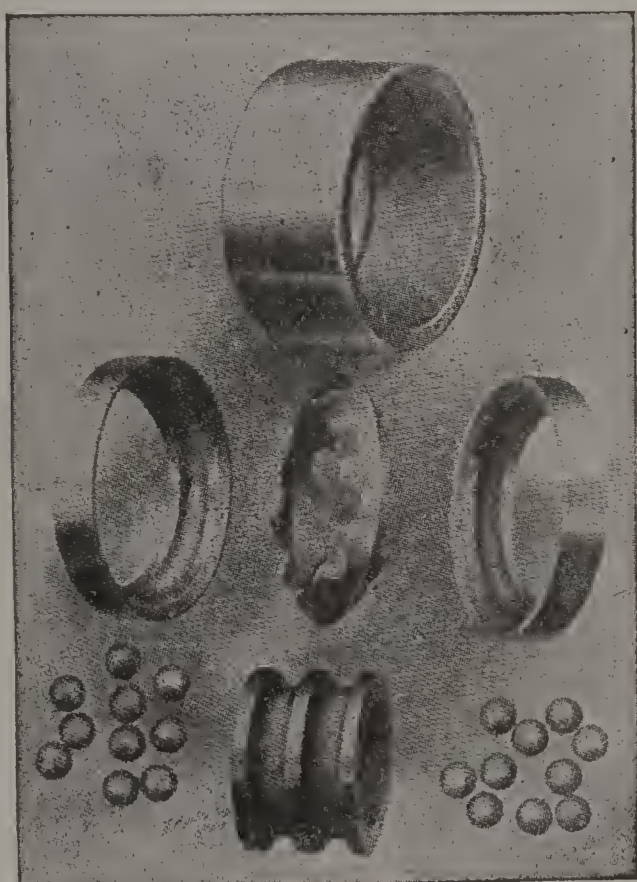


Fig. 39

and balls is at an angle of 45 degrees with the horizontal, and this feature applies equally to both rows of balls, thus adapting the bearing to withstand a load from any angle. Two semi-circular races are turned in the cone to receive the balls, while the sheet metal separator is so stamped that the ball retaining notches are staggered with reference to each other. These openings are made slightly larger than the ball diameter, so that the contact between the ball and separator is said to be a point contact at one end of the axis of rotation, while the weight by separator is carried on the balls at the top of the bearing. By maintaining the relative positions of the balls at all times, cross friction

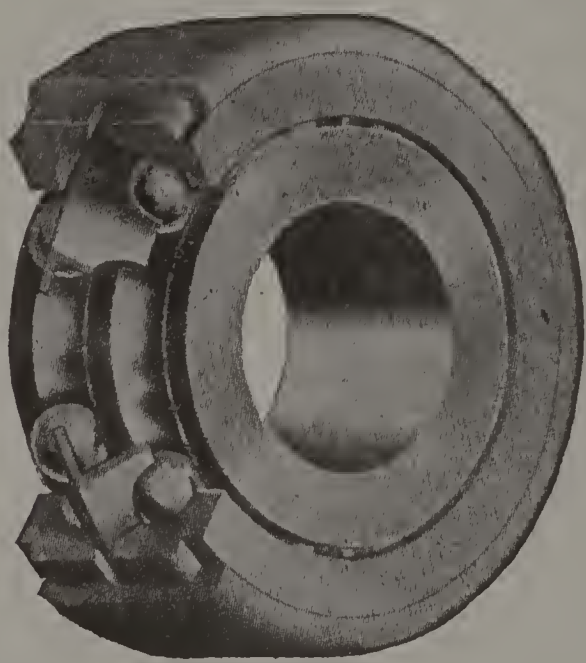


Fig. 40
Sectional View of Bearing

it is claimed is entirely eliminated, while the friction introduced by the use of the separator is practically negligible.

Ball Bearings—Lubrication of. Ball bearings must be so housed in as to retain lubricant and exclude dust, grit, etc. An impression that ball bearings will operate without lubricant is quite general. It is barely possible that absolutely true spheres might roll on absolutely true surfaces if both were made of materials that were absolutely inelastic, and therefore would remain true under load. But since such absolute perfection of the shape is not to be had, some means must be taken to provide and retain lubricant.

Rust and acid must be kept out of ball bearings. Experience and most carefully conducted tests have proven that long life under load can be realized from ball bearings only when the surfaces are not only true, but are also highly polished and smooth. Roughness will be broken down and leave still greater roughness. Rust and acid will destroy originally true and smooth surfaces. Since not a few lubricants contain free acids, care in their choice must be exercised. Plentiful lubrication and a properly closed mounting are safeguards against rust.

In the lubrication of ball bearings it is advisable to use vaseline; or, when a lubricant of greater body or stiffness is desired, to use a mixture of vaseline and some high-grade mineral grease. The grades known as semi-fluid are very well suited for this use and any combination may be used with success in such cases.

Annular Ball Bearings. In the annular ball bearing, Fig. 42, a race of balls C is contained between an inner retainer A and an outer race B, there being grooves in the opposing surfaces of these to receive the balls. In a Hess-Bright bearing of this type, as illustrated in Fig. 41, the entire space between the races C and B is not occupied by balls, but is utilized in different ways. In this only enough balls to make a half circle in the bearing are used, and these are spaced apart by means of small helical springs. These springs contain oil pads of felt, and are headed by sheet-metal discs that extend far

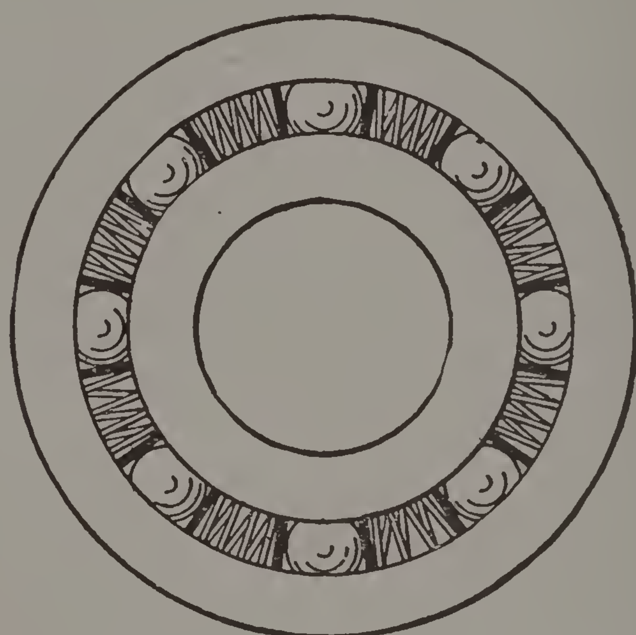


Fig. 41
Hess-Bright Bearing

enough into the grooves to prevent sidewise displacement of the springs, without, however, producing any more than a negligible friction. Assembling this bearing one race is placed eccentric to another race and the requisite number of balls slipped into positions, after which the races are made concentric and the balls regularly distributed. This done, the separating springs with lubricating means are installed.

Once the springs are in place the tension of them is such as to make the bearing self-contained.

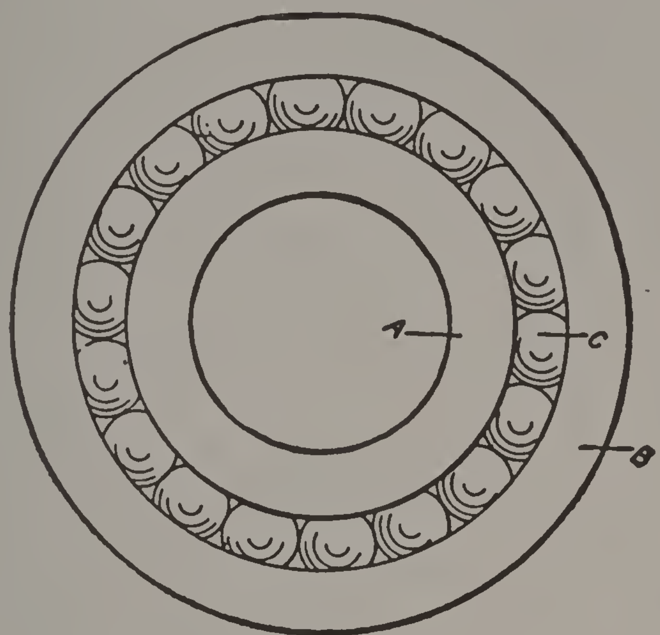



Fig. 42
Annular Ball Bearing

It is not practicable to disassemble or repair the various forms of annular ball bearings in the ordinary shop. These forms are not adjustable and are not designed to be taken apart. It is quite possible to reform the races and to insert new balls when the bearing is badly worn or scratched, but such work must be done with machinery and tools especially designed for handling it. Ball bearing repairs are handled by various companies who specialize on such work and it will always be advisable to communicate with one of them.

Hard and Soft Bearings. There are two general classes of solid bearings, those which contain a large per cent of copper and a small amount of the softer metals; which are known as hard metals, as brass or bronze. Those which contain a large proportion of tin or lead and a small per cent of copper are known as soft metals—as babbitt-metal, anti-friction metal and white metal.

In some instances and under certain conditions it has been found that a good close-grained cast iron makes an excellent bearing metal. Being of a granular nature, it has the property of retaining the lubricant in place, even when highly polished and under great pressure, with

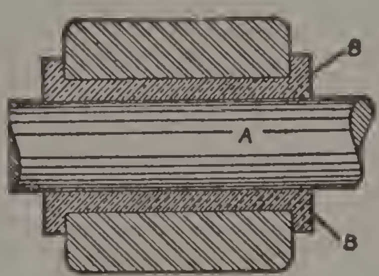



Fig. 43

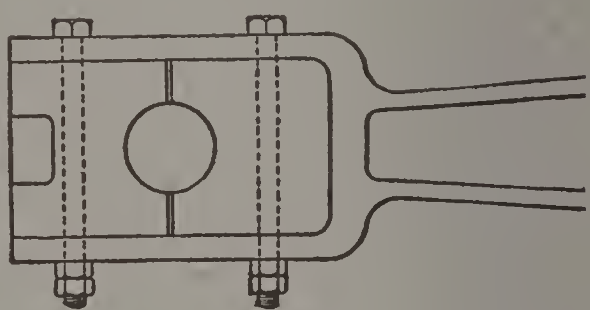


Fig. 44

Types of Plain Bearings

a low co-efficient of friction, but is too brittle to withstand severe shocks.

Plain Bearings. Plain solid bearings are used on many parts of an automobile, particularly in the engine and transmission bearings, although ball and roller bearings are taking their place in many constructions. The majority of the cars use brass, bronze or babbitt-metal on the main and crankshaft bearings, while ball and roller bearings are used on the transmission and wheel bearings. A typical plain bearing is shown in Fig. 43, in which A is the journal made of steel, while the bearing members shown at

B. B. are made of either brass, bronze, or babbitt metal. Figures 44 and 45 show different types of connecting rod bearings. For plain-bearings, the shafts of which are continuously running at a high rate of speed, such as motors and speed-change gears, the working pressure

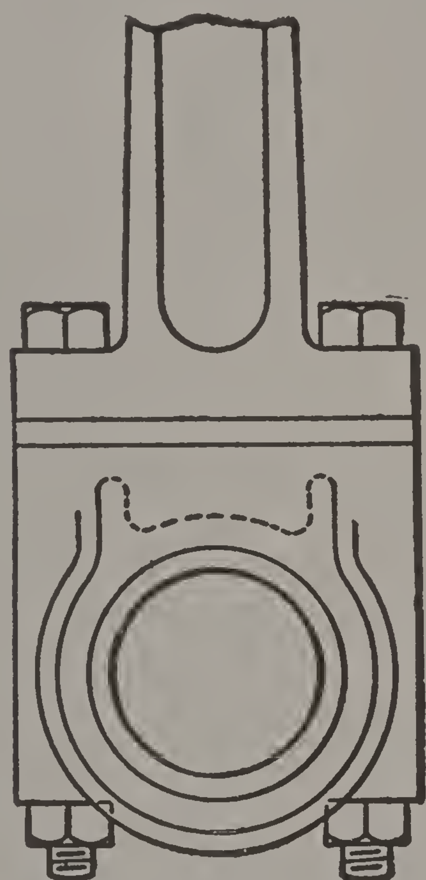


Fig. 45
Solid Connecting Rod Bearing

per square inch should not exceed 400 pounds. As the arc of contact or actual bearing surface of a journal bearing is assumed as one-third of the circumference of the journal itself, the pressure per square inch upon a bearing is therefore equal to the total load upon the bearing, divided by the product of the diameter of the journal times the length of the bearing.

Let D be the diameter of the journal or shaft at its bearing, and L the length of the bearing, if W be the total load or pressure upon the bearing and P the pressure in pounds per square inch of bearing surface, then

$$P = \frac{W}{D \times L}$$

If the total load or pressure on the bearing be known and the diameter of the shaft given, then the proper length of the bearing will be

$$L = \frac{W}{D \times P}$$

If the length of the bearing be known and other conditions as before given, then the proper diameter of the journal will be

$$D = \frac{W}{P \times L}$$

**Bearing, Roller.** A form of bearing used in a large number of cars of all types is that known as the roller. This form is made in three distinct types, one of which is known as the taper roller, another one the solid straight roller, and the third one the flexible roller.

The taper roller bearing, Fig. 46, is composed of an inner and outer race, the inner race being

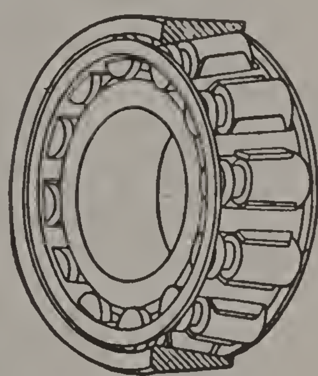


Fig. 46
Taper Roller Bearing

designed to fit over the shaft and the outer one being carried by the bearing housing. The outer surface of the inner race is conical in form and the inner surface of the outer race is of a form to correspond, that is, its internal diameter is smaller at one side than at the other. Between the two races is carried a series of steel rolls, each one of which is tapered so that it fits between, and bears along its entire length on both races. This forms a bearing of anti-friction qualities similar to the annular ball, with the exception that the contact between the rolling members and their supports

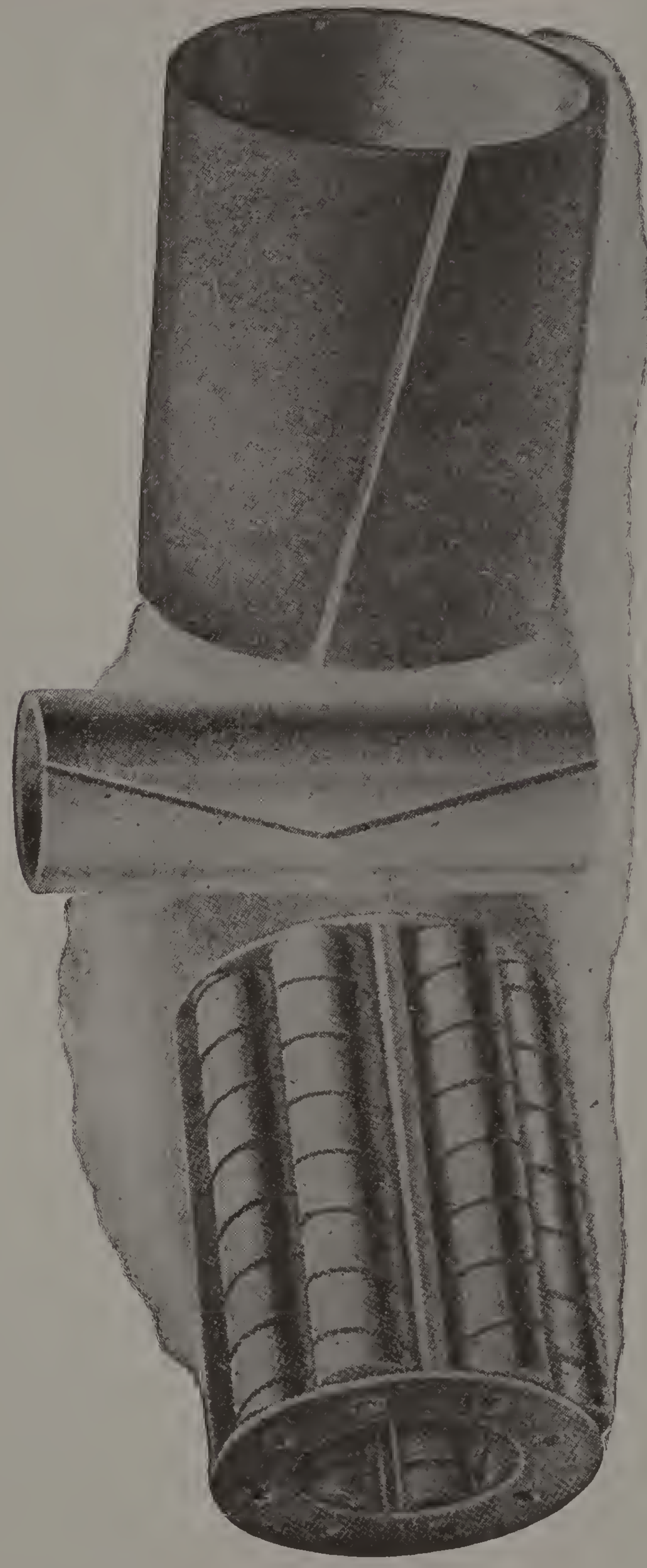


Fig. 48
Hyatt Self-Oiling Self-Contained Roller Bearing

is a line rather than a point. It is customary to maintain a predetermined distance between the separate rolls by providing cages into which the rolls fit loosely. It will be seen that because of the tapered formation it would be impossible to press the inner race hard enough to cause it to pass completely through the outer race with the rolls in place, while in the other direction the inner race would drop out because of its own weight. This feature allows the tapered roller bearing to withstand a large amount of end thrust when this thrust is applied on one side of the bearing only.

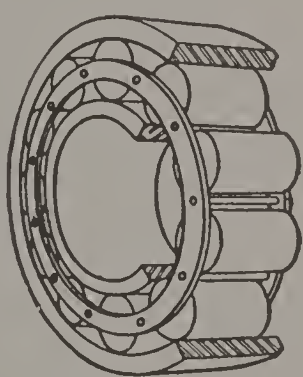


Fig. 47
Straight Solid Roller Bearing

Roller bearings are made of an inner and outer race with both surfaces of each race truly cylindrical, Fig. 47, and between these races is carried a series of straight cylindrical rolls. With plain rolls in use, the bearing will not withstand any end thrust because of the fact that the races and rollers will move freely over each other in the direction of their axes. When it is desired to have this type of bearing withstand a thrust load, one or both of the races must be made with either a ridge or a groove at or near one edge and the rolls must then have a corresponding ridge or groove to engage the race.

The flexible roller bearing is made by the Hyatt Roller Bearing Co. and consists of two races, each of which is tubular or cylindrical in form, and between these races is carried a series of rollers, as in other types previously described, differing in that the rolls are formed from a piece of comparatively thin flat steel twisted into a spiral. It is from the springiness of this form of spiral roller that the bearing takes its name, "Flexible."

**Bendix Drive.** The Bendix drive, Fig. 49, consists of a solid or hollow shaft having screw threads on the outside, and a hollow gear having screw threads on the inside, so that the gear screws on the shaft like a nut on a bolt. A circular weight is fastened to the gear, and is slightly out of balance. A coil spring connects the electric motor shaft and the hollow screw shaft.

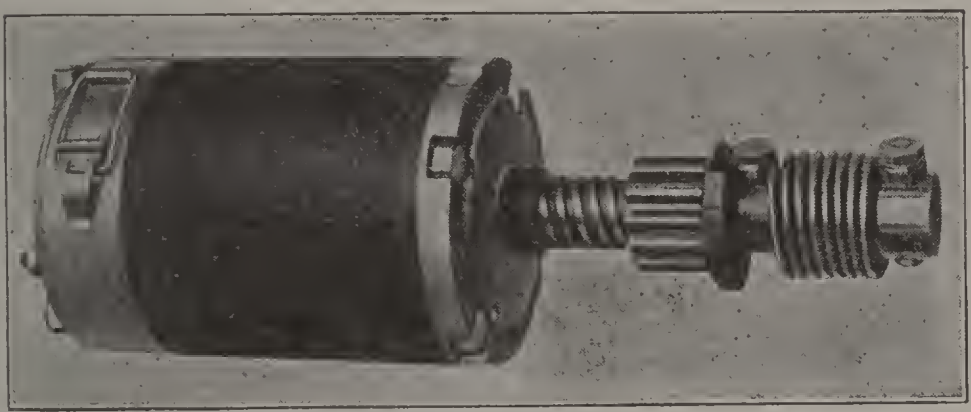


Fig. 49
Starting Motor With Bendix Drive

When the electric motor starts it drives through the spring and turns the screw shaft. Because of the weight, the gear is too heavy to turn with the screw shaft, and because the gear does not turn it must move along the screw shaft (just the same as if you turned a bolt having a nut on it, and kept holding the nut with your fingers to keep it from turning so that it would be screwed along the bolt). After the screw gear has moved along the screw shaft and engages with the flywheel gear it then keeps on moving along until it reaches the stop at the end of the screw shaft. The two gears then are fully meshed, and it is obvious that when the screw gear has reached the stop it cannot move any farther, and it then must turn with the screw shaft. At this particular moment the screw shaft and electric motor are revolving at a great speed, and this great blow and the power of the electric motor are both taken through the coil spring. The spring keeps coiling until all this power has been applied to the flywheel gear and the engine starts turning.

As soon as the engine starts exploding and runs under its own power, the flywheel of course turns much faster than it was cranked by the starter. Because it is now turning so much faster it increases the speed of the screw gear so that the latter runs faster than the screw shaft on which it is mounted. It is therefore plain that if the screw gear runs faster than the screw shaft, that it will be screwed on the threads of the shaft (like a nut on a bolt) until it has been screwed out of mesh with the flywheel gear. This demeshing movement is entirely automatic and eliminates the use of an overrunning clutch. And now that the screw gear is out of mesh it is natural to suppose if the electric motor keeps running that the gear will be automatically screwed right back into the mesh with the flywheel gear. But the unbalanced weight on the screw gear performs its automatic function. That is, being slightly out of balance, the weight twists or cocks the screw gear so that it clutches and binds on the screw shaft and turns with it. This automatic clutching is all due to the centrifugal force of the unbalanced weight.

When the electric motor stops running, the screw gear has been fully screwed away from the flywheel gear, and it remains in that retarded position until it is again required to start the engine.

The screw shaft should never be oiled or lubricated. It is not necessary and, in fact, the screw gear works to the best advantage when the screw shaft is dry.

Through accident or otherwise, should the flywheel ever be entirely exposed and unprotected, and should the gear tend to stick on the shaft, it may then be necessary to clean the screw.

The teeth on the screw gear and flywheel are chamfered or pointed on only one side to make the meshing natural and easy. However, should the teeth meet, end to end, the screw shaft itself is designed to move automatically backwards, against and compress the coil spring. This gives the screw gear time enough to turn and enter the flywheel gear. Should sticking of gears ever occur, they can be released by throwing in the clutch and moving the car. Such trouble would be due to incorrect chamfering or inaccurate alignment of the gears. Also it might be due to the binding of the drive parts and prevent compressing and proper functioning. Such defects should be corrected.

If while the engine is running, the electric motor should be accidentally started, the screw gear will of course screw over against the turning flywheel gear. But instead of the clashing and smashing of gears that might be expected there is no damage whatsoever, as the gears simply touch once. This is because the flywheel gear will speed up the screw gear, and thus automatically screw it away. The turning screw gear will then automatically clutch and bind on the screw shaft, in exactly the same manner as when it is cranking and has been demeshed when the engine starts exploding.

**Bodies.** In the construction of automobile bodies the sills are made strong, and the superwork is rendered independent of the actual structural strains. Wood is generally used in the framing, although it is sometimes replaced by cast aluminum.

When wood is used for framing, sheet aluminum, steel and thin layers of wood are employed. The aluminum is laid on a form and beaten to the shape required for the panel. The steel sheets are die formed, while the wood is made flexible in order that it may be bent to its proper shape when fastened to the body. In order to have the car of light weight, all body builders use the lightest materials possible in the construction of that portion which lies above the chassis.

When aluminum is used in the panels and for facings, care must be exercised to prevent water from creeping in between the metal and the framing, because water causes an electrolytic action on the aluminum plates. To prevent the oxidation of sheet steel, the plates are either coated with aluminum or zinc, or they are given a priming coat of paint on the inside.

As a general thing, putty is not used in the construction of bodies, as there are few joints which require it. In the very best body painting twenty coats are used before the paint assumes its proper finish. The first coat, or priming coat, generally consists of pure white lead mixed in oil. After that the second priming coat is given to it, and from then on the number of coats of rough paint will depend upon the nature of the surface and the degree of finish. For a very fine finish, the last coats consist of varnish, but when wagon finish is desired, the last coats consist of paint.

Finishers must take into account the fact that all cars are more or less abused in service, and it is to be expected that the magnificently equipped limousine will have a somewhat finer finish than the hard used touring car.

Classification of Bodies. Besides being classified according to the type of gasoline engine, methods of transmission, number of cylinders, etc., automobiles are also classified according to the type of body which is mounted on the chassis. While there are a considerable number of names which are given to the same types of pleasure automobiles, they may be generally classified as runabouts, roadsters, tourabouts, touring cars, town cars or taxicabs, landaulets, limousines and semi-limousines. Electric automobiles are generally divided into coupes, brougham, stanhopes, runabouts, phaetons, etc. Steam cars follow the same general classification as gasoline machines. Commercial vehicles may be classified as taxicabs, delivery wagons, trucks, busses, wagonettes, ambulances, patrol wagons and other forms for fire service.

Commercial Vehicles. In the commercial vehicle field steam, electric and gasoline machines are used. Electric vehicles are used for certain purposes, from heavy trucks to light delivery wagons, usually only for short distances. Steam power is not at present being used to any extent for heavy trucks, while the gasoline commercial is used for trucks, business wagons and quick deliveries.

The commercial vehicle may be classed as follows: Taxicabs, general delivery, light trucks, heavy trucks, coal wagons, sight-seeing cars, busses, ambulances and particular other types for special purposes.

Since, for general purposes, the speed of commercial vehicles is small, they are not necessarily equipped with high power, as a heavy car, which would travel at a high speed, would be apt to be dangerous. The speeds obtainable range on an average between twenty miles per hour for delivery wagons, to five miles per hour for heavy trucks.

While there are many distinct types of car bodies, there are more names in use than there are bodies, because different makers often apply different names to the same type of body, and often list a certain type of body under a name different from the one ordinarily accepted. This practice makes it difficult to state positively that a certain type of body will be called by a given name by a maker although that particular body is of its own distinctive type regardless of the name applied in the catalogues.

Bodies may be classified according to the number of persons carried, whether they are wholly or partly enclosed and according to the purpose

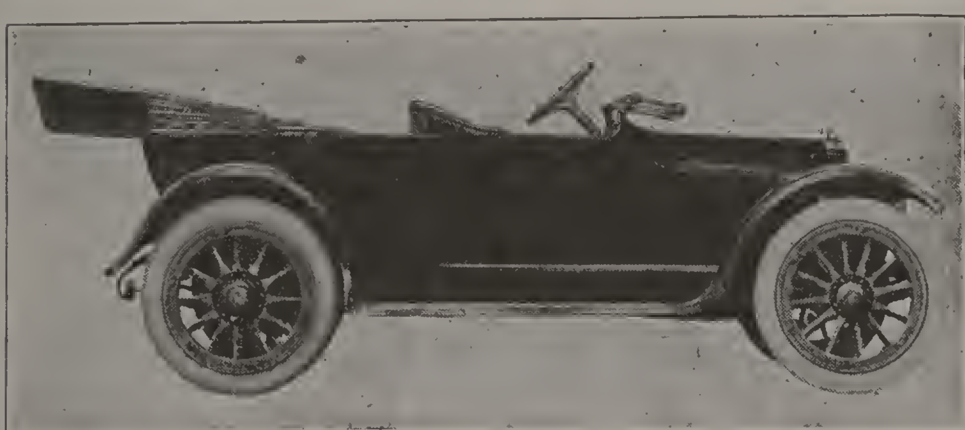


Fig. 50
Five-Passenger Touring Car

for which they are designed. None of these divisions is very satisfactory, because some types would appear in more than one division. The following definitions are those generally accepted.

Touring Car. This is an open car, Figs. 50 and 51, for general purposes which may seat four, five, six or seven persons, including the driver. It has sides and doors, but when protection from the weather is desired the operator uses a folding top and curtains.

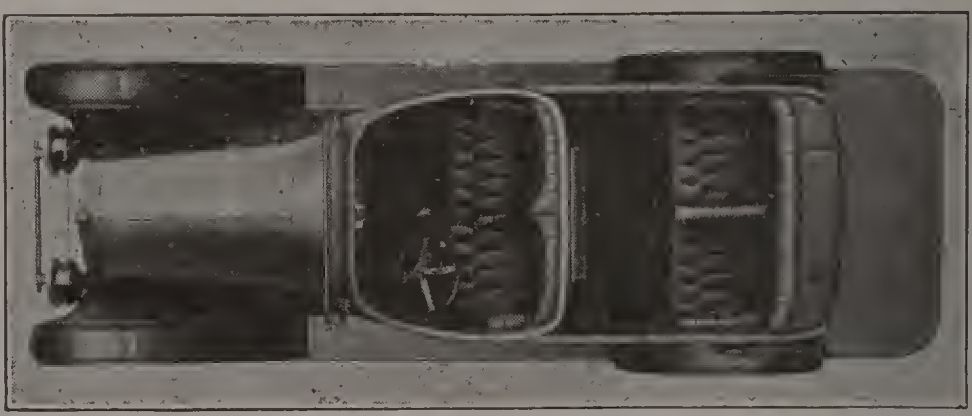


Fig. 51
Seating Arrangement in Four-Passenger Car

A touring car seating five is called a five-passenger touring car, one seating seven is called a seven-passenger touring car, and so on for any number of passengers. The rear compartment of a touring car is called a tonneau, the front compartment is called the driver's compartment.

Close-Coupled or Toy Tonneau. A four-passenger touring car with the rear seat brought well forward is sometimes called by one of these names.

Torpedo. This is a touring car having the body as small and low as possible while seating the number of passengers desired. The body is of a form that offers the least resistance to wind pressure and is called "stream line" in shape.

RUNABOUT. This is an open body seating two passengers, mounted on a comparatively small, light or low powered chassis for use in town and city travel and short country trips.

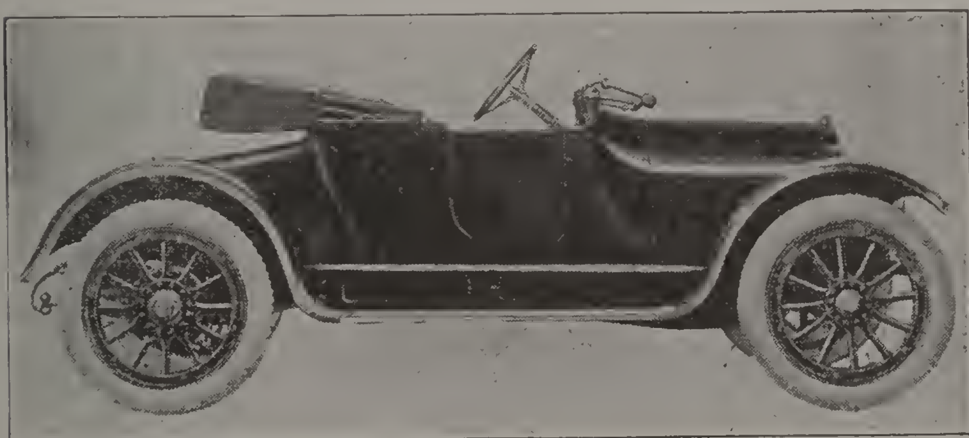


Fig. 52
Two-Passenger Roadster

ROADSTER. This is also an open body, Fig. 52, seating two passengers, but mounted on a chassis whose size, weight and power fits it for heavy work and long distance touring.

SPEEDSTER OR RACEABOUT. This is a powerful chassis carrying small, light seats for two passengers and designed for high speed work. The body is made as small and light as possible with "bucket" seats, floor, dash, gasoline and oil tanks, but no sides or doors, and in most cases without a top.

LIMOUSINE. This is a type of body, Fig. 53, used mostly for town and city driving in bad weather or during the cold season.

It seats four, five, six or seven persons in addition to the driver. It has a permanent top and the rear compartment is entirely enclosed and has full doors. The driver's compartment is di-

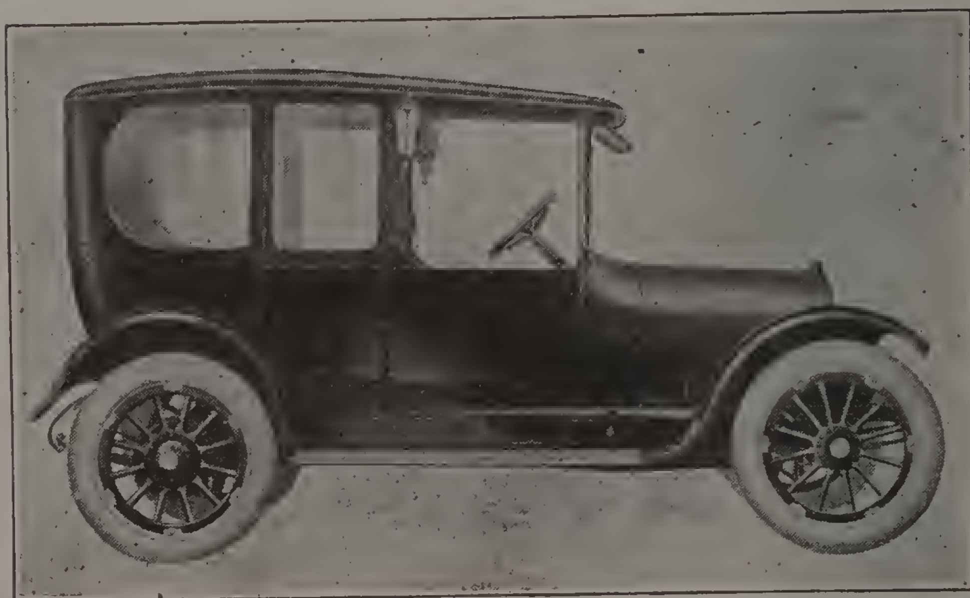


Fig. 53
Limousine Body

vided from the rear by a partition and this compartment is only partly enclosed.

Berline or Berlin. This type is exactly like the limousine except that the driver's compartment is fully enclosed and has full doors.

Sedan. This body is like the Berline, that is to say, fully enclosed, but there is no partition between the driver's and rear compartment.

Landaulet or Landau. This is a limousine which has the rear half of the passenger compartment closed with a top that is rigid when raised but that lets down like those tops of closed carriages in common use.

Town Car. This type has the rear compartment entirely enclosed with full doors, and seats four or five persons in this part of the car. The driver's compartment is open, the same as in a touring car. The driver may be protected by a small canopy extending forward from the enclosed portion.

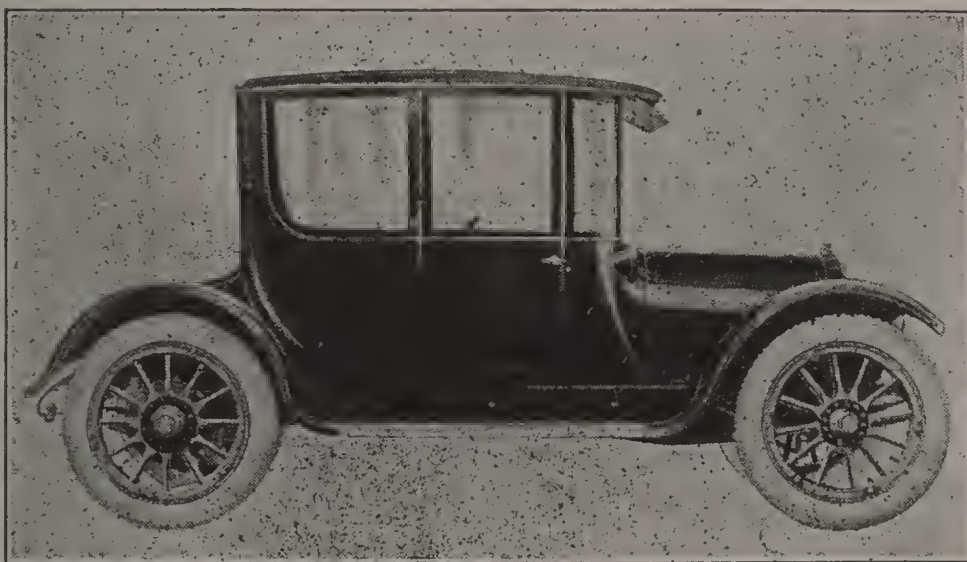


Fig. 54
Coupe

Coupe. This type of body, Fig. 54, is entirely enclosed and has full doors. It may seat two, three or four passengers in the enclosed part, the driver being one of these. It is mounted on a roadster chassis and bears the same relation to the roadster that the Sedan bears to the touring car.

Convertible Coupe or Sedan. These bodies are built in such a way that they give exactly the same appearance as a regular Coupe or Sedan from either the outside or inside. The upper portion is removable so that the Coupe or Sedan is converted into a roadster or touring car, depending on the arrangement and number of passengers carried.

Cabriolet or Couplet. A convertible coupe may be called by either one of these names, both meaning the same thing.

Taxicab. A car used as a public vehicle and being for hire according to certain designated rates of fare is called a taxicab. It is fitted with a "taximeter" which records the distance traveled and the time spent in waiting, and automatally computes and indicates the fare to be paid.

Taxicabs may be made from limousines, landaulets or town cars, the landaulet being the type most generally used.

Commercial Car Bodies. These types include those used for carrying merchandise and also those used for carrying passengers as a business. Commercial car bodies may be designated according to the type of construction, the class of work to be handled or the weight to be carried.

Truck Bodies. These include the express, platform, stake and panel types, and also many special designs. Truck bodies are usually made from designs prepared for each individual job and according to the customer's requirements, except in the lower priced cars.

Passenger Bodies. These include taxicabs, sight seeing cars, carrying from eight to twenty persons, and closed bodies suitable for carrying passengers and baggage in interurban work.

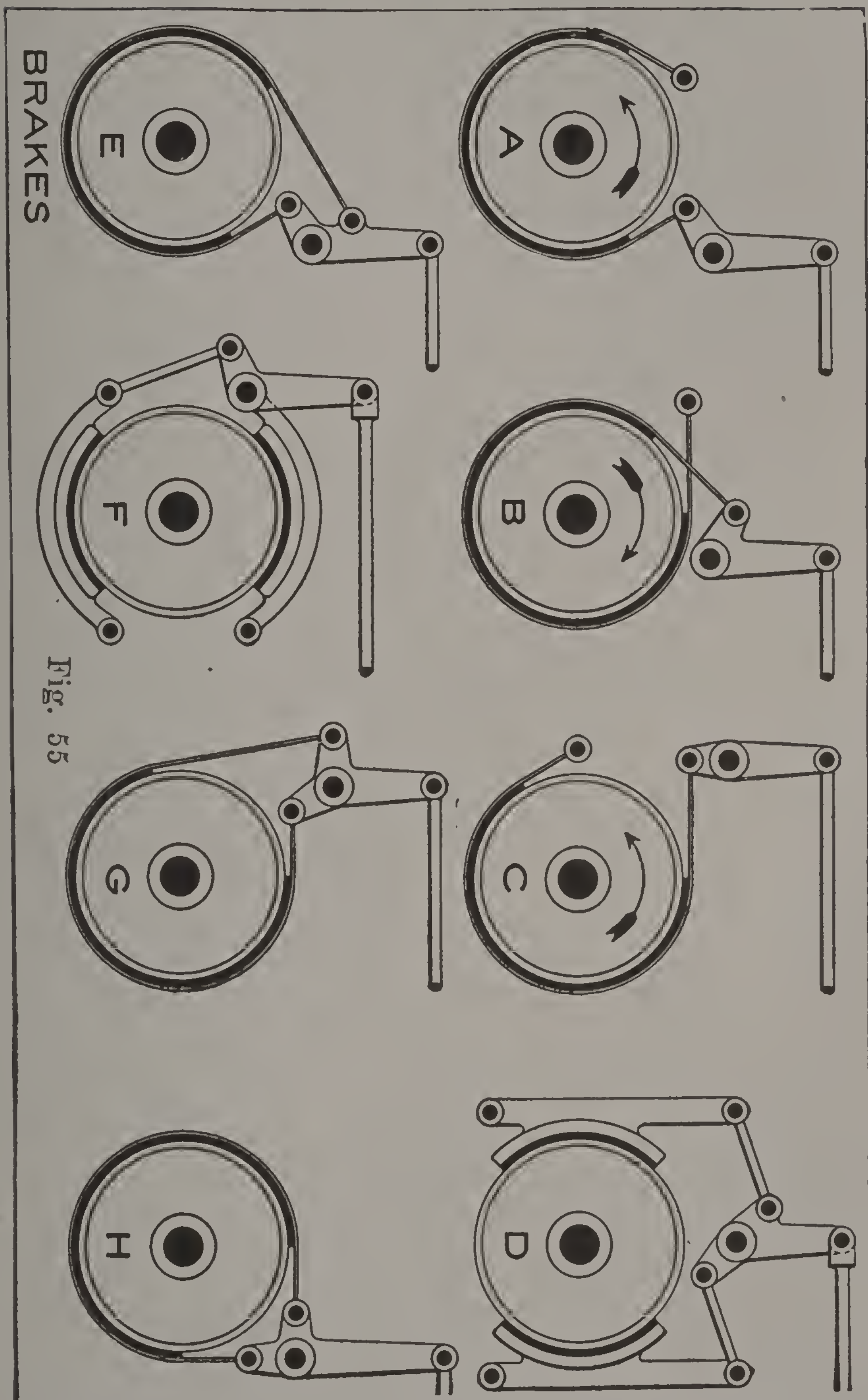


Fig. 55

**Brakes.** A brake is a mechanism which is a necessary part of the machinery of an automobile and enables the operator by exerting a slight amount of force on a lever to reduce the momentum of the moving car. Brakes used on automobiles may be divided into three classes: Hub or rear wheel brakes, transmission and differential gear brakes. Brakes have also been applied to the tires of the rear wheels, but have proved unsatisfactory and have been abandoned. The forms of brakes in use are single, or double-acting, foot or hand operated, and of the band, block or expanding ring types.

Figure 55, at A, B and C, shows three forms of the simplest type of single-acting band-brake. This type of brake can only be operated successfully with the brake wheel running in one direction only, which is indicated by the arrows in the drawing. If the brakes be operated in the reverse direction to that indicated by the arrows the result will be to jerk the lever or pedal out of the control of the operator of the car.

The three forms of band-brakes shown at A, B and C are all of the same principle, the difference being in the location of the fixed end of the brake-band and the shape of the operating lever. Type D is a form of double acting block-brake, which is designed with a view to eliminate any strain or side thrust upon the shaft of the brake wheel which may be caused by the braking action of the device. Types E, G and H are three types of double acting band-brakes, in which the brake may be applied with the brake wheel running in either direction.

Type F is a form of double acting block-brake, in which the right hand ends of the brake-shoe arms are pivoted to stationary supports, and the left hand ends connected together by means of a link and bell-crank lever as shown in the drawing.

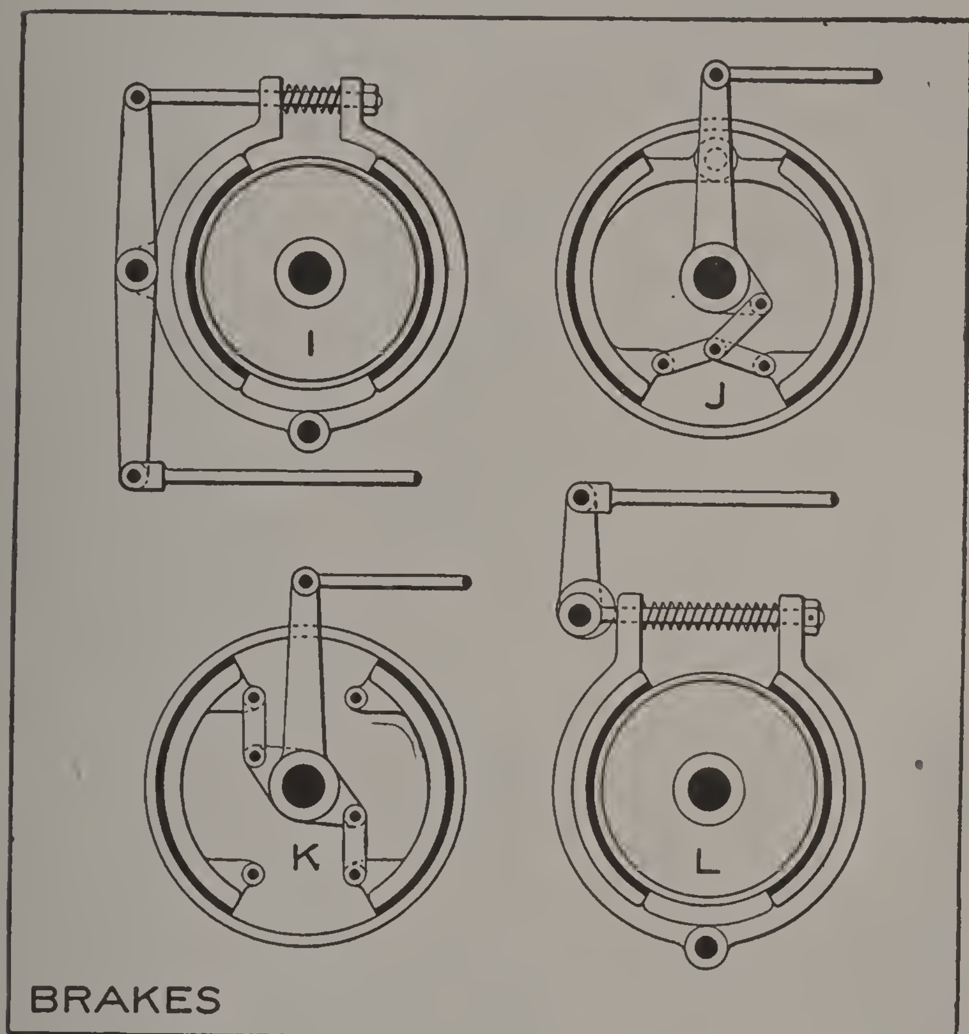



Fig. 56

In Figure 56 a form of double acting block-brake I is shown, which is extremely powerful on account of its peculiar construction, in that is has a double leverage upon the brake wheel, which may be readily seen by reference to the drawing. Types J and K are of the form known as internal brakes and of the expanding ring type, the brakes operating upon the inner surface or periphery of the brake wheel, instead of the outside. They are known as hub brakes, being usually attached to the hubs of the rear wheels of the car. Type L shows a form of block-brake in which the pivoted brake arms are drawn together by the eccentric located on the brake lever shaft. When the lever is re-

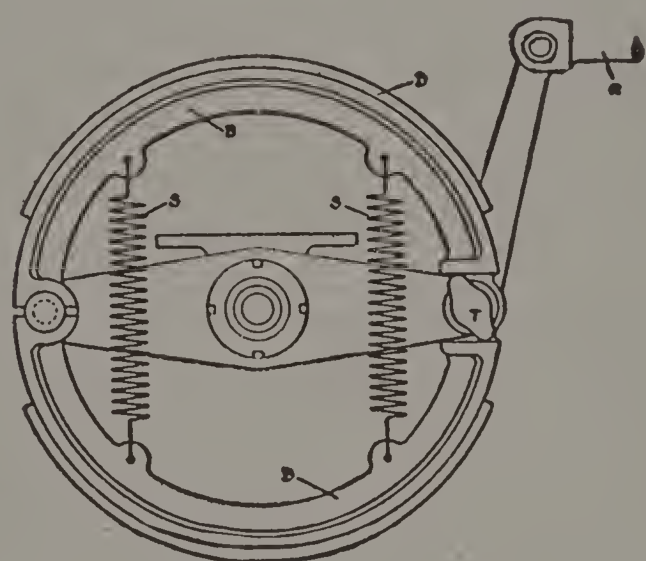


Fig. 57

leased the brake-shoe arms are forced apart by the action of the coil spring between the upper ends of the arms.

Expanding Brake. In the internally expanding brake, Figure 57, a hollow metal drum or pulley D is carried upon some continuously revolving portion of the car mechanism, and within this drum are supported two metallic shoes B B, which conform in shape to the inside surface of the drum by means of a spring, S S. The shoes are capable of being strongly pressed against the revolving inner surface of the drum by means of a cam or toggle arrangement, T, operated through a wire rope or metal rod, R, from the operator's lever or pedal. It is important that brakes of both these types should have their bands or shoes so arranged that an equal frictional effect is produced upon their drums for a given force applied by the operator,

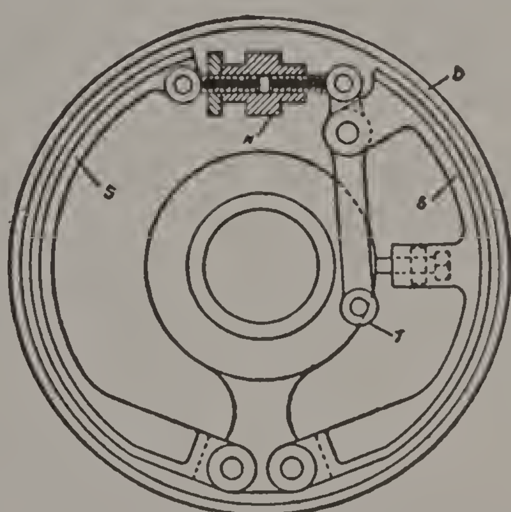



Fig. 58
Expanding Brake

whether the vehicle is running forward or backward. A brake so arranged is said to be double acting. Another type of expanding brake is shown in Figure 58, where D is the brake drum; S S, the brake shoes; T, the toggle arrangement which connects with the brake lever, and N is a nut which is used for adjusting the movement of the brake shoes.

Advantages of the Expanding Brake. The expanding brake is coming more and more into general use, and is taking the place of the contracting brake in many cases, although the latter is still being used extensively as an emergency brake.

The advantages of the expanding brake are: (1) it is less liable to drag upon the drum; (2) it is easily made double acting; (3) it has more braking power for a given pressure; (4) the friction surfaces are better protected from mud and grit.

A form of brake designed for heavy service is that known as the "hydraulic," in which the braking force is carried by means of oil through suitable piping from a compressing cylinder to a working cylinder. The lever operated by the driver is located in the usual place and is connected to the piston of a powerful oil pump. From this pump connections lead to a similar cylinder on the chassis and from the piston and plunger of this second cylinder connection is made with the usual forms of brake mechanism. The pump is operated by successive strokes of the lever that increase the pressure; while the brakes are released by pressing a button that opens a valve and by releasing the hand lever.

**Brake Linings**. For expanding brakes, metal shoes have become standard, owing to the practicability of maintaining proper lubrication between the frictional surfaces. In external brakes the metal band is provided with some form of nonmetallic lining that forms the braking surface applied to the drum. The reason for this is that it is practically impossible to properly lubricate an external brake. Various kinds of material, viz., leather fabric, asbestos, vulcanized fibre and camel's hair belting, are used for lining external brake bands. A material which is used for this purpose must have great resisting powers, a constant co-efficient of friction, even in the presence of oil and water, and it must have the ability to resist the influence of heat due to the brake's action. In practice it has been found that leather lined brakes burn out, and fibre linings become brittle and cannot be depended upon, so that inorganic materials, which cannot be carbonized, such as asbestos fibre, are widely used. Asbestos fibre may be readily woven into a fabric which answers this requirement, but when used by itself its strength is not sufficient. When, however, it is woven over a metal wire gauze foundation it appears to have the necessary stability to withstand very severe service, and this is the method employed in manufacturing the incombustible brake linings which are being used.

Cork is the bark of the cork tree, and is the lightest known solid. Its weight is one-eleventh of aluminum, and one-thirtieth of cast-iron. It has a very high co-efficient of friction, and is not affected by many of the conditions which seriously impair the efficiency of other substances.

Cork possesses qualities which distinguish it from all other solids, namely, its power of altering its volume to a very marked degree in consequence of a change of pressure. It consists, practically of an aggregation of minute air vessels, having thin, water-tight, and very strong walls, hence, if compressed, the resistance to compression rises in a manner more like the resistance of a gas, for instance, than to that of an elastic solid, such as a spring. The elasticity of cork has a wide range and is very persistent. It is this elasticity which makes it valuable when used as an insert in a metal shoe. Cork is of rather a brittle nature, though extremely strong, and for that reason it cannot be used in the form of a lining or facing. The method of application is to insert corks in holes in the brake provided for the purpose. Cork is not particularly affected by heat or oil, and will largely increase the efficiency in any application to a brake or clutch.

Where metal-to-metal surfaces, with or without cork inserts, are used, the surfaces are usually of different materials. The most common material for drums in all cases is steel, but that of shoes is either malleable cast iron, brass or a bronze. Different metals make a better wearing surface, and some combinations will have a higher degree of friction adhesion than others.

In the selection of material for brake linings, the co-efficient of friction is an important factor to be considered. Table 7 gives the relative values existing in combinations of different materials.

TABLE 7.

| Material— | Co-efficient of friction |
|---|---|
| Metal to Wood | 0.25 to 0.50 |
| Metal to Fibre | 0.27 to 0.60 |
| Metal to Leather | 0.30 to 0.60 |
| Metal to Metal | 0.15 to 0.30 |
| Metal to Cork | 0.36 to 0.65 |

EQUALIZERS. In connection with all brakes which are used in pairs, some method is used to equalize the pressure of the brake handle or foot pedal so that the same pressure will be applied

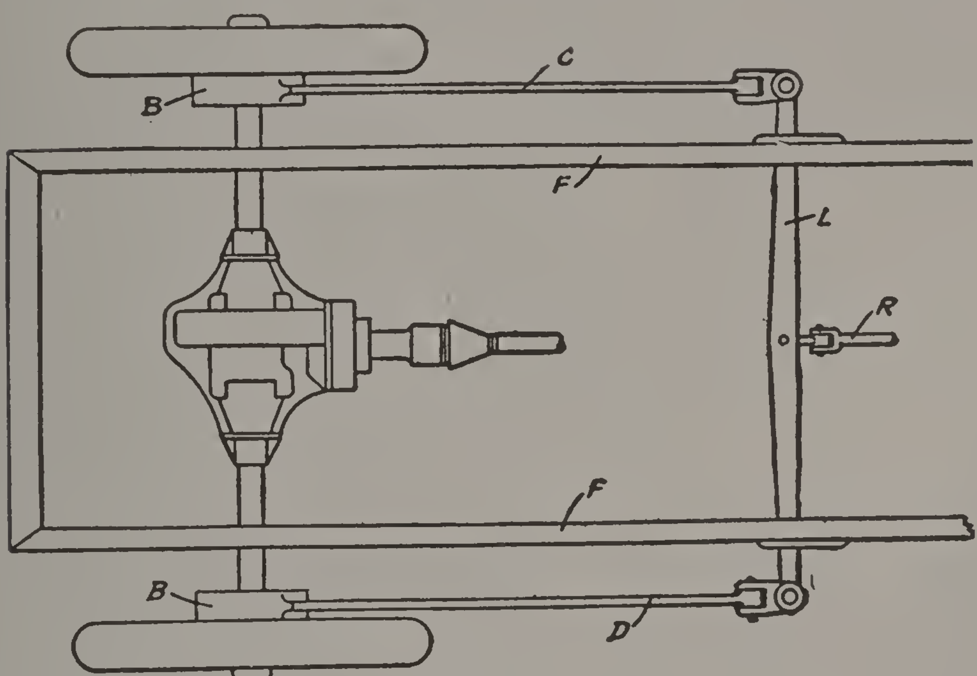



Fig. 59
Floating Lever Type of Equalizer

to both brakes. If the power is not equally applied to each brake, side slip or "skidding" will result.

The different methods of equalizing brakes are shown in Figs. 59, 60, 61 and 62, the majority of cars using what is known as the floating lever type, the cable arrangement being used only on several makes of cars. The floating lever type of equalizer is illustrated in Fig. 59. L is the floating lever, connected at its central point to the brake lever, or pedal by means of rod R. The ends of lever L are connected to the brakes B, B, by means of the brake rods C and D. When rod R is drawn forward, lever L draws rods C and D forward thus giving an equal pressure on the hub brakes.

Fig. 60 shows another type of floating lever equalizer. Shaft S connects to the brakes by

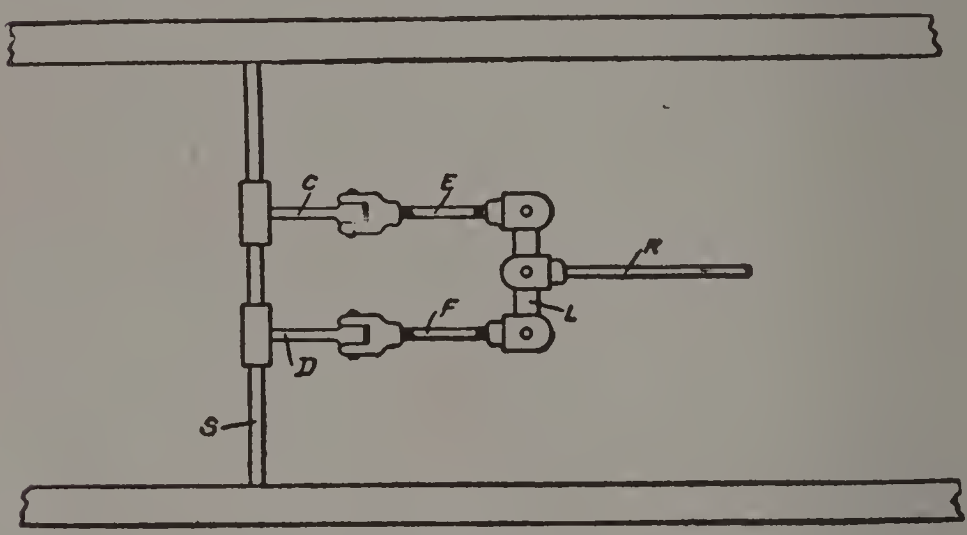



Fig. 60
Floating Lever Equalizer

means of rocker arms located just outside the frame. Two rocker arms, C and D are connected to shaft S, and to the equalizing lever L by means of rods E and F. In some cases the equalizing lever is located outside of the frame. It then takes the form shown in Fig. 61, in which L is the lever that equalizes the pressure on both brakes connected to shaft S. Fig. 62 shows the arrangement of the cord equalizer. Shaft S is connected to the two brakes, one at each end, and it has two rockers, or cranks E and F attached to it. Parallel to S is another shaft C, which carries a grooved roller R. A cable is connected to crank E, carried over R, and then passing back, is connected to crank F. When R is moved in the direction of the arrow, by the brake lever, the cord distributes the tension between E and F, and as a consequence the brake also. This type is much cheaper than the others, but it requires more care and attention.

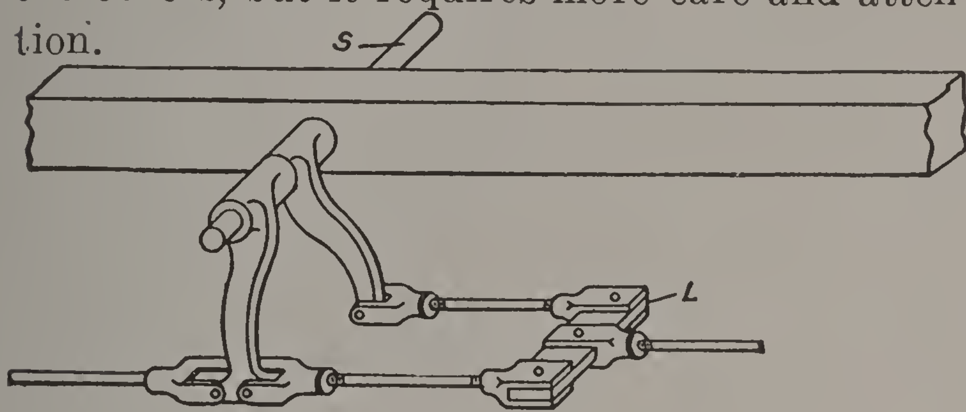



Fig. 61
Equalizer Lever Outside the Frame

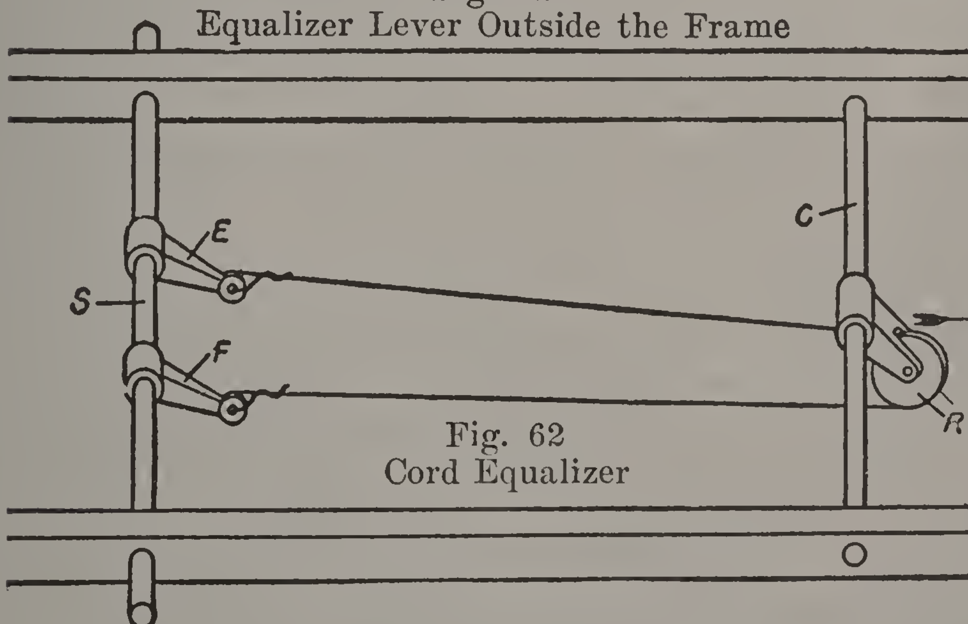



Fig. 62
Cord Equalizer

**Brazing.** Many workmen labor under the impression that a brazing job cannot be done unless the parts are a loose fit, in order, as they say, to allow the brazing material to enter and form a bond. The result is, when they do the work, the parts are a very loose fit, with accentuated shearing tendencies in the section of the brazing material, and if the brazing happens to be poorly done, the result is anything but good, since, in the absence of brazing, there is not even a good mechanical bond.

A good mechanical bond is possible to procure without, in any way, interfering with the brazing process, since the parts, if they are well fluxed, will take a coat of brazing material, even when the recess is but a thousandth or two. In brazing, if the work is to be up to a sufficient standard to use in steering gear, it is necessary to clean and brighten the surfaces in a most thorough manner. This will best follow by mechanical scraping rather than by dipping in some corroding material. Dipping may be of value as a preliminary, but a file, and scraper, in the hands of a man of competence, will go a long ways toward success.

When the parts are well brightened, and the grease is thoroughly removed, by the use of soda water, benzine, or equally good solvents, it remains to flux the parts with borax, and then apply the heat, either by a forge or from a special form of brazing torch which uses gasoline, kerosene, or other fuel oil, to produce the necessary heat. All forms of burners have means of adjusting the flame, and two or more burners are usually placed in such position that their flames strike the work. Torches are similar to the Bunsen burner; if fire brick, or clay, is used to build up around the parts, the heating process will be attended with less difficulty, and the work will be better at the finish. A rather hard brazing material may be used. This may be purchased ready for use, and there is no reason at all why a motorist of even slight skill cannot make a good job of brazing.

**Camshaft.** Fig. 63 is a sectional view of a motor cylinder and illustrates the principle and action of the camshaft. In many motors one camshaft serves to open both intake and exhaust valves, while in other motors there is a cam-shaft for each set of valves. Besides opening the valves, the cams determine the length of time the valves remain open, also the speed with which it opens and closes. Referring to Fig. 63, A is the crank-shaft, P the piston, D is the cam-shaft which carries the cam E. The speed of the cam-shaft depends upon the type of engine. The one shown in Fig. 63 is driven at half the speed of the crank-shaft through the gear wheels B and C, B being one half the size of C. H is the valve to be opened, which in opening must be lifted off its seat. This is done when the cam E revolves and raises the roller G on the lower end of lifter rod F which extends upward resting against the lower end of the stem of valve

H, although between the two rods, or rather at their point of contact are nut and lock-nut L,

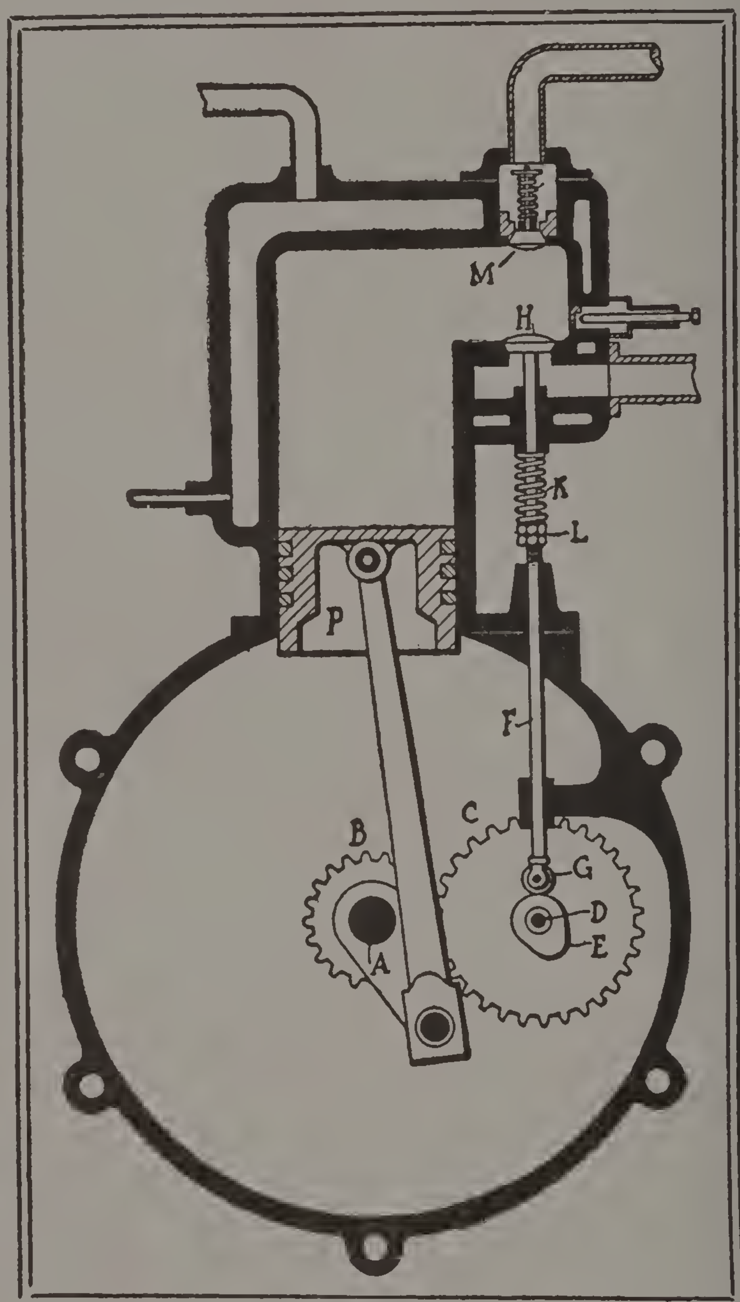



Fig. 63
A Camshaft and Its Location

for adjusting the length of F when timing the valve. K is a spiral spring, the function of which is to close the valve, after the cam E travels around and allows G to drop. Directly above valve H is the intake valve M, which in this case opens downward. This valve opens automatically, due to the suction of the piston in moving downwards on the intake stroke, but is kept closed during the compression and exhaust strokes of the piston, by the pressure in the cylinder.

Modern forms of construction make the camshaft and cams from one piece of steel, and the cams are then said to be integral with the shaft. This method makes it possible to place the cams in exactly the right position at the factory, and the danger of lost power from improper placing is thus greatly reduced.

**Carbon Deposit—Symptoms of.** One of the most fruitful sources of trouble in internal combustion motors is that of the carbon deposit. If the cylinders get too much oil, or if oil of a heavy or inferior grade is used, a portion of it will work up past the pistons, where it will be evaporated or consumed by the intense heat, leaving a deposit of carbon. This may be augmented by too rich a mixture, which serves to deposit film upon film of carbon on the inside, and top of the compression chamber, and on the head of the piston. The films thus formed will in time commence to scale, and the projections fused by the heat of the explosions will serve to prematurely ignite the charge. The symptoms are back-firing and knocking in the cylinders

—as if the spark were too far advanced. An almost infallible symptom of excessive carbon deposit in the cylinders is the motor showing plenty of power at high car speeds, but deficient in hill-climbing on high gear. At slow engine speeds the incandescent carbon projections serve to pre-ignite the charge, thereby reducing the power of the motor. The cure is to take off the cylinder head and scrape off the carbon deposit from the top of the piston and inside of the cylinder head. Carbon also will form on the porcelain portion of the spark plugs, thereby furnishing a circuit which the high tension current may follow, rather than jump the gap between the points of the plug. Usually only a part of the current will pass by way of the carbon film, still leaving a weak spark at the points, which in open air, when testing plugs, may seem strong enough. This causes intermittent firing. The symptoms are similar to a poor contact commutator. This condition is difficult to detect, for the reason that when the plug is subjected to the usual test of removing from the cylinder and closing the electrical circuit, the spark is seen to jump free and fat between the sparking points. This is because electrical energy which is sufficient to jump between two points ½-inch apart in the open air will jump less than 1/16-inch in the explosion chamber under 60 pounds compression. The causes of overheating in motors may be summed up as follows: Poor oil, insufficient oil, bad mixture, slow spark, obstructed water pipe, low water and valves out of time.

Lubricating oil is charged with the crime of depositing carbon on the surfaces of the combustion chamber, and this carbon in turn causes "bucking," and pre-ignition. It probably is true that inferior cylinder lubricating oil will deposit carbon, to some extent, but the main trouble is from the gasoline which will not vaporize until it is allowed to contact with the hot cylinder walls, and this process of reducing the gasoline to vapor is bound to lead to a carbon deposit for the same reason that wood is "coked" if it is heated to a temperature of about 650 deg. C., provided the amount of air present is less than that which would cause complete combustion.

**Carburetors, Principles of.** Internal combustion engines used for the propulsion of motor cars use gasoline for fuel in almost all cases. Experimenting is now going on in the endeavor to use kerosene or alcohol, and in some cases even lower grades of fuel. Gasoline and kerosene are secured by heating crude petroleum until vapor is given off, and this vapor is passed through pipes that are kept cool enough to condense the vapor into a liquid. Alcohol is secured by the distillation of fermented vegetable matter, and may be secured in almost any part of the country if suitable means for distillation were to be developed.

Before the gasoline is ready to burn in the engine cylinders, it must be turned into a gas or vapor. If gasoline stands exposed to the air it will vaporize at a comparatively slow rate, but if ejected from a small opening in a fine stream it will turn to vapor and mix with air much more rapidly. It is always necessary to mix the gasoline vapor with air in certain proportions to make a combustible mixture. The instrument that turns the gasoline into a gas and then mixes the gas with air is called the *carburetor* and the process is called *carbureting.*

Many forms of carburetors have been made and used, but all instruments now fitted are of the type known as automatic float feed. The spray nozzle is the small opening inside of the carburetor through which the liquid gasoline is drawn when it is to be made into a vapor.

The nozzle opening is placed in a tube through which the air must pass on its way to the engine cylinders. See Fig. 64. One end of this tube is open to the outside air and the other end attaches to the piping that goes to the engine cylinders. The end open to the air is called the primary air intake.

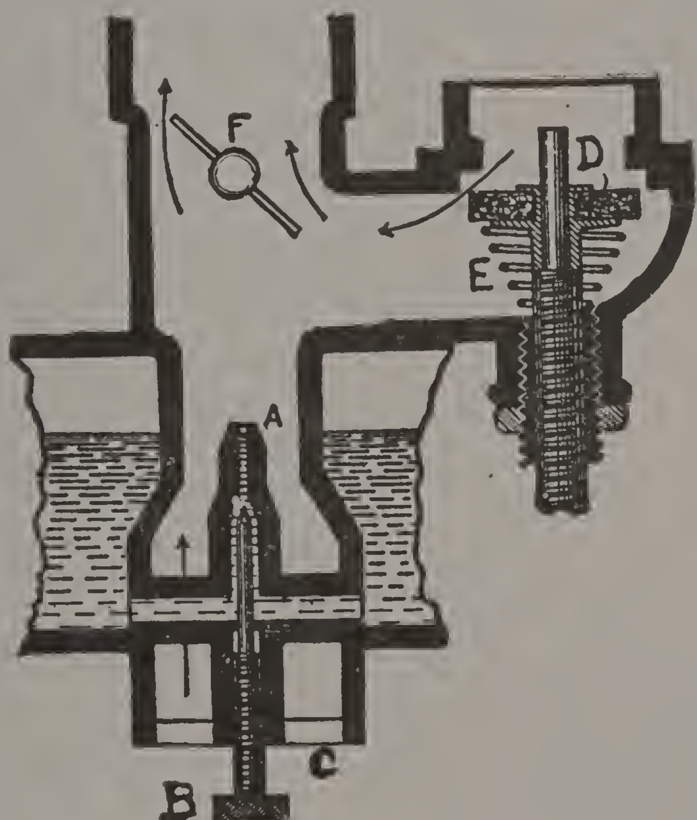



Fig. 64

Float-Feed Carburetor Mixing Chamber and Air Valve. A, Spray Nozzle. B, Adjusting Needle Valve. C, Primary Air Intake. D, Auxiliary Air Valve. E, Air Valve Spring. F, Throttle Valve.

When the piston travels away from the cylinder head on the inlet stroke, the inlet valve opens and a cylinder full of mixture is drawn from the carburetor. The air to make the mixture is drawn through the carburetor primary air intake and must pass by the nozzle opening. The gasoline is maintained at a height slightly below the nozzle opening, and the suction, or partial vacuum, of the incoming air causes some of the gasoline to be drawn out of the nozzle so that its spray mixes with the air. This is the principle on which all modern carburetors operate, but certain added features are necessary to compensate for the different conditions obtaining under different rates of car speed and engine load.

The first difficulty that would be encountered with the simple form of carburetor just described would be that of a falling gasoline level in the nozzle as the fuel was drawn into the engine. This would finally result in a failure of the fuel supply and stoppage of the engine. In actual practice, the gasoline from the car's tank does not pass directly into the nozzle, but goes first into a small tank on the carburetor, which tank is called the float chamber. Of the two openings in this small tank, one goes to the gasoline supply and the other communicates with the carburetor nozzle. Inside of the float chamber is a piece of cork covered with shellac or else a hollow metal cylinder, either of which will float on the surface of whatever gasoline may be in the chamber. At the opening of the pipe that comes into the float chamber from the gasoline tank is a small valve, Fig. 65, operated by connections attached to the float itself. When the float is low down in the chamber this valve is open; but as the float rises on the surface of the liquid coming from the tank, it finally reaches a height

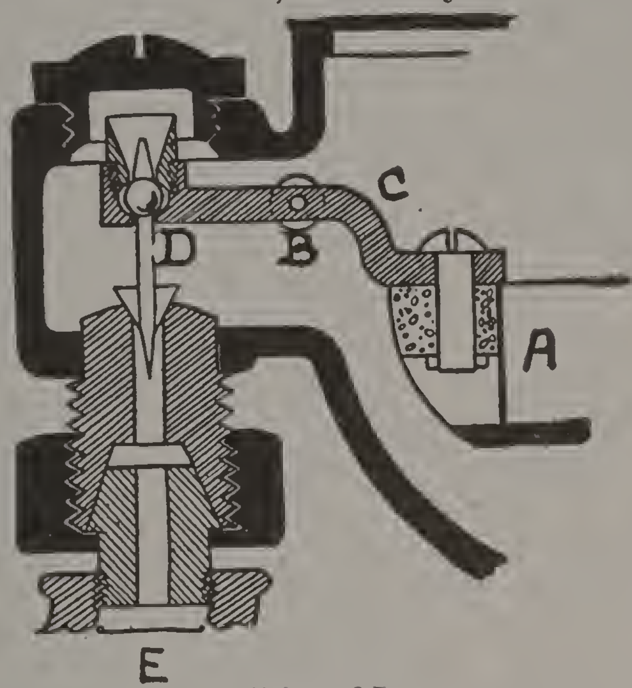



Fig. 65

Carburetor Float Valve Mechanism. A, Float. B, Float Lever Pivot. C, Float Lever. D, Float Valve. E, Gasoline Inlet.

at which the valve is closed, and it will therefore be seen that the level of the liquid cannot rise above the point determined by the position of the float when the valve closes. When gasoline is drawn from the float chamber, through the nozzle, the float falls with the fuel level until the valve is again opened, and by this repeated action the level is maintained constant.

Other parts of the carburetor, such as the auxiliary air valve, are described in the following pages and the construction and adjustment of the well known makes are taken up.

Almost any carburetor will give a reasonably good mixture through a limited range of action. Frequently, however, this range is found insufficient for a particular engine. If right for low speeds, it is wrong for high speeds, and vice versa.

The theory of carburetor action as regards the behavior of the gasoline jet under different air velocities is still only partially understood, and has been the subject of a great deal of more or less blind theorizing, based in many cases on wholly inadequate data.

A non-automatic spraying carburetor (i. e., a simple nozzle in an air tube) makes no mixture at all till the velocity of the air stream reaches a certain minimum. Beyond this point, the richness increases with the speed. Dilution from the auxiliary valve is therefore required only when the richness of the mixture exceeds the normal. At this point it should be remembered that, so far as the spray is concerned, there is no difference between a wide open throttle at slow engine speed (as for instance, up hill) and reduced throttle with high engine speed. The spraying action is concerned only with the velocity of the air past the nozzle before the throttle is reached.

Almost every carburetor is provided with the needle valve controlling the spray orifice. With this provision it is very easy to determine whether or not the carburetor is doing as well as it should at either low or high speed. For example, suppose we start with an adjustment known to be satisfactory for medium speeds. If the low speed performance is under suspicion, it is only necessary to increase the needle valve opening slightly to ascertain whether starting is thereby made easier, and a walking pace more smoothly maintained. If overheating results, reducing the needle opening will probably cure it. Similarly slight changes in the needle opening, without changing any other adjustment, will determine whether or not the mixture is improved by less, or more gasoline at high speed. When the carburetor is set for a medium speed, if the mixture is weak at low speeds, and rich at high speeds, more air should be admitted, but if the mixture is rich at low speeds, and weak at high, less air should be admitted. Much depends upon the spring.

It is a characteristic of all springs that their flexure is in direct proportion to the load imposed, up to the elastic limit of the spring.

THE FLOAT FEED CARBURETOR, Fig. 66, consists of two principal parts: a gasoline receptacle which contains a hollow metal or a cork float, suitably arranged to control the supply of gasoline from the tank or reservoir, and a tube or pipe in which is located a jet or nozzle in communication with the gasoline receptacle. This tube or pipe is called the mixing chamber. The gasoline level is maintained about one-sixteenth of an inch below the opening in the jet

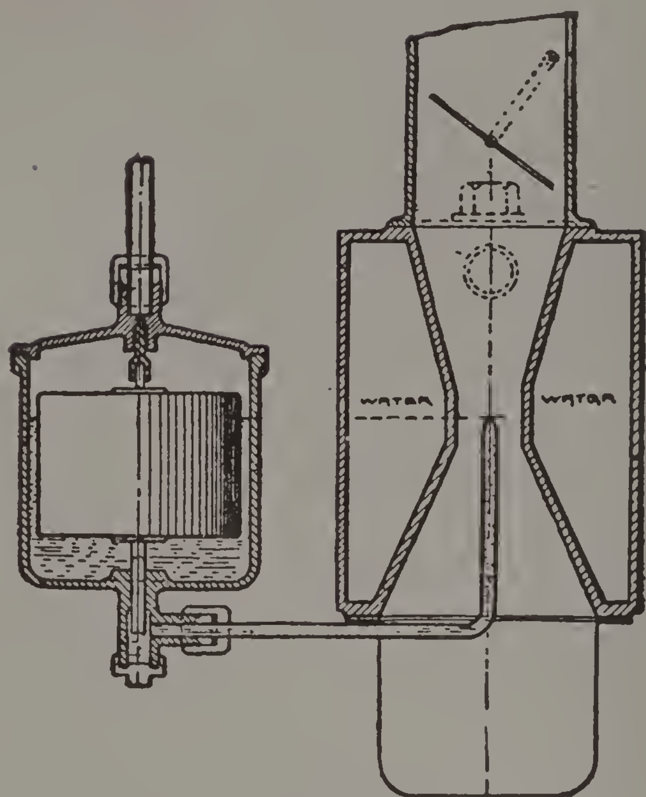



Fig. 66
Float Feed Carburetor

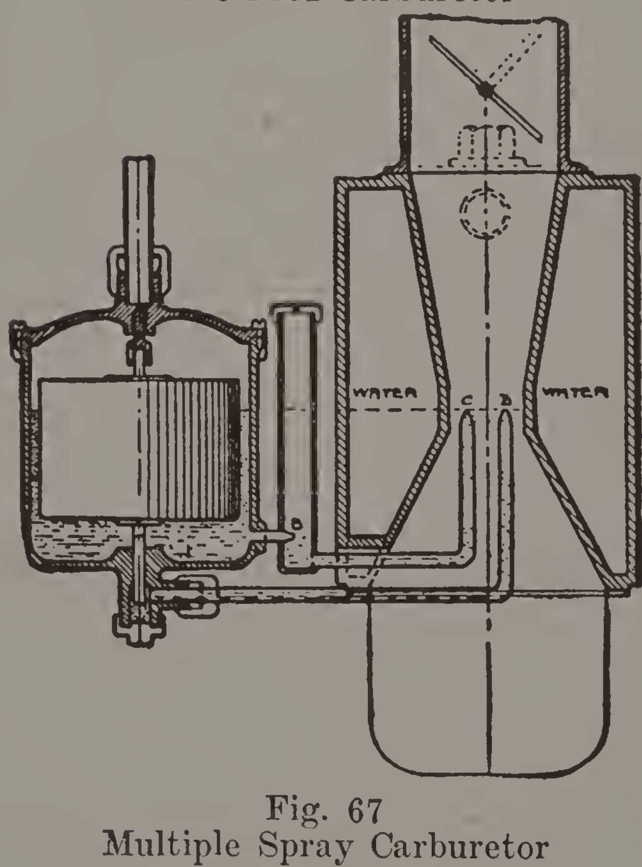



Fig. 67
Multiple Spray Carburetor

in the mixing chamber. The inductive action of the motor-piston creates a partial vacuum in the pipe leading from the mixing chamber of the carbureter to the motor, thereby causing the gasoline to flow from the jet and mixing with the air supply, to be drawn into the cylinder of the motor in the form of an explosive mixture.

SPRAYING CARBURETORS. In this type of carburetor the quantity of gasoline delivered is not proportional to the volume of air delivery at different rates of flow. This difficulty has, however, been met by providing a supplementary air inlet to the carbureter, which may be regulated by the driver at will.

Another method of correcting the variations in the proportions of the gasoline charge is shown in Fig. 67, and consists in providing a second spray nozzle. In the majority of cases in which multiple nozzle carburetors are used, there are two nozzles, practically two carbureters, a small one for idle running, and slow speeds, and a larger one for heavy work. In some instances, three, and even four nozzles are used.

THE VENTURI TUBE CARBURETOR operates on the principle that if two converging air nozzles have their small ends brought together, there is a point where the suction remains practically constant, therefore if the fuel nozzle be located at this point the result will be, a constant mixture at all speeds. In a carburetor of this type there are no auxiliary spring controlled air valves, no moving strangling cage, nor any mechanical interregulation between the air, and the gasoline.

An elementary Venturi tube is shown in Fig. 68, which represents the tube A having a head of water on it. The discharge at A is greatly increased by the addition of the divergent nozzle at the outlet end. Under these conditions,

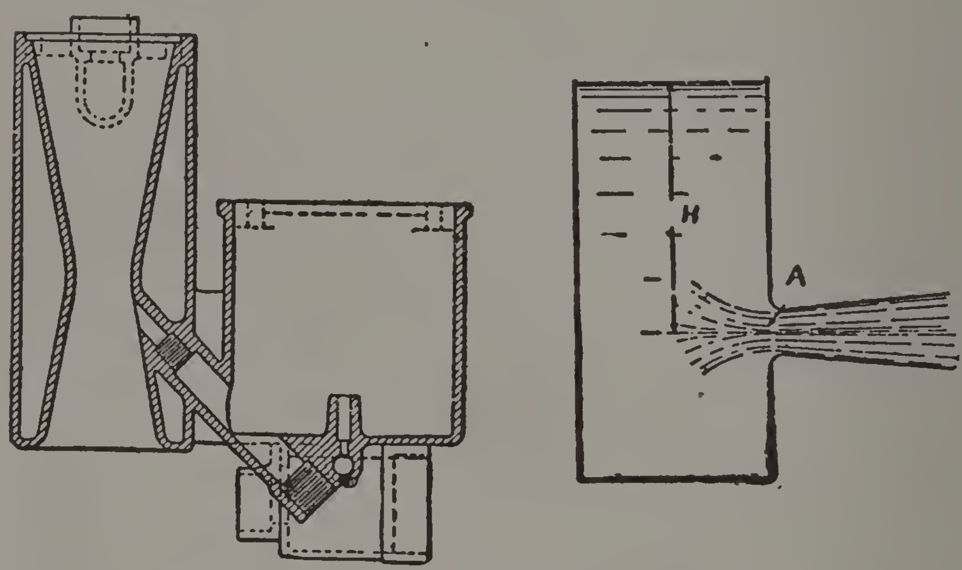



Fig. 68
Principles of the Venturi Carburetor

the velocity of flow in the throat at A is greater than that produced by the head H. When a pressure gauge is placed at A the pressure is found to be less than atmospheric; in fact, the fluid is discharging into a partial vacuum, and the velocity at A is due to the head H plus the head due to the vacuum. Advantage is taken of this fact by placing the gasoline outlet at the point A, in which case the velocity of the suction controls the flow of gasoline at all times thus giving a perfect mixture.

AUXILIARY AIR-VALVE. It has been determined from the result of experiments that to get the maximum power at any speed from a gasoline motor equipped with a float-feed carburetor, the jet of the carburetor must have a larger opening for low speeds than for high speeds. As this practice would require a very delicate adjustment it consequently becomes almost impracticable, because necessitating a constantly varying regulation for each fractional variation of speed of the motor. The difficulty may be obviated by the use of an auxiliary air-valve, located in the induction-pipe close to the inlet-valve of the motor.

The jet of the carburetor is set for the maximum quantity of gasoline at the slowest speed of the motor, and as the speed is increased the auxiliary air-valve comes into action and reduces the supply of air passing through the carbureter, thereby reducing the suction or partial vacuum at this point, and maintaining a constant quality of mixture at all times.

The auxiliary air valve has been attached to a dash pot construction in many makes of modern carburetors. The dash pot may operate with air or with gasoline for its fluid, but in either case the purpose is to prevent sudden opening and closing of the valve or "fluttering." Such fluctuation is a cause of noise and also tends to destroy the proportions of the mixture.

Frequently it is observed that the intake to the carburetor is so restricted that noise issues, and a little further investigation in such cases will disclose, in all probability, that wire-drawing is one of the ills. It is not alone the noise that is objectionable in such cases; the power of the motor will be less, due to the restriction which has the effect of reducing the weight of mixture that enters into the cylinders, and the power of a motor is undoubtedly proportional to the weight of mixture that enters the cylinders, assuming, of course, that the same is in acceptable form, and that it is completely burned. True, there must be a depression in the carburetor in order that there will be a difference in pressure, so that gasoline will be sucked into the train of air; equally true, it is of the greatest importance to have the depression as low as possible in order that the power of the motor will be a maximum. If the depression is but slight, provided the carburetor is properly designed, the amount of fuel entrained will be adequate for the purpose. If, on the other hand, the depression is very large and holds considerable fuel, it will soon be found to be wasteful of the liquid.

With the low grades of fuel now in use, wire-drawing is very harmful, inasmuch as it tends to separate the gasoline from the air and causes the gasoline vapor to again become a liquid and deposit on the tubing walls.

Effect of Cold on Gasoline. The temperature has a very marked effect on the rapidity with which gasoline vaporizes, and in cold weather it is necessary to supply heat to the carburetor.

The carburetor should preferably be jacketed, and it may be warmed either from the circulating water, or by taking a small quantity of the hot gases from the exhaust pipe. If water is used it should be taken from a point just beyond the discharge of the pump, and should be delivered to the return pipe from the engine jacket to the radiator.

Whether exhaust gases or water is used, the flow should be regulated by a cock, otherwise too much heat will be received in warm weather. When the carburetor is cold, the engine may be started by pouring warm water over it, care being taken not to let any portion of the water get into the gasoline through any aperture in the top. Another method of warming up the carbureter is to wring cloths out of hot water, and wrap them around it.

While it is not generally realized, the flow of gasoline through the nozzle is greatly influenced by the temperature of the liquid. Gasoline at very low temperatures, such as freezing, and slightly above, is reduced as much as 30% in volume of flow below the point reached when the liquid itself is warmed to between 65° and 80° Fahrenheit. This forms one more reason for jacket heating on all carburetors.

Carburetor Inspection. The float valve of the carburetor should be tested for leaks by opening the valve between it and the tank and looking for gasoline drip. If gasoline escapes, it may simply be because the float is set too high, so that it does not close the needle valve before gasoline issues from the spray nozzle. Or, it may be that the valve itself leaks.

At this stage, it is well to assume that the float is properly adjusted, and to begin by shutting off the main gasoline valve, and then unscrewing the washout plug below the needle valve. It may be found that dirt, waste, or a splinter of wood has got past the strainer, through which, presumably, the gasoline passes on its way to the float, and is lodged in the needle-valve opening. It may be of advantage to open the top of the float chamber, which can usually be done without disturbing other parts, and take out the float and needle valve. A little gasoline washed down through the needle-valve orifice will then generally carry away any dirt that may have clung to the valve when the plug was unscrewed. If the gasoline still drips when the parts are reassembled, the mixing chamber should be opened and the top of the spray nozzle examined to see if gasoline is escaping from it. An electric light should be used in making an examination of the carbureter, as, with any other illuminant, a fire might be started. The portable electric flashlights answer the purpose very well.

Occasionally a carburetor is found to be too large for the engine, or to have too large a spray orifice. The advice has been given in such a case to reduce the size of the spray orifice by lightly pening the top of it with a hammer. This is counsel of doubtful value, even if the hole be afterward reamed true, since it is manifest that the burr formed in the top of the orifice cannot possibly be deep enough to be at all regular in its form. It will almost inevitably throw a jet slantwise, instead of straight, and this jet failing to strike the main part of the air stream will be only partly atomized, with resulting misfiring and general bad behavior, especially at low speeds. If a new nozzle of smaller size cannot be substituted, the best thing to do in case there is no needle valve to adjust the flow of gasoline to the jet is probably, to warm the ingoing air as much as possible, in order to make evaporation by temperature take the place of atomizing due to the air's velocity.

HOLLY CARBURETOR, MODEL H. This carburetor is shown in Fig. 69. Before the fuel enters the float chamber it passes a strainer disk A which removes all foreign matter that might interfere with the seating of the float valve B under the action of the cork float and its lever C. Fuel passes from the float chamber, D, into the nozzle well E, through a passage F, drilled through the wall separating them. From the nozzle well the fuel enters the nozzle proper, G, through the hole H, and then rises past the needle valve I, to a level in its cup-shaped upper end, which just submerges the lower end of a small tube, J, which has its outlet at the edge of the throttle disk.

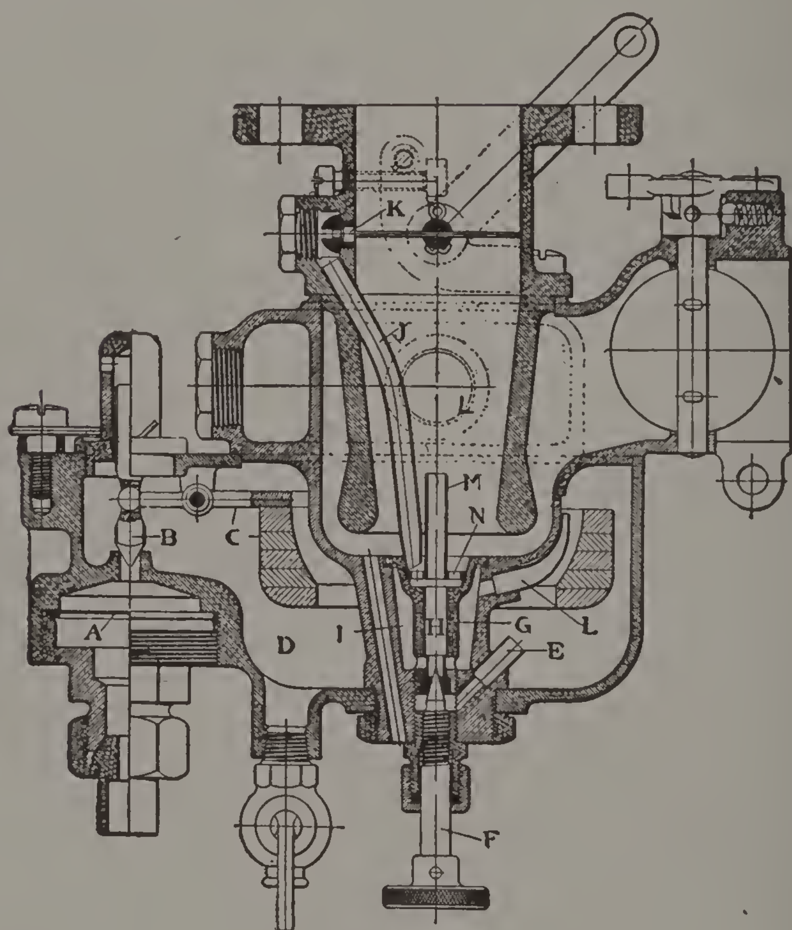



Fig. 69
Holly Carburetor, Model "H"

Cranking the engine, with the throttle kept nearly closed, causes a very energetic flow of air through the tube J and its calibrated throttling plug K, but the lower end of this tube is submerged in fuel, with the engine at rest. Therefore, the act of cranking automatically primes the motor. With the motor turning over, under its own power, flow through the tube J takes place at very high velocity, thus causing the fuel entering the tube with the air to be thoroughly atomized upon its exit from the small opening at the throttle edge. This tube is called the "low speed tube" because, for starting and idle running, all of the fuel and most of the air in the fuel mixture are taken through it.

As the throttle opening is increased beyond that needed by idling of the motor, a considerable volume of air is caused to move through the passage bounded by the conical walls L of the so-called strangling tube. In its passage into the strangling tube, the air is made to assume an annular, converging-stream form, so that the point in its flow at which it attains its highest velocity is in the immediate neighborhood of the upper end of the "standpipe" M, set on to the body of the nozzle piece G. The velocity of air flow being highest at the upper, or outlet, end of the standpipe, the pressure in the air stream is lowest at the same point. For this reason there is a pressure difference between the top and bottom openings of the pipe M, thus causing air to flow through it from bottom to top, the air passing downward through the series of openings N in the standpipe supporting-bridge and then up through the standpipe.

With a very small throttle opening, the action through the standpipe keeps the nozzle thoroughly cleaned out, the fuel passing directly from the needle opening into the entrance of the standpipe. To secure the utmost atomization of the fuel, the passage through the standpipe is given aspirator form, which further increases the velocity of the flow through it, and insures the greatest possible mixture of the fuel with the air. A further point is that the atomized discharge of the standpipe enters the air stream at a point at which the latter attains its highest velocity and lowest pressure.

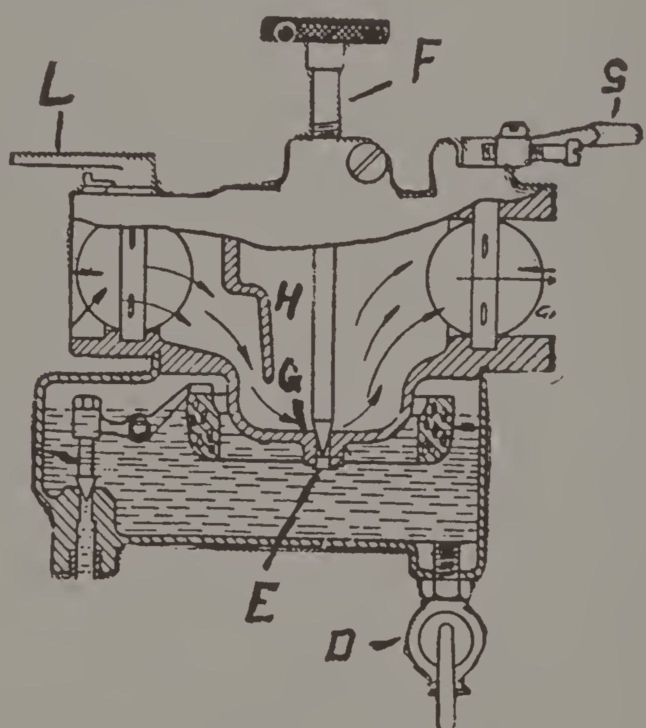



Fig. 70
Holly Carburetor, Model "G"

There is but one adjustment, the needle valve I. The effect of a change in its setting is manifest equally over the whole range of the motor.

HOLLY CARBURETOR, MODEL G. This design is especially for Ford cars. Its method of operation is identical with that of the Model H, its chief differences as compared with the other model being structural ones, giving a horizontal instead of a vertical outlet, a needle valve controlled from above, and a general condensation of the design to secure compactness.

Fuel enters the carburetor, shown in Fig. 70, by way of a float mechanism in which a hinged ring float, in rising with the fuel, raises the float valve into contact with its seat. The seat is a removable piece and the float valve is provided with a tip of hard material.

From the float chamber the gasoline passes through the ports E to the nozzle orifice in which is located the pointed end of the needle F. It is noted that the ports E are well above the bottom of the float chamber, so that, even should water or other foreign matter enter the float chamber it would have to be present in a considerable quantity before it could interfere with the carburetor operation.

A drain valve D is provided for the purpose of drawing off whatever sediment, or water, may accumulate in the float chamber. The float level is so set that the gasoline rises past the needle valve F and fills the cup G to submerge the lower end of the small tube H. Drilled passages in the casting communicate with the upper end of this tube with an outlet at the edge of the throttle disk. The tube and passage give the starting and idling actions, as described in connection with the Model H.

The strangling tube I gives the entering air stream an annular converging form, in which the lowest pressure and highest velocity occur immediately above the cup G; thus it is seen that the fuel issuing past the needle valve F is immediately picked up by the main air stream at the point of the latter's highest velocity.

The lever L operates the throttle in the mixture outlet, and a larger disk with its lever S is a spring-returned strangler valve in the air intake, for facilitating starting in extremely cold weather.

Kingston Carburetor. The Kingston carburetor, Fig. 71, uses a ball type of auxiliary

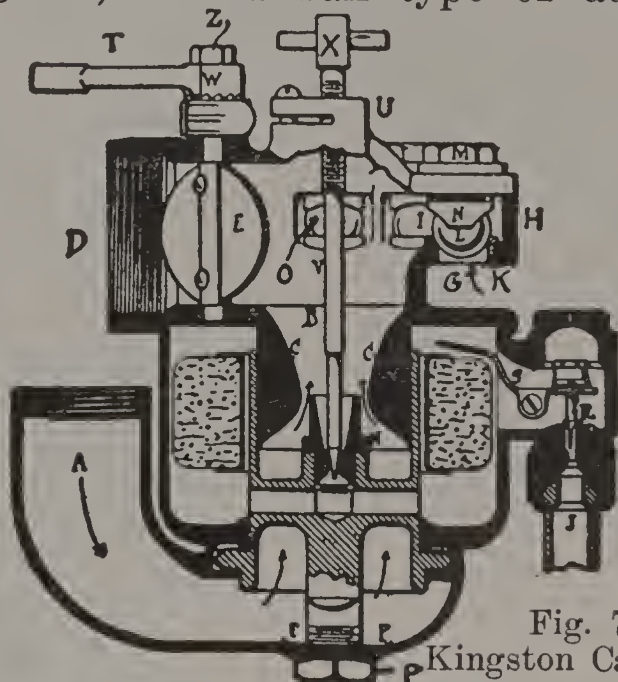



Fig. 71
Kingston Carburetor

air valve instead of the employment of spring control dashpot, diaphragm or auxiliary air valve. The main air intake A communicates with the vertical mixing chamber B, in which the sides C are beveled outward, giving a center tube effect, so that the air current converges above the nozzle N, as indicated by the arrows. D marks the exit to the motor controlled by the butterfly throttle E. Auxiliary air enters through five circular openings G, arranged in a semi-circle in the floor of an extension H of the mixing chamber. Each of these five openings consists of a bushing K threaded into the opening in the extension H, and having its top beveled to receive a five-eighths inch bell metal bronze ball L, which is retained in position by a threaded bushing M, fitting in the top of the extension H. It has a pair of downward projecting hooks N for preventing the ball getting out of position, but not interfering with the ball rising vertically when forced to do so by the pull of the motor, at which time additional air is admitted. Two others of the five auxiliary entrances are shown at I and O, all of the five containing balls of the same size and weight. The air entering through the openings guarded by these balls has an unrestricted passage into the mixing chamber and thence to the motor. Any ball is easily moved by unthreading the cap M, after which the ball can be lifted out.

The gasoline enters the carburetor from the gasoline tank by way of the connection J, which is guarded by the needle valve R, operated through the lever S, pivoted in the side of the casting and with its long arm bearing on the top of the cork float. The float is fitted with a metal bushing. Complete control of the nozzle N is through the needle valve V, which, at the top of the carbureter, has a T-piece X, by which it can be raised or lowered, thereby regulating the flow of gasoline. A feature of the throttle connection T is the serrated lower face of its hub W, so that by loosening a lock nut Z, the handle T may be turned in any direction most convenient. The air intake A consists of an L-shaped piece secured to the carbureter casting by a nut P, and in the base of this is a circle of openings F where currents of air can enter, the object of these openings being that by priming the carburetor, and overflowing the open mouth of nozzle N the gasoline falls to the vicinity of the holes F, and the air entering through these openings will facilitate the breaking up of the gasoline, and thereby assist the starting of the motor.

Krebs Carburetor. In the Krebs style of carburetor, a constant proportion of gasoline and air is maintained by means of suitable sections of air and gasoline outlets. The openings are so arranged that a proper mixture is maintained at minimum suctions, after which gradually increasing quantities of supplementary air are admitted.

A number of attempts have been made to improve upon the Krebs principle by variously shaping the supplementary air openings, or the spring on the supplementary air valves, so as to insure complete compensation for the increase in richness of the mixture formed in the spray chamber with increasing suction, by the addition of the correct amount of supplementary air at all suctions. The mixture formed in an ordinary spray carbureter becomes richer as the suction increases. At first the only means provided to correct this defect was a hand-regulated air valve; but since the advent of the Krebs carbureter, practically all new carbureters brought out have some arrangement for automatically keeping the mixture constant, regardless of variations in suction. In general the means provided are close copies of the Krebs supplementary air valve, though in some instances this valve, instead of being actuated by the suction, is operated either hydraulically by means of a diaphragm in a chamber communicating with the water cooling system, or mechanically by direct connection with the throttle valve.

Master Carburetor. This carburetor, shown in Fig. 72, is unique in that it has no adjust-

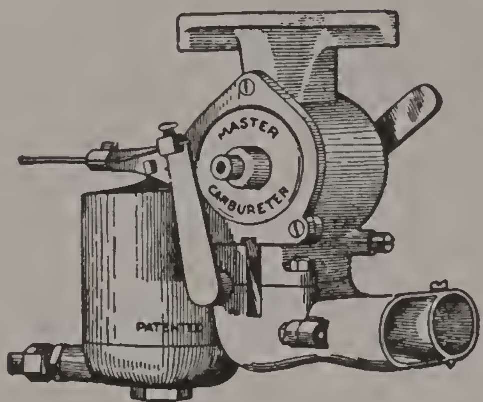



Fig. 72
Master Carburetor

ments, and is so simple that it may be readily taken apart and put together again. In the Master carburetor both the fuel and the air are positively regulated. This regulation is accomplished by a rotary throttle, which not only uncovers a series of minute holes in the fuel dis-

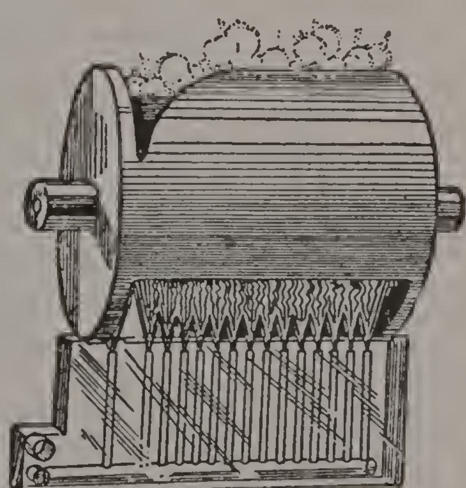


Fig. 73
Master Carburetor Vaporizing Action

tributer, but eliminates the butterfly valve found in most other carburetors. This action is shown in Fig. 73. When the throttle is closed fuel is admitted through but one hole, sufficient for slow speed or idling. As the throttle is opened additional holes are uncovered, one by one, and the fuel supply increased. The rotary valve does not become worn, as it does not come in contact with the throttle chamber in which it rotates. The

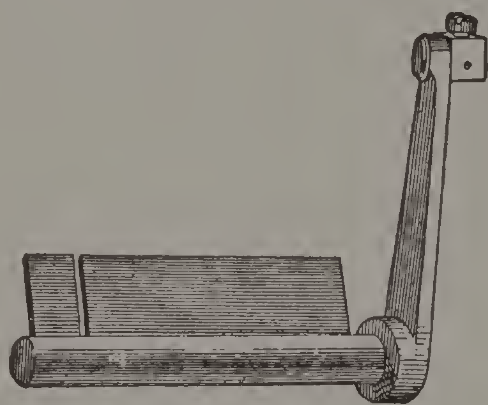


Fig. 74
Master Carburetor Damper

damper shown in Fig. 74 is a rigid plate, extending entirely across the passageway, paralleling the fuel distributer. This damper lever is attached to the hand control located on the steering post by means of a steel wire passing through a brass tubing. A trap is located under the float chamber and it contains a brass screen that filters the fuel, which is again filtered by another screen of tubular form.

Rayfield Carburetor. The Rayfield carburetor has no direct adjustment for the nozzle opening such as would be provided by a screw needle valve, but to take the place of such an adjustment a type of lever mechanism is used that increases or decreases the gasoline supply according to the degree of throttle opening, and also provides means for adjusting the fuel flow for high or low speeds independently of each other. Adjustment is provided through two screws with milled heads, one of these serving to fix the position of the nozzle adjustment at low engine speeds or with a nearly closed throttle and the other one operating only when the throttle is more than half way open. The construction of this instrument is clearly shown in Figs. 75, 76 and 77, and the method of adjustment is described on the following pages.

Model D, Fig. 75—Adjusting low speeds:—Close needle valve by turning low speed screw to the left until arm U slightly leaves contact with the cam. Then turn to the right one and one-half turns, open throttle one-quarter, prime carburetor and start motor. Close throttle until motor runs slowly without stopping. Turn low speed screw to the left one notch at a time until motor idles smoothly. If motor does not throttle low enough turn screw in stop arm to the left with a screw driver. Carburetor is now adjusted for low speed.

Adjusting high speed:—Now open the throttle slowly until wide open. Should motor backfire turn high speed adjusting screw to the right, a half turn at a time, until motor runs without a miss. Should motor not backfire turn high speed adjusting screw to the left until it does, then to the right until motor runs smoothly and powerfully.

Do not use low speed adjustment to get a correct mixture at high or intermediate speeds.

Should motor backfire or mixture be too light at intermediate speeds (throttle about ¼ open)

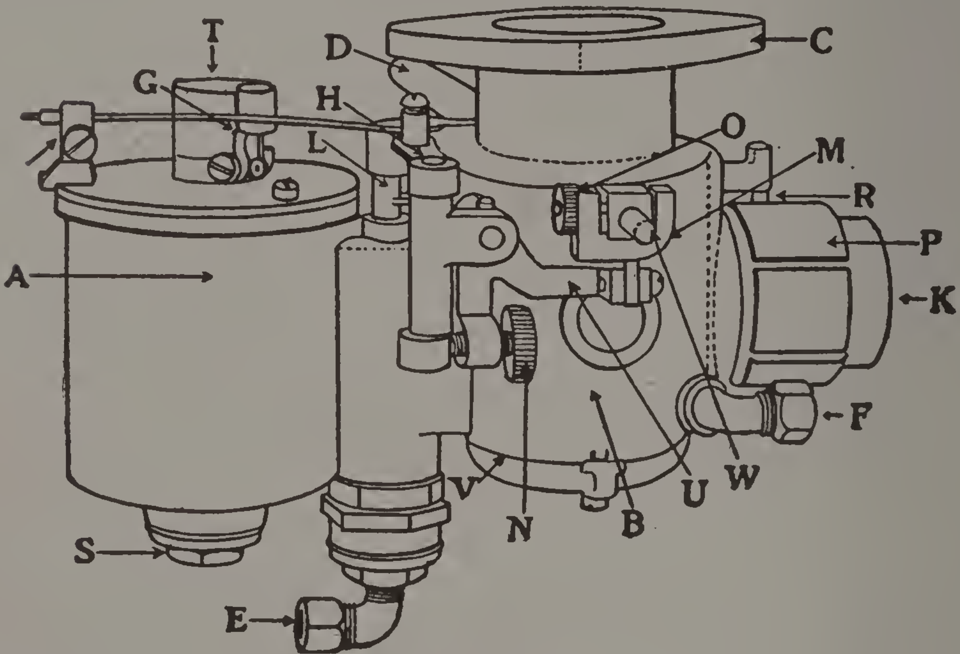



Fig. 75

Rayfield Carburetor, Model "D". A, Float Chamber. B, Mixing Chamber. C, Flange. D, Throttle Lever. E, Gasoline Intake. H, Gas Arm. J, Dash Adjustment. K, Air Valve. L, Needle Valve. M, Regulating Cam. P, Air Adjustment. R, Air Lock. S, Drain Plug. T, Priming Cap. U, Needle Arm. F, Water Connection. G, Priming Lever. N, Low Speed Adjustment. O, High Speed Adjustment. V, Primary Air Intake. W, Cam Shaft.

turn air valve adjustment P to the right a turn or two, thus increasing the spring tension and decreasing quantity of air slightly.

Remember that it is best to use all the air that the motor will handle without being sluggish.

Do not change the float level. It is correctly set at the factory. Always prime carburetor well before starting motor. Pull steadily on primer string. Don't jerk.

Do not cut down the air supply, unless the gasoline adjustments fail to give you a powerful and fast mixture.

If motor does not get the correct mixture at intermediate speed or high speed, do not try to remedy it through a low speed adjustment. Remember, the low speed adjustment is to be adjusted only when the motor is running idle.

In starting motor, do not open throttle more than one-quarter. The motor will start more readily with the throttle slightly opened and it is harmful as well as useless to race the motor in starting.

Before cranking motor pull dash button up. After motor has "warmed up" push dash button down to Running Position.

In stopping motor pull up dash button, open throttle about ¼ inch, and switch off ignition, thus leaving a sufficient volume of rich mixture in the cylinders, which assures easy starting when the motor is again used.

Models G and L, Figs. 76 and 77, have no air valve adjustment and only two gasoline adjustments.

Always adjust carburetor with dash control down. Low speed adjustment must be completed before adjusting "high."

Adjusting low speed:—With throttle closed, and dash control down, close nozzle needle by turning Low Speed adjustment to the left until

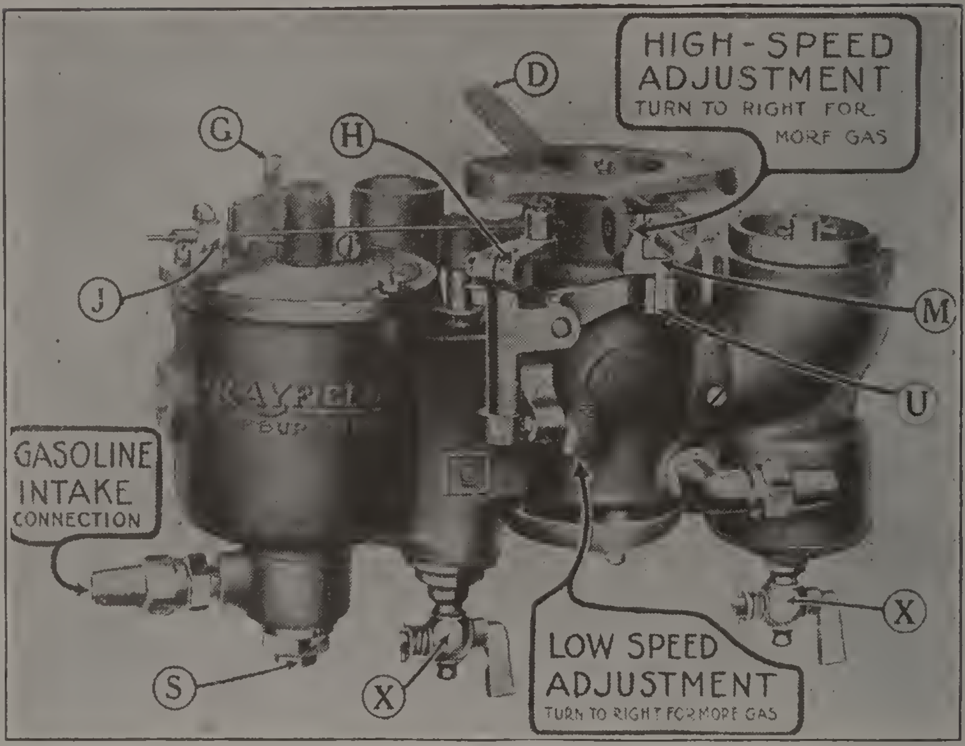



Fig. 76
Rayfield Carburetor, Model "G". D, Throttle Arm. G, Priming Lever. H, Gasoline Arm. M, Regulating Cam. S, Drain Cock. U, Needle Valve Arm. X, Drain Cock. J, Gasoline Control Lock.

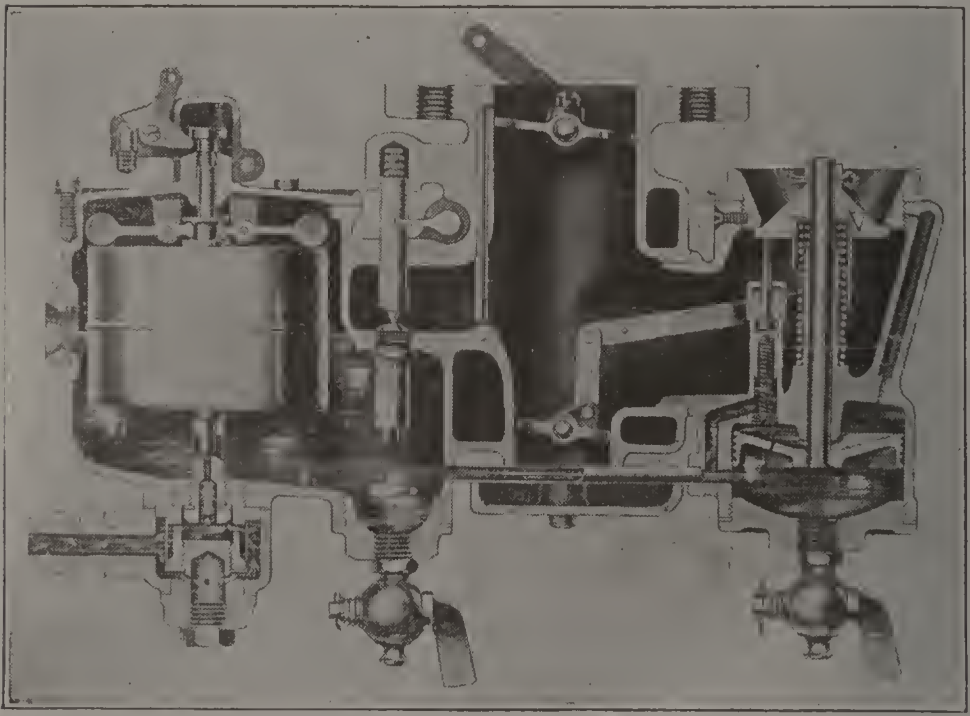


Fig. 77—Rayfield Carburetor, Model "G", Internal Construction

Block U slightly leaves contact with the cam M. Then turn to the right about three complete turns. Open throttle not more than one-quarter. Prime carburetor by pulling steadily a few seconds on priming lever G. Start motor and allow it to run until warmed up. Then, with retarded spark, close throttle until motor runs slowly without stopping. Now, with motor thoroughly warm, make final low speed adjustment by turning low speed screw to left until motor slows down, and then turn to the right a notch at a time until motor idles smoothly.

If motor does not throttle low enough, turn stop arm screw A to the left until it runs at the lowest number of revolutions desired.

Adjusting High Speed:—Advance spark about one-quarter. Open throttle rather quickly. Should motor backfire it indicates a lean mixture. Correct this by turning the high speed adjusting screw to the right about one notch at a time, until the throttle can be opened quickly without a backfiring.

If "loading" (choking) is experienced when running under heavy load with throttle wide open, it indicates too rich a mixture. This can be overcome by turning high speed adjustment to the left.

Adjustment made for high speed will in no way affect low speed. Low speed adjustment must not be used to get a correct mixture at high speed. Both adjustments are positively locked.

Starting:—Before starting motor when cold observe the following. Open throttle not more than one-quarter. Enrich the mixture by pulling up dash control. Prime carburetor by pulling on priming lever G for a few seconds.

When stopping motor, pull up dash control. Open throttle about one-quarter and switch off ignition. This leaves a rich mixture in the motor, which insures easy starting.

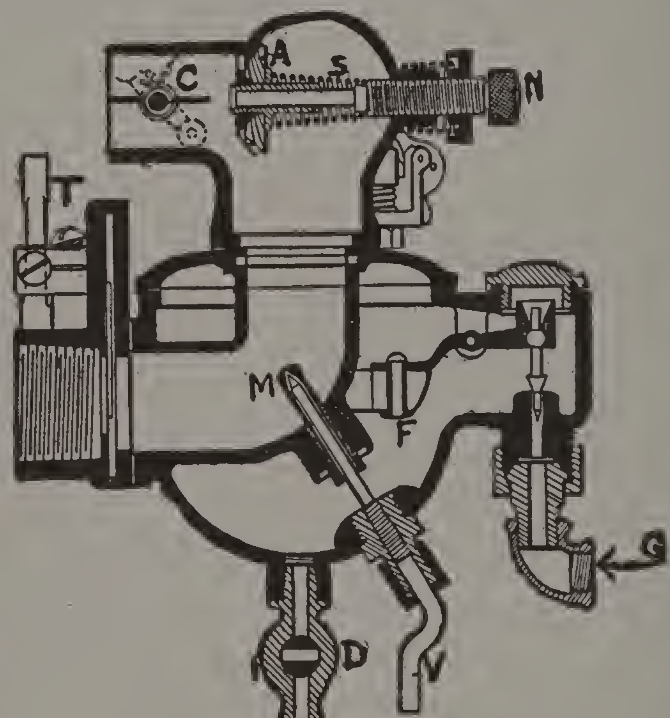



Fig. 78

Schebler Carburetor, Model "D". A, Auxiliary Air Valve. C, Choke Valve. D, Drain Cock. F, Float. M, Spray Nozzle. G, Gasoline Inlet. N, Air Valve Adjustment. S, Air Valve Spring. T, Throttle Valve Lever. V, Gasoline Adjustment Valve.

Raising dash control enriches the mixture by lifting the nozzle needle. Control button should be down for running, except when a richer mixture is required.

Pull button up full distance for starting.

Adjustment of carburetor should always be made with dash control down and motor warm.

SCHEBLER CARBURETORS. This make of instrument has been built in a number of different models, the first one of which to be used in large numbers was the Model D, Fig. 78. All of the important types of Schebler carburetors now in use are described and instructions given for their adjustments on the following pages.

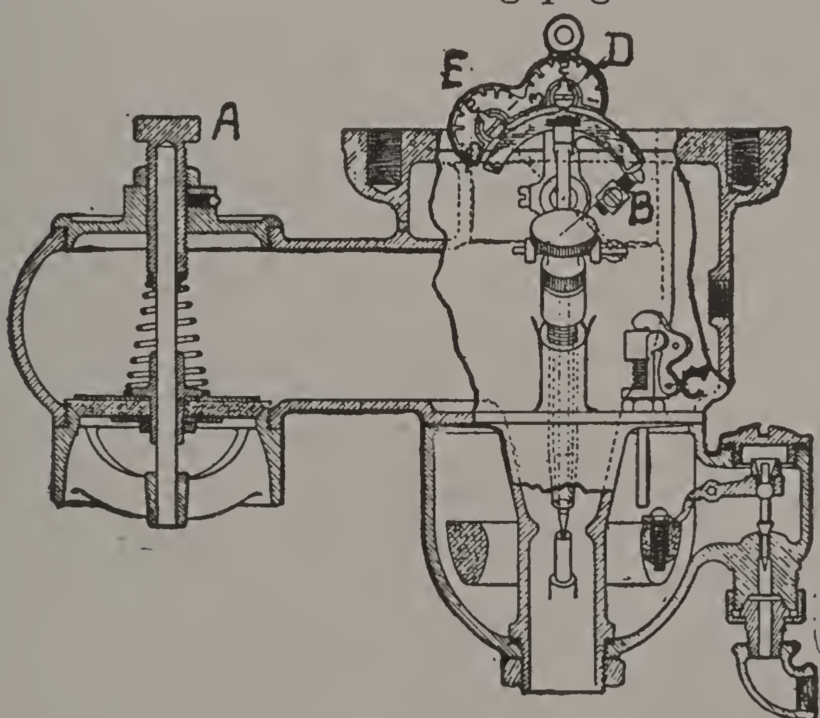



Fig. 79
Schebler Carburetor, Model "L". A, Auxiliary Air Valve. B, Gasoline Needle Valve. C, Priming Lever. D, Intermediate Speed Cam. E, High Speed Cam.

The Model L carburetor, Fig. 79, is a type of lift needle carburetor and is so designed that the amount of fuel entering the motor is automatically controlled by means of a raised needle working automatically with the throttle. The adjustment or control of gasoline in this instrument can be adjusted for low, intermediate or high speed, each adjustment being independent and not affecting either of the other adjustments.

In adjusting the carburetor, first make adjustment on the auxiliary air valve A so that it seats firmly but lightly; then close the needle valve by turning the adjustment screw B to the right until it stops. Do not use any pressure on this adjustment screw after it meets with resistance. Then turn it to the left from four to five complete turns and prime or flush the carburetor by pulling up the priming lever C and holding it up for about five seconds. Next, open the throttle about one-third, and start the motor; then close the throttle slightly, retard the spark and adjust throttle lever screw F and needle valve adjusting screw B so that the motor runs at the desired speed and fires on all cylinders.

After getting a good adjustment with the motor running idle, do not touch the needle valve adjustment again, but make all intermediate and high speed adjustments on the dials D and E. Adjust pointer on the first dial D from the number 1 towards 3, about half way between. Advance the spark and open throttle so that the roller on the track running below the dials is in line with the first dial. If the motor backfires with the throttle in this position, and the spark advanced, turn the indicator a little more toward number 3; or if the mixture is too rich turn the indicator back or toward number 1, until motor is running properly with the throttle in this position, or at intermediate speed. Now, open the throttle wide and make adjustment on the dial E for high speed in the same manner as for intermediate speed on dial D.

In the majority of cases in adjusting this carburetor the tendency is to give too rich a mixture. In adjusting the carburetor both at low, intermediate and high speeds, cut down the gasoline until the motor begins to backfire, and then increase the supply of fuel, a little at a time, until the motor hits evenly on all the cylinders. Do not increase the supply of gasoline by turning the needle valve adjusting screw more than a notch at a time in the low-speed adjustment, and do not turn it any after the motor hits regularly on all cylinders. In making the adjustments on the intermediate and high speed dials, do not turn the pointers more than one-half way at a time between the graduated divisions or marks shown on the dials.

The Model R Schebler carburetor, Fig. 80, is a single jet raised needle type of carburetor, automatic in action. The air valve controls the lift of the needle and automatically proportions the amount of gasoline and air at all speeds.

The Model R carburetor is designed with an adjustment for low speed; as the speed of the motor increases the air valve opens, raising the gasoline needle, thus automatically increasing the amount of fuel. The carburetor has but two adjustments—the low speed needle adjustment, which is made by turning the air valve cap and an adjustment on the air valve spring for changing its tension.

This carburetor has an eccentric which acts on the needle valve, intended to be operated either from the steering column or from the dash, and insures easy starting, as by raising the needle from the seat an extremely rich mixture is furnished for starting, and for heating up the motor in cold weather. A choker in the air bend is also furnished.

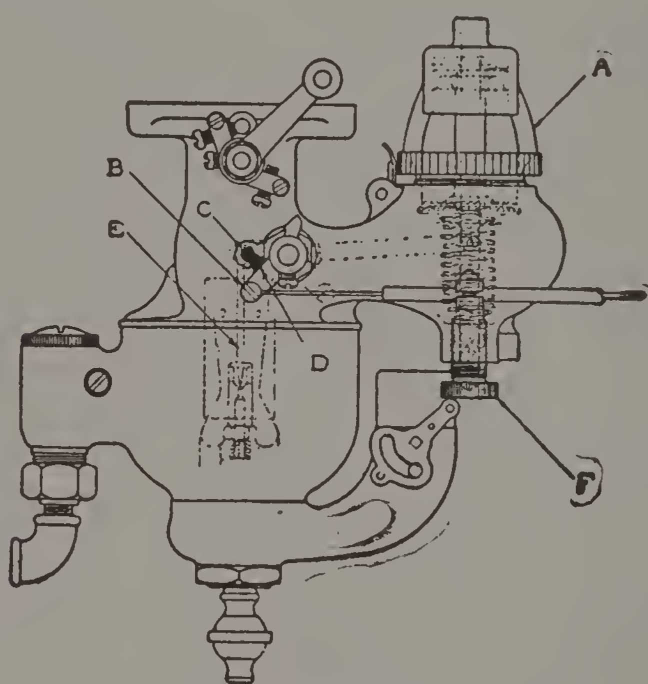



Fig. 80

Schebler Carburetor, Model "R". A, Low Speed Adjustment. B, Starting Cam Lever. C, Needle Valve Connection. D, Starting Cam. E, Needle Valve. F, High Speed Adjustment.

When carburetor is installed see that lever B is attached to steering column control or dash control, so that when boss D of lever B is against stop C the lever on steering column control or dash control will register "Lean" or "Air."

This is the proper running position for lever B.

To adjust carburetor turn air valve cap A clockwise or to the right until it stops, then turn to the left or anti-clockwise one complete turn.

To start engine open throttle about one-eighth or one-quarter way. When motor is started let it run till engine is warmed, then turn air valve cap A to left or anti-clockwise until engine hits perfectly. Advance spark three-quarters of the way on quadrant, if engine backfires on quick acceleration turn adjusting screw F up (which increases tension on air valve spring) until acceleration is satisfactory.

Turning air valve cup A to right or clockwise lifts needle E out of nozzle and enriches mixture; turning to left or anti-clockwise lowers the needle into nozzle and makes mixture lean.

When motor is cold or car has been standing, move steering column or dash control lever towards "Gas" or "Rich" which lifts needle E out of gasoline nozzle and makes rich mixture for starting. As motor warms up, move control lever gradually back towards "Air" or "Lean" to obtain best running conditions until motor has reached normal temperature. When this temperature is reached control lever should be at "Air" or "Lean."

For best economy and power, the slow speed adjustment should be made as lean as possible.

Stromberg Carburetors are made with a nozzle, the opening in which is not adjustable. This nozzle is a separate part of the carburetor and is screwed into place from below. In order to adjust the gasoline flow it is necessary to remove one nozzle and replace it with one having a larger or smaller opening. The nozzles are marked according to drill gauge sizes and the opening becomes larger as the number becomes lower, that is to say, a number 59 is larger than a number 60 and a number 58 is larger than a number 59.

If, after making low speed adjustment it is found that the air valve remains off its seat or that indications of a rich mixture are still present, the nozzle is too large. If the high speed adjustment has to be screwed very tight it indicates that the nozzle is too small. In changing nozzles do so one size at a time, that is, do not drop from number 60 to a number 58, but use a 59 first.

The several types of Stromberg carburetors that have been fitted up to the present time are described and adjustment instructions given in the following pages.

*Instructions for type A.* Type A, Fig. 81, is a water jacketed carburetor. It has its spray nozzle PN mounted in the center of the carburetor with its point 3-16 of an inch above the normal gasoline level and surrounded by a modified venturi tube. This nozzle is proportionate in size to the carburetor and never needs attention or adjustment.

After the carburetor is installed and the gasoline turned on, note the level of the gasoline in the float chamber. It should be about one inch from the lower edge of the glass. This level is adjusted at the factory and should be right. In case it is obviously wrong, remove the dust cap D and turn the adjusting screw S until the proper level is obtained. If the gasoline is too high, screw the nut down. If gasoline is too low, screw the nut up. Don't change unless absolutely necessary.

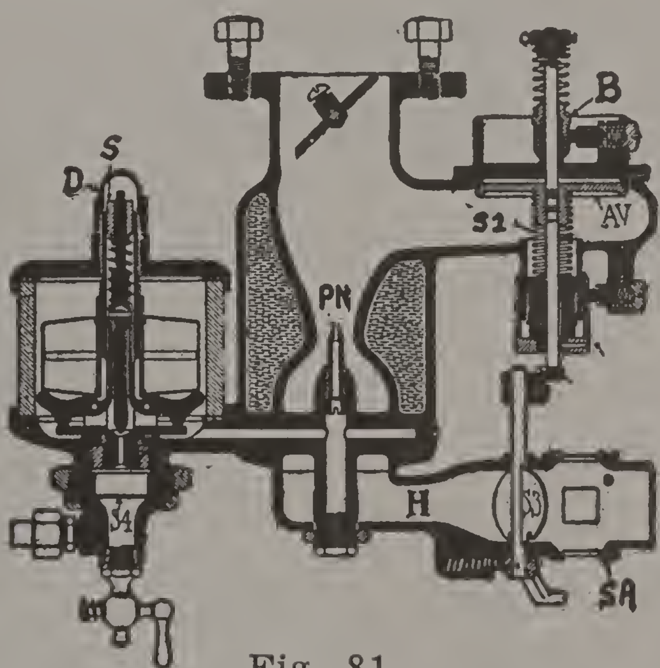



Fig. 81
Stromberg Carburetor, Model "A"

To start the motor close the valve S3 in the hot air horn H. The motor should then start on the second or third turn of the crank. If not, open the valve and it ought to start on the next turn. Great care should be taken to see that this valve is instantly opened as the motor starts, and is kept open.

*Season adjustments.* Open and close shutter SA—open in summer and closed in winter.

*Low speed adjustment.* Turn up the adjusting nut A until the spring S1, which is the low speed spring, seats the valve lightly. See that the high speed spring above B is free and does not come in contact with the nut on top of the auxiliary air valve stem. Start the motor and turn nut A up or down until motor idles properly. This is the low speed adjustment.

*High speed adjustment.* Advance the spark and open the throttle. If the motor backfires through the carburetor, turn high speed adjusting nut B up until backfiring ceases. If, with this adjustment and running at low speeds, motor gallops, or the carburetor loads up, the mixture is too rich. The nut B should then be turned down until galloping or loading ceases. This is the high speed adjustment. The spring above nut B should always have at least 1-32 inch clearance between it and the nut at the top when the motor is at rest.

*Instructions for type B.* Type B, Fig. 82, is a concentric type carburetor. It has its spray nozzle PN mounted in the center of the carburetor, and in the center of the float chamber, with its point 3-16 of an inch above the normal gasoline level and surrounded by a modified venturi tube.

The level of the gasoline in the float chamber should be about 15-16 of an inch from the lower edge of the glass marked X. This level is adjusted at the factory and should be right. In case it is wrong, remove the dust cap D and turn the adjusting screw S until the proper level is obtained. If the gasoline is too high screw the nut down. If the gasoline is too low screw the nut up. Don't change unless absolutely necessary.

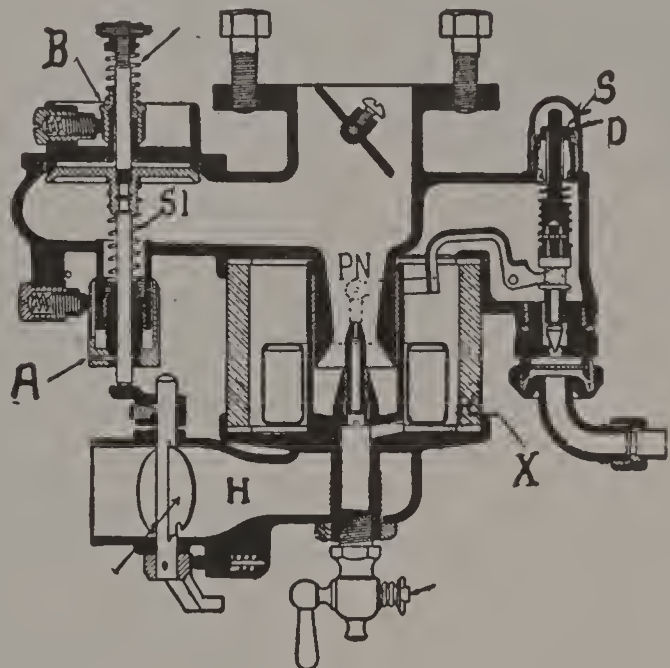



Fig. 82
Stromberg Carburetor, Model "B"

*Low speed adjustment.* Turn up the adjusting nut A until the spring S1, which is the low speed spring, seats the valve lightly. See that the high speed spring above B is free and does not come into contact with the nut on top of the auxiliary air valve stem. Start the motor and turn nut A up or down until motor idles properly. This is the low speed adjustment.

*High speed adjustment.* Advance the spark and open the throttle. If motor backfires through the carburetor, turn high speed adjusting nut B up until backfiring ceases. If, with this adjustment and running at low speeds motor gallops, or the carburetor loads up, the mixture is too rich. The nut B should then be turned down until galloping or loading up ceases. This is high speed adjustment. The spring above nut B should always have at least 1-32 inch clearance between it and the nut at the top when the motor is at rest.

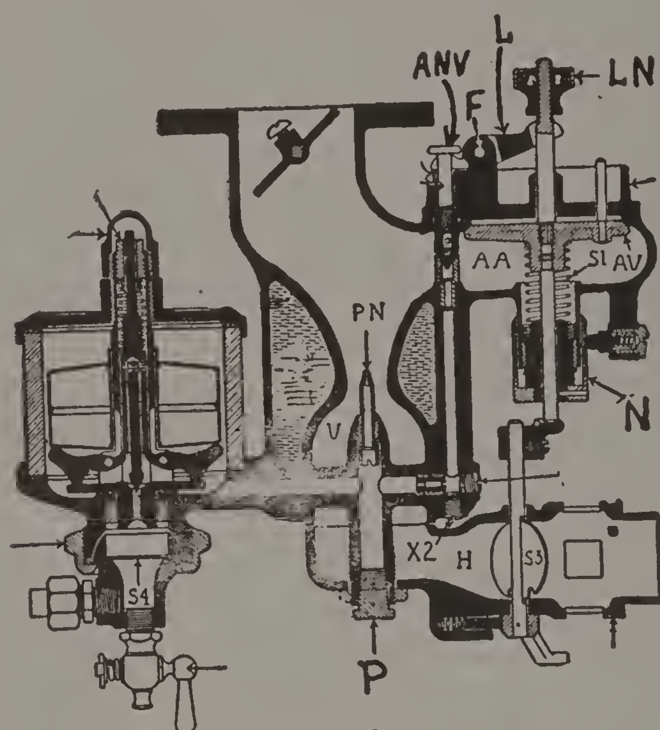



Fig. 83
Stromberg Carburetor, Model "C"

*Instructions for type C.* Type C, Fig. 83, is equipped with two separate gasoline spray nozzles. The first or primary nozzle PN is mounted in the venturi tube V; this nozzle supplying sufficient gasoline for all speeds up to twenty or twenty-five miles per hour. The second or auxiliary nozzle is mounted just beneath the secondary gasoline needle valve ANV in the auxiliary air passage AA, and is opened by the lever L operating over a fulcrum F by the opening of the auxiliary air valve AV.

Turn up the lower adjusting nut N, located underneath the auxiliary air valve, so that the valve is brought up to seat, then give two full turns to the right as a starting adjustment. This valve should be seated on extreme idle. The spring S1 is the low speed spring and does the work up to the opening of the auxiliary needle.

Start the motor and turn low speed nut N up or down until the motor idles properly, then advance the spark, open the throttle, and if the motor backfires turn nut LN down until it ceases. If mixture is too rich, turn it up. Be sure that nut LN and lever L have some clearance on low speed.

The proper gasoline level is about 1 inch from the lower edge of the glass. If more than ⅛ inch either way remove the dust cap and adjust by screws.

*High speed adjustment.* The high speed is regulated by the lock nut LN on top of the auxiliary air valve. As it is raised or lowered it determines the point at which the auxiliary needle valve ANV will be brought into play. To lock nut LN should be about 3-32 of an inch above the lever L for normal adjustment, but this distance can be increased or decreased to suit the motor.

*To find primary nozzle size.* If the mixture is too rich on low speed after adjustments are made according to instructions, take out the plug P and remove the nozzle PN with a screwdriver. Insert smaller nozzle (59 is smaller than 58). If the mixture is too lean on low speed a larger nozzle should be inserted. If the engine misses on low speed it may be caused by an air leak, and all the joints between the carburetor and the motor should be examined before a large nozzle is inserted.

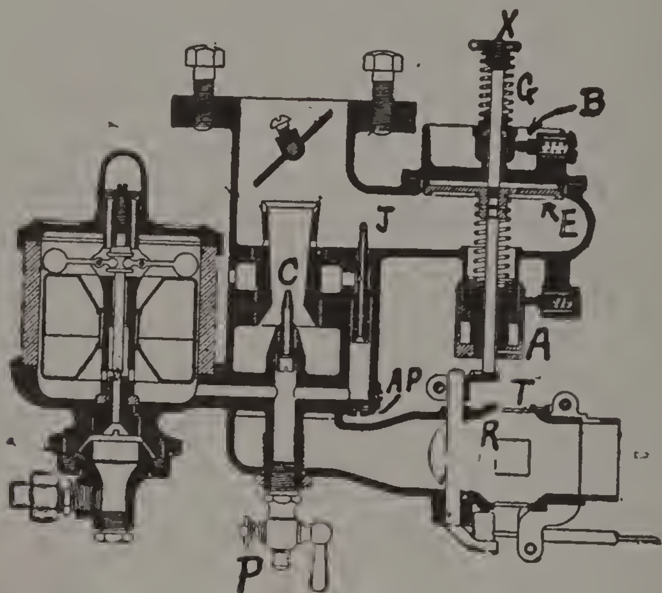



Fig. 84
Stromberg Carburetor, Model "G"

*Instructions for type G.* Type G, Fig. 84, is a non-water-jacketed model furnished in either single or double jet according to motor requirements.

*Air adjustments.* There are only two adjustments that ever need attention, A, the low speed nut, and B, the high speed nut.

With the motor at rest, set the high speed nut B so there is at least 1-16 of an inch clearance between the spring G and the nut X above it. This is imperative.

Set the low speed nut A so the air valve E is seated lightly. Do not adjust carburetor until motor is thoroughly warmed up. When motor is warm and with spark retarded adjust nut A up or down until motor runs smoothly at low speed. To determine proper adjustment open the air valve with finger by depressing X slightly. If, when so doing, motor speeds up noticeably it indicates too rich a mixture and A should be turned down notch by notch. If, on the other hand, motor dies suddenly when slightly opening the air valve it indicates too lean a mixture and A should be turned up until this is overcome.

Once properly set for idling do not change this adjustment when making the high speed adjustment.

Advance the spark at the normal position and open the throttle gradually. If motor backfires through the carburetor it is positive indication of too lean a mixture and nut B should be turned up notch by notch until this is overcome.

If mixture is too rich, as indicated by loading of the motor and heavy black smoke from the exhaust, turn B down until motor operates properly. A further test for the correct mixture at high speed can be made by depressing the air valve when the motor is running at this speed. If when so doing motor speeds up it indicates too rich a mixture.

Turning either adjusting nut up means a

richer mixture or more gas. Down means a leaner mixture or more air. To get highest efficiency from this carburetor, hot air equipment should be used.

*Double jet type.* If, after following the instructions given below, and with the motor running idle at low speed, the air valve E remains tightly seated, it indicates too small a primary nozzle C, and a larger one should be substituted. If with the proper adjustment, and after stopping the engine, the air valve hangs off its seat the primary nozzle is too large and a smaller one should be used. To change the primary nozzle remove the petcock, insert a narrow screwdriver and unscrew the nozzle.

If the mixture at low speed is correct, but in order to get the proper high speed adjustment it is necessary to turn the nut B up so far that the spring G is in contact with X above it, after the engine has been stopped, it indicates that the auxiliary nozzle J is too small and a larger one should be used. If it is necessary, in order to get the proper high speed adjustment, to turn the nut B down so that there is more than 1/8 inch clearance between G and X when the engine is idle, it indicates too large an auxiliary nozzle and a smaller one should be used.

*Instructions for types H and HA.* There are only two adjustments on this carburetor, Fig. 85. A, the low speed, and B for high speed. A is a needle valve, seating in an open nozzle, the opening of which is usually two sizes larger than is ordinarily necessary, and which permits an increase in gasoline flow to that extent or allows a complete closing. The high speed adjustment controls the flow of gasoline for high speeds by regulating the time at which the secondary needle valve begins to open.

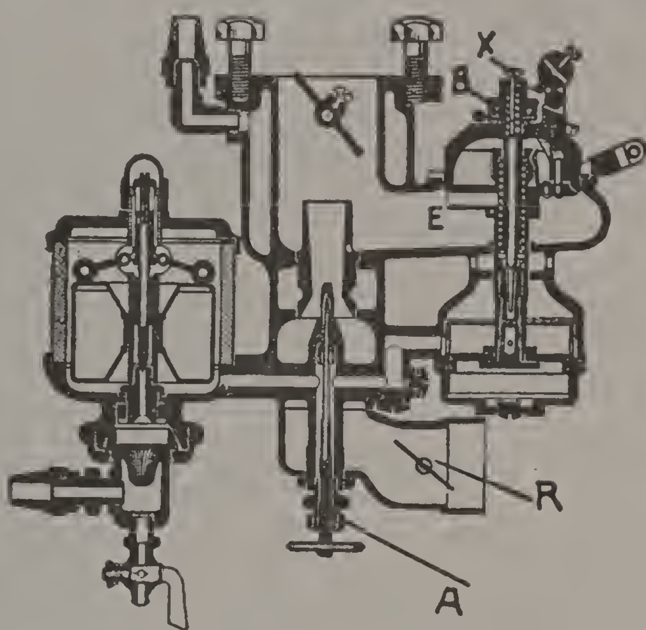



Fig. 85
Stromberg Carburetor, Models "H" and "HA"

To adjust, set the high speed nut B so that there is at least 1-32 of an inch clearance between it and the needle valve cap above it at X when the air valve E is on its seat. The needle valve does not begin to open until B comes into contact with X. Before starting the engine be sure that the rocker arm of the dash adjustment on the carburetor is not in contact with the collar above it at Z when the steering post button is all the way down.

To start the engine, pull the steering post control to its highest position, thus producing a rich mixture. In cold weather it may also be necessary to close the air supply in the hot air horn by means of a rod connected to R. This should be again opened as soon as the engine starts. As the engine warms up, gradually lower the steering post control and make sure that it is at its lowest position before commencing to adjust the carburetor.

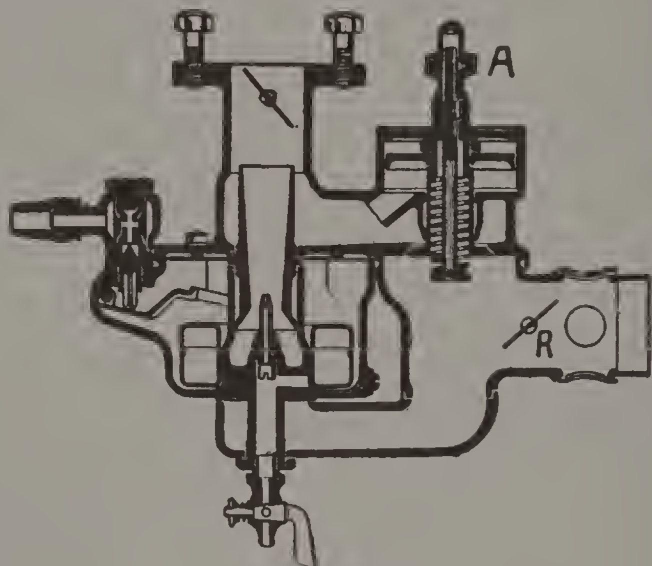



Fig. 86
Stromberg Carburetor, Model "K"

The mixture at low speed is controlled by the needle valve A. If too rich is indicated, by the engine "rolling" or "loading," turn A up or anti-clockwise. If the mixture is not rich enough, turn A down or clockwise. To adjust high speed, advance the spark and open the throttle. If the mixture is not rich enough at high speeds, turn B up or anti-clockwise, and if the mixture is too rich turn B down or clockwise.

*Instructions for types K and KO.* The nut

A is the only adjustment on this carburetor, Fig. 86. The stem of this nut supports the lower end of a spring that controls the air valve. This air valve opens downward into the air chamber. Turning the nut A clockwise or down tightens this spring, admitting less air and producing a richer mixture. Turning A in the opposite direction or anti-clockwise produces a leaner mixture.

Before starting the engine turn A anti-clockwise until a point is reached where, when lifting or pulling up on A, a decided click is heard. This is the air valve coming in contact with its seat. Then turn A clockwise or down until the click is no longer obtained. This turning should be a notch at a time, and when the click can not be heard, turn two more notches in the same direction. To start the engine, raise the steering post control to its highest position. Gradually lower the control as the engine warms up, and make sure that this control is at its lowest position before starting to adjust the carburetor. With the engine warm, turn A up or down, notch by notch, until the engine idles properly. It should not be necessary to change the initial setting more than a few notches.

The high speed mixture can only be affected by changing the nozzle. If the high speed mixture is too thin, so that slightly closing the dash throttle valve R causes an increase of engine speed, a larger nozzle should be used. If the high speed mixture is too rich use a smaller nozzle. The nozzle size furnished is based on 18 inches of hot air tubing. If this tubing is

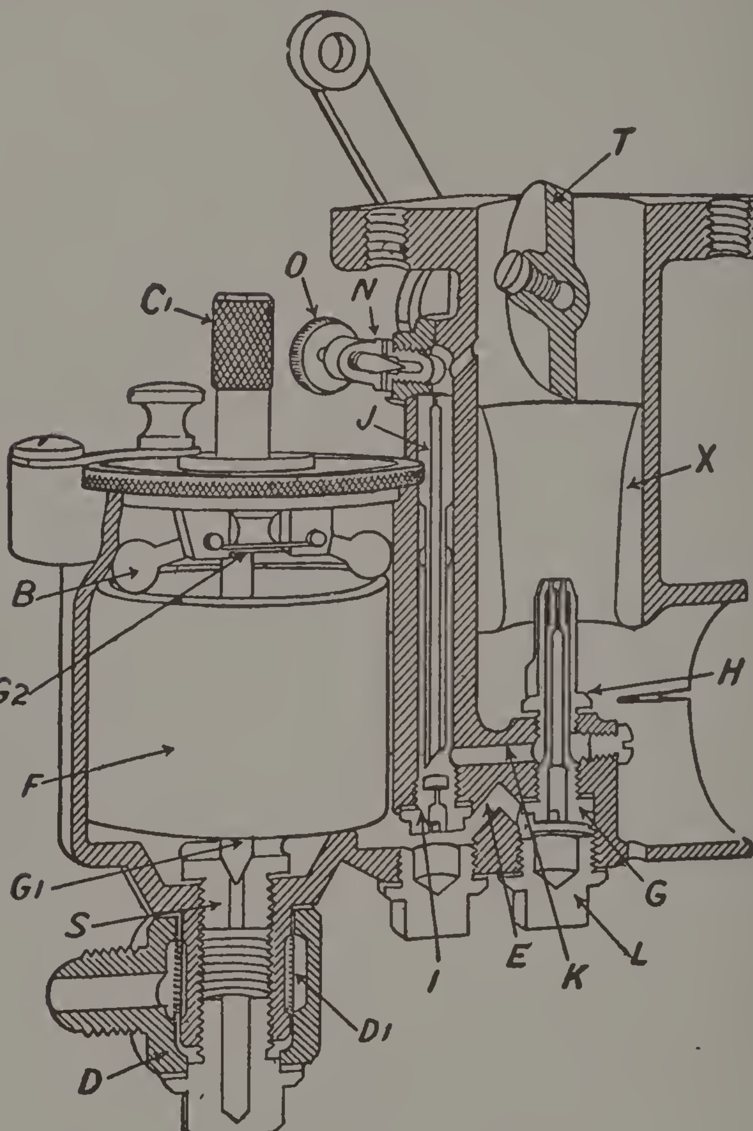



Fig. 87

Zenith Carburetor, Model "O". B, Float Control Lever. C1, Dust Cap. D, Strainer Body. D1, Wire Gauze. E, Gasoline Channel. F, Float. G, Main Jet. G1, Needle Valve. G2, Float Control Collar. I, Gas Well Opening. H, Secondary Nozzle. J, Gasoline Well. K, Gasoline Passage. L, Drain Plug. N, Idling Adjustment. S, Float Valve Opening. T, Throttle. X, Choke Tube.

more than 24 inches long, one size smaller nozzle can probably be used, while if the tubing is less than 10 inches long one size larger may be required.

Zenith Carburetor, Model O. This carburetor, a cross-section of which is shown in Fig. 87, consists of a float chamber, a carbureting chamber, a system of nozzle and air passages and a hot air sleeve.

Gasoline from the tank enters the strainer body D, passes through the wire gauge D1, and enters the float chamber through the valve seat S. As soon as the gasoline reaches a predetermined height in the float chamber the metal float F, acting through the levers B and collar G2, closes the needle valve G1 on its seat. To see if there is any gasoline in the carburetor remove dust cap C1. If the needle valve can be depressed with the finger there is no gasoline in the carburetor. From the float chamber to the motor gasoline flows through three different channels in various quantities and proportions according to the speed of the motor and degree of throttle opening. With the throttle fully open, most of the gasoline flows through the channel E and main jet G. Some flows through compensator I, then through K to the cap jet H, which surrounds the main jet. The main jet and cap jet work together and their combination furnishes the mixture required for various engine speeds. At slow speed when the throttle T is nearly closed they give but little or no gasoline, but, as there is considerable suction on the edge of the butterfly the tube J, terminating in a hole near the edge of the butterfly, picks up gasoline, which is measured out by a small hole at the top of the priming plug. The well over compensator I is open to the air through two holes, one of which is indicated below the priming plug in the illustration. These air openings are important.

The hot air sleeve is provided with an air strangler actuated by a lever and having a coiled spring to bring it back to the open position. The flexible hot air tubing is attached to this sleeve and feeds the carburetor with air that has been heated by contact with the exhaust pipe.

To start the engine open the throttle a little way. There will be a strong suction on the tube J which will raise the gasoline and thus prime the motor. The only adjustment that may be useful is the slow speed adjustment, which is obtained by the screw O. Tightening this screw restricts the air entrance to the slow speed nozzle, giving a richer mixture.

It is essential that none of the parts shall be tampered with, or the size of the jets altered by reaming or hammering. These jets are tested for actual flow of gasoline and brought to a standard. The nominal size of the hole in hundredths of a millimeter is stamped on the jet: the higher the number, the larger hole.

Variables that can be modified for the initial setting of the carburetor: First, the choke tube X. This choke tube is held in place by set screws and can be removed after taking apart the throttle.

It is really an air nozzle, of such a stream line shape that there will be no eddies in the air drawn through it.

For a 4 cylinder engine whose maximum speed is 1,500 R. P. M., to obtain the choke number, multiply the bore in inches by five and add one to the result.

For 6 cylinder, take a choke one size larger up to 4½" bore and two sizes larger above 4½" bore.

If the engine is so built that it can turn up to 1,800 R. P. M., increase these results 8%; up to 2,000 R. P. M., increase 16%; up to 2,500 R. P. M., increase 25%.

A choke tube too small will cause a loss of charge at high speed, the car will not attain its proper speed.

A choke tube too large will lead to irregularities when slowing down and picking up.

Second—Main Jet C. The effect of this jet is most marked at high speed, 1,400 R. P. M.

Third—Compensating Jet I. This jet, which compounds with the main jet, exerts its maximum influence at lower speeds, 600 R. P. M., and in picking up.

Fourth—Secondary Well P. This regulates the amount of gasoline used when idling.

## Change Speed Gearing.

The means provided for securing different ratios of speed between the engine and road wheels of the car is oftentimes called the transmission. Strictly speaking, the transmission system includes all the parts between engine and wheels; the clutch, universals and rear axle parts, as well as the mechanism that allows various forward speeds and the reverse. The Change Speed Gear takes various forms; planetary, friction, sliding gear and magnetic, each being described.

**Change Speed Gears.** When a gasoline engine is loaded above a certain limit it slows down, and the intervals of time between explosions in each cylinder become so far apart that the engine begins to labor, and will finally stop altogether, unless some means is provided whereby the revolutions of the engine may be increased without increasing the number of revolutions of the driven shaft, or car axle. This is accomplished by means of the change speed gear, of which there are two classes, viz., those in which an infinite series of variations in speed ratio is possible, and those in which only a comparatively small number of step-by-step ratios can be utilized. In the first class are several styles of belt and friction disc drives, while in the second class are the change speed gears proper, namely, sliding gears, individual clutch gears, and planetary gears.

Belt and friction drives constitute the only practical forms of change speed devices in which variation from the highest to the lowest speed may be possible. In other change speed gears the ratio is changed by passing from one to another in a series of definite steps.

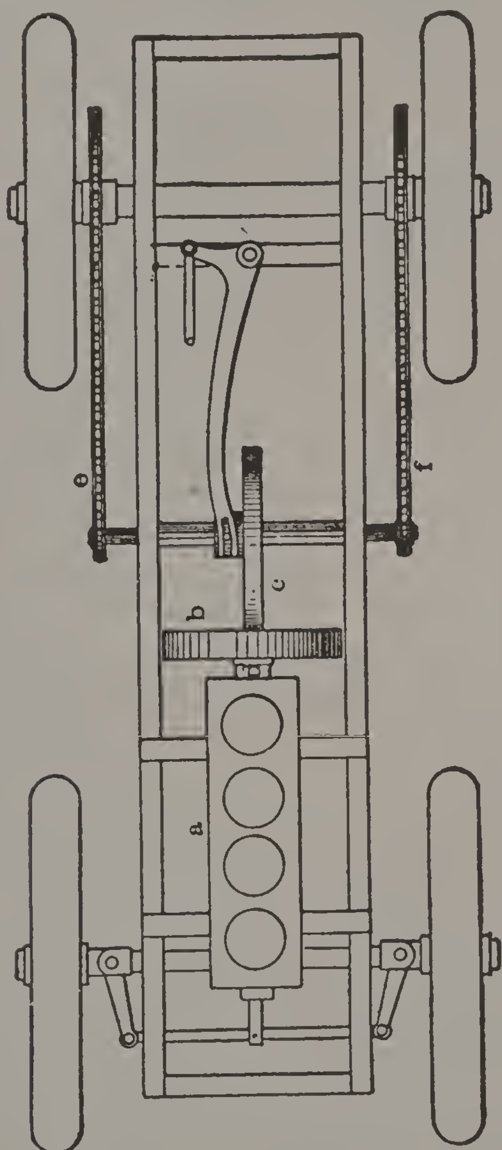



Fig. 88
Friction Disc Change Speed Gear

FRICTION DRIVE. One of the most simple methods of changing the speed ratio between the motor and the driven shaft is the friction drive, which in its simplest form consists of two discs at right angles to each other, see Fig.

88, in which b is the fly wheel, the exterior surface of which is made a true plane, and usually covered with a special friction metal. A horizontal shaft located crosswise of the car body carries a friction pulley c, in close proximity to the surface of the fly wheel b.

Friction pulley c while secured from turning on shaft, may at the same time be shifted along at the will of the operator, and thus be brought in contact with any portion of the surface of the flywheel, from its center to its outer edge. The shaft also carries on its outer ends, the sprocket wheels which drive chains e and f, by means of which the power is transmitted to the drivers. In this device if the friction pulley c be brought in contact with the exact center of fly wheel b, no motion will be imparted to c, but if it be moved outward from the center of the flywheel it will revolve, the number of revolutions it makes being governed by its distance from the center. The maximum speed is attained by friction pulley c when it is brought into contact with the surface of the fly wheel near the periphery of the latter. All positions of friction pulley c upon one side of the center of fly wheel b impart a forward motion to the car, and all those on the other side of the center impart a reverse, or backing motion. The traversing movement of pulley c along its shaft is usually produced by a hand lever provided with a notched quadrant, whereby the pulley is held at all times in some one of the many positions giving graduations of speed. The method usually employed for making and breaking contact between the friction pulley, and flywheel face, consists in mounting the bearings of the cross, or countershaft in swinging brackets. Another method is to mount these bearings in eccentric housings, a slight rotation of which in the bearing brackets will cause the shaft and with it the pulley to approach, or recede from the face of flywheel b. The movement of the shaft toward, or away from the flywheel is produced by a ratchet retained pedal through a reducing linkage, which multiplies the foot pressure.

Double Disk Friction Drive. The limitation of the single disc and wheel to small power, and light loads, has led to the development of the double disc, double wheel type of friction gear illustrated in Fig. 89.

The engine shaft is extended, and carries two disc fly wheels A and B, while friction pulleys C and D are each carried upon one half of the cross shaft which is divided at its center. Friction pulleys C and D are made to slide along the shafts H and F, and are controlled by a common sliding mechanism, so that they always bear upon points of discs A and B, having the same velocities. Driving contact is effected by swinging shafts H and F in a horizontal plane, and it is obvious that if one of the pulleys, D for instance, is pressed against the face of A, it will revolve in one direction, while if brought to bear on B it will revolve in the opposite direction, thus providing for a go-ahead, or a back-up motion being imparted to either friction wheel at will, dependent upon whether it is in contact with the forward, or the

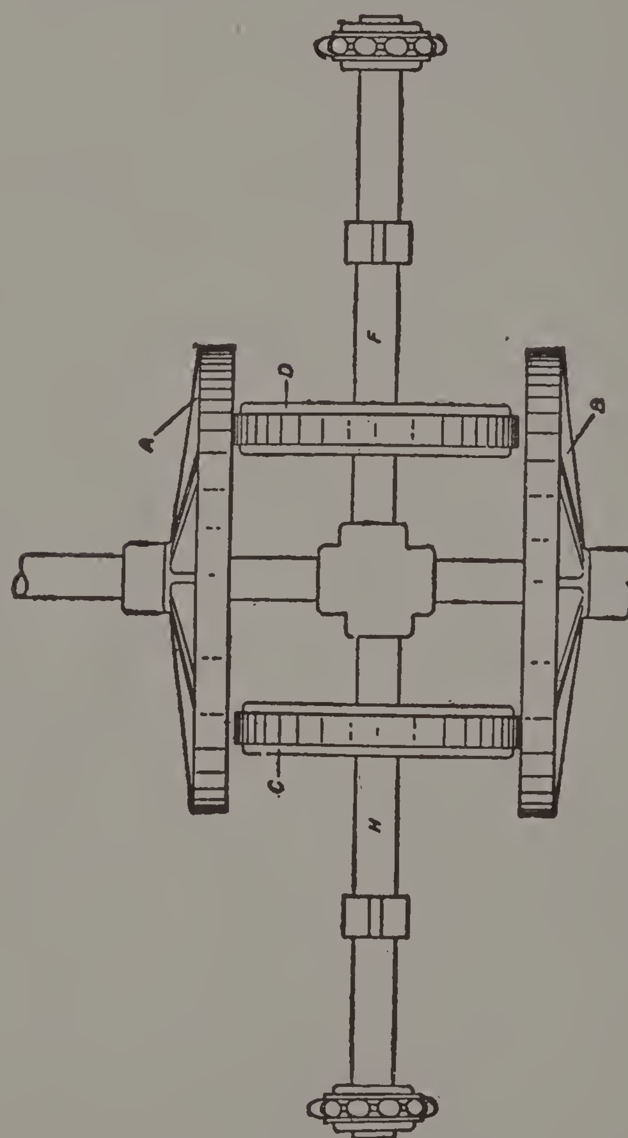



Fig. 89
Double Disc, Double Wheel Change Gear

rearward disc. It is also evident that if one of the wheels, say D, is pressed against A, and the other wheel C is also pressed against B, their shafts will rotate in opposite directions. The ratio of the common angular velocity of the wheels and their shafts to that of the discs is in proportion to their distance from the center of the discs. Sprockets upon the extremities of shaft H and F drive the road wheels by chains, and sometimes no differential is employed, power being shut off when turning corners, or, if not, the inevitable slip is divided between the frictional contacts, and the contacts of the tires with the road. A differential may be mounted in either shaft H or F at will.

Instead of the two shafts H and F being separate, they may be joined to form a continuous shaft and pivoted in the center. The shaft as a whole is capable of being slightly swung in a horizontal plane about its center, so as to bring friction wheel D in contact with one disc, and friction wheel C in contact with the other, thus producing either the forward or reverse drive. In this case a single sprocket is carried by the shaft and drives a live rear axle.

Friction Drives—Materials For. In friction drives, one of the surfaces in contact is generally a metal, while the other surface is composed of some kind of organic material, of a slightly yielding or conforming nature. Cast iron with cork inserts may be used for the metallic surface, the cork inserts serving to increase the co-efficient of friction, besides absorbing any oil that may accidently reach the surfaces. Aluminum is no doubt the best material for the metallic surface, on account of its plastic nature. Copper also possesses similar properties. For the non-metallic surface, leather is good so long as oil is kept from accumulating on it, but its co-efficient drops rapidly as soon as oil gets between the contact surfaces.

Some kind of vegetable fibre, made into a paper or mill board, seems to be the preferred material, and it is comomn to treat such paper with a tarry composition, which tends to raise the co-efficient of friction, as well as to render its value more nearly constant under the influence of water and oil.

The non-metallic friction face is the one worn out in service, or at least it wears the more rapidly. This part of the combination, though of limited life, can be renewed at a comparatively small expense, and it fails only after giving due notice. It is the practice to make the disc face metallic, and the friction wheel rim non-metallic. Great care should be exercised in starting the car, as at such times the disc is liable to slip at speed upon the rim of the friction wheel which is then either stationary or revolving very slowly, and flat spots may very easily be worn upon its surface.

THE PLANETARY CHANGE SPEED GEAR. This system of transmitting the power at various speeds comprises a high-speed connection for the direct drive, and an arrangement of gears that reduces or reverses the motion when one or another drum on which these gears or pinions are mounted is held stationary. Most planetary systems give only two forward speeds and the reverse, but in some instances they are made to give three forward speeds. They are used chiefly on small automobiles, or runabouts; but when cheapness of construction is an object they are sometimes employed on touring cars.

In Fig. 90 is shown one form of planetary system. The gear a is the only one keyed to

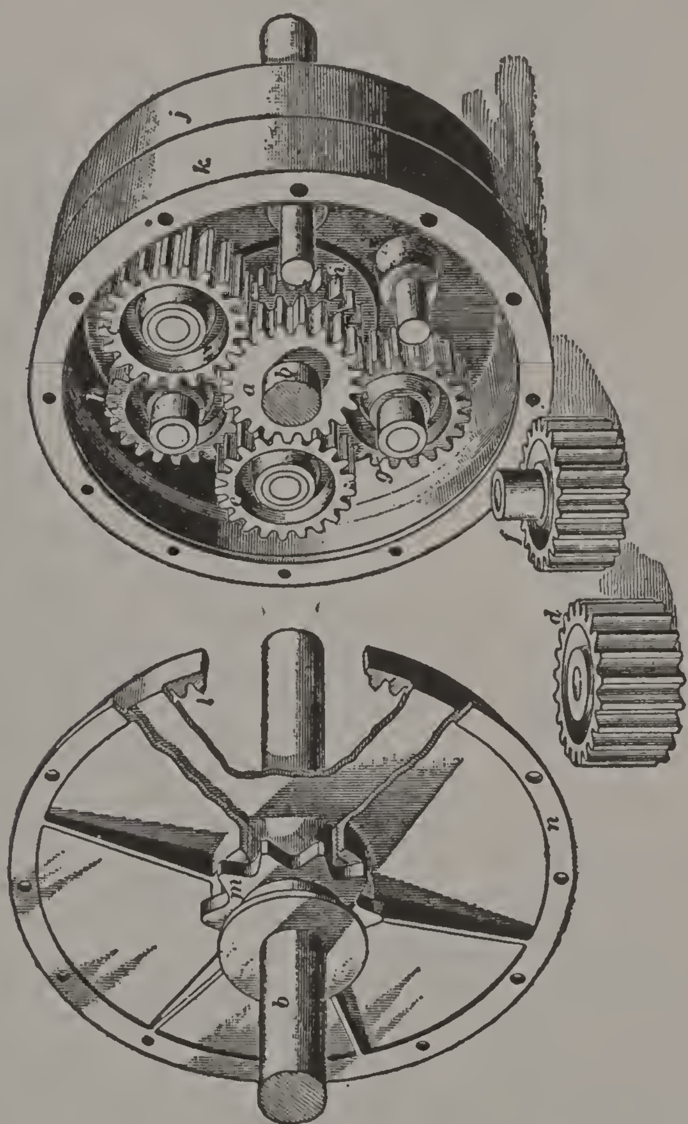


Fig. 90
Planetary Gear

the engine shaft b. The gears c, d and e all mesh with the gear a, and are made long enough to extend beyond a and mesh with the gears f, g and h in pairs. The last three gears in turn extend beyond the gears c, d and e, and mesh with the gear i, which is keyed to a sleeve connected to the drum j. The gears c, d, e, f, g and h turn on pins fastened to the drum k, but only the gears c, d and e mesh with a, and only f, g and h mesh with the gear i which turns loosely on the shaft b. The internal gear l meshes only with the gears c, d and e, and is rigidly connected to the sprocket m that drives the automobile. The cover n is attached to the face of the drum k by means of screws, thus forming an oil reservoir that keeps the gears well lubricated when the automobile is running. There are separate brake bands around the drums j and k, and a friction disc keyed to the shaft just outside of the drum j.

When the friction disc is pressed against the drum j, the gear is held so that it must turn with the shaft; consequently, the entire mechanism is locked together and the sprocket m turns at its highest forward speed. If now the friction disc is released and the brake band around the drum j is applied so as to hold it from turning, then the gear a turns the gears c, d and e, causing them to turn the gears f, g and h; but, as the gear i is held stationary with the drum j, the gears f, g and h, and also the drum k, to which they are attached, must revolve around the gear i in the same direction as the shaft turns, but more slowly. The gears c, d and e turn on pins that are fastened to the drum k; consequently, they revolve with it as they turn on their axes and thus cause the internal gear l and the sprocket m to turn in the same direction as the shaft. This gives the slow forward speed.

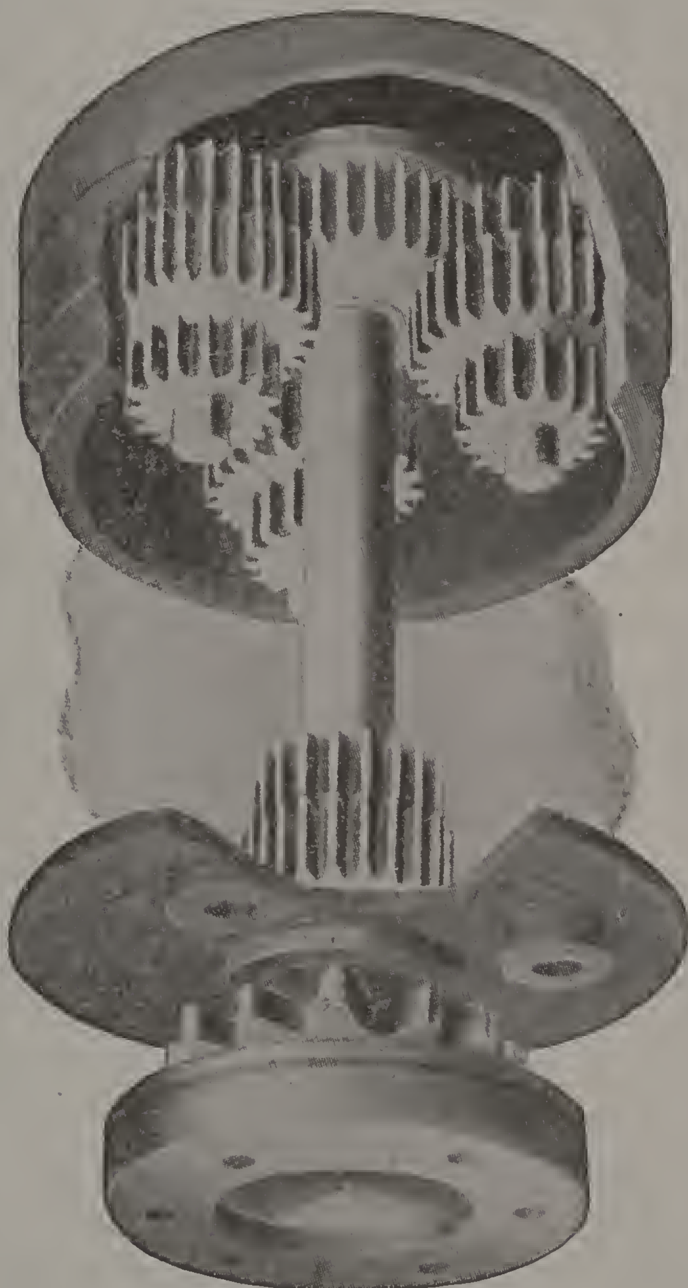


Fig. 91
Planetary Transmission Gear with Case Opened

When the drum j is released, and the drum k is held by a brake band, the gears c, d and e are caused to turn on their pins, and consequently drive the internal gear l in a direction

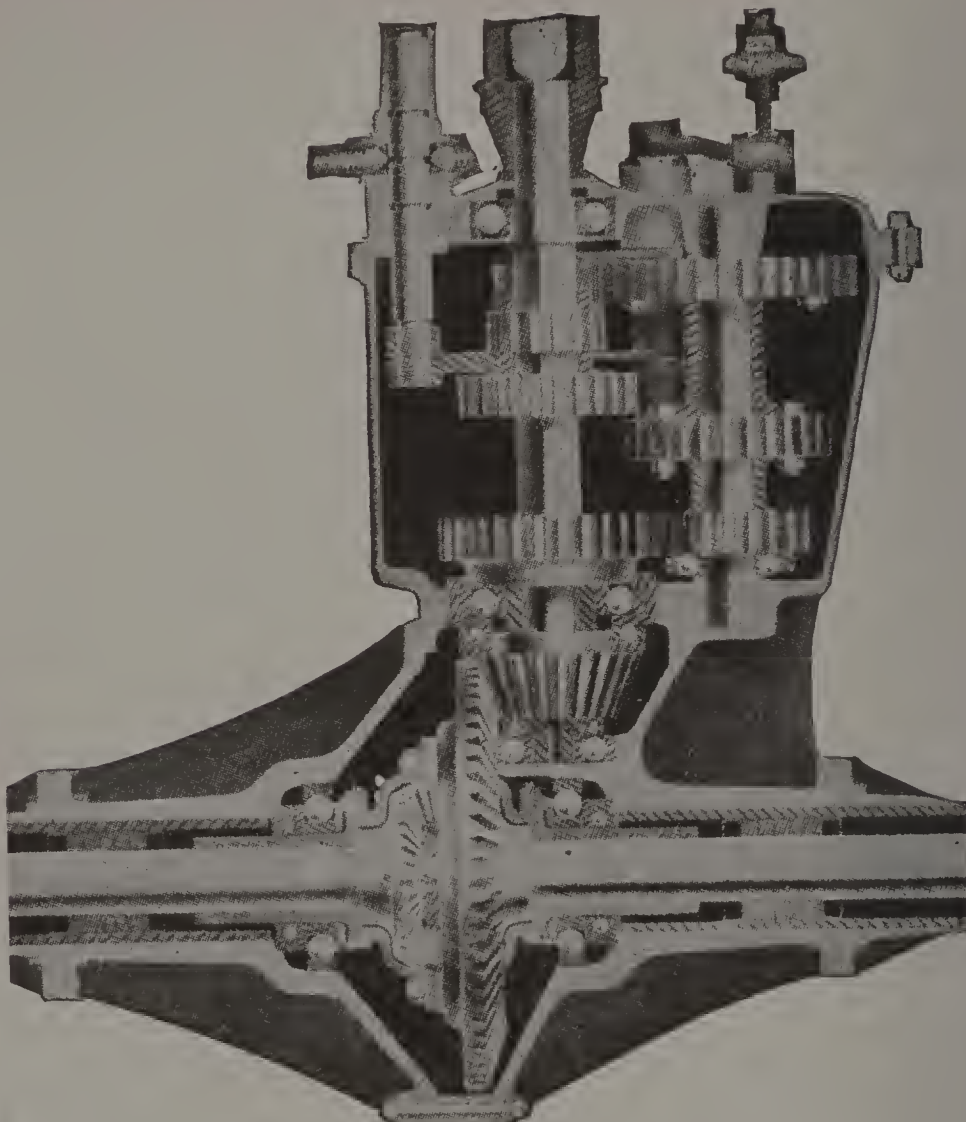


Fig. 92
Combination Transmission and Differential Gear

opposite to that of the engine shaft, driving the automobile backwards. When the brake bands and friction disc are all free from the drums, the gears turn idly, and if the engine is running, no motion is transmitted to the sprocket and the automobile stands still.

A form of change speed gearing that is in use on a large majority of cars is that known as the sliding gear. All sliding gear transmissions consist of two principal shafts lying parallel to each other and placed one above the other or side by side. Each shaft carries a series of gears, those on one shaft being permanently fastened against lengthwise movement, while those on the other shaft are capable of being moved along the shaft while turning with it. This latter set of gears is built with either a square or key-waved hub and the shaft on which the set slides is made square or with spline keys to correspond. The gears on the other shaft are made of such sizes that when the sliding members are moved they come into mesh with the gears on the other shaft so that when together they form pairs, that is to say, when a gear on one shaft is in mesh with one on the other shaft it is impossible to cause any other gears to mesh at the same time.

The gears are graduated in size so that the several pairs or combinations that may be formed vary in ratio, and in this way it is possible to obtain different degrees of speed reductions between the two shafts and therefore between the engine and road wheels.

In forms of construction that use the two shafts exactly as described in the previous paragraphs, and in which one shaft is connected through the clutch to the engine and the other one through the drive parts to the rear wheels, the series of sliding gears is made with all of the gears fastened together so that there can be no relative motion between them, and in this

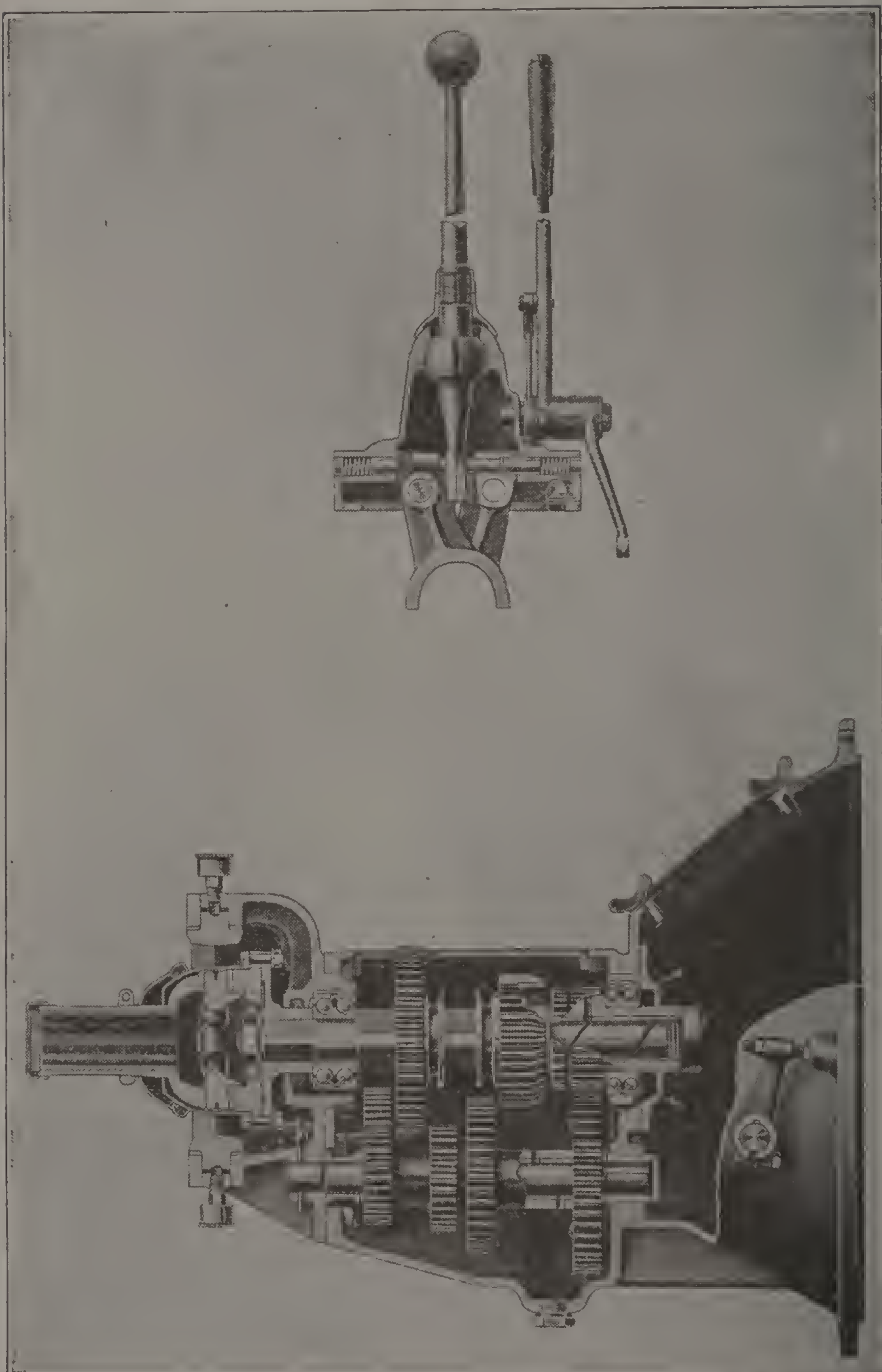


Fig. 93
Selective Sliding Change Speed Gears

case the entire sliding member is moved bodily along the shaft. This particular form is known as a progressive sliding gear. It is necessary, with this type of construction, to pass from one ratio to another in the same order for each operation, and if it is desired to pass from the extreme low ratio to the highest ratio, it is nec-

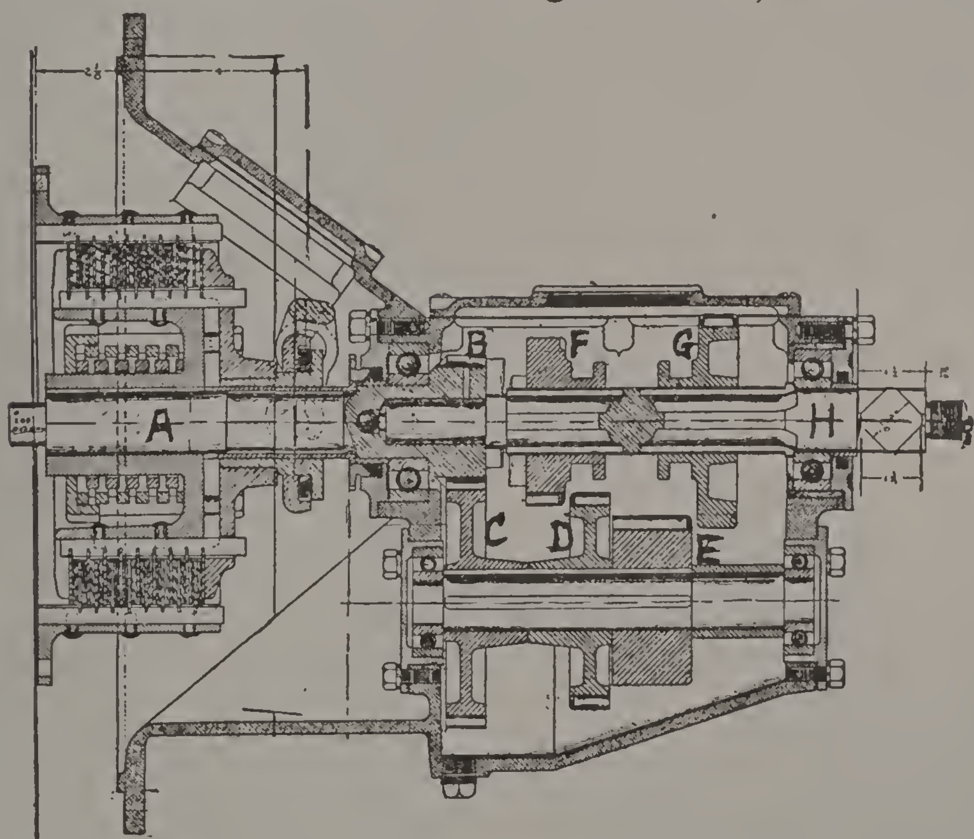



Fig. 94
Selective Sliding Gear With Disc Clutch in a Unit Power Plant. A, Clutch Shaft. B, Clutch Shaft Gear. C, Countershaft Gear. D, Second Speed Gear. E, Low Speed Countershaft Gear. F, Second Speed Sliding Gear. G, Low and Reverse Sliding Gear. H, Sliding Gear Shaft.

essary to pass through all intermediate ratios. The progressive form of transmission is no longer fitted to cars and an extended description is not considered necessary

The type of sliding gear transmission that is most popular is called the selective sliding gear and with the exception of some important modifications is similar in operation and construction to the progressive type already described. Selective sliding gears are shown in Figs. 92 to 97 and the following description will apply more or less to all of them although the form shown in Fig. 94 is specifically covered. It will be noted that the clutch is at the left hand end of the illustration, and through this clutch the power of the engine is transmitted to the shaft marked A. At the right hand end of the shaft A is carried a gear B, and this gear is in mesh with the gear C on the lower shaft of the transmission, it will therefore be seen that whenever the clutch causes shaft A to revolve, gears B and C will also turn, and inasmuch as C is fastened solidly to the lower shaft of the transmission, this lower shaft will turn whenever the engine is running and the clutch engaged. The upper shaft in the transmission marked H is not made in one piece with shaft A, but its left hand end is made of a diameter sufficiently small to fit into a recess in the shaft A and in the hub of the gear B. This construction simply provides a bearing for one end of the shaft H so that it may revolve independently of shaft A. Shaft H is formed with four longitudinal keys integral, and on this shaft are mounted the gears F and G with their hubs formed with keyways to engage the keys on shaft H. This construction allows the gears F and G to be moved lengthwise while turning with the shaft. Gears D and F are made of such diameter that when F is moved to the right it meshes with D and gears E and G will mesh when G is moved to the left. The right hand end of shaft H is fastened to the universal joint that leads to the rear axle.

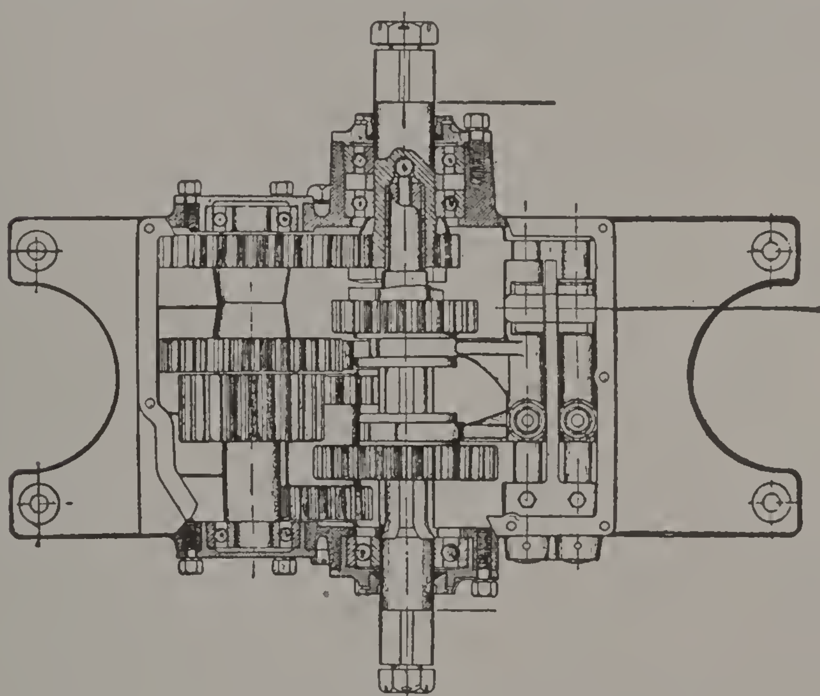


Fig. 95
Sliding Gear Set for Separate Mounting

The operation is as follows: With the engine running and the clutch engaged, power is transmitted through gears B and C to the lower shaft of the transmission, and inasmuch as gear C is larger than B, the lower shaft will run at a lower rate of speed than the clutch shaft. If now the gear G be caused to mesh with E, the shaft H will be revolved but at a still lower rate of speed than the bottom shaft.

and inasmuch as H drives the rear axle it will be seen that the mechanism has given a positive drive at a speed much below that of the engine.

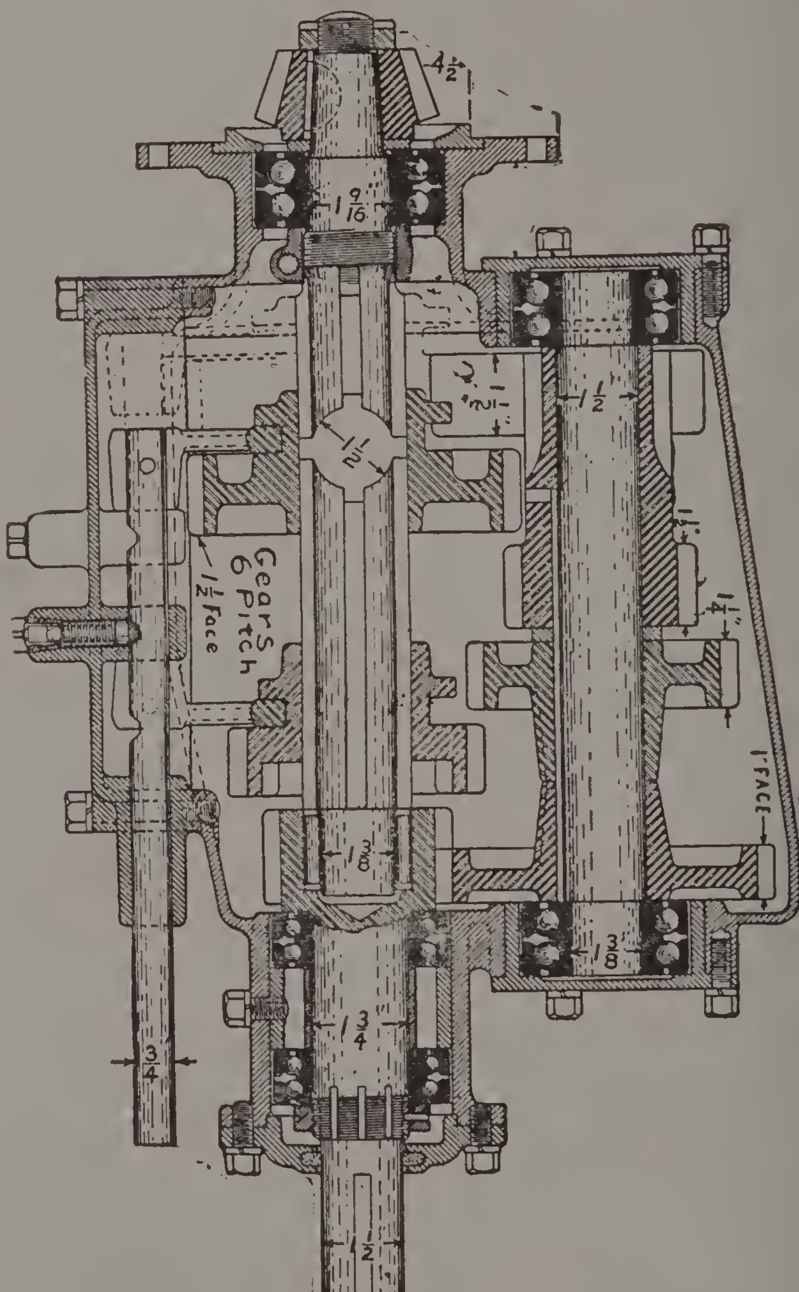



Fig. 96
Heavy Duty Selective Sliding Gear for Rear Axle Mounting

When it is desired to secure a higher speed of the car relative to that of the engine, gears

G and E are withdrawn from each other and gear F is moved into engagement with D. It will be noted that gears D and F are approximately the same size, and the upper shaft will then turn at a speed very nearly the same as that of the bottom shaft, but still less than the speed of the engine. This position is known as second speed or intermediate speed.

When it is desired to secure a still higher ration of speed it is done by moving gears D and F out of engagement and then moving F to the left. Gear F carries one-half of a jaw, or toothed clutch, and gear B carries the other half of this same clutch. It will thus be seen that when F and B are together the clutch will be engaged and shaft A will drive shaft H at the same speed at which A is revolving. This provides high speed or direct drive.

When it is desired to reverse the direction of motion of the car, gear G is moved into engagement with an idler gear that is not shown, and this idler gear is driven through another one on the bottom shaft of the transmission. The idler gear being interposed between the upper and lower transmission shaft gears causes the upper shaft to reverse its previous direction of motion.

Certain variations of selective sliding gears are in use, one of which is shown in Fig. 97. In this particular form the spur gears remain in mesh at all times, but neither set is keyed to its shaft. Between the gears are mounted jaw clutches, and these clutches are keyed to the shaft. In place of moving the gears into or out of engagement, the jaw clutches are moved, and depending on which clutch is moved and which way it is moved,

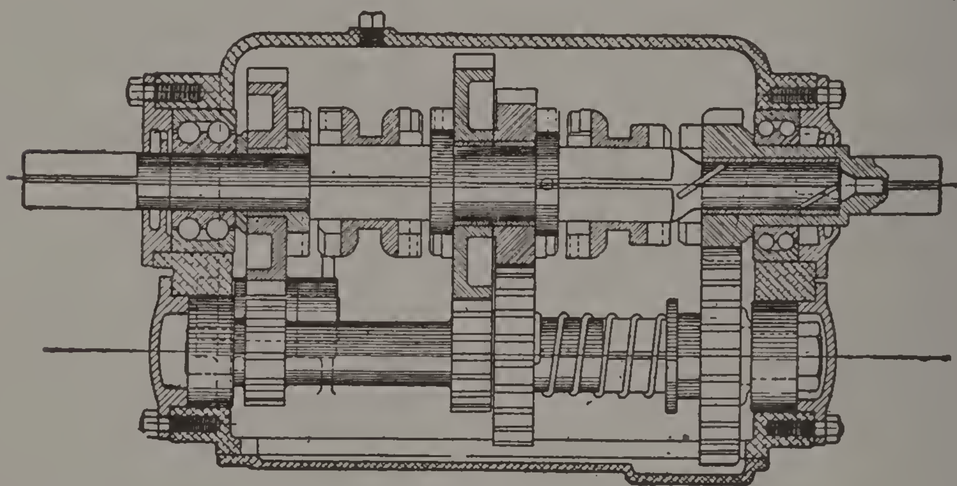


Fig. 97
Individual Jaw Clutch Sliding Gear Set

the several sets of gears may be successively used, providing speed ratios similar to those in other forms of selective sliding gears.

## Magnetic Transmission.

The difference between a car with magnetic transmission and other gasoline cars lies only in this transmission. There is no change in the engine or its operation. There is no change in the driving parts, save as regards their connection with the power. The parts omitted are the clutch and the clutch pedal, gears and shifting lever, flywheel, starter and lighting system, this one transmission unit taking the place of all. There is no mechanical connection between the engine and the driving shaft. This

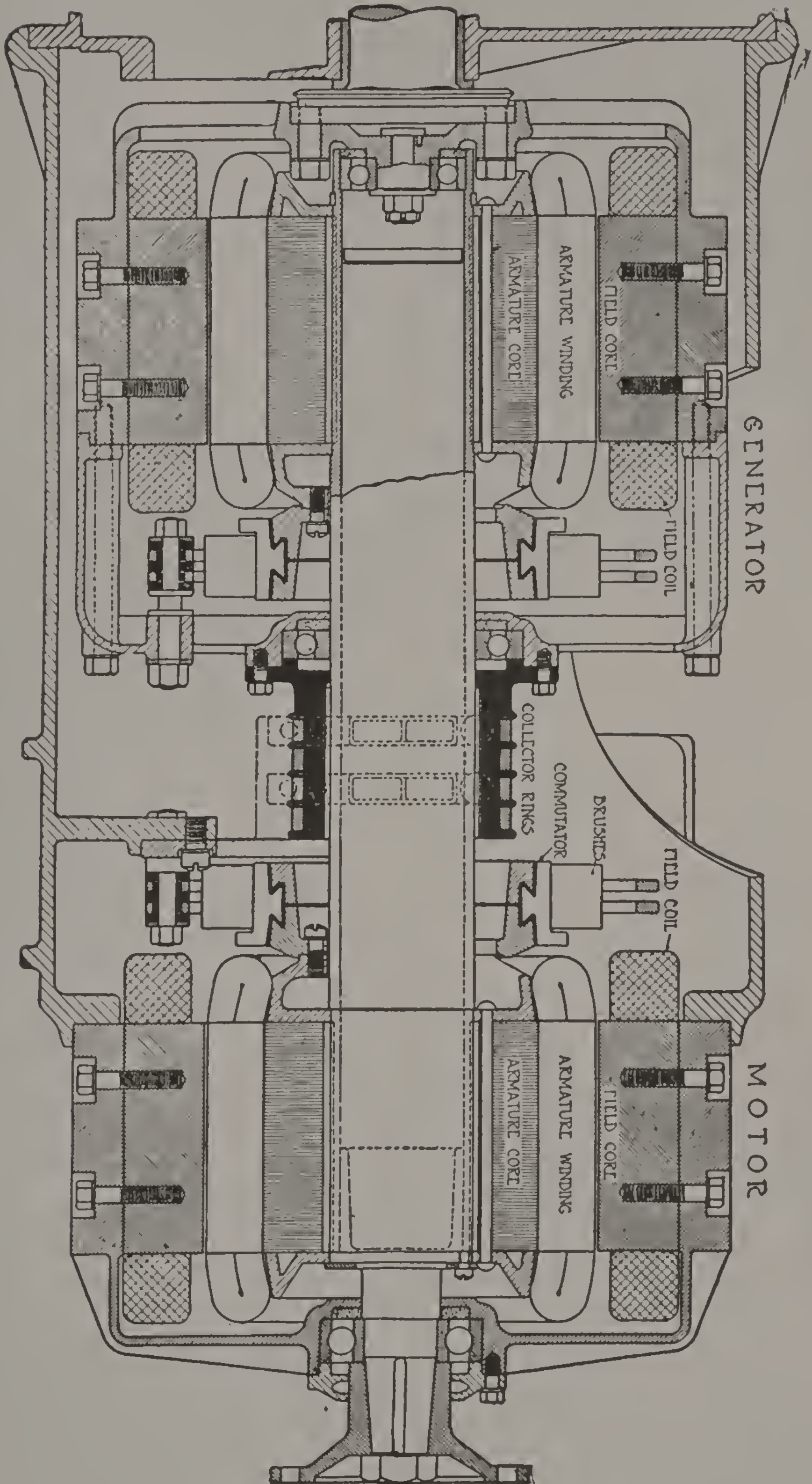



Fig. 98
The Owen Magnetic Transmission

control also embodies an electric brake, and an automatic electric sprag, which absolutely prevents the car backing down hill, even though the motor is stalled. Should the engine be stalled on a hill, the car can be held without use of the brakes by simply moving this control lever into high speed position.

The power is never disconnected from the driving wheels of the car from the moment of starting up to the highest speed.

The electrical apparatus consists of two units, Fig. 98, contained in a one-piece construction: the one nearest to the engine has its magnetic field pieces keyed to the engine crankshaft and acts as a flywheel to the engine. Its armature is mounted on the propeller or drive shaft, hence it will be seen that both these parts can revolve. The second unit of the apparatus has stationary magnetic fields and its armature, as in the first case, is mounted on the propeller shaft. The first unit becomes in turn a dynamo, magnetic clutch and a motor, the second unit, a motor and dynamo.

A controller, with resistance coils internally contained, is bolted to the chassis frame forward of the dash, alongside of the engine, and is operated by a lever on the steering wheel through a small gearing at the bottom end of the steering column.

By placing the control lever in the position "cranking," a battery is connected through the first unit, which in this instance becomes a motor, and once the engine is cranked, the lever can be placed in the "neutral" position until ready to start the car.

On moving the control lever to the first position, turning effort is produced by weakening, with a shunt resistance, the field of the first unit, which becomes a dynamo, and

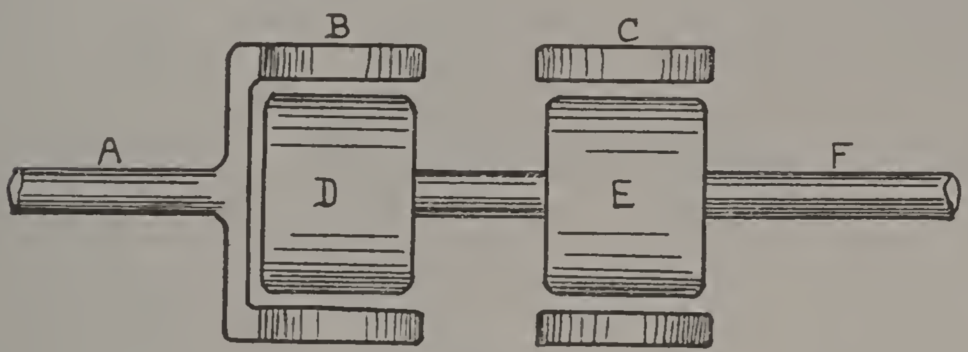



Fig. 99

Principle of the Magnetic Transmission: A, Engine Crankshaft. B, Revolving Field. C, Stationary Field. D, Front Armature. E, Rear Armature. F, Propellor Shaft.

the current generated, due to the electrical slip between the magnetic fields and the armature, is fed to the second unit, which, acting as a motor, produces a powerful starting torque. At the same time the pull of the magnetic fields of the first unit acts as a magnetic drag on its armature, and thus two forces assist in rotating the propeller shaft, which, through the bevel drive, communicates power to the road wheels.

The second position of the control lever cuts the resistance out of the first unit (dynamo) field and shunts through a high resistance some of the field current in the second unit (motor), thereby increasing the speed of the car.

In the third, fourth and fifth control lever positions, the second unit (motor) field is successively weakened until in the sixth control lever position, the field current is almost entirely shunted, so that previous to placing the control lever in the seventh (and last) position, the second unit is practically of itself not doing any work, apart from the fact that there is very little slippage between the first unit (dynamo) field and armature, resulting in generating of but small current. In other words, the drive shaft is being carried around almost entirely by the magnetic drag of the first unit's field on its armature. It will hence be seen that there is an electrical balance in effect throughout the entire sequence of operations.

On placing the control lever in the seventh position, the first unit becomes what may be termed a "magnetic clutch," the armature and field are closed-circuited, and an almost negligible slip only is required to generate sufficient current to enable the field to drag its armature around with it.

The second unit with the control lever in high speed position becomes a generator, and when the car is running, charges the lighting and starting battery with a predetermined charge.

From this point on the entire control is brought about by accelerating or decelerating the gas engine, the armature of the first unit follows its magnetic field promptly, generating of its own accord whenever necessary more current and hence getting more magnetic drag to bring it up to the same speed as the magnetic fields. Thus, so long as the control lever is in any position other than neutral on accelerating, an increase of speed is obtained, but on decelerating, the car coasts just like an ordinary car with the clutch released. This is brought about by the armature of the first unit traveling faster than the fields, and thus not generating any current until such a time as the car comes back to the speed, where the armature of the first unit is traveling at the same or slightly lower speed than the field pieces or the engine, when again current is generated and the drive taken up as before.

Should excessive grades be encountered where extra torque may be desired, the placing of the control lever in a lower position will give the desired result, and naturally by increasing the engine speed with the control lever in a lower position than high, more current will be generated, due to the extra electrical slip, and thus give added torque.

At neutral position the maximum electrical braking effect is obtained. Here the first unit is open-circuited and the second unit closed-circuited and the magnetic braking reaction brakes the car to 10 miles per hour, below which speed the armature does not revolve within the motor field fast enough to create the braking effect, thus automatically holding the car on a grade at about the above speed.

**Chassis.** The word chassis since its adoption into the English language, is taken to mean the frame, springs, wheels, transmission and in fact all mechanism except the automobile body. In its original French it does not mean all this, but is strictly restricted to mean the frame, or the frame and springs.

**Chauffeur.** This term when literally translated means the stoker or fireman of a boiler. The use of the word has been extended to the operator of a motor car, but does not usually refer to the paid driver, who is generally known as the mechanician or mechanic.

**Clutch.** Clutches may be classified as follows: a, cone; b, disc; c, band; cone clutches may, in turn, be subdivided as follows: a, metal to metal; b, leather faced; c, cork insert; while disc type may be classed as: a, leather faced; b, multiple disc; c, cork insert; and band clutches may be put down as of the a, constricting, b, spiral, or c, expanding types. Clutches, of whatever type or class, have but one prime object, i.e., to enable the operator to start and stop the car without having to stop the motor. There is a secondary consideration, if we take into account the fact that it is convenient to be able to slip the clutch, on occasion. Some types lend themselves to this secondary purpose with greater facility than others, and it is also true that some clutches are most easy of application, all things considered.

As clutches are at present designed, the question is, can slipping be tolerated? or, can clutches be slipped to control the speed of a car? It is believed not. The average clutch has very little of the character of the average braking system, and when it comes to brakes they do not last so long that it is desirable to wear them out sooner than they will naturally need replacement. In other words, it seems quite out of the question to consider the clutches of today as suitable for the double purpose of clutching and speed controlling, by way of slipping the clutch at will. It is not uncommon to hear autoists talking of the multiple disc clutch as one that undergoes little or no deterioration as a result of continuous slipping under variations of load.

They seem to think that the large surface exposed, especially in view of the fact that the discs are submerged in oil, will prevent damage if the clutch is caused to slip. They forget that the discs are thin, and also that they are loose on the splines, keys, or feathers that prevent the discs from rotating. No member keyed onto a shaft will stand much abuse. This is especially so, if the member has but little bearing surface on the key. Even a considerable number of such members working in unison will fail to stand up under the work because the joint is not firm. Lost motion is bound to result in more lost motion in a short while, and in a multiple disc clutch the discs soon fray out and interfere with each other, and with the clutching functions, within a space of time so short as to surprise even those most experienced in the use of this type.

Band Clutch. A band, or friction ring, clutch, is shown in Fig. 100. The wheel which is connected to one of the shafts is shown at a, and the band, or ring which is connected to the other shaft and which is made in two parts, is shown at b and c. At d and e are curved arms

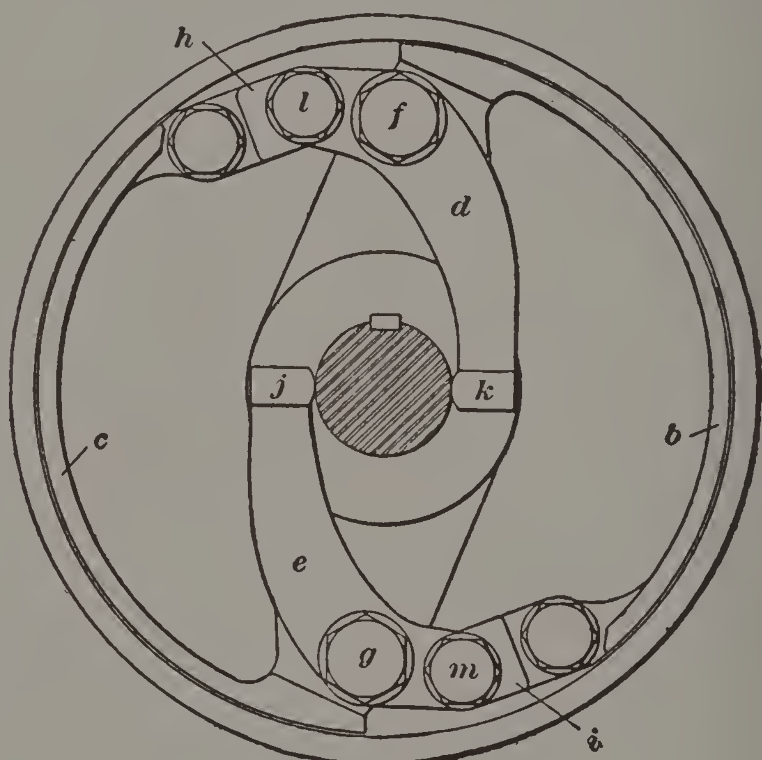



Fig. 100

pivoted at f and g. The links h and i connect these curved arms to the parts b and c of the band. By means of a fork, and tapered sleeve, not shown, the ends j and k of the arms are forced apart when the clutch is brought into use. This throws toward the shaft the ends l and m of the levers d and e, and brings the two parts b and c of the clutch ring in contact with the friction or driving surface of the wheel a, which is thereby forced to turn with the driving shaft. The band clutch has had many exponents in the motor car art, but is open to centrifugal effects to such an extent that it requires considerable ingenuity to overcome troubles arising therefrom. At high engine speeds the operating levers have been so arranged as to lower the normal expanding pressure.

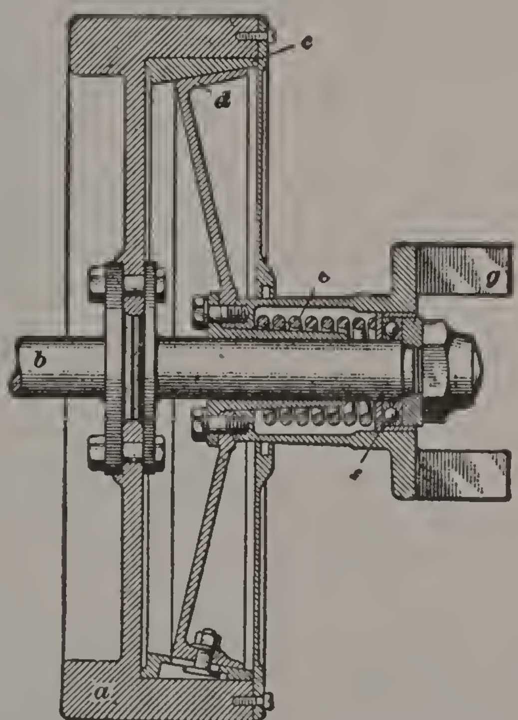



Fig. 101

Cone Clutch. There are a number of modifications of this type of clutch, the general principles of which are illustrated in Fig. 101. The flywheel a is secured to the shaft b by means of bolts through the web of the wheel. At c is an expansion ring into which the friction cone d fits. The helical spring e holds the cone against the expansion ring with the required amount of force. At f is a ball bearing that takes the end thrust when the cone is pulled away from the expansion ring.

The arms g are coupled to the shaft that turns with the friction cone. Ordinarily the two parts of the clutch are held together by the pressure of the spring, and when it is desired to disconnect the cone, a foot pedal is forced down so as to act on a fork and sleeve and pull the cone

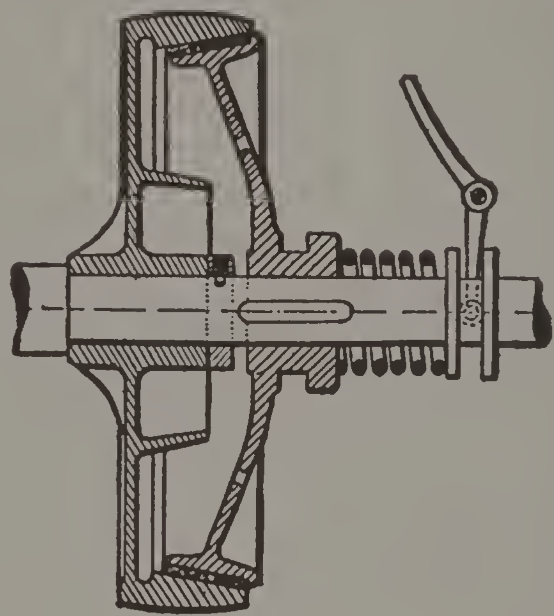


Fig. 102

away from the expansion ring. When the pedal is released, spring e forces the clutch into action again.

Fig. 102 is a sectional view of a form of leather faced cone clutch in which the male part of the cone moves axially toward the engine. Fig. 103 shows a clutch constructed on the same principle, but in place of having one strong actuating spring surrounding the axis, it has three weaker spiral springs near the periphery of the male member. Fig. 104 is a vertical section of a clutch suitable for a 50 H. P. car. The cone angle is 13 degrees, and the diameter 16 inches, with a total frictional area of 128 square inches, the axial pressure resulting from the spring being 375 lbs. A small spiral plunger spring A under the leather face B causes it to pick up the load more quietly and smoothly. Fig. 105 illustrates an early form of clutch intended for a car of about 20 H. P. One form of toggle joint is also shown at A.

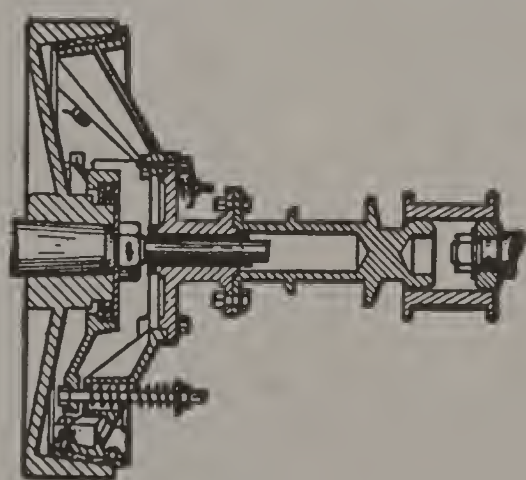


Fig. 103

This clutch also has multi-springs for creating the proper frictional contact, and a peculiar form of spring application simple in the extreme. A multi-cone clutch is shown in section in Fig. 106. Its action is as follows: When the clutch engages, the smallest cone seizes first, commences to revolve and subjects the spiral springs between the next two clutches to torsional movement, which draws them together and brings the two outer cones into action; the idea being that the small clutch shall slip, tend to accelerate the car, that the medium clutch shall behave in a similar manner and that when the large clutch comes into play the three combined pick up the load and move the car.

The so-called inverted cone is well illustrated

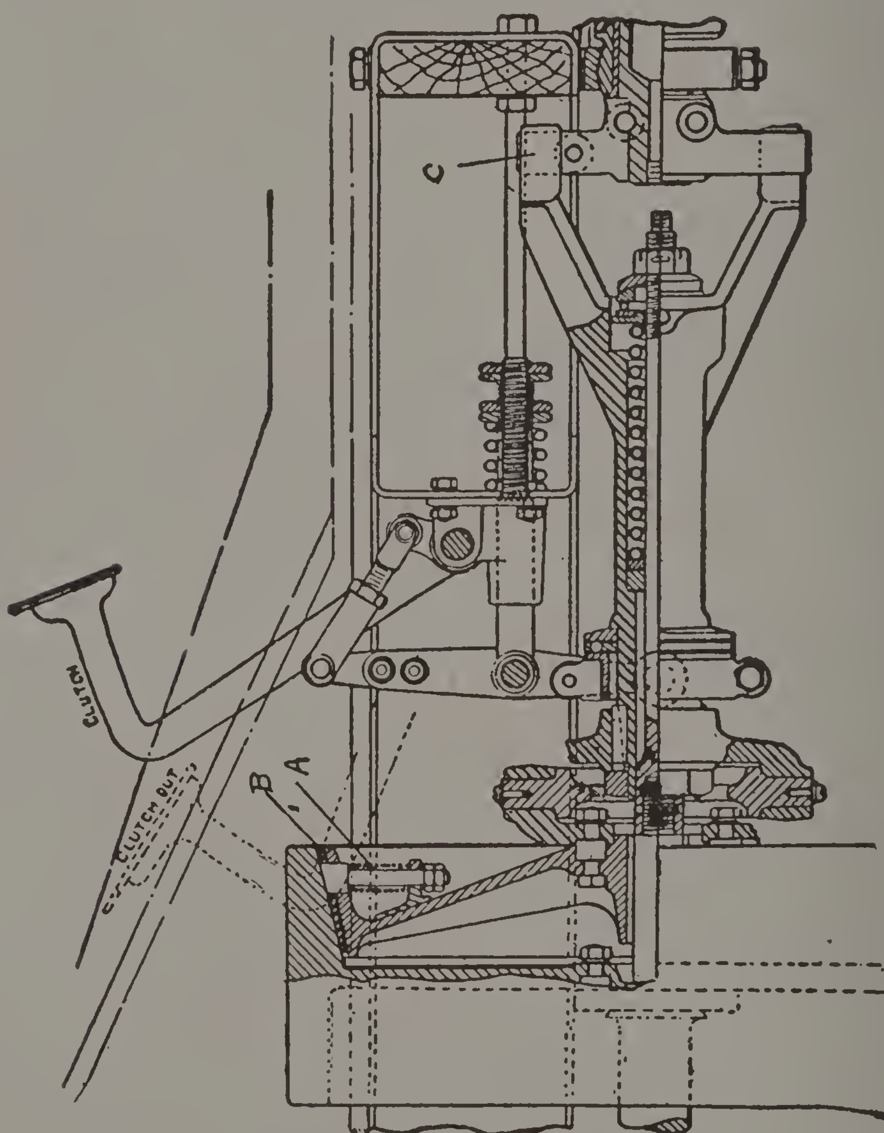



Fig. 104

in figure 107. The reversed cone is contained in an extension A, built onto the flywheel B. When the cone is disengaged it moves toward the engine, exactly reversing the action of the foregoing type. This clutch has its adherents, and it is a good one, differing very slightly, if properly assembled, in its efficiency from the direct-acting cone. It may be kept free from dirt and oil much more perfectly than in the other form.

DISK CLUTCH. A clutch of the multiple-disc type is shown in Fig. 108. A two-arm spider a, keyed to the shaft b, serves to hold in place a number of metal discs c, between which are other metal plates d held on the sleeve e by means of a key f. The sleeve e is in turn keyed

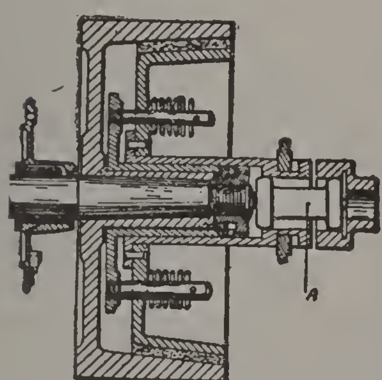


Fig. 105

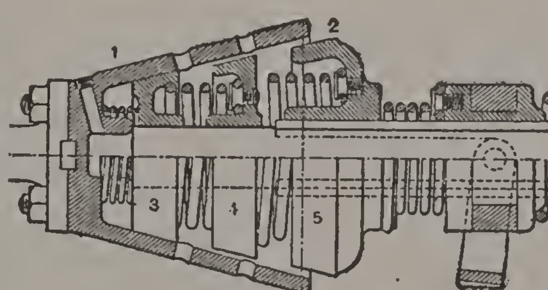


Fig. 106

to the shaft g, and to it is screwed a ring h having three pairs of lugs carrying three levers i, with rollers j at their outer ends, as shown. The other ends of the three levers press against the plate k when the clutch is engaged by an inward movement of the collar l, plate k being free to move along the key f. Discs c are free to move longitudinally on the arms of the spider a, and also on sleeve e, around which they rotate when the clutch is out of engagement; but the arms of the spider, fitting into slots in the discs, cause them to rotate with the shaft b.

The plates d are free to move longitudinally on the key f in the sleeve e; and since the sleeve is keyed to the shaft g, it is evident that, when in engagement with the discs c, the plates d must cause the shaft g to turn with the shaft b. The discs c and plates d run in an oil bath,

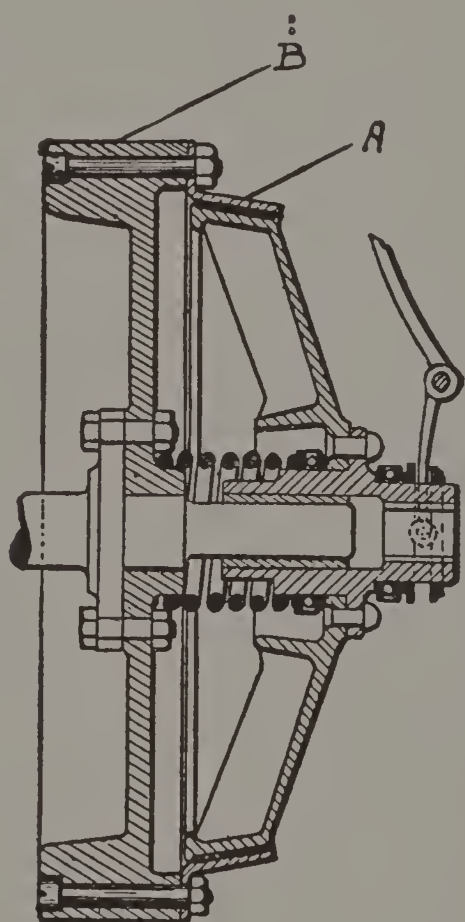



Fig. 107

obviating wear of the plates and discs. These are brought together forcibly by throwing the cone faced end of the collar l against the rollers j, thereby causing the ends of the three levers i to press the plates and discs together with sufficient force to cause the shafts b and g to rotate as one shaft.

**Five-plate Clutch.** In the matter of the number of plates in the disc clutch there is no agreement between designers. Some use a very large number of thin plates, as many as fifty or sixty, and others use a very small number, as few as six or eight; in fact, it may be said that the single disc clutch, which has only two frictional

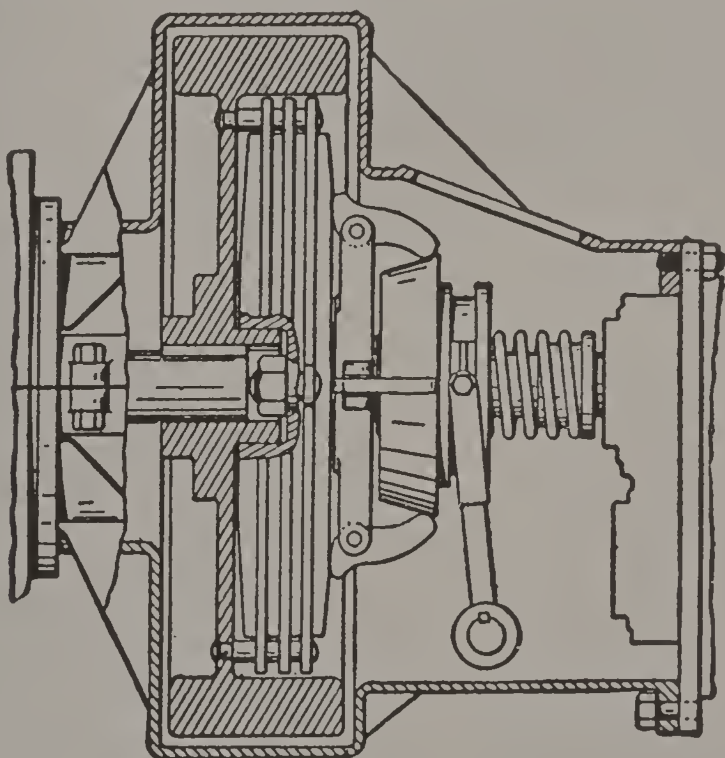


Fig. 108
Five-Plate Clutch

surfaces, is the lower limit. One arrangement which uses five plates is shown in Fig. 108. The diameter of the clutch is somewhat smaller than that of the single or three-plate types, but its diameter must be quite large in order to transmit considerable horse power.

Clutches are made with various numbers of plates, from three to more than sixty, depending on the work required and the size and material of which the plates are made. Plate materials include hardened steel for both members, steel and bronze, steel with cork inserts, and steel covered with some friction material similar to brake lining.

Disc clutches using steel to steel are operated in a bath of oil. Those using bronze and steel may or may not operate in oil. As a general rule, clutches that are not enclosed are fitted with cork or an asbestos composition as the friction material. However, either of the forms just mentioned operate satisfactorily in an oil bath, and it is, therefore, simply a question of choice with the designer. Unenclosed clutches are called "dry-plate clutches."

CLUTCH TROUBLES. One of the greatest sources of trouble for the novice lies in the clutch. This may be just right, it may be slipping, or it may be what is called fierce. The second manifests itself in such pleasant situations as climbing a hill when, with the engine running at its highest speed and the proper gear engaged, the car starts to run backward instead of forward. Or on the level, with the engine racing and the high gear in, no speed results.

The last condition shows itself in the sudden jumping forward of the car when the clutch has been let in, or it may even be so severe as to shear off the bevel driving gear when used with studded non-skid tires or any form that will not slip easily.

To repair the first, look at the leather, if this is all in good shape with an apparently good surface, but has lubricating oil on it, wash the surface well with gasoline. It is not a bad idea to roughen the surface of the leather a little with a coarse file.

The harsh or fierce clutch is remedied by the application of a proper oil for this purpose. Castor oil is universally used and a good way is to soak the complete clutch in it over night. This will cure a case of harsh leather, but it may be that the trouble is only a lack of adjustment of spring tension. Usually there is an adjusting nut and a locking nut. Back off the latter and make an adjustment. Then tighten the lock nut to retain it. For the beginner, it is better to adjust a little at a time and make several successive jobs of it than to try to do it all at once. But always adjust it as soon as possible.

The leather of the ordinary cone clutch by degrees acquires a sort of coarse surface glaze, which may or may not represent actual charring of the leather, but is certainly due to the slipping it experiences. A leather with its surface so glazed has a very harsh action, since the surface is so hard that it grips all at once. The glazed surface will not absorb oil to any appreciable extent, a fact which is easily seen on attempting to dent the surface with a thumb nail after giving the oil time to soak in. In this condition the best thing to do is to put on a new leather. Unless the angle of the cone is too abrupt, a piece of ordinary belting will serve the purpose, provided it is of uniform thickness throughout. The belting may be soaked in neatsfoot oil over night before applying, and this will render it pliable enough to take the shape of the cone. If the old leather is retained in service it becomes almost essential to squirt a little oil on it every day or two, as otherwise it may take hold with such a jerk as to endanger the transmission shafts. If the cone releases by drawing backward, there are probably openings in the web of the cone through which the spout of a squirt can may enter. Oil squirted into the flywheel interior will then quickly find its way to the clutch surface. Sooner or later, however, the leather will become glazed so smooth that it will not hold at all, and it is then liable to slip and burn up without warning. There are few things more exasperating than a clutch which cannot be made to hold properly, particularly when the car happens to be covering a bad stretch on which every available bit of power that can be transmitted to the rear wheels is necessary. The use of emergency remedies under such circumstances most often leads to the necessity for clutch repairs, as road dirt and grit are not the best things possible for the leather facing, and frequently no other friction producing compound is to be had at the time.

Renewal of Leather on Cone Clutch. Remove the old leather by cutting off the rivets on the underside, and driving the rivets through to the outside. Keep the old leather and use it as a pattern by which to cut the new piece. It will be much better, however, to purchase from the factory a new leather of the proper width and thickness. As a new leather will have considerable "give," it must be stretched tightly over the cone. First cut one end of the leather square and fasten it to the cone with two rivets. The other end should not be cut at this stage of the work, but brought around to meet the fastened end, and, after tightly stretching it over the small end of the cone, fasten it with a single rivet. Then force the leather up onto the cone, drill out and countersink the holes and rivet up securely. The only knack in the operation is to keep the leather tight that it may be a snug fit on the cone. A loose leather will, naturally, be a dead failure. After the leather has been forced into its place the uncut end should be trimmed to make a good joint. Any unevenness may be trued up with a file. The new leather will readily absorb several applications of castor oil before it becomes smooth and pliable.

Care should be taken that the rivet heads are countersunk below the surface of the leather. In case they work flush, owing to the wearing down of the leather face, they should be riveted. The "biting" or jerky action of a cone clutch may often be traced to the rivets working out, and this will frequently prevent the clutch from being readily disengaged. Reriveting will prove an effective remedy in this case, and considerable additional service may be had from the leather before it wears down to the rivet heads.

**Combustion Chamber.** That part of an explosive motor in which the gases are compressed, and then fired, usually by an electric spark, is known as the combustion chamber. The interior of the combustion chamber should be as smooth as possible and kept free from soot, or hard carbon deposits such as are induced by excessive lubrication, or the use of too rich an explosive mixture.

It will be found to be no small task in designing an explosive motor with the usual form of valve construction and operation, to keep the combustion chamber down to the required dimensions and at the same time have it free from bends or contracted passages between the combustion space and the valve chamber.

Many attempts have been made to obviate this difficulty by making the combustion chamber simply a straight extension, or continuation of the cylinder. In this manner both the admission and exhaust-valves can be placed in the cylinder itself and an ideal combustion space secured. This plan has, however, certain disadvantages, from the fact that it not only lengthens the motor, but requires a more complicated form of valve operating mechanism than if the valve chamber were at the side of the cylinder as is usual.

**Commutators, Ignition.** The commutator of the ignition system of a multi-cylinder gasoline motor has a three-fold use: To switch the battery current in and out of the electrical circuit at the proper time—To transfer the battery current successively from one coil to another—To vary the point or time of ignition of the explosive charge in the motor cylinder.

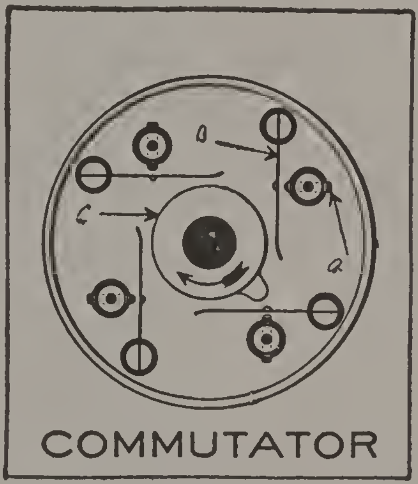



Fig. 109

The commutator shown in Figure 109 is for a four-cylinder motor and is designed for use with induction coils without vibrators, which are known as single-jump spark coils. The studs of the screws A and springs B are carried by insulated bushings located in the back of the commutator case. The nose of the cam C successively engages with the springs, causing them in turn to make contact with their respective screws. The battery and coil circuit is completed through the screws A, and a ground to the cam C, by means of the springs B, when in contact with their respective screws and the cam.

This device is said to cause a good spark at the plug on account of the quick break between the spring and the screw, the electrical circuit being broken the instant the spring leaves the screw and before the cam has allowed the spring to resume its normal position. This form of commutator cannot be short-circuted by oil

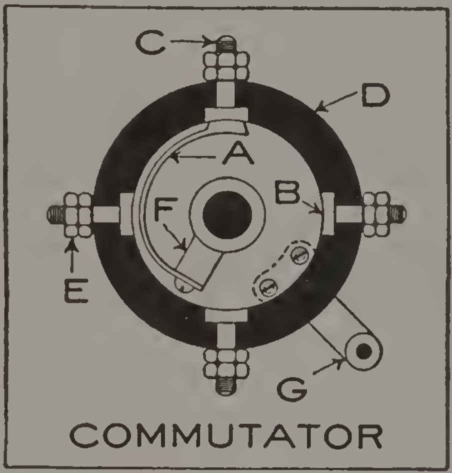



Fig. 110

or dirt getting between the spring and the screw, as the spring B only forms a part of the electrical circuit when in contact with both the cam C and the screw A.

Another form of commutator for a four-cylinder motor is illustrated in Figure 110, which has a rotary spring contact-maker A, which engages successively with the heads B of the screws C. The screws are spaced equidistant around the fiber ring D, which also forms the case of the commutator, and are held in position by the locknuts E. The spring contact-maker A is attached to a hub F on the cam shaft of the motor. The time or point of ignition may be varied by moving the commutator case about its axis by means of a rod attached to the arm G.

Figure 111 shows two commutators of very similar construction. The one at the left in the drawing is for a two-cylinder motor, and has flat spring-steel contact-makers. The commu-

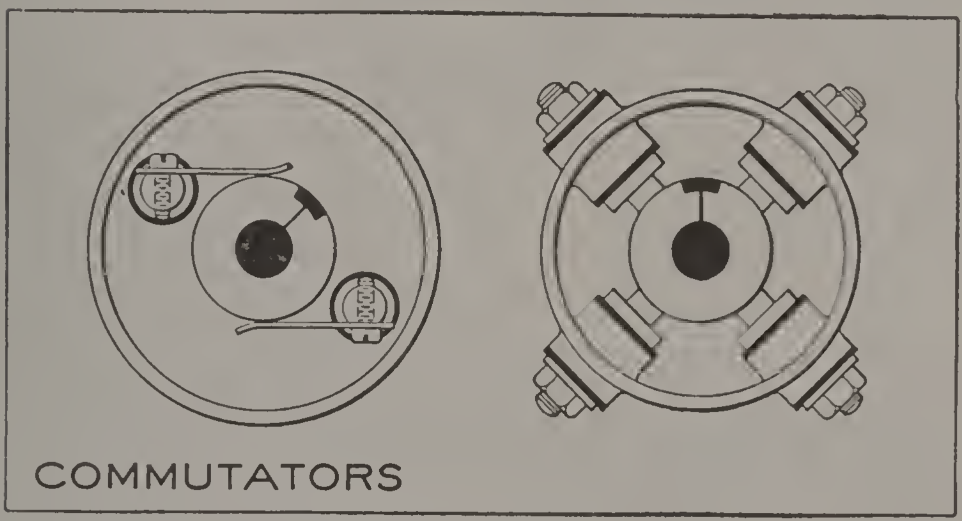



Fig. 111

tator shown at the right of the drawing is for a four-cylinder motor and instead of having flat spring contact-makers, it has either carbon or copper contact-brushes, which are held against the commutator by short coil springs in the insulated bushings located around the periphery of the commutator case. The commutator is made of vulcanized fiber with a short brass or or copper segment, which is grounded to the cam shaft as shown.

The forms of commutators illustrated in the drawings may be constructed for use with a motor of any number of cylinders, by increasing or decreasing the number of contact-makers located around the commutator.

**Compression.** Normal compression in any given design of motor would be the compression (cold) fixed by the designer by the relation of the sweep of the piston to the clearance space. Normal compression is not the same, as measured in pounds per square inch, in all motors. The normal compression as against loss of compression would be evident to a motorist in the act of cranking. Were the compression to become abnormal, as a result of carbon deposit, it would be rendered manifest by knocking on a gradient, or by way of pre-ignition.

Limits of Compression. With gasoline vapor and air, the compression cannot be raised much above 85 pounds per square inch, but with the heavier fuels, such as kerosene, a compression as high as 250 pounds per square inch has been used economically. It has been the advantages of high compression that has turned the designer of automobiles toward the heavier fuels; but, with the increase of compression, there are many troubles in regard to loss of power and increased fuel consumption, owing to the wear of the valves, pistons and cylinders, which produces a loss in compression and explosive pressure, and a waste of fuel by leakage.

Compression, How to Calculate. The compression in atmospheres of a motor may be readily found by dividing the cubic contents of the piston displacement by the cubic contents of the combustion chamber in cubic inches, and then adding one to the result.

To ascertain the compression in atmospheres of a motor, when the cubic contents of the combustion chamber are known: Let S be the stroke of the piston in inches and A the area of the cylinder in square inches. If C be the contents of the combustion chamber in cubic inches and N the required compression in atmospheres, then

$$N = \frac{S \times A}{C} + 1$$

Example: Find the compression in atmospheres of a motor of 4-inch bore and 6-inch stroke, whose combustion chamber has a capacity of 18 cubic inches.

Answer: Six multiplied by 12.56 equals 75.36, which divided by 18 gives 4.19, and 4.19 plus 1 equals 5.19, or the compression in atmospheres required. One atmosphere = 14.75.

If it is desired to ascertain the compression in atmospheres of a motor, the combustion chamber of which is of such shape that its dimensions cannot be accurately calculated, its cubic contents may be found by filling the combustion chamber with water, and after removing the water, ascertaining its weight in ounces, and then multiplying the result by 1.72. This gives the capacity of the combustion chamber in cubic inches. The compression of the motor can then be readily calculated from the formula given herewith.

Compression, How to Test for Leaks in. To discover if there are any leaks in the compression of a gasoline motor, a small pressure gauge reading up to 75 pounds should be fitted into the spark plug opening in the combustion chamber by means of a reducing bushing. When turning the starting crank of the motor slowly the gauge should indicate at least 60 pounds per square inch if the compression is in good condition.

To test for leaks, fill a small oil can with soapy water and squirt round every joint where there may be a possible chance for leakage. Get an assistant to turn the crank and watch for bubbles at the joints.

If the joints are all tight, next examine the condition of the admission and exhaust-valves and if either of them needs regrinding, it should be done, first with fine emery powder and oil, then finished with tripoli and water.

When the valves have been ground to a perfect fit, if the compression still leaks, the piston rings should be examined, as the trouble will be found to be with them.

**Condenser, Use of.** A condenser is used in connection with a Rumkorff, or jump-spark form of induction coil to take up or absorb the static charge of electricity, occasioned by the self-induction, or electrical reaction in the primary winding of the coil upon the breaking of the battery circuit by the interrupter or vibrator. This static charge is given up or dis-

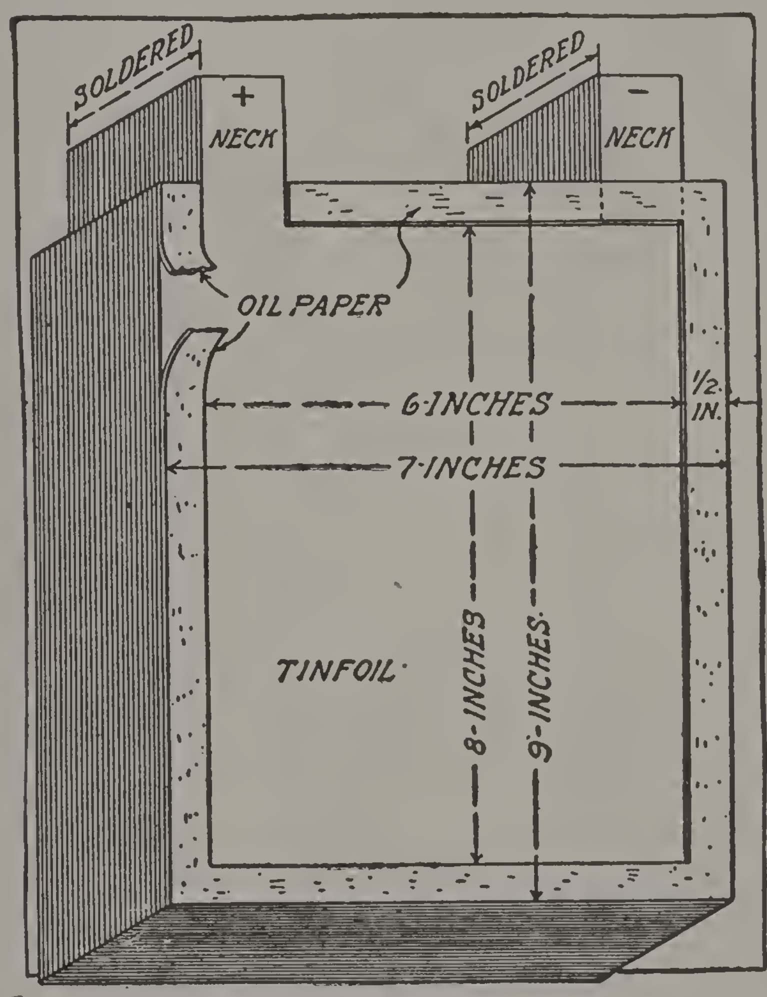



Fig. 112
Condenser

charged into the primary winding of the coil along with the battery current upon the closing of the circuit, thus intensifying the action of the secondary winding of the coil in a great degree.

By absorbing the static charge of electricity the condenser helps to decrease the spark or arc between the platinum contact points of the interrupter or vibrator, thereby lengthening the life of the platinum contacts by reducing the erosive action of the induced current spark. A jump-spark coil very often refuses to work properly on account of the condenser connections having become loose.

The capacity of a condenser is directly proportional to the area of the tinfoil sheets composing it, to the distance between the sheets, and to the inductive capacity of the dielectric, or separating medium.

In condenser work it is the custom to cut the tin-foil sheets to some convenient rectangular shape, as shown in Fig. 112, each one with a neck so that all the + sheets can be soldered together, on one side, and all the — sheets on the other. The dielectric paper is cut without necks, so that the necks of the tin-foil sheets can be readily contacted with each other, in such a way, however, that the + sheets will not contact with the — sheets at any point. The paper is 1 inch wider than the tin-foil, so that the paper extends out for ½ inch all around, and beyond the tin-foil. In the illustration the top sheet of paper is removed to show the shape of the tin-foil sheets, and it will be observed that all the tin-foil sheets are of the same size, but they are so turned that the + sheets have their necks all to one side, while the — sheets have all their necks to the other side. Any number of sheets can be used, with the understanding that a sheet of oil-paper will be placed between adjacent tin-foil sheets, so that the + and — sheets will not contact with each other at any point.

If the paper is pierced, or if the + and — tin-foil sheets contact with each other, the condenser will fail to perform its functions, and it sometimes happens that the sheets are punctured in service, thus rendering the condenser valueless for the intended purpose until the puncture is repaired, to do which requires that the fault be found, and a new sheet of paper substituted.

Condensers are made to fit into housings that allow of ready application on the instrument with which they are used. In many cases it is desirable to use a cylindrical form, while in others a rectangular outline may be permissible. Condensers of unusual form are often made from two long strips of tin foil, laid one upon the other, and separated by waxed paper or other insulating material. The long strip is then rolled or folded into the shape that is desired and the ends of the foil are attached to the condenser terminals.

A punctured or faulty condenser will cause the spark to be very weak and will also cause quite violent arcing at the breaker contacts, this arcing burning and pitting the contacts until they can no longer carry the current. The condenser connections must always be secure.

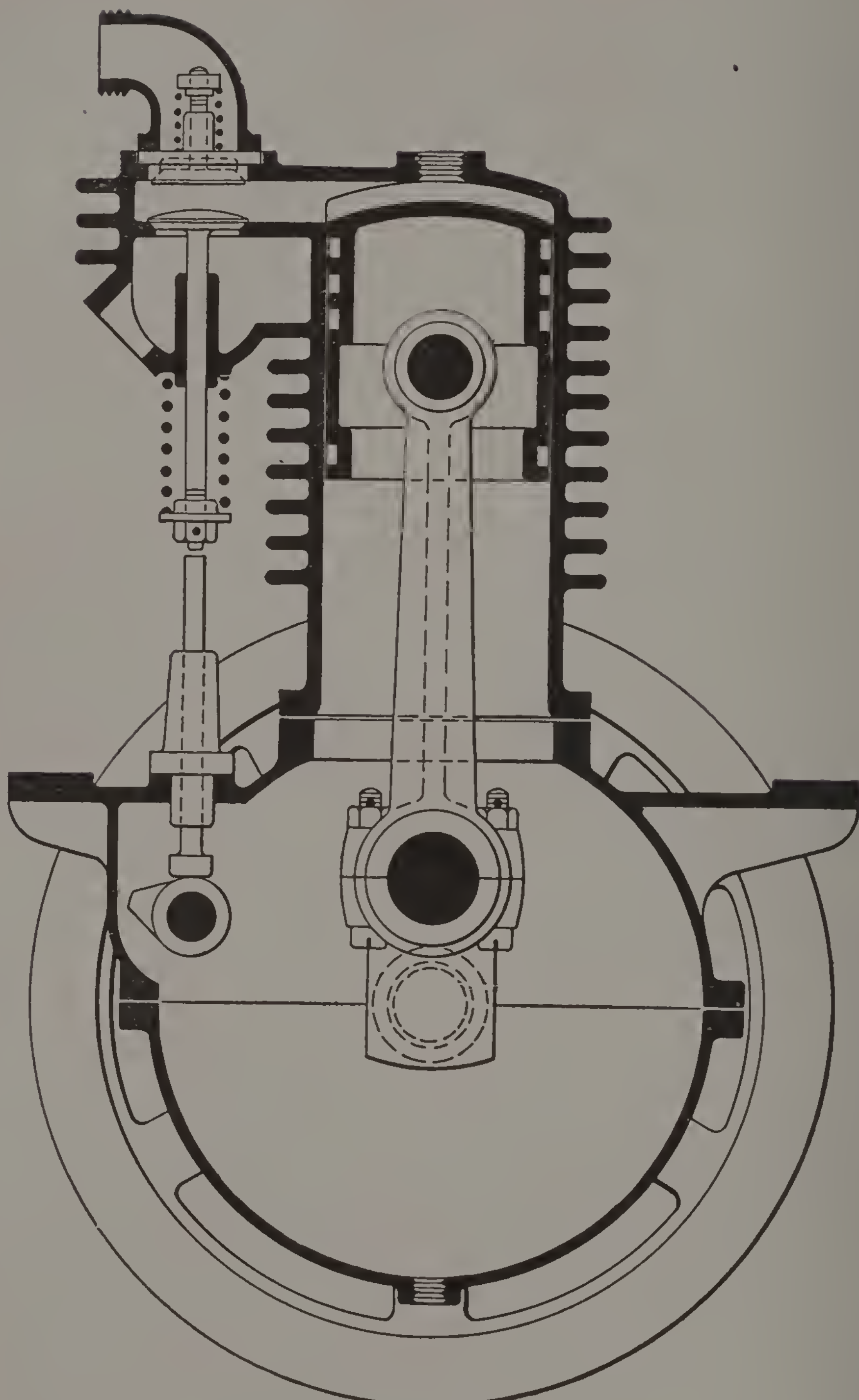
**Cooling Systems.** The cooling of a gasoline, or other automobile engine may seem a simple thing to the uninitiated, but in reality it is far from that and it is a fact that the deeper one goes into it, the more complex the situation becomes.

The cooling of internal combustion engines, in which category automobile engines come, is divided into two classes, viz., air cooled and liquid cooled. There are two reasons for cooling the cylinder walls. One is to permit of proper lubrication, and the other is to prevent pre-ignition. But it is advisable to allow the cylinder to work at as high a temperature as the lubricating oil will stand without carbonizing. The nearer the cylinder temperature can be kept to 350 degrees the more efficient will the motor be, speaking from the thermal standpoint, while on the other hand, mechanical efficiency may be sacrificed by too high temperatures. Therefore, a balance between the two should be established, and this course is usually pursued in practice.

Air-Cooled Automobile Engines. The successful air cooling of an engine cylinder depends chiefly on an abundant flow of cool air over it. Some cylinders, however, are arranged to utilize a more rapid flow than others. Generally speaking, the designer can take his choice between a comparatively plain cylinder surface over which a current of air can flow almost unchecked, and a cylinder with its heat-radiating surface greatly multiplied by numerous pins, deep ribs, or other projections. These projections increase greatly the radiating surface, but tend to obstruct the flow of air, although they aid in carrying away the heat. In the latter case, the velocity of the air stream does not need to be high, provided it is continuous; while in the former case, a constant and abundant supply of air is essential.

Air-Cooling Systems. In modern automobile practice two systems of cooling are used—the air system and the water system, each of which has its adherents. As its name indicates, the air cooling system allows the air to strike the exterior of the engine cylinder, and thus carry off the excess of heat generated within it. To give the radiating surface, required for air cooling, the exteriors of the cylinders are either grooved or corrugated, or the surface of the cylinder is studded with metal pins or fins, so as to present as much surface to the outside air as possible. The object in the construction of all air-cooled motors is to make their external surfaces offer as great a surface to the air as possible, and to furnish these surfaces with as large a supply as possible. A fan is therefore used, driven by the engine itself, which constantly directs a current of fresh, unheated air upon the surface of the cylinder.

Fig. 113 is a sectional view of a vertical air-cooled gasoline motor. The radiating ribs cast



AIR-COOLED MOTOR

Fig. 113

around the cylinder and valve chamber are plainly discernible. This motor has a detachable atmospherically operated admission-valve, without packing. The valve and cage may be removed by simply removing two nuts.

Modern forms of air cooling give excellent satisfaction regardless of the temperature of the outside air. Individual air leads for each cylinder insure even cooling.

Water Circulation. There are two systems of water circulation in use for cooling the cylinders of explosive motors: The natural or thermo-siphon system and the forced water circulation.

In natural or thermo-siphon water circulation the fact that cold water is heavier than hot water is taken advantage of. A head of water is obtained by placing the tank above the level of the cylinder water-jacket, and as the water in the jacket is heated by the combustion, the cooler water from the tank flows in, forcing the heated water in the tank to take its place, and in this manner an automatic circulation of water is set up. The pipes must be so arranged that they offer every facility for the free circulation of the water, the cold water leaving through a pipe at the bottom of the tank and entering at the lowest point of the cylinder, while the hot water leaves the top of the cylinder and enters the tank at the side near the top. The water circulation, though automatic, is very slow, and for this reason requires a

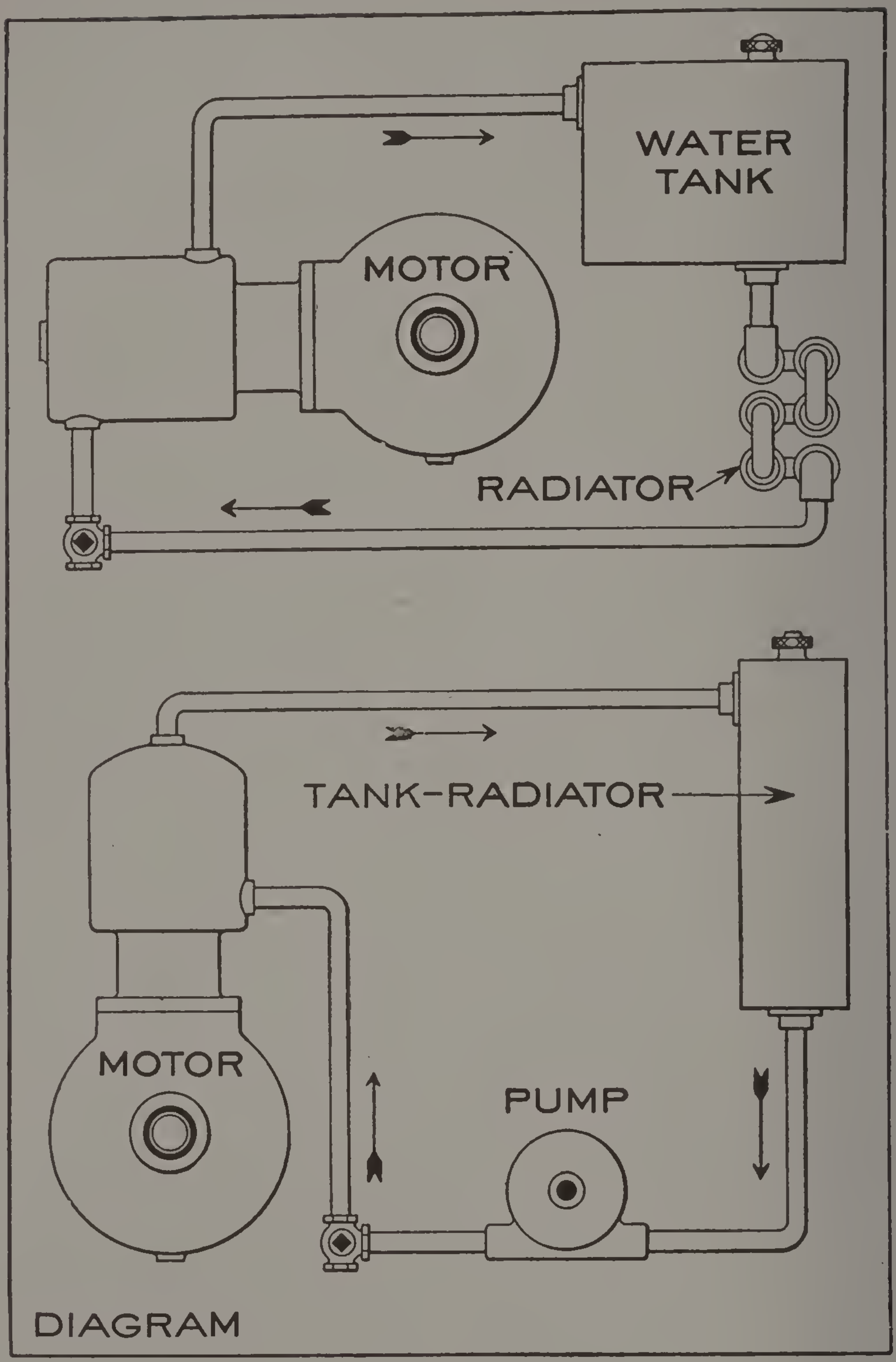



Fig. 114

larger body of water to produce as good a cooling effect as a forced circulation.

In forced circulation a rotary pump is used, the direction of the flow being such that the water passes from the pump to the cylinder, thence to the radiator, on to the tank, and then through the pump again, thus completing its circuit. The water in this way gets the maximum cooling effect from the radiator, and the body of water in the tank is kept cool. On account of the high speed of a gasoline automobile motor, and the comparatively small amount of power required to circulate the water, rotary pumps are much used. As there are no valves to get out of order, and high speed is obtainable, this type of pump is very suitable for automobile use.

In order that a thermo-syphon system may operate successfully, it is absolutely essential that the water passages around the cylinders, as well as the connections to the radiator, be of large capacity and perfectly free from obstructions. Sharp bends should be avoided in every case.

Overheating—Causes of. Overheating of the engine, when not traced to poor circulation, is almost always caused by too much gasoline. There are, however, many possible causes of over rich mixture, some of which on the face of them might seem to be causes of lean mixture rather than rich. Prominent among these latter is too low a gasoline level in the float chamber due to the float valve closing too soon. The immediate effect of this is to make the mixture too lean at starting, and at low speeds. Starting is therefore difficult, and if the auxiliary air valve begins to open at the usual motor speed, the mixture will again be much too lean. These symptoms, however, unless properly interpreted will probably lead the owner to increase the gasoline supply, or to adjust the spring tension of the auxiliary valve so that the latter will not open until quite high speed is attained. In other words, he adjusts to give a suitable mixture at one speed, and at other speeds the mixture is extravagantly over rich. It is well not to be too easily satisfied with the carbureter's performance, as it may be found that one fault such as the above has been imperfectly offset by another fault in the other direction instead of the correct adjustment being made where the fault really lies. A good carbureter will give a sensibly correct mixture at all speeds within the ordinary range of the engine. If it fails to do this the thing to do is to investigate until the trouble is found.

Insufficient lubrication increases the friction between the piston and cylinder, and so generates extra heat. Bad or unsuitable oil may have the same effect.

Wear of the cams, tappets and valve stems may be the cause of overheating, as it would not require much loss from the faces of the various moving parts that come in contact to cause a more or less appreciable difference in the operation of the valves, and as this wear tends to bring about a later action, it may be sufficient in the case of the exhaust valve to retain the burnt charge considerably beyond the time at which it should be allowed to escape. Where a motor runs at a speed of 800 revolutions per minute or over, it will be evident that it is a matter of very small fractions of a second.

Another cause of overheating may be the deposit of a fine film of scale on the inside of the circulating pipes and radiator. This scale is of a mineral nature, and, in addition to being an excellent nonconductor of heat, it is deposited in such intimate contact with the metal that the latter is practically insulated and its radiating power entirely lost.

Overheating—Effects of. The immediate effect of overheating is to burn up the oil in the cylinders, or crank case. This causes a smell of burning, and an ordor of hot metal. There is sometimes a slight smoke and the motor will make a knocking sound. The cooling water begins to steam, and the car will gradually slow down and finally stop.

The most serious cause of a stoppage on the road is overheating, which causes the lubricating oil to burn up and the piston to expand and grip or seize in the cylinder.

Overheating—Remedies for. As soon as any of the above symptoms are noticed:

The motor should be stopped at once.

Kerosene should be copiously injected into the cylinders and the motor turned by hand to free the piston-rings.

The parts should then be allowed to cool.

Do not pour cold water on the cylinder jackets, for fear of cracking them, but pour the water into the tank so as to warm the water before it reaches the cylinder jackets.

A simple test in the case of an overheated motor is to let a few drops of water fall on the head of the cylinder. If it sizzles for a few moments the overheating is not bad, but if the water at once turns into steam, the case is serious.

Detach the spark plug or plugs, and turn the starting-crank slowly. This draws in cold air and cools the inside of the cylinder and the piston.

After the parts are cool, it will be advisable to put some oil in each cylinder.

**Dalton's Laws.** The relation between the vapor tension and the quality of vapor is expressed by two laws known as Dalton's laws, as follows:

I. The pressure, and consequently the quantity, of vapor that will saturate a given space are the same for the same temperature, whether the space contains a gas, or is a vacuum.

II. The pressure of the mixture of a gas and a vapor is equal to the sum of the pressures that each would exert if it occupied the same space alone.

If a volatile liquid is added to a gas, and the resulting mixture of gas and vapor is allowed to expand so that the pressure remains unchanged, the volume of the mixture will exceed the original volume of the gas. The ratio of this new volume to the original volume of the gas is equal to the ratio between the combined pressure of the gas and vapor, and the pressure of the gas alone, had the volume remained constant.

**Deposits in Water Jacket.** If the cooling water contains lime or alkali, the heating of the water in the jacket will cause these solid substances to be deposited in the cooling spaces. This will soon choke any narrow ports and prevent proper circulation, resulting in overheating, rapid wearing of the valves, and loss of power and efficiency. A simple remedy consists of the application, at regular intervals, of a dilute solution of hydrochloric, or muriatic, acid, made as follows: Dilute one part of muriatic acid with nineteen parts of water, and, after draining the jacket completely, pour in enough of the solution to fill the entire cooling space. Allow the mixture to remain in the jacket for not more than 8 to 12 hours, after which wash the cooling space thoroughly by running clear water through it. If the solution is permitted to remain in the jacket longer than the period stated, there is danger that the metal may be damaged by the action of the acid. The acid will soften and dissolve the lime or alkali, and the clean water will remove it from the jacket.

It is generally sufficient to apply this method of removing the deposits once every two weeks. If neglected too long, the acid will not dissolve the deposit.

**Differential Gears.** So long as an automobile moves in a perfectly straight path, its two driving wheels turn at equal speed, since they must cover equal distances in equal periods of time, and it would be perfectly allowable that the two wheels should be locked together, as there would be no relative motion between them. The power could be transmitted to either one, or to both of them with perfectly satisfactory results under these circumstances. When, however, a car is to be moved in a curved path, as in turning a corner, the driving wheels must move at different speeds, since the outside one has to cover a longer distance in the same time than does the wheel which is on the inside of the curve. If the two wheels were locked together under these conditions, one or both of them would be forced to slip, as the speeds transmitted to them would be equal, while the distances they are to travel are unequal. This difficulty is successfully overcome by the use of the differential gear which transmits the power from the change-speed gear to the rear axle, or driving wheels of the car. Differential gears consist of a set of four or more gears attached to the ends of two shafts that meet, and are usually in line, so that both are rotated in the same direction. But, if either meets with extra resistance it may rotate more slowly than the other, or may stop altogether.

These gears are used on the driving axles of automobiles. The axle is made in two parts, with a gear on the end of each, where the parts come together. Other gears mesh with both these axle gears, and are driven from the engine by a sprocket and chain, or by bevel gears and shaft. These gears turn the axle, but permit

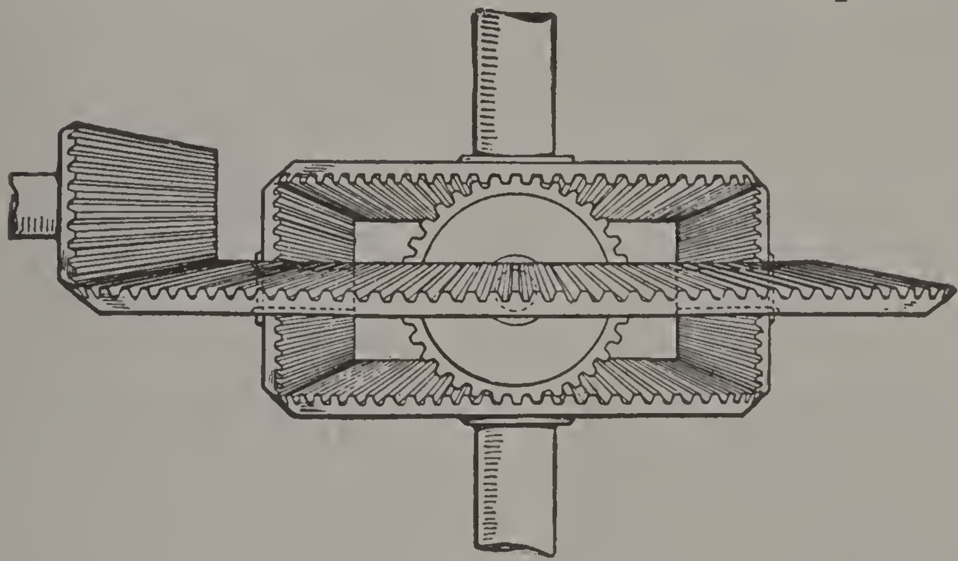


Fig. 115
Bevel Gear Differential With Bevel Driving Gear and Pinion

its two parts to turn in respect to each other so as to allow the automobile to go around a corner without causing the wheels to slide, or skid. The rear wheels are each fixed to a half of the rear axle, and both receive power, hence it is necessary to allow one wheel to turn at a different speed from the other, and this is accomplished by means of the differential gear.

Bevel Gear Differential. Fig. 117 shows a bevel gear differential in which A and B are the two halves of the rear axle, which is divided at its center. One of the driving wheels is carried on A, and the other one on B, while the inner ends of the two half axles are each fitted with bevel gear wheels C and D. Meshing with these two bevel gears are two, three or four bevel gears, two of which are shown at E and F. These pinions are supported on radial studs which project inwardly from the casing. Upon this casing are sprocket or bevel gear teeth which are driven from the engine. The teeth of each pinion, E and F are at all times in mesh with the teeth of both the bevel gears C and D on the axle. When the car is in operation, the chain or bevel drive revolves the case containing the pinions, and the power is transmitted through the teeth of the pinions E and F to the teeth of the gears C and D and thence to the axle and wheels. So long as the vehicle travels in a straight line, the pinions act as stationary driving members, and have no occasion to revolve, as the two halves of the axle and their gears are moving at equal speeds. They merely revolve with the frame. The same teeth of the bevel pinions and gears are in contact so long as a straight path is traversed. When, however, the car is steered in a curve and different velocities are required in the drivers and the bevel gears with which they are connected, the pinions no longer act as fixed driving members, but each turns upon its stud and allows the necessary relative motion between the two bevel gears, and at the same time they continually transmit power to the two ends of the axle because they are always in mesh with each other. This compensating action may continue indefinitely through any amount of variation between the driving wheel rotation, because one

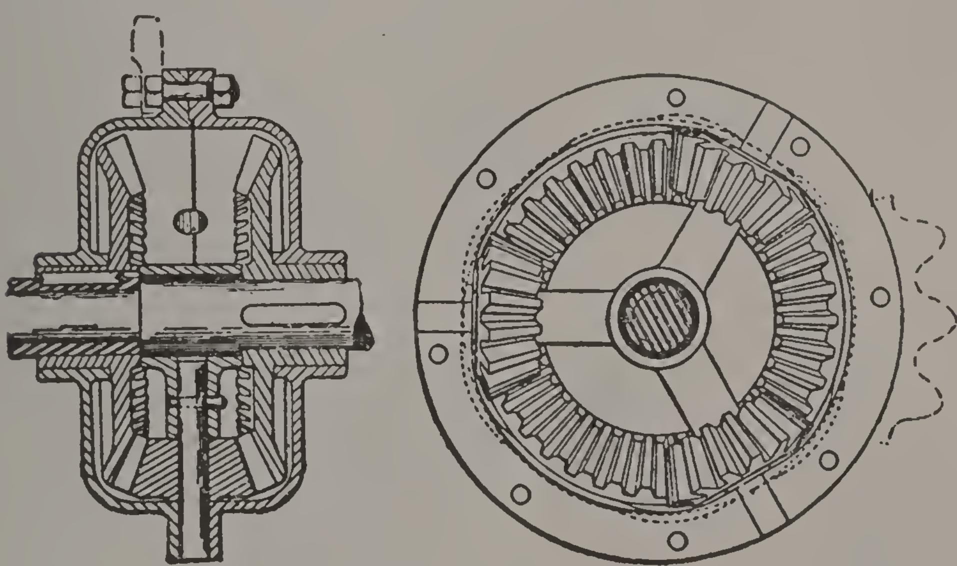


Fig. 116
Bevel Gear Differential Connected to Sprocket

tooth of the pinions comes into play as fast as the preceding one disengages with the bevel wheels on the shaft. Fig. 116 presents a larger view of the bevel gear differential, the two gears on the rear axle being shown as secured to the shaft, and to a sleeve on the shaft. The differential employed here has three bevel pinions turning on radial studs, which are secured to the arms of a spider at their inner end. A differential bevel gear, although most extensively used, is open to the objection that the bevel gears impose an end thrust upon the two halves of the mainshaft on rear axle. This has led to the design of differentials in which only spur gears are used.

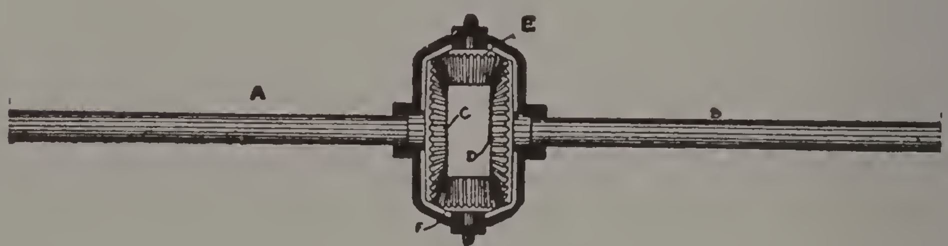



Fig. 117.
Bevel Gear Differential.

BEVEL GEAR DIFFERENTIAL. Fig. 118 shows a semi-sectional view of the bevel differential gear. The engine shaft carries a bevel gear wheel shown in section at a. This gear meshes with the large bevel gear b, on the differential gear case c. On the inside of this gear case are carried a number of small bevel gears, one of which is shown in section at d. These are free to turn on the studs that hold them to the gear case. These gears in turn mesh with bevel gears e and f, on the ends of the half axles.

The principle governing the action of the bevel gear differential is similar to that of the spur gear differential. When the two bevel gears e and f on the half axles meet with the same resistance, the small bevel gears d do not turn on their bearings; but when the movement of one of the gears e or f is resisted more than

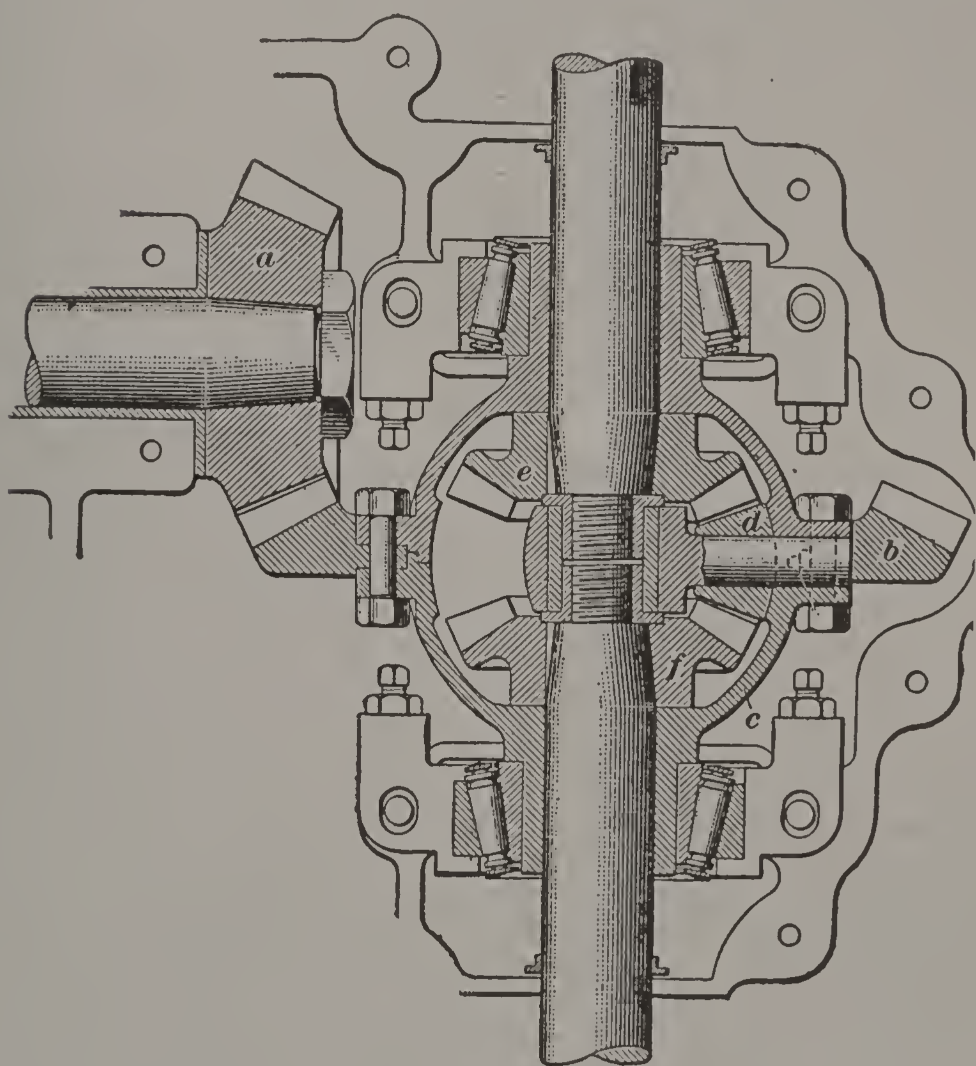



Fig. 118

that of the other it lags behind, causing the small bevel gears d to turn on their axles sufficiently to equalize the resistance.

Spur Gear Differential. In the spur differential, bevel gears are replaced by gears of the spur type, as shown in Fig. 119, a large spur gear being secured to each half axle, as shown at A and B, exactly as are the bevel gears. A double set of spur pinions, E and F, having their bearings in the frame, revolve

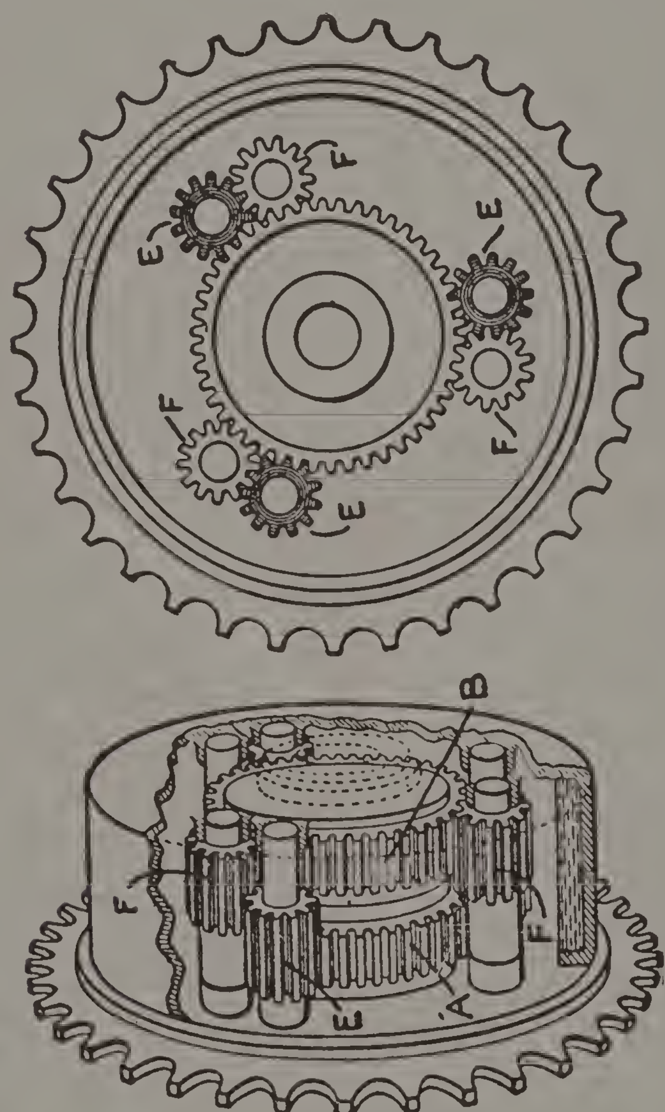



Fig. 119
Spur Gear Differential

upon axes parallel with the axle. For each bevel pinion is substituted a pair of spur gears, E and F, which mesh with each other, and at the same time each one of them is in mesh with one of the large gears. The combination of the motion of each pinion of the pair upon its gear, and the motion of the pair upon each other produces the same effect as the use of a bevel pinion. When the vehicle is rounding a curve, one rear wheel moves less rapidly, causing the pinions with which it is geared to revolve upon their bearings, and thus compensate for the increased resistance.

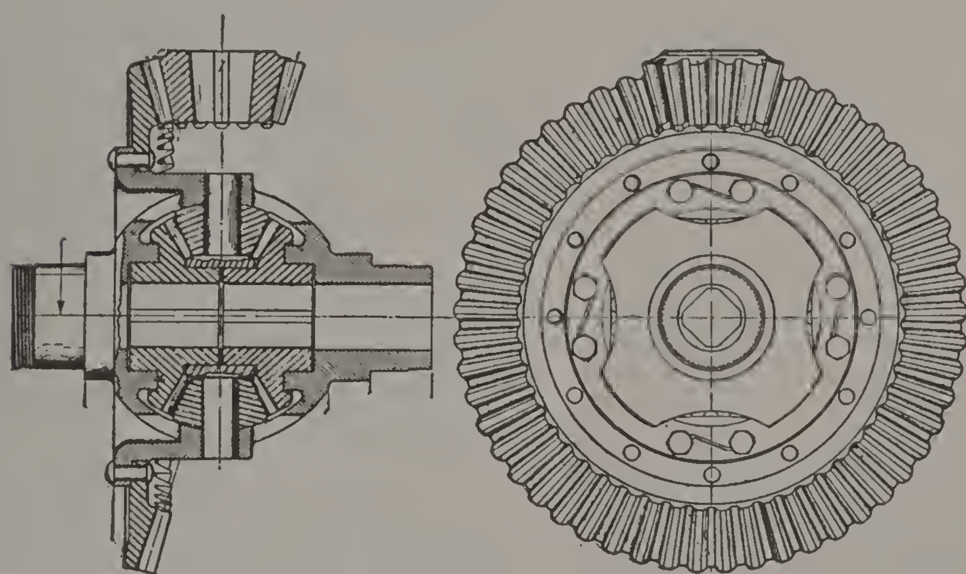


Fig. 120
Sectioned and Side View of Bevel Gear Differential

TESTING DIFFERENTIAL GEARS. The differential gear should be tested with a view to locating any wear or side play. This may be done by jacking up the rear axle and shaking one wheel forward and backward while the other is held stationary, and noting how far the wheel must be turned before the movement is taken up by the flywheel of the engine. Any noticeable play will generally be found either in the center pinions of studs of the differential gear, in the large and small bevel gears, in the clutch sleeve, or in the universal joints. The differential gear, and live axle of modern cars seldom give trouble if kept properly lubricated, and the car's mileage should run up into many thousands before any considerable amount of play is evident. The joint pins of the propeller shaft may become loose through wear, in which case a knocking noise in the transmission gear will indicate the cause and location of the trouble. These pins may be readily replaced with new ones at small cost. If the play is found in the bevel gears, the small gear should be adjusted to mesh deeper with its larger mate. This may be done by means of the adjustable locking ring or by inserting a washer of the proper thickness. It may be found, however, that no adjustment is necessary, and a thorough cleaning with gasoline to remove all oil and grease will be all that is required. The case should then be refilled with the quantity of oil and grease recommended by the manufacturers.

**Distributers.** Instead of employing a separate spark coil for each cylinder of a multi-cylinder engine, the primary circuits of which are made and interrupted in rotation, a device known as the distributer may be used, which permits of any number of cylinders being sparked from a single coil. In magnetos designed for jump spark ignition of multi-cylinder engines the distributer forms part of the magneto and is rotated by it. The distributer is nothing more than a timer of secondary current, and generally consists of a cylindrical shell of insulating material, upon the inside of the cylindrical surface of which equidistant metallic segments in number equal to the motor cylinders are inserted. A conducting arm rotating upon a shaft concentric with the insulated shell carries a brush, which successively makes contact with the segments. The arm is in permanent electrical connection with the free secondary terminal of the coil, and each one of the segments is wired to the spark plug of a cylinder.

In the case of four-cylinder motors the moving arm is geared at one-half the speed of the motor, thus making contact for each cylinder once in each two revolutions or complete cycle.

**Dynamometer.** A dynamometer is a form of equalizing gear which is attached between a source of power and a piece of machinery when it is desired to ascertain the power necessary to operate the machinery with a given rate of speed.

**Electricity, Forms of.** Electricity or electrical energy may be generated in several ways—mechanically, chemically and statically or by friction. By whatever means it is produced, there are many properties which are common to all. There are also distinctive properties. The current supplied by the storage battery will flow continuously until the battery is practically exhausted, while the current from a dry battery can only be used intermittently; that is, it must have slight periods of rest, no matter how short they may be.

The dynamo or magneto current is primarily of an alternating nature, or one which reverses its direction of flow rapidly. In use, this alternating current is changed into a direct or continuous current flowing in one direction only, by means of a commutator. Any of the forms described are capable of igniting an explosive charge in a motor cylinder, but the static or frictional form of electricity is not used for this purpose on account of its erratic nature.

**Electric Apparatus—Care of.** The following instructions apply particularly to electric apparatus in connection with the operation of automobiles. Look over the electrical plant and replace worn wires with new. Clean out the timer with gasoline and lubricate with light oil. The magneto need not be taken apart, as it will probably only need a little surface cleaning, a few drops of oil, and the amateur had better not meddle with its internal mechanism. The storage battery should be examined, and if the brown deposit collects in any quantity at the bottom, the electrolyte should be poured out into a glass bottle, and the battery washed out with clear water (rain water preferred). Clean the top of the battery and make it a point to keep it clean and free from acid. Clean the terminals of any corrosion, and see that the air vents are not clogged up. If the accumulator has been neglected, either in the electrolyte having been allowed to get below the proper level or in not giving it the regular monthly "charge," it may get a bad case of sulphating.

To get the battery into its normal condition, empty out the electrolyte and wash the case thoroughly with soft water. Pour in only about seven-eighths of the acid solution and fill up with distilled water to cover the top of the plates. The battery should then be charged with a low current until the plates are restored to their normal condition. If very badly sulphated, the white coating should be washed off with a rag, and in case this fails to remove it, scraping must be resorted to. If the electrolyte is not sufficient to cover the top of the plates, fill up with distilled water so that the liquid will just cover them. The specific gravity of the electrolyte should not be less than 1.150, and, although varying somewhat, a hydrometer reading of 1.250 is recommended. This is approximately 1 part of sulphuric acid to 4½ parts of water, which will be found sufficiently accurate if no hydrometer is at hand. If the electrolyte should test lower than the first figure, add pure sulphuric acid until the 1.250 mark is reached.

In case the plates are broken down or "buckled," or if the paste has dropped out of the pockets of the grids, the accumulator should be sent to the manufacturers for repair. In some accumulators the liquid is not used, but a jelly made of silicate of sodium and dilute sulphuric acid takes its place. If your battery is of this type, it is well to remember that the jelly must be kept moist on the top, and as the emulsion becomes dry a little water should be added to replace that which is lost through evaporation.

The contact points of the coil will probably require adjusting. This is very easily accomplished by trimming up the points with emery paper. Do not rub away the metal unnecessarily, only removing enough to true the points so that they make a good contact. In adjusting the vibrator, remember that a light tension is much better than a stiff tension. A light flexible vibration with a moderately high-pitched buzzing note will not only give a better spark, but will keep the points in better shape.

A heavy tension will make the coil less responsive and will pit the contact points and exhaust the battery more quickly. As a coil will render the most efficient service only when the vibrators are adjusted as nearly alike as possible, a special ammeter is often used to determine the current consumption of each unit. The ammeter should show a reading of 6-10 amperes.

**Electric Horsepower.** See *Horsepower.*

**Electric Ignition.** See *Ignition.*

**Electric Lighting and Starting.** See *Starting and Lighting Systems.*

**Electric Lighting and Starting.** See last part of this volume.

**Electromotive Force, Definition of.** The cause of a manifestation of energy is force; if it be electric energy in current form it is called electromotive force. An electromotive force or pressure of one volt will force one ampere through one ohm of resistance.

## Engines, Internal Combustion.

**Engine—Construction of.** An automobile engine should answer the following requirements in order to meet the demands of the motor user: It must be of light weight in proportion to its horse power, so that as large a proportion of its power as possible may be available for propelling the useful load, and but little demanded to move its own weight; it must be compact, in order that it shall not occupy too large a proportion of the available room of the car; it must operate without undue noise and vibration; it must be fully enclosed as a protection against the weather, and still it must be so located as to be easily accessible for inspection, oiling and repairs; its operation must be automatic for considerable periods of time, as regards cooling and lubrication; it must be capable of running very slowly, or very fast at will, and of developing little, or much power; it must be supported upon the car in such a manner that its power may be most readily and efficiently transmitted to the driving wheels, and it must further be carried upon springs so that the jar and shock from the road shall not be transmitted to it.

Explosive Motors. Explosive motors are of three forms, known as stationary, marine and automobile. Their general characteristics are implied by their various designations. The stationary motor may be either vertical or horizontal. Marine motors, designed for application to boats, are almost invariably vertical. Automobile motors are of comparatively recent introduction and of great variety, the aim of the designers being to secure the maximum of power and minimum of weight. They also may be vertical or horizontal.

These three forms may be again divided into two-cycle and four-cycle types. In the former an explosion occurs at every revolution. In the latter there is an explosion at every alternate revolution.

Explosive motors are dependent for successful operation on two things: First, a charge of gas or vapor, mixed with sufficient air to produce an explosive mixture, and second, a method of firing the charge after it has been taken into the combustion chamber of the motor.

When coal gas is used the supply is taken from the main and mixed directly with the necessary proportion of air. When gasoline is used, air is mixed with it in the correct proportion by carbureting devices.

After the charge of gas and air has been taken into the cylinder it is compressed, as will be shown later, by the action of the motor itself and then fired, usually by an electric spark actuated by the motor, but sometimes by the use of a tube screwed into the cylinder and

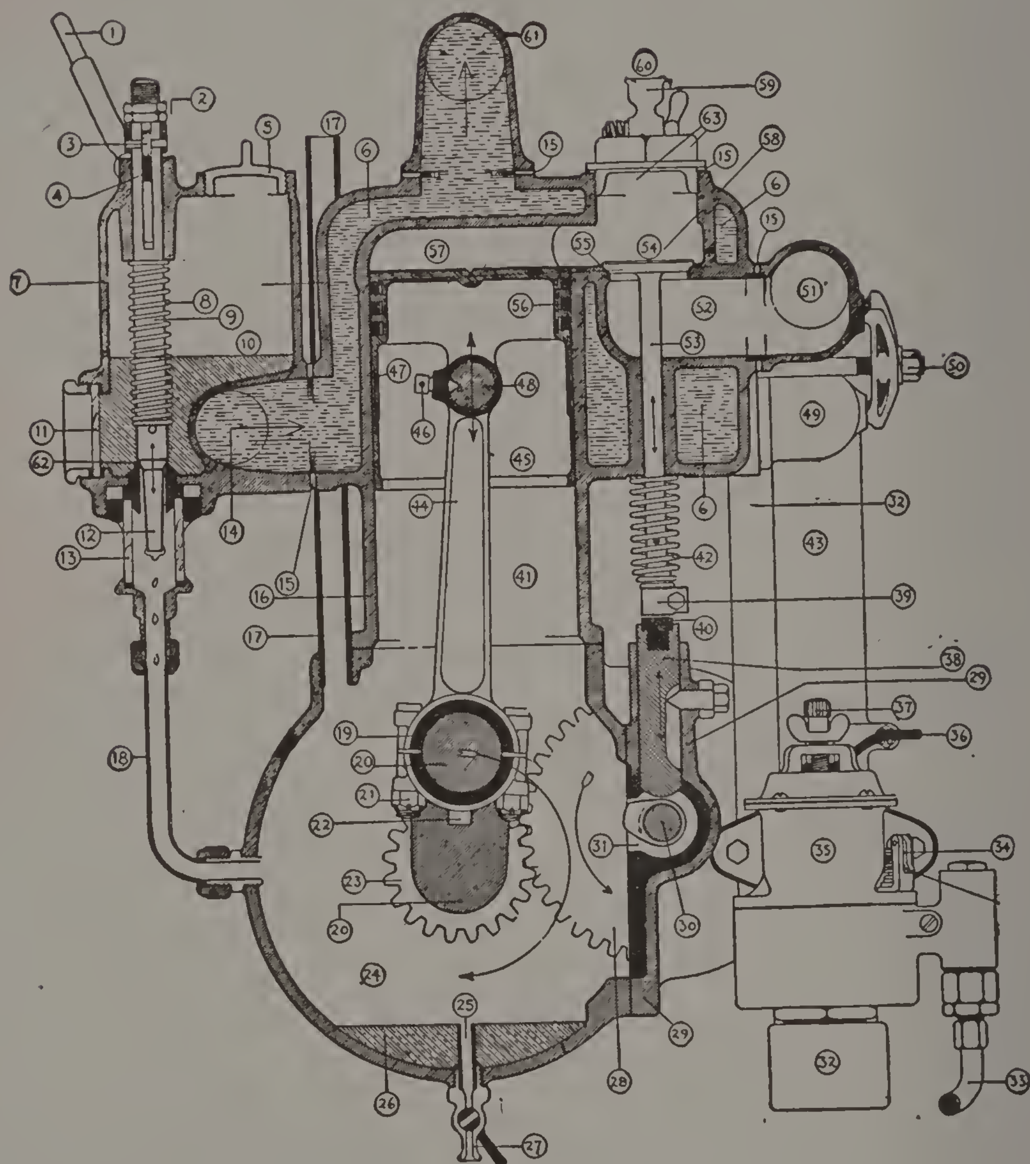


**Fig. 121**

Internal Combustion Automobile Engine. 1, Oil Valve Lever. 2, Oil Valve Adjustment. 3, Oil Valve Lifter. 4, Oil Valve Slot. 5, Oil Tank Cover. 6, Water Jacket. 7, Oil Tank. 8, Oil Valve Spring. 9, Oil Valve Plunger. 10, Oil. 11, Oil Gauge Glass. 12, Oil Valve. 13, Oil Feed Window. 14, Water Inlet. 15, Cylinder Joint. 16, Cylinder Wall. 17, Crank Case Breather. 18, Oil Feed Pipe. 19, Connecting Rod Bearing. 20, Crank Pin. 21, Rod Bearing Bolt. 22, Oil Scoop. 23, Crank Shaft Timing Gear. 24, Crank Case. 25, Oil Lever Overflow. 26, Crankcase Oil. 27, Oil Drain Cock. 28, Cam Shaft Timing Gear. 29, Cam Shaft Plate. 30, Cam Shaft. 31, Cam Shaft Housing. 32, Exhaust Outlet. 33, Gasoline Pipe to Carburetor. 34, Carburetor Priming Lever. 35, Carburetor. 36, Throttle Lever Rod. 37, Gasoline Adjustment. 38, Valve Lifter Rod. 39, Valve Stem Adjustment. 40, Fibre in Valve Plunger. 41, Cylinder Space. 42, Valve Spring. 43, Exhaust Pipe. 44, Connecting Rod. 45, Piston. 46, Wrist Pin Set Screw. 47, Oil Groove in Piston. 48, Wrist Pin. 49, Exhaust Manifold. 50, Manifold Clamp Nut. 51, Intake Manifold. 52, Intake Passage in Cylinder. 53, Valve Stem. 54, Valve Head. 55, Valve Opening, Seat and Face. 56, Piston Rings. 57, Combustion Space. 58, Valve Pocket. 59, Priming Cup. 60, Valve Cap. 61, Water Outlet Header. 63, Valve Cap.

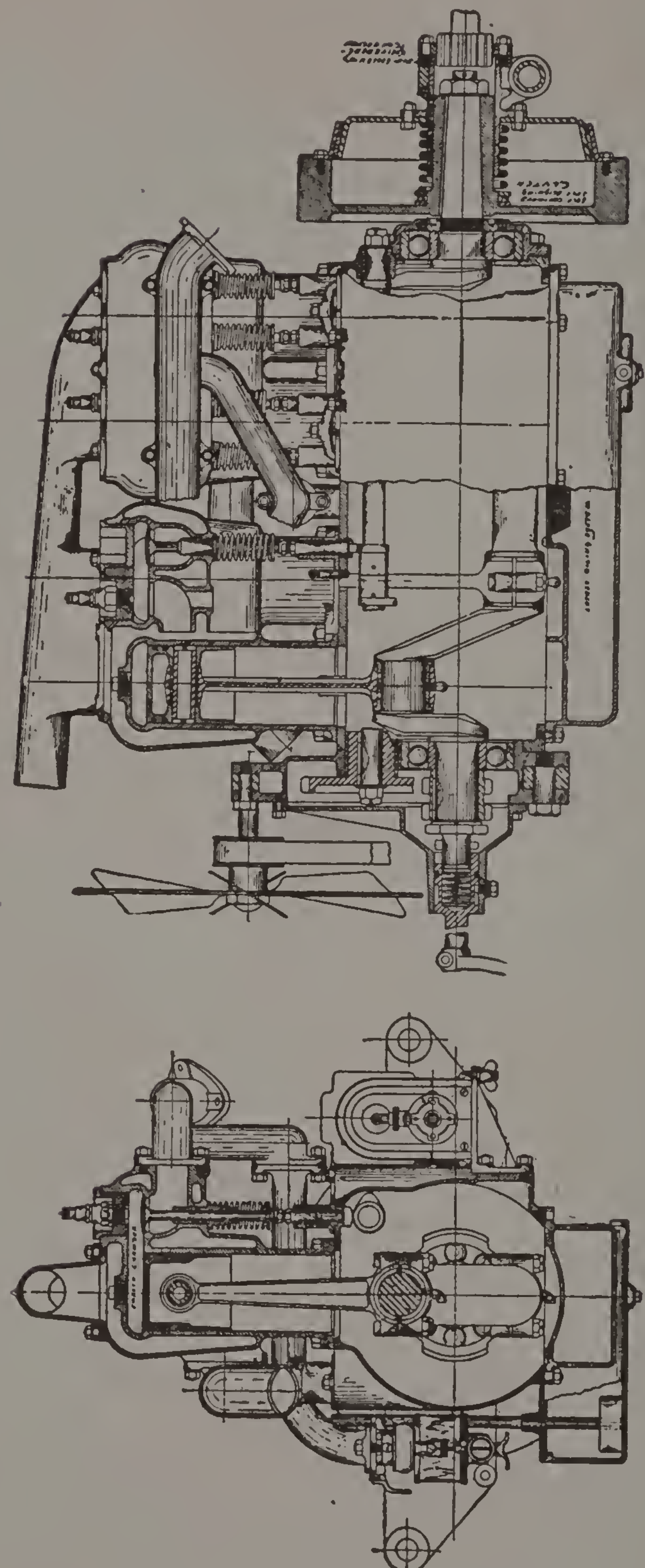


Fig. 122

Front and Side View of Section Through Four Cylinder Automobile Engine heated from the outside, the heat, of course, being communicated to the gas. The resulting explosion operates the motor.

The principal parts of a four-cycle explosive motor are the cylinder, the piston, the piston rings which fit into grooves in the piston: two sets of valves, one to admit the charge and the other to permit it to escape after the explosion; a crank shaft and connecting rod which connect it with the piston head, and a flywheel, whose presence insures steady running of the motor, and whose further functions will be better understood as the description proceeds. In the two-cycle form of motor there is really but one valve, the exhaust and admission-ports being covered and uncovered by the piston itself.

All of the parts referred to are of the motor proper. Other parts, which are separate from the motor but on which its operation depends, are the carbureter, which supplies the charge of gasoline vapor and air for a gasoline motor, or a mixing chamber for mixing air and gas in the case of a gas motor, and the batteries and other parts of the electrical ignition device.

A part which has no connection with the actual running of the motor but with which practically all are fitted is the muffler, whose purpose is to deaden the sound of the explosion.

The cylinders of all except very small motors are as a rule partly encased in a chamber through which water is circulated, the object of this being to keep the cylinder cool.

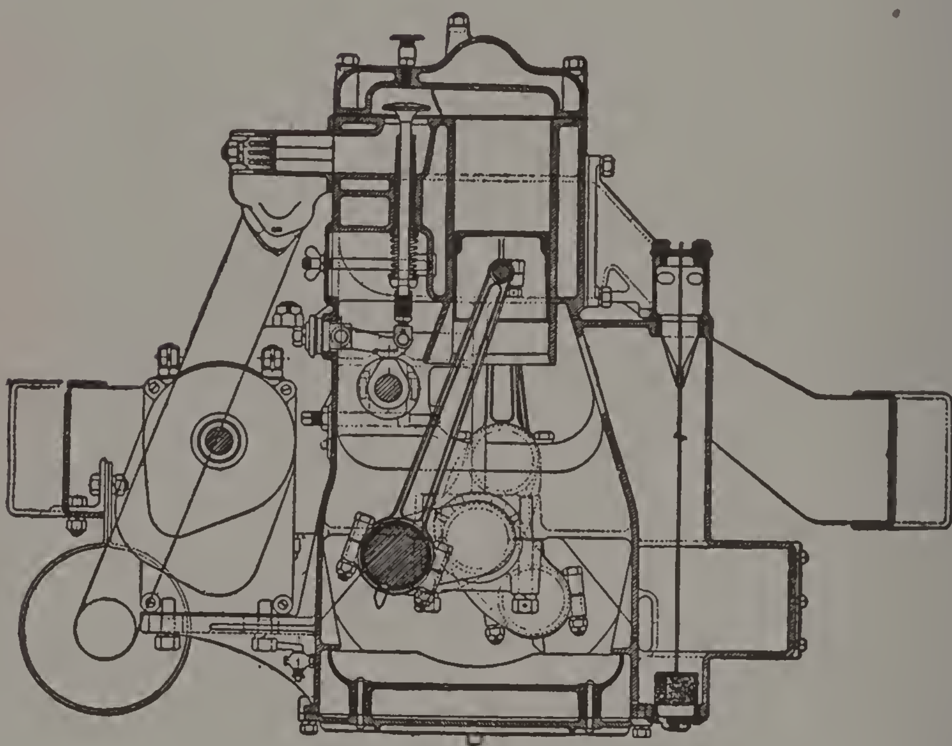


Fig. 123

Section Through Six Cylinder Long Stroke Engine

Offset Crankshafts. The practice of offsetting the crankshaft in automobile motors is rapidly gaining converts, and there are numerous examples of offsetting to be seen at the present time. In this scheme, it will be remembered, the crankshaft is not set in the plane of the middle of the cylinders. In other words, the crankshaft is set slightly to one side. The exact amount of this offset seems to be variable

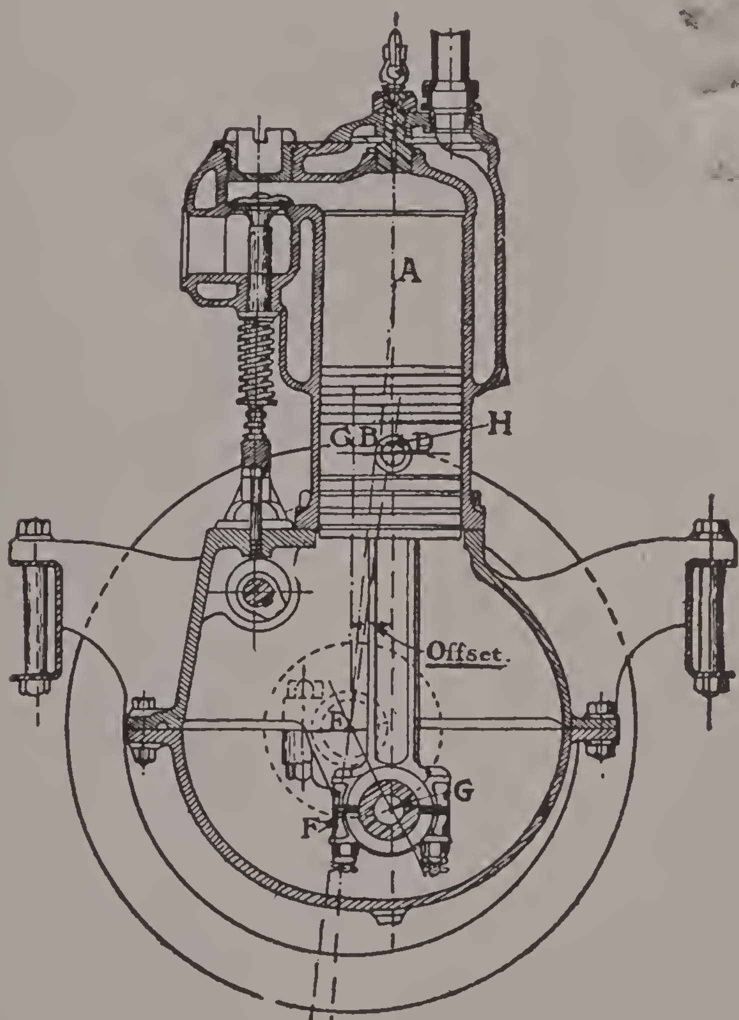



Fig. 124
Section Through Engine with Offset Crank

with different designers, but the object is always the same. When the piston is in the position of maximum compression involving the ignition and flame propagation, it is the idea to have the connecting rod in the vertical position. The force of the explosion will then come on the connecting rod endwise and the piston will not be pressed unduly against the cylinder walls.

OFFSET CRANK SHAFT ENGINE—TIMING THE VALVES. To time the valves of an engine having an offset crankshaft, the inclination of the axis of the connecting rod must be taken into account. As Figure 124 shows, the connecting rod is vertical, and if the shaft center were not

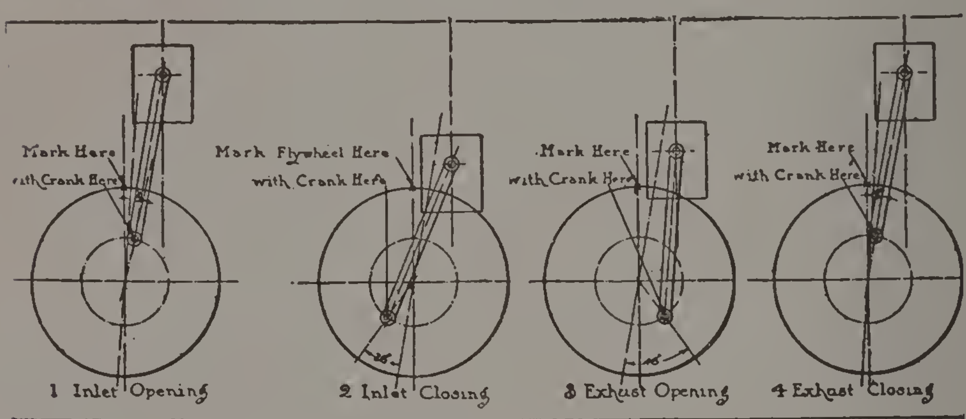



Fig. 125
Diagrams Showing the Four Positions of the Offset Crankshaft

to one side, the flywheel would be marked at the exact center of the upper face, namely, at C. In the case where the center is set over, the rod, when in a vertical position as at G is not at the end of the stroke. If the flywheel were marked at C it would not indicate correctly the lower dead center. This does not appear until the three centers, piston pin, crank pin, and crankshaft are in line, as shown by the line D E F. The flywheel should be marked at this point, and the mark may be on a vertical line through the crankshaft center or on a diagonal as the line just indicated. In the latter instance, the mark for the lower center would be at H.

Similarly, the upper dead center, if marked, would be at a vertical point above the shaft center as C, but would assume a different position, located on a diagonal, as at A, on the center line A B E.

Of course, in actual timing, the upper and lower centers are not used, as good practice decrees an overlap for the valve action, but they have been used as an illustration in this case because their use simplifies the matter.

In Fig. 125, the actual marking of a flywheel is shown for a complete cycle. In this the angles selected follow the best modern practice, being as follows: Inlet opens at 8 degrees past the upper center, and closes at 26 past the lower center, giving an inlet opening, total, of 198 degrees. Exhaust opens at 46 degrees before the lower center and closes at 5 past the upper. This gives the whole angle for the exhaust, 231 degrees on the crankshaft.

As shown, the markings are put on the flywheel directly above the center of the crankshaft, but the offset is taken into account.

Pistons. The piston used in a gasoline motor cylinder is of the single-acting or trunk type. It is made of an iron casting which is a good working fit in the cylinder. Around the upper end of the piston three or four grooves are cut, and in these grooves the piston-rings fit. The rings are made of cast iron, and the bore of the ring being eccentric to its outer diameter, there is a certain amount of spring in them, and so pressure is caused against the cylinder wall, preventing any of the expanding gases passing the piston.

PISTON MATERIALS. Until recently it has been the universal practice to make internal combustion engine pistons of cast iron for the reason that this material does not warp under heat to such an extent as does steel. The principal objection to cast iron has been its comparatively high weight, this weight being necessary because of the lack of great strength in the metal. It is a well known fact that cast iron is very brittle. With the advent of the modern high speed engine, experiments were conducted with steel pistons because of the fact that they allowed of lighter construction with equal strength. Steel pistons have done satisfactory work, but are very high in production cost, and this has prevented their general introduction.

The necessity for reducing the weight of the reciprocating parts has more recently led to the introduction and use of pistons made from alloys of aluminum, which, of course, gives the desired reduction in weight. The fit of the piston in the cylinder cannot be so tight when cold as with cast iron or steel, but as soon as the engine has run a few moments, the expansion due to heat allows the piston to fit close enough for all practical purposes. These pistons are now fitted in many makes and models of stock cars and may be fitted to cars already in use.

Piston Displacement. The piston displacement of a motor is the volume swept out by the piston, and is equal to the area of the cylinder multiplied by the stroke of the piston. The expression, cylinder volume, is sometimes confounded with the term piston displacement. This is erroneous, as the cylinder volume is equal to the piston displacement, plus the combustion space in the cylinder head.

Pistons, Length of. For vertical cylinder motors the length of the piston should not on any account be less than its diameter, while a length equal to one and one-quarter or even one and one-third diameters is better. For motors with horizontal cylinders the length of the piston, in any case, should not be less than one and one-third diameters, and if possible one and one-half diameters or over.

Piston Position. There is nothing more confusing to many motorists—not only to the beginner, but to many who are proficient in the general care and operation of their motor cars —than the relative various positions, in a four-cycle engine, of the four pistons on any of their four cycles of compression, work, explosion, and exhaust, this being the order of the cycles.

In the following illustrations the pistons are shown as they are usually placed in relation to

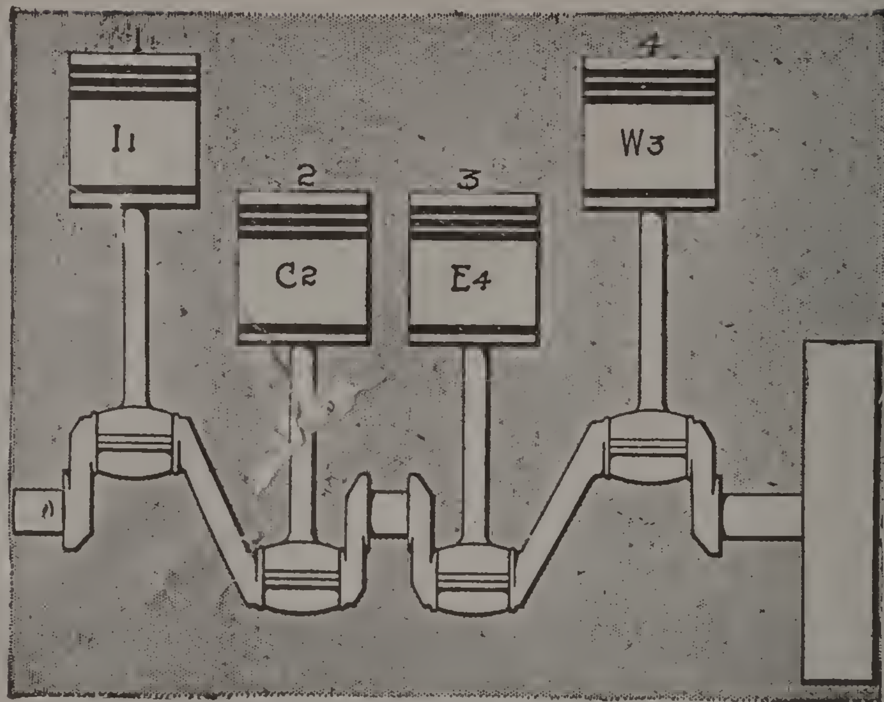



Fig. 126

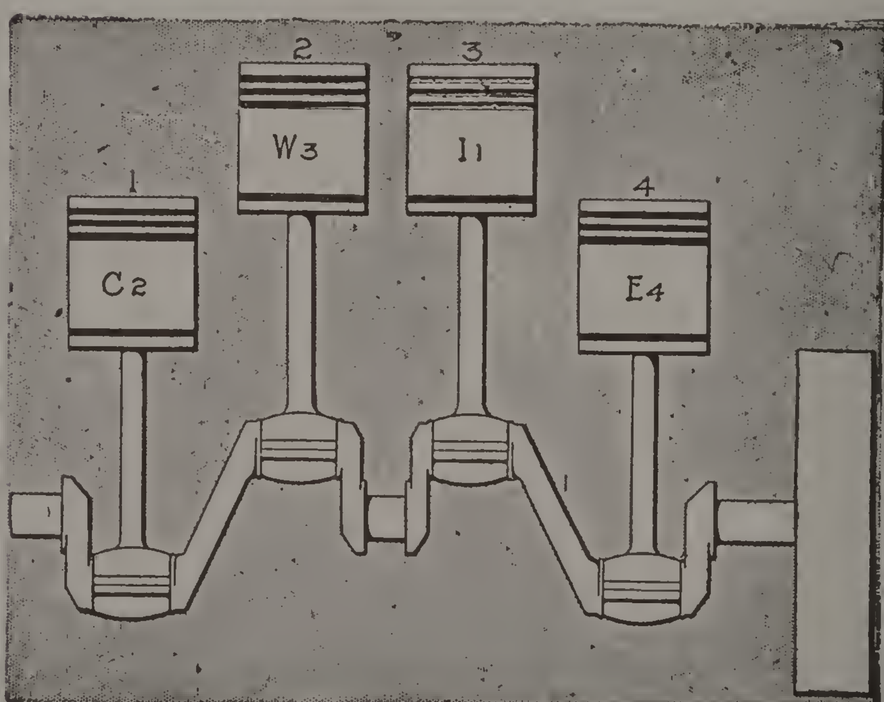



Fig. 127

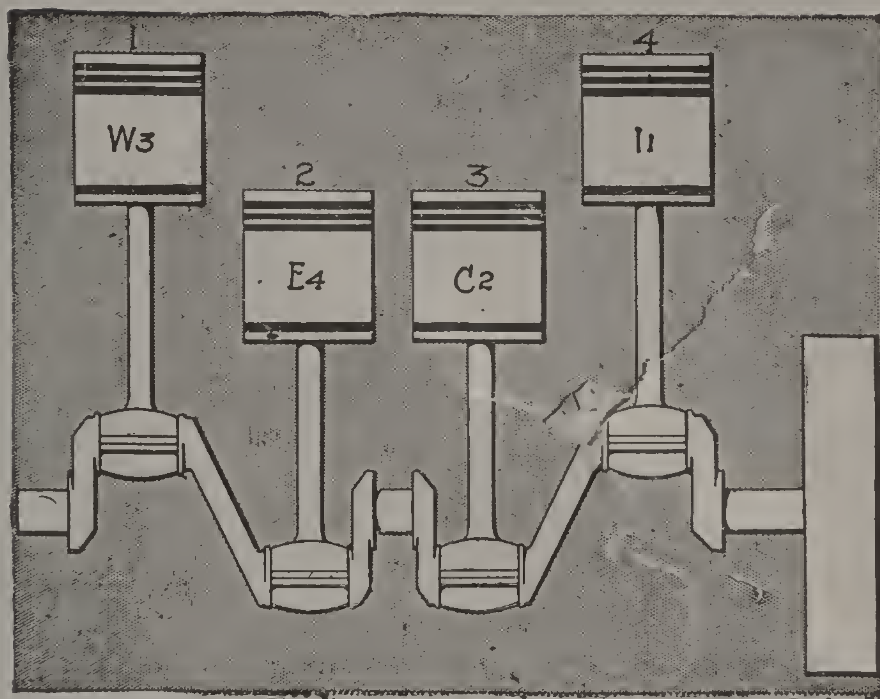



Fig. 128

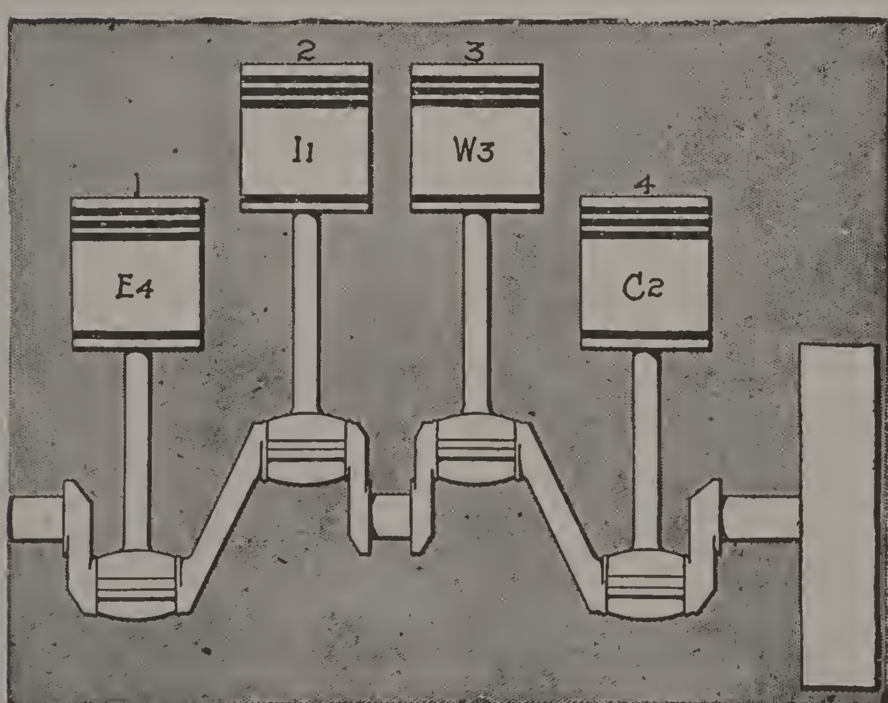



Fig. 129

one another. That is, pistons 1 and 4 are at the top of their strokes when pistons 2 and 3 are at the bottom, and, obviously, vice versa. The figures over the pistons in each diagram represent their order of number, counting from either end of the engine.

In Fig. 126, cylinder I is ready to descend on its intake stroke—having finished its exhaust stroke—and cylinder 4 is ready to descend on its working stroke—having finished its compression stroke. Cylinders 2 and 3 are ready to move on their up strokes, No. 2 on its compression, having finished its intake, and No. 3 on its exhaust, having finished its working stroke. The results are that the pistons are brought into the positions shown in Fig. 127. This means that cylinder No. 1, having completed its intake downward stroke, is ready for its compression up stroke; No. 2 has moved up on compression and is ready to go down on work; No. 3 has finished exhausting and is ready for intake and No. 4 has finished the work stroke and is ready to move up on exhaust. Piston No. 2, having completed its work stroke, the pistons are brought back to the positions shown in Fig. 126, but with an altered condition of the cycle represented by each, as shown in Fig. 128. The pistons are now ready to move to the positions shown in diagram 2, with an altered cycle condition. Cylinder No. 1 moves down on work; No. 2 up on exhaust;

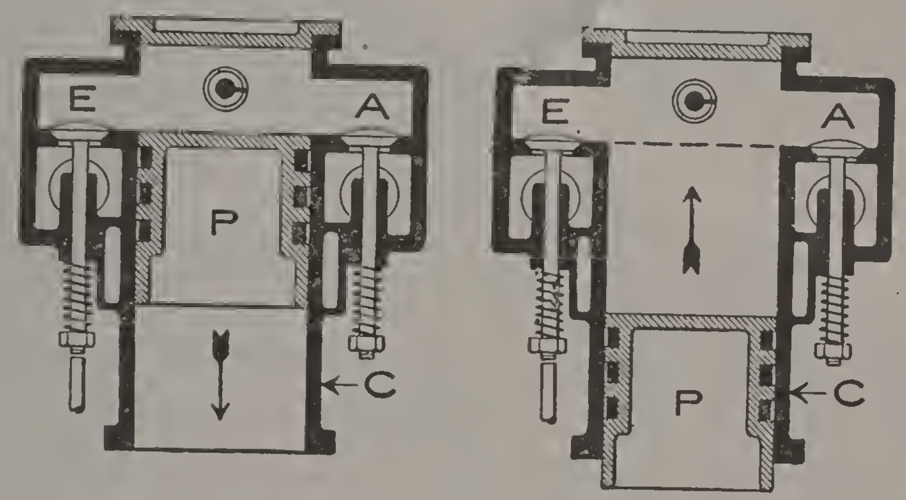
No. 3 up on compression and No. 4 down on intake, see Fig. 129.

When the cycle of each has been completed, from the above starting points of No. 1, exhaust; No. 2, intake; No. 3, work, and No. 4, compression, the pistons are then back not only in the position of Fig. 126, but with the same condition of cycles.

This explanation has been in the order of the cylinder numbers, but the effect of each cycle of each cylinder will be easier traced if it be remembered that the order in which the cylinders work is: Cylinder 1, then cylinder 3, then cylinder 4, and then cylinder 2, and then repeat indefinitely. From this and the above illustrations it will be easily understood that as piston No. 1 goes down on its work stroke, No. 3 comes up on compression stroke, and is then ready for the work, which is a down stroke bringing No. 4 up on compression. No. 4 then goes down on work and brings No. 2 up on compression, then it goes down on work and brings No. 1 up on compression for the repeating of cycles. This shows that each synchronized pair, 1-4 and 2-3, always have one cycle between them as they move together, either up or down.

Piston-Rings. To ensure proper compression, it is absolutely essential that the piston-rings should be kept lubricated; consequently when the motor has been idle for some time, the compression at the start is often poor. Any failure in the lubrication while running will, of course, have the same effect, such, for example, as in the case of overheating, or when the supply is intermittent. Sometimes the piston-rings get stuck in their grooves with burnt oil, through overheating, and the compression escapes past them. Thorough cleaning with kerosene, and fresh lubricating oil will settle the matter. In motors where the rings are not pinned in position, the slots may work round so as to coincide. In this case they will have to be moved around. Sometimes burnt oil may, apparently, have the opposite effect on piston-rings, for by causing the piston to grip in the cylinder, it will produce considerable resistance, and the operator might erroneously think in consequence that his compression is good. In every case, after a long run, a little kerosene should be injected into the cylinders to clean the rings.

Piston-Rings—Method of Turning. A pattern should be made from which to cast a blank cylinder or sleeve with two projecting slotted lugs on one end to bolt same to face plate of lathe. This blank should first be turned off outside to the required diameter, making it, of course, sufficiently larger to allow for the cut in the rings, after cutting from the blank. The blank should then be set over eccentric sufficiently to allow the thick side of the rings to be twice the thickness of the thin side after turning. The inside of the blank can then be bored out, and the rings cut off to the exact thickness required with a good sharp cutting off tool. A mandrel or arbor should be made with two cast iron washers or collars to fit it, one fastened to the mandrel and the other loose, with lock nut on mandrel with which to tighten up the loose collar. After the rings have been sawed open and a piece cut out the required length, they can be placed on a collar or ring




FOUR-CYCLE MOTOR DIAGRAM

Fig. 130.

about 1-32 to 3-64 of an inch larger than the cylinder bore, and slipped on to the mandrel one at a time, of course, with the loose collar and nut off the same. The loose collar and nut can then be put on the mandrel, the ring clamped tightly between the two collars, the mandrel put in the lathe and the ring turned off, without leaving any fins or having to cut the ring off afterward as is done in many cases. This is the only way in which a perfectly true ring can be made.

Four-Cycle Motor. Fig. 130 furnishes two sectional views of a four-cycle type of motor with some of the parts removed, as in Fig. 121. It shows a cylinder C, admission-valve A, a piston P, and exhaust-valve E.

The left-hand view shows the piston P about to suck in a charge of vapor, by the same method as previously described, through the admission-valve A into the cylinder C. The suction continues until the piston P reaches the position shown in the right-hand view. Then the piston returns until it again arrives at the position shown in the left-hand view, compressing the charge of mixture during this operation. Just before the piston arrives at the end of its travel in this direction, the charge of vapor, now under compression, is ignited by the method previously explained and its expansion forces the piston back to the position shown in the right-hand view. When the piston has, for the second time, reached the position shown in the right-hand drawing, a mechanical device opens the exhaust-valve. The exhaust-valve remains open until the piston has again arrived at the position in the left-hand view. Then it closes, the piston again commences to draw in a charge of vapor and the cycle of operation of the motor is repeated.

Four-Cycle Motor, Operation of. A four-cycle motor has only one working stroke or impulse for each two revolutions. During these two revolutions which complete the cycle of the motor, six operations are performed:

1. Admission of an explosive charge of gas, or gasoline vapor and air to the motor-cylinder.

2. Compression of the explosive charge.

3. Ignition of the compressed charge by a hot tube, or an electric spark.

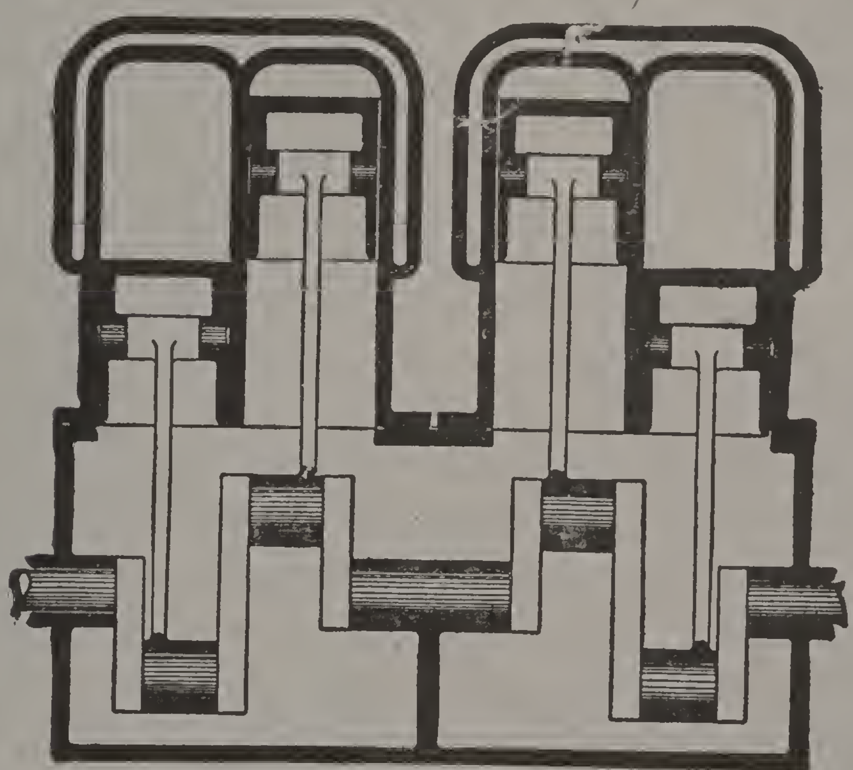


Fig. 131
Four-Cylinder Engine

4. Explosion or extremely sudden rise in the pressure of the compressed charge, from the increase in temperature after ignition.

5. Expansion of the burning charge during the working stroke of the motor-piston.

6. Exhaust or expulsion of the burned gases from the motor-cylinder.

Two-Cycle Motor. The foregoing outline of the functions of the parts of the motor prepares us for a description of the two-cycle form of motor. This particular form of motor draws in a charge of gas or vapor, compresses it, fires it and discharges the product of combustion or burned gases while the crank makes but a single revolution, and while the piston makes one complete travel backward and forward.

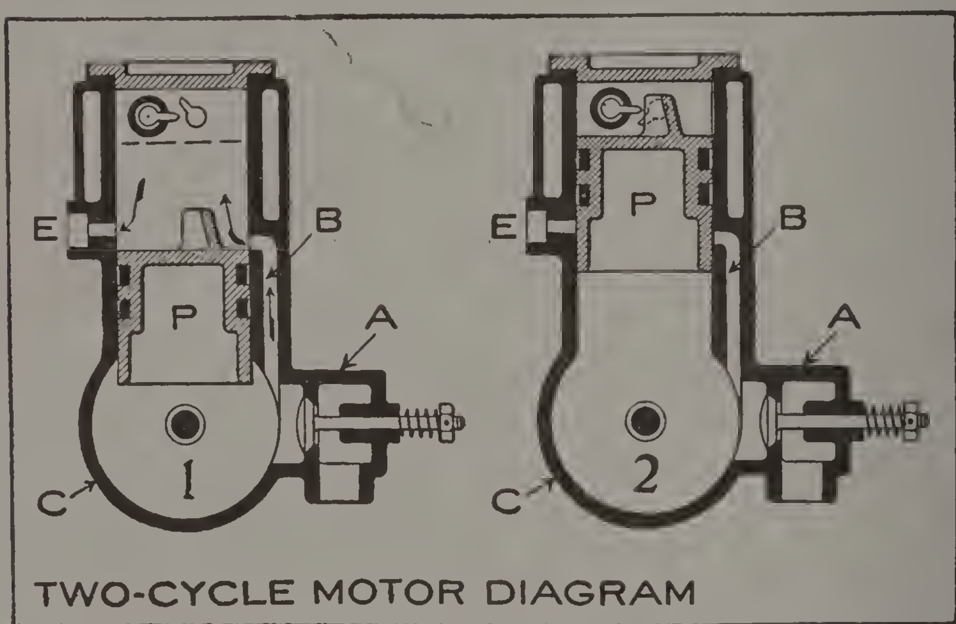



Fig. 132

Fig. 132 shows two sectional views—that is to say, views of the motor cut in two, longitudinally—of the principal parts of a two-cycle motor. Other parts, such as the crankshaft, connecting rod and flywheel, are omitted to avoid confusion. C is the crankcase and A the admission valve, through which the vapor passes to the crank case. B is the inlet passage, through which it passes from the crank chamber to the cylinder. P is the piston. The igniter, which makes the electric spark when the lower point comes in contact with the upper, is shown immediately below the cylinder cover. This causes the explosion of the vapor. E is the exhaust port, through which the burned charge escapes after the piston has been driven outward by the explosion and has reached the end of its stroke.

Let it be supposed that the motor is still and the crank chamber C is full of gas or vapor. To start the motor the piston is started by means of a crank on the flywheel shaft, and as it passes to the position shown in the left-hand drawing it forces the charge of vapor through the port B into the cylinder. The piston then returns to the position shown in the right-hand view, moving away from the crank chamber C, and in doing so closes the port B and the exhaust opening E and compresses the charge of vapor. The points of the igniter come together, a spark occurs and the resulting explosion forces the piston outward again. When the piston reaches a point near the end of the stroke, as shown in the left-hand drawing, it uncovers the port E and the burned charge passes out, the new charge coming through the port B immediately afterwards.

The admission of the new charge to the crank chamber is controlled by the action of the piston. As the latter travels outward it has a tendency to create a vacuum in the crank chamber. This draws the valve inward and admits the charge of vapor.

It will be observed that there is a projection on the head of the piston. This is generally known as a baffle-plate. Its object is to prevent the incoming charge from passing directly across the cylinder and out at the exhaust port E, which, it will be observed, is directly opposite it. The baffle-plate directs the incoming charge toward the combustion chamber end of the cylinder, providing as nearly as may be, a pure charge of vapor and assisting in the expulsion of the remainder of the burned gases remaining in the cylinder as a result of the last explosion.

Motors—Two and Three Port. In the two-port motor, as illustrated in Fig. 133, the functions are as follows:

The first stroke of the piston produces a vacuum in the crankcase and the mixture rushes in (as a consequence) through the check valve in the motor case. The second stroke compresses the mixture, and when the communicating port is uncovered the mixture surges into the cylinder. The next (third) stroke compresses the mixture entrapped in the cylinder, since the ports are then covered by the piston, and at the proper instant the mixture is ignited.

From this point on it is a normal repetition of functions, and once the motor gets under way it two cycles. The three-port motor, Fig. 134, differs in that the mixture is taken in through a third port uncovered by the piston, instead of through a check valve in the case, and the details in practice change accordingly.

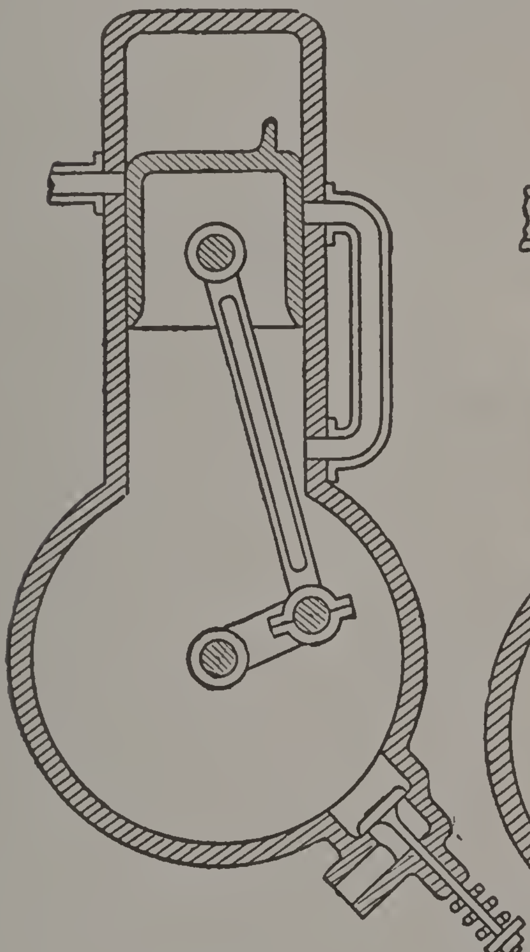


Fig. 133
Two-port Motor

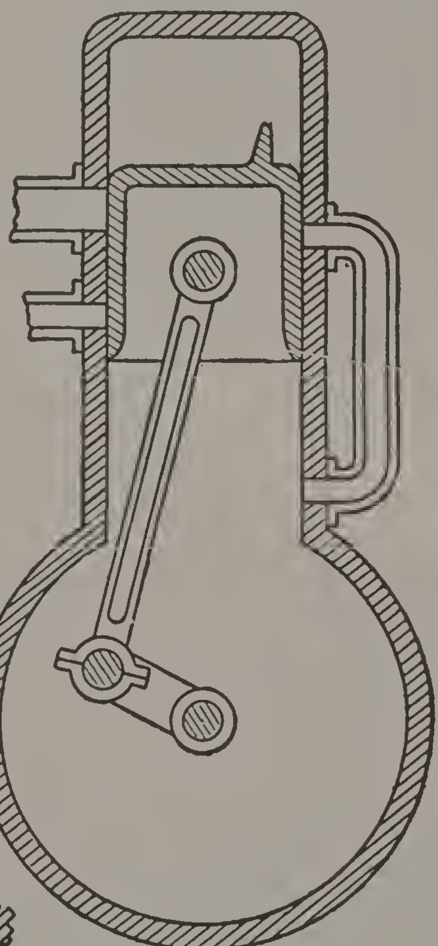


Fig. 134
Three-port Motor

**Engine, Gasoline, Fuel Consumption of.** The fuel consumption of a motor is always a serious question, and one of importance to the purchaser as well as to the manufacturer.

Ordinarily about one and two-tenths pints of gasoline per horsepower hour under full load will cover the fuel consumption. That is, when the mixture is of the proper explosive quality and the water comes from the jacket at a temperature of about 160 degrees Fahrenheit.

The temperature of the water in the jacket around the cylinder has a great deal to do with the fuel consumption.

If the water is forced around the cylinder so as to keep it cold, the heat from the combustion is cooled down so quickly by radiation that the expansive force of the burning gases is materially reduced, and consequently less power is given up by the motor.

The object of the water is not to keep the cylinder cold, but simply cool enough to prevent the lubricating oil from burning. The hotter the cylinder with effective lubrication the more power the motor will develop.

**Engine, Two-Cycle, Fuel Consumption of.** The two-cycle engine uses more fuel than the four-cycle. The greatest consumption is not so much due to the fact that the two-cycle motor makes an explosion for every revolution, in contrast with the missed stroke of the four-cycle, as it is to the fact that there is a considerable retention in the cylinder of the exhaust charge, and that, despite the deflector, more or less of the fresh charge escapes at the exhaust. The two-cycle is also harder on a battery owing to the greater frequency of the demands upon it, but with improved methods of ignition, even dry batteries have been found to give very satisfactory service.

**Engine, Sliding Sleeve Type.** The Knight sleeve valve engine, Fig. 135, is a four cycle gasoline engine in which the usual poppett valves have been replaced by two concentric sleeves sliding up and down between the cylinder walls and the piston. Certain slots in these sleeves register with one another at proper intervals, producing openings between the combustion chamber and the inlet and exhaust

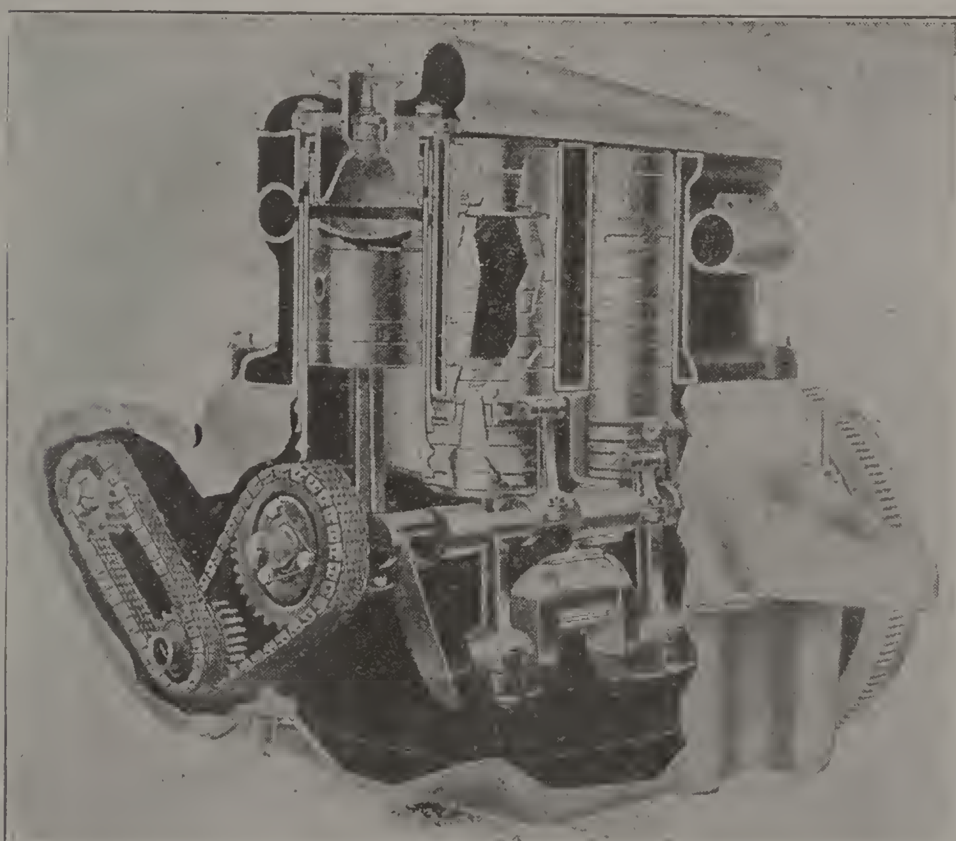


Fig. 135
Knight Sliding Sleeve Engine

manifolds for the passage of fresh gas into the cylinder and burned gas from it.

It will be noted that the two sleeves are independently operated by small connecting rods working from a shaft made with eccentrics. This eccentric shaft is driven at one-half crankshaft speed, usually by silent chains. This shaft takes the place of, and performs the same

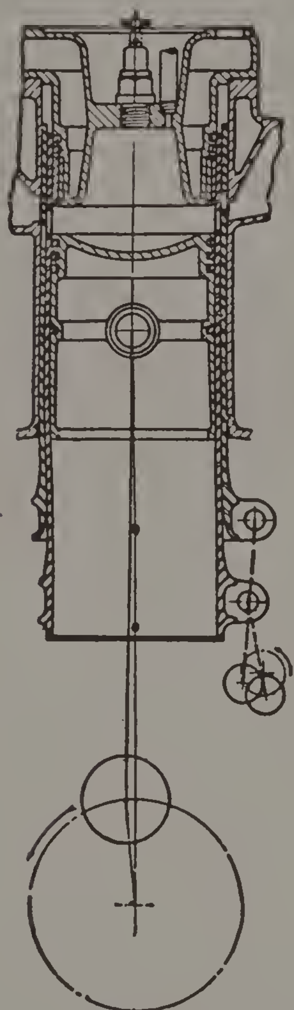


Fig. 136
Inlet Opening on
Knight Engine

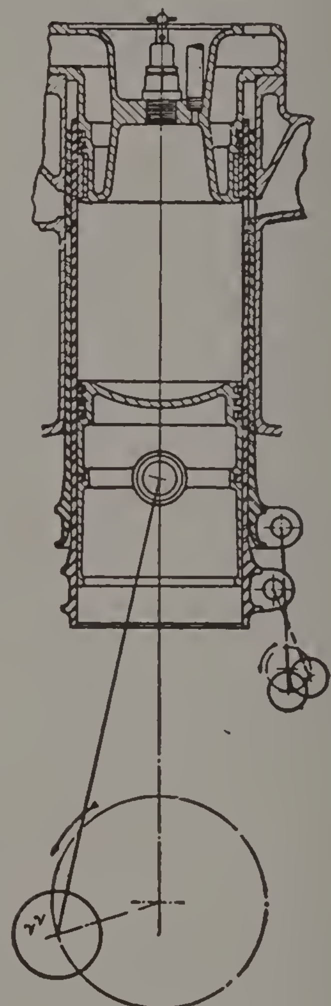


Fig. 137
Inlet Open on
Knight Engine

functions as the camshaft in the poppett valve engine. The eccentric pins that operate the inner sleeves are given a certain advance or lead over those operating the outer sleeves. This lead, about 90 degrees, together with the half-speed rotation of the shaft, gives the following valve action:

In Figs. 136 to 142 the relative positions of the pistons, sleeves and ports are shown in

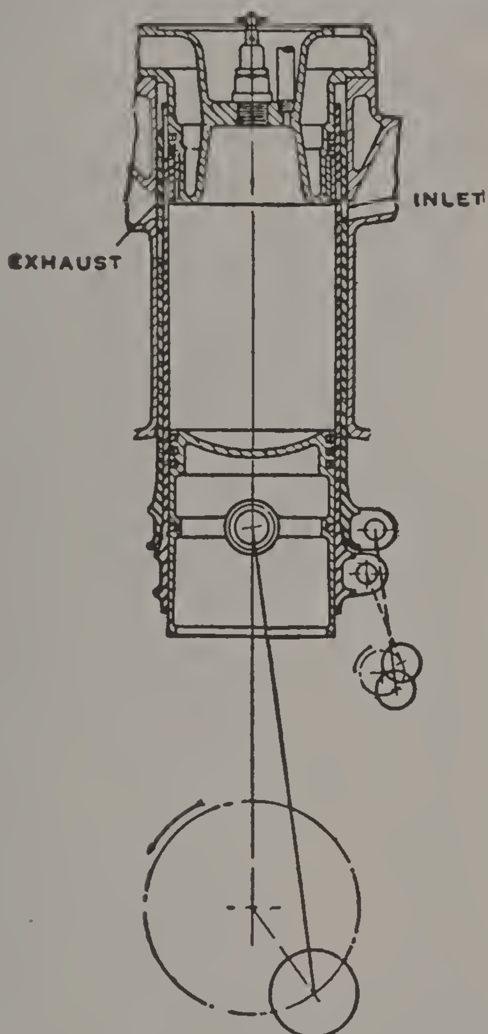



Fig. 138
Inlet Closing

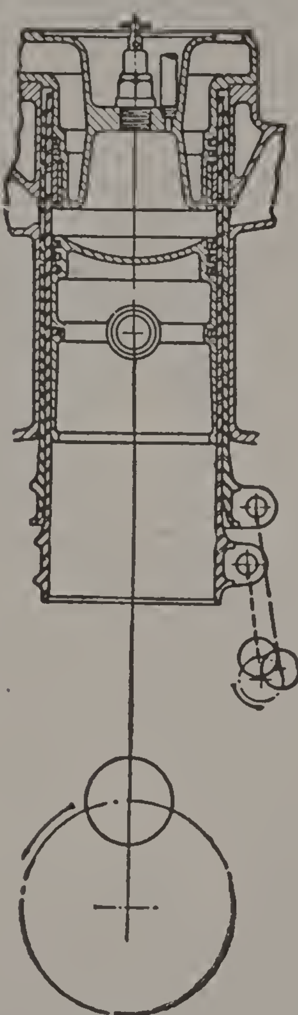


Fig. 139
Firing Point

various positions during the two revolutions of the crankshaft that make up one working cycle of inlet, compression, power and exhaust strokes. Fig. 136 shows the inlet just opening. The port, or slot in the inner sleeve is coming up, the port in the outer sleeve is going down and the passage for the incoming gas is formed by the rapidly increasing opening between the upper edge of the slot in the inner sleeve and the lower edge of the slot in the outer sleeve.

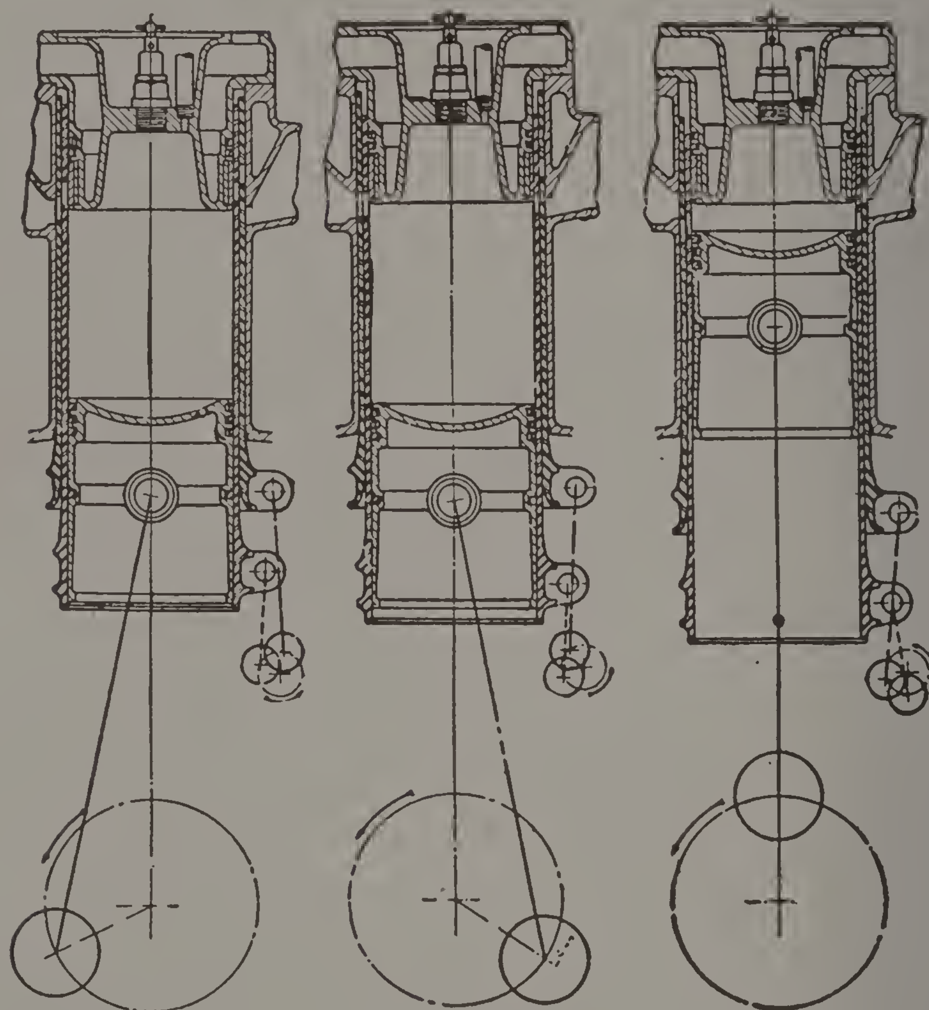


Fig. 140
Exhaust Opening

Fig. 141
Exhaust Open

Fig. 142
Exhaust Closing

Fig. 137 shows the inlet fully open. The inner and outer slots are exactly opposite each other and the inlet opening in the cylinder wall. Fig. 138 shows the closing of the inlet. The cylinder has been filled with fresh mixture and is ready for the compression stroke. Fig. 139 shows the position of the sleeves at the top of the compression stroke; the combustion space having been completely sealed by the expansion rings in the cylinder head above and in the piston below. The firing of the mixture takes place at this point.

Fig. 140 shows the exhaust port just starting to open. The slot in the outer sleeve is coming up and the slot in the inner sleeve is going down. Fig. 141 shows the exhaust ports fully open. The inner and outer slots are opposite each other and at the same time opposite the cylinder opening that leads to the exhaust piping. Fig. 142 shows the closing of the exhaust opening and is practically identical with the position shown in Fig. 136. The four strokes of the cycle (inlet, compression, power and exhaust) have now been completed, the crankshaft has made two complete revolutions and each sleeve has moved up and down once.

The timing of inlet and exhaust opening and closing is not different from that ordinarily used in poppett-valve engines, but the opening secured with this construction is greater than that ordinarily found in the poppett type. Some advantage is also gained because of the more direct path of the incoming and outgoing gases. The timing of the valve openings is not affected by spring pressure or engine speed.

**Engines, Eight and Twelve Cylinder Types.** The development of the automobile engine has been along the lines of increase in number of cylinders and decrease in the size of the individual cylinders, without any considerable increase in the total horsepower delivered by the engine. This development has resulted in the power being delivered more evenly, inasmuch as an impulse is delivered to the crankshaft each time a cylinder fires. With the single cylinder engine, one impulse was given for each two revolutions and with the increase to four, six and eight cylinders, the crankshaft has received two, three and four impulses for each single revolution. The twelve cylinder secures a power stroke for each sixty degrees revolution of the crankshaft and consequently gives six impulses for each revolution.

The most radical change between former types of engine and the eight and twelve cylinder types is that of placing the cylinders in two equal divisions, and, in place of standing vertically, they are placed at an angle of ninety degrees in the eight and sixty degrees in the twelve. This design does not materially increase the length of the engine over one having four or six cylinders of equal size and, of course, makes the height somewhat less, due to the inclination. While these engines naturally require additional cylinders, valves, connecting rods and pistons, they make use of only one

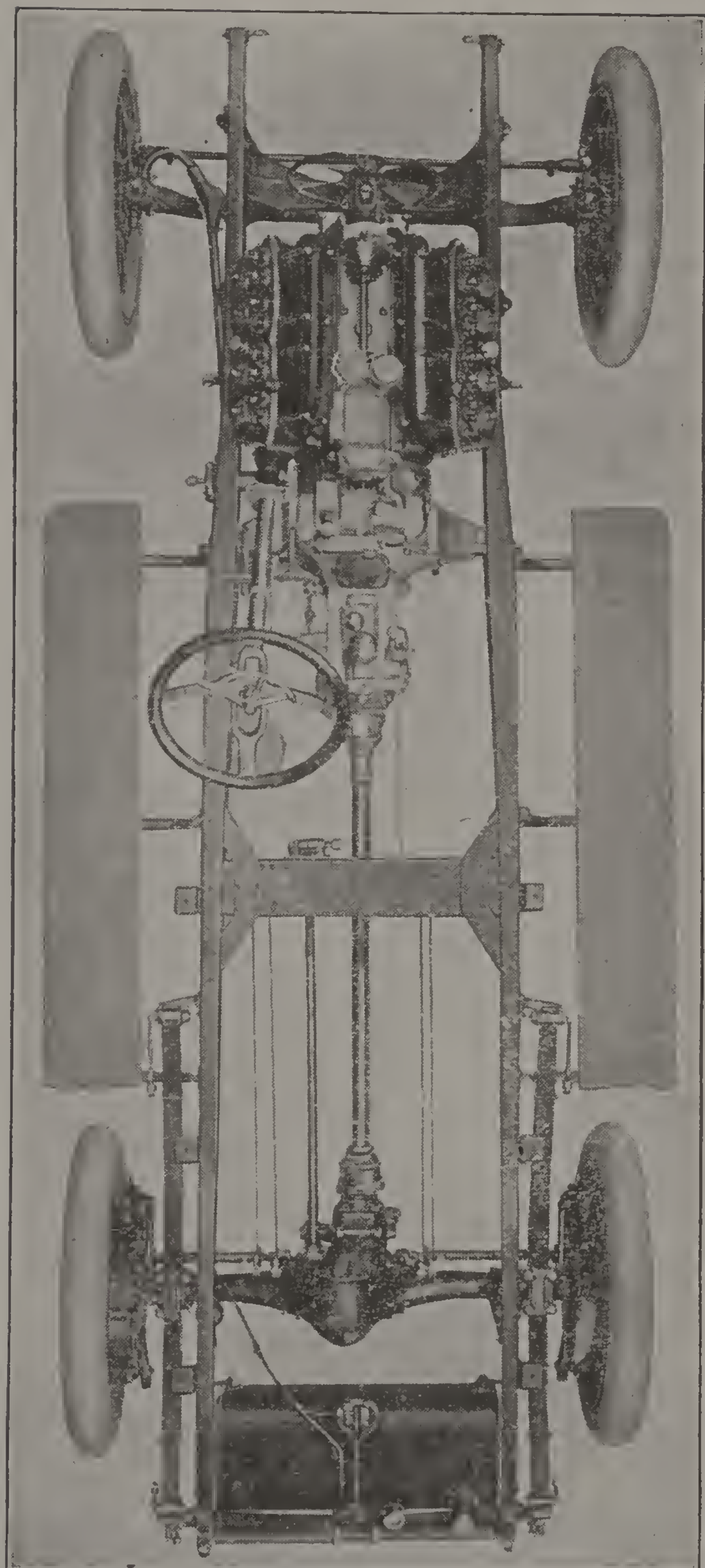


Fig. 143
Eight Cylinder Chassis

crankshaft and generally of but one camshaft. No other increase in number of parts or accessories is necessary, one carburetor, one ignition device and one of each of the other power-plant units doing the work for both sets of cylinders.

The mounting and construction of the generally accepted type of eight cylinder engine is shown in Figs. 143 to 145. As will be noted from the top view shown in Fig. 143, a space is left between the cylinder blocks which provides suitable location for such fittings as the carburetor, the ignition unit and usually the lighting dynamo. The valves are located on the inside of their respective castings and the resulting position of the caps allows easy removal, inspection and grinding.

The center lines of the two cylinder blocks intersect at the center of the crankshaft, and, as will be noted from the side elevation in Fig. 144, the crankshaft itself does not differ from the usual four-throw type used with four cylinder engines. Depending on the type of connecting rod construction used, the cylinders in the blocks are set so that corresponding ones on opposite sides are exactly opposite or slightly offset from each other in a lengthwise direction. In any case the connecting rods from the two front cylinders fasten to one crankpin, while those from the second cylinders are on the next crankpin, and so on for those remaining.

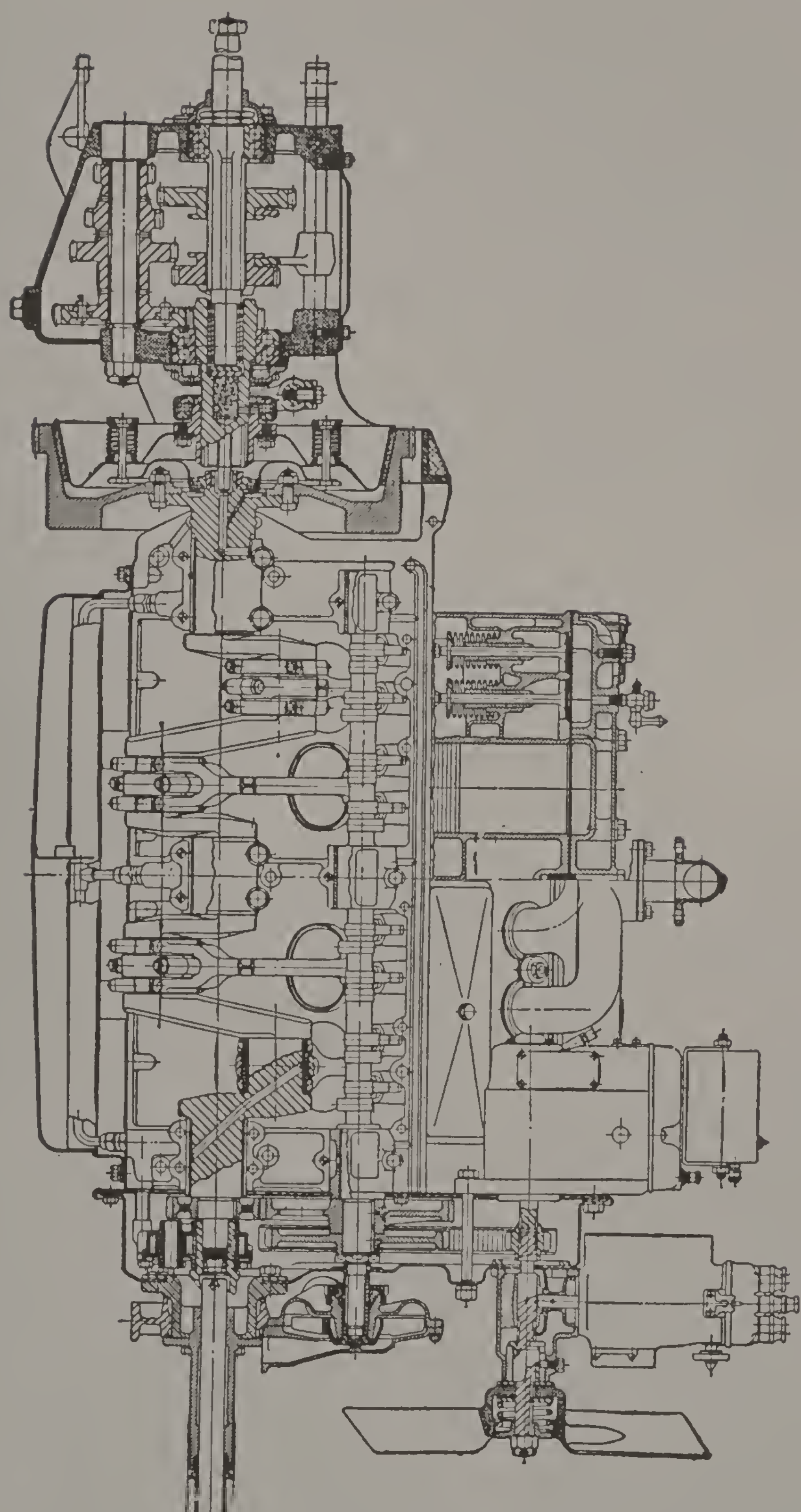


Fig. 144
Side View of Eight Cylinder "V" Type Engine

Three types of construction are in use for the lower end of the connecting rods; the most commonly used method being shown in Figs. 144 and 145, in which one rod is straight and of

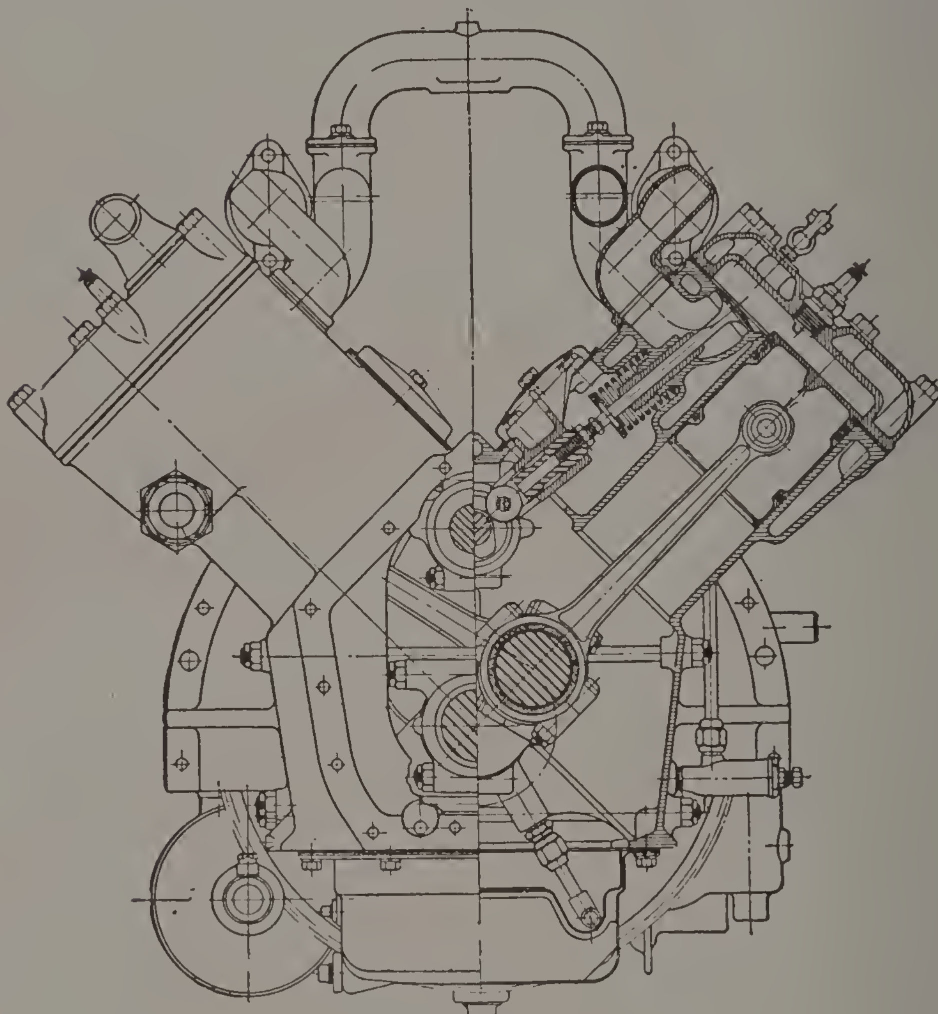


Fig. 145
End View of Eight Cylinder Engine

the usual pattern while the corresponding one is forked and has the two sides of the fork so placed that they are on either side of the straight member. With this construction, the crankpin is surrounded with a sleeve or liner of bearing metal and the forked rod is clamped

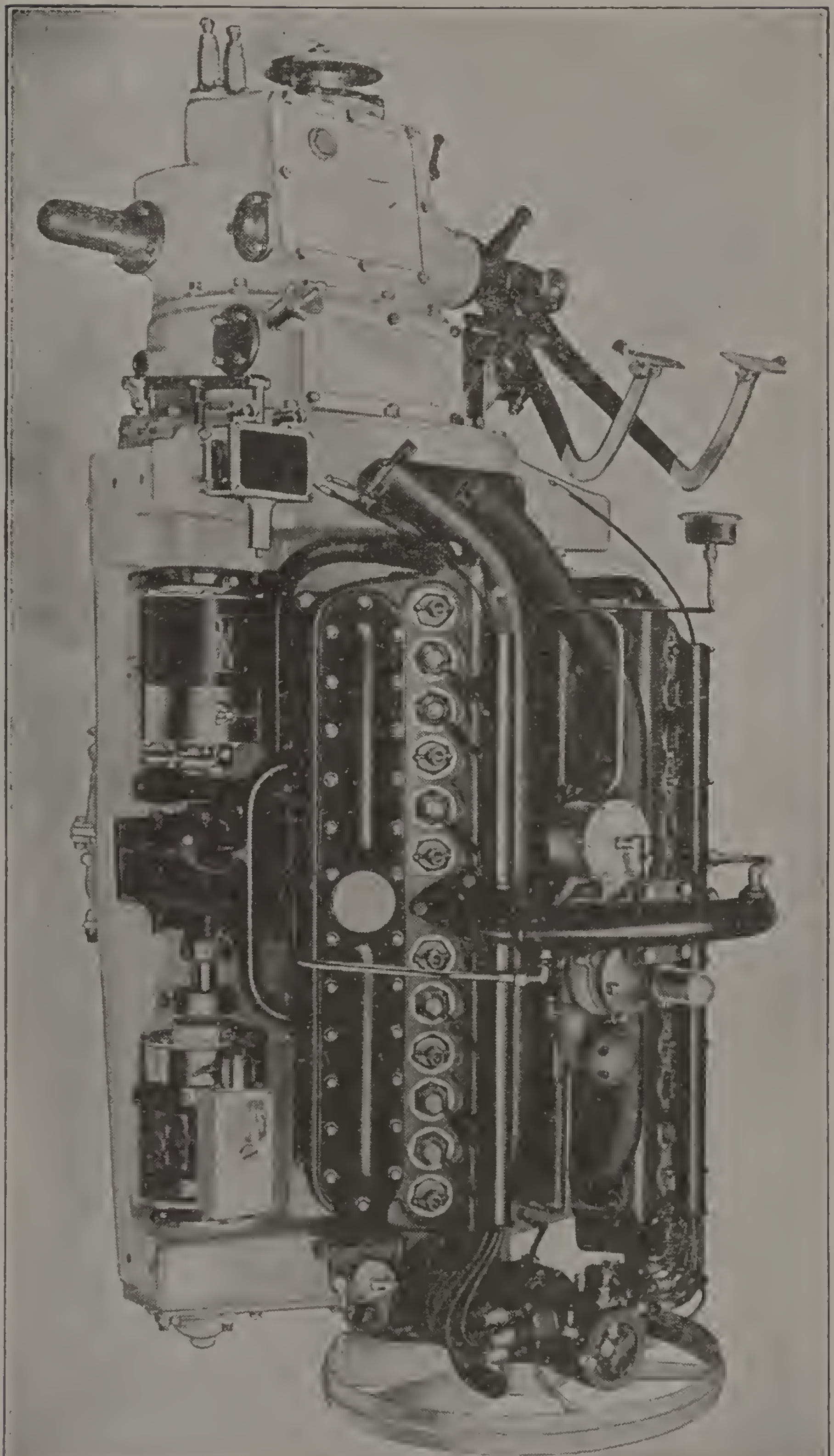


Fig. 146
Packard Twelve Cylinder Engine

around this liner so that the liner is held tightly by the rod, and the shaft turns inside the liner. The end of the straight connecting rod has its bearing on the outside of the liner just mentioned and therefore has only a reciprocating motion on the liner in place of turning all the way around. The bearing of the straight rod on the liner is adjustable, but the liner is not adjustable on the crankshaft.

Another form of connecting-rod construction forms one of the rods in the usual way with an adjustable bearing on the crankpin. On the big end of the rod just mentioned is a boss that carries a pin similar to a wristpin, and on this pin is mounted the bearing of the second connecting rod. The end of the second rod does not surround the crankshaft but is mounted on the end of the one with the bearing.

The third form of rod construction is little used on eight cylinder types, but is quite common on twelves. This method uses a complete rod end and bearing on each rod, the ends and liners being placed side by side so that each connecting rod has a bearing on one-half of the length of the crankpin. The rods are not in the same plane and therefore the cylinders are offset, the set on one side of the engine being a little forward or back of the opposite set. This method allows individual adjustment of each bearing.

In engines with either eight or twelve cylinders, the camshaft is mounted directly above the crankshaft and therefore between the cylinder blocks. Two designs are in common use, one making use of separate cams for each of the sixteen or twenty-four valves, and the other using but one cam for the inlet valves of opposite cylinders and another cam for the corresponding exhaust valves. With but one cam for two valves, the valve plunger rollers do not rest directly on the cam, but the plungers are operated from rocker arms, hinged at one end to the crankcase and having a roller at the end that rests on the cam. When individual cams are used for each valve, the cams are of necessity placed side by side, but the slight distance between each pair makes it necessary to offset the valves or offset the cylinder blocks in a lengthwise direction.

As mentioned, it is customary to use one carburetor with a manifold that divides near the instrument with one branch for each cylinder block. Some difficulty was met with in providing suitable ignition for engines with eight or twelve cylinders, but this has been overcome by improved forms of ignition breakers, by the use of two distributors and two breakers in some cases and by the adoption of new principles of magneto construction in others. When it is realized that a twelve cylinder engine running at 1,800 revolutions a minute (a moderate speed) requires 10,800 accurately timed and powerful sparks every minute, the reason for the difficulty will be seen.

In considering the firing order of these engines, it should be borne in mind that an eight is similar to two four cylinder engines, side by side, while a twelve is similar to two sixes. All four cylinder engines fire in one of two orders, either 1-3-4-2 or else 1-2-4-3, considering the front cylinder as number one. Each set of four cylinders in an eight, that is, the left hand set and the right hand set fires in one of these orders, the only difference with the eight being that one of the cylinders of the left hand set fires just half way between two on the right, while each cylinder on the right fires midway between two on the left. The cylinders on the left, from front to back are usually designated as No. 1 Left, No. 2 Left, and so on; while those in the right are No. 1 Right, No. 2 Right, etc. The firing order of a number of eight cylinder engines is therefore as follows: 1L, 4R, 3L, 2R, 4L, 1R, 2L, 3R; in which it will be seen that, looking at either the "Ls" or "Rs," they fire 1-3-4-2.

The principles explained above apply equally to the twelve, in which the engine may be considered as two sixes, each set of cylinders firing in one of the orders possible for a six. It is possible to number all the cylinders in either an eight or twelve cylinder engine consecutively from 1 up and in this case the front right hand cylinder is usually called number one. The numbering may then continue from front to back on the right hand side, in which case these cylinders will be numbered from 1 to 6, or may pass to the left side, calling the left

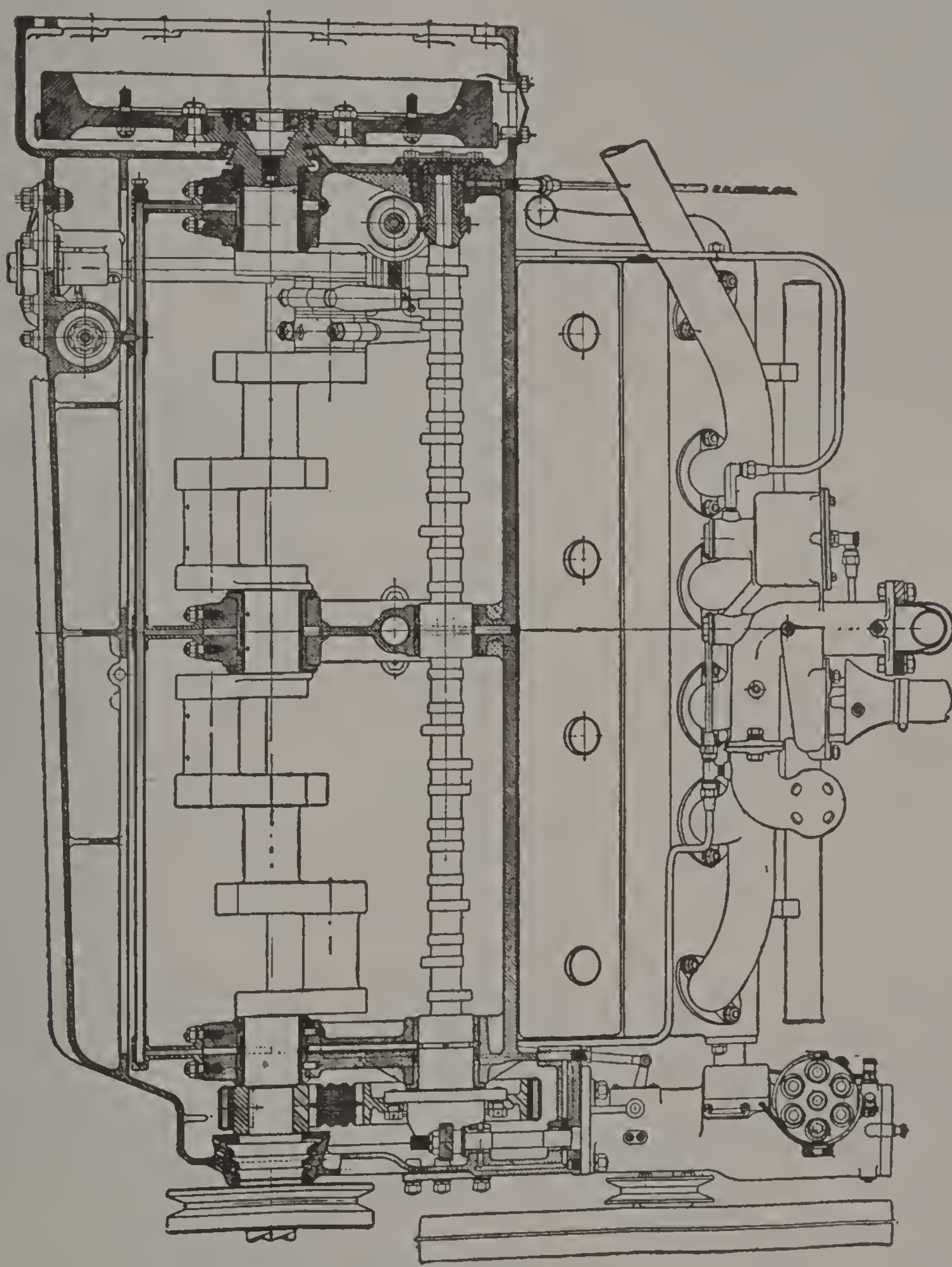


Fig. 147
Section Through Twelve Cylinder Engine

front cylinder No. 2, the second one on the right No. 3, etc. This last method would bring all the odd numbers on the left and all the even numbers on the right.

Designating the cylinders of a twelve by the numbers 1 to 6 and showing their position by letters, a common firing order would be as follows: 1R, 6L, 5R, 2L, 3R, 4L, 6R, 1L, 2R, 5L, 4R, 3L. This fires each set in the common order: 1-5-3-6-2-4.

A twelve cylinder engine is shown in Figs. 146 and 147, and most of the data given in the foregoing pages applies equally to the twelve and the eight. The principal difference between the two types is that the angle included between the cylinder blocks of the twelve is less than that of the eight, thus leaving less space between the blocks in the location often called the "valve alley." Because of the smaller space between the cylinders, a larger one is left outside of the cylinders before the sides of the hood are reached. This fact has led to the practice on twelves of locating the accessories, with the exception of the carburetor, outside of the cylinder blocks and in the same place that they usually occupy on four and six cylinder types.

**Exhaust—Cause of Smoky.** Smoke coming from the exhaust of a gasoline motor is due to one of two conditions: Over-lubrication—too much lubricating oil being fed to the cylinder of the motor– or too rich a mixture, that is, too much gasoline and an insufficient supply of air.

The first condition may be readily detected by the smell of burned oil and a yellowish smoke. The second, by a dense black smoke accompanied by a pungent odor.

**Expansion—Best Conditions for.** The efficiency of the expansion in an engine cylinder depends upon the initial volume of the charge, the condition of the mixture, the compression pressure, the point of ignition, the speed of expansion and the losses due to radiation.

The losses due to improper expansion may therefore be decreased by making large valves and valve passages, but these often mean greater heat losses. The losses due to radiation may be reduced by increasing the temperature of the jacket water, and decreasing the area of the cylinder. But if the cylinder wall temperature is increased, there are considerable difficulties with lubrication, and the increased gain in thermal efficiency will be more than offset by the increased friction.

In order to obtain the highest efficiency the difference in the temperature of the water entering and leaving the cylinder jacket should be a maximum. In practical tests it has been found that the best results are obtained when the jacket water is near the boiling point.

**Flywheels.** One of the first and most important considerations in connection with the construction of a gasoline automobile motor is the proper diameter and weight of the flywheel. If the diameter and weight of the flywheel be known, the speed of the motor or its degree of compression will become a variable quantity. On the other hand, if the speed of the motor and the degree of compression be fixed, the diameter or weight of the flywheel rim must be varied to suit the other conditions. If the speed of the motor and its degree of compression be known, the diameter of the flywheel or the weight of the flywheel rim may be readily ascertained from the following formulas.

Weight of Rims of Flywheels. The weight of the rim of the flywheel is the only portion which enters into the following calculations, the weight of the web, or spokes and hub being neglected.

Let M.P be the mean pressure of the compression, and A the area of the cylinder in square inches. If S be the stroke of the piston in inches, and N the number of revolutions per minute of the motor, let D be the outside diameter of the flywheel in inches and W its required weight in pounds, then

$$W = \frac{M.P \times A \times S \times N}{2560 \times D}$$

Diameter of Rims of Flywheels. A motor

that is intended to operate at a slow rate of speed, and consequently with a high degree of compression, will require a flywheel of much greater diameter and weight than a high speed motor of the same bore and stroke. It may be well to remember that within certain limitations the diameter and weight of a flywheel should be as small as is possible, as an increase in either means a reduction in motor speed, and a consequent loss of power.

To ascertain the diameter of a flywheel when all other conditions are known, if D be the required diameter of the flywheel in inches, then

$$D = \frac{M.P \times A \times S \times N}{2560 \times W}$$

WEIGHT OF RIMS OF FLYWHEELS WITH A GIVEN FLUCTUATION IN SPEED. If it be desired to run a motor at a practically uniform speed and with only a slight fluctuation or variation in the velocity of the flywheel, if W be the required weight of the flywheel and **x** be the allowable fluctuation of the flywheel in revolutions per minute above and below its normal speed, then

$$W = \frac{M.P \times A \times S \times N}{365 \times \mathbf{x}}$$

HORSEPOWER STORED IN RIMS OF FLYWHEELS. It is sometimes desirable to know the amount of energy or horsepower which may be stored in the rim of a flywheel of known diameter and weight, with a given speed. If H.P be the horsepower stored in the rim of the flywheel, then

$$H.P = \frac{D^2 \times W \times N^2}{792,000}$$

SAFE SPEED FOR RIMS OF FLYWHEELS. The safe velocity for the rim of a cast iron wheel is taken at 80 feet per second. Let N be safe speed of the flywheel in revolutions per minute, then

$$N = \frac{18,335}{D}$$

The mean pressures corresponding to varying degrees of compression may be found by reference to Table 2.

M.P = Mean pressure.
A = Area of cylinder in square inches.
S = Stroke of piston in inches.
N = Number of revolutions per minute.
D = Diameter of flywheel in inches.
W = Weight of flywheel in pounds.

BALANCING WITH THE RECIPROCATING PARTS OF THE MOTOR. The flywheel should be balanced as accurately as is possible before mounting on the crank shaft. In the first place set the crank shaft on two perfectly straight parallel bars, one bar under each end. Then attach the connecting rod and piston to the crank and turn the shaft until the crank jaws are parallel with the floor, or in other words, at right angles to a perpendicular line drawn through the center of the shaft. Place a scale under the crank pin, or use a hanging scale attached to some rigid support above the pin and connect it to the crank pin by a wire or cord sufficiently strong to carry the weight. Then find the weight of the parts according to the scale and attach the same amount to the flywheel at the same distance from the shaft on the side opposite the crank, and the result will be a fairly balanced motor. It is impossible to obtain a perfect balance, but the above method will assist greatly in reducing the vibration of the motor.

While it is true that the weight of the flywheel may be reduced as the number of cylinders is increased, there is a practical limit below which it is inadvisable to reduce the weight at the rim. Even should the number of cylinders be sufficient to cause a balance between the working strokes, it would still be desirable to add a rotating weight to compensate in some measure for the several reciprocating masses, such as pistons, connecting rods, crankshaft webs, etc. Engines have been built for racing purposes without flywheels, but they were unsuccessful.

**Friction.** Friction, being the resistance to motion of two bodies in contact, depends upon the following laws: It will vary in proportion to the pressure on the surfaces; friction of rest is greater than friction of motion; the total friction is independent of the area of the contact surfaces when the pressure and speed remain constant; and friction is greater between soft bodies than hard ones.

The behavior of lubricated surfaces is quite different from dry ones, the laws of fluid friction being independent of the pressure between the surfaces in contact, but it is proportional to the density of the fluid and in some manner to the viscosity. When a bearing is thoroughly lubricated it does not seem to make much difference what the metals are, because there is a layer of oil running around with the journal and sliding over another layer adhering to the bearing. If, however, the feed fails, or the pressure gets too heavy for the nature of the lubricant, and so squeezes it out, or the temperature has risen so high as to affect the body of the oil, then the surfaces come into contact and the peculiar nature of the contact asserts itself, some combinations abrading and seizing more readily than others. When the lubrication is thorough, the condition of the fluid friction being realized, the intensity of the load makes less difference than would be expected.

**Fuels for Automobiles.** Apart from the possibility of an increase in the fuel resources of the world due to some revolutionary discovery, the ingredients in any mixed fuel for automobile use must be confined to the following list, in which, for completeness, gasoline is included:

**Gasoline**. Average composition, C=84, H=16.

Source, petroleum.

Boiling point, 50° to 150° Cent.

Specific gravity, .680 to .720.

Calorific value, 19,000 B. T. U.

Latent heat, small.

**Benzine.** Average composition, C=92, H=8.

Source, coal tar.

Boiling point, 80° Cent.

Freezing point, 5° Cent.

Specific gravity, .899.

Calorific value, 19,000 B. T. U.

Latent heat, small.

**Alcohol.** Average composition, C=32, H=8, O=35.

Source, vegetable matter, principally corn, beets, potatoes, sugar cane.

Boiling point, 70° Cent.

Specific gravity, .806.

Calorific value, 12,600 B. T. U.

Latent heat, considerable.

**Tar Benzol.** Average composition, C=92, H=8.

Source, a by-product in the manufacture of coke.

Boiling point, 80° to 120° Cent.

Specific gravity, .895.

Calorific value, 19,000 B. T. U.

Latent heat, small.

**Kerosene.** Average composition, C=85, H=15.

Source, petroleum.

Boiling point, 150° to 300° Cent.

Specific gravity, .800 to .825.

Calorific value, 19,000 B. T. U.

Latent heat, considerable.

**Motor Spirit, Naphtha, Benzoline, Benzine.** Average compositnon, C=85, H=15.

Source, petroleum and shale.

Boiling point, 60° to 160° Cent.

Specific gravity, .750.

Calorific value, 19,000 B. T. U.

Latent heat, appreciable.

**Methyl Alcohol, Wood Spirit, Naphtha.** Average composition, C=38, H=12, O=50.

Source, the distillation of wood.

Boiling point, 66° Cent.

Specific gravity, .812.

Calorific value, 9,600 B. T. U.

Latent heat, appreciable.

**Acetylene Ethene.** Average composition, C=92, H=8.

Calorific value, 25,000 B. T. U.

## Fuel Feed, Vacuum.

The Stewart vacuum gasoline tank, Figs. 148 to 152, consists of two chambers. The upper one is the float or filling chamber, and the lower one is the reservoir or empty chamber. The upper chamber is connected with the intake manifold of the motor, and also with the main gasoline supply tank. The lower or emptying chamber is connected with the carburetor. Between these two chambers is a valve. The suction of the piston on the intake stroke creates a vacuum in the upper chamber. This closes the valve between the two chambers, and in turn draws gasoline from the main supply tank. The gasoline, being sucked or pumped up into this upper chamber, operates a float valve. When this valve has risen to a certain mark it automatically shuts off the suction valve and opens an air valve. This open air valve creates an atmospheric condition in the upper chamber and opens the valve into the lower chamber, and the gasoline immediately commences to flow to the lower or emptying chamber. The lower chamber is always open to outside atmospheric conditions, so that the filling of the upper chamber in no way interferes with an even, uninterrupted flow of gasoline from this lower chamber to the carburetor.

A is the suction valve for opening and closing the connection to the manifold and through which a vacuum is extended from the engine manifold to the gasoline tank.

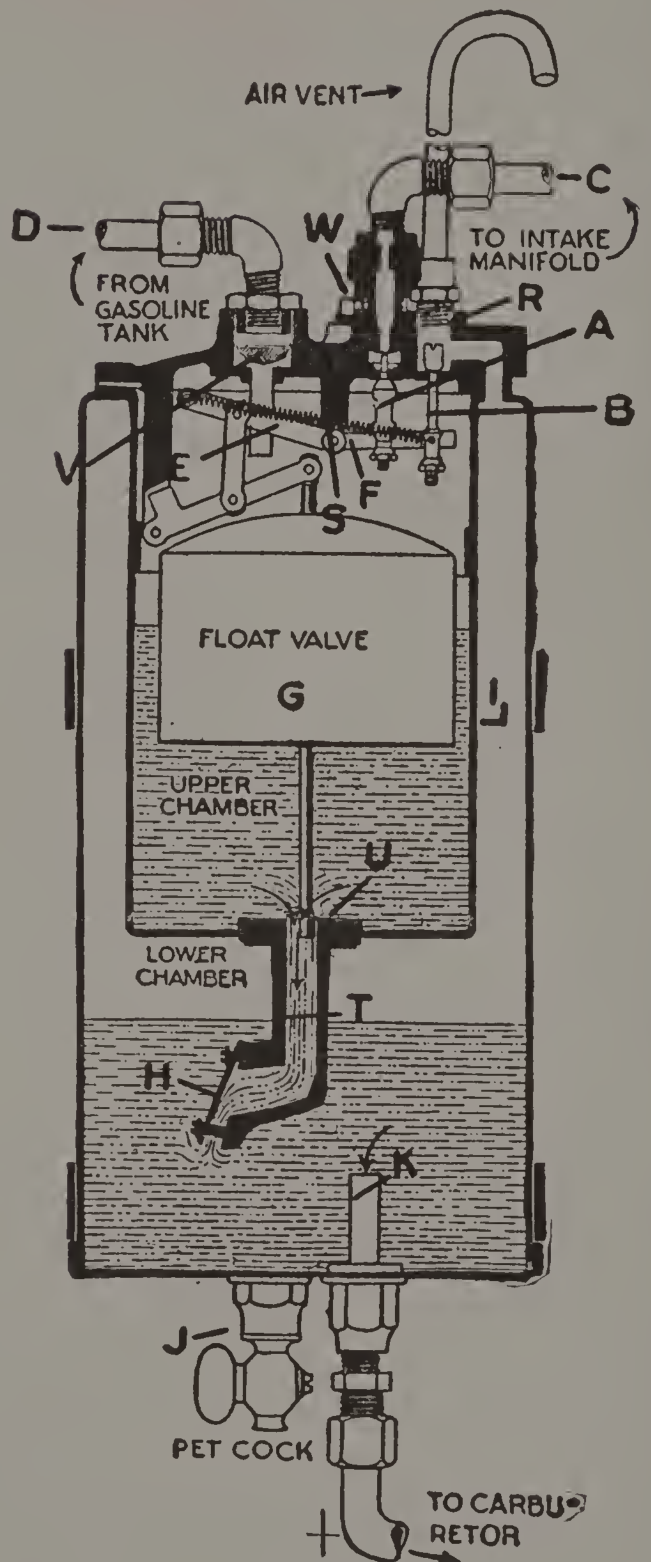



Fig. 148
Stewart Vacuum Fuel Feed Tank

B is the atmospheric valve, and permits or prevents an atmospheric condition in the upper chamber. See Fig. 149. When the suc-

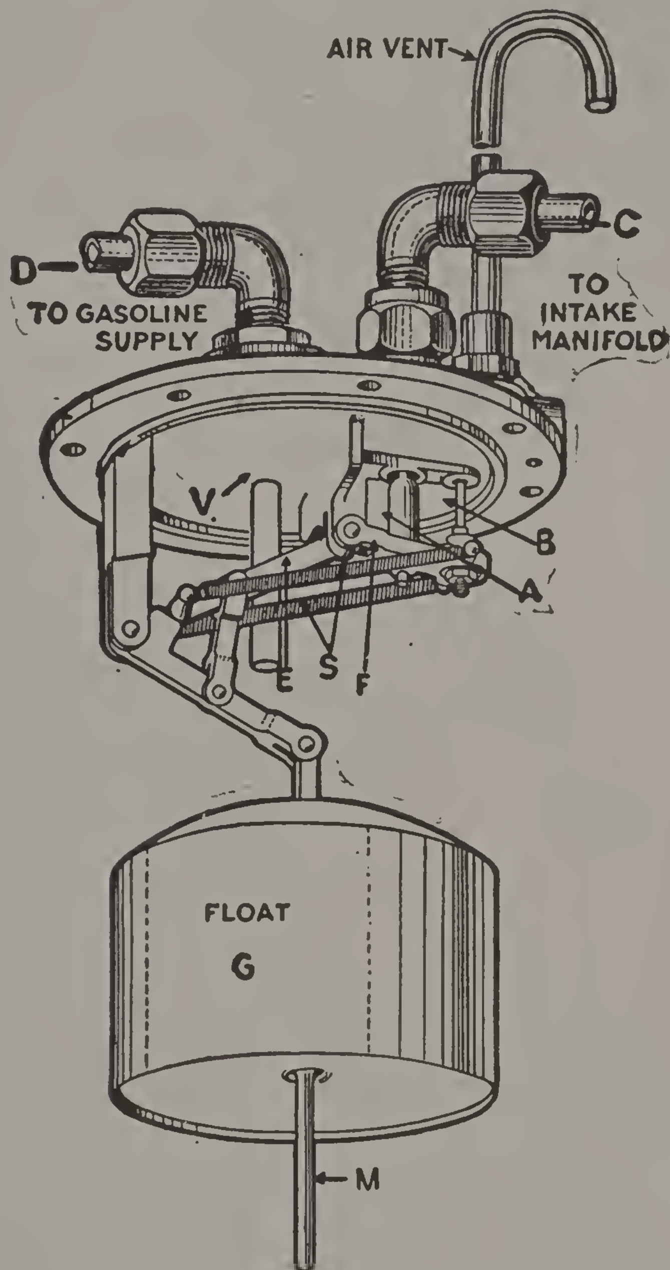



Fig. 149
Float and Levers of Vacuum Tank

tion valve A is open and the suction is drawing gasoline from the main reservoir, this atmospheric valve B is closed. When the suction

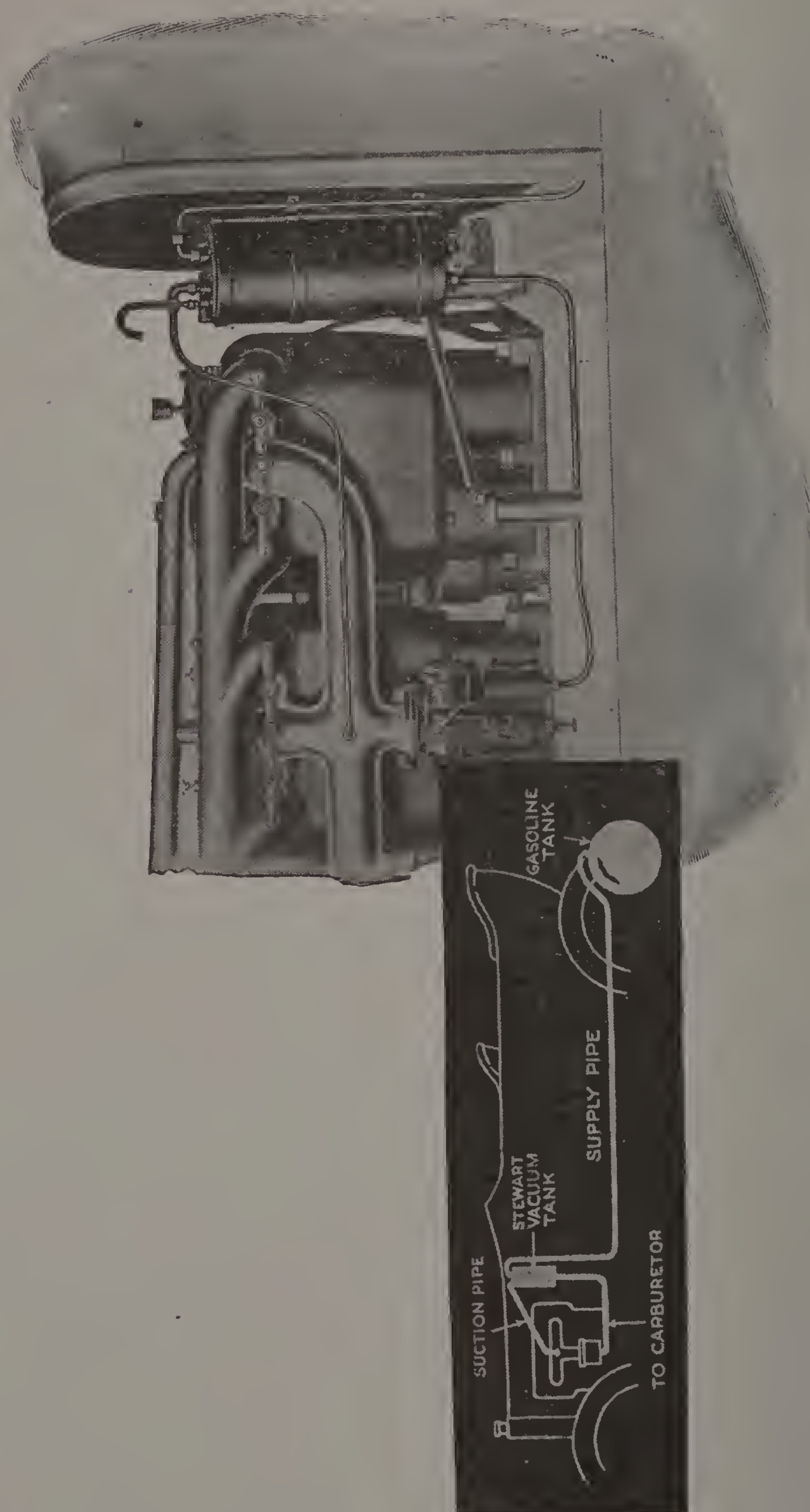



Fig. 150
Arrangement of Parts of Vacuum Fuel Feed

valve A is closed, then the atmospheric valve B must be open, as an atmospheric condition is necessary in the upper tank in order to allow the fuel to flow through the flapper valve H into the lower chamber.

C is a pipe connecting tank to manifold of engine.

D is a pipe connecting vacuum tank to the main gasoline supply tank.

E is a lever to which the two coil springs S are attached. This lever is operated by the movement of the float G.

F is a short lever, which is operated by the lever E and which in turn operates the valves A and B.

G is the float.

H is flapper valve in the outlet T. This flapper valve is held closed by the action of the suction whenever the valve A is open, but it opens when the float valve has closed the vacuum valve A and opened the atmospheric valve B.

J is a pet cock for drawing water or sediment out of the reservoir. This may also be used for drawing gasoline for priming or cleaning purposes.

K is a line to the carburetor extended on inside of the tank to form a pocket for trapping water and sediment which may be drawn out through pet cock J.

L is a channel space between inner and outer shells, and connects with air vent R, thus maintaining an atmospheric condition in the lower chamber at all times, and thereby permitting an uninterrupted flow of gasoline to the carburetor.

M is the guide for float.

R is an air vent over the atmospheric valve. See Fig. 151. The effect of this is the same as if the whole tank were elevated and is for the purpose of preventing an overflow of gasoline should the position of the car ever be such

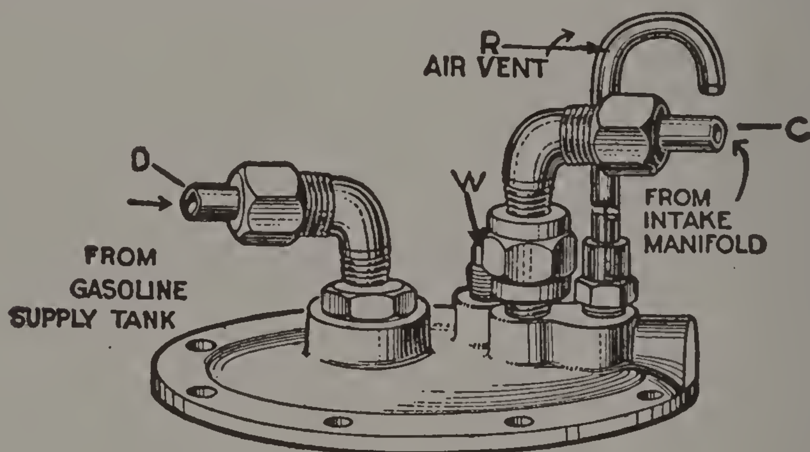



Fig. 151
Upper Connections of Vacuum Tank

as would raise the gasoline supply tank higher than the vacuum tank. Through this tube also the lower, or reservoir chamber, is continually open to atmospheric pressure, so that the flow of gasoline from this lower chamber to the carburetor is always allowed.

T is the outlet located at the bottom of the float reservoir in which is the flapper valve H.

The flapper valve is ground on its seat and should be trouble-proof. A small particle of dirt getting under the flapper valve might prevent it from seating absolutely air-tight and thereby render the tank inoperative: In order to determine whether or not the flapper valve is out of commission, first plug up air vent; then detach tubing from bottom of tank to carburetor. Start motor and apply finger to this opening. If suction is felt continuously, then it is evident that there is a leak in the connection between the tank and the main gasoline supply or else the flapper valve is being held off its seat and is letting air into the tank instead of drawing gasoline.

Any troublesome condition of the flapper valve can be remedied by removing tank cover, then lift out the inner tank. Fig. 152. The flapper valve will be found screwed into the bottom of this inner tank.

Coupling and elbow connections should be kept screwed down tight. Care should be taken that tubing contains no sharp flat bends that might retard the gasoline flow.

Gasoline for priming or cleaning purposes can be obtained by opening pet cock.

To make certain that the tank is not at fault in case of trouble, take out the inner tank entirely. This will leave only the outer shell, which will then be nothing more than an ordinary gravity tank. Fill this tank with gasoline and start to run. If you still have trouble it will be apparent that the fault lies elsewhere and not in the tank.

Carburetor pops and spits are due to improper carburetor adjustments. Running the engine at low speed with an open throttle for any length of time might not produce sufficient suction to fill the tank when empty. But this condition might take place because of dirt or foreign matter getting in and clogging the gasoline feed tube.

If you have any doubt as to the tank being full of gasoline, it is only necessary to close the throttle and the suction of the motor will then fill the tank almost instantly.

To fill the tank, should it ever become entirely empty, close the engine throttle and turn the engine over a few revolutions. This will create sufficient vacuum in the tank to fill it. If the tank has been allowed to stand empty for a considerable time and does not easily fill when the engine is turned over, look for dirt or sediment under the flapper valve H, or the valve may be dry. Removing the plug W in the top and squirting a little gasoline into the tank will wash the dirt from this valve; also wet the valve and cause the tank to work immediately. This flapper valve sometimes gets a black carbon pitting on it, which may tend to hold it from being sucked tight on its seat. In this case the valve should be scraped with a knife.

If the motor speeds up when the vacuum tank is drawing gasoline from the main supply it shows that either the carburetor mixture is too rich, or the connections are so loose that it is drawing air into the manifold. There should

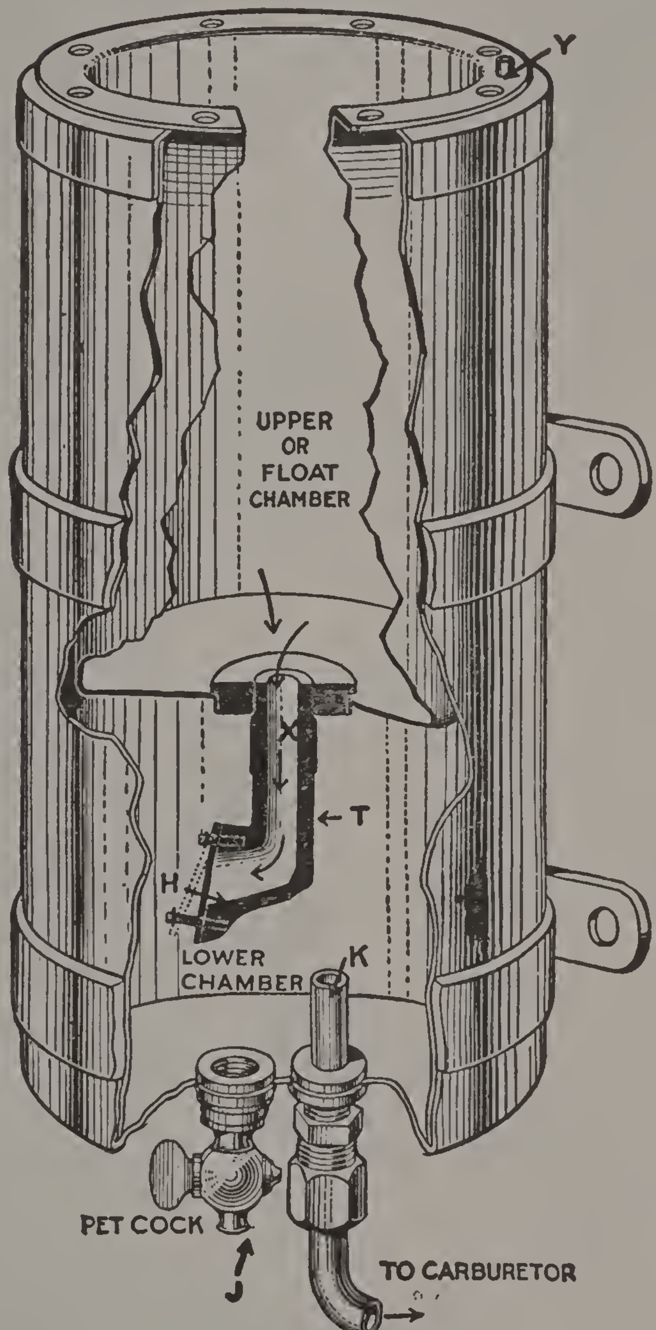



Fig. 152
Shell of Vacuum Tank

be no perceptible change of engine speed when the tank is operating.

**Gases, Expansion of.** All gases expand equally, 1/273 part of their volume for each degree of temperature, Centigrade, of 1/491 part of their volume for each degree of temperature, Fahrenheit.

**Gasoline, How Obtained.** Benzine, Gasoline, Kerosene and the kindred hydro-carbons are products of crude petroleum.

They are separated from the crude oil by a process of distillation. The process is very similar to that of generating steam from water.

Crude petroleum subjected to heat will give off in the form of vapor such products as Benzine, Gasoline and Kerosene, etc. The degrees of heat at which these products are separated are comparatively low. Various degrees of heat will separate the distinct products. As a means of illustration, it may be said that the crude oil when raised to certain temperatures gives off vapors which when cooled liquefy into oils.

VISCOSITY OF GASOLINE. It is a mistake to assume that because gasoline does not thicken up, it is retarded in its flow through the nozzle of the carbureter. Taking gasoline having a specific gravity of 0.71 the quantity that will pass through the nozzle of a carbureter under a given pressure will increase as the temperature is increased, as shown in the following table:

| Temp. degrees F. | Relative Flow. |
|---|---|
| 50° | 1 |
| 59° | 1.073 |
| 68° | 1.145 |
| 77° | 1.212 |
| 86° | 1.27 |
| 95° | 1.335 |

Since carbureter nozzles are not readily adjustable, nor with any degree of certainty, it follows from the above that the influence of temperature upon the weight of fuel ejected will most certainly affect the efficiency of the carbureter. This source of trouble goes to indicate that some means of maintaining a constant temperature is of the greatest advantage, and in a measure it argues for the adaptation of water (hot) jacketing, not around the depression chamber, as is usually the practice, but around the gasoline (float) bowl, in order to maintain a constant temperature of the liquid gasoline as it flows through the nozzle.

**Gasoline Explosions.** There are two entirely different kinds of explosion, which would undoubtedly both be referred to as gasoline explosions. The real gasoline explosion is the kind taking place in the cylinder of a gasoline motor, in which heat and pressure are suddenly produced by the combustion of gasoline vapor in air. The other kind of explosion referred to may be explained as follows:

If a tank of gasoline be placed on a woodpile and the latter set on fire, the heat would raise a pressure in the tank, which would rapidly increase and the tank would finally explode from the pressure. The gasoline would then be thrown in all directions, and, owing to its superheated condition, the greater part of it at least would instantly vaporize, mix with the air of the atmosphere and be ignited by the flame which caused the explosion.

**Gasoline Fires, Extinguishing.** A number of fires have been caused by leaky gasoline pipes on automobiles, and many persons would like to know of chemicals which can be used to put out such fires. Water is exceedingly dangerous to use, and it is not always possible to get at the fire to smother it with wet rags or waste.

In case of fire due to gasoline, use fine earth, flour or sand on top of the burning liquid.

A dry powder can be used for this purpose which will extinguish the fire in a few seconds. It is made as follows: Common salt, 15 parts—sal-ammoniac, 15 parts—bicarbonate of soda, 20 parts. The ingredients should be thoroughly mixed together and passed through a fine mesh sieve to secure a homogeneous mixture.

If by any chance a tank of gasoline takes fire at a small outlet or leak, run to the tank and not away from it, and either blow or pat the flame out. Never put water on burning gasoline or oil, the gasoline or oil will float on top of the water and the flames spread much more rapidly.

Several gallons of ammonia, thrown in the room with such force as to break the bottles which contain it, will soon smother the strongest fire if the room be kept closed.

It is not advisable to operate a pleasure car, and certainly not a truck, without having a portable extinguisher on the car. Such extinguish-ers are made in sizes suitable for carrying in an easily accessible place and should be so mounted. A fire starting in the under-pan or under the hood may be smothered in the beginning, while delay would mean the car's destruction.

**Gasoline, Thermo-dynamic Properties of Gasoline and Air.** The following table, 8, gives the thermo-dynamic properties of gasoline and air, and may be of interest, in view of the fact that information on this subject is sparse, and most of that only theoretical, or empirical deductions.

This table gives the explosive force in pounds per square inch of mixtures of gasoline vapor and air, varying from 1 to 13 down to 1 to 4, also the lapse of time between the point of ignition and the highest pressure in pounds per square inch attained by the expanding charge of mixture. The tests from which the results given were obtained, were made with a charge of mixture at atmospheric pressure, so as to more accurately note the results, as the mixture takes much longer after ignition to attain its highest pressure, and is slower also in expanding.

It may be well to remember that there are no more heat-units, and consequently no more foot-pounds of work in a mixture of gasoline and air, under 5 atmospheres compression, than under 1 atmosphere compression.

Flanged or ribbed air-cooled motors will approach the figures given in the table for the initial explosive force for the varying compressions, very closely, while thermal-siphon water-cooled motors will come within about 20 per cent of these results, and pump and radiating coil cooled motors will come within about 30 per cent. While it appears at the first glance that the proper thing to do to get the greatest efficiency from a motor would be to let it run as hot as possible, experience has shown that the repair bill of a hot motor will more than offset its efficiency over the cooler water-jacketed motor, with pump and radiating coils. The last two columns in the table give the temperature of the burning gases, the first of the two columns the actual temperature with the accompanying mixture of gasoline and air, and the second the theoretical temperatures, or temperature to which the burning mixture should attain, if there were no heat losses.

TABLE 8.

THERMO-DYNAMIC PROPERTIES OF GASOLINE AND AIR.

| Gasoline, Vapor and Air. | Time in Seconds between Ignition and Highest Pressure.* | Explosive Force in Pounds per sq. in. — Compression in Atmospheres. | | | Temperature of Combustion in Degrees Fahrenheit.* | |
|---|---|---|---|---|---|---|
| | | 3 | 4 | 5 | Actual. | Theoretical. |
| 1 to 13 | 0.28 | 156 | 208 | 260 | 1857 | 3542 |
| 1 to 11 | 0.18 | 183 | 244 | 305 | 2196 | 4010 |
| 1 to 9 | 0.13 | 234 | 312 | 390 | 2803 | 4806 |
| 1 to 7 | 0.07 | 261 | 348 | 435 | 3119 | 6001 |
| 1 to 5 | 0.05 | 270 | 360 | 450 | 3226 | 6854 |
| 1 to 4 | 0.07 | 240 | 320 | 400 | 2965 | 5517 |

*At atmospheric pressure.

**Gearless Transmission.** This name has been applied to a wide variety of transmission, or change speed devices. It is quite customary to refer to the friction drive as a gearless system, and this is true to the extent of not using toothed gearing of any form.

A car using this name was built several years ago, and its construction embodied a novel method of change speed mechanism. The transmission system of the gearless car made use of a central cone, long in proportion to its diameter, and faced with friction material. Placed so that they might engage with this driving member, were several sets of rollers, which were, in turn, brought into contact with driven members or clutches. The principle of operation was that of the planetary, or internal epicyclic, gear. In place of using toothed gears, this car secured its drive by bringing one or the other sets of rollers into play and thereby secured three forward speeds and one reverse. Large power was transmitted and little trouble found.

**Gears, Diametrical Pitch System of.** Table 9 gives the necessary dimensions for laying out and cutting involute tooth spur gears from No. 16 to No. 1 diametral pitch. Formulas are also given so that if the number of teeth and the diametral pitch are known, the pitch diameter can be ascertained—also, the diametral pitch, outside diameter, number of teeth, working depth, and clearance at bottom of tooth:

P = Pitch diameter in inches.
D = Diametral pitch.
W = Working depth of tooth in inches.
T = Thickness of tooth in inches.
O = Outside diameter in inches.
C = Circular pitch in inches.

(1) $$\text{Pitch diameter} = \frac{T}{D}$$

(2) $$\text{Outside diameter} = P + \frac{2}{D}$$

(3) $$\text{Diametral pitch} = \frac{T}{P}$$

(4) $$\text{Circular pitch} = \frac{3.142}{D}$$

(5) $$\text{Working depth of tooth} = \frac{2}{D} = 2 \div D$$

(6) $$\text{Number of teeth} = P \times D$$

(7) $$\text{Thickness of tooth} = 1.571 \times D$$

(8) $$\text{Clearance at bottom of tooth} = \frac{C}{20}$$

For example: Required, the pitch diameter of a gear with 20 teeth and No. 5 diametral pitch. From Formula No. 1, as the pitch diameter is equal to the number of teeth divided by the diametral pitch, then 20 divided by 5 equals 4, as the required pitch diameter in inches.

What is the outside diameter of the same gear? From Formla No. 2, as the pitch diameter is 4 inches, and the diametral pitch No. 5, then 4 plus 2/5 equals 4 2/5 as the proper outside diameter for the gear.

What would be the diametral pitch of a gear with 30 teeth and 5 inches pitch diameter? From Formula No. 3, 30 divided by 5 equals 6, as the diametral pitch to be used for the gear. In this manner by the use of the proper formula any desired dimension may be obtained.

TABLE 9.

DIMENSIONS OF INVOLUTE TOOTH SPUR GEARS.

| Diametral Pitch. | Circular Pitch. | Width of Tooth on Pitch Line. | Working Depth of Tooth. | Actual Depth of Tooth, | Clearance at Bottom of Tooth |
|---|---|---|---|---|---|
| 1 | 3.142 | 1.571 | 2.000 | 2.157 | 0.157 |
| 2 | 1.571 | 0.785 | 1.000 | 1.078 | 0.078 |
| 3 | 1.047 | 0.524 | 0.667 | 0.719 | 0.052 |
| 4 | 0.785 | 0.393 | 0.500 | 0.539 | 0.039 |
| 5 | 0.628 | 0.314 | 0.400 | 0.431 | 0.031 |
| 6 | 0.524 | 0.262 | 0.333 | 0.360 | 0.026 |
| 7 | 0.447 | 0.224 | 0.286 | 0.308 | 0.022 |
| 8 | 0.393 | 0.196 | 0.250 | 0.270 | 0.019 |
| 10 | 0.314 | 0.157 | 0.200 | 0.216 | 0.016 |
| 12 | 0.262 | 0.131 | 0.167 | 0.180 | 0.013 |
| 14 | 0.224 | 0.112 | 0.143 | 0.154 | 0.011 |
| 16 | 0.196 | 0.098 | 0.125 | 0.135 | 0.009 |

**Gears, Horsepower Transmitted by.** The following formulas will give the horsepower that may be transmtited by gears with cut teeth of involute form and of various metals.

H.P = Horsepower.
P = Pitch diameter in inches.
C = Circular pitch in inches.*
F = Width of face in inches.
R = Revolutions per minute.

$$H.P = \frac{P \times C \times F \times R}{90} \quad \text{(Annealed tool steel.)} \quad (1)$$

$$H.P = \frac{P \times C \times F \times R}{140} \quad \text{(Mach. steel or Phosphor Bronze.)} \quad (2)$$

$$H.P = \frac{P \times C \times F \times R}{410} \quad \text{(Cast Brass.)} \quad (3)$$

$$H.P = \frac{P \times C \times F \times R}{550} \quad \text{(Cast Iron.)} \quad (4)$$

Example: Required, the horsepower which a tool steel pinion, 2 inches pitch diameter, 1 inch face and No. 10 diametral pitch, will transmit at 900 revolutions per minute.

Answer: From the table the circular pitch corresponding to No. 10 diametral pitch is

---

*The circular pitch corresponding to any diametral pitch number, may be found by dividing the constant 3.1416 by the diametral pitch.

Example: What is the circular pitch in inches corresponding to No. 6 diametral pitch.

Answer: The result of dividing 3.1416 by 6 gives 0.524 inches as the required circular pitch.

0.314. Then by Formula No. 1, $2 \times 0.314 \times 1 \times 900$ equals 565.2. This, divided by 90, gives 5.29 horsepower.

**Gear, Internal-Epicyclic.** It is often desired to ascertain the speed of rotation of the different members of this form of gearing. To calculate their speeds, the following formulas are given, which, by reference to the letters designating the different parts in Figure **153**, may be readily solved.

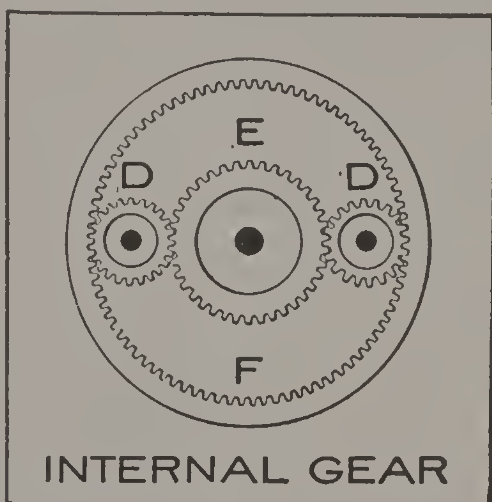



Fig. 153

Let R be the revolutions per minute of the disk or spider carrying the pinions D.

Let N be revolutions per minute of the gear E.

Let G be the revolutions per minute of the internal gear F.

When the internal gear F is locked and gear E rotating, the speed in revolutions per minute of the disk or spider carrying the pinions D is

$$R = N \frac{E}{E + F}$$

If the internal gear be locked and the spider carrying the pinions D be rotated, then the speed in revolutions per minute for the gear E will be

$$N = R \frac{E + F}{E}$$

If the spider carrying the pinions D be held rigid and the gear E be rotated, the speed in revolutions per minute for the internal gear F is

$$G = \frac{N \times E}{F}$$

If the pitch diameter of the gears is not readily obtainable, the number of teeth in each gear may be used instead, as the result will be exactly the same.

It will be recognized that this is the form of gearing employed in the older forms of planetary transmission devices. Newer types use no internal toothed gears.

**Heat of Combustion.** The quantity of heat generated by the complete combustion of various gases and petroleum products is known as the heat value of the fuel, and represents the maximum amount of heat that can be obtained from a given quantity of the fuel. No accurate rule has yet been devised by which to compute the heat value of any chemical compound from its formula and the heat values of the elements of which it is composed. Hence, the heat values of compounds must be found by a separate determination for each one in the laboratory. The heat developed by the combustion of some of the commoner fuels and gases is given in Table 14. In the case of carbon, the heat developed by its complete combustion, forming $CO_2$, and the heat of its partial combustion to CO, are given; also the heat of combustion of CO to $CO_2$.

HEAT VALUE OF A MIXTURE. The heat value of a mixture may be found from the heat values of the substances of which it is composed and the percentage of each substance. If $h_1$, $h_2$, $h_3$, etc., represent the heat values of the substances forming the mixture, and $p_1$, $p_2$, $p_3$, etc. represent the percentage of each substance, the heat value of the mixture will be represented by the following formula:

$$hm = p_1h_1 + p_2h_2 + p_3h_3 + \text{etc.}$$

Example.—A certain gas has the following composition:

| Constituents of Gas | Per Cent. |
|---|---|
| Hydrogen, H | 20 |
| Marsh gas, $CH_4$ | 70 |
| Acetylene, $C_2H_2$ | 10 |

What is the heat value per cubic foot of the mixture?

Solution.—Referring to Table 10, the heat

TABLE 10.

MIXTURES OF AIR AND GASES, AND RESULTING HEAT OF COMBUSTION.

| Fuel | Chemical Proportions | Weight of Gas at 30°, per Cubic Foot | Volume of 1 Pound of Gas at Atmospheric Pressure (Cubic Feet) | | Volume Required to Burn 1 Cubic Foot of Gas (Cubic Feet) | | Weight Required to Burn 1 Pound of Gas (Pounds) | | Specific Heat of Gas at Constant Pressure | Heat of Combustion | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pound | 32° | 62° | O | Air | O | Air | | B. T. U. per Pound of Fuel | B. T. U. per Cubic Foot of Gas at 62° |
| Oxygen, O | 23 lb.O + 77 lb.N = 100 lb. air | .08927 | 11.20 | 11.88 | ... | ..... | .... | ..... | .21751 | ...... | ..... |
| Nitrogen, N | 21 vol.O + 79 vol.N = 100 vol. air | .07847 | 12.77 | 13.55 | ... | ..... | .... | ..... | .24380 | ...... | ..... |
| Hydrogen, H | $2H + O = H_2O$ | .00562 | 178.80 | 189.80 | .5 | 2.38 | 8.00 | 34.80 | 3.40900 | 62,000 | 327 |
| Carbon, C | $C + O = CO$ | ...... | ...... | ...... | ... | ..... | .... | ..... | ....... | 4,400 | ..... |
| Carbon, C | $C + 2O = CO_2$ | ...... | ...... | ...... | ... | ..... | .... | ..... | ....... | 14,600 | ..... |
| Carbon monoxide, CO | $CO + O = CO_2$ | .07704 | 12.77 | 13.55 | .5 | 2.38 | .57 | 2.48 | .24790 | 4,385 | 324 |
| Carbon dioxide, $CO_2$ | 1 lb.C + 2.66 lb.O = 3.66 lb. $CO_2$ | .12323 | 8.12 | 8.60 | ... | ..... | .... | ..... | .21700 | ...... | ..... |
| Methane, $CH_4$ | $CH_4 + 4O = 2H_2O + CO_2$ | .04538 | 22.37 | 23.73 | 2.0 | 9.52 | 4.00 | 17.40 | .59290 | 23,976 | 1,010 |
| Ethylene, $C_2H_4$ | $C_2H_4 + 6O = 2H_2O + 2CO_2$ | .07830 | 12.77 | 13.55 | 3.0 | 14.28 | 3.43 | 14.90 | .40400 | 21,476 | 1,585 |
| Ethane, $C_2H_6$ | $C_2H_6 + 7O = 3H_2O + 2CO_2$ | .08369 | 11.94 | 12.67 | 3.5 | 16.66 | .... | ..... | ....... | 22,356 | 1,765 |
| Benzol vapors, $C_6H_6$ | $C_6H_6 + 15O = 3H_2O + 6CO_2$ | .22363 | 4.47 | 4.74 | 7.5 | 35.7 | .... | ..... | .37540 | 18,183 | 3,836 |
| Acetylene, $C_2H_2$ | $C_2H_2 + 5O = H_2O + 2CO_2$ | .07251 | 13.79 | 14.63 | 2.5 | 11.9 | .... | ..... | ....... | 21,421 | 1,464 |

values per cubic foot of these gases are seen to be 327, 1,010 and 1,464 B. T. U., respectively. Apply the formula just given. $p_1 = .20$, $p_2 = .70$, and $p_3 = .10$. Also, $h_1 = 327$, $h_2 = 1{,}010$, and $h_3 = 1{,}464$. Substituting, $hm = .20 \times 327 + .70 \times 1{,}010 + .10 \times 1{,}464 = 65.4 + 707 + 146.4 = 918.8$ B. T. U. Ans.

TEMPERATURE OF COMBUSTION. The theoretical temperature of the combustion of a given fuel can easily be calculated. Making no allowance for losses of heat, and supposing that just enough air is furnished for the combustion, burning carbon should have a temperature about 4,940° above zero; while burning hydrogen should have a temperature about 5,800° above zero. In practice, these temperatures are never attained, on account of heat losses.

LOSS OF HEAT. The loss of heat from any hot object is accomplished in three ways: by convection, by conduction and by radiation. In all practical cases a body loses heat by a combination of these processes.

When heat is produced in the cylinder by the combustion of the gases, the piston is at or near the upper dead center; that is, it remains nearly stationary when the heat is greatest and when the heat loss per unit area of inclosing walls is most rapid.

Under the usual conditions of ignition, the gas contained in the cylinder must be set into violent motion by the spread of the flame through it, and this motion will aid the dissipation of the heat in the gas to the containing walls. So convection will be an important factor in the process and perhaps the principal factor. Perhaps a part of the gain in power which has resulted, in some instances, from the use of multiple ignition may be due to violent motion of the gas. Practically all air cooled motors have their valves in the head, so the charge is contained between the cylinder walls and the piston head.

The heat absorbed by the water-jacket is equal to the weight of water passed through the jacket multiplied by the temperature range; or, in other words, it is the difference between the temperature of the water when it enters the water-jacket and that of the water when it leaves the jacket. For instance, if the temperature of the entering water is 50° and that of escaping water is 180°, the temperature range is $180° - 50° = 130°$. Then, if the weight of the water passing through the jacket in 1 hour is 100 pounds, the heat carried away is $100 \times 130 = 13.000$ British thermal units.

**Horsepower.** The actual horsepower of an engine can only be determined by making a test with suitable brakes or dynamometers. This method would give the actual brake horsepower. In order to allow ready calculation, the Society of Automobile Engineers' formula is used and is generally recognized. The bore or diameter of the cylinder is first squared; that is, the size in inches is multiplied by itself. This number is then multiplied by the number of cylinders and the result divided by $2\frac{1}{2}$. Thus, for an engine with 5-inch bore: 5x5=25. If of 4 cylinders, 25x4=100, and 100 divided by $2\frac{1}{2}$ gives the result as 40 horsepower. In order to secure approximately correct results, the engine is supposed to be operating at 1,000 feet per minute piston speed.

**Horsepower of Explosive Motors.** The first requisite is to find the number of power strokes made per minute by the motor. In a single cylinder motor of the four-cycle type there is one power stroke for every two revolutions, and if the motor has four cylinders there is one power stroke for every revolution of the crank shaft. The number of power strokes then may be found by the following formula (referring to a four-cycle motor):

$$N = \frac{C}{4} \times S$$

in which N = Number of power strokes per minute.

C = Number of cylinders.

S = Angular velocity of crank shaft in revolutions per minute.

Having ascertained the number of power strokes per minute, the horsepower is found by the formula,

$$H.P = \frac{P\,L\,A\,N}{33{,}000}$$

P = Mean effective pressure (M. E. P.).
L = Length of stroke in feet.
A = Area of piston in sq. in.
N = Number of power strokes per minute.

This formula does not discriminate between mechanical friction and losses in "fluid" friction. A formula that is more arbitrary and that fits the majority of cases, requiring only the use of a few facts, such as diameter of cylinder, length of stroke, and revolutions per minute, is presented as follows:

$$H.P = \frac{V \times N}{10{,}000}$$

in which

V = volume of cylinder in cu. inches.
N = number of power strokes per min.

The constant used varies from 9,000 to 14,000 depending upon certain types of engines; 10,000 being an average figure for four cycle engines. The brake horsepower will be from 65 to 85 per cent of the result obtained; 80 per cent may be taken as an average. As an example we may take a four-cycle, four-cylinder motor 4½-in. bore and 4½-in. stroke making 1,200 power strokes per minute. Volume (V) of cylinder equals area of piston 15.9 sq. in. × length of stroke 4½=71.55 cu. in., and multiplying this by 1,200 (N) and dividing the product by 10,000 gives 8.05 H.P. Taking 80 per cent of this as the brake horsepower the result is 6.44 H.P.

From a theoretical standpoint a two-cycle explosive motor should not only have as great a speed, but also be capable of developing almost twice the power that a four-cycle motor does. It is a fact nevertheless that its actual performance is far different.

The horsepower of a two-cycle motor may be calculated from the following formula,

$$H.P = \frac{D^2 \times S \times N}{21,000}$$

in which

D=diameter of cylinder in inches.
S=stroke of piston in inches.
N=number of revs. per minute.

Example: Required, the horsepower of a two-cycle motor of 4½ inches bore and stroke, with a speed of 900 revolutions per minute.

Answer: The square of the bore multiplied by the stroke is equal to 91.125, which multiplied by 900, and divided by 21,000, gives 3.91 as the required horsepower. The results given by the above examples agree very closely with those obtained from actual practice.

**Horsepower, Electrical.** One electrical horsepower is equal to the current in amperes multiplied by the electro-motive force or voltage of the circuit and divided by 746.

Let C be the current in amperes and E the voltage of the circuit. If E. H. P. be the required electrical horsepower, then

$$E.H.P = \frac{E \times C}{746}$$

In practice with motors of small power, 1,000 watts are necessary to deliver one mechanical or brake horsepower at the driving shaft of the motor.

If the actual or brake horsepower of an electric motor be known, the efficiency of the motor may be readily found by the following formula:

If E be the voltage of the circuit and C the current in amperes consumed by the motor, let B. H. P be the brake horsepower of the motor and e the efficiency of the motor, then

$$e = \frac{B.H.P \times 746}{E \times C}$$

Table 10 gives the electrical horsepower of motors with voltage from 20 to 100 volts, and current strengths from 10 to 80 amperes.

The mechanical efficiency of a motor may be found by use of the table as follows

Example: Required the mechanical efficiency of a 40-volt, 60-ampere motor, which is rated by its maker as of 3.25 horsepower—the motor when under full load using 80 amperes.

Answer: Reference to the column in the table corresponding to 40 volts and 60 amperes gives 3.22, while the 80 ampere column gives 4.29. Then 3.22 divided by 4.29 gives 0.75, or 75 per cent, as the mechanical efficiency of the motor.

## Ignition Systems.

**Ignition.** In order that an explosive motor may operate economically, and with the highest percentage of efficiency, it is absolutely necessary that two objects shall be attained, viz.: A

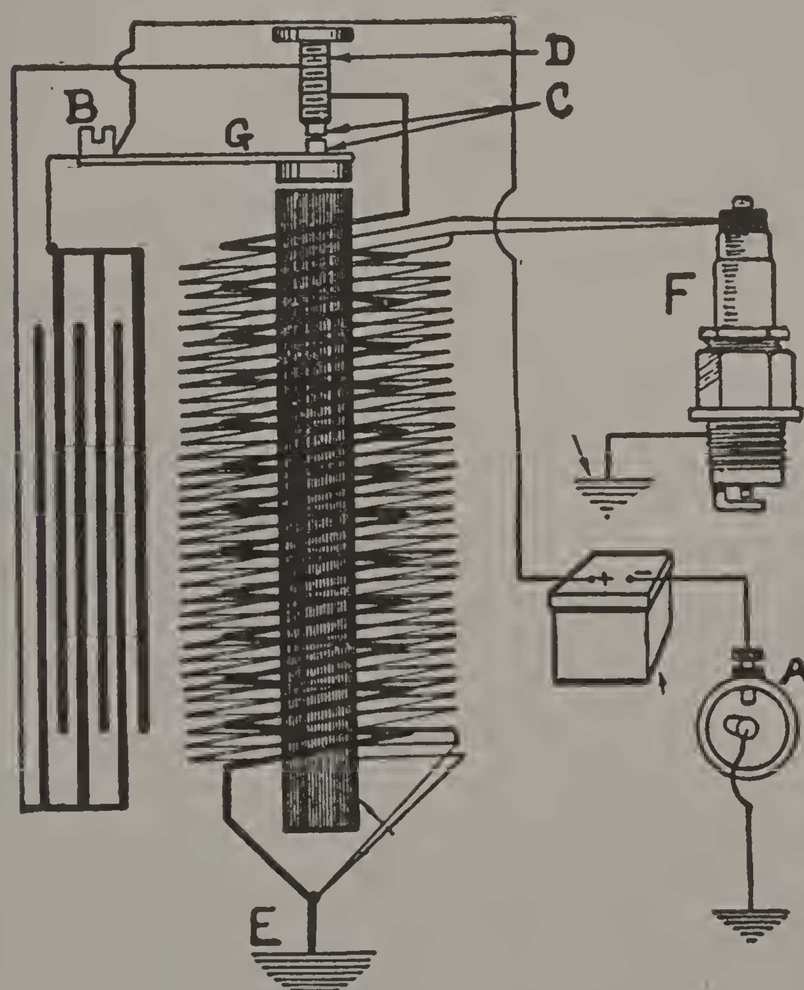



Fig. 154
Coil and Timer Ignition With Storage Battery

correct mixture of the gasoline and air, and that this mixture be correctly ignited at the proper time.

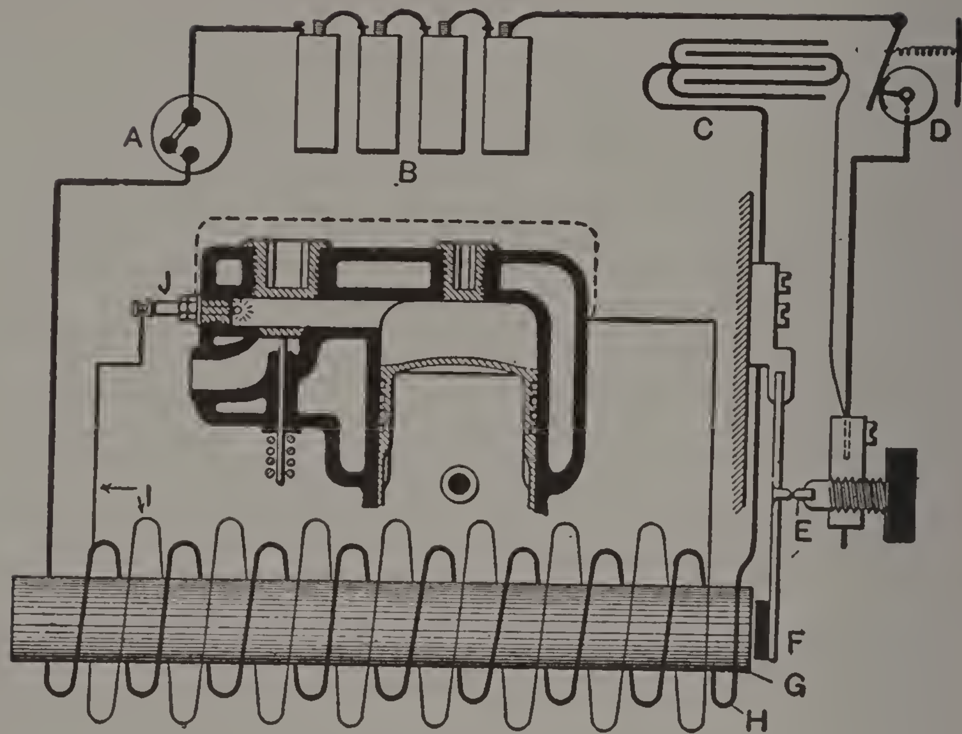



Fig. 155

Coil and Timer With Dry Cells. A, Switch. B, Dry Cells. C, Condenser. D, Timer. E, Contacts. F, Armature. G, Core of Coil. H, Primary Winding. I, High Tension Winding. J, Spark Plug.

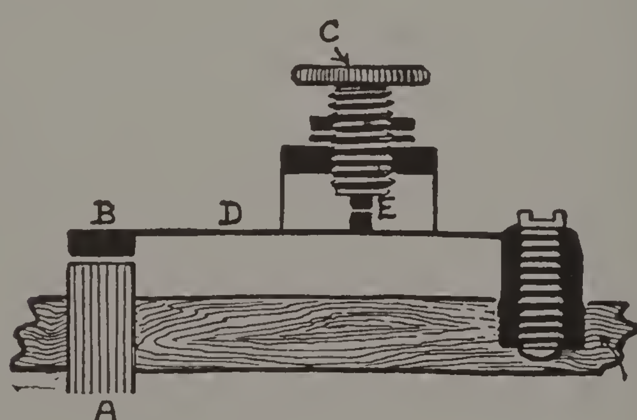



Fig. 156

Coil Vibrator Principle. A, Core of Coil. B, Armature of Coil Magnet. C, Adjusting Screw. D, Trembler Blade. E, Contacts.

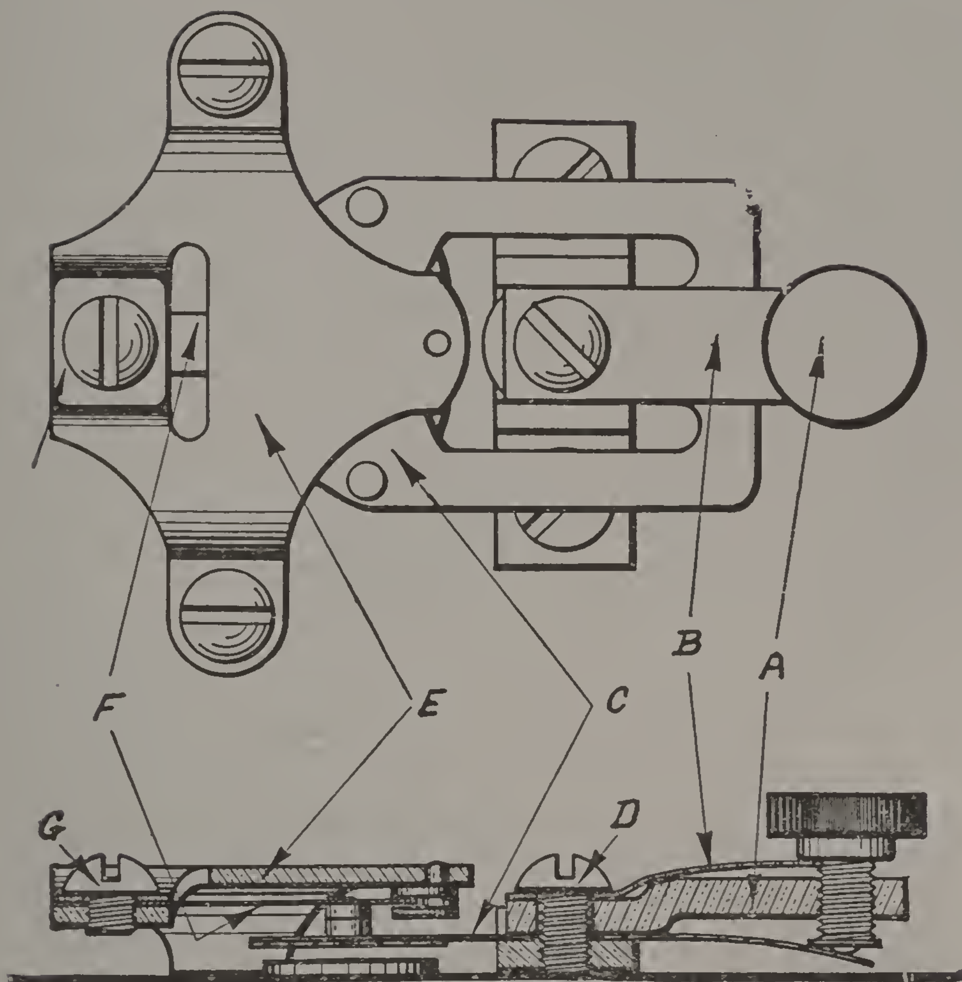



Fig. 157

Coil Vibrator Details. A, Adjustment. B, Tension Spring. C, Trembler Blade. D, Holding Screw. E, Contact Bridge. F, Contact Blade. G, Locking Screw.

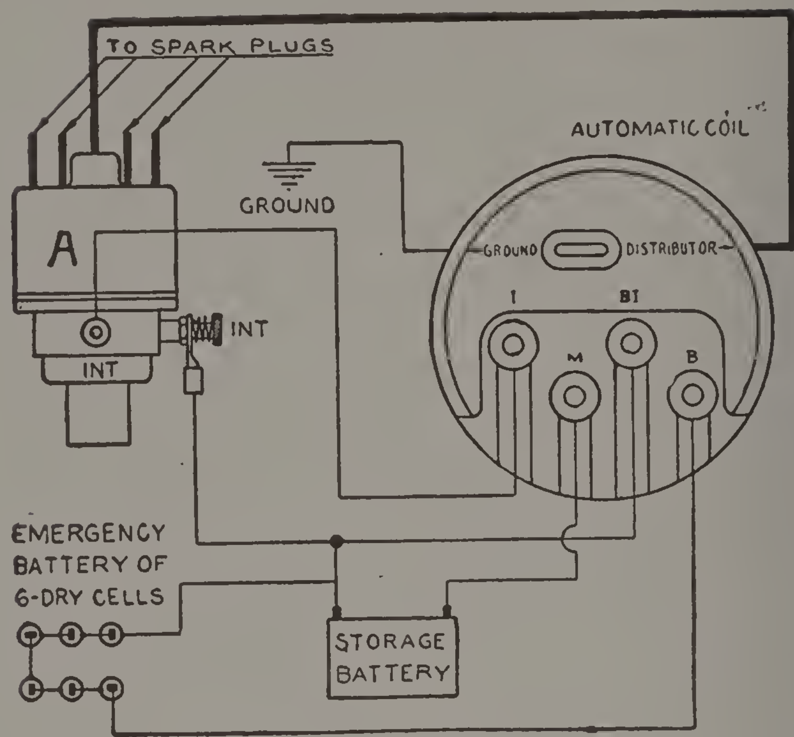



Fig. 158
Connecticut Storage Battery Ignition Wiring

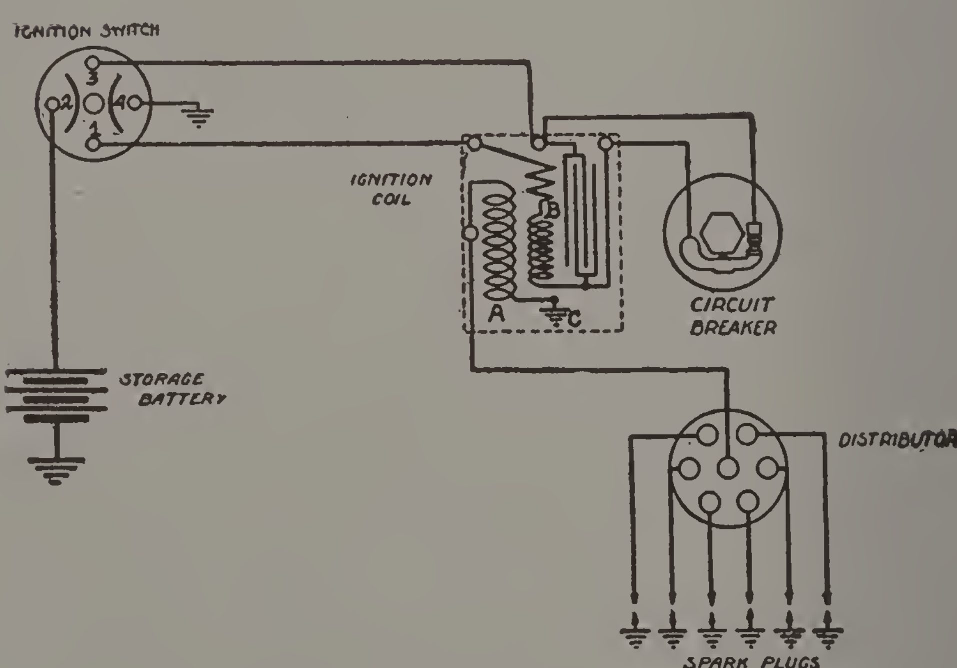



Fig. 159
Circuits Through Remy Battery Ignition System

Induction Coil. Induction is the process by which a body having electrical or magnetic properties calls forth similar properties in a neighboring body without direct contact. This property is known as self-induction, and is caused by the reaction of different parts of the same circuit upon one another, due to variations in distance or current strength. The current produced by an induction coil has a very high electro-motive force, and hence great power of overcoming resistance.

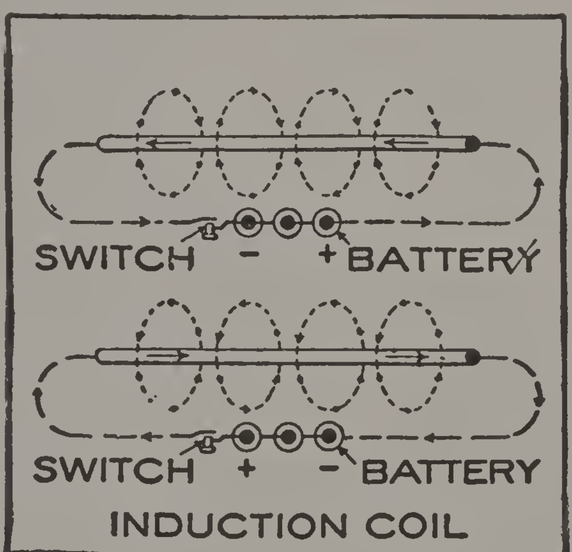



Fig. 160.

If a current of electricity be caused to flow through a straight conductor forming a part of a closed electric circuit, lines of force, commonly called magnetic whirls or waves, are induced in the air and rotate around the conductor.

If the current of electricity be flowing in the circuit and through the straight conductor from right to left, as shown in the upper view in Fig. 160, the lines of force or magnetic whirls will rotate around the conductor from left to right, or in the direction of the hands of a clock. On the other hand, if the conditions be reversed and the current flows from left to right the lines of force or magnetic whirls will rotate from right to left, as shown in the lower view in Fig. 160. The direction of rotation of these lines of force or magnetic whirls may be positively determined by the use of a galvanometer, an electric testing instrument having a needle similar in appearance to that of an ordinary compass. Upon placing this instrument in the path of the lines of force and making and breaking the battery circuit by means of the switch, the needle of the galvanometer will be deflected from its zero point in the direction of the rotation of the lines of force. If the direction of the flow of the electric current through the circuit be changed by reversing the poles of the battery, the needle of the galvanometer will be deflected from its zero point in the opposite direction. Whether these lines of force or magnetic whirls rotate continuously around the wire has not been demonstrated. They rotate with sufficient force to be tested by the galvanometer only until the electric current in the closed circuit has reached its maximum value after closing the circuit; that is to say, only during the infinitesimal space of time required by the current to reach its full value or power.

If, instead of a straight conductor, a loop of insulated wire, in the form of a circle, be untilized for the passage of the current, as at A and B in Fig. 161, the lines of force will still rotate around the wire as shown, their direction being dependent on the direction of the electric current. If the electrical circuit be provided with

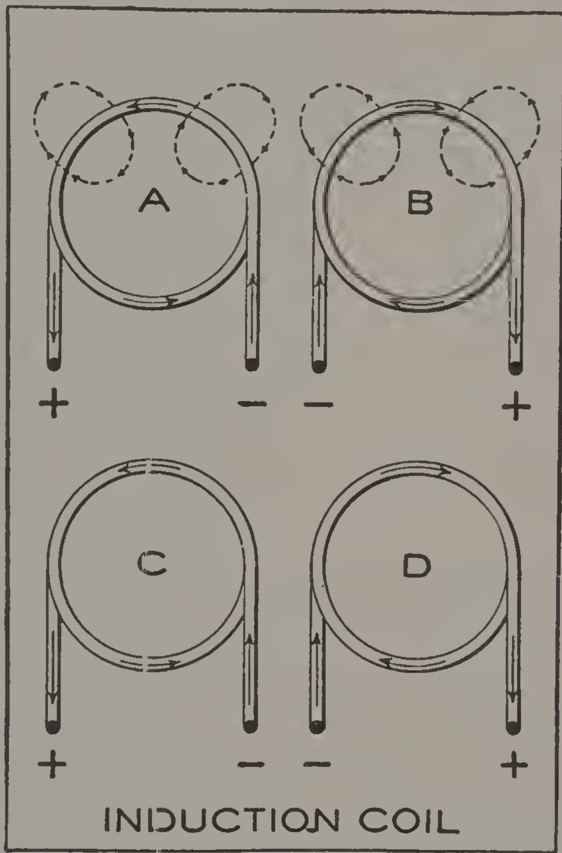



Fig. 161

a current reverser, or device for changing the battery connections in the circuit from positive to negative and vice versa, the lines of force can be made to rotate rapidly first in one direction and then in the other, as indicated in Fig. 160.

Suppose this loop of insulated wire be composed of a great number of turns, it then becomes a coil or closed helix, and as all the lines of force cannot pass between the turns of the electrical conductor forming this helix they must pass completely through the helix instead of rotating around a single loop, as at A and B, Fig. 161. If the current flows through the conductor in the direction indicated by the arrows, at C in Fig. 161, and over and around the coil in the direction shown, the lines of force will flow through the coil towards the observer, and complete their path or circuit through the air, returning into the coil at the opposite end. If the current be reversed and flow around the coil in the direction of the hands of a clock, the lines of force will flow through the coil in the opposite direction, that is, away from the observer, as at D, Fig. 161.

This form of coil or closed helix may be designated as the primitive form of an electromagnet. When forming part of a closed electric circuit it possesses the property of magnetizing a bar of wrought iron placed within it. If a short round bar of wrought iron be placed a short distance within the coil, and the battery circuit be closed, the iron bar will, if the current is sufficiently strong, be sucked or drawn into the center of the coil, and a considerable effort will be required to withdraw it.

The object of the bundle of soft iron wires, which form the core of any form of spark coil, is to increase the magnetic effect of the lines of force or magnetic flux, or rather to reduce the resistance to their passage through the coil.

As has been previously stated, when a current of electricity flows through a conductor of wire forming a coil or closed helix, lines of force are induced and flow through, and also around the exterior of the coil. In a like manner, when the electric circuit is broken, the lines of force suddenly reverse their direction, and travel through the coil with a tremendous velocity until they

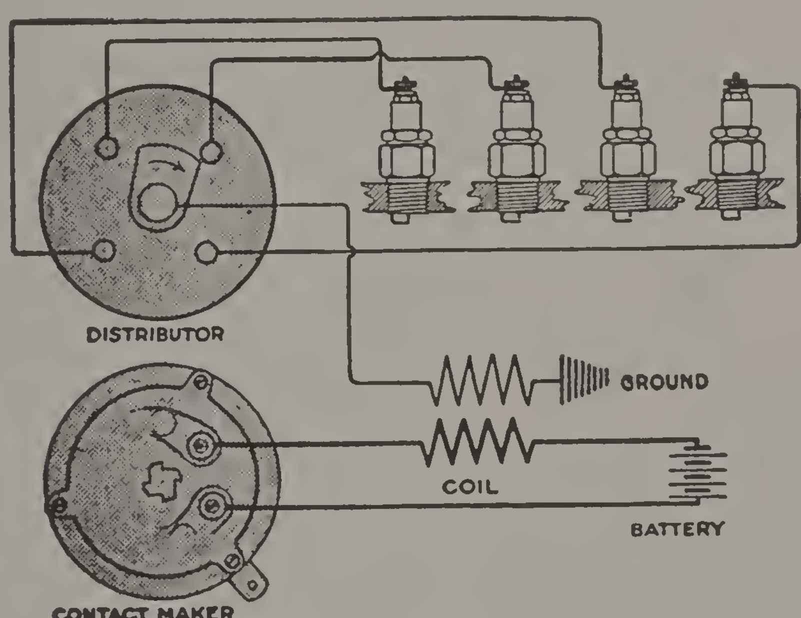



Fig. 162
Principle of Atwater Kent Battery Ignition

reach a state of neutralization. During this reverse travel of the lines of force through the coil, a current of electricity is induced in the winding of the coil, but in the opposite direction to that in which the battery current was flowing. The effect of this induced current, which is of far greater intensity or pressure than the bat-

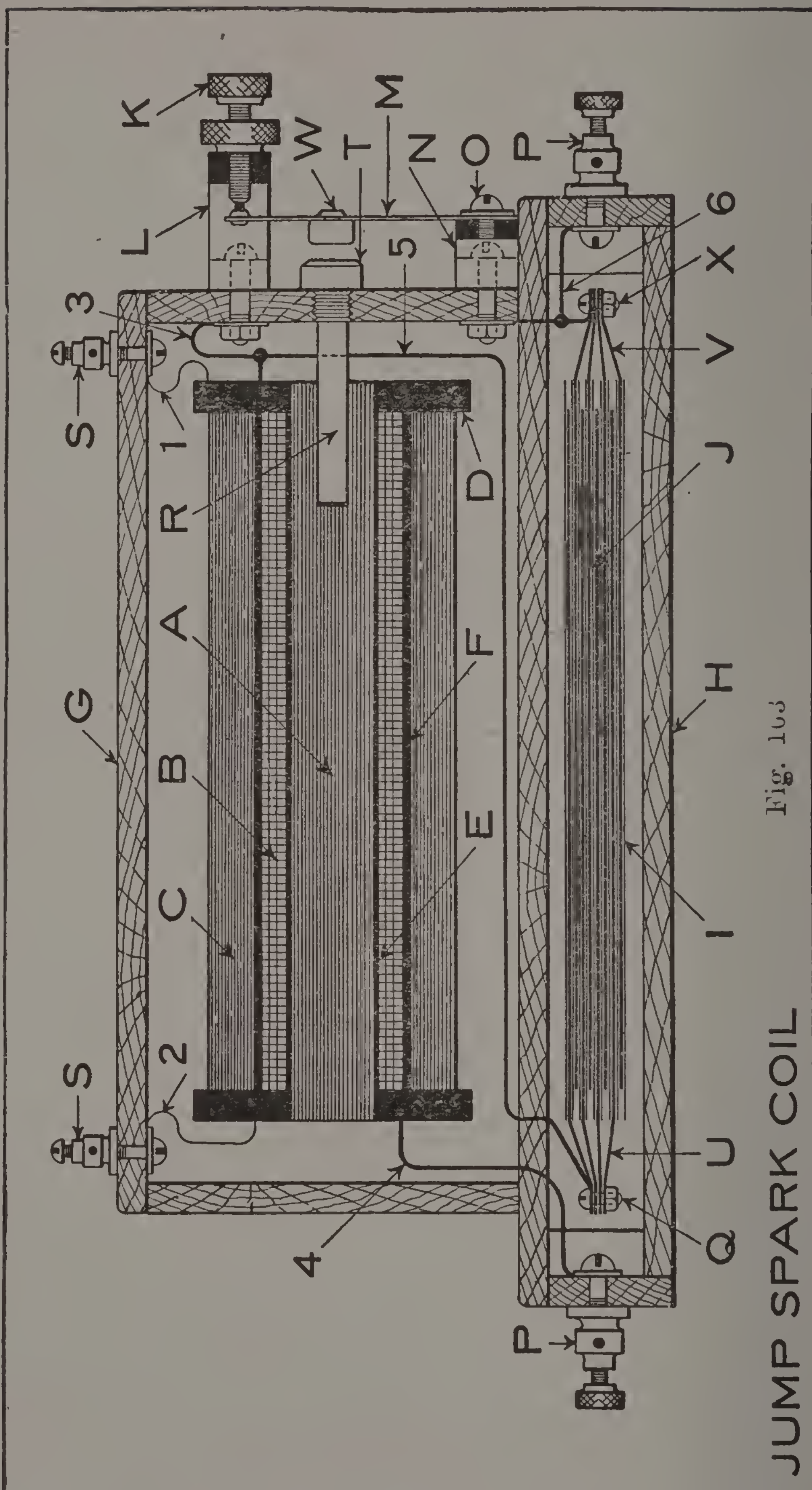



Fig. 163

tery current which induced it, is to form an arc or spark at the breaking point in the circuit.

Secondary Spark Coil. Fig. 163 shows the secondary or jump-spark form of coil. It is composed of an iron core and a primary winding similar to that described in conjunction with Fig. 162, with the addition of an outer winding of many turns of fine wire. This wire, of very small size, is known as the secondary winding, varying in diameter from No. 36 to No. 40 B. & S. Gauge, and in length from 5,000 to 10,000 feet. In the drawing the induction coil is shown equipped with an electro-magnet make and break, or vibrator device, which is the form mostly used for ignition purposes. The other form, known as the plain jump-spark coil, has a mechanically operated make and break device attached to the motor to operate the coil.

The arc or spark produced at the breaking point of the electrical circuit in which the primary winding of the coil is connected is not utilized for ignition purposes in this type of coil. When the circuit is broken the sudden reaction or backward flow of the lines of force or magnetic flux in the iron core produce an induced current in the secondary winding, but in the opposite direction to that of the battery current. This induced current is of so much greater intensity and velocity than that induced in the primary winding by this same reaction, that the arc or spark induced in the secondary winding of the coil will jump across a space from one end of the wire to the other, varying from $\frac{1}{8}$ inch to as much as 8 or 10 inches in length, dependent upon the length of wire in the secondary circuit, the electro-motive force of the battery and the frequency of the interruptions or number of times per minute the electric circuit is made and broken.

Referring to Fig. 163 A is the core, B the primary winding and C the secondary. The two coils are held in place upon the core by the washers D. The primary wire B is wound over a paper tube E, and the secondary wire C is insulated from the primary wire by a mica insulating tube F. The coil proper is enclosed in a wood case G.

The terminals or binding posts on top of the case G are connected with the ends of the secondary wire 1 and 2. The secondary terminals are plainly indicated by the letter S. In the base H of the coil case is the condenser J, an essential feature of this form of coil, which utilizes the induced primary current to produce a greater reactive energy in the secondary winding.

At the right-hand end of the coil and outside the casing G is located the electro-magnetic vibrator or trembling device, which automatically makes and breaks the primary circuit. The end 3 of the primary wire is connected with the contact screw K through the bracket L. The spring M, carried by the bracket N, with screw O, is connected with the terminal or binding post P, immediately beneath it, by the wire 6 through the bracket N. The end 4 of the primary wire is connected with another terminal or binding post P, at the other end of the base of the coil. The condenser J is connected across the contact points of the screw K and the spring M, by the wires 5 and 6 and screws Q and X. The condenser is composed of a number of sheets of tinfoil V, laid between sheets of specially insulated paper I, with the opposite end of every alternate sheet of tinfoil projecting from the paper insulation, as shown. These projecting ends are connected together, and by the wires 5 and 6 to the contact screw K and spring M, respectively, as previously described.

When the coil is connected in, or forms part of a closed electric circuit by means of the terminal or binding posts P, on the base of the coil, the current flows through the primary winding B. This instantly produces a high degree of magnetism in the core A, and the pole-piece T of the core extension R becomes strongly magnetic and attracts the iron button W of the spring M. This draws the spring M away from the end of the screw K, and in consequence breaks the electric circuit. This results in the demagnetizing of the pole-piece T and the consequent return of the spring M to its normal position in contact with the end of the screw K. So long as the electric circuit remains closed this operation is repeated at a very high rate of speed. The effect of this continuous operation of the coil is to produce an intermittent current in the secondary winding of high intensity and velocity. If wires are placed in the holes in the small terminals or binding posts on the top of the coil and brought within a short distance of each other, a stream of sparks will pass from one wire to the other in a peculiar zigzag manner and emit a loud, crackling noise, accompanied by a peculiar odor, caused by the formation of ozone through the electro-chemical action of the spark.

Under ordinary circumstances the arc or spark which occurs on the breaking of the contact between the platinum points of the screw K and spring M would not be utilized, but by means of the condenser in the base, which is connected to these parts; as before described, the static charge of electricity generated by this action is stored in the condenser. When the contact is again made this stored electric energy is given up or discharged by the condenser and flows through the primary winding of the coil in connection and in the same direction as the battery current and increases the magnetic effect of the core A enormously.

The construction and operation of the condenser is fully described under the heading *Condenser*. It should be understood that this is one of the most important elements of the ignition system, whether battery or magneto type, and its care should never be neglected if efficient ignition is desired.

Ignition—Timing. In timing the ignition of a motor one should base his operations on one particular cylinder, and this should be the most accessible one. Let it be assumed that a mechanic is required to test or correct the timing of a four-cylinder, four-cycle vertical engine. He would have to know the order in which the cylinders fired, and how to find the firing center of No. 1 cylinder. As the operation of the valves on most motors may be readily seen, the firing center and the order in which the cylinders fire can be easily learned from the action of either set. For instance, if on turning the motor over slowly the intake valve of No. 1 cylinder opens and closes, then that of No. 3 cylinder, and following No. 3 that of No. 4 operates, the mechanic need go no further, for he knows that the engine fires 1-3-4-2. The exhaust valves, of course, may be used in the same way. However, if the valves are entirely enclosed, as on the Winton cars, open the priming or relief cocks, and beginning with cylinder No. 1 note the order in which the air is forced out through the cocks. There are two rules for finding which cylinder is on its firing center, that are based on the action of the valves; these are as follows: When an exhaust valve is open the following cylinder is about to fire. When an intake valve is open the previous cylinder is about to fire. One very simple method of finding the firing center of a cylinder is to open the priming cocks of all the cylinders but one, turn the motor over slowly till compression is encountered, open the cock, insert a stiff wire till it rests on the piston head, then carefully bring the piston to the top of its stroke. The cylinder will then be on its firing center. When the firing center, and the order in which the cylinders fire are known, all that remains to be done in timing an engine is to set the revolving segment of the commutator or distributer so that a spark will occur in the proper cylinder when the spark control lever is advanced about one-third or, with the spark control lever fully retarded, and the piston about ½ to 1 inch down on the explosion stroke, set the segment so that it just begins to make contact.

Many troubles arise from faulty or defective insulation.

A wire placed too close to an exhaust-pipe invariably fails after a time, owing to the insulation becoming burnt by the heat of the pipe.

A loose wire hanging against a sharp edge will invariably chafe through in course of time.

If the insulation of the coil breaks down it cannot be repaired on the road, it should be returned to the makers. A slight ticking is usually audible inside the coil when this occurs.

All wires where joined together should be carefully soldered, the joints being afterwards insulated with rubber or prepared tape. Never make a joint in the secondary wires. See that all terminals are tightly screwed up. When connecting insulated wire, the insulation must be removed, so that only the bare wire is attached. Wires sometimes become broken, and being loose make only a partial contact.

Battery terminals frequently become corroded; they should be covered with vaseline, and require periodical cleaning. See that all connections at the battery are clean and bright.

The porcelain of the spark plug may be cracked and the current jumping across the fracture. The points may be sooty and require cleaning. They may be touching and require separating, or they may be too far apart. The usual distance between the points is about one thirty-second of an inch, which is approximately the thickness of a heavy business card.

Clean all oil and dirt from the commutator. Most commutators are so placed as to give the maximum possible opportunity to collect oil and dirt. They should always be provided with a cover.

In course of time dry or storage batteries will become weak or discharged. Always carry an extra set.

Spanners, oil-cans, tire-pumps, etc., have been known to get on the top of the batteries, thereby connecting the terminals together and causing a short-circuit.

The platinum contacts of the coil may become corroded. They should be cleaned with a small piece of emery cloth or sandpaper.

**Ignition, Atwater Kent.** This device is designed to draw from a battery, as nearly as possible, only the electrical energy necessary to ignite the charge, and to keep the batteries until the energy remaining in them is too small to produce an effective spark. Its principal constituent parts are, a jump-spark coil and condenser, a primary contact maker, the time of which may be advanced or retarded, and a high tension distributer. Its distinguishing features are—

a. But one spark is made for each ignition.

b. The primary contact, rupture of which produces the spark, is exceedingly brief, no longer in fact than is actually required to build up the magnetism in the core of the spark coil.

c. The duration of this contact is independent of the engine speed in the same way that the contact of the ordinary coil vibrator is.

d. Contact is made and broken mechanically through a shaft driven by the engine, consequently a spark may be obtained from a battery that is too weak to operate a vibrator. The mechanism by which the instantaneous primary contact is produced is similar to a snap contact produced by a small spring-controlled hammer pulled out of position by a ratchet on the shaft. The ratchet has as many teeth as there are cylinders, and runs at the camshaft speed. When used with a two-cycle engine, it runs at the crankshaft speed if there are four cylinders. If there are two cylinders, it runs at half the engine speed and the ratchet has four teeth. The ordinary commutator is not used in connection with it, but a driving connection must be made from the crankshaft or camshaft to the vertical shaft of the spark generator itself, which is mounted on the back of the dashboard.

The Atwater-Kent system consists of three parts: 1, The unisparker, which combines the special form of contact-maker, which is the basic principle of this system, and a high tension distributor.

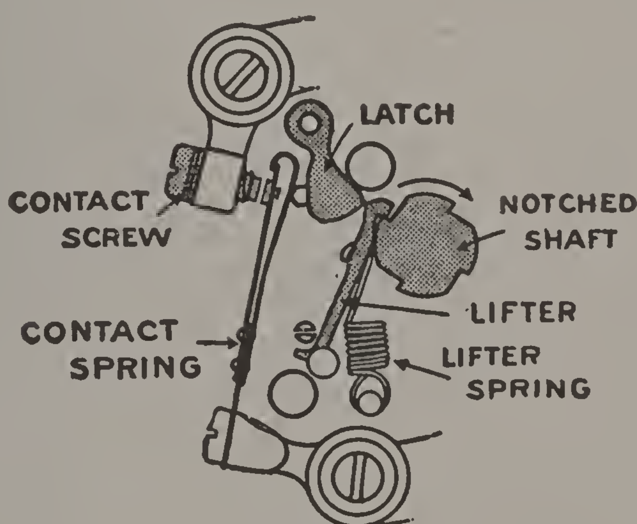



Fig. 164
Atwater Kent Timer Before Moving Lever

2, The coil, which consists of a simple primary and secondary winding, with condenser—all imbedded in a special insulating compound. The coil has no vibrators or other moving parts.

3, The ignition switch.

The operation of the unisparker is shown in Figs. 164 to 167. This consists of a notched shaft, one notch for each cylinder, which rotates at one-half the engine speed, a lifter or trigger which is pulled forward by the rotation of the shaft and a spring which pulls the lifter back to its original position. A hardened steel latch and a pair of contact points complete the device.

Fig. 165
Atwater Kent Timer Before Lever Escapes

The figures show the operation of the contact-maker very clearly. It will be noted that in Fig. 164 the lifter is being pulled forward by the notched shaft. When pulled forward as far as the shaft will carry it, Fig. 165, the lifter is suddenly pulled back by the recoil of the lifter spring. In returning it strikes against the latch, throwing this against the contact spring and closing the contact for a very brief instant—far too quickly for the eye to follow the movement, Fig. 166.

Fig. 167 shows the lifter ready to be pulled forward by the next notch.

Note that the circuit is closed only during the instant of the spark. No current can flow at any other time, even if the switch is left "on" when the motor is not running.

By means of the distributor, which forms the upper part of the unisparker, the high-tension current from the coil is conveyed by the rotating distributor block, which seats on the end of the unisparker, to each of the spark plug terminals in the order of firing.

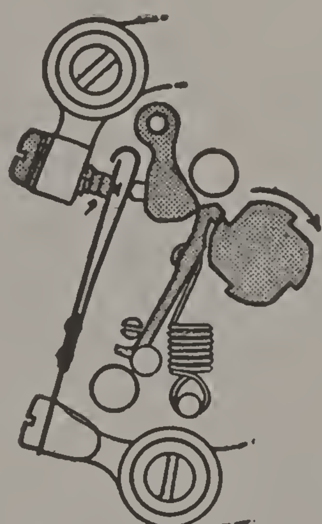


Fig. 166
Atwater Kent Timer With Contacts Closed

Where the lighting and starting battery is used for ignition, two wires from the ignition system should run directly to the battery terminals. They should not be connected in on any other branch circuit.

The automatic type is cylindrical in shape and consists of a pressed steel casing with a hard rubber cap, the latter forming the base of the high-tension distributor. The device is mounted on a shaft which is driven at half the speed of the crankshaft. Within the casing is located the mechanism, consisting of the governor which automatically controls the advance, the circuit breaker and high-tension distributor.

Fig. 167
Atwater Kent Timer With Contacts Re-opened

At the bottom of the casing is the governor, a modification of the centrifugal type which consists of two pairs of weights, each pair being pivoted together at their centers, and two double arm brackets. When the shaft starts to revolve, the weights extend away from the center and the arms change their angular relation in direct proportion to the speed of the driving shaft.

In order that the weights will not move away from the center too easily and give too great an advance to low speeds, the brackets carrying the springs are so arranged that the weights have to act against them when obeying the impulse of centrifugal force, and moving away from the axis of rotation. Virtually each weight is a bell-crank lever with one point of connection pivoted to the arm and the other point of connection pivoted to the weight. The four weights thus give four bell-crank levers working in the same direction at the same time against the four respective springs.

In timing with automatic advance the piston in No. 1 cylinder should be raised to high dead center, between compression and power strokes, then, with the clamp which holds the unisparker loose, the unisparker should be slowly and carefully turned backwards, or counter clockwise (contrary to the direction of rotation of the timer-shaft), until a click is heard. This click happens at the exact instant of the spark. Now clamp the unisparker tight, being careful not to change its position.

Now remove the distributor cap, which fits only in one position, and note the position of the distributor block on the end of the shaft. The terminal to which it points is connected to No. 1 cylinder. The other cylinders in their proper order of order of firing are connected to the other terminals in turn, keeping in mind the direction of rotation of the timer shaft.

When timed in this manner the spark occurs exactly on "center" when the engine is turned over slowly. At cranking speeds the governor automatically retards the spark for safe starting, and as the speed increases, the spark is automatically advanced, thus requiring no attention on the part of the driver.

The first operation in timing the hand advance unisparker is to crank the engine until the piston of No. 1 cylinder is on high dead center between the compression and power strokes.

The unisparker is then placed on the shaft, the advance rod from the steering post being connected to the lug on the side of the unisparker, which is provided for that purpose.

The position of the spark advance lever on the steering wheel sector should be within ½ inch of full retard, and the connecting levers should be such as to give the unisparker a movement of at least 45 degrees to 60 degrees for the full range of spark advance.

After the spark lever is connected up and the unisparker is in position it should be left loose at the driving gear, and, with the motor on dead center as above directed, the shaft of the unisparker should then be turned forward or in the same direction as that in which the timer shaft normally rotates, until a click is heard, at which point it should be set by tightening the driving connection.

The contact points are the only adjustable feature of the unisparker. These points should never touch when engine is at rest and the space between them should vary from 1/100 to 1/64 of an inch, depending upon the strength of the batteries, spark, heat required, etc. The spark can be made hotter by decreasing the distance, and current can be economized by increasing it. Once or twice a season these contacts should be examined and should be kept flat and bright by means of a small file or emery cloth on a stick. The proper adjustment when starting with new batteries is about 1/32 of an inch, if dry cells are used. If storage battery is used, it may be necessary to reduce this a little. At intervals of six or eight hundred miles of service as the batteries decrease in strength, these contacts should be closed from a quarter to a half turn, or until regular firing is obtained. Do not attempt under any circumstances to adjust the tension of the springs.

Frequently when high-tension wires are run from the distributor to the spark plugs through metal or fibre tubing, trouble is experienced with missing and back-firing, which is due to induction between the various wires in the tube. This trouble is especially likely to happen if the main secondary wire from the coil to the center of the distributor runs through this tube with the spark-plug wires.

Wherever possible, the distributor wires should be separated by at least ½ inch of space and should be supported by brackets or insulators rather than run through a tube. In no case should the main distributor wire be run through a conduit with the other wires.

If irregular sparking is noted at all plugs, examine first the battery and connection therefrom. If the trouble commences suddenly, it

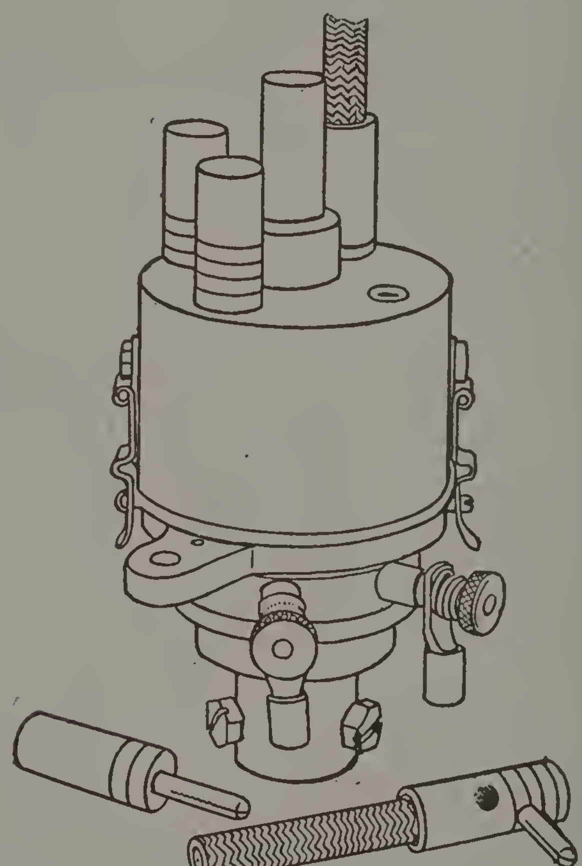


**Fig. 168**
Connecticut Igniter Head

is probably due to a loose connection in the wiring. If gradually, the batteries may be weakening or the contact points may require attention. See that the contacts are clean and bright, and also that the moving parts are not gummed with oil or rusted.

**Ignition, Connecticut.** The Connecticut automatic igniter system, Fig. 168, produces a single spark upon a break occurring in the primary circuit which, though being closed, has energized a coil. This break is effected in the igniter by means of a cam revolving against a breaker arm. The high tension spark is distributed in the same instrument. The igniter is mounted on a vertical shaft running at half engine speed irrespective of the number of

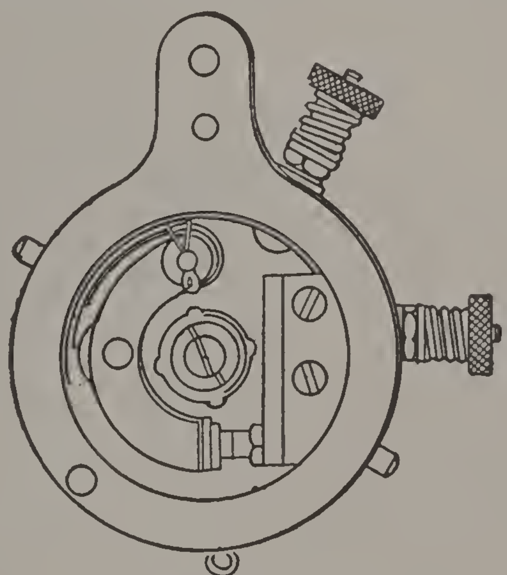


Fig. 169
Connecticut Breaker Mechanism

cylinders. The breaker arm is insulated from the base. This provides a metallic circuit; or in other words, no engine ground need be utilized in the primary or battery circuit, as the primary winding is insulated from the secondary ground in the coil. In this case there is no possibility of the ignition being affected through grounding or shorts in any other circuit of the car, such as disarrangement in lighting or starting systems.

The igniter may be taken apart and reassembled without the aid of any tools. The distributor case can be removed by unsnapping the two spring clips on the side, thus exposing the distributor arm carrying the carbon brush, Fig. 169, which can be slipped off the shaft.

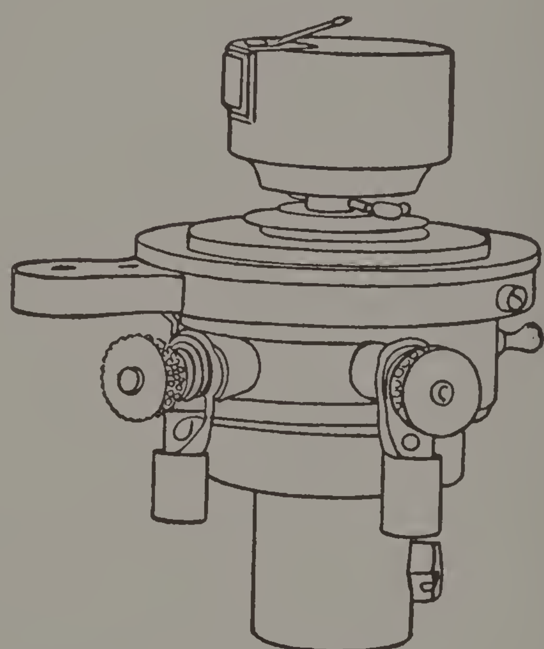


Fig. 170
Connecticut Distributor Rotor

Then remove cotter pin passing through shaft and the dust proof cover carrying the upper bearing can be taken off and the breaker box complete, Fig. 170, can be lifted from the shaft. As the shaft is not disturbed the timing is in no way affected when the igniter is reassembled on the shaft.

The system is not recommended for use on dry cells except as an emergency, but is designed to operate from a storage battery charged by a dynamo.

The automatic switch of the Connecticut automatic igniter system is a feature that is individual to this system and unique in ignition apparatus. Its function is to kick off the switch should the primary circuit be closed an unwarranted length of time, as in the case of a car being left with the switch on the engine stopped. This will prevent the draining of batteries.

Another purpose is to protect the ignition wiring should a disarrangement occur in the lighting or starting circuit and an excessive and destructive amount of current be introduced into the ignition circuit.

The circuit is closed in the automatic switch through contacts of the plunger type. These plungers are held in contact by a slotted locking plate. This plate is released by the "off" button on the switch; or in cases of prolonged or excessive flow of current, by a vibrating magnetic release thermostatically effected. The construction is such that no amount of outside vibration or jar can in any way affect the locking plate.

This automatic "kick off" is accomplished thermostatically and is a mechanism that has been employed for many years in telephone switches.

To time the igniter, turn the engine over, with petcocks open, until the piston of the first cylinder has reached the top of the compression stroke. Now advance the spark lever on the steering wheel about three-quarters of the way. Remove distributor cap, then set the igniter on driving shaft with set screws loose, connect advance lever, turn hub of igniter on shaft in direction of rotation until contact points are just open, which is the point at which the spark takes place, then tighten the hub set screws. Replace the distributor cap, carefully noticing which segment of the distributor the brush is opposite, for this is the connection to the spark plug of No. 1 cylinder. Connect up the balance of the spark plugs in their firing order. After connecting all wires you are then ready to try out the ignition. Before cranking, fully retard your spark lever. To suit individual requirements, it may be necessary to slightly advance the igniter hub if greater speed is required, or slightly retard it for very slow speed.

This igniter is completely housed and protected. Little care is required to keep it in working condition. About every four or five thousand miles the distributor cap should be removed and wiped out. On the ball-bearing igniter, the distributor arm should be withdrawn and one or two drops and no more of good oil injected into the hole in the end of the shaft which carries the distributor arm.

This will lubricate the lower ball-bearing. No other parts need oiling. Care should be taken to see that oil does not reach the contact points. On the plain bearings or self-lubricating type, the bearings require no attention whatever.

The contact points will probably require no attention until run at least ten thousand miles and in some cases they may operate for over thirty thousand miles without attention.

The points do not require refiling or cleaning even though they may be very rough and irregular, but when they become so badly burned as to cause missing they should then be renewed, in which case proceed as follows:

Remove the distributor cap and arm, disconnect advance lever and wires, remove cotter pin in igniter shaft, then spring washer and fibre washer, and lift the housing from its shaft.

The contact adjustment screw will be noticed under the dust ring, it being locked from turning by a hexagon nut on the screw inside near the end. Care should be taken to see that this nut is tightened up snugly after making a replacement or adjustment. When it is necessary to adjust these points they should be set so that when the roller rests on the point of the cam, they open about the same as a magneto interrupter. It is not necessary, however, to make this adjustment as accurately as on a magneto. The adjustable contact screw can be removed by taking off the lock-nut and then screwing it back out of the housing.

The contact on the breaker arm is riveted into it and a complete new arm is necessary in making a replacement.

This arm can be readily removed by taking out the small cotter pin in the end of the stud on which it moves, remove small fibre washers and the arm can then be lifted out.

When replacing the arm on the stud before putting the cotter pin in place, be sure and replace the little fibre washers which rest on the top of the arm just under the little cotter pin and the fibre washer on the stud in the bottom of the cup.

**Ignition, Delco.** The Delco system of battery ignition makes use of a combined breaker and distributor usually mounted on, and driven from, the lighting dynamo or motor-dynamo. In some installations the ignition unit is placed by itself, but the construction and operation is the same in either case.

The distributor and timer are driven through a set of spiral gears attached to the armature shaft or its extension. The distributor consists of a cap or head of insulating material, carrying one high-tension contact in the center, with similar contacts spaced equi-distant about the center, and a rotor which maintains constant communication with the central contact.

The rotor carries a contact button which sends the secondary circuit to the spark plug in the proper cylinder.

Beneath the distributor head and rotor is the timer, Fig. 171, which is provided with a screw in the center of the shaft, the loosening of which

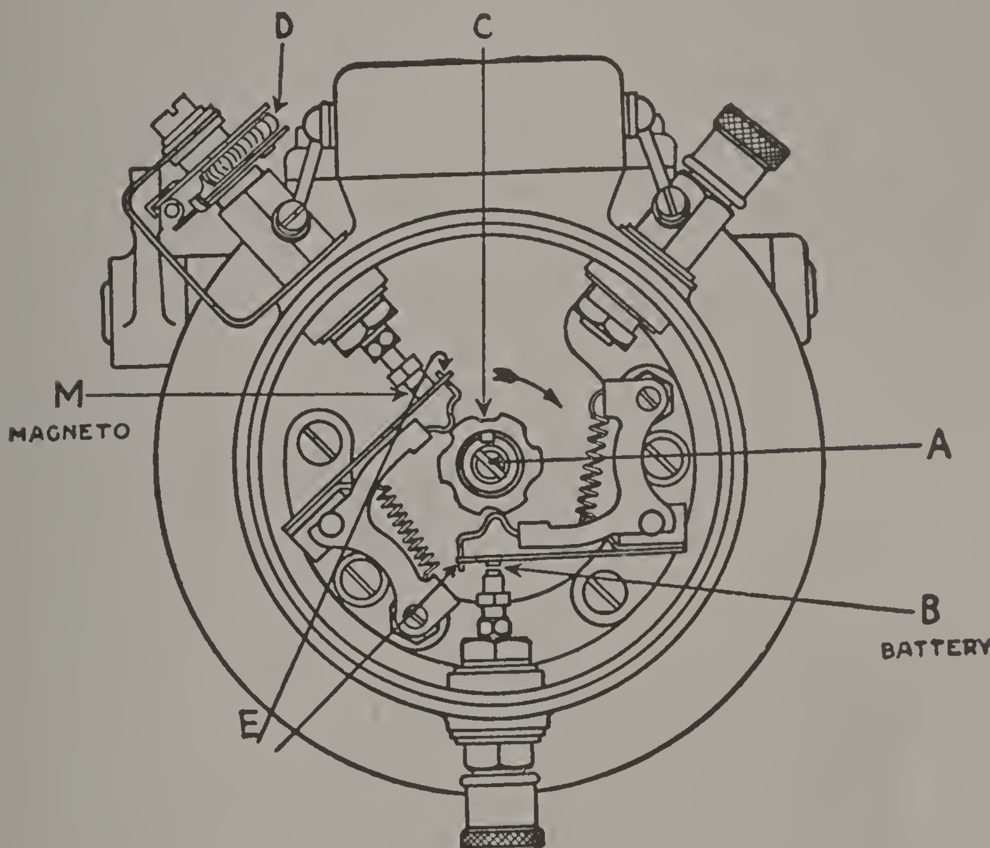



Fig. 171

**Delco Ignition Head Breaker.** A, Cam Holding Screw. B, Battery Current Contacts. C, Breaker Cam. D, Resistance Wire Spool. E, Cam Contact Levers. M, Dynamo Current Contacts.

allows the cam to be turned in either direction to secure the proper timing, turning in a clockwise direction to advance and counter-clockwise to retard.

The spark occurs at the instant the timer contacts are opened.

The adjustment screw must always be set down tight after the cam is adjusted.

The same weight which operates the arm on the regulating resistance also operates the automatic spark control. In addition to the automatic spark control, a manual spark control is provided, which is operated by the lever on the steering column, and is connected to the lever at the bottom of the motor generator. The manual spark control is for the purpose of securing the proper ignition control for variable conditions, such as starting, differences in gasoline and weather conditions. The automatic control is for the purpose of securing the proper ignition control necessary for the variations due to speed alone.

The resistance unit is a coil of resistance wire wound on a porcelain spool. Under ordinary conditions it remains cool and offers little resistance to the passage of current. If for any reason the ignition circuit remains closed for any considerable length of time, the current passing through the coil heats the resistance wire, increasing its resistance to a point where very little current passes, and insuring against a waste of current from battery and damage to the ignition coil and timer contacts. When the arm that cuts the regulating resistance into the shunt field circuit is at the top position (that is, at high speeds), the resistance unit is cut out of the ignition circuit. This increases the intensity of the spark at high speeds.

To time ignition: Fully retard the spark lever. Turn the engine so that upper dead center on flywheel is about one inch past dead center with No. 1 cylinder on the firing stroke. Loosen screw in center of timing mechanism and locate the proper lobe of the cam by turning until the button on the rotor comes under the high tension terminal for No. 1 cylinder. Set this lobe of the cam so that when the back lash in the distributor gears is rocked forward the timing contacts will be open, and when the back lash is rocked backward the contacts will just close. Tighten screw and replace rotor and distributor head.

If the motor fires properly on the "M" button, but not on the "B" button, the trouble must be in the wiring between the dry cells or the wires leading from the dry cells to the combination switch, or depleted dry cells.

If the ignition works on the "B" button and not on the "M" button, the trouble must be in the leads running from the storage battery to the motor-generator, or the lead running from the rear terminal on the generator to the combination switch, or in the storage battery itself, or its connection to the frame of the car.

If both systems of ignition fail and the supply of current from both the storage battery and dry cells is ample, the trouble must be in the coil, resistance unit, timer contacts or condenser. This is apparent from the fact that these work in the same capacity for each system of ignition.

The following directions for upkeep apply in a general way to the "M" or "Mag" ignition on all of the Delco systems, but do not apply to the dry battery ignition.

The contact points are of tungsten metal, which is very hard and requires a very high temperature to melt. These should be kept clean and smooth on the faces. This can be done by holding in a vice and using fine emery cloth held underneath a flat file. They should be so adjusted that when they are open they are apart ten-thousands of an inch and the contact arm should move about fifteen-thousands of an inch after the contacts close.

The most common causes of contact trouble are due to the following: (1) Resistance unit shorted out, resulting in excessive current through the contacts, especially at low speeds. (2) Abnormally high voltages due to running without the battery or with a loose connection in the battery circuit. (3) A broken down condenser.

The distributor head should be properly located, that is with the locating tongue of the hold-down clip in the notch on the distributor head. The head should be kept wiped clean from dust and dirt and in some cases it is advisable to lubricate this head with a small amount of vaseline.

The rotor should be kept free from dust and dirt and the rotor button polished bright. The rotor button should be fully depressed before putting on the distributor head to make sure

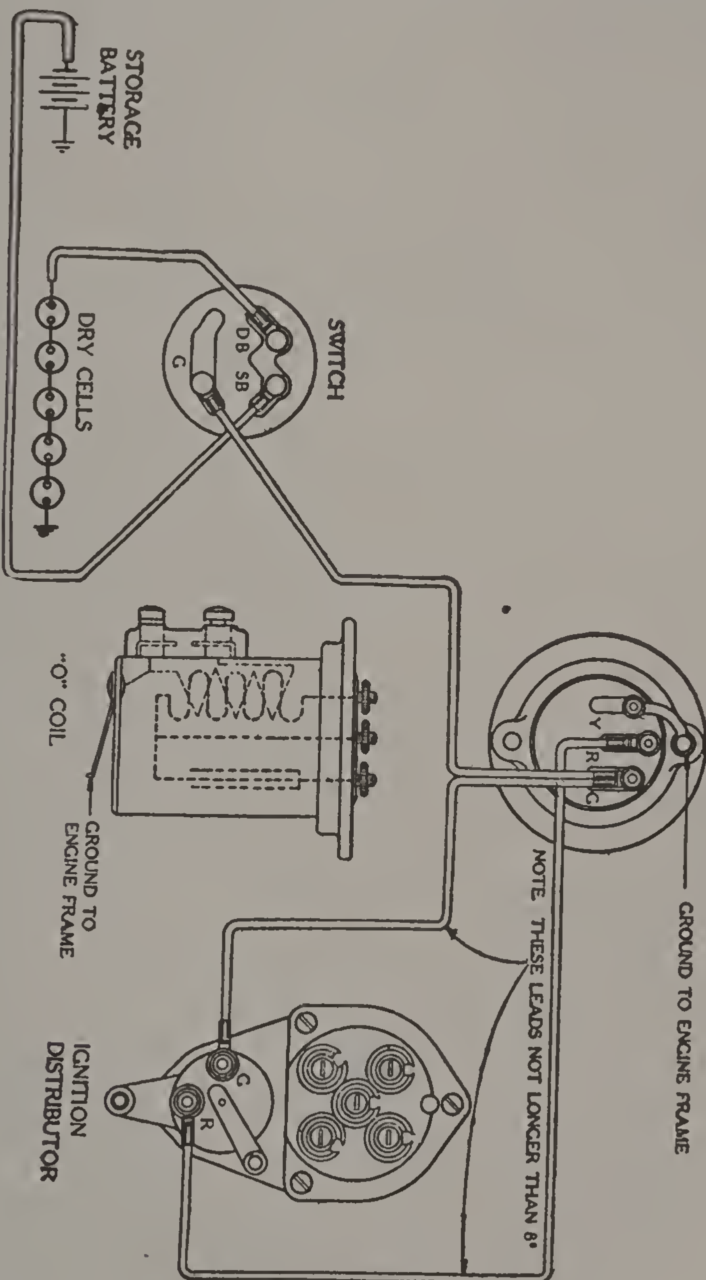



Fig. 172
**Remy Battery Ignition, Magneto Type**

the spring will allow the button to go down to the proper level and not subject it to undue pressure on the distributor head.

**Remy Battery System.** This make of ignition equipment is furnished in two principal types, one of which might be called "magneto type" and the other one a "vertical ignition head."

The magneto type equipment, Fig. 172, bears a very close resemblance to the breaker and distributor end of a separate unit magneto, being composed of a distributor having terminals for the spark plug leads and below the distributor a breaker exactly similar in construction to that with magnetos. In connection with this unit a two-way switch is used, giving either dry battery or generator as a source of ignition current. To transform the current to one of high-tension a separate coil is used.

This coil differs from ordinary coil construction inasmuch as both ends of the primary winding are insulated, so that, in the event of a ground occurring in the lighting or starting circuits, the ignition will be unaffected. The coil is provided with a safety gap as a further means of protection.

The coil is wound for six volts and is to be used in connection with a storage battery or with five dry cells. The coil is to be mounted on the crankcase within 6 or 8 inches of the breaker points as the condenser is incorporated in the coil and not on the generator. A special top plate is provided to securely hold coil in position.

The circuit breaker platinum points may be inspected by removing the Bakelite housing cover. The points should have a smooth, clean, flat surface at all times. The break, or gap, of these points should be from 15 to 20 thousandths of an inch. The circuit breaker may, if desired, be removed without the aid of tools.

The high-tension current is distributed to the spark plug cables by means of a hard carbon brush making contact with distributor segments. Neither distributor nor brush will require any attention whatsoever.

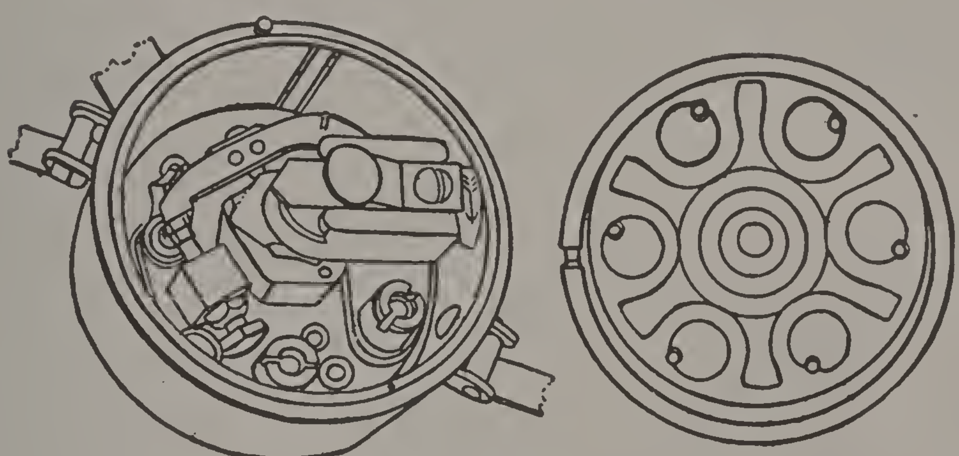


Fig. 173
Remy Vertical Ignition Timer

An oiler is provided for the distributor shaft, —only a few drops of light oil every one thousand miles will suffice.

The use of spark plugs which permit of the points being adjusted to a definite gap is recommended. The gap between the points should be from 20 to 25 thousandths of an inch.

If the motor misses when running idle or pulling light, the plug gaps should be wider. If motor misses at high speed or when pulling heavy at low speed, the plug gaps should be made closer.

The vertical ignition head consists of a combined breaker and distributor mounted in one case, Fig. 173, and adapted to be driven from a vertical shaft usually on or near the lighting dynamo.

Some of these distributors have a manual advance for the spark, while some are built with a mechanism which automatically advances the spark to meet the requirements of the engine upon which it is installed.

The high-tension current is distributed to the spark plug leads by a segment which revolves close to, but does not touch, the pins in the distributor head.

Either iridium-platinum, tungsten or silver is used in the contact points, the choice depending upon which is best suited to the installation.

The coil furnished with this system has a special ventilating base which may be bolted securely to the engine frame. Its current consumption is limited by a resistance located on top of the coil and which is in series with the primary winding.

The metal base of the coil makes an electrical connection with the engine or car frame for one side of the secondary winding. Therefore, it is very important before mounting the coil to see that all foreign matter, such as dirt, grease, paint, etc., is removed from the place where the coil is to be mounted. It is also very important that the base of the coil be fastened down securely at all times.

The switches furnished with this equipment are arranged to reverse the direction of current flow through the circuit breaker each time the ignition is used.

It is absolutely necessary that the ignition switch be placed in the "off" position when the engine is not running. If it is left in the "on" position, current from the storage battery will be dissipated in the ignition coil which, if continued, will exhaust the battery.

By an insulated system is meant one in which the circuit breaker is not grounded. By glancing at the wiring diagram it will be seen that the circuit from the switch around through the breaker box and back to the switch again is not grounded, and that the switch reverses the direction of the current flow through this circuit at each quarter turn.

If the insulation is worn off any one of the wires and the copper touches any of the metal parts of the car, a short circuit will result which will either render the system inoperative by burning out a fuse or will discharge the battery. A periodical inspection should be made of all wiring to see that it is not rubbing or chafing on any of the metal parts of the car and that all connections are tight and secure.

The contact screw should be adjusted with the wrench furnished with the system, so that the maximum opening of the points is .020 to .025 inch, or the thickness of the piece riveted upon the side of the wrench. The rebound spring should be at least .020 of an inch from the breaker arm when the points are at their maximum opening.

To obtain the best results the spark-plug gaps should be adjusted to .025 of an inch.

**Ignition, Westinghouse.** Dual ignition is obtained in the Westinghouse system; that is, the battery is an independent source of supply, as well as the generator operating with the battery, while the interrupter, ignition coil and distributer are common to both.

The interrupter is so constructed that the period of contact is practically the same at any speed. The spark voltage, therefore, does not fall off at high speeds, but is practically the same at all speeds.

Automatic spark advance is a feature of the Westinghouse generator. The automatic advance works over a range of 45°. Provision is made for manual operation also, and it is recommended that this be connected up, but the spark lever need not ordinarily be touched after the original adjustment, the automatic device taking care of all adjustments in running.

The interrupter is mounted on the generator shaft and contacts are operated by a centrifugal device that automatically adjusts the spark advance to the speed, keeps the period of contact nearly constant at all speeds and prevents any inequality between the two interruptions that occur in succession during each revolution.

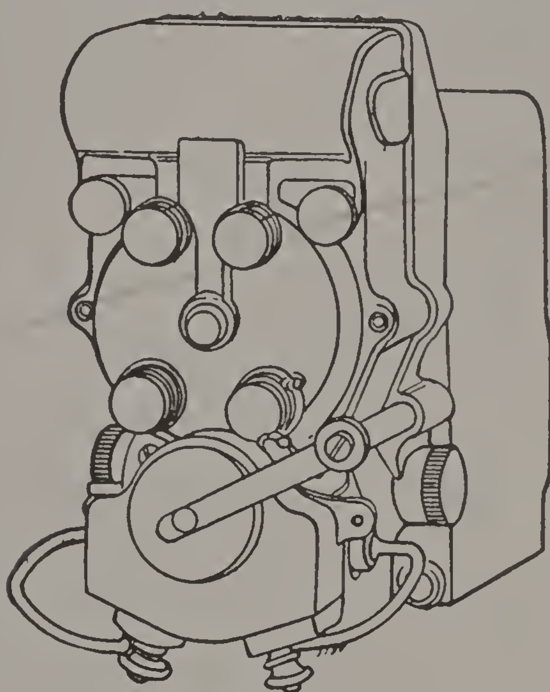


**Fig. 174**

Westinghouse Ignition and Lighting Dynamo

The ignition outfit consists, in addition to the lighting system and storage battery, of a distributer and an interrupter, which are made a part of the generator, Fig. 174, and an ignition coil and switch. The ignition coil transforms the six volts of the battery up to the high tension required for the spark plugs. The interrupter closes and then opens the ignition circuit at each half revolution of the generator shaft, and the distributer directs the high-tension current to each of the spark plugs in succession.

The operation of the ignition system, including the interrupter and distributer, ignition coil and switch, begins with the "making" of the primary circuit of the coil when the centrifugal weights push down the fibre bumper, allowing the interrupter contacts to close, Fig. 175. Then the weight moves off the fibre bumper, allowing the contacts to suddenly separate or open, when a high voltage is induced in the secondary of the ignition coil and directed by the distributer

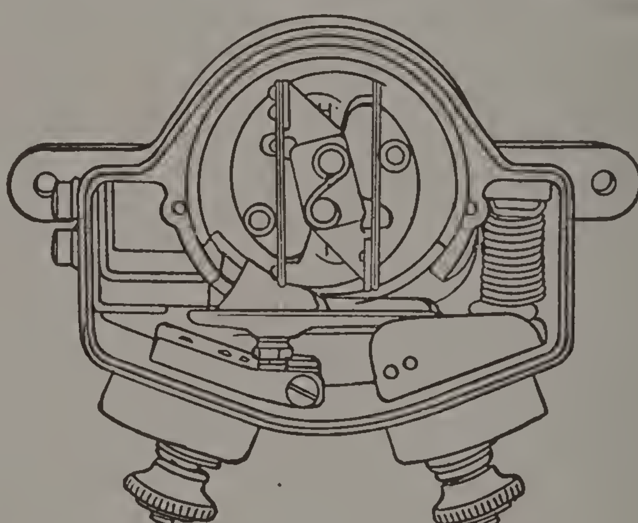


Fig. 175
Westinghouse Ignition Breaker, Low Speed Position

to the proper spark plug, causing a spark. As the speed of the engine increases, the weights are thrown out from the center and automatically advance the time of closing or opening the interrupter contacts, and hence advance the spark, Fig. 176. At the same time, due to their shape, they keep the contacts closed during a greater part of the revolution when running at high speed; this makes the period of contact practically the same at all speeds and prevents the spark voltage from falling off at high speeds.

To connect the ignition system to the circuit, insert the plug into the ignition switch and move the switch handle to the "on" position.

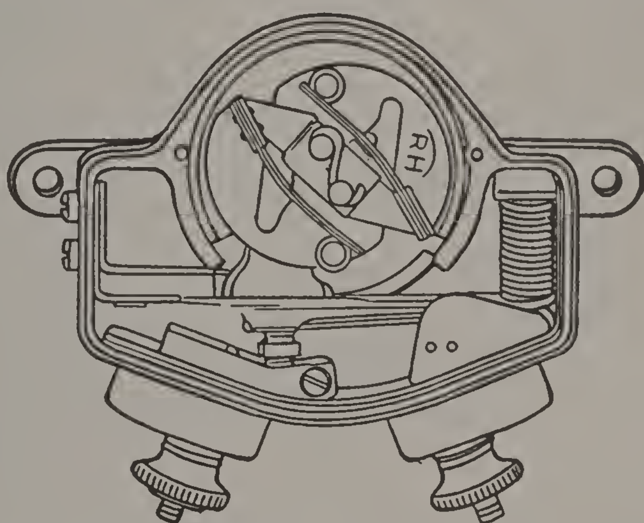



Fig. 176
Westinghouse Ignition Breaker, High Speed Position

In inserting the ignition plug pay no attention to the position of the brass contact pieces on the plug. It is desirable that the contacts will average up as often in one as in the other of the two possible positions, as this reverses the direction of the current through the interrupter contacts and greatly increases their life.

The spark plug should be set with slightly less than 1/32 inch between tips for best operation. Oily or carbonized plugs will often cause missing, and if dirty, they should be well brushed inside and outside with gasoline and wiped perfectly dry. A crack in the insulating material will, of course, probably lead to failure of spark in the cylinder.

The interrupter stop is adjusted so as to give the proper pressure on the bumper. When the engine is not running and the weights are in a closed position, there should be a space of 3/64 inch between the bumper lever and the stop. After the stop is adjusted, the contact screw should be adjusted by means of a wrench, so that with the cam lever against the upper stop, the contacts are open .005 inch. After setting for this separation, tighten the clamping screw so that the contact screw is held firmly. Be sure that the contacts open up positively and that the moving element moves clear up against the upper stop when released, with some spring tension still remaining to hold it in this position. See that the contacts are kept free from all oil and grit.

Interrupter weights should turn freely on their supporting pins and should also clear the centrifugal weight spring support by approximately .01 inch. They should show no lost motion between the two interlocking weights. In making any readjustments, be careful that when the engine is turned over very slowly by hand, both weights depress the moving part of the interrupter enough to definitely close the contacts, otherwise there will be a tendency to miss fire in every second cylinder, especially at low speeds and if the contacts are worn more or less.

When the weights are in the inner position, the springs should just touch the fibre-covered pins on the weights without exerting any appreciable pressure over that required to just positively return the weights to the innermost position. If necessary to adjust these springs, always bend the supporting arms and not the springs themselves.

Distributer brushes should slide freely in their holders and the springs should push them out so as to extend from the holder about ¼ inch when the distributer plate is removed from the generator. These brushes should, however, be retained firmly by their springs so as to never tend to fall completely out of the tubes. Be sure that both these brushes are in place in the distributer.

Distributer plate should be kept clean and free from carbon dust between brushes and contact surfaces by an occasional wiping. Any pitting of the distributer which is in advance of the contacts, indicates that the distributer gear is set one tooth or so too far back against the direction of its rotation. This may cause intermittent firing of the cylinders at the higher speeds, with consequent loss of power. The gear is set correctly at the factory, and if this setting is not disturbed the above trouble will not be encountered.

The distributer gear is meshed with the pinion on the generator shaft so that the mark at the edge of the gear lines up with the tooth of the pinion that is slightly beveled. In coupling the generator to the engine, place the piston of cylinder No. 1 on dead center at the end of the compression stroke. Remove the distributer plate and turn the generator back so that the line of the distributer brushholder block corresponds with the line on the end bracket. Couple the engine and generator shafts while in this position.

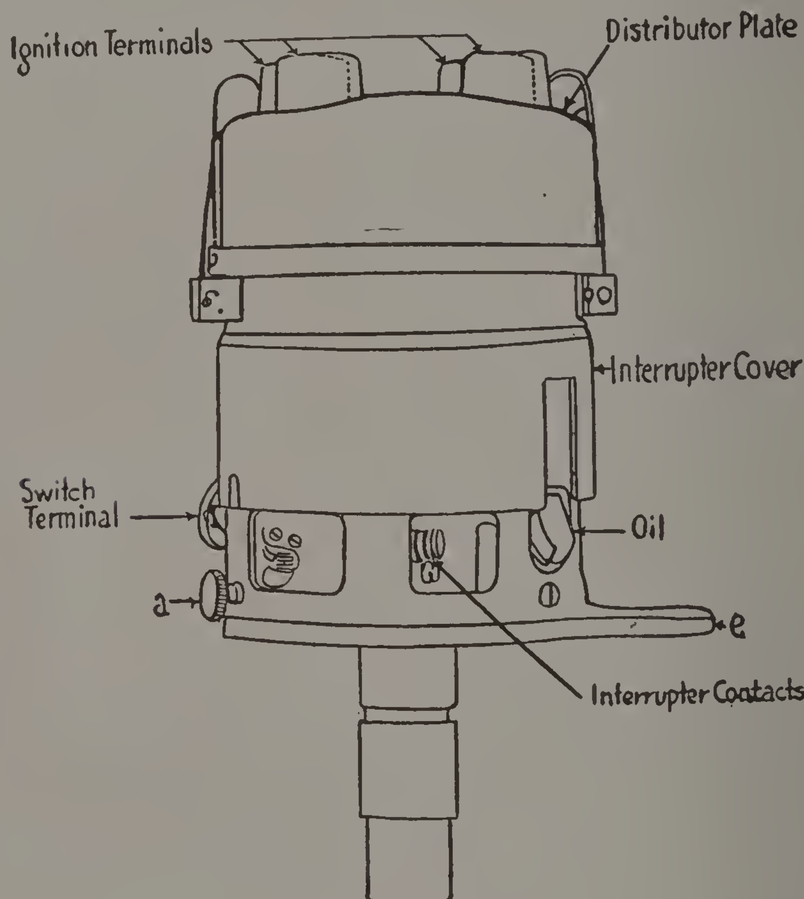



Fig. 177
Westinghouse Vertical Ignition Head

The Westinghouse vertical ignition unit can be used for ignition from storage batteries or plain lighting generators, Fig. 177. This set contains interrupter, spark coil and condenser, and distributer, all in one unit. One wire from the battery or generator to the ignition unit and one wire to each spark plug are all that are required.

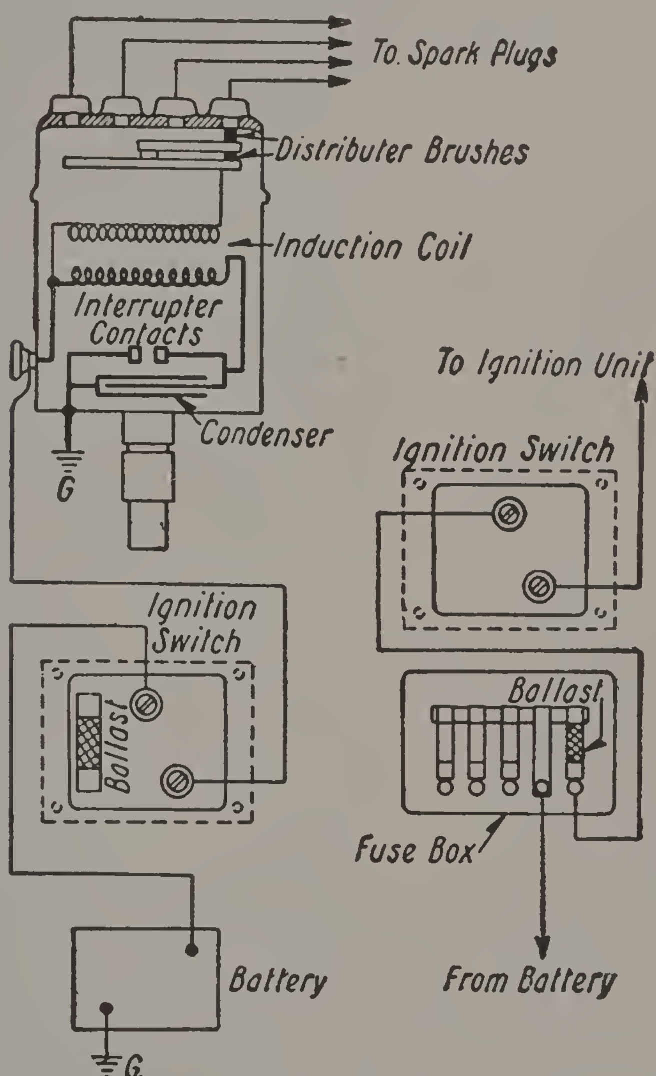



Fig. 178
Westinghouse Vertical Ignition Wiring

The interrupter, located at the lower end of the set, has the same type of circuit-breaker as that on the Westinghouse ignition and lighting generators, but no automatic spark advance feature. It can be used equally efficiently for either direction of rotation without charge. The interrupter is enclosed by a spring collar which can be readily removed for inspection or adjustment of the contacts. The collar makes a tight joint and is clamped by a screw which prevents it from slipping. See wiring diagram, Fig. 178.

The Westinghouse Ford vertical ignition unit is made up of four essential parts, namely, the interrupter, the condenser, the induction coil, and the distributer, all included in one case.

The operation of the interrupter can be observed by loosening the thumbscrew and sliding upward the loose section of the insulation case, which forms the interrupter cover.

With the ignition switch turned to the "on" position and the engine turning over, each segment of the interrupter cam in turn passes on and off the fibre bumper. As each cam passes off the bumper, the interrupter contacts close, closing the circuit from the battery to the primary winding of the induction coil. Then as they pass on the bumper, the contacts are opened, suddenly opening the circuit, thus inducing a high voltage in the secondary of the induction coil. This voltage is directed by the distributer on the top of the ignition unit to the proper spark plug, causing a spark at the spark gap of the plug inside the cylinder, and igniting the charge therein.

The contact screw should be adjusted with a screwdriver so that, with the cam against the bumper, the contacts are open .008 inch.

If the contacts show pitted or irregular surfaces they should be smoothed up with a very fine file, making certain that the surfaces come together squarely after adjustment has been made.

**Ignition, Magneto Type.** Magneto ignition makes use of a separately mounted machine having its own armature and field magnets (permanent magnets) and being driven from the engine. A magneto always consists of a rotating member, this being a shuttle wound armature in most cases, or simply pieces of iron in the inductor type. This rotating member, through the change in the path of the lines of force from the magnets, produces a current in a coil separate or on the armature in the shuttle wound form, or mounted separately in the inductor magneto. This current rises from zero to its maximum voltage twice for each revolution of the magneto shaft, one impulse flowing in one direction through the windings and the next one (on the other half revolution) flowing in the opposite direction. The current from a magneto always reverses its direction in this way and is, therefore, an alternating current. The current from a lighting dynamo does not reverse its direction and is a direct current. For this reason no magneto can ever be used for charging a storage battery, a battery requiring current that always flows in one direction through the circuit.

Combined with the armature and the permanent steel magnets that provide the field for the magneto is a breaker mechanism that interrupts the flow of current through the circuit whenever a spark is desired, and also a distributor that carries the contacts for delivering the high-tension current through the wires that lead to the spark plug in the cylinder that is ready to fire. While the details of construction of magnetos differ as described in the following pages, all types contain the parts described above. A shuttle wound armature with a breaker mounted on its shaft is shown in Fig. 179.

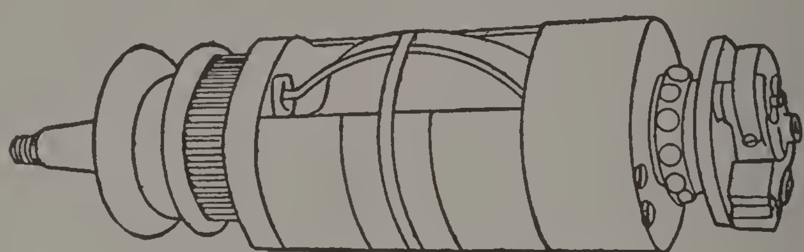


Fig. 179

Shuttle Type Magneto Armature With Breaker

The breaker may take any one of several forms, a commonly used construction being shown in Fig. 180. The circuit is completed through the contacts A, one of which is solidly mounted, and the other one attached to the movable arm B. The arm carries a fibre block that strikes a stationary cam when it is revolved on the armature shaft, and inasmuch as the arm is pivoted, the contacts are separated to interrupt the circuit and cause a spark to come from the winding of the high tension coil of the system. The fine winding that forms the high tension coil may be wound around outside of the armature winding on the shuttle type, or may be mounted in a housing separate from the magneto. With the high tension coil on the armature, the magneto is self-contained and produces a spark without outside parts, being called a true high tension magneto. Those magnetos using outside coils generate the current in their

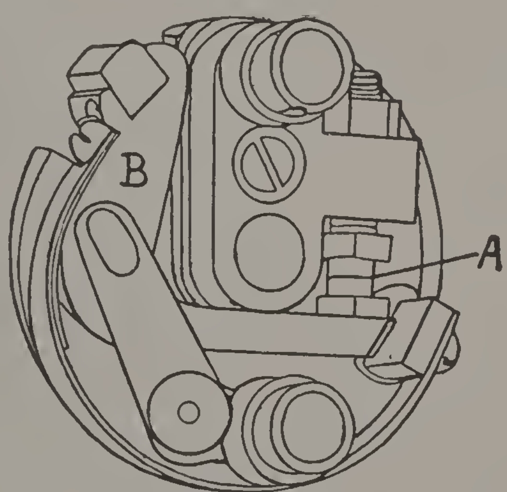



Fig. 180
Magneto Breaker

armature and send it through the heavy winding of the separate induction coil, or transformer coil. This separate coil has also a fine wire winding in which the high tension spark plug current is induced by the breaking of the circuit through the heavy wire when the breaker on the magneto opens.

The system known as "single ignition," when using a magneto, comprises a true high tension machine from which wires lead to the spark plugs. The only other wire required is one to the switch that will allow the driver to stop the production of sparks by connecting the armature winding to the frame of the car, or grounding it. No other source of current is provided with single ignition.

"Double ignition" provides a true high-tension magneto, as described, and in addition, a complete, and entirely separate, battery, timer and coil system with a separate set of spark plugs and wiring.

"Dual ignition" uses a magneto similar to the single ignition high-tension type, but provides an additional breaker and induction coil through which current may be led from a set of dry cells or a storage battery, thus providing a source of current other than that of the magneto armature when desired for starting or emergency use.

"Transformer coil ignition" makes use of a magneto that produces in its armature, or by inductor action, a current of low voltage that is led to a separately mounted transformer, or induction coil. The coil is connected by wires to the breaker and distributor on the magneto.

How to Remove and Replace a Magneto. When about to replace or remove a magneto it is well to see that all separable parts are properly marked, and if not, mark them. This may be done with a center punch, cold chisel, letters or numerals. In Fig. 181 is shown the guide marks generally used in connection with a high-tension magneto of a four-cylinder motor. The center punch marks C, on the Oldham coupling such as is usually employed on the magneto shaft between the magneto and its driving gear, serve as a guide in replacing the magneto. All that is necessary in replacing a high-tension magneto so marked on a four-cylinder, four-cycle motor is to see that the marks are directly opposite each other; but in two or six-cylinder motors, where the crankshaft and the armature of the magneto do not run at the same speed, care must be taken either not to move the crankshaft while the magneto is off or to check up the timing before it is replaced. In the same illustration is shown the method of mark-

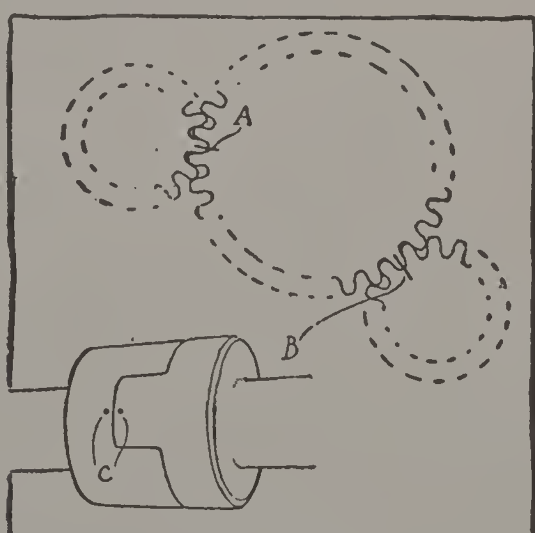



Fig. 181

ing the timing gears. These marks are made with a cold chisel and are generally present in up-to-date construction.

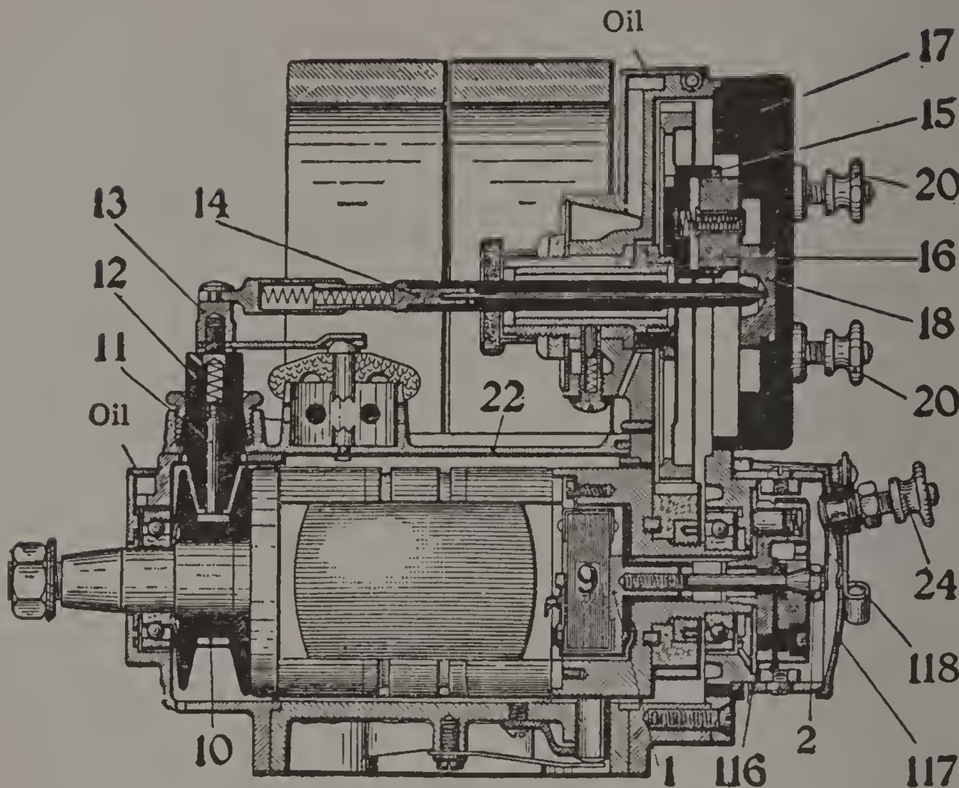



Fig. 182

Figs. 182 and 183

Bosch High Tension Magneto, Type "DU". 1, Armature End Plate for Primary Winding Connection. 2, Breaker Fastening Screw. 3, Breaker Contact Block. 4, Breaker Disc. 5, Long Platinum Contact Screw. 6, Short Platinum Contact Screw. 7, Flat Spring for Breaker Lever. 8, Breaker Lever. 9, Condenser. 10, Collector Ring for High Tension Current. 11, High Tension Carbon Brush. 12, Carbon Brush Holder. 13, Conductor Bar Terminal. 14, Conductor Bar. 15, Distributor Brush Holder. 16, Distributor Carbon Brush. 17, Distributor Plate. 18, Central Contact on Distributor. 19, Brass Segment. 20, Terminal for Spark Plug Wire. 21, Steel Breaker Cam. 22, Dust Cover. 24, Grounding Terminal. 25, Distributor Block Holding Spring. 116, Breaker Timing Lever. 117, Breaker Cover. 118, Conducting Spring for Grounding Terminal. 119, Breaker Cover Holding Spring.

Bosch Magnetos. The Bosch high tension magneto, Fig. 182, generates its own high-tension current directly in the armature winding and without the use of a separate coil or other apparatus. Apart from the cables connecting the magneto to the plugs, the Bosch high-tension magneto requires no external connections.

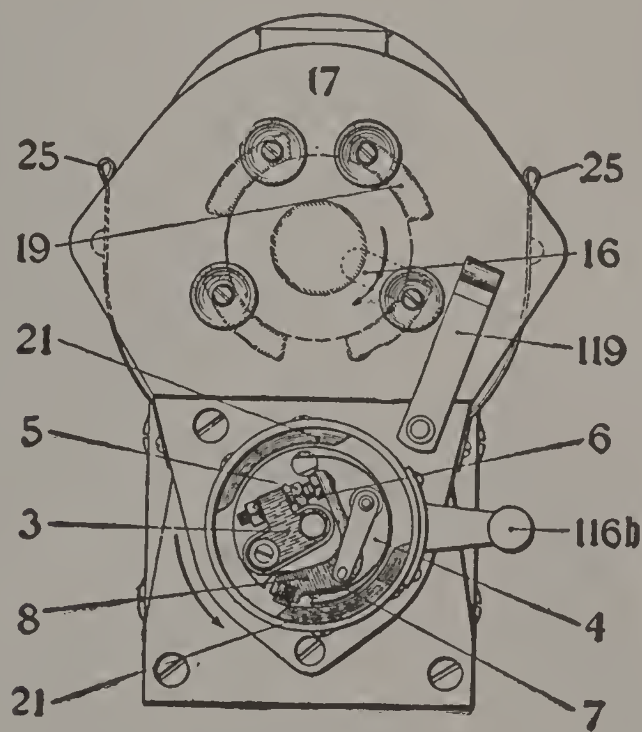



Fig. 183

The armature carries two windings. The primary consists of a few layers of heavy wire and the secondary of a great number of layers of fine wire. One end of the primary winding is grounded on the armature core, and the live end is brought out to a circuit-breaking device. The grounded end of the secondary winding is connected to the live end of the primary winding so that one is a continuation of the other.

During certain portions of the rotation of the armature the primary circuit is closed, and the variations in magnetic flux have their effect in inducing an electric current in it. When the current reaches a maximum, which will occur twice during each rotation of the armature, the primary circuit is broken, and the resulting armature reactions produce a high-tension current of extreme intensity in the secondary winding. This current is transmitted to a distributer by means of which it passes to the spark plug of the cylinder that is in the firing position.

The magneto interrupter, Fig. 183, is fitted into the end of the armature shaft which is taper-bored and provided with a key-way. The interrupter is held in position by a fastening screw, and may easily be removed. In replacing it, care should be taken that the key fits into the key-way and that the fastening screw is well tightened.

Twice during each revolution of the armature the primary circuit closes and opens, this being effected by the interrupter lever coming in contact with a steel segment, which is supported on the interrupter housing. When the magneto interrupter lever is not being acted upon by the steel segment, the platinum points are in contact, thus closing the primary circuit. Then as the armature rotates farther and the interrupter lever again comes in contact with a segment, the platinum points (interrupter contacts) open and thus interrupt the primary circuit. At the opening of the contact the ignition spark occurs instantaneously.

The distance between the platinum points when the magneto interrupter lever is fully depressed by one of the steel segments must not exceed 1/32 inch. This distance may be adjusted by means of a long platinum screw, and should be in accordance with the steel gauge that is pivoted to the adjusting wrench.

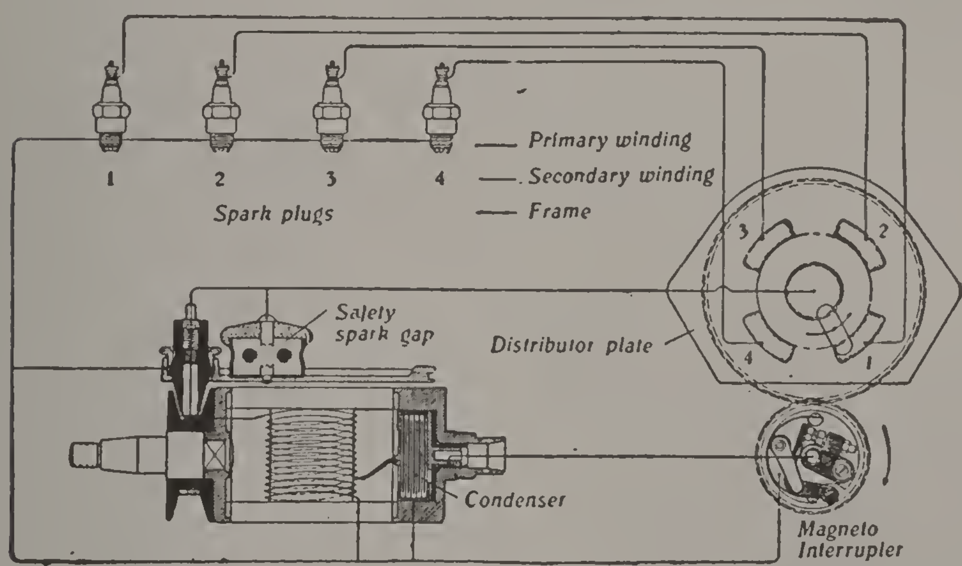



Fig. 184
High and Low Tension Circuits of Bosch Magneto

The connections of the magneto, Fig. 184, consist of a high-tension cable from the distributor to each spark plug, and a low-tension cable leading to the switch.

In order to protect the insulation of the armature and of the current-carrying parts of the apparatus against excessive voltage, a safety spark gap is arranged on the dust cover. It consists of a short pointed brass rod set on the dust cover, and a second pointed brass part supported a short distance from it in the center of the stealite cover of the housing. The insulated point is connected into the secondary circuit, and should there be any interference with the circuit normally provided through the spark plug the safety spark gap provides a point of discharge.

If a spark is observed passing in the safety spark gap it is an indication that there is an interruption in the regular secondary circuit, and the cause should be at once investigated.

A simple test for the magneto is to disconnect the grounding cable from grounding terminal and also to disconnect the spark plug cables. The motor should then be cranked briskly, and the safety spark gap closely observed. If sparks are seen at this point, it is an absolute indication that the magneto is in proper operating condition. If no sparks are observed it will be necessary to make sure that the primary circuit is properly interrupted by the magneto interrupter. Holding spring must be moved sideways, interrupter housing cover taken off, and it must be ascertained whether fastening screw is well tightened. After this it should be observed whether the platinum points are in contact when the steel cams are not acting on the magneto interrupter lever, also whether they separate the correct distance, 1/25th inch, when the interrupter lever is resting on one of the steel cams. Otherwise the distance must be adjusted by means of the platinum screw. The platinum contacts must be examined and any oil and dirt removed; in case the contacts are uneven (but only then) they must be smoothed with a fine flat file. If, after continued use, the platinum contacts are completely worn down, the two platinum screws must be renewed.

The Bosch dual magneto is of the standard Bosch type, and produces its own sparking current, which is timed by the revolving interrupter. The parts of this interrupter are carried on a disk that is attached to the armature and revolves with it, the segments that serve as cams being supported on the interrupter housing.

In addition, the magneto is provided with a steel cam having two projections, which is built into the interrupter disk. This cam acts on a lever that is supported on the interrupter housing, the lever being so connected in the battery circuit that it serves as a timer to control the flow of battery current through the coil.

It is obvious that the sparking current from the battery and from the magneto cannot be led to the spark plugs at the same time, and a further change from the magneto of the independent form is found in the removal of the conducting bar between the collecting ring and the distributer. The collecting ring brush is connected to the switch and a second wire leads from the switch to the terminal that is centrally located on the distributer.

When running on the magneto the sparking current that is induced thus flows to the distributer by way of switch contact. When running on the battery the primary circuit of the magneto is grounded, and there is, therefore, no production of sparking current by the magneto; it is then the sparking current from the coil that flows to the distributer connection. It will thus be seen that of the magneto and battery circuits the only parts used in common are the distributer and the spark plugs.

The end plate of the coil housing carries a handle by which the switch may be operated. By means of this switch either the magneto or the battery may be employed as the source of ignition current, and in its operation the entire coil is rotated within the housing. The inner side of the stationary switch plate is provided with spring contacts that register with contact plates attached to the base of the coil.

For the purpose of starting on the spark, a vibrator may be cut into the coil circuit by pressing the button that is seen in the center of the end plate. Normally, this vibrator is out of circuit, but the pressing of the button brings together its platinum contacts and a vibrator spark of high frequency is produced. It will be found that the distributer on the magneto is then in such a position that this vibrator spark is produced at the spark plug of the cylinder that is performing the power stroke; if mixture is present in this cylinder ignition will result and the engine will start.

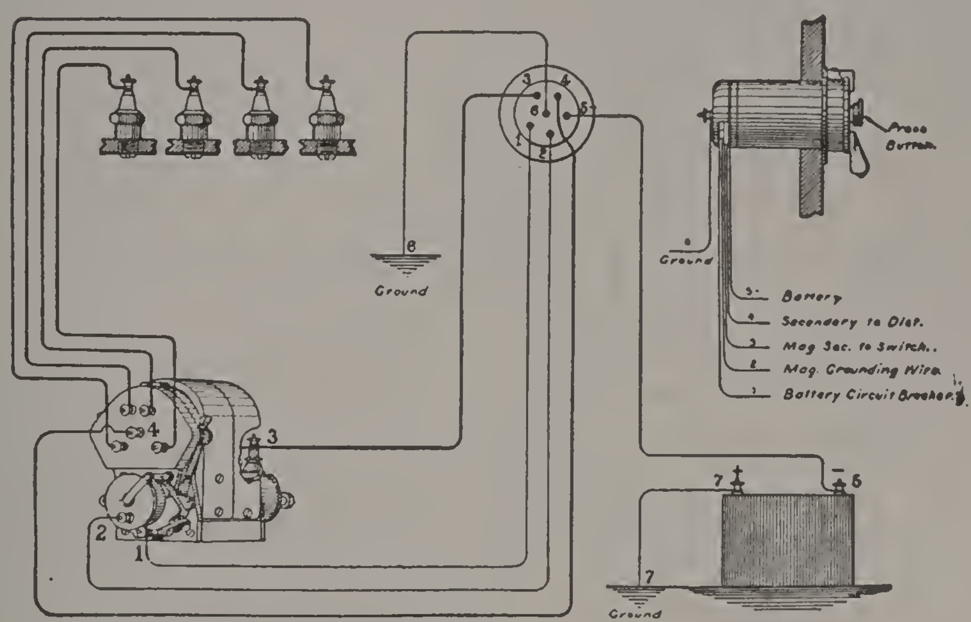



Fig. 185
Bosch Dual System Wiring Diagram

The dual system requires four connections between the magneto and the switch, Fig. 185; two of these are high tension and consist of wire No. 3 by which the high-tension current from the magneto is led to the switch contact, and wire No. 4 by which the high-tension current from either magneto or coil goes to the distributor. Wire No. 1 is low tension, and conducts the battery current from the primary winding of the coil to the battery interrupter. Low-tension wire No. 2 is the grounding wire by which the primary circuit of the magneto is grounded when the switch is thrown to the "off" or to the battery position. Wire No. 5 leads from the negative terminal of the battery to the coil, and the positive terminal of the battery is grounded by wire No. 7; a second ground wire No. 6 is connected to the coil terminal.

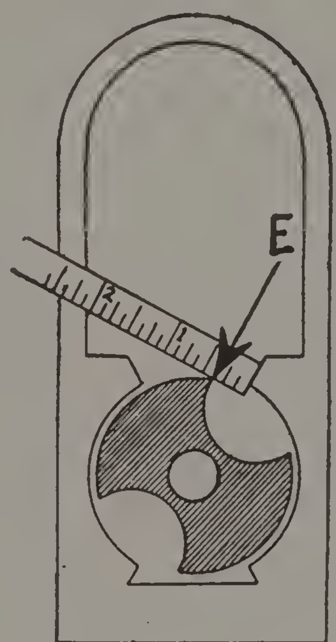



Fig. 186
Method of Setting Armature of Bosch Magneto

The timing of the Bosch Dual Magneto is identical with the standard type. The dual magneto is so arranged that the battery interrupter breaks its circuit approximately 10 degrees later than the magneto interrupter; this feature gives the full timing range of the magneto. With the timing lever fully retarded and the switch on the battery position, the battery spark will occur after the piston has passed dead center and is moving on the power stroke. The possibility of a back kick is thus eliminated.

The magneto should be placed in position on the bed plate or pad provided for it, the bolts or straps being properly secured; the driving gear or coupling, however, should be loose on the armature shaft. The dust cover, which is an aluminum plate located under the arch of the magneto, should then be removed, and this is accomplished according to the design of the various types of magnetos.

The engine should now be cranked until one of the pistons, preferably that of cylinder No. 1, is at the top of the compression stroke. With the engine in this position, the armature should be rotated by hand in the direction in which it will be driven until it is approximately in the position illustrated in Fig. 186. The setting of the armature is determined by the dimension marked E, Fig. 186, as follows:

| | |
|---|---|
| "DU3" Model 4 | 11 to 14 mm. |
| "DU4" Model 4 | 13 to 15 mm. |
| "DU6" Model 4 | 16 to 20 mm. |
| "DU3" Model 4 | 8 to 11 mm. |
| "DU4" Model 4 | 10 to 13 mm. |
| "DU6" Model 4 | 12 to 16 mm. |

With the armature held in the proper position, the gear or coupling should be secured. The greatest care should be exercised to prevent the slipping of the armature during this operation.

In the fully enclosed magneto it is unnecessary to remove either the interrupter housing cover or the distributer plate in order to determine the setting of the instrument, or to locate the distributer terminal with which contact is made.

The magneto having been bolted into position, the crankshaft is to be turned to bring one of the pistons, preferably that of cylinder No. 1, to the firing position for full advance.

The armature is then rotated until the figure "1" can be seen through the window in the face of the distributer plate. The cover of the oilwell on the distributer end of the magneto is then to be raised, and the armature is to be turned a few degrees in one direction or the other until the red mark on one of the distributer gear teeth is brought to register with the red marks on the side of the window located between the two oil ducts.

The magneto is then in time for the full advance position, and the gear or coupling is to be secured to the armature shaft. Great care should be taken not to disturb the position either of the crankshaft or the armature shaft when fitting the driving member.

Bosch Enclosed Types. In the "DU" dual magneto, the current is led from the collector ring connection to the coil and back to the distributer terminal that is located in the center of the distributer plate. In the enclosed dual magneto, this central terminal is eliminated, and the current is led internally to the distributer from a connection on the shaft end of the magneto. To expose this terminal, the shaft end bonnet should be removed, which is done by withdrawing the two screws in its lower flange, and sliding the bonnet backward. The terminal will then be seen to be a vulcanite post, with a boss that projects through a hole in the bonnet. In the top of this post are two vertical holes, in the bottom of each of which is a screw. These screws are to be withdrawn. The ends of the high-tension wires No. 3 and No. 4 leading to the coil are then to be cut off square, and after being led through the hole in the bonnet, are to be pressed to the bottoms of the slanting holes in the boss. The pointed screws are then to be replaced in the vertical holes, and in being driven home they will pierce the cables (and their insulation) and make the required connections. It is essential to use a screwdriver of the proper size, for a tool with too large a blade will inevitably crack the vulcanite. Great care must be taken to apply the screwdriver to the screws vertically in order to avoid cracking the vulcanite by side pressure. When the connections are made the bonnet is to be replaced.

Bosch Upkeep and Care. It will be noted that the press button on the coil is arranged to set in either of two positions, which are indicated by an arrow engraved on its surface, or projecting from its edge. When this button is in such a position that the arrow is pointing on the word "run" a single contact spark will be produced when the engine is cranked, or when the engine is running with the switch in the battery position. Under all ordinary conditions the button position should invariably be used.

When the engine is chilled, however, or under poor mixture conditions, starting can frequently be facilitated by pressing down the button and turning it slightly to the right so that the arrow is pointing to the word "start." This will lock the vibrator in circuit, and a shower of vibrator sparks will be produced in place of the single contact spark.

The platinum points of the magneto interrupter should be kept clean and smooth and so adjusted that they are open about 1/64 inch, or the thickness of the gauge attached to the adjusting wrench, when the magneto interrupter lever is wide open on one of the rollers or segments. It should not be necessary to clean or readjust these points oftener than once a season, and it is not advisable to readjust them until their condition and the missing of the engine show it to be absolutely necessary.

Each coil is stamped with the voltage of the battery current for which it is wound, and if this voltage is not exceeded the platinum contacts of the battery interrupter will not require attention for long periods. When this battery interrupter lever is being operated by the rollers or segments, the platinum points should be slightly wider open than the contact points of the magneto interrupter—the proper distance being about 1/50 inch.

If the magneto is at fault, all the cables and terminals should be examined for improper connections. The coil and battery system may then be disconnected by removing the wires from terminals Nos. 3 and 4 of the magneto, and with a short piece of wire magneto terminal No. 3 may be connected directly with magneto terminal No. 4. This will conduct the high-tension current induced in the magneto direct to the distributer. The grounding wire should then be disconnected from terminal No. 2 of the magneto. With this arrangement it should be possible to start the engine on the magneto, and it will be necessary to follow this plan should any accident happen to the coil.

To ascertain if the magneto is generating current, the grounding wire should be disconnected from terminal No. 2 on the magneto, and the high-tension wire should be disconnected from the collecting ring terminal No. 3. If the engine is then cranked briskly a spark should appear at the safety spark gap that is located under the arch of the magnets on the dust cover, provided the magneto is in proper condition. The grounding wire should then be reconnected to terminal No. 2, and the engine cranked. If no spark appears at the safety spark gap, the trouble may be determined as a leakage of the primary magneto current to ground by chafed insulation, incorrect connections, or an injury to the switch parts.

The coil may be tested by disconnecting wire

No. 4 from the magneto and throwing the switch to the battery position, operating the press button with terminal No. 4 3/16 inch from the metal of the engine. If the coil is in good condition, a brilliant spark should be observed. If the spark does not appear the test should be repeated with wire No. 3 disconnected. If the fault persists the coil body may be removed from the housing by withdrawing the holding screw that is located close to the supporting flange; the switch should then be unlocked and the end plate given a quarter revolution. This will release the bayonet lock and the coil body may then be withdrawn to permit the inspection of the switch contacts both of the coil and of the stationary switch plate. It may be that the spring contacts are bent or otherwise in bad condition. The withdrawing of the coil body and its handling should be performed with extreme care. No work should be done on the coil in the way of withdrawing screws, etc., and if the inspection does not disclose the fault the coil should be returned to its housing and the whole returned to the makers or to one of their branches.

Bosch "NU" Magneto. Like other Bosch high-tension magnetos, the type "NU4," Fig. 187, generates its own high-tension current directly in the magneto armature (the rotating member of the magneto) without the aid of a separate step-up coil, and has its timer and distributer integral. The distinct gear-driven distributor common to other types has been omitted in the "NU4" magneto, and in its stead is a double slipring combining the functions of current collector and distributor.

The armature winding is composed of two sections: one, primary, or low tension, consisting of a few layers of comparatively heavy wire, and the other, secondary, or high tension, consisting of many layers of fine wire.

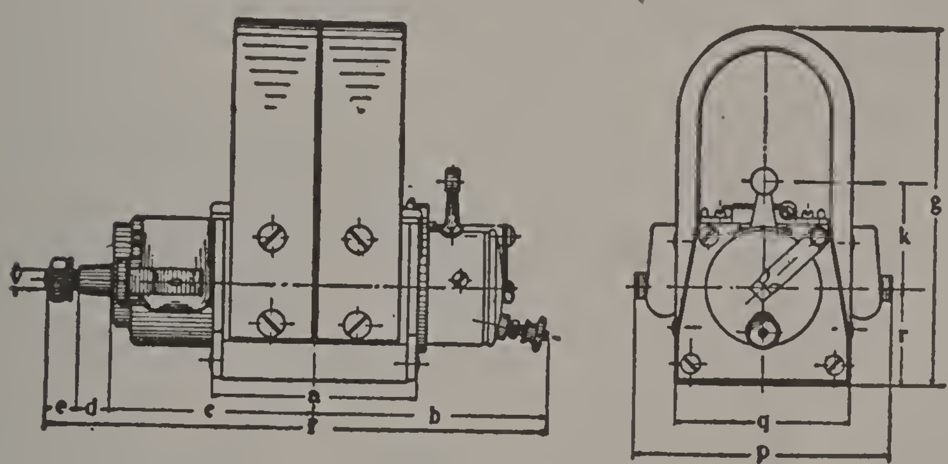



Fig. 187
Bosch High Tension Magneto, Model "NU"

The beginning of the primary winding is in metallic contact with the armature core, and the other, or live, end is connected by means of the interrupter fastening screw to the insulated contact block supporting the long platinum screw on the magneto interrupter. The interrupter lever, carrying a short platinum screw, is mounted on the interrupter disc which, in turn, is electrically connected to the armature core. The primary circuit is completed whenever the two platinum interrupter screws are in contact and interrupted whenever these screws are separated. The separation of the platinum screws is controlled by the action of the interrupter lever as it bears against the two steel segments secured to the inner surface of the interrupter housing. The high-tension current is generated in the secondary winding only when there is an interruption of the primary circuit, the spark being produced at the instant the platinum interrupter screws separate.

The secondary winding is insulated from the primary, and the two ends of the secondary are connected to two metal segments in the slipring mounted on the armature, just inside the driving shaft end plate of the magneto. The slipring has two grooves, each containing one of the two metal segments. These segments are set diametrically opposite on the armature shaft, that is, 180 degrees apart, and insulated from each other, as well as from the armature core and magneto frame.

The four slipring brushes which are part of the secondary circuit are supported by two double brush holders, one on each side of the driving shaft end plate, each holder carrying two brushes so arranged that each brush bears against the slipring in a separate groove. Upon rotation of the armature, the metal segment in one slipring groove makes contact with a brush on one side of the magneto at the same instant that the metal segment in the other slipring groove comes into contact with a brush on the opposite side of the magneto. The marks 1 and 2 appearing in white on both brush holders indicate pairs of brushes receiving simultaneous contact, those marked 1 constituting one pair, and those marked 2 the other.

A spark is caused at two plugs simultaneously. It is important to note that as two of the four slipring brushes receive contact simultaneously and each is connected by cable to the spark plug in one of the cylinders, the secondary circuit always includes two plugs, and the spark occurs in two cylinders simultaneously.

After removing one of the brush holders to permit observation of the slipring, the armature shaft is rotated in the direction in which it is to be driven, until the beginning of the metal slipring segment is visible in the slipring groove corresponding to Fig. 1 of the brush holder which has been removed. With that done, the cover of the magneto interrupter housing is to be removed to expose the interrupter. The armature shaft should then be further rotated until the platinum interrupter screws are just about to separate, which occurs when the interrupter lever begins to bear against one of the steel segments of the interrupter housing.

The armature should be held in that position while the magneto drive is connected to the engine, due care being taken that the piston of No. 1 cylinder is still exactly on top dead center of the compression stroke.

After the brush holder and interrupter housing cover have been replaced the installation is completed by connecting the cable of one of the brushes, marked 1, with cylinder No. 1, Fig. 188, and the other with cylinder No. 4; the remaining two cables, leading from the brushes, marked 2, must be connected with cylinders Nos. 2 and 3.

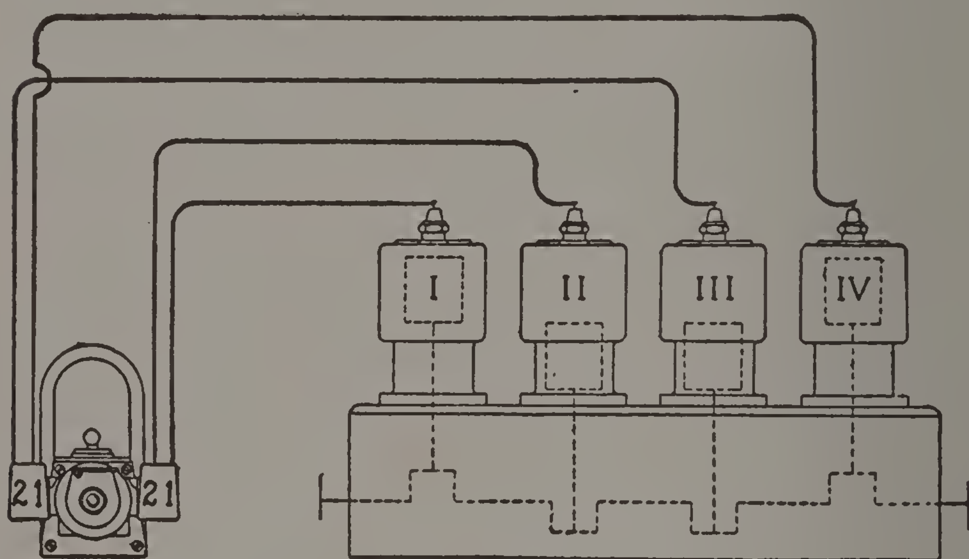



Fig. 188
Wiring Connections for Bosch Magneto, Model "NU"

Dixie Magneto. The Mason principle on which the Dixie magneto operates is shown in Fig. 189. The magnet has two rotating polar extremities, N S, which are always of the same polarity, never reversing. These poles are in practical contact with the inner cheeks of the permanent magnet M, all air gaps being eliminated. Together with the U-shaped magnet, they form a magnet with rotating ends.

At right angles to the rotating poles is a field consisting of pole pieces F and G, Fig. 190, carrying across their top the core C and the windings W. When N is opposite G, the magnetism flows from pole N on the magnet to G and through the core C to F.

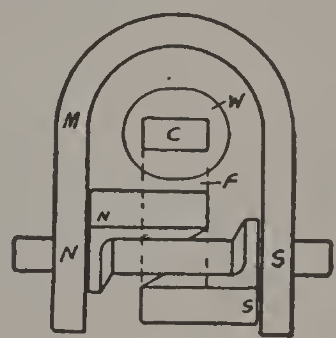



Fig. 189
Dixie Magneto Principle

In Fig. 191 the pole N has moved over to F and the direction of the flow of magnetism is reversed; it now flowing from F through C to G. The rotating poles do not reverse their polarity at any time, consequently the lag due to the magnetic reluctance in this part is eliminated.

The magneto has a rotating element consisting of two pieces of cast iron with a piece of brass between them, but no armature of the usual form, the revolving generating element being shown in Fig. 192. The pieces N S are separated by the brass block B and correspond to the pieces N S in Figs. 189, 190 and 191. The generating windings are carried on a small coil placed across the upwardly projecting ends of two pole pieces.

The core of the coil A, Fig. 193, is stationary, and the inner end G of the primary winding P is grounded on the core. Q indicates the metal frame of the machine, which is put to-

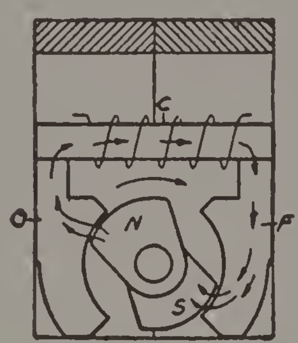



Fig. 190
Dixie Magneto Action

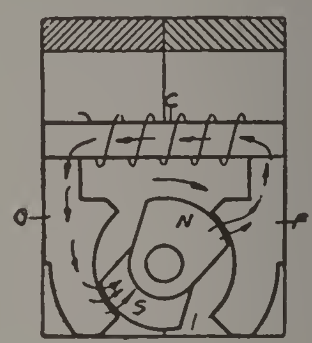



Fig. 191
Reversal of Magnetism Through Dixie Magneto

gether with screws. The condenser R is located immediately above the coil and is readily re-

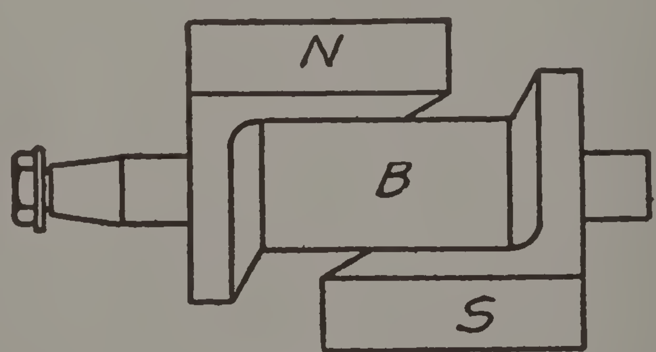



Fig. 192
Rotating Element in Dixie Magneto

movable. The terminal D is a screw on the head of the coil and the wire Z connects directly to the contact Y of the breaker. The breaker contacts are stationary and do not revolve as in the armature type.

Fig. 194 shows the high tension circuit. Here the end C of the high tension winding goes to a metal plate D carried on the upper side A of the coil. Against D bears a connection F, which is practically one piece with the traveling contact J, which connects to the spark plug segment L, the circuit being completed through the spark plug, engine frame and frame of magneto in the usual manner without brush G.

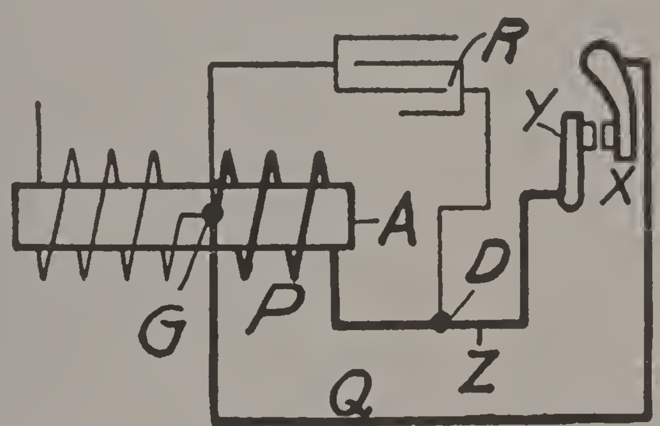



Fig. 193
Low Tension Primary Circuit of Dixie Magneto

The proper distance between the platinum points when separated should not exceed 1/50 of an inch, and a gauge of the proper size is attached to the screwdriver furnished with the Dixie.

The platinum contacts should be kept clean and properly adjusted. Should the contacts become pitted, a fine file should be used to smooth them in order to permit them to come into perfect contact. The distributor block should be removed occasionally and inspected for an accumulation of carbon dust. The inside of the distributor should then be wiped dry with a clean cloth. When replacing the block, care must be taken in pushing the carbon brush into the socket. The magneto should not be tested unless it is completely assembled, that is, with the breaker box, distributor cover and wires in position.

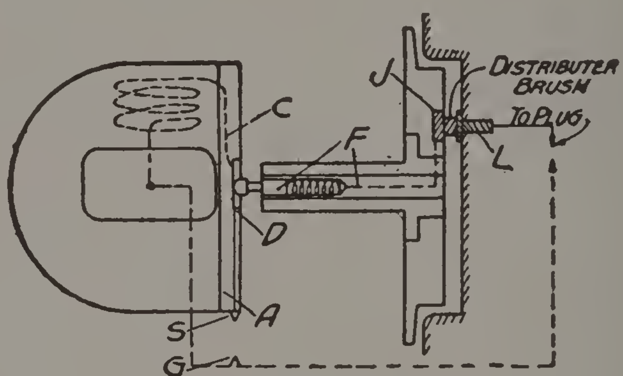



Fig. 194
High Tension Circuit of Dixie Magneto

In order to obtain the most efficient results with the Dixie magneto the normal setting of the spark plug points should not exceed .025 of an inch and it is advisable to have the gap just right before a spark plug is inserted into the cylinder. The spark plub electrodes may be easily set by means of the gauge attached to the screwdriver furnished with the magneto.

Eisemann Magneto. There are two types of the Eisemann magneto. First, the low-tension magneto requiring a transformer to raise the voltage of the current; and second, the high

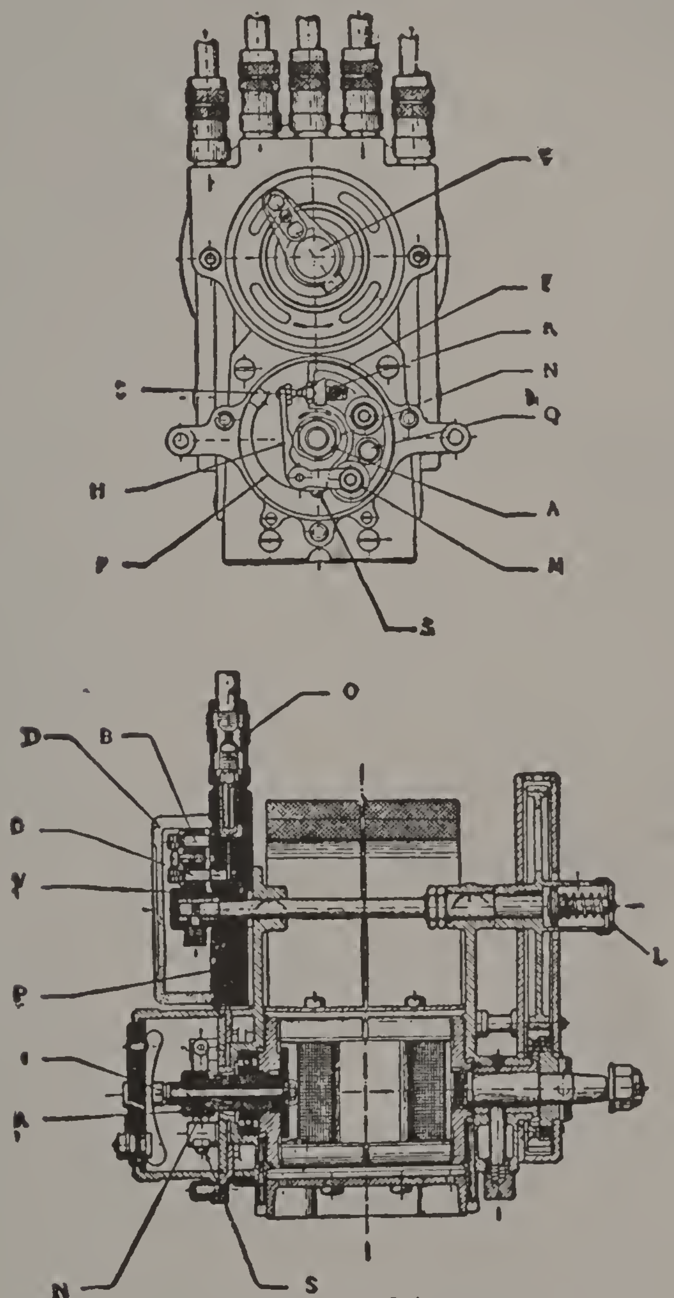


Fig. 195
Eisemann High-Tension Magneto

tension magneto, which has a double winding on the armature and does not require a non-vibrator coil.

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

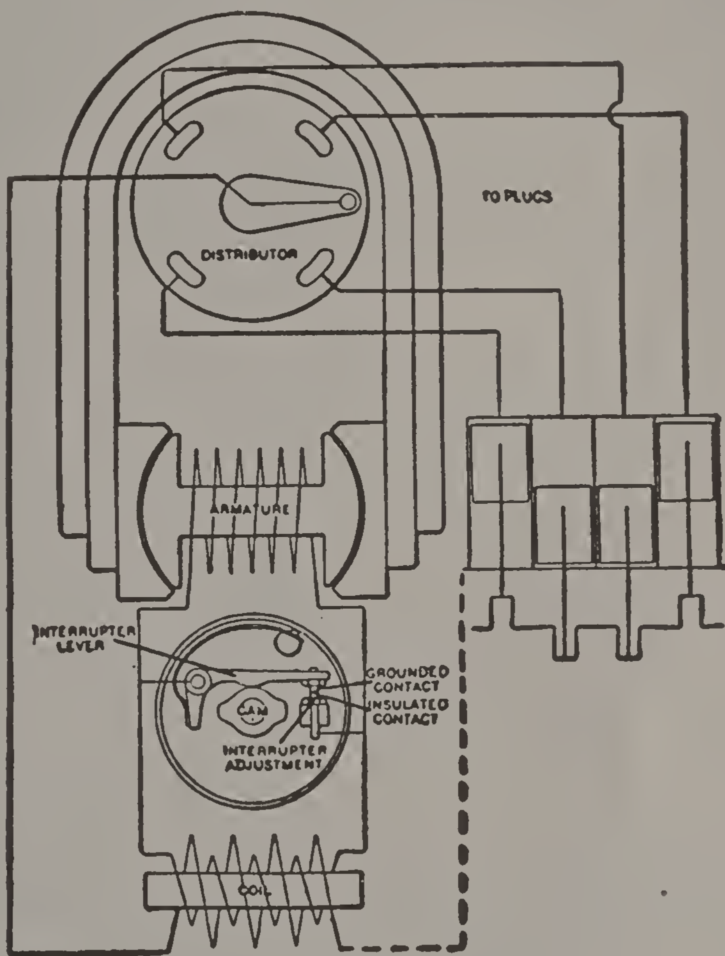



Fig. 196

General Wiring Diagram for Eisemann Magneto

A later Eisemann magneto is of the high-tension type, as shown in Fig. 195, in which A is the cam nut; B, steel contact for high-tension distributer; C, platinum contact for make-and-break lever; D, high-tension distributer cover; E, nut for adjustable contact screw;

F, spring for make-and-break lever; G, carbon contact for high-tension distributer; H, make-and-break lever; I, low-tension carbon brush; K, adjustable platinum contact screw; L, grease box for large toothed wheel; M, nut; N, cam; O, cable joints; P, distributer plate; Q, metal contact; S, screw for spring for make-and-break lever; V, high-tension distributer.

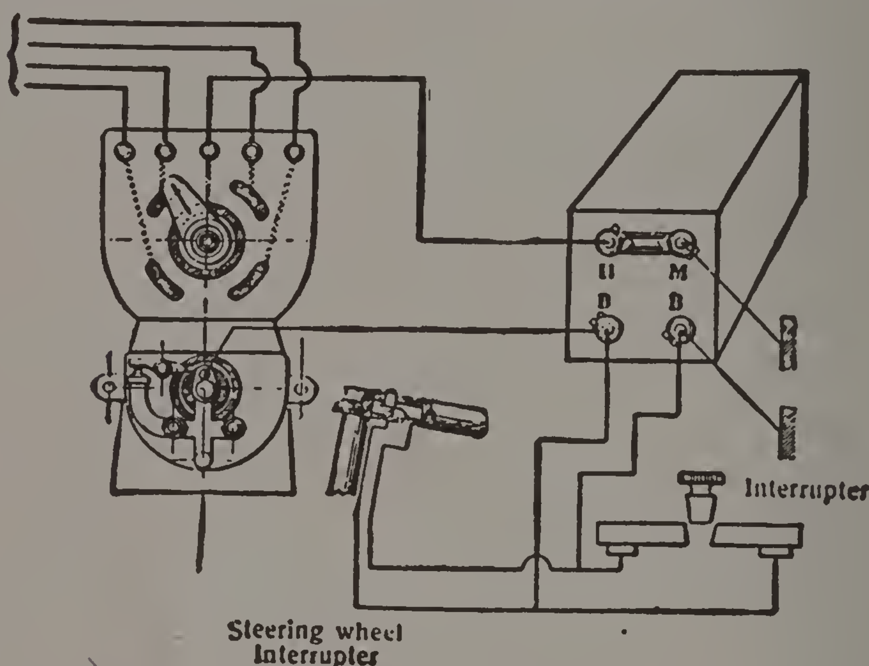



Fig. 197

Magnetos are made to turn in either direction, but the magneto once finished turns in one direction only, and this direction is indicated by an arrow placed on the gear wheel case.

The spark occurs in one of the cylinders at the moment that the contact points are separated by the cam. The advance mechanism is arranged in three different ways: (1) by means of a lever working the make-and-break mechanism (quadrant advance); (2) by means of a piston sliding longitudinally, and fitted to the end of the driving axle (piston advance); (3) by rocking the magnets bodily around the armature (pivoting advance). In all cases a displacement of 45 degrees can be obtained. In magnetos with quadrant advance the driving spindle is fixed by means of a pin and nut.

This type of magneto is consequently shorter than the one with piston advance. In the latter case the driving pinion is fixed on a hollow spindle.

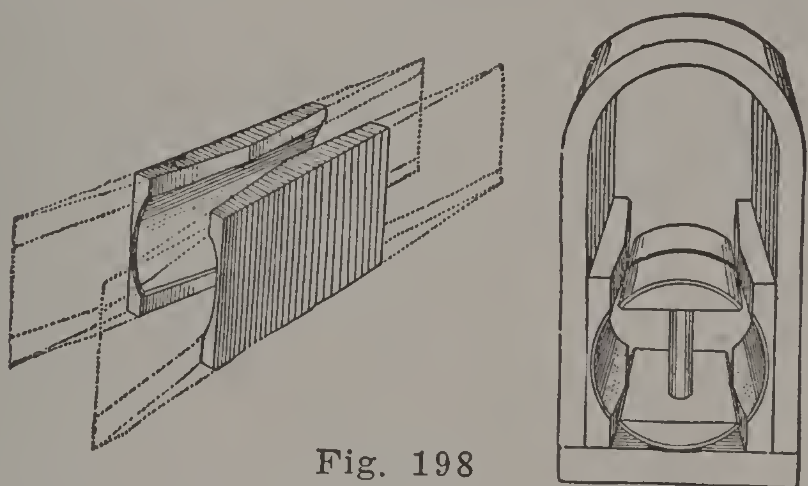


Fig. 198
Pole Piece Construction in Eisemann Magneto

The Eisemann dual system consists of a direct high-tension magneto and a combined transformer coil and switch. The transformer proper is used only in connection with the battery; the switch is used in common by both battery and magneto systems. The magneto is practically the same as the single ignition instrument. Separate windings and contact breakers are used for battery or magneto current. On the other hand, parts that are not subject to accident, or rapid wear, are used in common.

A distinctive feature is that the pole pieces are of a certain shape, Fig. 198, whereby the most extended portion thereof is approximately opposite the theoretical axis of the winding upon armature core. This construction results in the flow of the magnetic lines of force being drawn from the extremities of the pole pieces towards the center of the core; a large volume of the magnetic line of force is thus forced through the winding.

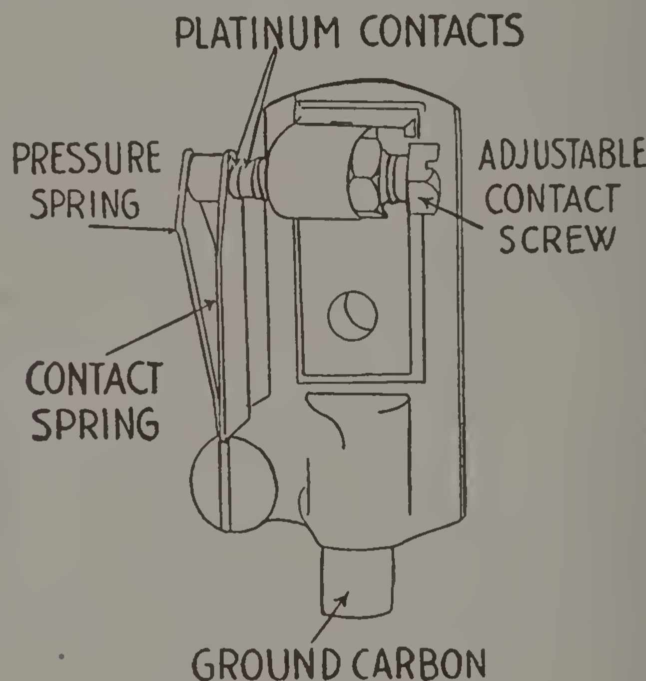



Fig. 199
Breaker of Eisemann Magneto

The make-and-break mechanism, Fig. 199, consists of a bronze plate on the back of which, and cast in one piece with it, is a cone, fitting into the armature shaft, which is bored out and provided with a key-way. It moves inside of the timing lever and is fastened to the armature by means of the screw. If this screw is extracted the whole mechanism can be removed.

The primary current is led from the winding through the armature shaft to the contact screw by the insulated screw, which also serves to hold the mechanism to the armature shaft as already described. When the armature reaches the correct position, a lever is lifted by two steel cams fastened to the magneto body; the primary circuit is broken and the current is induced in the secondary winding. The beginning of the secondary winding is connected with the end of the primary winding, and the other end, through several mediums, finally delivers the spark in the cylinder.

In addition to this the magneto is also fitted with the battery circuit breaker, which is mounted at the back of the magneto breaker. It consists of a steel cam, having two projections which actuate a steel lever mounted into the breaker housing.

A condenser is built in between the T-shaped end of the armature and the bearing. This prevents a spark occurring at the platinum contacts with the consequent pitting and burning, when the contact breaker opens, and it also increases the intensity of the spark at the plugs.

The coil consists of a non-vibrating transformer and a switch, which is used in common to put either the battery or magneto ignition into operation. It is cylindrical in shape, compact, and is placed through the dashboard. The end which projects through on the same side as the motor has terminal connections for the cables. The other end, facing the operator, contains the switch and the starting mechanism. The transformer proper is used only in conjunction with the battery.

As the spark occurs when the primary circuit is broken by the opening of the platinum contacts, it is necessary that the magneto will be so timed that at full retard the platinum contacts will open when the piston has reached its highest point on the firing stroke. To arrive at this, turn motor by hand until piston of No. 1 cylinder is on the dead center (firing point). Place the timing lever of the magneto in fully retarded position, then turn armature of magneto until No. 1 appears at the glass dial of the distributer plate, and make sure that the platinum contacts of the magneto are just opening. Fix the driving medium in this position.

If no window is seen, turn motor by hand until piston of No. 1 cylinder is on dead center (firing point), remove the distributer plate from the magneto and turn the drive shaft of the armature until the setting mark on the distributer disc is in line with the setting screw above the distributer. (For magneto rotating clockwise use setting mark R, and for counter clockwise use mark L.) With the armature in this position the platinum contacts are just opening and the metal segment of the distributer disc is in connection with carbon brush for No. 1 cylinder. The driving medium must now be fixed to the armature axle without disturbing the position of the latter, and the cables connected to the spark plugs.

If a spark plug cable becomes disconnected or broken, or should the gap in the spark plug be too great, then the secondary current has no path open to it, and endeavoring to find a ground will sometimes puncture the insulation of the armature of the coil. To obviate this, a so-called safety spark gap is placed on the top of the armature dust cover. It consists of projections of brass with a gap between them. One of these is an integral part of the dust cover, and therefore forms a ground. The other brass part is connected with the terminal H M and the secondary current will jump across the intervening gap above mentioned, thus protecting the armature secondary winding and the high tension insulations.

In the coil, this safety gap is placed at one end of the core, and hence is not visible. It consists of a pointed brass finger, attached to one end of the secondary, and pointing towards the iron core of the coil.

The contact points may be cleaned with gasoline until the contact surface appears quite white, or use a fine file, but very carefully, so that the surfaces remain square to each other. The gap at the contact points should not amount to more than 1/64 inch and, as the contacts wear away in time, they must be regulated now and then by giving the screw a forward turn, or eventually by renewing. When this platinum tipped screw is adjusted, care must be taken that the lock-nut is securely tightened in place. By loosening the center screw, the whole interrupting mechanism may be taken out, so that the replacement of the platinum contacts without removing the apparatus can be easily done at any time. The fixing screw of the make-and-break is held fast by a lock spring, so that it is impossible for this screw to loosen. When it is desired to remove this screw, the lock spring must first be removed by turning it over the head of the screw. Do not forget to put the spring in the original position after having fixed the make-and-break to the armature.

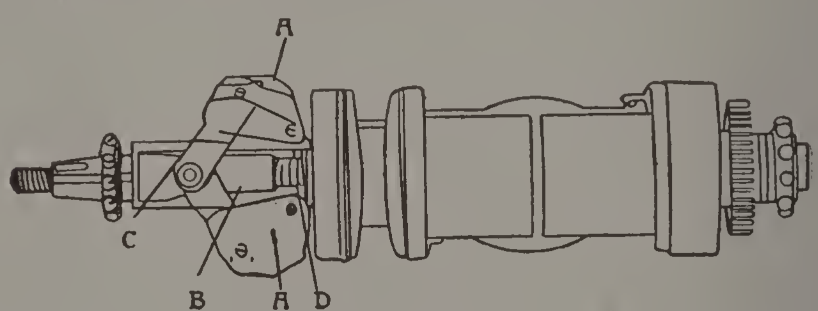



Fig. 200
Automatic Advance Mechanism of Eisemann Magneto

The Eisemann automatic advance, Fig. 200, is accomplished by the action of centrifugal force on a pair of weights A attached at one end to a sleeve B, through which runs the shaft C of the magneto, and hinged at the other end to the armature.

Along the armature shaft arm run two spiral ridges which engage with similarly shaped splines in the sleeve. When the armature is rotated the weights begin to spread and exert a longitudinal pull on the sleeve which in turning changes the position of the armature with reference to the pole pieces. In this way the moment of greatest current is advanced or retarded, and with it the break in the primary circuit, for the segments which lift the circuit breaker and cause the break in the primary circuit are fixed in the correct position and thus the break can only occur at the moment when the current in the winding is strongest. On magnetos without this advance it is the segments which are moved forward or back, as the case may be. As there is only one actually correct position for the segments, every degree away from this weakens the spark.

The spreading of the weights rotates the armature forward, and advances the spark and the resumption, either total or in part, of their original position close to the shaft, retards it by rotating the armature backward.

As the timing is accomplished by changing the relative positions of armature and motor and not those of the segments in the timing level which cause the breaking of the circuit, the spark is always bound to occur at the moment of greatest current and the apparatus thus given as strong a spark at retard as when fully advanced.

As the speed becomes slower a spring D brings the weights together again, so that by the time the motor has come to rest the magneto is fully retarded, this being the correct position for starting.

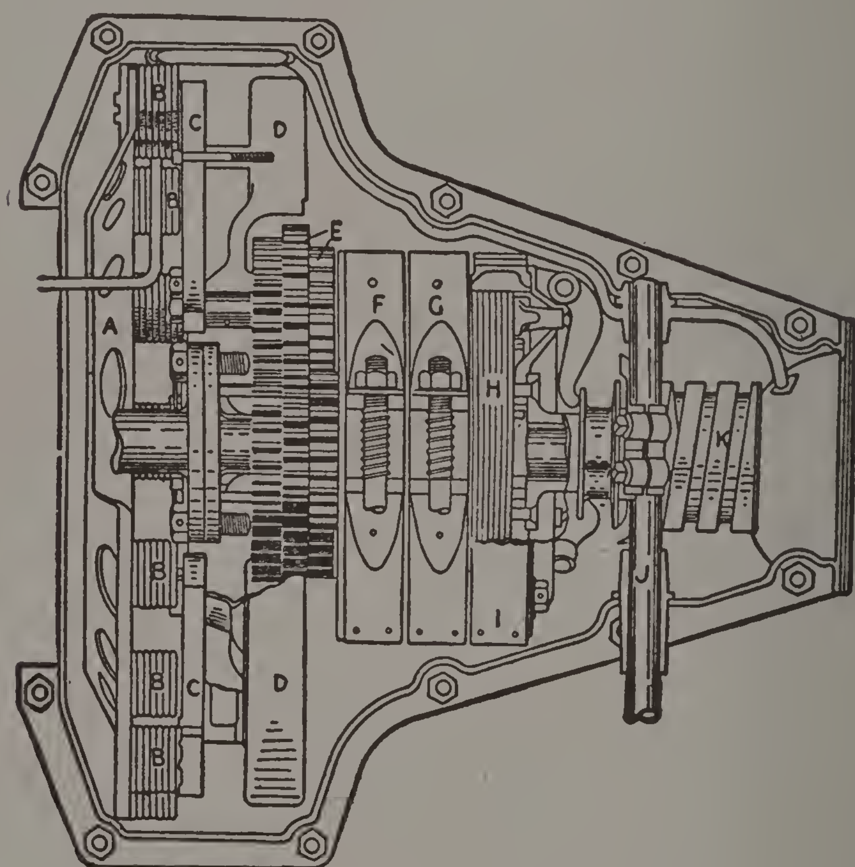



Fig. 201
Magneto Used on the Ford Cars

In the rear end of the governor housing there is a transverse slot into which fits a key, furnished with each magneto. When this key is shoved in as far as it can go the armature is fixed in the position where the platinum contacts begin to open. The shaft is held tight in the correct position and the coupling may be screwed up with the assurance that the magneto is correctly set and without danger of damaging the armature.

Ford Magneto. The Ford magneto, Fig. 201, is of a peculiar design, it being constructed as an integral part of the flywheel, in which A is the support for the magneto coils; BBB, magneto coils; CC, permanent horseshoe magnets; DD, the flywheel; E, planetary pinions; F, low speed brake band; G, reverse brake band; H, disc-clutch for high speed; I, transmission

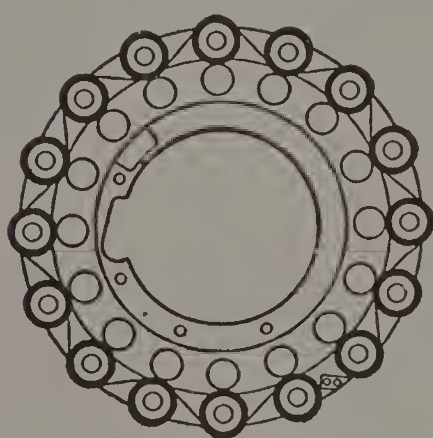


Fig. 202

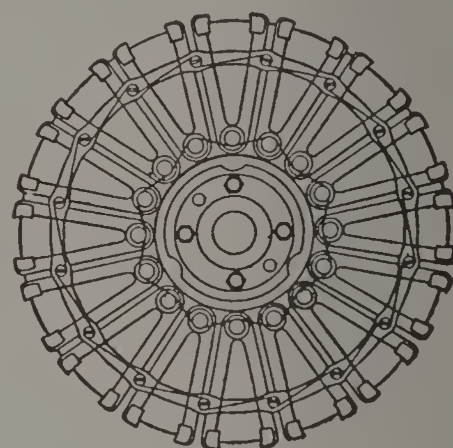


Fig. 203

Details of Ford Magneto

brake; J, clutch rocker shaft, and K, high speed clutch spring. The permanent magnets, which are U-shaped, are bolted to the forward face of the flywheel, as shown in Fig. 202. Close in front of their outer ends is a series of insulated coils mounted in a circle of practically full flywheel diameter, with their axes parallel with that of the crankshaft. They are supported upon a stationary spider, as shown in Fig. 203. As the flywheel revolves, this magnet and coil combination, which is similar to that used on some types of alternating current generators, produces a current which is used through a four-unit current timer to cause the ignition spark. The magneto is of the inductor type, the armature coils being stationary, and the field magnets moved past them. Sixteen separate field magnets are used, made of vanadium-tungsten steel. They are substantially horseshoe shape, being secured to the side of the flywheel as illustrated in Fig. 203. They are held in place by screws at their middle, and by clamps near their poles, all screws used for fastening them being securely locked in place by wire locks.

The magnets are so arranged that like poles are adjacent to each other, forming a sixteen pole field magnet crown. Instead of being placed close against the flywheel, these magnets are clamped against a ring of non-magnetic material (brass for instance), in order to reduce leakage of magnetism through the flywheel rim. At their middle these magnets are fastened directly to the flywheel, as at this point they are neutral, and there can be no leakage. A series of sixteen armature coils is carried on a coil supporting ring slightly in front of the flywheel, as shown in Fig. 202. These coils are wound with heavily insulated magnet wire, and are so grouped around the supporting ring that the winding of adjacent coils is in different directions, one being wound clockwise, and the next one counter clockwise. The coils are connected in series, the terminals being brought out near the top of the casing. As the poles of the magnets are located opposite and very close to the coils, the magnetic circuits are completed by the cores of these coils and the coil support. There are evidently sixteen electrical impulses produced during the revolution of the crankshaft and flywheel, although only two impulses are required for the ignition of the motor, one per stroke. However, as the armature circuit is closed only when a spark is wanted,

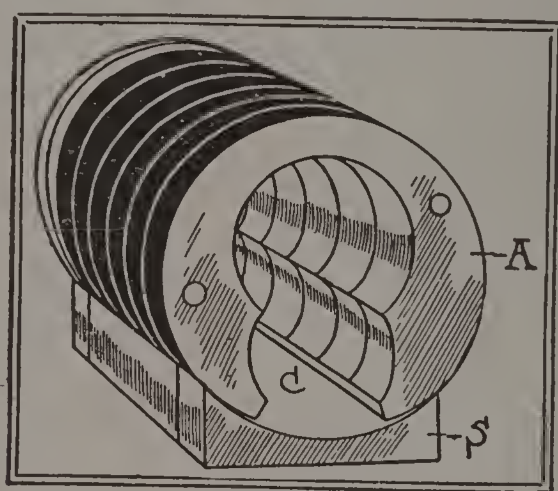



Fig. 204
Herz Magnets

a current only flows at that period, and there is no loss from the other impulses.

HERZ HIGH TENSION MAGNETO. This magneto differs from the regular conventional type in that it is cylindrical in shape, due to the employment of ring-shaped field magnets A—Fig. 204—instead of the horseshoe type generally adopted. The six Herz magnets are in reality as many flat steel rings clamped together with a polar space, or armature tunnel, C, cut in them. The ring surfaces are ground with the utmost accuracy in order to obtain the best magnetic effect when they are all clamped together. These magnets are mounted on an aluminum base S. A second unconventional-

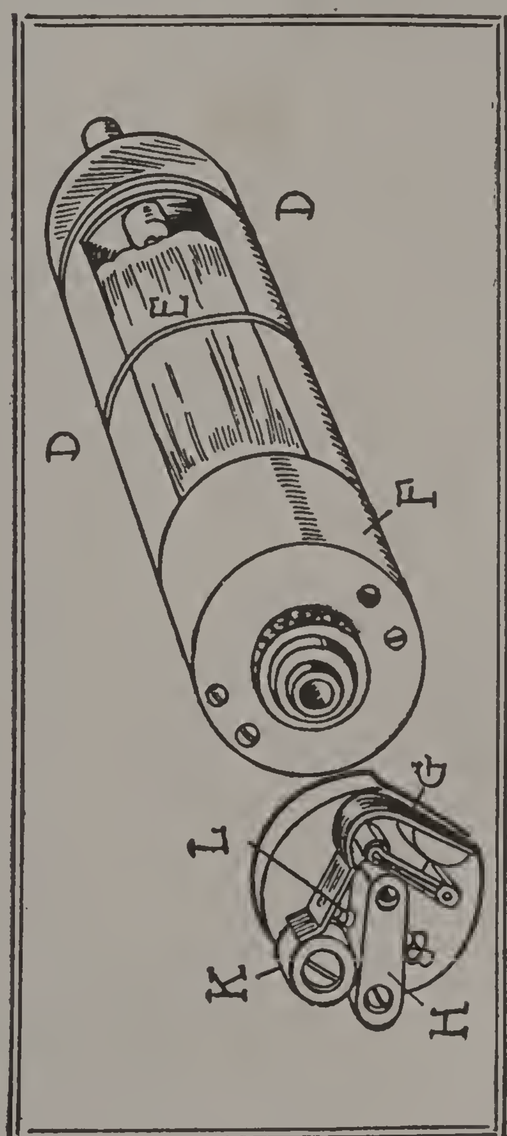



Fig. 205
Herz Make-and-Break and Armature

ity is that the usual independent, soft-metal pole pieces, which bolt to the ends of the horseshoe magnets in the conventional magneto, are dispensed with entirely. In the Herz system the space C, which accommodates the armature, is bored out from the magnets A, and in this manner sharp angles in the magnet system, which invariably result in a leakage of lines of force in the magneto, are avoided. The armature D, Fig. 205, is of shuttle shape, accommodating the low, and high-tension windings E within the frame portion of it. So careful has the construction of this armature been superintended that there is but 1-10-millimeter air space between it and the curved portions of the magnets A. The armature revolves on ball-bearings, mounted in special cages, and is fitted with lubricating means sufficient for many months' use. The armature windings consist of a primary winding, in which is generated the low-tension current and also a secondary winding in which is generated the induced, or high-tension circuit. At one end of the armature, and encased in a brass box, is the condenser, F, Fig. 205.

The make-and-break devices for interrupting the primary circuit are illustrated in Fig. 205, the entire device being a detachable unit, which secures to the armature shaft by a key-way and feather. This make-and-break mechanism contacts with one end of the primary winding of the armature through a small carbon brush, fitted into the contact disk, which presses against a ring alongside of the ball race on the armature. The contact device consists of three parts: First, a curved spring G, having a platinum flat contact on one end; a steel block H carrying an adjustable platinum contact, and a small, hard-fiber roller K carried on a pin. This roller is set so that if it is given a slight push at the edge it tends to move up the incline plane formed by the steel piece H, and in doing so pushes against the end of the spring G and separates the platinum contacts L. This

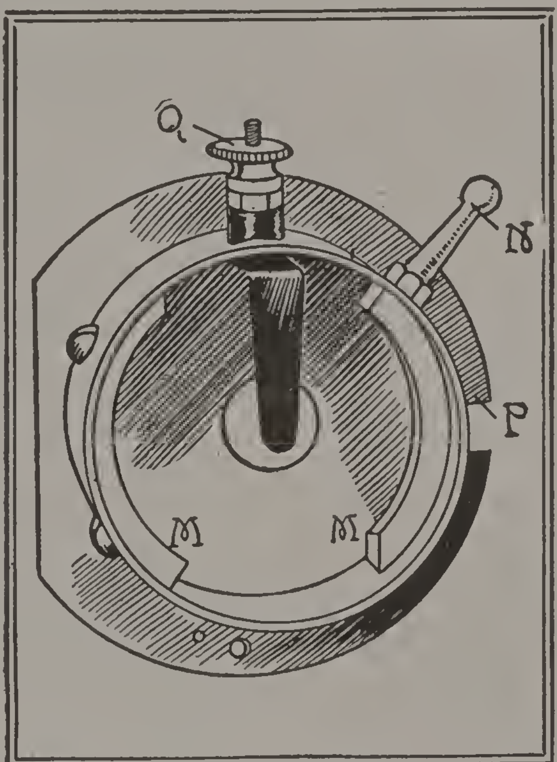



Fig. 206
Herz Magneto Advance

contact-maker revolves bodily with the armature, and in its rotation the fiber roller K strikes upon two steel projections M—Fig. 206—held in the case, thus breaking the circuit at the points of maximum induction twice in each revolution, at which time the induced current is set up in the secondary winding of the magneto.

It is scarcely necessary to comment here that the primary and secondary windings are thoroughly insulated from each other, and that, with the making and breaking of the primary current an induced current is set up in the secondary winding, which because of the many turns of wire in this winding, is of a particularly high voltage. For cutting off the spark when desired a terminal is provided on the contact-maker case, which gives a connection by means of a spring pressing on the head of a

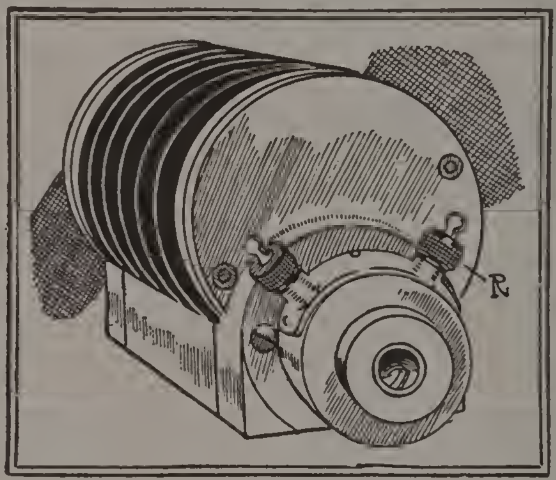



Fig. 207
High-Tension End

steel screw in connection with the insulated end of the primary winding, which thus can be short-circuited at will. In advancing or retarding the spark, connections are made with the ball-ending N, Fig. 206, the contact-maker having a 30-degree movement for this purpose. The high-tension end of the armature has mounted upon it a deeply recessed insulating collar, with a metallic sector within it. Upon this sector are small carbon brushes for drawing off the high-tension current. In Fig. 207 appears a magneto suitable for a two-cylinder engine with its high-tension terminals R located at 90 degrees to each other. To obtain the two sparks the high-tension contact piece, orsector is fitted with an insulating collar, which does not go quite half way round, and thus makes alternate contact with the two carbon brushes R, sending the spark to the respective cylinder. In four-cylinders a distributer is combined. The safety spark gap is located between the high-voltage sector and the armature, and if the spark exceeds 3/8 inch it bridges the insulating collar to the armature.

MEA MAGNETO. The most noticeable difference between the Mea magneto and other standard forms is that the magnets are bell-shaped and are placed horizontally and with their axes in line with the armature shaft. This is a distinct variation from the customary horseshoe magnets placed at right angles. This makes possible the simultaneous movement of the magnets and breaker instead of the advance and retard of the breaker alone.

It will be seen that, as a result of this construction, the relative position of armature and field at the moment of sparking is absolutely maintained, and the same quality of spark is therefore produced, no matter what the timing may be.

Fig. 208 shows a longitudinal section of a four-cylinder instrument. In the bell-shaped magnet 100, having the poles on a horizontal line near the driven end of the magneto, rotates armature 1 in ball bearings 17 and 18. The armature consists mainly of an I-shaped iron core, mounted on a spindle, and wound with a heavy primary winding of a few turns and a light secondary winding of many turns. On this armature are also mounted the condenser 12, the collector ring 4, and the low-tension

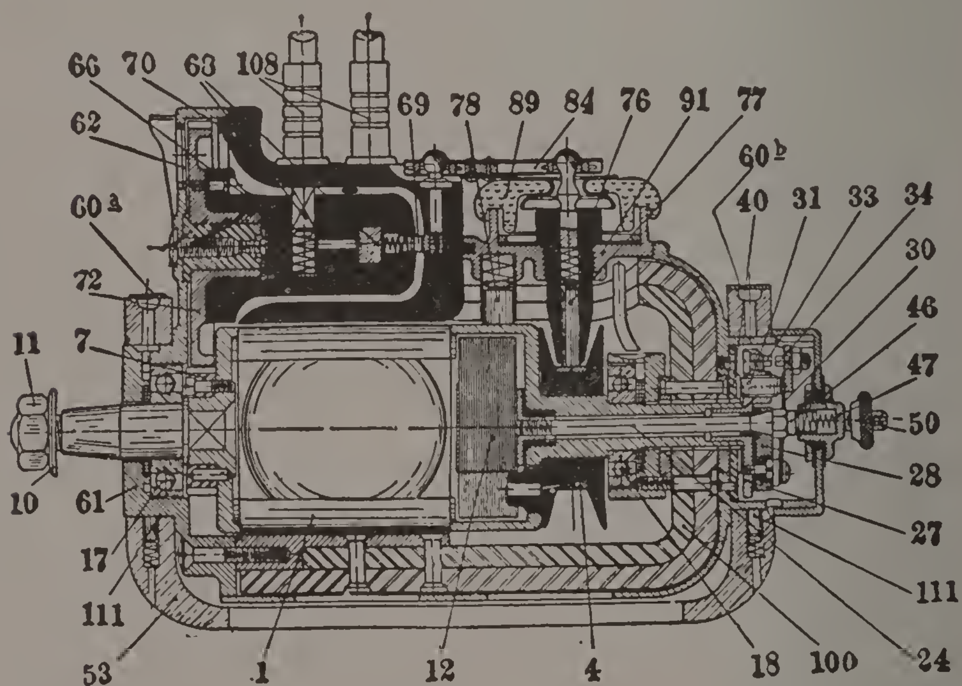



Fig. 208
Mea Magneto

breaker 26-39. The latter is built up of a disc 27, which carries the short platinum contact 33; the other contact point 34 is adjustable and supported by a spring 20, which in turn is fastened to the insulated plate 28 mounted on disc 27. The breaker is actuated by the fibre roller

31 in connection with cam disc 40, which is provided with two cams and located inside the breaker, being fastened to the field structure. In revolving with the armature the roller presses against the spring supported part of the breaker whenever it rolls over the two cams and in this manner opens the breaker twice every revolution. Inspection of the breaker points is made possible by means of an opening in the side of the breaker box, provided at the point of the circumference at which the breaker opens. The box is closed by a cover 74, supporting at its center the carbon holder 47, by means of which the carbon 46 is pressed against screw 24. This latter screw connects with one end of the low tension winding, while the other end is connected to the core of the armature. It will, therefore, be seen that the breaker ordinarily short-circuits the low tension winding and that this short-circuit is broken only when the breaker opens; it will also be apparent that when the screw 24 is grounded through terminal 50 and the low-tension switch to which it is connected, the low-tension winding remains permanently short-circuited, so that the magneto will not spark. The entire breaker can be removed by loosening screw 24.

The high tension current is collected from collector ring 4 by means of brush 77 and brush holder 76, which are supported by a removable cover 91, which also supports the low tension grounding brush 78 provided to relieve the ball bearing of all current which might be injurious. Cover 91 also carries the safety cap 89, which protects the armature from excessive voltages in case the magneto becomes disconnected from the spark plugs.

The distributer consists of the stationary part 70 and the rotating part 66, which is driven from the armature shaft through steel and bronze gears 7 and 72. The current reaches this distributer from carbon 77 through bridge 84 and carbon 69. It is conducted to brushes 68 placed at right angles to each other and making contact alternately with four contact plates embedded in part 70. These plates are connected to contact holes in the top of the distributer, into which the terminals of cables leading to the different cylinders are placed.

In the front plate of the magneto is provided a small window, behind which appear numbers engraved on the distributer gear which correspond to the numbers marked on the top of the distributer. This indicator allows a setting or resetting after taking out, without the necessity of opening up the magneto to find out where the distributer makes contact. Numbers on indicator and distributer show the sequence of sparks, not the numbers of cylinders which the magneto is firing, as the sequence of firing varies with different motors.

The variation of timing is effected by turning the magneto proper in the stationary base which is accomplished through the spark lever connections attached to one of the side lugs. The spark is advanced by turning the magneto in the direction of the rotation of the armature.

If the magneto is defective, the trouble will usually be located in the breaker. The platinum contacts burn off in time and a readjustment becomes necessary, although this should be the case only at very long intervals. The adjustment should be such that the breaker begins to open with the armature in the position of greatest current flow, and that the distance between contact points when fully open is about 1/64 inch or slightly more. The small gauge attached to the magneto wrench may be used for checking this adjustment. The small lock nut of the contact screw must be tightened securely after each readjustment of the contacts.

In addition any oil or dirt reaching the contact points will in time form a fine film which prevents perfect short-circuit of the low-tension winding. If the condition of these points is very bad, or if a complete inspection of the breaker is desired, the latter should be removed from the breaker box. This can readily be done by loosening the long center screw holding the breaker to the armature, and screwing it into the small tapped hole provided in the breaker, so that it may be used as a handle in lifting the breaker out. The cleaning of the points should be done with a fine crocus paper, or if necessary, with a very fine file, after which a piece of very fine cloth should be passed through between the points so as to remove all sand or filings. Special care must be taken not to round off the edges of the contact points; the satisfactory operation of a magneto depends largely upon the perfect contact at this point, and the whole surface of the contacts should therefore touch.

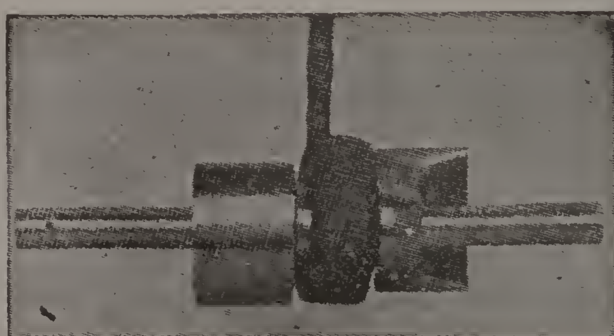


Fig. 209
Inductor Magneto Shaft

REMY INDUCTOR MAGNETO. This type of magneto, now so extensively used for ignition purposes, is a comparatively recent product, the result of many years of experiment and development. The principles of its action are as follows: By revolving a solid steel shaft on which are two drop-forged steel magnet inductor wings, as shown in Fig. 209, the magnetic field is reversed twice during each revolution, and creates two electrical current waves, or impulses per revolution. The direction of flow of the magnetic current is changed at each impulse, thereby generating an alternating current. A circular shaped stationary winding of magnet wire is imbedded between the poles of

Fig. 210
Distributor for Inductor Type

the magnets and around the inductor shaft, and a strong current is generated in it and carried directly through the circuit breaking device by means of heavy lead wires, thus dispensing with the use of carbon brushes and collector rings.

There are no revolving windings nor moving contacts, and consequently many sources of trouble are eliminated. The current is carried to the transformer coil located on the dashboard, where it is stepped up to the high voltage necessary for creating the hot jump-spark.

From the transformer the current is conducted back to a hard rubber distributer, see

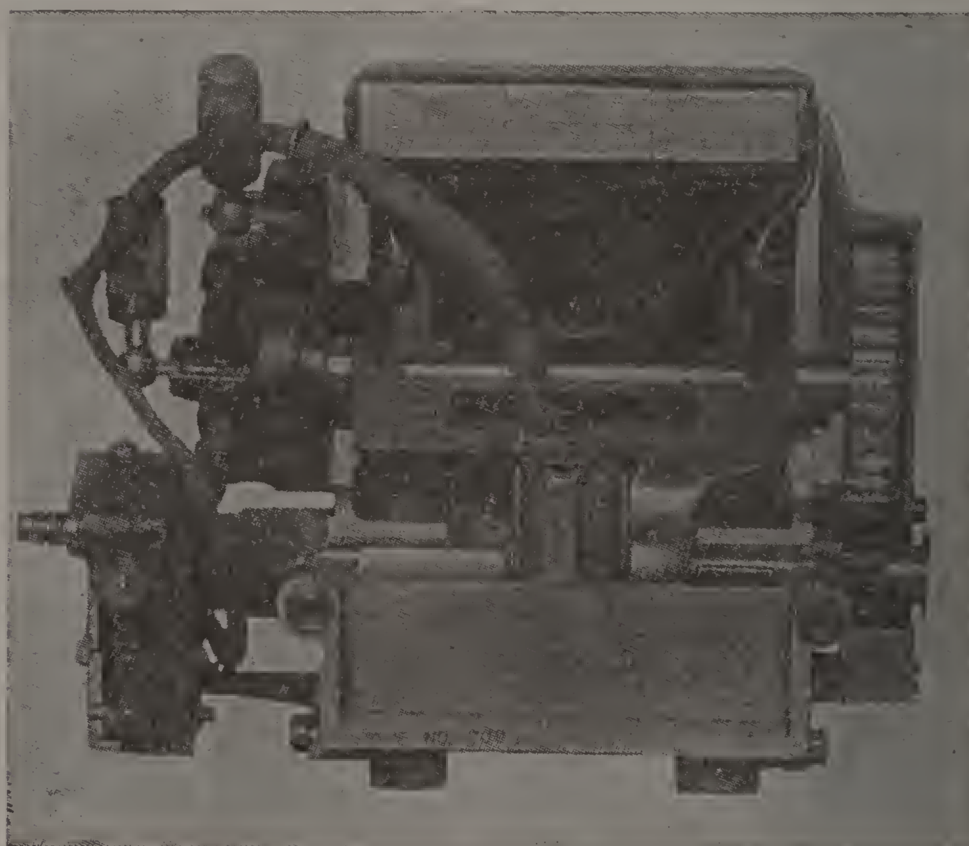


Fig. 211
Longitudinal Section Through Inductor Type of Magneto

Fig. 210, on the face of the magneto, and from thence to the spark plugs. The distributer shaft, located immediately above the inductor, revolves a metallic segment past the terminals of the wires leading to the spark plugs. The high tension current is carried to this segment, and transmitted to the spark plug. A magneto of this type, and gear-driven, gives what may properly be called perfect timing. A hot spark is delivered in the cylinder under compression at the exact instant desired.

The device is also reliable for starting the motor from the seat without cranking, for the reason that the motor always stops with the magneto in such a position that the first spark will occur in the cylinder under compression and where batteries are used a push button is provided, which by merely touching will create the spark where needed. Fig. 211 shows a sectional view of the magneto.

An important difference between the Remy magneto just described and other models of the inductor type is in the handling of the inductor weights. In models "RD" and "RL," each inductor wing has been balanced by a bronze weight fastened to the magneto shaft and on the opposite side of the shaft from the wing that it compensates for. The weight, being made of non-magnetic material, does not in any way affect the operation of the magneto electrically.

The inductor principle is not used in later models of the Remy magneto, this feature being replaced by an armature of the shuttle type with a single low-tension winding. A separately mounted transformer coil is used with these instruments, this coil carrying a switch that allows use of the current from the magneto armature or from a set of dry cells or storage battery, the current, from whichever source, passing though the same breaker, coil, distributor and plugs.

The breaker of the new models is composed of a steel cam mounted upon and turning with the armature shaft and which strikes against a contact piece in a pivoted arm that carries one of the contacts of the breaker. Except for the

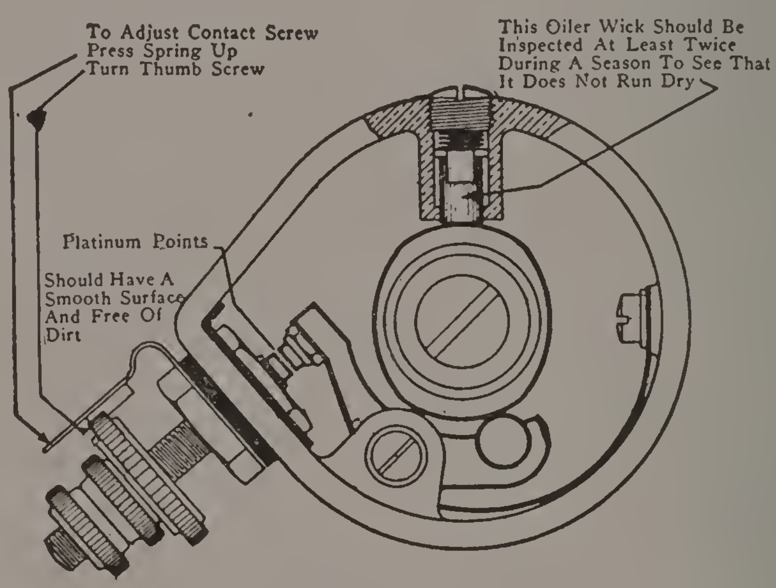



Fig. 212
Breaker Mechanism of Remy "RD" Magneto

movement required in altering the time of the spark, the contacts and the pivoted arm remain stationary, the cam being the only revolving part of the breaker mechanism. The condenser that is attached between the breaker contacts is carried in a housing that is mounted above the magneto armature and between the magnet legs. See Fig. 212.

A device, known as a timing button, is incorporated on the Models "P," "30," "31" and

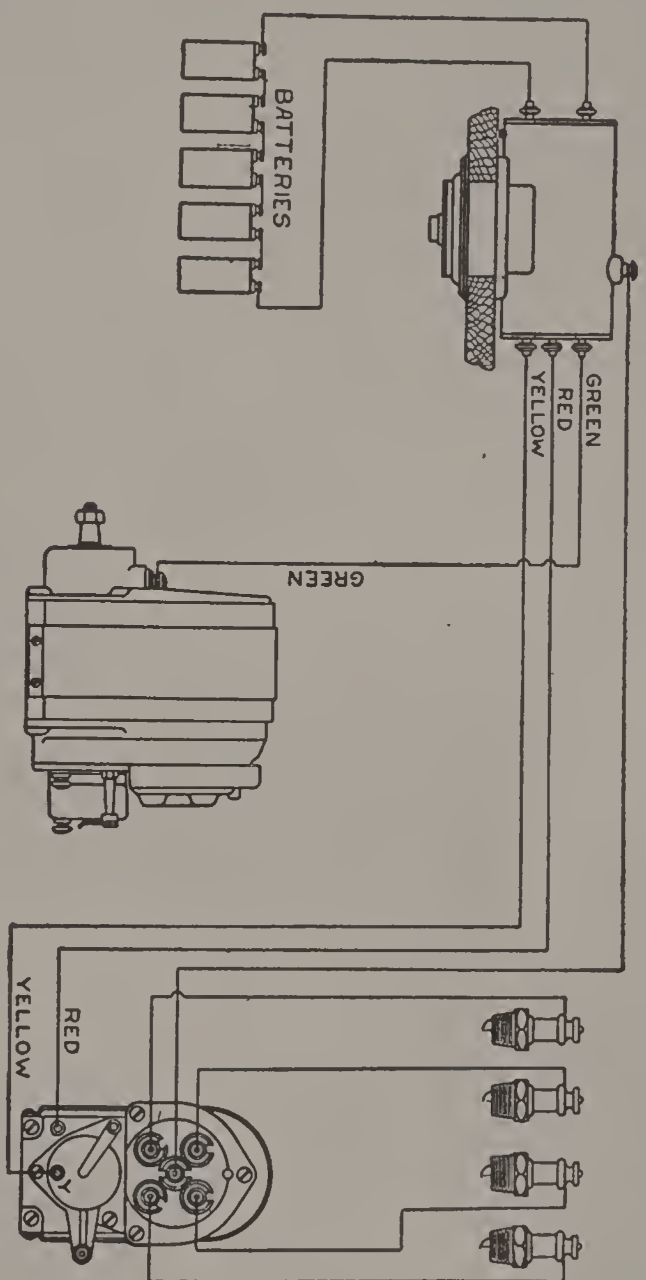



Fig. 213

Wiring of Remy Magnetos "P" and "32"

"32" Remy magnetos, for the purpose of timing the magneto in connection with the engine.

To set the magneto turn the engine crankshaft until the piston of No. 1 cylinder is at top cen-

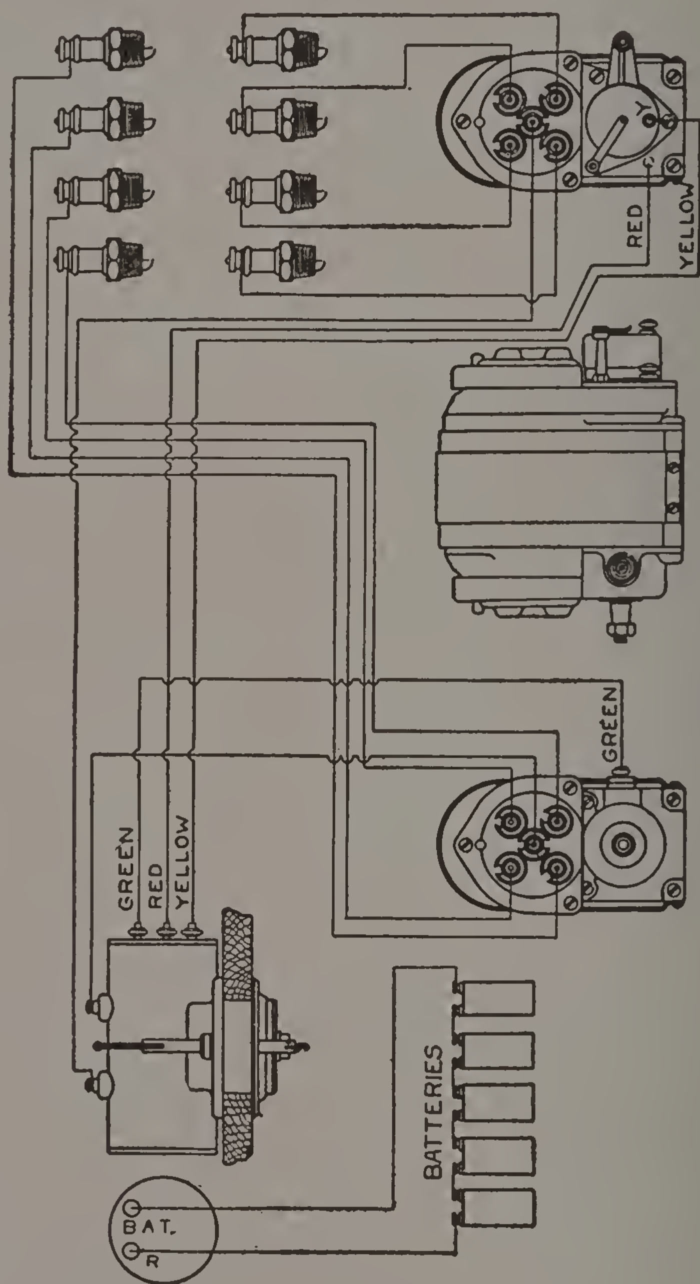



Fig. 214
Wiring of Remy Magnetos "30" and "31"

ter after the compression stroke. Press in on the timing button at the top of the distributor and turn the magneto shaft until the timing button is felt to drop into the recess on the distributer gear. With the magneto in this position, make the coupling with the engine without paying any attention to the position of the breaker cam. The location of the distributer terminal for the plug in No. 1 cylinder is determined by the direction of rotation of the magneto. If the magneto runs clockwise, No. 1 terminal is at the lower left hand corner of the distributer, while for anti-clockwise drive No. 1 terminal is at the lower right hand corner. The wiring for the Models "P" and "32" is shown in Fig. 213, while the connections for Models "30" and "31" are shown in Fig. 214.

SIMMS MAGNETO. The armature is of the true high-tension type, on which is wound both the low-tension primary and high-tension secondary windings, connected in series. The magneto generates a high-tension current directly in the armature, and does not use an exterior coil or other device to step-up or transform the current.

A safety spark gap is provided to prevent damage to the magneto, in the event of one or more of the high-tension cables becoming disconnected from the spark plugs. This gap is so located that its action may be readily observed for the purpose of locating the cause of possible misfiring.

The model "S U D" consists of a dual system in which is provided a small non-vibrating coil which can be either attached to the frame or dash of car, as the coil is unaffected by either moisture or heat.

The switch operating the battery circuit is in connection with the starting switch and when the starting pedal is depressed (thereby throwing the starting motor into operation) the current flows through the switch coil and magneto.

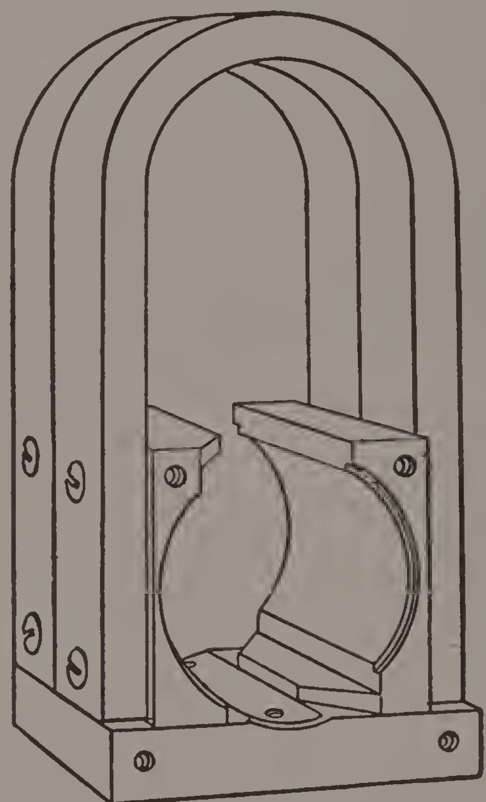


Fig. 215

Magnets and Extended Pole Pieces of Simms Magneto

As soon as the engine starts, or the starting pedal is released, the circuit is automatically disconnected, and the engine runs on the magneto. One of the principal features of the Simms magneto is the extended pole shoe, shown in Fig. 215.

To time the magneto to engine: Turn the engine over by the starting crank until No. 1 piston reaches top dead center on compression or firing stroke. Remove the dust cover, or if a dual magneto, the commutator, and turn the armature shaft until the figure 1 appears in the "sight-hole" of distributor, Fig. 216. This shows that that distributor brush is in contact

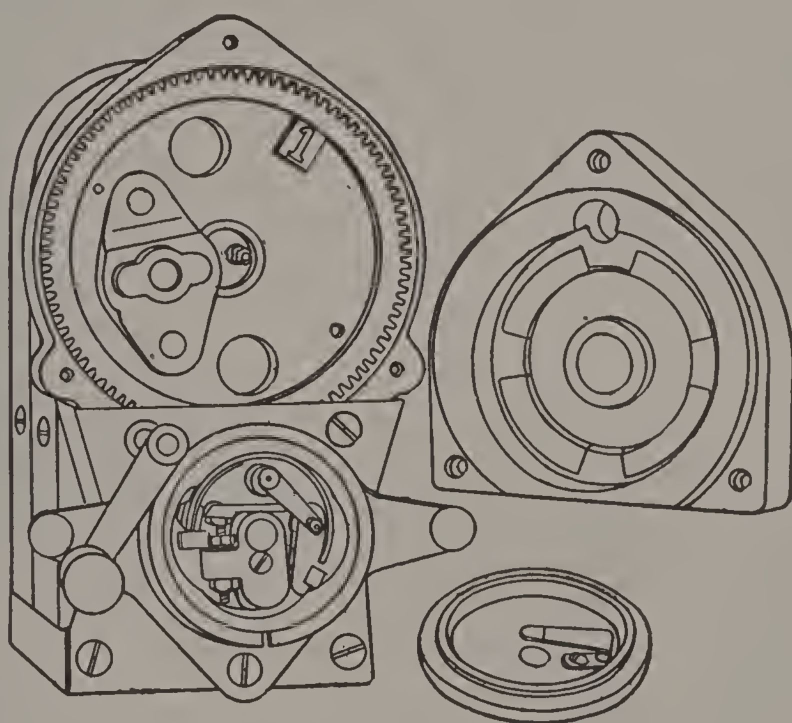



Fig. 216
Simms High Tension Magneto

with distributor post 1. Retard the contact breaker and move the armature, either to the right or left, as occasion requires, until the platinum points just break, or, in other words, just separate. With the magneto in this position couple it to the engine (to dead center on compression stroke), and connect the remaining terminals up in the proper firing order of the engine.

For timing the model S U D, proceed as above. The above instructions relative to engine position apply also in this instance. The only change is as follows:

For locating the position of the carbon brush on No. 1 distributer segment, remove the distributer, which is held in place by means of two spring clips, and turn the armature shaft until the distributer brush is brought into position, namely, opposite No. 1 segment.

If the magneto is not firing, try the following test. While the motor is running, disconnect one of the high tension cables from spark plug, being careful not to touch the metal terminal, and hold the cable with the terminal close, about 1/8″ to 3/16″, to any part of the motor. This will show the strength of the spark and each cable may be tested in turn. If the magneto is not delivering a good spark, examine the contact breaker. The break or gap between the platinum points, when open due to the cam action, should correspond to the thickness of the gauge furnished, which is approximately .015.

Splitdorf Magneto. The system used in older models is that having an armature with but one winding, and giving a current of comparatively low tension. The current is discharged through a transformer having a low and a high-tension winding somewhat similar to regular spark coil. This steps the current up to a voltage sufficiently high to enable it to jump the necessary gap between the points of a spark plug in the compressed mixture in the cylinder of the motor.

The plain H, or shuttle, armature is mounted between two annular ball bearings, Fig. 217. One end of the shaft is the driving end and the other is equipped with the breaker cam and the

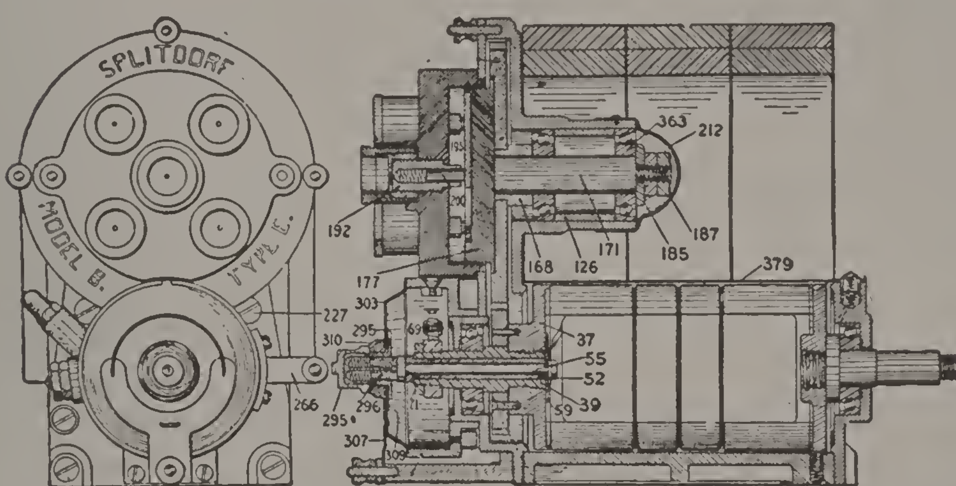



Fig. 217
Section Through Splitdorf Magneto

insulation plug which delivers the current generated in the armature to the collector brushes from which it is transmitted to the transformer connection.

From A, Fig. 218, the armature current goes through the primary of the transformer, returning through the binding post No. 2 to the contact screw bracket on the breaker box. No. 3 is a common ground connection for both the magneto and transformer. The circuit being broken at the proper moment, a very high voltage current is induced in the secondary winding of the transformer, and being delivered to the heavily insulated cable D, is conducted to the central brush of the distributor, whence it is delivered to the spark plugs in the different cylinders in correct sequence.

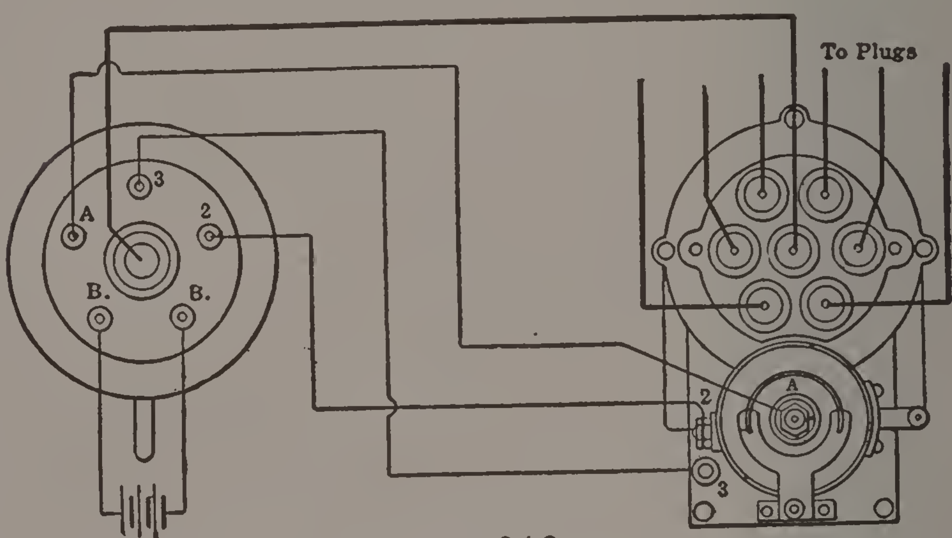



Fig. 218
Wiring of Model "S" Splitdorf Magneto

In addition to using the current from the magneto, the transformer may be used as a spark coil by using the breaker mechanism of the magneto in the circuit to interrupt a current from the battery, which can be switched in for starting purposes or for an emergency. The distributor is used to deliver the current thus generated to the spark plugs. This gives a dual system with one set of spark plugs, and the movement of the switch controls both systems. Fig. 219.

A later development is the new standard "T S" type of transformer, Fig. 220, which has practically superseded all other types, par-

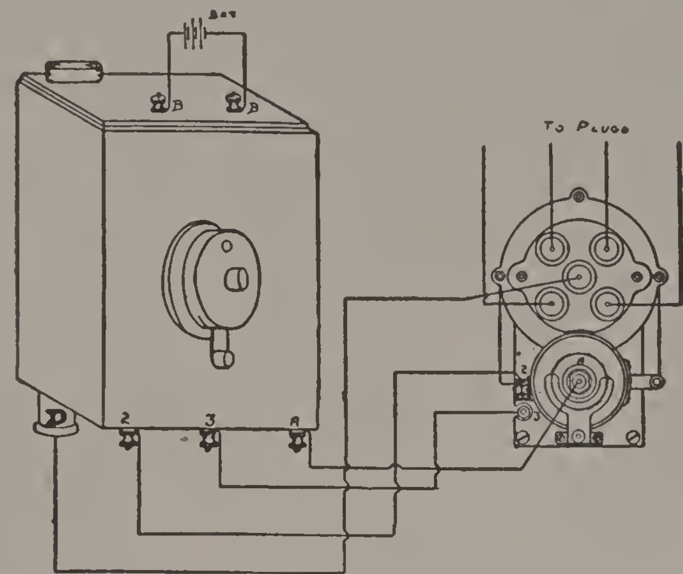


Fig. 219
Wiring of Splitdorf Magneto With Transformer Coil

ticularly as it does away with the separate switch and still leaves the dash free. Both leads from the battery must run direct to transformer.

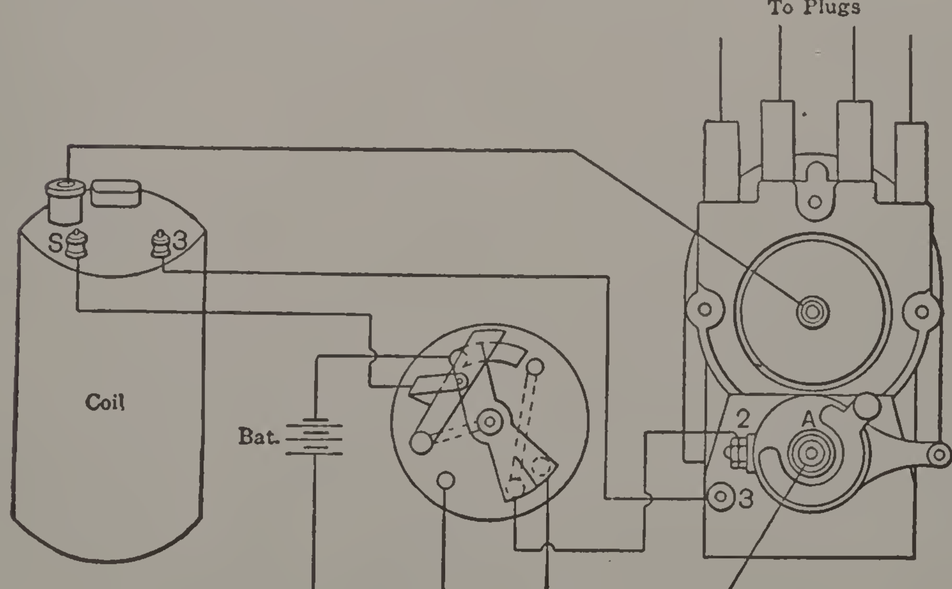



Fig. 220
Wiring of Splitdorf Magneto With Tubular Coil

After securing the magneto to the prepared base on the motor, crank it until cylinder No. 1 is exactly on its firing center (i. e., the point of greatest compression. The motor must remain in this position until the balance of the work is finished.

Retard the spark advance mechanism at the steering wheel to its limit and connect it to the spark advance lever on the breaker box of the magneto, so that if the magneto shaft revolves in a clockwise direction looking at the driving end, the breaker box lever will be at its topmost position. If the shaft revolves left-handed the lever should be at the bottom limit, and advanced upward.

Now revolve the armature shaft in its direction of rotation until the oval breaker cam comes in contact with the roller in the breaker bar and begins to separate the platinum contacts.

If it is desired to start on the magneto side, ignoring the battery entirely, advance the spark mechanism about one-half or two-thirds of the way and crank as before. No back kick should be observed. Do not drive the motor with the spark retarded, but as far advanced as the motor will permit.

If the platinum contacts after much usage become pitted so that a bad contact results, they can be filed flat with a fine file, taking care not to file off any more than is necessary. Then reset the screw so that the break is not more than .025 of an inch.

Don't forget to occasionally brush the distributer disc and interior of distributer block clean of any accumulation of carbon dust.

The "E U" magneto is a new high tension machine designed for four cylinder motors developing as high as 40 horse power.

The construction of this magneto embodies an aluminum base to which the pole pieces are secured, and between which revolves an armature on two annular ball bearings. The circuit breaker is attached to one end of the armature shaft and revolves with it. The magneto is self-contained, having both a primary and secondary winding on the armature.

The high tension winding of the armature is connected to a collector ring, imbedded in a spool mounted on the driving end of the armature shaft. From this ring a carbon brush leads the current through a water-proof holder to the center of the distributer disc.

The cam holder may be shifted to the extent of 30 degrees, enabling an advance or retard of the spark to be obtained, thereby causing ignition to take place earlier or later.

The condenser necessary for the protection of the platinum points and the proper functioning of the machine is placed in the driving head of the armature and revolves with it.

The distributer consists of a disc of insulating material having a metal segment to which the high tension current is led from the collector brush. The distributer block has four small carbon pencil brushes which lead the current to the brass connection imbedded in the block, to which the plug wires are fastened. The position of the segment on the disc can be seen through the little window in the face of the distributer block for the purpose of setting the machine when timing.

A spark gap for the protection of the armature winding is located at the inside end of the brush holder under the magnets.

The main bearings of the magneto are provided with oil cups, and a few drops of light oil every 1,000 miles are sufficient to lubricate them. The breaker arm should be lubricated with a drop of light oil applied with a toothpick to the hole in the bronze bearing pivoted on the steel pin. The cams are lubricated by a felt packing, and a little oil applied to the holes in the edge of the cams will last a long time; any surplus oil should be removed and care taken to prevent any oil getting on the platinum points.

The proper distance between the platinum points when separated should be .020 or 1/50 of an inch. A bronze gauge of the proper size is attached to the wrench furnished for the adjustment of the platinum screw and lock nut.

The fibre roller on the end of the breaker arm is held in position by a pawl spring. The wearing surface of the roller may be renewed by rotating the same a quarter turn, thus bringing a new surface to bear on the cam, and as there are four slots in the roller four wearing surfaces are available.

To time the magneto, rotate the crank shaft so as to bring the piston No. 1 cylinder 1/16 of an inch ahead of the upper dead center of the compression stroke. With the timing lever fully retarted, the platinum points of the circuit breaker should be about to separate. Some motors may require an earlier setting.

The distributor segment should show in the little window in the block and the plug wire to No. 1 cylinder should be fastened under the brass nut directly over the segment. The rest of the plug wires should be fastened in turn according to the proper sequence of firing of the cylinders to which they lead.

U and H Magneto. The particular feature of this magneto, is that the starting spark is a maximum, whether the crank is turned slowly or fast.

In the operation of the U and H magneto, Fig. 221, a low-tension current of electricity is generated by the rotation of the armature of the magneto. An interrupter, or timer, interrupts the flow of this low-tension current at the proper time, this interruption causing a high-tension current, similar to that delivered by the induction coil of a battery ignition system, to be induced in the rotating armature by a peculiar arrangement of the windings of the armature. The high-tension current is conducted to a so-called distributer, the duty of which is to distribute the high-tension current to the spark plugs of the various cylinders in the proper sequence of firing. The wiring diagram of the U and H magneto is shown in Fig. 222.

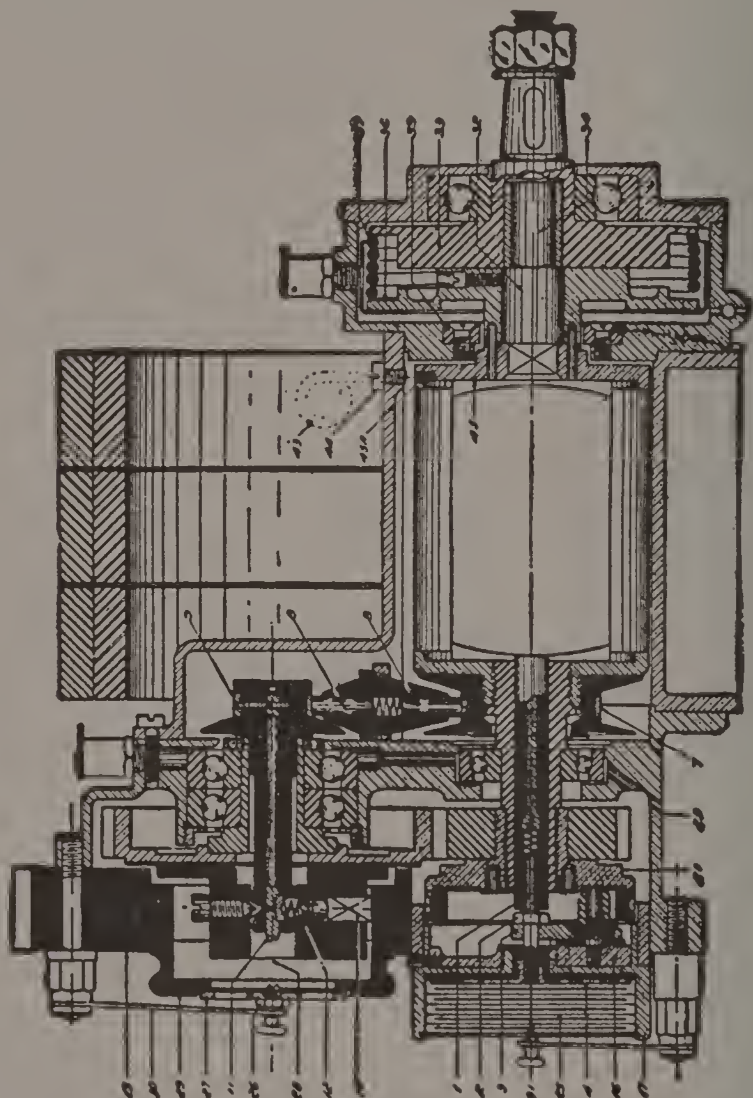


Fig. 221
U. & H. Magneto

The magneto consists of three pairs of permanent horseshoe magnets, placed parallel, and having secured to each of their free ends a soft iron block. These blocks are exactly alike, and form a permanent magnetic field. They are bored so as to allow an armature to revolve between them. The armature is of the shuttle type, and is provided with a double

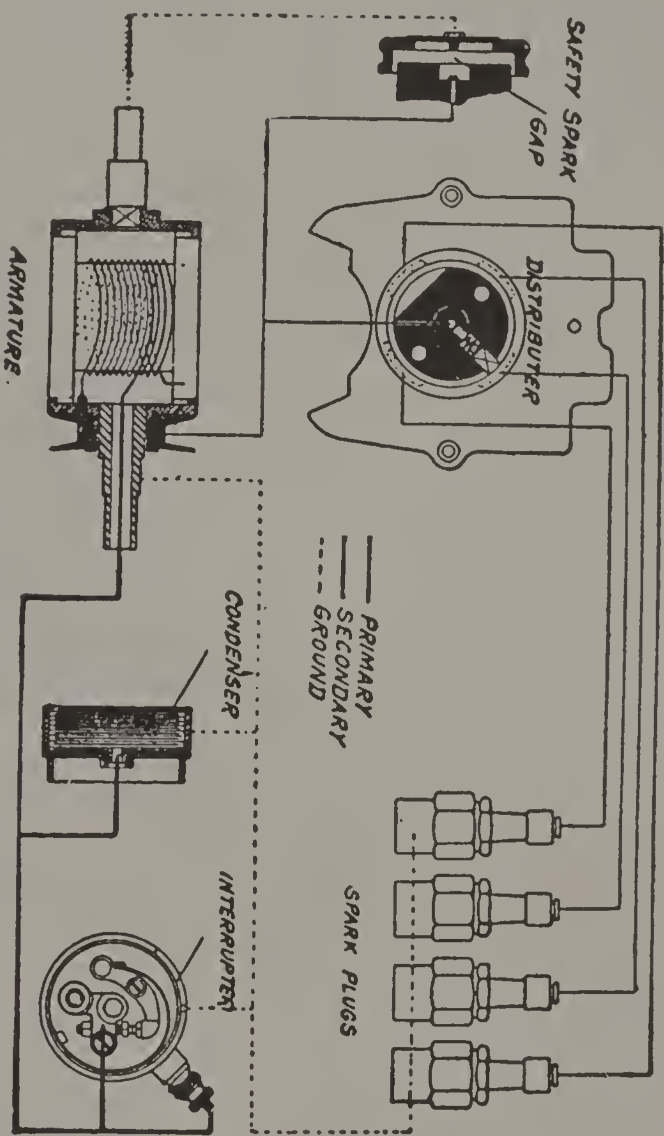



Fig. 222
Wiring Diagram of U. & H. Magneto

winding. The inner or primary winding consists of a few layers of coarse insulated wire. The outer or secondary winding consists of a great number of layers of fine insulated wire. The beginning of the primary winding is grounded to the armature itself. The end of the primary winding is connected with the carbon brush 1, which is carefully insulated from the armature shaft. Brush 1 bears against the interrupter block screw 2, which in turn conducts the current to the interrupter block 3, and to the condenser plate 4. From the interrupter block 3 the current is conducted by means of the platinum pointed interrupter contact screw 5 to the platinum contact on the interrupter lever 6. The interrupter lever 6 has metallic contact with the body of the magneto, and is therefore grounded and in electrical connection with the beginning of the primary winding. It will be seen that when the interrupter lever 6 is in contact with interrupter contact screw 5, the primary circuit is closed, and the primary winding of the armature is short-circuited.

The beginning of the secondary winding is connected to the end of the primary winding, being in fact a continuation of the primary winding. This fact should be borne in mind, as it has direct bearing upon the results attained with this magneto. The end of the secondary winding is connected to the armature slip ring 7, which is thoroughly insulated from the armature. From the armature slip ring 7 the current is conducted by means of the brushes 8-8 to the distributer slip ring 9, from whence it is led to the distributer brush 10 by means of the distributer brush spring seat 12.

The distributer plate 13 is provided with as many brass distributer segments 14, evenly spaced around the distributer bore, as there are cylinders to be fired, and as the distributer brush is revolved it comes into contact in succession with the segments. These segments are in turn connected with the secondary terminals 15, located at the top of the distributer plate, one terminal for each cylinder. From these terminals the high tension current is conducted

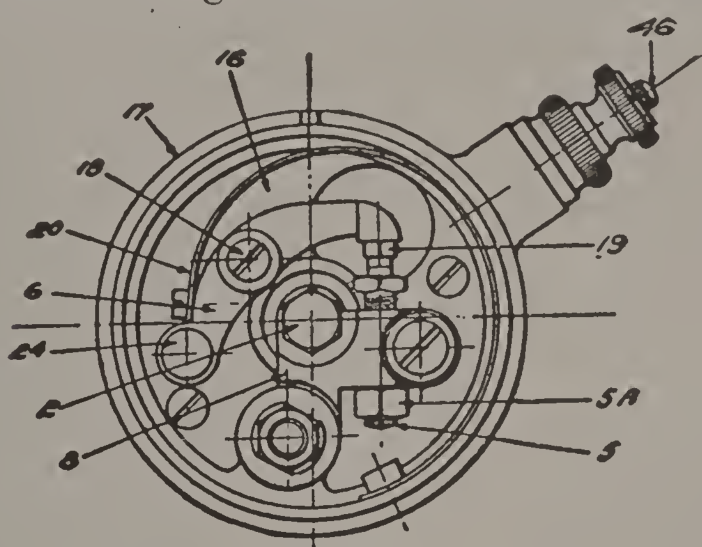



Fig. 223
U. & H. Magneto Interrupter

by cables to the spark plugs of the cylinders, from whence, after jumping the gap it is conducted to the grounded end of the primary coil, through the primary coil to the beginning of the secondary winding, thus completing the secondary or high tension circuit.

U AND H INTERRUPTER. The interruption of the primary circuit is accomplished by the interrupter, as shown in Fig. 223. This device consists of the interrupter plate 16, which is located in the interrupter 17. Attached to the interrupter plate 16 is a stud 18, upon which is pivoted the interrupter lever 6. The interrupter lever is provided with a platinum pointed contact screw 19, which is normally held by the flat spring 20 in contact with the platinum pointed interrupter contact screw 5. The interrupter contact screw 5 is connected to the end of the primary winding, as already described.

Keyed to the interrupter end of the armature shaft, and rotating positively with the armature, is the interrupter cam housing 21. Securely attached to the interrupter cam housing is the interrupter cam 22, consisting of a ring of hard fiber, having on its inner face two projections or cam faces 22A.

The interrupter housing 17 is held in accurate alignment with the interrupter cam 22 by the construction of the rear end plate 23, and as the armature revolves the projections 22A-22A are brought into contact with the interrupter cam pin 24, causing a movement of the interrupter lever 6 sufficient to separate the contact screws 5-19, and thereby interrupt the primary circuit twice in every revolution. As the projections 22A continue to revolve, the interrupter lever 6 instantly resumes its normal position, and completes the primary circuit. The entire housing of the interrupter is easily removed for inspection, or adjustment by pushing the spring clip 31 to either side.

**Induction Coil.** The form of coil generally used on gasoline cars is known as the jump-spark coil. It is of two types, one known as a plain or single jump-spark, the other as a vibrator or trembler coil.

A jump-spark coil consists essentially of a bundle of soft iron wire, known as the core, over which are wound several layers of coarse or large size insulated copper wire, called the primary winding. Over this are again wound a great many thousand turns of very fine or small wire, known as the secondary winding.

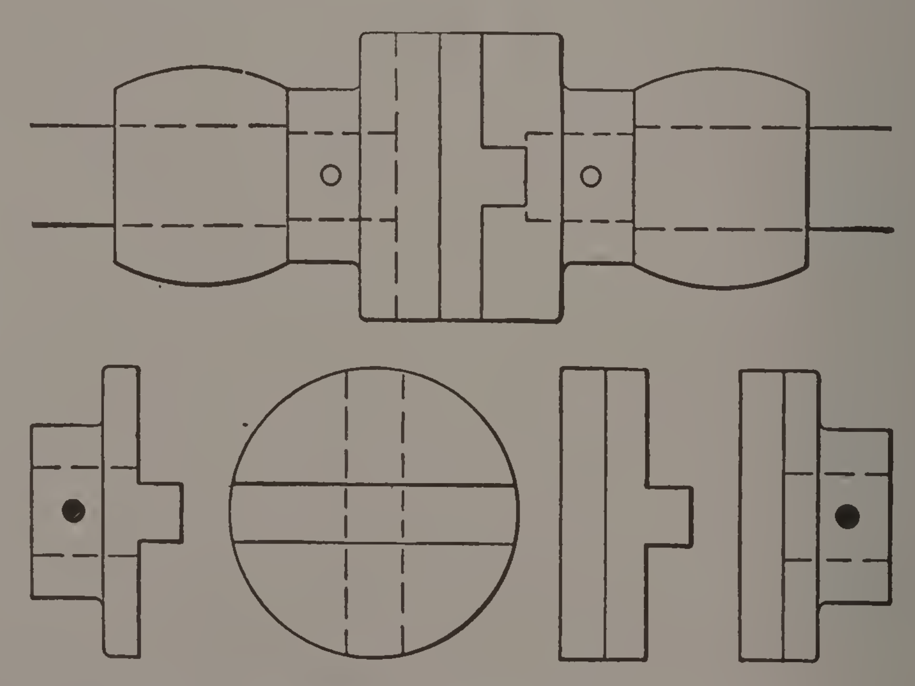
**Inertia.** Inertia is that property of a body by which it tends to continue in the state of rest or motion in which it may be placed, until acted upon by some force. As used by the non-technical, it is almost universally employed in the former sense, i. e., that of the resistance which a body offers against a change in its position, an inert body usually being intended, so that the definition is perfectly correct so far as it goes. The popular impression is that only inert bodies have inertia, it being likewise generally thought that a moving body is possessed of momentum alone, whereas an object at rest is possessed of inertia, and the same object in movement has both momentum and inertia.

**Insulating Material.** Asbestos, lava, and mica are severally used for the insulation of spark plugs and sparking devices.

Vulcanized fiber or hard rubber or even hard wood are used for the bases of switches, connection boards and other places.

India rubber, or gutta-percha form the basis of the insulated covering of wires used for electrical purposes. The coils of small magnets and the cores of induction coils are usually wound with cotton covered wire, or in some instances the fine wire is silk covered, as in the case of secondary or jump-spark coils.

**Joints, Ball and Socket.** To produce a flexible joint capable of operation within certain limitations in any direction, the ball and socket form of joint is generally used on the ends of the rod which connects the arm of the steering mechanism with the steering lever attached to the hub of one of the steering pivots of the front axle.



COMPENSATING DEVICE

Fig. 224

**Joints, Compensating.** On account of the distortion of the frame or running gear of an automobile, due to unequal spring deflection and irregularities of the road surface, means should be provided to insure flexible joints or connections between the various rotating parts of the mechanism of a car. The device shown in Figure 224 is not susceptible to any great amount of angular distortion, but will transmit power with a practically uniform velocity, with the axes of the shafts considerably out of align-

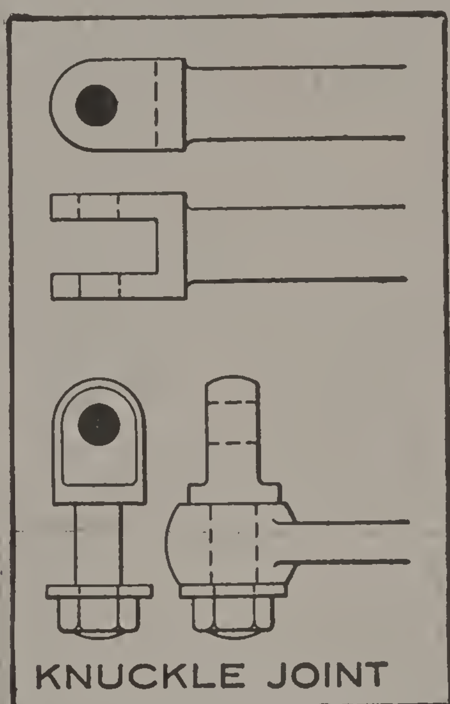



Fig. 225

ment in vertical or horizontal parallel planes.

The form of compensating joint shown in Figure 226 may be operated with the axes of the shafts at an angle to each other, or with the shafts out of alignment with each other in vertical or horizontal parallel planes, and has quite a range of operation with either condition. Both

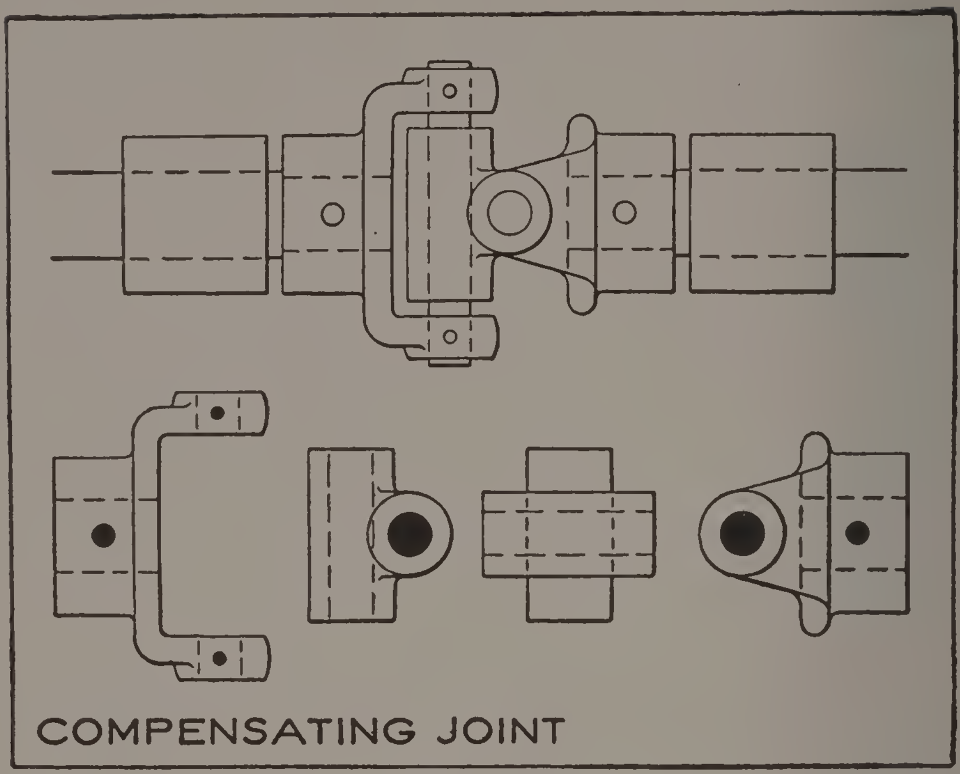



Fig. 226

forms of the device require to have bearings on either side, as shown, to insure their proper working.

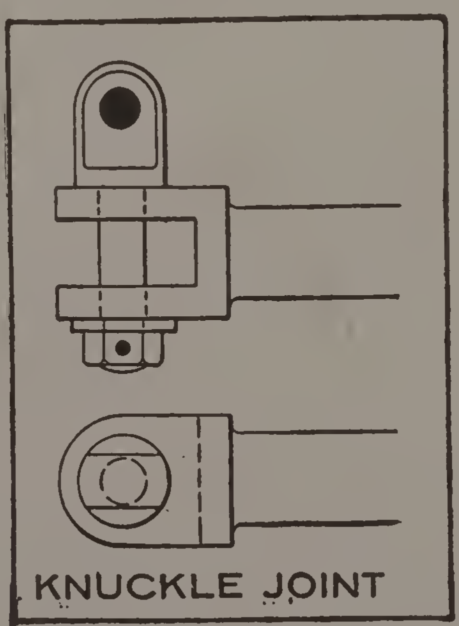



Fig. 227