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MAINTENANCE AND OPERATION

2

4-H

AUTOMOTIVE PROJECT

CARE AND SAFETY

CO 602

UNIT 2

MAINTENANCE AND OPERATION

4-H

AUTOMOTIVE PROJECT IN CARE AND SAFETY

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ACKNOWLEDGEMENTS

This educational material has been prepared for 4-H use by the National 4-H Automotive Program Development Committee, composed of representatives of the State and Federal Extension Services, the Automotive Safety Foundation, the National 4-H Council and The Firestone Tire and Rubber Company. The 4-H Automotive Program is conducted by the Cooperative Extension Services of the State Land-Grant Colleges and Universities with the U.S. Department of Agriculture cooperating. Nationwide support is arranged and announced by the National 4-H Council.

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OUTLINE OF UNITS

You are invited to participate in the 4-H Automotive Program which has been developed especially for older Club members. Its purpose is to help you achieve and enjoy the fullest opportunities as a safe and efficient automobile driver, upon acquiring a license. The impact of the automobile age on our lives makes it important that we have more educational opportunities to learn the safe care and operation of automobiles.

Even though you have not started to drive as yet, the 4-H Automotive Project offers you an opportunity to share with others in your age group the advantage of learning more about the automobile, how it should be handled on the road, and the cost involved.

Following is an outline of the contents of the three Units, this manual being Unit II.

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The engine is the heart of an automobile. The strength of an engine is measured in terms of Horsepower (HP). The goal of this section of the 4-H Automotive Care and Safety Project is to help you understand horsepower and its meaning to you as you become a driver, and to provide you with an opportunity to know the engine parts and their functions. This knowledge will aid you in taking care of the most important part of an automobile — the Power Unit.

From the birth of the automobile industry the term horsepower has been used to indicate the ability of an engine to propel a car with the performance expected of it by the purchaser.

The scientist knows that power is the rate of doing work. Almost 200 years ago a man named James Watt wanted to rate a steam engine in terms of power. He observed that the average horse traveled at the rate of 2½ miles per hour (M.P.H.), or 220 feet per minute, and could exert a force of 150 pounds. As work is force times distance, 150 lbs. x 220 ft. = 33,000 ft. lbs., and since this work was done in one minute, it was a time rate of doing work. James Watt called this amount of work "one horsepower." The term has been used since his day.

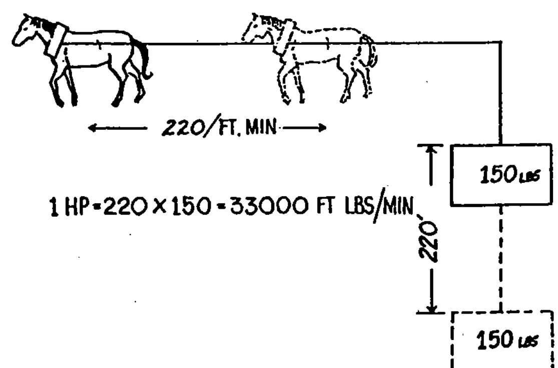
The advertised horsepower of an automobile is the Maximum or Gross Horsepower, which is obtained from a stripped engine on a test block. This method of rating the horsepower, automobile manufacturers agree, is not a very good overall measurement of the car's ability, but it is the best method that has been devised so far. All manufacturers use the same method.

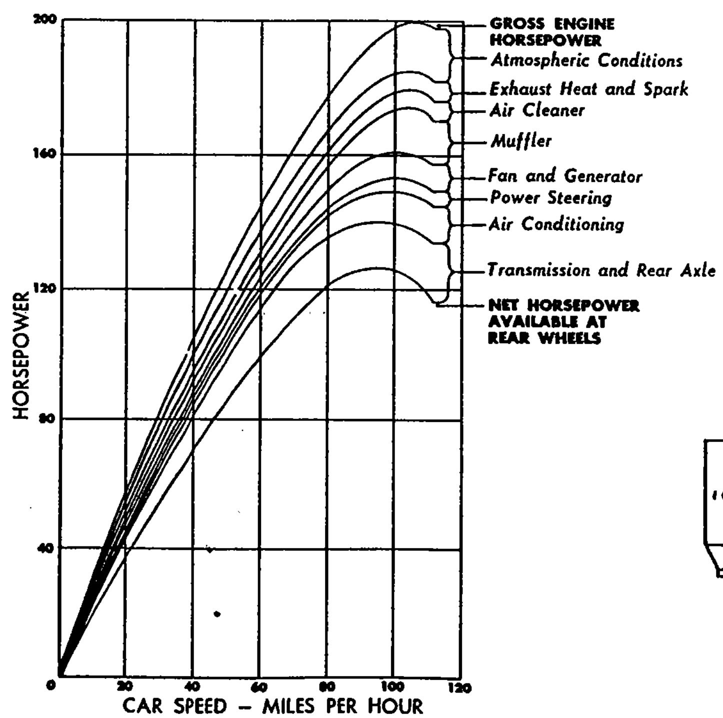
To obtain the Gross Horsepower rating the air filters, fan, generator, and muffler are removed from the engine before it is placed on the test block. The engine is operated with a manually adjusted spark and without exhaust heat being applied to the intake manifold. The gross horsepower which occurs at a fairly high engine speed, is measured on a machine called a dynamometer, then corrected to a standard atmosphere according to the code of the Society of Automotive Engineers (SAE).

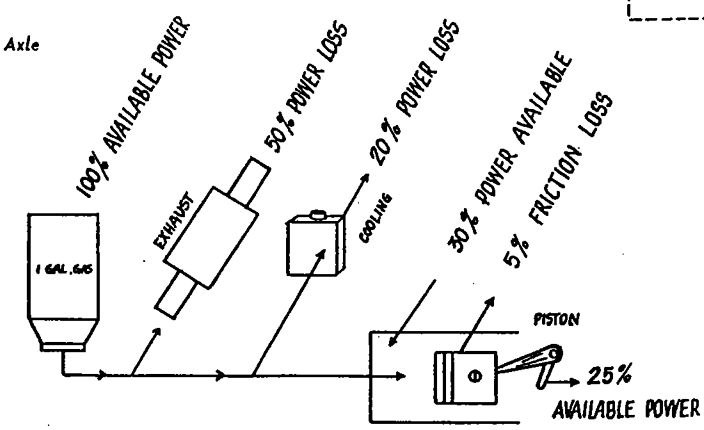
The reason the gross horsepower is used to rate an engine is because different models of cars, all with the same engine, may carry different power-absorbing equipment and accessories so that the power delivered to the rear wheels may not be the same from model to model.

When the engine is installed in a car, the manifold heat, the automatic spark, the generator, fan, muffler, and air filters all reduce the gross horsepower. Accessories such as power steering and air conditioning reduce it still further. Thus in a 200 gross horsepower car, equipped as described, about 135 horsepower actually is delivered to the flywheel. Additional power is lost through the transmission, drive line and rear axle so that the net power delivered to the rear wheels amounts to about 125 horsepower, or about 5/8ths of the rated gross horsepower of the engine.

More power is required to overcome air, tire and road resistance and chassis friction, with the result that the horsepower of the engine when the car is moving at any constant speed on a smooth, level, paved road would be something less than 120. This is further reduced when the car is operating at high altitudes or in conditions of extreme heat and humidity.







POWER USE FROM A GALLON OF GASOLINE

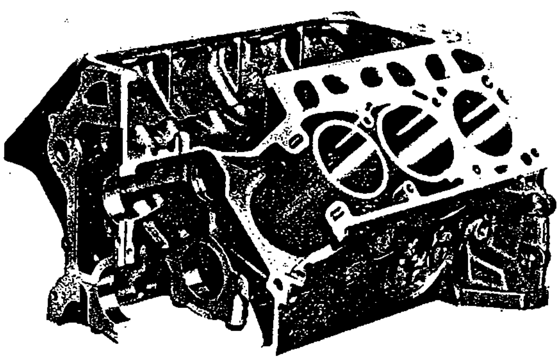
What's in the Power Unit?

For a power unit to deliver horsepower to the wheels over a long period of years, the materials used in building the engine must be carefully selected for the work each part will perform. These parts are machine ground and polished to a precision fit, one with the other, so as to give a powerful, smooth-running engine.

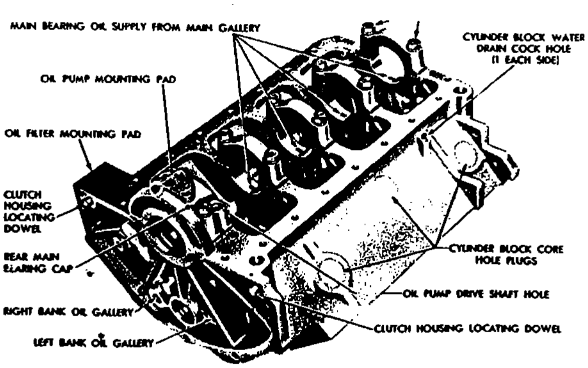
The cylinder block, crankcase and cylinder head form the foundation and main stationary body of the automobile engine and serve as support and enclosure for moving parts.

The CYLINDER BLOCK contains: (1) the smooth, round cylinders in which the pistons slide up and down; (2) the openings for the valves or push rods, and (3) the passages for the flow of cooling water. The cylinder surfaces are given a precision mirror finish by an accurate grinding and honing process. In nearly all modern day automobile engines the cylinders are cast in a single block, although removable liners of special hardened steel sometimes serve as cylinder walls.

The CRANKCASE acts as the base of the engine. It supports the crankshaft and camshaft in suitable bearings and provides arms or brackets for supporting the engine on the frame. Although the cylinder block and the crankcase must be considered as separate parts from a functional standpoint, physically the cylinder block and the upper half of the crankcase usually are cast as a single unit. The combined cylinder block and crankcase casting usually extends a short distance below the center line of the crankshaft. This casting normally is made of a ferrous alloy or semi-steel to provide a stronger, harder casting which will give greater wear resistance than the gray iron casting commonly used for many years. Although it is more difficult to machine than gray iron, the stronger, tougher material permits thinner casting walls, thus saving weight and improving cooling.



The cylinder block of a V-type engine cut-away to show construction.

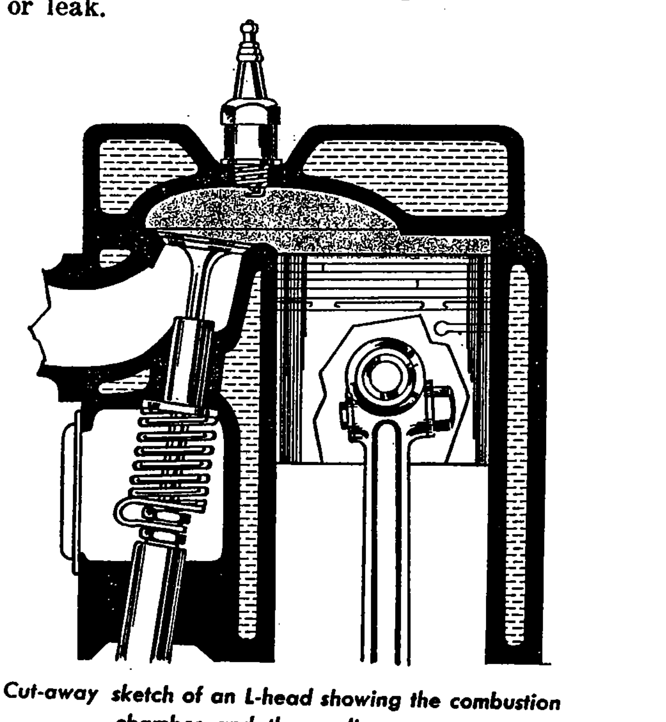


Engine block turned upside down to show crankcase area and main bearings.

The lower part of the crankcase is called the oil pan. It provides a reservoir for the storage, cooling and ventilation of engine lubricating oil. It also encloses the lower part of the crankcase. The oil pan is bolted or screwed to the lower flange of the main casting and usually is made of pressed steel or aluminum.

The CYLINDER HEAD is a separate casting bolted to the top of the cylinder block and contains the combustion chamber. In this cylinder head are mounted the spark plugs and, in most instances today, the valves. To carry the flow of cooling water, the cylinder head contains passages which meet those of the cylinder block. The cylinder head usually is made of gray iron or aluminum alloy. It is cast separately from the block to make possible removal for cleaning carbon and grinding valves. To retain compression in the cylinders, a gasket (constructed of a flat piece of copper asbestos or of steel and asbestos) is placed between the cylinder head and the cylinder block sealing the joint.

All cylinder heads, whether cast iron or aluminum, should be tightened down with a special tool, called a torque wrench, to the manufacturers' specifications. Uneven tightening causes distortion of the cylinder block, which in turn prevents the valves from seating squarely, eventually warping them and resulting in loss of compression. It is also possible that the cylinder head gasket will blow out or leak.



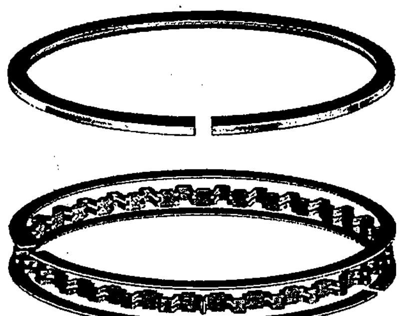
Cut-away sketch of an L-head showing the combustion chamber and the cooling area.

Pistons are slightly smaller in diameter than the bore of the cylinder. The space between the piston and cylinder wall is called the "piston clearance." This clearance is necessary for two reasons: (1) the pistons reach a higher temperature than the cylinder walls, which are cooled by the water surrounding them; and (2) it is necessary to provide space for a film of lubricant between the piston and the cylinder wall. Pistons are made of aluminum alloys, cast steel, cast iron, or chrome nickel. In today's automobiles surfaces of pistons are "anodized," that is, treated with a coating of tin or zinc oxide. Aluminum alloy pistons usually are lighter than other types and are excellent conductors of heat, but they expand more and consequently require some means of compensation for this characteristic, such as vertical slots.

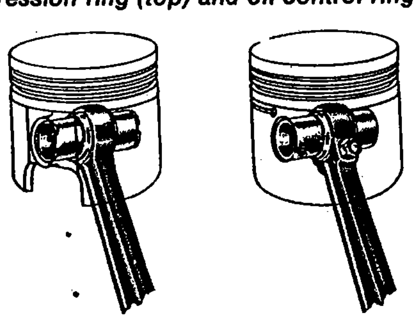
The top of the piston is called the head, and the part below the ring grooves is called the skirt. In some piston designs the cross section of the piston skirt is oval. As the piston expands the oval skirt tends to become round. The portion of the piston that separates the grooves is called the lands.

PISTON RINGS fit into the ring grooves and seal, with the help of oil, the compressed and expanding gases above the piston. At the same time the rings prevent the oil from entering the combustion space and causing carbon deposits on the cylinder head and the top of the piston. A third purpose of the rings is to transmit heat from the pistons to the cylinder walls.

The top two rings are called compression rings, and are designed to maintain cylinder pressure. The bottom one or two rings are called oil-regulating rings. They scoop the excess oil from the cylinder walls and return it through horizontal slots to the piston ring grooves. From there it passes through the oil drain holes inside the piston.



A compression ring (top) and oil control ring (bottom).

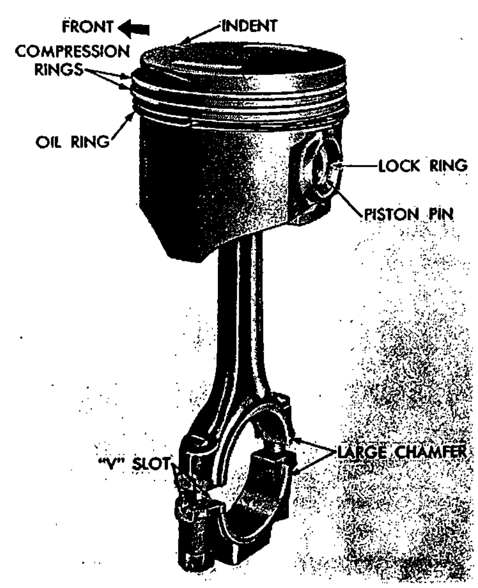


Two methods of securing piston pins: (left) floating piston pin held by retainer; (right) piston pin fastened in connecting rod.

Practically all piston rings are of the concentric type, that is, they are uniform in size around their entire perimeter. Piston rings have joints allowing them to be expanded and slipped over the piston into their grooves, and to compensate for expansion and wear. Rings usually are made of cast iron. Those used today are commonly plated with chromium, cadmium or tin, or given a surface treatment to reduce wear and eliminate scuffing.

The PISTON PIN, or wrist pin, links the piston to the connecting rod. Usually it is hollow and made of case hardened steel. There are three commonly-used methods of making the connection: (1) the pin is fastened to the piston by set screws through reinforced sections, called the piston bosses; (2) the pin is fastened to the connecting rod with a clamp screw; or (3) a floating pin is used. The latter is free in both the connecting rod and the piston, but is prevented from coming in contact with the cylinder wall by two lock rings which fit in grooves in the outer end of the piston bosses.

The CONNECTING ROD is the connection between the piston and the crankshaft. It joins the wrist pin with the crank of the crankshaft. The lighter the connecting rod and the piston, the greater the resulting power and the less the vibration, because the reciprocating weight is less. Connecting rods in American automobiles are made of steel forgings, although aluminum alloys have been used both in this country and in Europe. Rods are matched carefully in sets of uniform weight to maintain engine balance. The rod usually has an I-beam cross section. The lower part of the rod is split to permit clamping around the crankshaft. The split usually incorporates bearings lined with steel-backed copper-lead, or steel-backed cadmimum-silver. The lining may be either in the form of a separate split shell, called a bearing insert, or it may be spun on the inside of the rod and cap during the manufacture of the connecting rod. Thin pieces of metal called shims, sometimes are used with spun bearings.



Connecting rod and associated parts.

The CRANKSHAFT, along with the connecting rod, converts the power delivered to the piston by the burning gases from an up-and-down, reciprocating motion, to a rotary motion. In operation, it applies the principle of the simple machine known as the wheel and axle. The crankshaft is made from a steel forging or casting, and is machined and ground to provide suitable journals for the connecting rod and main bearings. The main bearings fit the main journals of the crankshaft and hold the crankshaft on its rotating axis. The number of main bearings depends on the design of the engine, and the number of cylinders. There must be at least two, one at the front of the crankshaft and one at the rear. The maximum number on a given engine cannot exceed the number of crankthrows plus one, that is, one between each crankthrow and one at each end. The more main bearings, the less possibility of vibration and distortion in a crankshaft of a given size. A flywheel is fastened to the back end of the crankshaft. It stores up energy and carries the rotating shaft over the points not receiving power impulses from the explosions. The flywheel also is a part of the clutch mechanism, fluid drive or automatic transmission. The starting motor drive connects to teeth on the outside rim of the flywheel.

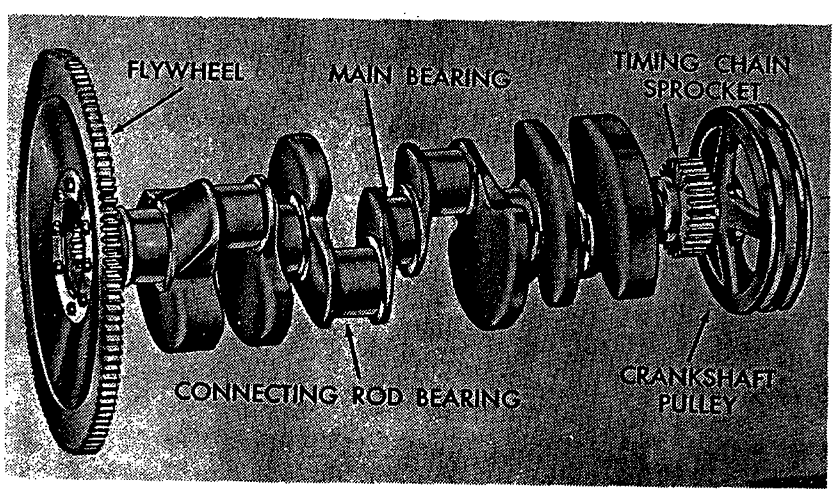
To reduce engine vibration to a minimum, the crankshaft and flywheel are balanced separately, and then often are tested for balance when mounted together. Balance tests are of two kinds — "static" and "dynamic."

In testing for static balance the parts to be tested are laid on a pair of flat bars called "ways," which are exactly level. If the part tends to roll when placed on this level surface, it is out of balance. To balance a flywheel small holes are bored in the rim. To balance a crankshaft metal is ground off at the throws until the parts will not roll when placed in any position.

An engine crankshaft and flywheel in perfect static balance may not be in correct dynamic balance, because it is possible to have the weight equally distributed around the centerline (thus giving correct static balance) and still not have the weight directly opposite another weight which balances with it (so as to produce correct dynamic balance). If the shaft is not balanced dynamically, it will wobble endwise setting up serious engine vibrations.

To further reduce vibration, counterweights are located opposite the crankthrows. Also, the main bearings between the crankthrows help to eliminate vibration.

Valves control the intake of fuel into the cylinder, and the output or exhaust of hot gases resulting from the combustion process. Two valves, an intake valve and an exhaust valve, are commonly used for each cylinder. Fuel is admitted by the intake valve, and the burned gases escape through the exhaust valve. Some special engines have two intake and two exhaust valves per cylinder. Valves also seal the combustion space when closed during the beginning of the power stroke. Loss of compression will result if the space is not sealed.



Crankshaft and flywheel of a V-8 engine.

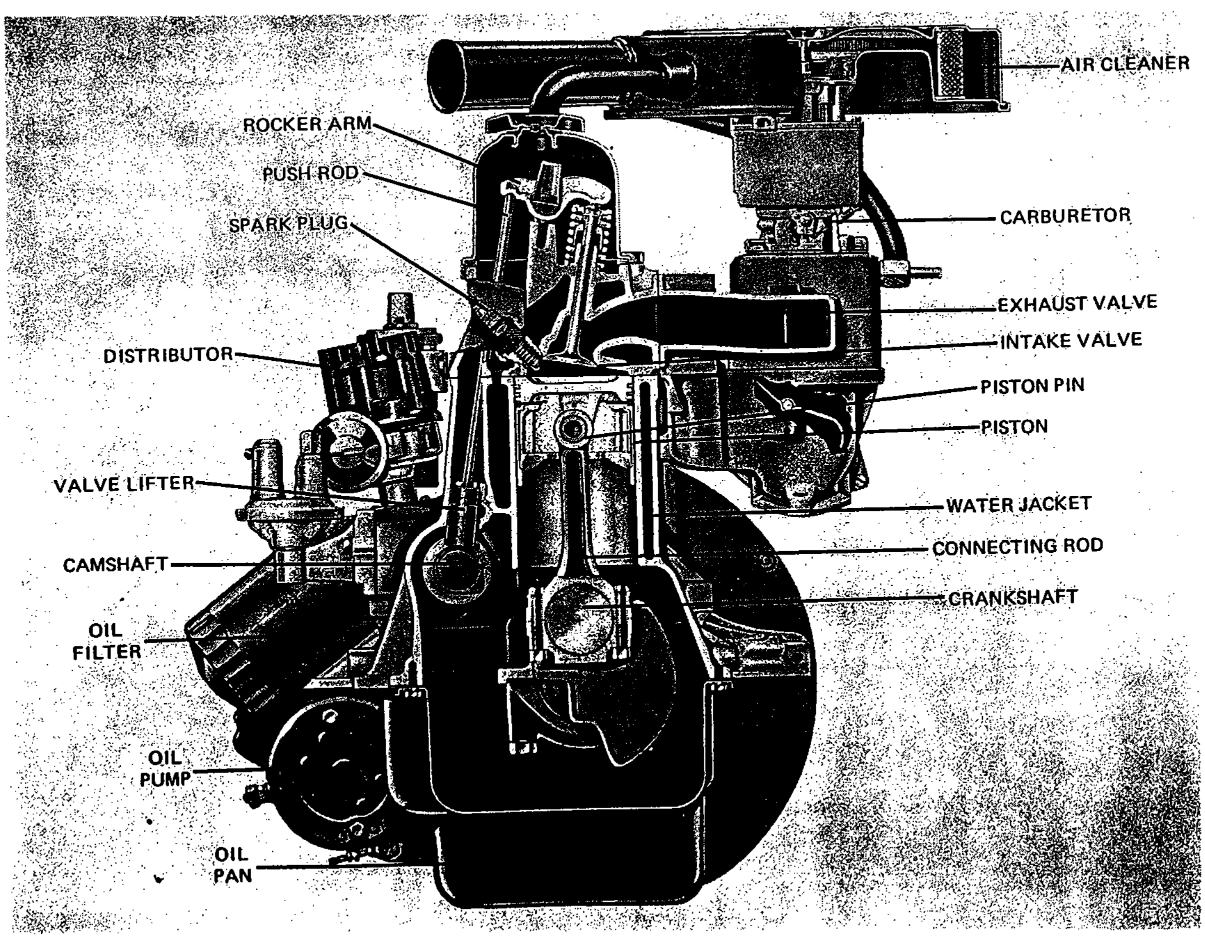
The movement of the valves is accomplished by a cam, which is a projection on the camshaft. The cams, one for each valve, are precision-ground and polished. The camshaft is driven by a chain drive or gears from the crankshaft. As the camshaft turns, the cam lifts the valves. The closing of the valves is accomplished by a spring. These valve springs must have considerable tension to assure prompt closing and prevent the valves from jumping away from the cams, especially at high engine speeds.

Exhaust valves are usually made of a special alloy of silicon and chromium, or some other alloy resistant to heat. Intake valves, being subject to less heat, generally are made from nickel-chromium alloy steel. The head of the valve is ground to an angle matching that of the valve seat in the head or block, so it makes a snug fit. Some engines have different angles for the exhaust and intake valves. Valve-seat inserts often are pressed into cylinder block or head to reduce wear, prevent leakage and to decrease frequency of valve grinding. These are of special alloy steel and are replaceable. The seat inserts usually are used only for exhaust valves.

It is highly important that valves open and close at exactly the correct moment in the engine cycle. During the suction stroke the intake valve must be open wide to admit the charge. In most automobile engines the intake valve opens slightly before the piston starts downward on the suction stroke, and closes after the piston has started upward following completion of the suction stroke.

Valve timing is controlled by the camshaft. Rotating at half the speed of the crankshaft, the camshaft allows only one valve to open on every other stroke in the four-stroke-cycle engine. The intake valve remains open to allow a full charge of fuel and an equalization of atmospheric and cylinder pressures until the piston is well along on its next stroke, the compression stroke. The piston moves upward, closing the space in the cylinder and compressing the charge. At that point the compressed gases are ready to be ignited and burned.

As the piston is forced down by the expanding gases it is necessary for the exhaust valve to open before the piston reaches the end of the power stroke. Obviously it would be wrong to keep the exhaust valve closed up to the very moment when the piston is about to move upward, because then (at the beginning of the exhaust stroke) the piston would be confronted for an instant with the force which had just driven it downward and, until the valve was open wide, there would be a considerable loss of power. On the other hand, if the exhaust valve opens too early, power is wasted because the gases are released before they have completed exerting pressure on the piston.



An engine showing the principal parts.

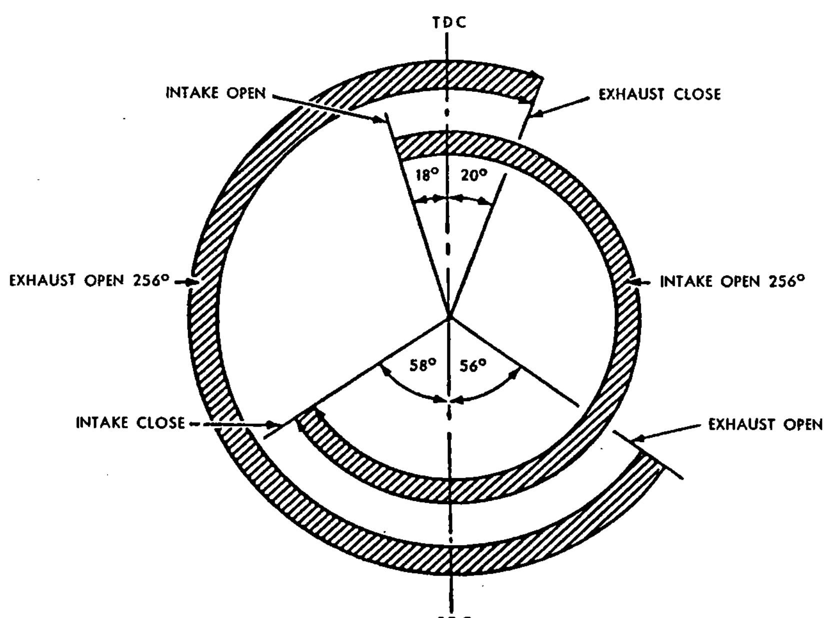
During the next upward stroke — the exhaust stroke — the remaining gases are forced out of the open exhaust valve, because the pressure in the cylinder exceeds that in the exhaust manifold. This causes a slight compressing of the gases ahead of the piston reaching its topmost position, thus there is a certain amount of compressed exhaust gases in the clearance space. If the exhaust valve were to be closed at this point, a large portion of those gases would be retained in the cylinder.

The best results are obtained when the exhaust valve is held open until a short time after the piston has begun to move downward on the next intake stroke. It might appear this would result in drawing the exhaust gases back into the cylinder. Two conditions, however, prevent such a drawback; (1) the gases under compression exceed the pressure in the manifold and consequently continue to flow out because of the difference in pressure; and (2) while at the top of the stroke, the piston moves but very little in relationship to the 10-15 degree movement of the crankshaft. This does not increase the combustion space. Usually it is in this region that the exhaust valve is closed after reaching top dead center (T.D.C.).

By comparing this valve data it is apparent that there are times when both valves are open simultaneously. This is called valve overlap. The pre-admission of the intake valve causes it to overlap 18 degrees with the exhaust valve before top dead center. After the T.D.C. closing of the exhaust valve a 20-degree overlap is produced between that valve and the intake valve. Therefore, in an engine with this arrangement there is a total valve overlap of 38 degrees.

As you have seen in this section, the automobile is made up of a number of parts. Those parts are precision-made from many different metals and alloys, each best suited for the purpose. The parts are carefully assembled and timed to produce a Power Unit capable of developing the horsepower and performing in accordance with the manufacturer's specifications. How well you take care of an automobile engine has a great deal to do with what happens to the horsepower as the car gets older. Experience has shown that it is possible for the horsepower after a year of driving, to remain about the same as when the car was new. Or, the horsepower can drop. This depends on the operator.

To maintain horsepower, cleanliness should be the watchword — you will want to keep the inside of the engine clean. To produce power the engine burns fuel and air, and exhausts the unburned gases. But foreign material which enters the engine stays in it and usually causes damage. If foreign material is kept to a minimum, better performance will be achieved. So you will want the engine to use clean air, clean fuel, clean hot spark, clean water and clean lubricants. In the sections which follow you will learn about those requirements in more detail.



Valve timing for a typical V-8 engine. Angles indicated are based on top dead center (T.D.C.) and bottom dead center (B.D.C.) positions of the piston.

UNIT 2, SECTION I THE ENGINE AS A POWER UNIT

LET'S DISCUSS

1. Should premium gasoline be used in your family's automobile? How many members' families use it?

2. How does the compression ratio affect the grade of gasoline used?

3. What is the advantage of a torque converter? How many members have a torque converter in their family automobile?

4. What is the relation of accessories on an automobile to the horsepower delivered to the wheels? How many accessories does your family's automobile have?

LET'S DO

1. Using worn parts, make an exhibit of parts studied in this section. Be able to show where each failed to do its part to develop power.
2. With the help of a mechanic, take the compression on your family automobile (with parent's consent). Keep a record of the reading. Compare it with those of other members.
3. With the help of a mechanic (and parent's permission), regap the plugs. Use a wire gauge.
4. Service the battery. Use a hydrometer.
5. Clean the outside of the engine, with the help of a mechanic. (NOTE: Do NOT Use Gasoline)
6. With the help of a mechanic (and family approval), check the timing with a timing light. What did you find?

Air is vital to the operation of the engine of a car. Indeed, the engine cannot run without air. Amounts used are enormous. Normally about 15 pounds are used for each pound of fuel burned in the engine (a pound of gasoline is not quite one and one half pints). That is called an air-fuel ratio of 15 to 1. By volume the engine uses about 9.000 times as much air as it does gasoline. Burning one gallon of gasoline requires an amount of air equal to that contained in a room 10 feet wide x 15 feet long x 8 feet high, like a good-sized bedroom.

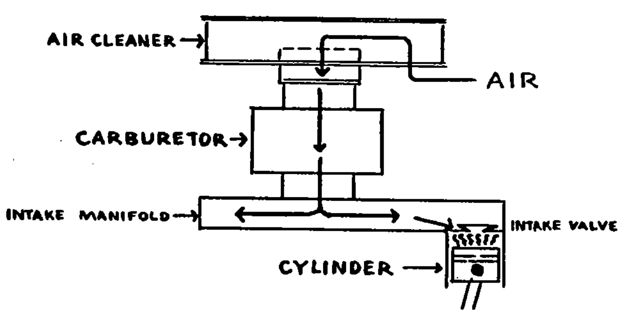
Actually, it is only the oxygen in the air which is used in burning the fuel. During combustion in the engine the oxygen in the air combines with the fuel. Nitrogen passes through the engine unchanged. Air contains about 12 per cent oxygen and 79 per cent nitrogen.

Air enters the engine of the car through the air cleaner on the carburetor, then follows this path: carburetor, intake manifold, intake valve, combustion chamber, exhaust valve, exhaust manifold, and exhaust pipe.

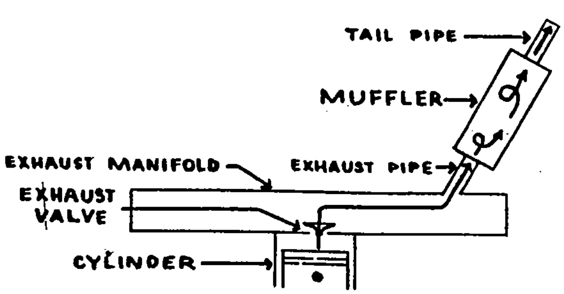
The partial vacuum caused by the piston moving down on the intake stroke causes air to rush into the engine. When air is forced in with a blower the engine is called a super-charged engine.

An air cleaner is needed on an engine for two reasons:
(1) to keep the dirt in the air from entering; and
(2) to act as a noise silencer.

All air contains dirt to some degree. When small particles of very hard material in the air get into the engine they cause rapid wear of the parts — intake valves, cylinders, piston rings and bearings. During 1,500 miles of driving the air taken into an average engine may contain up to 5 pounds of dirt.



The air intake system.



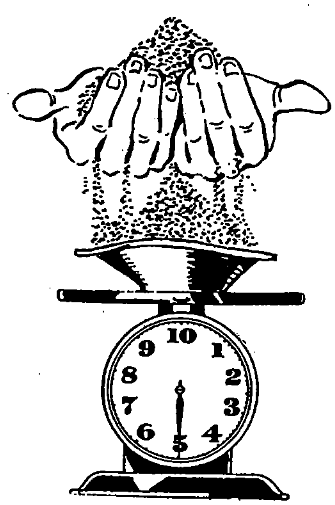
The exhaust system.

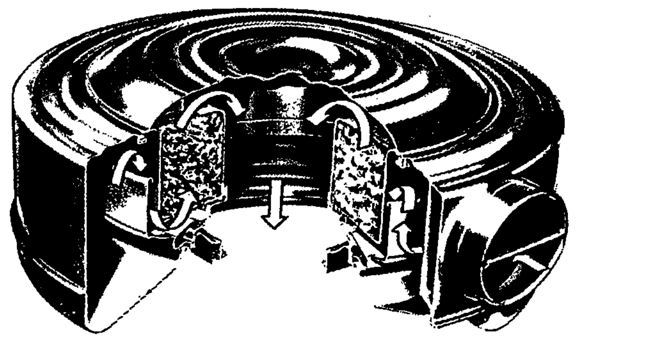
The large quantities of air used by the engine travel at very high speeds (up to 290 miles per hour) and the noise would be objectionable, if it were not for the air cleaner acting as a silencer.

Three types of air cleaners are used on motor vehicles to catch dirt particles as the air passes through — oil-wetted, oil-bath, and dry types. The two former types depend on oil-coated mesh or gauze to catch the dirt particles. The dry type utilizes a cellulose material treated with resin to make it water repellant. The holes in it for passage of air are smaller than the dirt particles, so the dirt is trapped mechanically rather than by the oil.

In the oil-wetted type the trapped dirt eventually soaks up the oil and the cleaner loses its effectiveness, permitting dirt to pass through into the carburetor and on into the engine. For that reason the filter element should be cleaned periodically. This is done by removing the filter and washing it in kerosene. After it is cleaned it should be dipped in oil, drained and replaced in the air cleaner. This should be done about every 1,000 miles of driving, or more often if the driving had been under dusty conditions.

The oil-bath filter is similar to the oil-wetted type, but has a larger element. In addition, a supply of oil is under the filter element. As air rushes


Dust collected in 1,500 miles of travel.


The oil bath air cleaner. Arrows show direction of air flow.