CHAPTER THREE

Fuel System

A fuel system has three basic jobs:

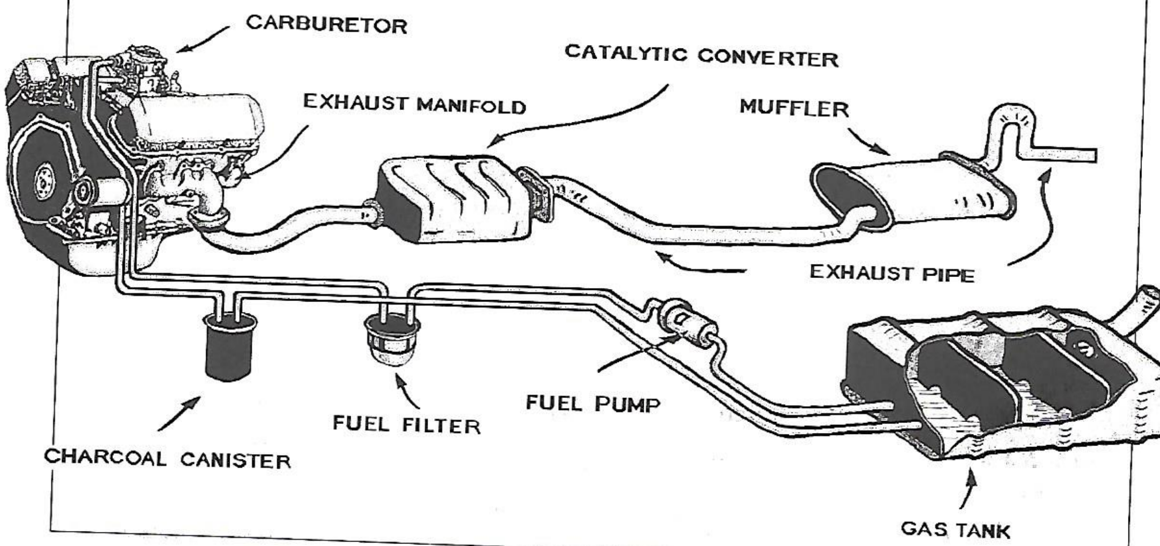
1. To supply an engine with fuel
2. To mix this fuel continuously with air in varying combinations
3. To discharge the burned remains safely

At top speed, the flow of air rushing through an engine approaches the speed of sound. Gasoline droplets are mixed into this air-flow as it enters an engine. The *air/fuel mixture* then burns in the combustion chambers, and the exhaust is blown out the tail pipe.

The air-flow through an engine is created by the action of the pistons moving up and down. As pistons move downwards, they create a partial vacuum which immediately pulls in the air/fuel mixture. After the mixture ignites and a piston is driven down, it moves up again to push the burned remains out. The opening and closing of the engine valves directs the air/fuel mixture through an engine and into the exhaust pipe.

A fuel system uses either a *carburetor* or *fuel injectors* to mix and deliver fuel.

THE FUEL SYSTEM



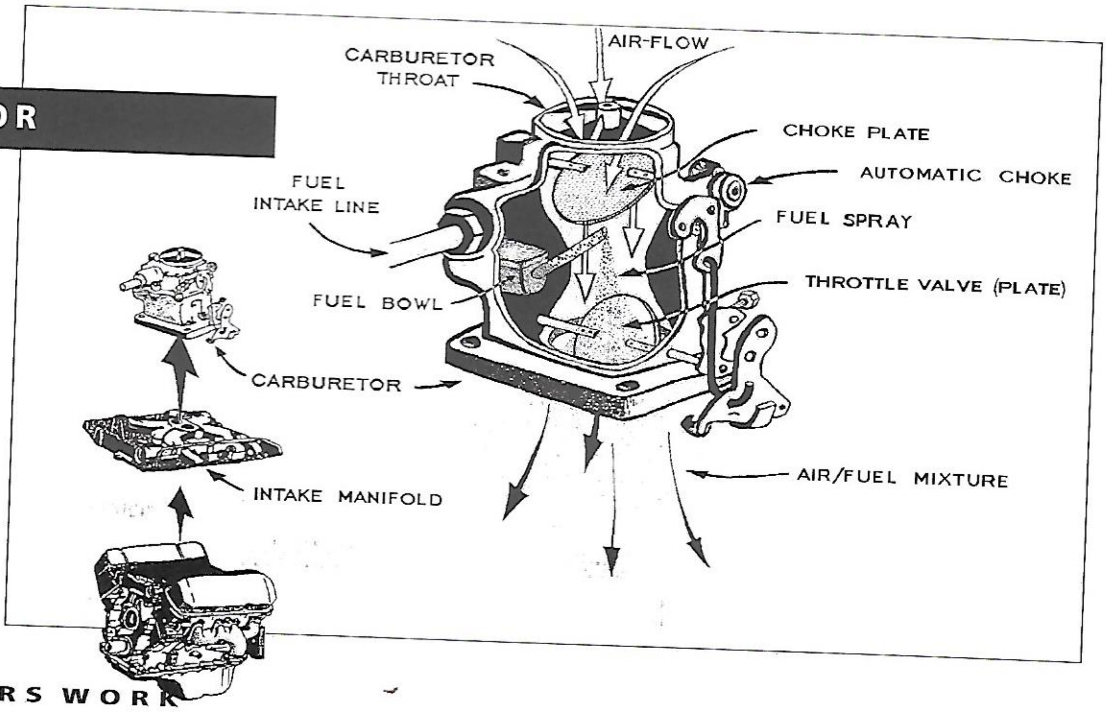
Carburetor

A *carburetor* controls the amount and mixture of fuel delivered to an engine. A *throttle valve* or *butterfly valve* regulates fuel volume. When a gas pedal is pushed down, a throttle valve correspondingly swings open, introducing more fuel into the air-flow. This increases engine revolutions and car speed.

A carburetor must continuously adjust the air/fuel mixture to create the most explosive combination possible inside a combustion chamber. The *choke plate* illustrated below is shown in half-open position. In this position, air entering the carburetor *throat* is partially blocked, causing less air to enter the air/fuel mixture. This mixture, rich in gasoline, is necessary for a cold engine to operate properly. As an engine warms, an *automatic choke* slowly moves a choke plate to a more open or straight-up position, automatically adjusting the air/fuel mixture.

At full throttle, the air-flow is funneled through a carburetor at great velocities. Droplets of liquid gasoline are automatically drawn from a fuel *bowl* into this air-flow by the force of the moving air. When the droplets hit the air-flow they *atomize* or break into very small particles. This air/fuel mixture enters an *intake manifold* and is then sucked into individual combustion chambers through the intake valve openings. Once in the combustion chambers, the air/fuel mixture is compressed, exploded, and the waste pushed out through the exhaust valve openings and exhaust pipe.

CARBURETOR



Fuel Injection

Fuel injection systems spray gasoline into the air-flow, rather than having fuel droplets drawn-in automatically, as with a carburetor. A spray system is a more precise, controllable, and efficient fuel delivery system, yielding greater economy and cleaner burning.

There are three main types of fuel injection systems:

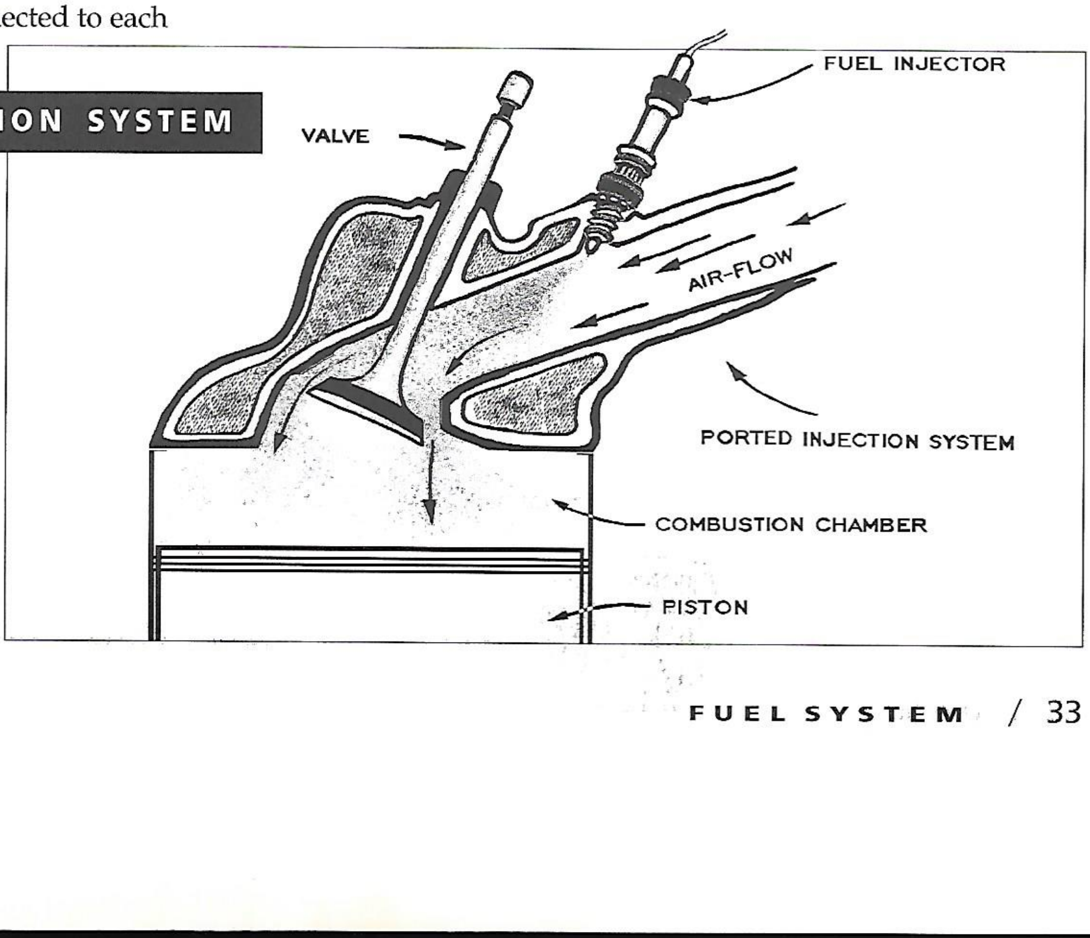
1. Direct fuel injection
2. Ported fuel injection
3. Throttle body fuel injection

Direct fuel injection uses a separate injector for each combustion chamber and represents the original design. These injectors screw into an engine head, extending into the combustion chambers, alongside the sparkplugs. A tiny gasoline pipe is connected to each injector and a control mechanism regulates the amount of spray.

Ported fuel injection (shown below) is a second generation injector system. This design also uses one injector for each combustion chamber, but the injectors do not spray directly into a combustion chamber. Here, an injector is in the intake manifold just outside each combustion chamber, in the "intake manifold port."

Throttle body fuel injection represents a third, more modern, and simplified injector system. Here, a single injector is positioned in a carburetor body and this injector acts as a more precise and controllable carburetor. Like a carburetor, a throttle body system directs atomized fuel into the air-flow for further mixture in an intake manifold.

FUEL INJECTION SYSTEM



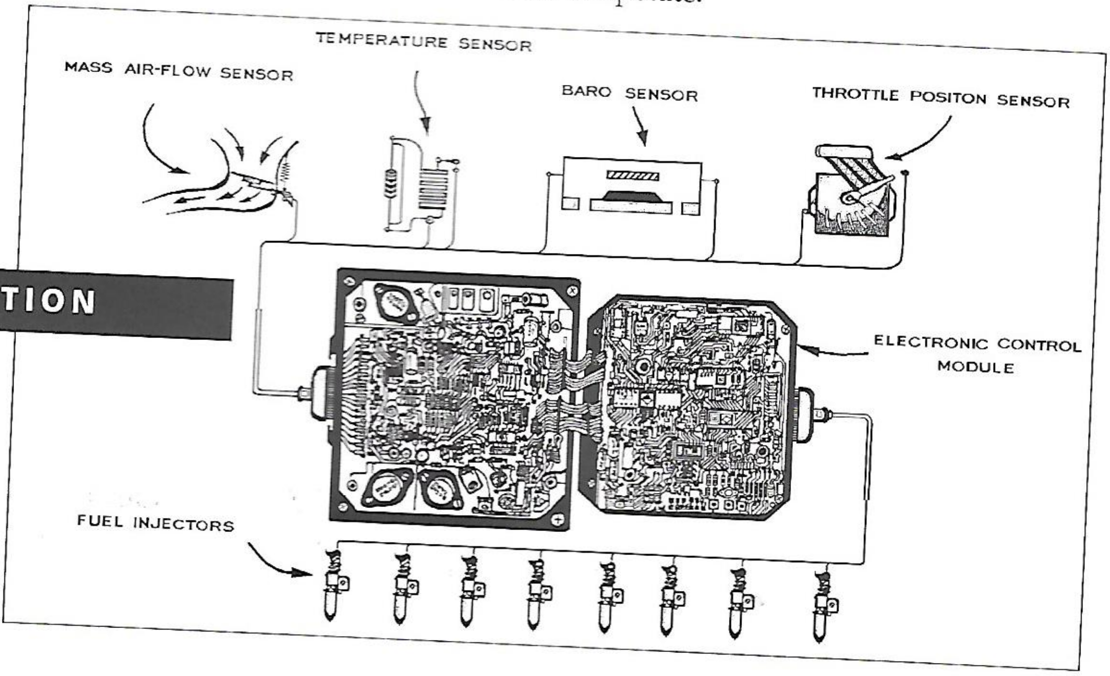
Computerized Fuel Injection

Computer controlled injector systems include *electronic fuel injection* (EFI), *digital electronic fuel injection* (DEFI), and more recently electronic *sequential multi-port fuel injection* (SMPI). In these systems, a computer receives information from a variety of sensors strategically placed throughout a vehicle. Sensors and injectors are connected to a central computer, often termed *electronic control module* (ECM), *electronic engine control* (EEC), or *engine control unit* (ECU), depending on the manufacturer.

Common sensors include a manifold air pressure (MAP) sensor, plate sensor, pivoting flap sensor, manifold oxygen sensors, mass air-flow sensor, speed-density air sensor, barometric pressure (BARO) sensor, manifold air temperature (MAT) sensor, coolant temperature sensors, variable-resistance sensors, and crankshaft position sensors.

The main advantage of any injection system is the high degree of control over the fuel mixture. Depending on the computer analysis of sensor data, three variables can be used to control the amount of gasoline injected: the size of the spray nozzle, the length of spray time, and the spray pressure. These complex operations require computer control. As with most automotive computers, a system failure defaults to average settings, enabling vehicles to continue to operate.

FUEL INJECTION

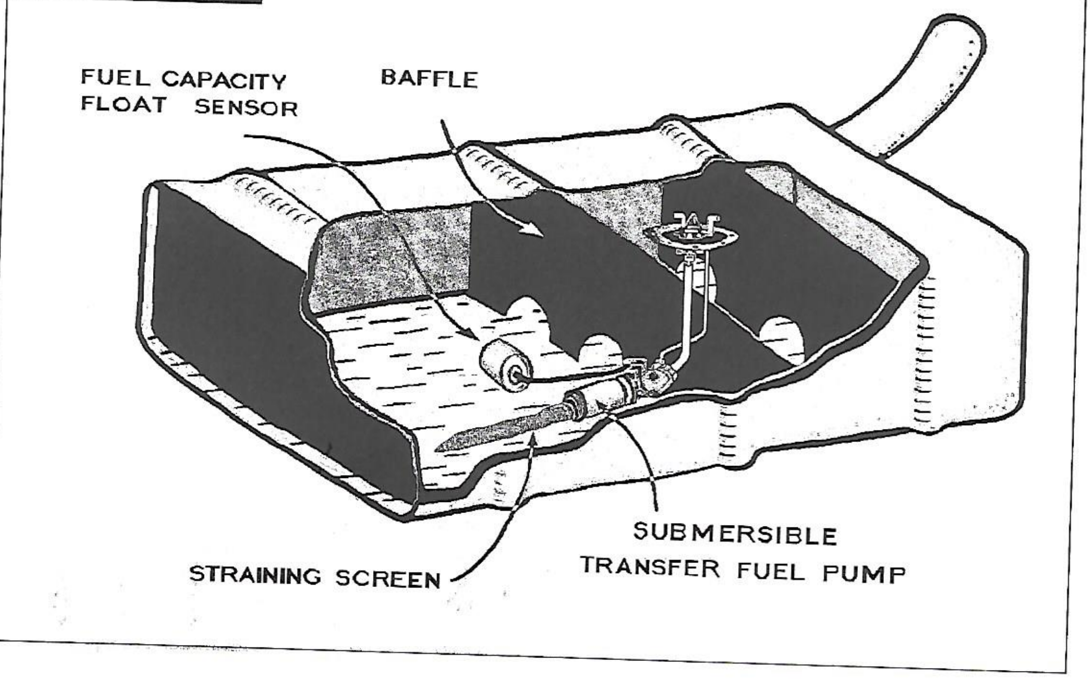


Gasoline Tank

The primary purpose of a *gasoline tank* is to store gasoline, but tanks have other jobs as well. For example, a sensor system for the *dashboard fuel gauge*, often a plastic float, is built into most tanks. Gas tanks also have *baffle plates* inside to stop gasoline from sloshing during hard cornering, an electric submersible *transfer fuel pump* (shown below), a *water detector* sensor, and a filter for screening out large unwanted particles.

Gasoline tanks are also designed to prevent gasoline fumes from escaping into the atmosphere. Most vehicles use a *charcoal canister* (see page 31) or a *vapor holding canister* to trap fumes while allowing a free flow of air into a tank to equalize atmospheric pressure. Charcoal canisters are often located in an engine compartment and may also trap fuel-overflow from a carburetor, returning it to the tank.

GAS TANK



Fuel Pump

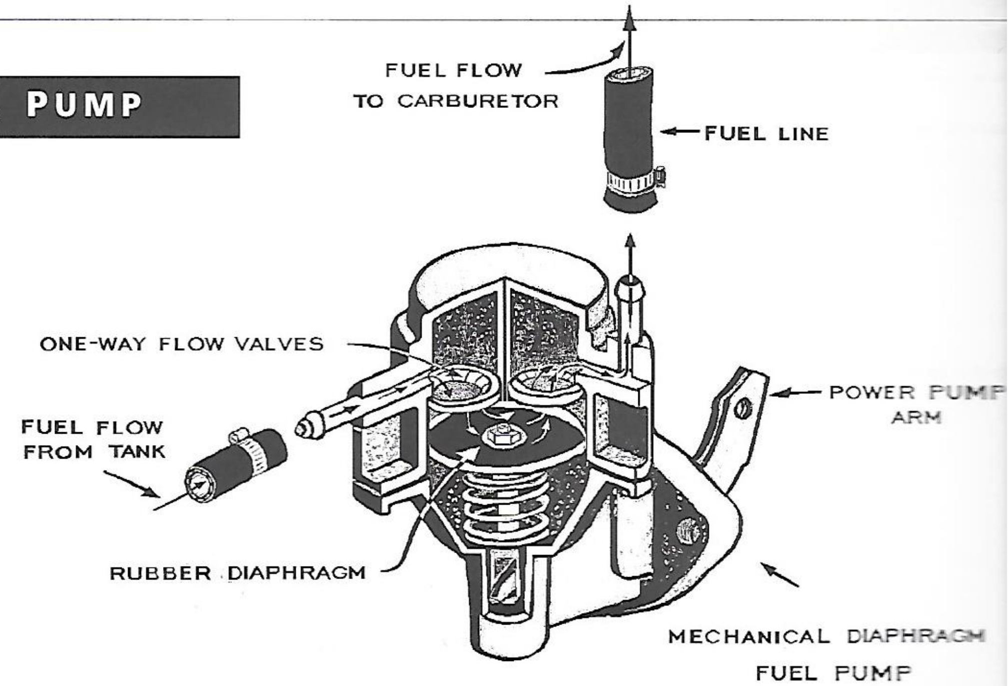
Providing enough fuel for rapid acceleration is the main job of a *fuel pump*. When a driver steps on a gas pedal the feeling of seamless acceleration is the result of mechanical and electronic devices including several sophisticated fuel pumps and *pressure regulators*.

A variety of fuel pumps deliver fuel to engines, including: the in-line *electric fuel pump*, *mechanical diaphragm pump*, *precision fuel injector pump*, carburetor *accelerator pump*, and a submersible gasoline tank turbine *transfer pump* (shown on page 35).

Most vehicles use a transfer pump to deliver fuel from a gasoline tank to the top of an engine. With some fuel injection systems, fuel must be pumped through individual fuel injector nozzles using precise pumps on each injector. Most injector systems have a single injector pump that supplies fuel pressure for all injectors. Electric fuel pumps are used in fuel injection systems because they can deliver a very reliable fuel pressure. Electric pumps are usually rotary types, where an electric motor turns an internal paddle wheel or *impeller*.

Carbureted fuel systems often use *mechanical diaphragm* pumps mounted to an engine block. Mechanical pumps use engine parts to move a *power arm* and a thick rubber *diaphragm* back and forth, creating the pumping force.

MECHANICAL PUMP



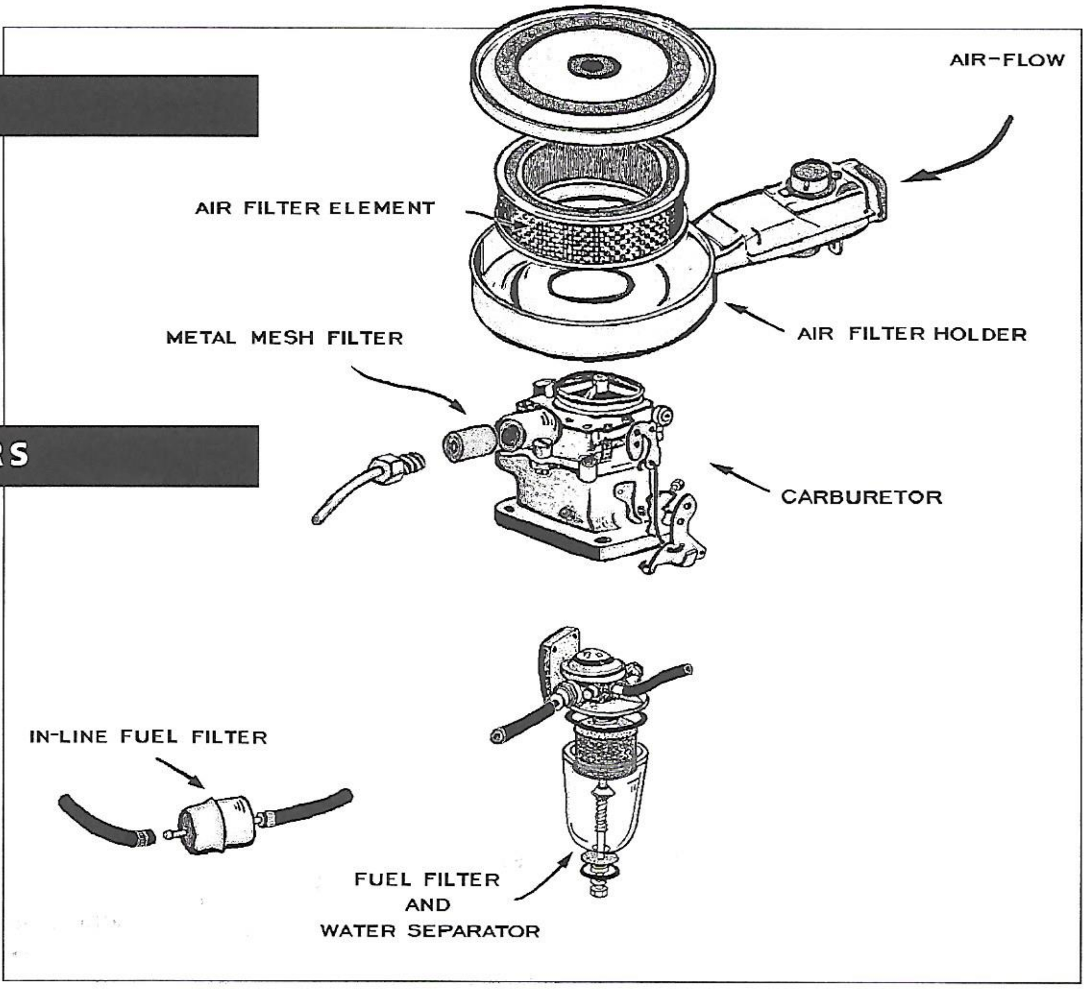
Air & Fuel Filters

Air filters trap dirt particles before they enter an engine. Without an air filter, dirt from the atmosphere would contaminate the sensitive air/fuel mixture and possibly clog the small passageways in a fuel system. Air filters are usually located on top of an engine and all air taken into an engine must pass through these filters. Filters are usually made of pleated paper and fine mesh screen. An air filter will clean about 10,000 gallons of air for every gallon of fuel burned.

Fuel filters trap unwanted particles, water, and other contaminants in the fuel before they enter a fuel pump, carburetor, or fuel injector. There are many types and locations for fuel filters.

AIR FILTER

FUEL FILTERS



Turbocharger

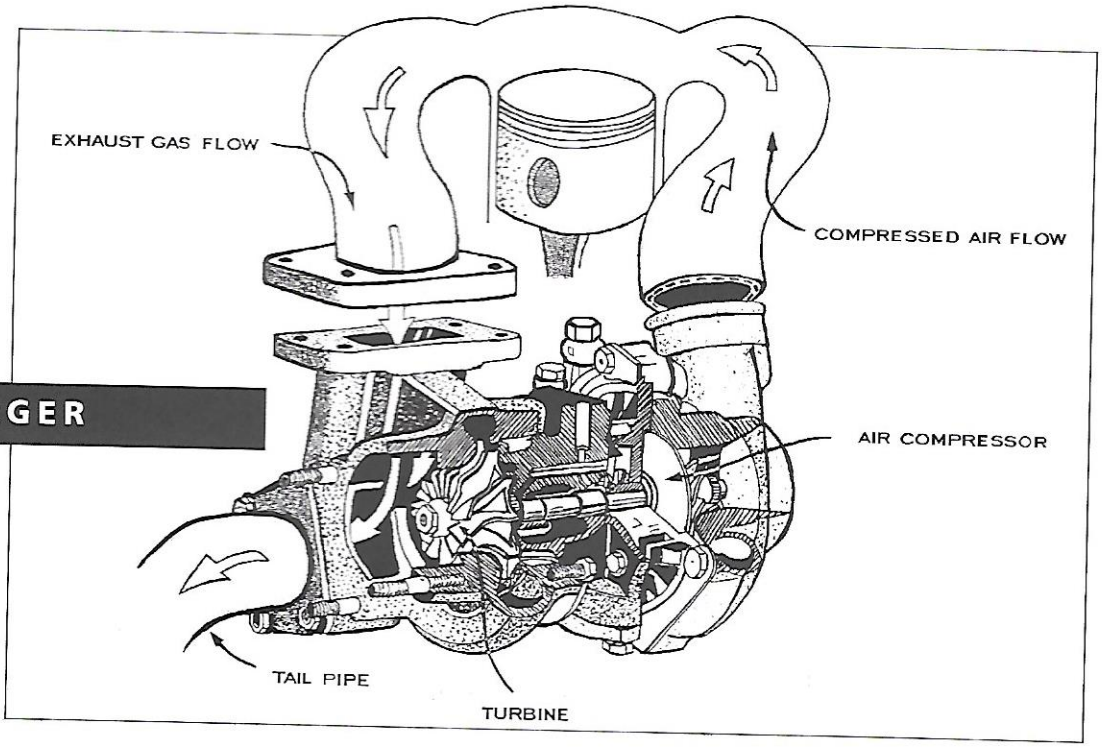
A *turbocharger* boosts engine power by increasing the volume of air/fuel mixture delivered to an engine. A turbocharger uses an *air compressor* to increase air pressure in an intake manifold and this additional pressure forces extra air/fuel mixture into the combustion chambers. This extra fuel increases engine power.

A turbocharger is often used to increase power in small engines. Some designs use full-time turbochargers that continuously regulate pressure in the manifold, while others only engage when an accelerator pedal is pushed to the floor and extra power is needed.

A turbocharger directs engine exhaust fumes against the blades of a *turbine*. These powerful exhaust gases can rotate a turbine up to 140,000 revolutions per minute (a crankshaft typically turns 3,000 rpm). This strong rotating force operates the air compressor that packs extra air/fuel mixture into the combustion chambers.

A *supercharger* is another device used to increase air pressure in an intake manifold. A supercharger, however, uses a belt drive from the engine, rather than exhaust gases, to power the air compressor.

TURBOCHARGER



Emission Controls

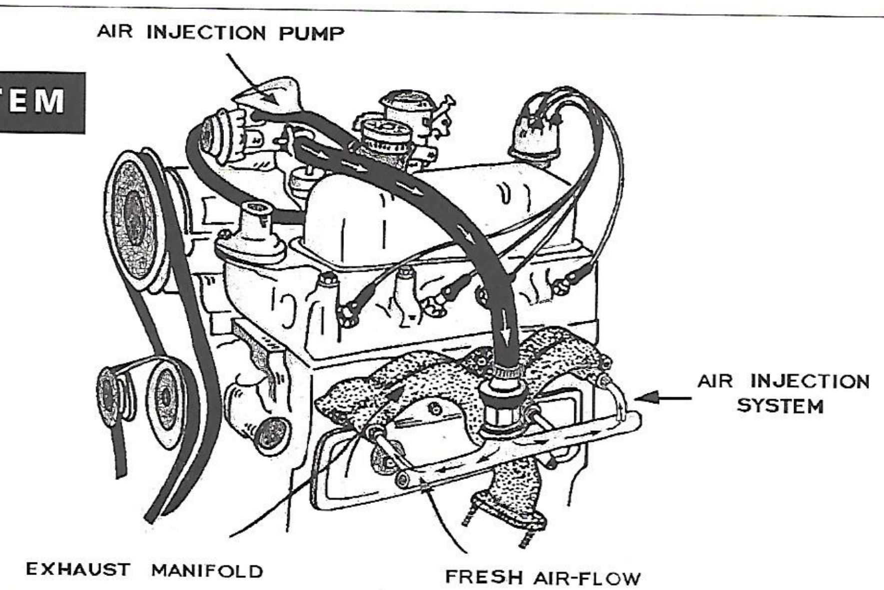
Positive crankcase ventilation (PCV) was the first emissions control device. The PCV system uses a simple rubber hose to carry polluting fumes from an engine's crankcase to an air cleaner, carburetor body, or intake manifold. These fumes are then added to the air/fuel mixture and burned a second time. This reburning further destroys hydrocarbon vapor, and other harmful emissions. A one-way, *PCV valve* prevents explosive fumes from going the wrong way and entering a crankcase.

The *exhaust gas recirculation* (EGR) system represents a second generation pollution control mechanism. This arrangement pumps exhaust fumes into an intake manifold. As with the PCV system, harmful fumes are mixed with the air/fuel mixture for reburning.

A third type of pollution control system is the *air injection* method. With this system, fresh air is pumped into an *exhaust manifold* to mix with exhaust fumes as they leave an engine. The fresh air increases oxidation, further destroying harmful hydrocarbons.

The *catalytic converter* is another mechanism used to decrease pollutants. A catalytic converter is usually located under a car and looks like a large, flat muffler. This device contains compounds that react with hydrocarbons in exhaust gases and chemically converts them to water and other less harmful compounds. Some vehicles have two catalytic converters, one under the car and a smaller one attached to the exhaust manifold.

AIR INJECTION SYSTEM

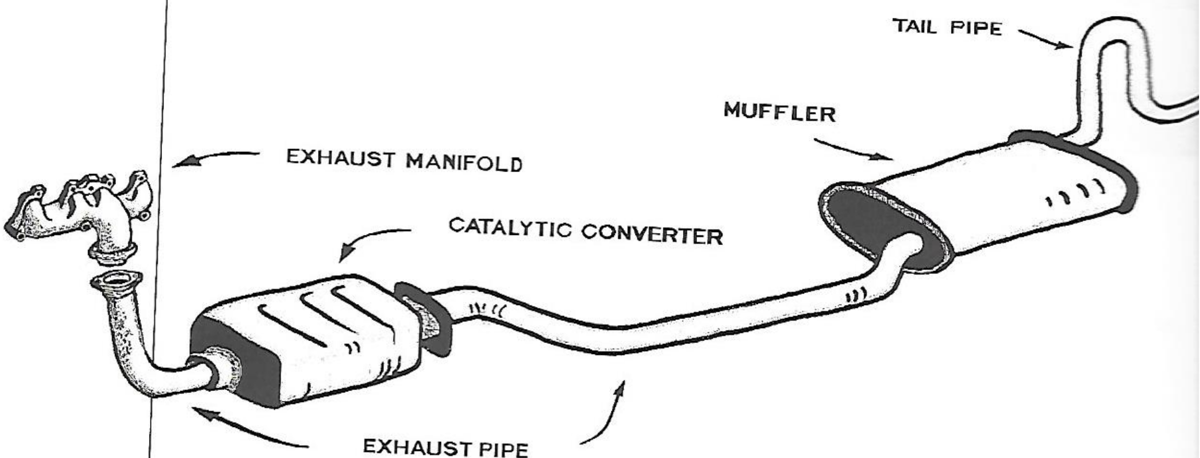


Exhaust Manifold & Muffler

An *exhaust manifold* collects exhaust gases from the combustion chambers and funnels them into the relativity small area of an *exhaust pipe*. A "V" shaped engine must have two exhaust manifolds, one on each side of the "V."

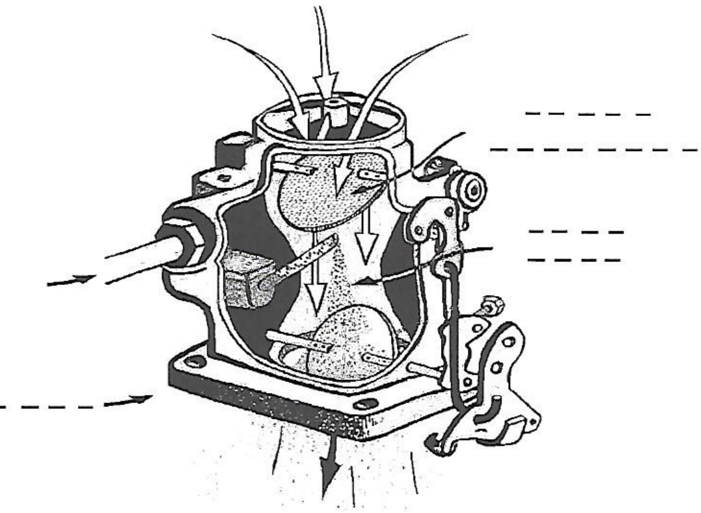
A *muffler* reduces engine noise by using a series of passageways, *baffles*, and compartments to trap sound. An exhaust pipe carries exhaust fumes away from the passenger compartment, to the muffler, and out the *tail pipe*.

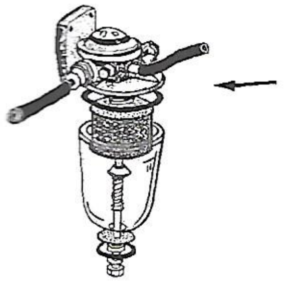
EXHAUST SYSTEM

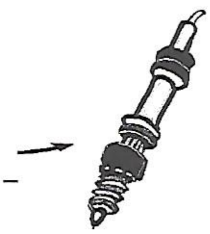


FUEL SYSTEM TEST

Identify the parts:







1. A rich air/fuel mixture has more ____________ and less ____________. (p. 32)

2. The two types of air/ fuel mixers are ____________ & ____________. *(p. 31)*

3. A supercharger increases air pressure in an exhaust manifold. (T) or(F) *(p. 38)*

4. A BARO sensor measures ____________________ pressure. *(p. 34)*

5. A butterfly valve controls fuel ____________________________. *(p. 32)*

6. ____________ fuel injection uses a single injector in a carburetor body. *(p. 33)*

7. A ____________ changes hydrocarbons to less harmful compounds. *(p. 39)*

8. Gasoline tank____________________ are used to stop fuel from sloshing. *(p. 35)*

9. A ____________ ______________ is used to trap gasoline fumes. *(p. 35)*

10. Only mechanical fuel pumps are used in gasoline tanks. (T) or (F) *(p. 36)*

11. A turbocharger uses ______________ to rotate a turbine. *(p. 38)*

12. An air/fuel mixture enters combustion chambers through the ______________ valve openings. *(p. 17)*