Study of Engine Subsystems

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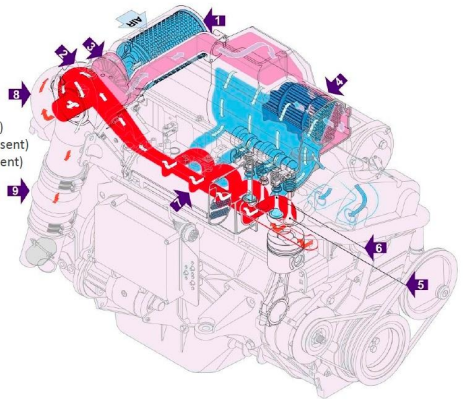
Different Engine Subsystems

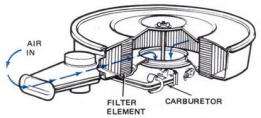
1. **Air Intake and Exhaust System:** It supplies clean air to the engine and expels burned gases.
2. **Fuel System:** It supplies the engine with combustible air-fuel mixture.
3. **Starting System:** It starts the engine.
4. **Lubrication System:** It reduces wear between moving parts.
5. **Cooling System:** It keeps the temperature of the engine within operable range.
6. **Ignition System:** It delivers the spark to initiate combustion.

Air Intake System

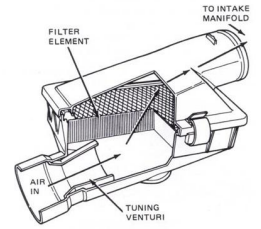
1: Air filter
2: Turbine (if turbocharger present)
3: Compressor (if turbocharger present)
4: Intercooler (if turbocharger present)
5: Exhaust valve
6: Intake valve
7: Exhaust manifold
8: Hi-riser
9: Exhaust outlet



Air Cleaners



(A) RING-TYPE FILTER ELEMENT

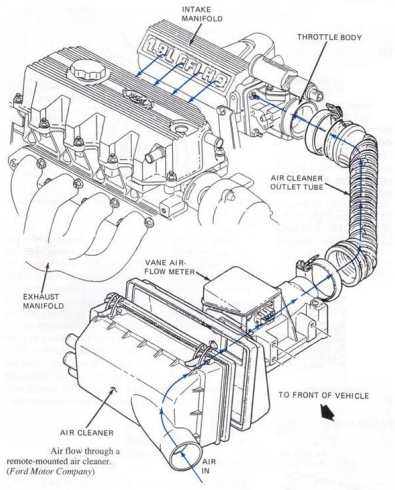


(B) PANEL-TYPE FILTER ELEMENT
Air cleaners with (A) ring-type and (B) panel-type filter elements. (*Chrysler Corporation*)

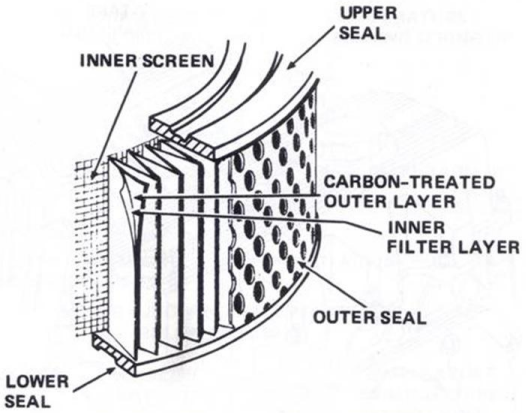
The grit and dust particles in the intake air must be removed before it enters the engine. Otherwise, engine wears and is damaged.

- *The filter paper traps dust and dirt as the air passes through the cleaner.*
- *The filter paper or material could have a ring arrangement or panel arrangement.*
- *The air cleaner also muffles **induction noise**. The opening and closing of intake valve causes induction noise.*
- *The tuning venturi reduces induction noise.*

Remote Air cleaners

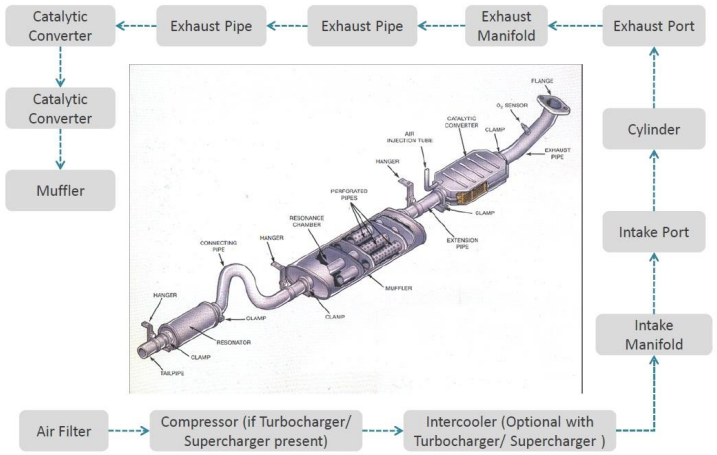


Construction of Filter Element



Construction of a pleated-paper filter element made with two-ply paper. (*Chrysler Corporation*)

Exhaust System



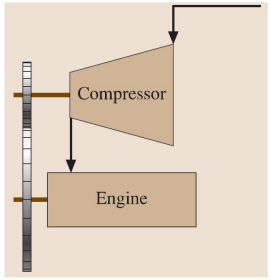
Air Charging Methods

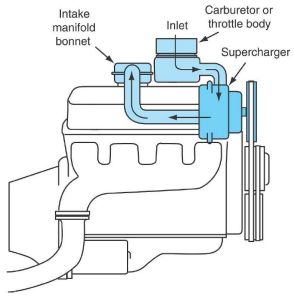
- *Burning more fuel efficiently means the maximum power output of the engine will be increased.*
- *But burning more fuel requires more air.*
- *So the amount of air inducted into the engine cylinder must be increased.*
  1. Natural Aspiration: Induction depends on pressure difference.
  2. Forced Induction: Charge is forced into the cylinder at substantially higher pressure.

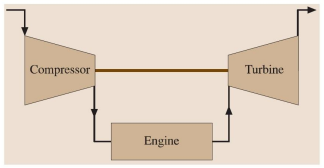
Natural Aspiration

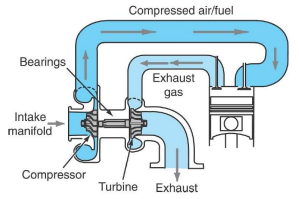
1. *Inertia Ram Charging :* Employs 'ram effect' to tune the timing of closing of intake valve. Thus more charge is trapped inside the cylinder at high engine speed since the momentum of incoming air flow keeps it flowing inside the cylinder.
2. *Pressure Wave Tuning:* The high-pressure wave, created when the exhaust valve opens and rapidly blows down the cylinder contents, travels to the end of exhaust pipe and is reflected as a low-pressure wave or rarefaction wave. If this wave is tuned to enter the cylinder near the end of the exhaust stroke it can assist in evacuating the residual gases and draw in fresh charge as the intake valve opens.

Forced Induction





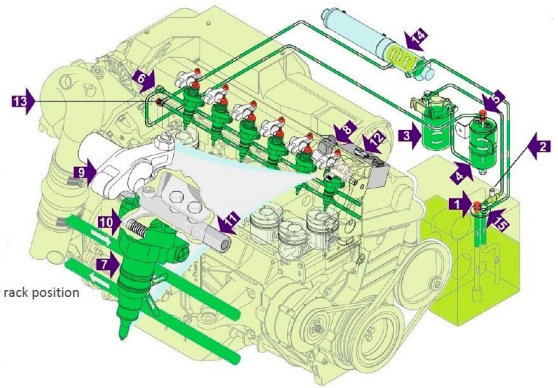




Forced Induction

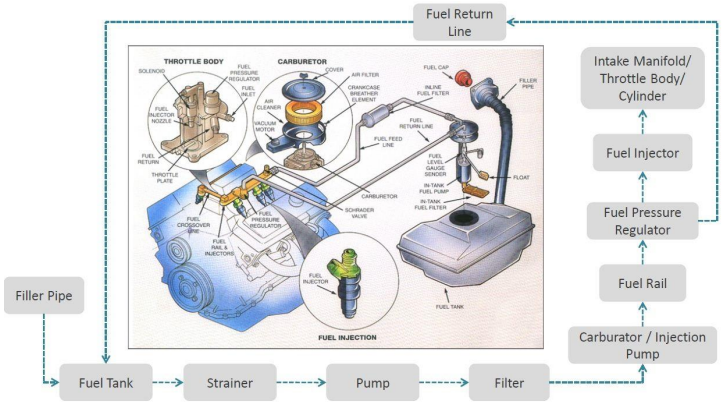
1. *Mechanical Supercharging :*
   - The supercharger is powered directly by the engine.
   - It is a simple unit mounted on the 'cold side' of the engine and exhaust is not involved.
   - The supercharger is driven at a fixed transmission ratio.
   - It responds immediately to load changes.
   - Directly engine driven hence increases fuel consumption.
2. *Turbocharging:*
   - The turbocharger is powered by the energy in exhaust gases and significantly reduces fuel consumption..
   - The exhaust-driven turbine is employed to convert the energy in the exhaust gases into mechanical energy, making it possible for the turbocharger to compress the induction gas.
   - A waste gate valve bypasses additional exhaust gases.
   - The losses due to back pressure generated in the exhaust system is more than offset by the effect of the higher induction pressure in reducing specific fuel consumption and increasing power.
   - Turbocharger Lag: Owing to the inertia of the rotating assembly it may take several seconds to respond to higher load demand.
   - Installation of turbocharges requires high temperature resistant materials and space for compressor, intercooler and turbine.

Fuel System

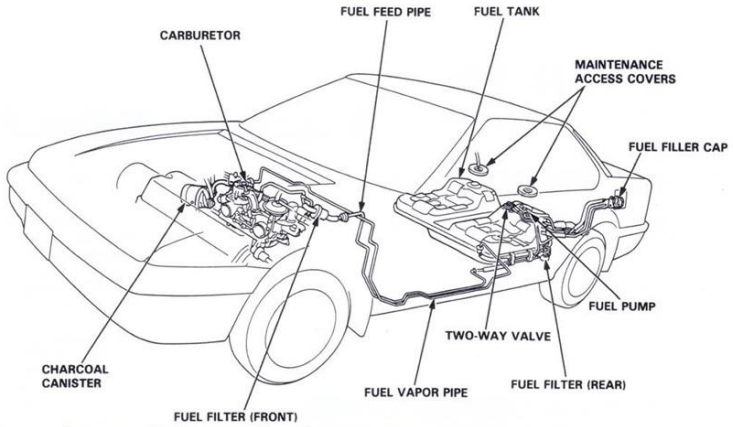


1: Anti-siphon valve
2: Fuel stop cock
3: Fuel filter
4: Fuel pump
5: Check valve
6: Fuel supply mains
7: Unit injector
8: Potentiometer for rack position
9: Rocker arm
10: Adjustment lever
11: Common rack
12: Control solenoid
13: Fuel check valve
14: Fuel cooler
15: Fuel return line

Fuel System

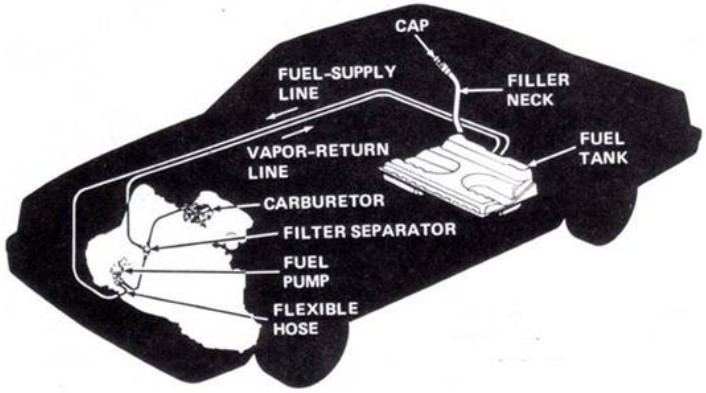


Fuel System



Passenger car with a fuel system using a carburetor. (*American Honda Motor Company, Inc.*)

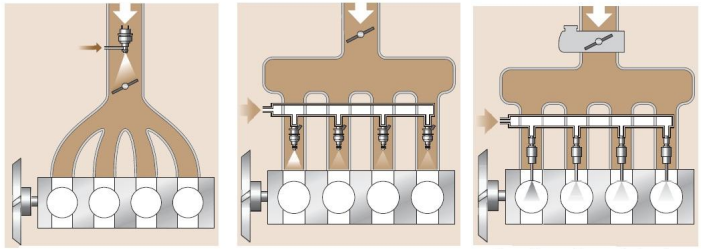
Fuel System



Fuel Injection

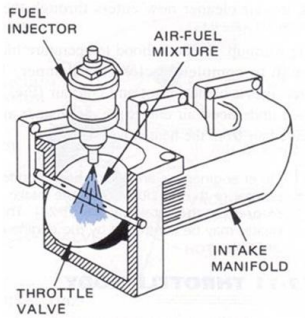
Fuel injection system can be divided into two basis types:

1. manifold : (a) throttle body & (b) port
2. gasoline direct injection



Throttle body injection *Port injection* *Gasoline direct injection*

TBI System

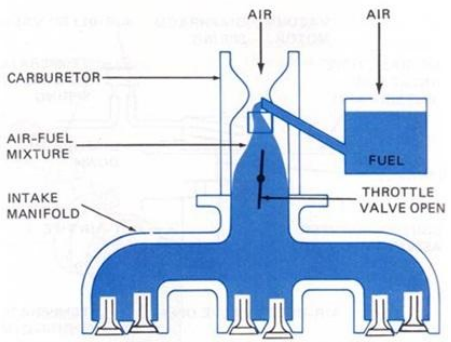


Throttle Body Injection (TBI) has one or two fuel injectors located above throttle valves.

- *Requires fewer injectors and less fuel-line tubing and hose.*
- *However, it is not as accurate as PFI system in balancing A/F ratios among cylinders.*
- *Fuel puddling may occur at ends of intake manifold that tends to enrich the end cylinders.*

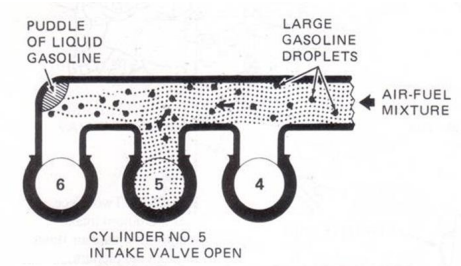
Puddling

Fuel puddling may occur at the ends of intake manifold that reduces fuel economy.



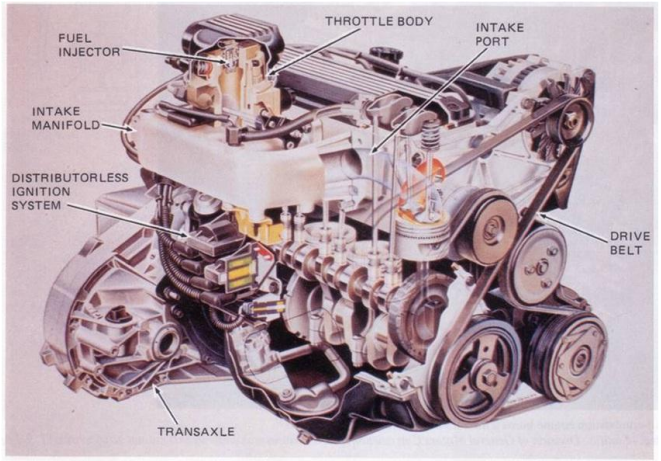
Fuel Distribution Pattern

Fuel puddling may occur at the ends of intake manifold that reduces fuel economy.



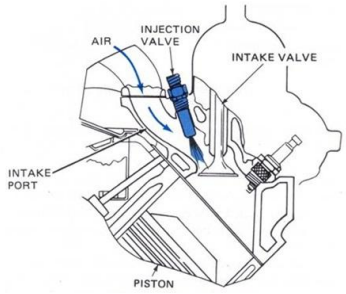
Distribution pattern in an intake manifold. The gasoline particles tend to continue to the end of the manifold, enriching the mixture flowing into the end cylinders. (*Chevrolet Division of General Motors Corporation*)

TBI System



A four-cylinder engine with throttle-body injection. A fuel injector is located above the intake manifold in the throttle body. (*Chevrolet Division of General Motors Corporation*)

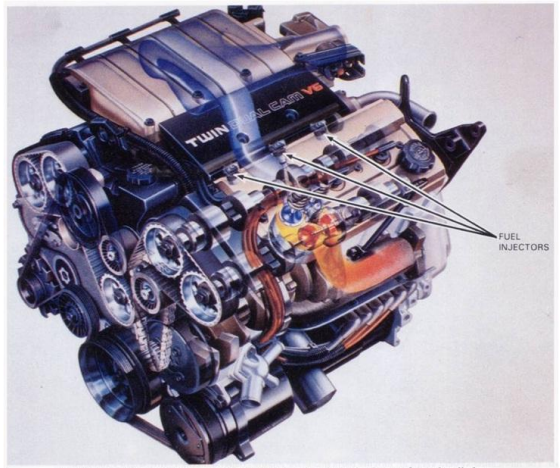
PFI System



Port Fuel Injection (PFI) has an injection valve or fuel injector in each intake port.

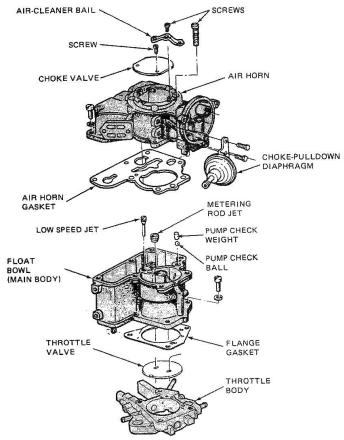
- *Provides more accurate control.*
- *Same amount of Fuel is delivered to each cylinder.*
- *Improves fuel economy and reduced exhaust emissions.*

PFI System



A V-6 engine with port injection. A fuel injector is located in the intake port for each cylinder.
(Pontiac Division of General Motors Corporation)

Carburettor

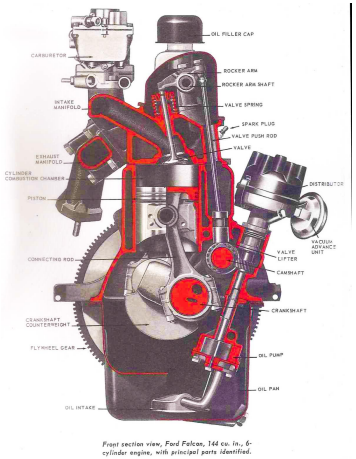


The carburettor is a mixing device that delivers the engine a combustible air-fuel mixture continously.The three main parts of carburettor are :

1. *Air horn*
2. *Float Bowl*
3. *Throttle Body*

Carburettor

The carburettor typically sits at the top the engine cylinder.



Front section view, Ford Falcon, 144 cu. in., 6-cylinder engine, with principal parts identified.

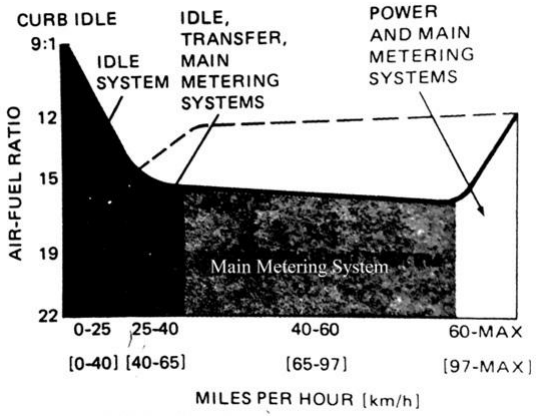
Carburation System

- *The carburettor employs venturi principle. The venturi is a restricted space through which the air entering the engine must pass.The inlet air flows through a necked-down area (venturi). where the flow increases in speed and decreases in pressure.*
- *The pressure drop at the venturi increases with engine speed and with throttle position, thus causing fuel flow from the reservoir to the venturi to increase as engine speed and throttle position increase.*
- *Carburettors may have fixed venturi or variable venturi.*
- *Carburettors may have single barrel or multi-barrel (two or four) for better engine performance.*

Carburation System

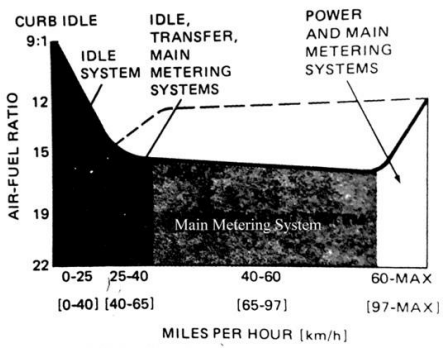
- *Carburation system consists of the following subsystems:*
  1. **Float system** *to maintain a constant level of fuel in the reservoir.*
  2. **Idle & low speed system** *to deliver rich air-fuel mixture during starting and low speed operation.*
  3. **Main metering system** *to deliver air-fuel mixture of desired A/F ratio.*
  4. **Power system** *to deliver rich A/F mixture for high speed, full-power, wide-open throttle(WOT) operation.*
  5. **Accelerator pump system** *to deliver extra fuel during acceleration.*
  6. **Choke system** *to provide rich air-fuel mixture for starting a cold engine.*

A/F ratio vs. Vehicle speed curve



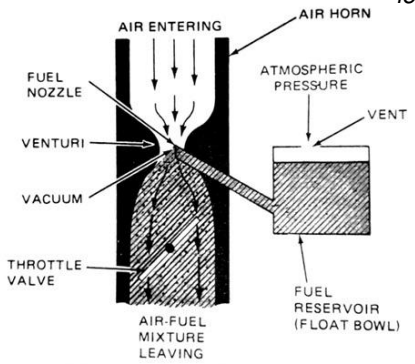
Air-fuel ratios with different carburettor systems operating at different speeds. (Courtesy: Chevrolet Division, GMC)

A/F ratio vs. Vehicle speed curve



- *A rich mixture is needed for starting, especially in cold conditions when a high proportion of the fuel condenses out on to the cold walls of the induction manifold.*
- *Enrichment of the mixture is needed for idling because of the fuel being consumed are so small.*
- *A slightly weak mixture for cruising, at part throttle, ensures that there is enough air to burn all the fuel completely.*
- *An extra supply of fuel for acceleration is essential because, when the throttle is suddenly opened, the flow or air increases more rapidly than that of the fuel.*
- *To obtain the maximum possible power output, the maximum possible quantity of fuel must be supplied to it, so the mixture must be enriched. However, it is achieved at the expense of higher brake specific fuel consumption.*

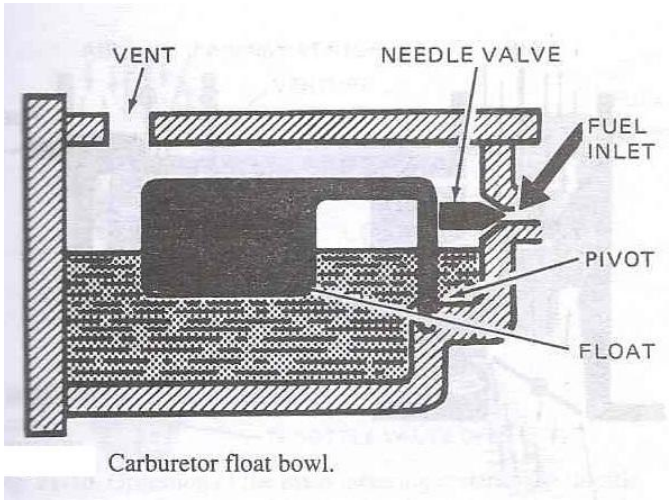
Carburettor Operation



The actions in a carburettor are as follows :

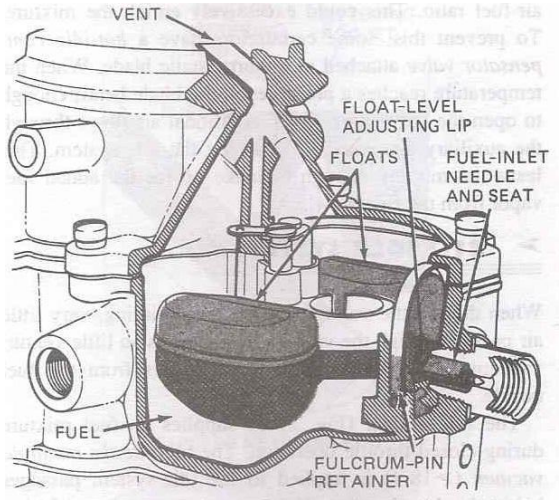
- *Air enters the air horn and picks up fuel from fuel nozzle.*
- *The mixtures then flows past the open throttle valve and into the intake valve.*
- *For normal operations the choke valve remains fully open. (not shown in figure)*

Float System



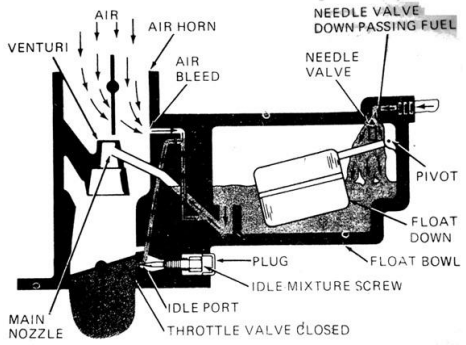
Carburetor float bowl.

Float System



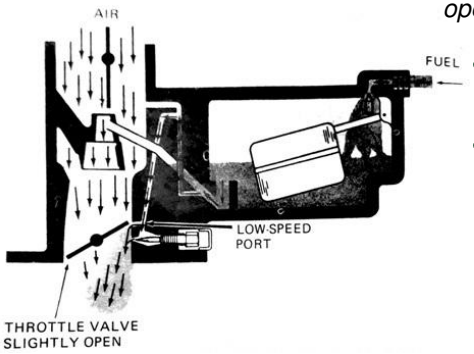
Idle system

The idle system operates as follows :



- *The throttle valve is closed so only a small amount of air can pass.*
- *All fuel is discharged past the idle mixture screw.*
- *No fuel is discharged through main fuel nozzle.*

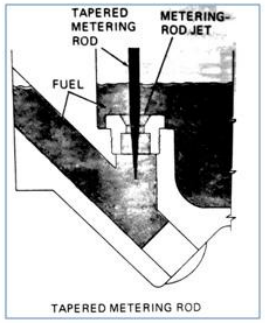
Low speed operation

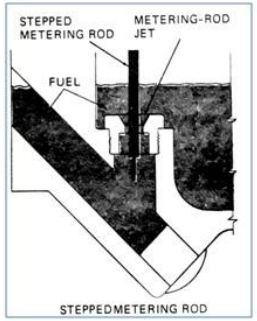


At low speeds the idle system operates as follows :

- *The throttle valve is slightly opened.*
- *Fuel is discharged past the both low speed port and the idle port.*

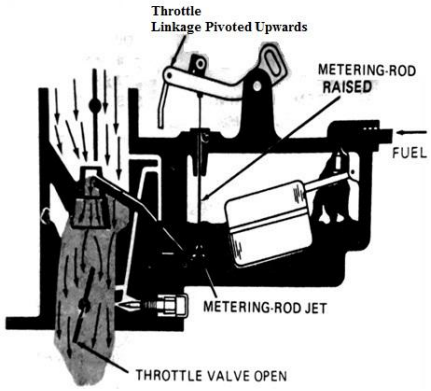
Main metering system





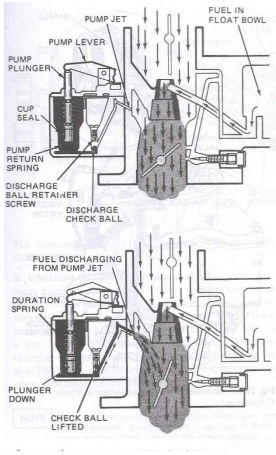
Tapered or stepped metering rod is used to deliver the appropriate amount of fuel through the main fuel nozzle.

Mechanically-operated power system



When the throttle valve is open (as shown), the metering rod is raised so that the smaller diameter of the rod clears the jet. This allows additional fuel to flow.

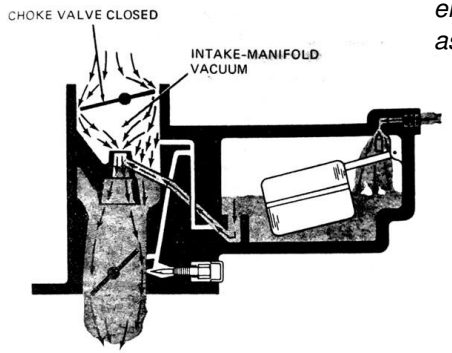
Accelerator pump system



The accelerator pump supplies additional fuel needed for quick acceleration.

- *When the throttle valve opens, the pump lever (linked to throttle) releases the duration spring.*
- *The spring forces the plunger down, sending a squirt of fuel from the pump jet into air stream that enriches the Air-fuel mixture for quick acceleration.*
- *The duration spring allows the accelerator pump to discharge fuel for about a second or until the power system takes over.*

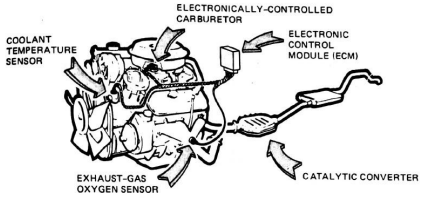
Choke system

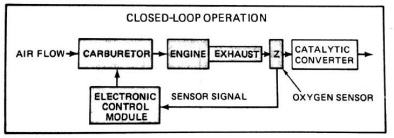


At low temperatures or to start a cold engine the choke system operates as follows :

- *When the choke valve is closed, little air can get past it.*
- *This produces a partial vacuum in the carburetor air horn when the engine is cranked.*
- *The partial vacuum causes the main fuel nozzle to discharge fuel.*

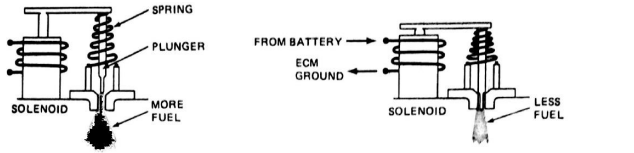
The oxygen sensor(z)



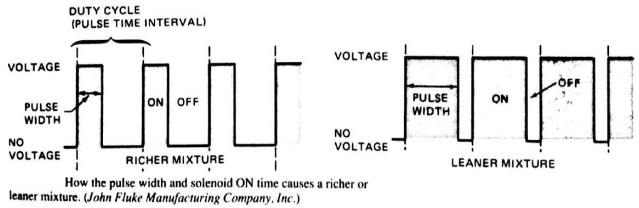


Electronic engine control system for a carbureted engine. Top, major components in the system. Bottom, diagram showing closed-loop operation. The oxygen sensor is reporting the exhaust-gas oxygen content to the electronic control module (ECM). The ECM then adjusts the carburetor to achieve the proper air-fuel ratio for the operating conditions. (*Rochester Products Division of General Motors Corporation*)

Mixture control solenoid operation

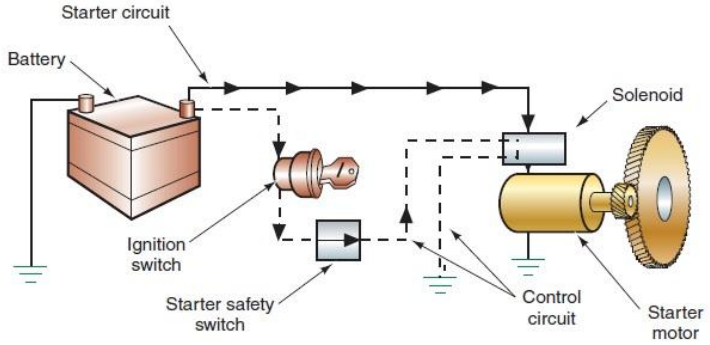


How operation of the mixture-control solenoid affects fuel delivery. (*John Fluke Manufacturing Company, Inc.*)

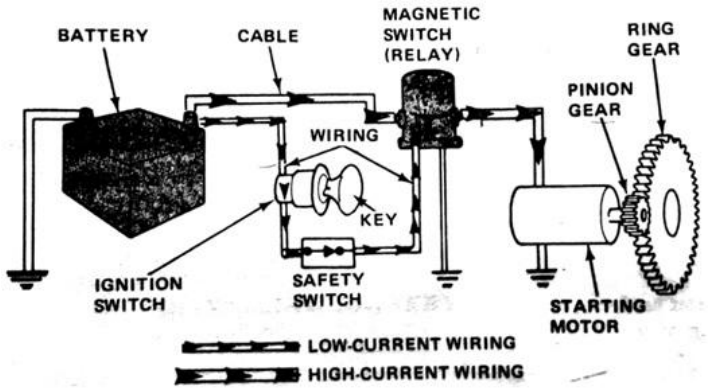


How the pulse width and solenoid ON time causes a richer or leaner mixture. (*John Fluke Manufacturing Company, Inc.*)

Starting System

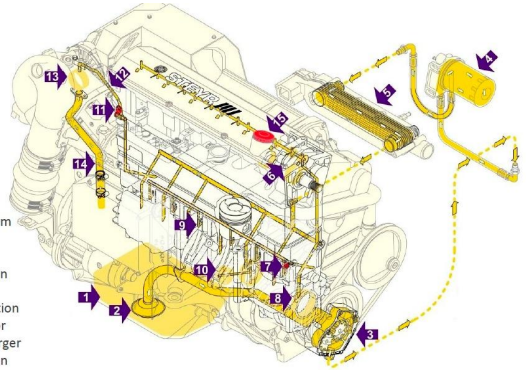


Starting System

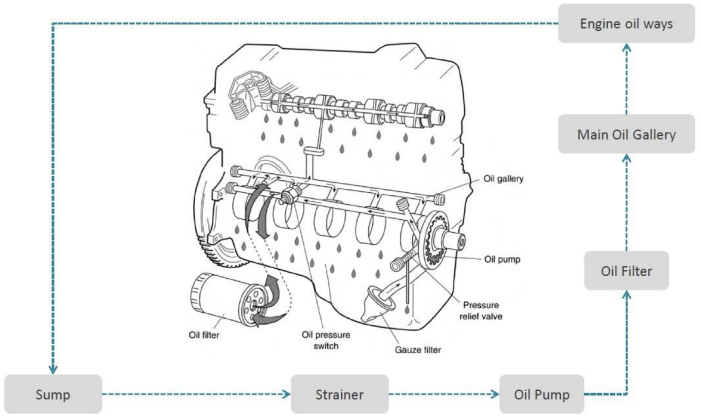


Lubrication System

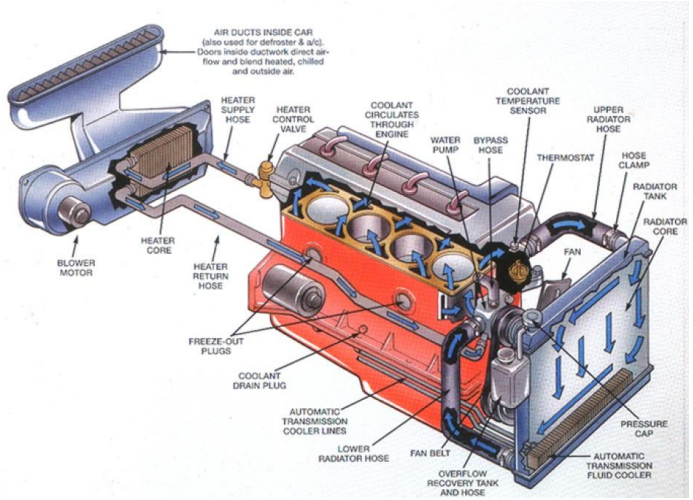
1: Oil sump
2: Oil suction pipe
3: Oil pump
4: Lubricant filter
5: Engine oil cooler
6: Camshaft and rocker arm lubrication
7: Piston cooling valve
8: Main bearing lubrication
9: Jet piston cooling
10: Connecting rod lubrication
11: Lube oil pressure sensor
12: Oil supply for turbocharger
13: Turbocharger lubrication
14: Oil return from turbocharger
15: Engine oil filler cap



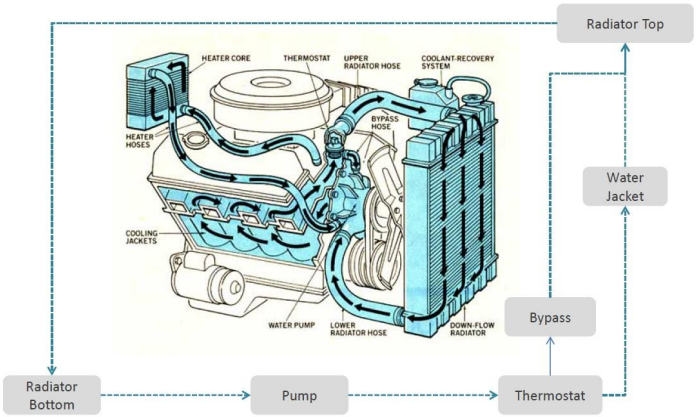
Lubrication System



Cooling System



Cooling System



Ignition System