Automotive Learning

Bumpers

Bumpers are made of heavy sheet metal and are mounted on the front and rear of the car. Bumpers are bent and formed into specific shapes in order to absorb and deliver momentum during a collision.

In the event of a collision, the bumper absorbs some of the impact, which decreases damage to the car and its occupants. It also protects the front of the car by diverting all of the car's momentum to the object with which it has collided. The bumper is mounted to the car's chassis with special impact absorbers. These shock absorbers are often spring loaded. In slow speed collisions, this allows the bumper to compress, and then extend back to its original position. All bumpers are designed to absorb the energy of the impact. They do this through a series of valves and air chambers. Some car bumpers have hydraulic chambers. In the event of a collision, the absorption unit allows air and/or hydraulic fluid to pass through small openings. Forcing the air/fluid through the valve openings absorbs the energy from the collision.

The bumper's job is to minimize damage, primarily to the occupants of the vehicle and to the vehicle itself. US law requires cars to pass special crash tests at various speeds. In order to pass, the car's damage level during the crash must be below a specific dollar level. Sometimes bumpers are constructed with built-in "crumple zones." Crumple zones are designed to absorb impact; they will flex on impact. As the metal flexes, the action of the bending metal converts the kinetic energy of the car into heat. Kinetic energy is the energy an object possesses while it is in motion.

Air Dam

An air dam is a projection of the body shell underneath the front of the chassis. Its function is to reduce the amount of air turbulence and drag underneath the car, and to channel air to the radiator.

Radiator Grille

The radiator grille is the part of the body shell on the front of your car that covers the area where the air enters. The radiator grille can also be part of the bumper on some cars. The radiator is connected to the shroud for the radiator. The shroud directs the air that comes in through the radiator grille to the radiator only. This prevents the air from escaping around the radiator and failing to cool the engine. On newer cars, the radiator grille has been lowered to take advantage of lower hood lines, brought about by an effort to increase fuel efficiency. Older cars had massive grilles, whereas the cars now produced have smaller more aerodynamic grilles.

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Headlights

Headlights are mounted on the front of your car, to light the road ahead of you. They have reflectors and special lenses. A headlight is usually the sealed beam construction type. This means that the filament, reflector and lens are fused together into an airtight unit. Installation and removal are easily accomplished because of prongs that fit into a wiring socket. The most popular type of headlight is the halogen type, because it provides such good illumination. Adjusting screws allow you to aim, or change the direction of the headlight's beam. If you replace a halogen bulb, remember that it is filled with pressurized gas (halogen) and can produce flying fragments if shattered. Wear protective glasses for changing a halogen lamp, and always throw out the old one in the protective carton that comes with the new one. Delay headlights are lights that keep the headlights on for about 30 seconds after you have turned the ignition off. This feature is nice for finding your way into your house, or in a strange parking lot.

Lighting Circuit

The automobile lighting circuit includes the wiring harness, all the lights, and the various switches that control their use. The complete circuit of the modern passenger car can be broken down into individual circuits, each having one or more lights and switches.

In each separate circuit, the lights are connected in parallel, and the controlling switch is in series between the group of lights and the fuse box. The parking lights, are connected in parallel and controlled by a single switch. In some installations, one switch controls the connection to the fuse box, while a selector

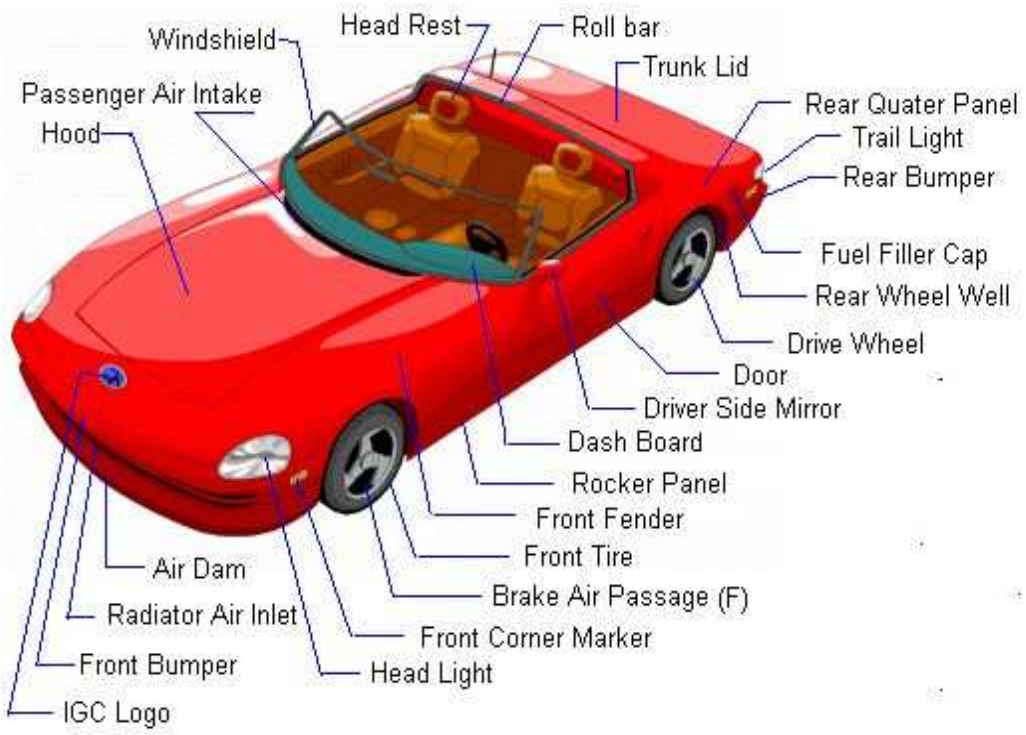
switch determines which of two circuits is energized. The headlights, with their upper and lower beams, are an example of this type of switch. Again, in some cases, such as the courtesy lights, several switches may be connected in parallel so that any switch may be used to turn on the lights.

Hood

The car's hood is another type of door. It also consists of an inner and an outer panel. The inner panel provides strength. The outer panel is just a metal cover, or "skin". The underside of the hood is often covered with a sound-absorbing material. Some high performance cars have openings in the hood to allow the engine to "breathe" easier. "Hood scoops" are used to channel outside air directly to the air filter, which gives improved performance and efficiency.

Front Quarter Panel

The front quarter panel is composed of the body skin, or sheet metal, that runs from the front corner of the hood to the front of the door. It is usually a separate piece that is welded on in a few places. This makes it easy to replace if you get in a "fender bender." Front quarter panels can usually be replaced relatively inexpensively. Some newer vehicles use a rubber-like plastic for the fenders, which allows small impacts to be absorbed without damage.



Body and Exterior

Rear Quarter Panel

The rear quarter panel is the body skin, or sheet metal, that runs from the rearmost part of the rear door edge, around the back and to the rear door on the other side of the car. On many cars, the rear quarter panels are integral with the roof. The rear quarter panel is composed of an outer skin and inner panels. The inner panels are reinforcements for the rear of the passenger compartment, the trunk, and the wheel housings. Without the inner panels, there would be severe vibration and weak construction in the back of the car.

The Air Conditioning and Heating System

Not only do we depend on our cars to get us where we want to go, we also depend on them to get us there without discomfort.

We expect the heater to keep us warm when it's cold outside, and the air conditioning system to keep us cool when it's hot. We get heat from the heater core, sort of a secondary radiator, which is part of the car's cooling system. We get air conditioning from the car's elaborate air conditioning system.

Despite its relatively small size, the cooling system has to deal with an enormous amount of heat to protect the engine from friction and the heat of combustion. The cooling system has to remove about 6,000 BTU of heat per minute. This is a lot more heat than we need to heat a large home in cold weather. It's good to know that some of this heat can be put to the useful purpose of keeping us warm. Air conditioning makes driving much more comfortable in hot weather. Your car's air conditioner cleans and dehumidifies (removes excess moisture), the outside air entering your car. It also has the task of keeping the air at the temperature you select. These are all big jobs. How do our cars keep our "riding environment" the way we like it? Most people think the air conditioning system's job is to add "cold" air to the interior of the car. Actually, there is no such thing as "cold," just an absence of heat, or less heat than our bodies are comfortable with. The job of the air conditioning system is really to “remove” the heat that makes us uncomfortable, and returns the air to the car's interior in an "un-heated" condition. Air conditioning, or cooling, is really a process of removing heat from an object (like air).

A compressor circulates a liquid refrigerant called Refrigerant-12 (we tend to call it "Freon," a trade name, the way we call copy machines "Xerox" machines). The compressor moves the Refrigerant-12 from an evaporator, through a condenser and expansion valve, right back to the evaporator. The evaporator is right in front of a fan that pulls the hot, humid air out of the car's interior. The refrigerant makes the hot air's moisture condense into drops of water, removing the heat from the air. Once the water is removed, the "cool" air is sent back into the car's interior. Aaaaaah! Much better. Sometimes we worry when we catch our car making a water puddle on the ground, but are relieved to discover that it's only water dripping from the air conditioning system's condenser (no color, no smell, and it dries!). Note: Refrigerant-12 is extremely dangerous. Many special

precautions must be taken when it is present. It can freeze whatever it contacts (including your eyes), it is heavier than air and can suffocate you, and it produces a poisonous gas when it comes in contact with an open flame.

Tires

A tire is a tubular corded carcass covered with rubber or synthetic rubber, which is mounted on a wheel and inflated to provide traction for moving a vehicle and for assisting the brakes in stopping it. Today's tires, when properly inflated, will absorb bumps on a road's surface and give a safe, comfortable ride, while providing a reassuring grip on the road at all speeds.

There are two basic types of tire: the tubeless tire for passenger cars and light-duty trucks; and those requiring inner tubes for medium and heavy-duty trucks. In 1830, Charles Goodyear experimented with turning raw rubber into a more solid and useful product. He bought a load of raw rubber from a shoe factory on credit and couldn't pay. He wound up in debtor's prison and started his experiments. He finished his sentence, and kept on experimenting. In 1839, Goodyear invited some friends over to a fund-raiser for his experiments. He showed them a ball of rubber that he had hardened on the surface to prove to them that his experiments were worthy of their money. At this point he accidentally threw the rubber ball into the hot wood stove. While he was scraping the ball off with a knife, he realized that the rubber had hardened into just the right texture. This was the start of "vulcanization" and the rubber tire industry. Tires have changed a great deal since the 1950s. New rubber components have been introduced into tire compounds which improve the skid resistance. Recently new types have been developed to cope with the dangers of sudden deflation. One of the most interesting of these is a tire mounted on a relatively narrow wheel, so that the tire can be run totally deflated without damage to the tire side walls. In addition, the tire contains a special liquid which, when the tire is run under the deflated condition, vaporizes and generates a pressure so that the tire will partially reinflate.

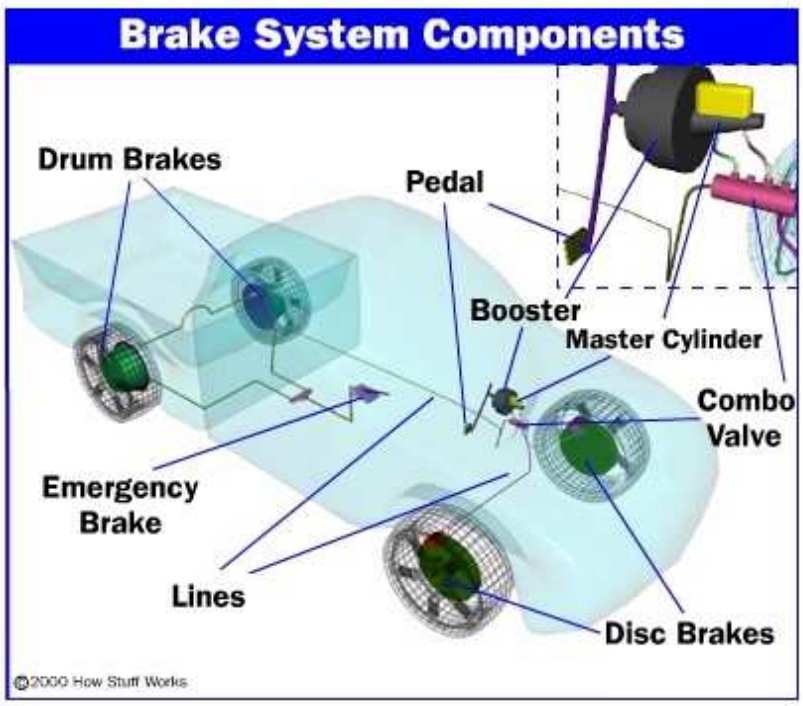
Disc Brake

Disc brakes use a clamping action to produce friction between the wheel and the suspension members, which hold the wheel. Firmly mounted to the spindle, the caliper works like a c-clamp to pinch the rotor, which is attached to the spinning wheel.

"Floating" calipers allow themselves to move slightly when the brakes are applied, because only one pad moves (in relation to the caliper). If the caliper is solid-mounted, there are pistons on each side of the rotor. These are called "dual cylinder" or "dual piston" calipers, and are standard equipment on many performance cars. Inside the caliper, the piston(s) press against the pads due to the pressure generated in the master cylinder. The pads rub against the rotor, slowing the vehicle. Because disc brakes can fling off water more easily than

drum brakes, they work much better in wet conditions. They allow better airflow cooling, which also increases their effectiveness. Some high performance disc brakes have drilled or slotted holes through the face of the rotor, which helps to prevent the pads from "glazing" (becoming hardened due to heat).

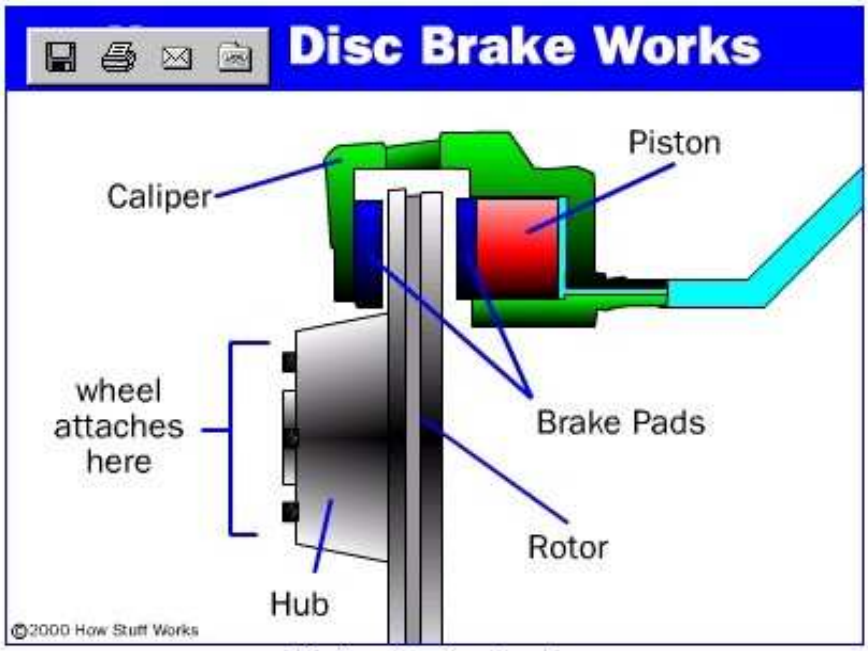
Disc brakes were introduced as standard equipment on most American cars in the early seventies. The disc (rotor) is a heavy plate that attaches to the spindle to provide a two-sided braking surface. Fluid from the brake line flows into a cylinder mounted on the side of a clamp-like caliper. Part of the fluid pressure is exerted against a piston, which forces the brake shoe and pad against the inside surface of the disc. The fluid also exerts pressure in the other direction against the back of the cylinder. This back pressure causes the whole arm of the caliper to move sideways, bringing an outboard shoe and pad tight against the outside of the disc to provide additional stopping power. Ventilation slots around the outside rim of the disc allow friction heat that is generated to be transferred to the air quickly.



Layout of typical brake system

The main components of a disc brake are:

- The **brake pads**
- The **caliper**, which contains a piston
- The **rotor**, which is mounted to the hub



Parts of a disc brake

The disc brake is a lot like the brakes on a bicycle. Bicycle brakes have a caliper, which squeezes the brake pads against the wheel. In a disc brake, the brake pads squeeze the **rotor** instead of the wheel, and the force is transmitted hydraulically instead of through a cable. Friction between the pads and the disc slows the disc down.

A moving car has a certain amount of kinetic energy, and the brakes have to remove this energy from the car in order to stop it. How do the brakes do this? Each time you stop your car, your brakes convert the kinetic energy to heat generated by the friction between the pads and the disc. Most car disc brakes are **vented**.

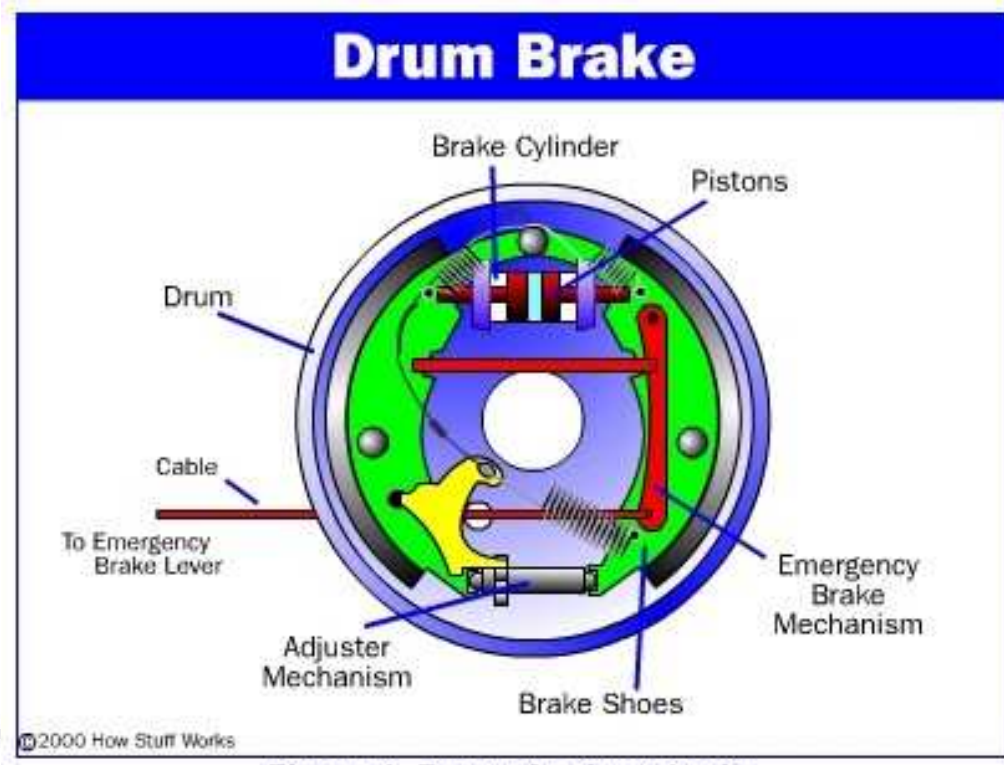


Figure 4. Parts of a drum brake

Dash Controls

Most or all of the control panel of your car is located on the dashboard behind the steering wheel. Sometimes it extends onto the car's console, between the two front seats, and onto your steering column. Little duplicate fragments of the control panel are scattered around the interior of your vehicle, such as automatic door locks, extra light switches, etc.

The dash controls enable you to operate your headlights, turn signals, horn, windshield wipers, heater, defroster, air conditioning, radio, etc. All of the vehicle's controls should be within the reach of the driver. The control panel also contains all of your gauges; gas, temperature, tachometer, etc. These enable you to monitor the operating conditions of your engine and charging system, fuel level, oil pressure and coolant temperature. Warning lights come on to alert you to dangerous coolant temperatures, or loss of oil pressure. In 1924 the Nash Co. introduced the electric clock as an accessory.

Rocker Panels

A rocker panel is a three or four inch piece of metal that runs along the bottom of the car body underneath the doors. Rocker panels are usually coated with a rock proof protectant, which rubberizes the exterior surface before the car is painted.

If you have mud flaps behind your wheels, this protects your rocker panels, as well as your fenders and your doors. Rocker panels are often made of chrome plating, and enhance the car.

Door

A door consists of an inner and an outer panel. The inner panel provides strength. The outer panel is just a metal cover, or "skin." The inner panel has a variety of holes and stems for the attachment to the window mechanisms and locks. The upper part of the door is the window glass that rides in grooves on two sides of the door frame.

Windshield

Up until 1935 many cars had hinged windshields that could be folded on the hood of the car or opened up. Today, most windshields are stationary. They are fixed in place with a weather-strip made of rubber. The strip has a groove on the inside and a groove on the outside. The inside groove holds the glass; the outside groove holds the metal rim of the windshield opening in place. The glass "floats" in a plastic sealant that is spread out between the edge of the glass and the frame of the windshield.

Windshields are made of laminated safety plate glass, which is a sandwich of glass and clear plastic. The plastic acts as a soft, protective barrier, keeping the glass in place, if it is struck during a collision. The glass sticks to the plastic to eliminate glass from flying around the interior and injuring someone. Safety glass for windscreens was one of the first passive safety devices introduced into cars in the 1930s, but its use remains a controversial question. North America and Scandinavia favor a laminated glass, which consists of two sheets of annealed glass, separated by a layer of transparent plastic.

The rest of Europe and Japan favor toughened glass because it is cheaper. This type is a single sheet of glass, which is heat strengthened, and which on impact fractures into small cubic fragments without very sharp edges. In recent years, laminated glass has been improved by changes in the properties of the plastic interlayer. Research has demonstrated that this new laminated glass is about 4 times safer than toughened glass, but because it is more expensive, controversy continues as to whether or not toughened glass windscreens should be banned by legislative action and replaced by laminated glass. Recent developments have combined the benefits of both laminated and toughened material in that a laminated construction is used, but the sheet next to the inside of the car is made of toughened glass.

Windshield Wipers

There are three types of motors that can be used for windshield wipers. The permanent "magnet" motor has two ceramic magnets that are cemented to the field frame and does not use field windings. It needs less energy than the other

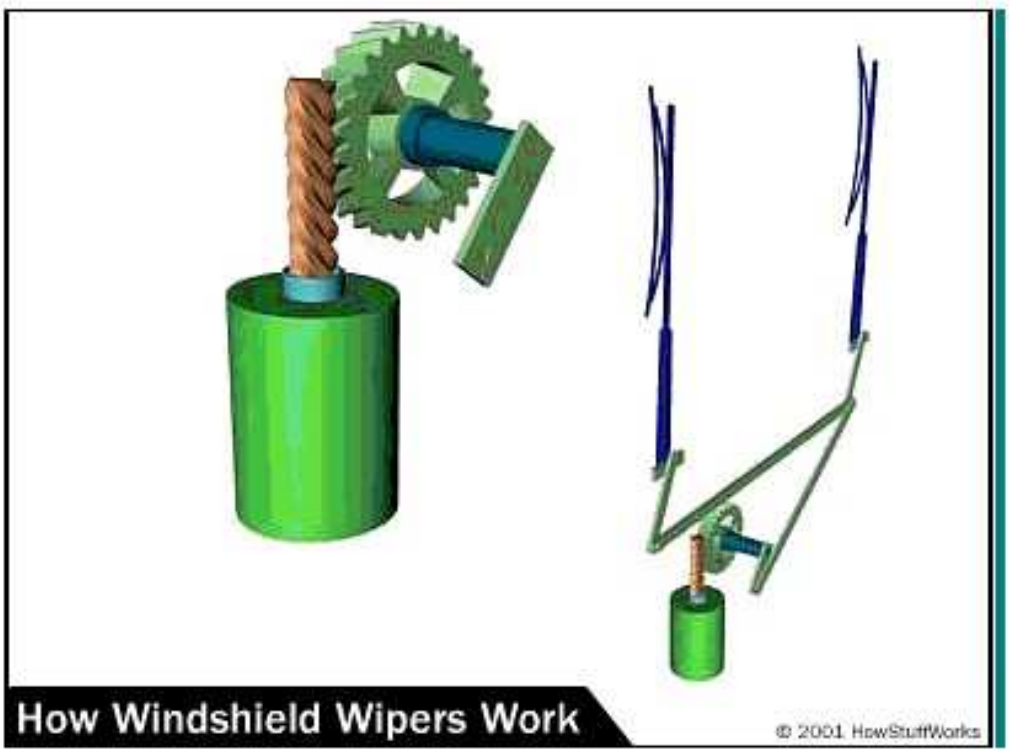
types of motor design, but the switch must be wired in series, creating many areas of resistance. The "shunt wound" motor provides a very consistent speed, but doesn't provide much torque upon starting. The "compound" motor wiper has a strong starting torque and provides consistent speed, but it is the most expensive. Most cars have an intermittent wiper system, which permits the driver to select a delayed wipe that operates only every few seconds.

A representative wiper/washer unit is the wiper assembly, which incorporates a depressed park system that places the wiper blades below the hood line in the parked position. The relay control uses a relay coil, relay armature, and switch assembly. It controls starting and stopping of the wiper through a latching mechanism. An electric washer pump is mounted on the gearbox section of the wiper. It is driven by the wiper unit gear assembly.

Inside the Wipers

The wipers combine two mechanical technologies to perform their task:

- A combination electric motor and worm gear reduction provides power to the wipers.
- A neat linkage converts the rotational output of the motor into the back-and-forth motion of the wipers.



Motor and Gear Reduction

It takes a lot of force to accelerate the wiper blades back and forth across the windshield so quickly. In order to generate this type of force, a worm gear is used on the output of a small electric motor.

The worm gear reduction can multiply the torque of the motor by about 50 times, while slowing the output speed of the electric motor by 50 times as well. The output of the gear reduction operates a linkage that moves the wipers back and forth.

Inside the motor/gear assembly is an **electronic circuit** that senses when the wipers are in their down position. The circuit maintains power to the wipers until they are parked at the bottom of the windshield, then cuts the power to the motor. This circuit also parks the wipers between wipes when they are on their intermittent setting.

Linkage

A short cam is attached to the output shaft of the gear reduction. This cam spins around as the wiper motor turns. The cam is connected to a long rod; as the cam spins, it moves the rod back and forth. The long rod is connected to a short rod that actuates the wiper blade on the driver's side. Another long rod transmits the force from the driver-side to the passenger-side wiper blade.

Radio Antenna

The radio antenna is what receives the radio waves from your favorite stations. Usually they are simple telescoping metal rods mounted to the roof or fenders. Some cars use windshield antennas, which are tiny wires which are inside the glass of the windshield. Other cars have power antennas, which protrude automatically when the radio is turned on, and retract when the radio is turned off.

Trunk Lid

The trunk lid is another type of door. It consists of an inner and an outer panel. The inner panel provides strength. The outer panel is just a metal cover, or "skin".

Fuel Filler Cap

Although all of us know how to use the fuel filler cap, it is actually more complicated than it looks. Inside the fuel filler cap is a pressure release valve. This allows it to vent the fumes in the gas tank if they build up to predetermined levels. Until the fumes reach these levels, they are shunted through the charcoal canister, which collects the fuel from the air before the air escapes. When the fumes build up above the predetermined (differing from car to car) threshold level of the fuel filler cap's pressure release valve, they are vented into the atmosphere. The fuel filler cap has a rubber flange around the neck. This flange should be

inspected for cracks or inflexibility. If the flange does become cracked or inflexible, it should be replaced to keep the environment clean.

Wheel Well

The wheel well is either plastic or metal. Metal wheel wells are usually part of the body shell. Metal wheel wells strengthen the structure of the car because of their shape, and because they are strongly welded to the body shell. Most rear wheel wells are made of metal. Wheel wells are coated with a rock-proof, rubberized coating underneath, in order to prevent the rocks kicked up by the wheels from damaging the metal and making a lot of noise when they hit. Often the front wheel wells are made of plastic. This is because it is harder to mount the engine with the front wheel wells in place. Plastic wheel wells can be removed, and make it easier to mount the engine during the manufacturing of the car.

Drive Wheel/Axle

The drive wheel is the end of the axle shaft; it has lugs protruding from it. The lugs are separate pieces that are mounted in the drive wheel. The drive wheel bolts onto the brake drum and the wheel rim of the car itself. It is usually a disc about six or seven inches in diameter. Occasionally the drive wheel and the axle shaft are all one piece.

Drum Brake

The working parts of a drum brake are contained in a hard metal drum that is attached to the hub of a wheel and revolves with it.

Inside, but unattached to the drum, are a pair of stationary curved brake shoes that are normally held away from the drum by springs. When the brake pedal is depressed, fluid is forced through the brake lines and into the wheel cylinder. Pushrods in the cylinder then apply pressure to both shoes, overcoming the spring tension and pressing the shoes against the drum. Hydraulic drum brakes can also be mechanically activated as parking brakes by a cable attached to the lever. When pressure is removed from the brake pedal, springs on the brake shoes force the shoes back to their normal released position. This movement of the shoes forces the pistons inward, returning the fluid to the master cylinder reservoir.

Sprung and Unsprung Weight

"Sprung" weight is a term used to describe the parts of an automobile that are supported by the front and rear springs. They suspend the vehicle's frame, body, engine, and the power train above the wheels. These are quite heavy assemblies. The "Unsprung" weight includes wheels and tires, brake assemblies, the rear axle assembly, and other structural members not supported by the springs.

The Steering/Suspension System (Overview)

"Suspension," when discussing cars, refers to the use of front and rear springs to suspend a vehicle's "sprung" weight. The springs used on today's cars and trucks are constructed in a variety of types, shapes, sizes, rates, and capacities. Types include leaf springs, coil springs, air springs, and torsion bars. These are used in sets of four for each vehicle, or they may be paired off in various combinations and are attached by several different mounting techniques.

The suspension system also includes shocks and/or struts, and sway bars. Back in the earliest days of automobile development, when most of the car's weight (including the engine) was on the rear axle, steering was a simple matter of turning a tiller that pivoted the entire front axle. When the engine was moved to the front of the car, complex steering systems had to evolve. The modern automobile has come a long way since the days when "being self-propelled" was enough to satisfy the car owner. Improvements in suspension and steering, increased strength and durability of components, and advances in tire design and construction has made large contributions to riding comfort and to safe driving.

Cadillac allegedly produced the first American car to use a steering wheel instead of a tiller. Two of the most common steering mechanisms are the "rack and pinion" and the standard (or recirculating-ball) systems, that can be either manual or assisted by power. The rack and pinion was designed for sports cars and requires too much driver muscle at low speeds to be very useful in larger, heavier cars. However, power steering makes a heavy car respond easily to the steering wheel, whether at highway speeds or inching into a narrow parking place, and it is normal equipment for large automobiles.

The suspension system has two basic functions, to keep the car's wheels in firm contact with the road and to provide a comfortable ride for the passengers. A lot of the system's work is done by the springs. Under normal conditions, the springs support the body of the car evenly by compressing and rebounding with every up-and-down movement. This up-and-down movement, however, causes bouncing and swaying after each bump and is very uncomfortable to the passenger. These undesirable effects are reduced by the shock absorbers.

Rust Prevention

Rust is very bad for your car. It will also depreciate the value of your car more than any other problem. It is the most difficult and expensive problem to fix. The best way to protect your car against rust is to keep the body clean and check it regularly. If you see a light brown stain, don't ignore it, have it fixed before it gets worse. Although most rust problems can be repaired, if it involves chrome parts, you will need to replace them.

The major cause of rust is salt on the roads. The salt carries moisture into every nook and cranny of your car. Rising temperatures bring on salt-caused oxidation. This makes the salt already in your car worse in the spring. Heat in your garage will also bring out the worst in the salt. Acid rain is also bad for your car's body; it ruins the paint that protects the metal of the body. Undercoating is not rust

proofing. Its job is to deaden sound. If any salt or moisture gets into the undercoating, it aids in the rusting process.

To prevent rust: 1. Keep your car clean and well waxed. 2. Rinse the underside with water when salt is in use or if you live in a salty area. 3. Keep your wheel wells clean and free from material that holds moisture, such as dirt or leaves. 4. Make sure that all drain holes in the frame, floor and bottoms of doors are clear. 5. After you wash your car, open the doors to let the water drain out. Rust proofing is a treatment of waxy paste sprayed inside the body panels by an "after market" specialist. The specialist drills holes in hidden areas, sprays in the paste, and plugs the holes. Another type of rust proofing is a clear silicon-based spray that is applied to your paint to protect it from chemicals and pollution. Modern cars come with good built-in corrosion protection and warranties against corrosion. You might wind up sealing in the corrosives you are trying to protect against. Also, many car manufacturers void your corrosion warranty if you have your car rust proofed. The best course is to take the rust preventative measures listed above.

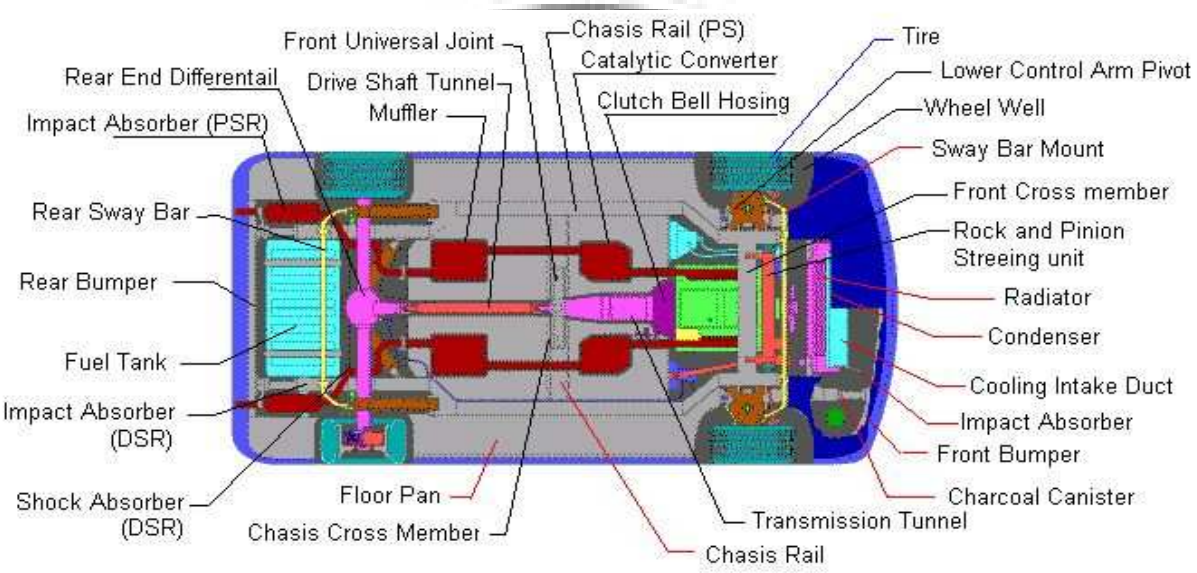
Wheel Alignment

Aligning a vehicle's front wheels is the job of balancing the steering angles with the physical forces being exerted. The steering angles are; caster, camber, toe-in, steering axis inclination, and toe-out on turns. The physical forces are gravity, momentum, friction, and centrifugal force. Since so many factors are involved in front wheel alignment, it is also called front-end alignment, steering alignment, steering balance, or steering geometry. Alignment is more than just adjusting the angularity of the front wheels. With steadily increasing production of front wheel drive vehicles with independent rear suspension, four-wheel alignment is often required. For ideal wheel alignment, certain conditions would have to be met. Both front tires will be the same brand, size, and type. Each will have the same degree of tread wear, and be inflated with the same pressure. Each wheel is properly and equally adjusted for angularity, each tire will maintain the same area of tread contact on a smooth road surface. Obviously, it is impossible to maintain all these requirements. The steering control rods are used to adjust toe-in and toe-out. The upper and/or lower control arms are adjusted to affect the camber angle. Caster is usually not adjustable. With all the weight balance factors to be checked out and corrected, it is obvious that wheel alignment is more than just an adjustment of the steering angles. The whole theory of wheel alignment revolves around balanced weight distribution on the wheels and proper tire tread contact with the road surface while the vehicle is in motion.

The Body (Overview)

The body shell is a fairly complex assortment of large steel sections. These sections have been stamped into specific shapes which make up the body of your car. These parts are designed to do many jobs at once; protect the

occupants from the elements and in collisions, provide solid mounts for all other systems, and to slice through the air with minimal resistance. The body also has one other job which is usually important to the owner... it has to look good! Although the zillions of parts that make up a car are all very important, it is also important that the car's body be able to make riding in a car bearable for you. Early cars were so uncomfortable to ride in, that the human body could stand it only for short periods of time. Auto bodies have come a long way since then. The body and the suspension system now give us a smooth ride, and cushion us from the jarring of the road. The idea is that the body of the car should go forward with as little up-and-down, and side-to-side movement as possible.



Underside View

Radiator

The radiator is a device designed to dissipate the heat, which the coolant has absorbed from the engine. It is constructed to hold a large amount of water in tubes or passages, which provide a large area in contact with the atmosphere. It usually consists of a radiator core, with its water-carrying tubes and large cooling area, which are connected to a receiving tank (end cap) at the top and to a dispensing tank at the bottom. Side flow radiators have their "end caps" on the sides, which allows a lower hood line. In operation, water is pumped from the engine to the top (receiving) tank, where it spreads over the tops of the tubes. As the water passes down through the tubes, it loses its heat to the air stream, which passes around the outside of the tubes. To help spread the heated water over the top of all the tubes, a baffle plate is often placed in the upper tank, directly under the inlet hose from the engine. Sooner or later, almost everyone has to deal with an overheating car. Since water is readily available, it is not beyond the ability of most people to add some to their radiator if it's low. BUT PRECAUTIONS MUST BE TAKEN OR SERIOUS BURNS CAN RESULT.

Here are a few pointers for dealing with an overheated radiator: 1. Turn off the A/C. If the car is not seriously overheating, this will reduce the engine's temperature. The AC evaporator is located in front of the radiator, and it adds heat to the air going to your engine. The hotter the incoming air is, the less efficient the radiator will be. 2. Turn on your heater (set on highest temperature setting, with blower on highest setting). This will be uncomfortable for you, but it will cool the engine by transferring the heat to the air. Roll down the windows, and remember how 'hot' you'll get if your engine needs replacement! 3. If you're stuck in traffic, pull over and stop. Unless you're moving, very little cool air reaches the radiator. Open the hood and let the engine cool off. This takes time, so be patient. Use the time to go get a jug of water or antifreeze. 4. Check the overflow tank coolant level. If it's empty, the radiator is probably low on coolant. 5. Check the pressure of the system by wrapping a cloth around the upper radiator hose and squeezing it. If it's still under pressure (hot) it will not squeeze easily. Wait until it does. 6. Place a large cloth over the radiator cap, and CAREFULLY release the pressure. DANGER: SERIOUS BURNS CAN RESULT FROM THE HOT COOLANT. IF IN DOUBT, WAIT UNTIL THE ENGINE COOLS COMPLETELY. 7. If the coolant is low, start the engine, and slowly add the water or coolant necessary to fill it up. THE ENGINE MUST BE RUNNING. ADDING COOLANT TO A WARM ENGINE CAN CRACK THE BLOCK. By running the engine, the coolant keeps moving and reduces the chances of this type of damage occurring.

Radiator Grille

The radiator grille is the part of the body shell on the front of your car that covers the area where the air enters. The radiator grille can also be part of the bumper on some cars.

The radiator is connected to the shroud for the radiator. The shroud directs the air that comes in through the radiator grille to the radiator only. This prevents the air from escaping around the radiator and failing to cool the engine. On newer cars, the radiator grille has been lowered to take advantage of lower hood lines, brought about by an effort to increase fuel efficiency. Older cars had massive grilles, whereas the cars now produced have smaller more aerodynamic grilles.

Radiator Shroud

If the fan that pulls air through the radiator core to cool the engine coolant is too far back, it will end up re-circulating the same hot air that has collected behind the radiator. For this reason, the radiator often has a shroud. The radiator shroud prevents the re-circulation of air around the fan. It is usually a plastic hood that encloses the fan to guide the air through the core, and stop it from coming back around and through the fan again. It also protects you from the fan blades!

Air Dam

An air dam is a projection of the body shell underneath the front of the chassis. Its function is to reduce the amount of air turbulence and drag underneath the car, and to channel air to the radiator.

Brake Cooling Ducts

In high performance cars, small brake cooling ducts are built into the bodywork near the front and/or rear wheels. On the air dam, the duct is a small opening. Behind the opening, a small tube runs to the backing plate. This allows cool air to be directed onto the brakes, increasing braking potential and reducing brake fade. Brakes tend to "fade" (lose their effectiveness) if they get hot. Lots of cars have very small sheet metal projections on the backing plate that serve as an air scoop for the front disc brakes.

Heat Transfer

When air passes over an object, it can accumulate heat energy or deposit heat on the object. This is thermal convection in action. The radiator is designed to transfer the coolant's heat energy to the air. As air passes through the radiator, the heat in the coolant actually passes through the metal and is absorbed by the air. When the air reaches the far side of the radiator, it is at a greater temperature and the coolant is at a lower temperature because it dissipated its heat into the air.

The same principle is at work within the transmission cooler of a radiator, if the car has an automatic transmission. The transmission fluid flowing through the cooler gives off it's heat to the coolant within the radiator, which then gives off it's heat to the air flowing through the radiator. Disc brakes and various other parts, which need cooling dissipate heat directly into the air without using water. Some types of cars, such as Volkswagens, use air-cooled engines. These eliminate the need for water by having more engine surface area through the use of cast fins. These allow the air to pass over a large surface area of the engine and thus transfer heat directly to the air.

As your car travels down the road, the air that passes through the radiator grille either exits through the floor of the engine compartment, or it may pass out through the sides of the car, through what are known as gills. These side vents allow the air, which is compressed within the engine compartment to exit to an area, which is of relatively low pressure rather than trying to force it under the car where there isn't as much room for it.

Spoiler

A spoiler is a kind of wing that is mounted on the rear of the car in a horizontal position. Its function is to provide high-speed stability. For most cars, the spoiler is purely cosmetic; a car has to be going over 100 mph to take advantage of the

aerodynamics of the spoiler. Some mini-vans also make use of a spoiler, but it's upside down, and angled. The purpose of this type of spoiler is simply to keep the rain off the rear window.

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Seats

There are basically two types of seats; bench seats or bucket seats. A bucket seat is a low, separate seat for one person. Although we think of them as relatively new, it is interesting to note that in 1905 Henry Ford's first model A had bucket seats. Bench seats are a continuous cushion and backrest across the width of the car (although some vans might have them running along the length of the van). Bucket seats are single units with a separation between the left and right seats.

Usually vinyl leather and fabric are used for upholstery. "Flatsprings" are used for comfort. A flatspring is a piece of wire that is bent into a zigzag pattern. Both ends of the wire are attached to the seat frame, with additional lengths added every six inches. Foam padding is used to cover the flatsprings. The front seats ride on rails that are bolted to the floor. This arrangement allows the seats to move backwards and forwards to suit the driver or passenger. The seat adjustment lever is attached to a latch that fits into teeth along the rail. Moving the lever releases the seat, and allows the seat to move. At any point of the seat's movement, releasing the lever engages the latch with one of the teeth. Usually there is also a pull-spring; this draws the seat forward when the latch is released. The rear seat usually doesn't move, because it is secured to the floor of the car. It's backrest is attached to the partition between the passenger compartment and trunk.

Headrests

Headrests are a safety device and enhancement. If a headrest is properly positioned behind your head, it can protect you from injury during a collision. Some safety conscious car manufacturers have headrests for both front and rear seats. Headrests can also be safety hazards if they are positioned improperly. A headrest that is adjusted too high can obscure the driver's rear view. If a

headrest is adjusted too low, during the event of a collision, it can "chop" the driver or passengers in the neck, rather than protect the head.

Rear-impact accidents occur frequently and are increasing with the greater density of today's traffic. In rear end collisions, the car is suddenly accelerated forward, with the result that the head of an occupant is snapped backwards over the seat back. This can cause a serious "whiplash" injury to the neck. To prevent such injuries, some seats are fitted with head restraints. Many of these, however, are not used as designed, because the user has to adjust his own head restraint so that it is in the right position to protect them in a collision. In the United States, for example, where nearly all head restraints are adjustable, field surveys have shown that 80% of the head restraints are in the fully down position all the time. As a result, head restraints are of hardly any benefit in an accident.

Seat Belts and Air Bags

The first federal study of automobile air bags in actual traffic accidents has found that air bags used in conjunction with seat belts are far more effective than seat belts alone. Air bags reduce the risk of death in head-on collisions by 26% and in all serious accidents by 13%. Contrasting earlier findings that did not involve actual road conditions, the study showed that air bags protected occupants in ways that seat belts alone, did not. The air bag spread out the violent impact of a crash and kept occupants from smashing against the steering wheel, dashboard or windshield. Having an air bag and wearing an effective seat belt offers the best protection of all. Not only are you protected from frontal crashes by the air bag -- you are also protected by the seat belt in all other types of crashes.

Studies show that 60% of the people killed or injured in automobile accidents would have been saved from serious injury by safety belts. Unfortunately, many people choose not to wear them. With an "effective" safety belt (one that is worn and operating correctly), your body will stop, in a crash, before you have a chance to hit or go through the windshield and parts of your car. Seat belts are especially important in small cars, because your chances of being killed or badly hurt in a collision with a big car is eight times greater. Wearing your belt will greatly improve your chances of survival. In a Department of Transportation study made public on June 26, 1992, it was announced that air bags are far more effective than seat belts alone. Air bags can reduce the risk of death in a head-on collision by 26% and in all serious accidents by 13%. However, the DOT cautioned that air bags work this well ONLY when occupants were wearing a properly buckled seat belt over lap and shoulder. Other studies have shown that WITHOUT A BELT, AIR BAGS ARE OF SLIGHT BENEFIT. Air bags are only useful in frontal crashes, so it is not a good idea to skip your seat belt because you have an air bag. Air bags provide very effective protection in frontal crashes, inflating instantly to protect the driver or passenger that has a air bag. They spread the impact of the crash over the individual's head and chest and protect fragile body parts from the car's hard surfaces. More than 6 million cars (about 4% of cars on the road today) have air bags, but the majority of them have air bags on the driver's side only.

Federal officials estimate that air bags have inflated in more than 57,000 accidents since they were introduced, six years prior to 1992, and saved about 300 lives. This report came out in the middle of the most sweeping safety overhaul since the introduction of the seat belt almost 30 years ago. For the first time, most new cars sold in the US in 1992 have driver's side airbags. Within 6 years, federal law will require that every new car, light truck and van have air bags on both sides. The main concern of car safety research in the last few years has been the development of passive safety design features, where the aim is to improve the "crash-worthiness" of vehicles. The fundamental aim of good passive safety design is to ensure that only tolerable loads are applied to a car occupant's body during a crash. This is done first by restraining the occupant within the passenger compartment by means of a seat belt or other device, so that chances of making contact with the interior parts of the car are reduced. Secondly, when contacts cannot be avoided, the structures, which are likely to be hit by the occupants, must be designed to collapse and cushion them.

It is important for the designers to have some knowledge of the forces that the human body can withstand, but as yet this branch of biomechanics has not been fully researched. Work is done at low impact energy levels using volunteers, but for high-speed crashes it is necessary to use dummies. The relationship between dummy performance and that of a real person in a crash is complex, and it may be that these differences are very considerable. To reduce this problem, some work is currently being done using human cadavers. In spite of the difficulties in this area, many basic improvements have been introduced into cars in recent years. These include anti-burst door latches, safety glass, energy-absorbing steering wheels and columns, head restraints and various seat belt systems. The benefits of the three-point seat belts have been firmly established: over 50% of fatal and serious injuries to car occupants would be avoided if all occupants wore their seat belts. Most states now have a law that both passengers and driver must have seat belts buckled while in motion. Those states, which do not enforce a seat belt law for all passengers, have an effective law for children under five years of age to be strapped in.

Steering Systems

The manual steering system incorporates: 1. Steering wheel and column, 2. a manual gearbox and pitman arm or a rack and pinion assembly, 3. Linkages; steering knuckles and ball joints and 4. The wheel spindle assemblies.

In Pittman arm systems, the movement inside the steering box causes the Pitman shaft and arm to rotate, applying leverage to the relay rod, which passes the movement to the tie rods. Power steering systems add a hydraulic pump; fluid reservoir; hoses; lines; and either a power assists unit mounted on, or integral with, a power steering gear assembly.

There are several different manual steering gears in current use. The "rack and pinion" type is the choice of most manufacturers. The "re-circulating ball" type is a past favorite because the balls act as a rolling thread between the worm shaft and the ball nut. Another manual steering gear once popular in imported cars is the "worm and sector" type. Other manual gears are the "worm and tapered pin steering gear" and the "worm and roller steering gear."

The steering wheel and column are a major source of injury to the driver, and a range of energy absorbing and non-intrusion designs have been developed. There is great variation in these designs, some of which are now thought to be not fully effective. Energy-absorbing columns have to serve two functions. First, they must stop the steering wheel and column from being pushed to the rear as the front of the car is crushed in an impact. Before such designs were invented, a common feature of driver injury was for the chest to be impaled by the steering column. The energy-absorbing column must also provide the driver with a tolerable impact as he moves forward and strikes the wheel with his chest. At that point in the crash, the column should build up the load on the driver's chest to a tolerable level, and then deform under that load to give a "ride-down" for the driver. Several design problems are presented in providing this system. One major problem is that collapse of the column due to the frontal crush of the car should not hinder its performance for providing ride-down for the driver's chest. The system must also be so designed that under crash conditions, the wheel stays in such a position that it will strike the driver's chest and not move upwards into the region of his face, or downwards into his abdomen.

Floor Pan

The floor pan is at the bottom of the car assembly. This is the foundation of the body shell. The floor pan is stamped with bulges and curves to accommodate the spatial requirements of the engine, transmission and rear axle, as well as the passenger compartment. A second floor pan is often used for the trunk of the car. If the car has a separate frame, the floor pan is bolted to the side rails buffered by large rubber cushions. With uni-body construction, the floor pan is attached to the several metal pieces that make up the chassis center section.

It's Just Another Statistic

From the very first, automobiles have attracted each other like magnets, even when there were only two in the same town. The first incident (or accident) occurred when horse met car. The car-haters over-dramatized the runaways and foretold all sorts of catastrophes for the future. On the other hand, the motorists blamed it on the horses and predicted a great new day of personal transportation. Each side had an element of truth. There was no question that the automobile was a boon to mankind, but it was also to prove to be a killer of people, a destroyer of property, and the accomplice of criminals. Even in the beginning of

the automobile age, when numbers were few and bad roads limited the amount of traffic, deaths due to accidents in automobiles began to mount. Before the U.S. entered WWI, auto accidents had killed more than 36,000 Americans. By comparison, only 22,424 had lost their lives in the Revolutionary War, the War of 1812, the Mexican War, and the Spanish-American War combined. This trend to kill more people with cars than with weapons worsened as the years rolled by. Before the turn of the century, anti-horseless carriage sentiments began to express themselves in restrictive regulations.

In the late 1890s, Louis Greenough and Harry Adams of Pierre, South Dakota, built a homemade car out of an Elkhart wagon and a two-cylinder Wolverine gas motor, hoping to haul passengers at the county fair. They were not only denied permission to haul passengers, the authorities would not even let them bring their contraption inside the city limits. Automobiles were banned in the streets of many cities: Boston, Chicago and Bar Harbor, Maine, to name a few. In Massachusetts, an act to require that all cars be equipped with a bell which would ring with each wheel revolution was voted down, as was one for shooting off roman candles to warn of the vehicle's approach. There were laws that required motorists to stop completely while buggies, surreys and freight wagons dragged by. Speed limits as low as two and three mile per hour were imposed by a few cities and towns. In some, night-time driving was prohibited. In 1907, Glencoe, Illinois, built humps in the streets to discourage speeding. Three years earlier, they had stretched a steel cable across the road to stop the "devil wagons." Most of this was antagonism rather than an attempt to accomplish constructive regulations. While the jumble of confusing ordinances continued to plague pioneer motorists, a new wrinkle was added: the "speed trap." In smaller towns, particularly, marshals and other law officials lay in wait for unsuspecting drivers, timing them by stop-watch or "by guess and by gosh." Some lawmen were authorized to shoot at tires or to stretch chains or wire across the road. Until the motorcycle became a police vehicle, the local sheriff's office was somewhat limited in their pursuit of fleeing cars, since they were either on foot or on bicycles. Motorists tried to find ways to defend themselves.

One way was by organization, and in 1902, the American Automobile Association was formed in Chicago to take up the pennant for the motor car operator. That same year, the city passed an ordinance prohibiting the driver of a car to wear "pince-nez" glasses. The A.A.A. proved to be a good watchdog for its members as it fostered realistic regulations and fought against abusive police action, especially the common practice of arresting owners of expensive cars on the premise that such people could afford to pay a stiffer fine. In the middle of this confusion, there seemed to be no stemming the growing tide of accidents. It was a case of simple arithmetic; more cars meant more collisions. With each year, too, the autos were made faster and more powerful. Narrow roads with no shoulders and sharp, unbanked curves simply couldn't accommodate speed runs, and from the beginning, auto owners have had the desire to "see how fast she'll go." Gradually, the automobile was accepted as a permanent fixture, and traffic regulations shifted from anti-car priority to that of anti-accident.

On October 13, 1913, The National Council for Industrial Safety opened a three-room headquarters in Chicago. The original emphasis had been on the "industrial," but in that year, the Public Safety Commission of Chicago and Cook County reported that in July, twenty people had been killed by automobiles, eighteen of them children. The commission launched an education program - with leaflets and slides - in the schools and parks, and the new NCIS realized that the motor car would have to be the subject of its most intense study. In 1914, the organization's name was changed to The National Safety Council, and it began to the compile statistics on automobile accidents. From 1913, when the death toll was 4,000, or 4.4% of a 100,000 population, it rose, in 1930, to 32,900, or 26.7%. The desire to "do something about it" was growing among Americans everywhere; but the urge to find unfettered freedom in a fast car was even stronger. In 1914, Detroit installed a manually operated stop-and-go sign. In August that year an electrical traffic signal was put in operation at 105th and Euclid Avenue in Cleveland, Ohio. The Ford Motor Company gave each car purchaser a card reminding him to "Stop, Look, and Listen," at all railroad crossings. Magazines and newspaper articles carried "don't drink and drive" cartoons; this cooled off during the prohibition when "nobody" was drinking. But bootleggers, in their big touring cars, and the bathtub gin guzzlers, in their sporty rumble seat models, continued to add to the highway toll.

In 1924, the National Conference on Street and Highway Safety, whose chairman was the Secretary of Commerce, Herbert Hoover, authorized a committee to draft a uniform motor vehicle code for all forty-eight states. Two years later, the laws were presented and adopted by the second conference. The individual states didn't move so quickly, and some adopted the package in their own time, but a standardized code of laws was a major achievement of effective nation-wide traffic regulations. Die-hard horse-lovers saw the entire development with an "I told you so" attitude. They knew that the nation was going to suffer for its folly in permitting roads to be over-run with those mechanical contraptions. They were snickering in the wilderness, however. The automobile had a solid footing in America, and no amount of finger pointing could make it go away. Men began to feel that buying a car was like taking a bride, you just have to take what you get, for better or for worse.

Did Anyone Get That License Number?

After the end of WWII, teenagers, trying to find their individualism, made their cars into hot rods, low-riders and high-riders. They put chrome on everything that would hold it, and painted everything that was paintable - often with florescent colors, and otherwise extended their efforts to make their car their "own." Many people hung a pair of oversized dice from their mirror in an effort to show independence. Some displayed logos of their school or club. Then came the bumper sticker. The bumper sticker was first held on with wires and probably said, "Buy War Bonds." After the war, the stickers actually began to stick. Probably due to our need to "do (or say) our own thing." Nearly every car now has a message; some subtle, some clever, and some down-right obnoxious.

In 1901, Connecticut passed laws regulating the registration and speed of motor vehicles. That same year, New York state required "that every vehicle shall have the separate initials of the owner's name placed upon the back thereof in a conspicuous place." That was fine when there were only 954 cars involved, but when registrations increased, the variety of lettering and location of the initials was so great that the state amended the decree and required that assigned registration numbers be shown on plates or leather pads. The state collected a $1.00 fee and assigned the owner a number. He had to buy brass numerals, bolt them to a strip of leather, and attach his homemade tag to his car. In 1903, Massachusetts issued the first official state-made license plates, heavy porcelain-enameled white on dark blue tags. Other states followed suit with variations of metal, leather, wooden shingles, sheet metal and some do-it-yourself styles. The first state driver's license laws were passed by Rhode Island in 1908 and then New Hampshire in 1909. When the states took over the production of license plates, they used their prison population for the actual work - rehabilitating their inmates for a position for which there was no job on the outside.

In 1937, Connecticut offered the first "vanity tags." Other states, seeing an opportunity to get more money for no more service, followed suit. They soon found that personalized license plates could become a giant problem. Just a few letters, chosen by some clever motorist, could produce an embarrassing sentiment to the issuing office. After a few incidents, they hired staff to carefully review each request so that it would not reflect badly on the state. It is now prestigious to buy a license plate or "Vanity tag" in order to display a personal message. These, as the car itself once was, are symbols of status. Losing tags to a thief is not unusual. Authorities report that these prestige license plates are being stolen in increasing numbers. To make matters worse, motorists are discovering that it doesn't pay to be too smart. The more clever and creative a tag is, the more apt it is to be stolen. On the other hand, the owner may derive some pleasure and comfort from this implied salute to his creativity.

Fuel Vapor Canister

The fuel vapor canister is used by the vapor recovery system to trap fuel from the carburetor float bowl and fuel tank. Starting the engine causes the vacuum port in the canister to pull fresh air into the canister to clean out the trapped fuel vapor. The trapped fuel vapor is then fed into the carburetor to be burned.

The Condenser

The condenser is a long tube that goes back and forth through a multitude of cooling fins, quite similar to the evaporator in structure. The condenser is mounted in front of the radiator to take advantage of the forced air provided by the fan and the motion of the car. As the highly pressurized refrigerant (vapor) flows into the condenser, it gives off heat and warms the condenser. This causes the condenser to be hotter than the forced air coming through the condenser.

The condenser hands its heat off to the forced air and turns the refrigerant back into cool liquid in the expansion valve, where it heads back to the evaporator.

Sway Bar

Some cars require stabilizers to steady the chassis against front-end roll and sway on turns. Stabilizers are designed to control this centrifugal tendency that forces a rising action on the side toward the inside of the turn. When the car turns and begins to lean over, the sway bar uses the upward force on the outer wheel to lift on the inner wheel, thus keeping the car more level.

Control Arms

A control arm is a bar with a pivot at each end, used to attach suspension members to the chassis. When coil springs are used in both front and rear suspension, three or four control arms are placed between the rear axle housing and the frame to carry driving and brake torque. The lower control arms pivot on the frame members and sometimes support the rear coil springs to provide for up-and-down movement of the axle and wheel assembly. A-arms are control arms with two inboard pivots, giving strength. Some front-end designs use control arms instead of A-arms, usually to save weight and add adjustability.

The Catalytic Converter

When your engine burns fuel, it produces gases that are bad for the environment. These noxious gases are hydrocarbons, carbon monoxide and nitrogen oxides. To prevent the engine from polluting the environment with these gases, we include a catalytic converter in our emission systems. The catalytic converter is installed in the exhaust line, between the exhaust manifold and the muffler, and makes use of chemicals that act as a catalyst. A catalyst is a chemical that causes a reaction between other chemicals without being affected itself. In the case of the catalytic converter, the chemicals it contains cause a reaction in the pollutants in the exhaust. The pollutants are changed from harmful gases to harmless ones before they are let into the environment through the tail pipe.

Basically, the harmful gases enter the catalytic converter, a kind of stainless steel container. The converter is lined with chemicals such as aluminum oxide, platinum and palladium. These chemicals cause the carbon monoxide and hydrocarbons to change into water vapor and carbon dioxide. Some converters have a third lining of chemicals, platinum and rhodium, that reduce nitrogen oxides (three-way, dual bed converter). The reason that leaded gas cannot be used in an engine with a catalytic converter is that the lead coats the chemicals in the converter. This makes them unable to do the job anymore, since the chemical lining can't come in contact with the pollutants. At first, this was a big disappointment, because lead acted as a lubricant and helped to reduce wear on some of the engine parts. Luckily for our engines and the environment (not to

mention us), car manufacturers soon got around the problem by making tougher parts and coating them with special metal.

Frame (Chassis)

The frame provides a firm structure for the body, as well a good anchor point for the suspension system. There are two types of frames; integral frames (you've probably heard of them as "unibody") and conventional frames.

A conventional frame is basically a "one-piece" frame, or two "one-piece" frames fastened together. The frame is extremely rigid in order to keep all the other parts of the car in perfect alignment. The manufacturer takes this type of frame and attaches all the other parts of the car to it, like the way a sculptor starts with a wire frame to build his sculpture on and give it shape. To keep things smooth, rubber insulator blocks, or "pads" are placed between the frame and the other car parts. Because the conventional frame is so important to the structure of your car, (without it, your car would be a pile of doors, hoses, seats, wires and metal) it is usually constructed of heavy steel and welded or cold riveted together. Cold riveting keeps the rivets from shrinking after they cool off.

The integral, or unibody, frame is just the opposite. With this type of frame, the body parts are used to structurally strengthen the entire car, and all of the sections are welded into one piece. Sometimes the parts of the body and the suspension system are attached and reinforced. Also, some unibody frames have partial front and rear frames for attaching the engine and suspension members.

The Muffler

Exhaust gases leave the engine under extremely high pressure. If these gases escaped directly from the engine the noise would be tremendous. For this reason, the exhaust manifold sends the gases to a muffler where they go through metal plates, or tubes, with a series of holes. The pressure of the gases is reduced when they pass through the muffler, so they go out of the tail pipe quietly.

The muffler is made of metal and is located underneath the body of the car. It's connected between the tail pipe and the catalytic converter. There are two types of muffler design. One type uses several baffled chambers to reduce noise. The other type sends the gases straight through perforated pipe wrapped in metal or fiberglass. This type of muffler is designed for the purpose of reducing back pressure and consequently, makes slightly more noise. Since a muffler cannot reduce the noise of the engine by itself, some exhaust systems also have a resonator.

Resonators are like little mufflers, and are usually the "straight through" type. They are added at the end of the exhaust system to take care of any noise that has made it through the muffler. The muffler quiets the noise of the exhaust by "muffling" the sound waves created by the opening and closing of the exhaust valves. When an exhaust valve opens, it discharges the burned gases at high

pressures into the exhaust pipe, which is at low pressure. This type of action creates sound waves that travel through the flowing gas, moving much faster than the gas itself (up to 1400 m.p.h.), that the muffler must silence. It generally does this by converting the sound wave energy into heat by passing the exhaust gas and its accompanying wave pattern, through perforated chambers of varied sizes. Passing into the perforations and reflectors within the chamber forces the sound waves to dissipate their energy.

Drive Shaft Clearance Tube

The drive shaft clearance tube is a section of the floor pan. It is actually shaped more like a tunnel than a tube. It provides clearance for the drive shaft, the universal joints and the rear of the transmission. The underside of the drive shaft clearance tube is coated with a rubberized sound absorption coating that reduces road noise. Only rear-wheel drive vehicles have drive shaft clearance tubes.

Fuel Tank

All modern fuel systems are fed through a pump, so the fuel tank is usually at the rear of the chassis under the trunk compartment. Some vehicles have a rear engine with the tank in the forward compartment. The fuel tank stores the excess fuel until it is needed for operation of the vehicle. The fuel tank has an inlet pipe and an outlet pipe. The outlet pipe has a fitting for fuel line connection and may be located in the top or in the side of the tank. The lower end is about one-half inch above the bottom of the tank so that collected sediment will not be flushed out into the carburetor. The bottom of the tank contains a drain plug so that tank may be drained and cleaned. The gas tank of the early cars was placed higher than the engine. The idea was that the gas would flow down to the engine. This arrangement caused a problem when the car went uphill -- the gas flowed away from the engine. Solution: drive up the hill backwards!

Shock Absorbers

In the past, a wide variety of direct and indirect shock absorbing devices were used to control spring action of passenger cars. Today, direct, double-acting hydraulic shock absorbers and shock absorber struts have almost universal application. The operating principle of direct-acting hydraulic shock absorbers is in forcing fluid through restricting openings in the valves. This restricted flow serves to slow down and control rapid movement in the car springs as they react to road irregularities.

Usually, fluid flow through the pistons is controlled by spring-loaded valves. Hydraulic shock absorber automatically adapt to the severity of the shock. If the axle moves slowly, resistance to the flow of fluid will be light. If the axle movement is rapid or violent, the resistance is stronger, since more time is required to force fluid through the openings. By these actions and reactions, the shock absorbers permit a soft ride over small bumps and provide firm control

over spring action for cushioning large bumps. The double-acting units must be effective in both directions because spring rebound can be almost as violent as the original action that compressed the shock absorber. In the 1930s, there was a school for chauffeurs of the Rolls Royce. Since the car had a reputation to maintain for its smooth and quiet ride, the students had to pass a special test. They were required to drive a Phantom II model with a glass of water on the radiator without spilling a drop!

The Universal Joint (U-joint)

The Universal joint (U-joint) is used to connect the drive shaft to the transmission output shaft and the differential pinion gear shaft. This joint must be flexible enough to allow changes in the driving angle (road incline) and the drive shaft. This way, the torque is constantly transmitted when the rear axle is moving up and down. Smaller U-joints are used to route the turning motion of the steering wheel through the steering column to the steering box. There are two types of U-joints, the cross and roller type and the ball and trunnion type. The cross and roller type is used the most; it allows the drive shaft to bend. The ball and trunnion type less frequently used; it allows the drive shaft to bend and also permits backward and forward motion of the drive shaft.

The Differential

The differential is the thing that works both drive axles at the same time, but lets them rotate at different speeds so that the car can make turns. When a car makes a turn, the outer wheel has to turn faster than the inner wheel, due to the difference in the length of the paths they take. The differential is located between the two wheels, and is attached to each wheel by a half-shaft rotated through a bevel gear.

Four-wheel drive cars have a separate differential for each pair of wheels. A grooved or splined, axle side gear is positioned on the splined end of each axle. The side gears are driven by "spider" gears, which are little gears mounted on a shaft attached to the differential case. As it is supported by the differential case, the side gear can turn inside the case. The differential case can be turned, revolving around the axle gears. The differential pinion (a pinion is a small gear that either drives a larger gear or is driven by one) shaft turns the ring gear, which is fastened to the differential case.

The propeller shaft (drive shaft) connects the transmission output shaft to the differential pinion shaft. The turning differential case is mounted on two large bearing holders. These bearings are called carrier bearings. The propeller shaft rotates the ring gear pinion, and the pinion turns the ring gear. The ring gear then turns the differential case and pinion shaft, but the axle side gears will not turn. By passing the differential pinion shaft through two differential pinion gears that mesh with the side gears, the case will turn and the axle side gears will turn with it. During turns, the side gears turn at rates dictated by the radius of the turns,

and the spider gears then turn to allow the outer wheel to turn faster than the inner one.

The Drive Shaft

The drive shaft, or propeller shaft, connects the transmission output shaft to the differential pinion shaft. Since all roads are not perfectly smooth, and the transmission is fixed, the drive shaft has to be flexible to absorb the shock of bumps in the road. Universal, or "U-joints" allow the drive shaft to flex (and stop it from breaking) when the drive angle changes. Drive shafts are usually hollow in order to weigh less, but of a large diameter so that they are strong. High quality steel, and sometimes aluminum are used in the manufacture of the drive shaft. The shaft must be quite straight and balanced to avoid vibrating. Since it usually turns at engine speeds, a lot of damage can be caused if the shaft is unbalanced, or bent. Damage can also be caused if the U-joints are worn out.

There are two types of drive shafts, the Hotchkiss drive and the Torque Tube Drive. The Hotchkiss drive is made up of a drive shaft connected to the transmission output shaft and the differential pinion gear shaft. U-joints are used in the front and rear. The Hotchkiss drive transfers the torque of the output shaft to the differential. No wheel drive thrust is sent to the drive shaft. Sometimes this drive comes in two pieces to reduce vibration and make it easier to install (in this case, three U-joints are needed).The two-piece types need ball bearings in a dustproof housing as center support for the shafts. Rubber is added into this arrangement for noise and vibration reduction. The torque tube drive shaft is used if the drive shaft has to carry the wheel drive thrust. It is a hollow steel tube that extends from the transmission to the rear axle housing. One end is fastened to the axle housing by bolts. The transmission end is fastened with a torque ball. The drive shaft fits into the torque tube. A U-joint is located in the torque ball, and the axle housing end is splined to the pinion gear shaft. Drive thrust is sent through the torque tube to the torque ball, to transmission, to engine and finally, to the frame through the engine mounts. That is, the car is pushed forward by the torque tube pressing on the engine.

The Steering/Suspension System (Overview)

"Suspension," when discussing cars, refers to the use of front and rear springs to suspend a vehicle's "sprung" weight. The springs used on today's cars and trucks are constructed in a variety of types, shapes, sizes, rates and capacities. Types include leaf springs, coil springs, air springs, and torsion bars. These are used in sets of four for each vehicle, or they may be paired off in various combinations and are attached by several different mounting techniques.

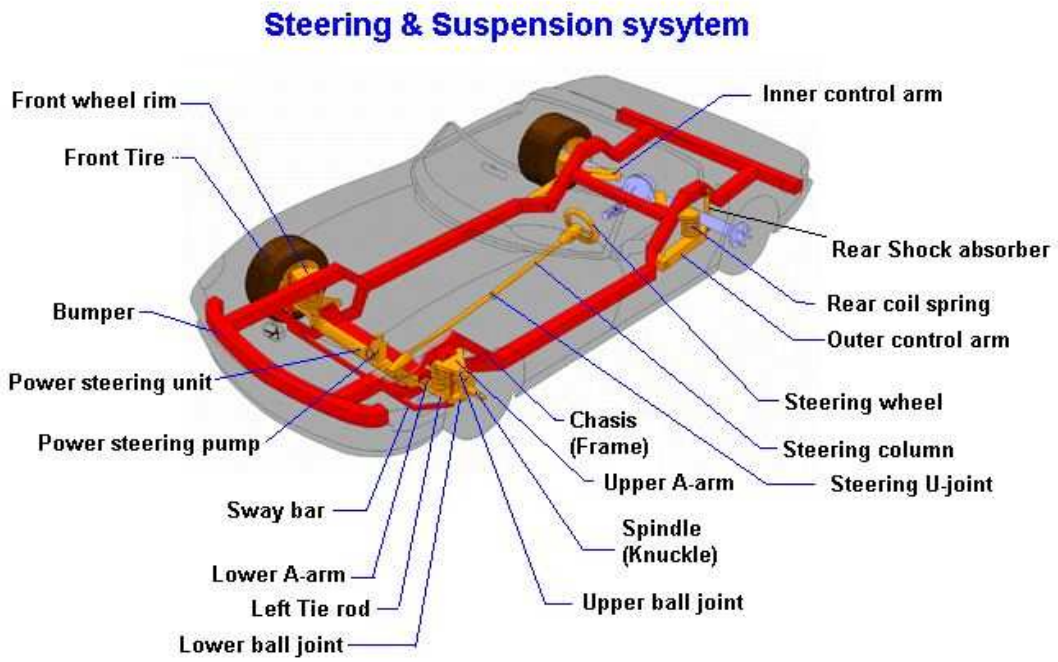
The suspension system also includes shocks and/or struts, and sway bars. Back in the earliest days of automobile development, when most of the car's weight

(including the engine) was on the rear axle, steering was a simple matter of turning a tiller that pivoted the entire front axle. When the engine was moved to the front of the car, complex steering systems had to evolve. The modern automobile has come a long way since the days when "being self-propelled" was enough to satisfy the car owner. Improvements in suspension and steering, increased strength and durability of components, and advances in tire design and construction have made large contributions to riding comfort and to safe driving.

Cadillac allegedly produced the first American car to use a steering wheel instead of a tiller. Two of the most common steering mechanisms are the "rack and pinion" and the standard (or re-circulating-ball) systems that can be either manual or assisted by power. The rack and pinion was designed for sports cars and requires too much driver muscle at low speeds to be very useful in larger, heavier cars. However, power steering makes a heavy car respond easily to the steering wheel, whether at highway speeds or inching into a narrow parking place, and it is normal equipment for large automobiles. The suspension system has two basic functions, to keep the car's wheels in firm contact with the road and to provide a comfortable ride for the passengers. A lot of the system's work is done by the springs. Under normal conditions, the springs support the body of the car evenly by compressing and rebounding with every up-and-down movement. This up-and-down movement, however, causes bouncing and swaying after each bump and is very uncomfortable to the passenger. These undesirable effects are reduced by the shock absorbers.

Torsion Bars

Torsion bar suspension uses the flexibility of a steel bar or tube, twisting lengthwise to provide spring action. Instead of the flexing action of a leaf spring, or the compressing-and-extending action of a coil spring, the torsion bar twists to exert resistance against up-and-down movement. Two rods of spring steel are used in this type of suspension. One end of the bar is fixed solidly to a part of the frame behind the wheel, the other is attached to the lower control arm. As the arm rises and falls with wheel movement, the bar twists and absorbs more of the road shocks before they can reach the body of the car. The bar untwists when the pressure is released, just like a spring rebounding after being compressed. Adjusting the torsion bars controls the height of the front end of the vehicle. The adjusting bolts are located at the torsion bar anchors in the front cross member. The inner ends of the lower control arms are bolted to the cross member and pivot through a bushing.



Braking Systems

The Brake System (An Overview)

The braking system is the most important system in your car. If the brakes fail, the result can be disastrous. The brakes are in essence energy conversion devices, which convert the kinetic energy (momentum) of your vehicle into thermal energy (heat). When you step on the brakes, you command a stopping force ten times as powerful as the force that puts the car in motion. The braking system can exert as much as 1,000 pounds of hydraulic pressure on each of the four brakes. In modern systems, the master cylinder is separately power-assisted to activate the front and rear brakes. If one set fails, the other can provide adequate braking power. Many such safety systems within the braking system make modern brakes very complex, but much safer than earlier braking systems. High-performance disc brakes originally were developed for racing, but are now used on many newer cars.

On most cars, the front brakes are of the disc type, and the ones in the rear are the drum type. The parking brake is a cable-operated system, which usually is attached to the rear wheels. In almost all braking systems, the brake pedal is connected to a "master cylinder" by a push rod. The master cylinder is connected to the brake cylinders ("slave cylinders") at each wheel by steel brake lines and flexible rubber hoses. The entire hydraulic system is filled with a special brake fluid, which is forced through the system by the movement of the master cylinder pistons. The front disc brakes use friction "pads" which are mounted in "calipers". The pads are forced against machined surfaces of a rotating disc called the

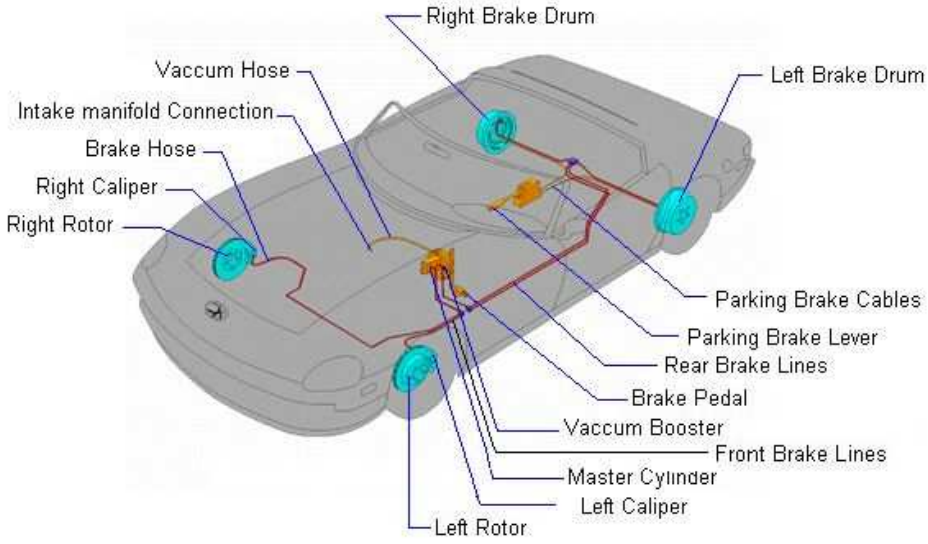
"rotor". The rear brakes are usually of the "drum" type. In these, the internal expanding brake "shoes" are forced against the inside machined surface of a rotating drum. In recent years, brakes have changed greatly in design. Disc brakes, due to their lighter weight and better performance, are replacing drum types on the rear wheels. Instead of linings which press outwards against the inside of a drum, a disc attached to the axle is gripped from either side by friction pads attached to the calipers. The greatest advantage of disc brakes is that they are essentially "fade" free. That is, repeated application does not result in excessively high temperatures developing in the linings and drums, lowering the stopping power of the brake. Commonplace on newer cars are "anti-lock" brake systems, (ABS) which prevent the wheels from completely stopping when the brakes are applied in a panic stop. As impressive as these advances are, the basic process of converting a vehicle's momentum into (wasted) heat has not changed since the days of horse and buggy. To stop carriages, the driver would pull on a lever which would rub on the wheel. But with the advent of brake-charging electric vehicles, a new braking equation is opening up the possibility of recapturing this lost energy, instead of warming the air with it. In modern electric cars, when you step on the brake the motor switches into "generator mode", and stores the car's momentum as chemical energy in the battery, to be used when the light turns green! In 1923, a Packard was the first car in America with four-wheel brakes. In 1927, four-wheel brakes were introduced in the Lincoln production cars.

Brake Drum

The brake drum is a heavy flat-topped cylinder, which is usually sandwiched between the wheel rim and the drive wheel. The inside surface of the drum is acted upon by the friction material of the brake shoes. When the brakes are applied, the friction material of the brake shoes is forced into contact with the brake drums to slow the rotation of the wheels. The friction between the tires and the road surface then slows the car's speed. Drum brakes are found on the rear wheels of most cars, but they are increasingly being fazed out in favor of rear disc brakes. Drum brakes were standard equipment on the front wheels of most cars until the early 70's.

Parking Brake

The parking brake is a brake system used to hold one or more brakes continuously in applied position. The parking brake employs the regular drum brakes on the rear wheel. Instead of hydraulic pressure, however, a simple mechanical linkage is used to engage the brake shoes. When the parking-brake pedal is depressed (or, in some cars, a hand lever is raised), a steel cable pulls taut a tension lever; other cables draw the brake shoes firmly against the drums. The release knob slackens the cables and disengages the brake shoes. The parking brake is self-adjusting. An automatic adjuster in the piston moves on the thrust screw to compensate for lining wear.



Braking Systems

Brake Lines

Brake lines are steel tubing with copper and lead coatings to prevent rust and corrosion. As the brake pedal is depressed, it moves pistons within the master cylinder and forcing hydraulic brake fluid throughout the brake system and into the wheel (or brake) cylinders. The pressure placed upon this fluid causes the cylinder pistons to move, forcing the brake shoes or friction pads and brake drums or rotors to slow the vehicle.

Brake Pedal

The brake pedal is located on the left side of the accelerator pedal. Stepping on this pedal begins the process of slowing down or stopping a vehicle. The pedal is solidly mounted to the firewall, and works as a force-multiplying lever. If the power assist fails, the pedal's leverage is designed to allow the driver to still generate thousands of pounds of pressure at each wheel cylinder. Attached to the piston within the master cylinder via a pushrod, the brake pedal is a most important item indeed, unless you're a crash dummy!

When the brake pedal is pressed, the brake shoes and friction pads are forced into contact with the brake drums and rotors to slow the rotation of the wheels. The friction between the tires and the road surface then slows the speed of the vehicle. A brake pedal should not sink more than an inch or two, no matter how hard it is pressed with the foot; and the driver should not feel as if he were stepping on a wet sponge: a spongy pedal spells trouble in the braking system.

ANY change in the "feel" of your brake pedal should be a cause for serious concern. With brakes, there is NO excuse for poor maintenance.

Brake Booster

A booster is a mechanical or vacuum device that is attached to the master cylinder in power brake systems. The function of the brake booster is to increase the power and effectiveness of brake systems. Vacuum boosters tap into the vacuum created by the engine, and use this to assist braking. In some systems, the booster is connected to the power steering system. In this case, the power steering pump supplies pressurized fluid to the booster cylinder.

All boosters are designed to assist braking force from the pedal, not to provide all of the braking force. This is done as a safety feature in case the engine quits, cutting off the booster's power supply. Some boosters use electrical motors to generate their power, which allows them to remain effective without the engine running.

Master Cylinder

The master cylinder displaces hydraulic brake fluid under pressure to the rest of the brake system. When the brake pedal is depressed, the push rod moves the primary piston forward in the cylinder. The hydraulic pressure created and the force of the primary piston spring moves the secondary piston forward. When the forward movement of the pistons causes their primary cups to cover the bypass holes, hydraulic pressure builds up and is transmitted to the wheel cylinders. When the pedal retracts, the pistons allow fluid from the reservoir to fill the chamber if needed. Special sensors within the master cylinder are used to monitor the level of the fluid in the reservoir, and to alert the driver if a pressure imbalance develops. The standard dual master cylinder gives the front and rear brakes separate hydraulic systems. If a brake fluid leak occurs in one system, the other system will still operate, making it possible to stop the car.

Vacuum Hoses and Motors

Vacuum lines are a series of hoses, or tubing, to the intake manifold. These hoses supply vacuum to various components of the engine, such as the emissions control system. Most air conditioning systems have vacuum motors to open and close the doors on the air conditioning ducts. A vacuum motor is just a small diaphragm with connecting rods to activate the valves of the system. They have the advantages of simplicity and quietness.

Intake Manifolds

An intake manifold is a system of passages, which conduct the fuel mixture from the carburetor to the intake valves of the engine. Manifold design has much to do with the efficient operation of an engine.

For smooth and even operation, the fuel charge taken into each cylinder should be of the same strength and quality. Distribution of the fuel should, therefore, be as even as possible. This depends greatly upon the design of the intake manifold. Dry fuel vapor is an ideal form of fuel charge, but present-day fuel prevents this unless the mixture is subjected to high temperature. If the fuel charge is heated too highly, the power of the engine is reduced because the heat expands the fuel charge. Therefore, it is better to have some of the fuel deposited on the walls of the cylinders and manifold vents. Manifolds in modern engines are designed so that the amount of fuel condensing on the intake manifold walls is reduced to a minimum. In a V-8 engine, the intake manifold is mounted between the cylinder heads. The L-head engine's manifold is bolted to the side of the block, and the I-head manifold is bolted to the cylinder head.

Brake Caliper

The brake caliper straddles the disc (rotor) and contains the hydraulic wheel cylinder(s). It is mounted firmly to the spindle, which allows it to deliver the torsional force of the wheel to the chassis via the control arms.

Single piston, sliding, or "floating caliper" disc brakes have been used on the front wheels of passenger cars for many years. With standard single piston calipers, the caliper "floats", or slides on its mounting bolts or pins to apply both friction pads to the machined surfaces of the rotating disc. The caliper's piston seals are designed to retract the piston enough to allow the pads to lightly contact the rotor without any drag. Some calipers have as many as four pistons actuating the friction pads. These calipers are fixed in place; i.e., there is no lateral movement.

Rotor (Disc)

The rotor is a parallel-faced circular plate, which is clamped by the pads in order to slow the vehicle. The rotor often has a series of vents, which allow it to be cooled by outside air.

The surfaces of the rotor are "turned" (machined) when the brake pads are replaced, in order to remove the "glazed" surface, which forms with extended use. The turning process also "trues" the disc, which eliminates the pulsations experienced when the rotor is warped. Warped rotors give a slight tugging when the brakes are applied. If the rotor has been turned several times, it may become too thin to resurface, and require replacement. Semi metallic pads give good performance, longer replacement intervals and reduced "fade", but they also wear down the rotor more quickly than organic (non-metallic) pads.

Brake Hoses

The master cylinder is connected to each wheel by brake lines and hoses. Brake hoses are specially constructed flexible tubes with metal ends for transmitting fluid under extreme pressure. The entire hydraulic system is filled with a special brake fluid, which is forced through the hoses by the movement of the master cylinder's pistons. If they appear cracked or brittle, the hoses should be replaced immediately. Close inspection of the brake hoses is a good way to prevent catastrophe!

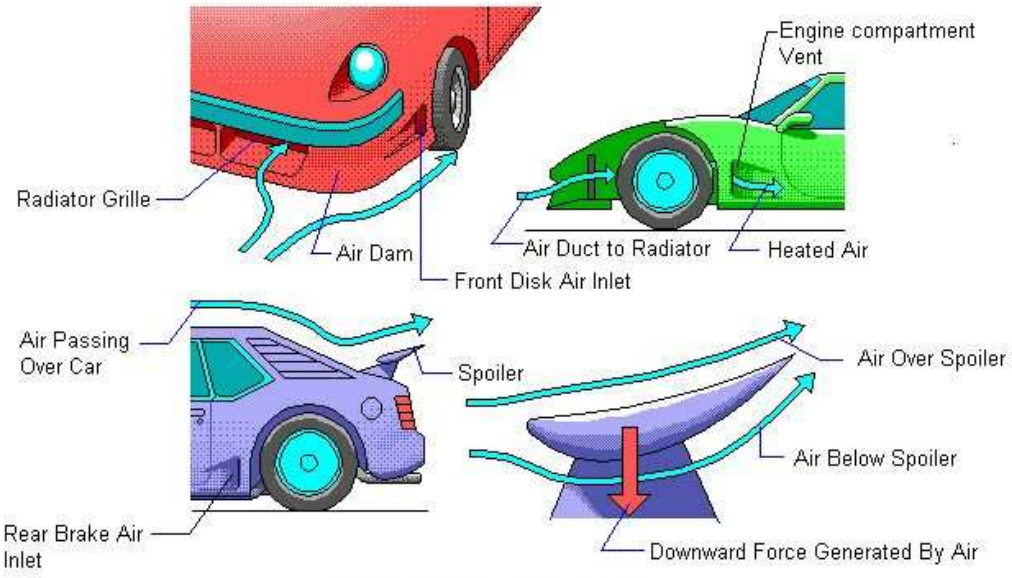
Aero Dynamic Body

Brake Cooling Ducts

In high performance cars, small brake cooling ducts are built into the bodywork near the front and/or rear wheels. On the air dam, the duct is a small opening. Behind the opening, a small tube runs to the backing plate. This allows cool air to be directed onto the brakes, increasing braking potential and reducing brake fade. Brakes tend to "fade" (lose their effectiveness) if they get hot. Lots of cars have very small sheet metal projections on the backing plate that serve as an air scoop for the front disc brakes.

Air Dam

An air dam is a projection of the body shell underneath the front of the chassis. Its function is to reduce the amount of air turbulence and drag underneath the car, and to channel air to the radiator.



Aero Dynamic Body

Radiator Grille

The radiator grille is the part of the body shell on the front of your car that covers the area where the air enters. The radiator grille can also be part of the bumper on some cars. The radiator is connected to the shroud for the radiator. The shroud directs the air that comes in through the radiator grille to the radiator only. This prevents the air from escaping around the radiator and failing to cool the engine. On newer cars, the radiator grille has been lowered to take advantage of lower hood lines, brought about by an effort to increase fuel efficiency. Older cars had massive grilles, whereas the cars now produced have smaller more aerodynamic grilles.

Spoiler

A spoiler is a kind of wing that is mounted on the rear of the car in a horizontal position. Its function is to provide high speed stability. For most cars, the spoiler is purely cosmetic; a car has to be going over 100 mph to take advantage of the aerodynamics of the spoiler. Some mini-vans also make use of a spoiler, but it's upside down, and angled. The purpose of this type of spoiler is simply to keep the rain off the rear window.

Heat Transfer

When air passes over an object, it can accumulate heat energy or deposit heat on the object. This is thermal convection in action. The radiator is designed to transfer the coolant's heat energy to the air. As air passes through the radiator, the heat in the coolant actually passes through the metal and is absorbed by the air. When the air reaches the far side of the radiator, it is at a greater temperature and the coolant is at a lower temperature because it dissipated its heat into the air. The same principle is at work within the transmission cooler of a radiator, if the car has an automatic transmission. The transmission fluid flowing through the cooler gives off it's heat to the coolant within the radiator, which then gives off it's heat to the air flowing through the radiator. Disc brakes and various other parts which need cooling dissipate heat directly into the air without using water. Some types of cars, such as Volkswagens, use air cooled engines. These eliminate the need for water by having more engine surface area through the use of cast fins. These allow the air to pass over a large surface area of the engine and thus transfer heat directly to the air. As your car travels down the road, the air that passes through the radiator grille either exits through the floor of the engine compartment, or it may pass out through the sides of the car, through what are known as gills. These side vents allow the air, which is compressed within the engine compartment to exit to an area which is of relatively low pressure rather than trying to force it under the car where there isn't as much room for it.

Radiator Shroud

If the fan that pulls air through the radiator core to cool the engine coolant is too far back, it will end up recirculating the same hot air that has collected behind the radiator. For this reason, the radiator often has a shroud. The radiator shroud prevents the recirculation of air around the fan. It is usually a plastic hood that encloses the fan to guide the air through the core, and stop it from coming back around and through the fan again. It also protects you from the fan blades!

Pop the Hood

Radiator Cap (Pressure Cap)

The radiator cap acts as more than just a "lid" for your radiator; it keeps your engine cool by sealing and pressurizing the coolant inside it. What makes the radiator cap special is that it is designed to hold the coolant in your radiator under a predetermined amount of pressure. If the coolant was not kept under pressure, it would start to boil, and soon you would have boiled all of your coolant away. However, the radiator (or pressure) cap prevents this from happening by exerting enough pressure to keep the coolant from boiling. Normally, water (coolant) boils at 212 degrees F, but if the pressure is increased, the boiling temperature is also increased. Since the boiling point goes up when the pressure goes up, the coolant can be safely heated to a temperature above 212 degrees F without boiling. What makes this important is that the higher the temperature of the coolant is, the greater the temperature gap between it and the air temperature is. This is the principle that causes the cooling system to work; the hotter the coolant is, the faster the heat in it moves to the radiator and the air passing by. So, a

cooling system under pressure takes heat away from the engine faster, which makes it more efficient. If your cooling system is under too much pressure, it can "blow its top"! To prevent this, the radiator cap has a pressure relief valve. The valve has a preset rating that allows it to take just up to a certain amount of pressure. When you turn the cap on the filler neck of the radiator, you seal the upper and lower sealing surfaces of the filler neck. The pressure relief valve spring is compressed against the lower seal when you lock the cap. The radiator filler neck has an overflow tube right between the two sealing surfaces. If the pressure in the cooling system exceeds the preset rating of your cap, its pressure relief valve allows the lower seal to be lifted from its seat. Then the excess pressure (coolant, air) can squish through the overflow tube to the ground or the coolant reservoir. Once enough pressure has been released (the caps preset rating), the pressure relief valve is again closed by the spring. The pressure cap can be tested with a cooling system pressure tester, using an adapter, to make certain that it is living up to its pressure rating. It should be replaced if it fails the test. Note: Most radiator pressure caps are not meant to be removed. Coolant should always be added through the expansion (overflow) tank. NEVER REMOVE THE RADIATOR CAP FROM A HOT ENGINE. REMOVING THE PRESSURE CAN CAUSE STEAM TO SHOOT OUT AND SERIOUSLY BURN YOU.

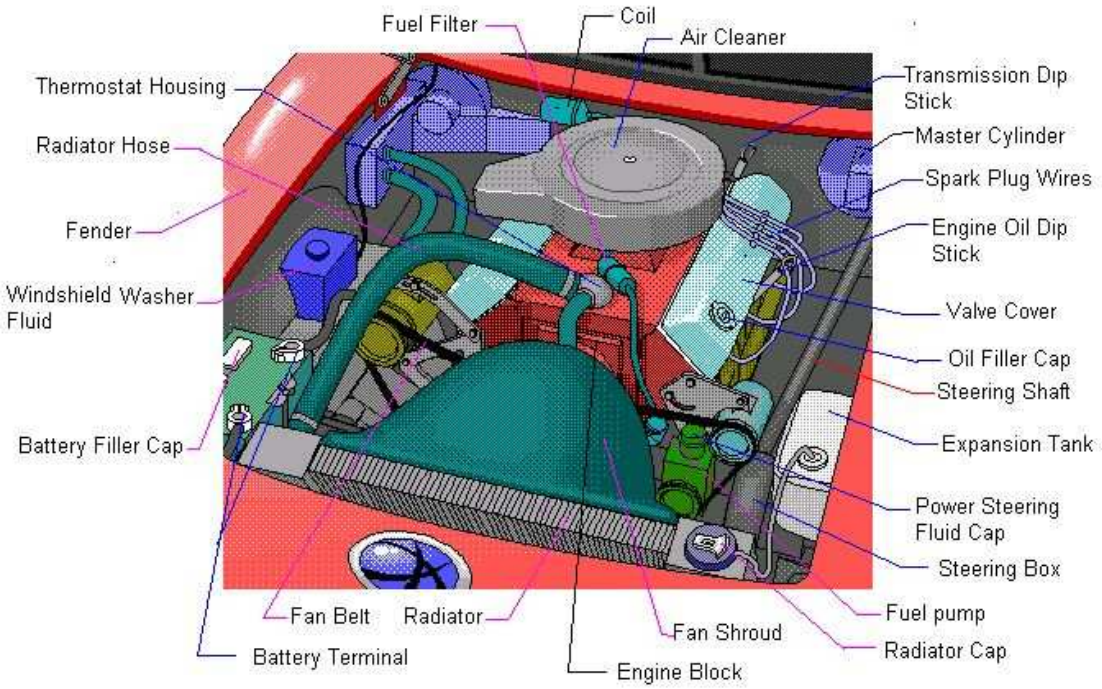
Manual Rack and Pinion Steering

A typical rack and pinion steering gear assembly consists of a pinion shaft and bearing assembly, rack gear, gear housing, two tie rod assemblies, an adjuster assembly, dust boots and boot clamps, and grommet mountings and bolts. When the steering wheel is turned, this manual movement is relayed to the steering shaft and shaft joint, and then to the pinion shaft. Since the pinion teeth mesh with the teeth on the rack gear, the rotary motion is changed to transverse movement of the rack gear. The tie rods and tie rod ends then transmit this movement to the steering knuckles and wheels.

Expansion (Overflow) Tank

Several cooling systems make use of a clear plastic container, which is connected to the overflow tube from the radiator. This container provides extra storage space for the coolant when it expands and is called the expansion, or overflow tank. It is also known as the coolant reservoir, or overflow canister. As the engine heats up, the coolant inside it expands. Without the expansion tank, the coolant would flow out of the overflow tube and be lost from the cooling system onto the street. Instead, the coolant flows into the expansion tank. Since a vacuum is created in the cooling system when the engine cools, the vacuum causes some of the coolant in the expansion tube to be sucked back into the system. Because a cooling system with an expansion tank is virtually a closed system, the coolant can flow between the system and the expansion tank as it expands and contracts. This way, no coolant is lost if the system is functioning properly. Another function of the expansion tank is to remove air bubbles from the cooling system. Coolant without air-bubbles is much more efficient than

coolant with air bubbles, because it absorbs heat much faster. The advantage of the expansion tank is that while the level of coolant contained in it rises and falls, the radiator is always full. Older cars can easily be fitted with expansion tanks, simply by mounting the tank near the radiator, connecting it to the overflow tube, and replacing the radiator cap.



Vane" Power Steering Pump

Several types of power steering pumps are in use. The "vane" pump uses a rotor with six to ten vanes which rotate in an elliptical pump ring. Fluid trapped between the vanes is forced out under pressure as the vanes move from the long diameter of the pump ring to the short diameter.

Mechanical Fuel Pump

The mechanical fuel pump differs in that it has a vacuum booster section. The vacuum section is operated by the fuel pump arm; otherwise, it has nothing to do with the fuel system. During the suction (or first) stroke, the rotation of the eccentric on the camshaft puts the pump operating arm into motion, pulling the lever and diaphragm down against the pressure of the diaphragm spring and producing suction (vacuum) in the pump chamber. The suction will hold the outlet valve closed and pull the inlet valve open, causing fuel to flow through the filter screen and down through the inlet valve of the pump chamber. During the return stroke, the diaphragm is forced up by the diaphragm spring, the inlet valve closes and the outlet valve opens to allow fuel to flow through the outlet to the carburetor. The operating lever is hinged to the pump arm, so that it can move

down but cannot be raised by the pump arm. The pump arm spring forces the arm to follow the cam without moving the lever. The lever can only be moved upward by the diaphragm spring. This process causes fuel to be delivered to the carburetor only when the fuel pressure in the outlet is less than the pressure maintained by the diaphragm spring. This happens when the passage of fuel from the pump into the carburetor float chamber is open and the float needle is not seated.

Steering Systems

The manual steering system incorporates: 1. steering wheel and column, 2. a manual gearbox and pitman arm or a rack and pinion assembly, 3. linkages; steering knuckles and ball joints; and 4. the wheel spindle assemblies. In Pittman arm systems, the movement inside the steering box causes the Pitman shaft and arm to rotate, applying leverage to the relay rod, which passes the movement to the tie rods. Power steering systems add a hydraulic pump; fluid reservoir; hoses; lines; and either a power assist unit mounted on, or integral with, a power steering gear assembly. There are several different manual steering gears in current use. The "rack and pinion" type is the choice of most manufacturers. The "recirculating ball" type is a past favorite because the balls act as a rolling thread between the wormshaft and the ball nut. Another manual steering gear once popular in imported cars is the "worm and sector" type. Other manual gears are the "worm and tapered pin steering gear" and the "worm and roller steering gear." The steering wheel and column are a major source of injury to the driver, and a range of energy-absorbing and non-intrusion designs have been developed. There is great variation in these designs, some of which are now thought to be not fully effective. Energy-absorbing columns have to serve two functions. First, they must stop the steering wheel and column from being pushed to the rear as the front of the car is crushed in an impact. Before such designs were invented, a common feature of driver injury was for the chest to be impaled by the steering column. The energy-absorbing column must also provide the driver with a tolerable impact as he moves forward and strikes the wheel with his chest. At that point in the crash, the column should build up the load on the driver's chest to a tolerable level, and then deform under that load to give a "ride-down" for the driver. Several design problems are presented in providing this system. One major problem is that collapse of the column due to the frontal crush of the car should not hinder its performance for providing ride-down for the driver's chest. The system must also be so designed that under crash conditions, the wheel stays in such a position that it will strike the driver's chest and not move upwards into the region of his face, or downwards into his abdomen.

Oil Filler Cap

The oil filler cap is a plastic or metal cap that covers an opening into the valve cover. It allows you to add oil when the dipstick indicates that you need it. Some cars have the crankcase vented through the filler cap. Oil which is added through the filler passes down through openings in the head into the oil sump at the bottom of the engine.

Valve Cover

The valve cover covers the valve train. The valve train consists of rocker arms, valve springs, push rods, lifters and cam (in an overhead cam engine). The valve cover can be removed to adjust the valves. Oil is pumped up through the pushrods and dispersed underneath the valve cover, which keeps the rocker arms lubricated. Holes are located in various places in the engine head so that the oil recirculates back down to the oil pan. For this reason, the valve cover must be oil-tight; it is often the source of oil leaks. The valve cover is often distorted on older cars, because at some point the valve cover screws were over-tightened, bending the valve cover. This happens because the valve cover is made of very thin sheet metal and cannot withstand the force of an over-tightened bolt. One way to determine if your valve cover is bent is to remove the gasket and put the valve cover back on to the cylinder head. When the valve cover and cylinder head come into contact, the cover should sit flat. If it rocks, it is bent. Cast aluminum valve covers cannot be straightened, they need to be replaced. Sheet metal valve covers can be straightened. A symptom of a bent or leaking valve cover is a pinching of the valve cover gasket. This means that the gasket is sealing one area and not sealing another area. This condition produces a leak; oil could be leaking down the side of the engine. Some valve covers are hard to access, because they are covered with other engine parts. Chronic valve cover leakage can sometimes be fixed by using two gaskets glued together instead of using just one.

Engine Oil Dip Stick

The engine oil dip stick is a long metal rod that goes into the oil sump. The purpose of the dip stick is to check how much oil is in the engine. The dip stick is held in a tube; the end of the tube extends into the oil sump. It has measurement markings on it. If you pull it out, you can see whether you have enough oil, or whether you need more by the level of oil on the markings.

Spark Plug Wires

The spark plug wire carries 20,000 or more volts from the distributor cap to the spark plug. Spark plug wires are made of various layers of materials. The fiber core, inside the spark plug wire carries the high voltage. The older design of spark plug wires used a metallic wire to carry the high voltage. This caused electrical interference with the radio and TV reception. Some spark plug wires have a locking connection at the distributor cap. The distributor cap must first be removed and the terminals be squeezed together, and then the spark plug wire can be removed from the distributor cap. To reduce interference with radio and TV reception, ignition systems are provided with resistance in the secondary circuit. Resistor spark plugs or special resistor type ignition cable may be used. To work effectively in modern ignition systems, it is important that the resistor

ignition cable is capable of producing a specifically designed resistance. The cable must also have enough insulation so that it can withstand heat, cold, moisture, oil, grease, and chafing. High tension electricity passing through a cable builds up a surrounding electrical field. The electrical field frees oxygen in the surrounding air to form ozone, which will attach to the rubber insulation if it is not properly protected. Ozone causes the rubber to deteriorate and lose its insulating qualities. Electrical losses will seriously weaken the spark at the plug gap.

Filler Cap (Brake Fluid Reservoir Cover)

The cap on the brake fluid reservoir has a hole for air, or is vented, to allow the fluid to expand and contract without creating a vacuum or causing pressure. A rubber diaphragm goes up and down with the fluid level's pressure, and keeps out any dust or moisture.

Transmission Fluid Dip Stick

The transmission fluid dip stick is a long metal rod that goes into the transmission. The purpose of the dip stick is to check how much transmission fluid is in the transmission. The dip stick is held in a tube; the end of the tube extends into the transmission. It has measurement markings on it. If you pull it out, you can see whether you have enough transmission fluid, or whether you need more by the level of fluid on the markings. Most manual transmissions do not have dipsticks, instead they use a filler hole which is at the same level as the correct oil level. When the oil is topped up or refilled, the mechanic simply adds oil until the filler hole's level is reached.

Air Filters

Paper-element air filters were first introduced in 1957. The air cleaner element is the disposable dry type, which is made up of a cylindrical cellulose fiber material, pleated to permit the greatest filter area. On each end of this cylinder, the fiber is embedded in end plates to provide an efficient dust seal. On each side of the fiber, rust resistant wire screen furnishes compressive strength. The fine mesh located on the inner screen also acts as a flame arrester in case of backfire. The fiber passes air through the filter with low restriction, but any dust or dirt in the air is deposited on the pleated outer surface. The filter fiber is flame proof and keeps its filtering efficiency under normal concentrations of gasoline vapors, engine oil and water vapor, but should be changed at normal lubrication periods. Air filters can be cleaned by blowing compressed air back through the filter, but the danger exists that small holes can be created by excessive pressure. For this reason, it is usually a good idea to simply replace the filter element. Some air filters are of the washable variety, and can therefore be washed clean and re-used. A good way to determine if your air filter is still OK is to look through the filter on a bright day. If you can't see the sun through the filter, it needs replacement.

Fuel Filter

Clean fuel is important, because of the many small jets and passages in the carburetor and openings in a fuel injector. To ensure this cleanliness, fuel filters are installed in the fuel line. Fuel filters can be located at any point between the fuel tank and the carburetor. One may be in the tank itself, in the fuel pump or in the carburetor. The most common placement is between the fuel tank and a mechanical fuel pump. In this case, the fuel enters a glass bowl and passes up through the filter screen and out through an outlet. Any water or solid material which is trapped by the filter will fall to the bottom of the glass bowl where it can be easily seen and removed. Dirt particles usually come from scales of rust in the tank cars, storage tanks or drums. Water comes from condensed moisture in the fuel tanks.

The Thermostat

Just like your body needs to warm up when you begin to exercise, your car's engine needs to warm up when it starts its exercise. The thermostat provides control for your engine's warm-up period. The thermostat is located between the engine and the radiator. This little temperature-sensitive spring valve stays closed during engine warm-up. When the thermostat is closed, it prevents coolant from leaving the engine and circulating through the radiator until the correct running temperature is reached. The correct running temperature for most engines is between 180 degrees F and 200 degrees F. When the right temperature is reached, the spring valve opens, allowing coolant to circulate through the radiator to be cooled-- almost like our bodies begin to perspire after we've warmed-up. The temperature at which the thermostat is designed to open is called its rating, and may be stamped on the body. The 180 Degrees F thermostat begins to open at (you guessed it!) 180 Degrees F and is fully opened at 200 degrees F. Different engines use different temperature thermostats. Some high range thermostats maintain engine operating temperatures above 200 degrees F. This causes the engine to burn up more pollutants and aids in emissions control. However the range for your thermostat depends on the type of your engine, load requirements, weather, and other variables. Most thermostats are the "pellet" type; the name comes from the wax pellet that expands as the engine coolant warms. The pellet's expansion forces the valve open. Thermostats occasionally get "stuck shut" which cuts off the cooling capacity of the radiator, at least partially. This often occurs after an engine has overheated for some other reason, such as when the water pump fails, or if a large coolant leak develops. For this reason, car makers usually place the thermostat in an accessible position. Depending on the air temperature, the engine should take from five to fifteen minutes to warm up. If your engine takes a long time to warm up, or if it always runs hot, you might need to test the thermostat. A malfunctioning thermostat can cause excessive engine wear and waste fuel. A good time to have your thermostat checked is just before summer or winter.

Cylinder Block and Crankcase

The engine cylinder block, or "block" is cast in one piece. Usually, this is the largest and most intricate single piece of metal in the automobile. Even when the

cylinders, cylinder heads, or cylinder sleeves are separate pieces, the crankcase is still the largest single part in the engine. Almost all of the engine parts are attached to the crankcase, directly or indirectly. The crankcase houses the crankshaft and often the camshaft as well. With the oil pan, which goes on the lower surface of the crankcase, it forms an oil-tight housing in which the rotating and reciprocating parts operate. The cylinder block is laced with coolant passages, called the "water jacket". The cylinder block is usually made of high grade cast iron with alloys to improve wear of the cylinders, but many are aluminum. Plastic blocks have been developed but are not yet used in production cars. This major unit must be extremely strong and rigid to avoid bending and stretching. It also varies in thickness and does not always cool uniformly to prevent warpage by internal stresses of the cylinder bores.

Radiator Hoses

Hoses are used to connect the engine and the water pump to the radiator. Radiator hoses are made of flexible rubber; size varies depending upon the type of engine. Smaller hoses run to the heater core, these are known as (you guessed it) heater hoses. Three types of hoses are; the common hose, the molded or shaped hose, and the accordion type hose. All of these hoses may have spiral wire in their construction. Spiral wire can be molded or inserted into the hoses, in the required shape, when the hose is constructed. The common hose is straight and cannot take much bending before collapsing. It is made of rubber with fabric reinforcement. Molded or shaped hoses are the same as the common hose with one exception. They will not collapse when bent, because all of the bends that they need are already molded into them. Accordion type hoses not only put up with all kinds of severe bending, but they also absorb some of the vibration between the engine and the radiator.

Radiator Shroud

If the fan that pulls air through the radiator core to cool the engine coolant is too far back, it will end up recirculating the same hot air that has collected behind the radiator. For this reason, the radiator often has a shroud. The radiator shroud prevents the recirculation of air around the fan. It is usually a plastic hood that encloses the fan to guide the air through the core, and stop it from coming back around and through the fan again. It also protects you from the fan blades!

Battery

The car's initial source of electricity is a battery, whose most important function is to start the engine. Once the engine is running, an alternator takes over to supply the car's electrical needs and to restore energy to the battery. A 12-volt storage battery consists of layers of positively and negatively charged lead plates that, together with their insulated separators, make up each of six two-volt cells. The cells are filled with an electricity-conducting liquid (electrolyte) that is usually two-thirds distilled water and one-third sulfuric acid. Spaces between the immersed

plates provide the most exposure to the electrolyte. The interaction of the plates and the electrolyte produces chemical energy that becomes electricity when a circuit is formed between the negative and positive battery terminals.

Windshield Washers

All cars use an electric pump-operated windshield washer with a positive displacement washer pump. On some, the motor is placed in the washer reservoir, while on others, it is driven by a wiper motor. When the pump is attached to the wiper motor, the four lobe cam starts a spring-loaded follower, but the pump does not operate all the time that the wiper motor is running. This is because the pumping mechanism is locked out and pumping action occurs. A plunger is pulled toward the coil, allowing the ratchet pawl to engage the ratchet wheel, which begins to rotate, one tooth at a time. Each lobe of the cam starts the follower. The follower moves the piston actuator plate and piston away from the valve assembly and compresses the piston spring, creating a vacuum in the pump cylinder through the intake valve. As the high point of each cam lobe passes the follower, the piston spring expands, forcing the piston toward the valves. This pressurizes the washer solution so it flows out the exhaust valves to the spray nozzles.

Coil

The coil is a compact, electrical transformer that boosts the battery's 12 volts to as high as 20,000 volts. The incoming 12 volts of electricity pass through a primary winding of about 200 turns of copper wire that raises the power to about 250 volts. Inside the distributor, this low-voltage circuit is continuously broken by the opening and closing of the points, each interruption causing a breakdown in the coil's electromagnetic field. Each time the field collapses, a surge of electricity passes to a secondary winding made up of more than a mile of hair-like wire twisted into 25,000 turns. At this point, the current is boosted to the high voltage needed for ignition and is then relayed to the rotor.

Fuel Systems

Fuel Filler Cap

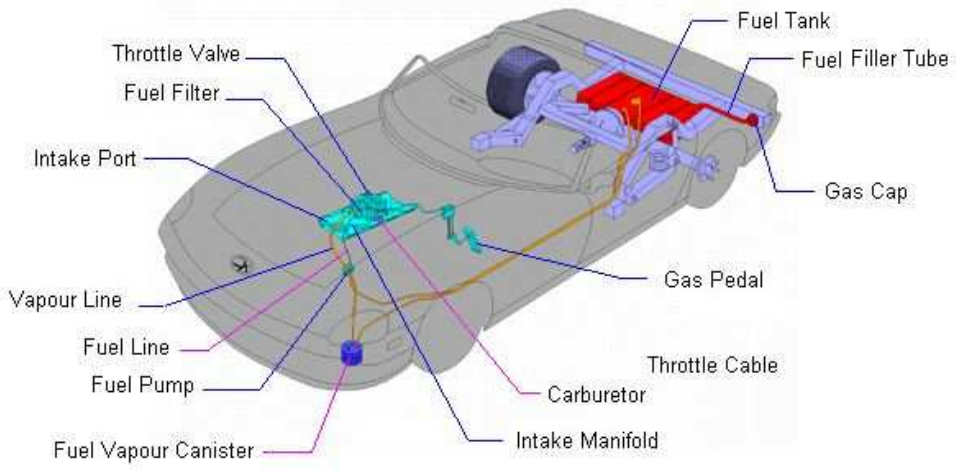
Although all of us know how to use the fuel filler cap, it is actually more complicated than it looks. Inside the fuel filler cap is a pressure release valve. This allows it to vent the fumes in the gas tank if they build up to predetermined levels. Until the fumes reach these levels, they are shunted through the charcoal canister which collects the fuel from the air before the air escapes. When the fumes build up above the predetermined (differing from car to car) threshold level of the fuel filler cap's pressure release valve, they are vented into the atmosphere. The fuel filler cap has a rubber flange around the neck. This flange should be inspected for cracks or inflexibility. If the flange does become cracked or inflexible, it should be replaced to keep the environment clean.

Fuel Tank Filler Neck

The fuel tank filler neck is a long tube that goes down to the center of the gas tank. It is also equipped with vapor return lines. Some filling stations collect the fuel vapor as you fill your car.

Fuel Tank

All modern fuel systems are fed through a pump, so the fuel tank is usually at the rear of the chassis under the trunk compartment. Some vehicles have a rear engine with the tank in the forward compartment. The fuel tank stores the excess fuel until it is needed for operation of the vehicle. The fuel tank has an inlet pipe and an outlet pipe. The outlet pipe has a fitting for fuel line connection and may be located in the top or in the side of the tank. The lower end is about one-half inch above the bottom of the tank so that collected sediment will not be flushed out into the carburetor. The bottom of the tank contains a drain plug so that tank may be drained and cleaned. The gas tank of the early cars was placed higher than the engine. The idea was that the gas would flow down to the engine. This arrangement caused a problem when the car went uphill -- the gas flowed away from the engine. Solution: drive up the hill backwards!



Fuel Systems

Gas Pedal

The gas, or accelerator, pedal is connected to the throttle valve by the throttle cable, or linkage. Pressing on the pedal causes the linkage to open the throttle

valve, and thereby increase engine speed. A return spring on the throttle valve returns the pedal to its normal position when foot pressure pedal is released.

Throttle Linkages

The throttle cable, or linkage, controls the throttle valve by connecting it to the accelerator pedal. Pressing on the pedal causes the linkage to open the throttle plate and the choke plate. This causes air to rush through the barrel.

Throttle Valve

All gasoline engines have a throttle valve to control the volume of intake air. The amount of fuel and air that goes into the combustion chamber regulates the engine speed and, therefore, engine power. The throttle valve is linked to the accelerator (gas pedal). The throttle valve is a butterfly valve that usually consists of a disc mounted on a spindle. The disc is roughly circular, and it has the same diameter as the main air passage in the throat or "venturi". In a carburetor, the throttle valve is usually located at the bottom of the carburetor, between the jet nozzle and the intake manifold. The throttle spindle is connected to the accelerator in such a manner that when the pedal is depressed, the valve opens. When the pedal is released, the valve closes. Fuel injected engines use throttle valves to regulate engine power, even though the fuel is also regulated through the injectors.

Carburetor

The purpose of the carburetor is to supply and meter the mixture of fuel vapor and air in relation to the load and speed of the engine. Because of engine temperature, speed, and load, perfect carburetion is very hard to obtain. The carburetor supplies a small amount of a very rich fuel mixture when the engine is cold and running at idle. With the throttle plate closed and air from the air cleaner limited by the closed choke plate, engine suction is amplified at the idle-circuit nozzle. This vacuum draws a thick spray of gasoline through the nozzle from the full float bowl, whose fuel line is closed by the float-supported needle valve. More fuel is provided when the gas pedal is depressed for acceleration. The pedal linkage opens the throttle plate and the choke plate to send air rushing through the barrel. The linkage also depresses the accelerator pump, providing added gasoline through the accelerator-circuit nozzle. As air passes through the narrow center of the barrel, called the "venturi", it produces suction that draws spray from the cruising-circuit nozzle. The float-bowl level drops and causes the float to tip and the needle valve to open the fuel line. To cause a liquid to flow, there must be a high pressure area (which in this case is atmospheric pressure) and a low pressure area. Low pressure is less than atmospheric pressure. The average person refers to a low pressure area as a vacuum. Since the atmospheric pressure is already present, a low pressure area can be created by air or liquid flowing through a venturi. The downward motion of the piston also creates a low pressure area, so air and gasoline are drawn through the carburetor and into the engine by suction created as the piston moves down, creating a partial vacuum in the cylinder. Differences between low pressure within the cylinder and

atmospheric pressure outside of the carburetor causes air and fuel to flow into the cylinder from the carburetor.

Fuel Filter

Clean fuel is important, because of the many small jets and passages in the carburetor and openings in a fuel injector. To ensure this cleanliness, fuel filters are installed in the fuel line. Fuel filters can be located at any point between the fuel tank and the carburetor. One may be in the tank itself, in the fuel pump or in the carburetor. The most common placement is between the fuel tank and a mechanical fuel pump. In this case, the fuel enters a glass bowl and passes up through the filter screen and out through an outlet. Any water or solid material which is trapped by the filter will fall to the bottom of the glass bowl where it can be easily seen and removed. Dirt particles usually come from scales of rust in the tank cars, storage tanks or drums. Water comes from condensed moisture in the fuel tanks.

Intake Manifolds

An intake manifold is a system of passages which conduct the fuel mixture from the carburetor to the intake valves of the engine. Manifold design has much to do with the efficient operation of an engine. For smooth and even operation, the fuel charge taken into each cylinder should be of the same strength and quality. Distribution of the fuel should, therefore, be as even as possible. This depends greatly upon the design of the intake manifold. Dry fuel vapor is an ideal form of fuel charge, but present-day fuel prevents this unless the mixture is subjected to high temperature. If the fuel charge is heated too highly, the power of the engine is reduced because the heat expands the fuel charge. Therefore, it is better to have some of the fuel deposited on the walls of the cylinders and manifold vents. Manifolds in modern engines are designed so that the amount of fuel condensing on the intake manifold walls is reduced to a minimum. In a V-8 engine, the intake manifold is mounted between the cylinder heads. The L-head engine's manifold is bolted to the side of the block, and the I-head manifold is bolted to the cylinder head.

Valve Ports

Valve ports are openings in the cylinder head. Intake ports let the fuel mixture into the cylinder head, and exhaust ports let the exhaust out.

Fuel Lines

Fuel lines, which connect all the units of the fuel system, are usually made of rolled steel or, sometimes, of drawn copper. Steel tubing, when used for fuel lines, is generally rust proofed by being copper or zinc plated. Fuel lines are placed as far away from exhaust pipes, mufflers, and manifolds as possible, so that excessive heat will not cause vapor lock. They are attached to the frame, the engine, and other units in such a way that the effect of vibration is minimal, and so that they are free of contact with sharp edges which might cause wear. In

areas where there is a lot of movement, as between the car`s frame and rubber-mounted engine, short lengths of gasoline resistant flexible tubing are used.

Mechanical Fuel Pump

The mechanical fuel pump differs in that it has a vacuum booster section. The vacuum section is operated by the fuel pump arm; otherwise, it has nothing to do with the fuel system. During the suction (or first) stroke, the rotation of the eccentric on the camshaft puts the pump operating arm into motion, pulling the lever and diaphragm down against the pressure of the diaphragm spring and producing suction (vacuum) in the pump chamber. The suction will hold the outlet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valve closed and pull the inlet valve open, causing fuel to flow through the filter screen and down through the inlet valve of the pump chamber. During the return stroke, the diaphragm is forced up by the diaphragm spring, the inlet valve closes and the outlet valve opens to allow fuel to flow through the outlet to the carburetor. The operating lever is hinged to the pump arm, so that it can move down but cannot be raised by the pump arm. The pump arm spring forces the arm to follow the cam without moving the lever. The lever can only be moved upward by the diaphragm spring. This process causes fuel to be delivered to the carburetor only when the fuel pressure in the outlet is less than the pressure maintained by the diaphragm spring. This happens when the passage of fuel from the pump into the carburetor float chamber is open and the float needle is not seated.

Fuel Vapor Canister

The fuel vapor canister is used by the vapor recovery system to trap fuel from the carburetor float bowl and fuel tank. Starting the engine causes the vacuum port in the canister to pull fresh air into the canister to clean out the trapped fuel vapor. The trapped fuel vapor is then fed into the carburetor to be burned.

Drive Train

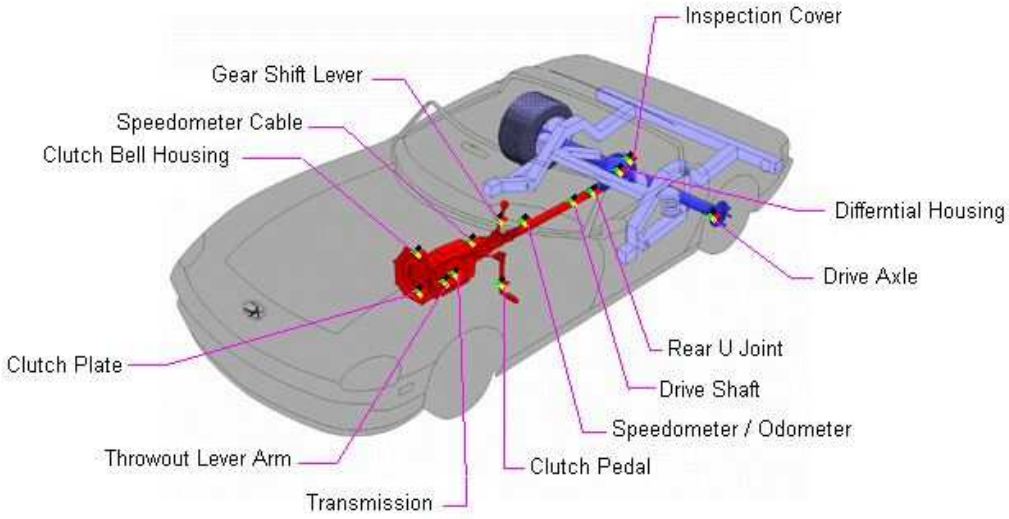
Drive Train (An Overview)

The drive train serves two functions: it transmits power from the engine to the drive wheels, and it varies the amount of torque. "Power" is the rate or speed at which work is performed. "Torque" is turning or twisting force. Multiple ratio gearboxes are necessary because the engine delivers its maximum power at certain speeds, or RPM (Rotations Per Minute). In order to use the same engine RPM's at different road speeds, it is necessary to change the "Gear Ratio" between the engine and the drive wheels. Just like a bicycle, the car has to switch gears in order to move at a wide range of speeds. Unlike your bicycle, the car's drivetrain also has to allow you to back up. (Well, you could push it backwards if you ate your Wheaties) There are actually two sets of gears in the drive train; the transmission and the differential. The transmission allows the gear ratio to be adjusted, and the differential lets the drive wheels turn at different speeds. Manual transmissions usually have four or five speeds, and often have "overdrive", which means that the output shaft can turn faster than the input shaft for fuel economy on the highway. Some use an electric clutch and a switch that controls whether the overdrive is engaged or not. An interesting development on a few cars is the "clutchless" manual transmission, which uses a stick shift and an automatic electric clutch. Speed and position sensors, mini computers, and throttle controls keep the engine from over-revving when the driver shifts gears. As with many automotive "inventions", this is an old idea which may now reach

feasibility due to the computer revolution. Automatic transmissions commonly use three forward gears to blend speed and torque. In the case of a three-speed transmission, first gear delivers maximum torque and minimum speed for starting. Second gear offers medium torque and speed for acceleration and hill climbing. Third gear allows maximum speed with minimum torque for highway travel. A reverse gear permits backward movement. A transmission is a speed and power changing device installed at some point between the engine and driving wheels of a vehicle. It provides a means for changing the ratio between engine RPM (Revolutions Per Minute) and driving wheel RPM to best meet each particular driving situation. Some types of drive train layouts use a "Transaxle", which is simply a combination of the transmission and the differential. These are usually found on front wheel drive cars, but are also used on mid- and rear-engine cars. Some exotic cars have their engine in the front, and a transaxle in the rear of the car for better weight balance. Torque is derived from power. The amount of torque obtainable from a source of power is proportional to the distance from the center of rotation at which it is applied. It is logical, then, that if we have a shaft (in this case, the crankshaft) rotating at any given speed, we can put gears of different sizes on the shaft and obtain different results. If we put a large gear on the shaft, we will get more speed and less power at the rim than with a small gear. If we place another shaft parallel to our driving shaft and install gears on it in line with those on the driving shaft, we can obtain almost any desired combination of speed or power within the limits of the engine's ability. That is exactly what an automobile transmission does by means of gears and other devices. There are two types of transmissions; manual and automatic. If you have a manual transmission, you have to shift the gears yourself, usually with a stick located on your console and the clutch pedal. If you have an automatic transmission, the mechanism changes without any help from you. This is accomplished through a system that works by oil pressure. Each shift of the gears is controlled by a shift valve; the gears shift change depending on speed, the road, and load conditions. Another basic component of all drive trains is some form of a clutch. it allows the engine to continue rotating while the gears and wheels are stationary. Automatic transmission cars use a "torque converter" in lieu of a clutch. From the back of the engine to where the rubber meets the road, the drivetrain encompasses one of the most complicated systems of your car. Some people say looking at a transmission "makes their brain hurt".

Drive Wheel/Axle

The drive wheel is the end of the axle shaft; it has lugs protruding from it. The lugs are separate pieces that are mounted in the drive wheel. The drive wheel bolts onto the brake drum and the wheel rim of the car itself. It is usually a disc about six or seven inches in diameter. Occasionally the drive wheel and the axle shaft are all one piece.



Drive Train

Differential Inspection Cover

The differential inspection cover is mounted to the rear end of the differential housing. It has to be removed for inspection of the rear end components. It is usually mounted by ten or twelve bolts. It usually has a drain plug halfway up the back of the inspection cover. This is used both as an indicator of the capacity of the rear end and as a filling point. When the rear end is filled with oil, it comes up to the level of the drain plug.

The Differential

The differential is the thing that works both drive axles at the same time, but lets them rotate at different speeds so that the car can make turns. When a car makes a turn, the outer wheel has to turn faster than the inner wheel, due to the difference in the length of the paths they take. The differential is located between the two wheels, and is attached to each wheel by a half-shaft rotated through a bevel gear. Four-wheel drive cars have a separate differential for each pair of wheels. A grooved, or splined, axle side gear is positioned on the splined end of each axle. The side gears are driven by "spider" gears, which are little gears mounted on a shaft attached to the differential case. As it is supported by the differential case, the side gear can turn inside the case. The differential case can be turned, revolving around the axle gears. The differential pinion (a pinion is a small gear that either drives a larger gear or is driven by one) shaft turns the ring gear, which is fastened to the differential case. The propeller shaft (drive shaft) connects the transmission output shaft to the differential pinion shaft. The turning differential case is mounted on two large bearing holders. These bearings are

called carrier bearings. The propeller shaft rotates the ring gear pinion, and the pinion turns the ring gear. The ring gear then turns the differential case and pinion shaft, but the axle side gears will not turn. By passing the differential pinion shaft through two differential pinion gears that mesh with the side gears, the case will turn and the axle side gears will turn with it. During turns, the side gears turn at rates dictated by the radius of the turns, and the spider gears then turn to allow the outer wheel to turn faster than the inner one.

The Universal Joint (U-joint)

The Universal joint (U-joint) is used to connect the drive shaft to the transmission output shaft and the differential pinion gear shaft. This joint must be flexible enough to allow changes in the driving angle (road incline) and the drive shaft. This way, the torque is constantly transmitted when the rear axle is moving up and down. Smaller U-joints are used to route the turning motion of the steering wheel through the steering column to the steering box. There are two types of U-joints, the cross and roller type and the ball and trunnion type. The cross and roller type is used the most; it allows the drive shaft to bend. The ball and trunnion type less frequently used; it allows the drive shaft to bend and also permits backward and forward motion of the drive shaft.

Speedometer and Odometer

The analog speedometer used on cars indicates the speed of the car and records the distance the car has traveled. A speedometer is driven by a flexible cable connected to the speedometer pinion in the transmission. Speedometers are calibrated in miles per hour and/or in kilometers. The instrument also records the distance traveled, recorded in miles or kilometers. That portion of the instrument is known as the odometer. Most odometers record the total distance traveled. Some also record the distance of individual trips. These can be reset to zero. The speedometer and odometer are driven by a cable in a casing. The cable is connected to a gear at the transmission. This gear is designed for a specific model, tire size, and rear axle ratio. The speed indication of an analog speedometer works on the magnetic principle. It includes a revolving permanent magnet driven by the cable connected to the transmission. The magnet sets up a rotating magnetic field which exerts a pull on the speed cup, making it revolve in the same direction. The movement of the speed cup is slowed and held steady by a hairspring attached to the spindle of the speed cup. The speed cup comes to rest where the magnetic drag is just balanced by the retarding force created by the hairspring. The hairspring also pulls the pointer of the instrument back to zero when the magnet stops rotating. As the speed of the magnet increases, due to movement of the car, the magnet drag on the speed cup increases and pulls the speed cup further around. In that way, a faster speed is indicated by the pointer on the face of the dial. The magnetic field is constant, and the amount of movement of the speed cup is always proportional to the speed at which the magnet is being rotated.

Gear Shift Mechanism

What causes the transmission to shift? It's shifted by shifter forks, also known as sliding yokes. These resemble the oarlocks you find in a row boat. and they ride in a groove in the clutch sleeve and sliding gear. Shifter forks are connected to a cam and shaft assembly. The cam assembly is kept in the selected gear by spring loaded steel balls that jump through notches (in the cam assembly) and hold the shifter forks in that gear. The shafts (of the cam and shaft assembly) go through the housing and are fastened to shift levers. The shifter forks move the synchronizers which engage the gears to the shafts they ride on. The shift levers are connected to a control on the steering column or a shift stick located on the floor. Both of these are powered by -- you!

Speedometer Cable

The speedometer cable is connected to the gearbox output shaft, the transmission shaft, or differential. The rotation of these shafts is used to measure the speed and record mileage. This information is sent back through the cable where it is recorded on the speedometer. The speedometer and odometer are driven by a cable housed in a flexible casing. This cable is connected to a gear in the transmission. Speedometer cables break as the result of age, lack of lubrication, or because the cable casing has sharp bends. It also breaks from too much friction in the speedometer head.

The Clutch Pedal, Cables and Levers

One way to activate the throw-out fork of the clutch is by using a system of levers and cables. These levers and cables are connected between the clutch pedal and the throw-out fork. When you press the clutch pedal with your foot, the pressure is transmitted to the fork through the cable and lever arrangement.

Manual Transmission

The manual transmission provides a means of varying the relationship between the speed of the engine and the speed of the wheels. Varying these gear ratios allows the right amount of engine power at many different speeds. Manual transmissions require use of a clutch to apply and remove engine torque to the transmission input shaft. The clutch allows this to happen gradually that so that the car can be started from a complete stop. Modern manual transmissions do not disengage any of the forward drive gears, they are simply connected to their shafts through the use of "synchronizers". Reverse is achieved through reverse idler gears, which are engaged to move the car backwards. Some manual transmissions have an "overdrive." An overdrive is a mechanical unit bolted to the rear of the transmission. It is usually known as fifth gear. When you use it, it will reduce the engine speed by about one-third, while maintaining the same road speed. Chrysler came out with the first overdrive transmission in 1934.

The Clutch Pedal, Cables and Levers

One way to activate the throw-out fork of the clutch is by using a system of levers and cables. These levers and cables are connected between the clutch pedal

and the throw-out fork. When you press the clutch pedal with your foot, the pressure is transmitted to the fork through the cable and lever arrangement.

Clutch Bell Housing

The clutch bell housing is a stamped or cast metal part which houses the clutch and connects the transmission housing to the back of the engine. The clutch bell housing has a pivot point mounted to it where the clutch throw-out bearing lever arm is mounted.

The Clutch Plate

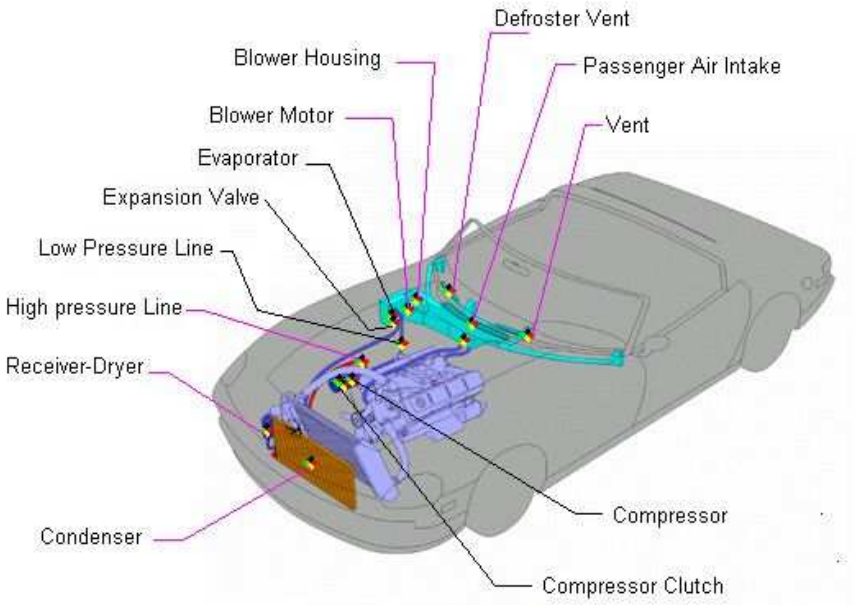
The clutch plate is a thin, steel, disc. Its center is connected to the transmission input shaft by a grooved piece of metal, or hub. The disc is covered with material that is similar to the break linings. This material allows the clutch to slip smoothly and quietly.

AC/Heat Systems

The Air Conditioning and Heating System

Not only do we depend on our cars to get us where we want to go, we also depend on them to get us there without discomfort. We expect the heater to keep us warm when it's cold outside, and the air conditioning system to keep us cool when it's hot. We get heat from the heater core, sort of a secondary radiator, which is part of the car's cooling system. We get air conditioning from the car's elaborate air conditioning system. Despite its relatively small size, the cooling system has to deal with an enormous amount of heat to protect the engine from friction and the heat of combustion. The cooling system has to remove about 6,000 BTU of heat per minute. This is a lot more heat than we need to heat a large home in cold weather. It's good to know that some of this heat can be put to the useful purpose of keeping us warm. Air conditioning makes driving much more comfortable in hot weather. Your car's air conditioner cleans and dehumidifies (removes excess moisture), the outside air entering your car. It also has the task of keeping the air at the temperature you select. These are all big jobs. How do our cars keep our "riding environment" the way we like it? Most people think the air conditioning system's job is to add "cold" air to the interior of the car. Actually, there is no such thing as "cold," just an absence of heat, or less heat than our bodies are comfortable with. The job of the air conditioning system is really to "remove" the heat that makes us uncomfortable, and return the air to the car's interior in a "un-heated" condition. Air conditioning, or cooling, is really a process of removing heat from an object (like air). A compressor circulates a liquid refrigerant called Refrigerant-12 (we tend to call it "Freon," a trade name, the way we call copy machines "Xerox" machines). The compressor moves the Refrigerant-12 from an evaporator, through a condenser and expansion valve, right back to the evaporator. The evaporator is right in front of a fan that pulls the hot, humid air out of the car's interior. The refrigerant makes the hot air's moisture condense into drops of water, removing the heat from the air. Once the

water is removed, the "cool" air is sent back into the car's interior. Aaaaaah! Much better. Sometimes we worry when we catch our car making a water puddle on the ground, but are relieved to discover that it's only water dripping from the air conditioning system's condenser (no color, no smell, and it dries!). Note: Refrigerant-12 is extremely dangerous. Many special precautions must be taken when it is present. It can freeze whatever it contacts (including your eyes), it is heavier than air and can suffocate you, and it produces a poisonous gas when it comes in contact with an open flame.



AC / Heat Systems

The Heater Core

The heater core is a smaller version of the radiator that is used to keep your toes warm when it's cold outside. The heater core is mounted under the dash board. Some of the hot coolant is routed through this little radiator, by more hoses. A small electric fan is also mounted there especially for the purpose of directing the heat inside the car. To turn this fan on, you use a switch called "fan" or "blower," located on your control panel. The principle is exactly the same as the one used in the radiator for your engine, except that the heat is released inside the car instead of outside. Most engines use the heater core to warm the air coming from the air conditioner if the dash setting is not on "cold". More efficient designs don't do this because it makes the engine work harder than it has to. They cycle the compressor on and off to lessen the cooling output. If your car is running hot, turning the heater on will help to reduce the heat in the engine. Unfortunately, most cars don't overheat in the winter.

Heater/AC Blower Motor

The blower motor is the motor that turns the electric fan in an air conditioning or heating system.

The Evaporator

The evaporator is a long tube, or coil, that goes back and forth through a multitude of cooling fins. It is quite similar to the condenser in structure. The refrigerant is a liquid when it enters the evaporator. A fan blows warm air over the evaporator. The warm air causes the liquid refrigerant to boil. This means that it absorbs the heat from the warm air. Once it has absorbed the heat from the warm air, the warm air isn't warm anymore. The same blower that blows the warm air (that is now "cool" air) over the evaporator, keeps on blowing it into the interior of your car, and you have -- air conditioning! The evaporator also removes the moisture from the air coming through its fins and turns it into water. The water just drains off. The temperature of the evaporator coil can go from 33 degrees F to 0 degrees F. If it goes below 32 degrees F, the moisture that's supposed to drain off the coils will freeze. This makes for a very (surprise!) inefficient system, so a thermostatic switch is used to connect and disconnect it to the compressor as necessary.

Expansion Valve

The expansion valve determines the correct amount of refrigerant going into the evaporator, and it lowers the valve, the refrigerant is correctly pressurized. As the evaporator calls for more refrigerant, the expansion valve allows the required amount of low pressure liquid refrigerant into the coils. The expansion valve maintains the delicate balance between the heat load and the cooling efficiency of the evaporator. pressure of the refrigerant. When the compressor starts, the expansion valve opens and the liquid refrigerant flows through a strainer in the high pressure liquid inlet. Once in the expansion

Low Pressure Line

The low pressure line is a hose, or tube containing refrigerant that connects the evaporator to the air conditioning system's compressor. The compressor draws the low pressure refrigerant from the evaporator in through the low pressure line in order to compress it.

High Pressure Line

The high pressure line is a hose, or tube containing refrigerant that connects the air conditioning system's compressor to the condenser. The compressor forces the compressed refrigerant into the condenser through the high pressure line.

The Compressor

The compressor used to air condition your car works in a similar way to the one in the refrigerator in your kitchen. The job of the compressor is to move liquid

refrigerant around in a pipe. The compressor pumps, or forces, the liquid from the evaporator into a condenser and expansion valve, and then back to the evaporator. There are three common types of compressors: Two cylinder reciprocating piston type Four cylinder RADIAL type Six cylinder AXIAL type The engine drives the compressor with a belt. In action, the compressor takes the low pressure refrigerant from the evaporator and compresses it according to speed and air temperature. The inlet side is known as the low (pressure) side and the outlet side is known as the high (pressure) side. The compressor compresses the refrigerant, and raises its temperature higher than that of the surrounding air. Then, the compressor forces the refrigerant into the condenser.

Compressor Clutch

The air conditioning compressor has an electromagnetic clutch that can engage or disengage the compressor pulley. The compressor pulley always turns when the engine is running, but the compressor only runs when the pulley is engaged to the compressor driving shaft. When this system is activated, current runs through the electromagnetic coil. The current attracts it to the armature plate. The strong magnetic pull draws the armature plate against the side of the turning pulley. This locks the pulley and the armature plate together; the armature plate drives the compressor. When the system is deactivated, and current stops running through the electromagnetic coil, flat springs pull the armature plate away from the pulley. The magnetic coil does not turn since its magnetism is transmitted through the pulley to the armature. The armature plate and hub assembly are fastened to the compressor drive shaft. When it's not driving the compressor, the clutch pulley turns on a double row of ball bearings.

Compressor Belt

The compressor is engine driven by a belt on the front of the crankshaft.

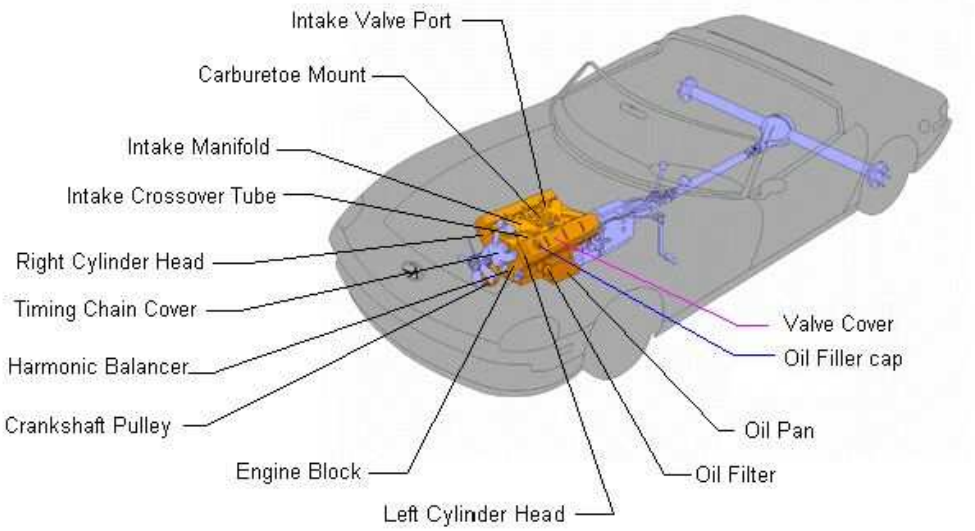
The Condenser

The condenser is a long tube that goes back and forth through a multitude of cooling fins, quite similar to the evaporator in structure. The condenser is mounted in front of the radiator to take advantage of the forced air provided by the fan and the motion of the car. As the highly pressurized refrigerant (vapor) flows into the condenser, it gives off heat and warms the condenser. This causes the condenser to be hotter than the forced air coming through the condenser. The condenser hands its heat off to the forced air and turns the refrigerant back into cool liquid in the expansion valve, where it heads back to the evaporator.

Engine Systems

The Engine System (An Overview)

The internal combustion engine burns fuel within the cylinders and converts the expanding force of the combustion or "explosion" into rotary force used to propel the vehicle. There are several types of internal combustion engines: two and four cycle reciprocating piston engines, gas turbines, free piston, and rotary combustion engines. The four cycle reciprocating engine has been refined to such a degree that it has almost complete dominance in the automotive field. The engine is the heart of the automobile. It converts fuel into the energy that powers the automobile. To operate, it requires clean air for the fuel, water for cooling, electricity (which it generates) for igniting the fuel, and oil for lubrication. A battery and electric starter get it going. Charles and Frank Duryea built the first American automobile in 1892. In the winter of 1895/96 they produced 13 Duryeas, which became the first horseless carriages regularly manufactured in the United States. In 1900, at the first National Automobile Show in New York City, visitors overwhelmingly chose the electric car. Most people thought the gasoline engine would never last. One critic of the engine wrote that it was noisy, unreliable, and elephantine; that it vibrated so violently as to "loosen one's dentures." He went on to give the opinion that the gasoline motor would never be a factor in America's growing automobile industry. People were afraid that gasoline engines would explode. Motorweek magazine referred to them as "explosives." At the show, a bucket brigade was standing by every time an "explosive," was cranked. However, just three years later, at the same show, the number of cars with four-stroke internal combustion gasoline engines had risen sharply. Each "cylinder" of the typical car engine has a "piston" which moves back and forth within the cylinder (this is called "reciprocating"). Each piston is connected to the "crankshaft" by means of a link known as a "connecting rod".



Engine Systems

Valve Ports

Valve ports are openings in the cylinder head. Intake ports let the fuel mixture into the cylinder head, and exhaust ports let the exhaust out.

Carburetor

The purpose of the carburetor is to supply and meter the mixture of fuel vapor and air in relation to the load and speed of the engine. Because of engine temperature, speed, and load, perfect carburetion is very hard to obtain. The carburetor supplies a small amount of a very rich fuel mixture when the engine is cold and running at idle. With the throttle plate closed and air from the air cleaner limited by the closed choke plate, engine suction is amplified at the idle-circuit nozzle. This vacuum draws a thick spray of gasoline through the nozzle from the full float bowl, whose fuel line is closed by the float-supported needle valve. More fuel is provided when the gas pedal is depressed for acceleration. The pedal linkage opens the throttle plate and the choke plate to send air rushing through the barrel. The linkage also depresses the accelerator pump, providing added gasoline through the accelerator-circuit nozzle. As air passes through the narrow center of the barrel, called the "venturi", it produces suction that draws spray from the cruising-circuit nozzle. The float-bowl level drops and causes the float to tip and the needle valve to open the fuel line. To cause a liquid to flow, there must be a high pressure area (which in this case is atmospheric pressure) and a low pressure area. Low pressure is less than atmospheric pressure. The average person refers to a low pressure area as a vacuum. Since the atmospheric pressure is already present, a low pressure area can be created by air or liquid flowing through a venturi. The downward motion of the piston also creates a low pressure area, so air and gasoline are drawn through the carburetor and into the engine by suction created as the piston moves down, creating a partial vacuum in the cylinder. Differences between low pressure within the cylinder and atmospheric pressure outside of the carburetor causes air and fuel to flow into the cylinder from the carburetor.

Valve Cover

The valve cover covers the valve train. The valve train consists of rocker arms, valve springs, push rods, lifters and cam (in an overhead cam engine). The valve cover can be removed to adjust the valves. Oil is pumped up through the pushrods and dispersed underneath the valve cover, which keeps the rocker arms lubricated. Holes are located in various places in the engine head so that the oil recirculates back down to the oil pan. For this reason, the valve cover must be oil-tight; it is often the source of oil leaks. The valve cover is often distorted on older cars, because at some point the valve cover screws were over-tightened, bending the valve cover. This happens because the valve cover is made of very thin sheet metal and cannot withstand the force of an over-tightened bolt. One way to determine if your valve cover is bent is to remove the gasket and put the valve cover back on to the cylinder head. When the valve cover and cylinder head come into contact, the cover should sit flat. If it rocks, it

is bent. Cast aluminum valve covers cannot be straightened, they need to be replaced. Sheet metal valve covers can be straightened. A symptom of a bent or leaking valve cover is a pinching of the valve cover gasket. This means that the gasket is sealing one area and not sealing another area. This condition produces a leak; oil could be leaking down the side of the engine. Some valve covers are hard to access, because they are covered with other engine parts. Chronic valve cover leakage can sometimes be fixed by using two gaskets glued together instead of using just one.

Intake Manifolds

An intake manifold is a system of passages which conduct the fuel mixture from the carburetor to the intake valves of the engine. Manifold design has much to do with the efficient operation of an engine. For smooth and even operation, the fuel charge taken into each cylinder should be of the same strength and quality. Distribution of the fuel should, therefore, be as even as possible. This depends greatly upon the design of the intake manifold. Dry fuel vapor is an ideal form of fuel charge, but present-day fuel prevents this unless the mixture is subjected to high temperature. If the fuel charge is heated too highly, the power of the engine is reduced because the heat expands the fuel charge. Therefore, it is better to have some of the fuel deposited on the walls of the cylinders and manifold vents. Manifolds in modern engines are designed so that the amount of fuel condensing on the intake manifold walls is reduced to a minimum. In a V-8 engine, the intake manifold is mounted between the cylinder heads. The L-head engine's manifold is bolted to the side of the block, and the I-head manifold is bolted to the cylinder head.

The Cylinder Head

The cylinder head is the metal part of the engine that encloses and covers the cylinders. Bolted on to the top of the block, the cylinder head contains combustion chambers, water jackets and valves (in overhead-valve engines). The head gasket seals the passages within the head-block connection, and seals the cylinders as well. Henry Ford sold his first production car, a 2-cylinder Model A, on July 23, 1903.

Timing Chain/belt

The automobile engine uses a metal timing chain, or a flexible toothed timing belt to rotate the camshaft. The timing chain/belt is driven by the crankshaft. The timing chain, or timing belt is used to "time" the opening and closing of the valves. The camshaft rotates once for every two rotations of the crankshaft.

Crankshaft

The crankshaft converts the up and down (reciprocating) motion of the pistons into a turning (rotary) motion. It provides the turning motion for the wheels. It works much like the pedals of a bicycle, converting up-down motion into rotational motion. The crankshaft is usually either alloy steel or cast iron. The

crankshaft is connected to the pistons by the connecting-rods. Some parts of the shaft do not move up and down; they rotate in the stationary main bearings. These parts are known as journals. There are usually three journals in a four cylinder engine.

Cylinder Block and Crankcase

The engine cylinder block, or "block" is cast in one piece. Usually, this is the largest and most intricate single piece of metal in the automobile. Even when the cylinders, cylinder heads, or cylinder sleeves are separate pieces, the crankcase is still the largest single part in the engine. Almost all of the engine parts are attached to the crankcase, directly or indirectly. The crankcase houses the crankshaft and often the camshaft as well. With the oil pan, which goes on the lower surface of the crankcase, it forms an oil-tight housing in which the rotating and reciprocating parts operate. The cylinder block is laced with coolant passages, called the "water jacket". The cylinder block is usually made of high grade cast iron with alloys to improve wear of the cylinders, but many are aluminum. Plastic blocks have been developed but are not yet used in production cars. This major unit must be extremely strong and rigid to avoid bending and stretching. It also varies in thickness and does not always cool uniformly to prevent warpage by internal stresses of the cylinder bores.

Harmonic Balancer (Vibration Damper)

The harmonic balancer, or vibration damper, is a device connected to the crankshaft to lessen the torsional vibration. When the cylinders fire, power gets transmitted through the crankshaft. The front of the crankshaft takes the brunt of this power, so it often moves before the rear of the crankshaft. This causes a twisting motion. Then, when the power is removed from the front, the halfway twisted shaft unwinds and snaps back in the opposite direction. Although this unwinding process is quite small, it causes "torsional vibration." To prevent this vibration, a harmonic balancer is attached to the front part of the crankshaft that's causing all the trouble. The balancer is made of two pieces connected by rubber plugs, spring loaded friction discs, or both. When the power from the cylinder hits the front of the crankshaft, it tries to twist the heavy part of the damper, but ends up twisting the rubber or discs connecting the two parts of the damper. The front of the crank can't speed up as much with the damper attached; the force is used to twist the rubber and speed up the damper wheel. This keeps the crankshaft operation calm.

Valve Cover

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Recycling Oil

People who change their own automobile oil remove at least 200 million gallons of oil each year. This oil is still useful, if it is recovered, but only about 10%% of it is recovered and recycled. Usually, the oil gets thrown in the trash in containers, or poured out someplace where it can find its way into our drinking water. This is not only a problem, but a waste, since the oil can be cleaned up and used again. Not only does this oil find its way back to our sources of drinking water, it also pollutes our lakes and streams. Used oil should be put in leak-proof containers. Different states have different ways of dealing with the oil to be recycled, but in general there are always places to drop off your used oil. If you don't know of one, call your local garage, or call your city or county to find out how you can have your old oil reclaimed and recycled. If you don't have time to let your fingers do the walking, at least ask your mechanic for ideas. Oil is a valuable resource; wars are fought over it. Don't let it be lost for its proper use, and instead be put to the use of ruining the environment.

Oil Filter

Oil filters are placed in the engine's oil system to strain dirt and abrasive materials out of the oil. The oil filter cannot remove things that dilute the oil, such as gasoline and acids. Removing the solid material does help cut down on the possibility of acids forming. Removing the "grit" reduces the wear on the engine parts. Modern passenger car engines use the "full flow" type of oil filters. With this type of filter, all of the oil passes through the filter before it reaches the engine bearings. If a filter becomes clogged, a bypass valve allows oil to continue to reach the bearings. The most common type of oil filter is a cartridge type. Oil filters are disposable; at prescribed intervals, this filter is removed, replaced and thrown away. Most states now require that oil filters be drained completely before disposal, which adds to the cost of an oil change, but helps to reduce pollution.

Oil Pan

At the bottom of the crankcase is the container containing the lifeblood of the engine. Usually constructed of thin steel, it collects the oil as it flows down from the sides of the crankcase. The pan is shaped into a deeper section, where the oil pump is located. At the bottom of the pan is the drain plug, which is used to drain the oil. The plug is often made with a magnet in it, which collects metal fragments from the oil.

Liquiefied Petroleum Gas (LPG-Natural Gas)

A mixture of gaseous petroleum compounds, principally butane and propane, together with smaller quantities of similar gases, is known as liquified petroleum gas (LPG). LPG is used as fuel for internal combustion engines, mostly in the truck and farm tractor fields. It is chemically similar to gasoline, since it consists of a mixture of compounds of hydrogen and carbon, but it is a great deal more volatile. It is a vapor and when used as a fuel, a special kind of carburetor is required. When LPG is stored or transported, it is compressed and cooled so that it is a liquid. It is under tremendous pressure and needs extremely strong tanks. LPG is made of surplus material in the oil fields. It is becoming more widely used as an increasing number of trucks and tractors are being fitted with the equipment required to make use of it. Besides being low in cost, LPG has the advantage of having a high octane value (93 for pure butane; 100 for propane). Since it is a dry gas, LPG does not create carbon in an engine, and does not cause dilution of the engine oil. As a result, maintenance and internal parts replacement is highly reduced. Oil changes are also less frequent because it is a cleaner burning fuel than gasoline. Other advantages are easy cold weather starting, lack of exhaust odor, and elimination of evaporation.

Shocking Developments

The first electric-powered road vehicle is believed to have been built in Scotland about 1839 by Robert Anderson, but it, along with others within the next several years, were generally unsuccessful. The steamer had to wait for a boiler to build up pressure and was very noisy besides. The concept of an electrical engine that could start immediately and run quietly was very attractive at that time. There were disadvantages, however. Electric batteries were heavy, bulky, unreliable, and needed recharging after a short run. In 1880, there was a general improvement in the development of longer-lasting batteries. There still existed, however, excessive weight and bulk of the batteries and a need for frequent rechargings, although electric cabs appeared on the streets of London in the late 1800s. Steamers and electric vehicles gained only restricted acceptance on the continent as well. In France, the electric had a shining, brief hour of public acclaim when Camille Jenatzy, driving a Jeantaud electric, pushed the cigar-shaped vehicle to a record of sixty miles per hour on April 29, 1899. The high-speed run, however, burned out the specially fabricated batteries and the interest in electrics died almost as soon as the cheers of the attending public. It was in America that steamers and electric cars gained their most sustained measure of

success. Eventually twenty different U.S. car companies would produce electrics; and in the peak of popularity, 1912, nearly 35,000 were operating on American roads. But even America could not shake the limitations of the bulky batteries and the short ranges between recharging. Steamers were actually more popular. More than 100 American plants were making steamers, the most famous of which were the Stanley brothers factory in Newton, Massachusetts. The "Stanley Steamer" had the affectionate nickname, "The Flying Teapot," and with good reason. In 1906, a Stanley Steamer was clocked at 127.6 miles per hour on the sands of Ormond Beach, Florida. In spite of this, the steamers, along with the electrics, were only living on borrowed time. Experiments were being made on an automobile powered by a gasoline-fueled, internal-combustion engine, and the steamers and electrics would not survive the impact of the coming collision. Internal-combustion automobiles did not just burst forth on the scene all of a sudden to crowd the electrics and steamers off the road. The theories of internal-combustion engines had been on the way ever since 1860, when Etienne Lenoir applied to the authorities in Paris for a patent on his invention, an internal-combustion engine powered by coal gas. Two years later, Lenoir hooked his engine to a carriage, and, although it was crude, it worked. It worked so poorly and so slowly (about one mile an hour), however, that he became discouraged and abandoned his efforts. In 1864, a resourceful Austrian in Vienna, Siegfried Marcus, built a one-cylinder engine that incorporated a crude carburetor and a magneto arrangement to create successive small explosions that applied alternating pressure against the piston within the cylinder. Bolting his engine to a cart, Siegfried geared the piston to the rear wheels, and while a strong assistant lifted the rear of the cart off the ground, Siegfried started the engine. The wheels began to turn and continued to turn with each successive "pop." Marcus signaled the assistant to lower the cart and watched it burp along for about 500 feet before it ran out of fuel. Ten years later, he built the new, improved version of his motorcar, and then, mysteriously washed his hands of the entire thing, saying it was a waste of time. (The second model, which is preserved in an Austrian museum, was refurbished and taken for a test run in Vienna in 1950. It reached a top speed of ten miles per hour on level ground.) Although Lenoir and Marcus did not have the grit and determination to pursue their enterprises, they made some valuable contributions to the theory of internal-combustion engines. It would be overstating the case to credit them with the creation of the internal-combustion automobile, however.

Alcohol as a Fuel

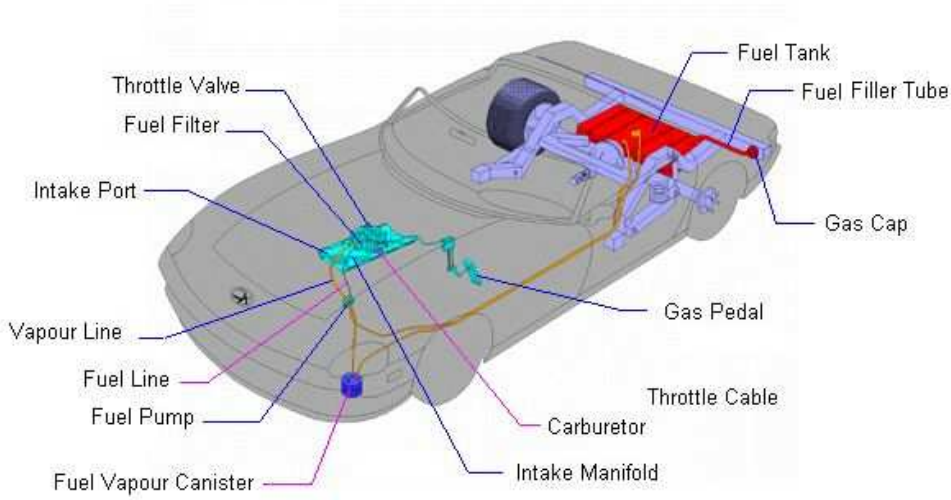
The increasing cost of gasoline, and the new laws requiring alternative fuels have turned the attention of car and truck designers to substitutes. Chief among alternative fuels is alcohol. Considerable research has been done, and is still carried out, for alcohol in spark ignition engines. Alcohol fuels were used extensively in Germany during WWII, and alcohol blends are used in many vehicles at the present time. Methanol and ethanol are the forms of alcohol receiving the most attention. Both are made from non-petroleum products. Methanol can be produced from coal, and ethanol can be made from farm

products such as sugar cane, corn, and potatoes. Both alcohols have a higher octane number than gasoline. High heat of vaporization, however, indicates that the use of alcohol could give harder starting problems than gasoline, which means a need for a larger fuel tank and larger jet sizes in the carburetor. It requires less air for combustion, though, which compensates for the high calorific values. In proportion, this could result in practically the same air-fuel ratio for all three. Experimental tests have shown that alcohol-fueled spark ignition engines can produce as much or slightly higher power than gasoline. Alcohol fuels have a higher self-ignition temperature than gasoline, which rates them better from a safety standpoint, but this same quality bars them from use in a diesel engine which depends on the heat of compression to ignite the fuel. At the present time, only ethanol can be blended in small concentrations (10%%) with gasoline. Because of the high octane rating, alcohols can be used in relatively high compression ratios, and experiments indicate that emissions from engines fueled by alcohol would require the use of exhaust gas recirculation controls.

Fuel Systems

Fuel Filler Cap

Although all of us know how to use the fuel filler cap, it is actually more complicated than it looks. Inside the fuel filler cap is a pressure release valve. This allows it to vent the fumes in the gas tank if they build up to predetermined levels. Until the fumes reach these levels, they are shunted through the charcoal canister which collects the fuel from the air before the air escapes. When the fumes build up above the predetermined (differing from car to car) threshold level of the fuel filler cap's pressure release valve, they are vented into the atmosphere. The fuel filler cap has a rubber flange around the neck. This flange should be inspected for cracks or inflexibility. If the flange does become cracked or inflexible, it should be replaced to keep the environment clean.



Fuel Systems

Fuel Tank

All modern fuel systems are fed through a pump, so the fuel tank is usually at the rear of the chassis under the trunk compartment. Some vehicles have a rear engine with the tank in the forward compartment. The fuel tank stores the excess fuel until it is needed for operation of the vehicle. The fuel tank has an inlet pipe and an outlet pipe. The outlet pipe has a fitting for fuel line connection and may be located in the top or in the side of the tank. The lower end is about one-half inch above the bottom of the tank so that collected sediment will not be flushed out into the carburetor. The bottom of the tank contains a drain plug so that tank may be drained and cleaned. The gas tank of the early cars was placed higher than the engine. The idea was that the gas would flow down to the engine. This arrangement caused a problem when the car went uphill -- the gas flowed away from the engine. Solution: drive up the hill backwards!

Gas Pedal

The gas, or accelerator, pedal is connected to the throttle valve by the throttle cable, or linkage. Pressing on the pedal causes the linkage to open the throttle valve, and thereby increase engine speed. A return spring on the throttle valve returns the pedal to its normal position when foot pressure pedal is released.

Throttle Linkages

The throttle cable, or linkage, controls the throttle valve by connecting it to the accelerator pedal. Pressing on the pedal causes the linkage to open the throttle plate and the choke plate. This causes air to rush through the barrel.

Throttle Valve

All gasoline engines have a throttle valve to control the volume of intake air. The amount of fuel and air that goes into the combustion chamber regulates the engine speed and, therefore, engine power. The throttle valve is linked to the accelerator (gas pedal). The throttle valve is a butterfly valve that usually consists of a disc mounted on a spindle. The disc is roughly circular, and it has the same diameter as the main air passage in the throat or "venturi". In a carburetor, the throttle valve is usually located at the bottom of the carburetor, between the jet nozzle and the intake manifold. The throttle spindle is connected to the accelerator in such a manner that when the pedal is depressed, the valve opens. When the pedal is released, the valve closes. Fuel injected engines use throttle valves to regulate engine power, even though the fuel is also regulated through the injectors.

Carburetor

The purpose of the carburetor is to supply and meter the mixture of fuel vapor and air in relation to the load and speed of the engine. Because of engine temperature, speed, and load, perfect carburetion is very hard to obtain. The carburetor supplies a small amount of a very rich fuel mixture when the engine is cold and running at idle. With the throttle plate closed and air from the air cleaner limited by the closed choke plate, engine suction is amplified at the idle-circuit nozzle. This vacuum draws a thick spray of gasoline through the nozzle from the full float bowl, whose fuel line is closed by the float-supported needle valve. More fuel is provided when the gas pedal is depressed for acceleration. The pedal linkage opens the throttle plate and the choke plate to send air rushing through the barrel. The linkage also depresses the accelerator pump, providing added gasoline through the accelerator-circuit nozzle. As air passes through the narrow center of the barrel, called the "venturi", it produces suction that draws spray from the cruising-circuit nozzle. The float-bowl level drops and causes the float to tip and the needle valve to open the fuel line. To cause a liquid to flow, there must be a high pressure area (which in this case is atmospheric pressure) and a low pressure area. Low pressure is less than atmospheric pressure. The average person refers to a low pressure area as a vacuum. Since the atmospheric pressure is already present, a low pressure area can be created by air or liquid flowing through a venturi. The downward motion of the piston also creates a low pressure area, so air and gasoline are drawn through the carburetor and into the engine by suction created as the piston moves down, creating a partial vacuum in the cylinder. Differences between low pressure within the cylinder and

atmospheric pressure outside of the carburetor causes air and fuel to flow into the cylinder from the carburetor.

Valve Ports

Valve ports are openings in the cylinder head. Intake ports let the fuel mixture into the cylinder head, and exhaust ports let the exhaust out.

Fuel Vapor Canister

The fuel vapor canister is used by the vapor recovery system to trap fuel from the carburetor float bowl and fuel tank. Starting the engine causes the vacuum port in the canister to pull fresh air into the canister to clean out the trapped fuel vapor. The trapped fuel vapor is then fed into the carburetor to be burned.

Mechanical Fuel Pump

The mechanical fuel pump differs in that it has a vacuum booster section. The vacuum section is operated by the fuel pump arm; otherwise, it has nothing to do with the fuel system. During the suction (or first) stroke, the rotation of the eccentric on the camshaft puts the pump operating arm into motion, pulling the lever and diaphragm down against the pressure of the diaphragm spring and producing suction (vacuum) in the pump chamber. The suction will hold the outlet valve closed and pull the inlet valve open, causing fuel to flow through the filter screen and down through the inlet valve of the pump chamber. During the return stroke, the diaphragm is forced up by the diaphragm spring, the inlet valve closes and the outlet valve opens to allow fuel to flow through the outlet to the carburetor. The operating lever is hinged to the pump arm, so that it can move down but cannot be raised by the pump arm. The pump arm spring forces the arm to follow the cam without moving the lever. The lever can only be moved upward by the diaphragm spring. This process causes fuel to be delivered to the carburetor only when the fuel pressure in the outlet is less than the pressure maintained by the diaphragm spring. This happens when the passage of fuel from the pump into the carburetor float chamber is open and the float needle is not seated.

Fuel Lines

Fuel lines, which connect all the units of the fuel system, are usually made of rolled steel or, sometimes, of drawn copper. Steel tubing, when used for fuel lines, is generally rust proofed by being copper or zinc plated. Fuel lines are placed as far away from exhaust pipes, mufflers, and manifolds as possible, so that excessive heat will not cause vapor lock. They are attached to the frame, the engine, and other units in such a way that the effect of vibration is minimal, and so that they are free of contact with sharp edges which might cause wear. In

areas where there is a lot of movement, as between the car`s frame and rubber-mounted engine, short lengths of gasoline resistant flexible tubing are used.

Intake Manifolds

An intake manifold is a system of passages which conduct the fuel mixture from the carburetor to the intake valves of the engine. Manifold design has much to do with the efficient operation of an engine. For smooth and even operation, the fuel charge taken into each cylinder should be of the same strength and quality. Distribution of the fuel should, therefore, be as even as possible. This depends greatly upon the design of the intake manifold. Dry fuel vapor is an ideal form of fuel charge, but present-day fuel prevents this unless the mixture is subjected to high temperature. If the fuel charge is heated too highly, the power of the engine is reduced because the heat expands the fuel charge. Therefore, it is better to have some of the fuel deposited on the walls of the cylinders and manifold vents. Manifolds in modern engines are designed so that the amount of fuel condensing on the intake manifold walls is reduced to a minimum. In a V-8 engine, the intake manifold is mounted between the cylinder heads. The L-head engine's manifold is bolted to the side of the block, and the I-head manifold is bolted to the cylinder head.

Carburetor

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Fuel Filter

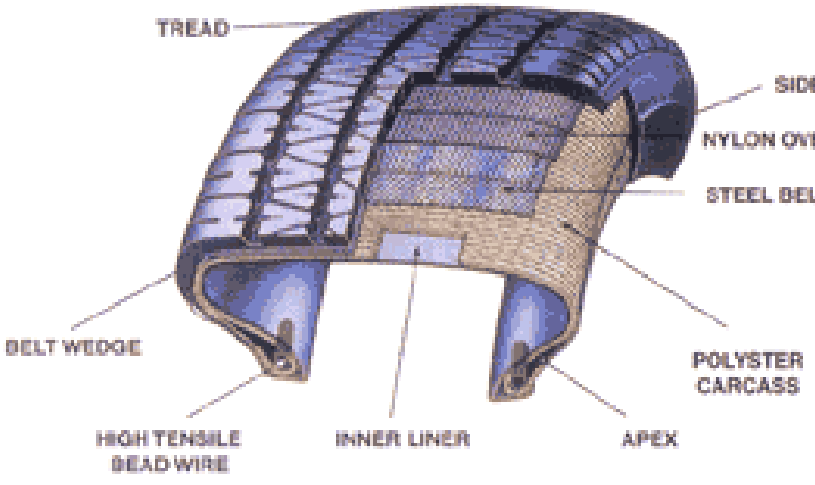
Clean fuel is important, because of the many small jets and passages in the carburetor and openings in a fuel injector. To ensure this cleanliness, fuel filters are installed in the fuel line. Fuel filters can be located at any point between the fuel tank and the carburetor. One may be in the tank itself, in the fuel pump or in the carburetor. The most common placement is between the fuel tank and a mechanical fuel pump. In this case, the fuel enters a glass bowl and passes up through the filter screen and out through an outlet. Any water or solid material which is trapped by the filter will fall to the bottom of the glass bowl where it can be easily seen and removed. Dirt particles usually come from scales of rust in the tank cars, storage tanks or drums. Water comes from condensed moisture in the fuel tanks.

Engine Configurations

V-Type Engines The V-type of engine has two rows of cylinders at (usually) a ninety degree angle to each other. Its advantages are its short length, the great rigidity of the block, its heavy crankshaft, and attractive low profile (for a car with a low hood). This type of engine lends itself to very high compression ratios without block distortion under load, resistance to torsional vibration, and a shorter car length without losing passenger room. In 1914, Cadillac was the first company in the United States to use a V-8 engine in its cars. In-line engines have the cylinders arranged, one after the other, in a straight line. In a vertical position, the number of cylinders used is usually either four or six, but three cylinder cars are becoming more common. Rotary Engine The rotary, or Wankel, engine has no piston, it uses rotors instead (usually two). This engine is small, compact and has a curved, oblong inner shape (known as an "epitrochoid" curve). Its central rotor turns in one direction only, but it produces all four strokes (intake, compression, power and exhaust) effectively. Flat (Horizontal-Opposed) Engines A horizontal-opposed engine is like a V-type engine that has been flattened until both banks lie in a horizontal plane. It is ideal for installations where vertical space is limited, because it has a very low height.

How Tyres Work

Tyres is a black art - pun very much intended. And with the Indian car buyer finally paying some heed to those four black round thingumajigs on his jalopy, making ising, consider upon unsuspe ooms. OVERDI es in which w yre is made ar de on the type



How Tyres are made

As the figure illustrates, a tyre is made up of several different components.

The Bead Bundle

The bead is a loop of high-strength, steel cable coated with rubber. It gives the tyre the strength it needs to stay seated on the wheel rim and to handle the forces applied by tyre-mounting machines when the tyres are installed on rims.

The Body

The body is made up of several layers of different fabrics, called plies. The most common ply fabric is polyester cord. The cords in a radial tyre run perpendicular to the tread. Some older tyres used diagonal bias tyres - in which the fabric ran at an angle to the tread. The plies are coated with rubber to help them bond with the other components and to seal in the air.

A tyres's strength is often described by the number of plies it has. Most car tyres have two body plies. By comparison, large commercial jetliners often have tyres with 30 or more plies.

The Belts

In steel-belted radial tyres, belts made from steel are used to reinforce the area under the tread. These belts provide puncture resistance and help the tyre stay flat so that it makes the best contact with the road.

Cap Plies

Some tyres have cap plies, an extra layer or two of polyster fabric to hold everything in place. These cap plies are not found on all tyres; they are mostly used on tyres with higher speed ratings to help all the components stay in place at high speeds.

The Sidewall

The sidewall provides lateral stability for the tyre, protects the body plies and helps keep the air from escaping. It may contain additional components to help increase the lateral stability.

The Tread

The tread is made from a mixture of many different kinds of natural and synthetic rubbers. The tread and the sidewalls are extruded and cut to length. The tread is just smooth rubber at this point; it does not have the tread patterns that give the tyre traction.

Assembly

All of these components are assembled in the tyre-bulding machine. This machine ensures that all of the components are in the correct location and then forms the tyre into a shape and size fairly close to its finished dimension.

At this point the tyre has all of its pieces, but it's not held together very tightly, and it doesn't have any markings or tread patterns. This is called a 'green tyre'. The next step is to run the tyre into a curing machine, which functions something like a waffle iron, moulding in all of the markings and traction patterns. The heat also bonds all of the tyre's components together. This is called vulcanising. After a few finishing and inspection procedures, the tyre is ready.

How seatbelt works?

Taking a Hit

In the last section, we saw that any time a car comes to a sudden stop, a passenger comes to a sudden stop as well. A seatbelt's job is to spread the stopping force across sturdier parts of your body in order to minimize damage.

A typical seatbelt consists of a lap belt, which rests over your pelvis, and a shoulder belt, which extends across your chest. The two belt sections are tightly secured to the frame of the car in order to hold passengers in their seats.

When the belt is worn correctly, it will apply most of the stopping force to the rib cage and the pelvis, which are relatively sturdy parts of the body. Since the belts extend across a wide section of your body, the force isn't concentrated in a small area, so it can't do as much damage. Additionally, the seatbelt webbing is made of more flexible material than the dashboard or windshield. It stretches a little bit, which means the stop isn't quite so abrupt. The seatbelt shouldn't give more than a little, however, or you might bang into the steering wheel or side window. Safe seatbelts will only let you shift forward slightly.

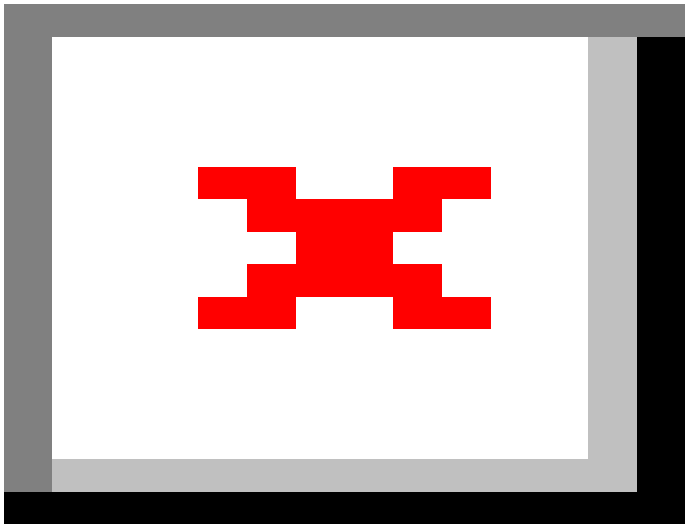
A car's crumple zones do the real work of softening the blow. Crumple zones are areas in the front and rear of a car that collapse relatively easily. Instead of the entire car coming to an abrupt stop when it hits an obstacle, it absorbs some of the impact force by flattening, like an empty soda can. The car's cabin is much sturdier, so it does not crumple around the passengers. It continues moving briefly, crushing the front of the car against the obstacle. Of course, crumple zones will only protect you if you move with the cab of the car -- that is, if you are secured to the seat by your seatbelt.

The simplest sort of seatbelt, found in some roller coasters, consists of a length of webbing bolted to the body of the vehicle. These belts hold you tightly against the seat at all times, which is very safe but not particularly comfortable.

Car seatbelts have the ability to extend and retract -- you can lean forward easily while the belt stays fairly taut. But in a collision, the belt will suddenly tighten up and hold you in place. In the next section, we'll look at the machinery that makes all this possible.

Extend and Retract

In a typical seatbelt system, the belt webbing is connected to a retractor



mechanism. The central element in the retractor is a spool, which is attached to one end of the webbing. Inside the retractor, a spring applies a rotation force, or torque, to the spool.

This works to rotate the spool so it winds up any loose webbing.

A spiraled spring rotates the spool to keep the seatbelt

webbing taut.

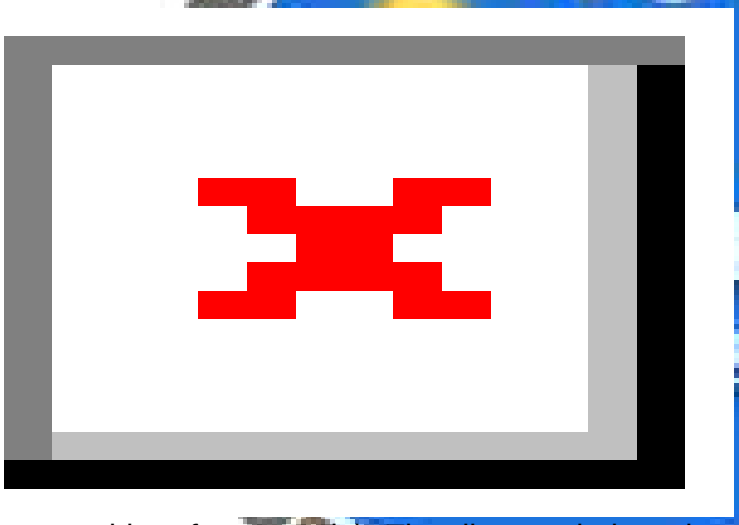
When you pull the webbing out, the spool rotates counter-clockwise, which turns the attached spring in the same direction. Effectively, the rotating spool works to untwist the spring. The spring wants to return to its original shape, so it resists this twisting motion. If you release the webbing, the spring will tighten up, rotating the spool clockwise until there is no more slack in the belt.

The retractor has a locking mechanism that stops the spool from rotating when the car is involved in a collision. There are two sorts of locking systems in common use today:

systems triggered by the car's movement

systems triggered by the belt's movement

The first sort of system locks the spool when the car rapidly decelerates (when it



hits something, for example). The diagram below shows the simplest version of this design.

The central operating element in this mechanism is a weighted pendulum. When the car comes to a sudden stop, the inertia causes the pendulum to swing forward. The pawl on the other end of the pendulum catches hold of a toothed ratchet gear attached to the spool. With the pawl gripping one of its teeth, the gear can't rotate counter-clockwise, and neither can the connected spool. When the webbing loosens again after the crash, the gear rotates clockwise and the pawl disengages.

The second kind of system locks the spool when something jerks the belt webbing. The activating force in most designs is the speed of the spool rotation. The diagram shows a common configuration.

The central operating element in this design is a centrifugal clutch -- a weighted pivoting lever mounted to the rotating spool. When the spool spins slowly, the lever doesn't pivot at all. A spring keeps it in position. But when something yanks the webbing, spinning the spool more quickly, centrifugal force drives the weighted end of the lever outward.

The extended lever pushes a cam piece mounted to the retractor housing. The cam is connected to a pivoting pawl by a sliding pin. As the cam shifts to the left, the pin moves along a groove in the pawl. This pulls the pawl into the spinning ratchet gear attached to the spool. The pawl locks into the gear's teeth, preventing counter-clockwise rotation.

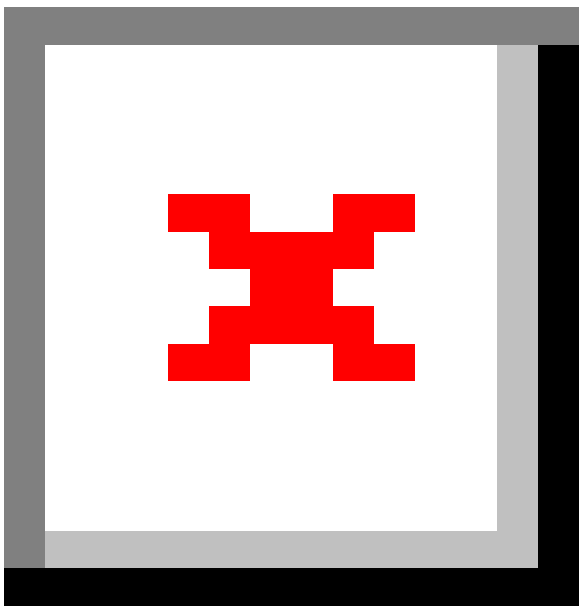
In some newer seatbelt systems, a pretensioner also works to tighten the belt webbing. In the next section, we'll see how these devices work.

The Pretensioner

The idea of a pretensioner is to tighten up any slack in the belt webbing in the event of a crash. Whereas the conventional locking mechanism in a retractor keeps the belt from extending any farther, the pretensioner actually pulls in on the belt. This force helps move the passenger into the optimum crash position in his or her seat. Pretensioners normally work together with conventional locking mechanisms, not in place of them.

There are a number of different pretensioner systems on the market. Some pretensioners pull the entire retractor mechanism backward and some rotate the spool itself. Generally, pretensioners are wired to the same central control processor that activates the car's air bags. The processor monitors mechanical or electronic motion sensors that respond to the sudden deceleration of an impact. When an impact is detected, the processor activates the pretensioner and then the air bag.

Some pretensioners are built around electric motors or solenoids, but the most popular designs today use pyrotechnics to pull in the belt webbing. The diagram



below shows a representative model.

When the gas is ignited, the pressure pushes the piston up to rotate the retractor.

The central element in this pretensioner is a chamber of combustible gas. Inside the chamber, there is a smaller chamber with explosive igniter material. This smaller chamber is outfitted with two electrodes, which are wired to the central processor.

When the processor detects a collision, it immediately applies an electrical current across the electrodes. The spark from the electrodes ignites the igniter material, which combusts to ignite the gas in the chamber. The burning gas generates a great deal of outward pressure. The pressure pushes on a piston resting in the chamber, driving it upward at high speed.

A rack gear is fastened to one side of the piston. When the piston shoots up, the rack gear engages a gear connected to the retractor spool mechanism. The speeding rack rotates the spool forcefully, winding up any slack belt webbing.

Load Limiters

In severe crashes, when a car collides with an obstacle at extremely high speed, a seatbelt can inflict serious damage. As a passenger's inertial speed increases, it takes a greater force to bring the passenger to a stop. In other words, the faster you're going on impact, the harder the seatbelt will push on you.

Some seatbelt systems use load limiters to minimize belt-inflicted injury. The basic idea of a load limiter is to release a little more excess belt webbing when a great deal of force is applied to the belt. The simplest load limiter is a fold sewn into the belt webbing. The stitches holding the fold in place are designed to break when a certain amount of force is applied to the belt. When the stitches come apart, the webbing unfolds, allowing the belt to extend a little bit more.

More advanced load limiters rely on a torsion bar in the retractor mechanism. A torsion bar is just a length of metal material that will twist when enough force is applied to it. In a load limiter, the torsion bar is secured to the locking mechanism on one end and the rotating spool on the other. In a less severe accident, the torsion bar will hold its shape, and the spool will lock along with the locking mechanism. But when a great deal of force is applied to the webbing (and therefore the spool), the torsion bar will twist slightly. This allows the webbing to extend a little bit farther.

Over the years, seatbelts have proven to be far and away the most important safety device in cars and trucks. They are by no means infallible, however, and car safety engineers see a lot of room for improvement in today's design. In the future, cars will be outfitted with better belts, better air bags and, most likely, completely new safety technology. Of course, the government will still have to address the biggest problem with safety devices -- getting people to use them.

For more information on seatbelts and other safety systems, check out the links on the next page.